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Vol. II

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THEORETICAL CALCULATIONS OF THE PHENOMENOLOGY OF HE DETONATIONS

Volume II

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

TECHNICAL REPORT NO. AFWL-TR-66-141, Vol. II

November 1966

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

Best Available Copy

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FOREWORD

This research was performed under Program Element 7.60.08.01.D, Project 5710, Subtask 1.027, and was funded by the Defense Atomic Support Agency (DASA).

Inclusive dates of research were 1 September 1965 to 1 June 1966. The report was submitted 27 October 1966 by the Project Officer, Capt William A. Whitaker (WLRTH).

This report has been reviewed and is approved.

William A. Whitaker
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Captain, USAF
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Chief, Research Division

ABSTRACT

The phenomenology of two atmospheric high-explosive detonations were calculated theoretically. The first was a 20-short-ton spherical charge of TNT (loading density--1.56 gms/cc). The second was a methane-oxygen mixture (mole ratio 1 to 1.5) contained in a 55-ft-radius balloon. Both detonations took place at an altitude of 670 meters (ambient pressure 13.6 psi) with a reflecting surface 85 feet below burst point. The calculations, taken out to 300 milliseconds after detonations, were performed by using SAP, a one-dimensional Lagrangian hydrodynamic code and SHELL-OIL, a two-dimensional pure Eulerian hydrodynamic code. Volume II of this report contains the details of the results in graphical form. Included are pressure and density contours, velocity vector plots, and wave forms for 19 test stations.

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SECTION I

INTRODUCTION

Volume II is divided into three sections, the last two of which are, in turn, divided into three parts.

Section II contains plots of the TNT calculations. Part 1 consists of profiles of the thermodynamic variables at selected times as calculated by SAP. Part 2 consists of pressure and density contours and velocity vectors at selected times as calculated by SHELL-OIL. Part 3 consists of traces of overpressure, dynamic pressure impulse, radial velocity and axial velocity as a function of time at the various test stations; again, the results of SHELL-OIL.

Section III contains plots of the methane calculation. The format of this section is the same as in Section II: first, SAP profiles; second, SHELL-OIL contours and velocity vectors; third, SHELL-OIL tracings at the test stations.

The output contained in this volume is small compared to that available. More detailed, or additional output, in graphical form is available upon request to AFWL (WLRTR).

Table I

POSITION OF TEST STATIONS

Test Stations	Range		Altitude	
	Meters	(Feet)	Meters	(Feet)
1	0		0	
2	7.62	(25)	0	
3	15.24	(50)	0	
4	24.38	(80)	0	
5	38.0	(125)	0	
6	50.0	(164)	0	
7	63.8	(209)	0	
8	78.0	(256)	0	
9	93.3	(306)	0	
10	26.0	(85)	2.8	
11	38.0	(125)	2.8	(9)
12	50.0	(164)	2.8	(9)
13	38.0	(125)	7.6	(25)
14	50.0	(164)	7.6	(25)
15	63.8	(209)	7.6	(25)
16	50.0	(164)	15.2	(50)
17	63.8	(209)	18.0	(59)
18	78.0	(256)	15.2	(50)
19	78.0	(256)	22.8	(75)

SECTION II

THE TNT CALCULATION

SAP Profiles

This part contains profiles of pressure, density, and velocity as calculated by SAP for the TNT detonation scaled to 20 short tons. There are plots for 25 different times.

The first plot contains the profiles describing the flow field behind the detonation front in the TNT. Also shown on this plot, as indicated by the symbols, is the similarity solution for the detonation wave, obtained using the LSZK equation of state for TNT. Agreement between the SAP "burn" calculation, which provides a nonself-similar solution, and the similarity solution is excellent.

Succeeding plots show the convergence of the rarefaction wave on the origin, the formation and expansion of the free-air shock, and the formation and motion of secondary shocks.

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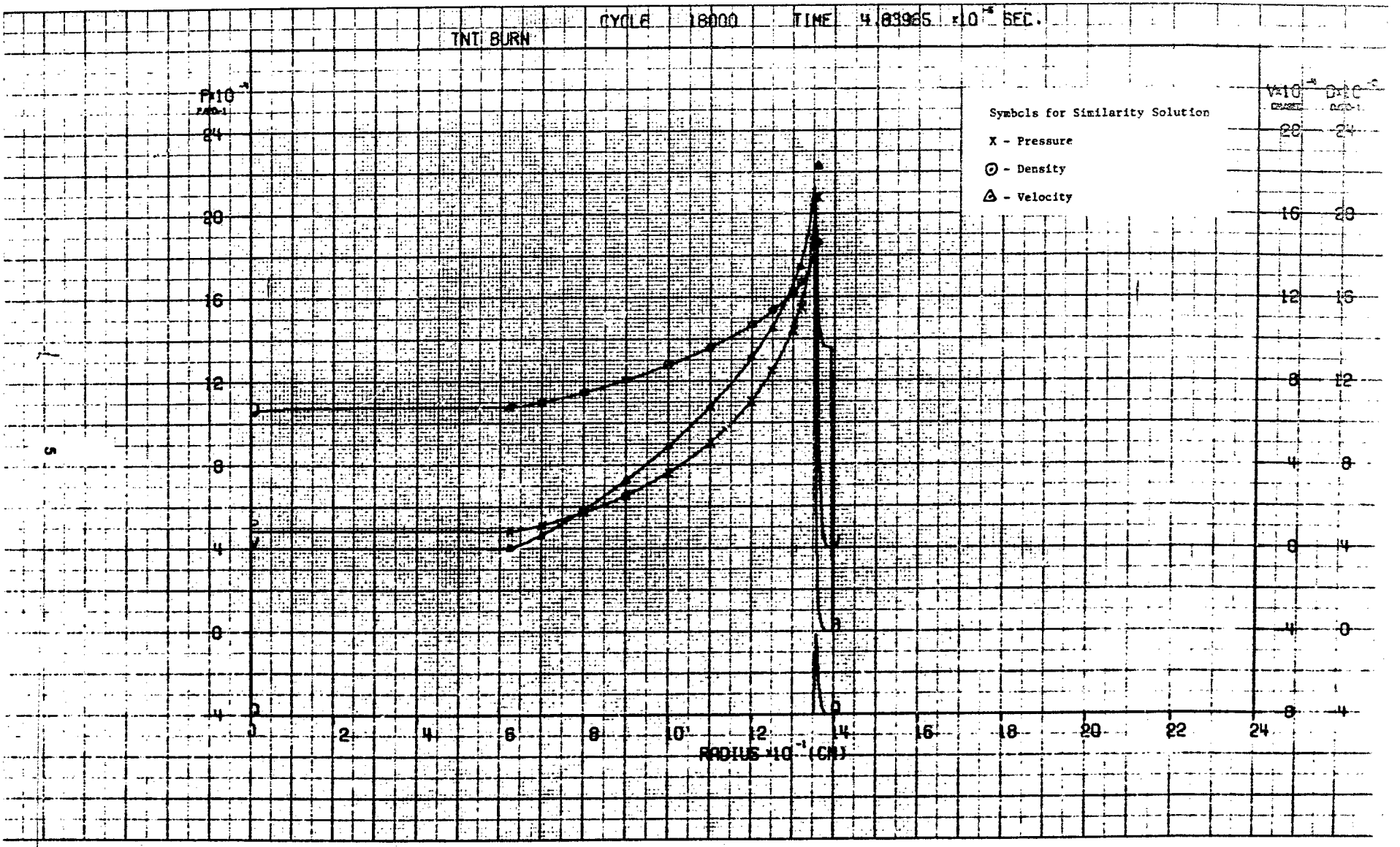
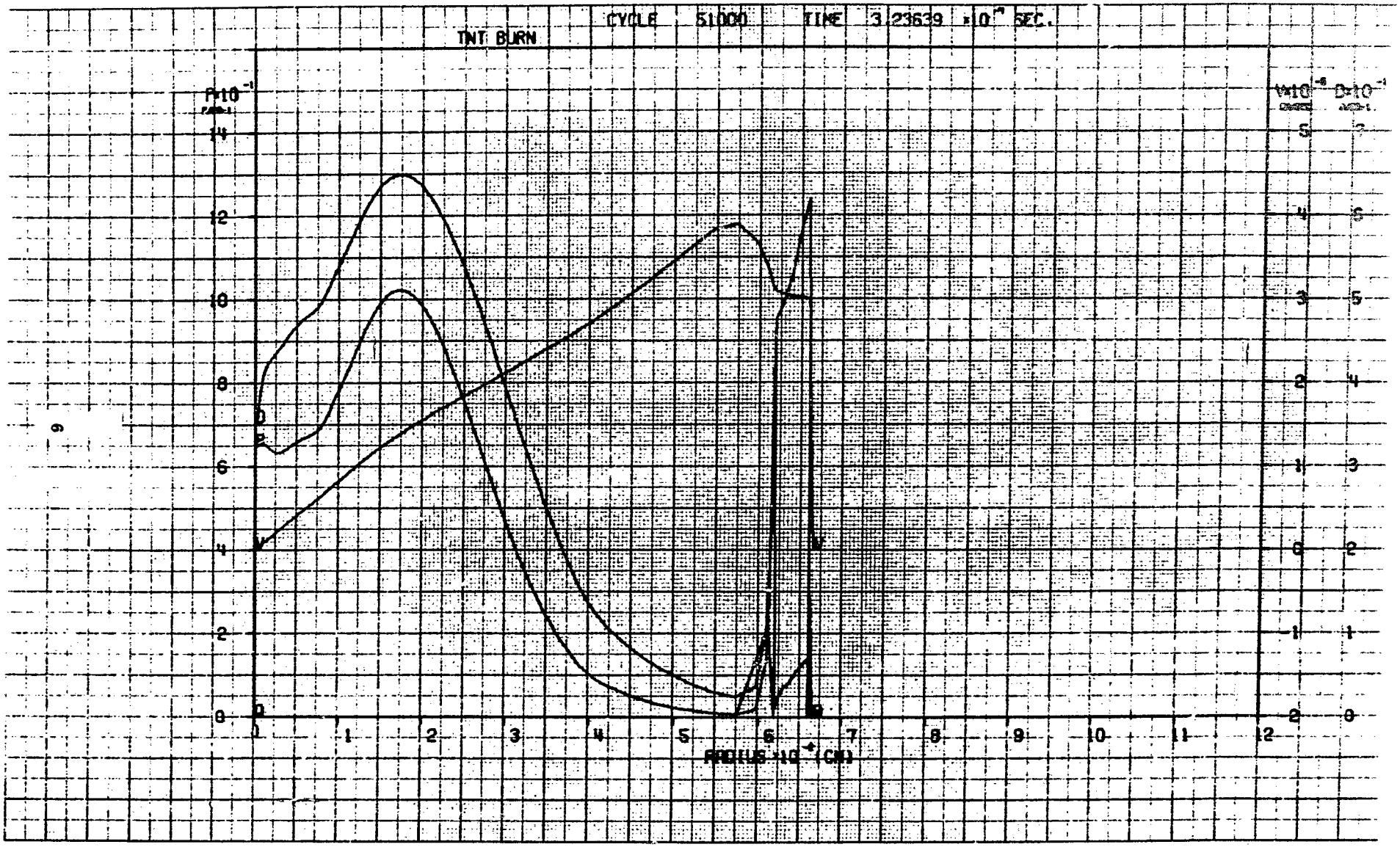
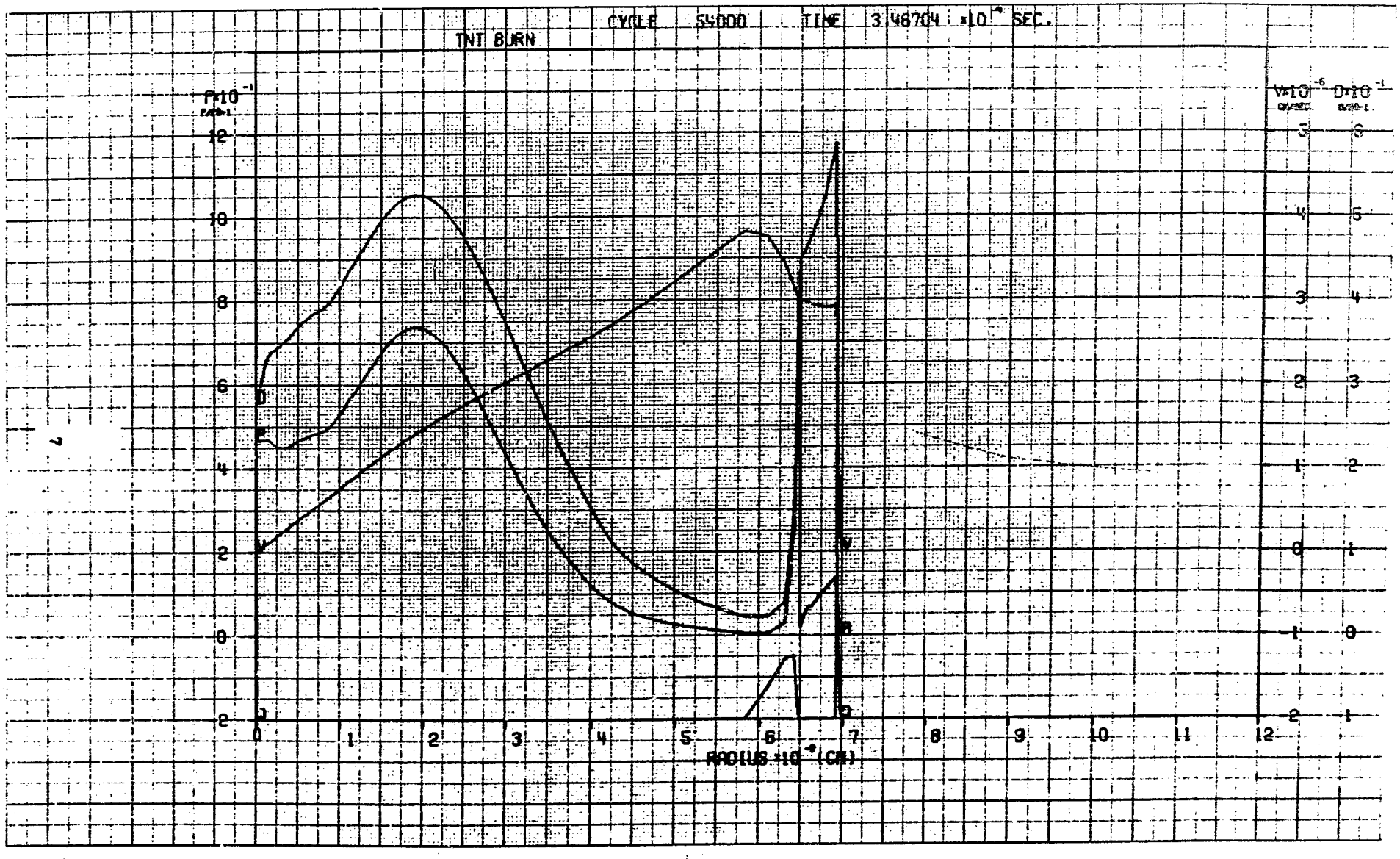
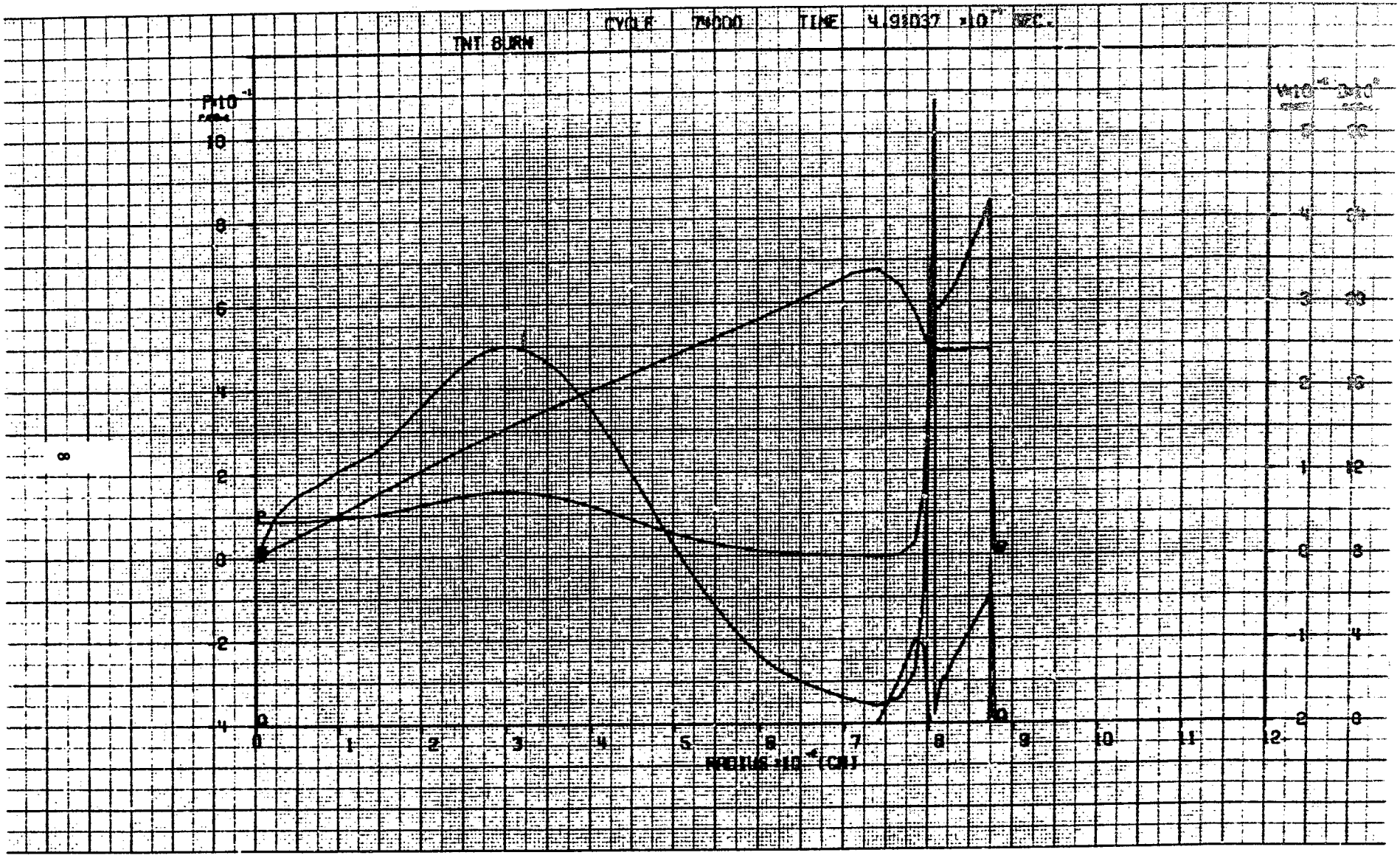
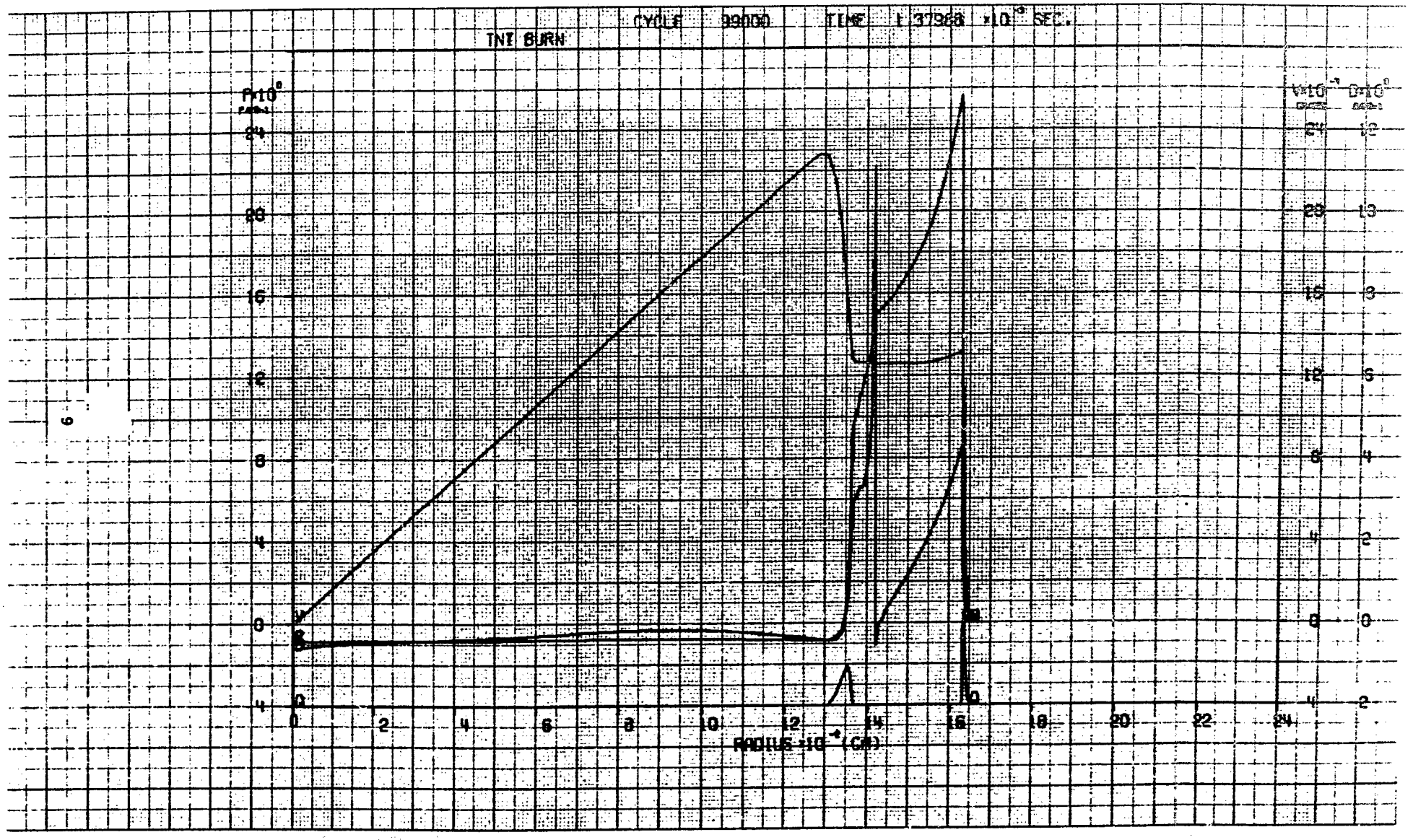
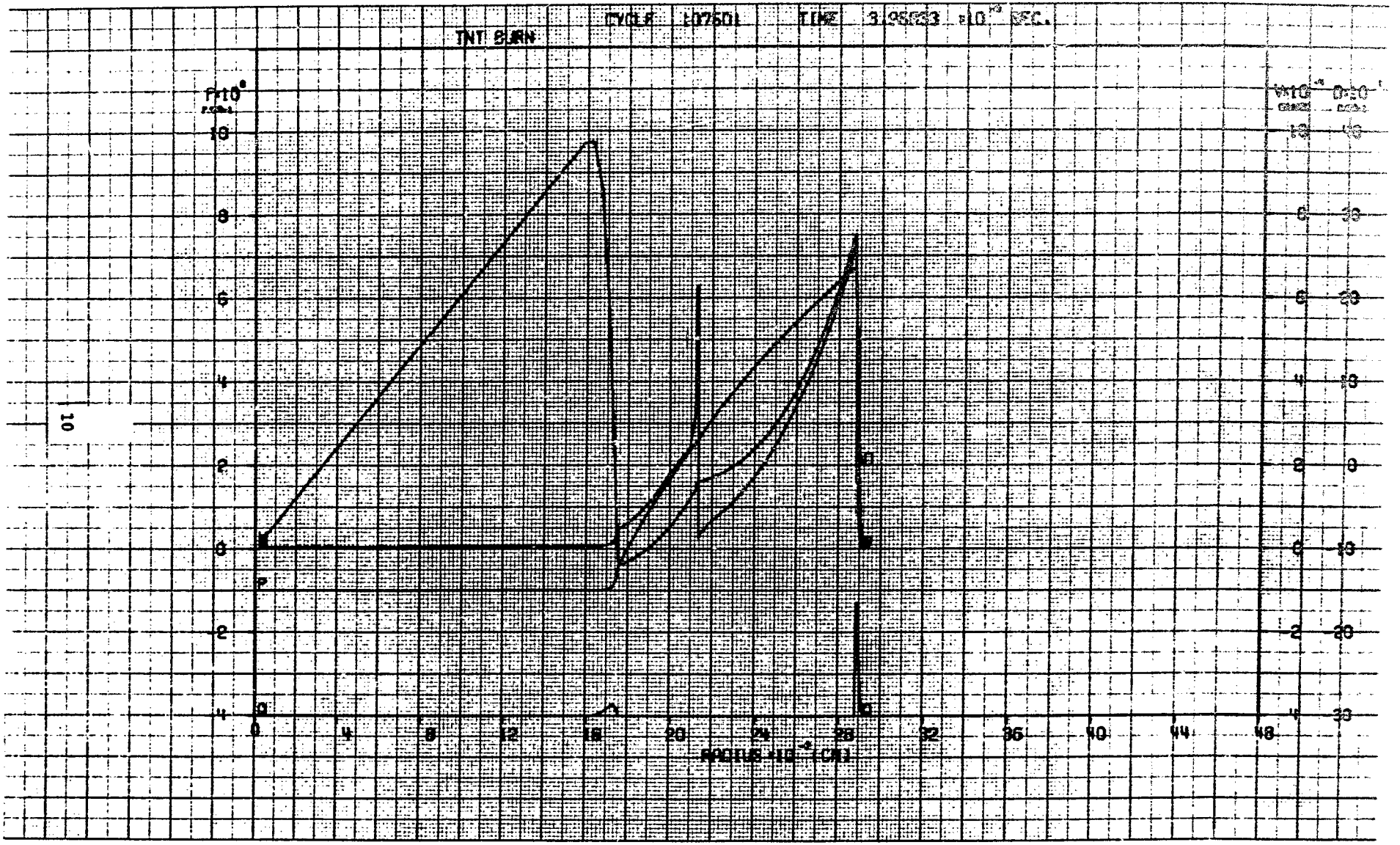

