UNCLASSIFIED

AD NUMBER

AD803863

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; OCT 1966. Other requests shall be referred to Air Force Weapons Lab., AFSC, Kirtland AFB, NM.

AUTHORITY

AFWC ltr, 30 Nov 1971

THIS PAGE IS UNCLASSIFIED

AFWL-TR
66-128

803863

THEORETICAL CALCULATIONS OF THE DETONATION OF A 1,000-POUND SPHERE OF TNT AT 15 FEET ABOVE GROUND LEVEL

Charles E. Needham
Edmund A. Nawrocki, Captain, USAF
William A. Whitaker, Captain, USAF

TECHNICAL REPORT NO. AFWL-TR-66-128
October 1966

AIR FORCE WEAPONS LABORATORY
Research and Technology Division
Air Force Systems Command
Kirtland Air Force Base
New Mexico

AFWL-TR-66-128

Research and Technology Division
AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base
New Mexico

When U. S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report is made available for study with the understanding that proprietary interests in and relating thereto will not be impaired. In case of apparent conflict or any other questions between the Government's rights and those of others, notify the Judge Advocate, Air Force Systems Command, Andrews Air Force Base, Washington, D. C. 20331.

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of AFWL (WLRTH), Kirtland AFB, N. M. 87117. Distribution of this document is limited because of the technology discussed.

Best
Available
Copy

AFWL-TR-66-128

THEORETICAL CALCULATIONS OF THE DETONATION OF A 1,000-POUND SPHERE OF TNT AT 15 FEET ABOVE GROUND LEVEL

Charles E. Needham

Edmund A. Nawrocki, Captain, USAF

William A. Whitaker, Captain, USAF

TECHNICAL REPORT NO. AFWL-TR-66-128

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of AFWL (WLRTH), Kirtland AFB, N.M. Distribution of this document is limited because of the technology discussed.

FOREWORD

This research was performed under Program Element 7.60.06.01.02, Project 5710, Task 571001, and was funded by the Defense Atomic Support Agency (DASA).

Inclusive dates of research were 10 July 1966 to 10 September 1966. The report was submitted 4 October 1966 by the AFWL Project Officer, Mr. Charles E. Needham (WLRTH).

This report has been reviewed and is approved.

Charles E Needham
CHARLES E. NEEDHAM
Project Officer

Ralph H Pennington
RALPH H. PENNINGTON
Colonel, USAF
Chief, Theoretical Branch

Claude K Stambaugh
CLAUDE K. STAMBAUGH
Colonel, USAF
Acting Chief, Research Division

ABSTRACT

The results of a theoretical calculation of the detonation of 1,000 pounds of TNT (loading density 1.608 gms/cc) are presented. The charge was detonated 15 feet above ground with an ambient pressure of 12.6 psi and an ambient temperature of appproximately 100°F. The calculation started with the burning of the TNT and was carried to 115 milliseconds. The calculation clearly shows Mach stem formation, triple point path, and flow field. The theoretical calculation agrees well with experimental data obtained from a test conducted by AFWL at Holloman AFB.

CONTENTS

Section		Page
I	INTRODUCTION	1
II	THE ONE-DIMENSIONAL CALCULATION	2
III	THE TWO-DIMENSIONAL CALCULATION	9
IV	COMPARISON OF CALCULATION AND EXPERIMENT	13
V	CONCLUSIONS	19
	APPENDIX I. Contours, Vectors, and Photos	21
	APPENDIX II. Station 1-11 Plots	62
	APPENDIX III. Station 12-19 Plots	162
	REFERENCES	227
	DISTRIBUTION	228

ILLUSTRATIONS

Figure		Page
1	Profiles of Hydrodynamic Variables as a Function of Distance for the One-dimensional Calculation at Selected Times	3
2	Profiles of Hydrodynamic Variables as a Function of Distance for the One-dimensional Calculation at Selected Times	4
3	Profiles of Hydrodynamic Variables as a Function of Distance for the One-dimensional Calculation at Selected Times	6
4	Profiles of Hydrodynamic Variables as a Function of Distance for the One-dimensional Calculation at Selected Times	7
5	Profiles of Hydrodynamic Variables as a Function of Distance for the One-dimensional Calculation at Selected Times	8
6	Triple Point Path	11
7	Overpressure and Overpressure Impulse vs. Ground Range	14
8	Arrival Time and Positive Phase Duration vs. Ground Range	16
9	Dynamic Pressure and Dynamic Pressure Impulse vs. Ground Range	18

TABLES

Table		Page
I	Test Station Positions	10
II	Overpressure and Overpressure Impulse Data	15

SECTION I

INTRODUCTION

In recent years much effort has been expended in attempts to experimentally measure the parameters of the Mach stem and associated phenomena. Most recently this was done in Operation Distant Plain* (reference 1).

In support of this operation the Air Force Weapons Laboratory was requested by the Defense Atomic Support Agency to make predictions of air blast parameters and associated two-dimensional effects to assist in pre-shot planning. These predictions are based on theoretical calculations made by large hydrodynamic computer codes, which begin from first principles rather than from scaling laws or empirical models.

After the theoretical calculations of Distant Plain phenomenology were completed, Colonel Ralph Pennington learned of a similar experiment just completed at Holloman AFB, New Mexico. In this experiment a 1,000-pound spherical charge of TNT was detonated and extremely fine field data were obtained. Therefore Colonel Pennington suggested a calculation be made of the Holloman shot for purposes of comparing theoretical calculations and experimental data.

Presented in this report are the results of and comparison between the theoretical calculations and the experimental data of the Holloman experiment.

---

*At this time, no experimental data have been received from the Distant Plain series.

SECTION II

THE ONE-DIMENSIONAL CALCULATION

The one-dimensional calculation was made using a modified version of the AFWL SAP Code on the AFWL CDC-6600 computer. SAP is a one-dimensional, spherically symmetric, Lagrangian hydrodynamic computer code. It has been modified to include two materials and a burn routine.

For this calculation 800 zones were given equal delta R's (where R is the radius) of 0.16 cm. The first 254 zones were given a density of 1.608 gm/cm^3 and were flagged as TNT zones. These conditions resulted in a charge weight of 996 pounds, the same weight as that used in the experiment. The remaining zones were given ambient atmospheric conditions.

Although a hydrodynamically stable real atmosphere is a standard part of the SAP program, it was not possible to make use of this because of the unusual conditions found at Holloman AFB. The low pressure and high temperature of the air at Holloman correspond--through the SAP equation of state for air--to a density which is far lower than that in a normal sea-level-based atmosphere for the same altitude (7000 feet). A stable atmosphere, which coincided with the 12.6 psi and 100°F conditions on the day of the experiment, was developed.

To calculate the burning of TNT, two input numbers were required: (1) the velocity of the detonation wave (a constant determined by density) in TNT, (2) the energy released per gram of TNT upon burning. The equation of state for TNT was also required.

The detonation velocity used for this run was 6.98×10^5 cm/sec, and the energy released was 4.26×10^{10} ergs/gm. The equation of state used was the LSZK formulation for TNT. (References 2 and 3.) For a detailed description of the SAP code and of the burn routine see reference 4.

The detonation wave reached the surface of the TNT at 0.058 msec with a peak pressure of 1.75×10^{11} dynes/cm^2. Figure 1 shows the wave profile just before it reaches the TNT surface, and figure 2 shows the profile after the front breaks the surface of the TNT. In this figure the velocity is seen to increase in this free expansion phase. The pressure and density curves have the same shape that they did prior to free expansion with the exception of the peak, which has been

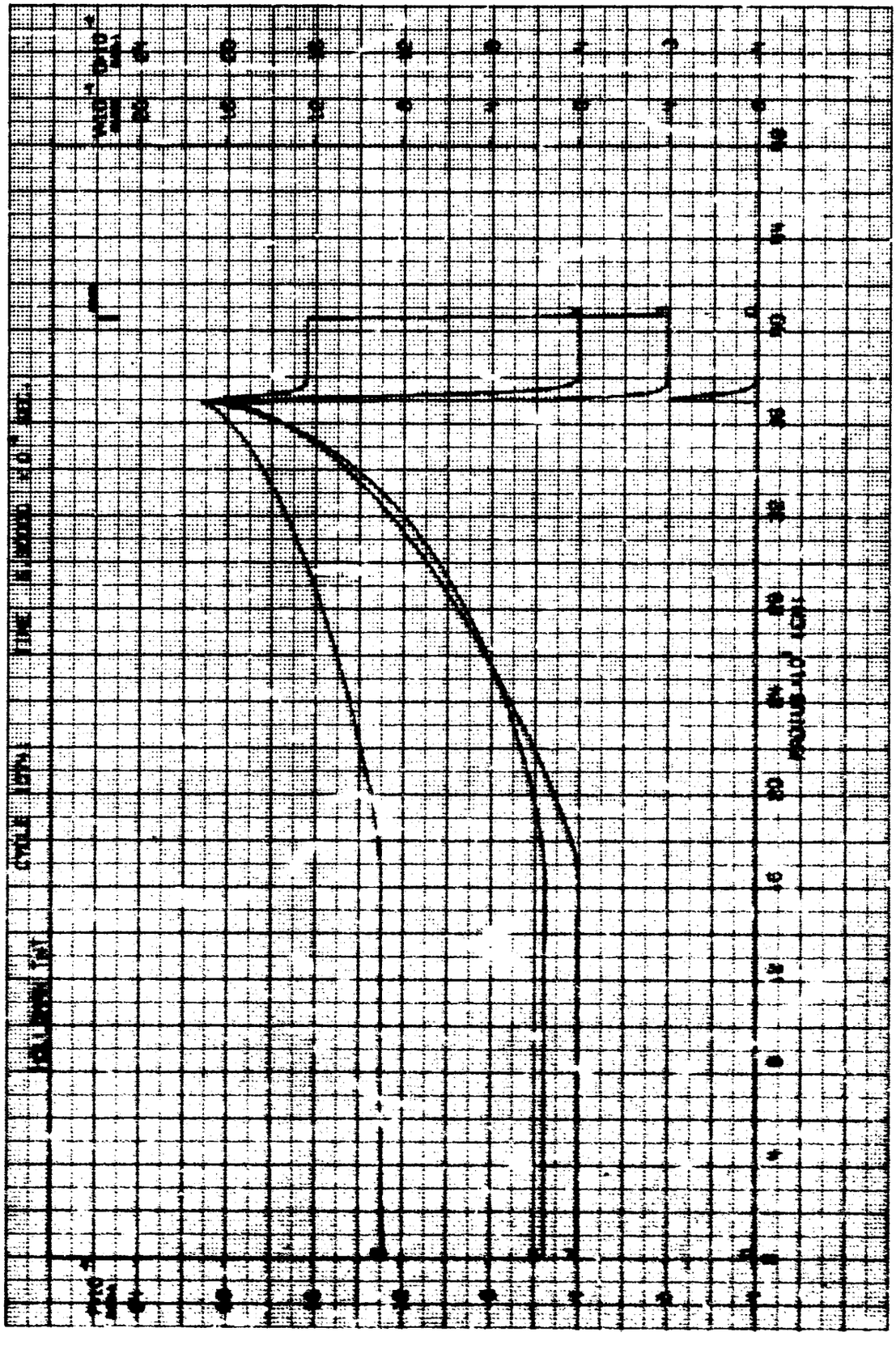


Figure 1. Profiles of Hydrodynamic Variables as a Function of Distance For the One-dimensional Calculation at Selected Times.

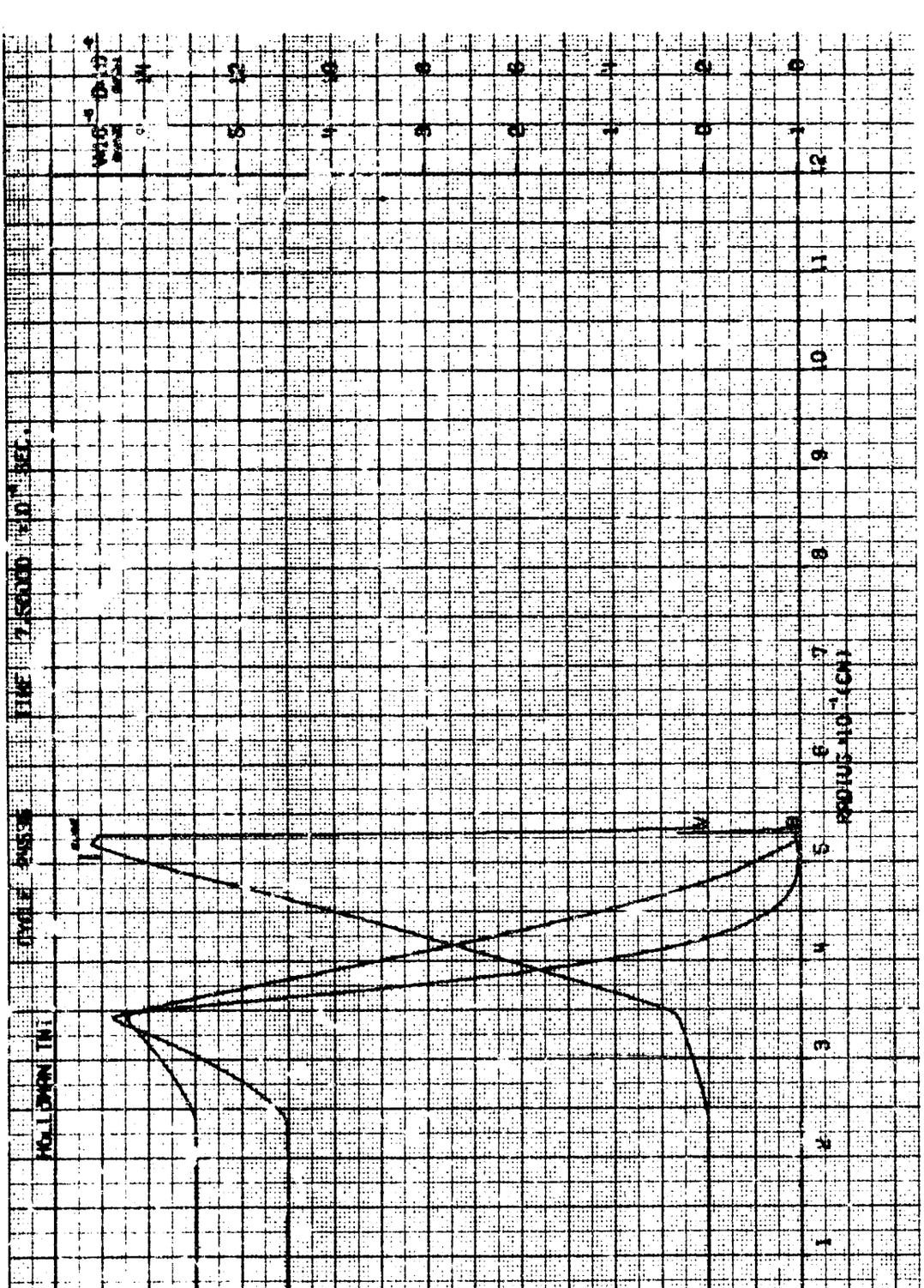


Figure 2. Profiles of Hydrodynamic Variables as a Function of Distance For the One-dimensional Calculation at Selected Times.

eaten away by the rarefaction wave. The free expansion cools the TNT and the TNT behaves like a cold piston compressing the low density air ahead of it. Figure 3 shows the profiles just before the rarefaction wave reaches the center.

Figure 4 shows the profile at the beginning of the two-dimensional calculation. Notice that all velocities are positive and that a sharp velocity gradient has developed just inside the TNT-Air interface.

The one-dimensional calculation was continued beyond the beginning of the two-dimensional calculation to compare the two runs and to show more clearly the two-dimensional effects. Figure 5 shows the profile as a shock moves inward from the TNT surface to the center. This shock is reflected from the center and forms a second outgoing shock. Many more small shocks are formed and follow in a similar manner. Following the reflected shocks in the one-dimensional case is interesting but probably of little value since two-dimensional effects are much more important.

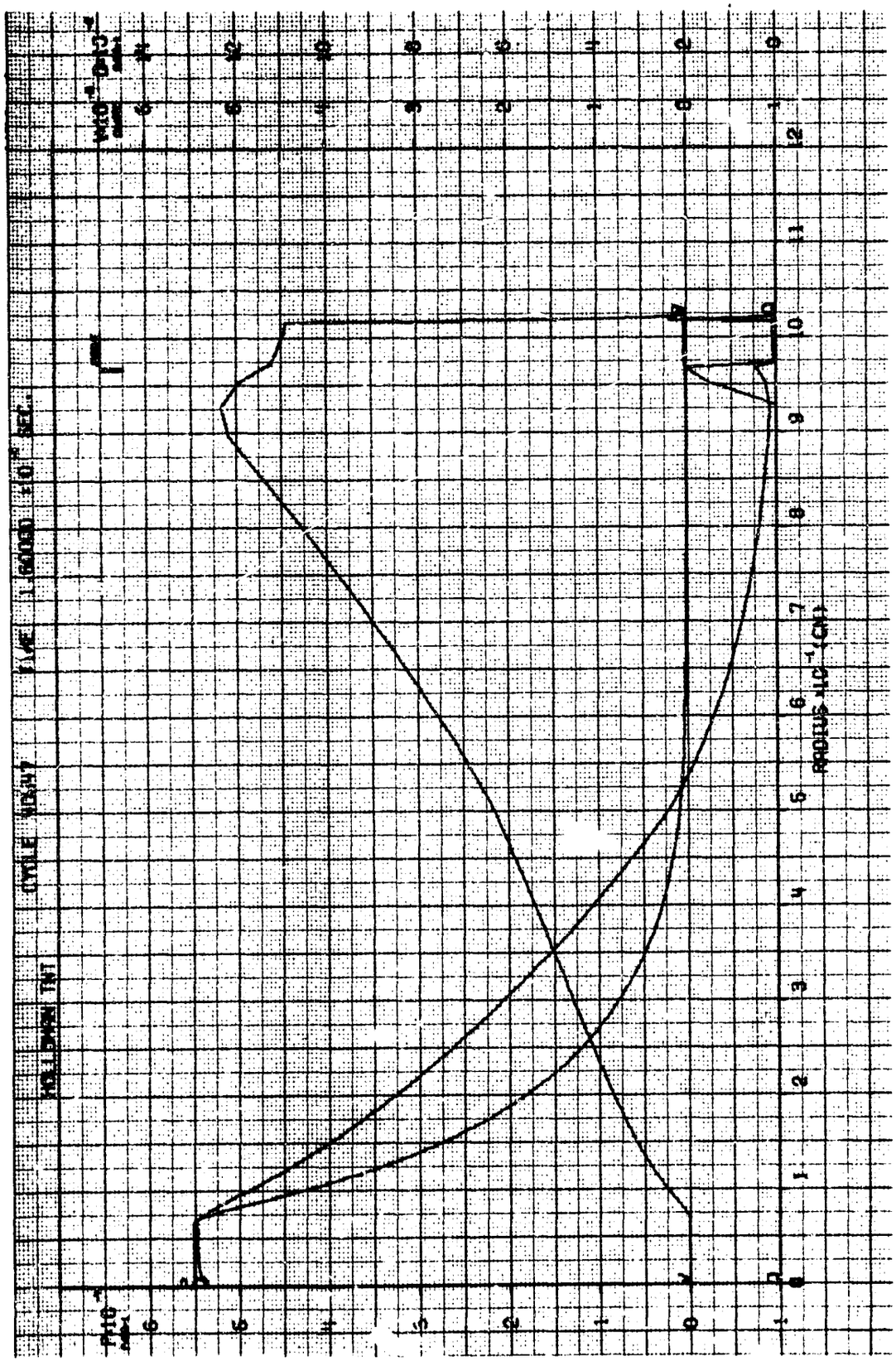


Figure 3. Profiles of Hydrodynamic Variables as a Function of Distance For the One-dimensional Calculation at Selected Times.

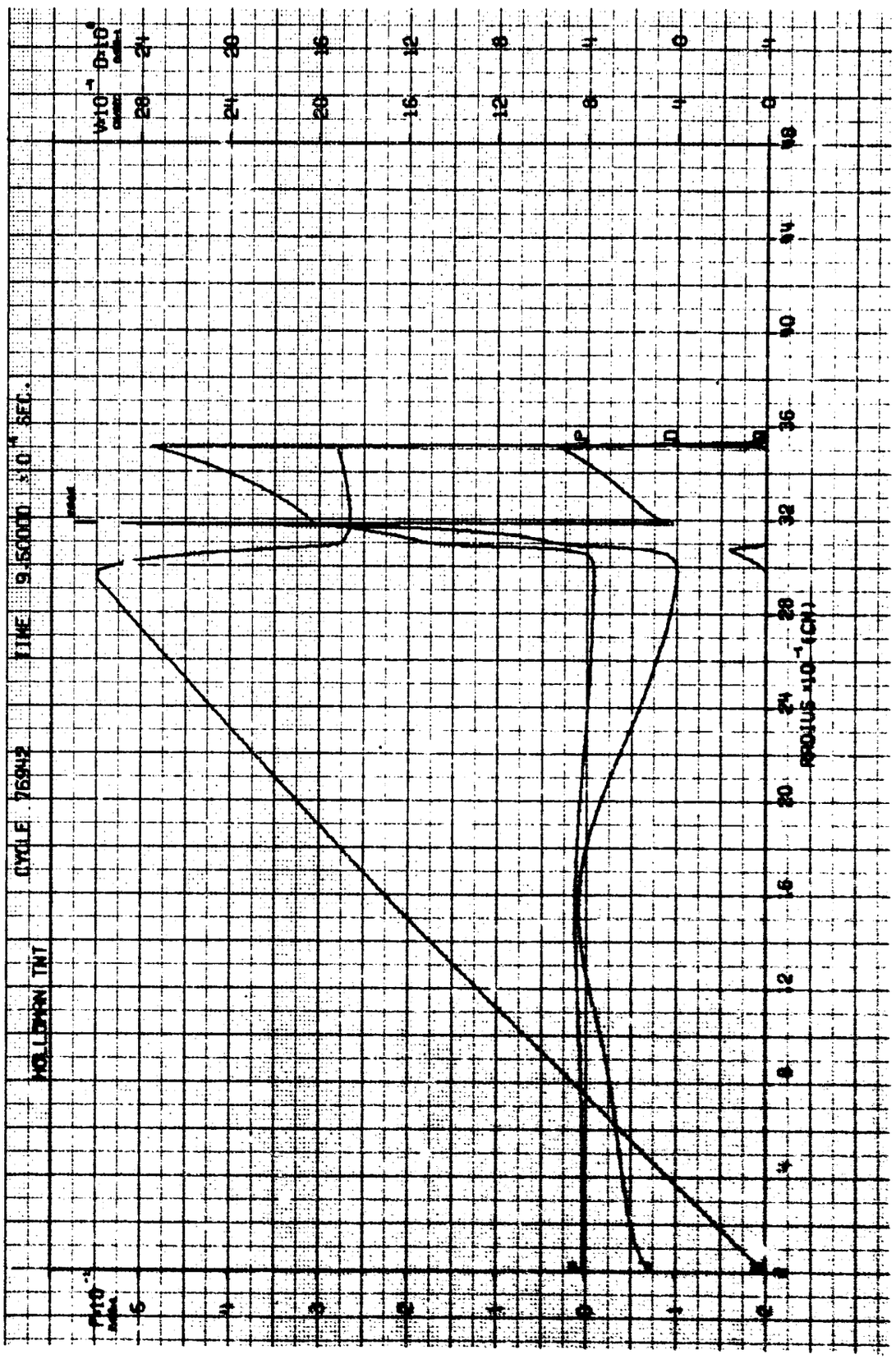


Figure 4. Profiles of Hydrodynamic Variables as a Function of Distance For the One-dimensional Calculation at Selected Times.

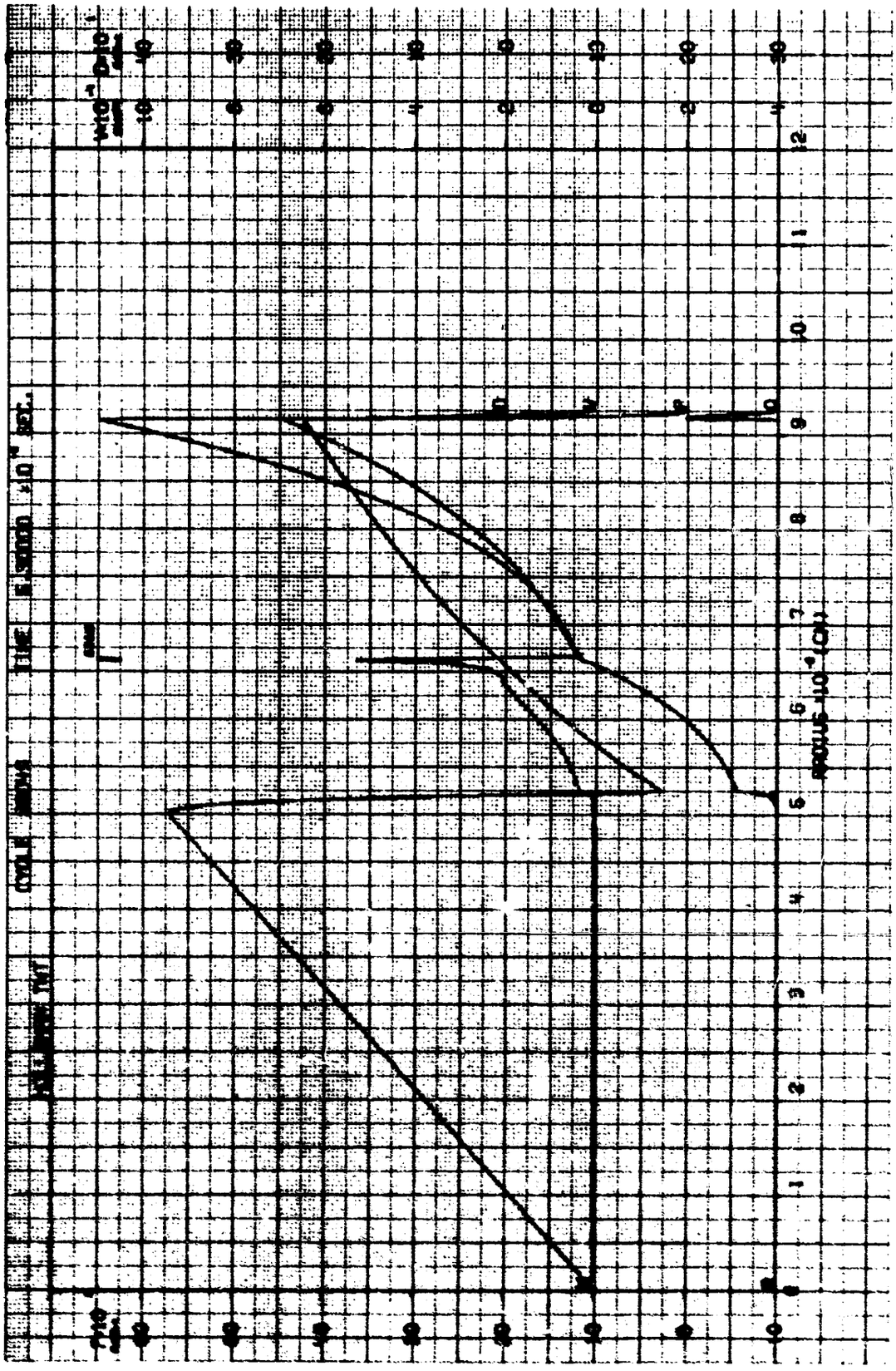


Figure 5. Profiles of Hydrodynamic Variables as a Function of Distance For the One-dimensional Calculation at Selected Times.

SECTION III

THE TWO-DIMENSIONAL CALCULATION

The two-dimensional calculation was made using the AFWL SHELL-OIL code on a CDC-6600 computer. SHELL-OIL is a two dimensional, pure Eulerian, axially symmetric, hydrodynamic code. SHELL is a one-material code; that is, all material in the problem is assumed to have the same equation of state. For this calculation the Doan-Nickel equation of state for air (reference 5), an empirical fit to Hilsenrath's data, was used. (For a detailed discussion of SHELL see reference 4.)

Some question arises as to the validity of treating TNT as air. At the time when the two-dimensional calculation was started (0.95 msec), the TNT had expanded to such an extent that it had a density comparable to that of the ambient air. This fact, combined with the relatively low temperature found throughout the TNT at this time, insures the validity of this assumption. To confirm this, a short one-dimensional calculation (SAP) was made using the air equation of state for all material. Differences between the two one-dimensional runs were on the order of 1 percent.

A minor modification was made in the SHELL program to allow monitoring at fixed points in the grid. Nineteen such points (test stations) were used in this calculation. The first eleven test stations were chosen to coincide with the experimental instrumentation stations. The twelfth through nineteenth test stations were placed at burst height at increasing radii. A complete list of station positions is given in table I.

The plots from these stations show the initial shock, the shock reflected from the ground, the second shock from the center, and the passage of the triple point past burst height. Figure 6 shows the triple point path relative to the test stations.

Included in this calculation were 801 trace particles. These particles follow the fluid motion but do not influence the hydrodynamics in any way. Initially, these particles were placed on the TNT-Air interface at equal intervals. The movement of these particles represents the motion of the interface as a function of time and appears as a heavy line on the contour and velocity vector plots in Appendix I.

Table I

TEST STATION POSITIONS

Station	Ground Range		Height	
	(Meters)	Feet	(Meters)	Feet
1	(10.67)	35.0	(1)	3.28
2	(12.8)	42.0	(1)	3.28
3	(15.5)	51.0	(1)	3.28
4	(17.98)	59.0	(1)	3.28
5	(19.5)	64.0	(1)	3.28
6	(21.03)	69.0	(1)	3.28
7	(23.47)	77.0	(1)	3.28
8	(26.52)	87.0	(1)	3.28
9	(29.26)	96.0	(1)	3.28
10	(31.39)	103.0	(1)	3.28
11	(35.35)	116.0	(1)	3.28
12	(5.0)	16.40	(4.57)	15.0
13	(6.0)	19.69	(4.57)	15.0
14	(8.0)	26.25	(4.57)	15.0
15	(10.0)	32.80	(4.57)	15.0
16	(12.0)	39.37	(4.57)	15.0
17	(15.0)	49.21	(4.57)	15.0
18	(20.0)	65.62	(4.57)	15.0
19	(25.0)	82.02	(4.57)	15.0

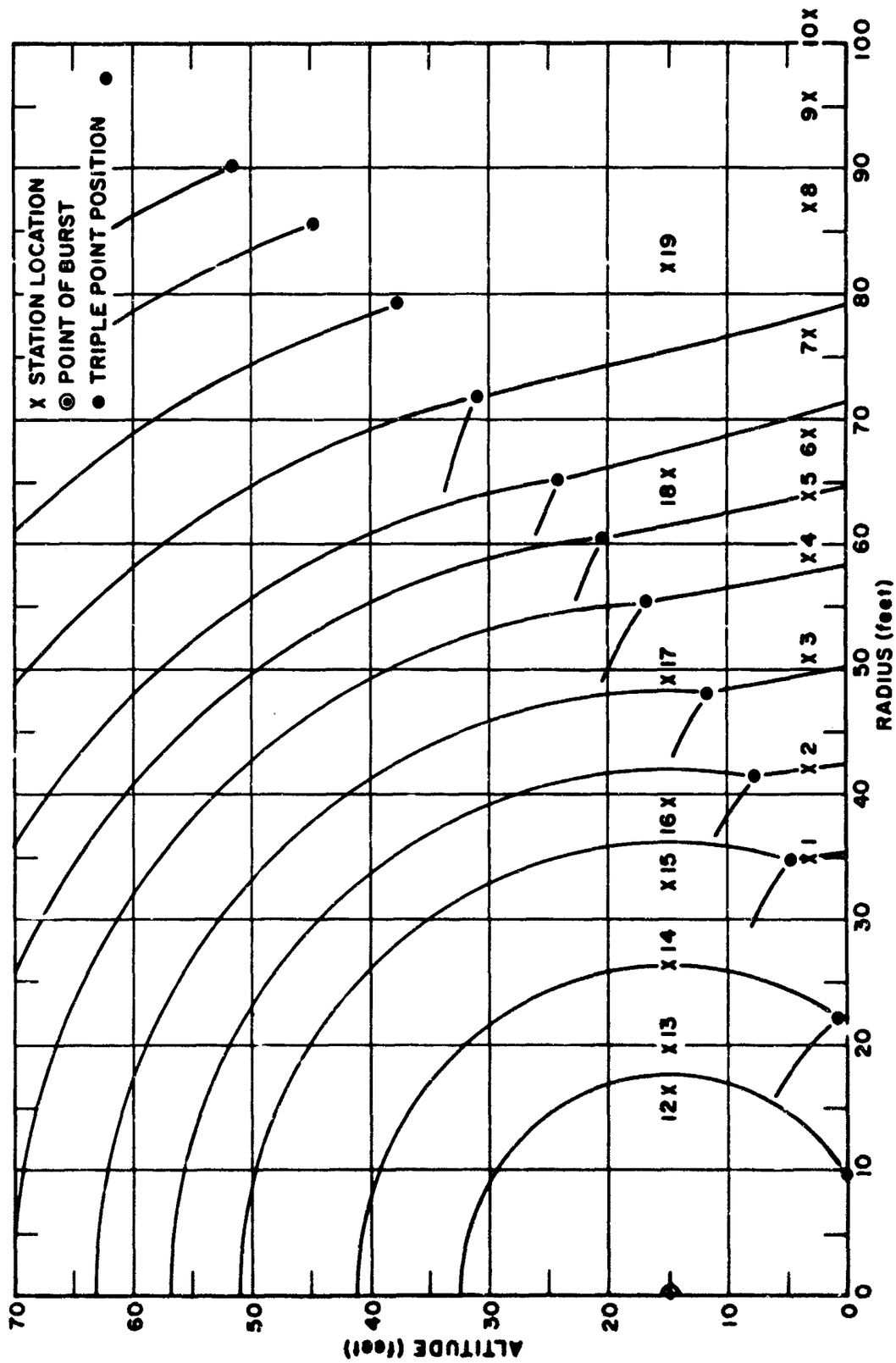


Figure 6. Triple Point Path.

Initially the SHELL mesh was a rectangle 142 zones in the radial (r) direction by 156 zones in the vertical (z) direction, in which each zone was 6 cm square. The entire rectangle has cylindrical symmetry about the verticle line r = 0. A sphere of radius 3.5515 m centered at r = 0, z = 4.572 m was generated. Into this sphere were placed the hydrodynamic variables as a function of radius, as calculated by SAP at 0.95 msec. Outside of this sphere the same ambient atmospheric conditions were generated as had been used previously in SAP. The bottom boundary, z = 0, was made reflective, and the calculations was begun.

As the calculation progressed and the shock expanded, an automatic rezone enlarged the grid by approximately 6-1/2 percent in linear extent each time the shock reached the edge (top or side) of the grid.

The small periodic jumps in the overpressure versus time curves and the associated plots in Appendixes I and II were due to this rezoning. The jumps occurred when a station, fixed in space, changed its position relative to the mesh by an amount sufficient for the station to occupy a different zone. This condition, in effect, changed the position of the station by one zone dimension. The jumps could have been smoothed very easily but would have only served aesthetic purposes.

In the discussion of the one-dimensional calculation, a shock was shown converging on the center of burst and forming a second outgoing shock. The radius of the outer shock was approximately 30 feet at this time. This means that the outer shock reached the ground and reflected to the center of burst before the converging shock had time to reach the center. Consequently, the convergence occurred at a point higher than the original center and also earlier than in the one-dimensional case. However, the second shock having been reflected from this new center, reached the ground at the same time in both calculations. It is this second shock that appears as the smaller peak on the overpressure versus time curves for stations 1-11. (Appendix II.)

SECTION IV

COMPARISON OF EXPERIMENT AND CALCULATION

The experiment was conducted by AFWL in conjunction with the Blast Environment Development portion of the Rocket Sled Blast Simulation Program at Holloman AFB, New Mexico.

A 996-pound sphere of TNT was detonated 15 feet above ground level. The data collected include the high-speed photographs and pressure-time histories at the first 11 stations listed in table I. All experimental instrumentation was below the triple point and thus in the Mach stem.

The analog data tapes were digitized, and plots were made at the Kirtland AFB Data Reduction Center. Arrival times and positive phase durations were read directly from the digitized tapes, but no direct measurements of overpressure impulse were made. The impulses given on the data graphs were computed by numerical integration of the overpressure time curves. Because of instrument noise, these impulses had oscillations of about 20 percent and have been included only for completeness.

Figure 7 shows the peak overpressure, both experimental and calculated, as a function of ground range. The overpressure impulse is that calculated by SHELL. The maximum difference between experimental and calculated overpressure is approximately 18 percent. The experimental curve oscillates about the calculated curve and the resulting differences have been interpreted as experimental error. Table II contains the exact values for overpressure and overpressure impulse data. Figure 8 shows the arrival time and positive phase duration of the main shock, both experimental and calculated, as a function of ground range. Again, the experimental data oscillate about the calculated curve with a maximum deviation of 7 percent in arrival time and of 12 percent in positive phase duration. The difference in arrival time is within experimental error. The larger percentage error in positive phase duration has been attributed to the compounded error in arrival time and to the electronic noise in the overpressure measurements. The noise present caused the overpressure to appear negative in some instances before and others after the negative phase had actually started.

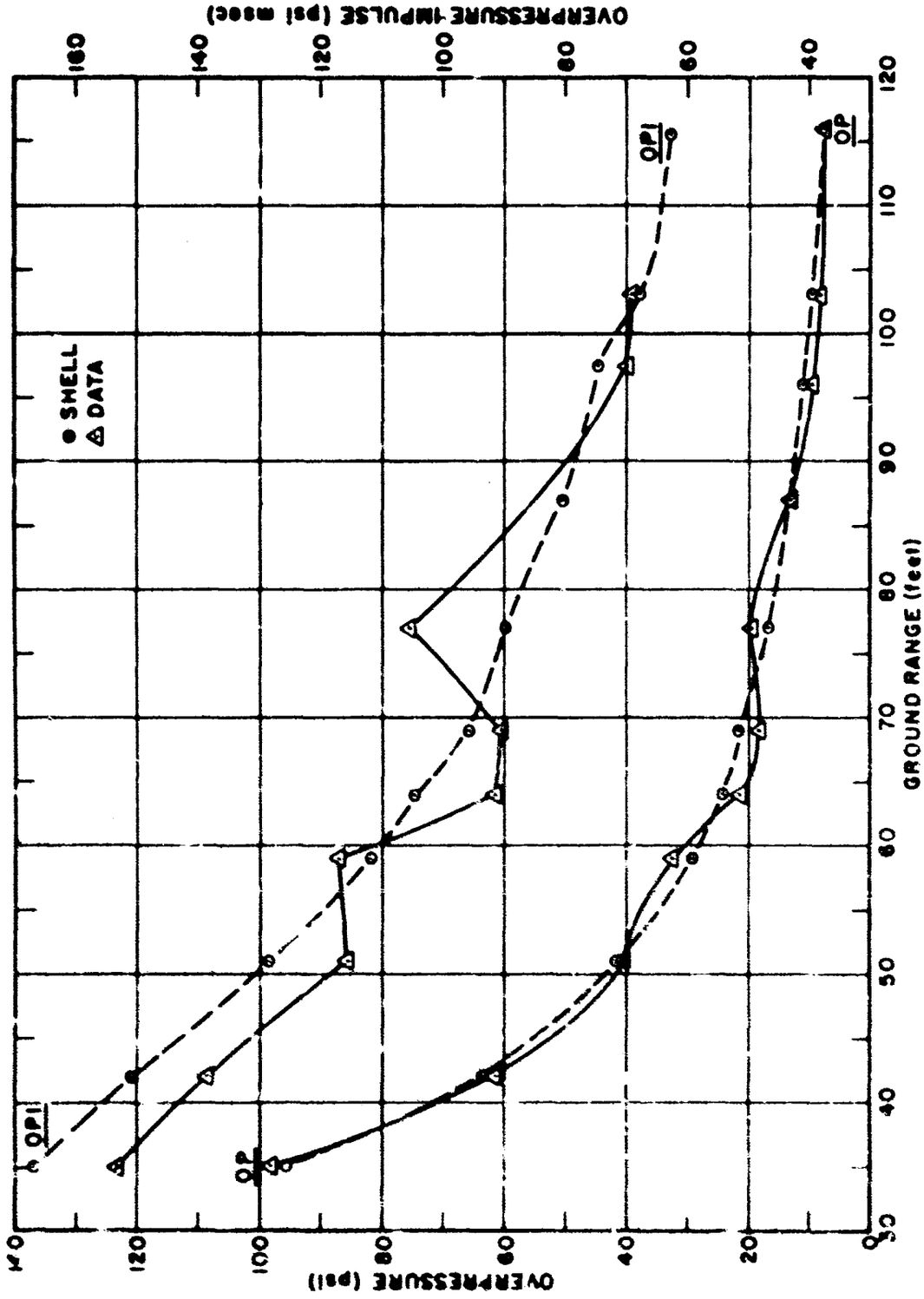


Figure 7. Overpressure and Overpressure Impulse vs. Ground Range.

Table II

OVERPRESSURE AND OVERPRESSURE IMPULSE DATA

Station	Distance (feet)	Data		Shell	
		OP	OPI	OP	OPI
1	35	98.2	153.4	95.8	167.0
2	42	61.5	138.8	63.8	151.0
3	51	40.7	115.9	41.9	128.4
4	59	32.5	117.2	29.2	111.9
5	64	21.3	91.4	24.2	104.8
6	69	18.2	90.4	20.8	96.0
7	77	19.8	105.5	16.9	89.8
8	87	13.1	57.9	13.2	80.2
9	96	9.5	69.9	11.0	74.5
10	103	8.1	69.0	9.6	67.7
11	116	7.4	38.0	7.7	62.8

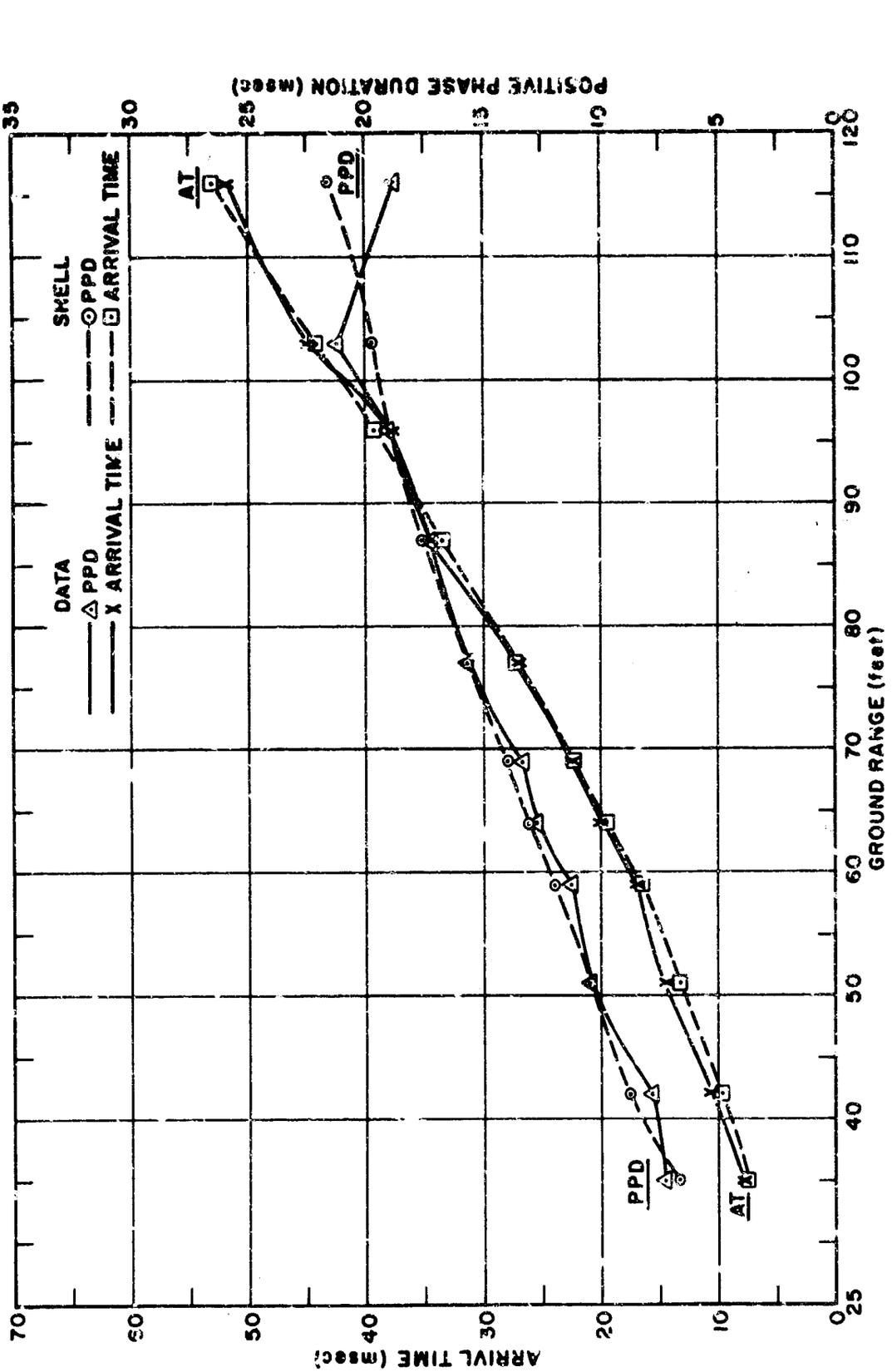


Figure 8. Arrival Time and Positive Phase Duration vs. Ground Range.

The depression at the back of the shock on the experimental curves was caused by instrument design and should be ignored. This depression, however, contributed, by lowering the impulses, to the previously described error, in the experimental overpressure impulse calculation. Figure 9 shows dynamic pressure and dynamic pressure impulse versus ground range.

The greatest discrepancy between the SHELL calculation and the experiment is due to the second shock arrival time. The calculation indicates a second shock arrival time about 8 milliseconds greater than that measured experimentally at the first station, and this difference in time increases with distance. (Compare the experimental and theoretical graphs in Appendix II.) At this time, no satisfactory explanation has been made for the difference, but several possibilities are being investigated.

The minimum overpressure before second shock arrival and the peak overpressure of the second shock agree within experimental error. This makes the discrepancy in second shock arrival time even more difficult to understand and explain.

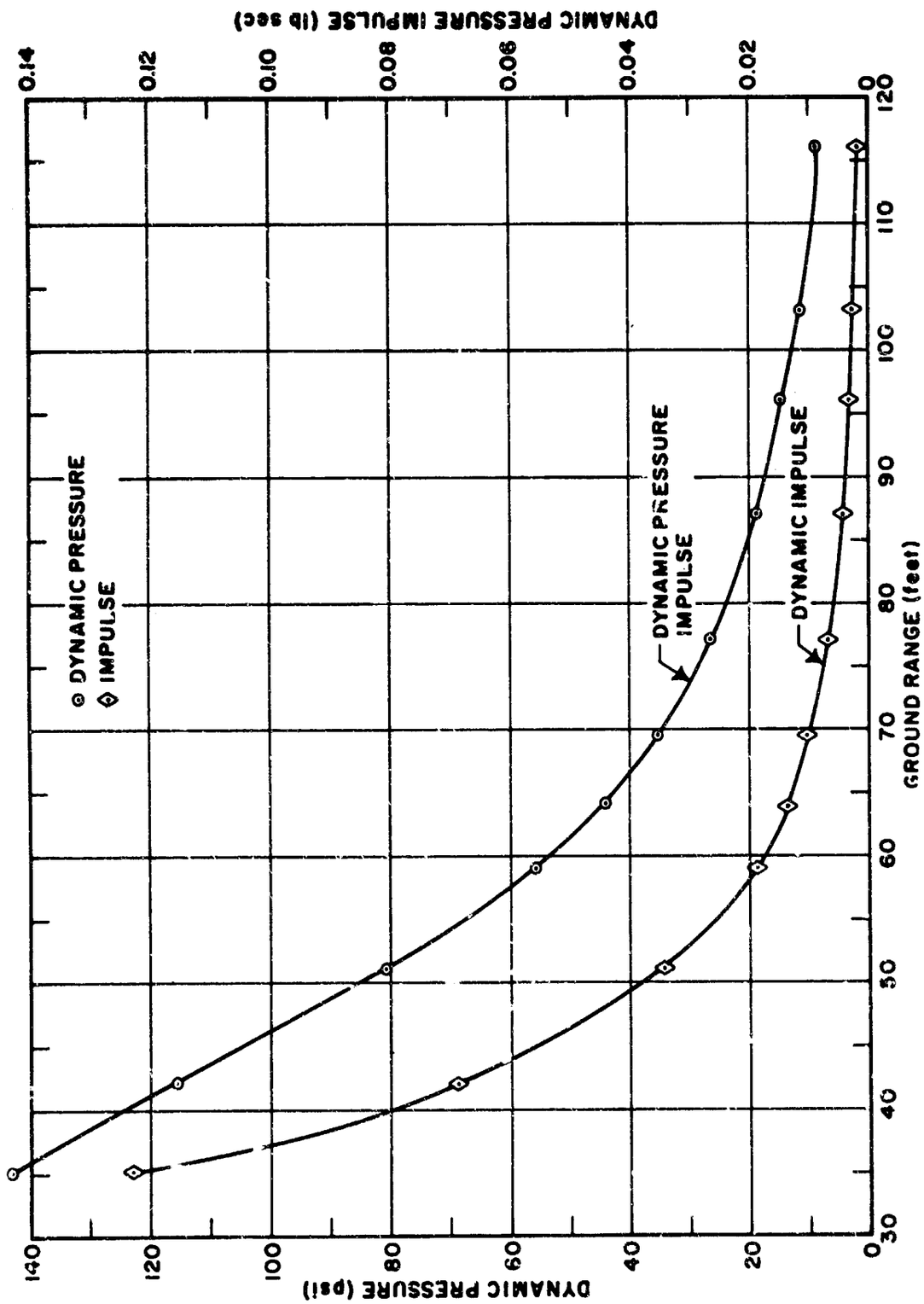


Figure 9. Dynamic Pressure and Dynamic Pressure Impulse vs. Ground Range.

SECTION V

CONCLUSIONS

The experimental data included in this report are believed by the experimenters to be some of the best data of this type available. If this is the case, one can conclude that the parameters measured in this type of experiment are more easily and accurately determined by SHELL than by experimental measurement. Further, parameters not measured in this experiment, such as dynamic pressure, dynamic pressure impulse, and velocity, are also more easily and precisely determined by SHELL. Even though the discrepancy in the second shock arrival time is of secondary significance, it should not be ignored. This discrepancy does not affect the principal parameters of the problem.

Included in Appendix I are photographs of the experiment and calculated contours both occurring at approximately the same times. The initial shock reflection, Mach stem formation, and second shock reflection are much more easily distinguished on the contours than on the films.

In view of the comparisons between the SHELL method and experimental measurement presented in this report, much time, effort, and expense could be saved with pre-experiment calculations. Instrument calibration and position could be determined to achieve maximum utilization. By using the results of a calculation such as this, much better field data could be collected, and from these field data the codes could be improved to make even more accurate calculations.

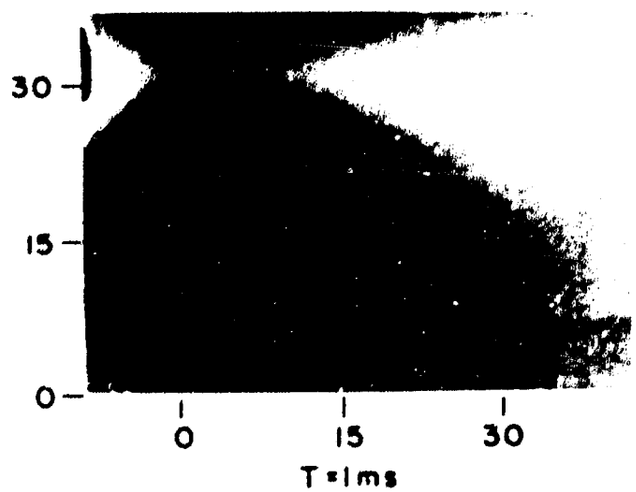
This page intentionally left blank.

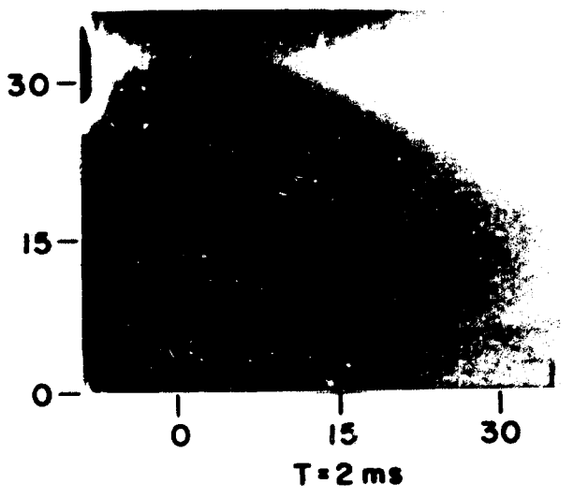
Appendix I

CONTOURS, VECTORS, AND PHOTOS

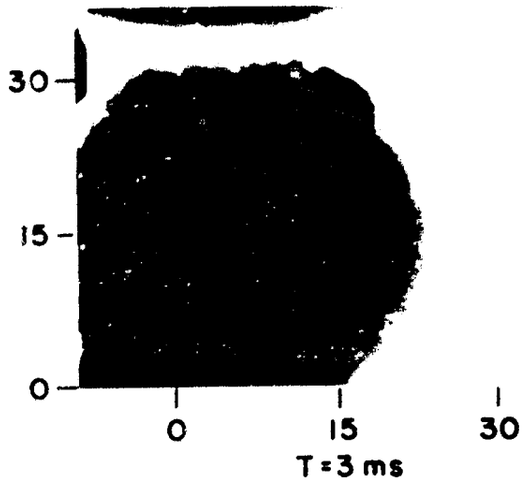
The first three figures contained in this appendix are photographs of the detonation at 1, 2, and 3 milliseconds. The edge of the fireball in the photographs corresponds to the edge of the TNT detonation products. These in turn correspond to the particles on the interface seen in the computer plots, but the air shock is not visible in these photographs. Comparisons between photographs and plots are possible but difficult due to the quality of the film. A more useful comparison can be found in Appendix II.

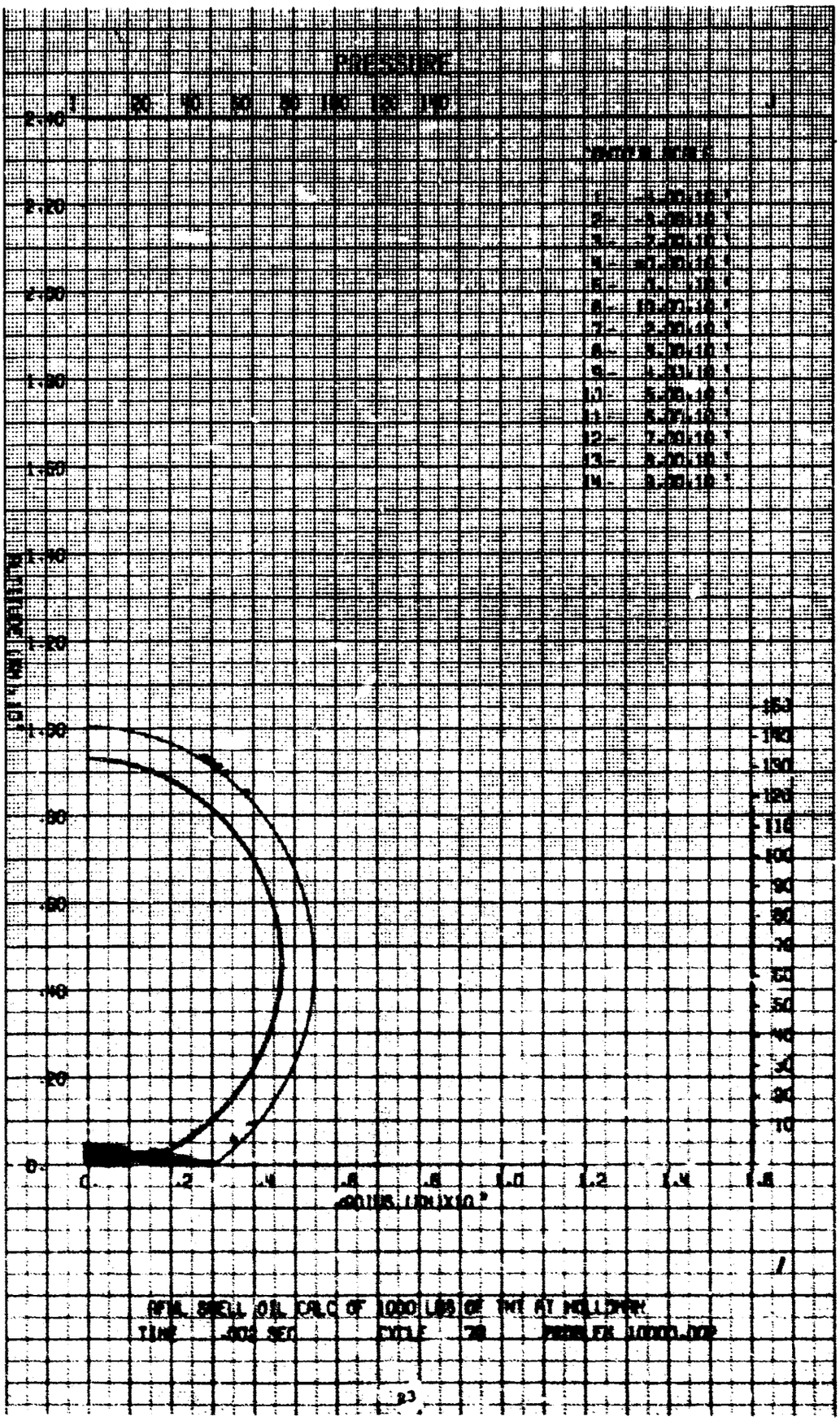
The plots included in Appendix I indicate the formation and growth of the Mach stem with the associated velocity, pressure, and density distributions.

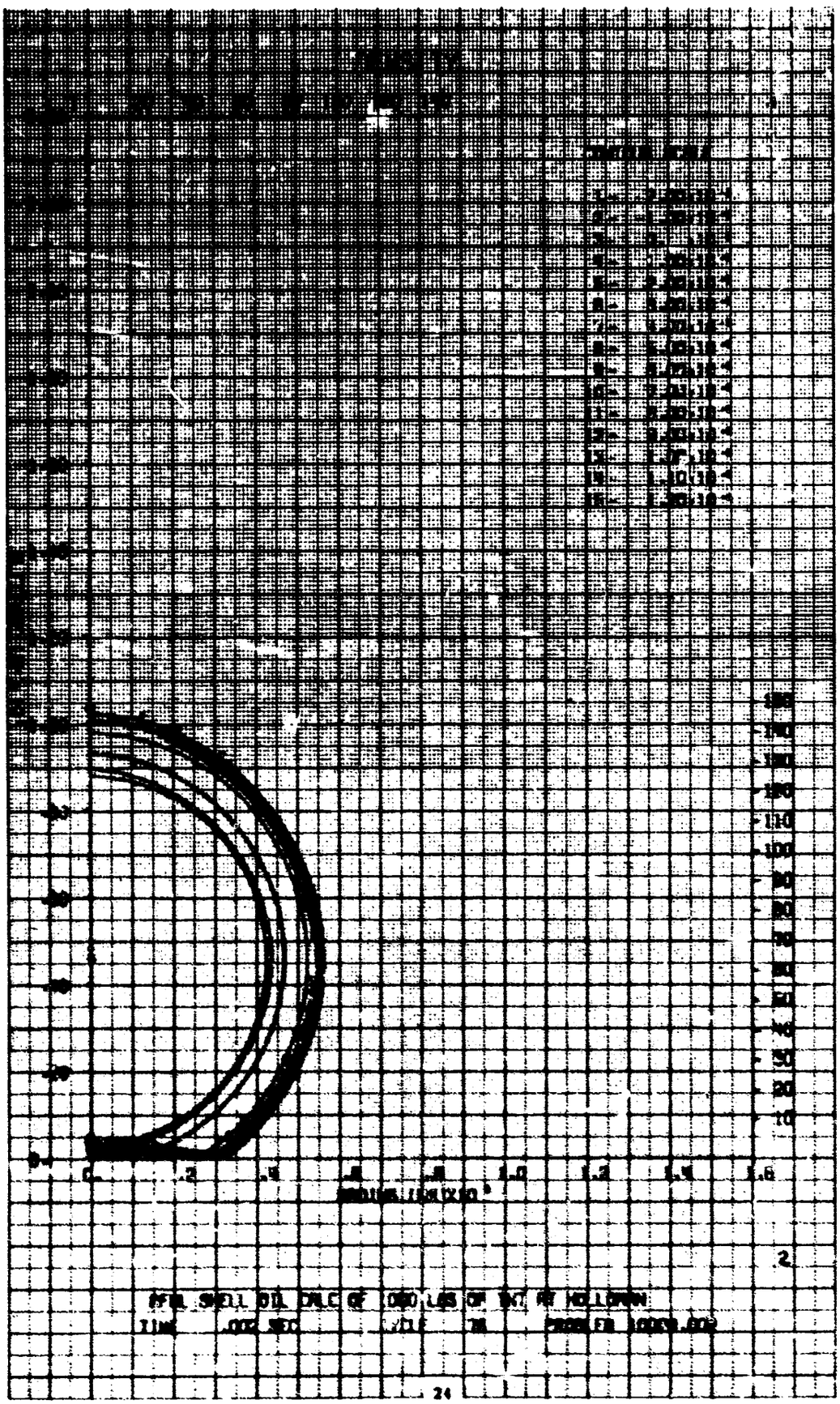


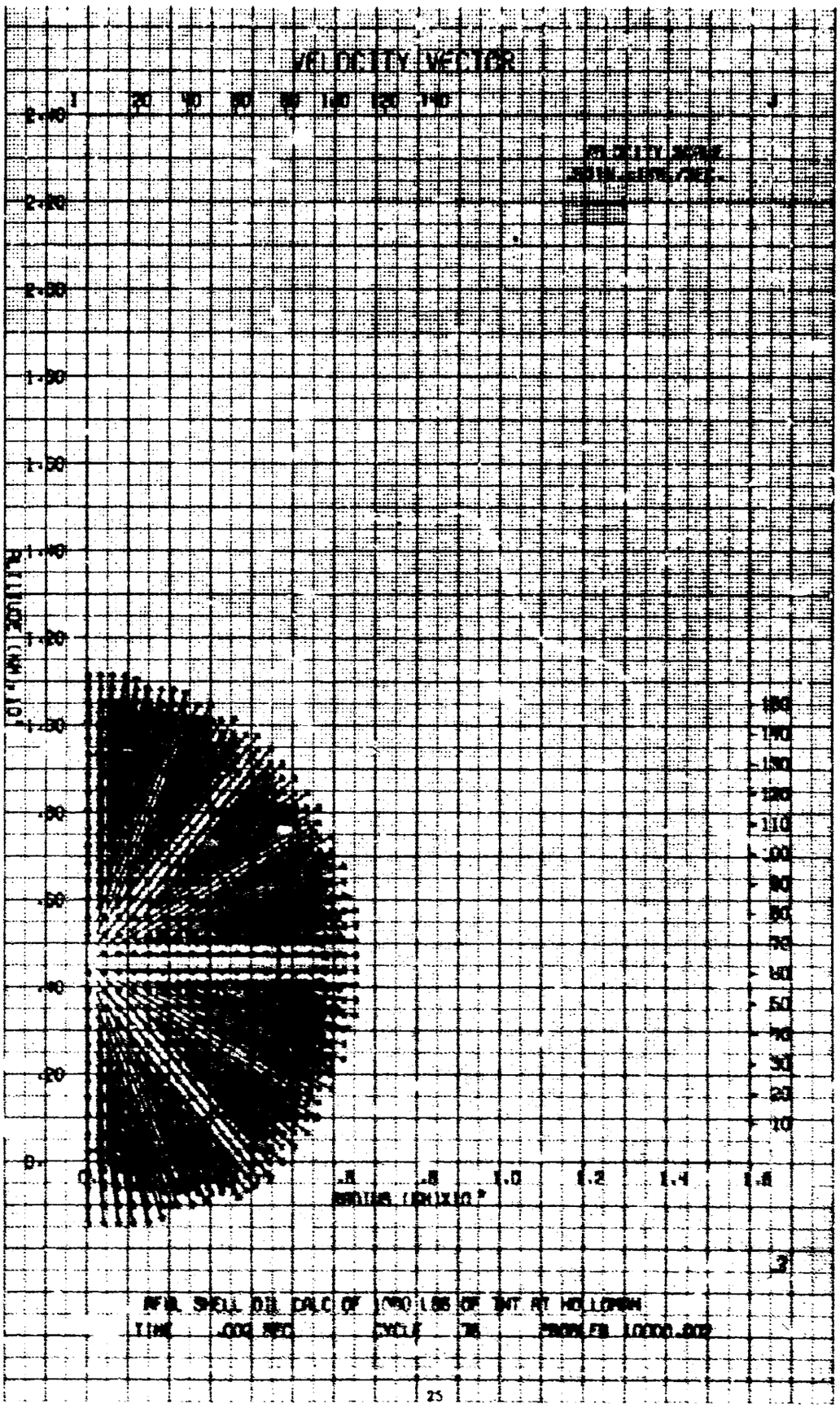


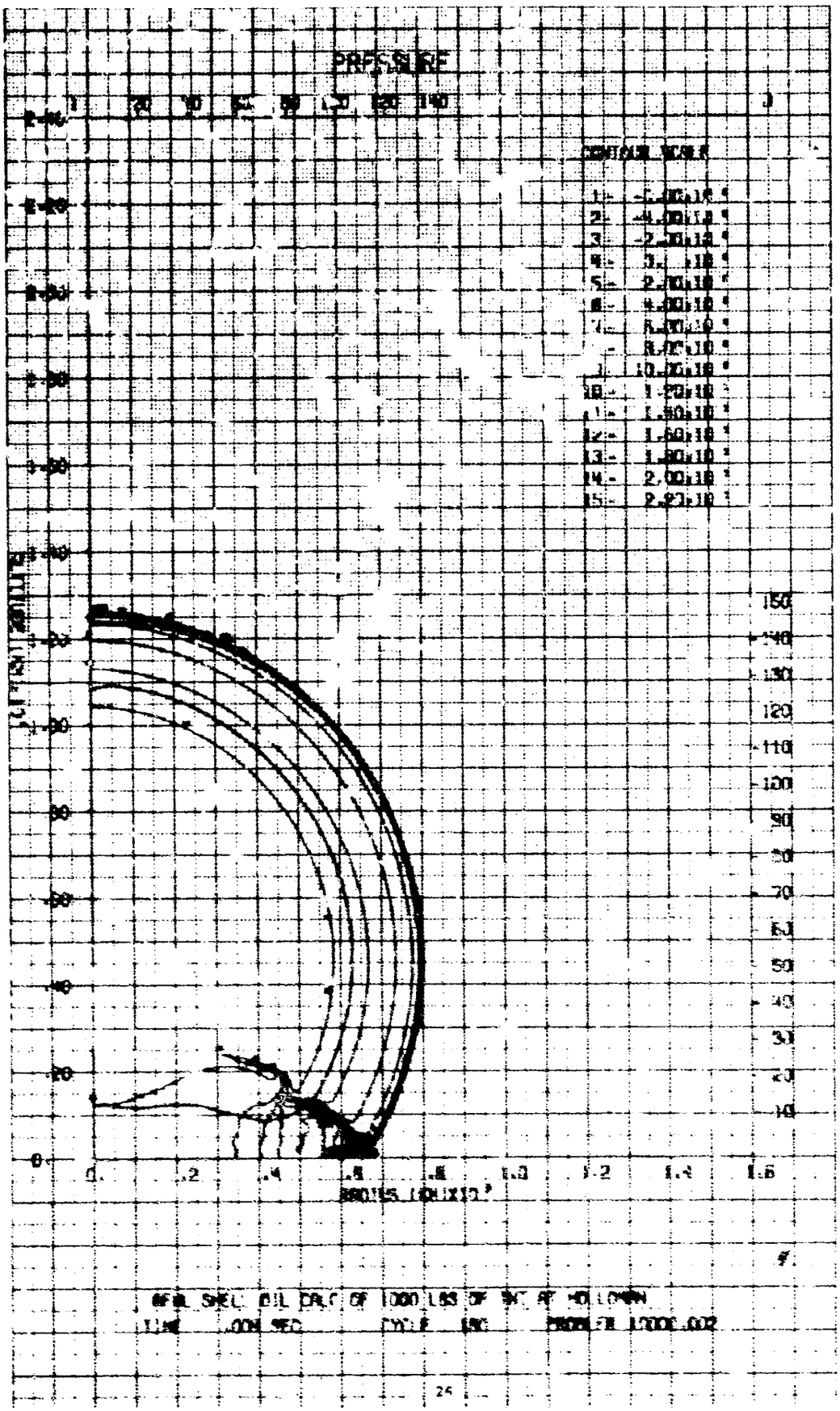
PHOTOGRAPHS HOLLOMAN TEST

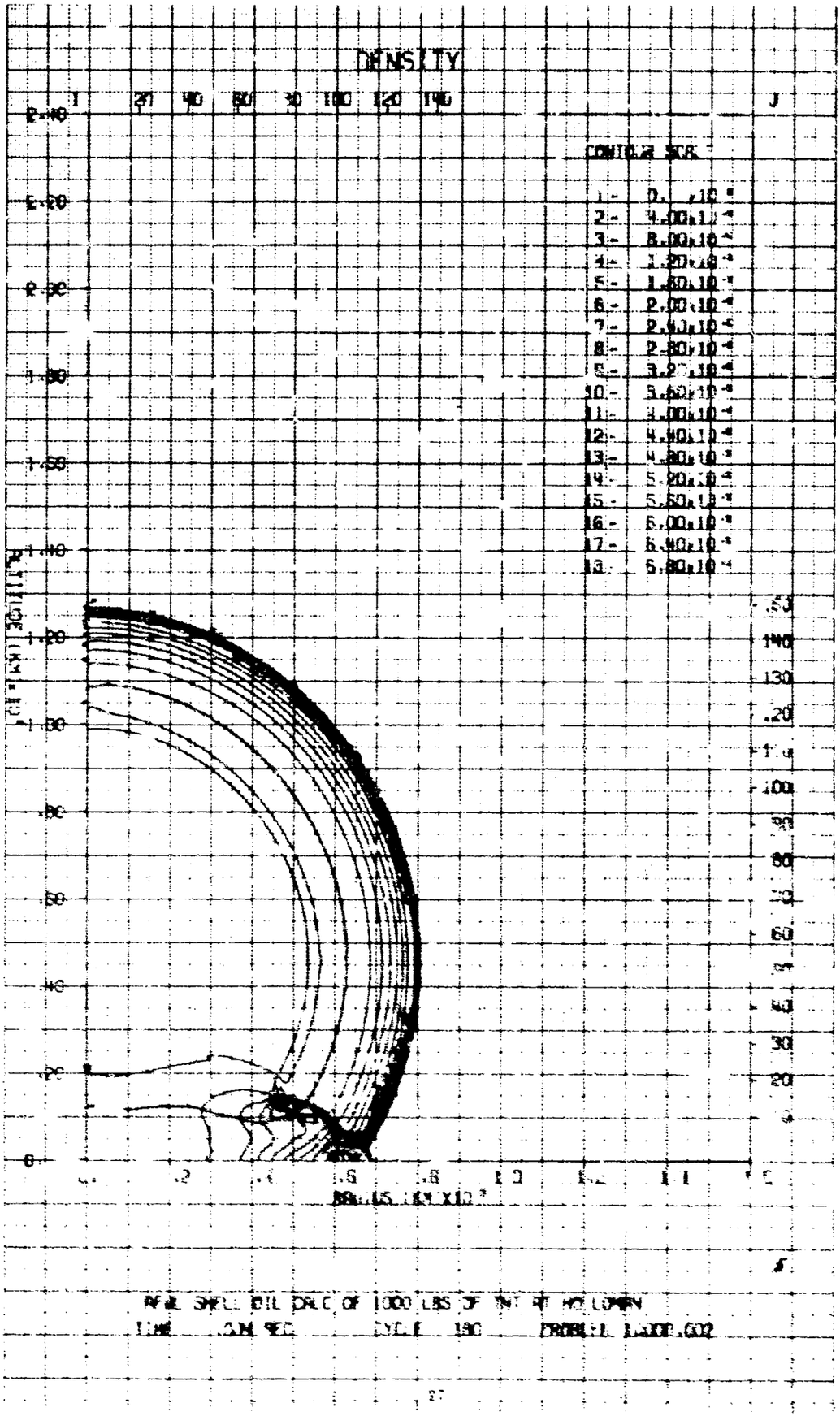


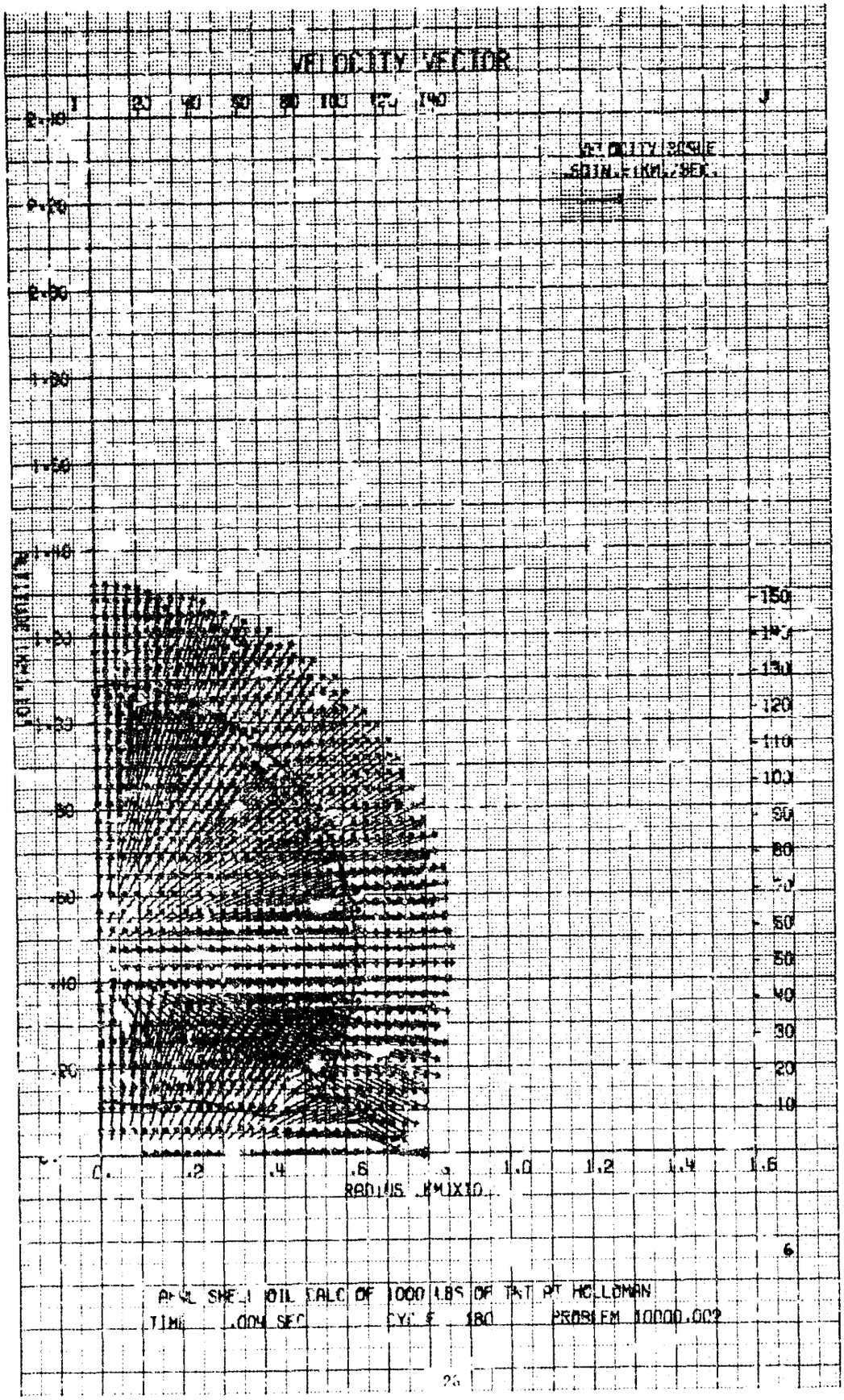

PRESSURE
2,40
2,20
2,00
1,80
1,60
1,40
1,20
1,00
.80
.60
.40
.20
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
163
150
130
120
116
100
90
80
70
60
50
40
30
20
10
TIME .002 SEC
CYCLE 78

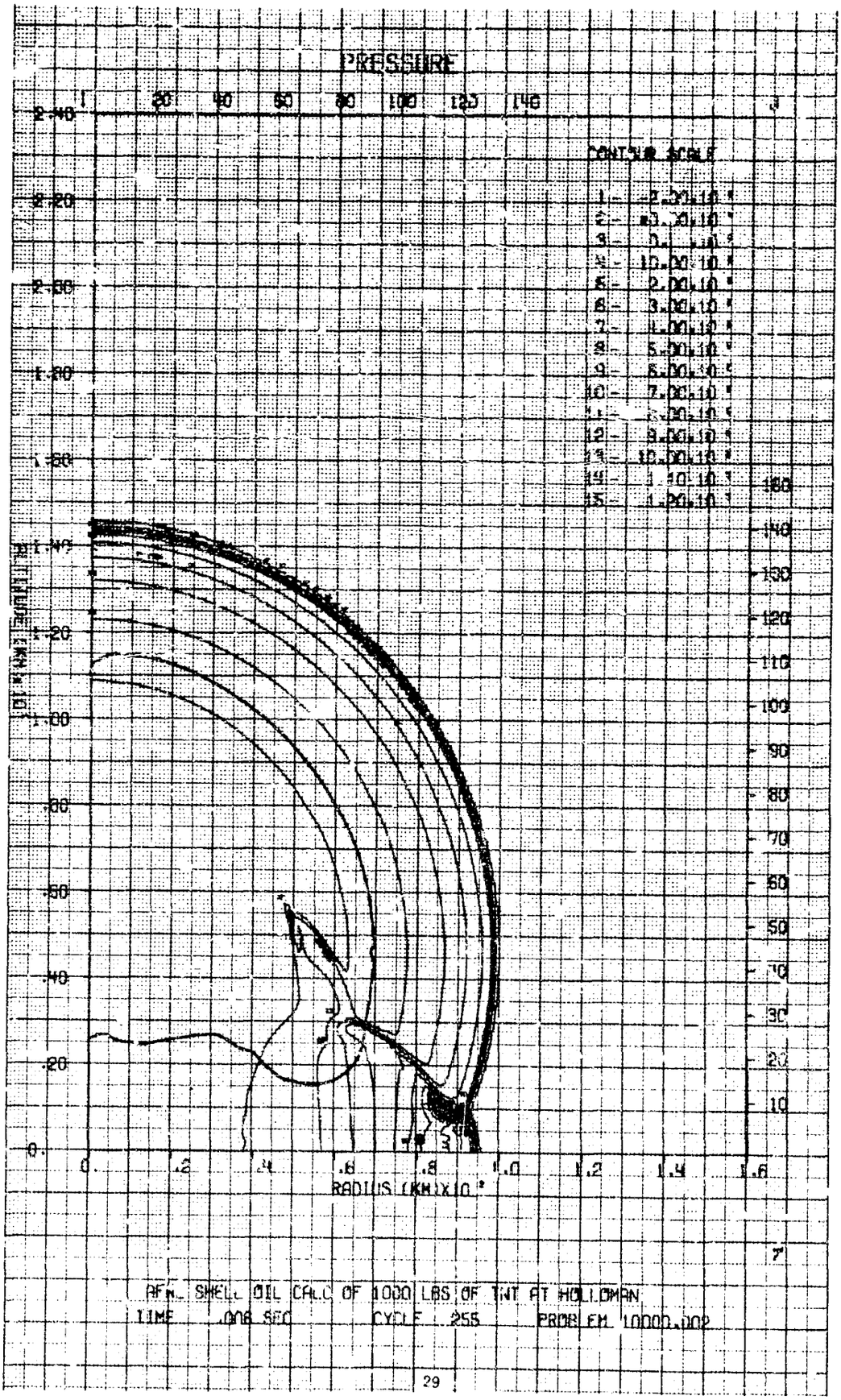


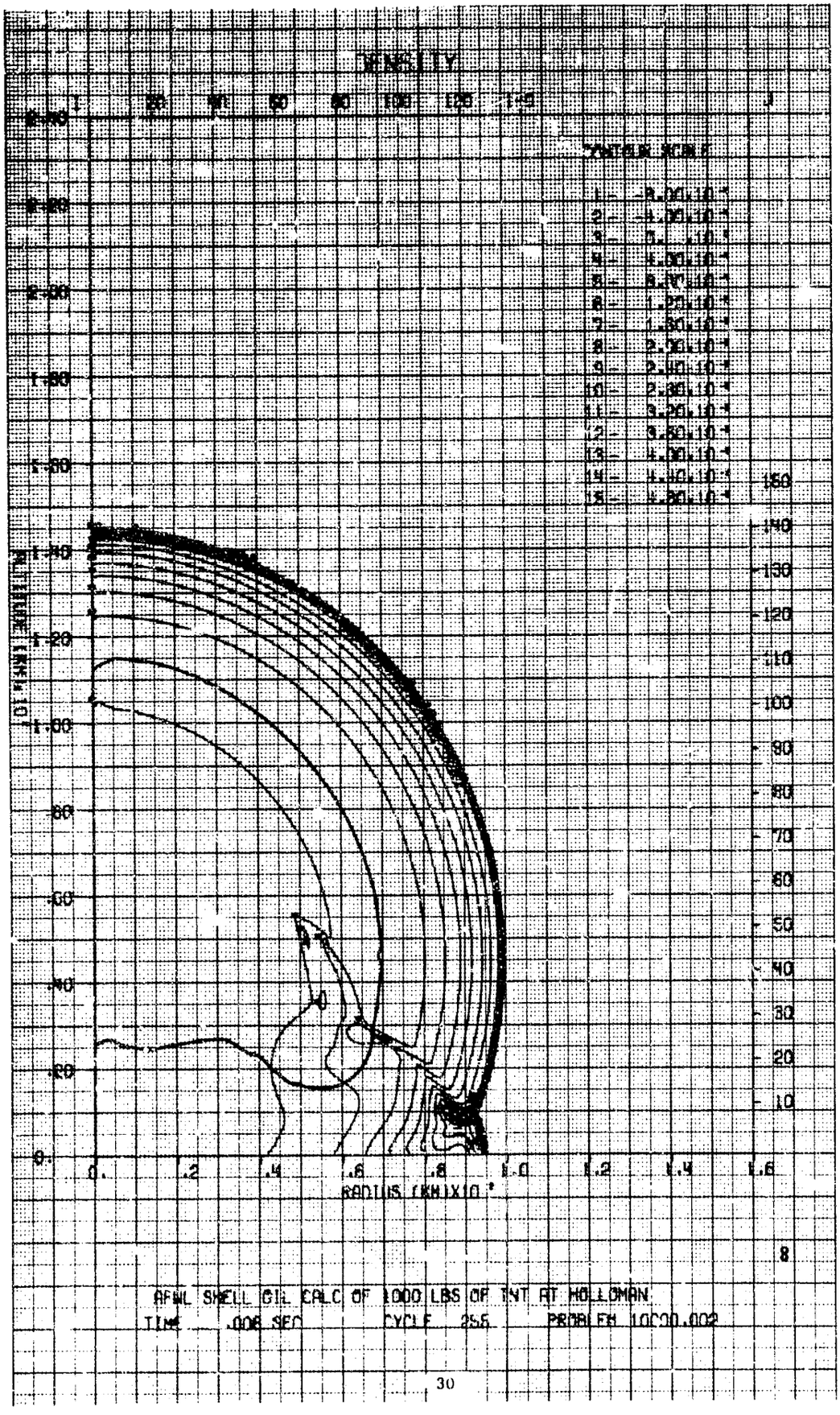

VELOCITY VECTOR
VELOCITY SCALE
2000 FEET/SEC
RADIUS (KM X 10)
ANGLE (DEG X 10)
FREE SHELL DIE CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .000 SEC CYCLE 76 PROBLEM 10000.002

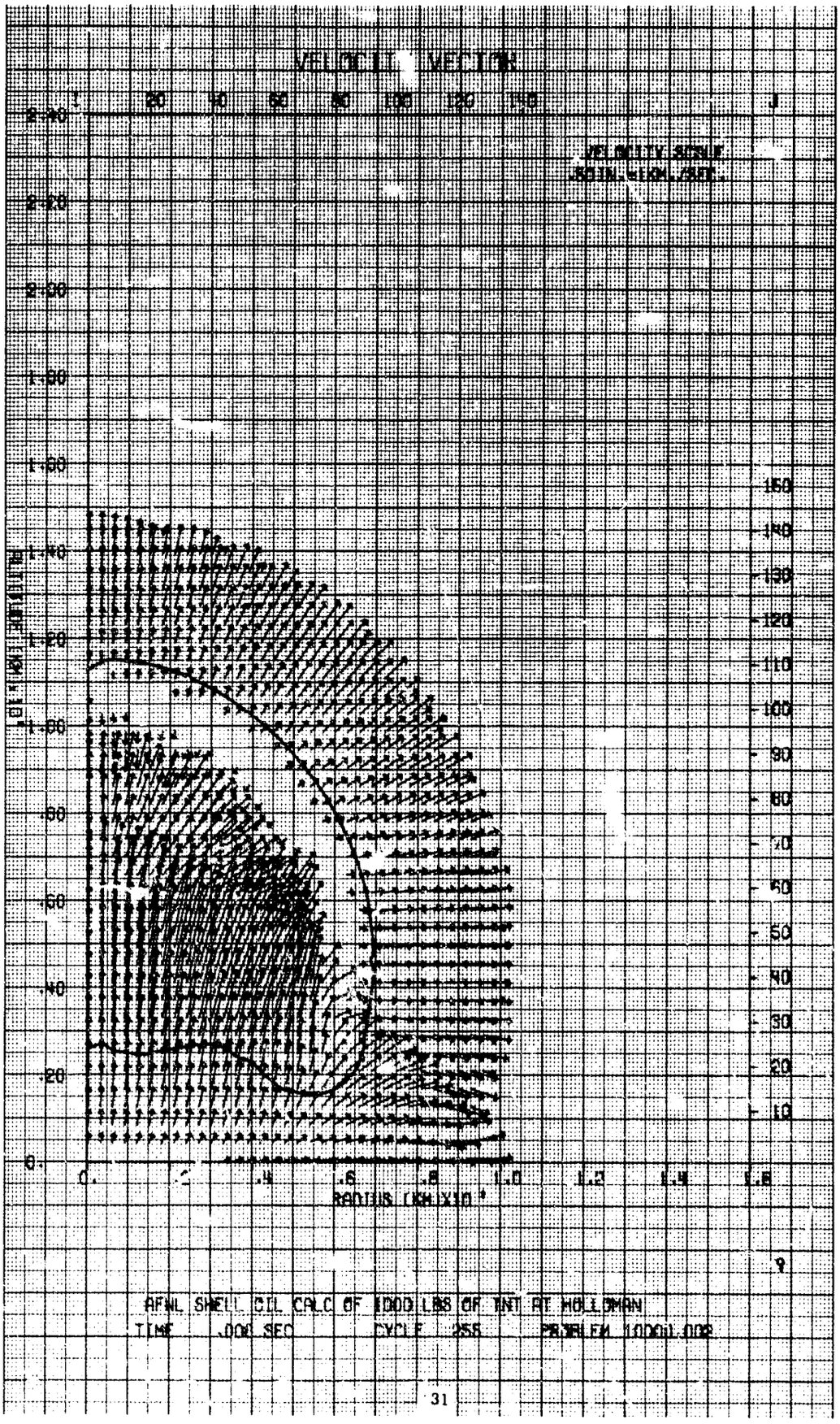

PRESSURE
CONTOUR SCALE
1.- -5.00x10
2.- -4.00x10
3.- -2.00x10
4.- 5.00x10
5.- 2.00x10
6.- 4.00x10
7.- 6.00x10
8.- 8.00x10
9.- 1.00x10
10.- 1.20x10
11.- 1.40x10
12.- 1.60x10
13.- 1.80x10
14.- 2.00x10
15.- 2.23x10
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6

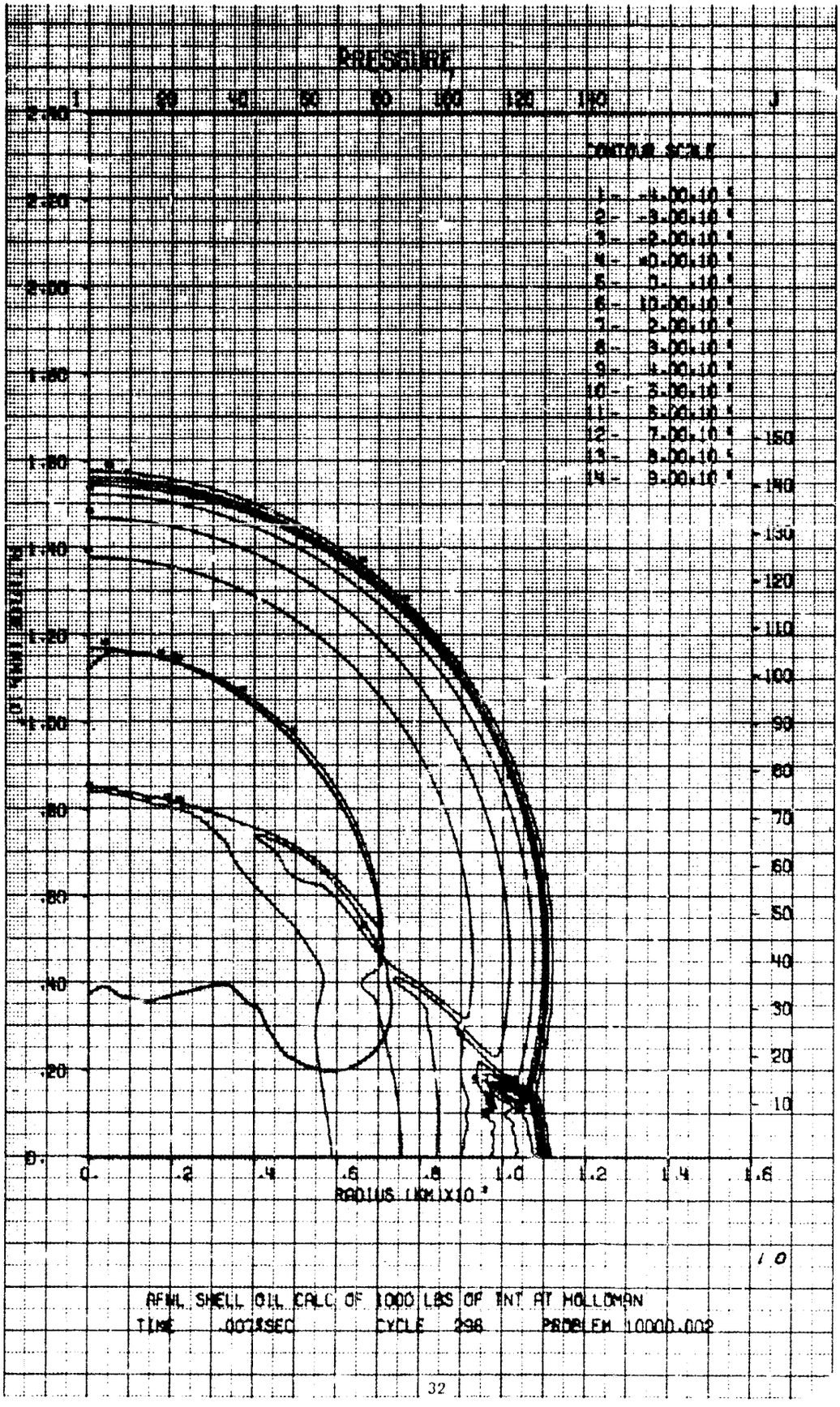

DENSITY
CONTOUR SCALE
1.- 0. x10⁻⁴
2.- 4.00x10⁻⁴
3.- 8.00x10⁻⁴
4.- 1.20x10⁻³
5.- 1.60x10⁻³
6.- 2.00x10⁻³
7.- 2.40x10⁻³
8.- 2.80x10⁻³
9.- 3.20x10⁻³
10.- 5.60x10⁻³
11.- 6.00x10⁻³
12.- 6.40x10⁻³
13.- 6.80x10⁻³
14.- 7.20x10⁻³
15.- 7.60x10⁻³
16.- 8.00x10⁻³
17.- 8.40x10⁻³
18.- 8.80x10⁻³

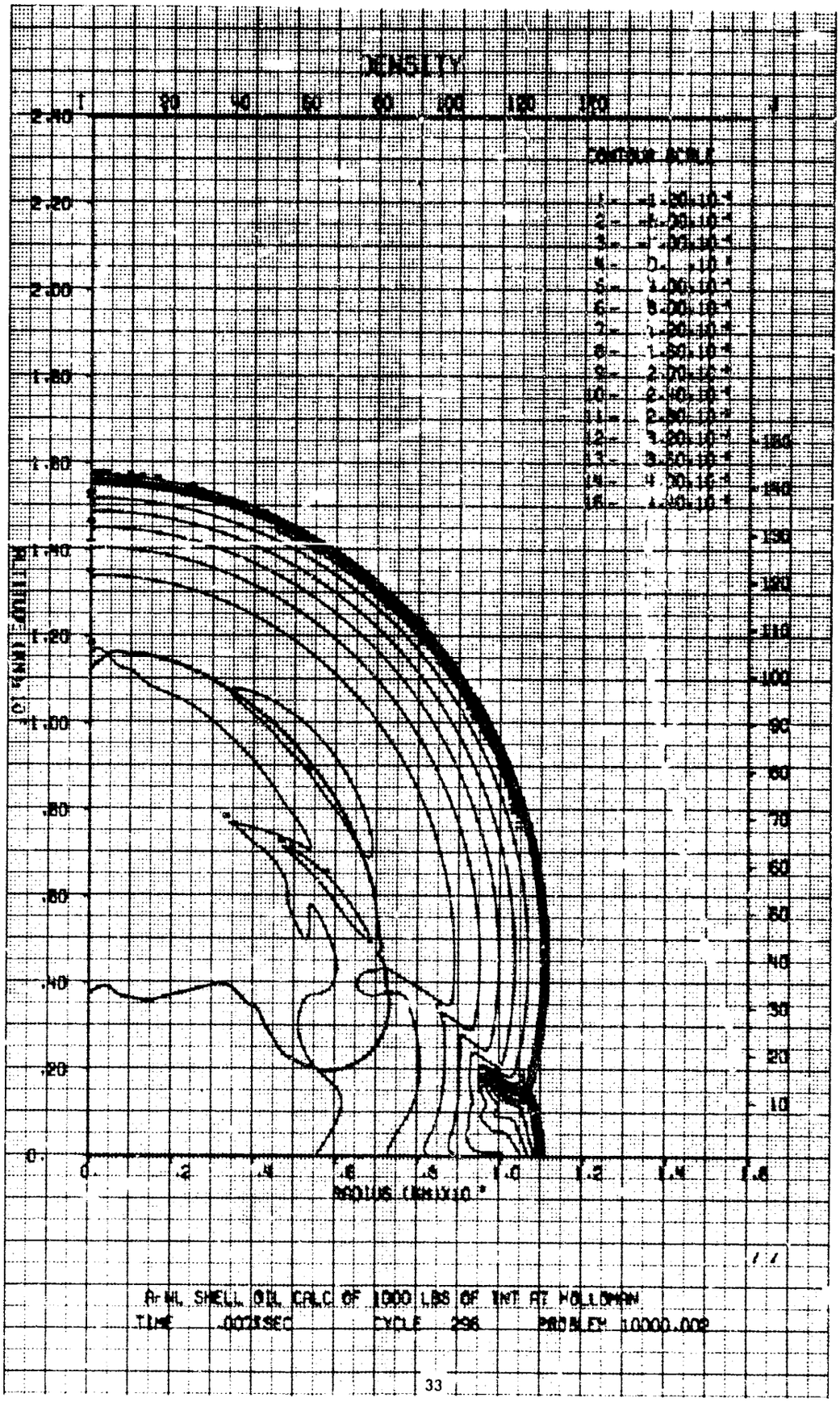

VELOCITY VECTOR
VELOCITY SCALE
SCALE=1KM./SEC.
RADIUS (M)X10.
APPL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .004 SEC CYCLE 180 PROBLEM 10000.002

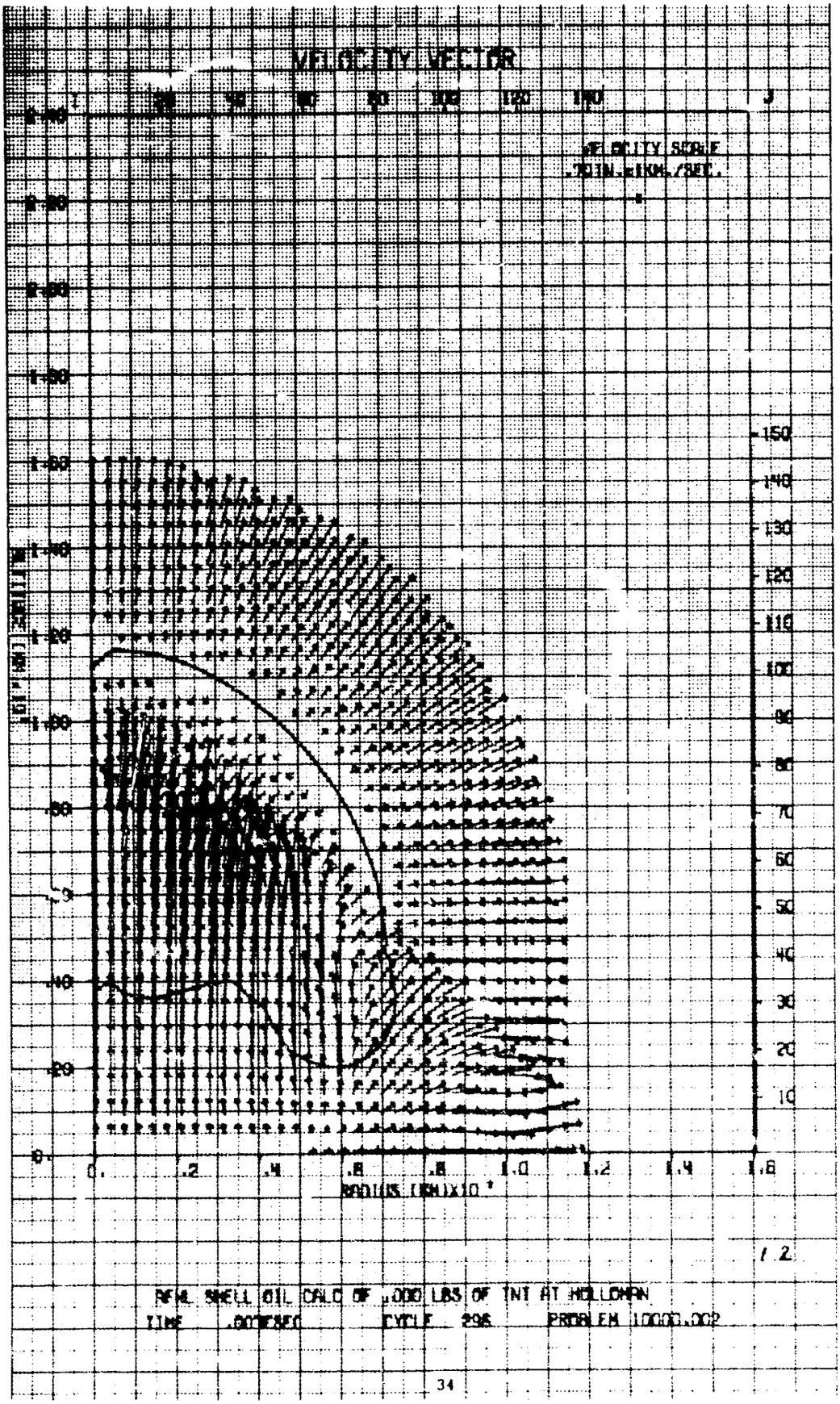

PRESSURE
CONTOUR SCALE
1- 2.00,10 *
2- 3.00,10 *
3- 5.00,10 *
4- 10.00,10 *
5- 2.00,10 *
6- 3.00,10 *
7- 4.00,10 *
8- 5.00,10 *
9- 6.00,10 *
10- 7.00,10 *
11- 8.00,10 *
12- 9.00,10 *
13- 10.00,10 *
14- 1.10,10 *
15- 1.00,10 *
ALTITUDE (KM*10)
RADIUS (KM)X10 *
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .008 SEC CYCLE 255 PROBLEM 10000.002

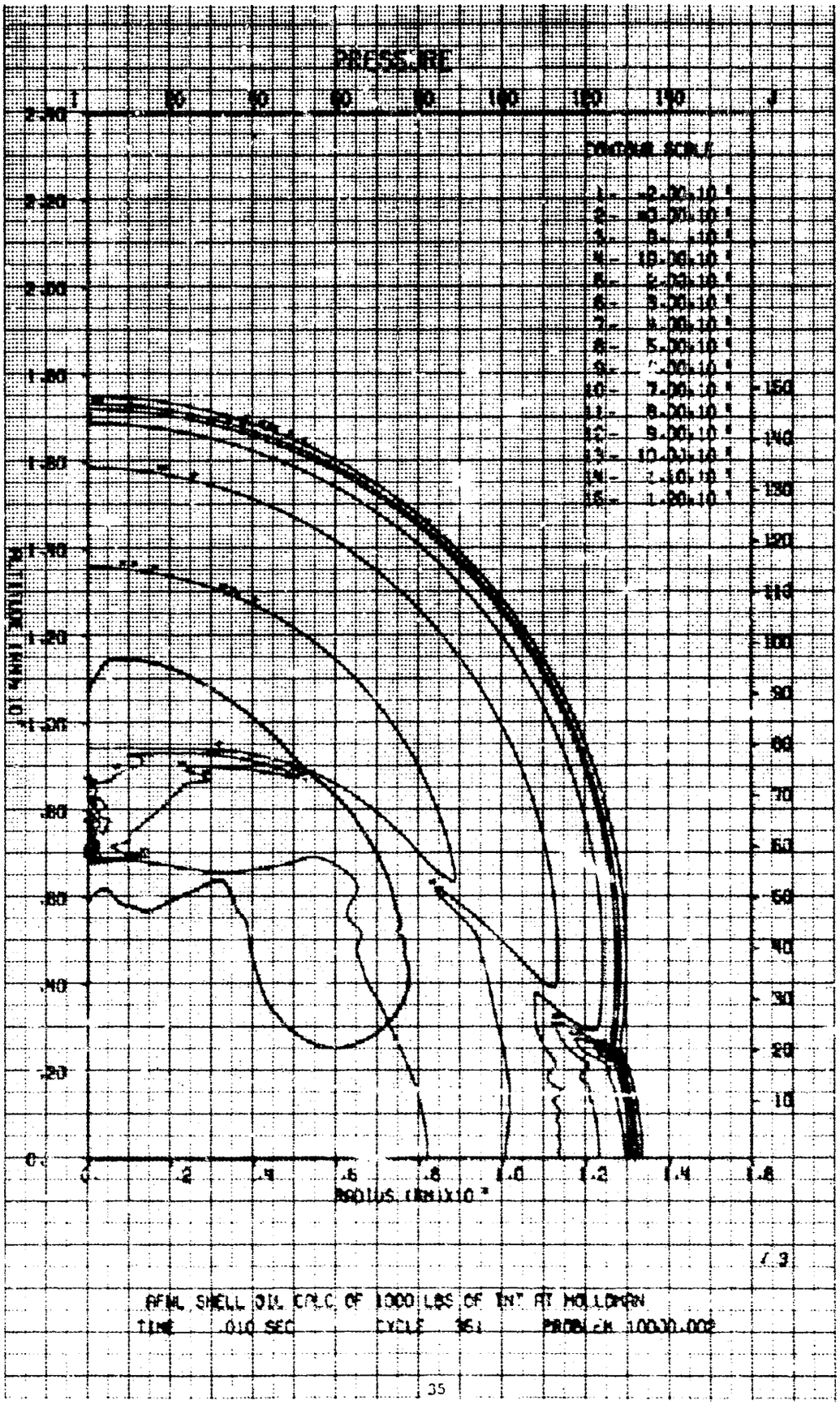

DENSITY
CONTOUR SCALE
1 - -9.00x10⁻¹
2 - -8.00x10⁻¹
3 - -7.00x10⁻¹
4 - -6.00x10⁻¹
5 - -5.00x10⁻¹
6 - -4.00x10⁻¹
7 - -3.00x10⁻¹
8 - -2.00x10⁻¹
9 - -1.00x10⁻¹
10 - 0.00x10⁻¹
11 - 1.00x10⁻¹
12 - 2.00x10⁻¹
13 - 3.00x10⁻¹
14 - 4.00x10⁻¹
15 - 5.00x10⁻¹
ALTITUDE (KM)X10³
RADIUS (KM)X10³
AFWL SHELL 61L CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .006 SEC CYCLE 256 PROBLEM 10C00.002

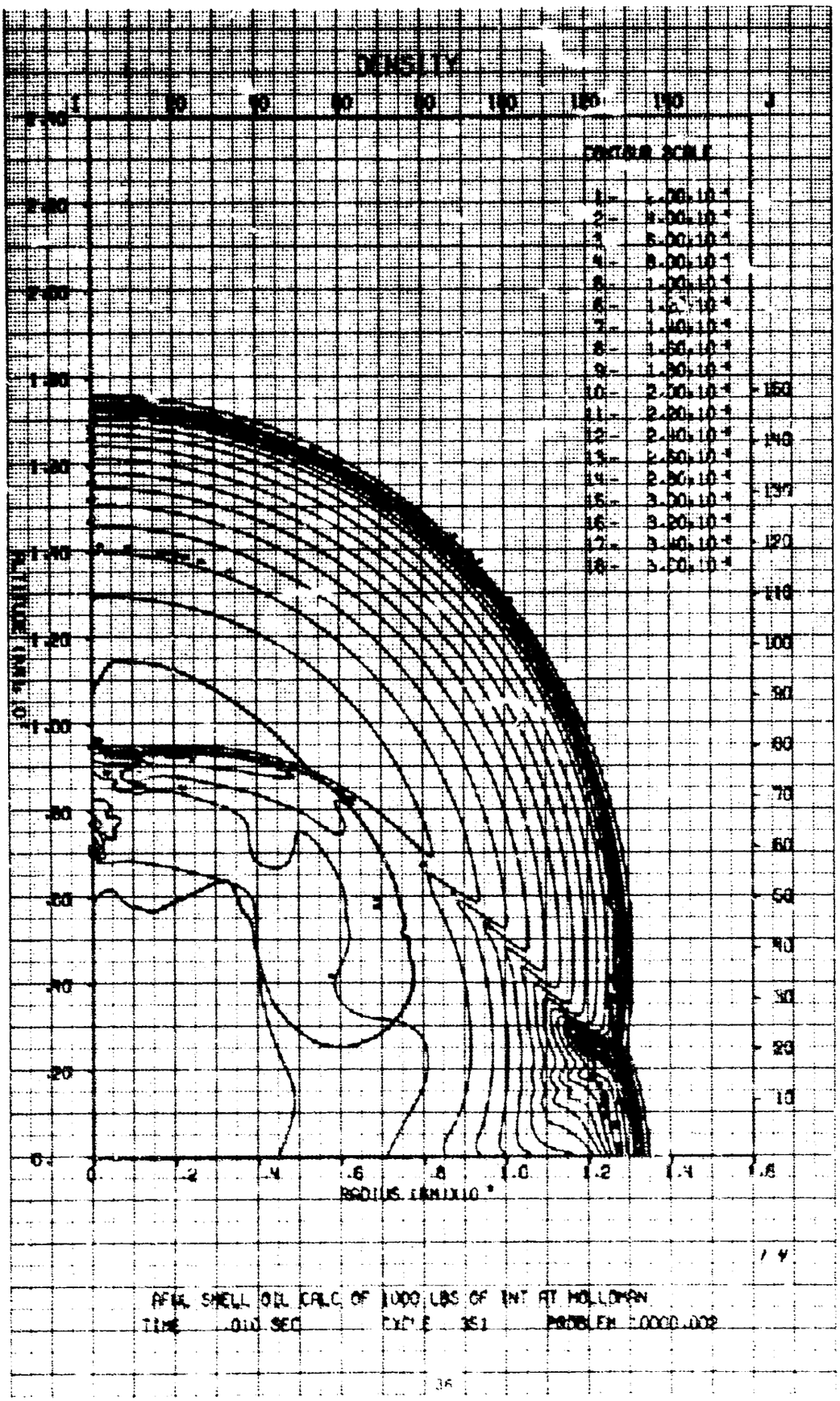

VELOCITY VECTOR
VELOCITY SCALE
.50 IN.=1KM./SEC.
RADIUS (KM)X10³
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .000 SEC
CYCLE 256
PROBLEM 1000L002

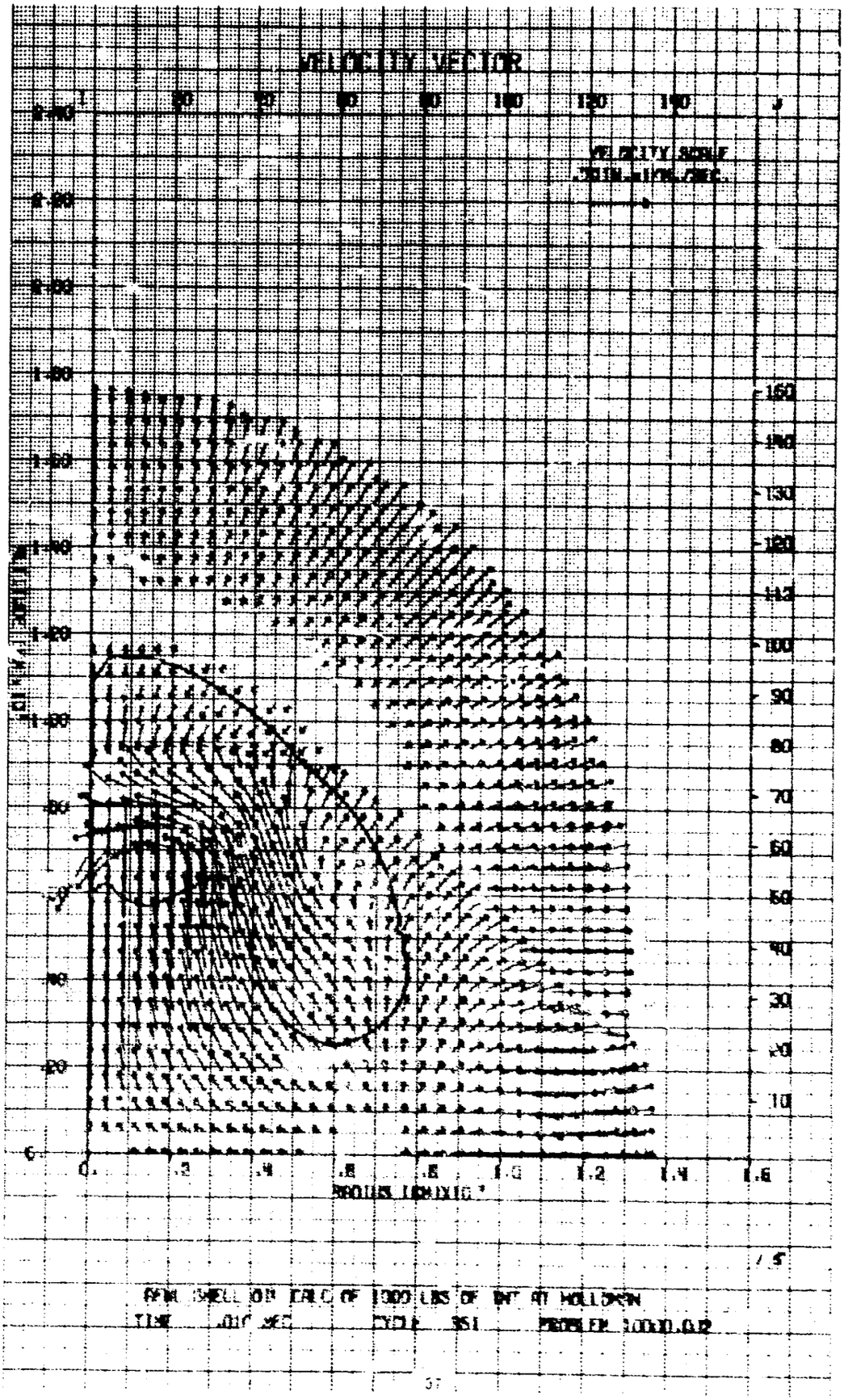

PRESSURE
CONTOUR SCALE
1- -4.00,10 4
2- -3.00,10 4
3- -2.00,10 4
4- -1.00,10 4
5- 0. ,10 4
6- 1.00,10 4
7- 2.00,10 4
8- 3.00,10 4
9- 4.00,10 4
10- 5.00,10 4
11- 6.00,10 4
12- 7.00,10 4
13- 8.00,10 5
14- 9.00,10 4
RADIUS (KM)X10 3
AFWL SHELL OIL CALC OF 1000 LBS OF INT AT HOLLOMAN
TIME .0035SEC CYCLE 298 PROBLEM 10000.002


DENSITY
CONTOUR SCALE
RADIUS (MM)X10.**
A.M. SHELL OIL CALC OF 1000 LBS OF INT AT HOLLOMAN
TIME .0021SEC CYCLE 296 PROBLEM 10000.002

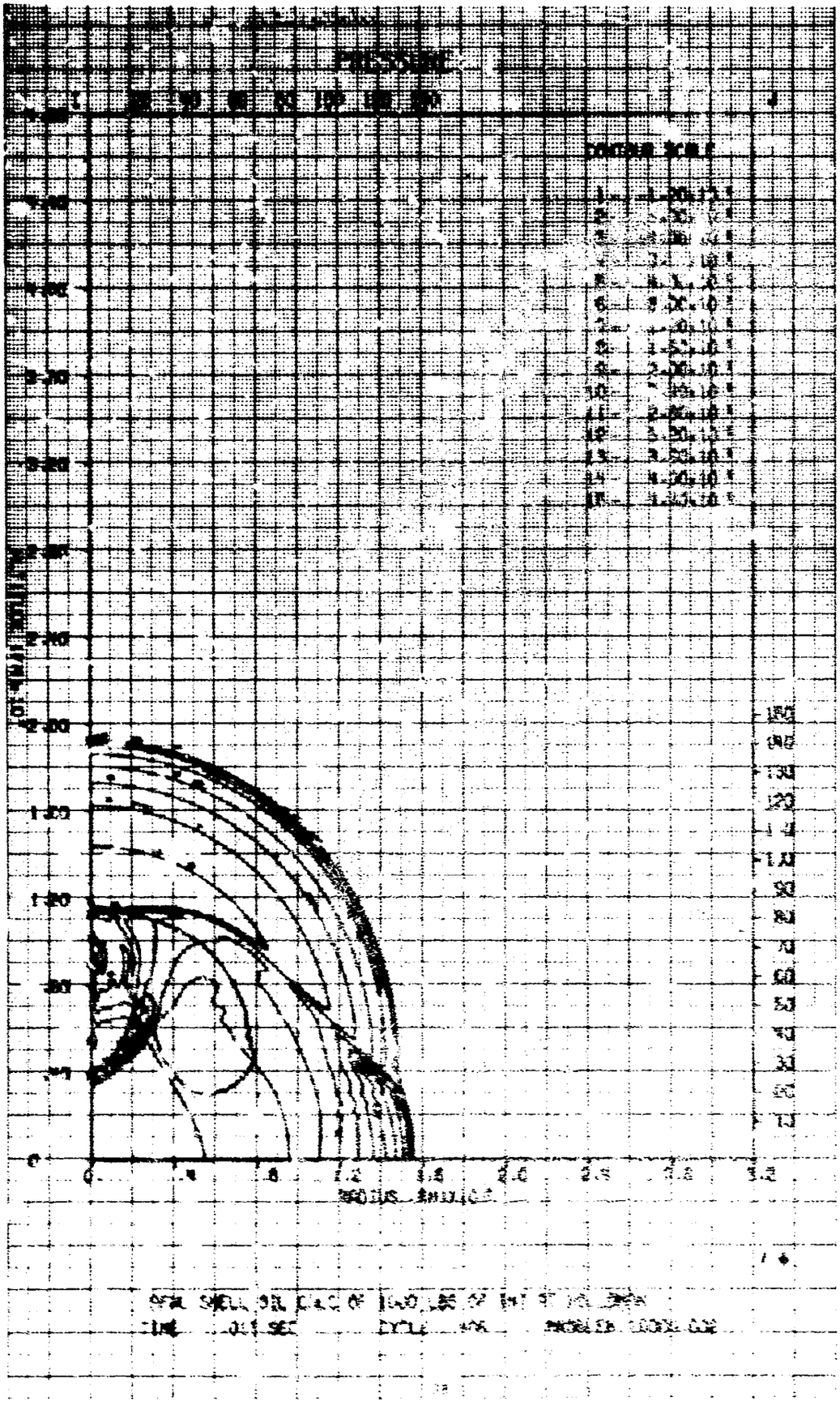

VELOCITY VECTOR
VELOCITY SCALE
.7DIN.=1KM./SEC.
RADIUS (KM)X10 *
REAL SHELL OIL CALC OF .000 LBS OF TNT AT HOLLOMAN
TIME .000MSEC CYCLE 296 PROBLEM 10000.002

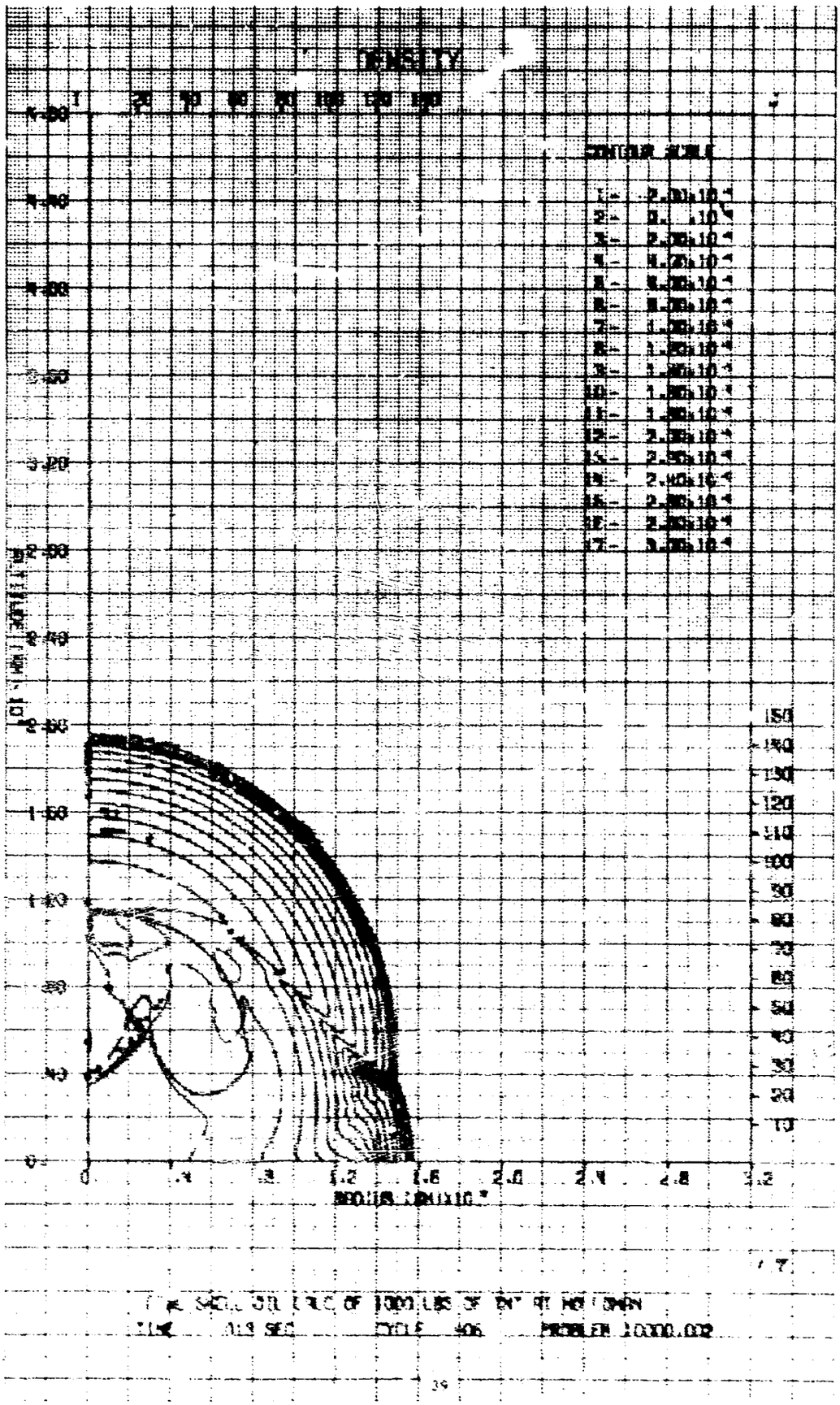

PRESSURE
RADIUS (IN)X10 *
AFML SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .010 SEC CYCLE 361 PROBLEM 100J0.002

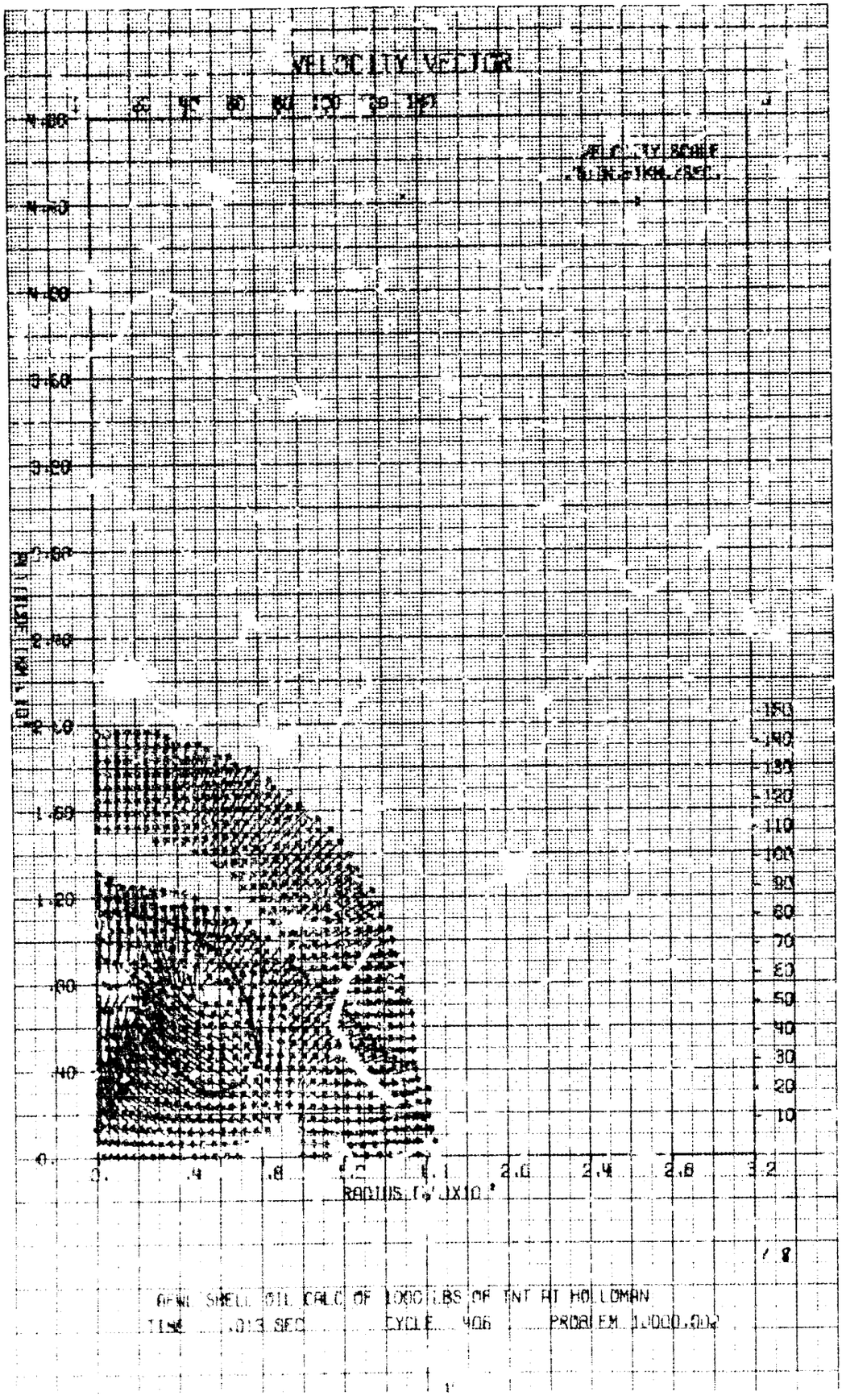

DENSITY
CONTOUR SCALE
RADIUS, CM X10 *
AFWL SHELL OIL CALC OF 1000 LBS OF INT AT HOLLOMAN
TIME .010 SEC CYCLE 351 PROBLEM 0000.002

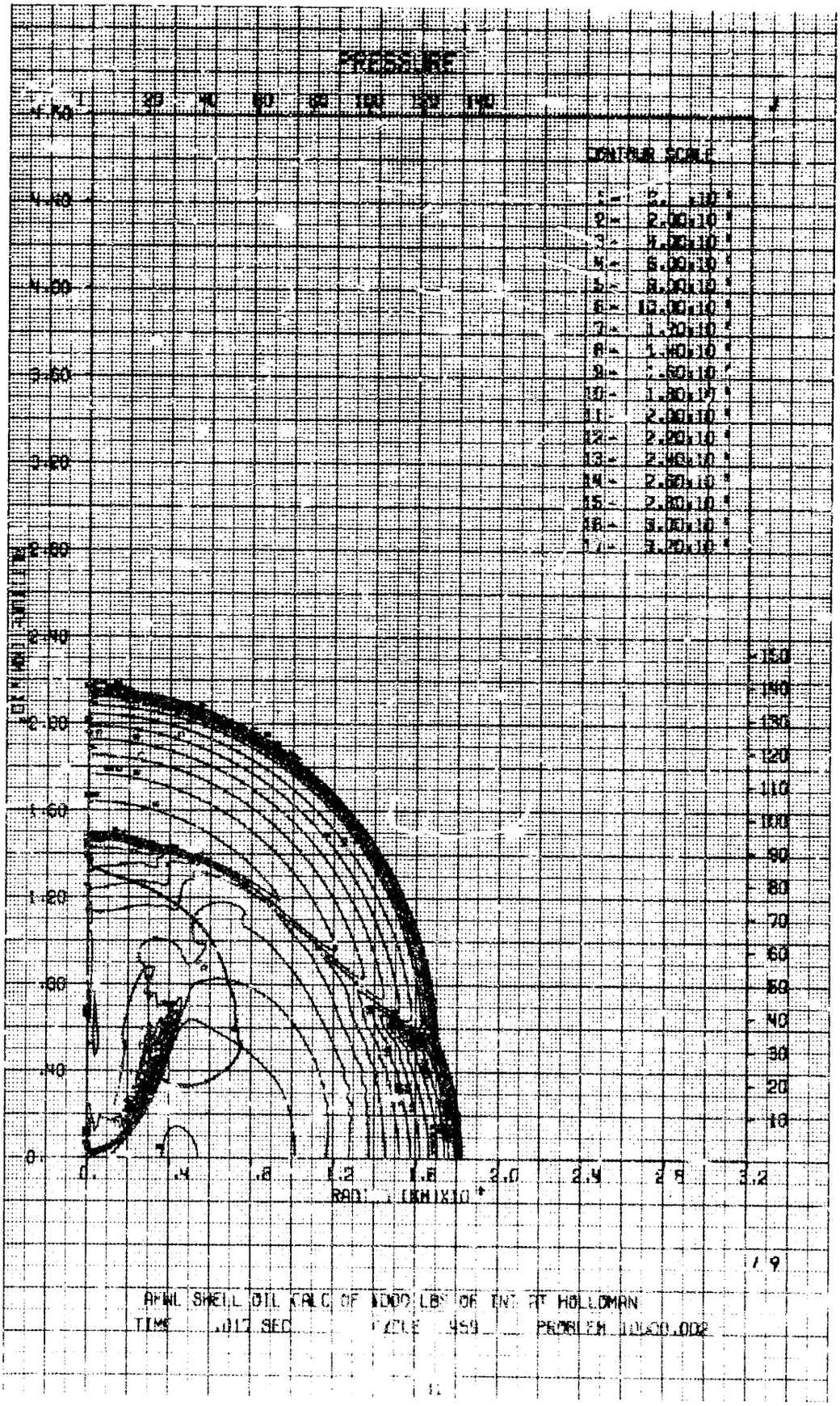


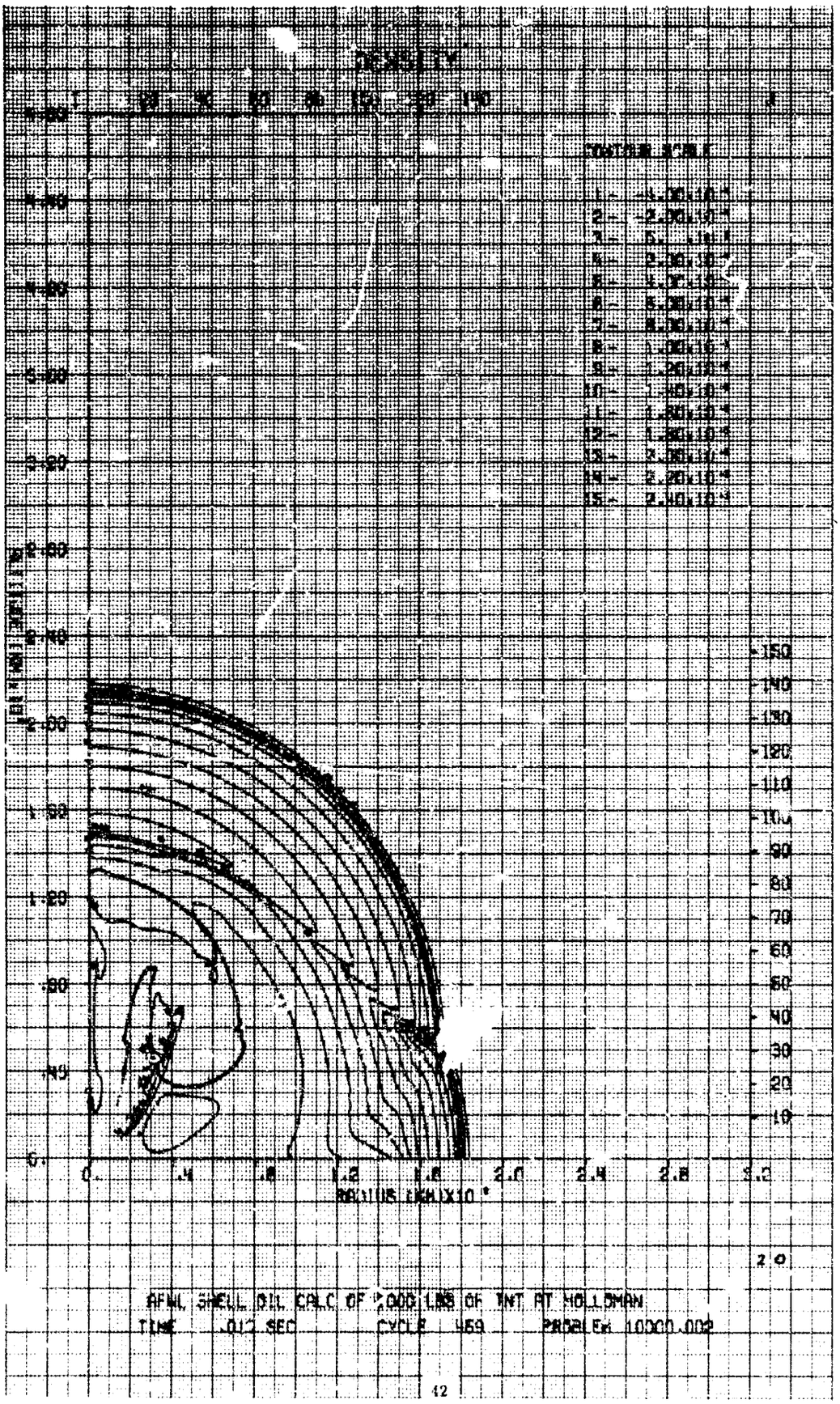
AIR SHELL OB [illegible] OF 1300 LBS OF [illegible] HOLLOW
TIME [illegible] CYCLE 351 PRESS FR 30000.0 LB

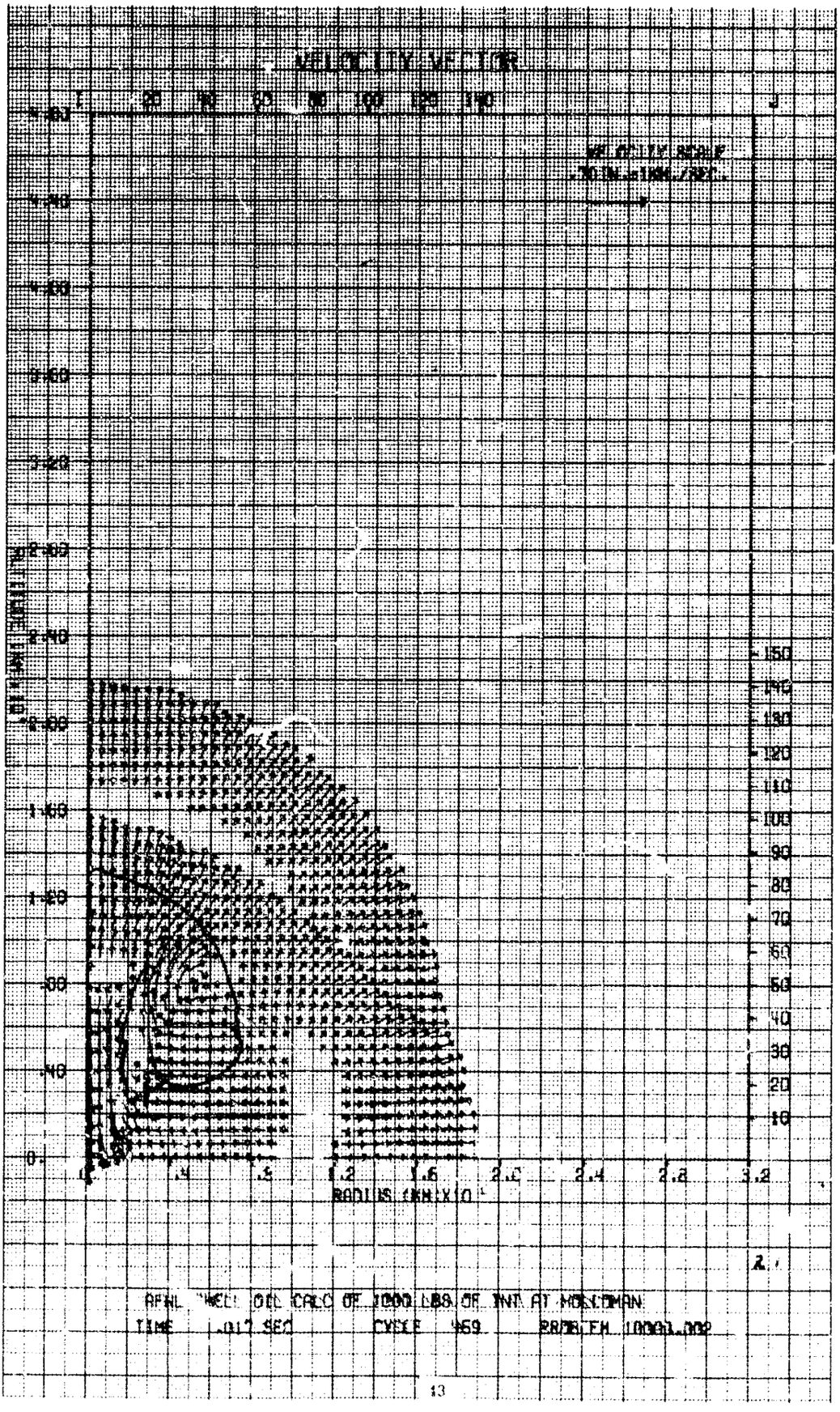


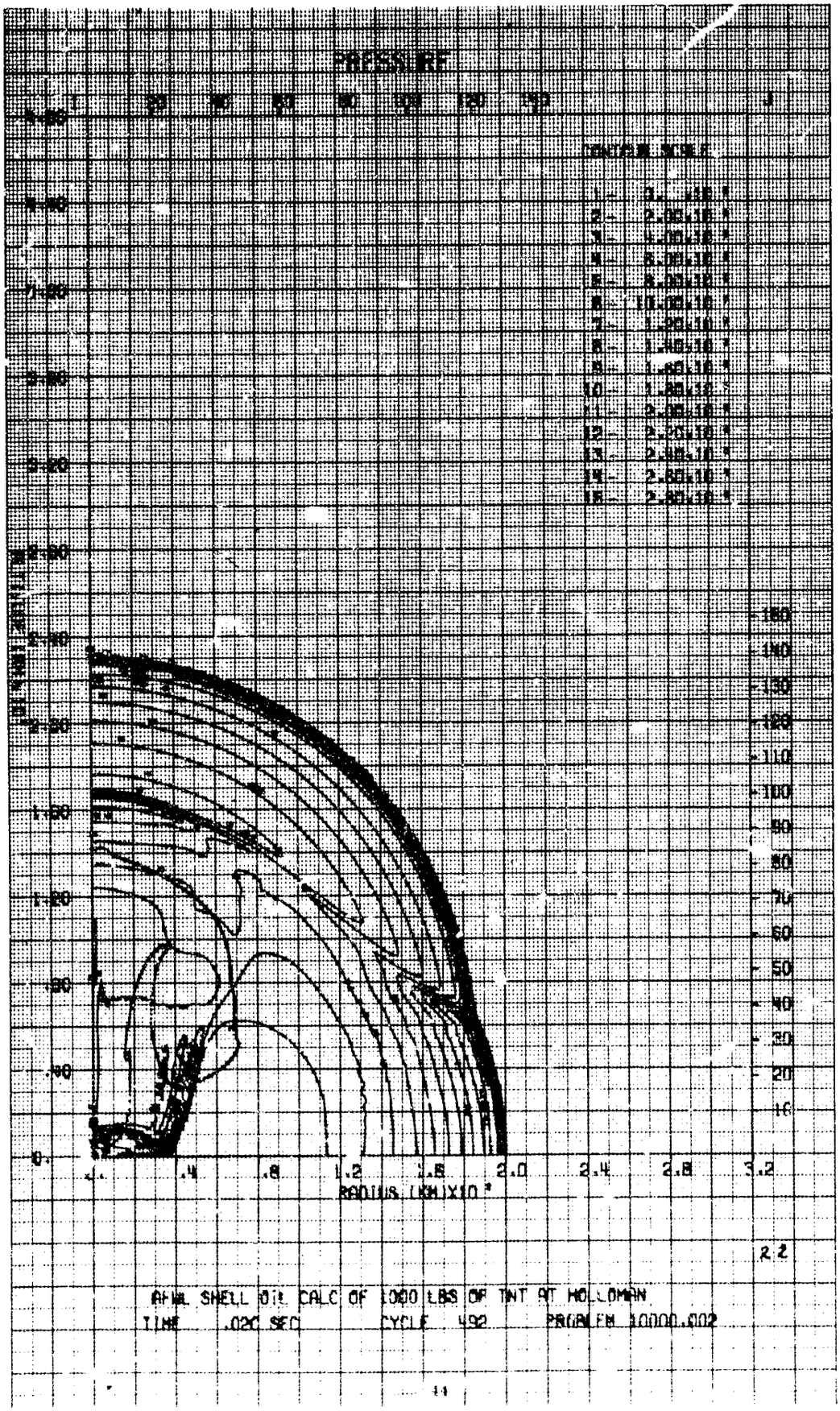

DENSITY
CONTOUR SCALE
1.- 2.00x10-4
2.- 2.20x10-4
3.- 2.40x10-4
4.- 2.60x10-4
5.- 2.80x10-4
6.- 3.00x10-4
7.- 3.20x10-4
8.- 3.40x10-4
9.- 3.60x10-4
10.- 3.80x10-4
11.- 4.00x10-4
12.- 4.20x10-4
13.- 4.40x10-4
14.- 4.60x10-4
15.- 4.80x10-4
16.- 5.00x10-4
17.- 5.20x10-4
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

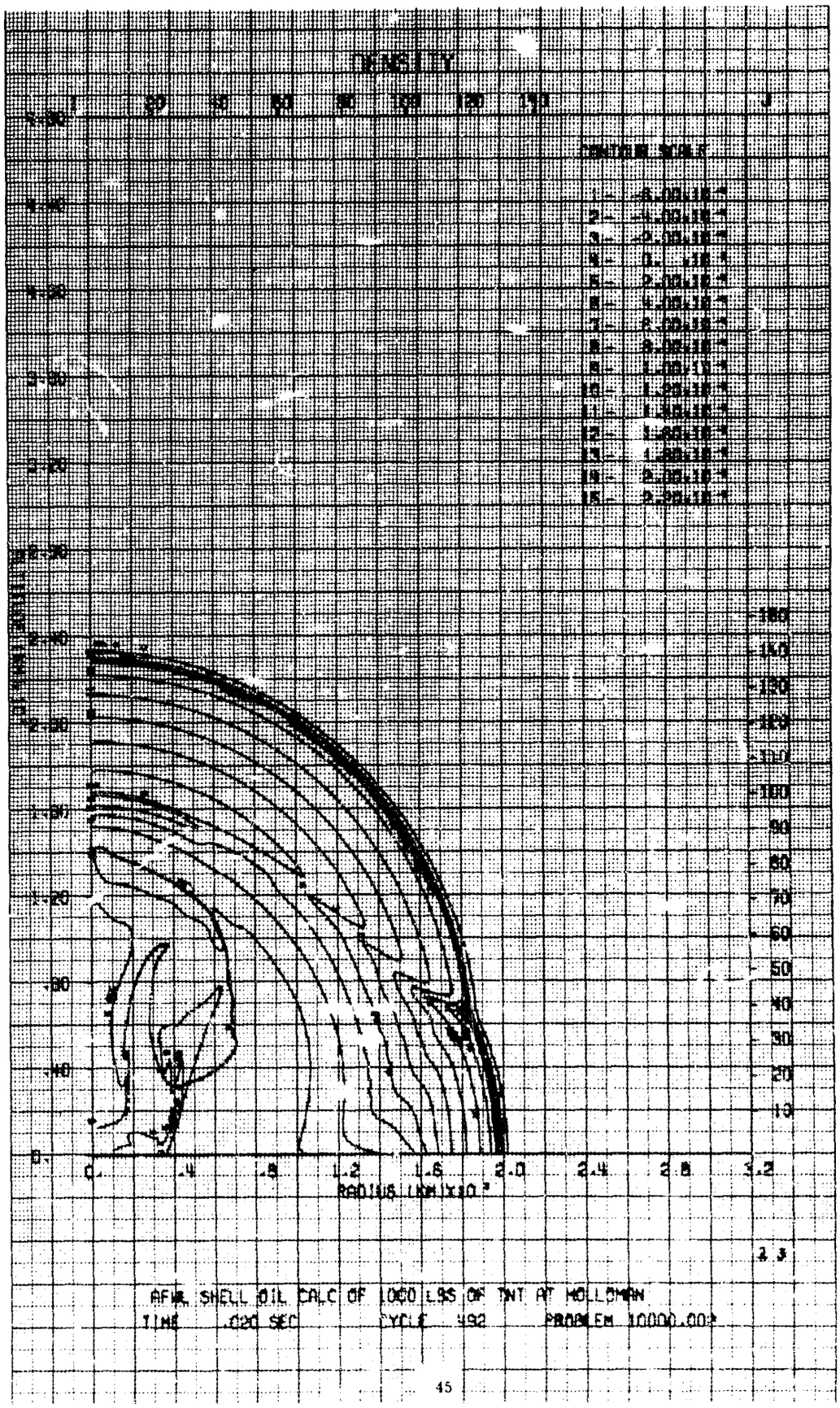

VELOCITY VECTOR
VELOCITY SCALE
1 IN = 1KM/SEC
RADIUS (CM) X10²
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .013 SEC
CYCLE 406
PROBLEM 1.000.00

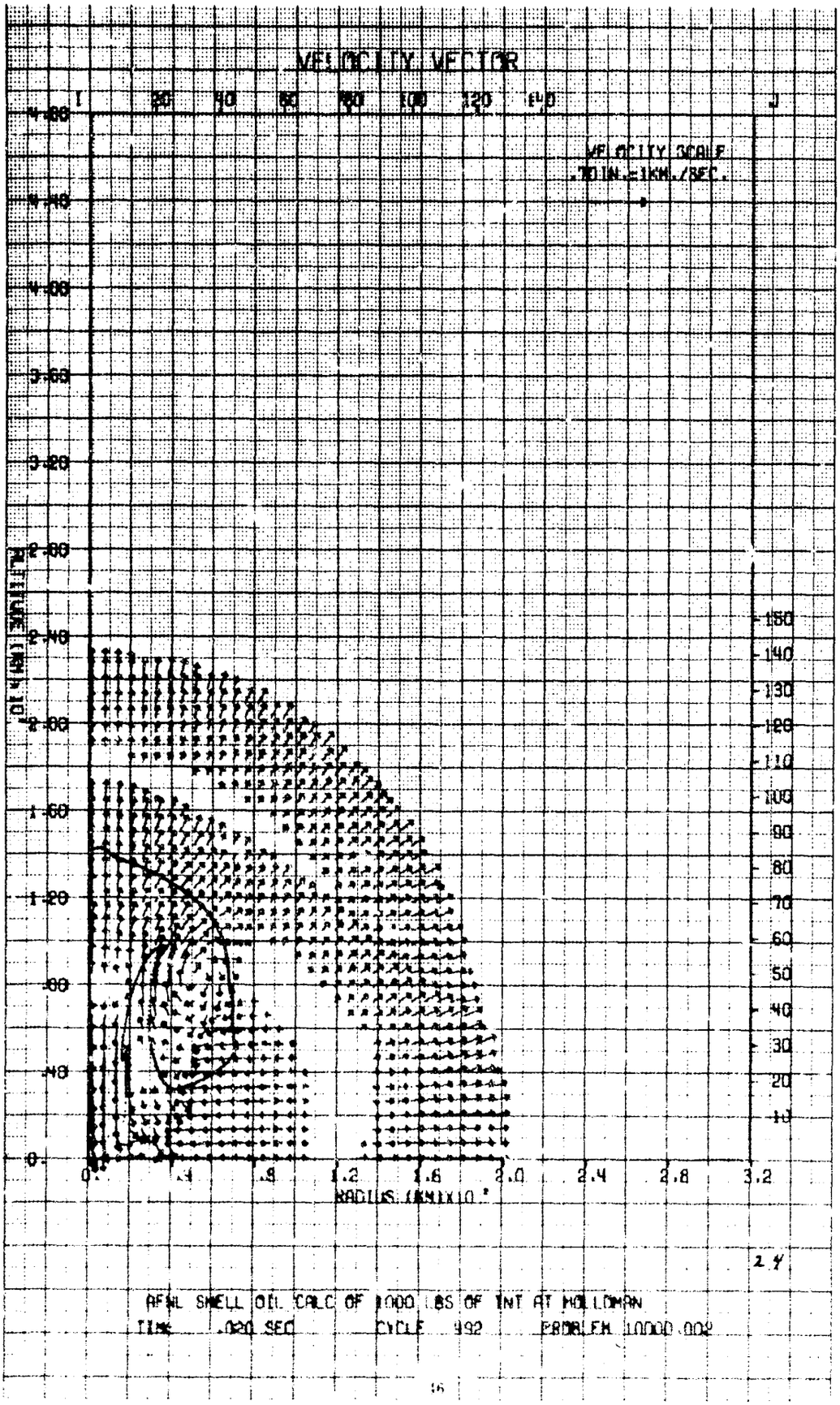

PRESSURE
CONTOUR SCALE
1= 1.00x10 4
2= 2.00x10 4
3= 4.00x10 4
4= 6.00x10 4
5= 8.00x10 4
6= 10.00x10 4
7= 1.20x10 5
8= 1.40x10 5
9= 1.60x10 5
10= 1.80x10 5
11= 2.00x10 5
12= 2.20x10 5
13= 2.40x10 5
14= 2.60x10 5
15= 2.80x10 5
16= 3.00x10 5
17= 3.20x10 5
RADIAL (KM)X10 4
/ 9
APML SHELL OIL CALC OF 1000 LBS OF INT AT HOLLOMAN
TIME .017 SEC CYCLE 459 PROBLEM 10620.002

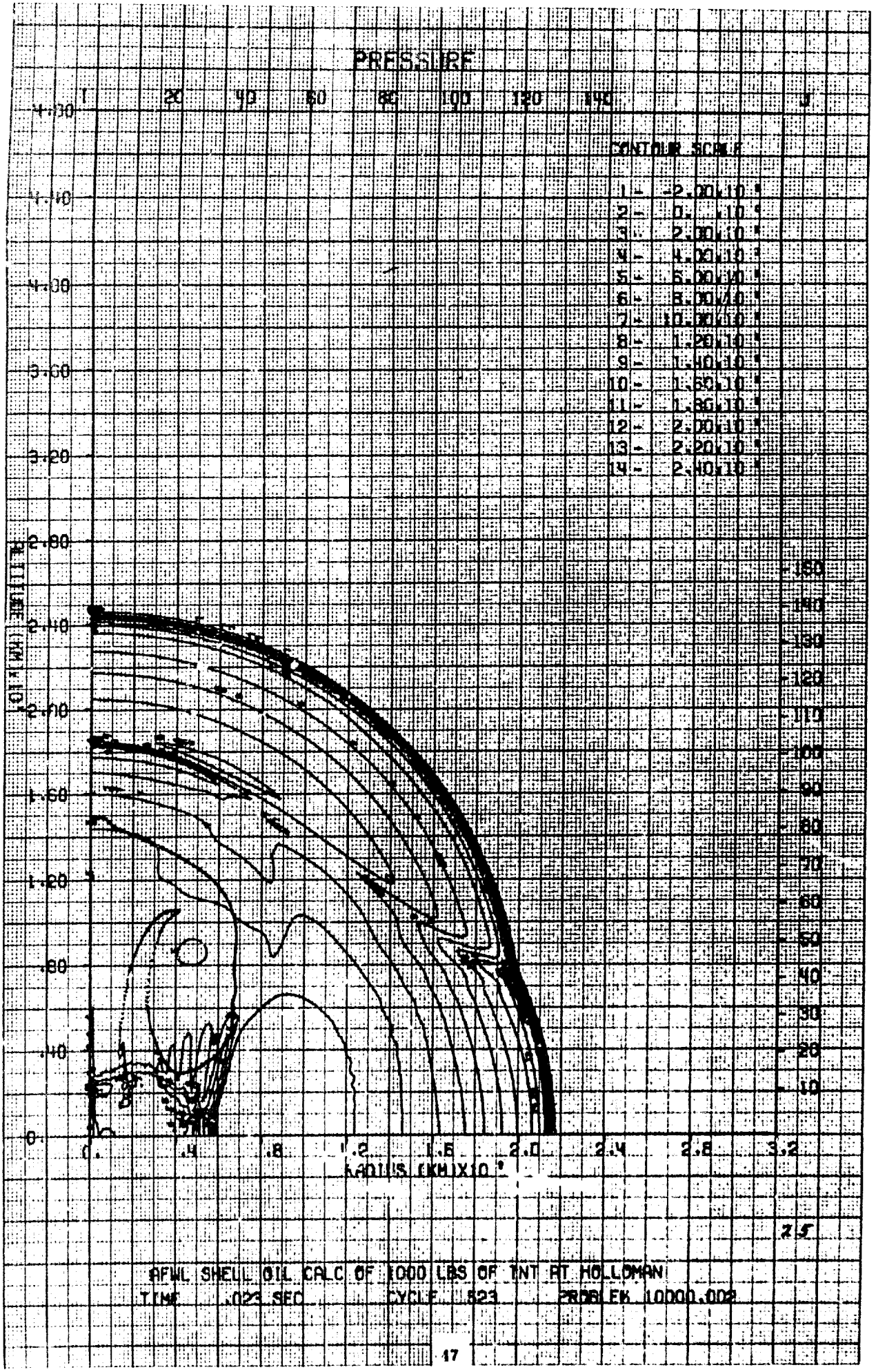

DENSITY
CONTOUR VALUES
1 - 1.00x10⁻⁴
2 - 2.00x10⁻⁴
3 - 5.00x10⁻⁴
4 - 1.00x10⁻³
5 - 2.00x10⁻³
6 - 5.00x10⁻³
7 - 8.00x10⁻³
8 - 1.00x10⁻²
9 - 1.20x10⁻²
10 - 1.40x10⁻²
11 - 1.60x10⁻²
12 - 1.80x10⁻²
13 - 2.00x10⁻²
14 - 2.20x10⁻²
15 - 2.40x10⁻²
RADIUS (KM) X10⁻⁵
AFWL SHELL OIL CALC OF 2000 LBS OF TNT AT HOLLOMAN
TIME .012 SEC CYCLE 459 PROBLEM 10000.002

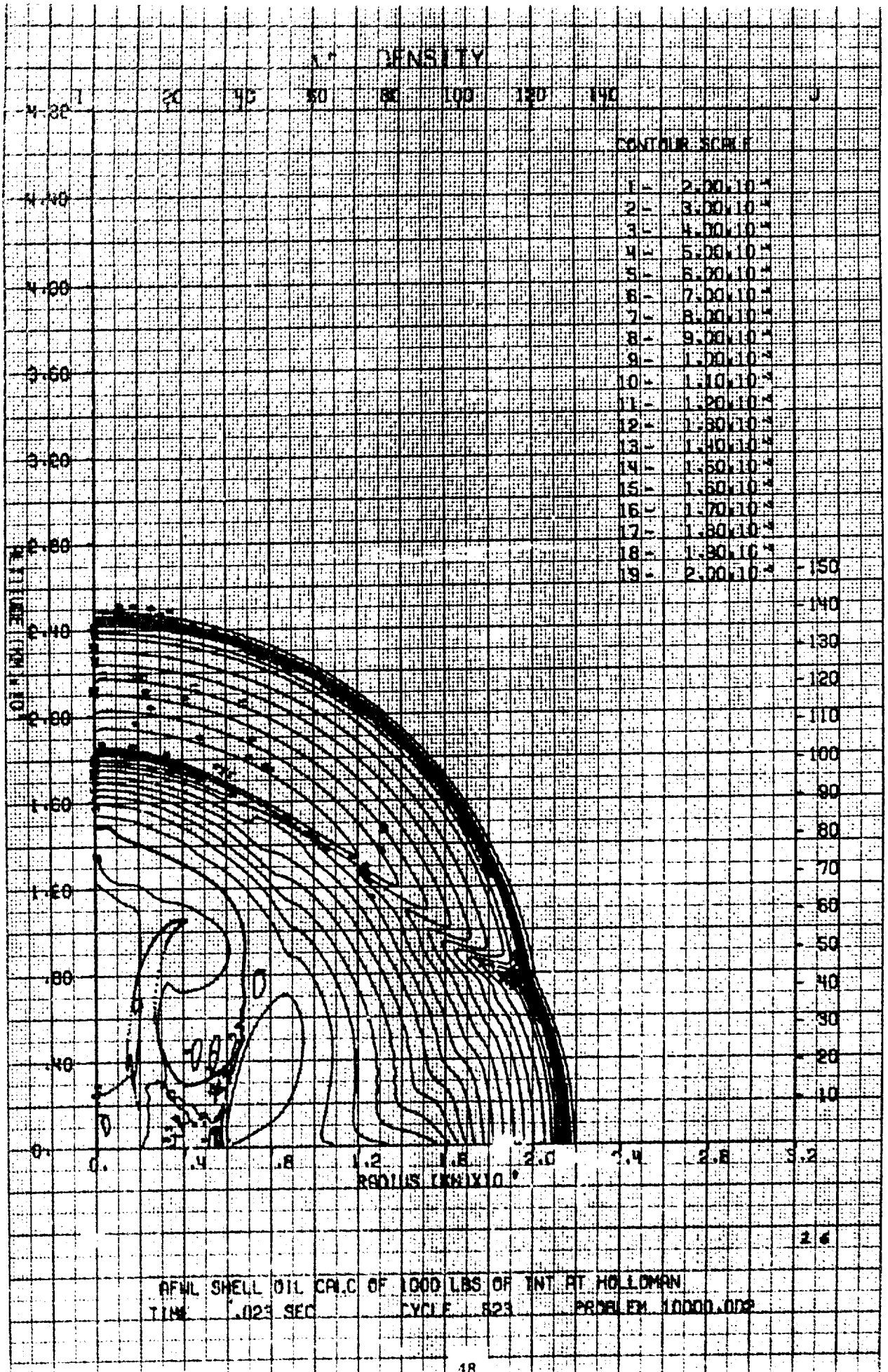

VELOCITY VECTOR
VELOCITY SCALE
.30 IN.=100 FT./SEC.
RADIUS (KM)X10
AFWL "HELL" GEL CALC OF 1000 LBS OF TNT AT MOLEMAN
TIME .017 SEC
CYCLE 959
PATTERN 10001.002

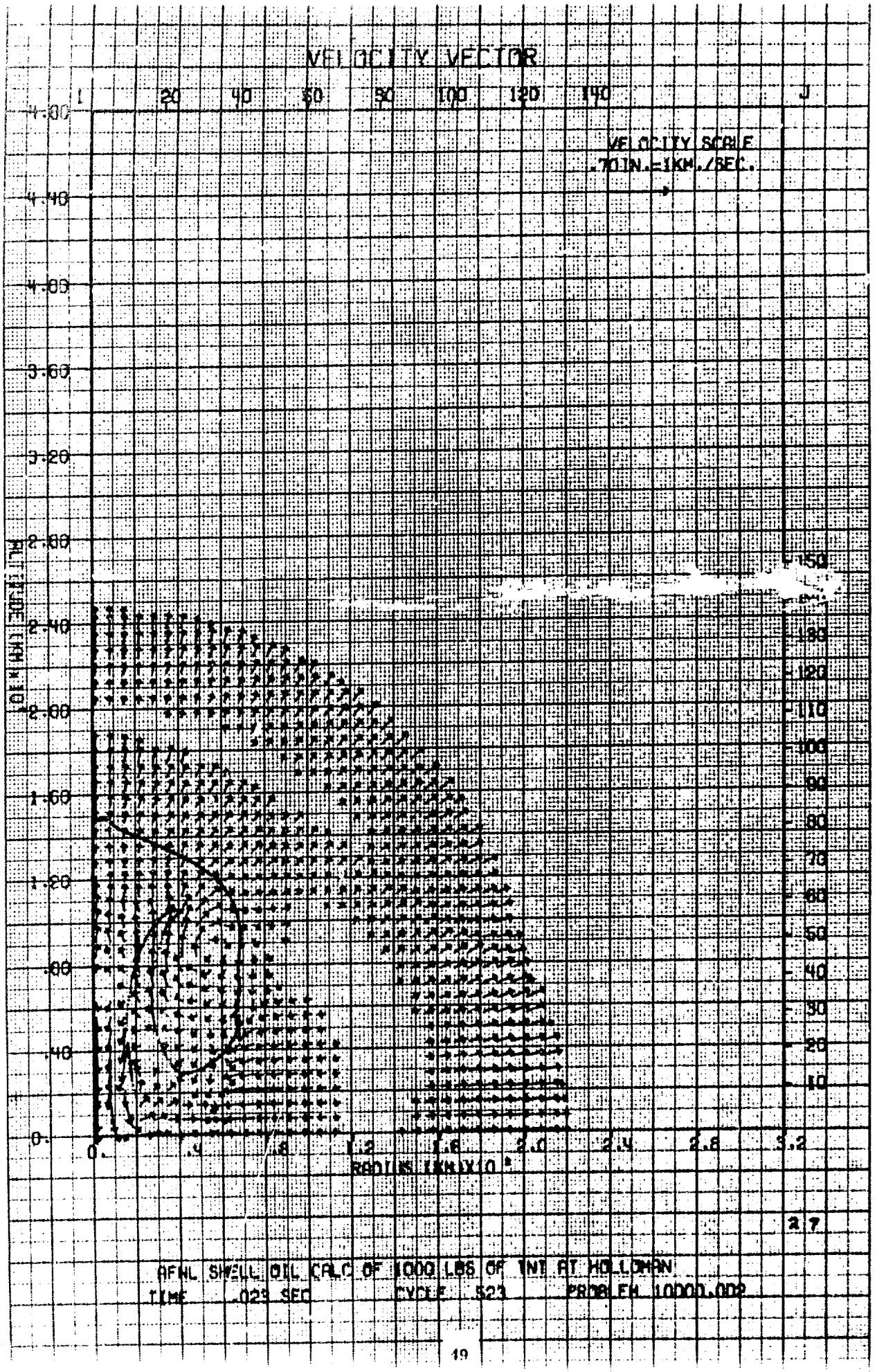

PRESSURE
CONTOUR SCALE
1- 2.00x10 *
2- 2.00x10 *
3- 4.00x10 *
4- 6.00x10 *
5- 8.00x10 *
6- 10.00x10 *
7- 1.20x10 *
8- 1.40x10 *
9- 1.60x10 *
10- 1.80x10 *
11- 2.00x10 *
12- 2.20x10 *
13- 2.40x10 *
14- 2.60x10 *
15- 2.80x10 *
RADIUS (KM)X10 *
AFWL SHELL DIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .020 SEC CYCLE 492 PROBLEM 10000.002