TNT BURN
CYCLE 18000 TIME 4.89965 ×10⁻⁶ SEC.
P×10⁻⁹
D×10⁻⁶
V×10⁻⁶
Symbols for Similarity Solution
X - Pressure
⊙ - Density
△ - Velocity
RADIUS ×10⁻¹ (CM)

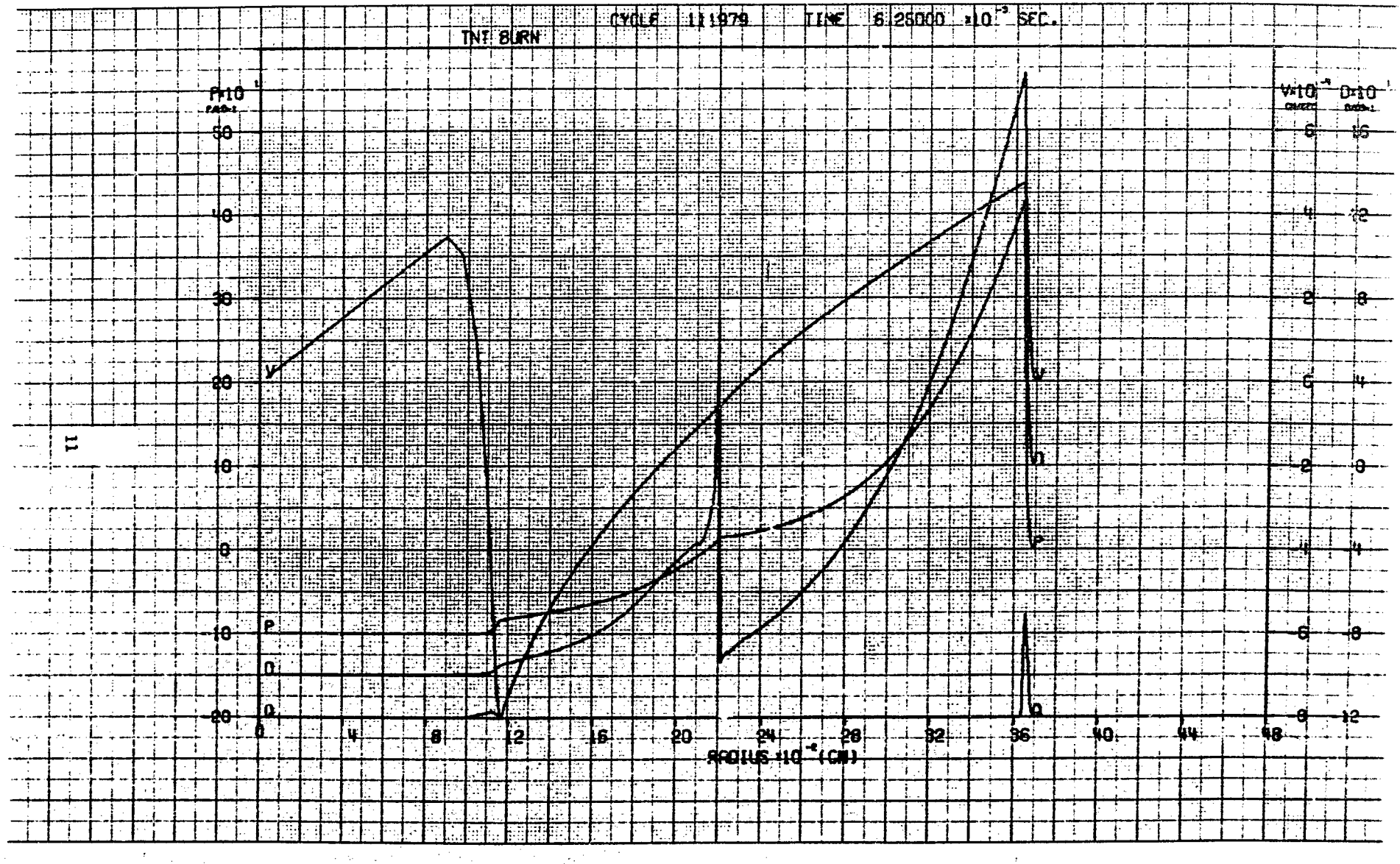

TNT BURN
CYCLE 51000 TIME 3.23639 ×10⁻⁷ SEC.
P×10⁻¹
V×10⁻⁶ D×10⁻¹
14
12
10
8
6
4
2
0
5
4
3
2
1
0
6
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12
RADIUS ×10⁻⁴ (CM)

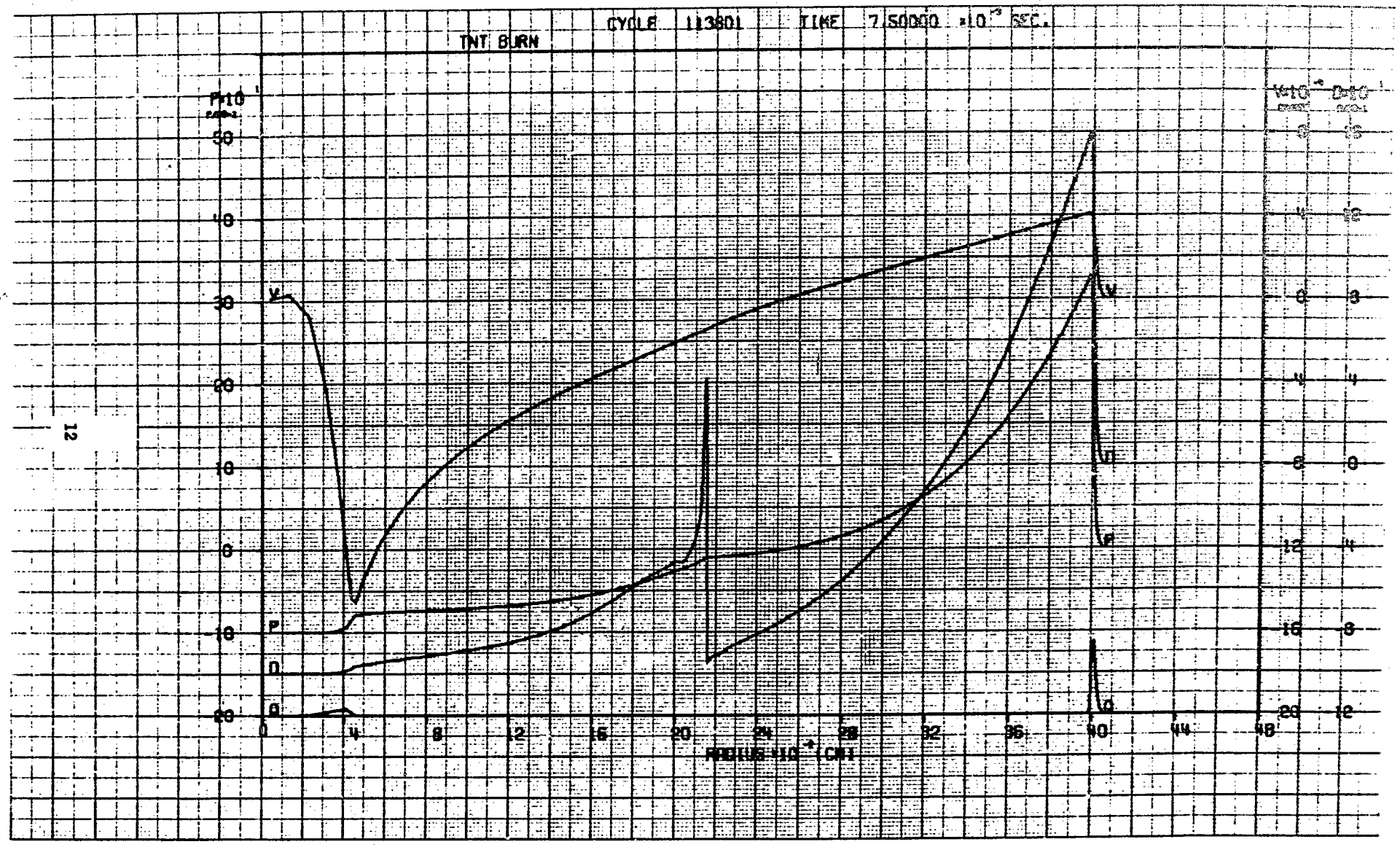

TNT BURN
CYCLE 54000 TIME 3.46704 ×10⁻⁴ SEC.
P×10⁻¹
V×10⁻⁶
D×10⁻¹
RADIUS ×10⁻⁴ (CM)