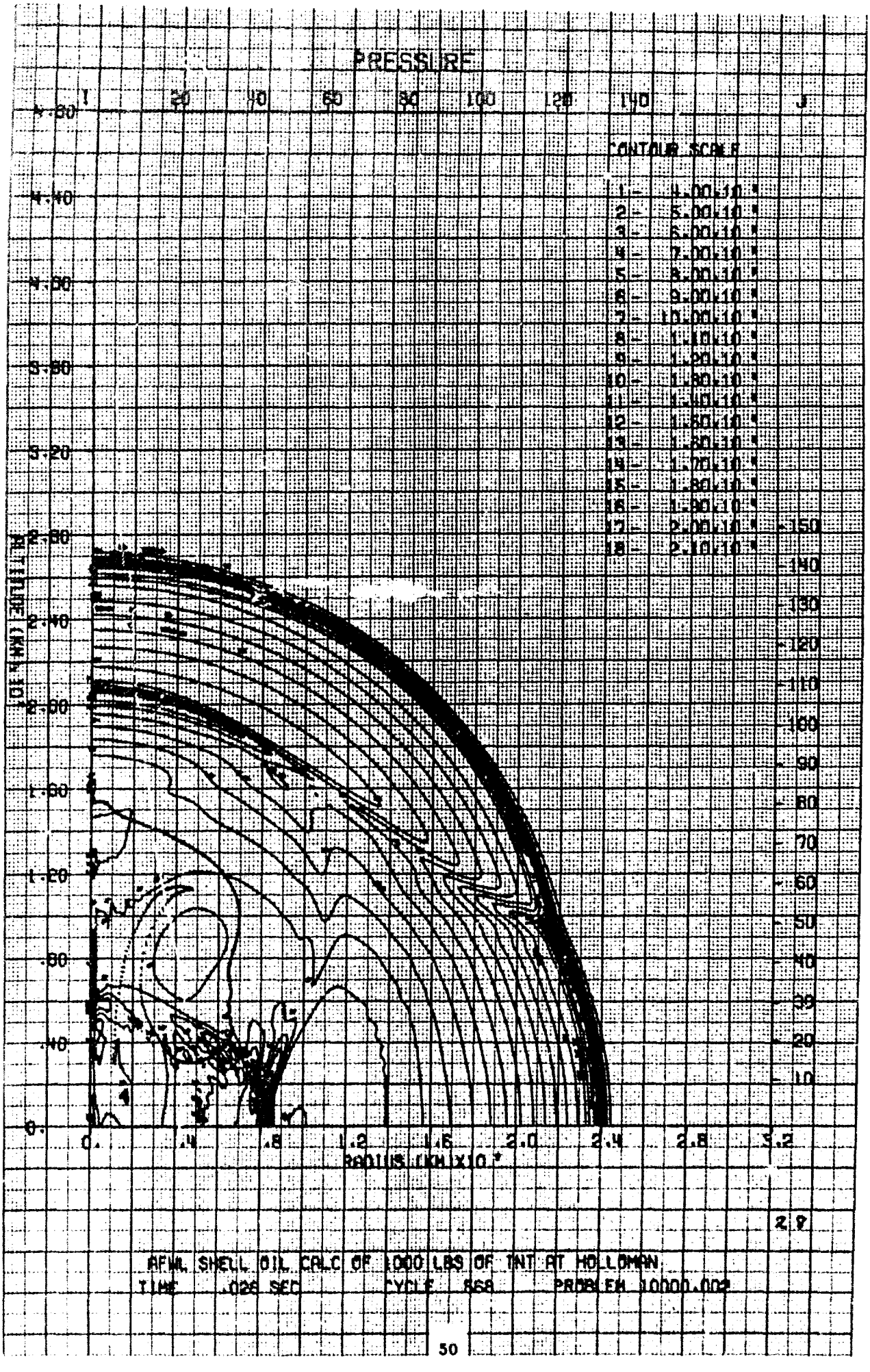

DENSITY
CONTOUR SCALE
1 - -6.00x10-1
2 - -4.00x10-1
3 - -2.00x10-1
4 - 0. x10-1
5 - 2.00x10-1
6 - 4.00x10-1
7 - 6.00x10-1
8 - 8.00x10-1
9 - 1.00x10-1
10 - 1.20x10-1
11 - 1.40x10-1
12 - 1.60x10-1
13 - 1.80x10-1
14 - 2.00x10-1
15 - 2.20x10-1
RADIUS (KM)X10-3
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .000 SEC CYCLE 492 PROBLEM 10000.002

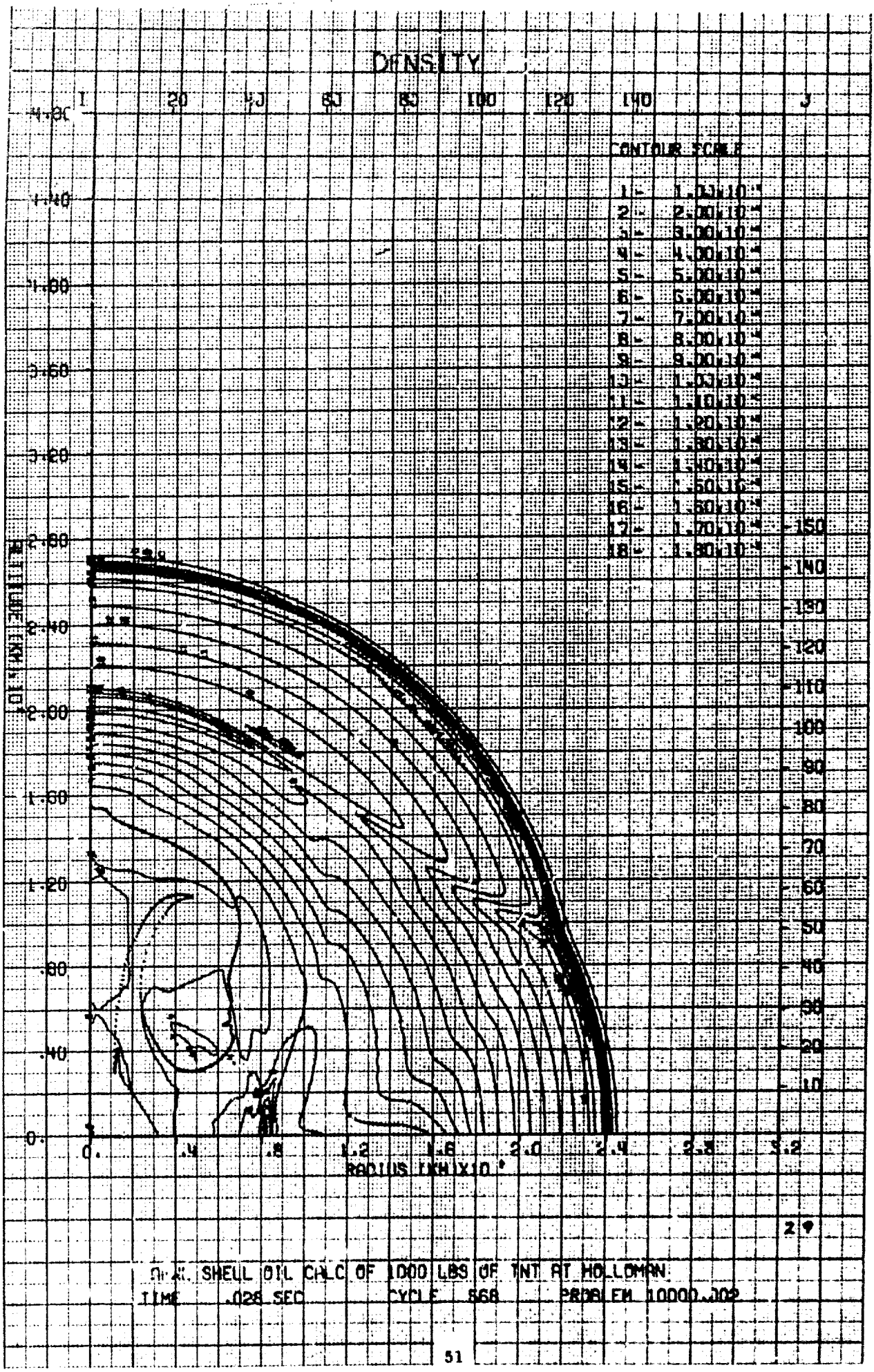

VELOCITY VECTOR
I
J
VELOCITY SCALE
.70 IN.=1KM./SEC.
ALTITUDE (KM X 10³)
RADIUS (KM X 10³)
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
AFNL SHELL OIL CALC OF 1000 LBS OF INT AT HOLLOMAN
TIME .020 SEC CYCLE 992 PROBLEM 10000.002


PRESSURE
CONTOUR SCALE
1 - -2.00,10 ³
2 - 0. ,10 ³
3 - 2.00,10 ³
4 - 4.00,10 ³
5 - 6.00,10 ³
6 - 8.00,10 ³
7 - 10.00,10 ³
8 - 1.20,10 ⁴
9 - 1.40,10 ⁴
10 - 1.60,10 ⁴
11 - 1.80,10 ⁴
12 - 2.00,10 ⁴
13 - 2.20,10 ⁴
14 - 2.40,10 ⁴
ALTITUDE (KM)X10 ³
RADIUS (KM)X10 ³
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .023 SEC CYCLE 523 PROBLEM 10000.002

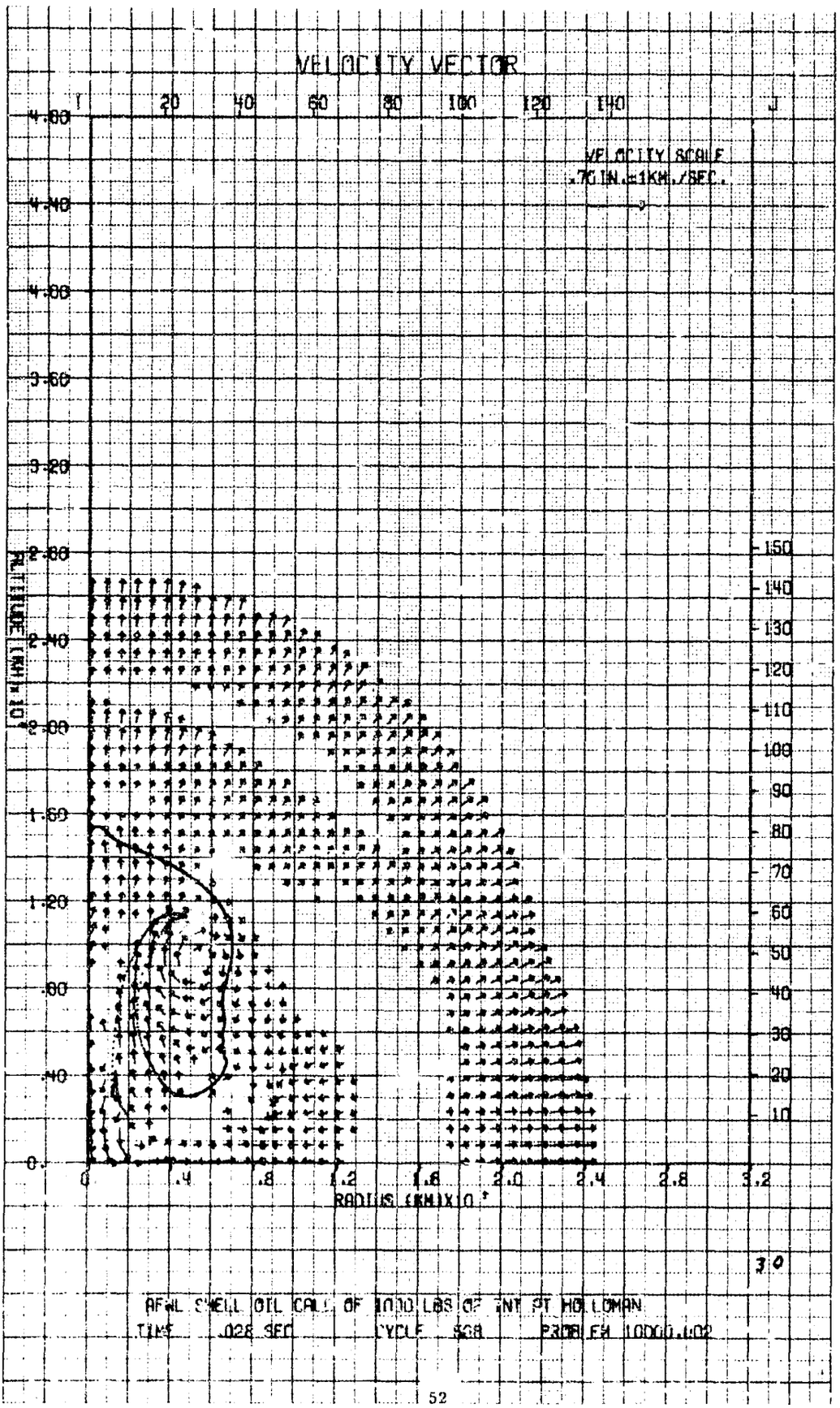

DENSITY
CONTOUR SCALE
1 = 2.00x10⁻⁴
2 = 3.00x10⁻⁴
3 = 4.00x10⁻⁴
4 = 5.00x10⁻⁴
5 = 6.00x10⁻⁴
6 = 7.00x10⁻⁴
7 = 8.00x10⁻⁴
8 = 9.00x10⁻⁴
9 = 1.00x10⁻³
10 = 1.10x10⁻³
11 = 1.20x10⁻³
12 = 1.30x10⁻³
13 = 1.40x10⁻³
14 = 1.50x10⁻³
15 = 1.60x10⁻³
16 = 1.70x10⁻³
17 = 1.80x10⁻³
18 = 1.90x10⁻³
19 = 2.00x10⁻³
RADIUS (KM)X10⁻¹
AFWL SHELL OIL CAL.C OF 1000 LBS OF TNT AT HOLLOMAN
TIME .023 SEC CYCLE 823 PROBLEM 10000.000

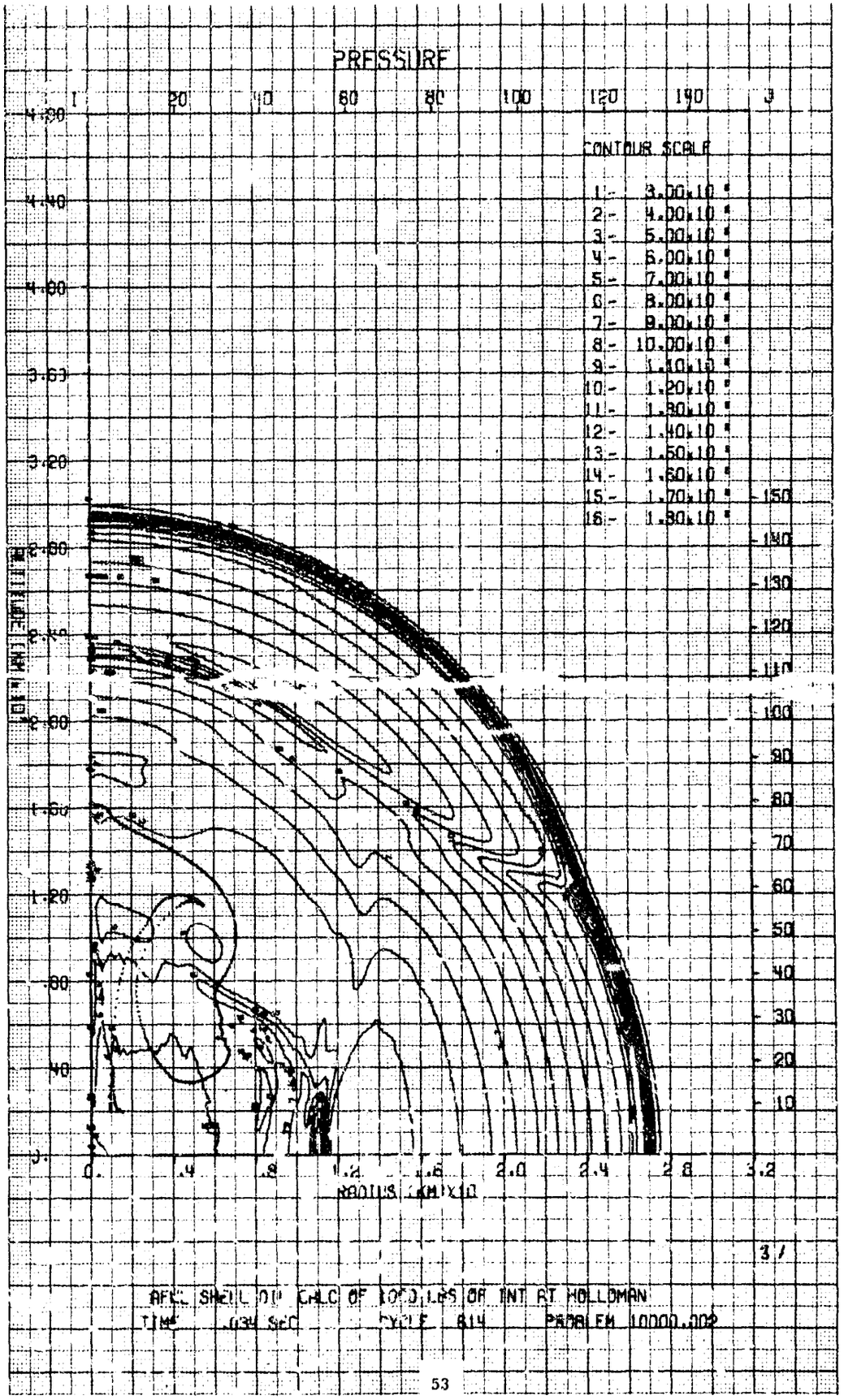

VELOCITY VECTOR
I
20
40
60
80
100
120
140
J
VELOCITY SCALE
.70IN.=1KM./SEC.
4.80
4.40
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
ALTITUDE (KM X 10)
150
130
120
110
100
90
80
70
60
50
40
30
20
10
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
RADIUS (KM X 10)
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .029 SEC CYCLE 523 PROBLEM 10000.002

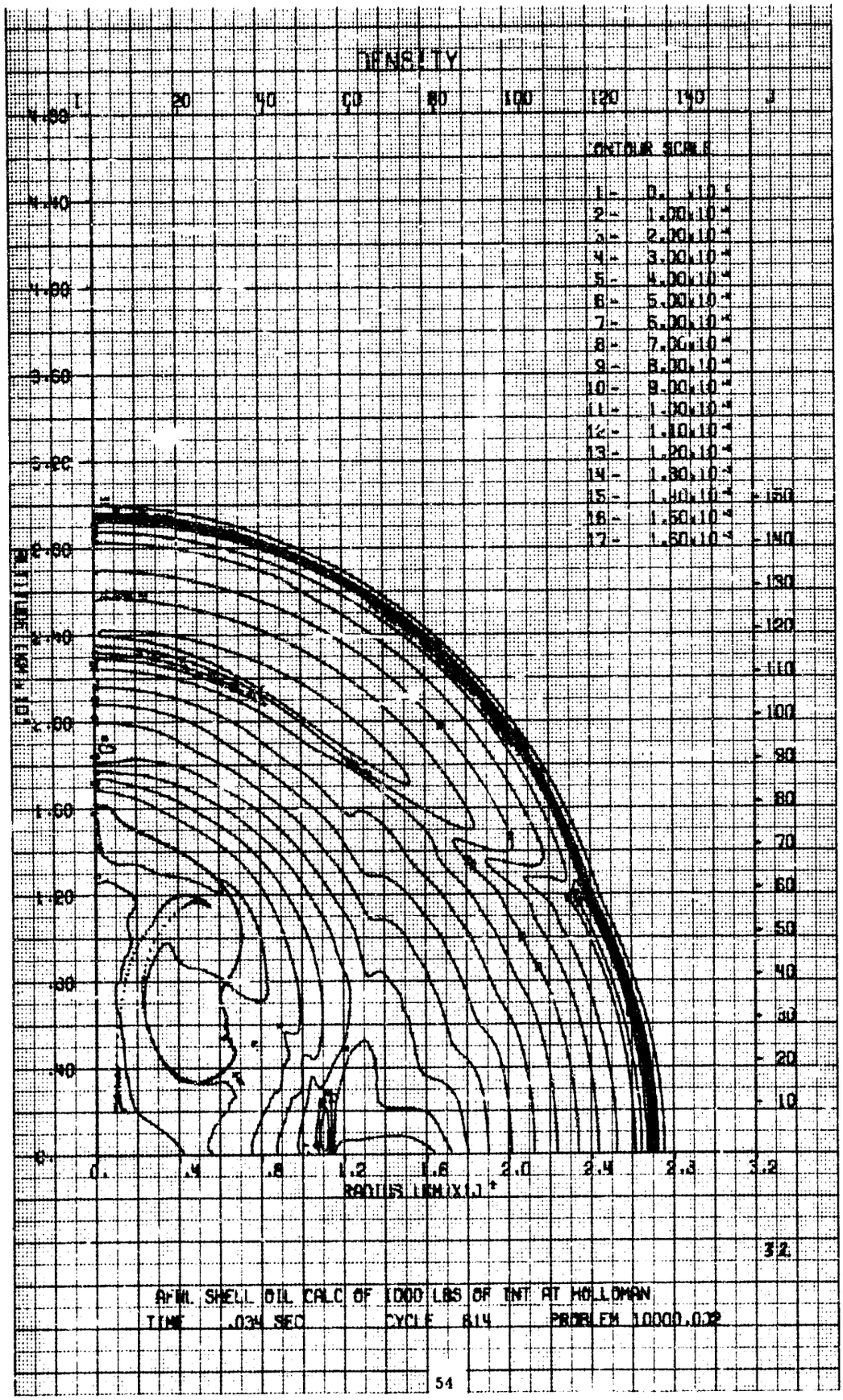

PRESSURE
CONTOUR SCALE
1 - 4.00,10 *
2 - 5.00,10 *
3 - 6.00,10 *
4 - 7.00,10 *
5 - 8.00,10 *
6 - 9.00,10 *
7 - 10.00,10 *
8 - 1.10,10 *
9 - 1.20,10 *
10 - 1.30,10 *
11 - 1.40,10 *
12 - 1.50,10 *
13 - 1.60,10 *
14 - 1.70,10 *
15 - 1.80,10 *
16 - 1.90,10 *
17 - 2.00,10 *
18 - 2.10,10 *
RADIUS (KM X10 *)
ALTITUDE (KM X10 *)
AFWL SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .026 SEC CYCLE 868 PROBLEM 10000.002

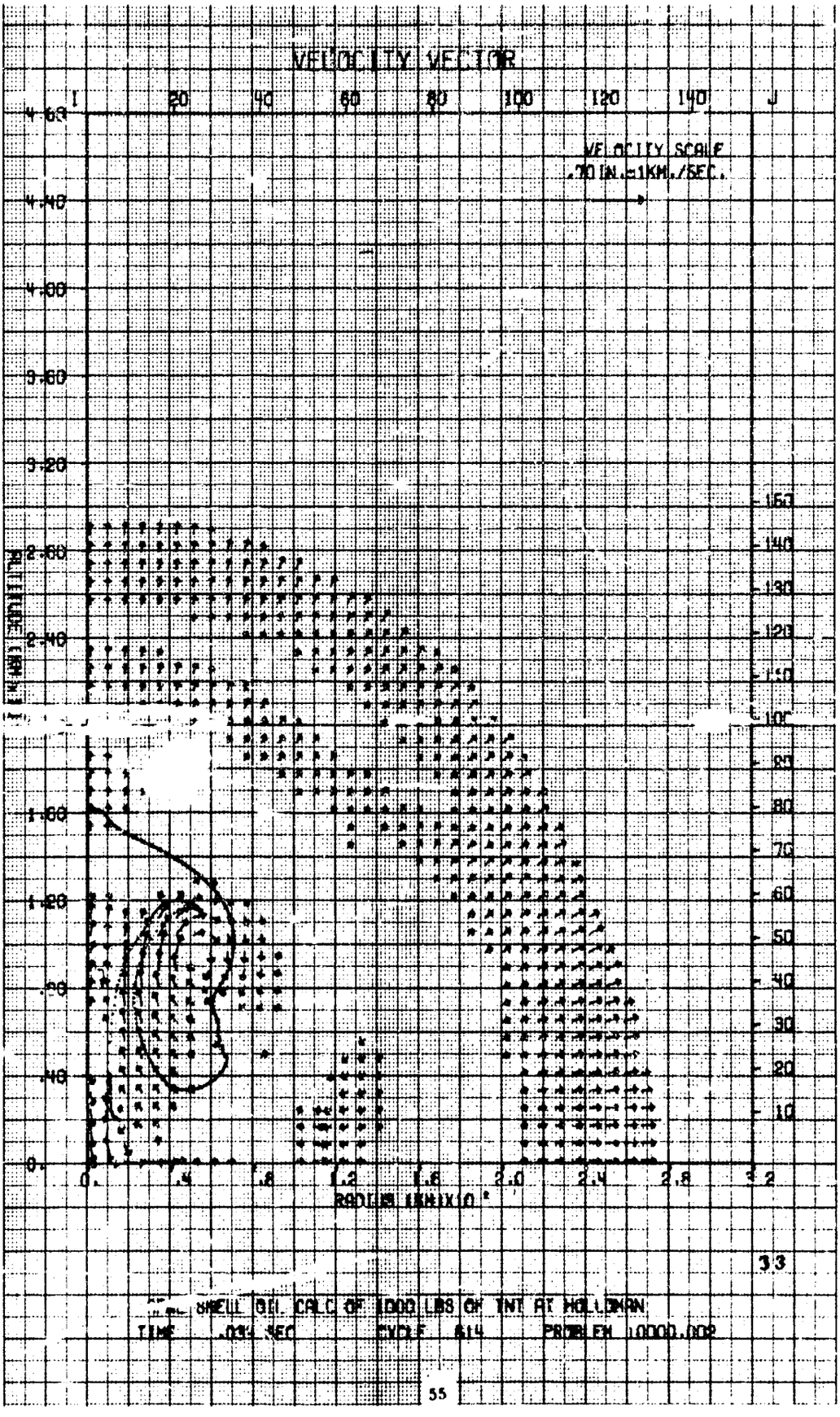


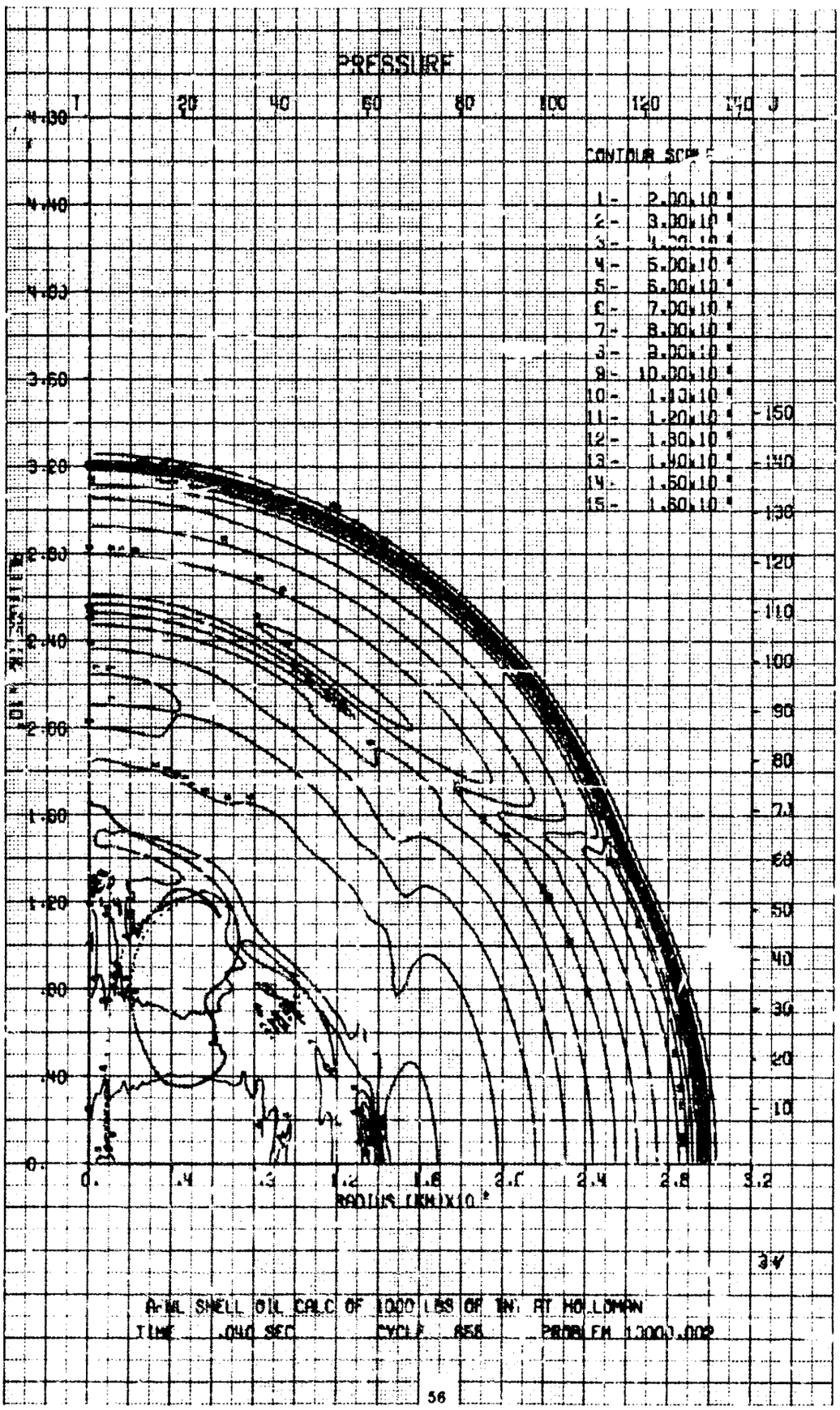
DNA. SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .028 SEC CYCLE 568 PROBLEM 10000.002

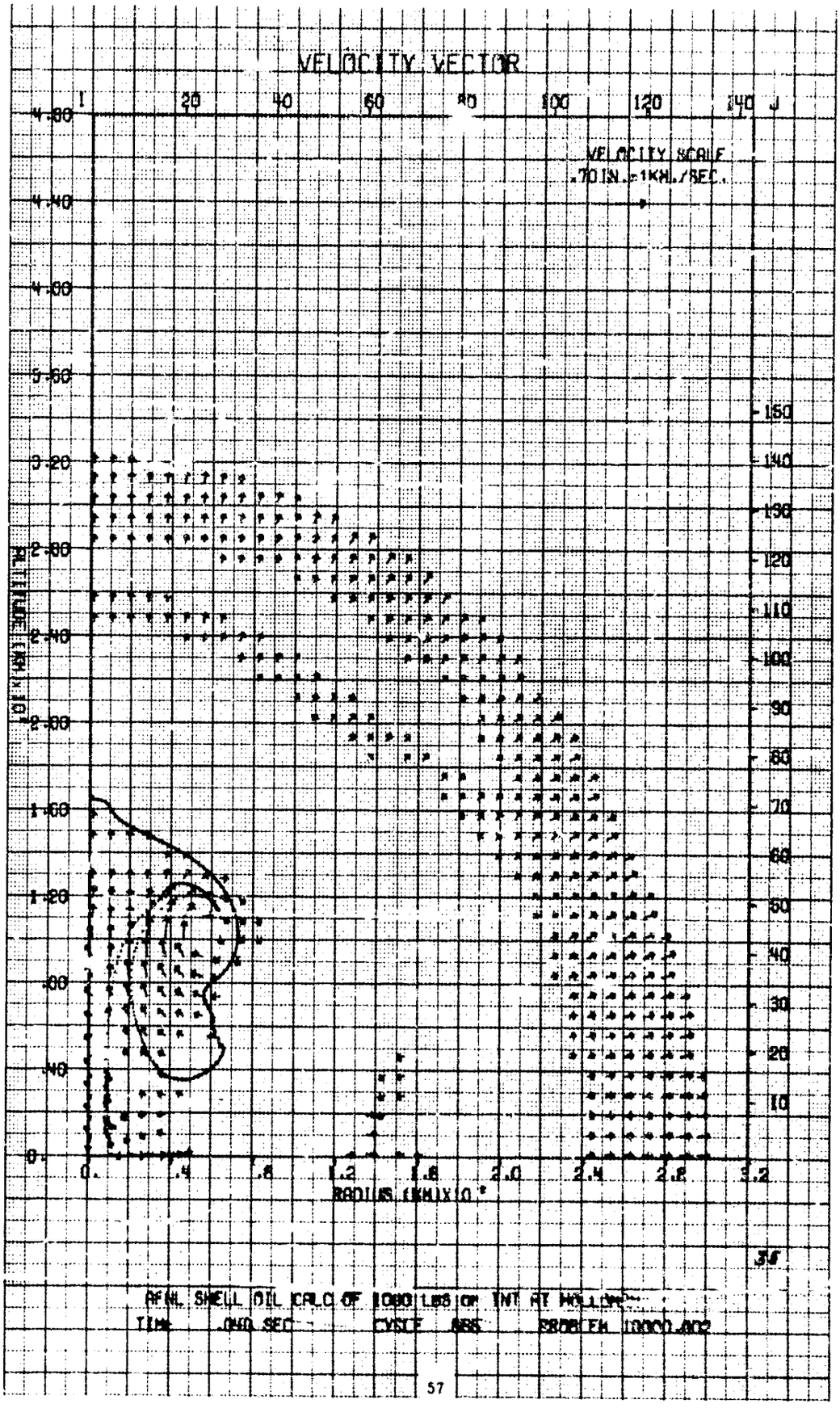

VELOCITY VECTOR
VELOCITY SCALE
.7 IN.=1KM./SEC.
ALTITUDE (KM)x10³
RADIUS (KM)X10³
AFWL SMALL OIL CAL. OF 1000 LBS OF TNT AT HOLLOMAN
TIME .028 SEC CYCLE 308 PROBLEM 10DG0.1.02

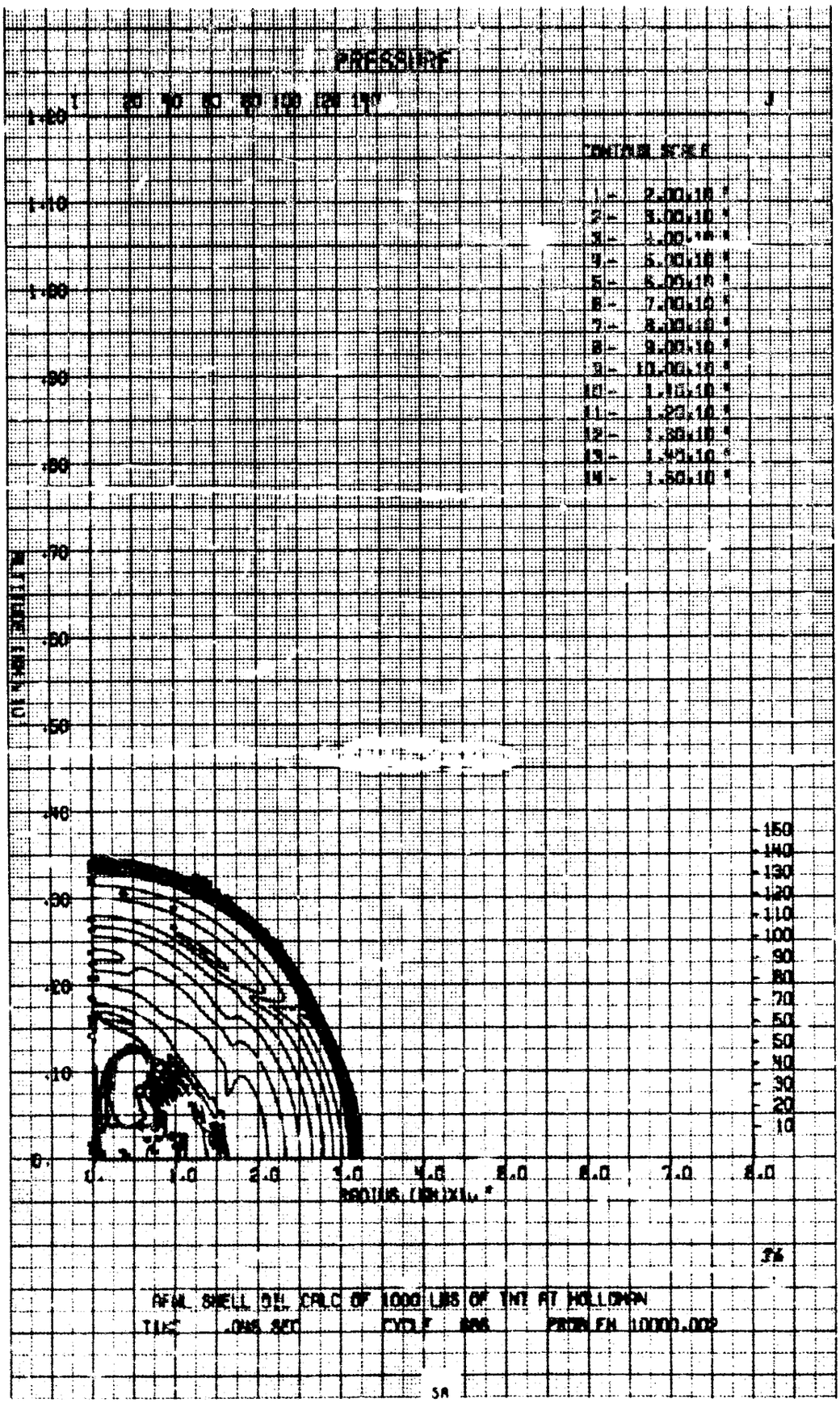

PRESSURE
CONTOUR SCALE
1.- 3.00x10 *
2.- 4.00x10 *
3.- 5.00x10 *
4.- 6.00x10 *
5.- 7.00x10 *
6.- 8.00x10 *
7.- 9.00x10 *
8.- 10.00x10 *
9.- 1.10x10 *
10.- 1.20x10 *
11.- 1.30x10 *
12.- 1.40x10 *
13.- 1.50x10 *
14.- 1.60x10 *
15.- 1.70x10 *
16.- 1.80x10 *
RADIUS (KM)x10
AFSC SHELL 01P CALC OF TOD LES OF INT AT HOLLOMAN
TIME .034 SEC CYCLE 814 PROBLEM 10000.002

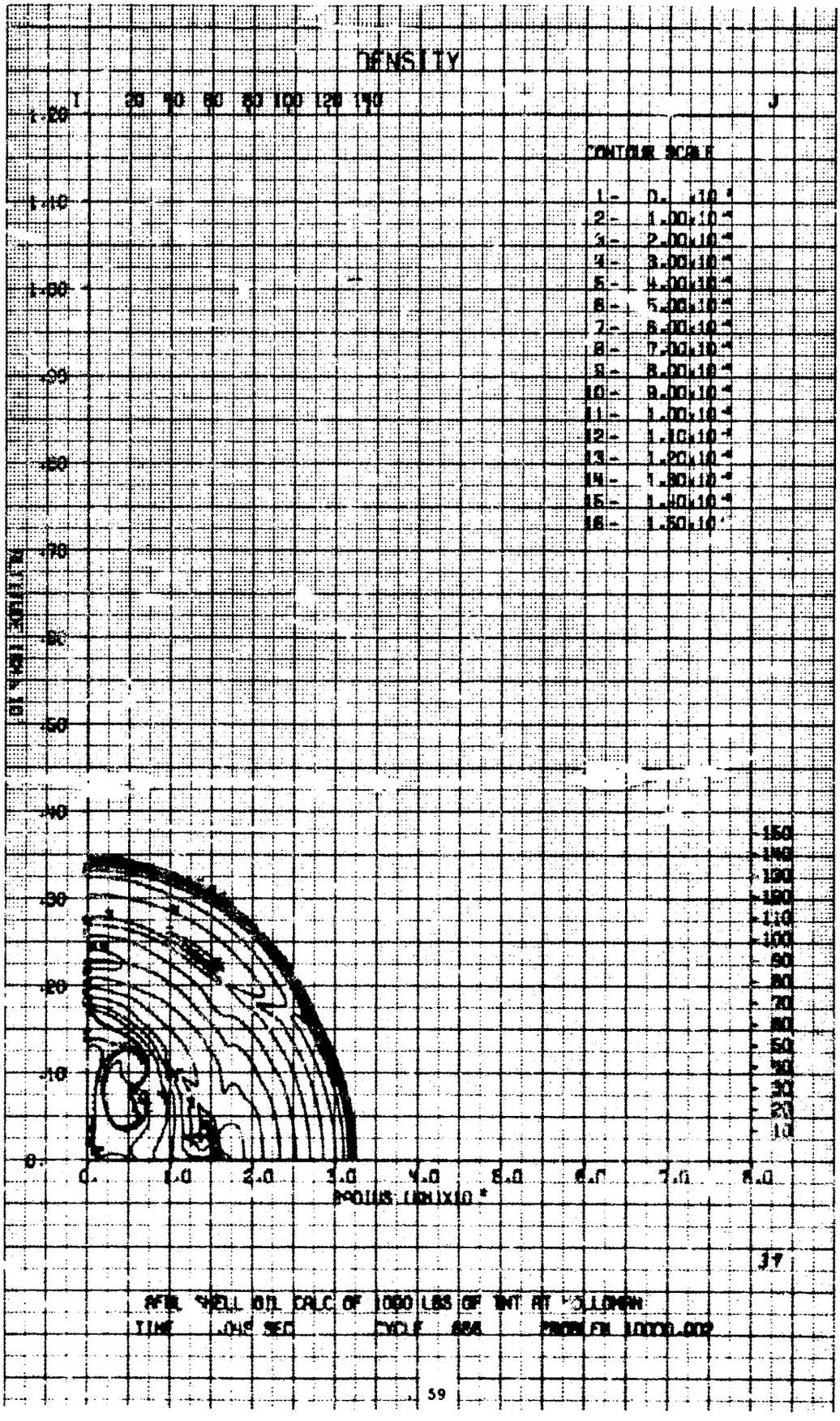

DENSITY
CONTOUR SCALE
1 - 0. x10 -4
2 - 1.00x10 -4
3 - 2.00x10 -4
4 - 3.00x10 -4
5 - 4.00x10 -4
6 - 5.00x10 -4
7 - 6.00x10 -4
8 - 7.00x10 -4
9 - 8.00x10 -4
10 - 9.00x10 -4
11 - 1.00x10 -4
12 - 1.10x10 -4
13 - 1.20x10 -4
14 - 1.30x10 -4
15 - 1.40x10 -4
16 - 1.50x10 -4
17 - 1.60x10 -4
RADIUS (CM X 10)
32.
ARML SHELL OIL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .034 SEC CYCLE 814 PROBLEM 10000.032

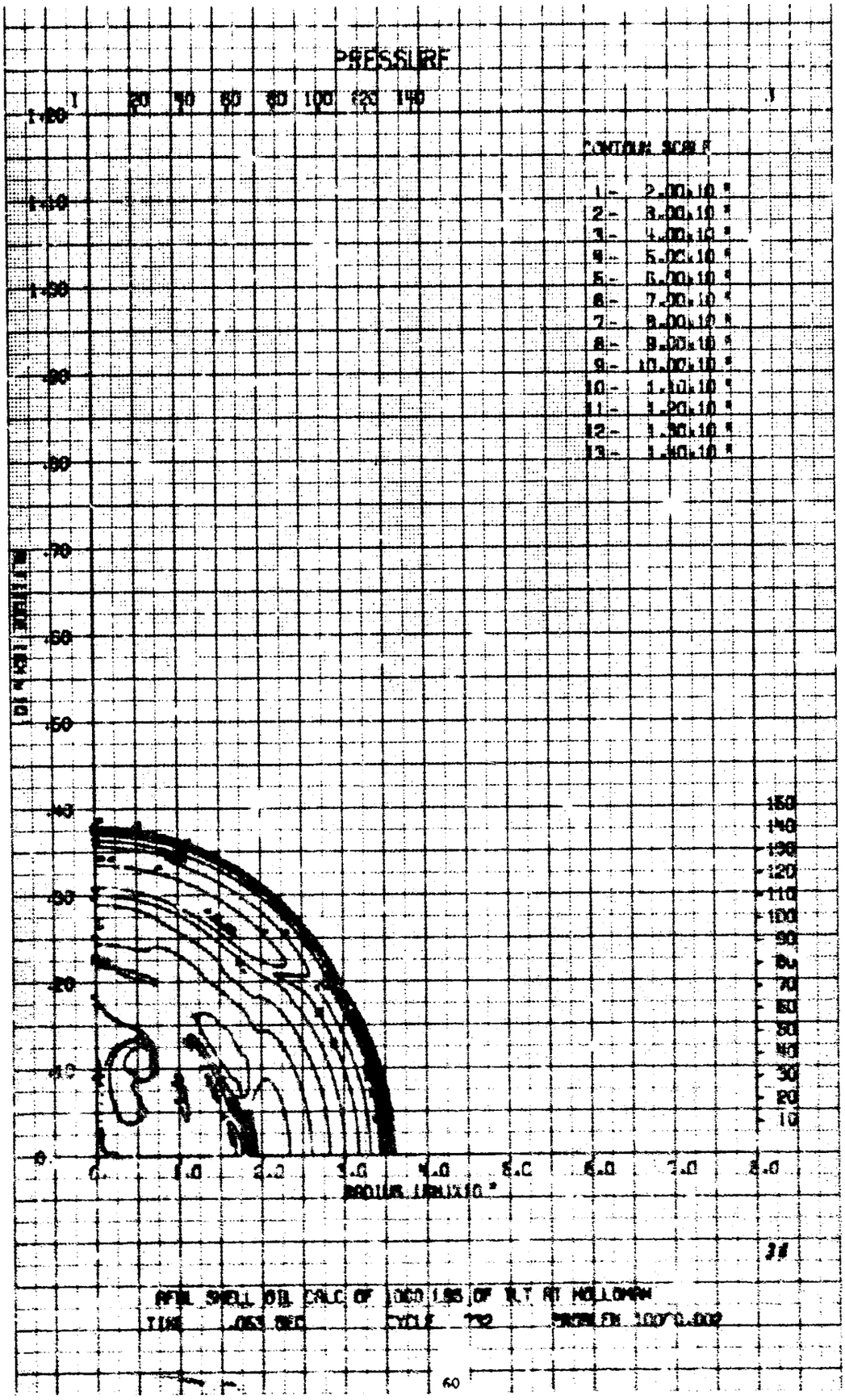

VELOCITY VECTOR
I
20
40
60
80
100
120
140
J
VELOCITY SCALE
.70 IN.=1KM./SEC.
4.80
4.40
4.00
3.60
3.20
2.80
2.40
1.60
1.20
.80
.40
0.
ALTITUDE (KM)
160
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
RADIUS (KM)X10
33
SHELL 8EL CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .031 SEC CYCLE 614 PROBLEM 10000.002

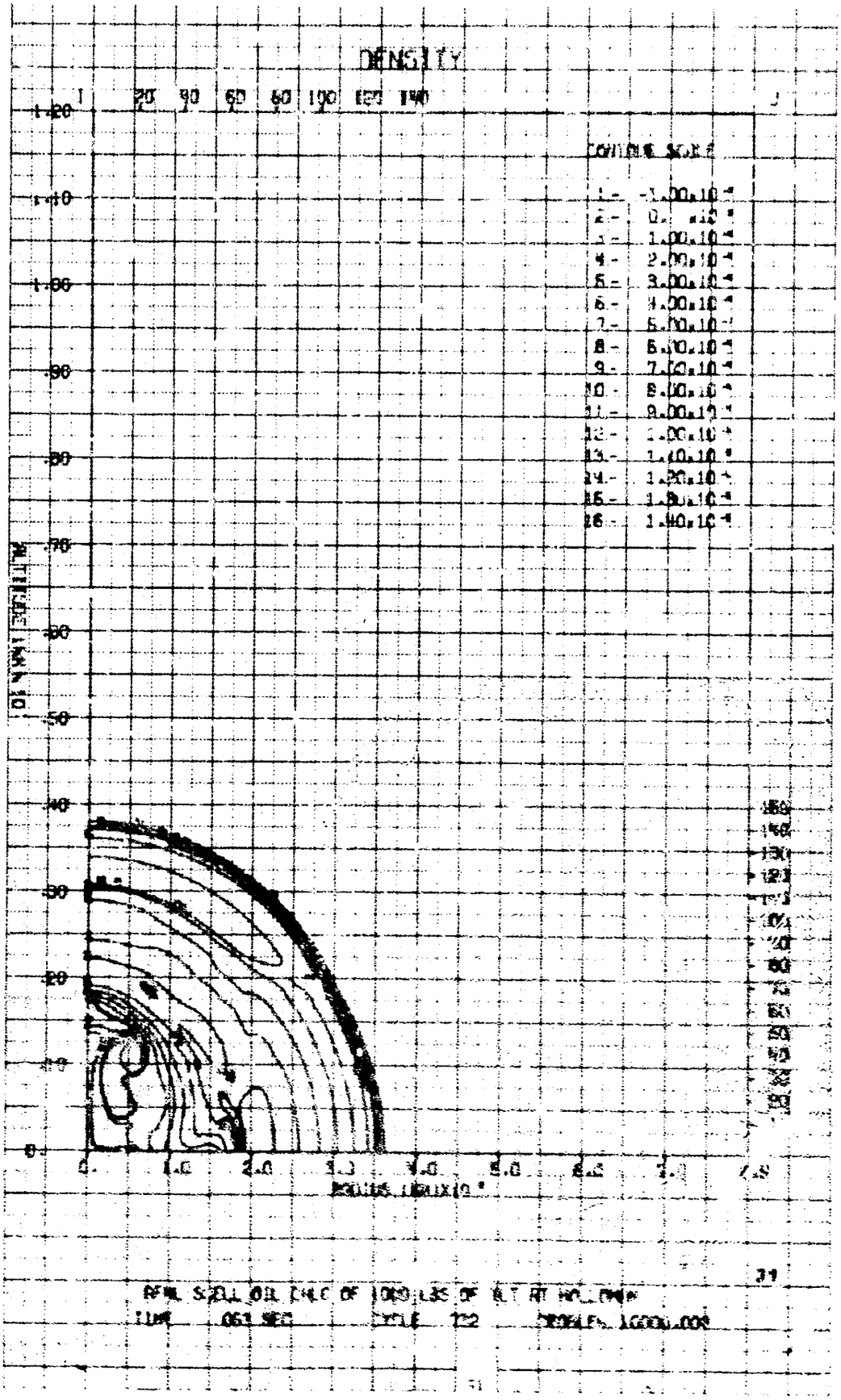

PRESSURE
CONTOUR SCALE
1 - 2.00x10
2 - 3.00x10
3 - 4.00x10
4 - 5.00x10
5 - 6.00x10
6 - 7.00x10
7 - 8.00x10
8 - 9.00x10
9 - 10.00x10
10 - 1.10x10
11 - 1.20x10
12 - 1.30x10
13 - 1.40x10
14 - 1.50x10
15 - 1.60x10
RADIUS (CM)X10
A-ML SHELL OIL CALC OF 1000 LBS OF TN. AT HOLLOMAN
TIME .040 SEC CYCLE 858 PROBLEM 1000.002


VELOCITY VECTOR
VELOCITY SCALE
.70 IN. = 1 KM./SEC.
ALTITUDE (KM) X 10³
RADIUS (KM) X 10³
AFWL SHELL OIL CRATER OF 1000 LBS OF TNT AT HEIGHT
TIME .040 SEC CYCLE 885 PROBLEM 10000.002


PRESSURE
CONTOUR SCALE
1 - 2.00x10 ⁴
2 - 3.00x10 ⁴
3 - 4.00x10 ⁴
4 - 5.00x10 ⁴
5 - 6.00x10 ⁴
6 - 7.00x10 ⁴
7 - 8.00x10 ⁴
8 - 9.00x10 ⁴
9 - 10.00x10 ⁴
10 - 1.10x10 ⁵
11 - 1.20x10 ⁵
12 - 1.30x10 ⁵
13 - 1.40x10 ⁵
14 - 1.50x10 ⁵
RADIUS (FEET)
RADIUS (KM) X10⁻³
AFWL SHELL 54 CALC OF 1000 LBS OF TNT AT HOLLOMAN
TIME .096 SEC CYCLE 886 PROBLEM 10000.002
56
58


DENSITY
I
J
CONTOUR SCALE
1 - 0. x10 -4
2 - 1.00x10 -4
3 - 2.00x10 -4
4 - 3.00x10 -4
5 - 4.00x10 -4
6 - 5.00x10 -4
7 - 6.00x10 -4
8 - 7.00x10 -4
9 - 8.00x10 -4
10 - 9.00x10 -4
11 - 1.00x10 -4
12 - 1.10x10 -4
13 - 1.20x10 -4
14 - 1.30x10 -4
15 - 1.40x10 -4
16 - 1.50x10 -4
RADIUS (INCHES)
RADIUS (INCH)X10 *
AFRL SHELL 601 CALC OF 1000 LBS OF TNT AT SEA LEVEL
TIME .045 SEC CYCLE 656 PROBLEM 10000.002


PRESSURE
CONTOUR SCALE
1.- 2.00x10 ⁴
2.- 3.00x10 ⁴
3.- 4.00x10 ⁴
4.- 5.00x10 ⁴
5.- 6.00x10 ⁴
6.- 7.00x10 ⁴
7.- 8.00x10 ⁴
8.- 9.00x10 ⁴
9.- 10.00x10 ⁴
10.- 1.10x10 ⁵
11.- 1.20x10 ⁵
12.- 1.30x10 ⁵
13.- 1.40x10 ⁵
MODULUS (PSI)X10⁴
AFWL SHELL OIL CALC OF LOCO LOS OF WLT AT HOLLOMAN
TIME .053 SEC CYCLE 732 PROBLEM 100*0.002

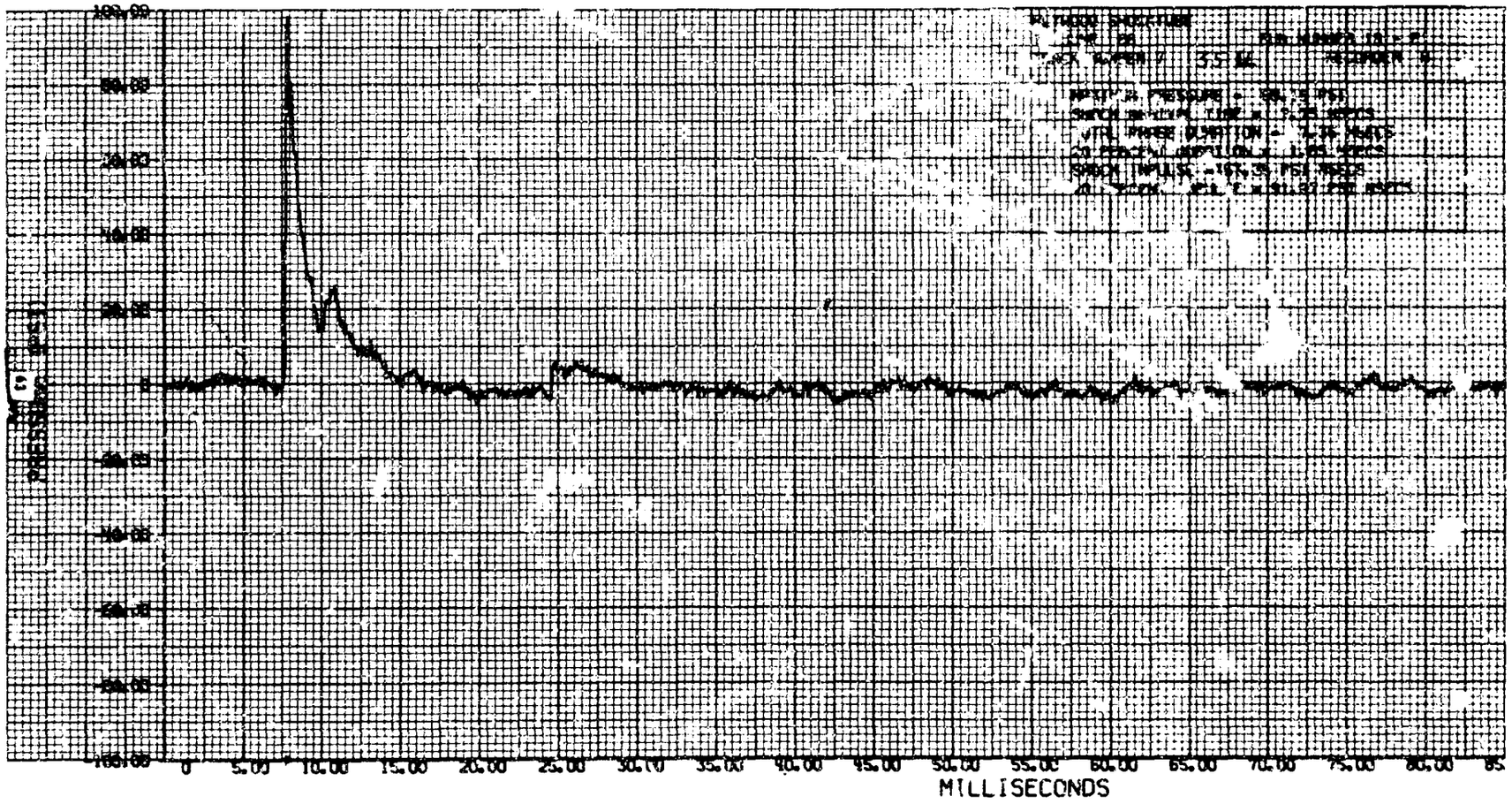

DENSITY
CONTOUR SCALE
1.- -1.00x10⁻⁴
2.- 0.
3.- 1.00x10⁻⁴
4.- 2.00x10⁻⁴
5.- 3.00x10⁻⁴
6.- 4.00x10⁻⁴
7.- 5.00x10⁻⁴
8.- 6.00x10⁻⁴
9.- 7.00x10⁻⁴
10.- 8.00x10⁻⁴
11.- 9.00x10⁻⁴
12.- 1.00x10⁻³
13.- 1.10x10⁻³
14.- 1.20x10⁻³
15.- 1.30x10⁻³
16.- 1.40x10⁻³
ALTITUDE (KM x 10)
RADIUS (KM x 10)
TIME .061 SEC
CYCLE 122

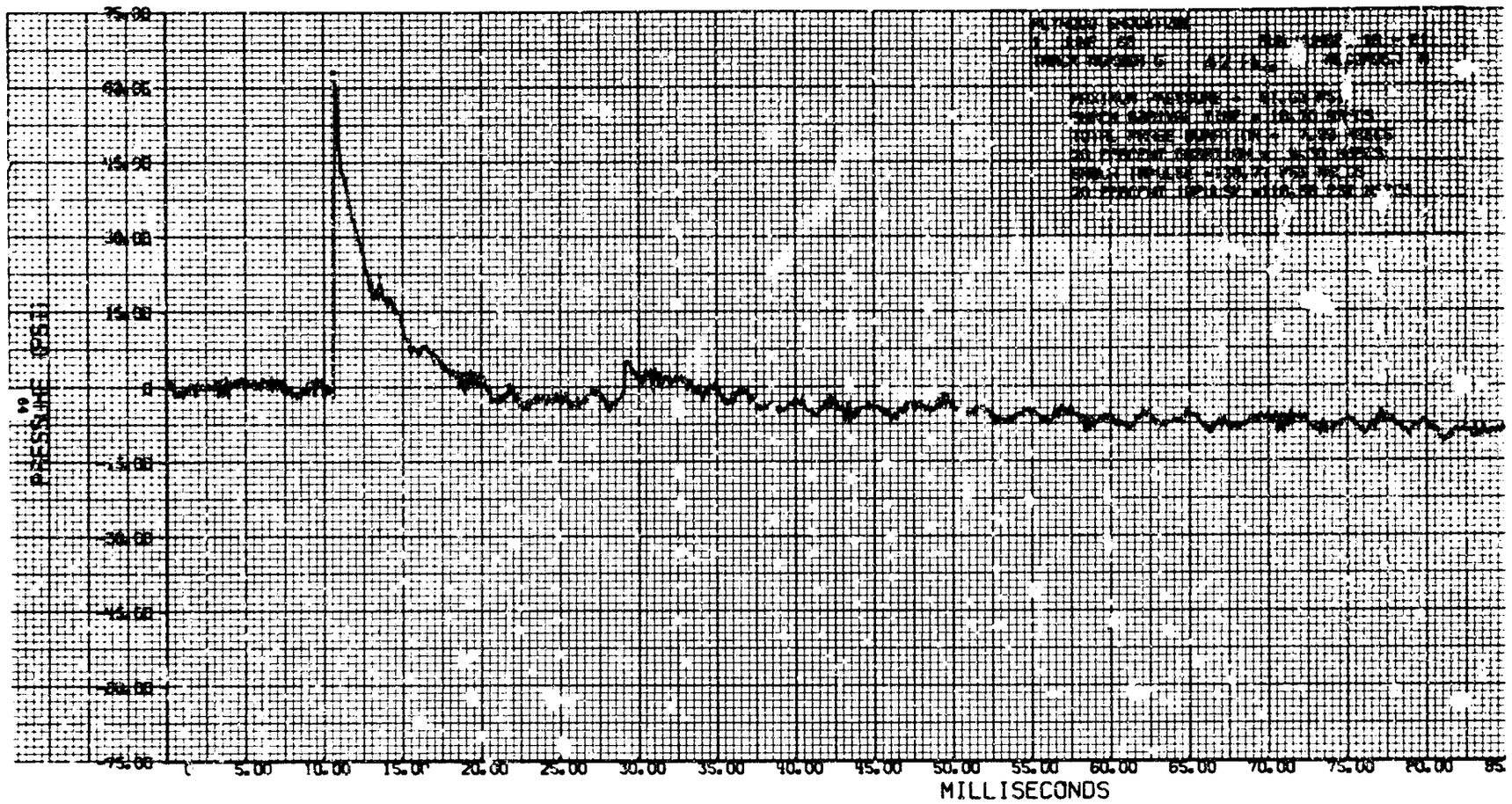
Appendix II

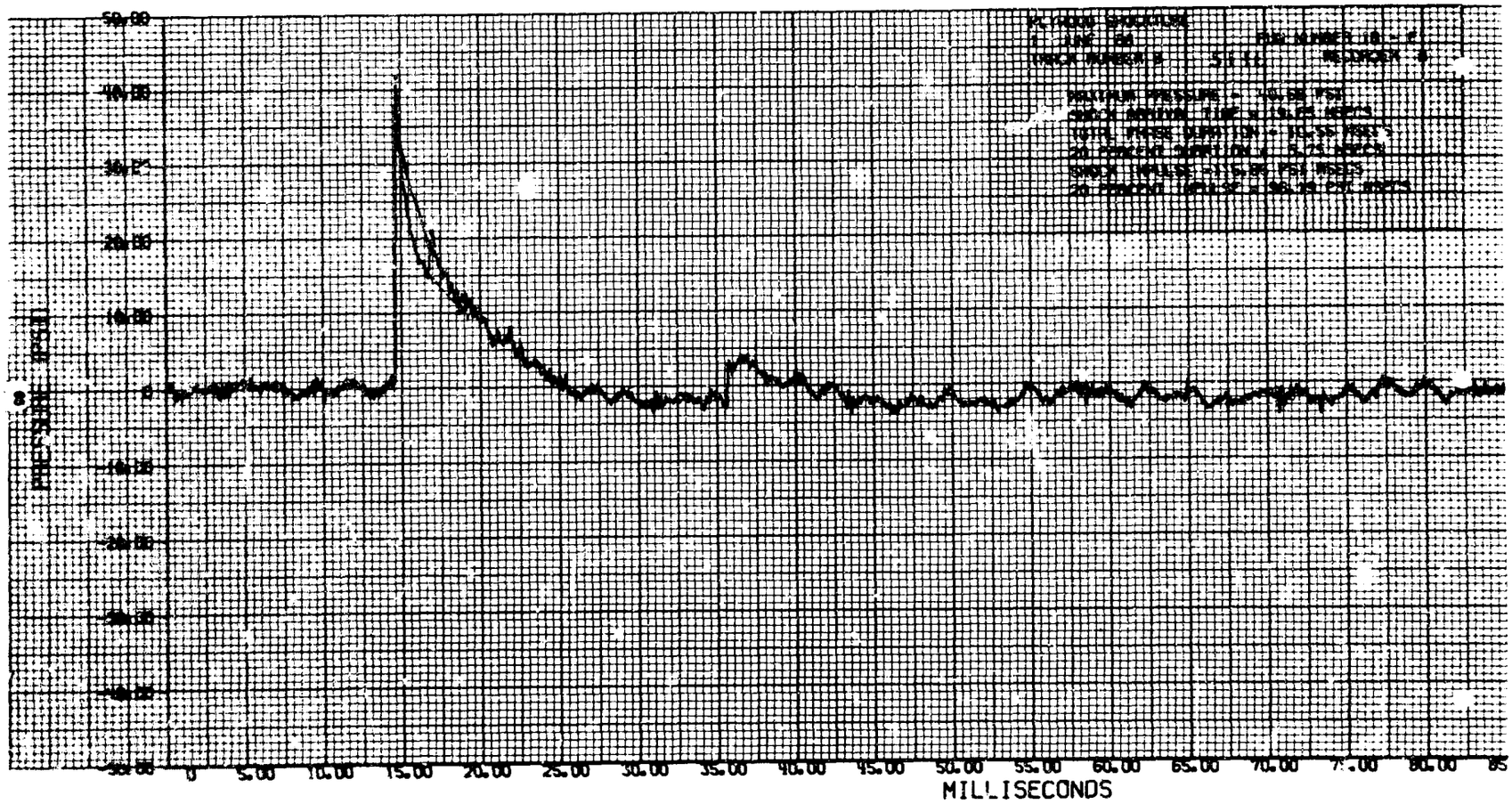
STATION 1 TO 11 PLOTS

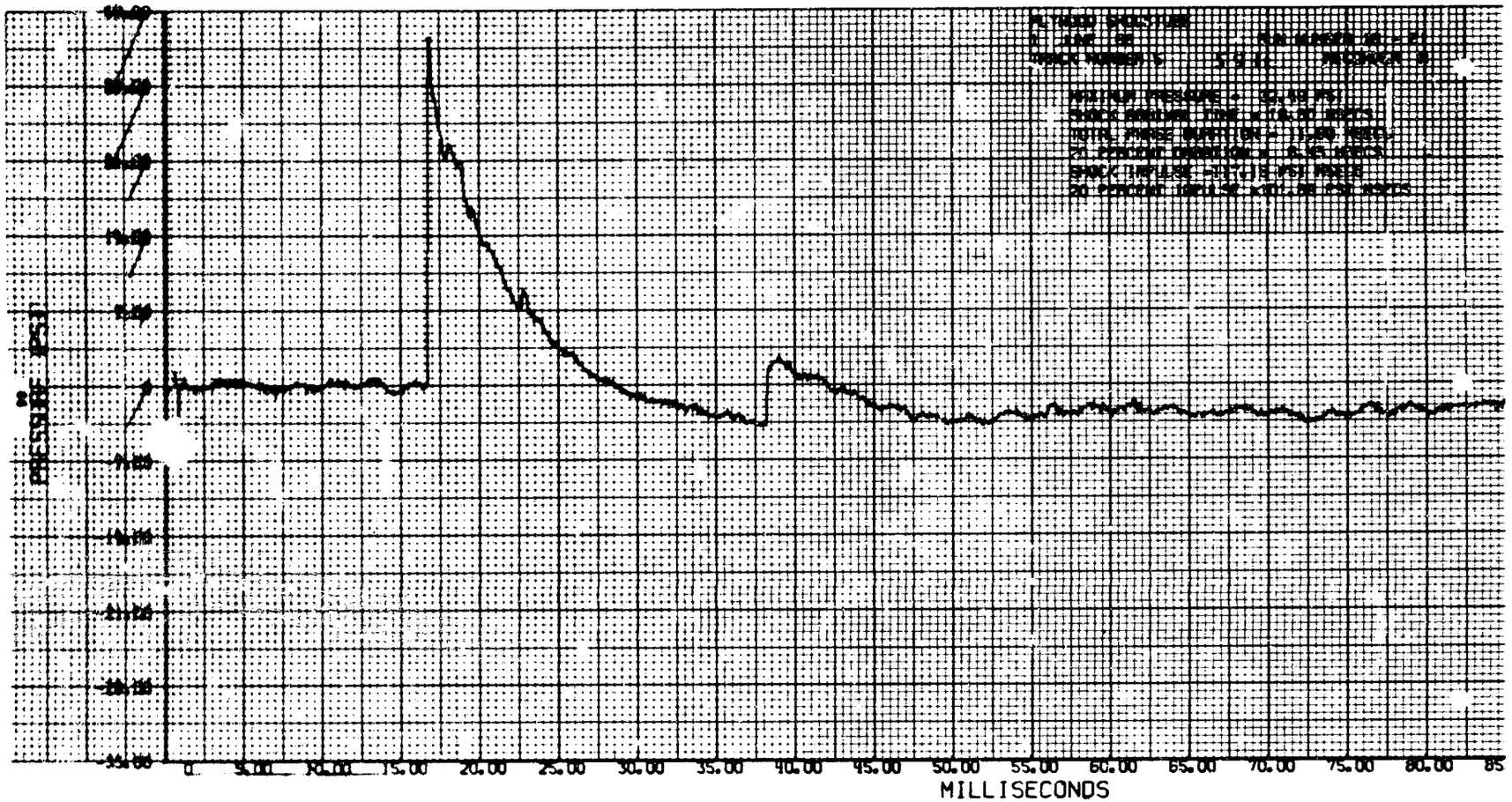
This appendix includes the experimental overpressure vs. time curves at the eleven test stations and the computed curves taken at the same positions as at the experimental stations. Computed curves include overpressure, two components of dynamic pressure, the corresponding impulses, and the two components of velocity.

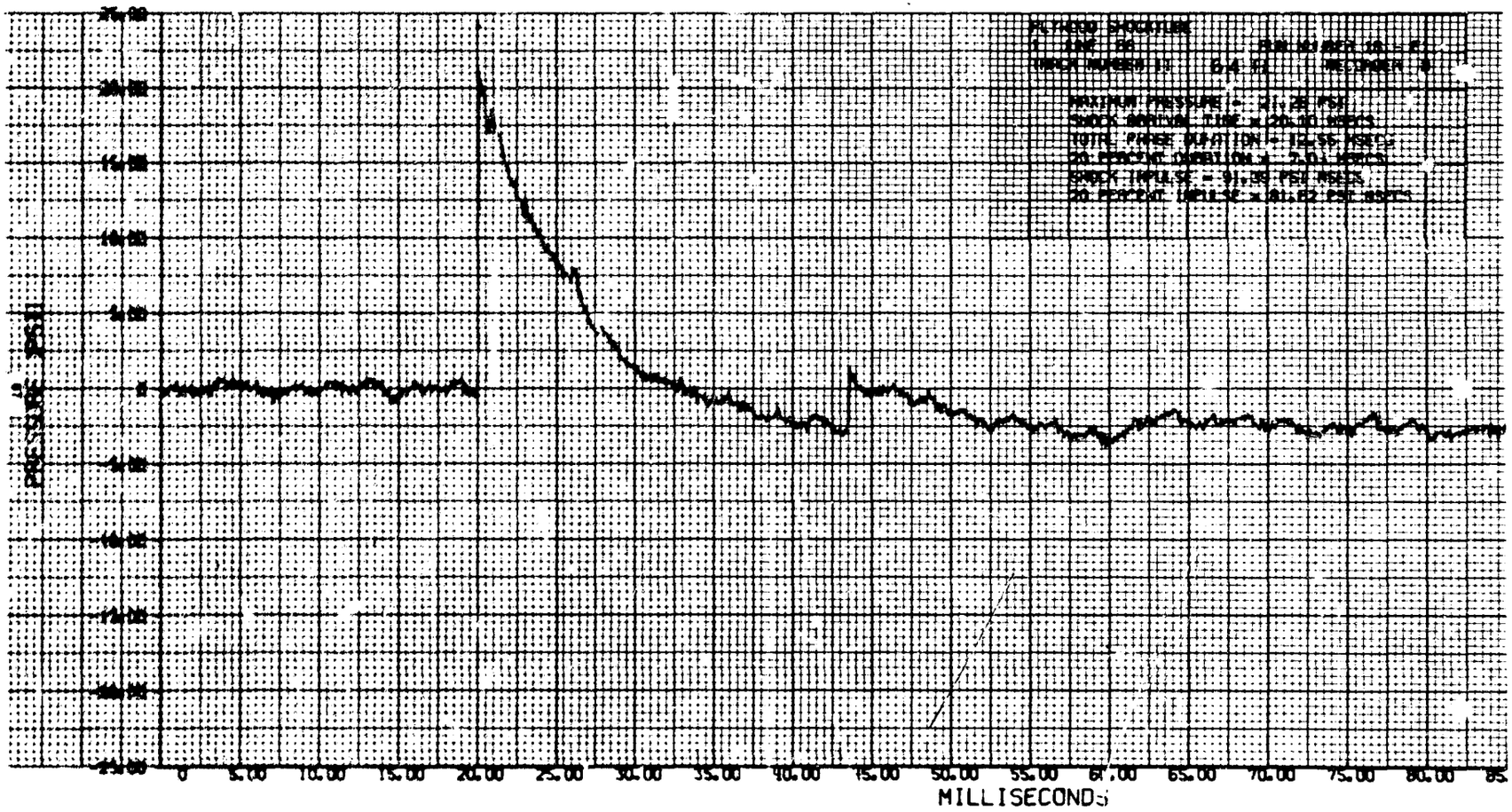
This appendix presents the most consistent comparison of experiment and calculation. A summary of this comparison is found in figures 6 and 7 of the text.

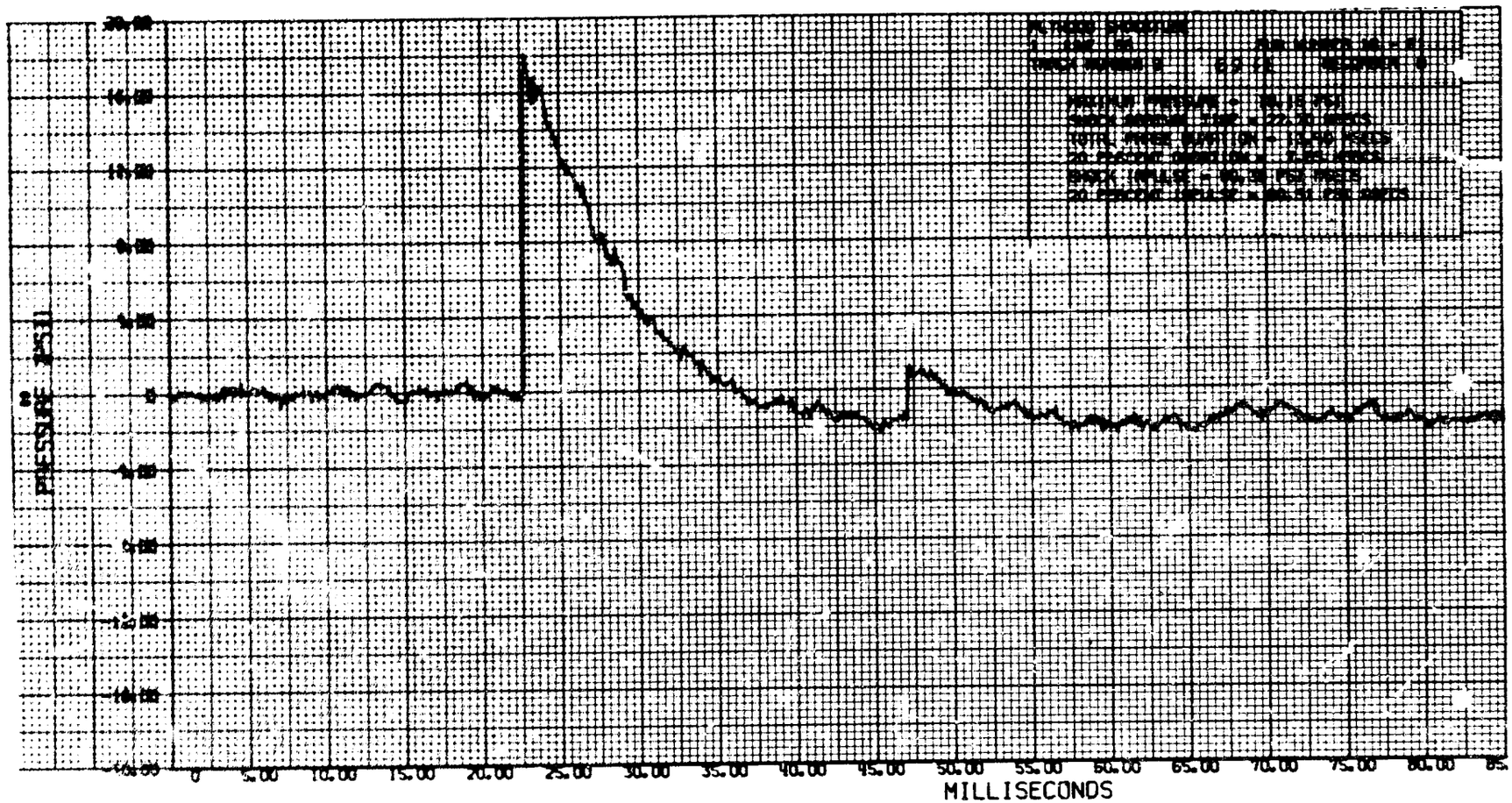

0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
MILLISECONDS

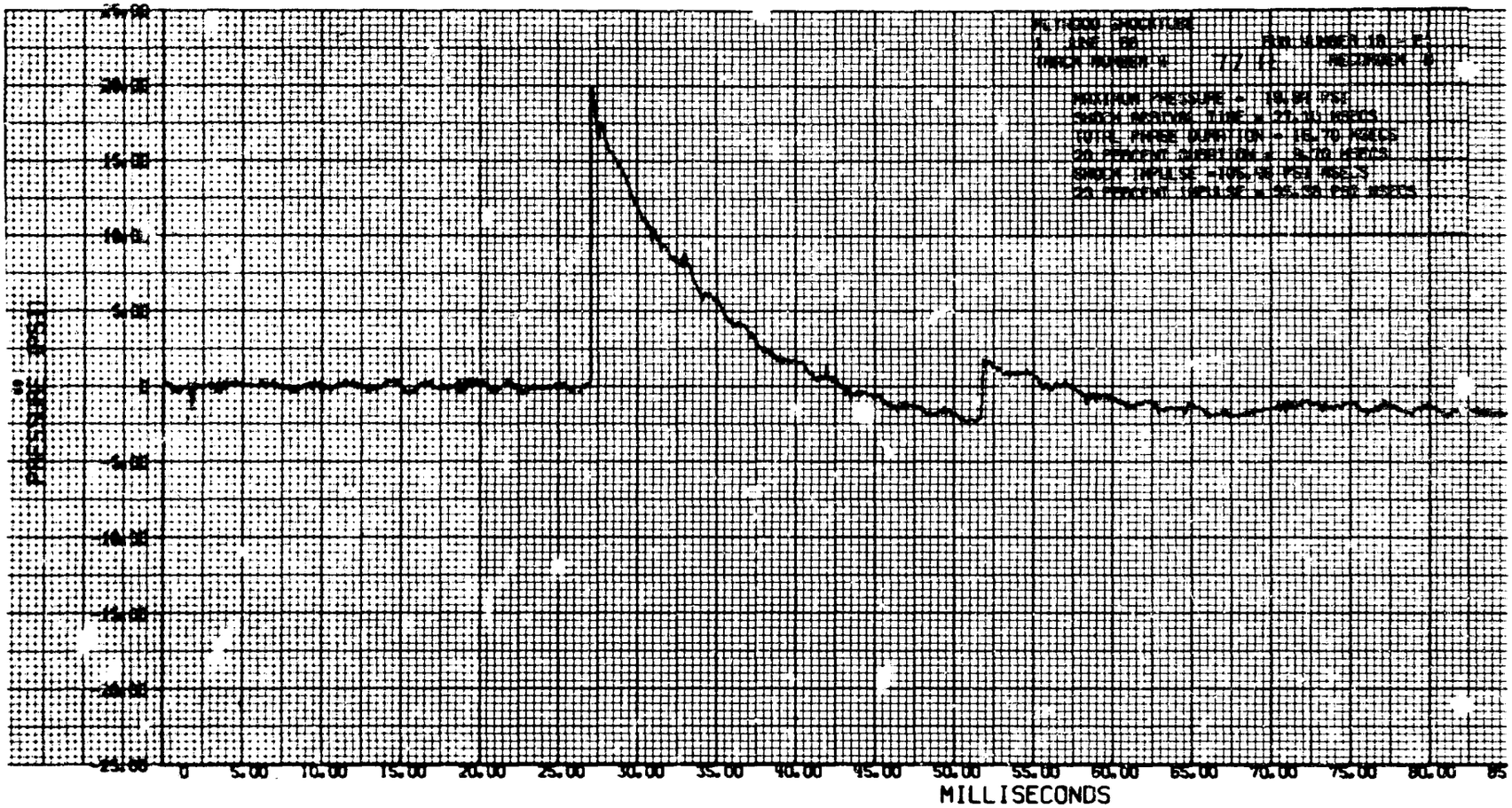

PRESSURE (PSI)
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85
MILLISECONDS

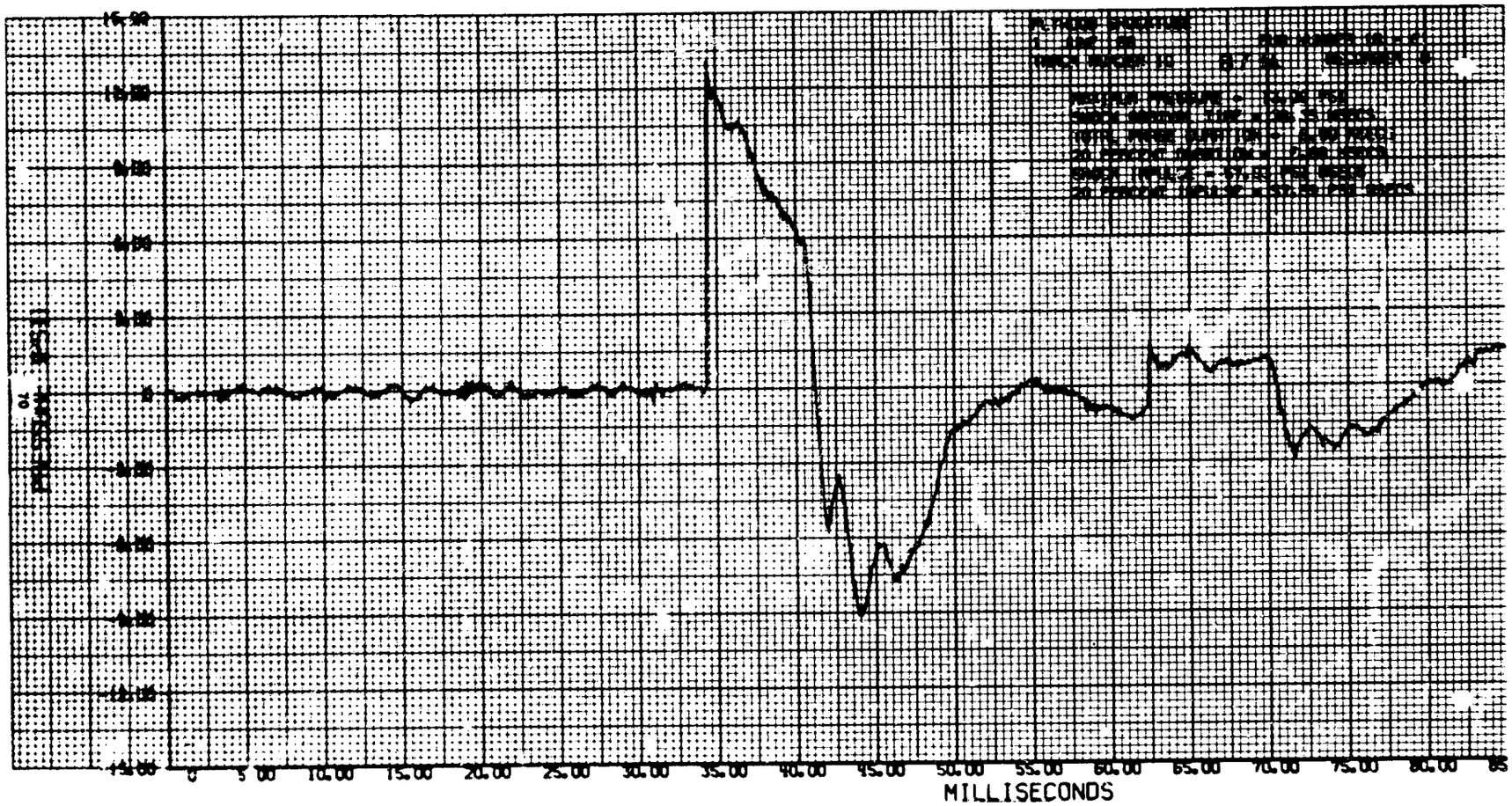

PRESSURE (PSI)
0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
80.00
MILLISECONDS

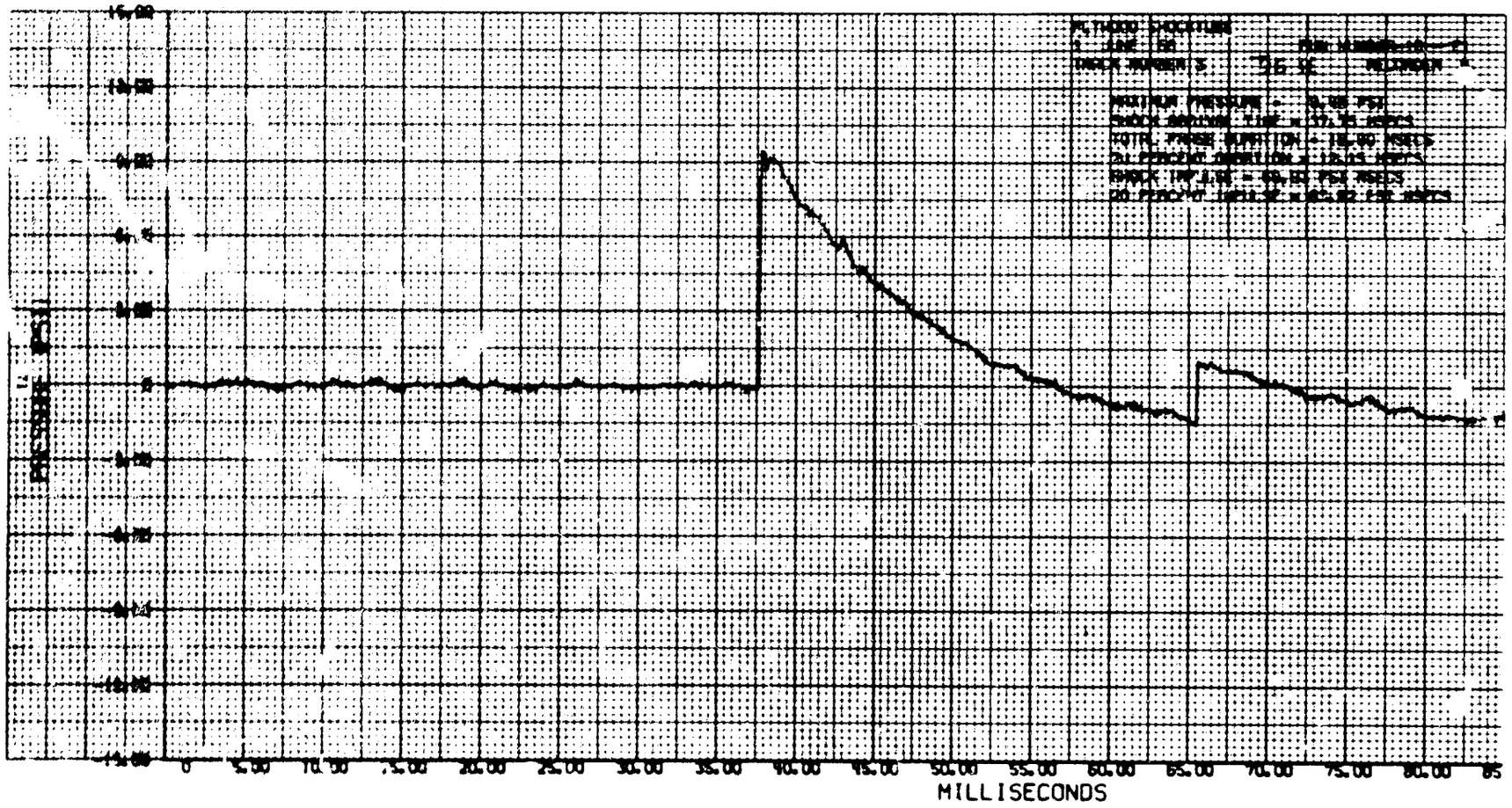

PRESSURE (PSI)
0
0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85
MILLISECONDS

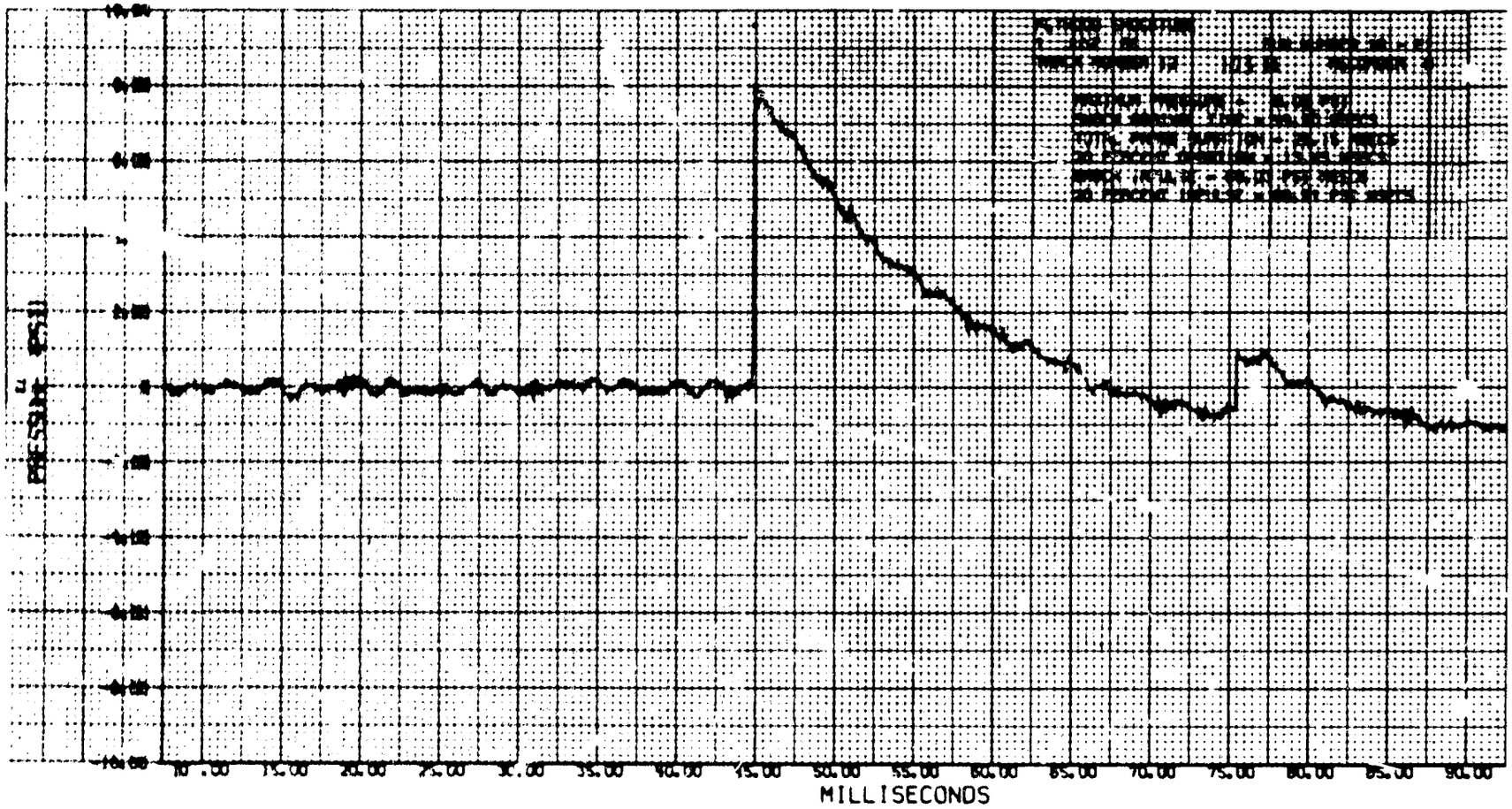

MILLISECONDS

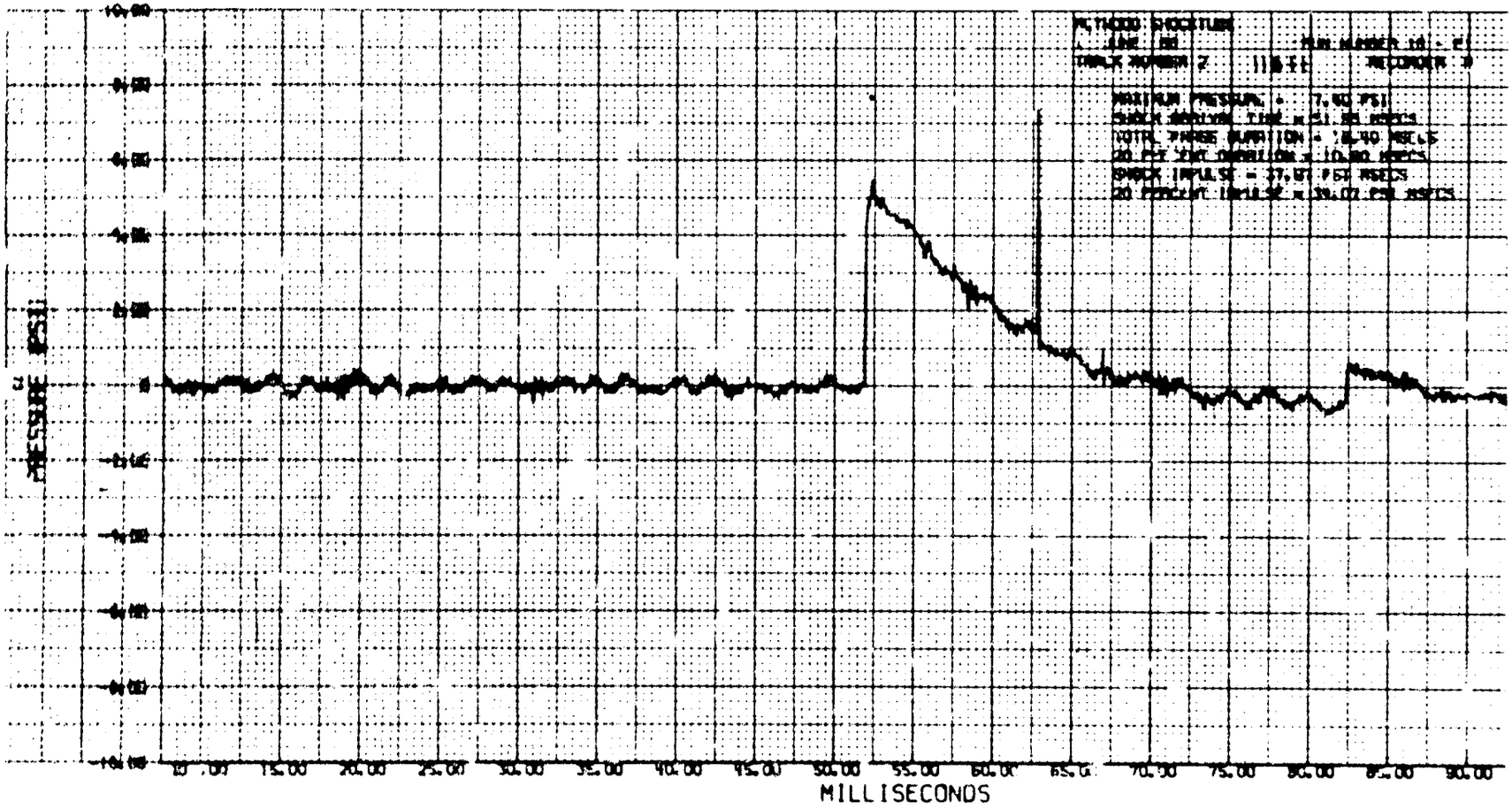

PRESSURE (PSI)
0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
MILLISECONDS

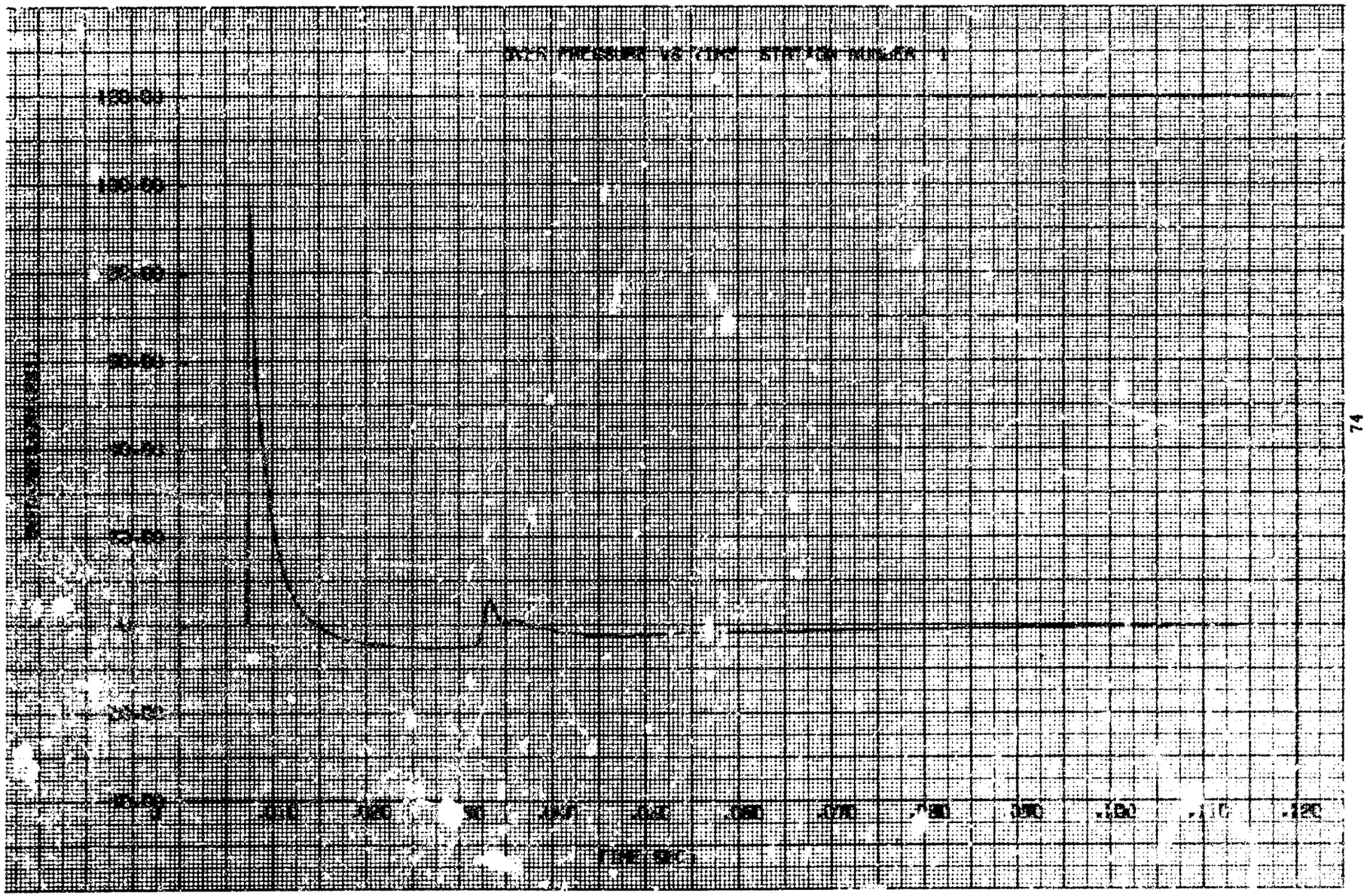

PRESSURE (PSI)
0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85
MILLISECONDS

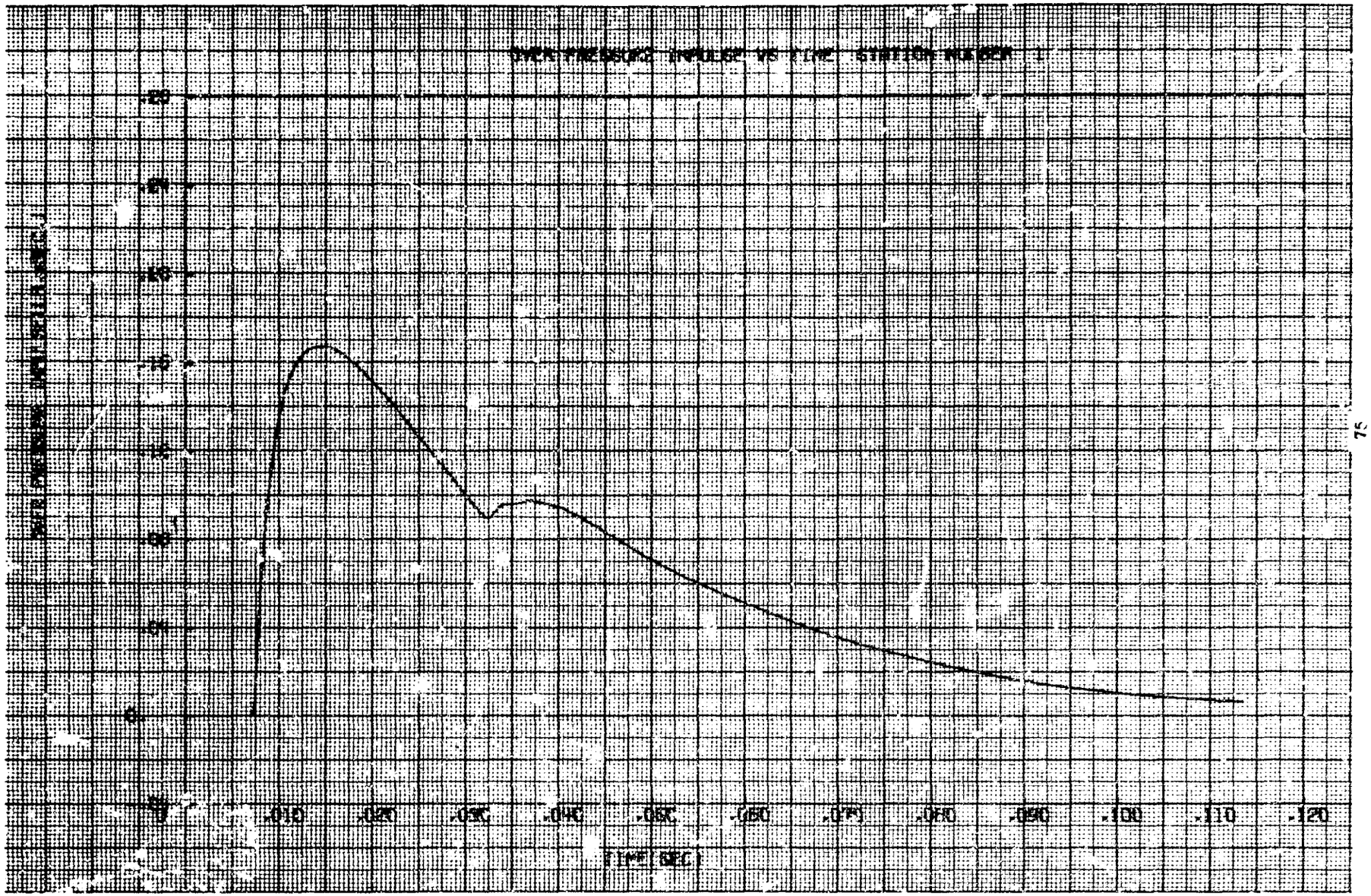

0
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
MILLISECONDS


MILLISECONDS

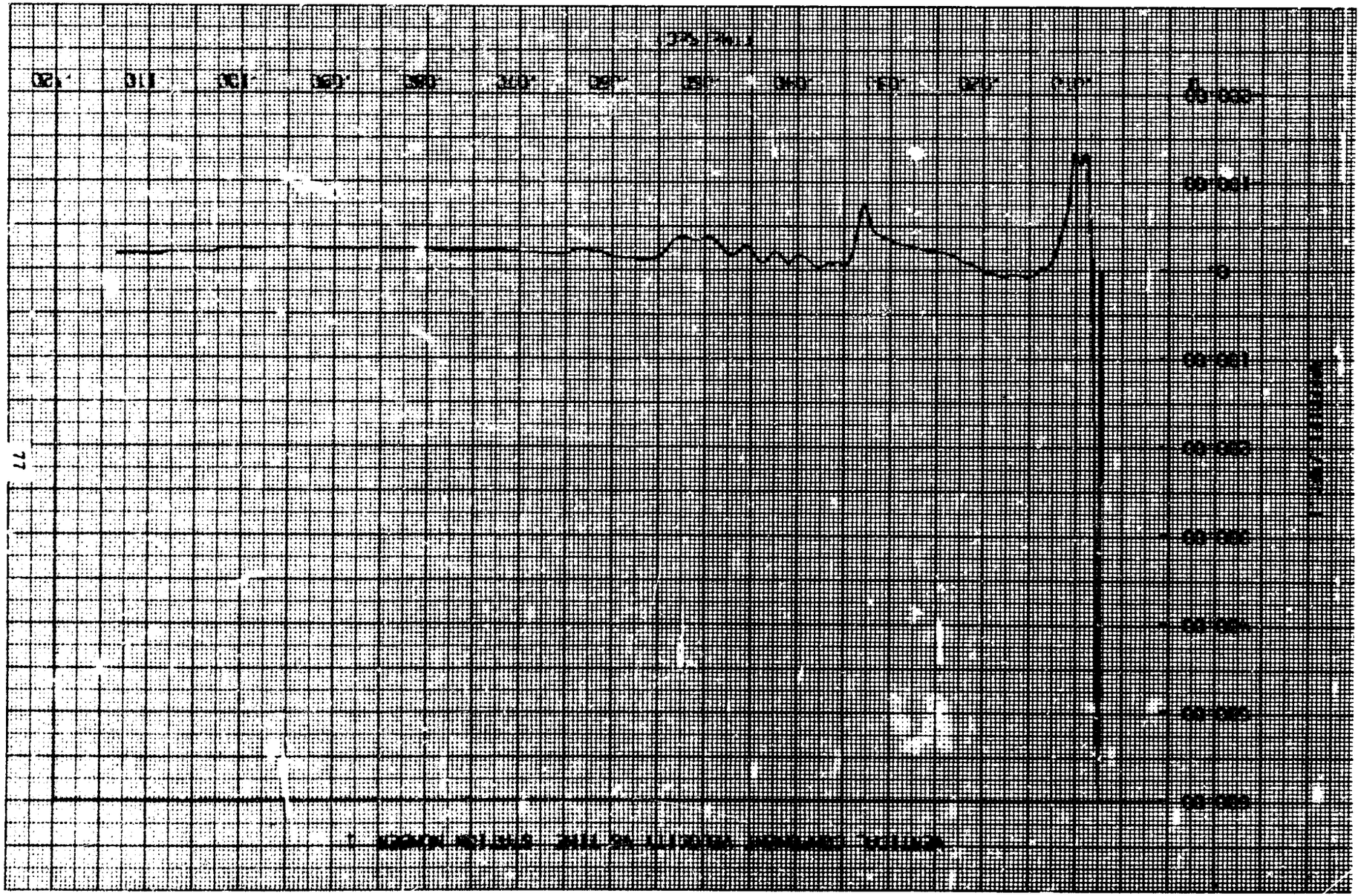

PRESSURE (PSI)
MILLISECONDS

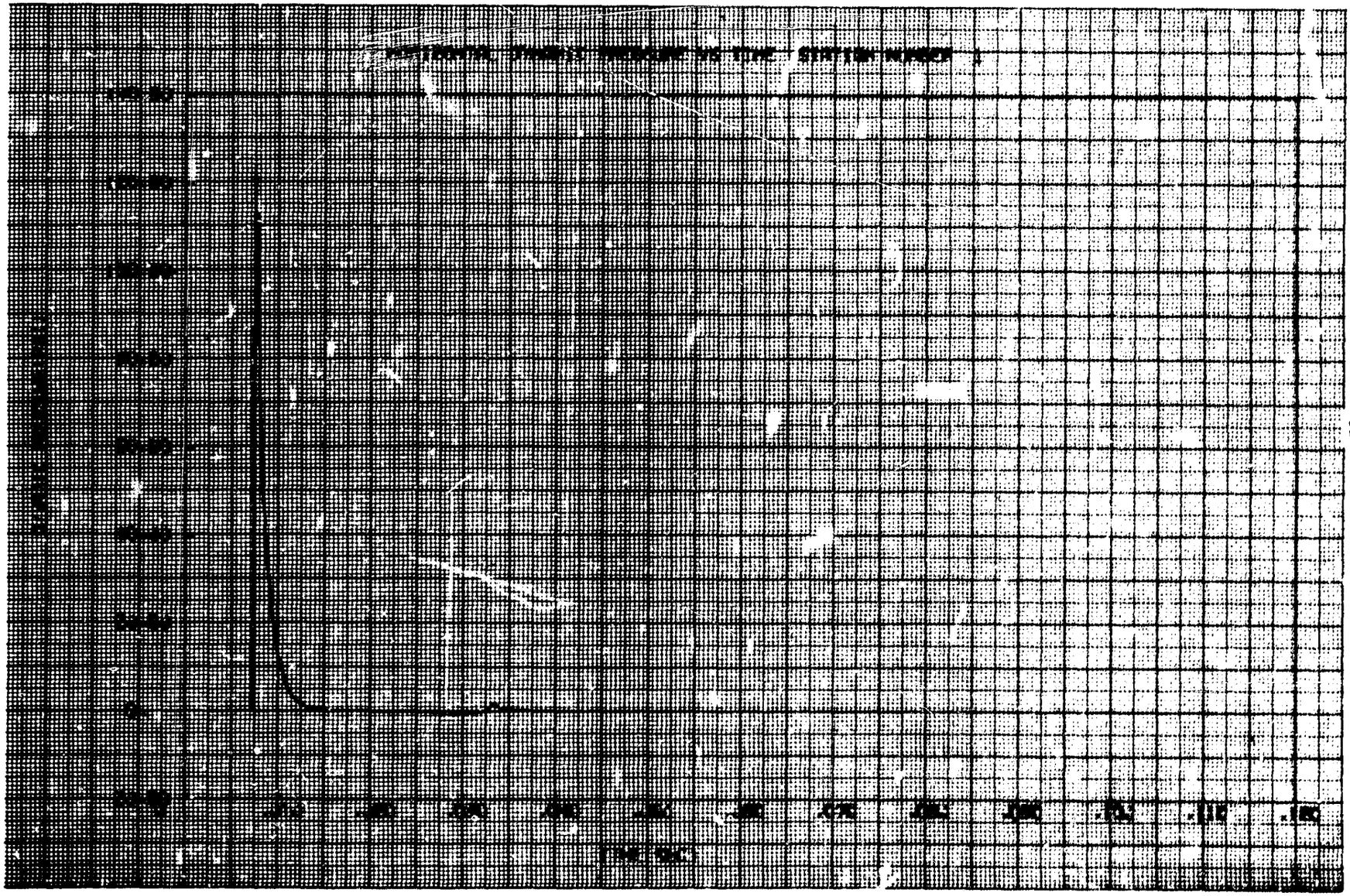

PRESSURE (PSI)
MILLISECONDS

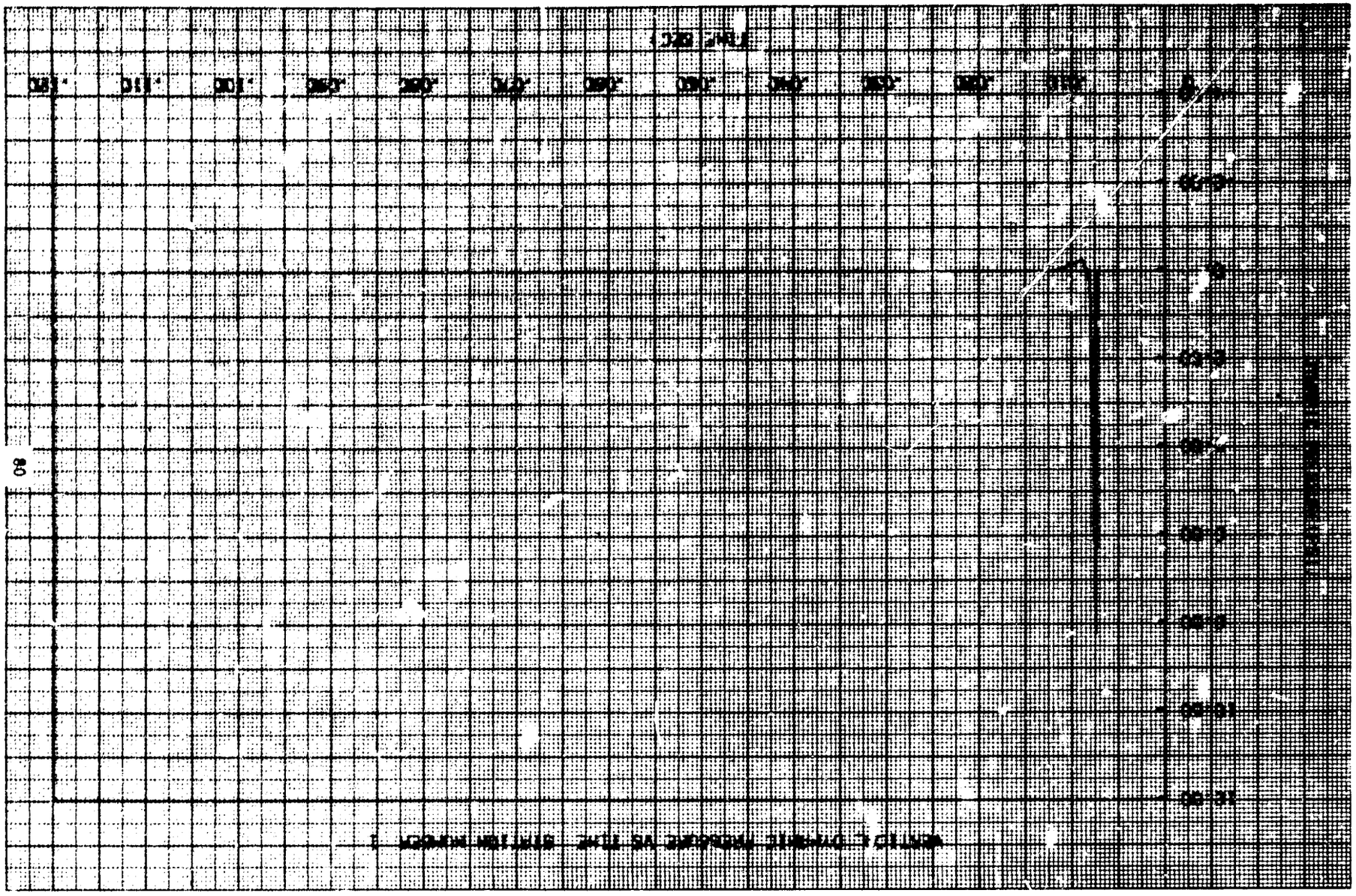


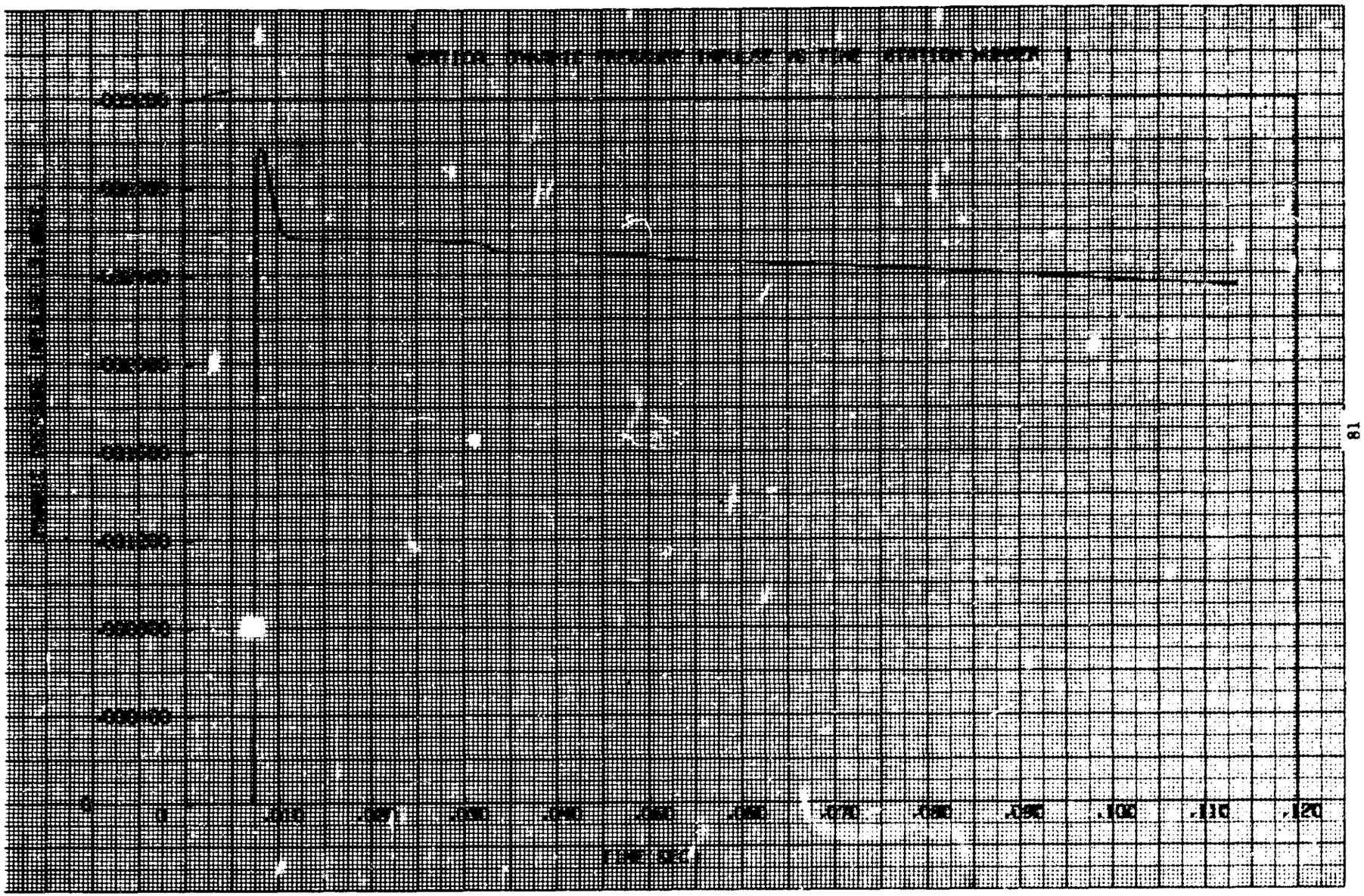

OVERPRESSURE IMPULSE VS TIME STATION NUMBER 1
+20
+16
+12
+8
+4
0
-4
-8
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
TIME (SEC)

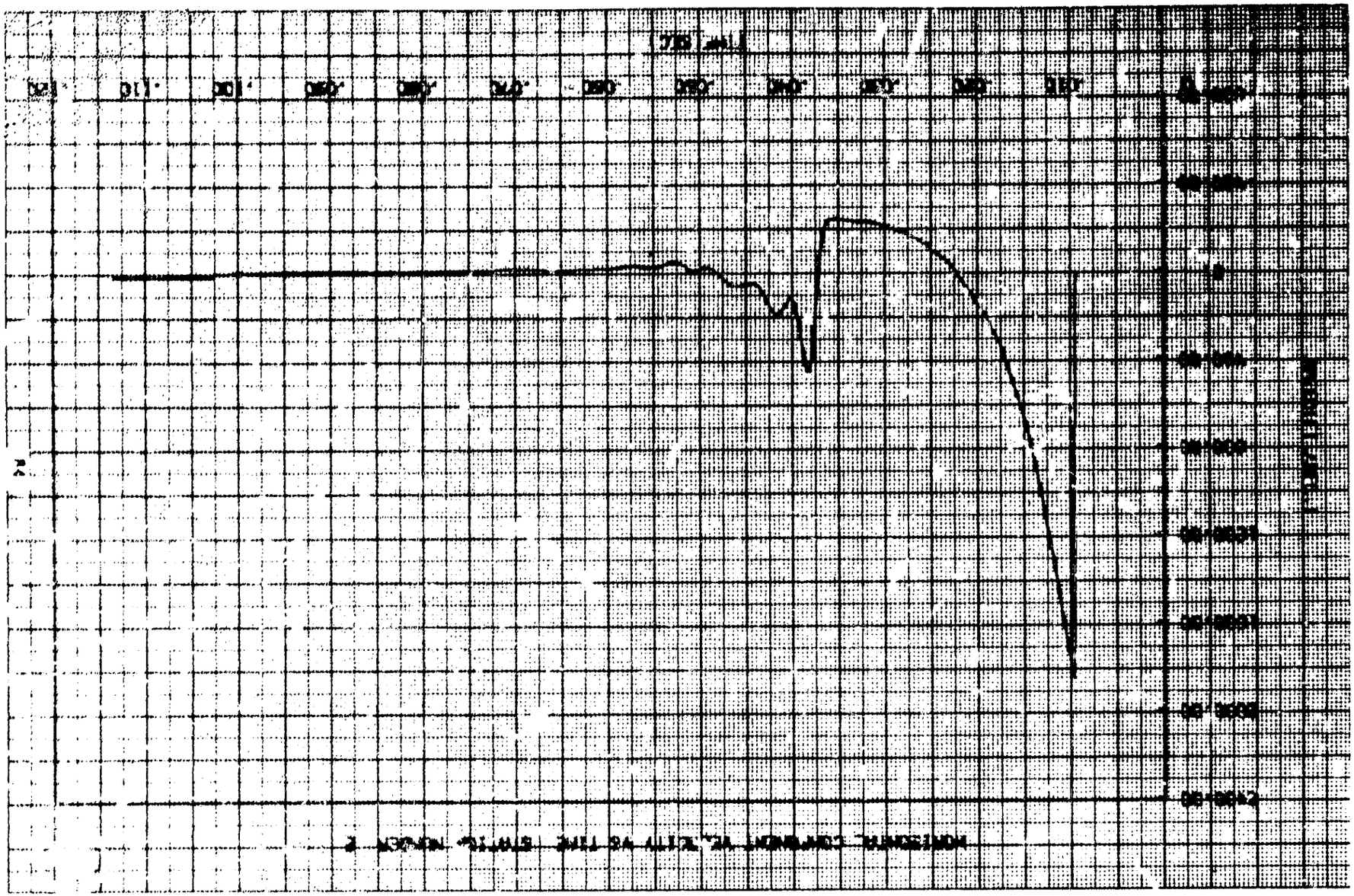
FOR FLIGHT CONDITIONS SPECIFIED
VELOCITY VS TIME








.120
TIME SEC.



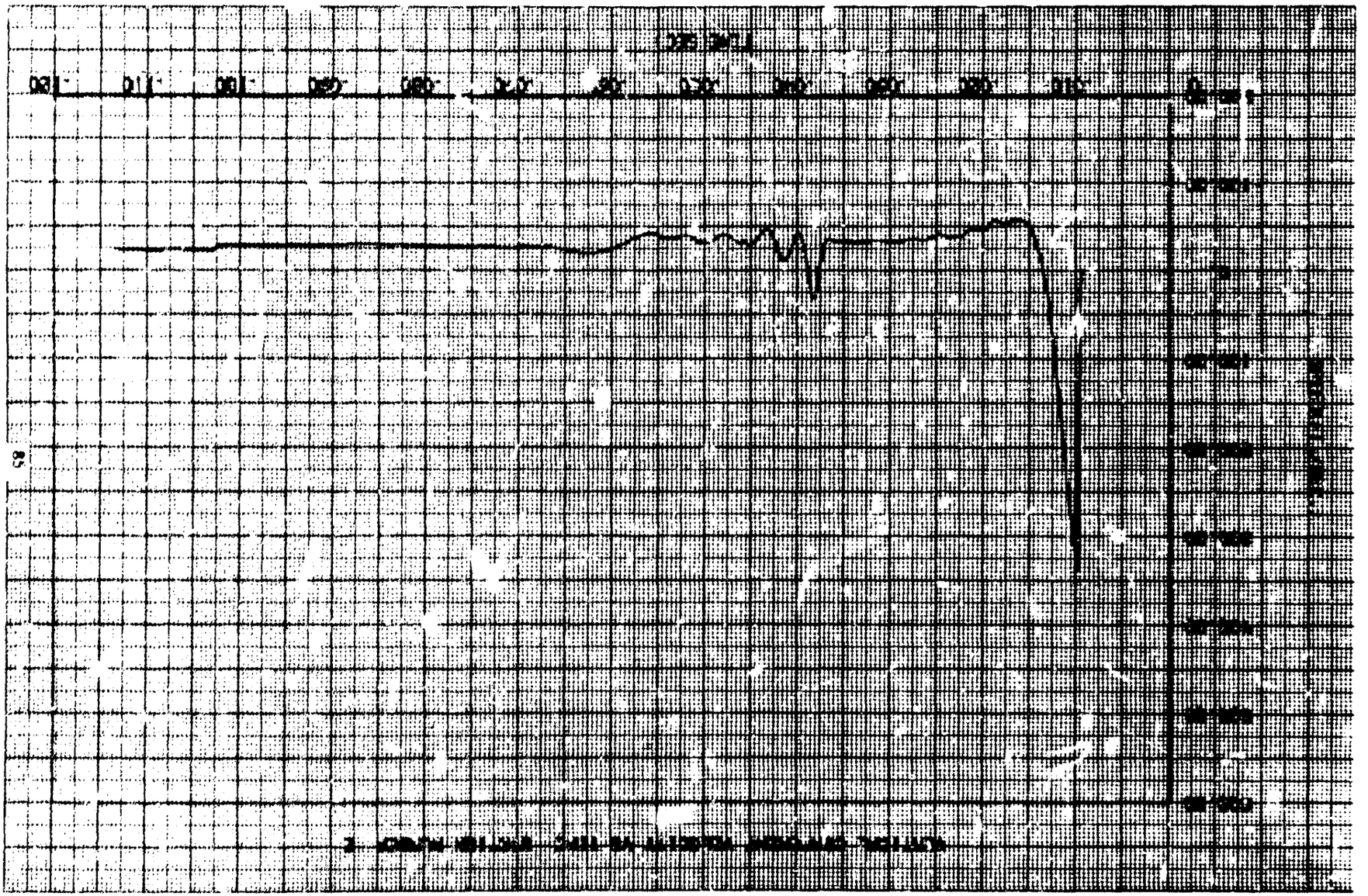
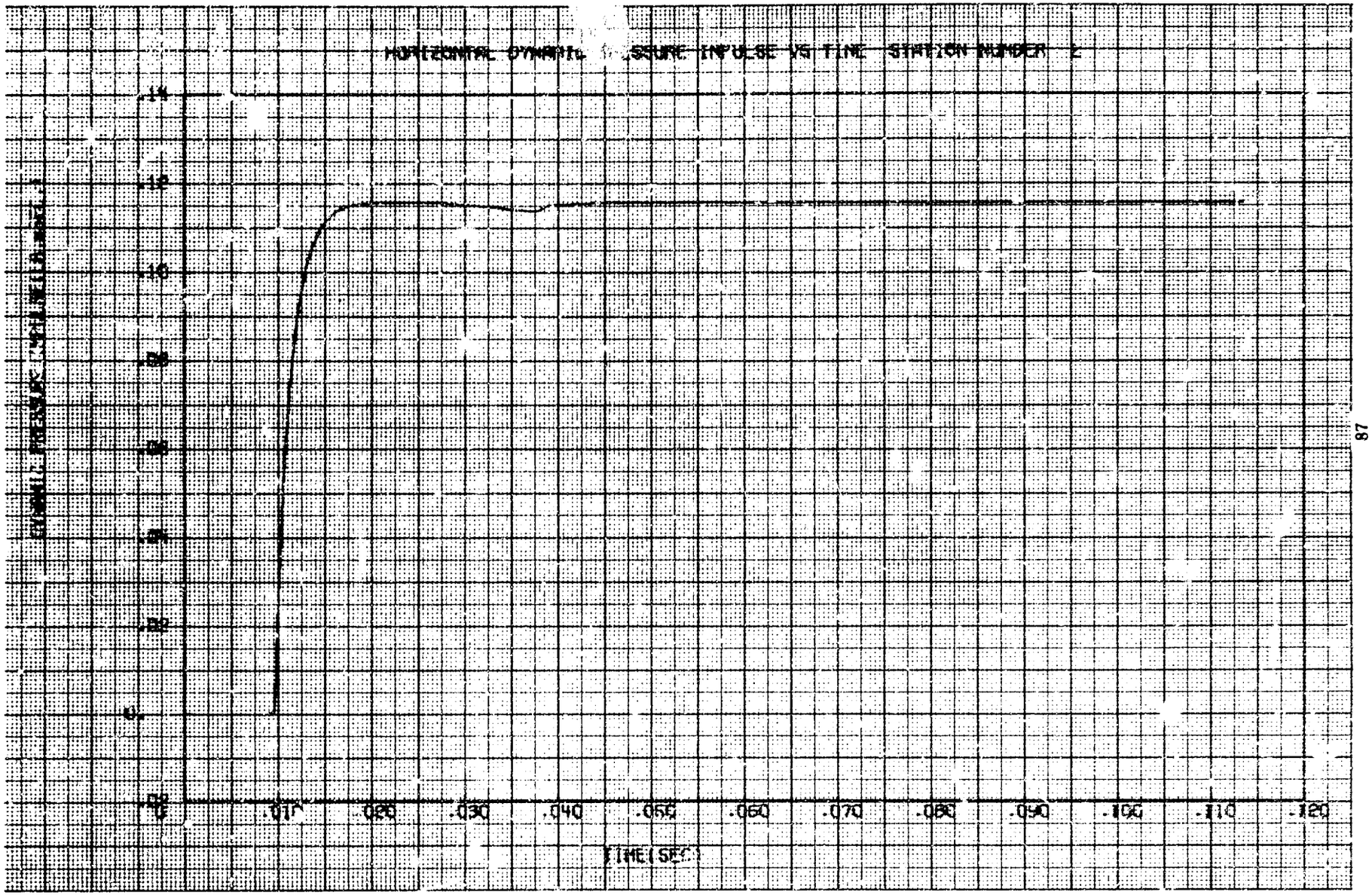


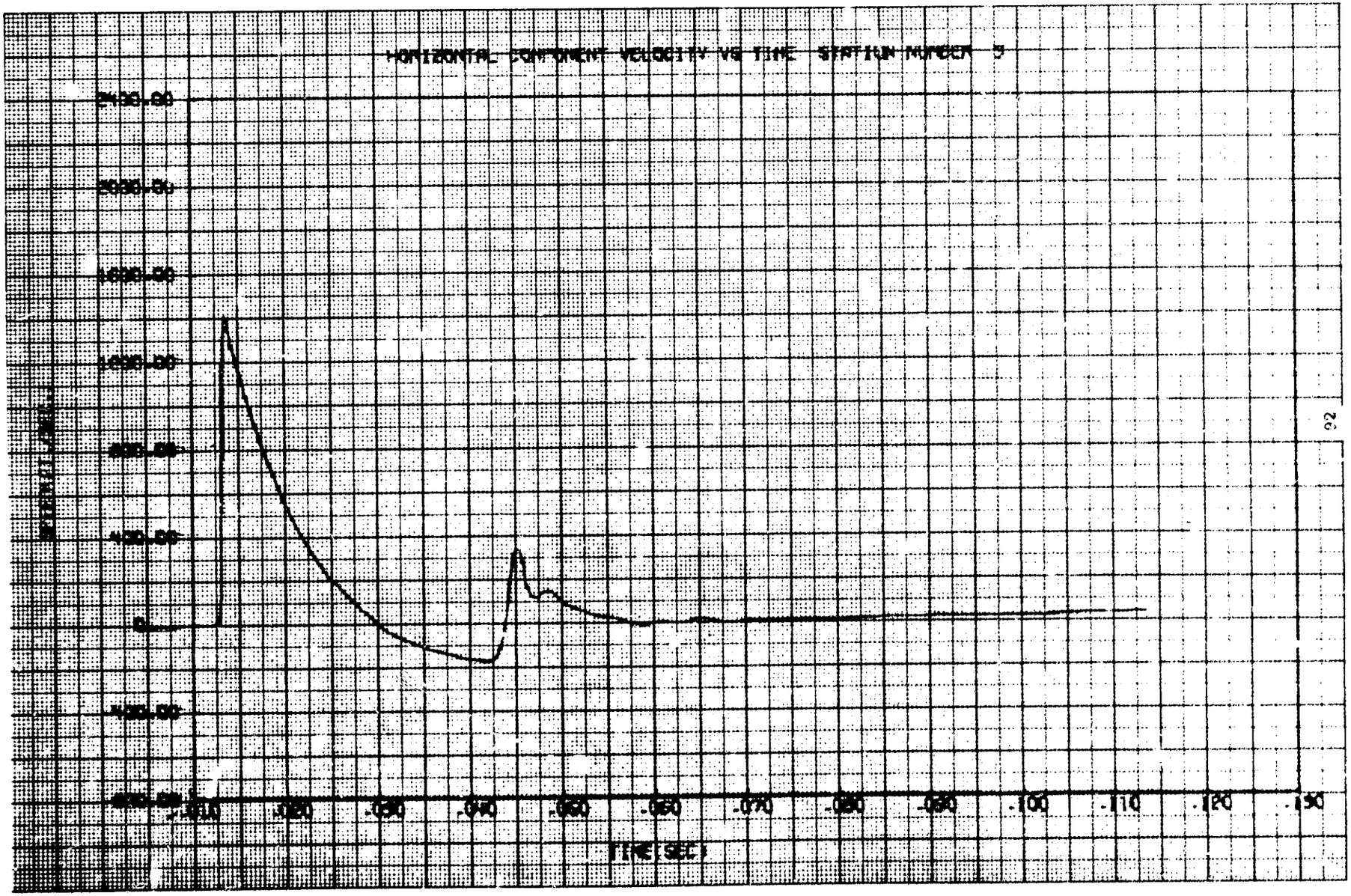
FIGURE 3.4
TRANSIENT RESPONSE
FORCE (LBS)
TIME (SEC)
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
.14
.12
.10
.08
.06
.04
.02
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

DYNAMIC PRESSURE [PSI]
0
-5.0
-2.5
-1.0
-0.5
0
0.5
1.0
2.5
5.0
TIME SEC
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
WEDGE DYNAMIC PRESSURE VS TIME STATION NUMBER 5

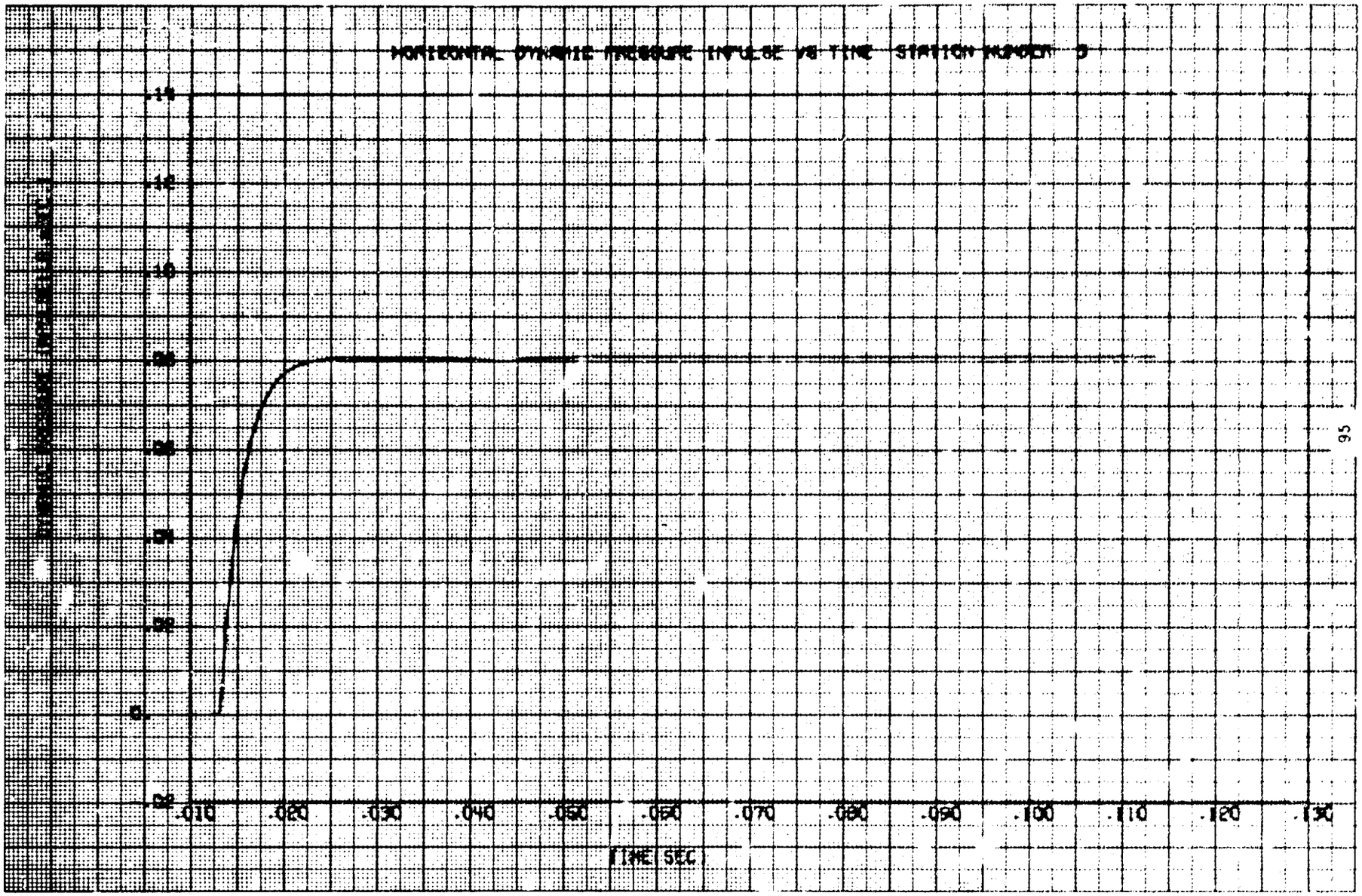
PUMPED PRESSURE (PSIA)
0.0000
0.0020
0.0040
0.0060
0.0080
0.0100
0.0120
0.0140
0.0160
0.0180
0.0200
0.0220
0.0240
0.0260
0.0280
0.0300
0.0320
0.0340
0.0360
0.0380
0.0400
0.0420
0.0440
0.0460
0.0480
0.0500
0.0520
0.0540
0.0560
0.0580
0.0600
0.0620
0.0640
0.0660
0.0680
0.0700
0.0720
0.0740
0.0760
0.0780

EYE RECOVERY INTENSITY
TIME SEC
0.0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
640
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800
810
820
830
840
850
860
870
880
890
900
910
920
930
940
950
960
970
980
990
1000
1010
1020
1030
1040
1050
1060
1070
1080
1090
1100
1110
1120
1130
1140
1150
1160
1170
1180
1190
1200
1210
1220
1230
1240
1250
1260
1270
1280
1290
1300
1310
1320
1330
1340
1350
1360
1370
1380
1390
1400
1410
1420
1430
1440
1450
1460
1470
1480
1490
1500
1510
1520
1530
1540
1550
1560
1570
1580
1590
1600
1610
1620
1630
1640
1650
1660
1670
1680
1690
1700
1710
1720
1730
1740
1750
1760
1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
2160
2170
2180
2190
2200
2210
2220
2230
2240
2250
2260
2270
2280
2290
2300
2310
2320
2330
2340
2350
2360
2370
2380
2390
2400
2410
2420
2430
2440
2450
2460
2470
2480
2490
2500
2510
2520
2530
2540
2550
2560
2570
2580
2590
2600
2610
2620
2630
2640
2650
2660
2670
2680
2690
2700
2710
2720
2730
2740
2750
2760
2770
2780
2790
2800
2810
2820
2830
2840
2850
2860
2870
2880
2890
2900
2910
2920
2930
2940
2950
2960
2970
2980
2990
3000
3010
3020
3030
3040
3050
3060
3070
3080
3090
3100
3110
3120
3130
3140
3150
3160
3170
3180
3190
3200
3210
3220
3230
3240
3250
3260
3270
3280
3290
3300
3310
3320
3330
3340
3350
3360
3370
3380
3390
3400
3410
3420
3430
3440
3450
3460
3470
3480
3490
3500
3510
3520
3530
3540
3550
3560
3570
3580
3590
3600
3610
3620
3630
3640
3650
3660
3670
3680
3690
3700
3710
3720
3730
3740
3750
3760
3770
3780
3790
3800
3810
3820
3830
3840
3850
3860
3870
3880
3890
3900
3910
3920
3930
3940
3950
3960
3970
3980
3990
4000
4010
4020
4030
4040
4050
4060
4070
4080
4090
4100
4110
4120
4130
4140
4150
4160
4170
4180
4190
4200
4210
4220
4230
4240
4250
4260
4270
4280
4290
4300
4310
4320
4330
4340
4350
4360
4370
4380
4390
4400
4410
4420
4430
4440
4450
4460
4470
4480
4490
4500
4510
4520
4530
4540
4550
4560
4570
4580
4590
4600
4610
4620
4630
4640
4650
4660
4670
4680
4690
4700
4710
4720
4730
4740
4750
4760
4770
4780
4790
4800
4810
4820
4830
4840
4850
4860
4870
4880
4890
4900
4910
4920
4930
4940
4950
4960
4970
4980
4990
5000
5010
5020
5030
5040
5050
5060
5070
5080
5090
5100
5110
5120
5130
5140
5150
5160
5170
5180
5190
5200
5210
5220
5230
5240
5250
5260
5270
5280
5290
5300
5310
5320
5330
5340
5350
5360
5370
5380
5390
5400
5410
5420
5430
5440
5450
5460
5470
5480
5490
5500
5510
5520
5530
5540
5550
5560
5570
5580
5590
5600
5610
5620
5630
5640
5650
5660
5670
5680
5690
5700
5710
5720
5730
5740
5750
5760
5770
5780
5790
5800
5810
5820
5830
5840
5850
5860
5870
5880
5890
5900
5910
5920
5930
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
6130
6140
6150
6160
6170
6180
6190
6200
6210
6220
6230
6240
6250
6260
6270
6280
6290
6300
6310
6320
6330
6340
6350
6360
6370
6380
6390
6400
6410
6420
6430
6440
6450
6460
6470
6480
6490
6500
6510
6520
6530
6540
6550
6560
6570
6580
6590
6600
6610
6620
6630
6640
6650
6660
6670
6680
6690
6700
6710
6720
6730
6740
6750
6760
6770
6780
6790
6800
6810
6820
6830
6840
6850
6860
6870
6880
6890
6900
6910
6920
6930
6940
6950
6960
6970
6980
6990
7000
7010
7020
7030
7040
7050
7060
7070
7080
7090
7100
7110
7120
7130
7140
7150
7160
7170
7180
7190
7200
7210
7220
7230
7240
7250
7260
7270
7280
7290
7300
7310
7320
7330
7340
7350
7360
7370
7380
7390
7400
7410
7420
7430
7440
7450
7460
7470
7480
7490
7500
7510
7520
7530
7540
7550
7560
7570
7580
7590
7600
7610
7620
7630
7640
7650
7660
7670
7680
7690
7700
7710
7720
7730
7740
7750
7760
7770
7780
7790
7800
7810
7820
7830
7840
7850
7860
7870
7880
7890
7900
7910
7920
7930
7940
7950
7960
7970
7980
7990
8000
8010
8020
8030
8040
8050
8060
8070
8080
8090
8100
8110
8120
8130
8140
8150
8160
8170
8180
8190
8200
8210
8220
8230
8240
8250
8260
8270
8280
8290
8300
8310
8320
8330
8340
8350
8360
8370
8380
8390
8400
8410
8420
8430
8440
8450
8460
8470
8480
8490
8500
8510
8520
8530
8540
8550
8560
8570
8580
8590
8600
8610
8620
8630
8640
8650
8660
8670
8680
8690
8700
8710
8720
8730
8740
8750
8760
8770
8780
8790
8800
8810
8820
8830
8840
8850
8860
8870
8880
8890
8900
8910
8920
8930
8940
8950
8960
8970
8980
8990
9000
9010
9020
9030
9040
9050
9060
9070
9080
9090
9100
9110
9120
9130
9140
9150
9160
9170
9180
9190
9200
9210
9220
9230
9240
9250
9260
9270
9280
9290
9300
9310
9320
9330
9340
9350
9360
9370
9380
9390
9400
9410
9420
9430
9440
9450
9460
9470
9480
9490
9500
9510
9520
9530
9540
9550
9560
9570
9580
9590
9600
9610
9620
9630
9640
9650
9660
9670
9680
9690
9700
9710
9720
9730
9740
9750
9760
9770
9780
9790
9800
9810
9820
9830
9840
9850
9860
9870
9880
9890
9900
9910
9920
9930
9940
9950
9960
9970
9980
9990
10000

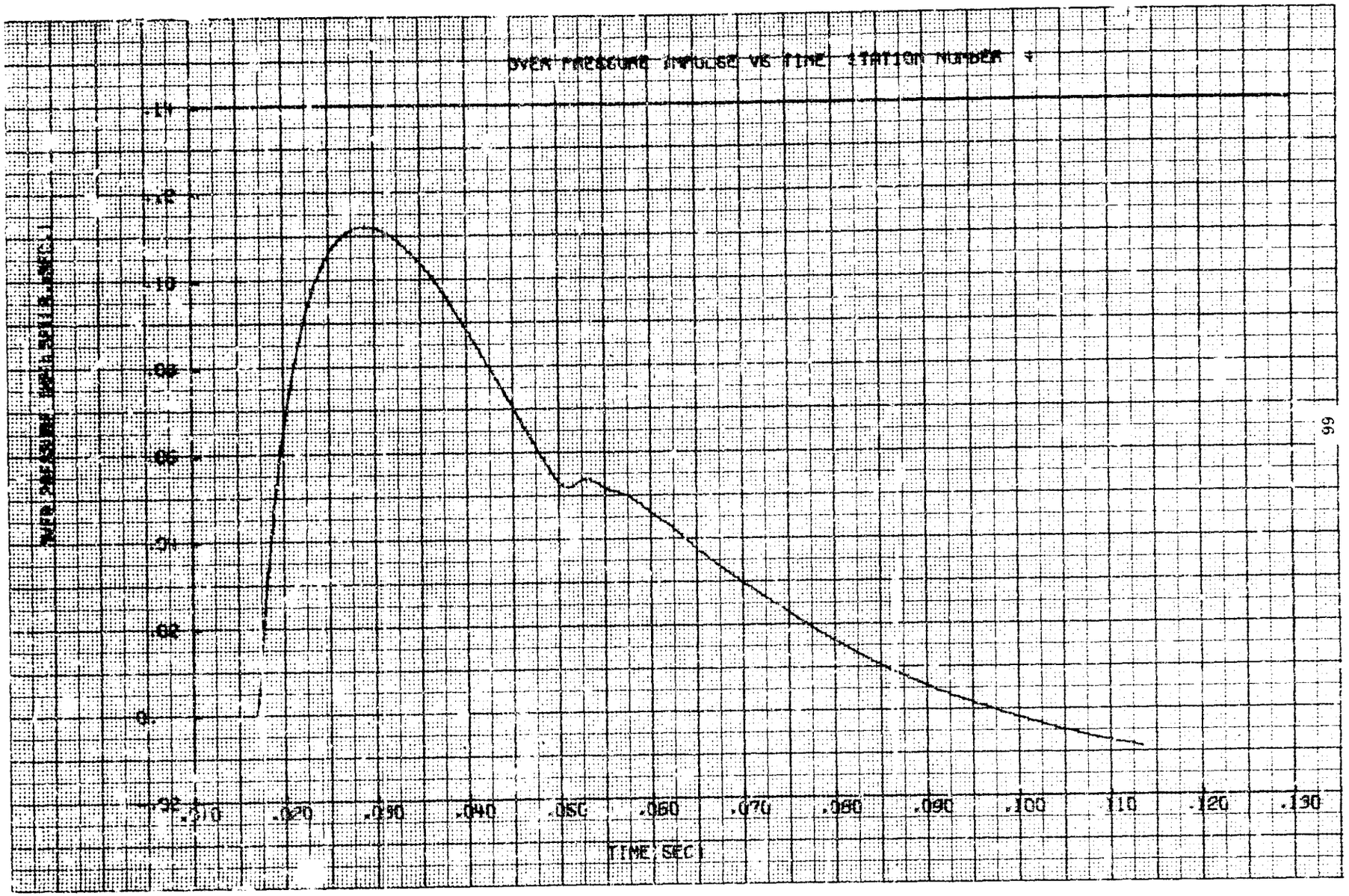

HORIZONTAL COMPONENT VELOCITY VS TIME STATION MUNECA 5
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME(SEC)

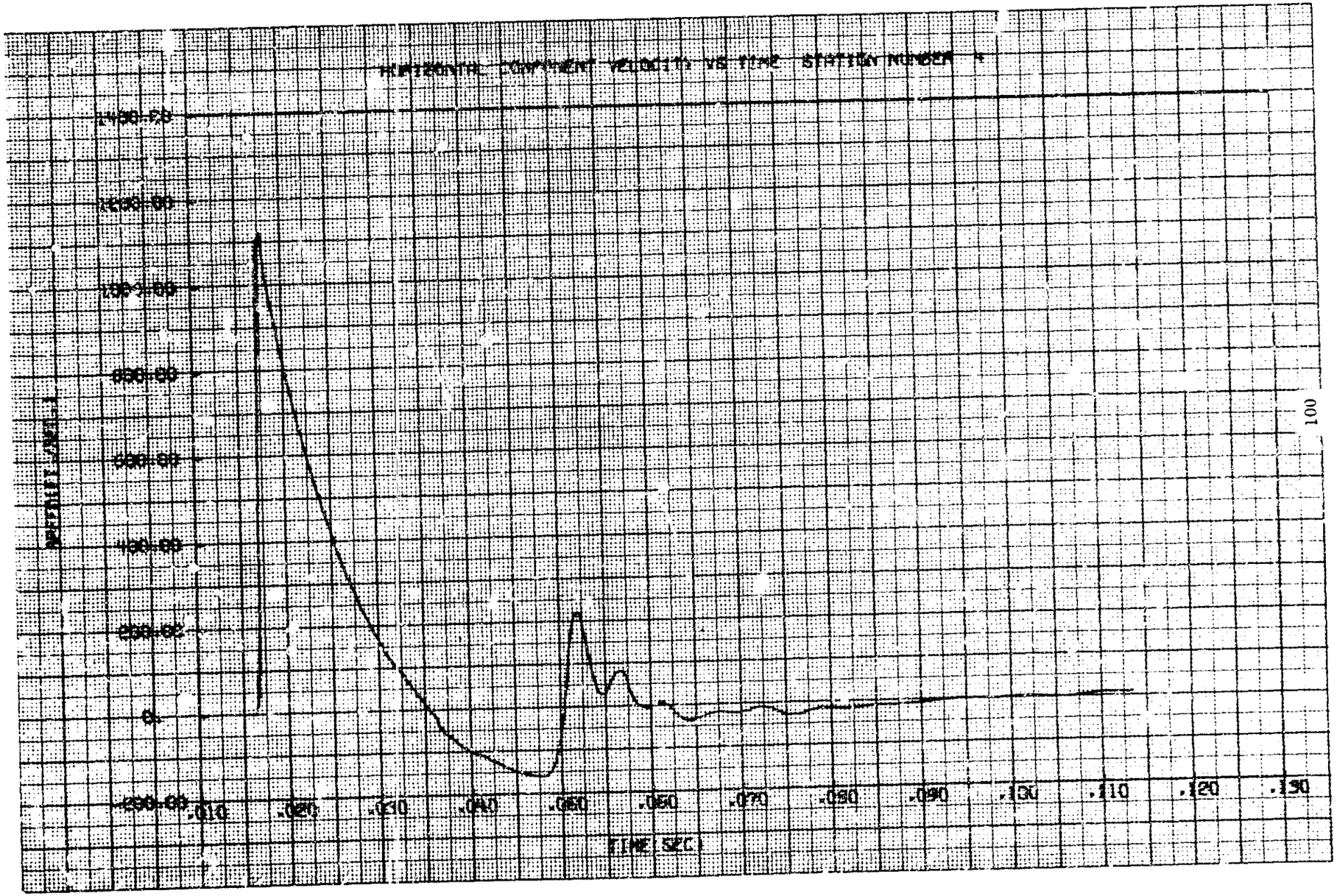
SPECIFIC WEIGHT
SPECIFIC WEIGHT VS. DEPTH

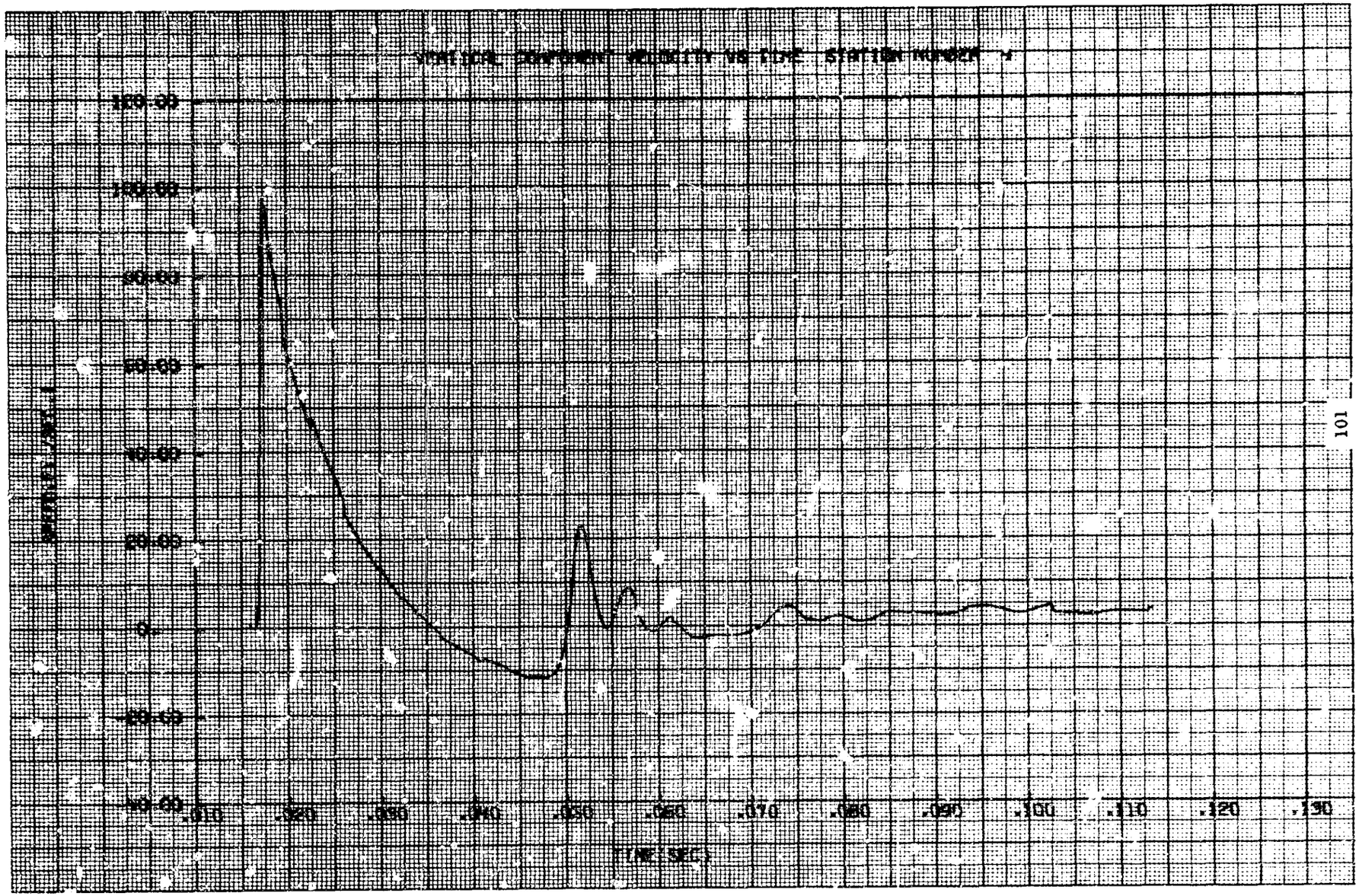
Cell Potential (mV)
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
-250
Time (sec)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
760
780