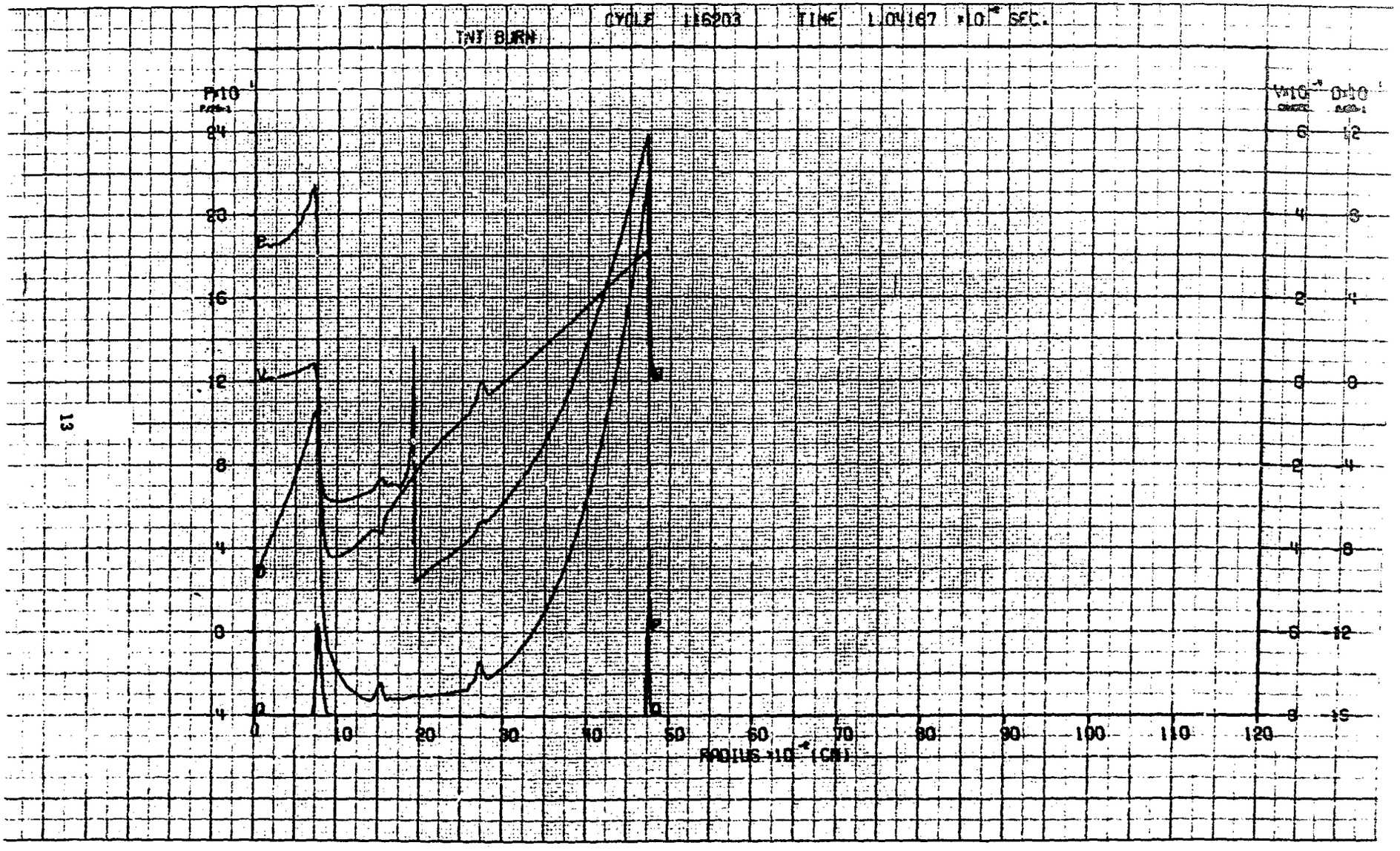

TNT BURN
CYCLE 74000
TIME 4.91037 ×10⁻⁷ SEC.
P×10⁻⁹
RADIUS ×10⁻⁴ (CM)

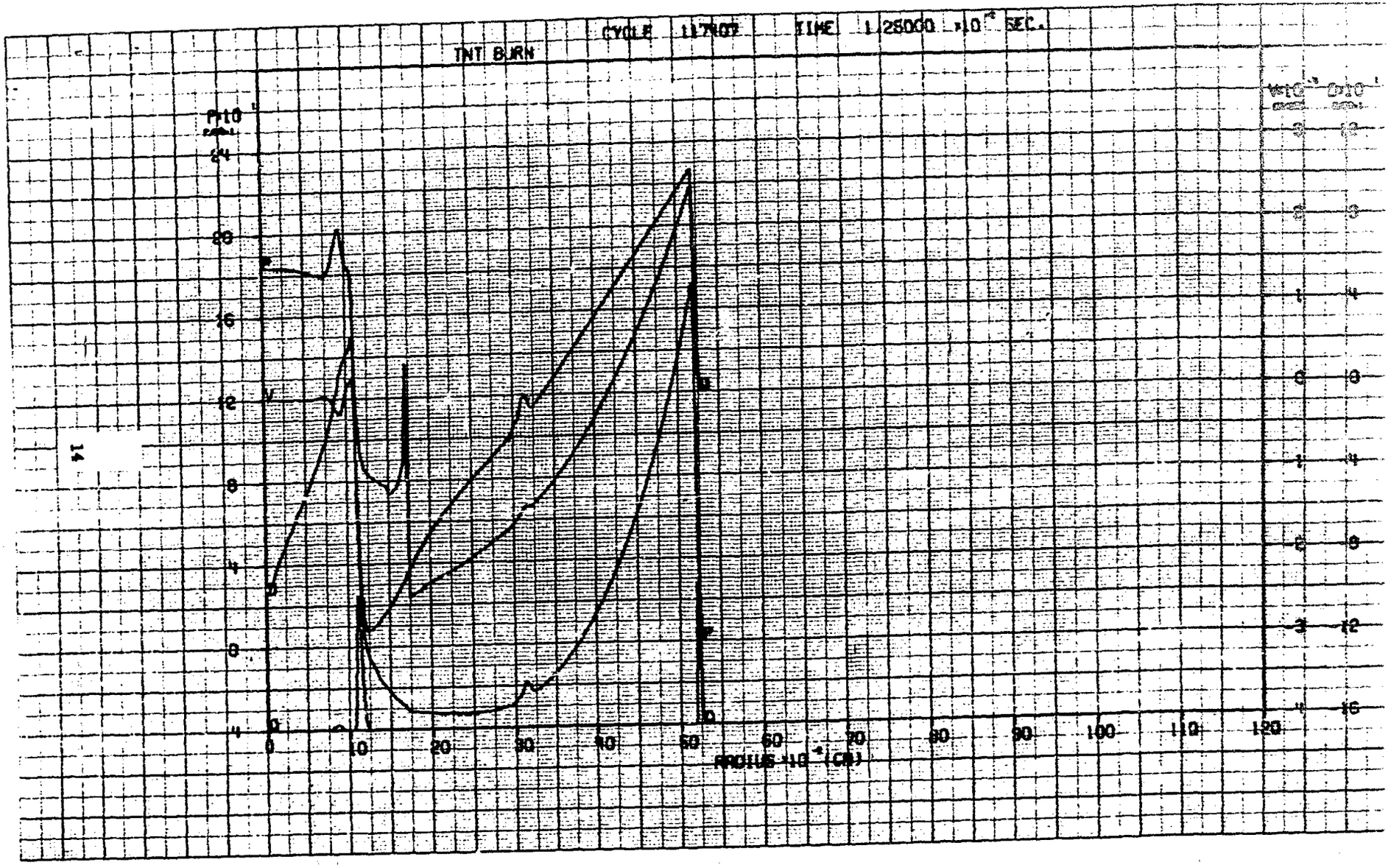

TNT BURN
CYCLE 99000
TIME 1.37368 ×10⁻³ SEC.
Pr10⁶
V×10⁻⁶
D×10⁶
24
20
16
12
8
4
0
2
6
10
14
18
22
RADIUS ×10⁻⁴ (CM)

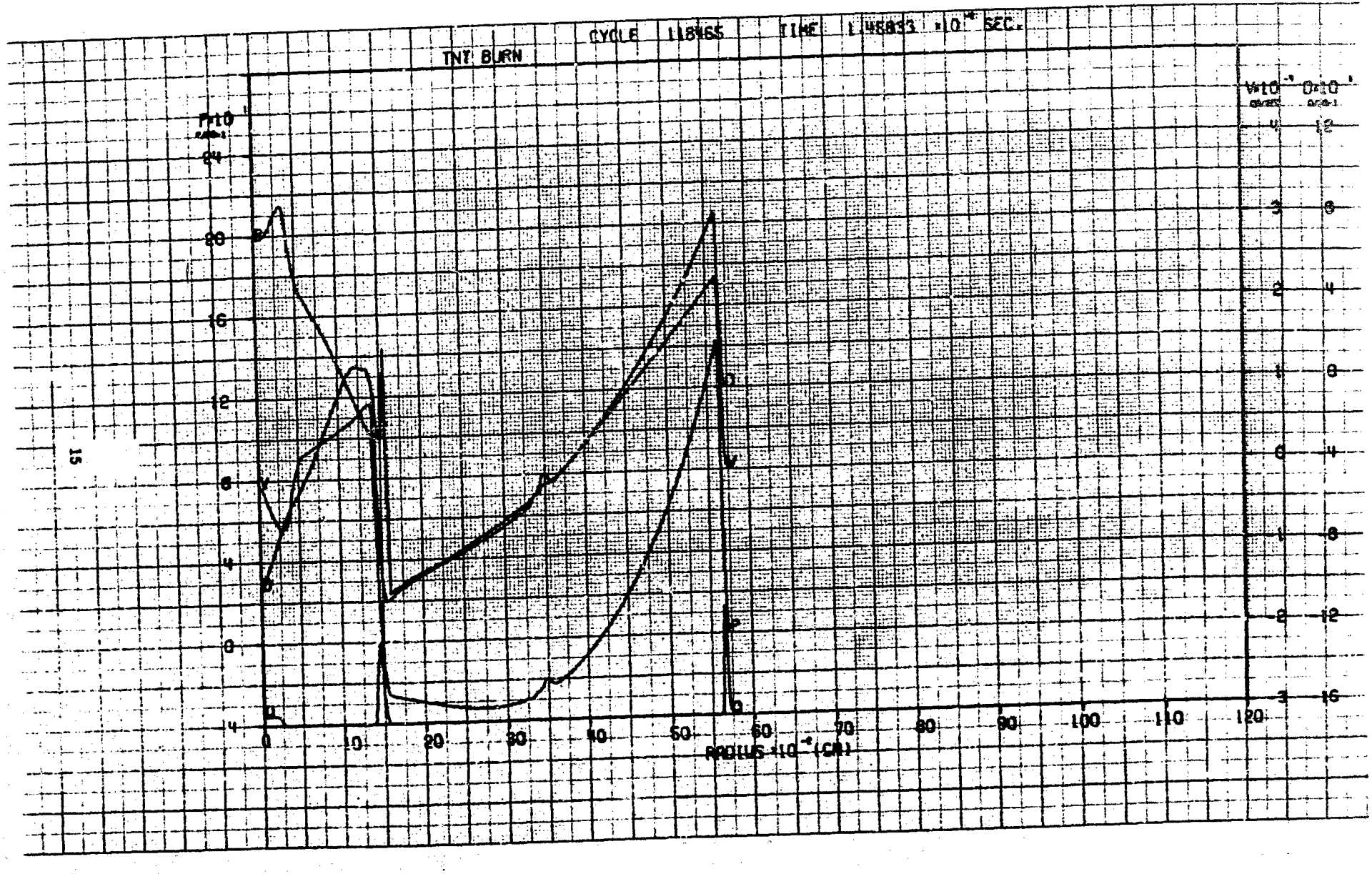

TNT BURN
CYCLE 107601
TIME 3.95633 ×10⁻³ SEC.
P×10⁻⁹
10
8
6
4
2
0
-2
-4
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)

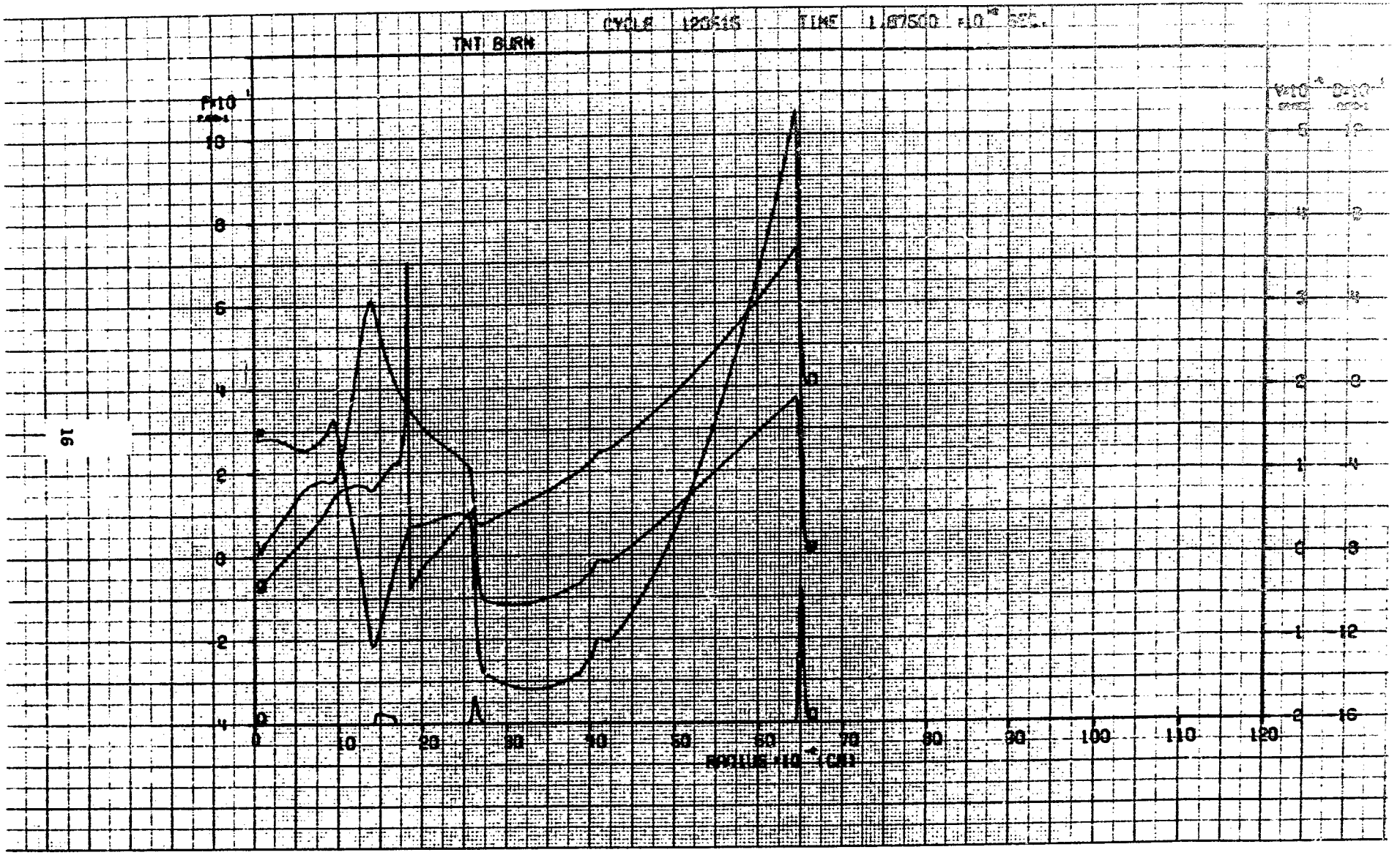

TNT BURN
CYCLE 11979
TIME 6.25000 ×10⁻³ SEC.
P×10⁻¹
V×10⁻⁴
D×10¹
50
40
30
20
10
0
-10
-20
6
4
2
0
-2
-4
-6
8
6
4
2
0
-2
-4
-6
-8
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)
V
V
P
P
D
D
11