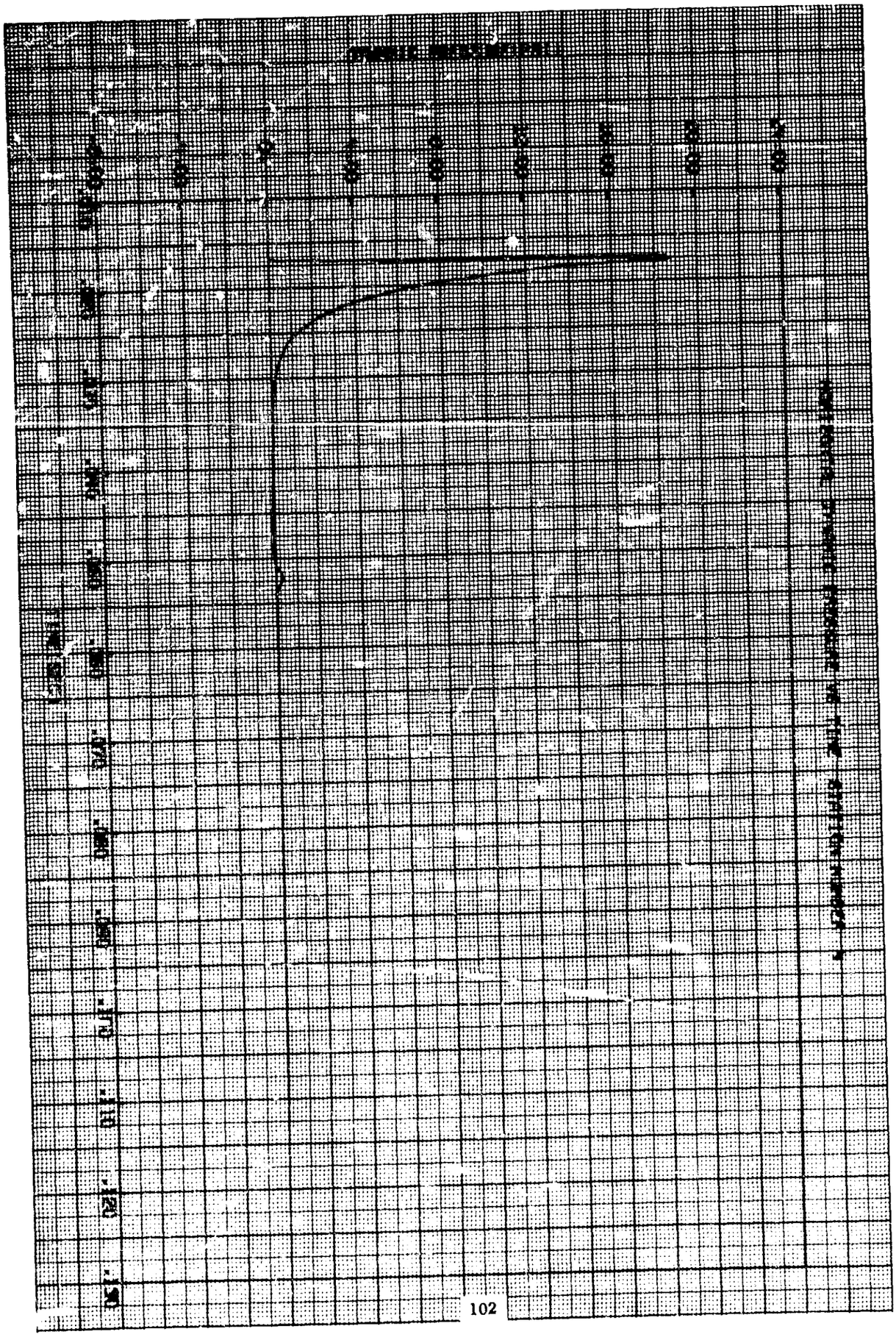

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
.14
.12
.10
.08
.06
.04
.02
0.
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME SEC

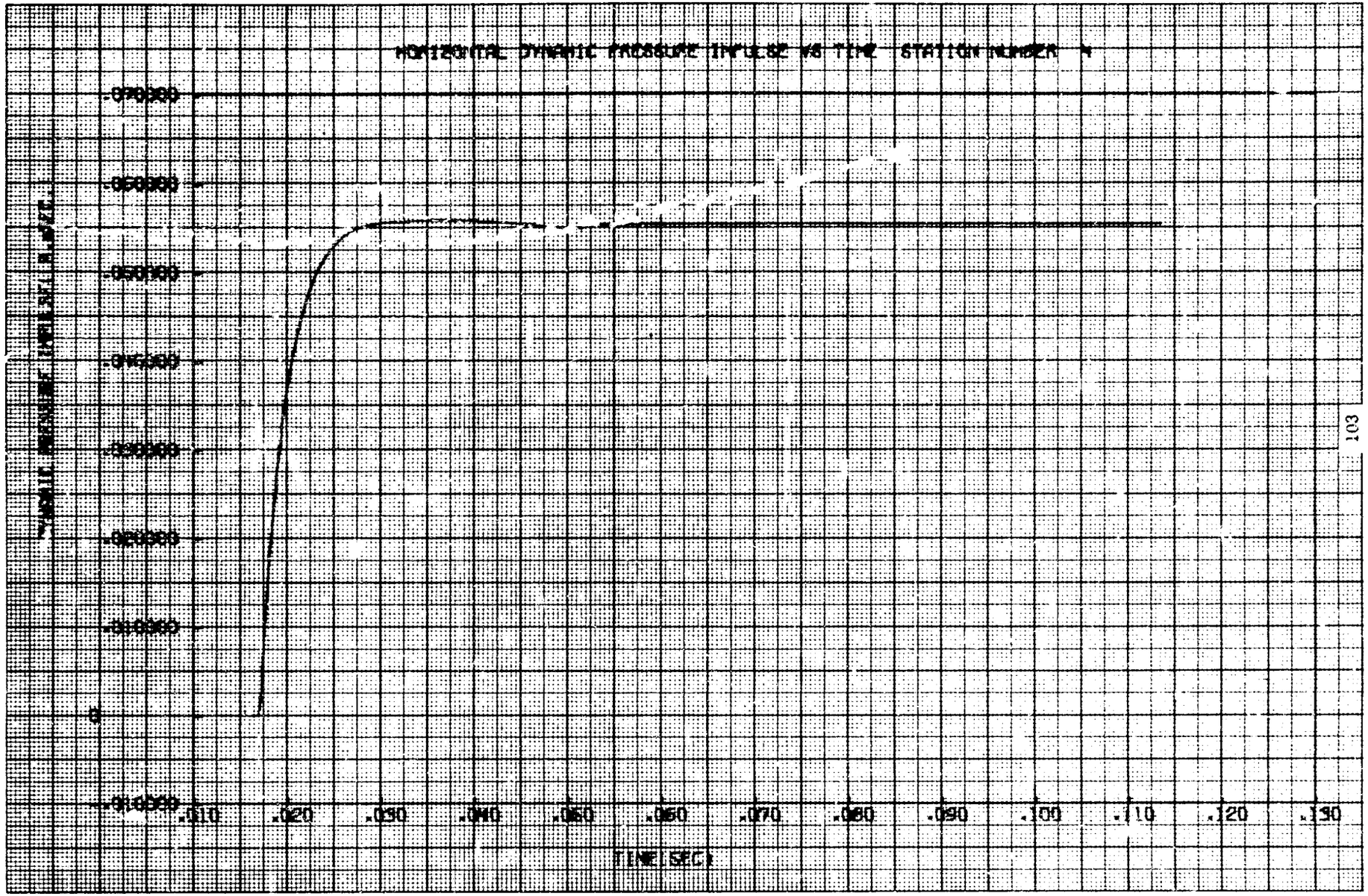
DISPLACEMENT VS. FREQUENCY
-40dB
-30dB
-20dB
-10dB
0dB
10dB
20dB
30dB
40dB
50dB
60dB
70dB
80dB
90dB
100dB
110dB
120dB
130dB
FREQUENCY

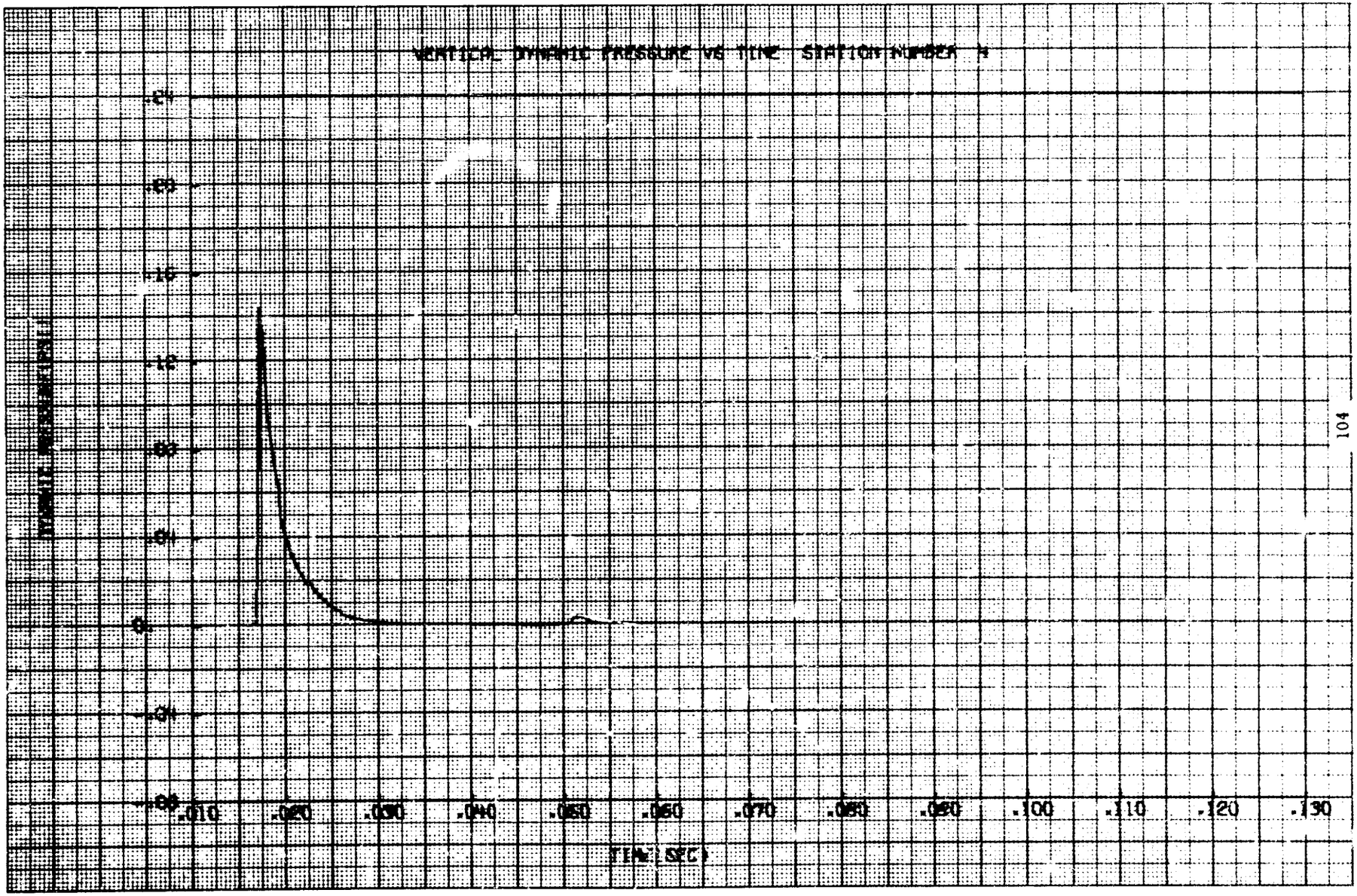

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 4
.14
.12
.10
.08
.06
.04
.02
0
-.02
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)
99


HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 1
+100.00
+000.00
-100.00
-200.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)
100

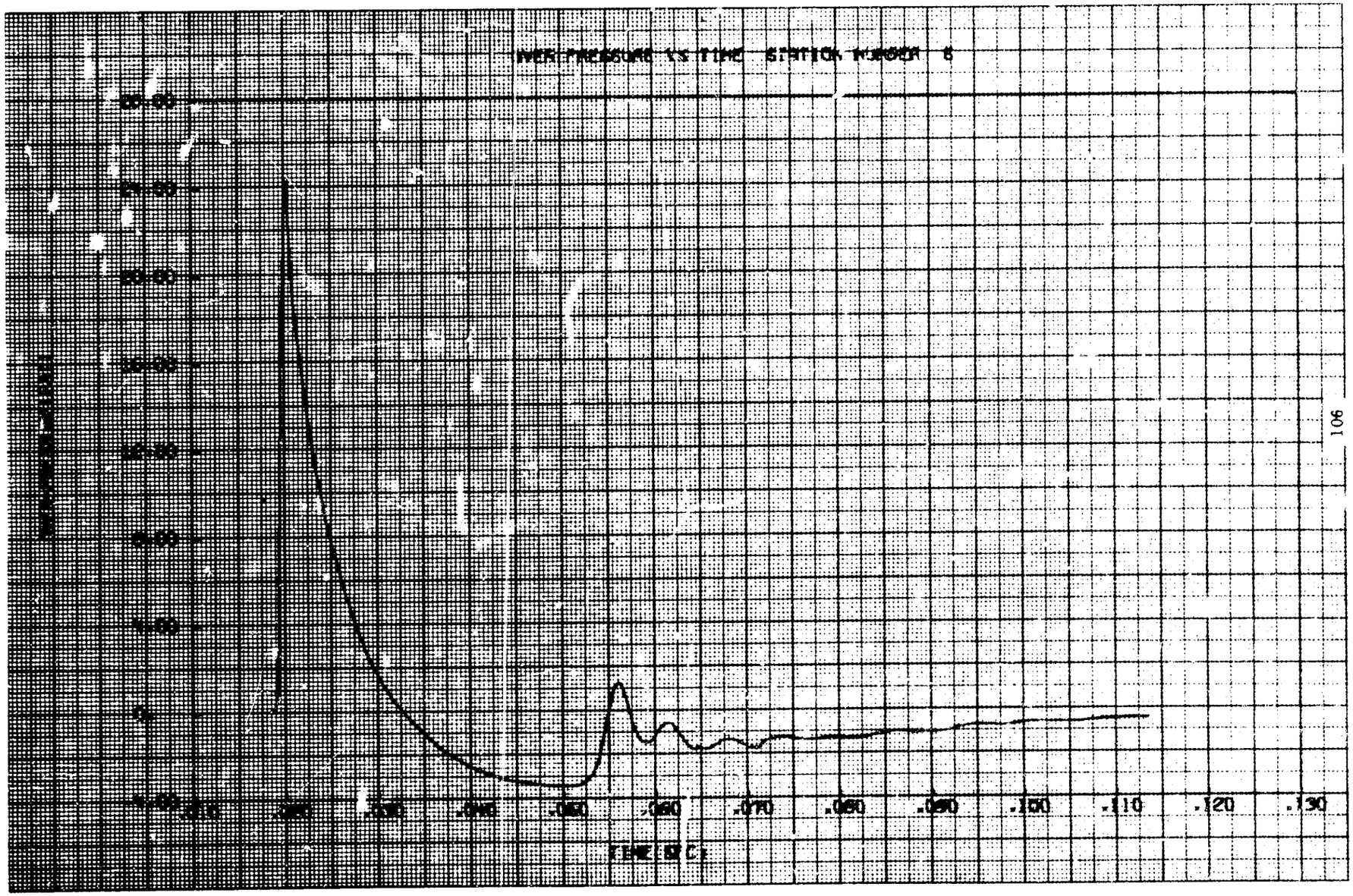

VERTICAL DISPLACEMENT VELOCITY VS TIME STATION NUMBER 1
100.00
50.00
0.
-50.00
-100.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME(SEC)

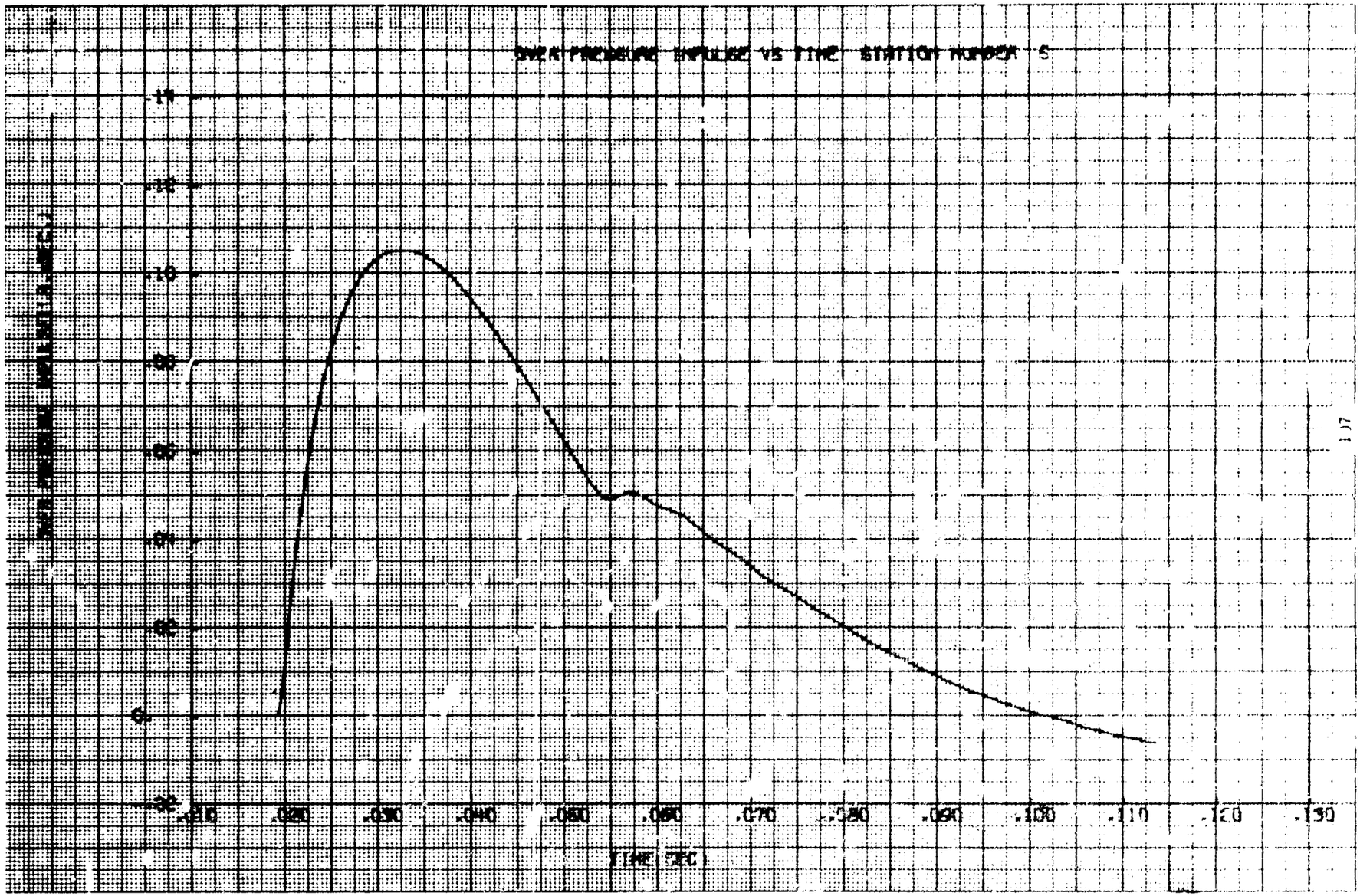


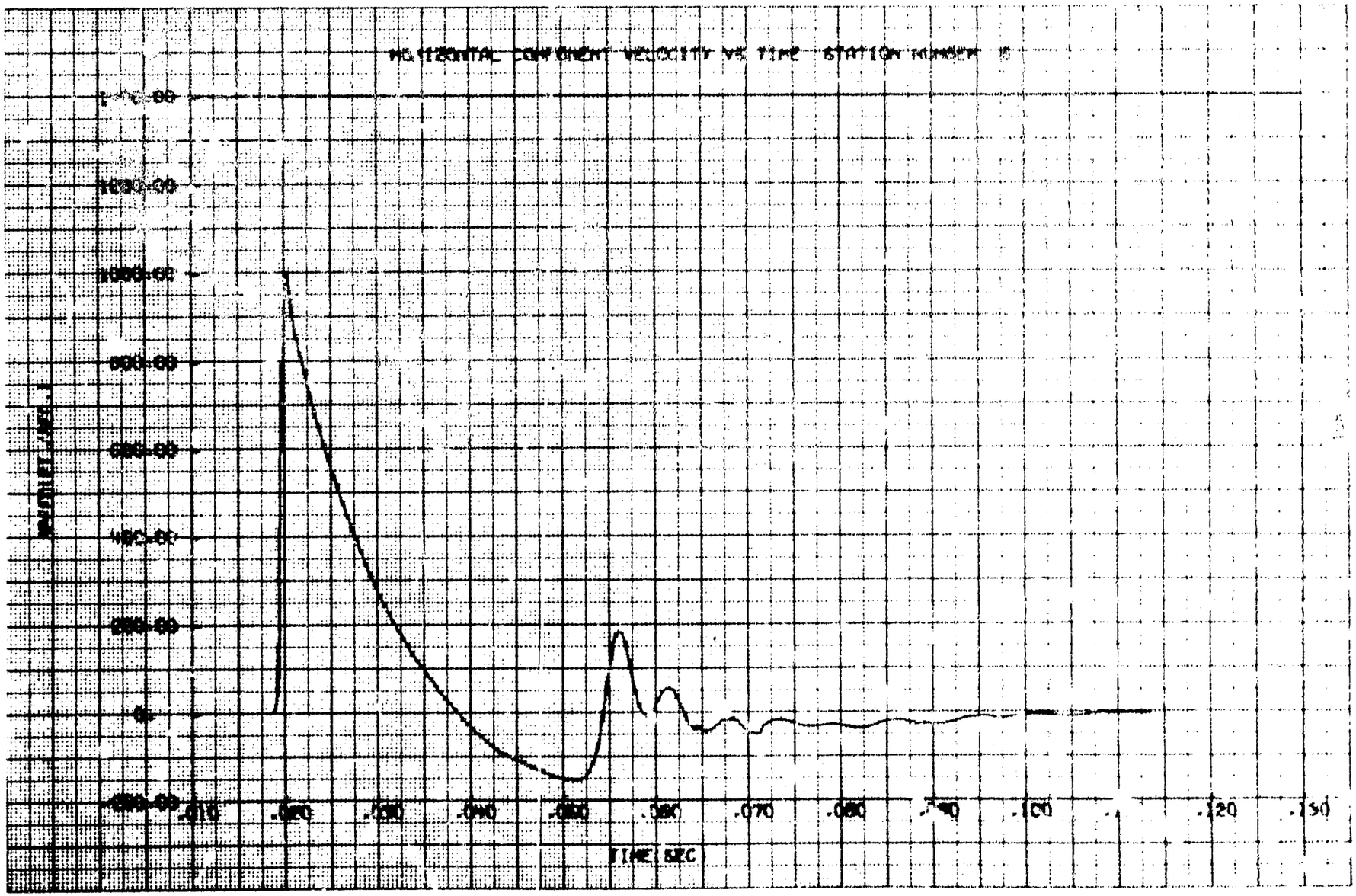

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME(SEC)

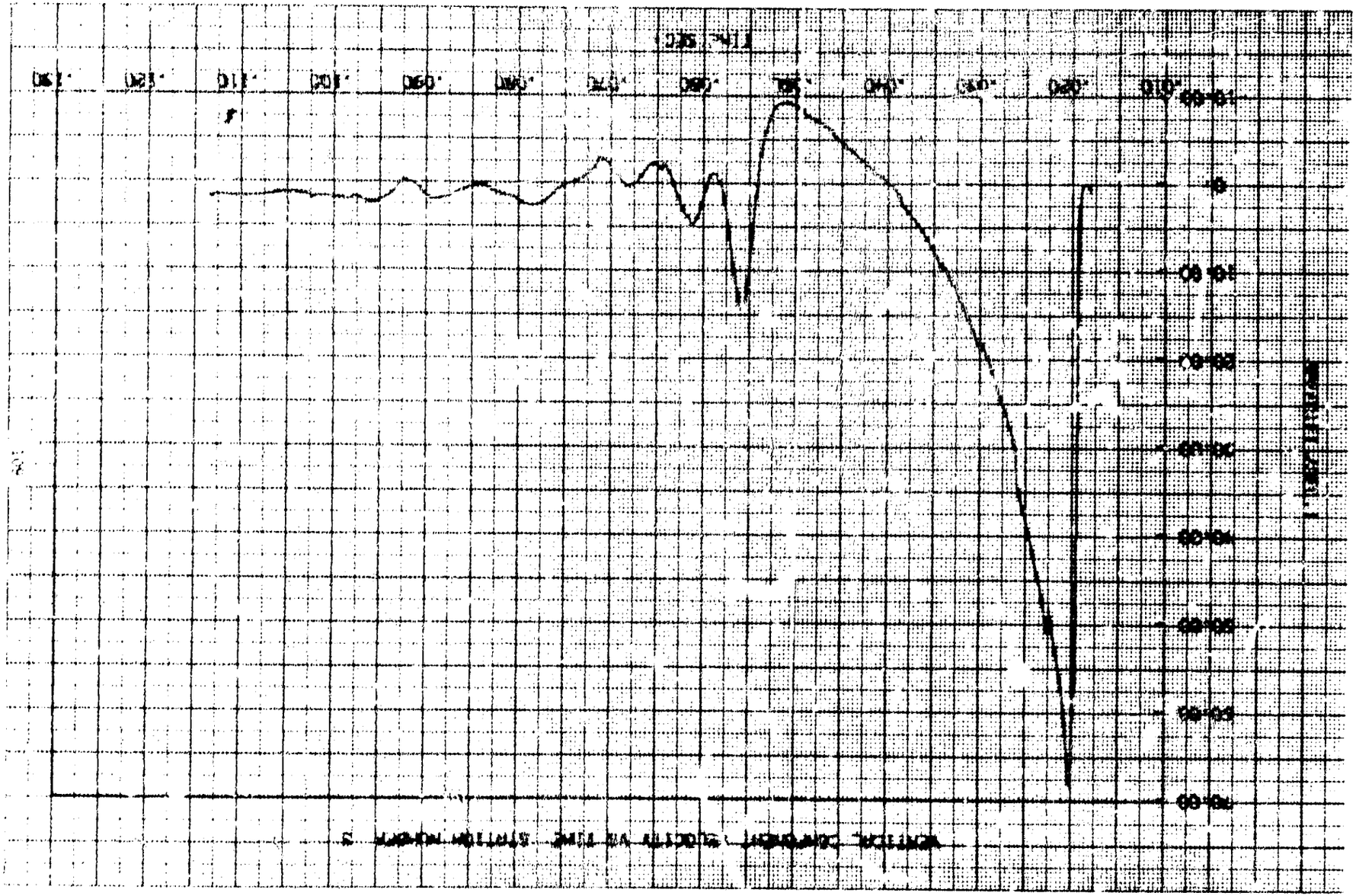

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 4
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

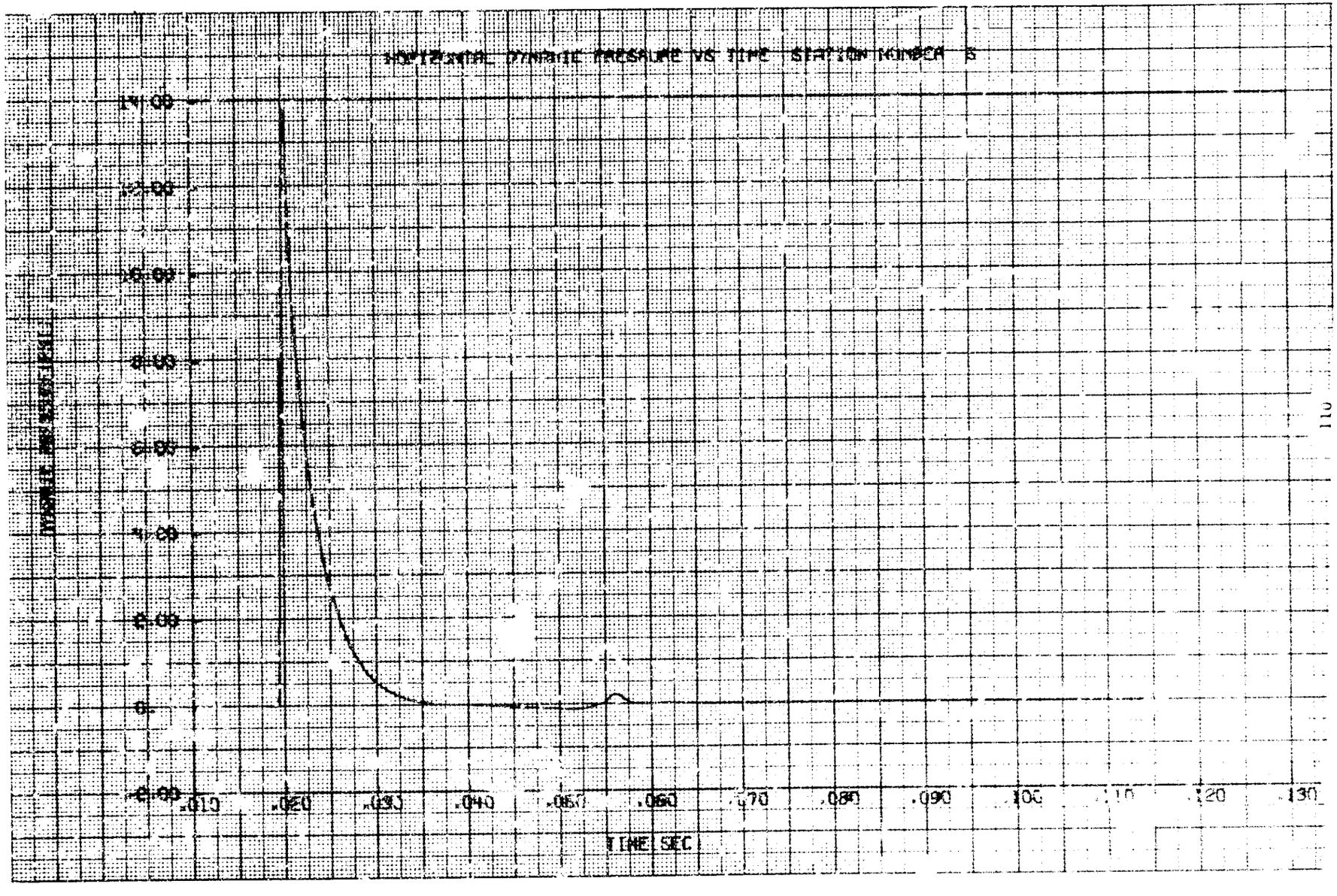
MAGNETIC PRESSURE (NEWTONS/M.SEC.)
0
-.00010
-.00020
-.00030
-.00040
-.00050
-.00060
-.00070
-.00080
-.00090
-.00100
-.00110
-.00120
-.00130
-.00140
-.00150
-.00160
-.00170
-.00180
-.00190
-.00200
-.00210
-.00220
-.00230
-.00240
-.00250
-.00260
-.00270
-.00280
-.00290
-.00300
-.00310
-.00320
-.00330
-.00340
-.00350
-.00360
-.00370
-.00380
-.00390
-.00400

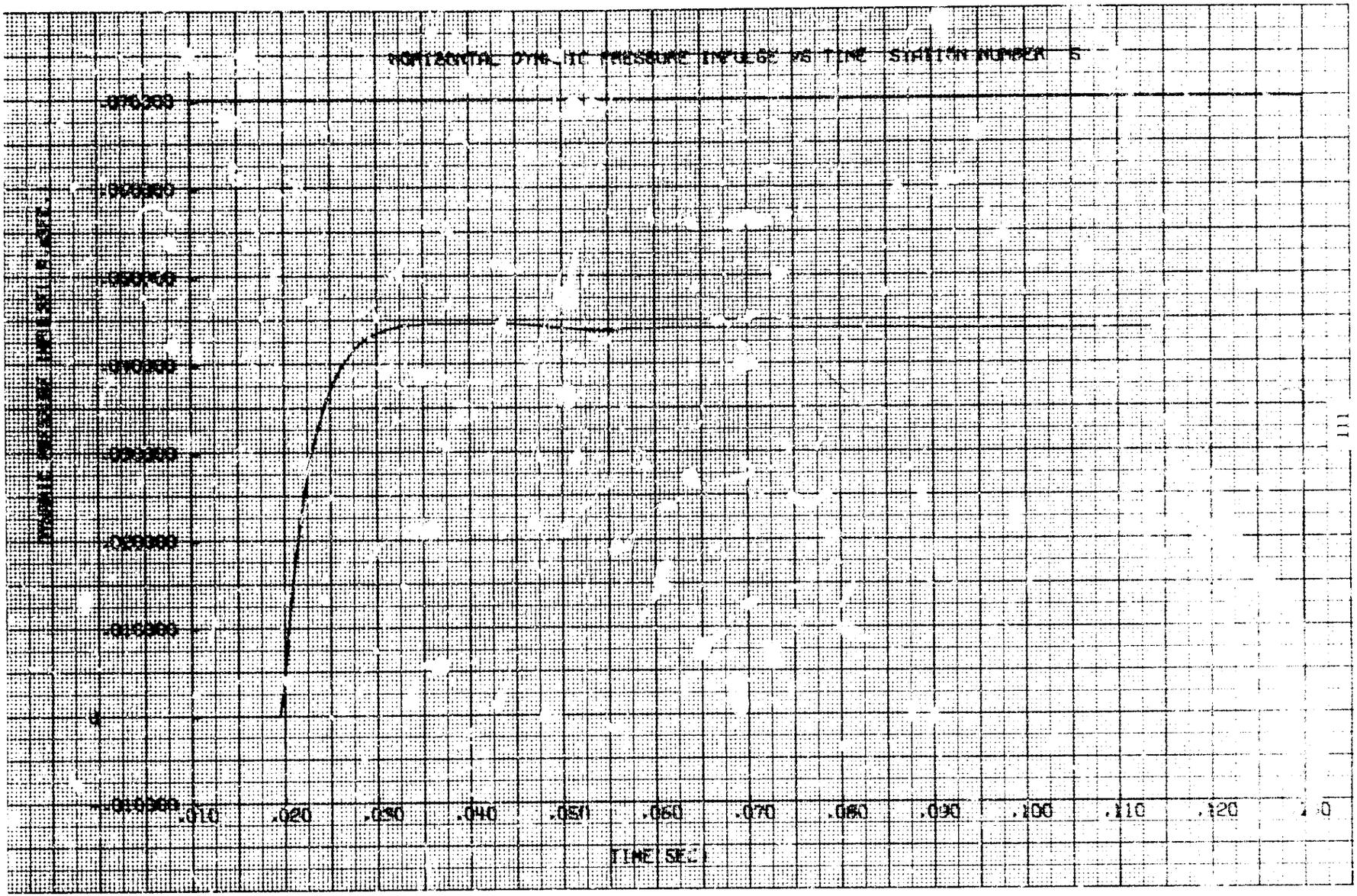

OVERPRESSURE VS TIME STATION NUMBER 6
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)


OVER PRESSURE IMPULSE VS TIME STATION NUMBER 5
-14
-12
-10
-8
-6
-4
-2
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
-.130
TIME SEC

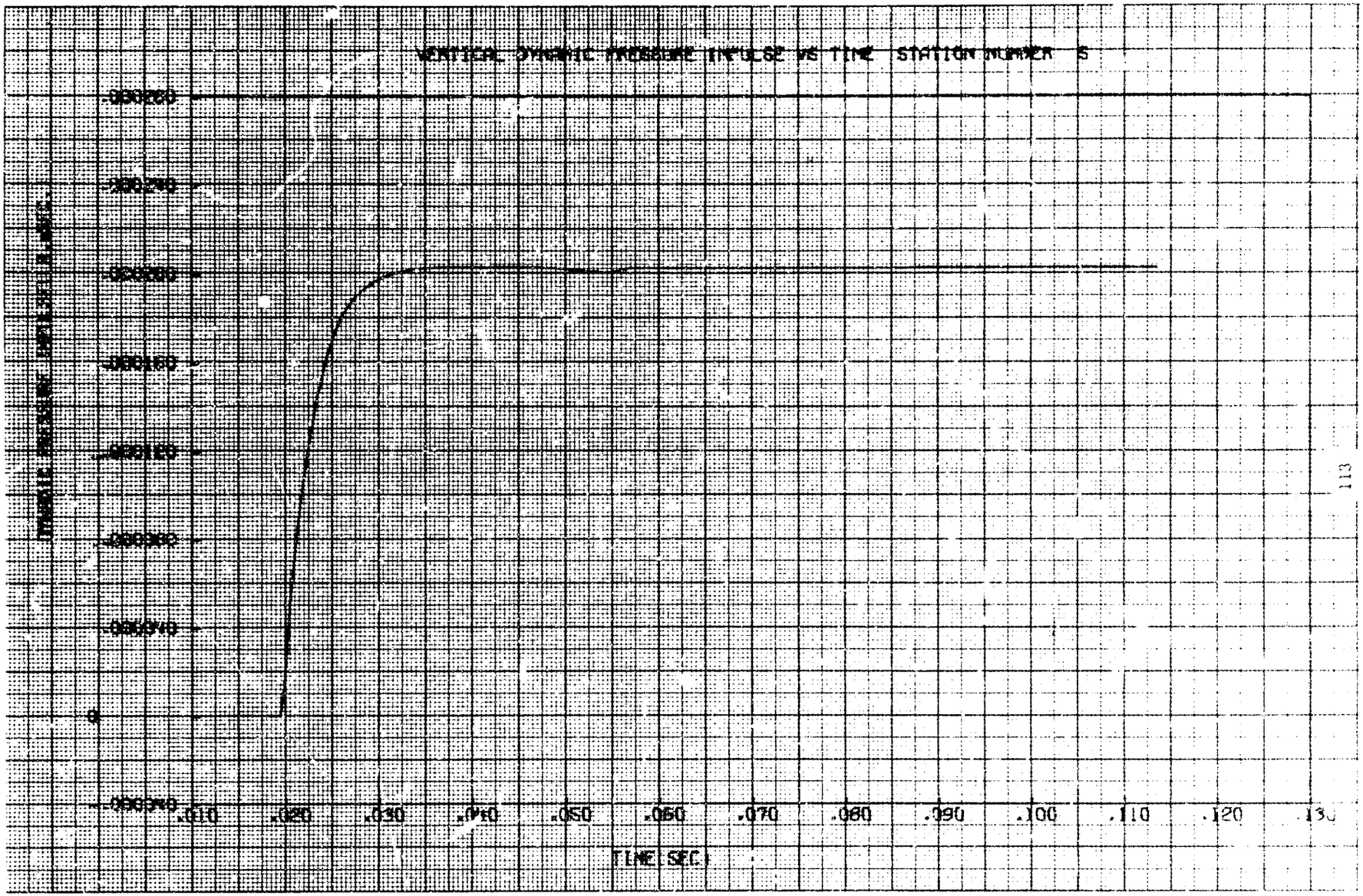

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 6
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.120
.130
TIME SEC

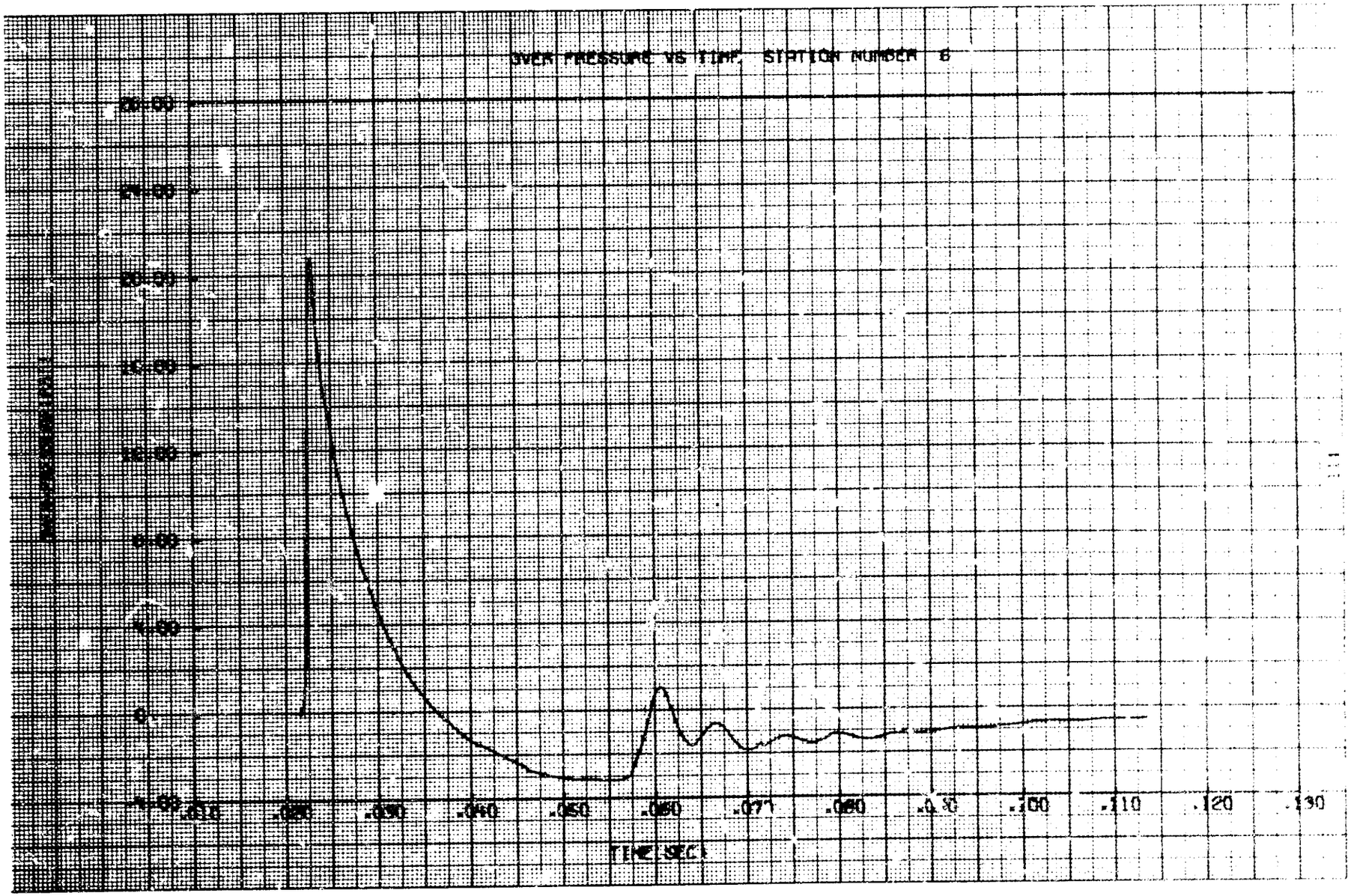



HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME SEC


HORIZONTAL DYNAMIC PRESSURE IN PSIG VS TIME STATION NUMBER 5
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC

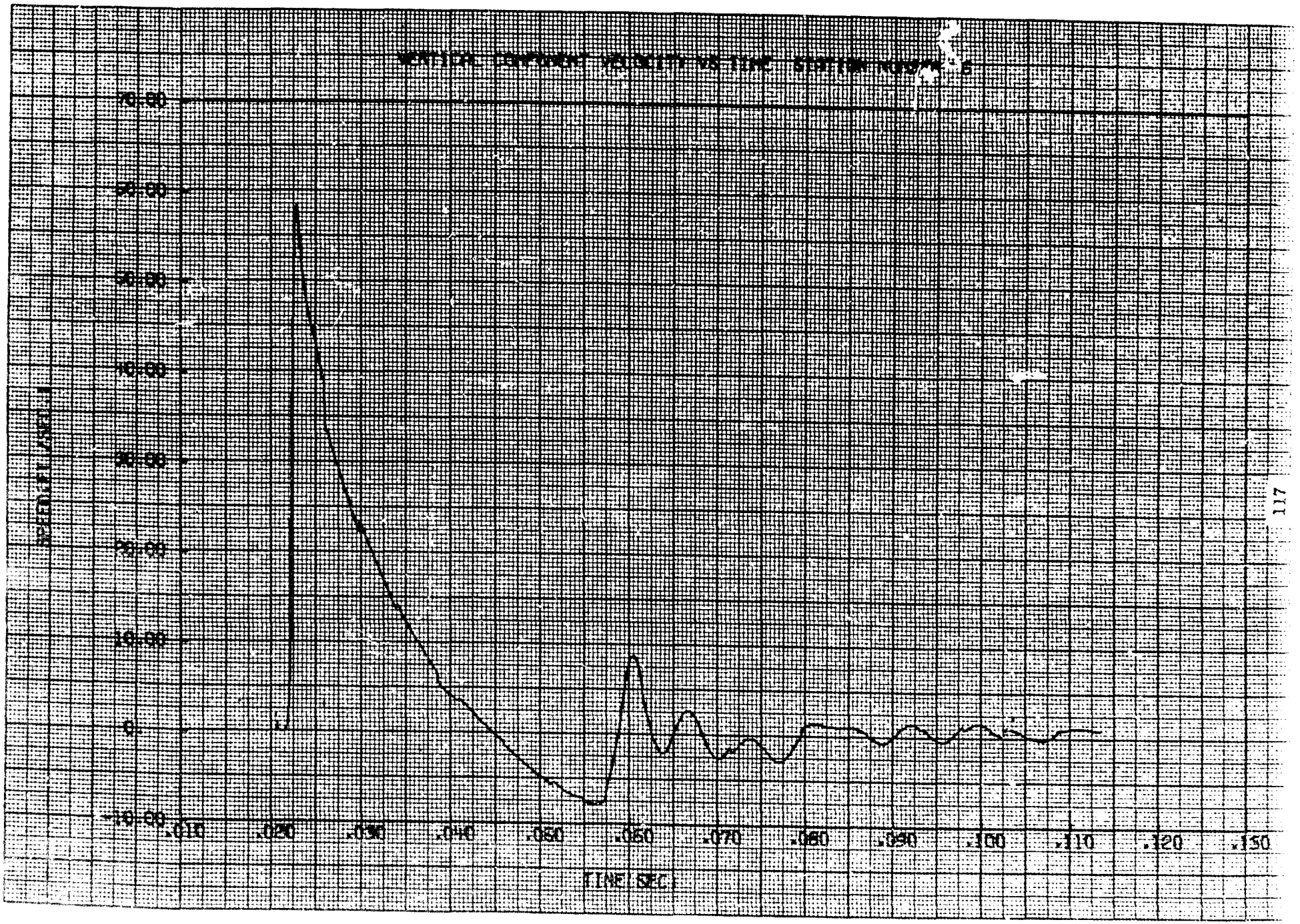
DYNAMIC PRESSURE (PSIA)
0.0
0.010
0.020
0.030
0.040
0.050
0.060
0.070
0.080
0.090
0.100
0.110
0.120
0.130
TIME (SEC)
CONICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5

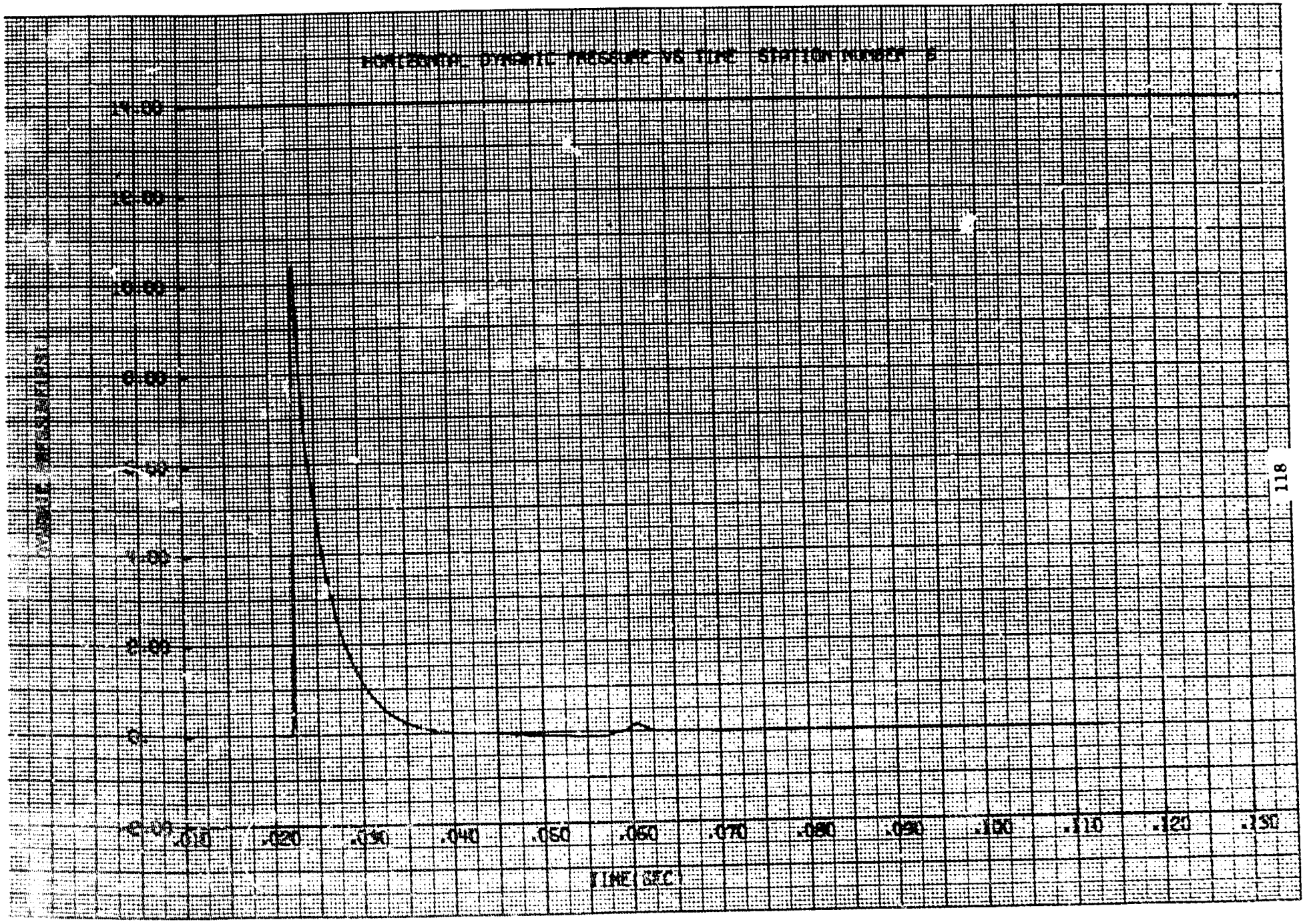

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 5
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC.

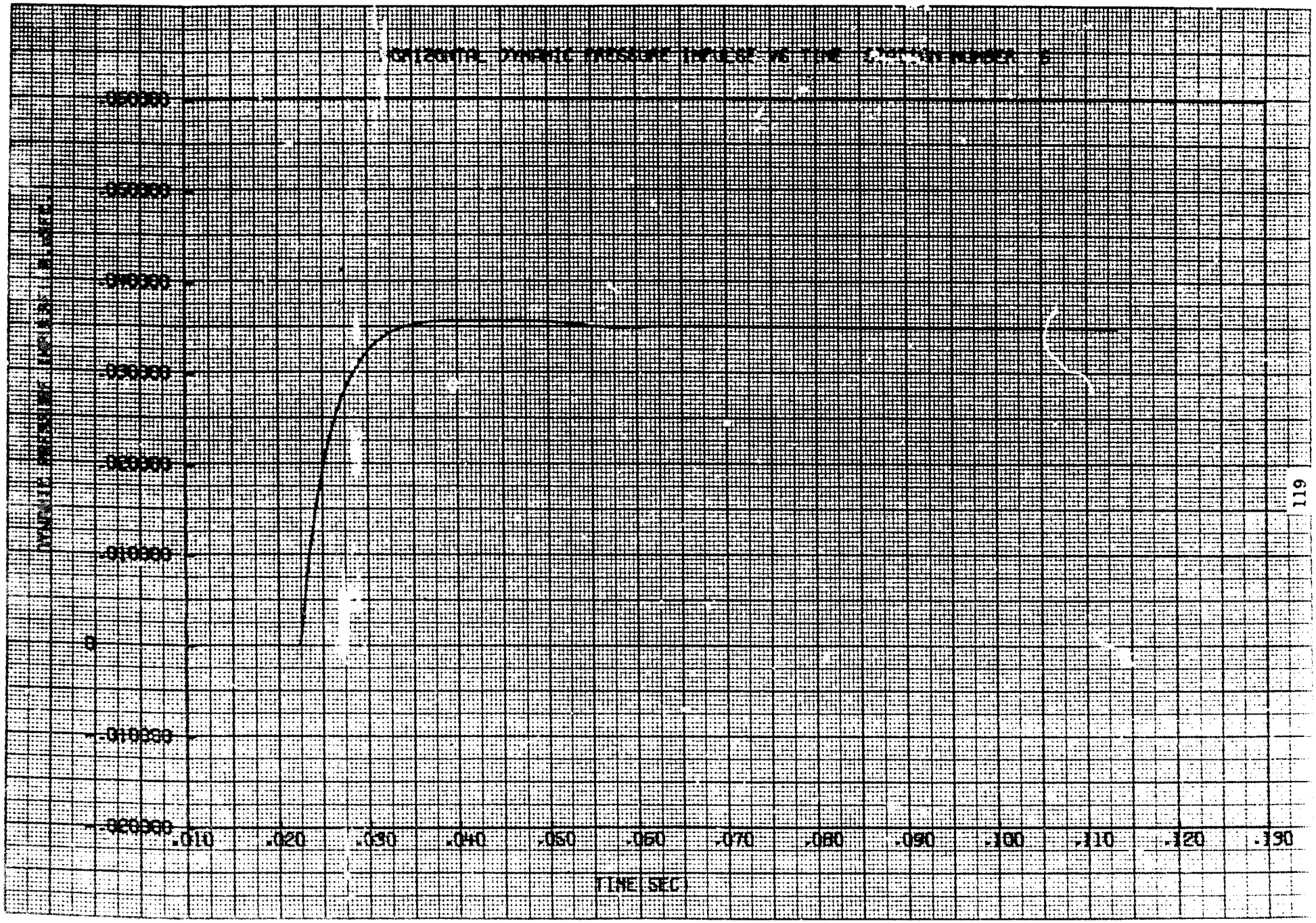

OVER PRESSURE VS TIME, STATION NUMBER 6
20.00
10.00
0.00
-10.00
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME SEC

AIR PRESSURE (PSI)
-10
-20
0
10
20
30
40
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

SPECTRUM LEVEL
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB
-90 dB
-100 dB
-110 dB
-120 dB
-130 dB
-40 KHz
-30 KHz
-20 KHz
0
20 KHz
30 KHz
40 KHz
FREQUENCY

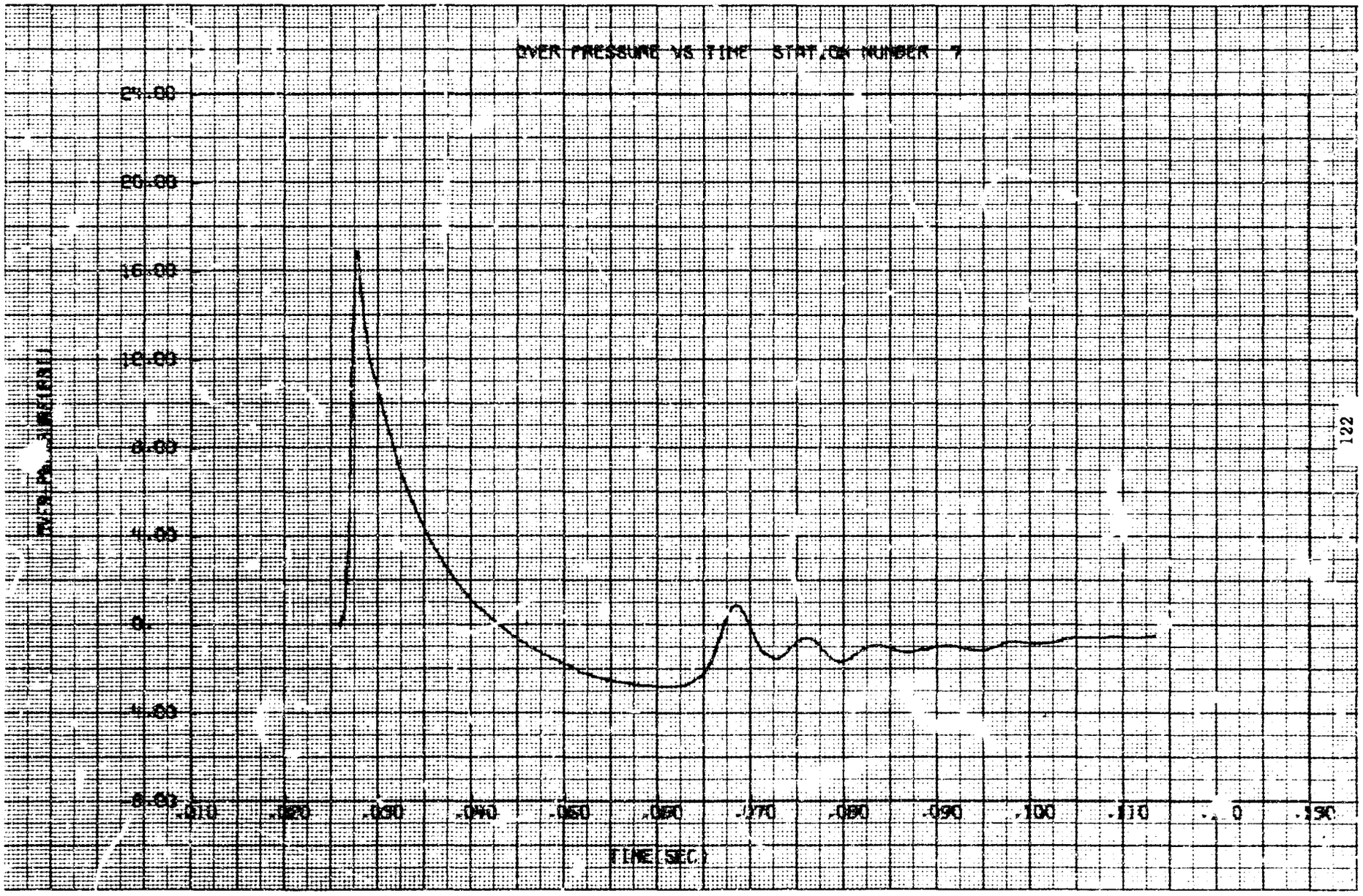

VERTICAL COMPONENT VELOCITY VS TIME STATION NO. 6
70.00
30.00
-10.00
-30.00
-50.00
-70.00
-10.00
0.
10.00
30.00
VELOCITY (FT/SEC)
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

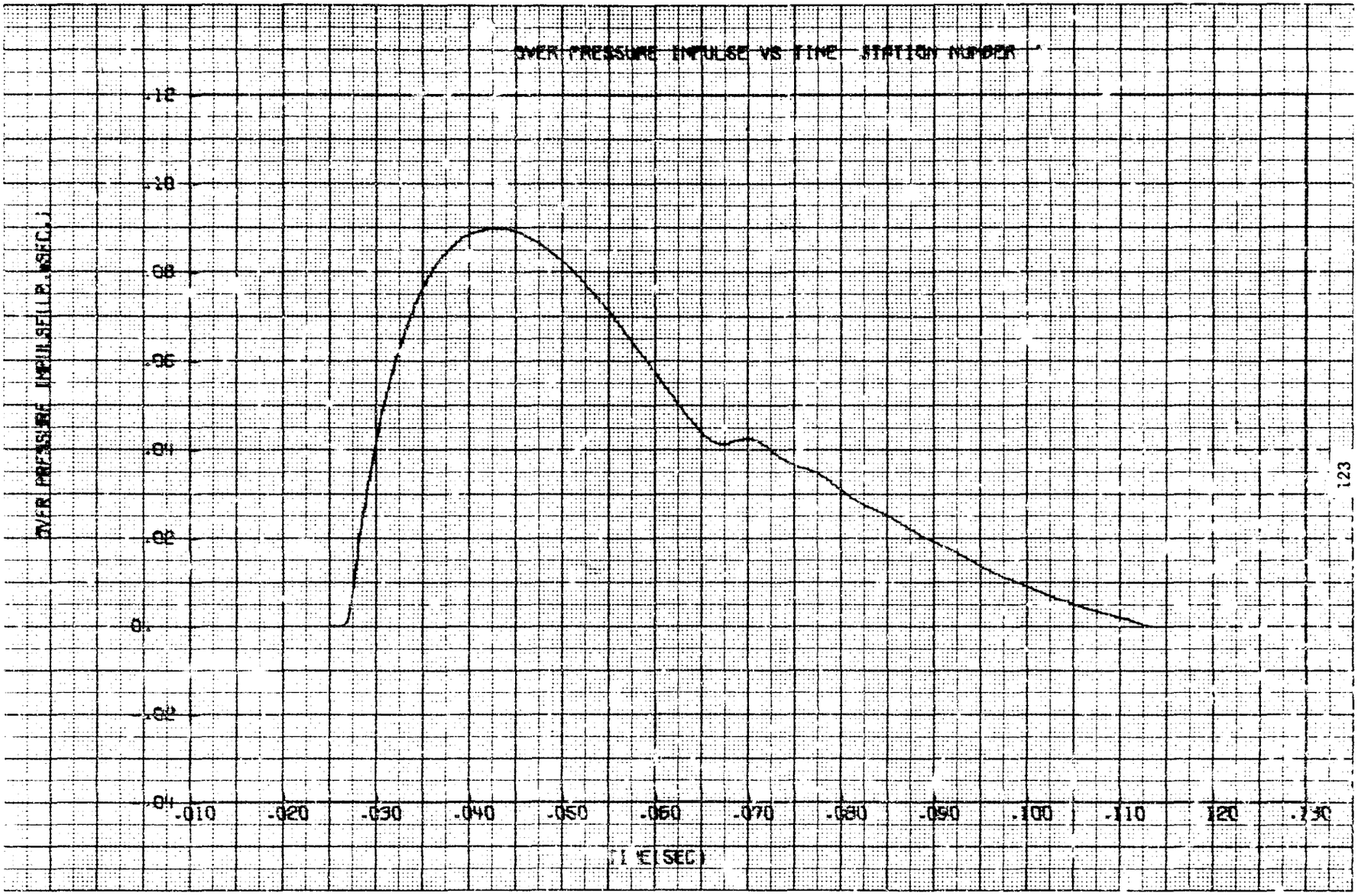

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

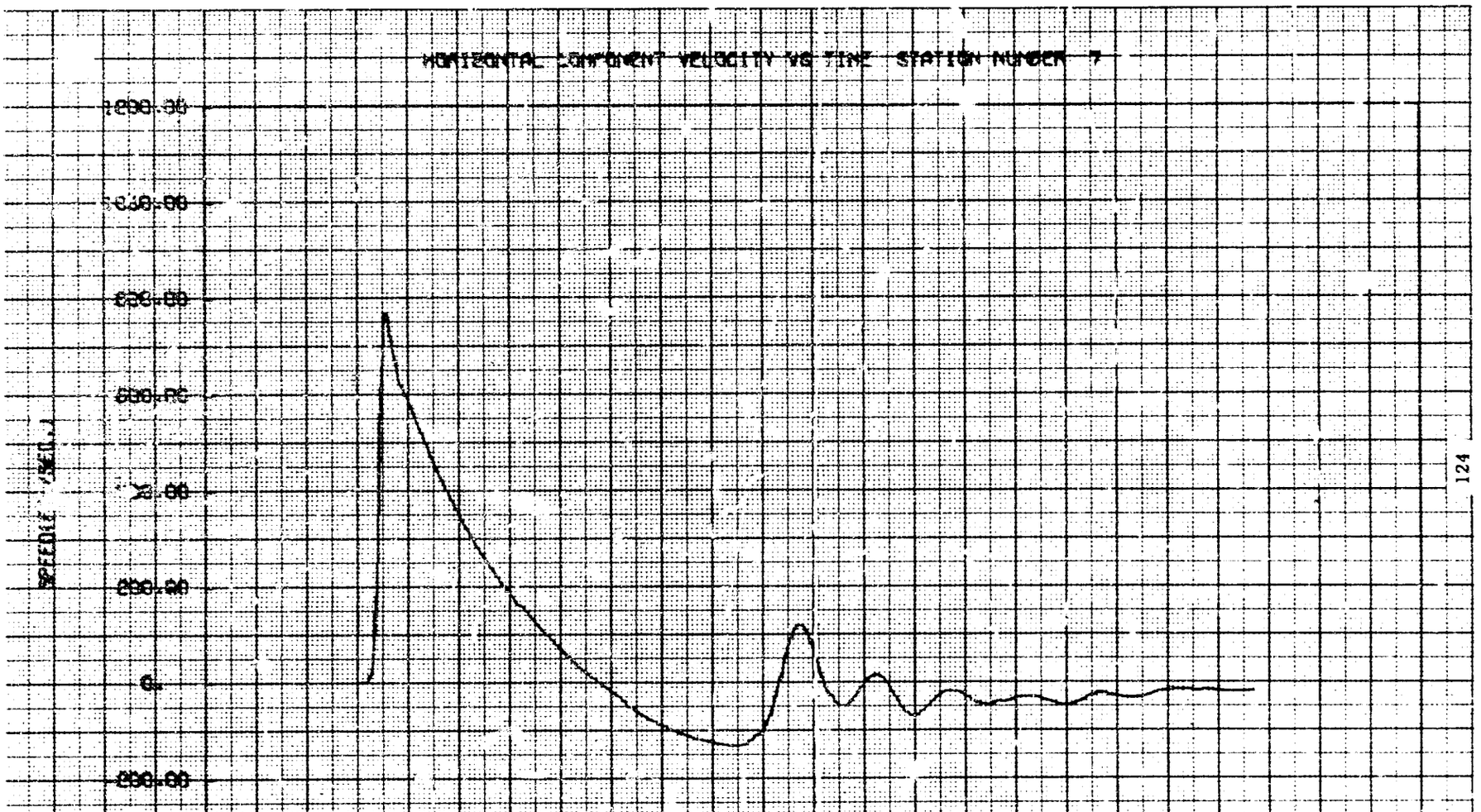

-.050000
-.040000
-.030000
-.020000
-.010000
0
.010000
.020000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

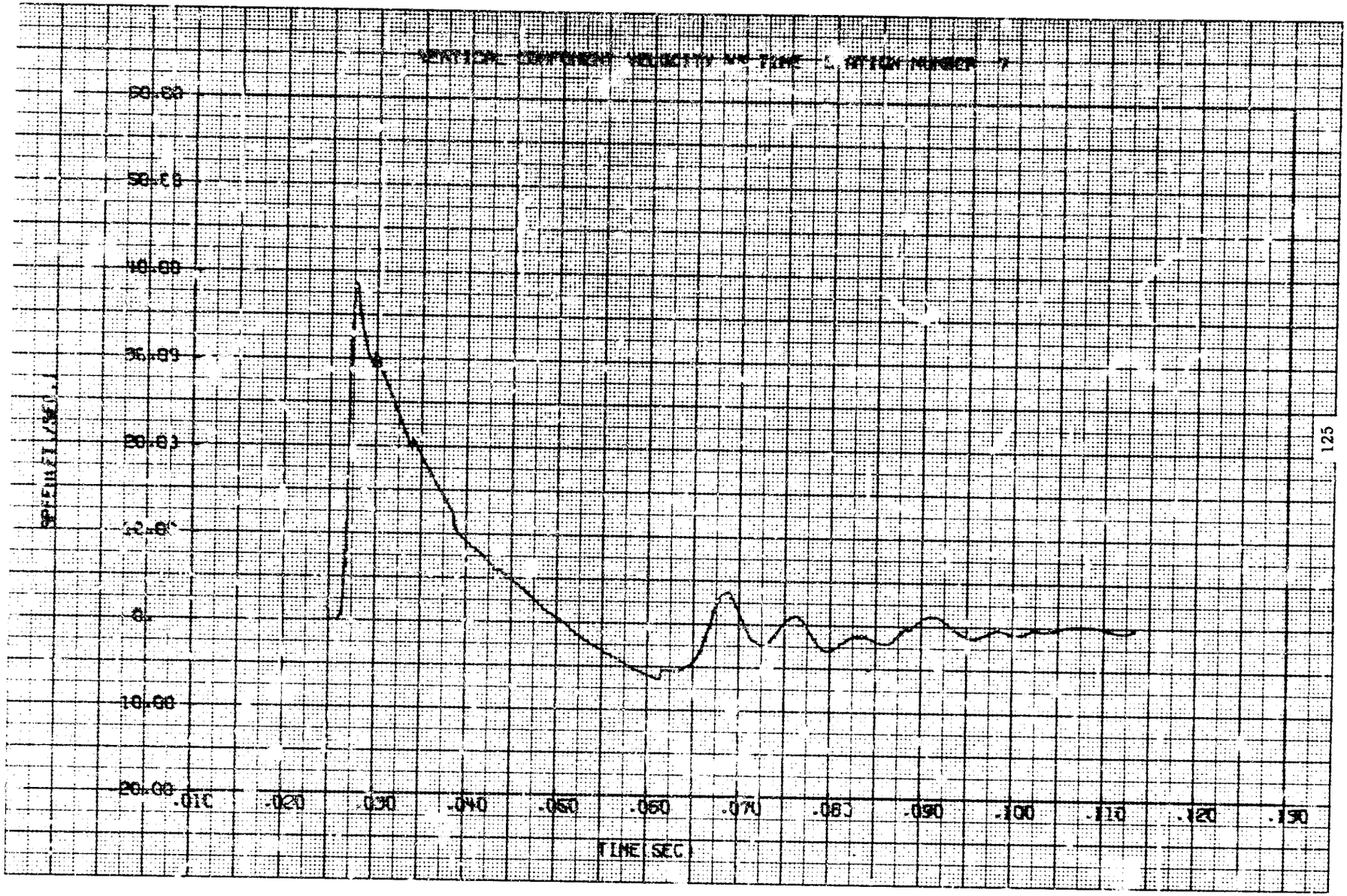
VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 6
TIME (SEC)
.000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
.150
.160
.170
.180
.190
.200
.210
.220
.230
.240
.250
.260
.270
.280
.290
.300
.310
.320
.330
.340
.350
.360
.370
.380
.390
.400
.410
.420
.430
.440
.450
.460
.470
.480
.490
.500

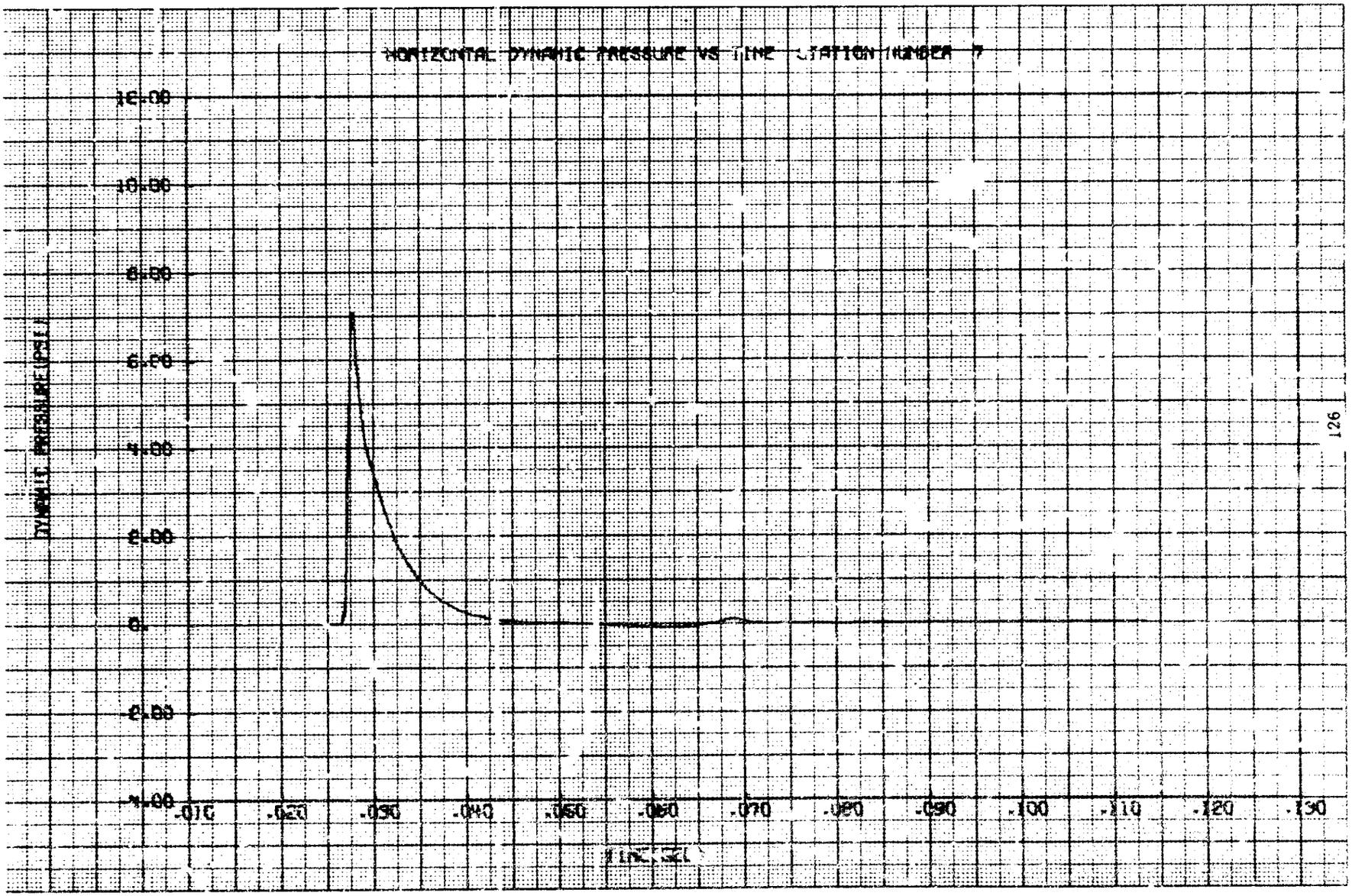
0.0000
0.0000
0.0000
0.0000
0.0000
0.0000
0.0000
0.0000
0.0
0.010
0.020
0.030
0.040
0.050
0.060
0.070
0.080
0.090
0.100
0.110
0.120
0.130
0.140
0.150
TIME (SEC)


OVER PRESSURE VS TIME STATION NUMBER 7
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC.)
122

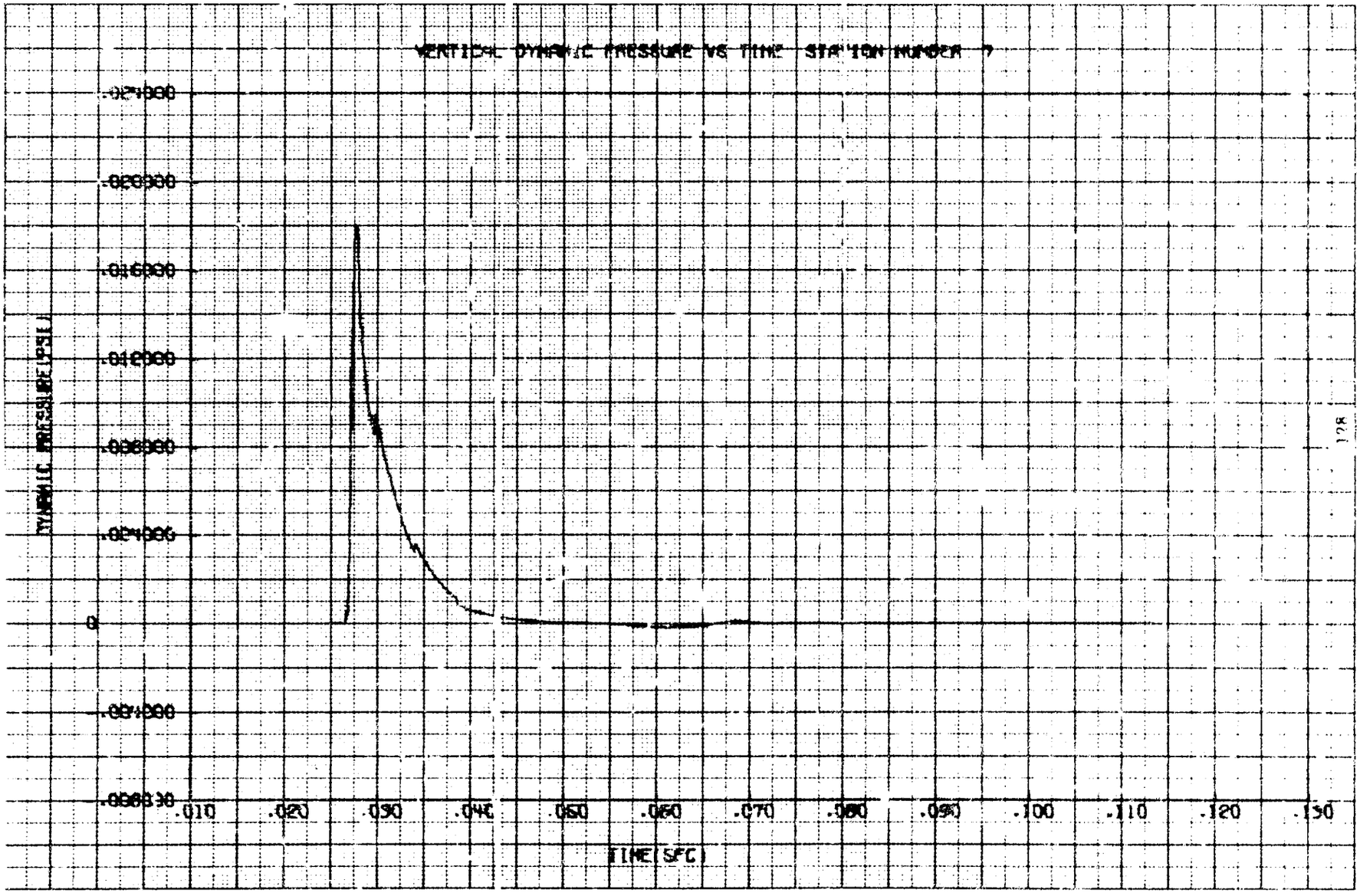

OVER PRESSURE IMPULSE VS TIME STATION NUMBER
.12
.08
.04
0.
-.04
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
120
TIME(SEC)
123

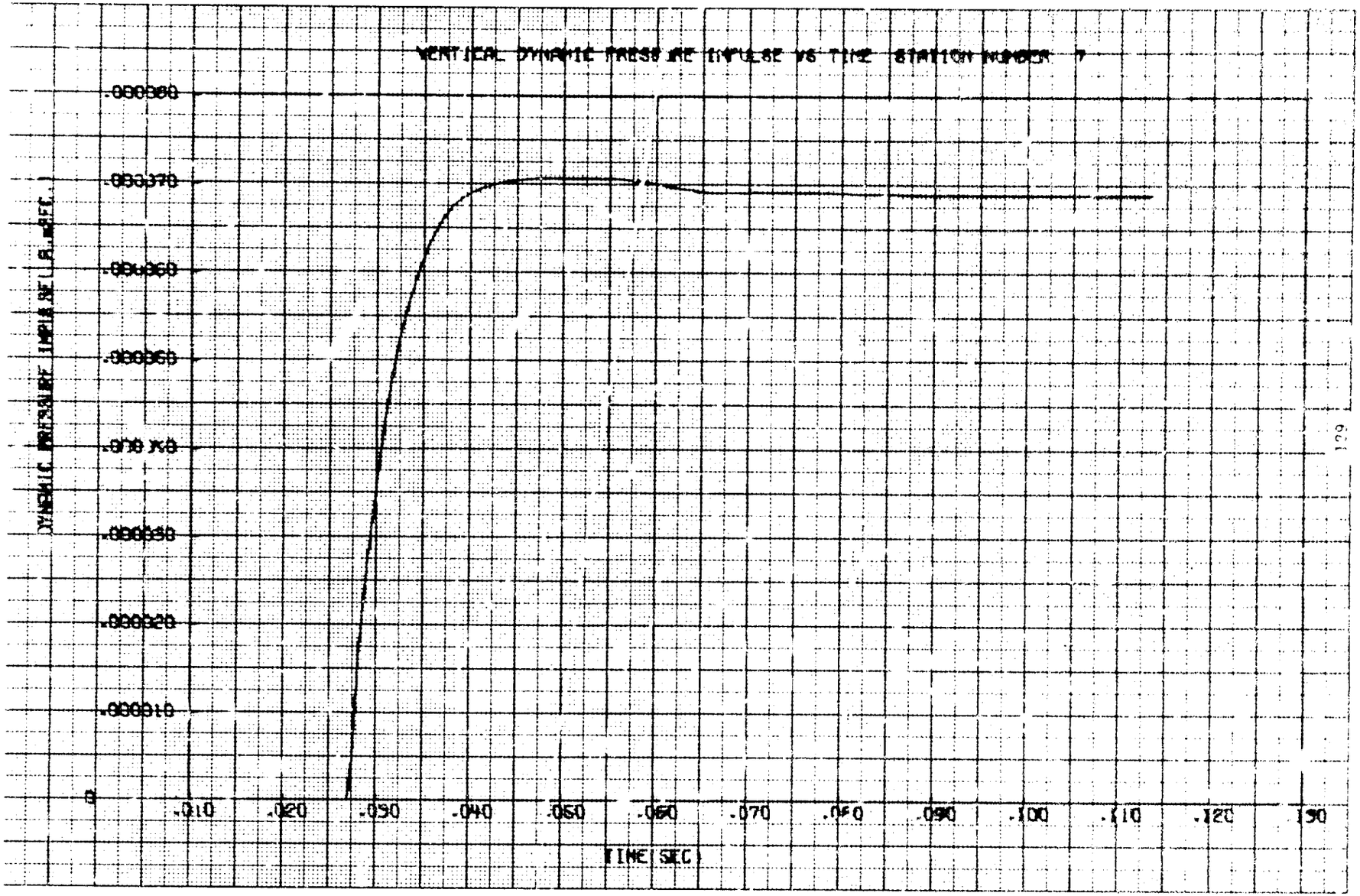

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 7
SPEED (M/SEC.)
TIME(SEC)
-010
-020
-030
-040
-050
-060
-070
-080
-090
-100
-110
-120
-130
124

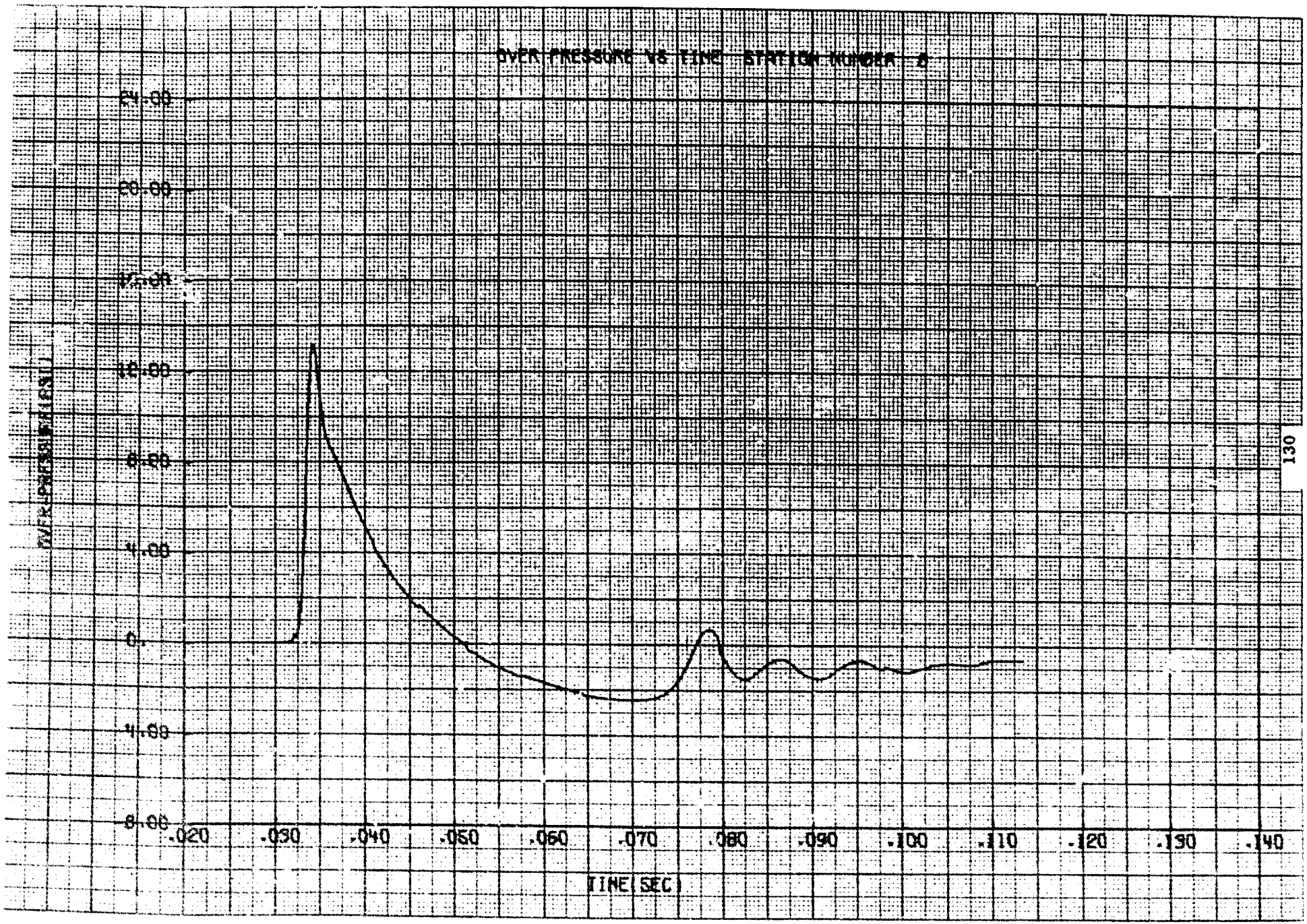

VERTICAL COMPONENT VELOCITY AND TIME - MACH NUMBER .7
50.00
40.00
30.00
20.00
0.
-10.00
-20.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)
125

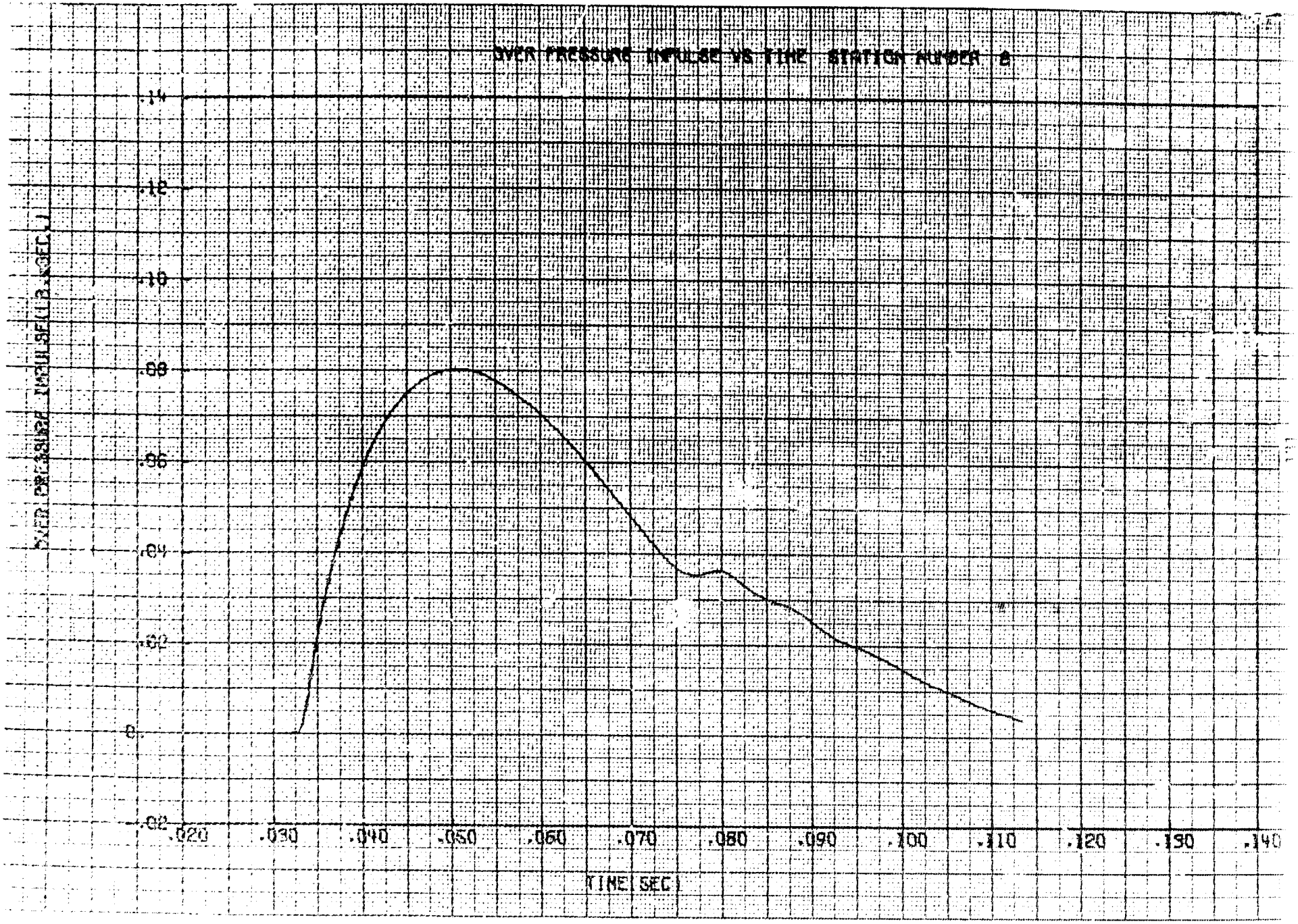

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION RANGER 7
10.00
8.00
6.00
4.00
2.00
0.
-2.00
-4.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
126

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
.032000
.028000
.024000
.020000
.016000
.012000
.008000
.004000
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)


VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
.020000
.016000
.012000
.008000
.004000
0
-.004000
-.008000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME(SEC)


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
.000360
.000270
.000180
.000090
.000080
.000020
.000010
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)

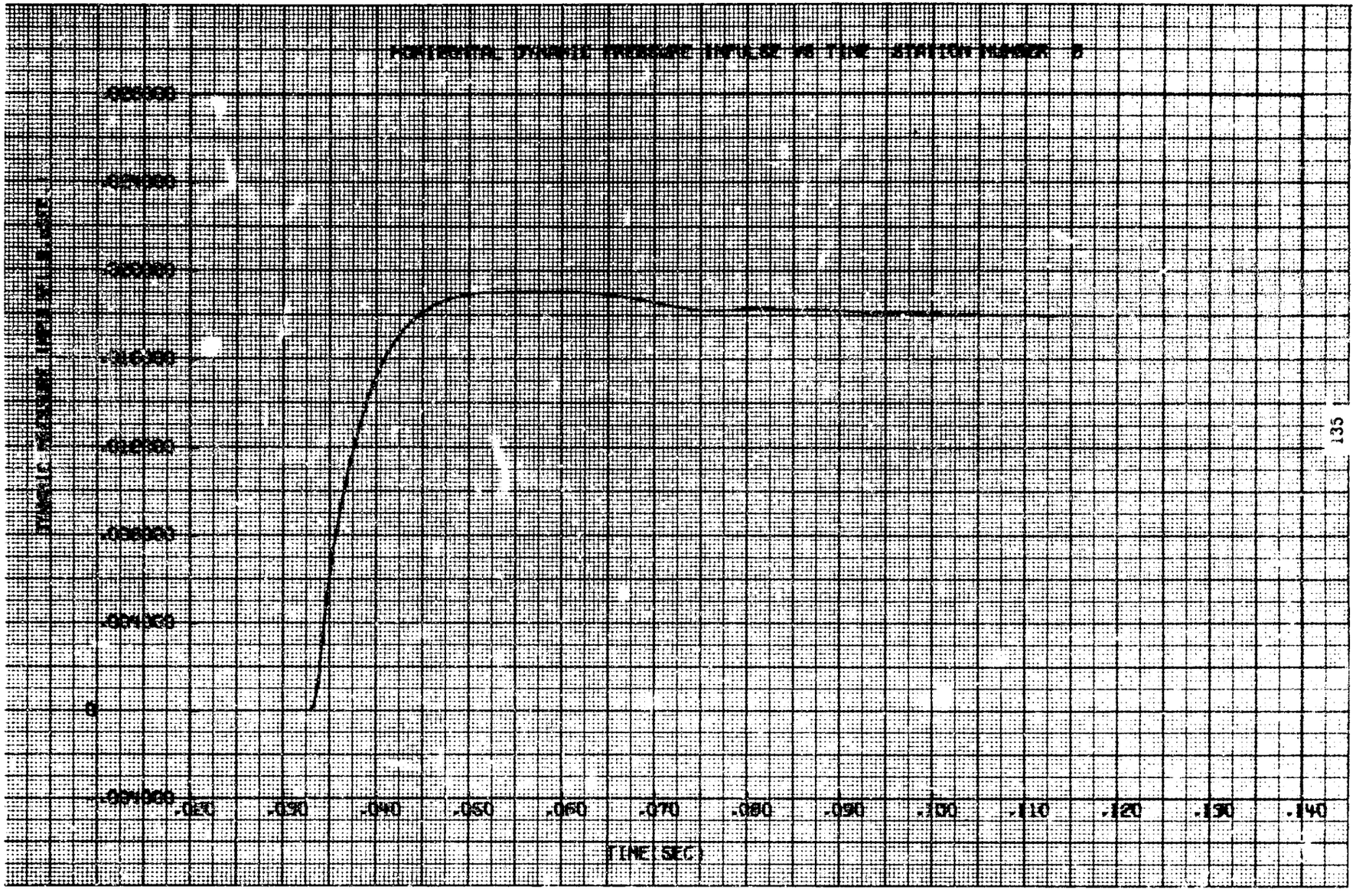

OVER PRESSURE VS TIME STATION NUMBER 6
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME(SEC)
130

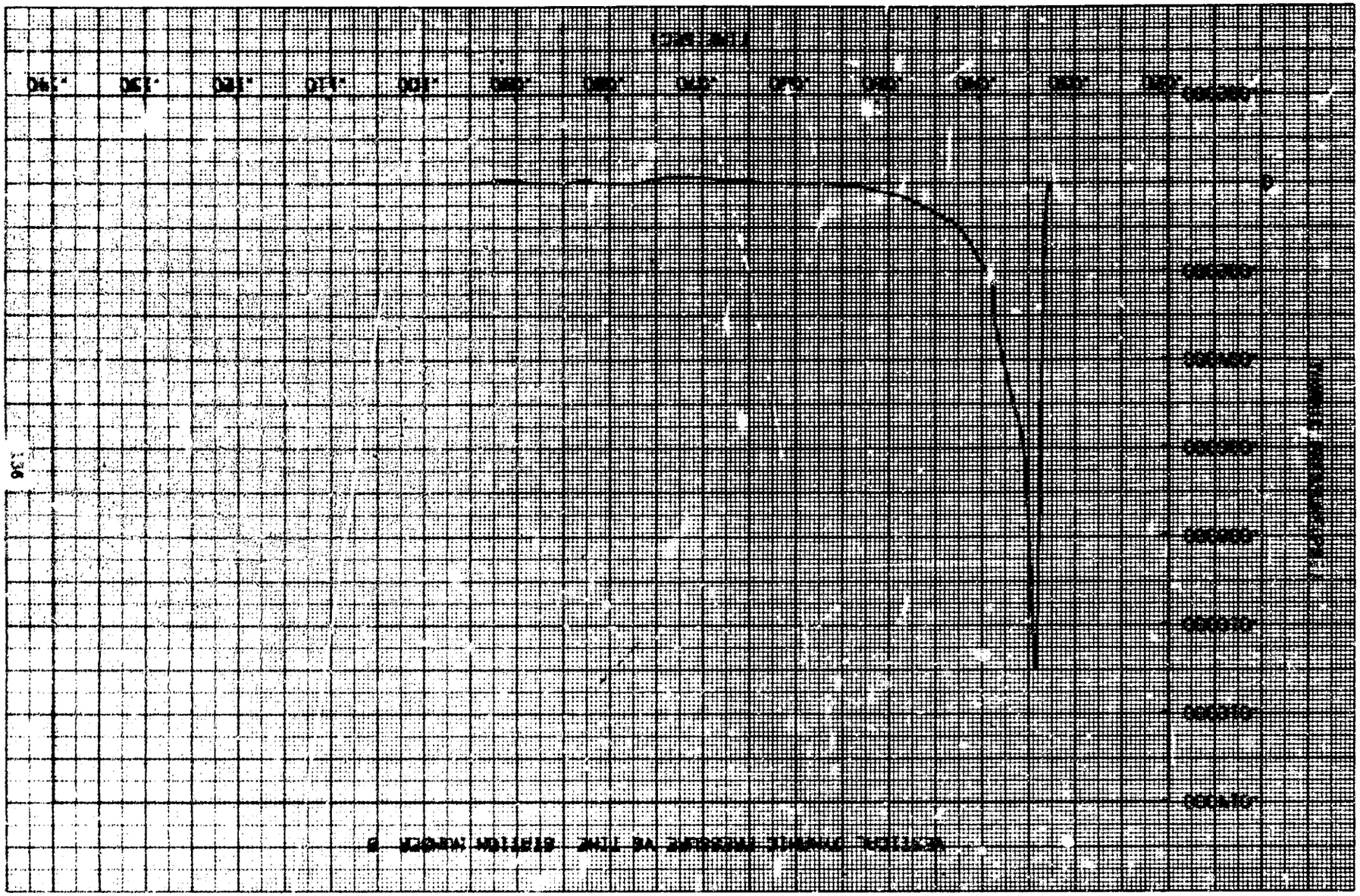

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 8
OVER PRESSURE IMPULSE (LB-SEC/FT)
.14
.12
.10
.08
.06
.04
.02
0
-.02
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)

TIME SEC.
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140

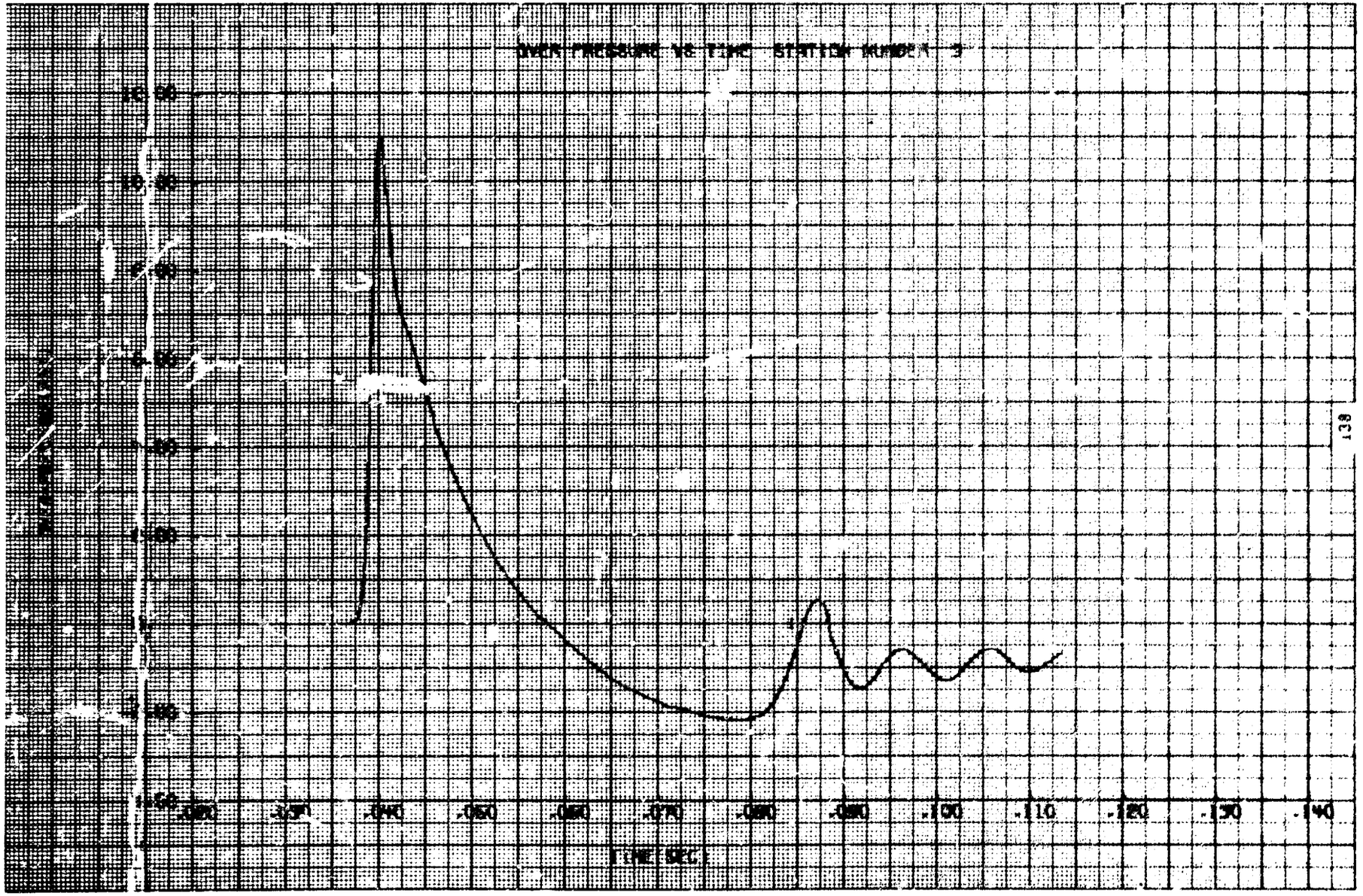
-40 dB
-30 dB
-20 dB
-10 dB
0
10 dB
20 dB
30 dB
40 dB
50 dB
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)

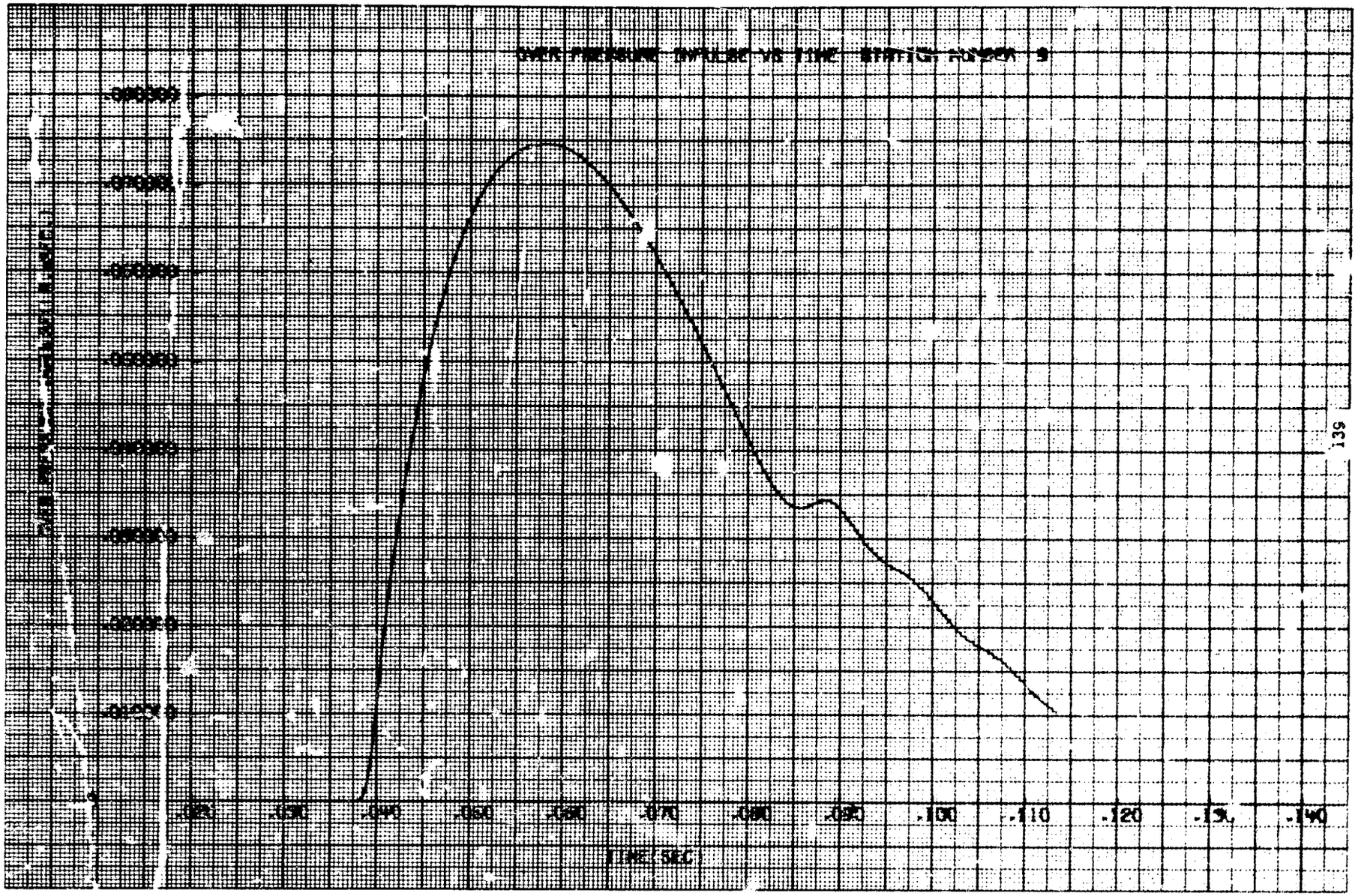
TYPICAL MICROWAVE FIELD
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
760
780


FORTRAN DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 8
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
-.130
-.140
TIME(SEC)
135

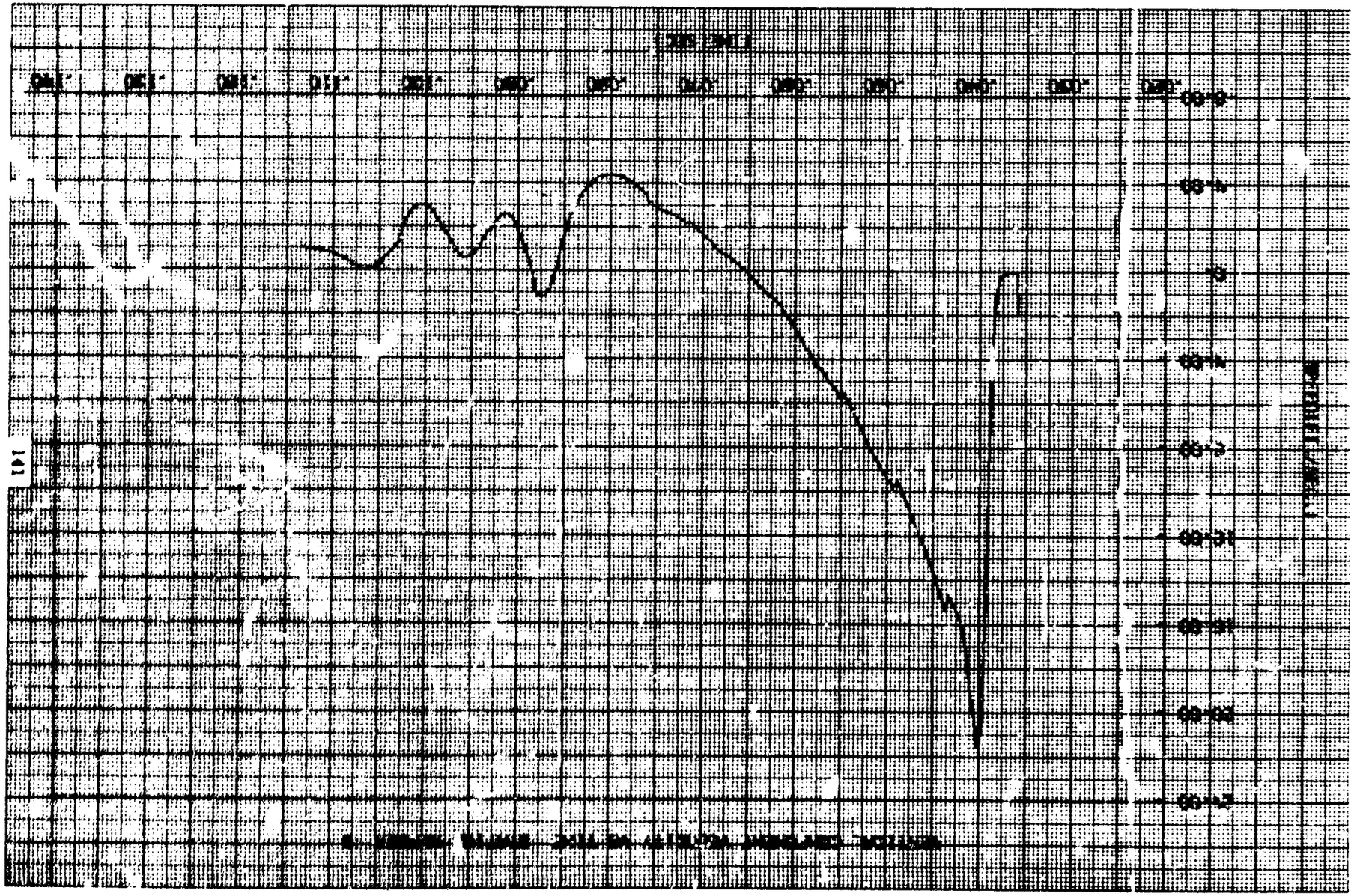


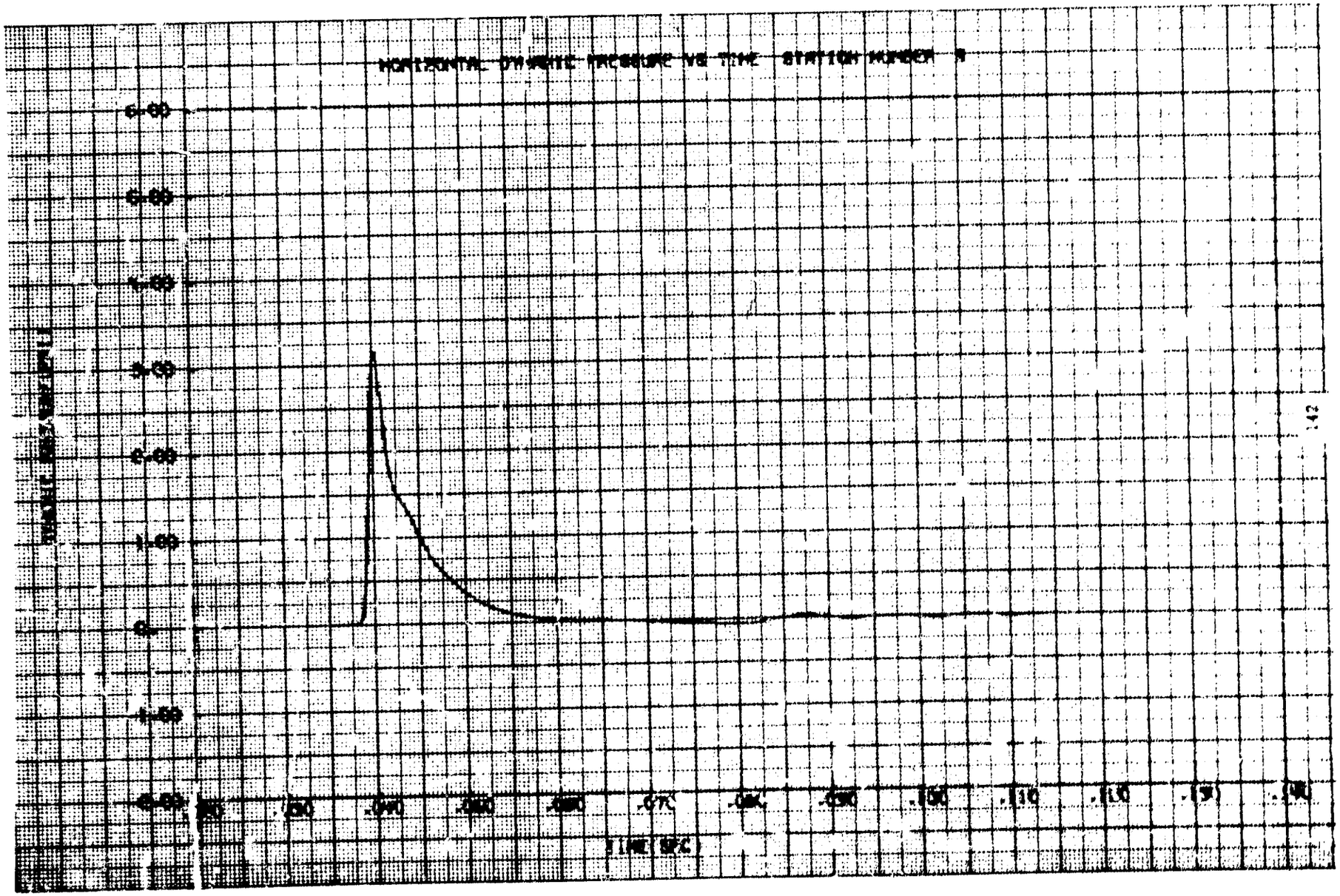
TIME SEC
.000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140

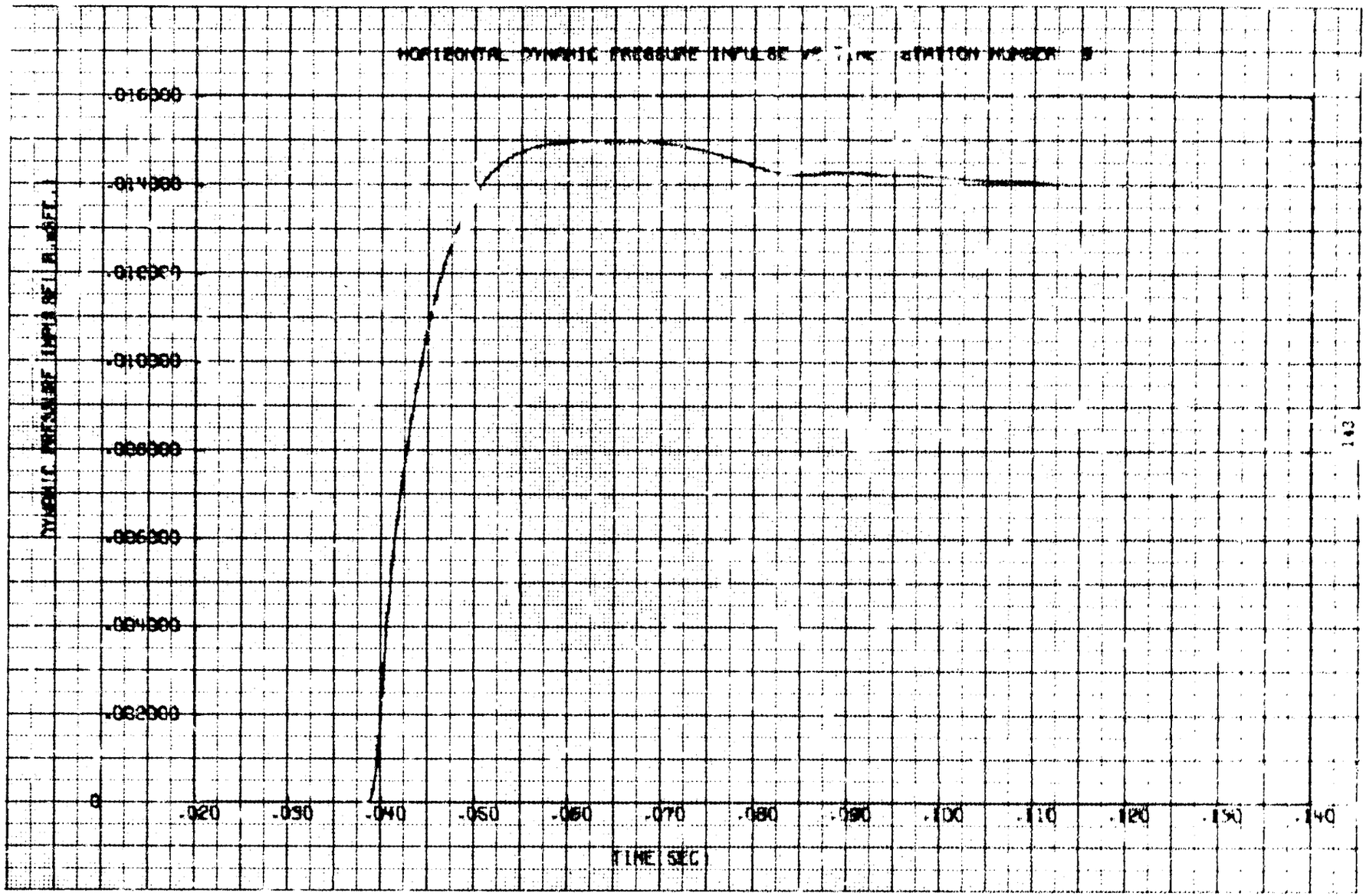

OVER PRESSURE VS TIME STATION NUMBER 3
TIME SEC.
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
-.130
-.140

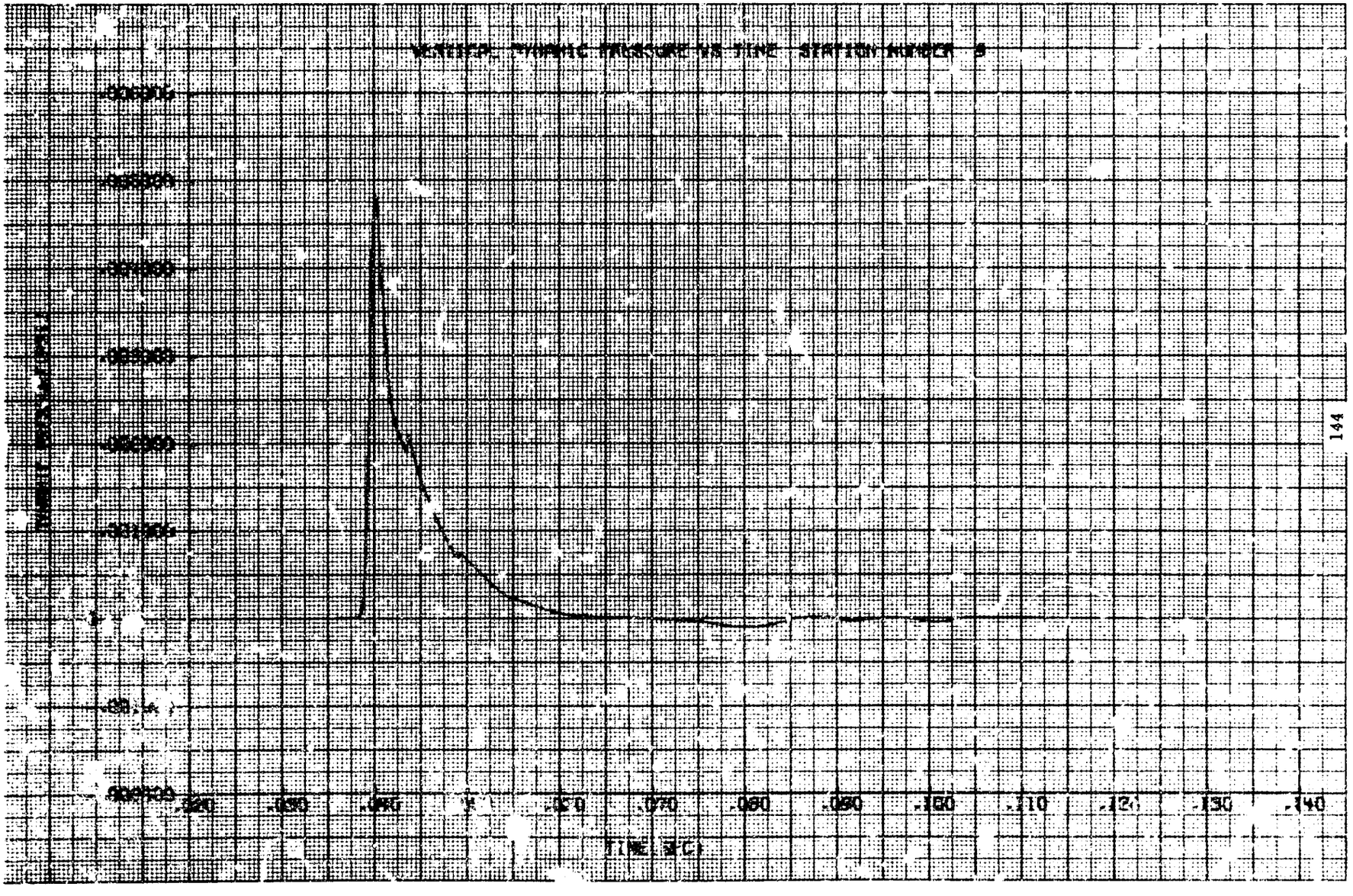

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 9
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)
139

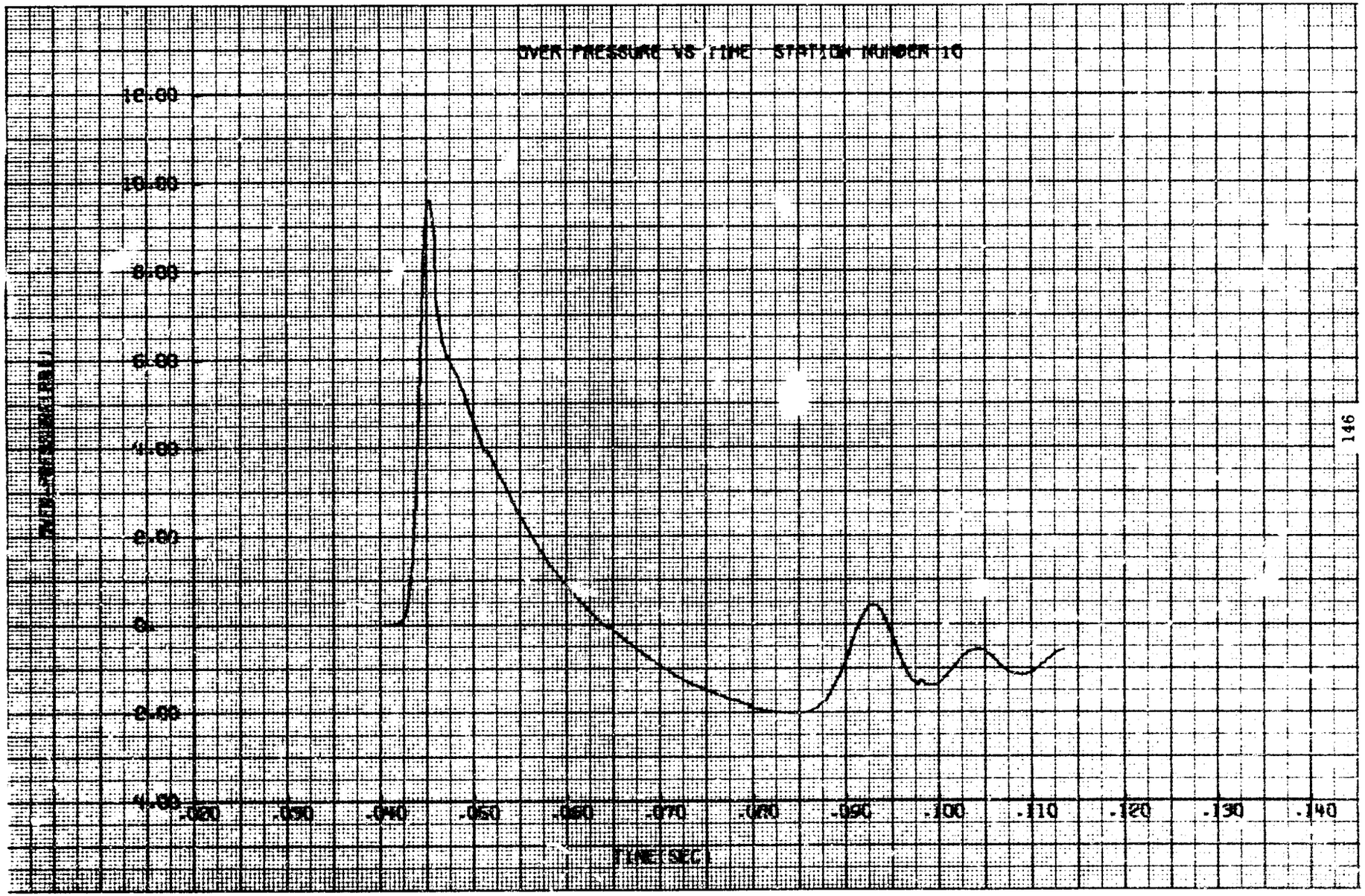
TIME SEC

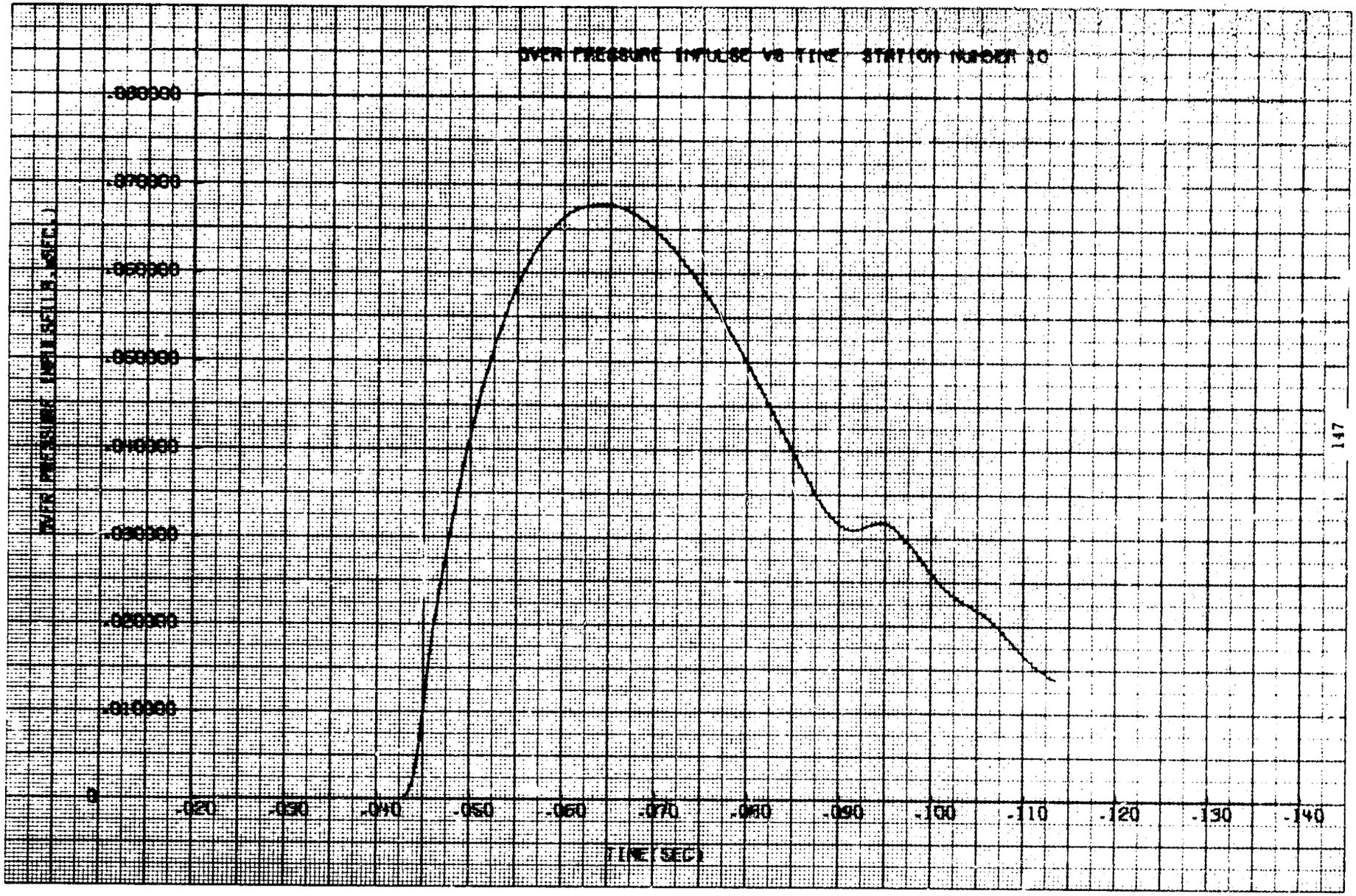


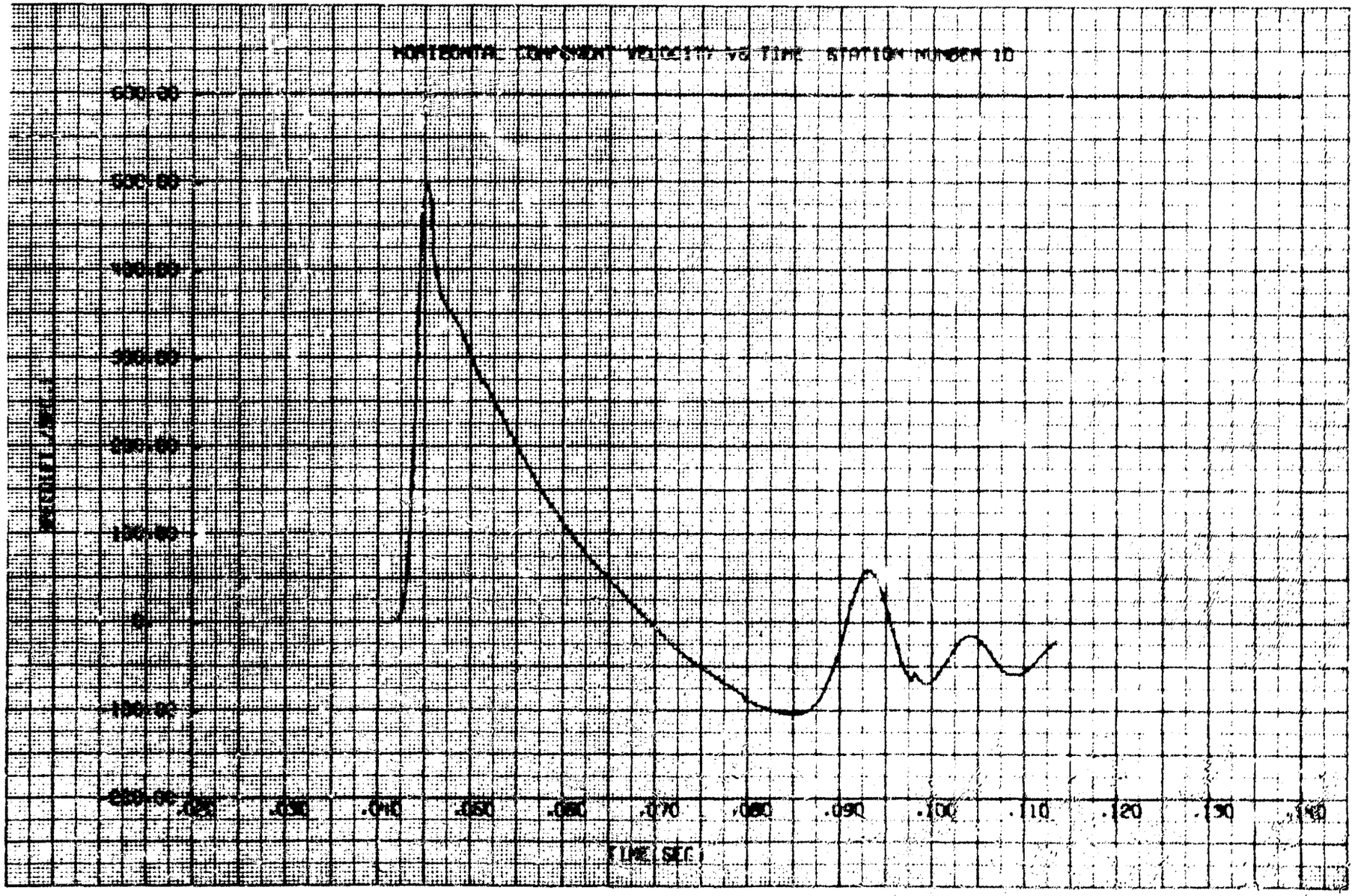

HORIZONTAL OVERPRESSURE VS TIME STATION NUMBER 9
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
TIME (SEC.)

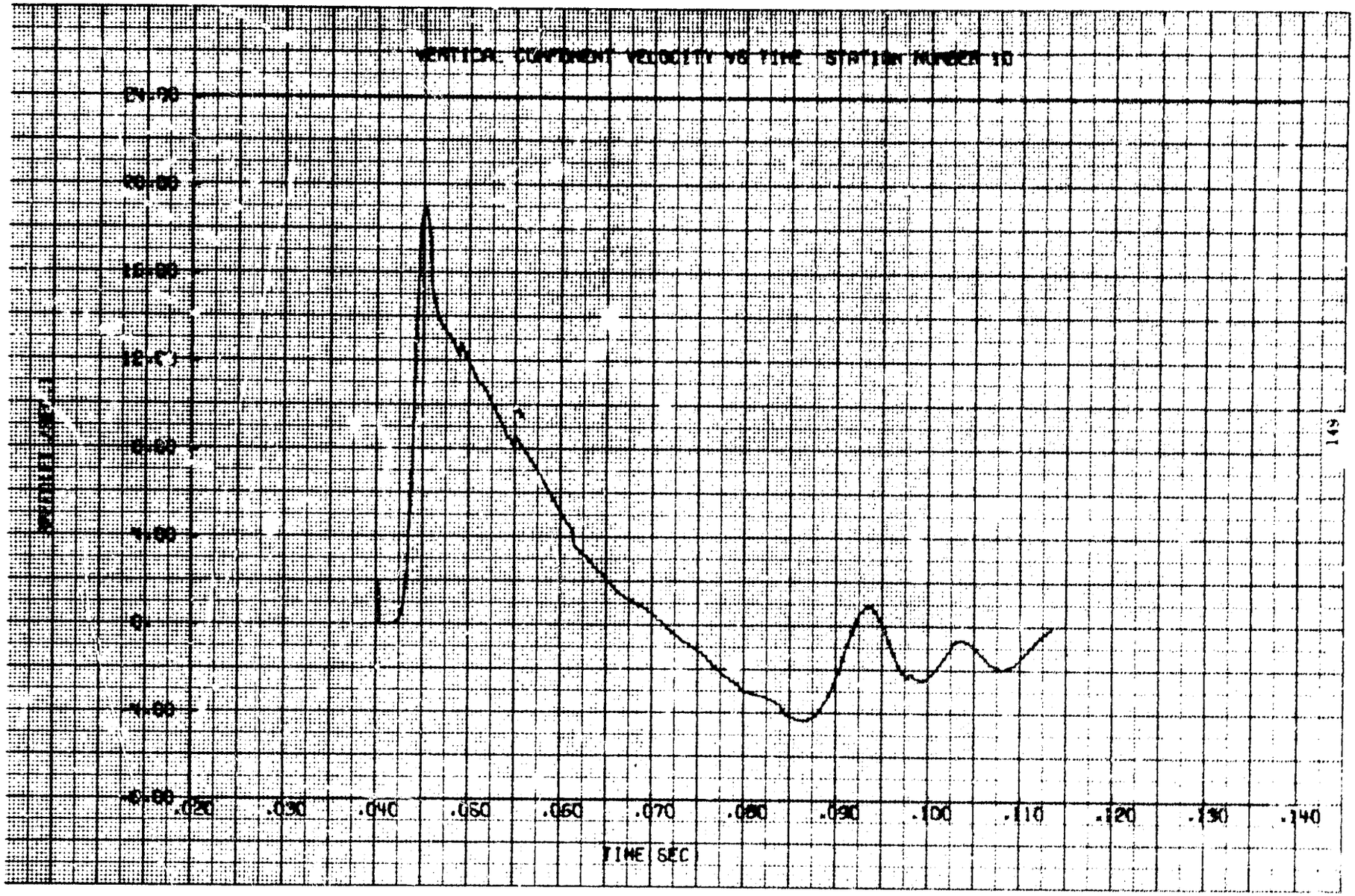

.016000
.014000
.012000
.010000
.008000
.006000
.004000
.002000
0
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)

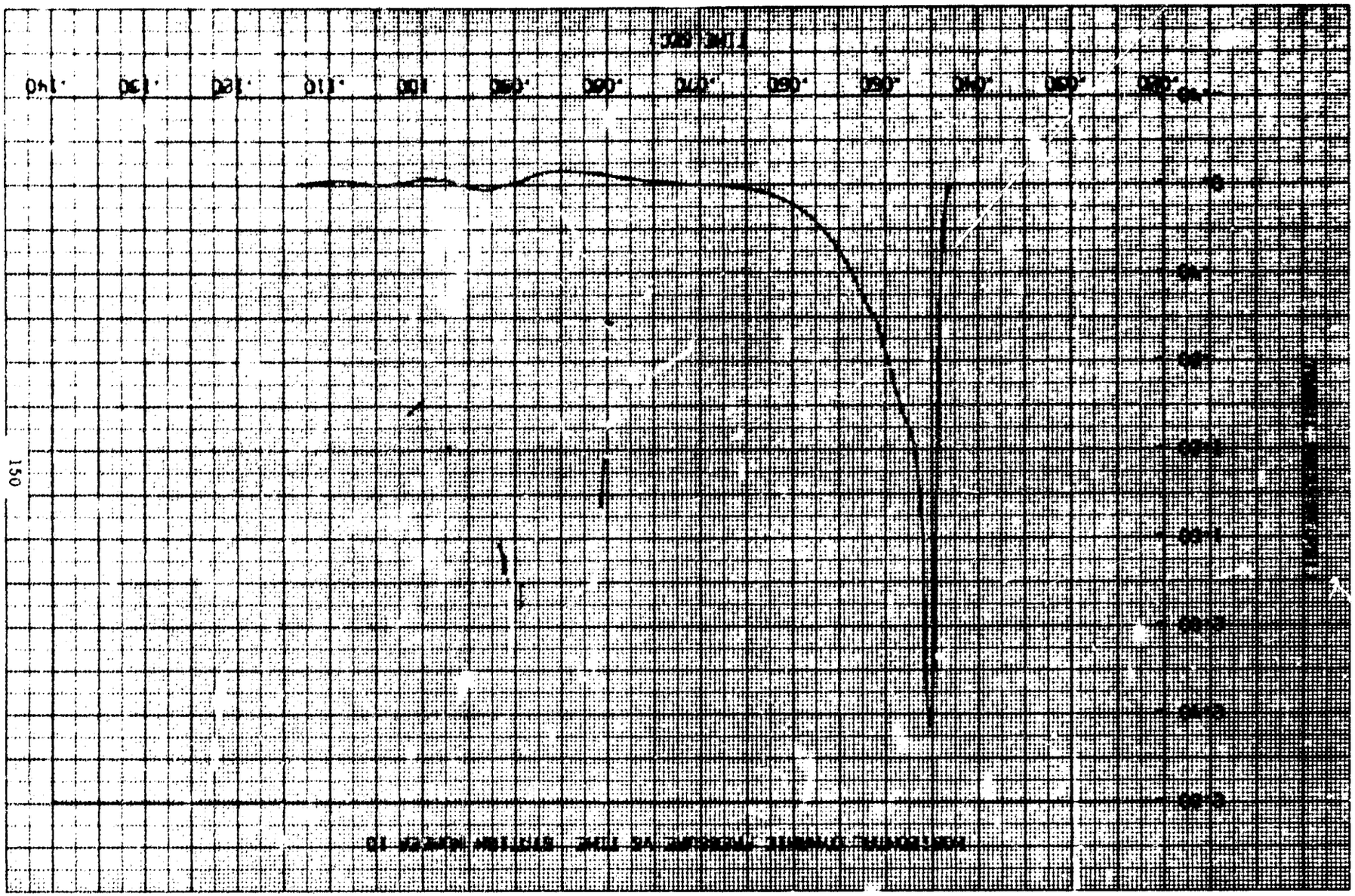

TIME (SEC)
144


OVER PRESSURE VS TIME STATION NUMBER 10
10.00
8.00
6.00
4.00
2.00
0.
-2.00
-4.00
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)


OVER PRESSURE IMPULSE VS TIME STATION NUMBER 10
OVER PRESSURE IMPULSE (PSI-SEC)
-000000
-070000
-050000
-030000
-010000
-000000
-020000
-010000
0
-020
-030
-040
-050
-060
-070
-080
-090
-100
-110
-120
-130
-140
TIME (SEC)


HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
VELOCITY (IN/SEC)
-500.00
-400.00
-300.00
-200.00
-100.00
0
100.00
200.00
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)


VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
24.00
16.00
8.00
0.
-8.00
-16.00
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME SEC



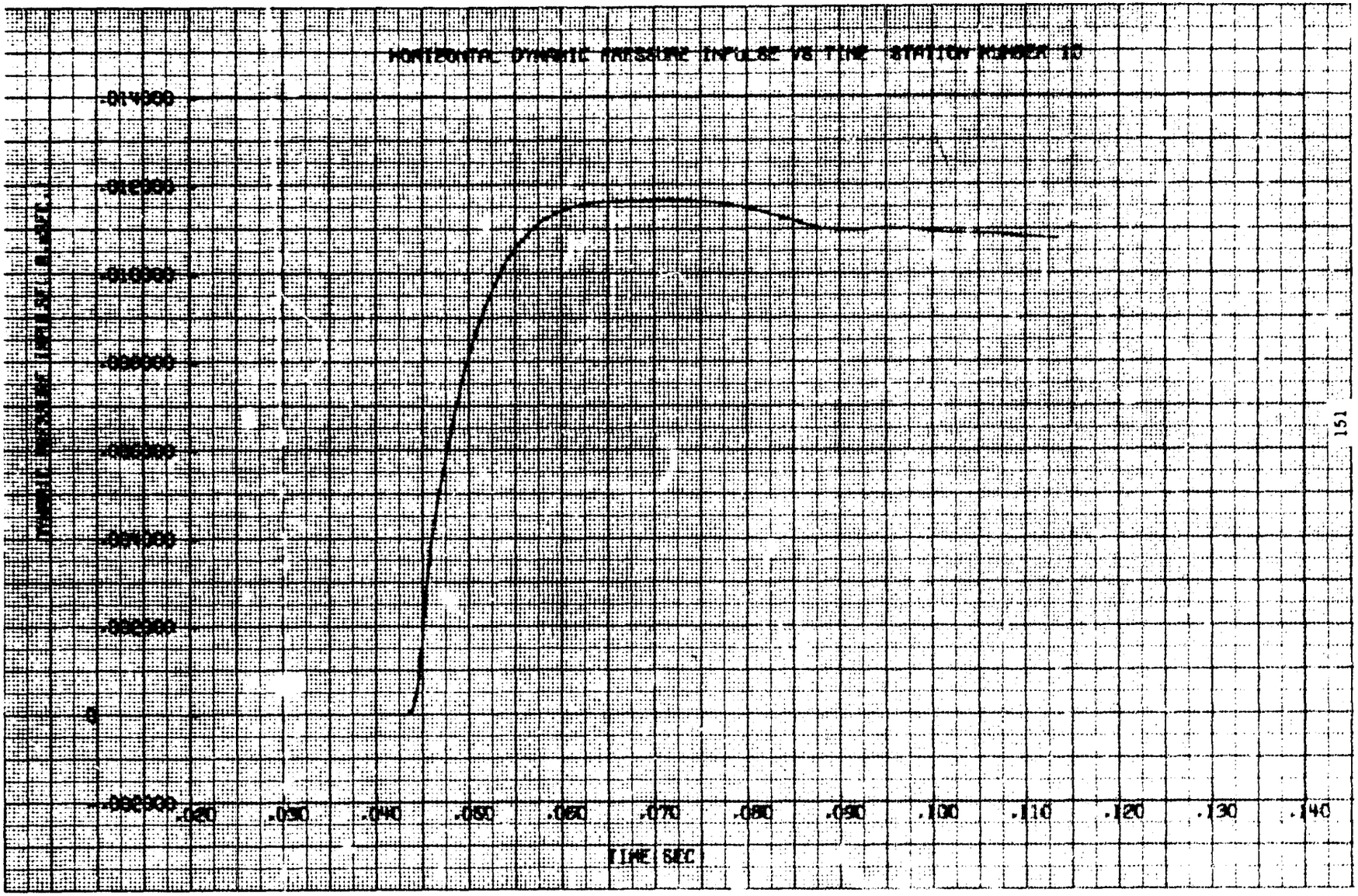
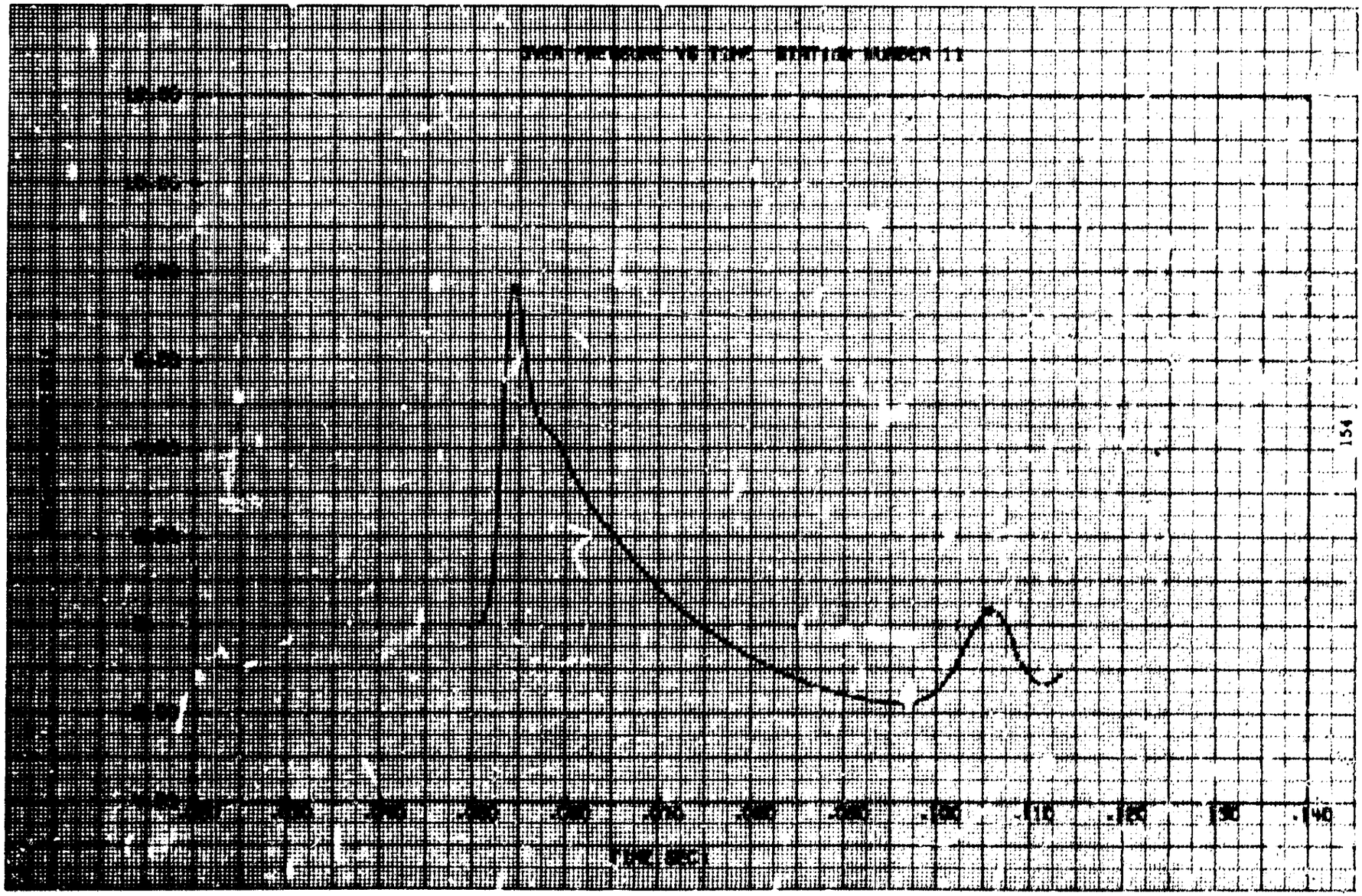
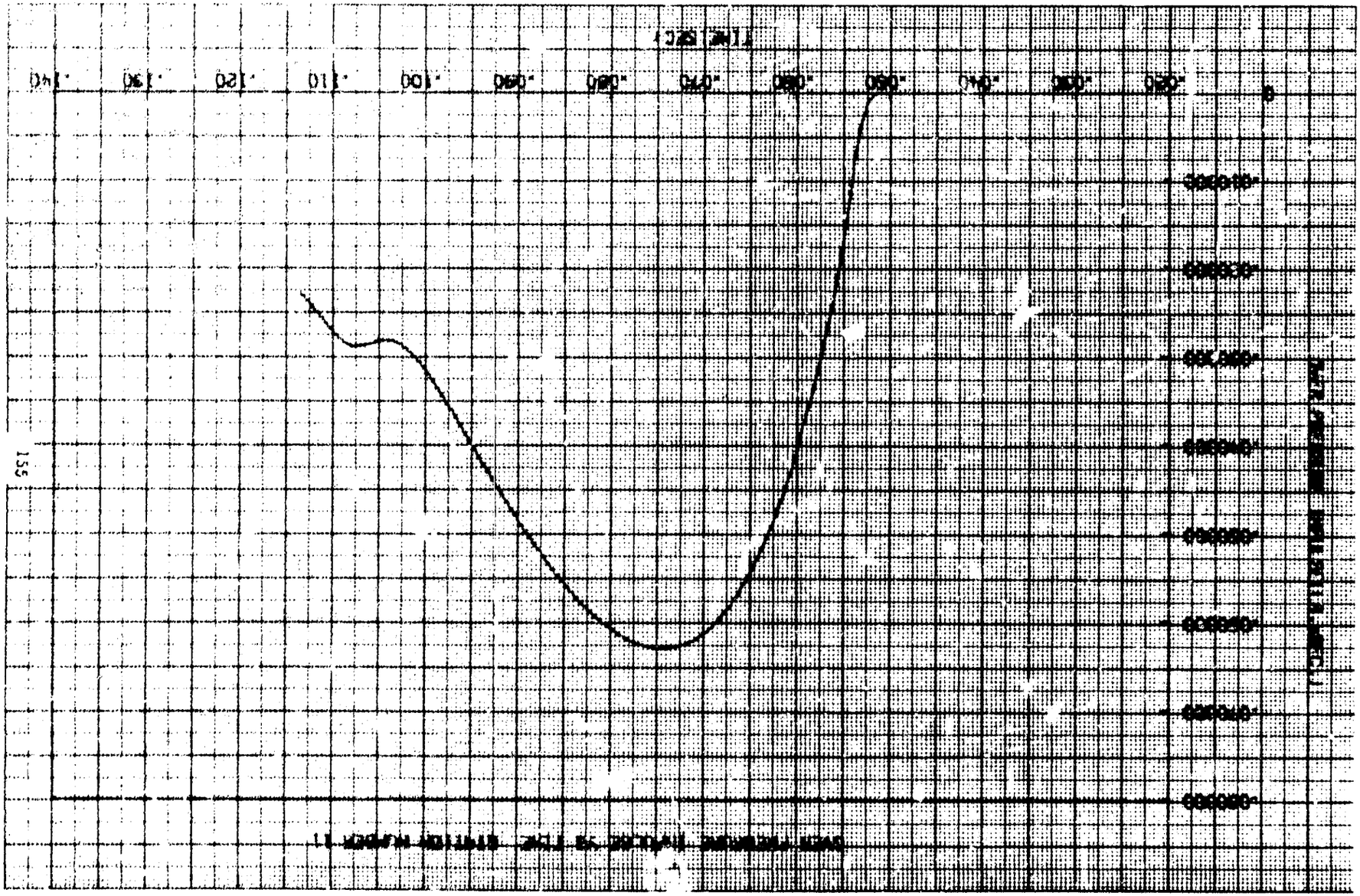

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
-.130
-.140
TIME SEC

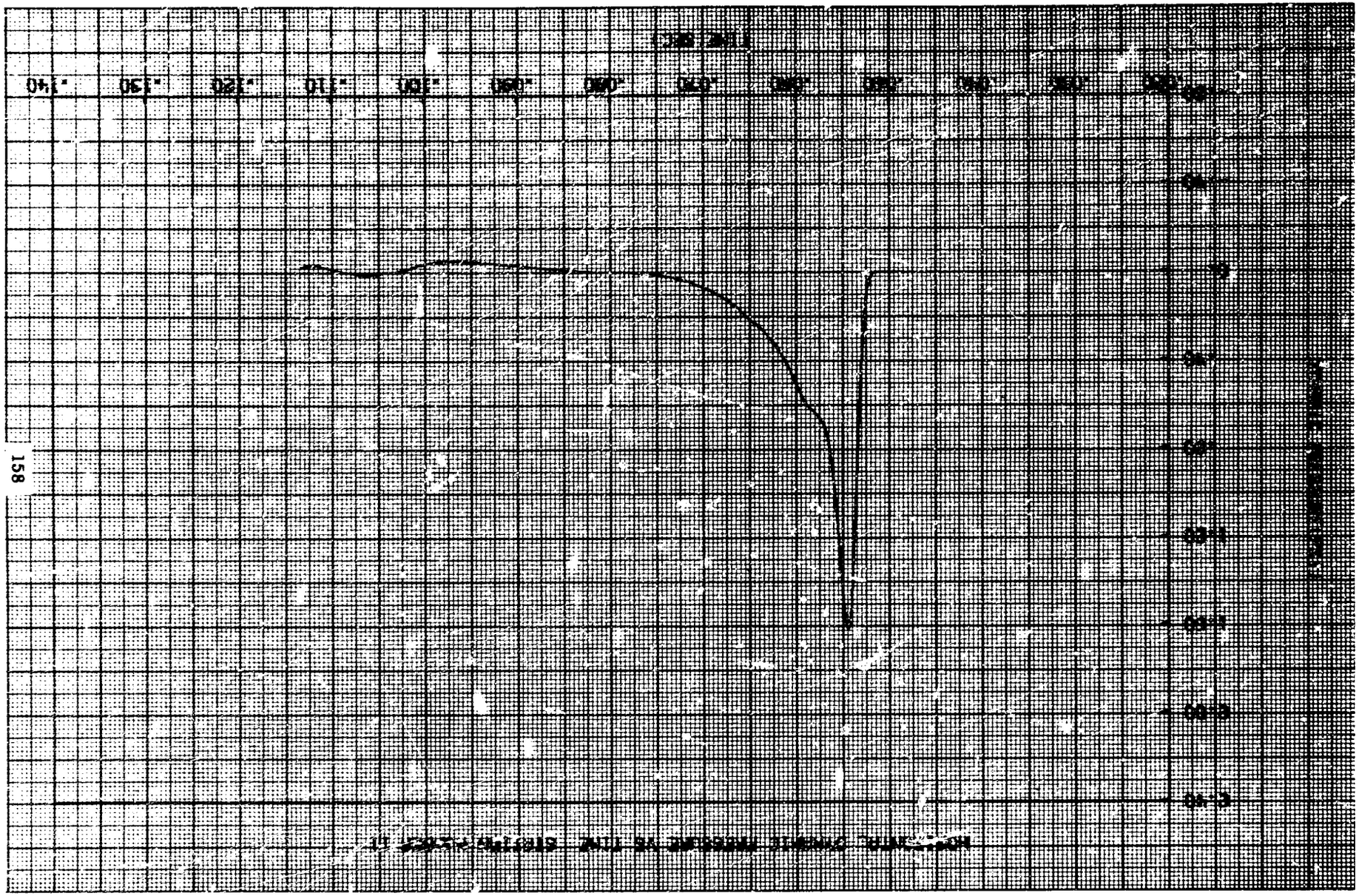
FIGURE 4.3 VARIATION OF THE DYNAMIC PRESSURE WITH TIME AT A POINT ON THE CYLINDER WALL

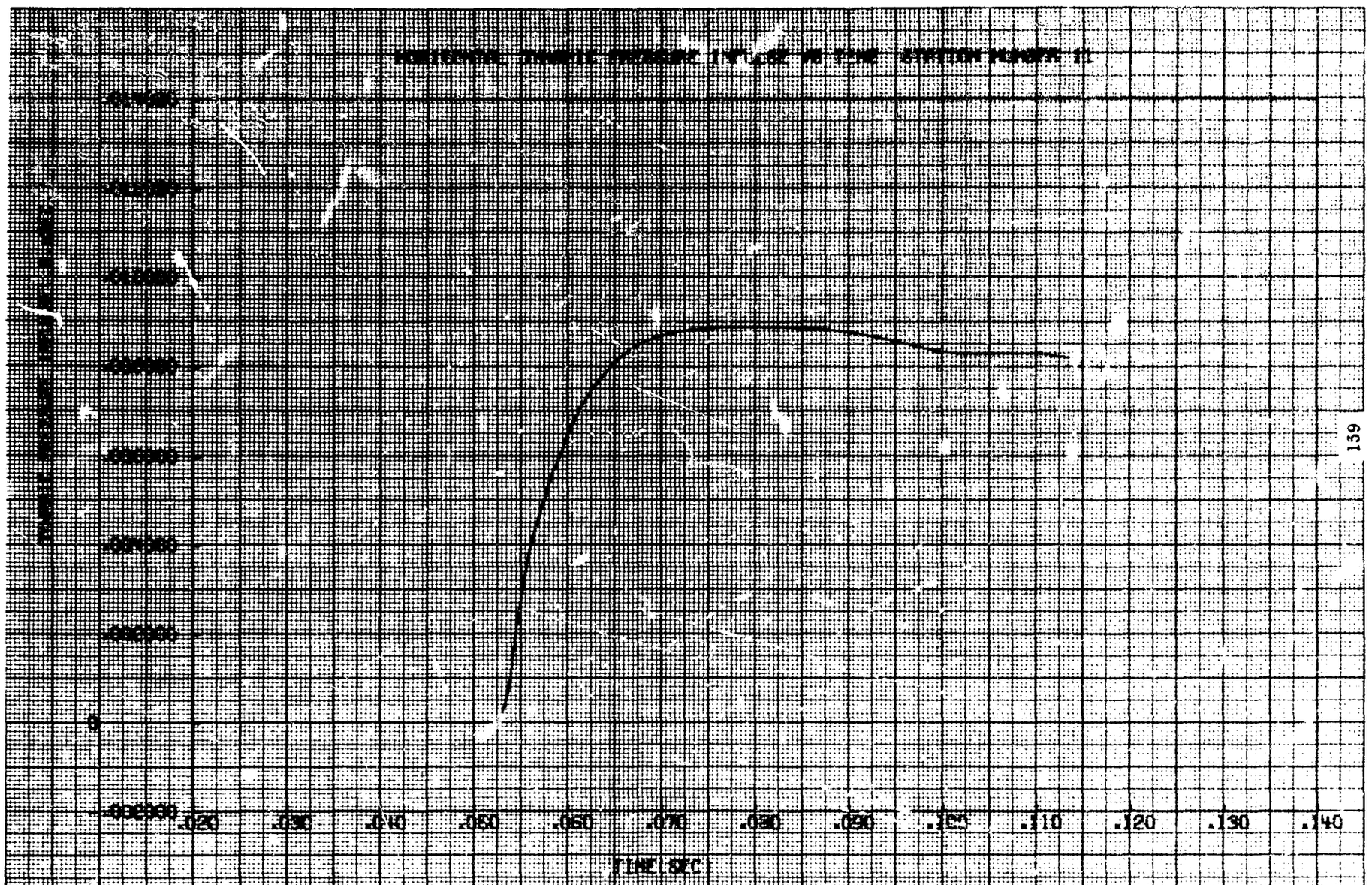
VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME BEHIND INCIDENT SHOCK
TIME SEC
.000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140