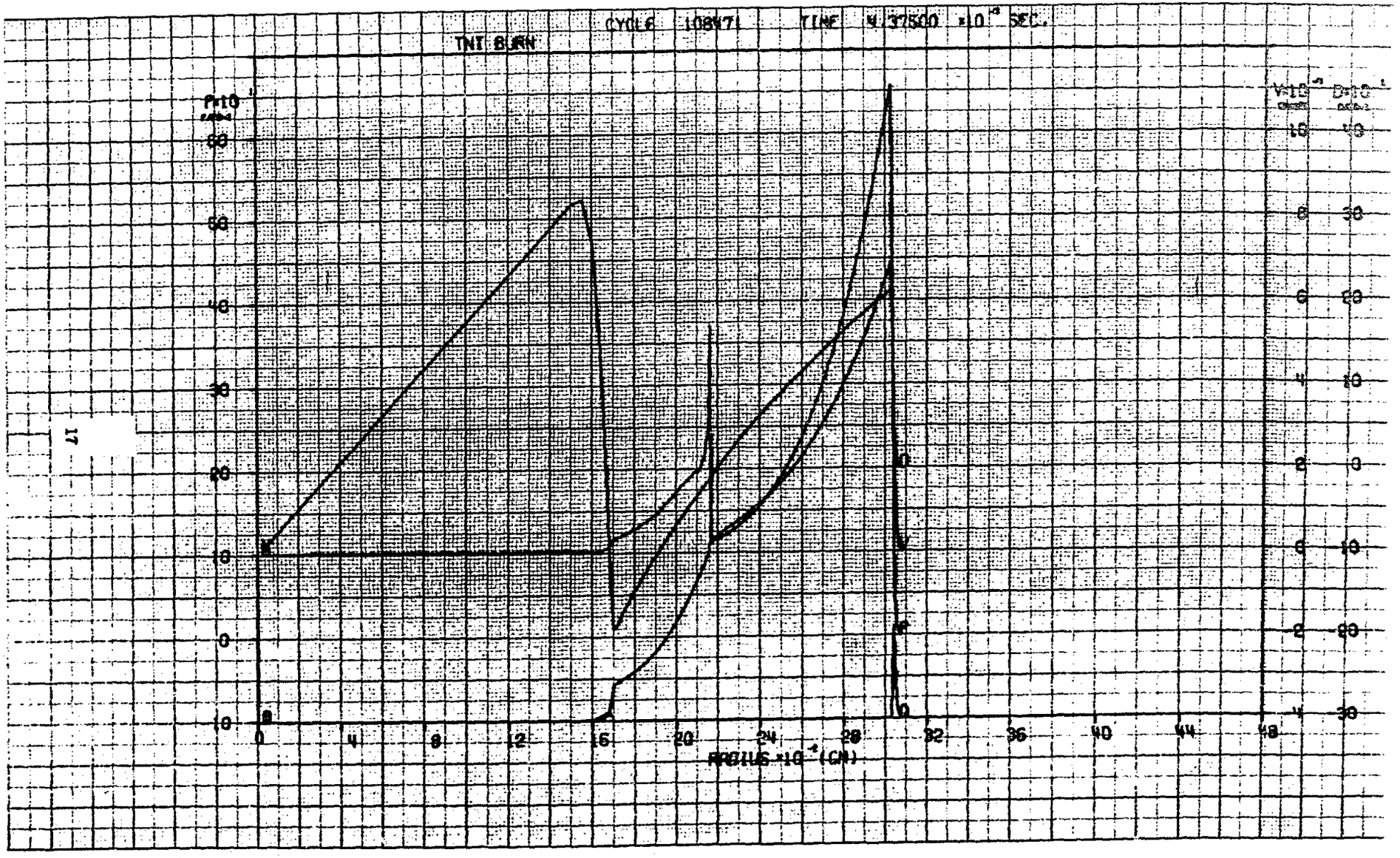

TNT BURN
CYCLE 113801
TIME 7.50000 ×10⁻³ SEC.
P×10⁻¹
W×10⁻³
D×10⁻¹
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻¹ (CM)
V
P
D
Q
W
12

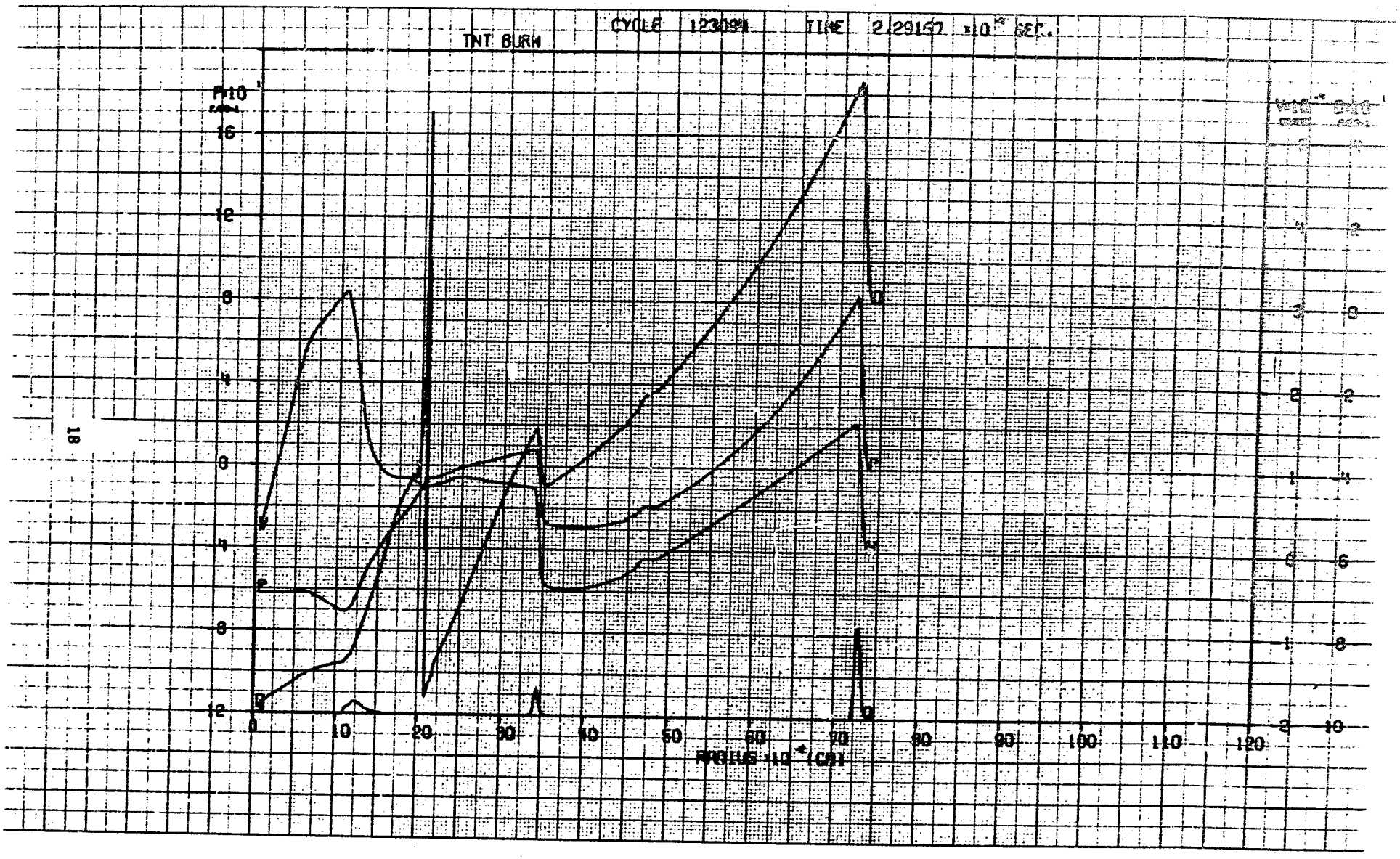

TNT BURN
CYCLE 116203
TIME 1.04167 ×10⁻⁶ SEC.
P×10⁻¹⁰
V×10⁻⁹
D×10⁻¹⁰
24
20
16
12
8
4
0
6
4
2
0
2
4
6
8
12
4
8
12
16
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻⁶ (CM)

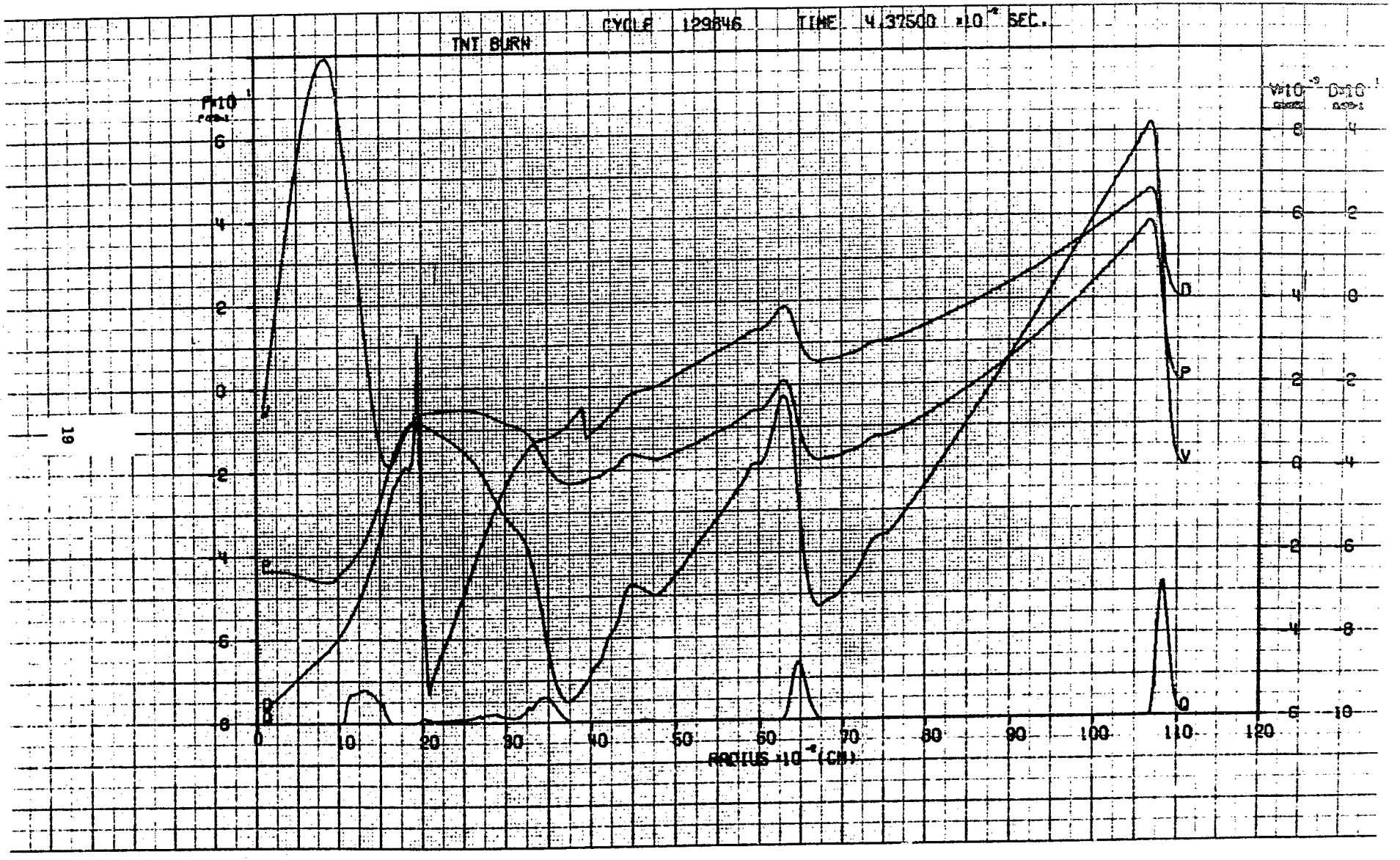

TNT BURN
CYCLE 117907
TIME 1.25000 ×10⁻⁶ SEC.
P×10⁻¹
24
20
16
12
8
4
0
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻¹ (CM)
V×10⁻³
D×10¹
3
2
1
0
4
8
12
16

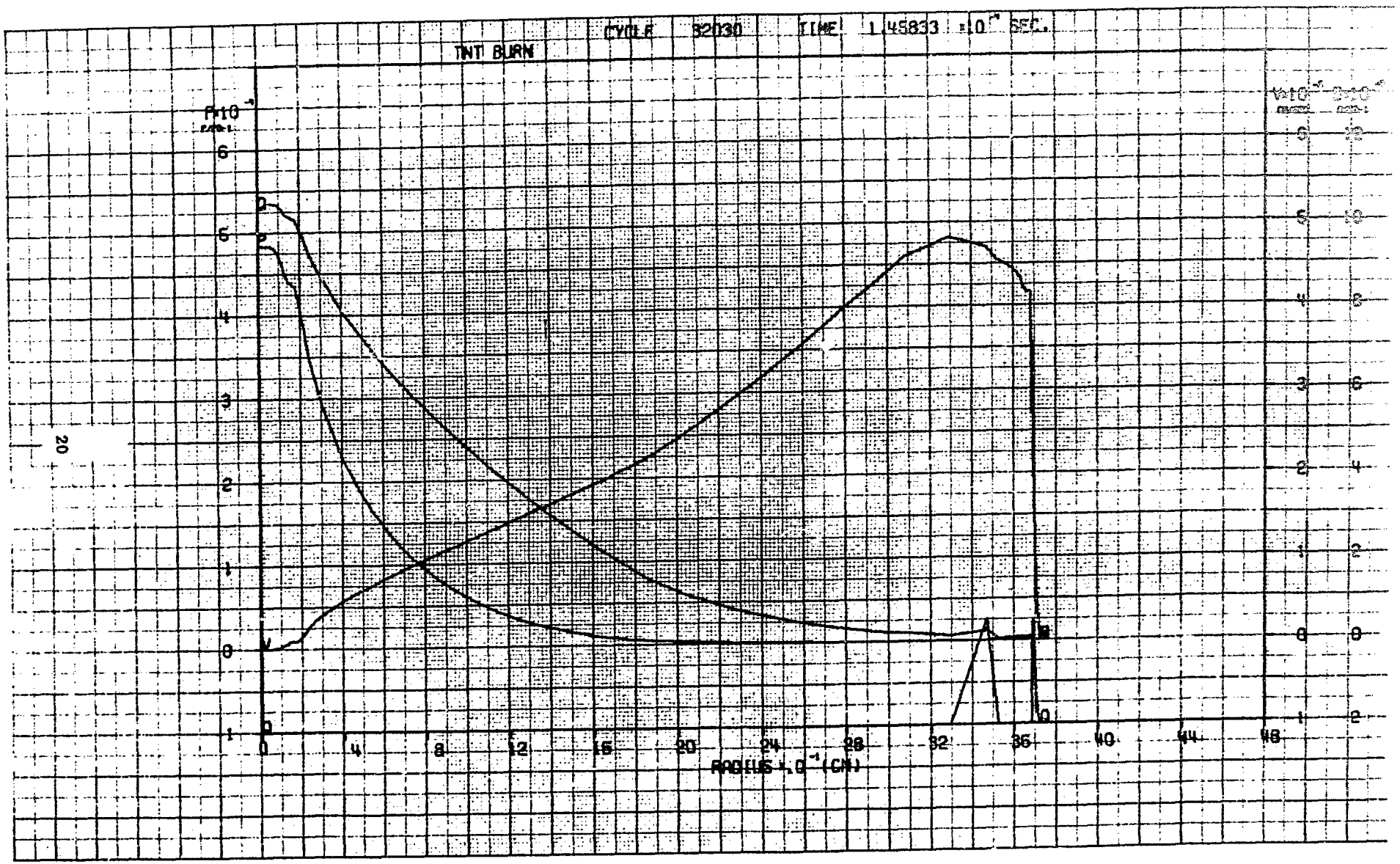

TNT BURN
CYCLE 118465 TIME 1.48833 ×10⁻⁴ SEC.
P×10⁻¹
V×10⁻⁹ 0×10⁻¹
24
20
16
12
8
4
0
-4
3
2
1
0
-1
-2
-3
12
8
4
0
-4
-8
-12
-16
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻⁹ (CM)

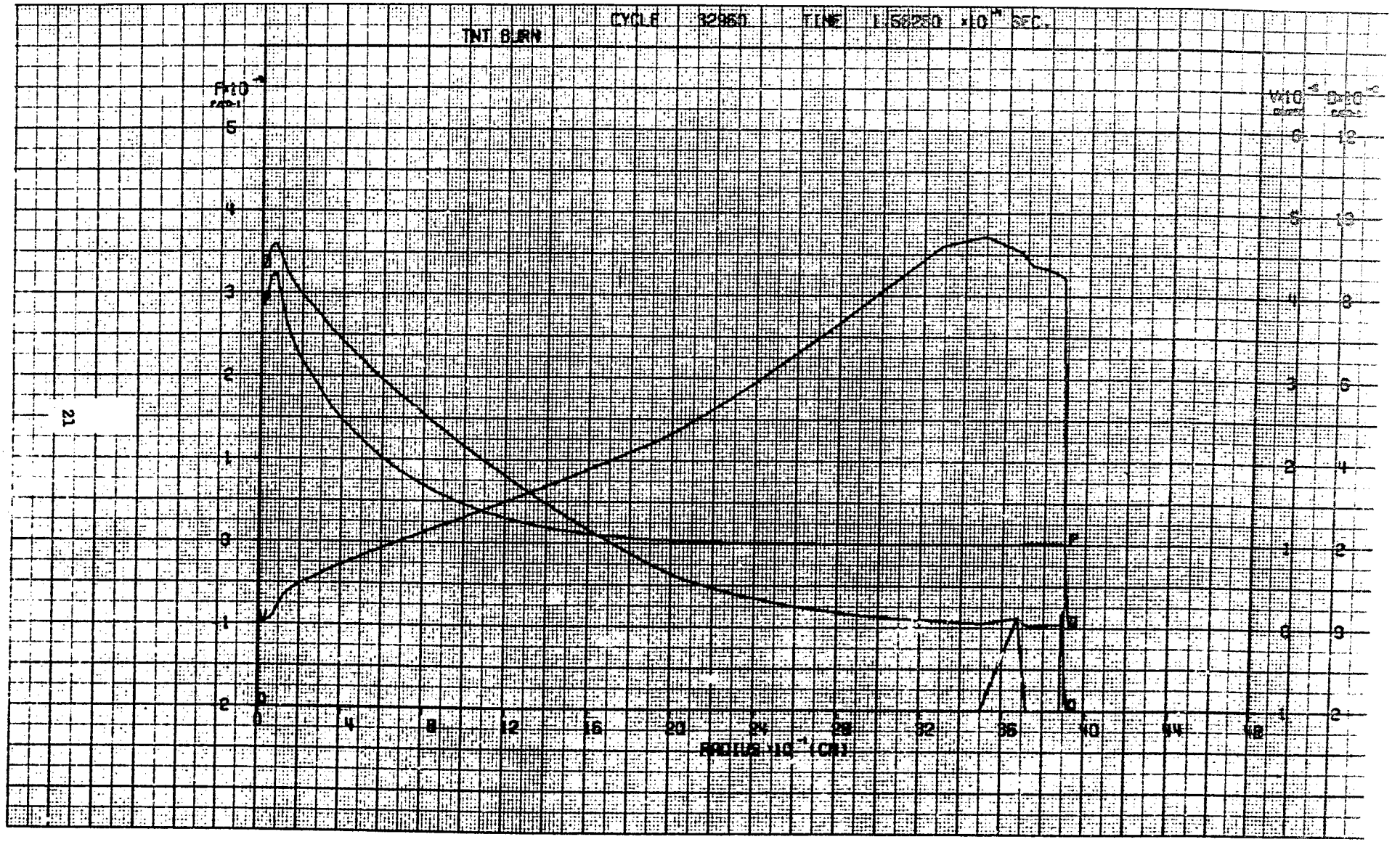

TNT BURN
CYCLE 120515
TIME 1.87500 ×10⁻³ SEC.
P×10⁻¹
10
8
6
4
2
0
-2
-4
16
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻¹ (CM)
V×10⁻⁴ D×10⁻¹
12
8
4
0
-4
-8
-12
-16

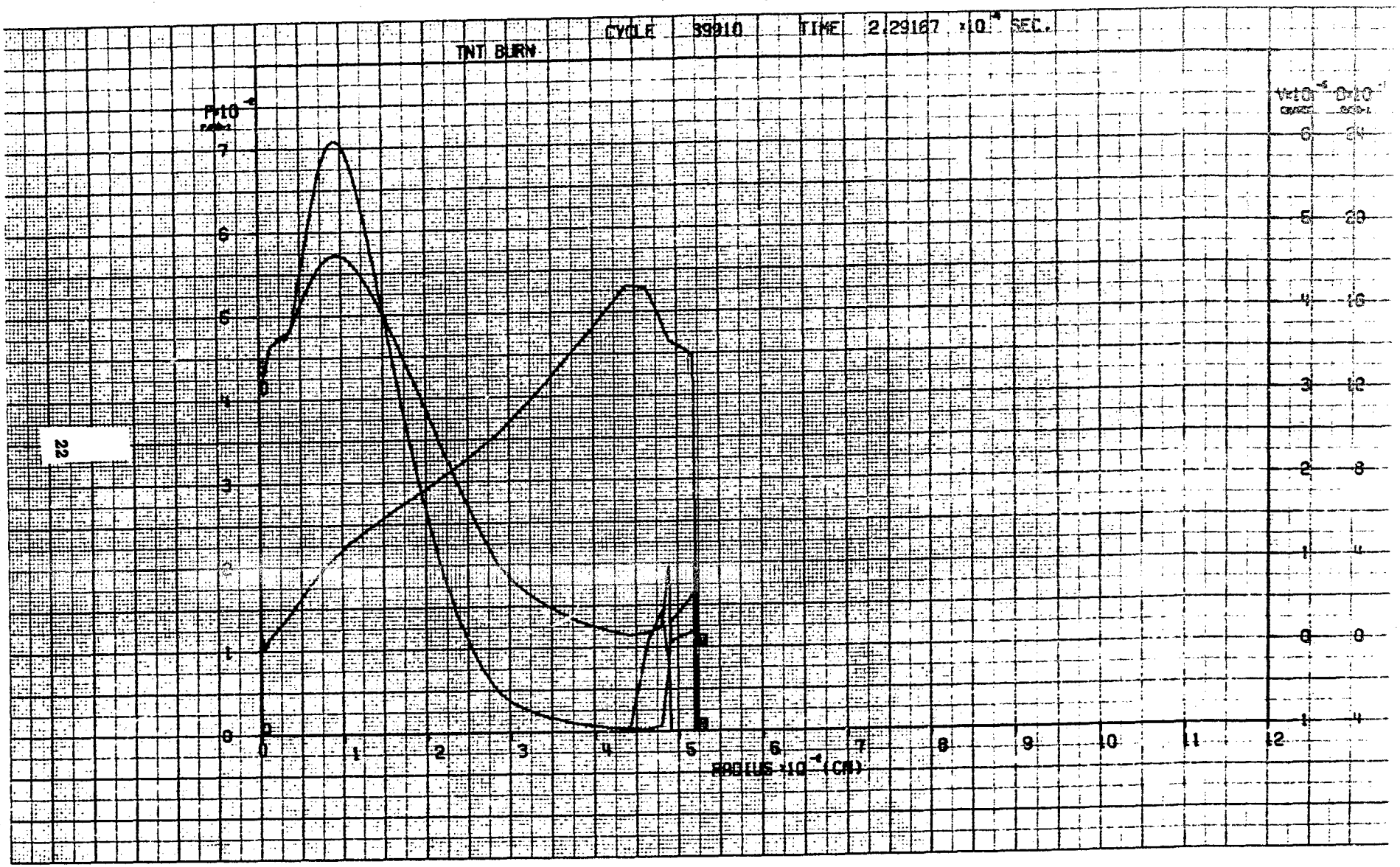

TNT BURN
CYCLE 10847
TIME 4.37500 ×10⁻⁵ SEC.
P×10⁻¹
V×10⁻⁵
D×10⁻¹
60
50
40
30
20
10
0
-10
10
8
6
4
2
-2
-4
30
20
10
0
-10
-20
-30
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)
17

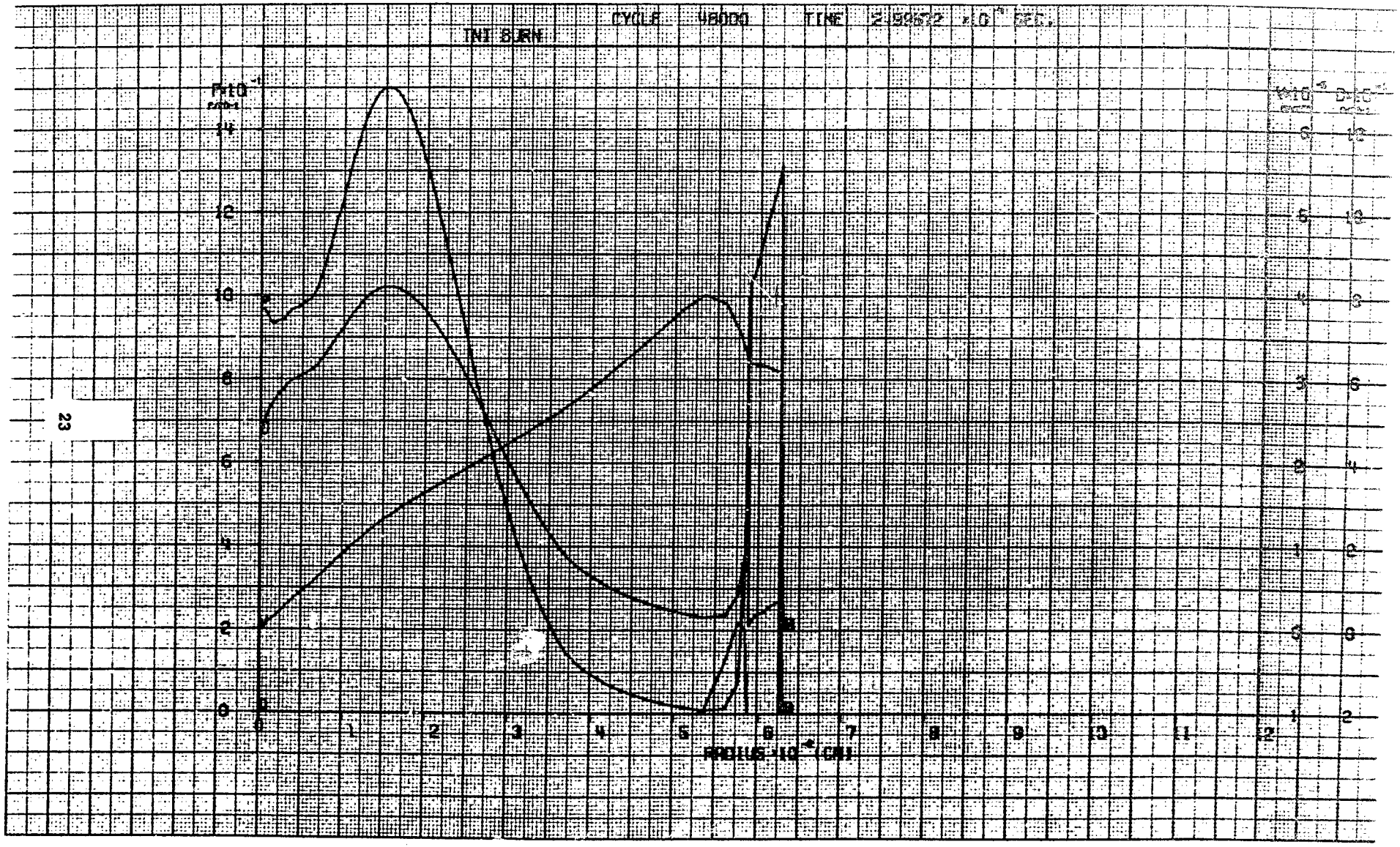

TNT BURN
CYCLE 123091
TIME 2.29157 ×10⁻⁵ SEC.
16
12
8
4
0
-4
-8
-12
0
10
20
30
40
50
60
70
80
90
100
110
120
PROFILES ×10⁻⁴ (CM)

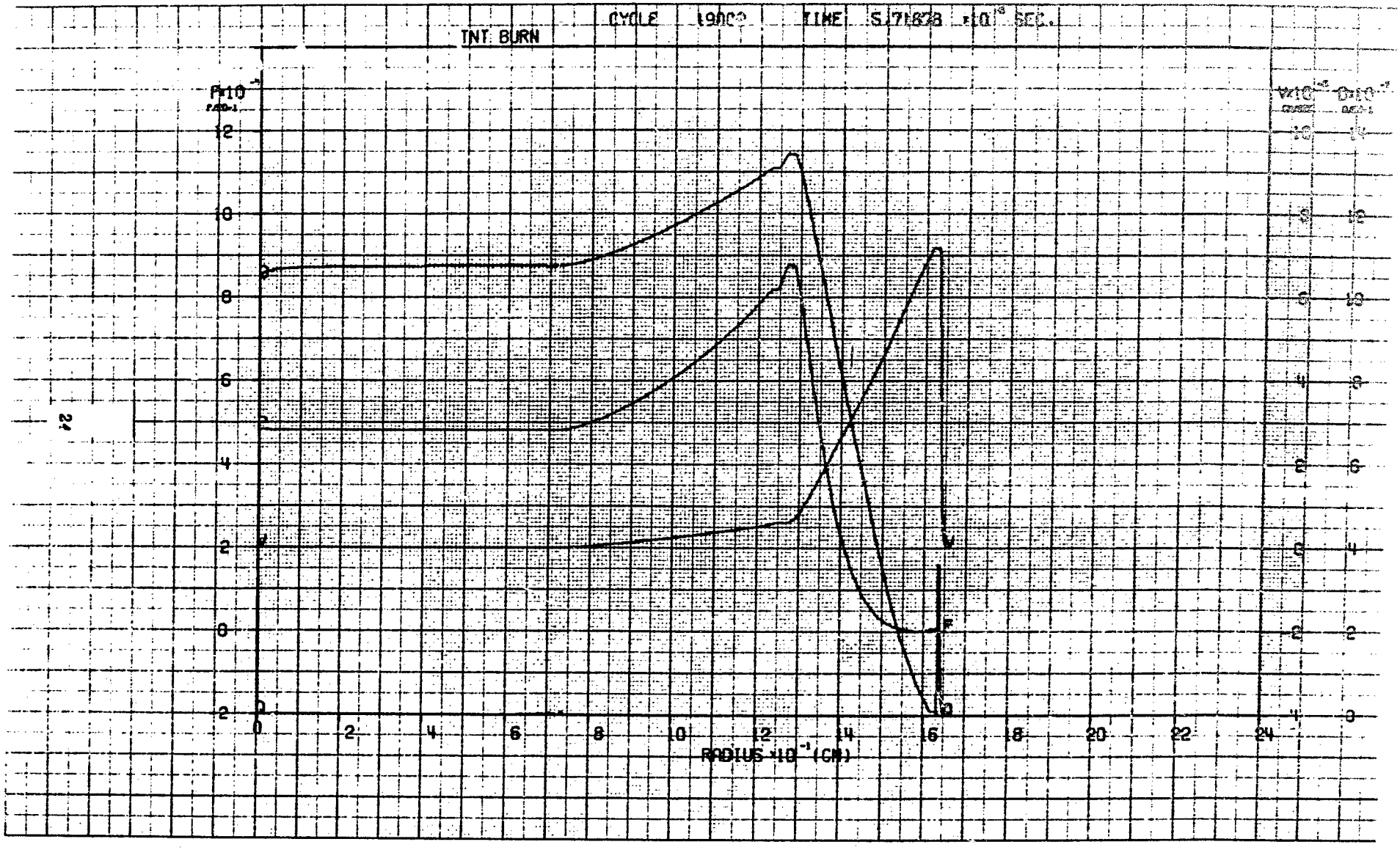

TNT BURN
CYCLE 129846
TIME 4.37500 ×10⁻² SEC.
P×10¹
V×10⁻⁹
D×10¹
RADIUS ×10⁻² (CM)
P
V
D
E
0
10
20
30
40
50
60
70
80
90
100
110
120

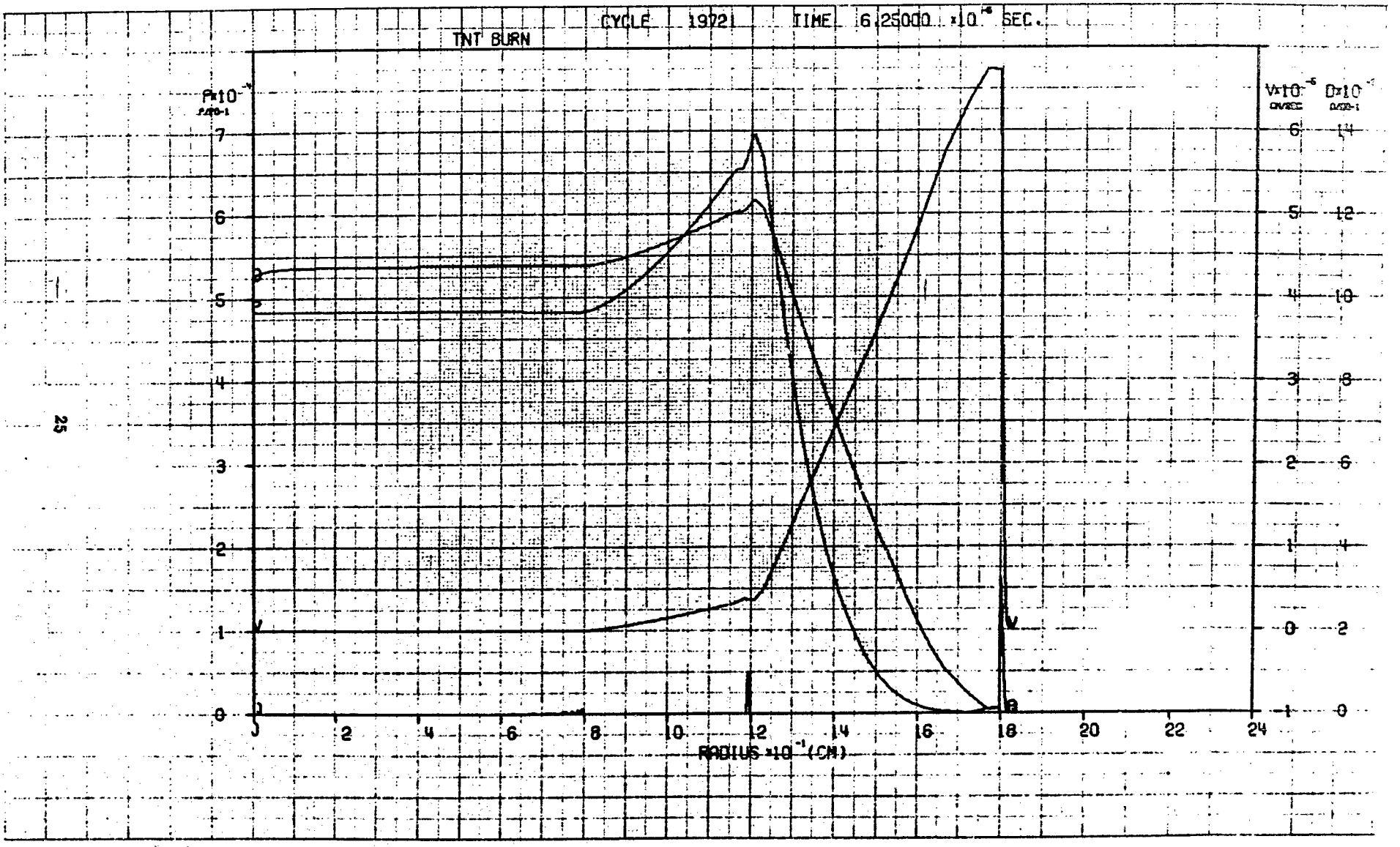

TNT BURN
CYCLE 32030
TIME 1.45833 ×10⁻⁶ SEC.
RADIUS ×10⁻¹ (CM)