154

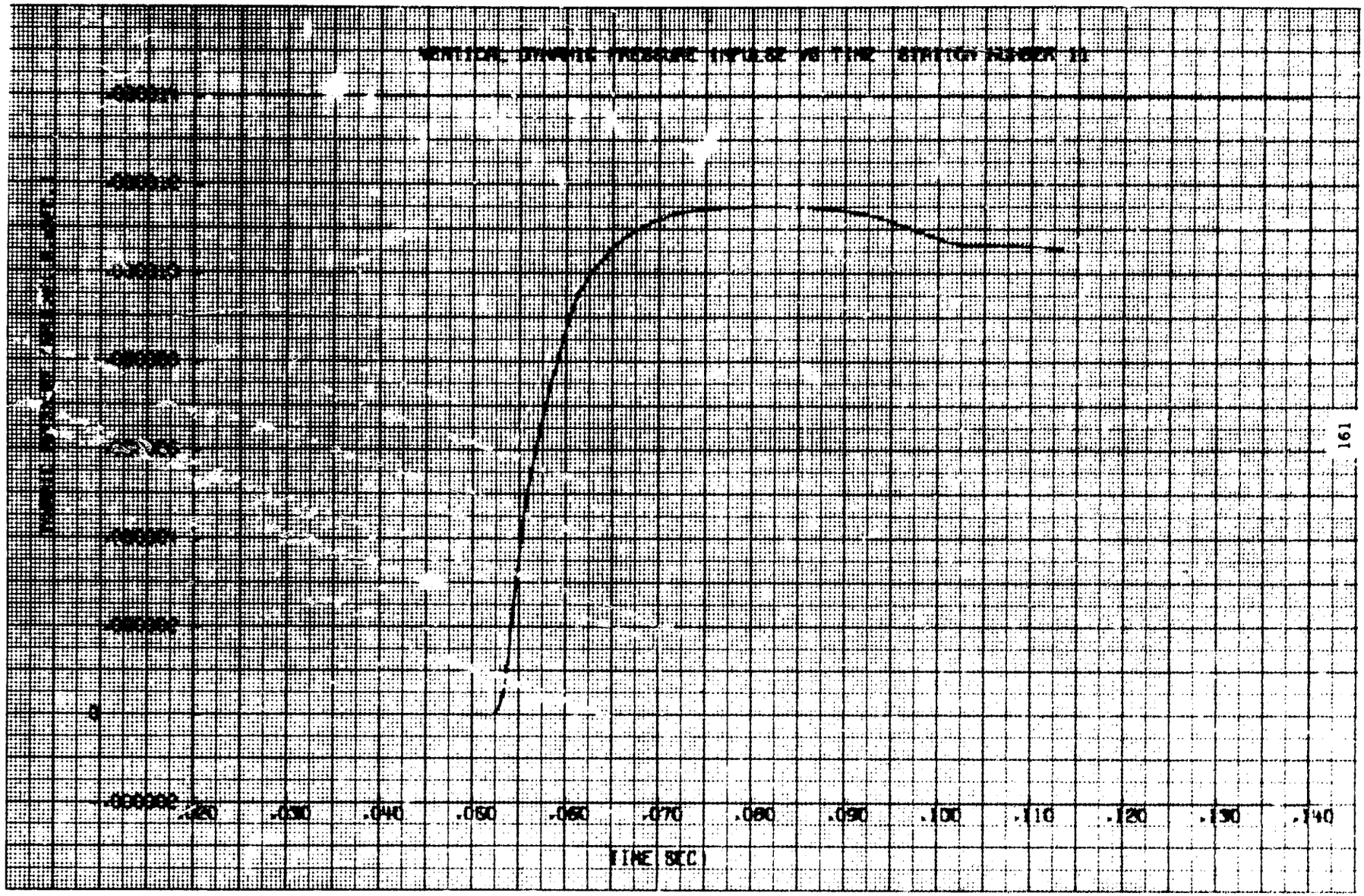


-40 -30 -20 -10 0 10 20 30 40
-140 -130 -120 -110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140




.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME (SEC)

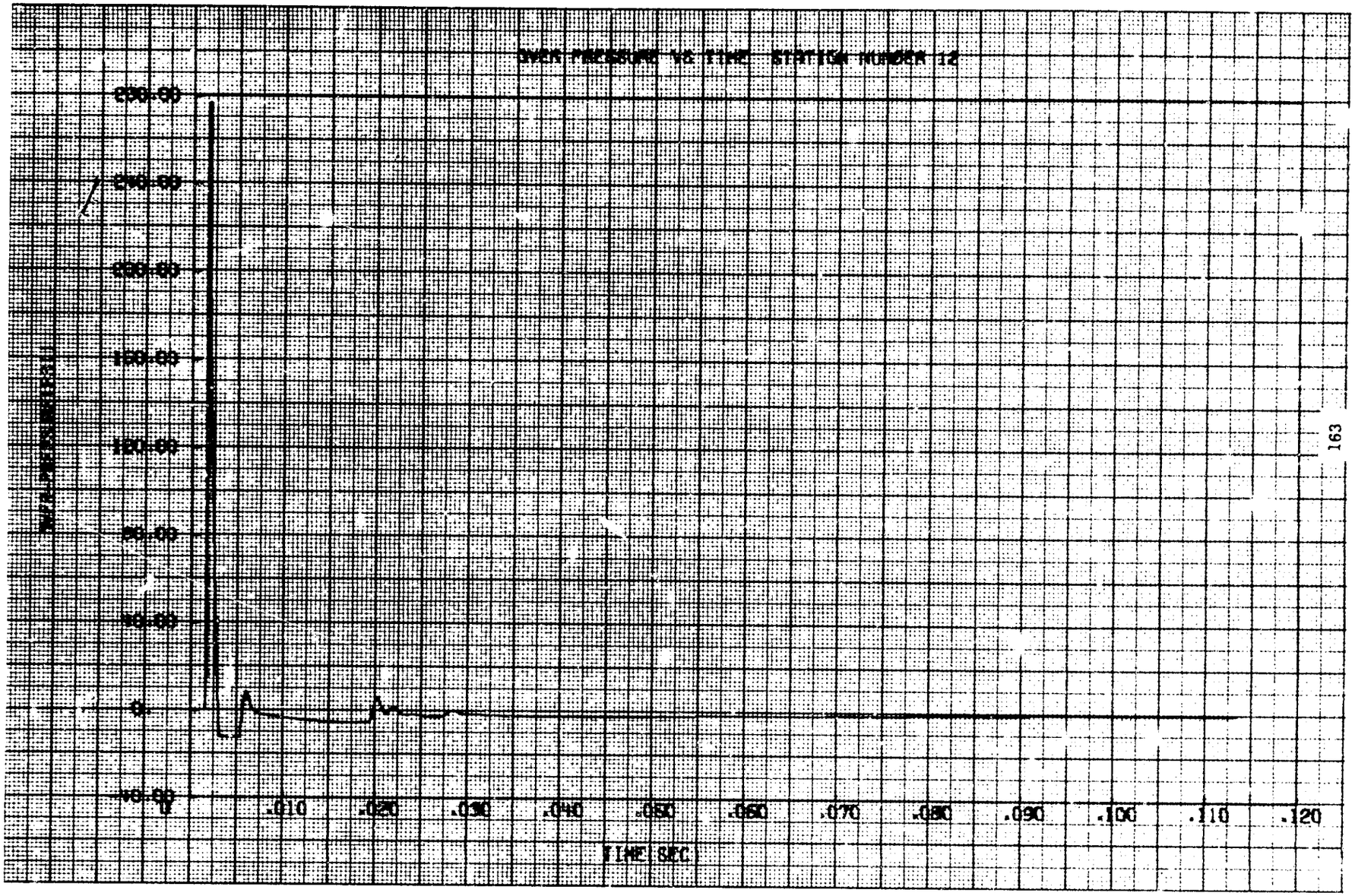
160

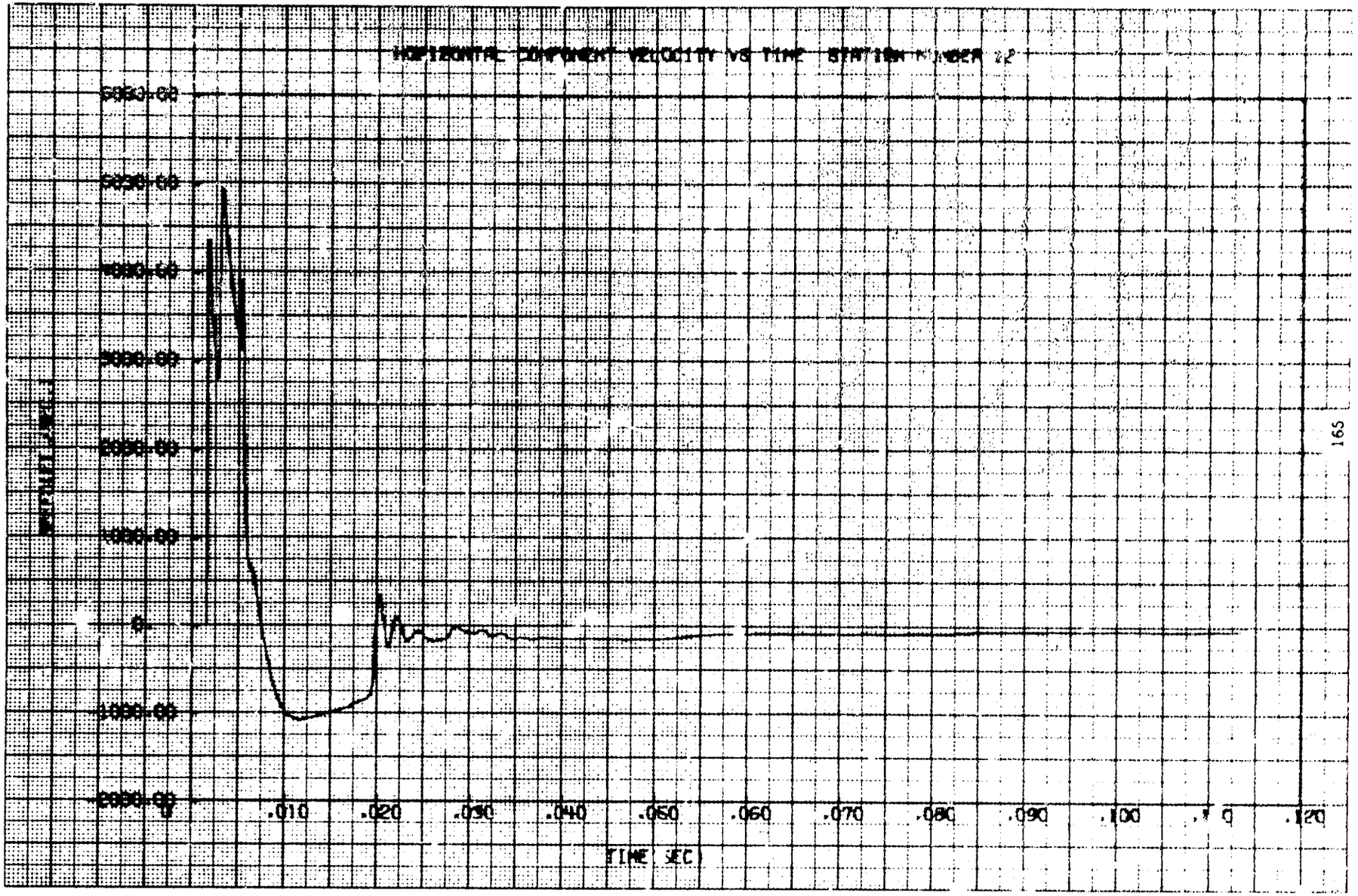

VERTICAL DYNAMIC PRESSURE TAP 6Z VS TIME STATION RUNWAY 11
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
TIME SEC)

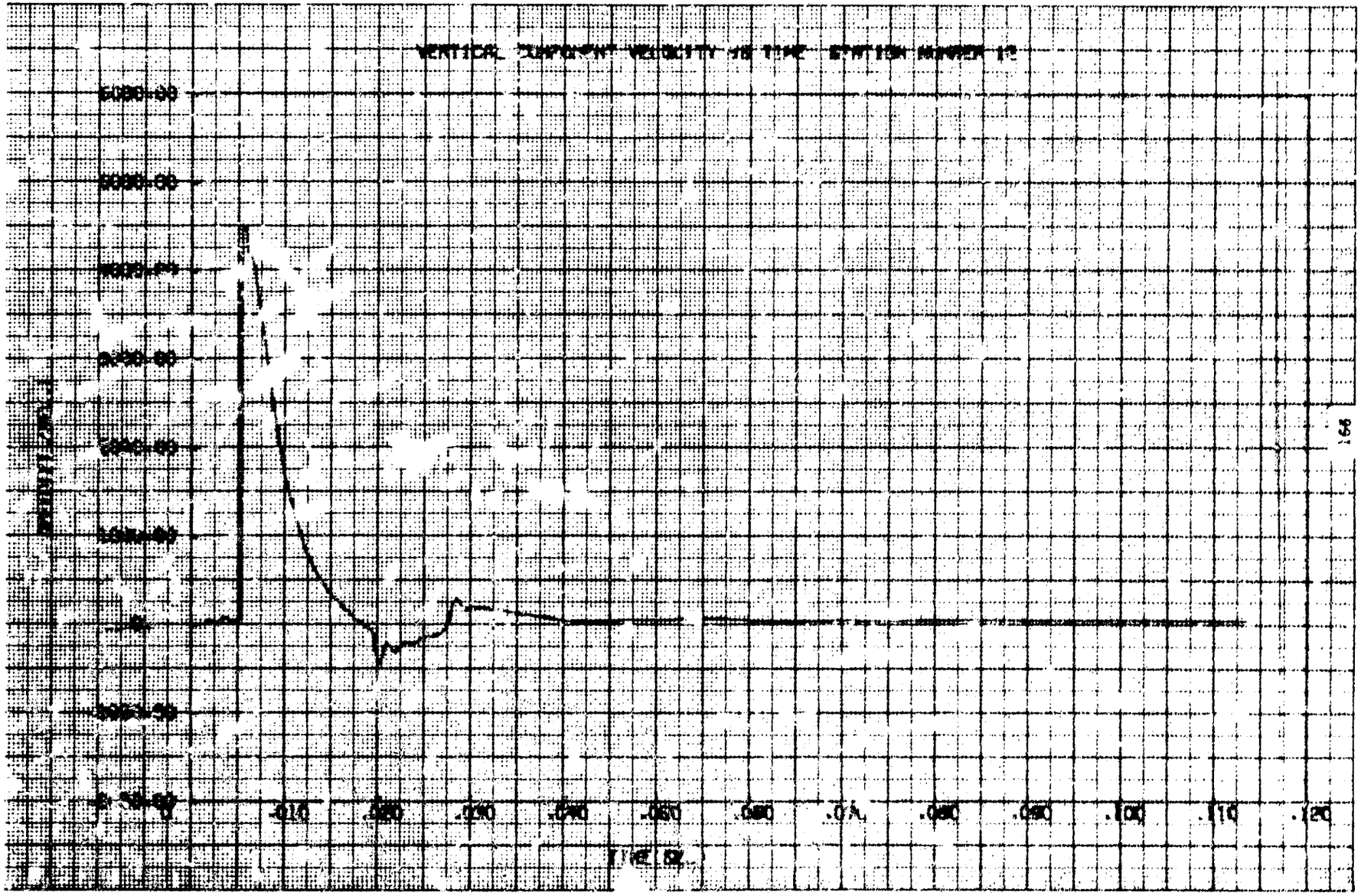
Appendix III

STATION 12 TO 19 PLOTS

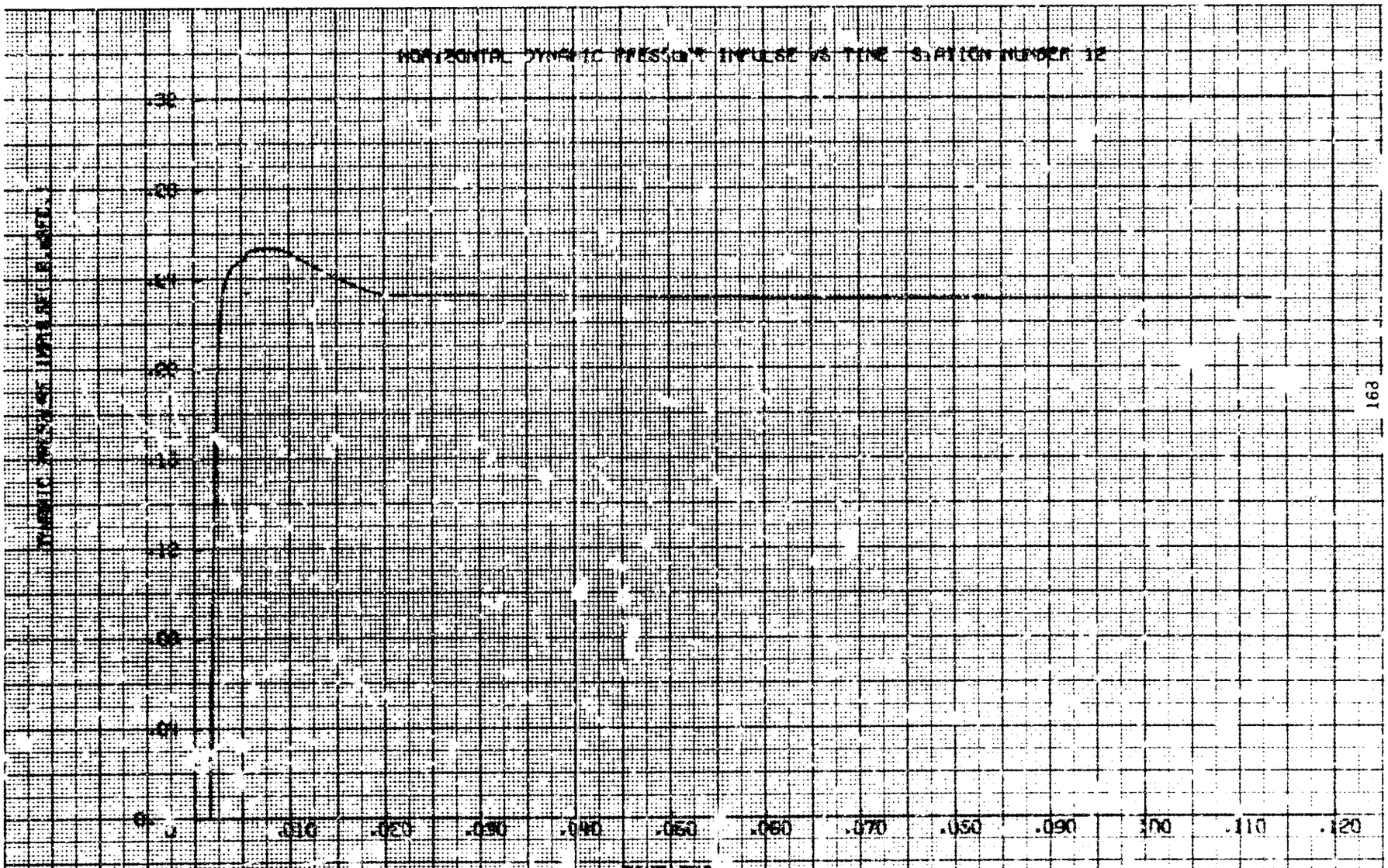
The stations used to obtain these plots were located at burst height with increasing radii.


OVER PRESSURE VS TIME STATION NUMBER 12
200.00
160.00
120.00
80.00
40.00
0.
-40.00
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC

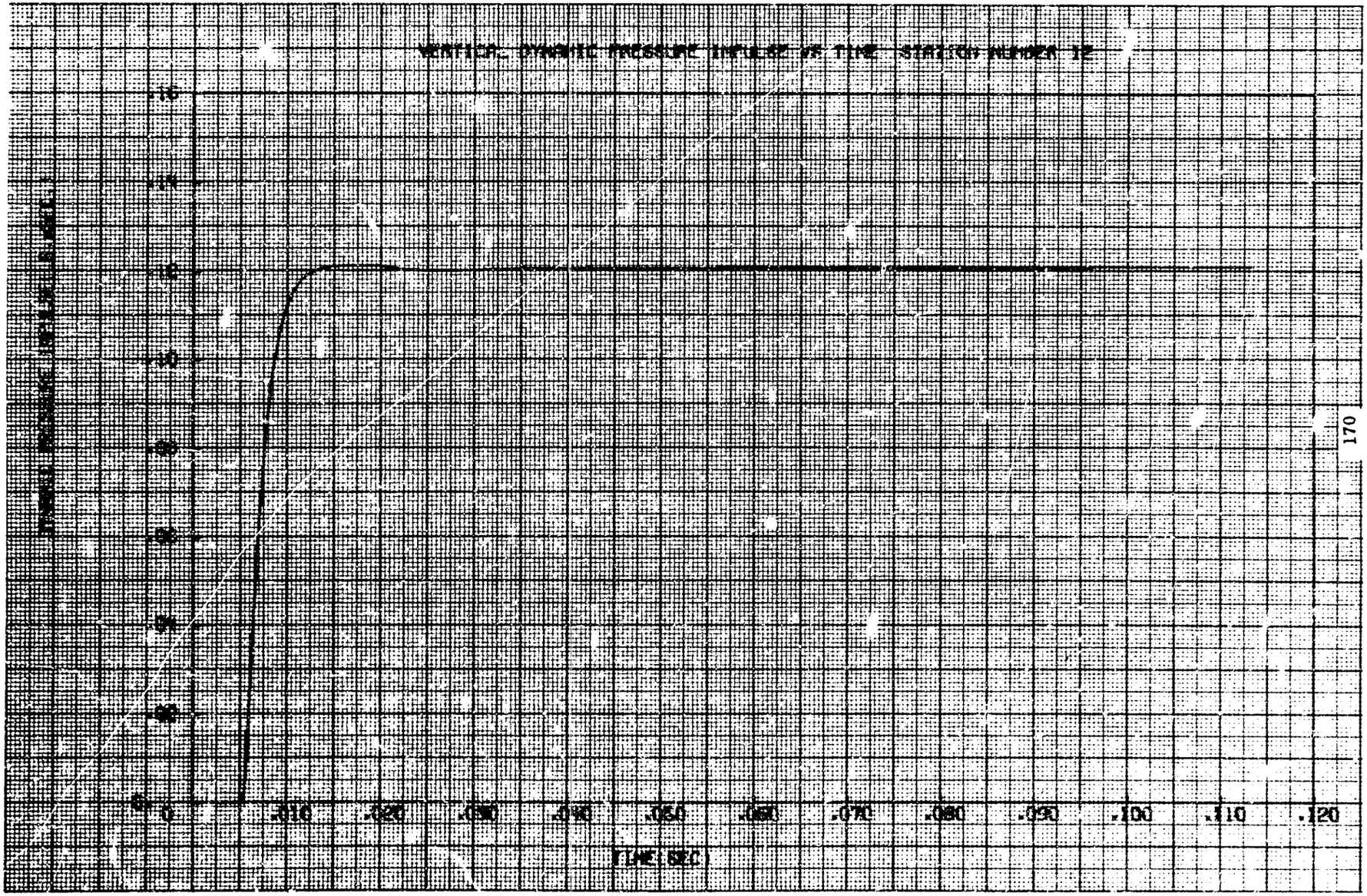

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 42
5000.00
2000.00
1000.00
0.
-1000.00
-2000.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.120
TIME SEC)
165

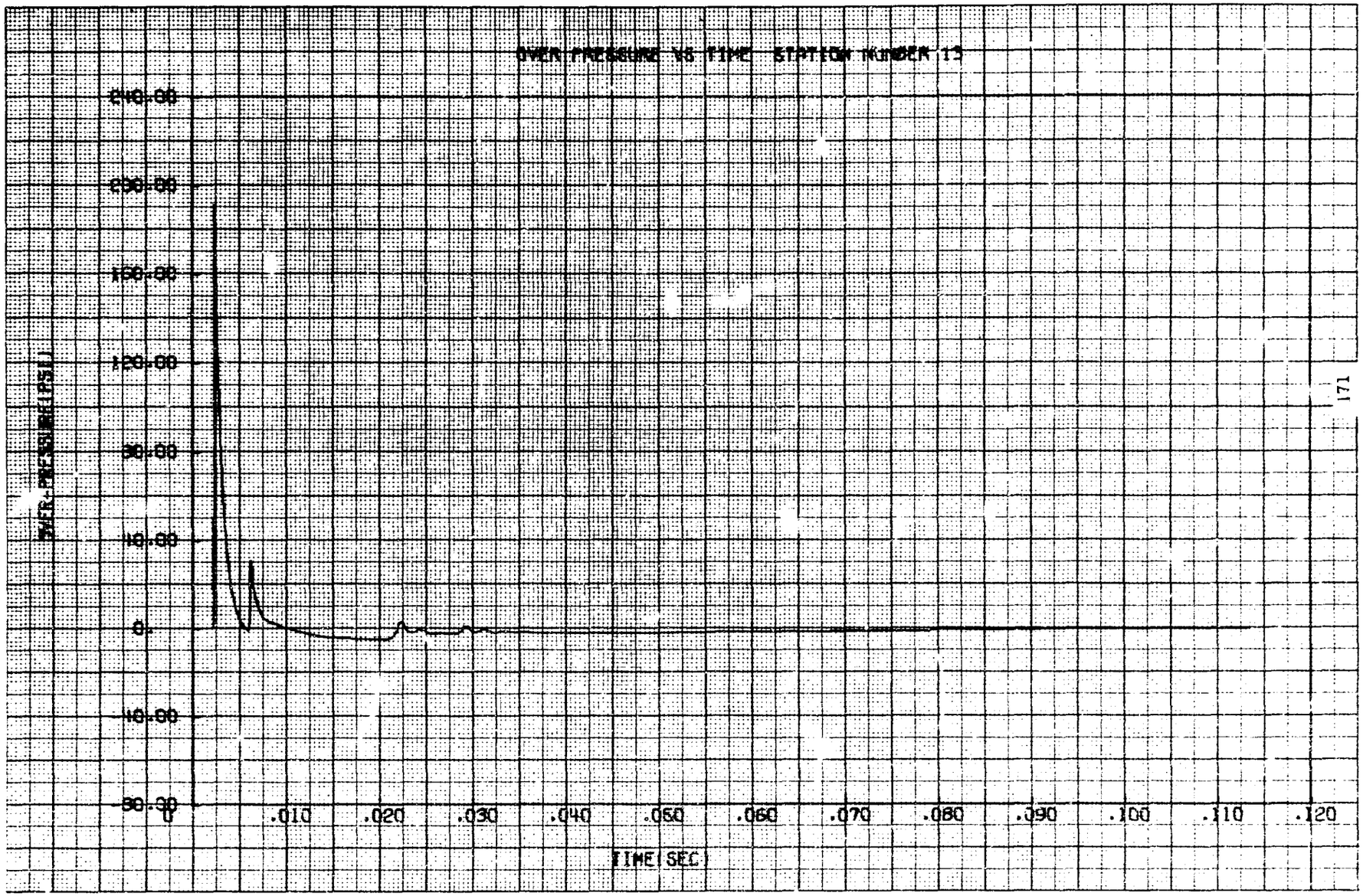

VERTICAL COMPONENT VELOCITY IN TIME STATION NUMBER 12
TIME (SEC.)

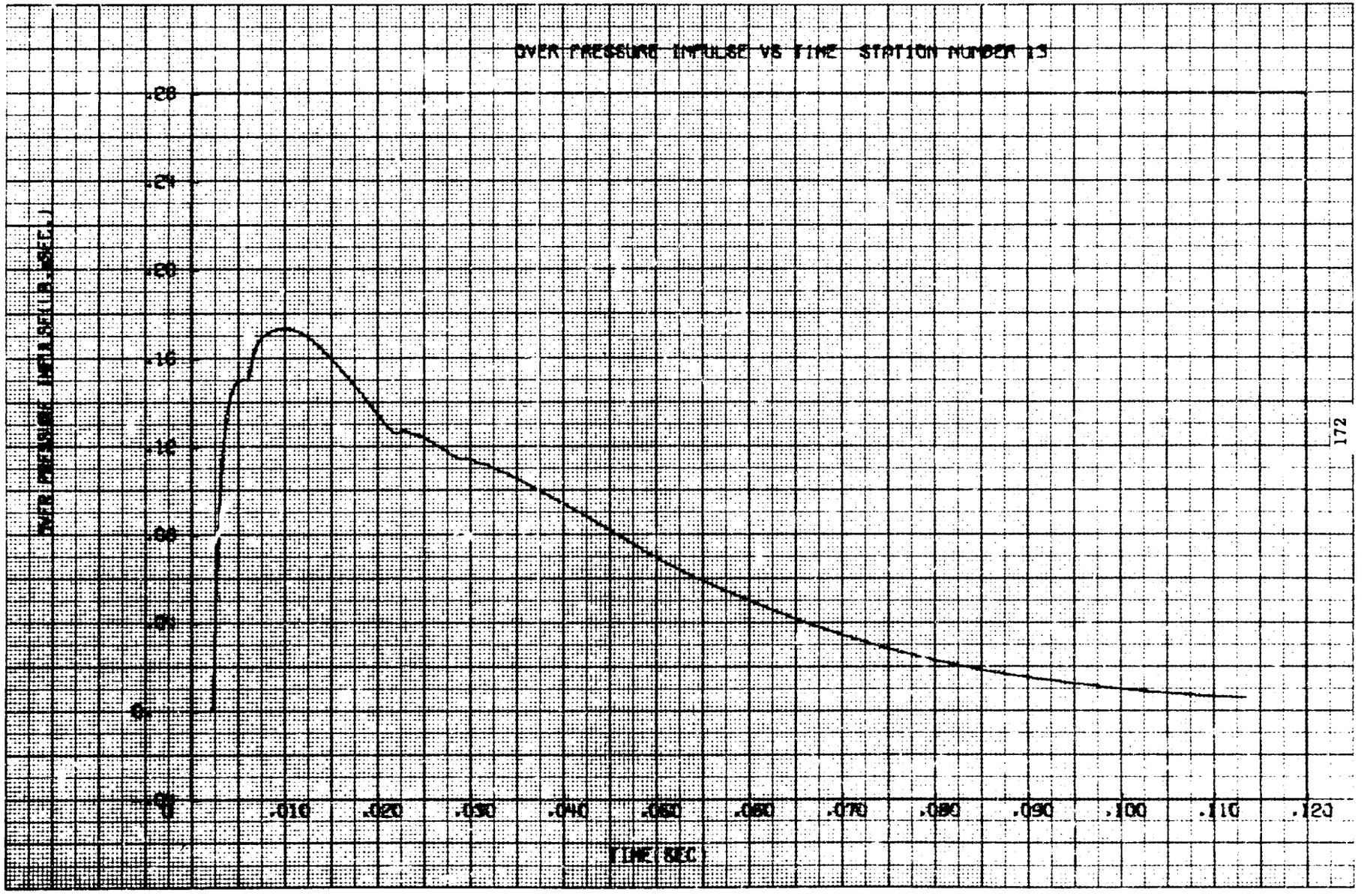
TIME (SEC)
0.0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120

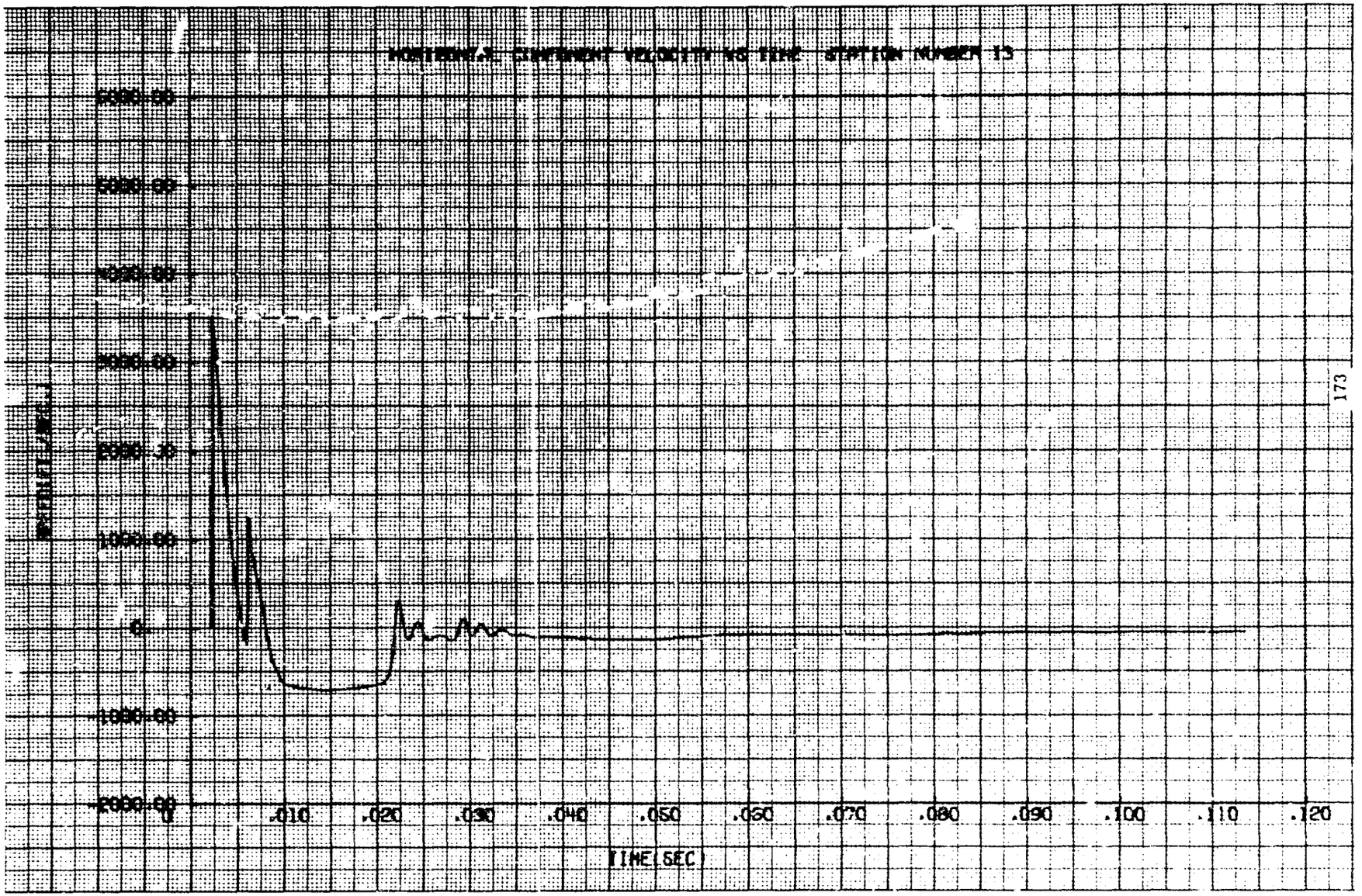

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 12
-30
-20
-10
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC
168

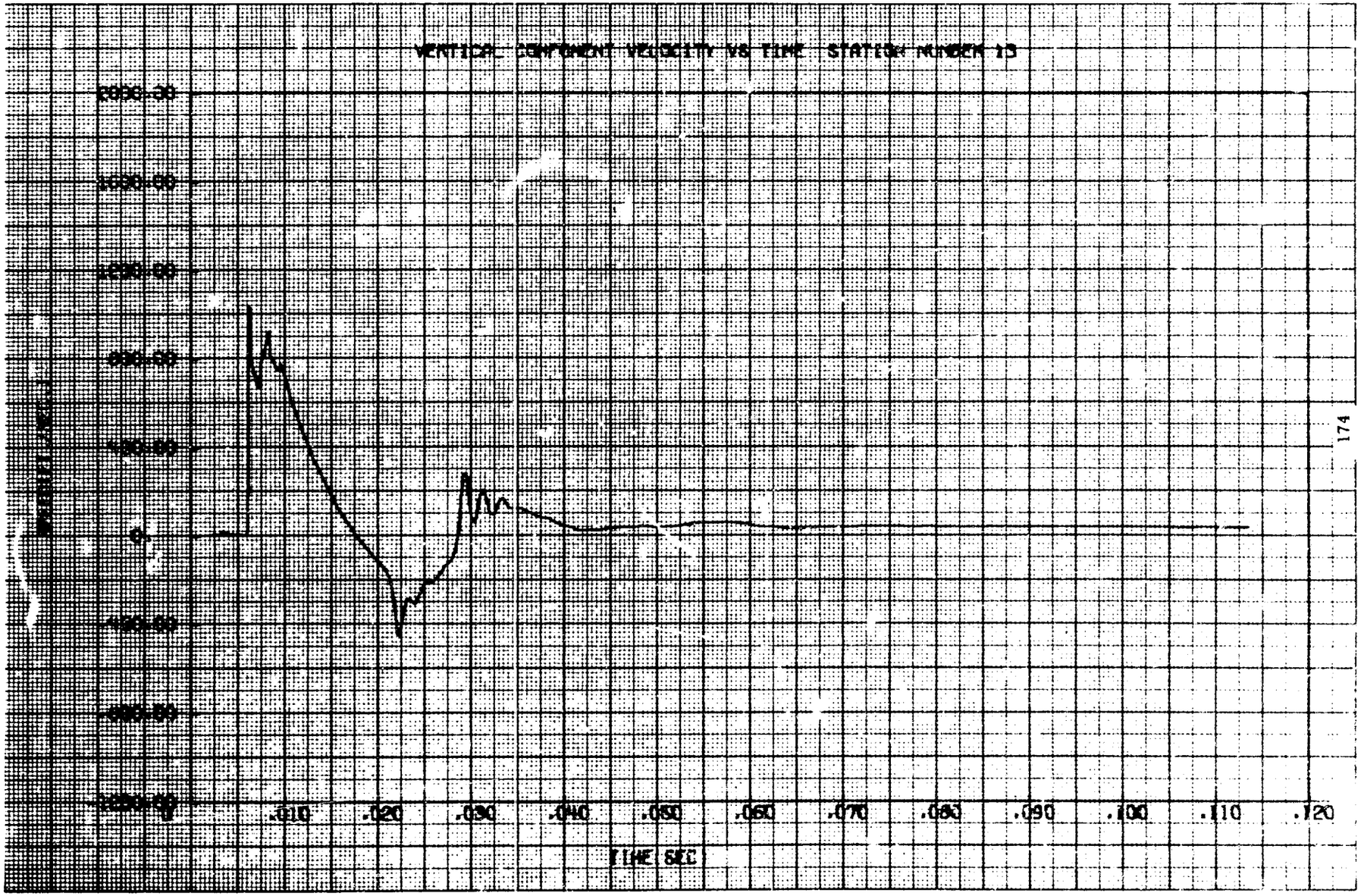
TIME (SEC)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20

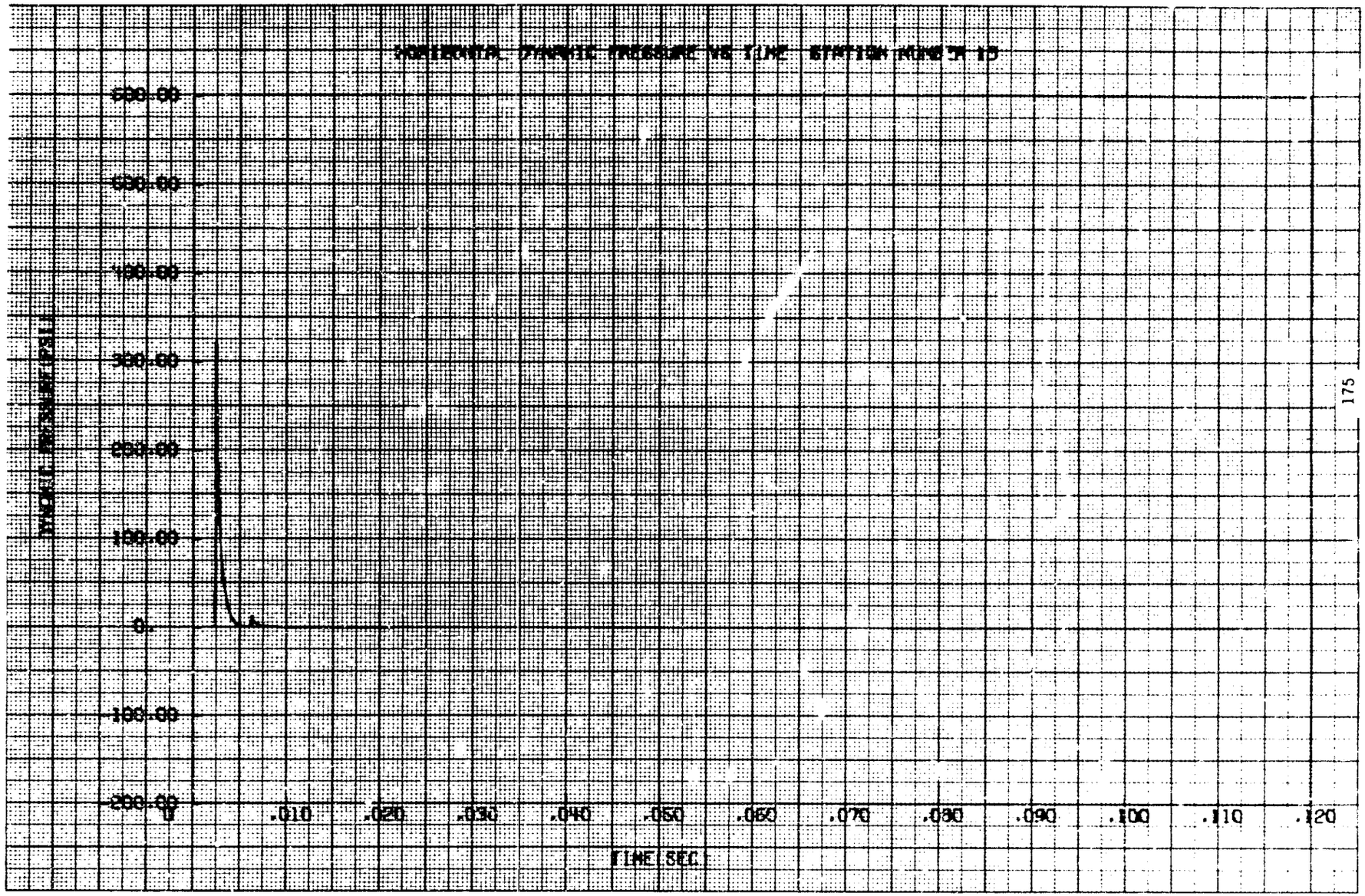

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 12
.16
.14
.12
.10
.08
.06
.04
.02
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)

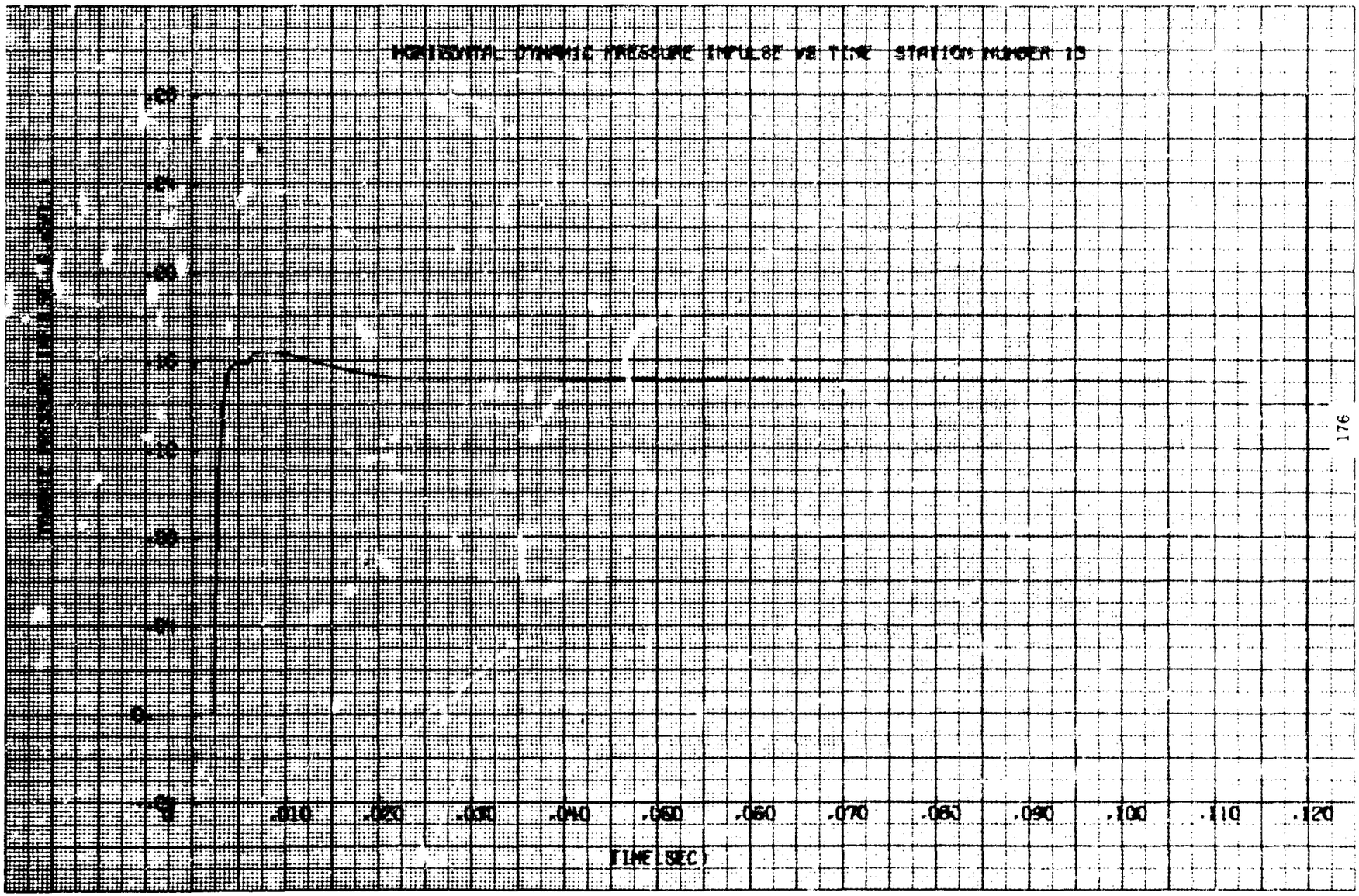

OVER PRESSURE VS TIME STATION NUMBER 15
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
OVER-PRESSURE(PSI)
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

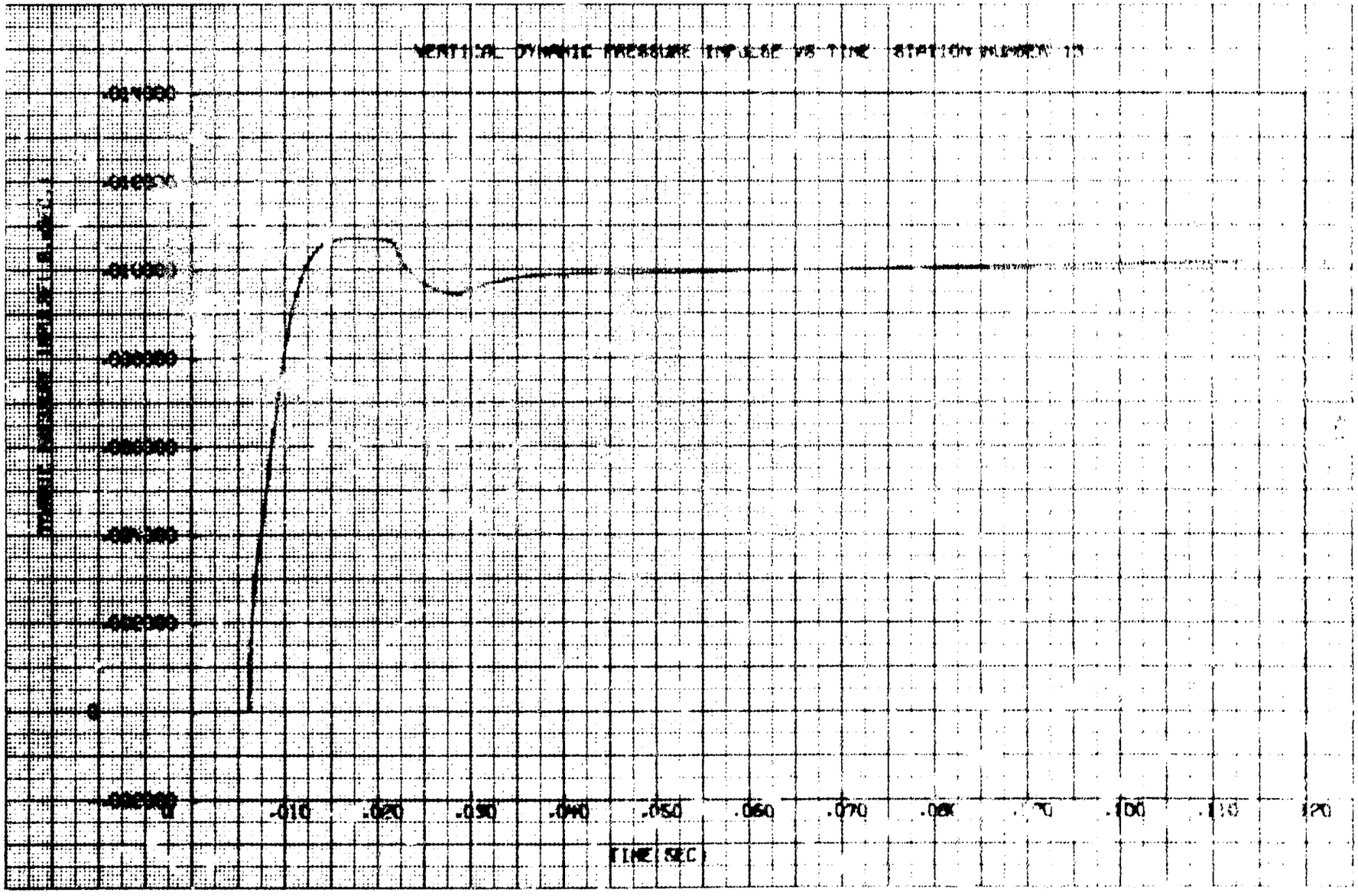

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 13
.28
.24
.20
.16
.12
.08
.04
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)


HORIZONTAL DISPLACEMENT VELOCITY VS TIME STATION NUMBER 13
5000.00
2500.00
0.
-1000.00
-2000.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

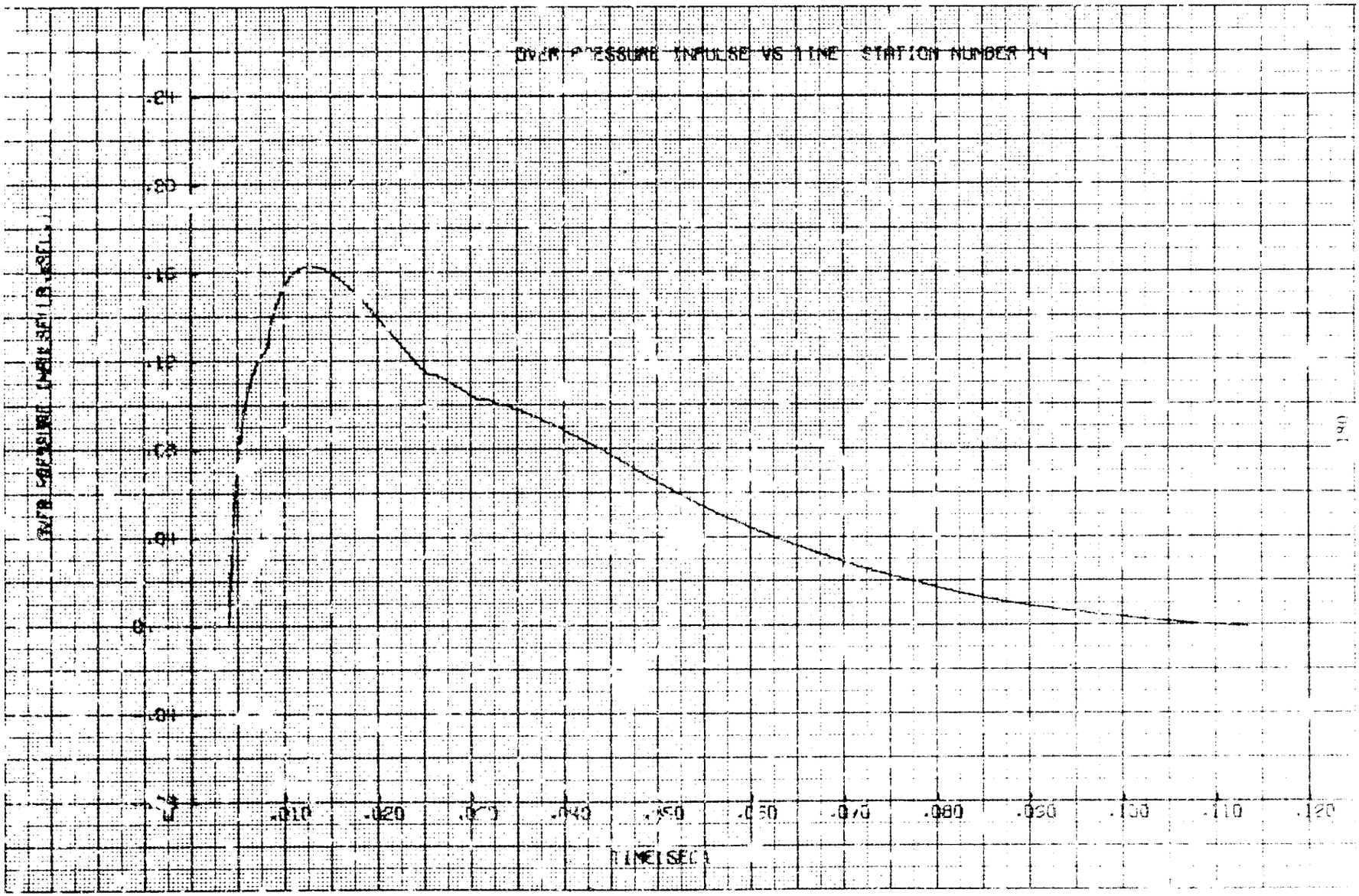

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 13
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC
174

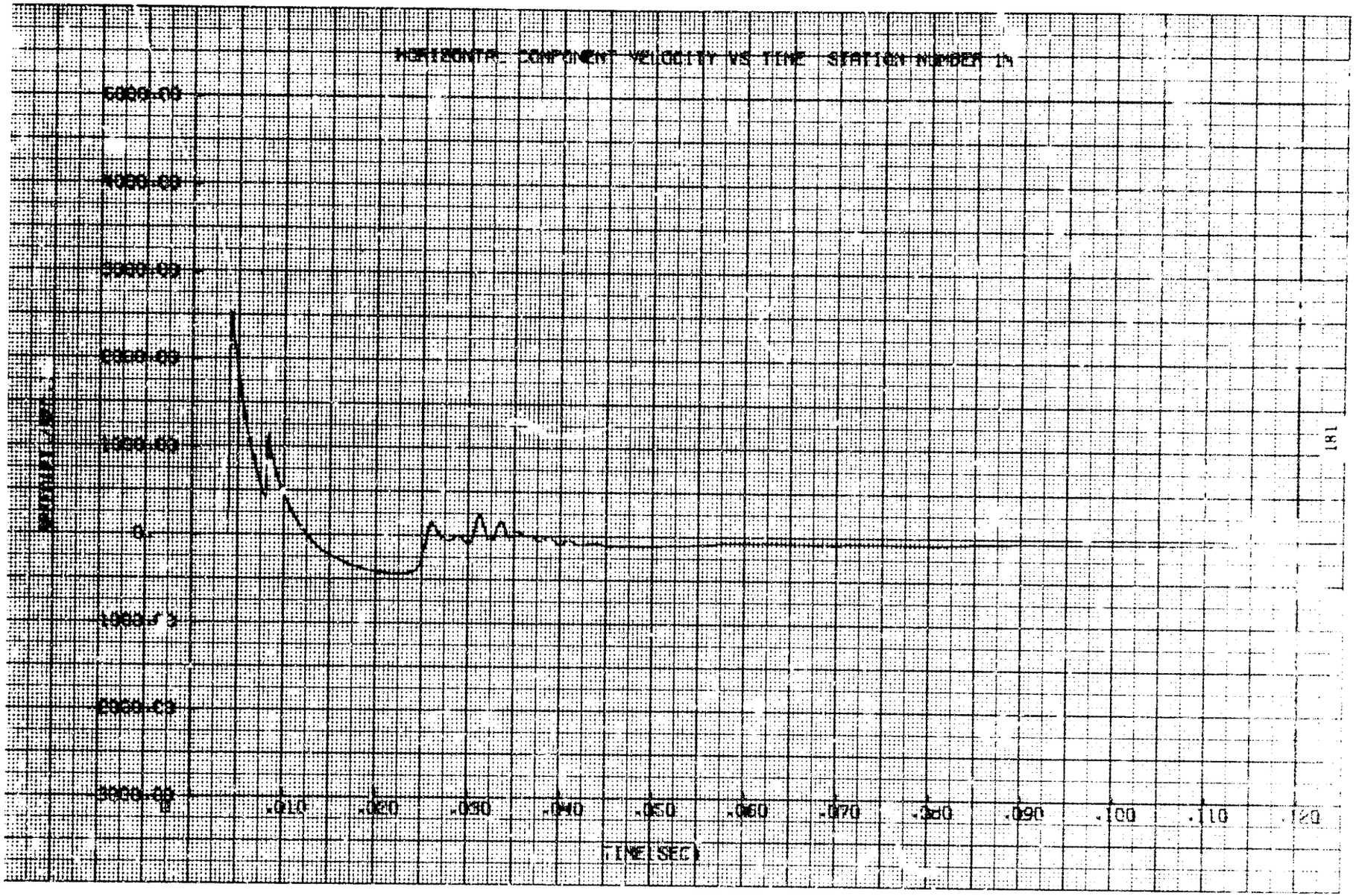

600.00
400.00
200.00
0.
-200.00
-400.00
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

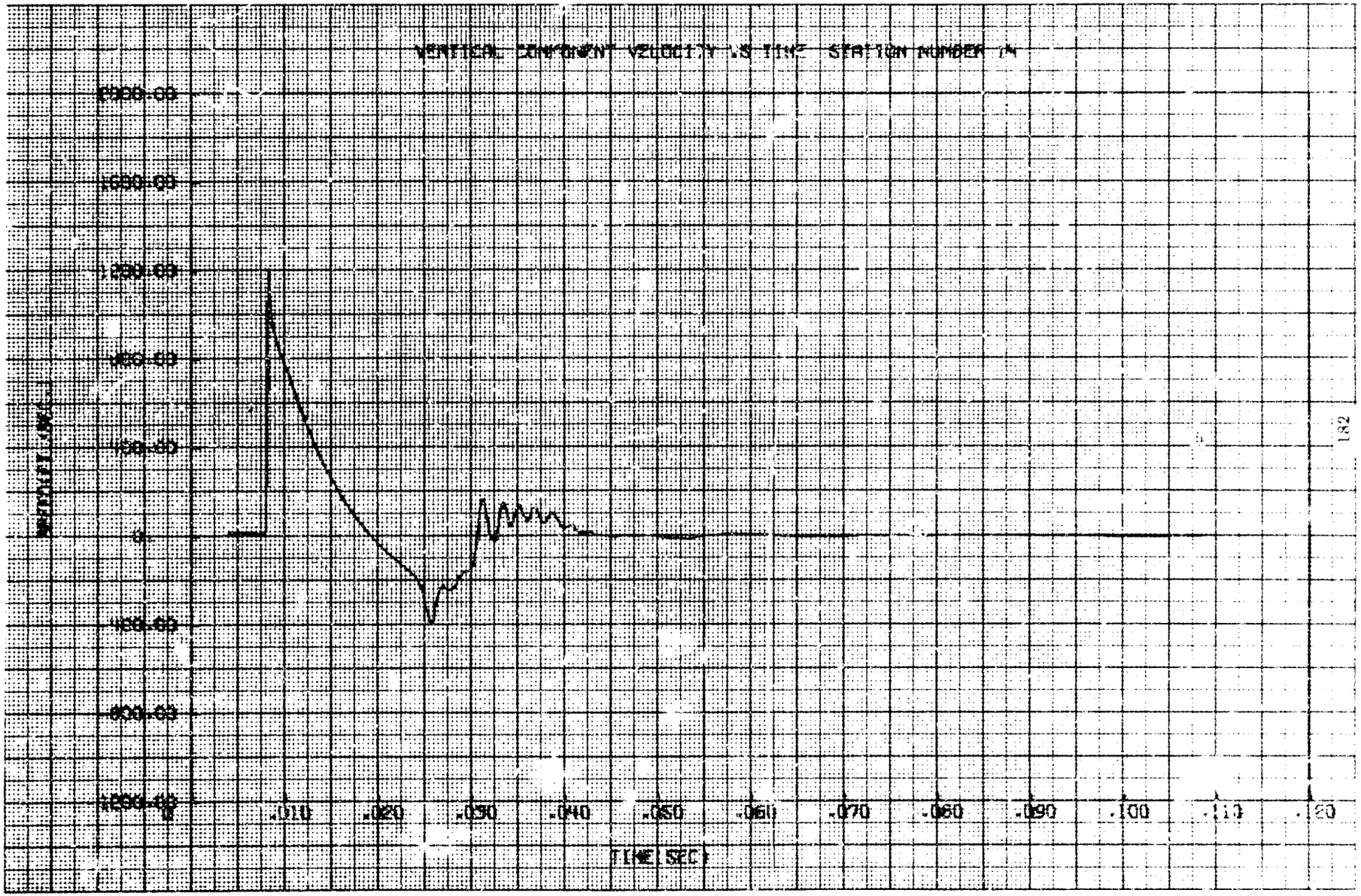

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 11
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
TIME (SEC)

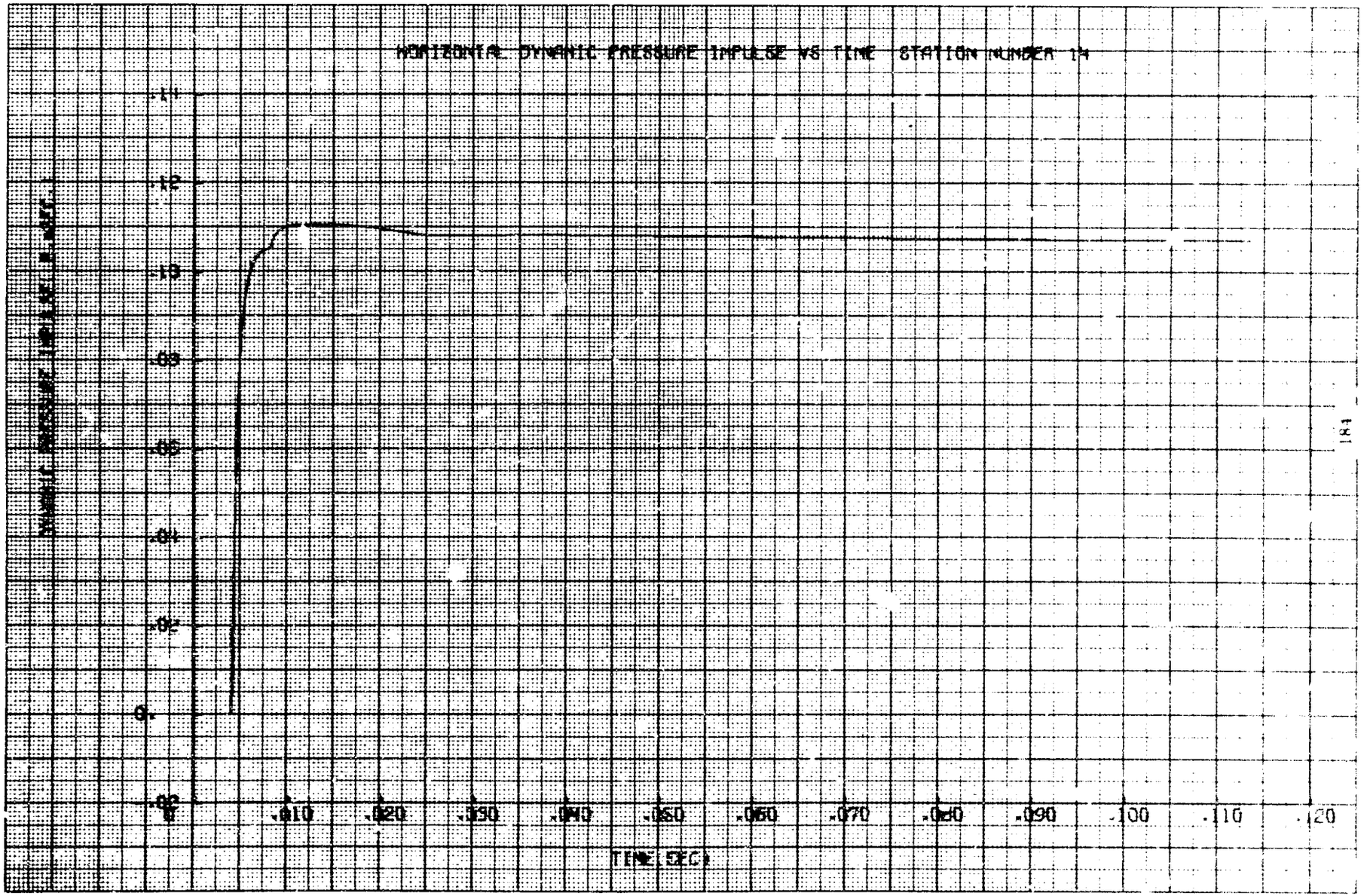
TIME (SEC)

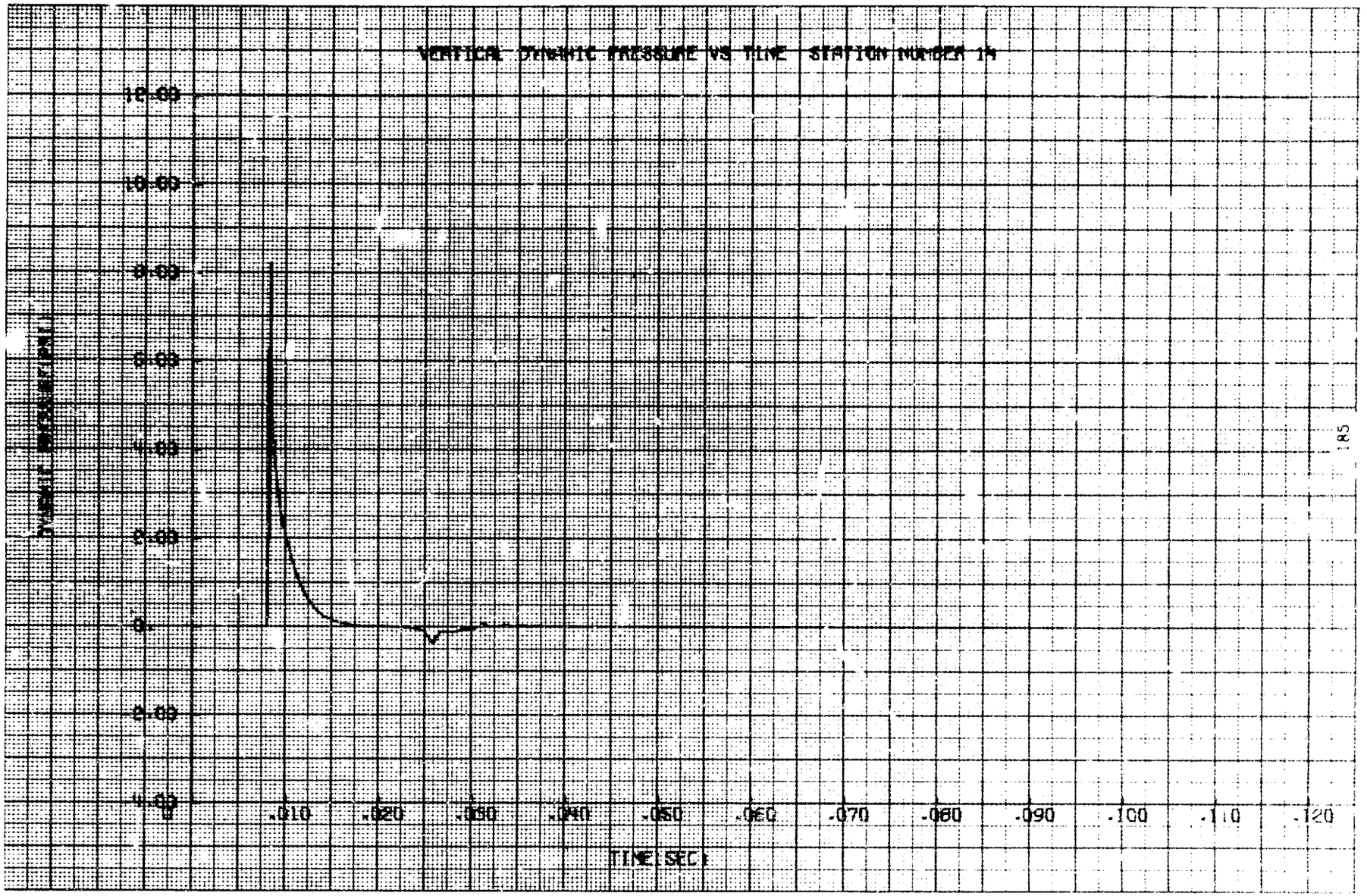

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 14
.24
.08
.16
.12
.04
0
-.04
-.08
-.12
.010
.020
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

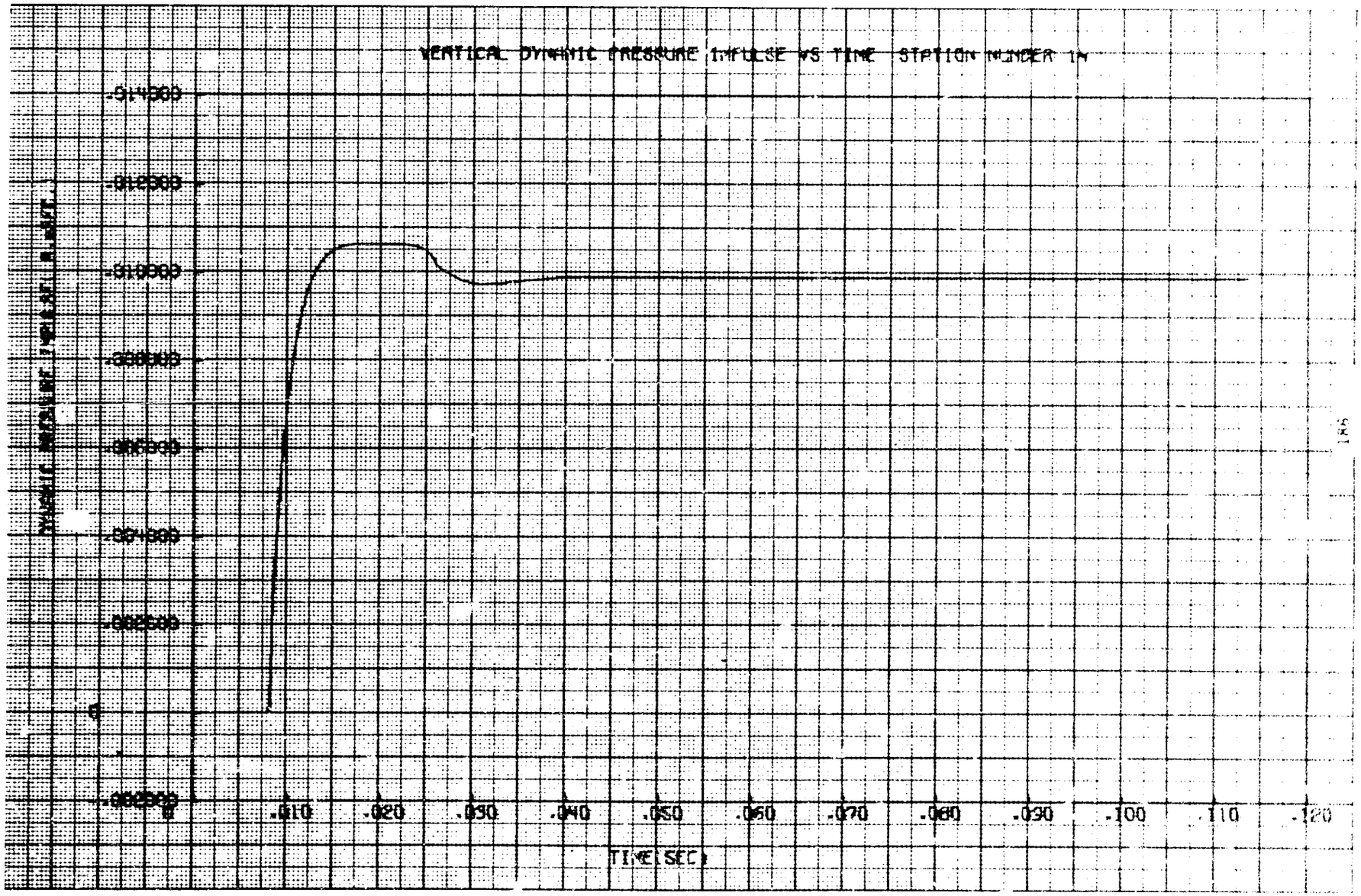

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 14
5000.00
0.
-5000.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)


VERTICAL COMPONENT VELOCITY .S TIME STATION NUMBER 14
VELOCITY (M/SEC)
+800.00
+600.00
+400.00
+200.00
0.
-200.00
-400.00
-600.00
-800.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)
182

HORIZONTAL DYNAMIC PRESSURE VS TIME AFTER DETONATION OF 4


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 14
.14
.12
.10
.08
.06
.04
.02
0.
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)

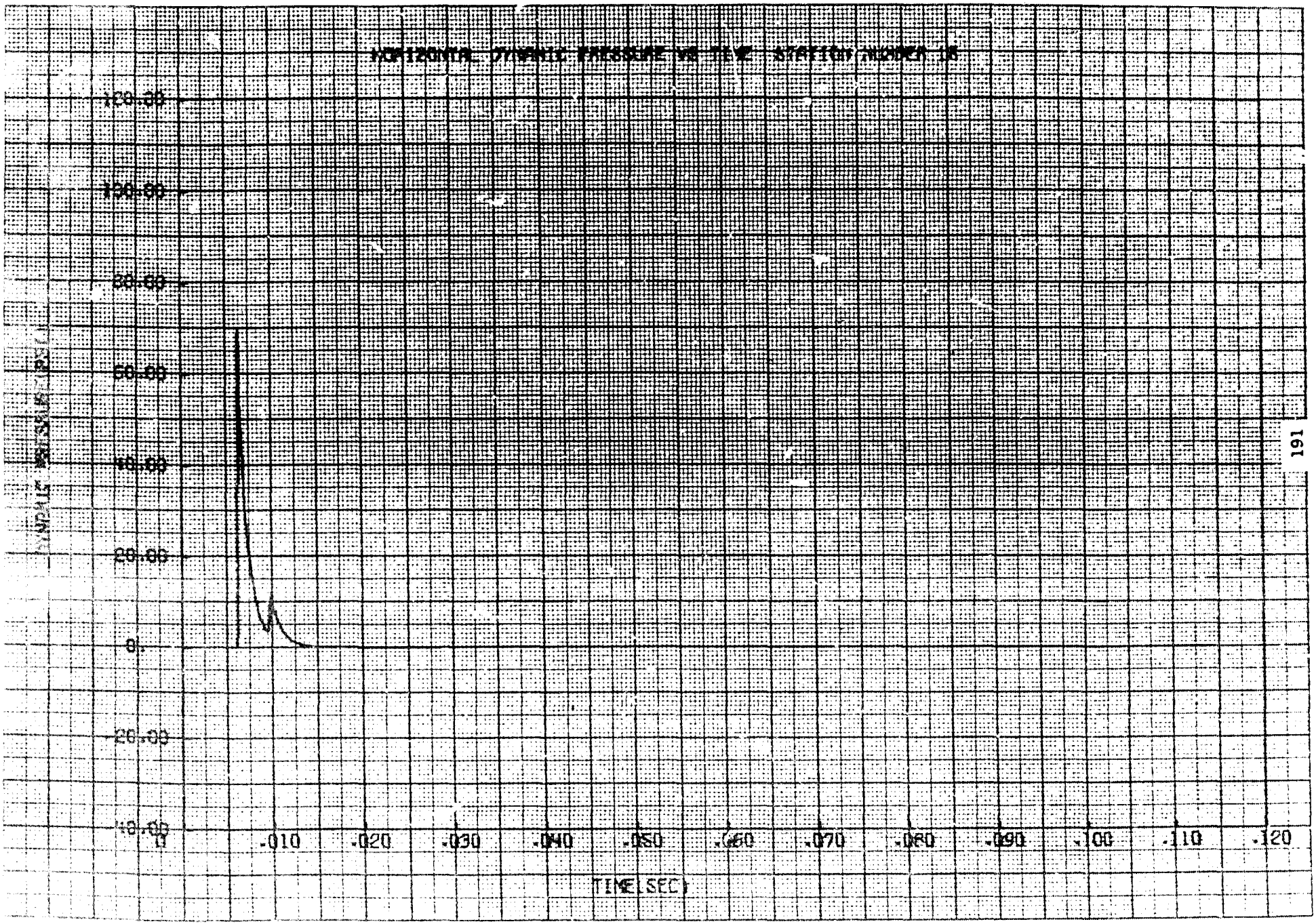

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 14
10.00
0.00
-5.00
-10.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)
185

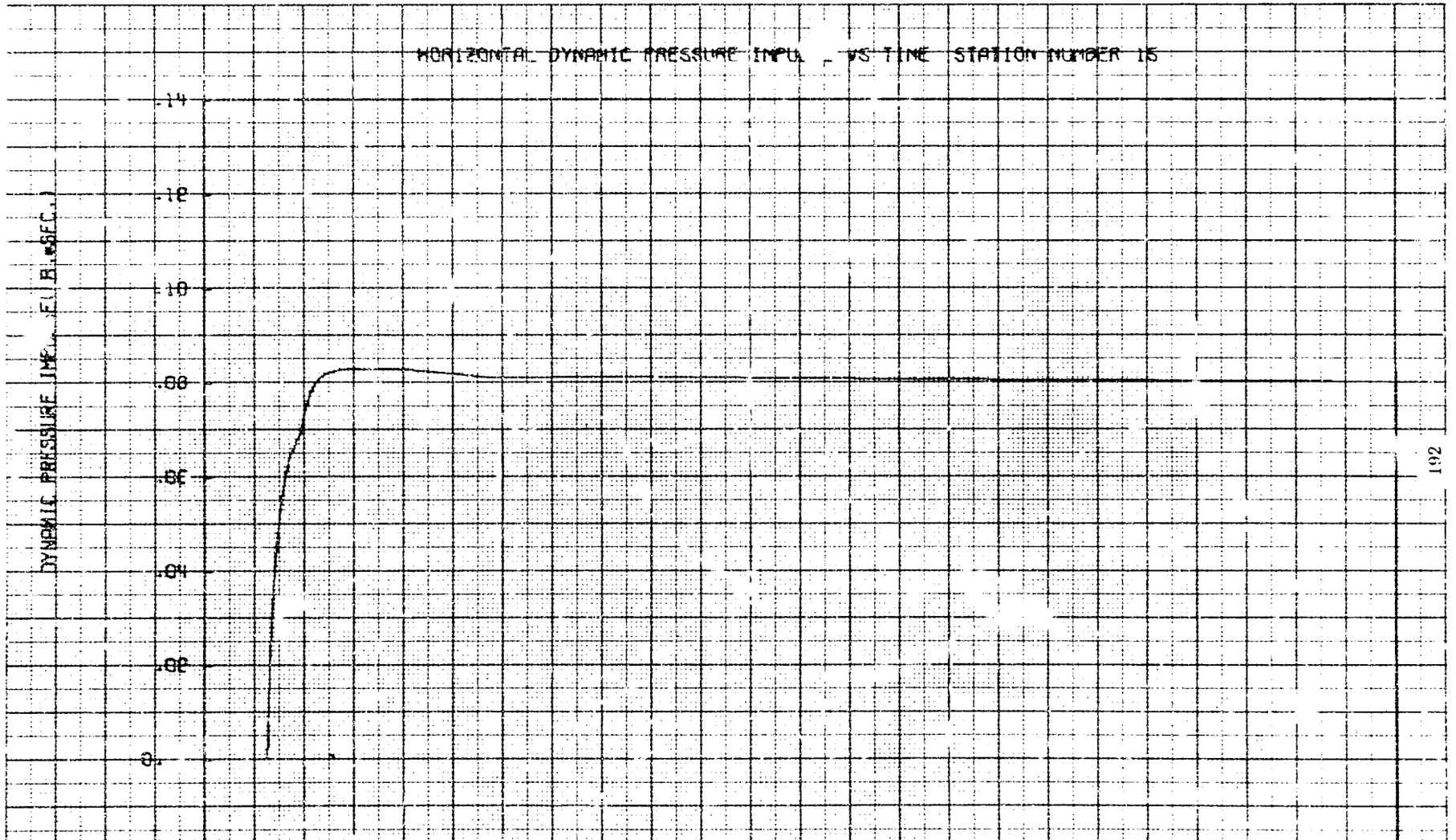

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 14
-.914300
-.610000
-.305000
-.000000
.305000
.610000
.914300
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