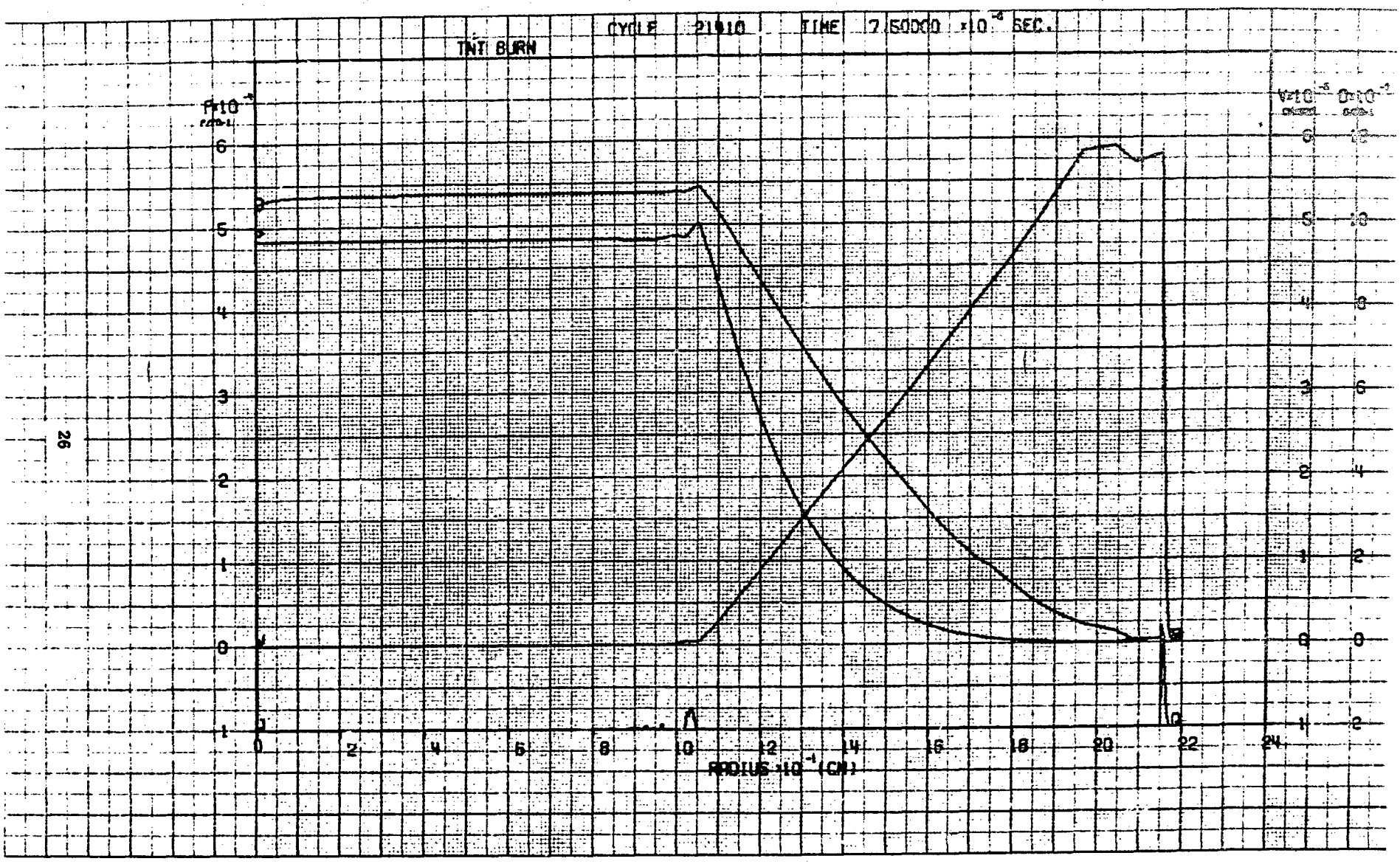

TNT BURN
CYCLE 32950
TIME 1.58250 ×10⁻⁴ SEC.
F×10⁻⁴
V×10⁻⁴
D×10⁻⁴
RADIUS ×10⁻¹ (CM)

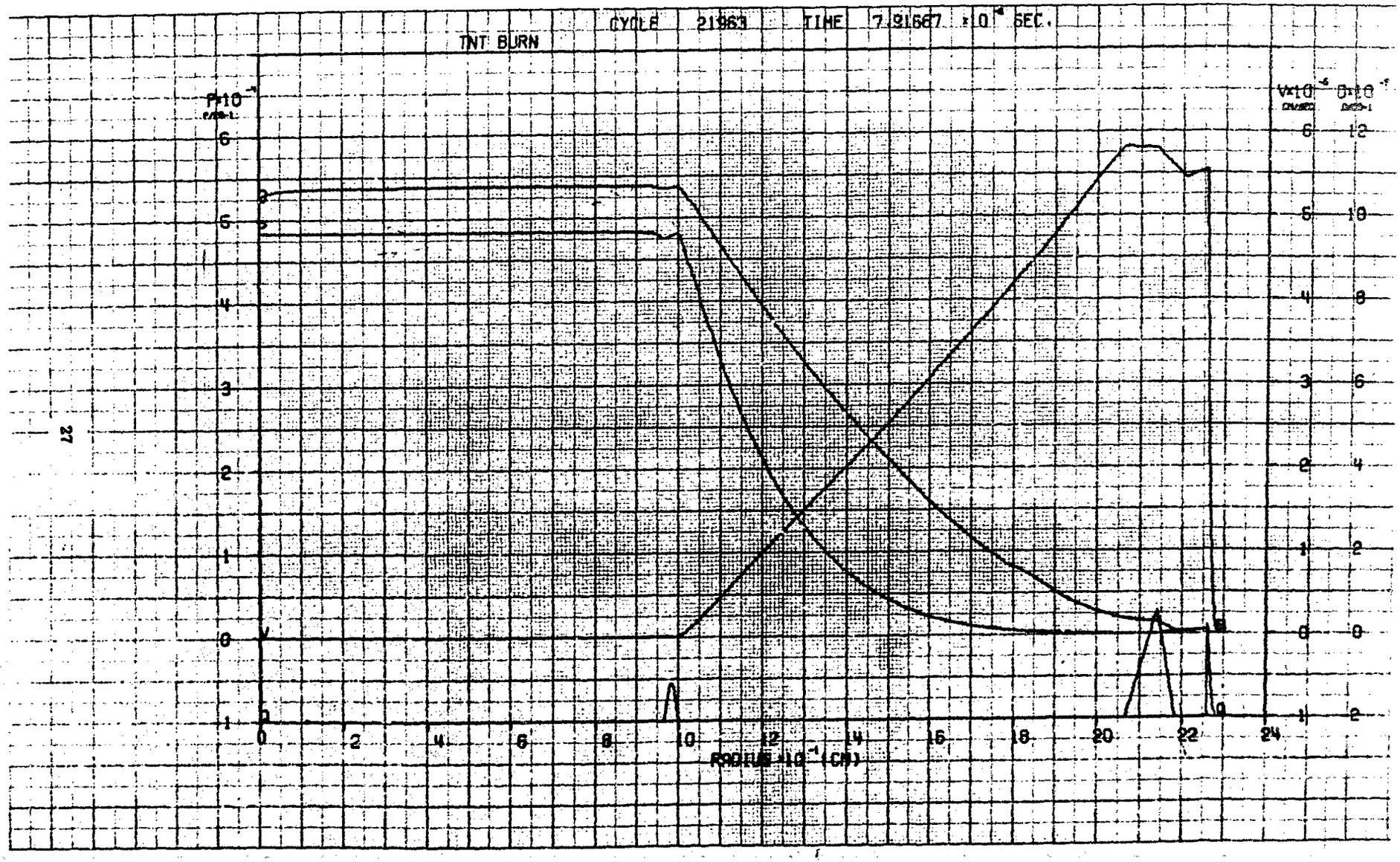

TNT BURN
CYCLE 39910
TIME 2.29167 ×10⁻⁴ SEC.
P×10⁻⁶
ρ×10⁻⁶
V×10⁻⁶
D×10⁻⁷
RADIUS ×10⁻⁴ (CM)
22

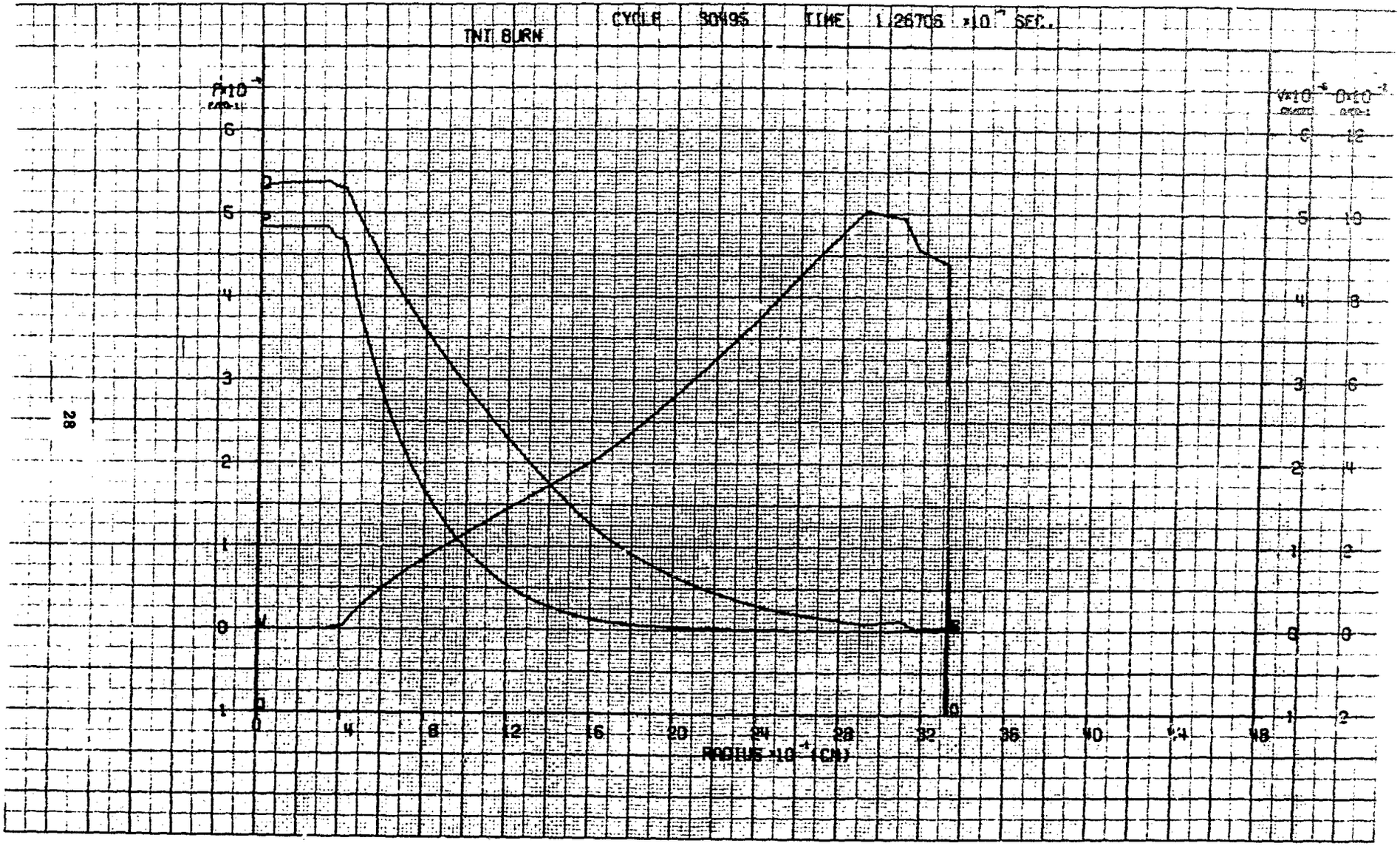

TNI BURN
CYCLE 48000 TIME 2.59572 +.0 SEC.
FRELG $\times 10^{-4}$ (CM)

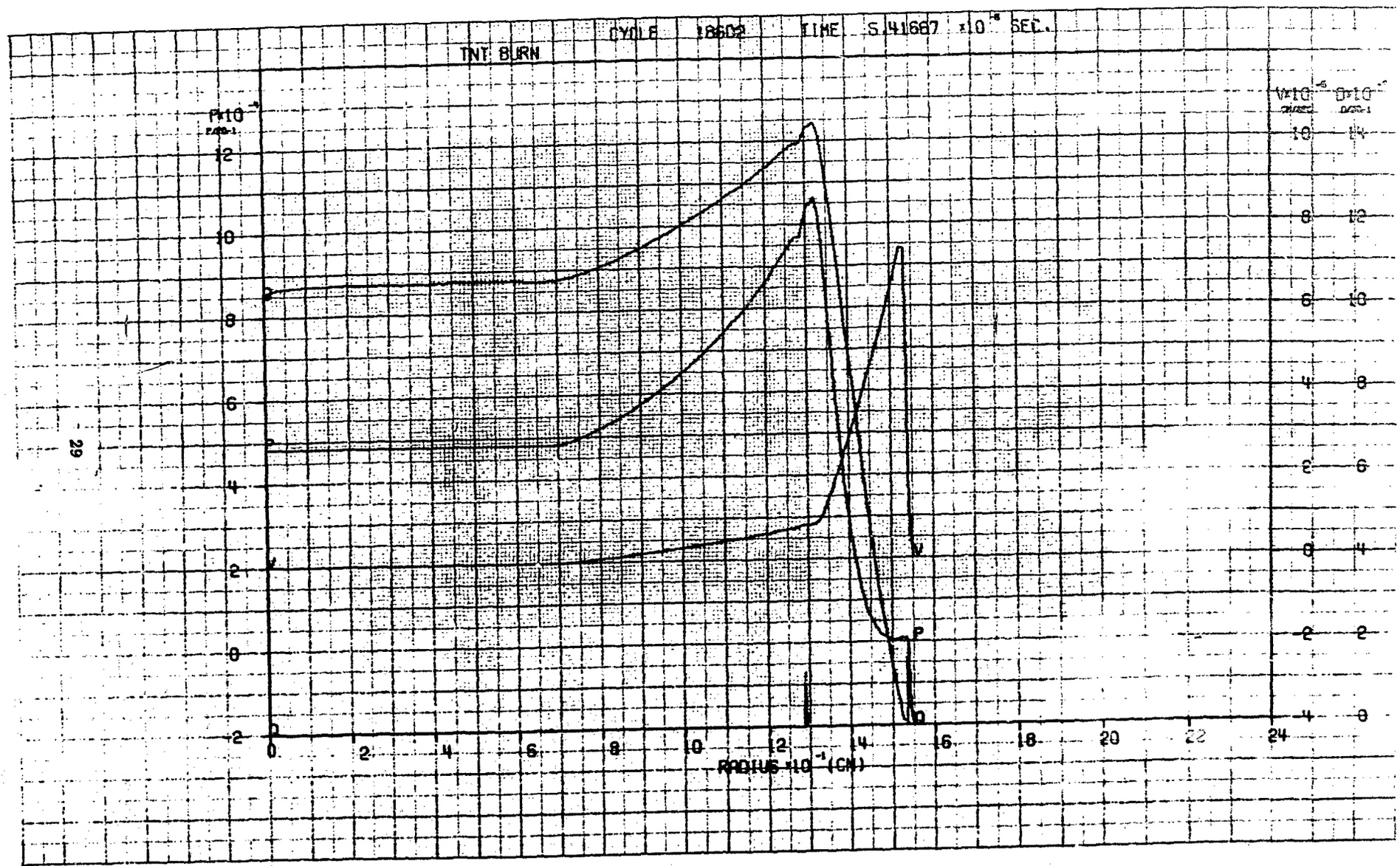

TNT BURN
CYCLE 1900
TIME 5.71623 ×10⁻⁶ SEC.
P×10⁻³
V×10⁻⁵
D×10⁻⁷
12
10
8
6
4
2
0
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10⁻¹ (CM)
F


CYCLE 1972 TIME 6.25000 ×10⁻⁶ SEC.
TNT BURN
P×10⁻⁹
V×10⁻⁵
D×10⁻¹
RADIUS ×10⁻¹ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24


TNT BURN
CYCLE 21910
TIME 7.50000 ×10⁻⁴ SEC.
P×10⁻⁹
V×10⁻⁵
D×10⁻¹
RADIUS ×10⁻¹ (CM)
26


TNT BURN
CYCLE 21963 TIME 7.21667 x 10⁻⁴ SEC.
P x 10⁻⁷
V x 10⁻⁵
ρ x 10⁻¹
RADIUS x 10⁻¹ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24


TNT BURN
CYCLE 30495 TIME 1.26705 ×10⁻⁷ SEC.
P×10⁻⁹
V×10⁻⁶
D×10⁻²
RADIUS ×10⁻⁴ (CM)
0
4
8
12
16
20
24
28
32
36
40
44
48
50


TNT BURN
CYCLE 18602
TIME 5.41687 x10⁻⁶ SEC.
P x10⁻⁹
12
10
8
6
4
2
0
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS x10⁻¹ (CM)
V x10⁻⁶
U x10⁻⁷
10
8
6
4
2
0
-2
-4
12
8
4
0
-4
-8
V
P
U

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SHELL Contours and Velocity Vectors

This part contains pressure and density contours and velocity vector plots of the results of the SHELL-OIL calculation of the TNT detonation (20 short-tons). There are plots for 8 different times.

The first plot shows the reflection of the free-air shock at the ground. Subsequent plots show the formation and movement of the triple point and mach stem. The heavy black line on each plot shows the location of the massless trace particles that represent the TNT-air interface at that time.

The numbers along the top of each plot represent the horizontal index of each cell of the mesh used in the calculation. The numbers along the right edge of the plot refer to vertical indices. The number associated with each contour line represents a value for that line appearing in the upper right hand corner of each contour plot. The velocity vector scale is similarly given in the upper right hand corner of each velocity vector plot.

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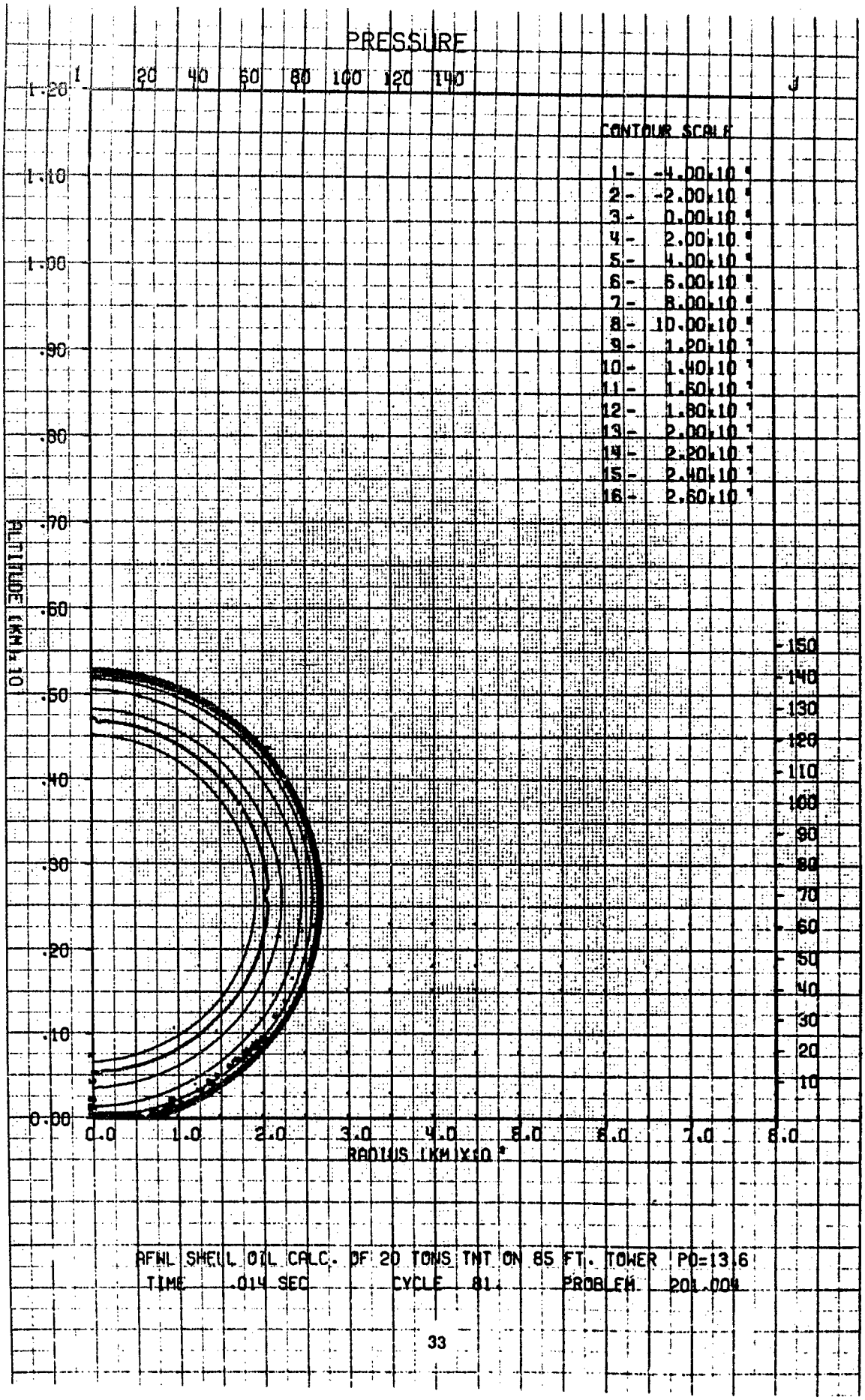
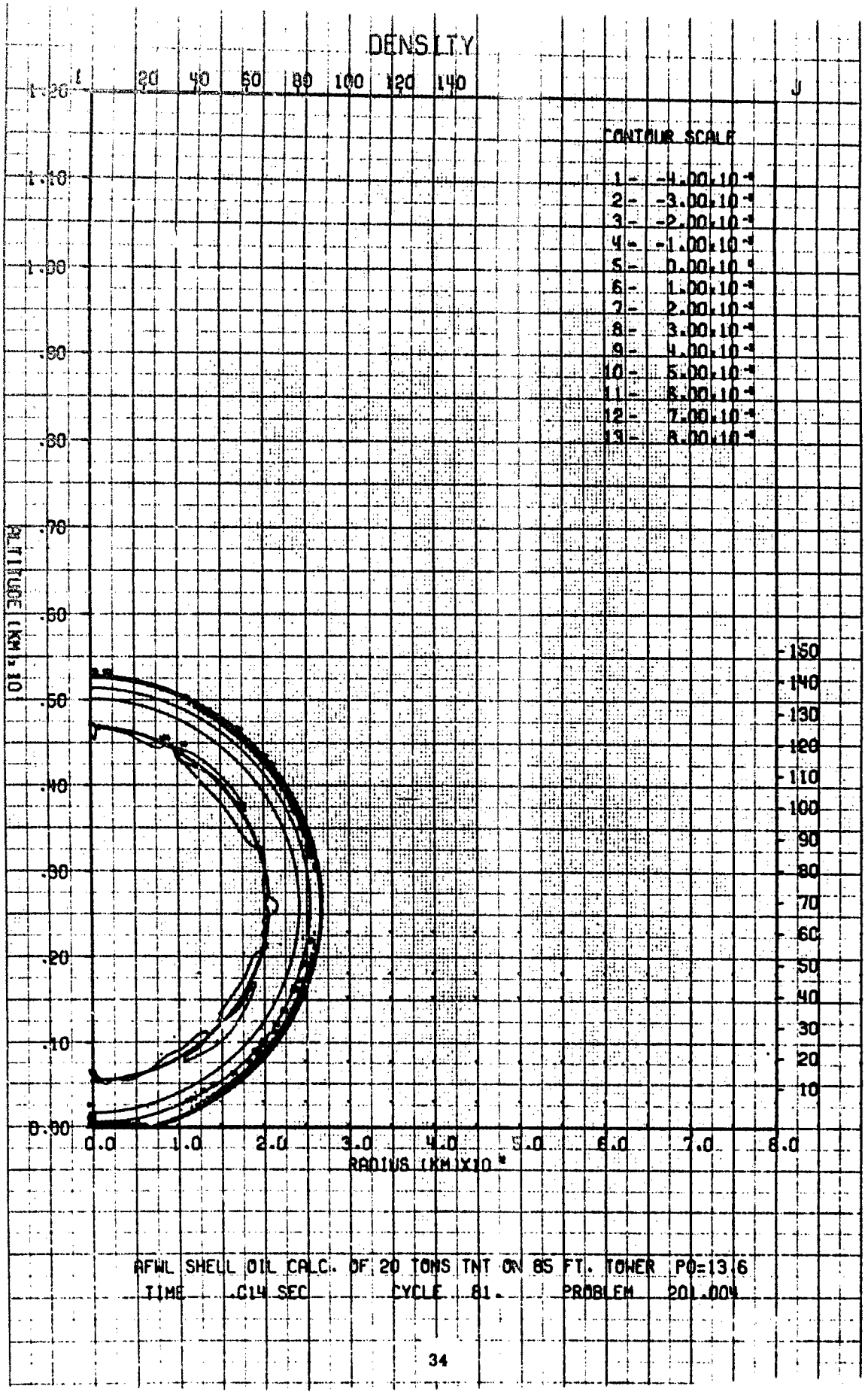
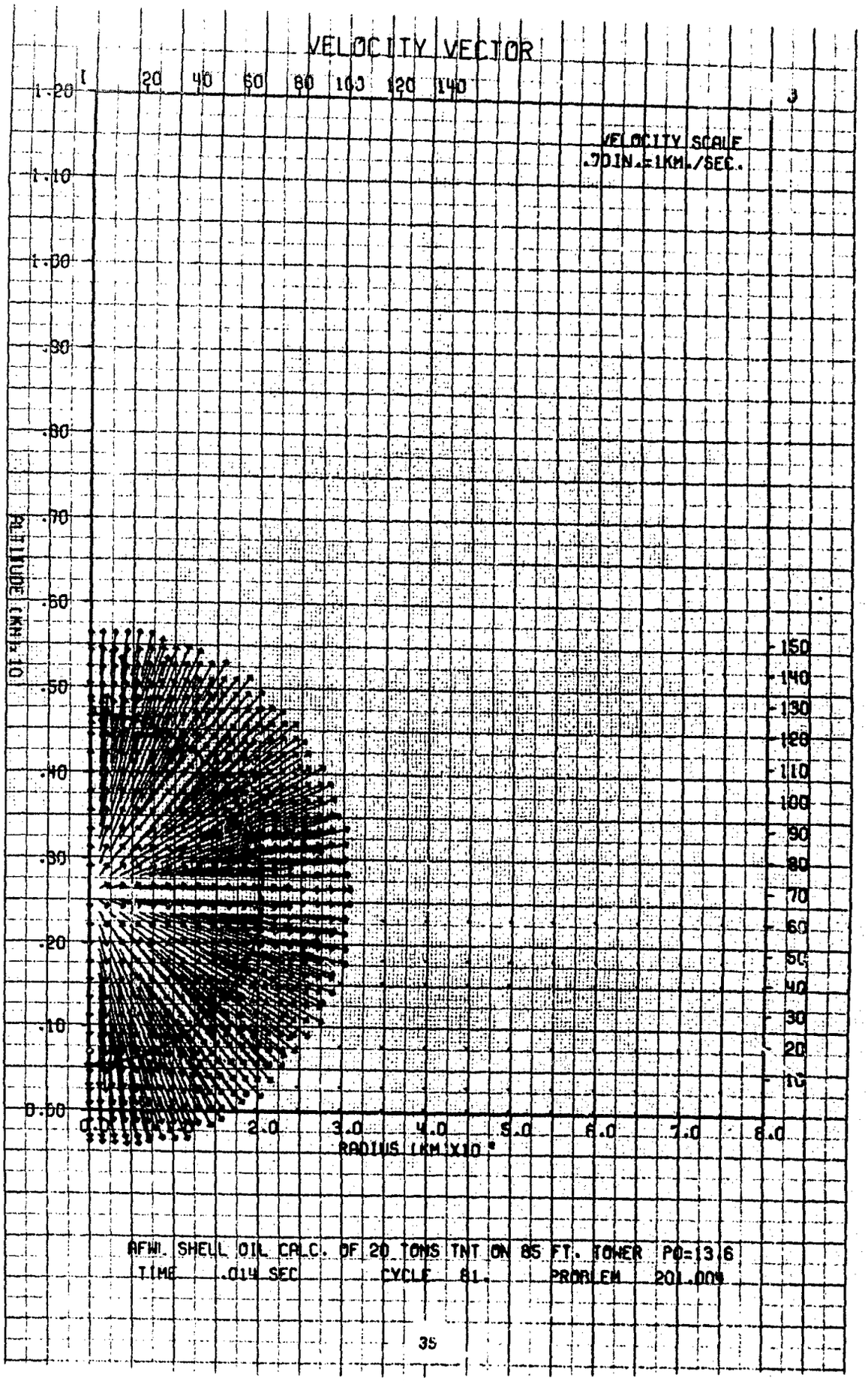
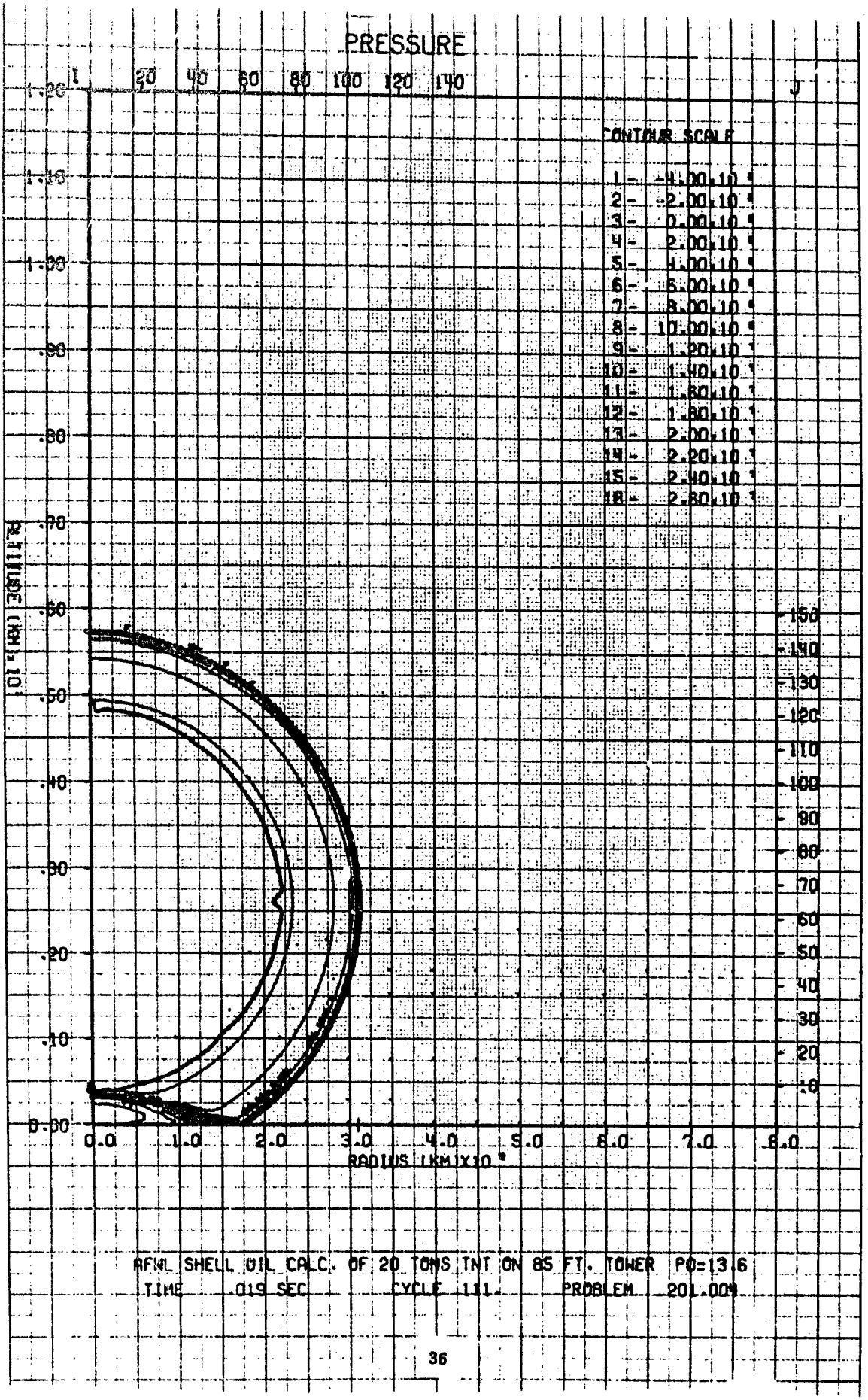
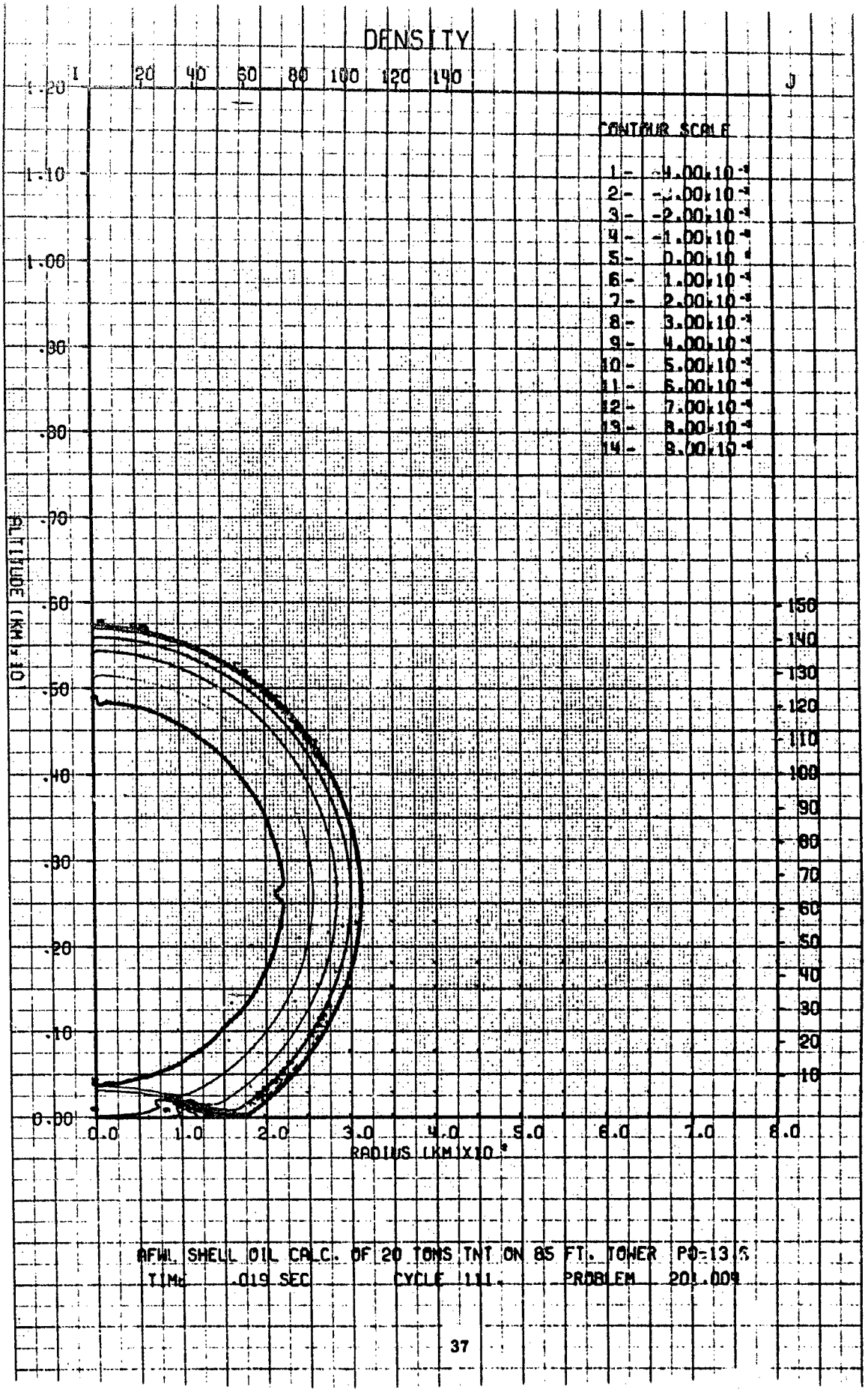
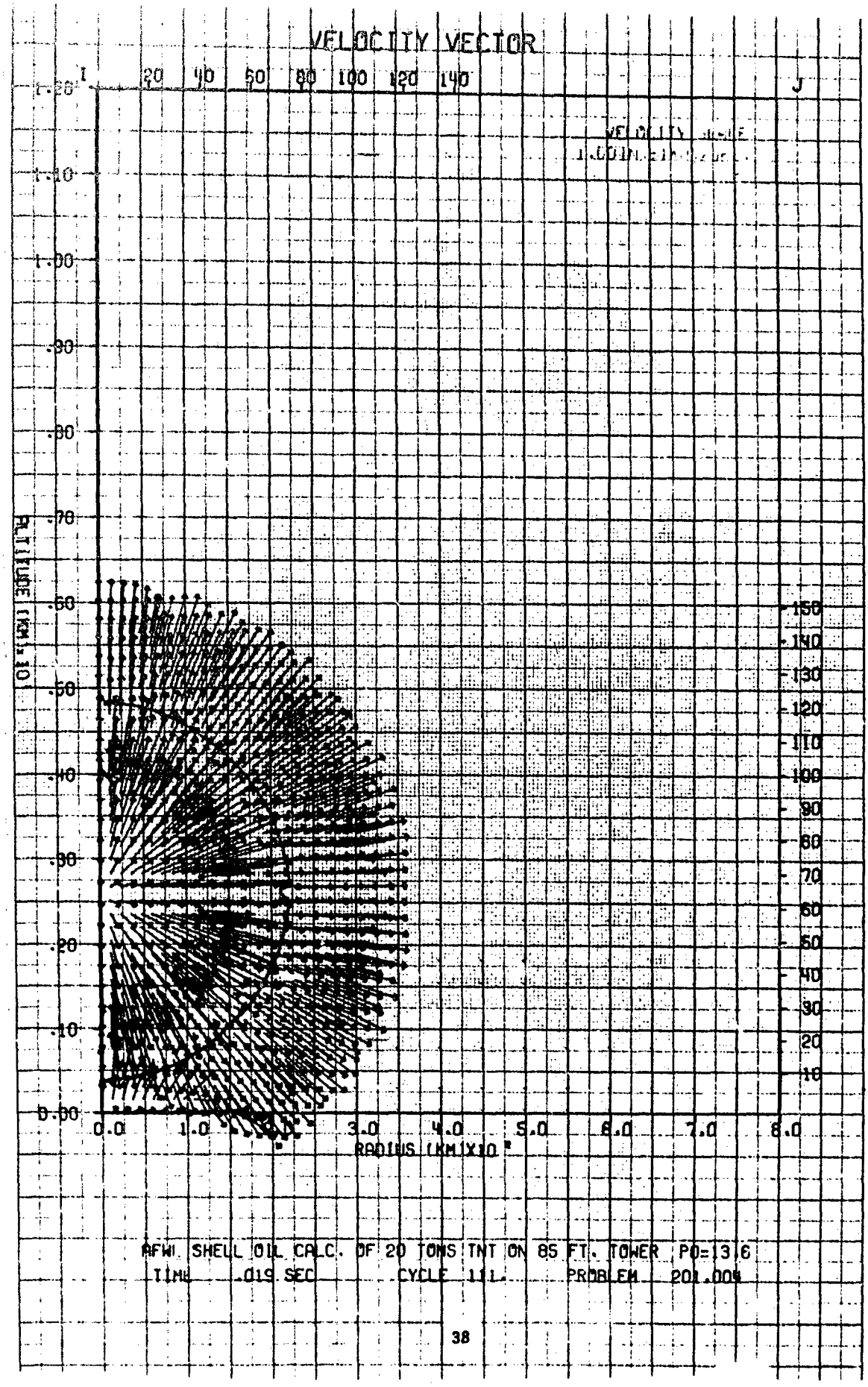