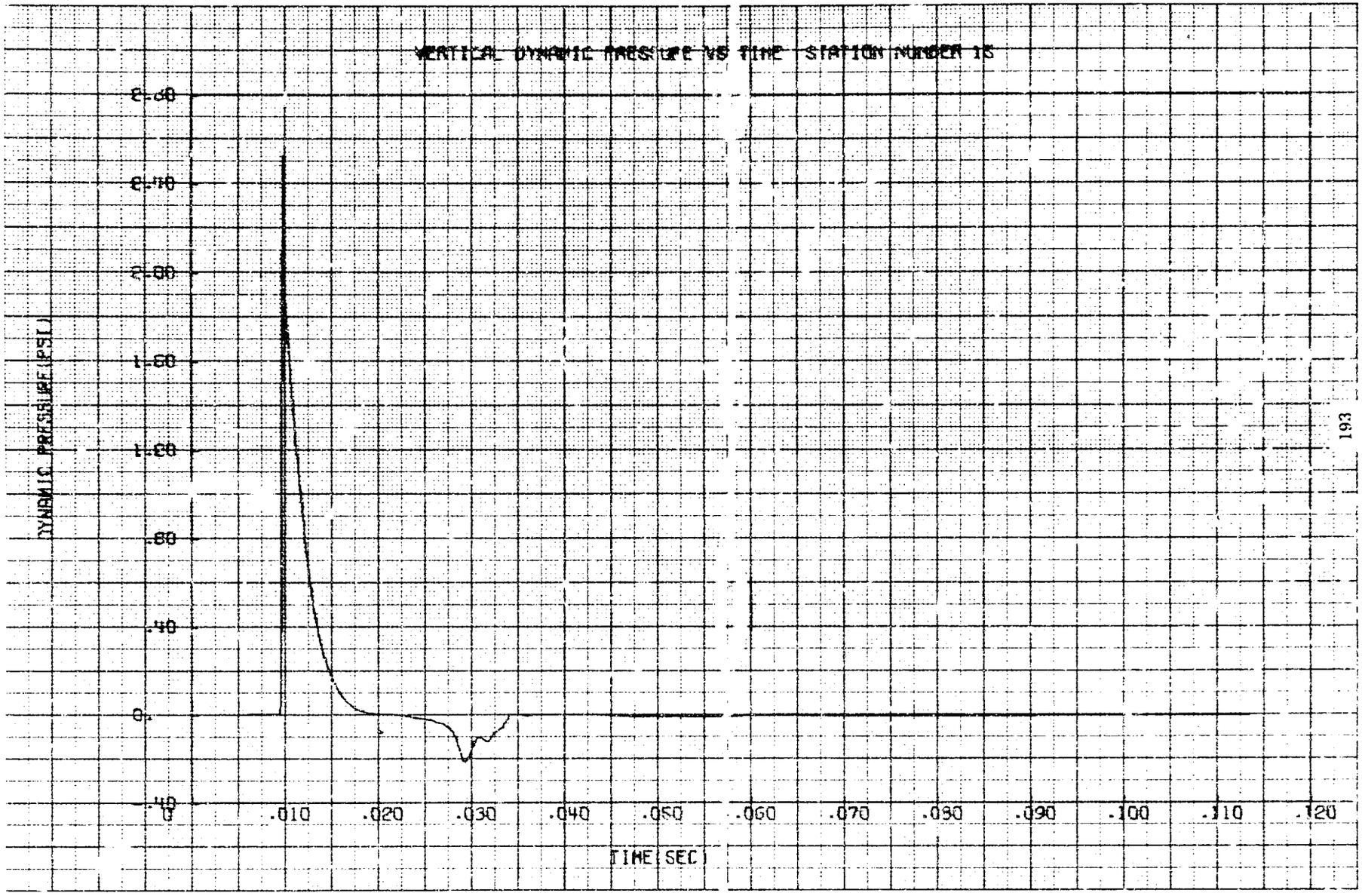
-8
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
P0.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

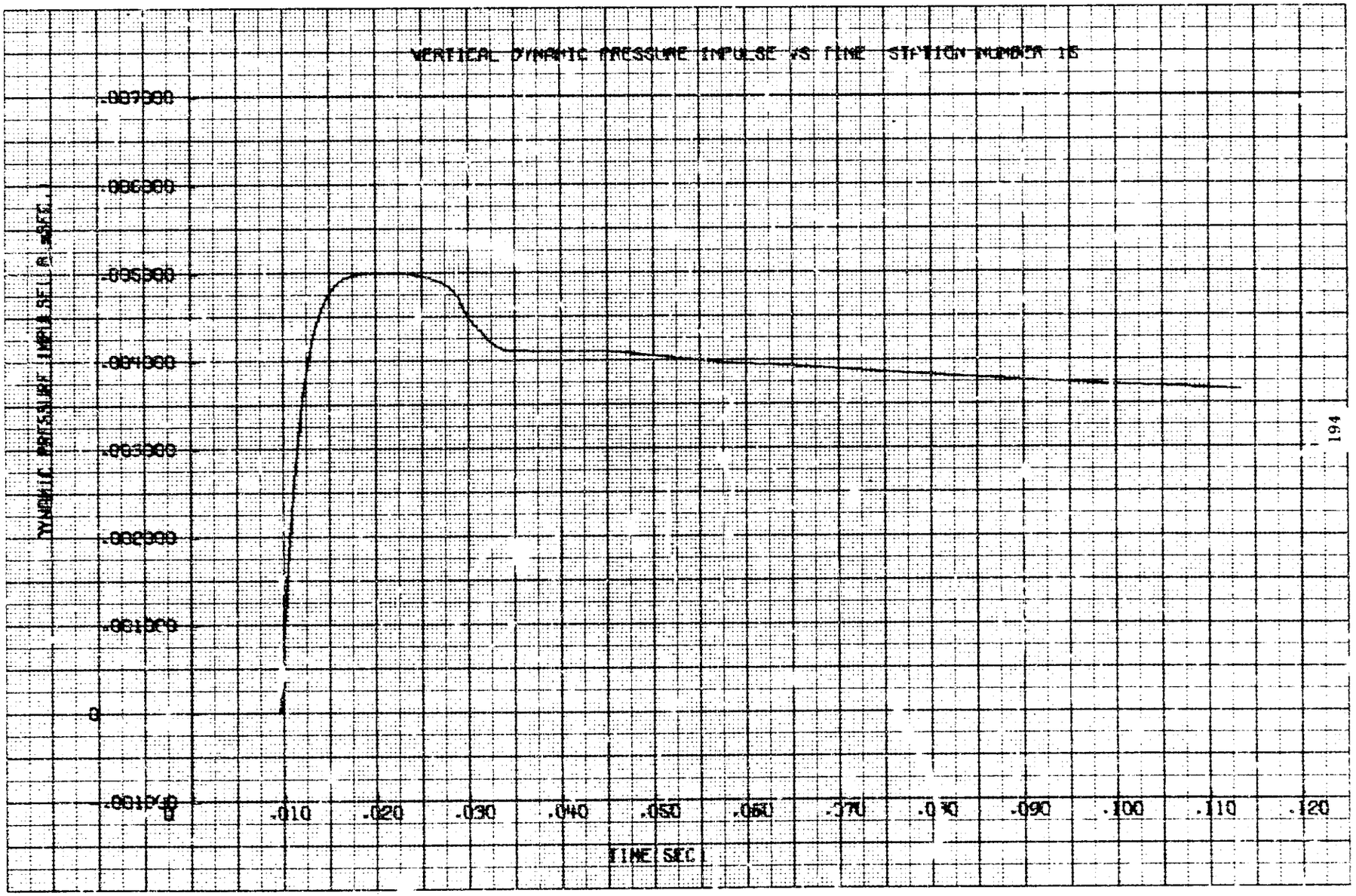
TIME (SEC)
.000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120

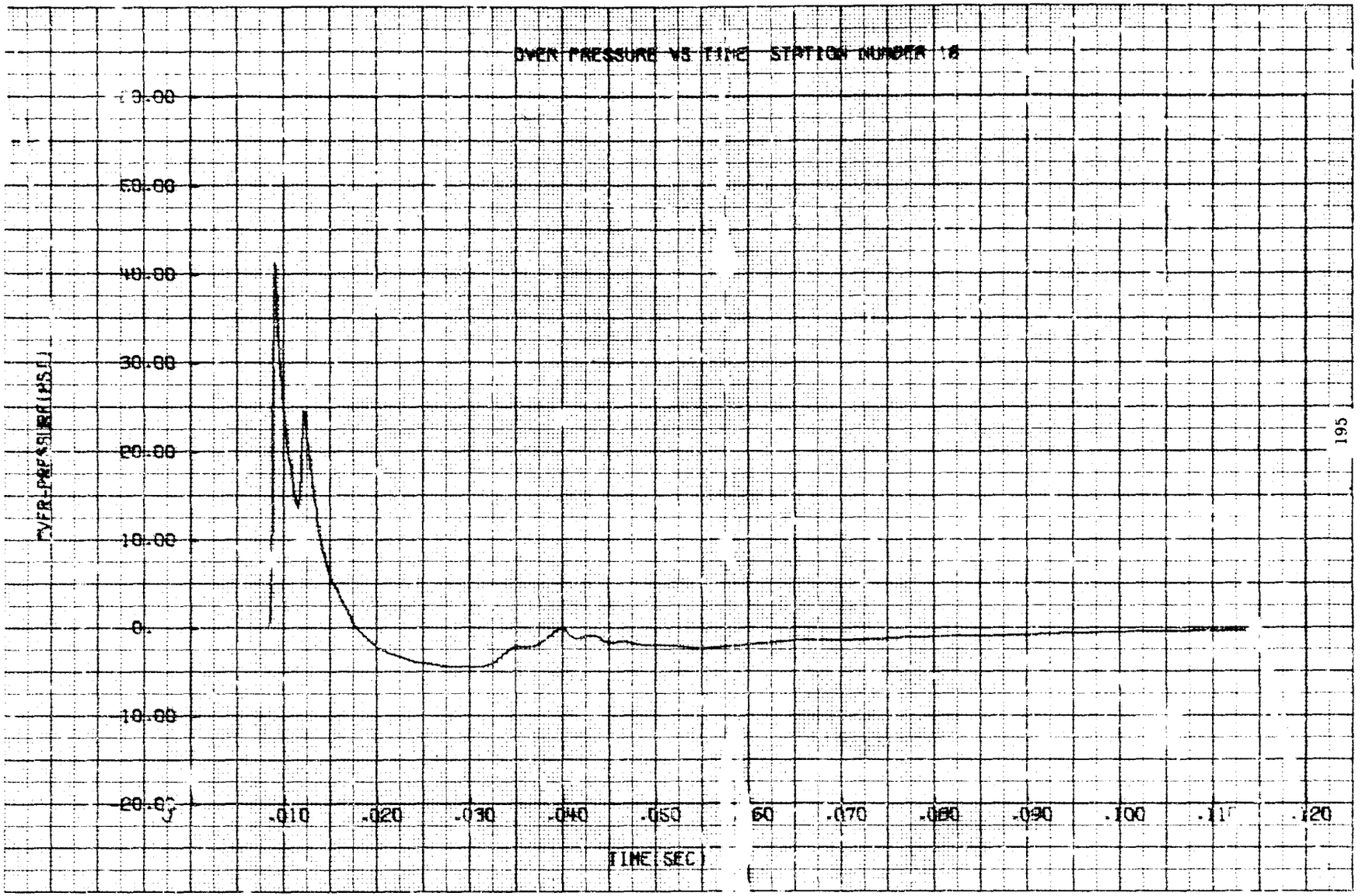
1 MM
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390

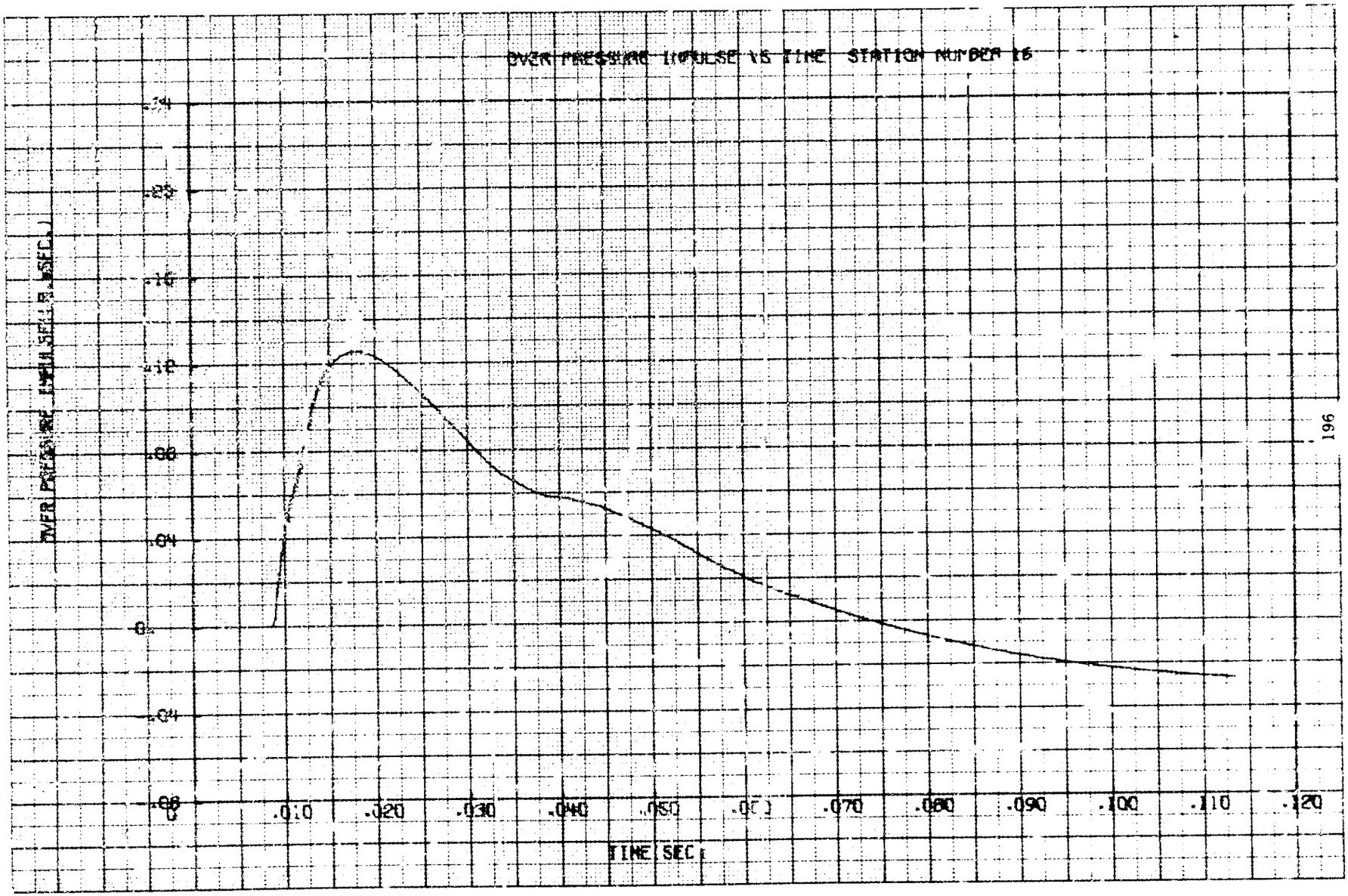

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 18
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

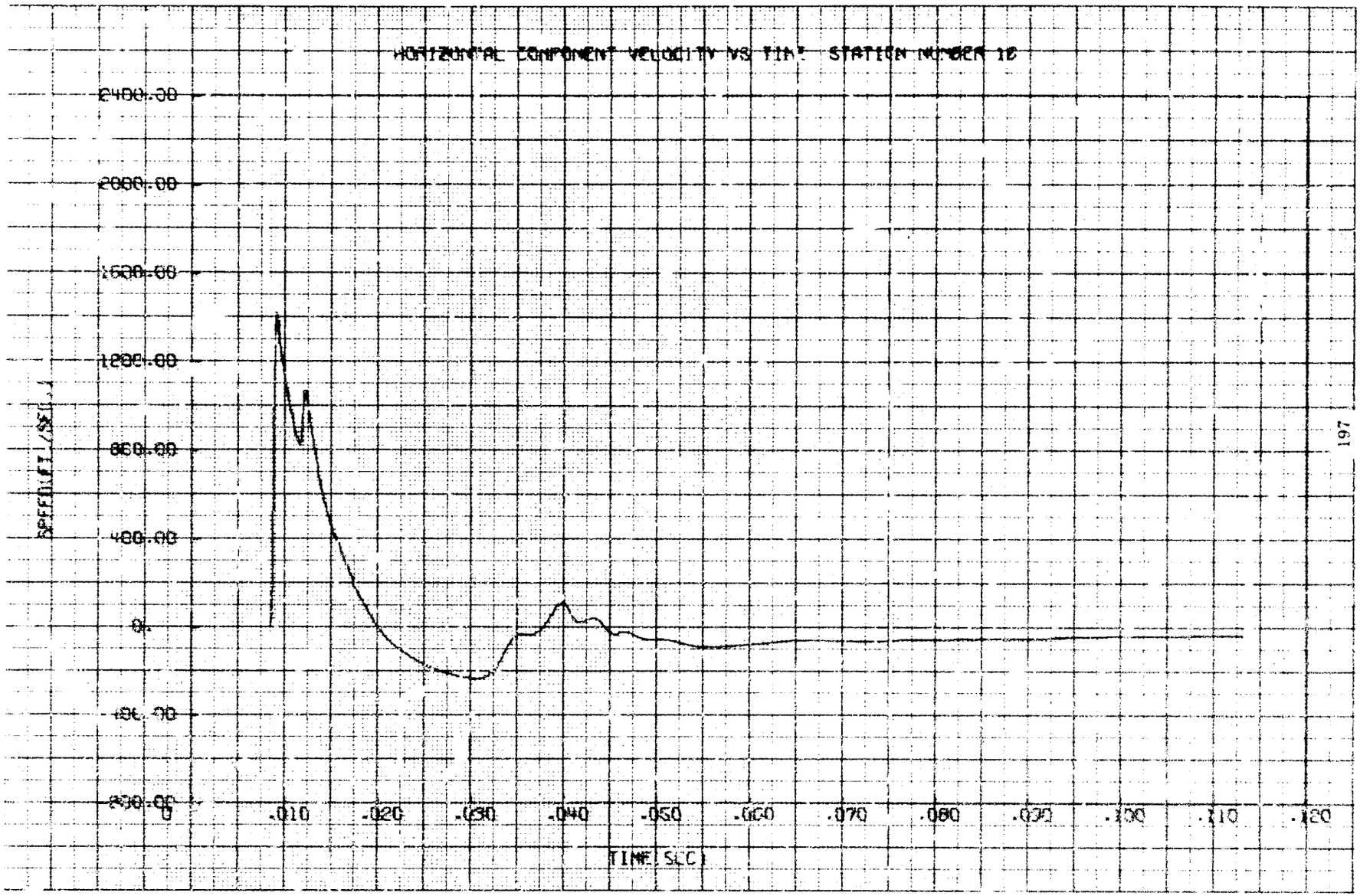

HORIZONTAL DYNAMIC PRESSURE IMPU _ VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMP _ E(B.*SEC.)
.14
.12
.10
.08
.06
.04
.02
0
-.02
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)


VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE(PSI)
TIME(SEC)
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
193

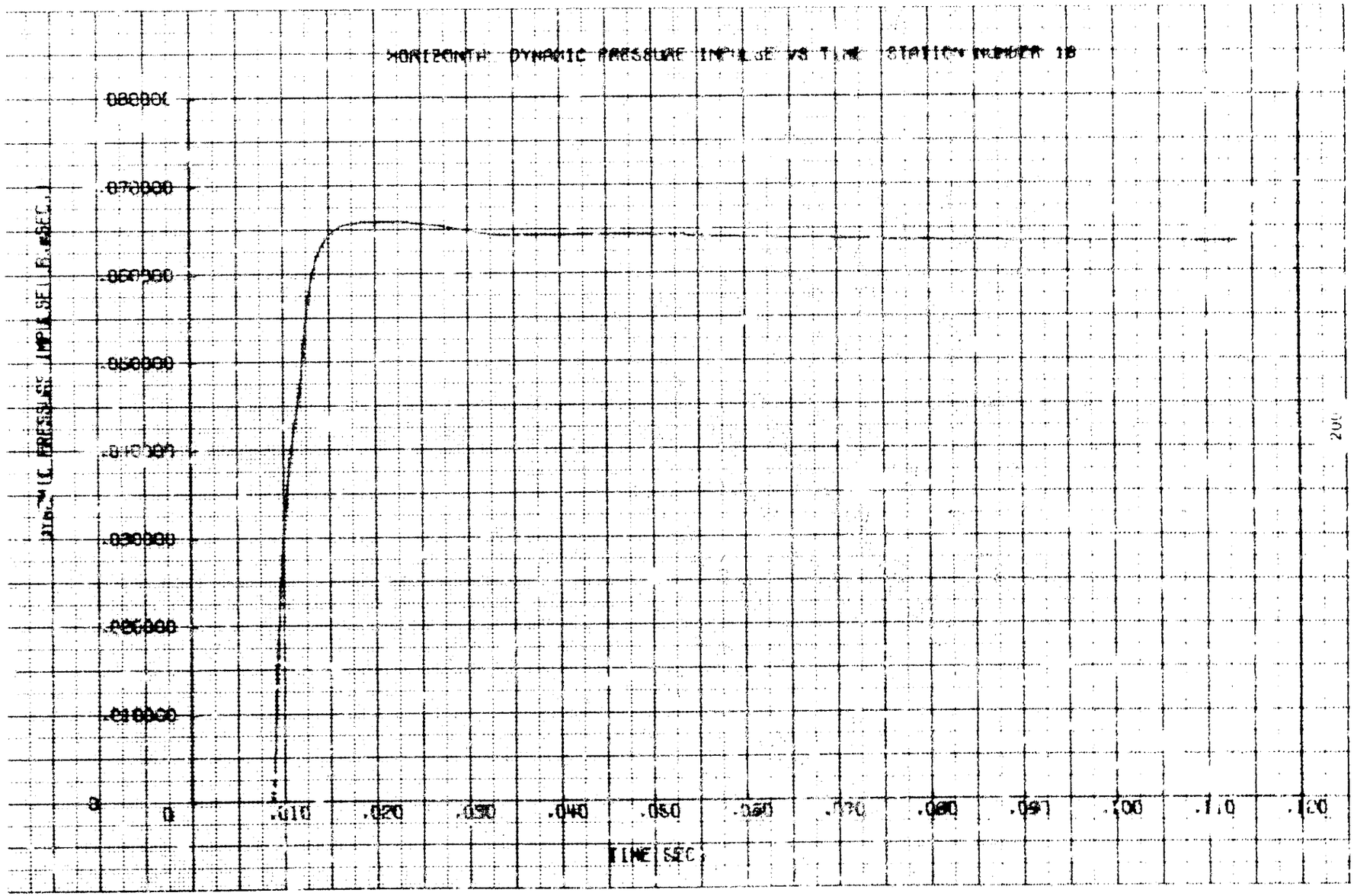

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
.007000
.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC
194

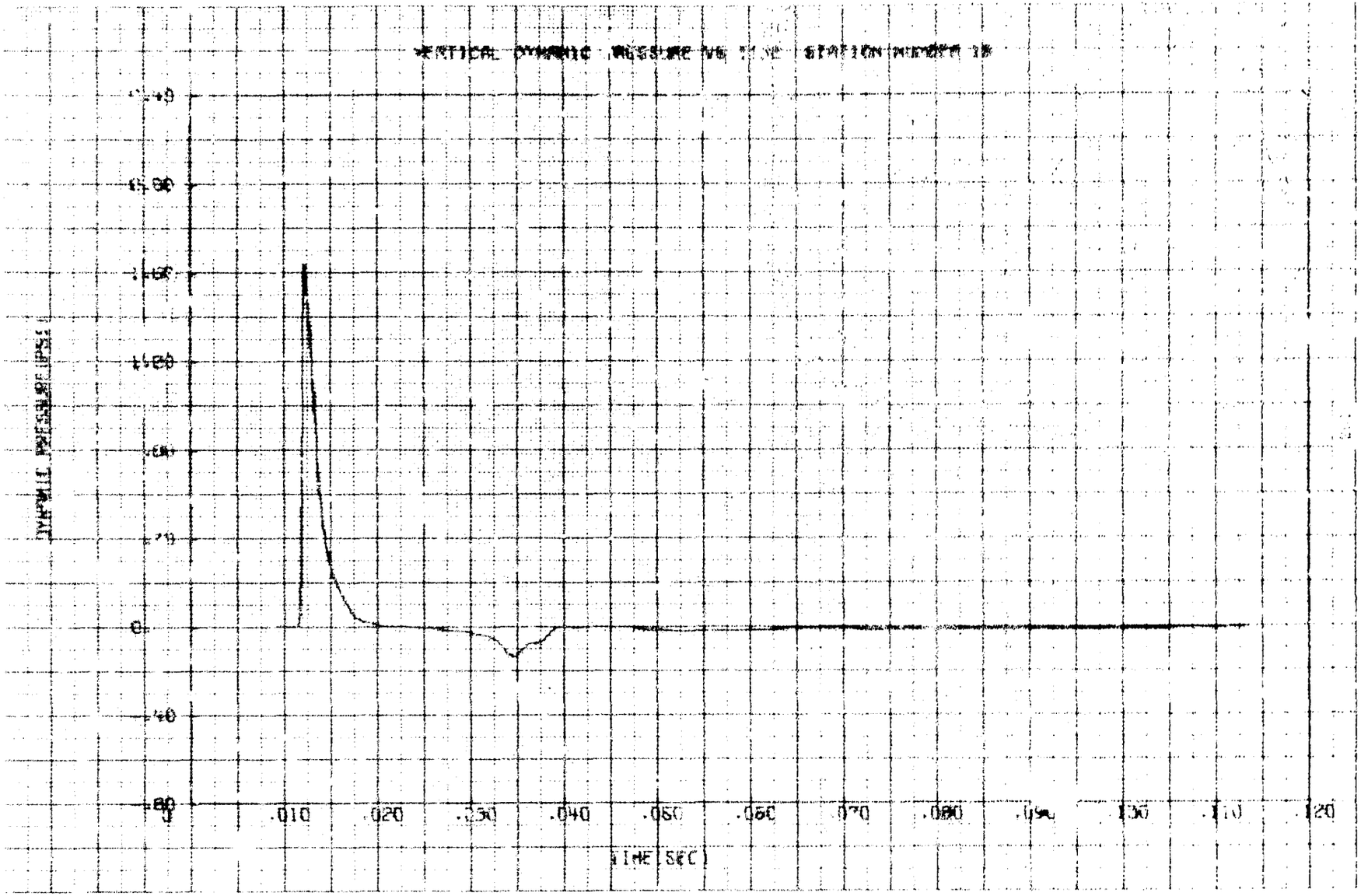

OVER PRESSURE VS TIME STATION NUMBER 16
30.00
20.00
10.00
0.
-10.00
-20.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.120
TIME(SEC)
195

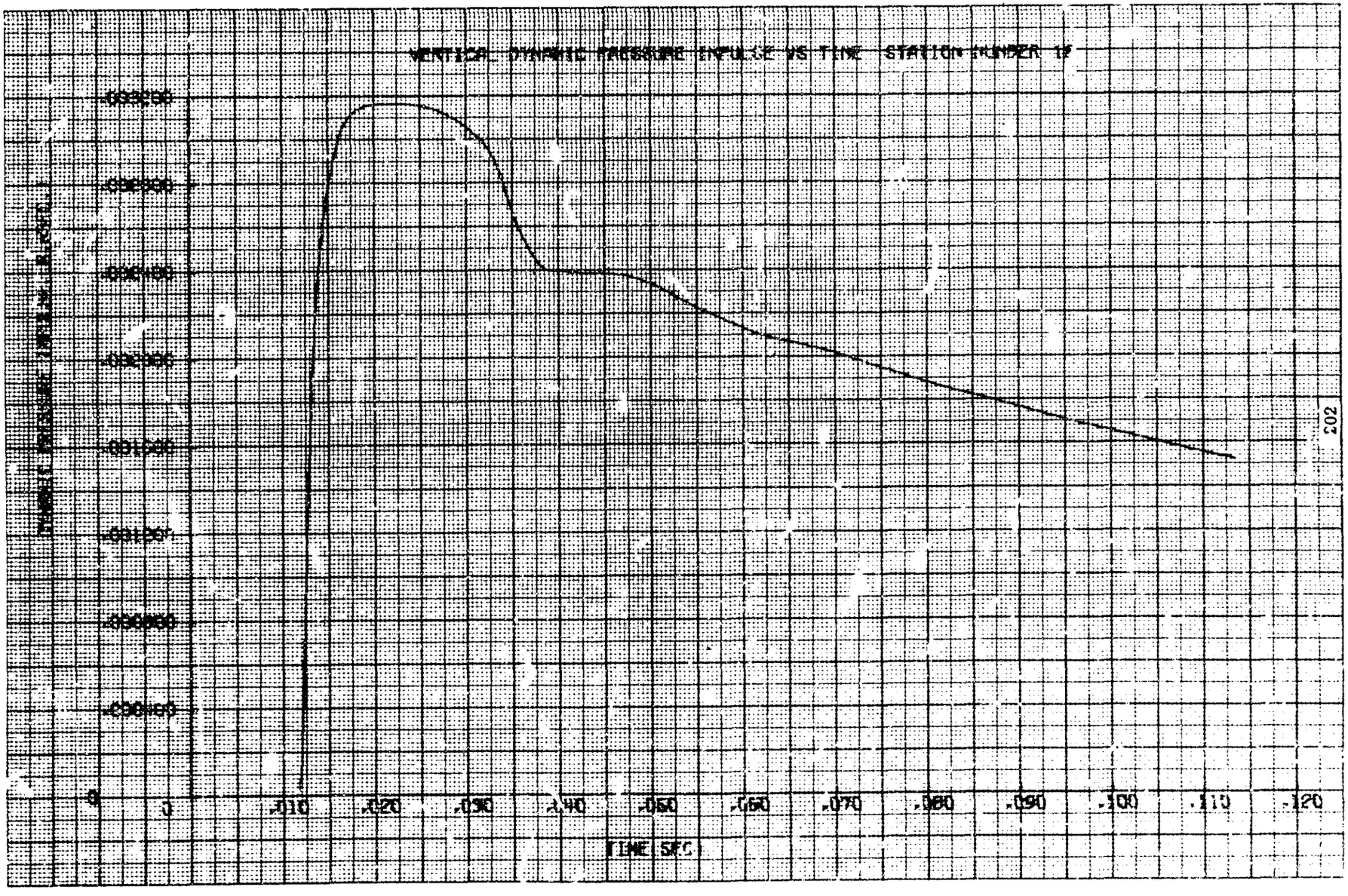

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 16
OVER PRESSURE IMPULSE, LB/SEC.
.24
.20
.16
.12
.08
.04
0
-.04
-.08
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME, SEC.
196


HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)

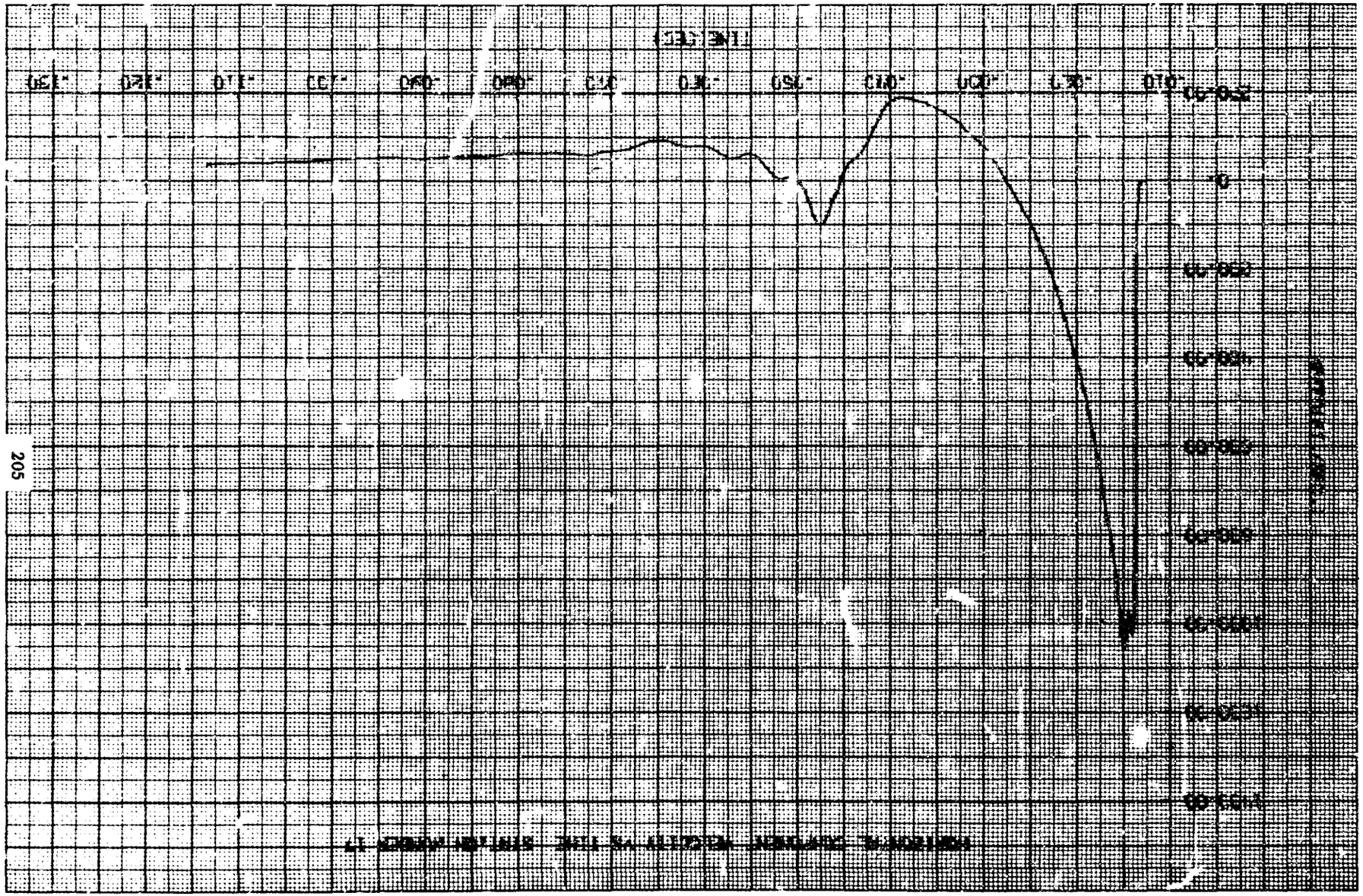
VERTICAL [illegible] VELOCITY VS TIME STATION NUMBER 19
SPEED(FT/SEC)
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME(SEC)

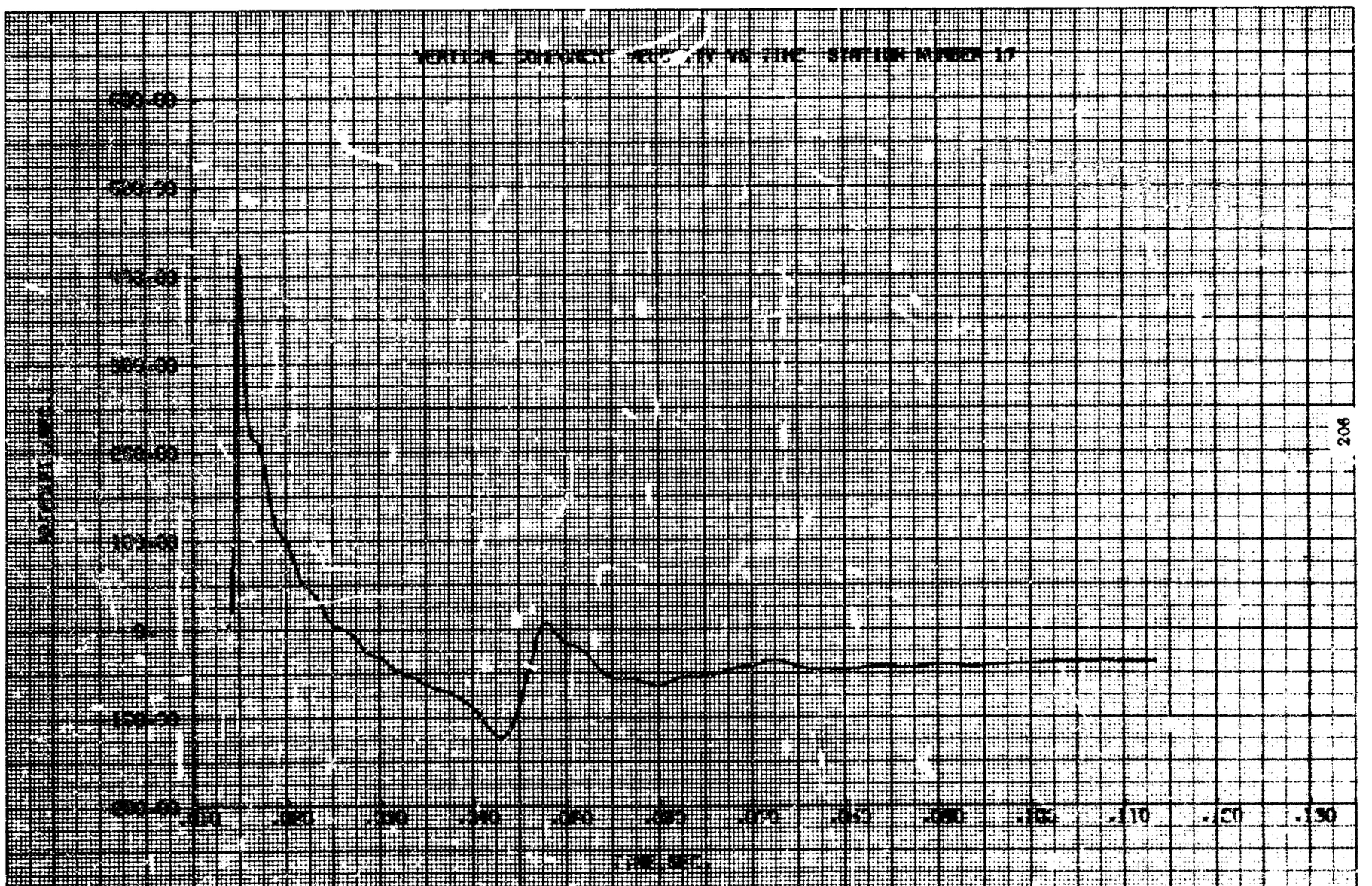

TIME SEC

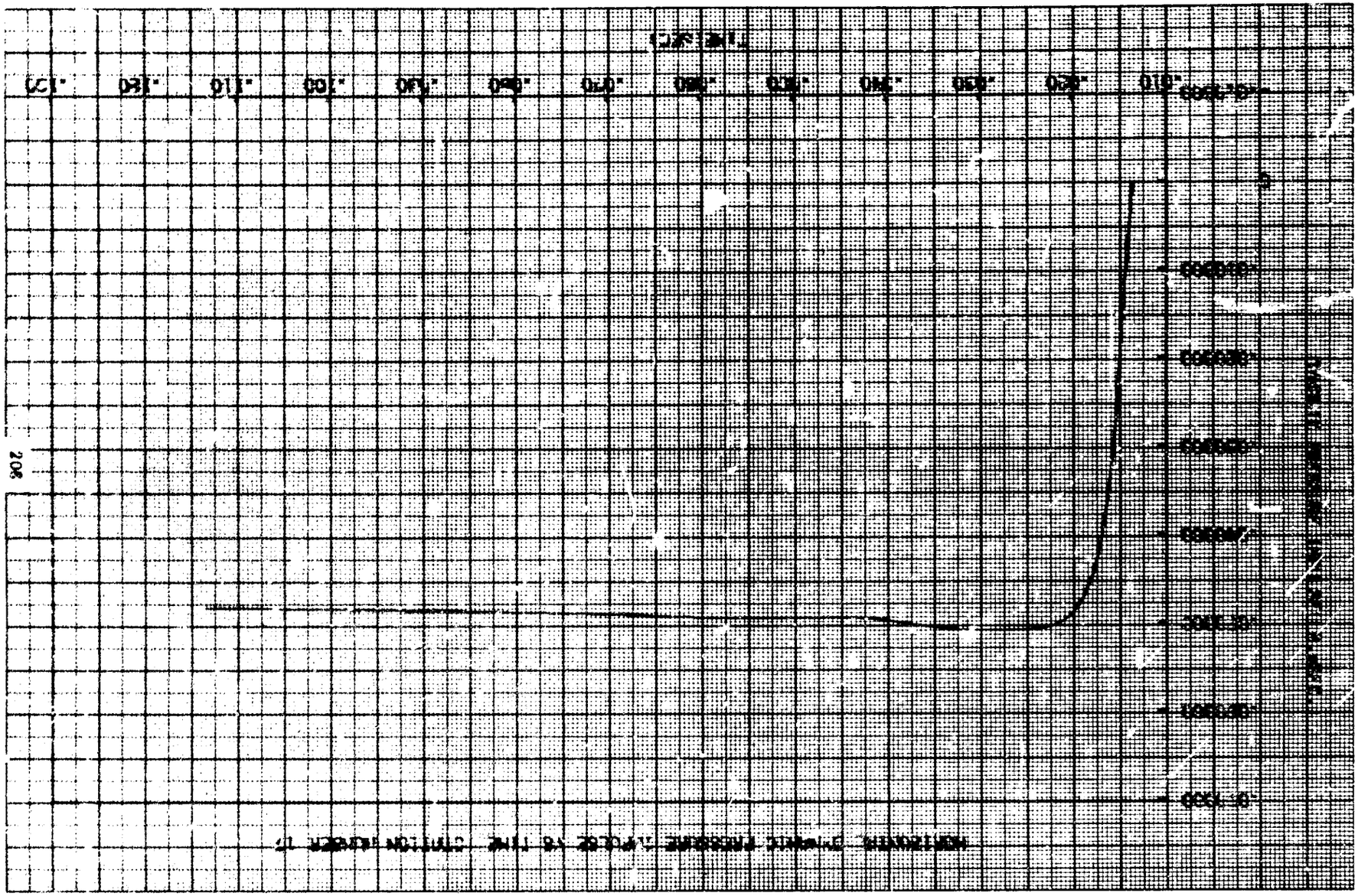

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 19
DYNAMIC PRESSURE (PSI)
+40
+20
0
-20
-40
-60
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME (SEC)


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1F
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
TIME SEC
202

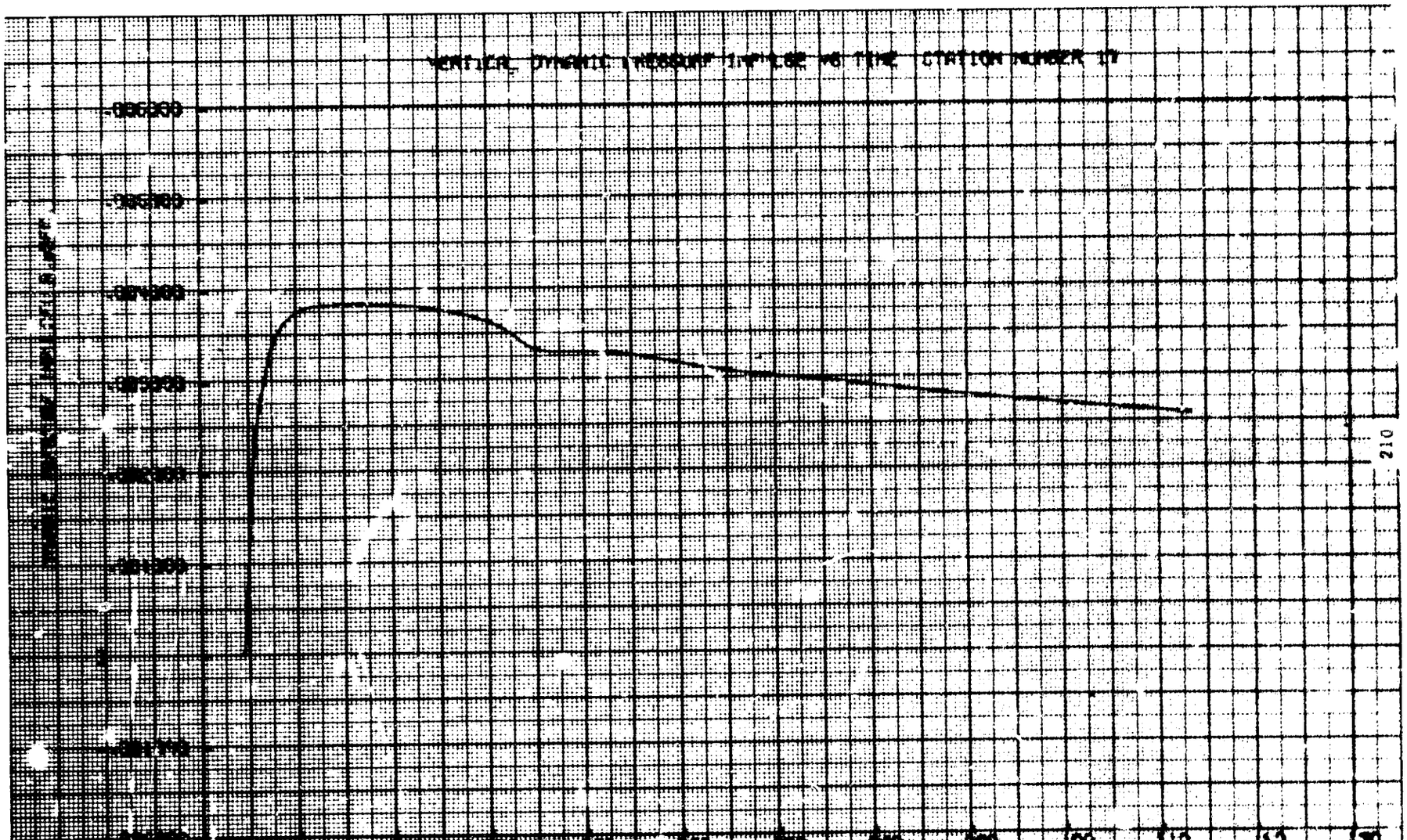
OVER-PRESSURE (PSI)
0.
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
-.010
-.020
-.030
-.040
-.050
-.060
-.070
-.080
-.090
-.100
-.110
-.120
-.130
TIME (SEC)

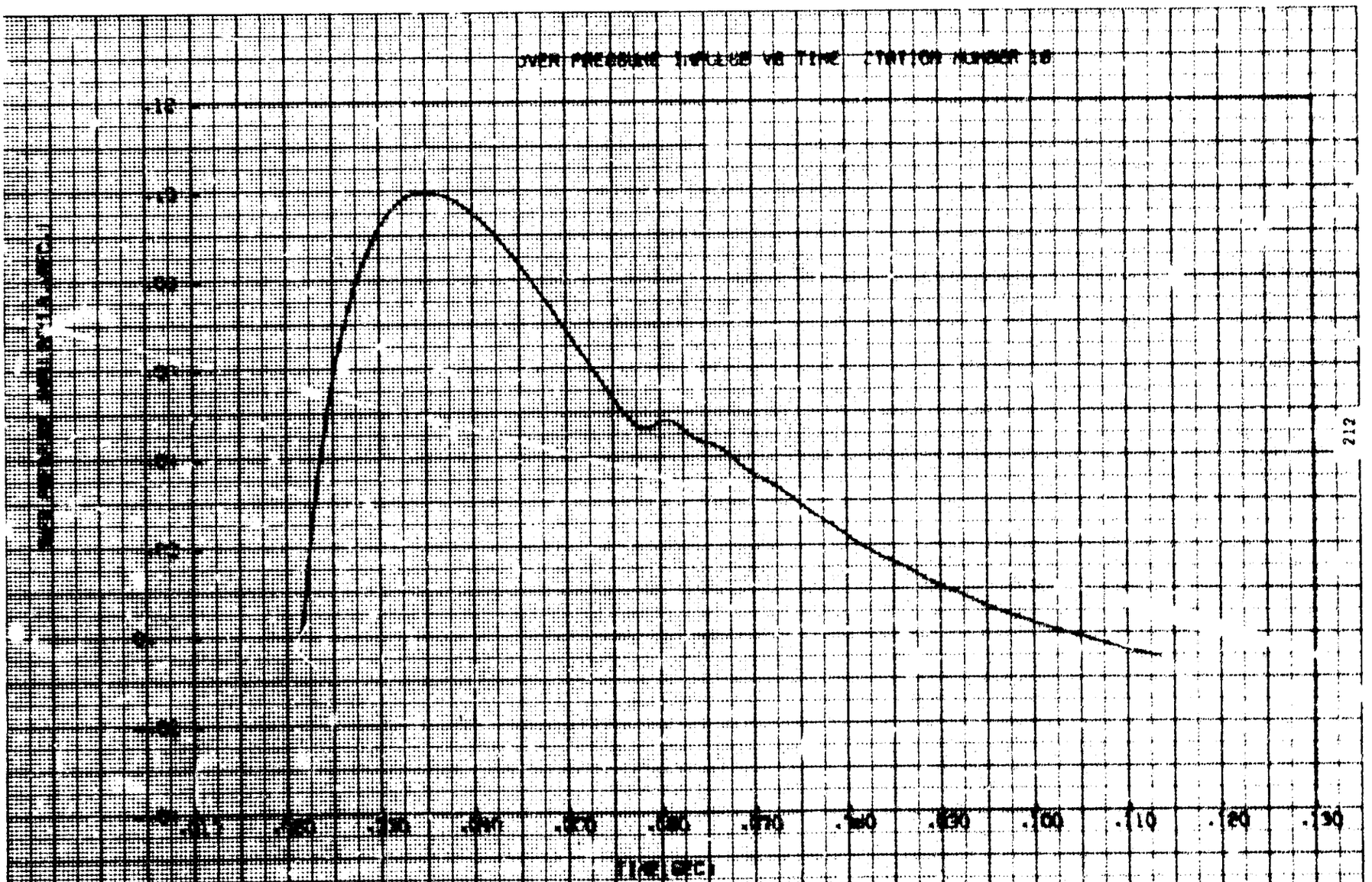


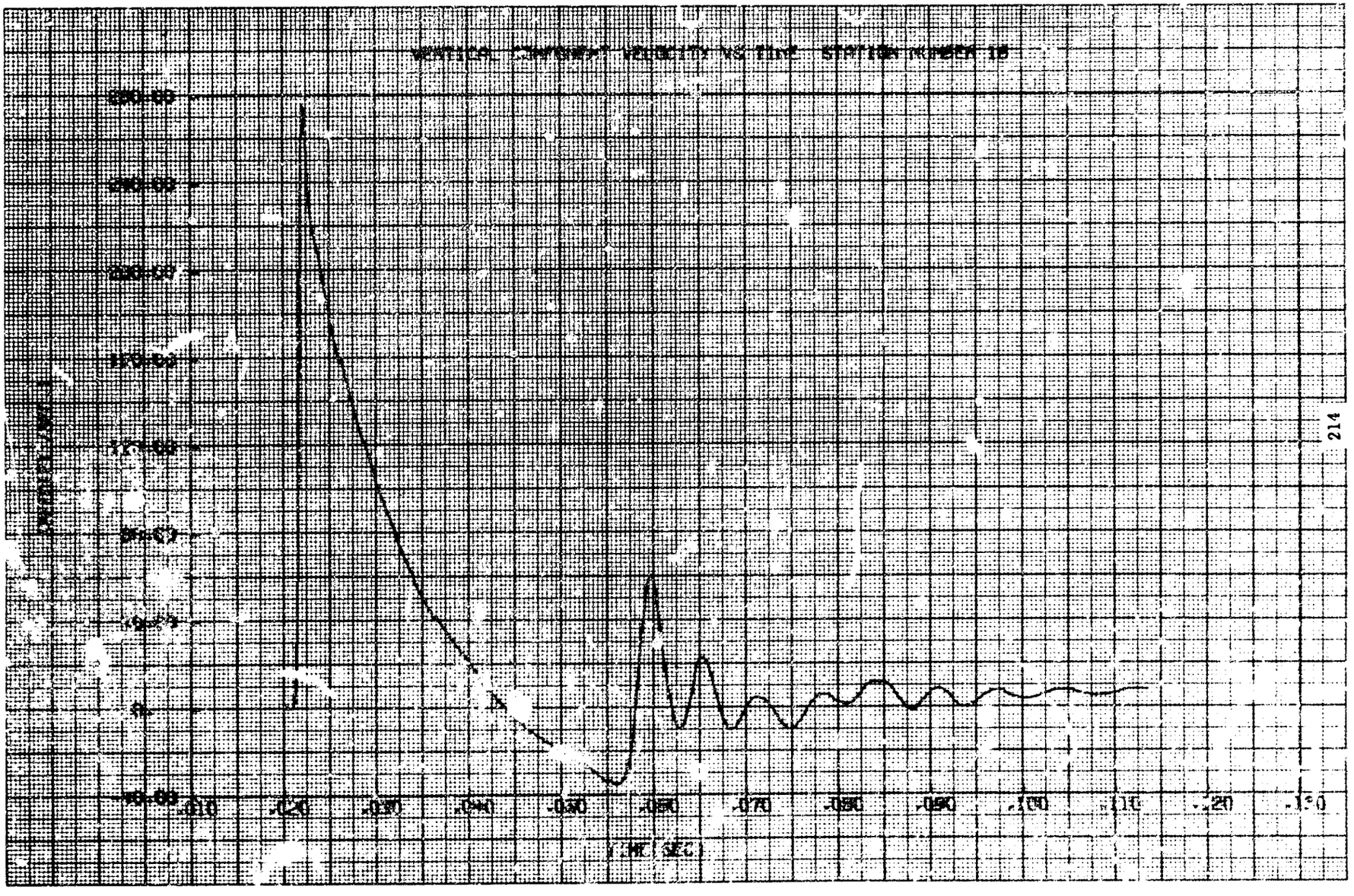

VERTICAL CURRENT DENSITY VS TIME STATION MARK 17
-200.00
-250.00
-300.00
-350.00
-400.00
-450.00
-500.00
-550.00
-600.00
-650.00
-700.00
-750.00
-800.00
-850.00
-900.00
-950.00
-1000.00
-1050.00
-1100.00
-1150.00
-1200.00
-1250.00
-1300.00
-1350.00
-1400.00
-1450.00
-1500.00
-1550.00
-1600.00
-1650.00
-1700.00
-1750.00
-1800.00
-1850.00
-1900.00
-1950.00
-2000.00
-2050.00
-2100.00
-2150.00

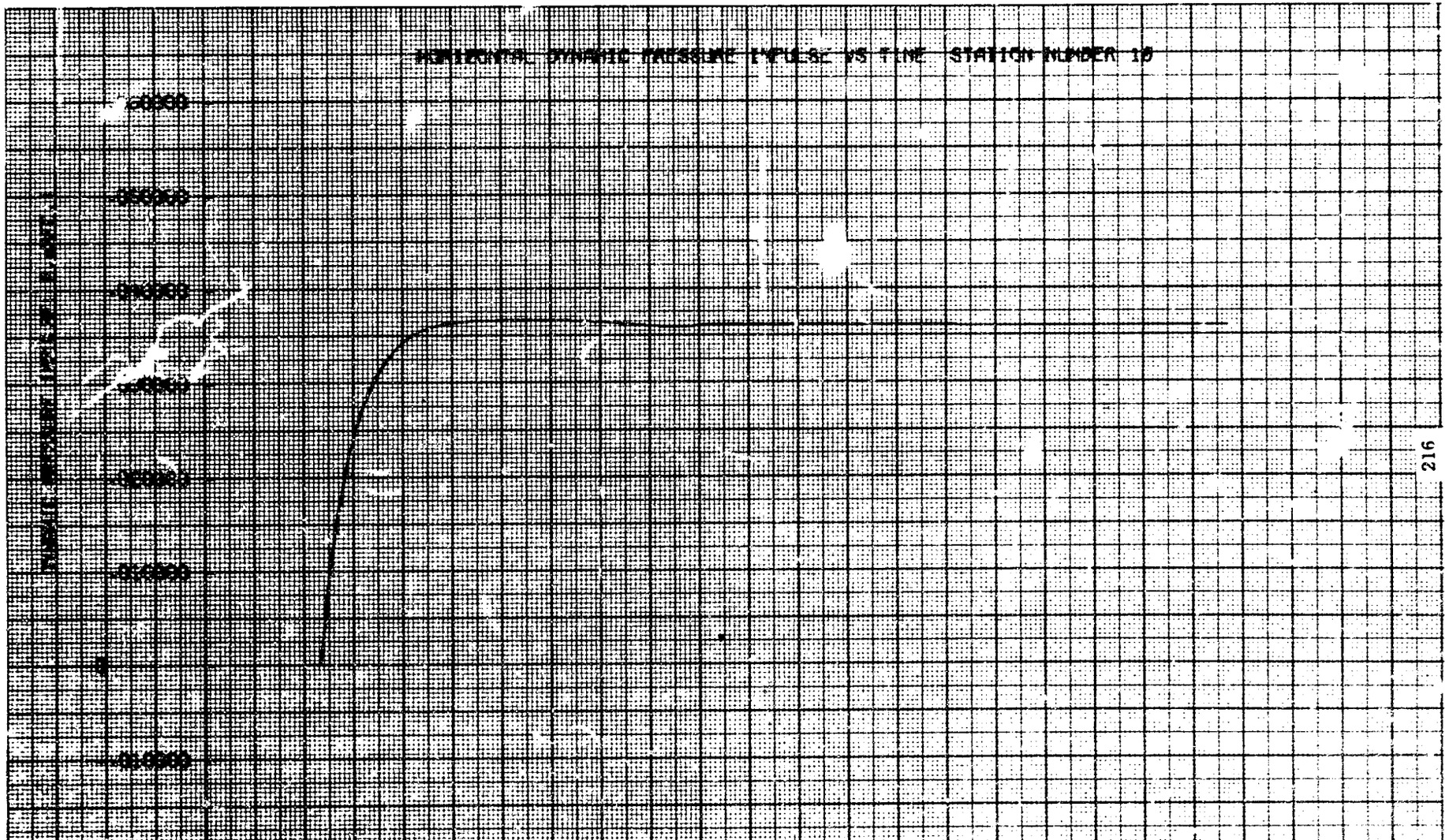


DYNAMIC PRESSURE (psi)
-6.0
-4.0
-2.0
0
2.0
4.0
6.0
.010"
.020"
.030"
.040"
.050"
.060"
.070"
.080"
.090"
.100"
.110"
.120"
.130"
GAS GAP

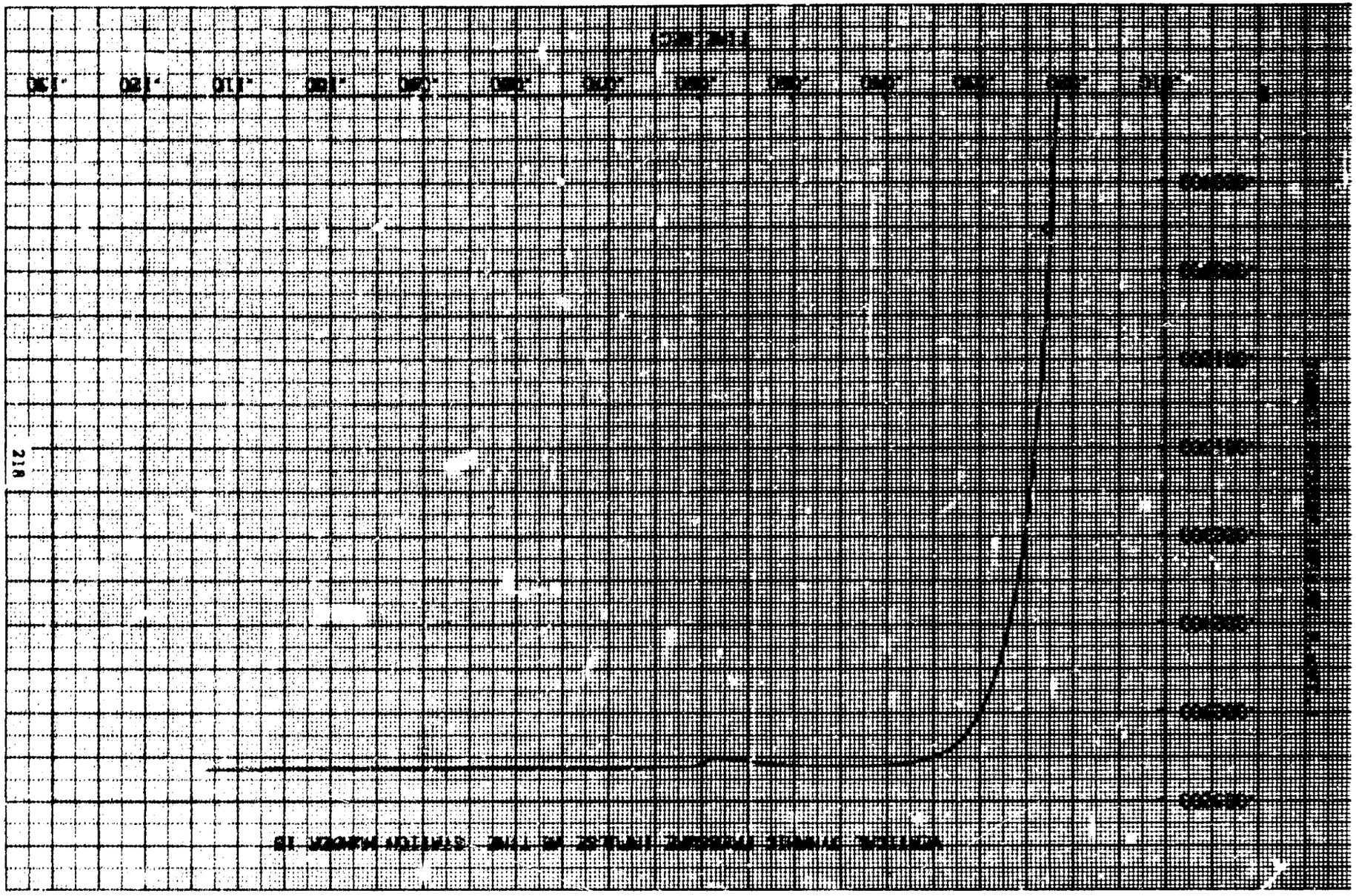

VERTICAL DYNAMIC PRESSURE VARIES AS TIME STATION NUMBER 17
TIME (SEC)

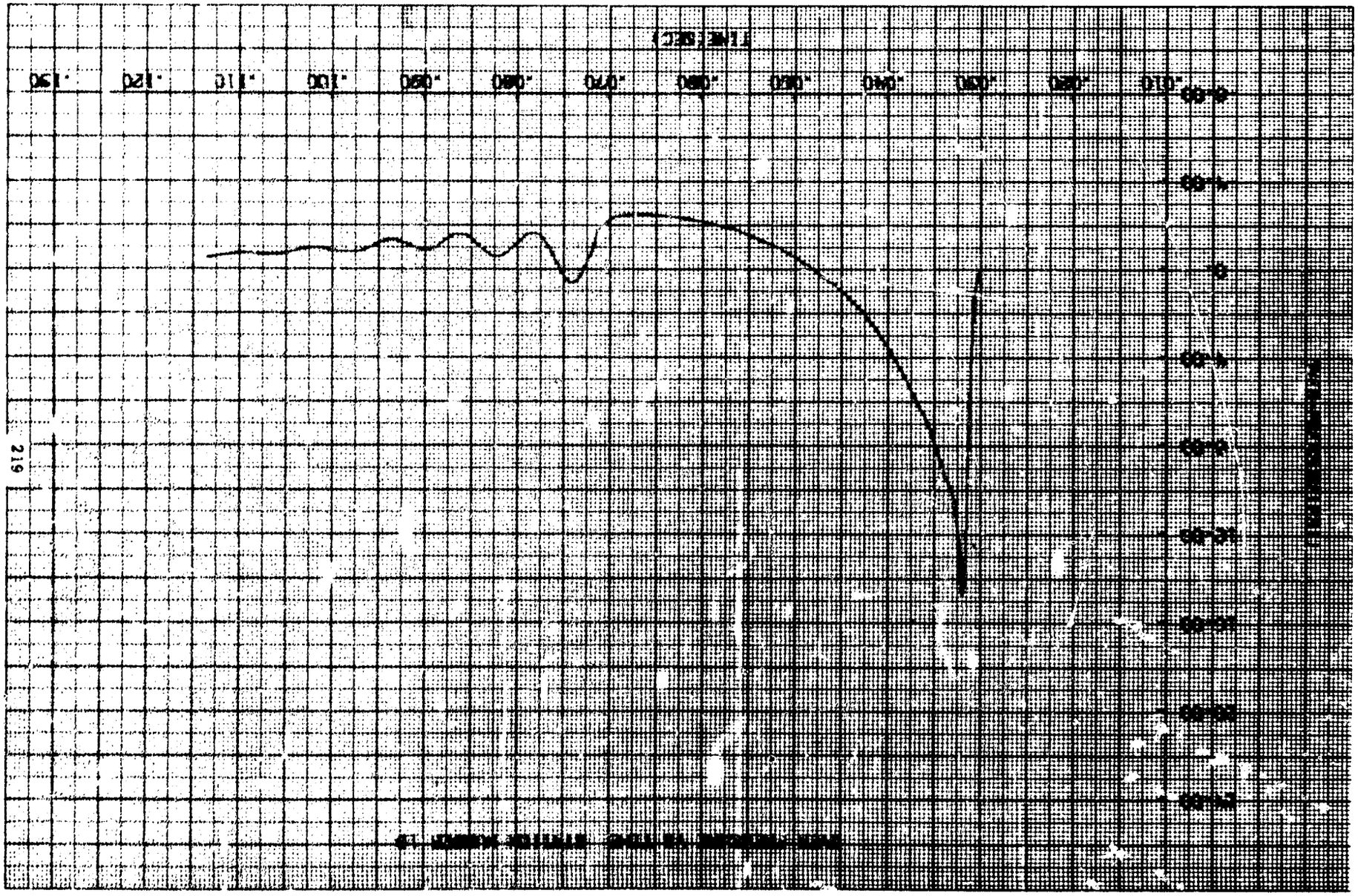

OVER PRESSURE INCREASE VS TIME STATION NUMBER 10
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.00
.10
.20
.30
TIME (SEC)

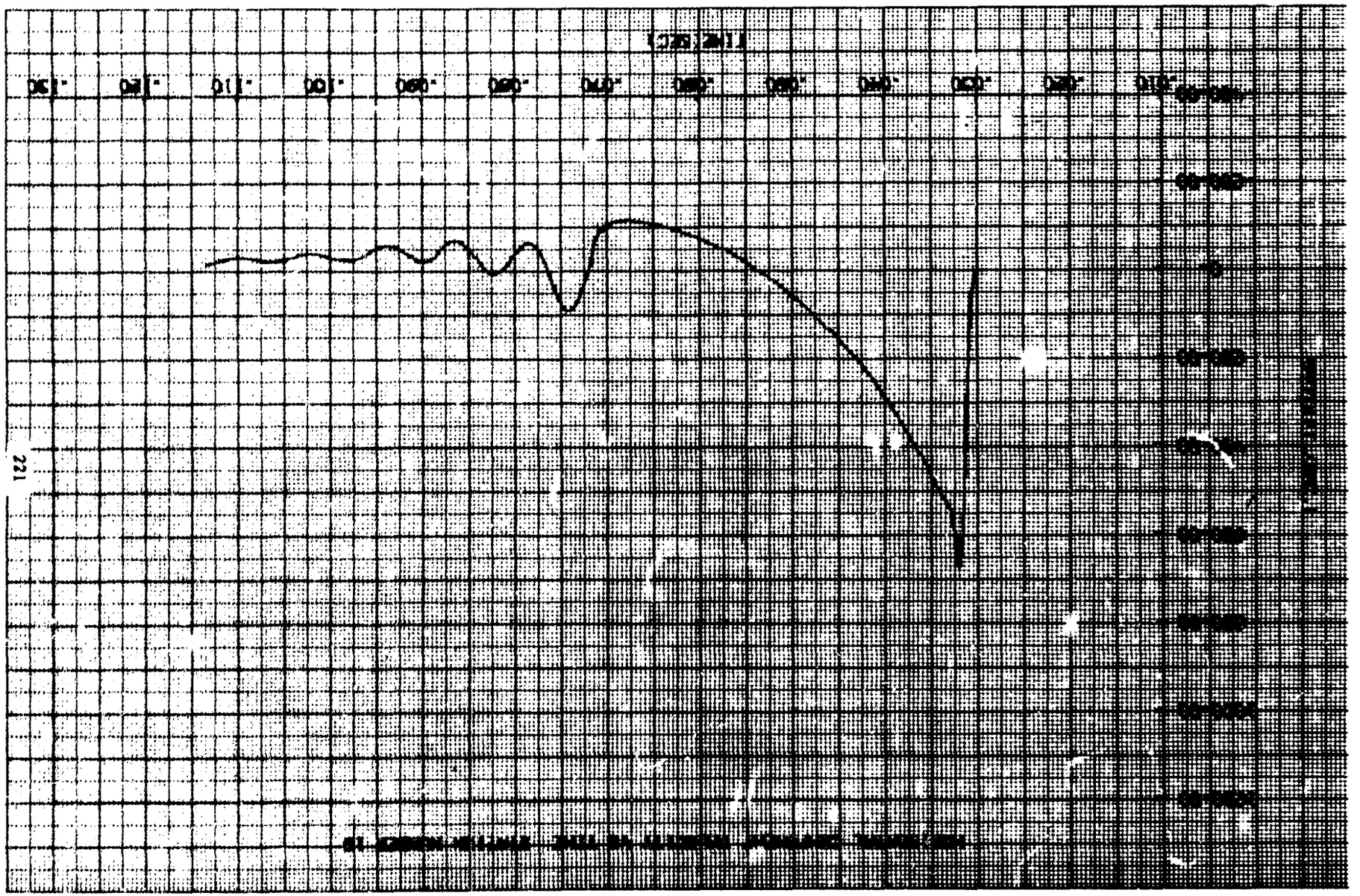

VERTICAL CARRIAGE VELOCITY VS TIME STATION NUMBER 10
-250.00
-200.00
-150.00
-100.00
-50.00
.00
50.00
VELOCITY (IN/SEC)
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)


HORIZONTAL DYNAMIC PRESSURE (PSI) VS TIME STATION NUMBER 10
.0000
-.05000
-.10000
-.15000
-.20000
-.25000
-.30000
-.35000
-.40000
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME (SEC)
216

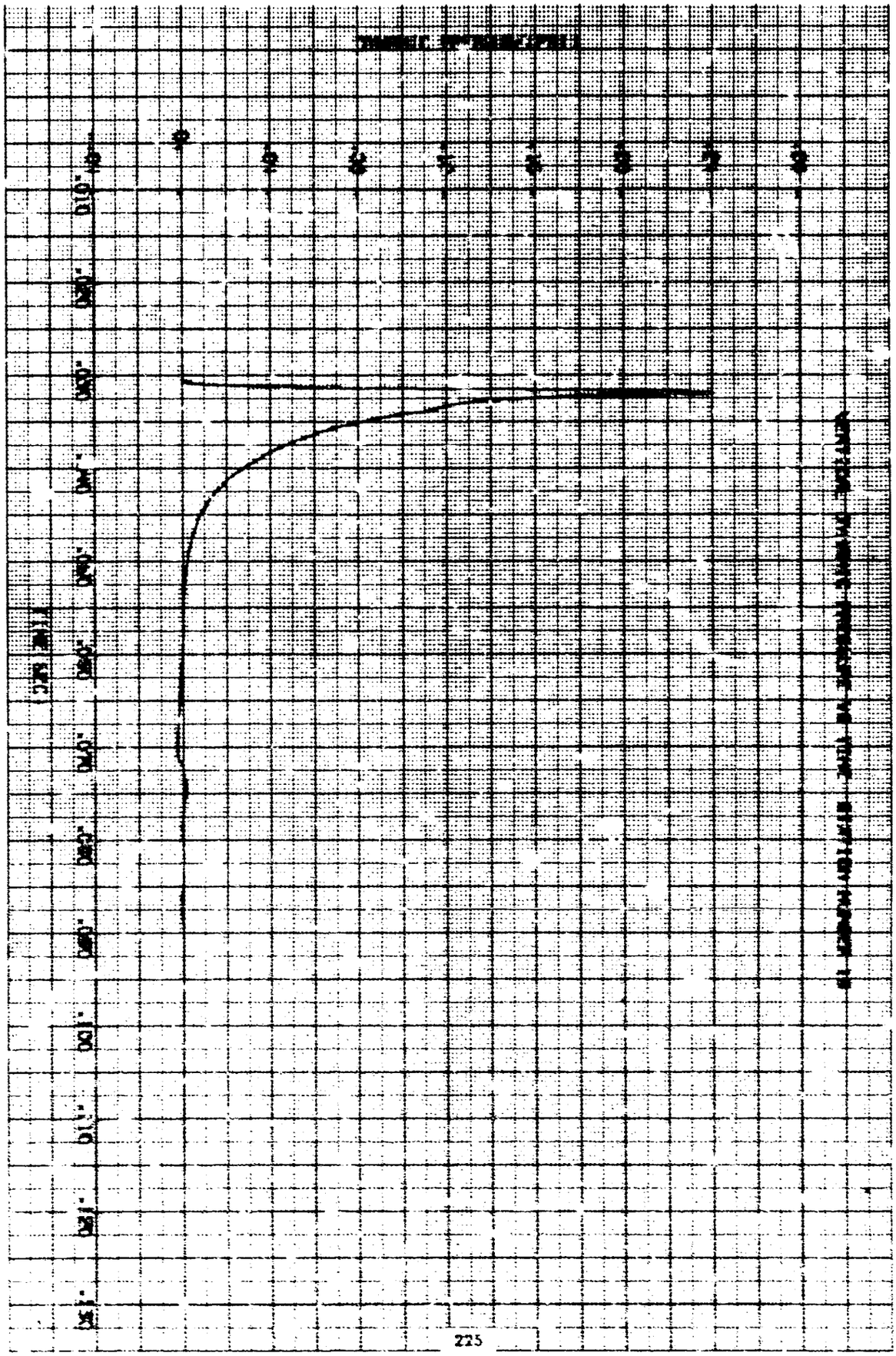
PARTICLE VELOCITY, FT/SEC
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800
840
880
920
960
1000
1040
1080
1120
1160
1200
1240
1280
1320
1360
1400
1440
1480
1520
1560

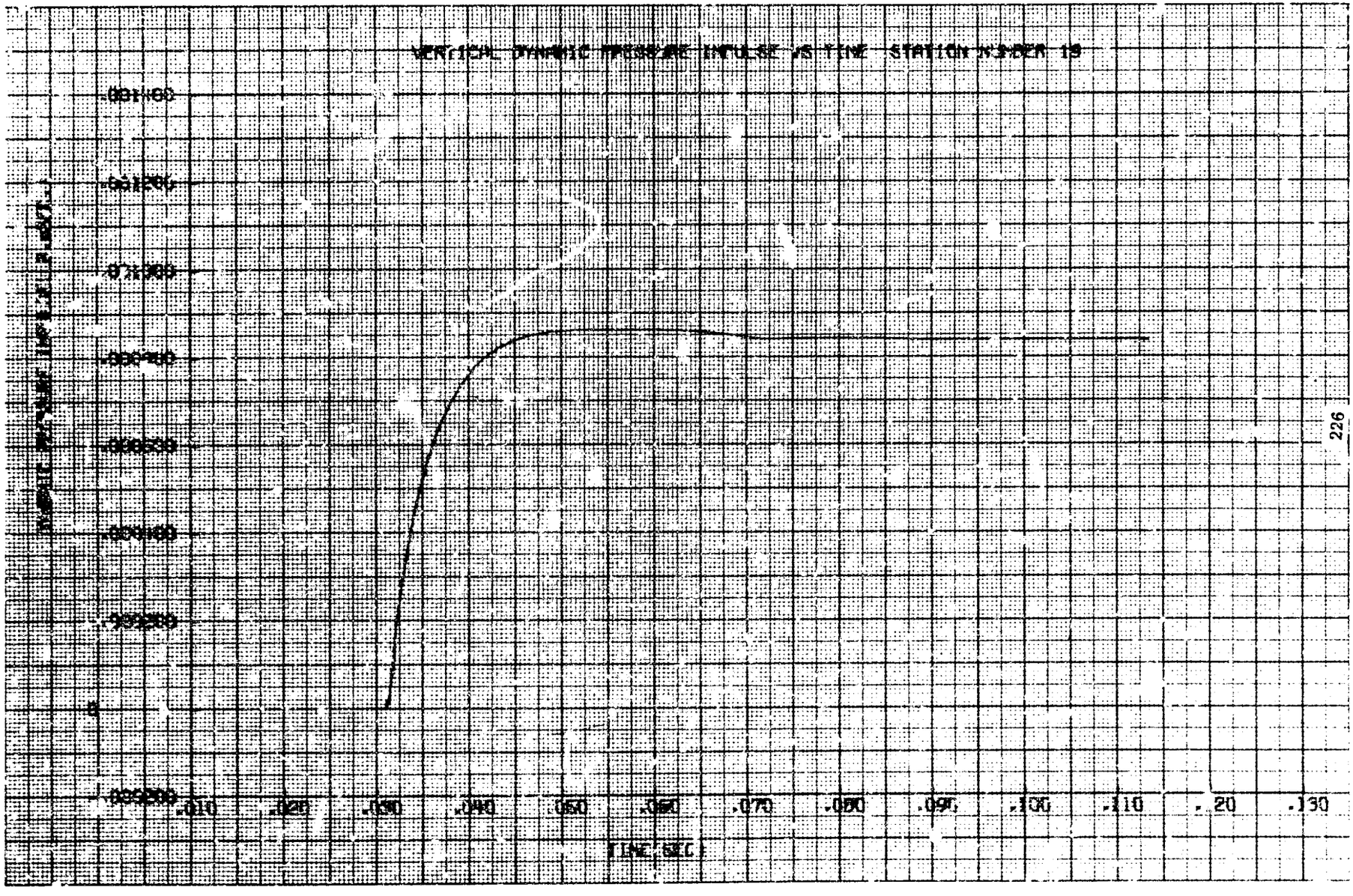






224




VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 19
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
TIME SEC
226

REFERENCES

1. Kelso, J. R., C. N. Kingery, J. Choromokos, Operation Distant Plain, DASA 1751, Headquarters, Defense Atomic Support Agency, Blast and Shock Division, Wash., DC, January 1966.

2. Zeldovich, I. B., add A. S. Kompaneets, Theory of Detonation, Academic Press, Inc., New York, 1960.

3. Lutzky, M., The Flow Field Behind a Spherical Detonation in TNT Using the Landau-Stanyukovich Equation of State for Detonation Products, NOLTR 64-40, U.S. Naval Ordnance Laboratory, White Oak, Md, February 1965.

4. Whitaker, W. A., E. A. Nawrocki, C. E. Needham, et al., A Preliminary Report of Theoretical Calculations of the Phenomenology of H. E. Detonations, WLRTH-6601, Air Force Weapons Laboratory, KAFB, New Mexico. (Unpublished Report.)

5. Doan, L. R., A Subroutine for the Equation of State of Air, RTD (WLR) TM-63-2, Air Force Weapons Laboratory, KAFB, New Mexico. May 1963.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author)

Air Force Weapons Laboratory (WLRTH)
Kirtland Air Force Base, New Mexico

2a REPORT SECURITY CLASSIFICATION

Unclassified

2b GROUP

3 REPORT TITLE

THEORETICAL CALCULATIONS OF THE DETONATION OF A 1,000-POUND SPHERE OF TNT AT 15 FEET ABOVE GROUND LEVEL

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

10 July 1966 to 10 September 1966

5 AUTHOR(S) (Last name, first name, initial)

Needham, Charles E.; Nawrocki, Edmund A., Capt, USAF; Whitaker, William A., Capt, USAF

6 REPORT DATE	7a TOTAL NO. OF PAGES	7b NO. OF REFS
October 1966	238	5

8a CONTRACT OR GRANT NO.	9a ORIGINATOR'S REPORT NUMBER(S)
b PROJECT NO. 5710	AFWL-TR-66-128
c Task No. 571001E	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d	

10 AVAILABILITY/LIMITATION NOTICES This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of AFWL (WLRTH), Kirtland AFB, N.M. Distribution of this document is limited because of the technology discussed.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	AFWL (WLRTH) Kirtland AFB NM 87117

13 ABSTRACT

The results of a theoretical calculation of the detonation of 1,000 pounds of TNT (loading density 1.608 gms/cc) are presented. The charge was detonated 15 feet above ground with an ambient pressure of 12.6 psi and an ambient temperature of approximately 100°F. The calculation started with the burning of the TNT and was carried to 115 milliseconds. The calculation clearly shows Mach stem formation, triple point path, and flow field. The theoretical calculation agrees well with experimental data obtained from a test.

DD FORM 1 JAN 64 1473

Unclassified

Security Classification

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Blast Wave						
Shock Reflection						
Mach Reflection						
Triple Point						
TNT Detonation, Calculation of						
SAP Code						
SHELL Code						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through

_____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through

_____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through

_____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.