PRESSURE
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1 - -4.00x10 ⁴
2 - -2.00x10 ⁴
3 - 0.00x10 ⁴
4 - 2.00x10 ⁴
5 - 4.00x10 ⁴
6 - 6.00x10 ⁴
7 - 8.00x10 ⁴
8 - 10.00x10 ⁴
9 - 1.20x10 ⁵
10 - 1.40x10 ⁵
11 - 1.60x10 ⁵
12 - 1.80x10 ⁵
13 - 2.00x10 ⁵
14 - 2.20x10 ⁵
15 - 2.40x10 ⁵
16 - 2.60x10 ⁵
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM x 10)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X 10 ³)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .014 SEC CYCLE 81. PROBLEM 201.004

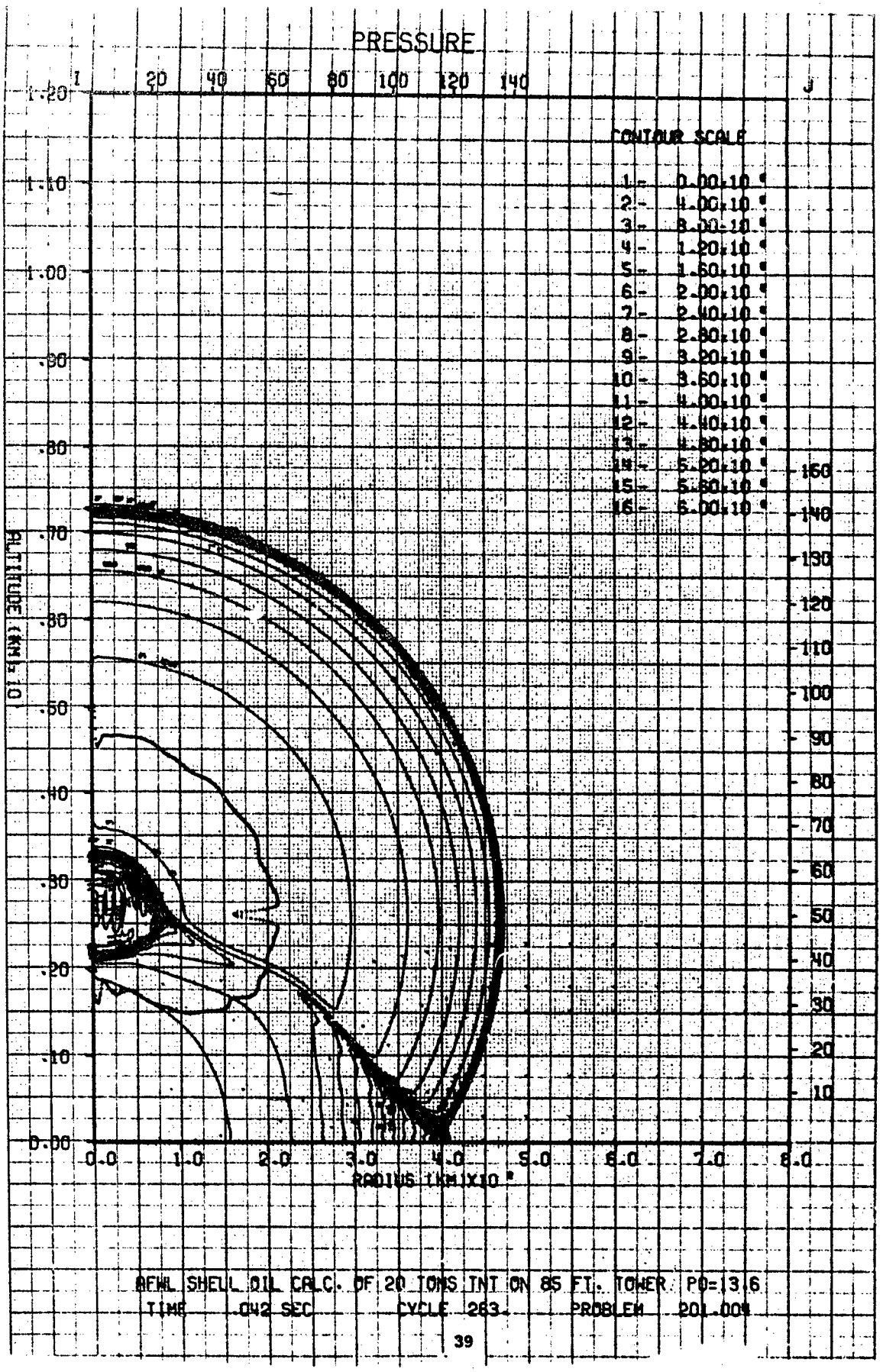

DENSITY
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1 - -4.00,10 -4
2 - -3.00,10 -4
3 - -2.00,10 -4
4 - -1.00,10 -4
5 - 0.00,10 -4
6 - 1.00,10 -4
7 - 2.00,10 -4
8 - 3.00,10 -4
9 - 4.00,10 -4
10 - 5.00,10 -4
11 - 6.00,10 -4
12 - 7.00,10 -4
13 - 8.00,10 -4
ALTITUDE (KM)X10
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10 *
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .C14 SEC CYCLE 81 PROBLEM 201.004

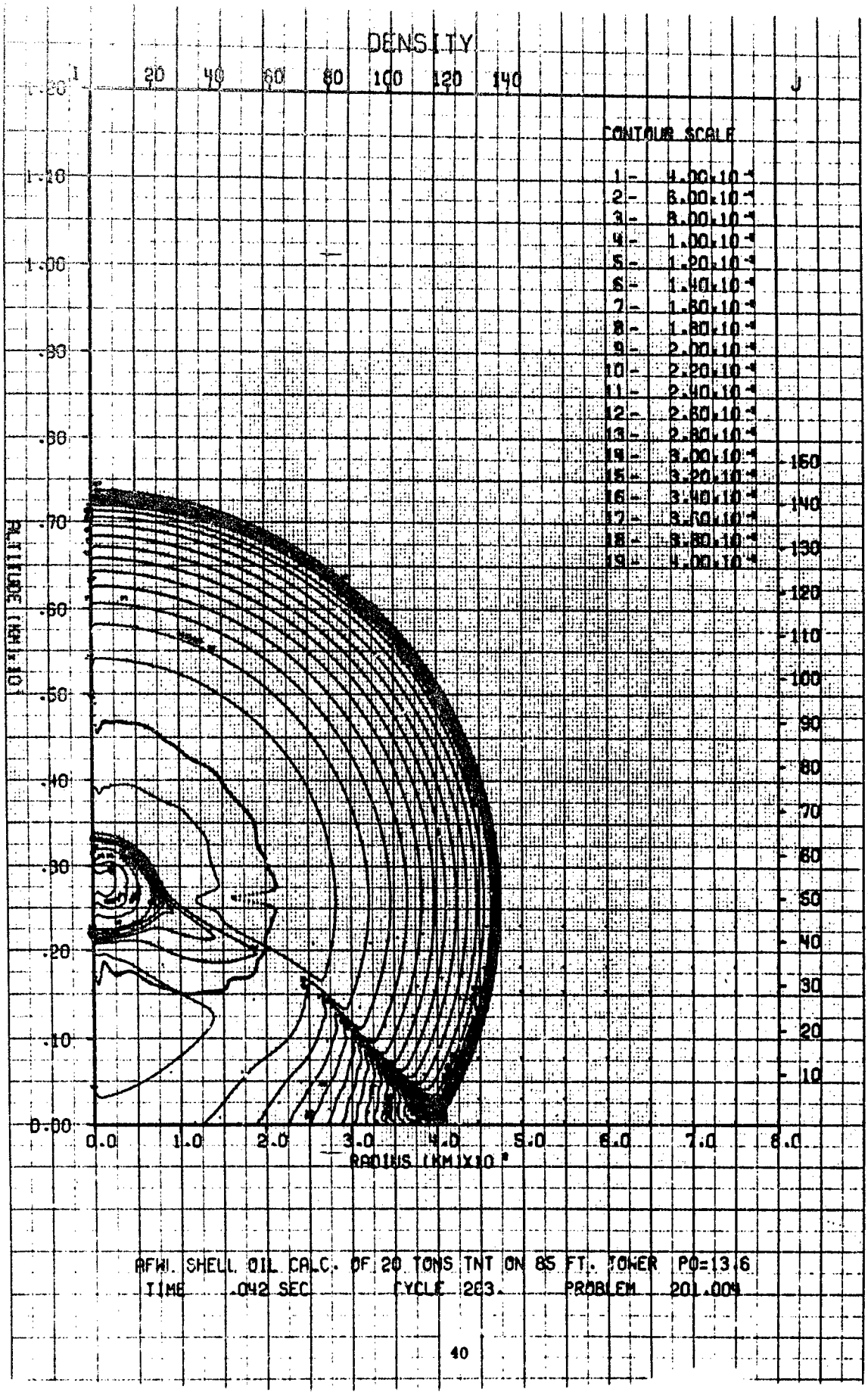

VELOCITY VECTOR
VELOCITY SCALE
.7DIN.=1KM./SEC.
ALTITUDE (KM)x10
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .014 SEC CYCLE 81. PROBLEM 201.009

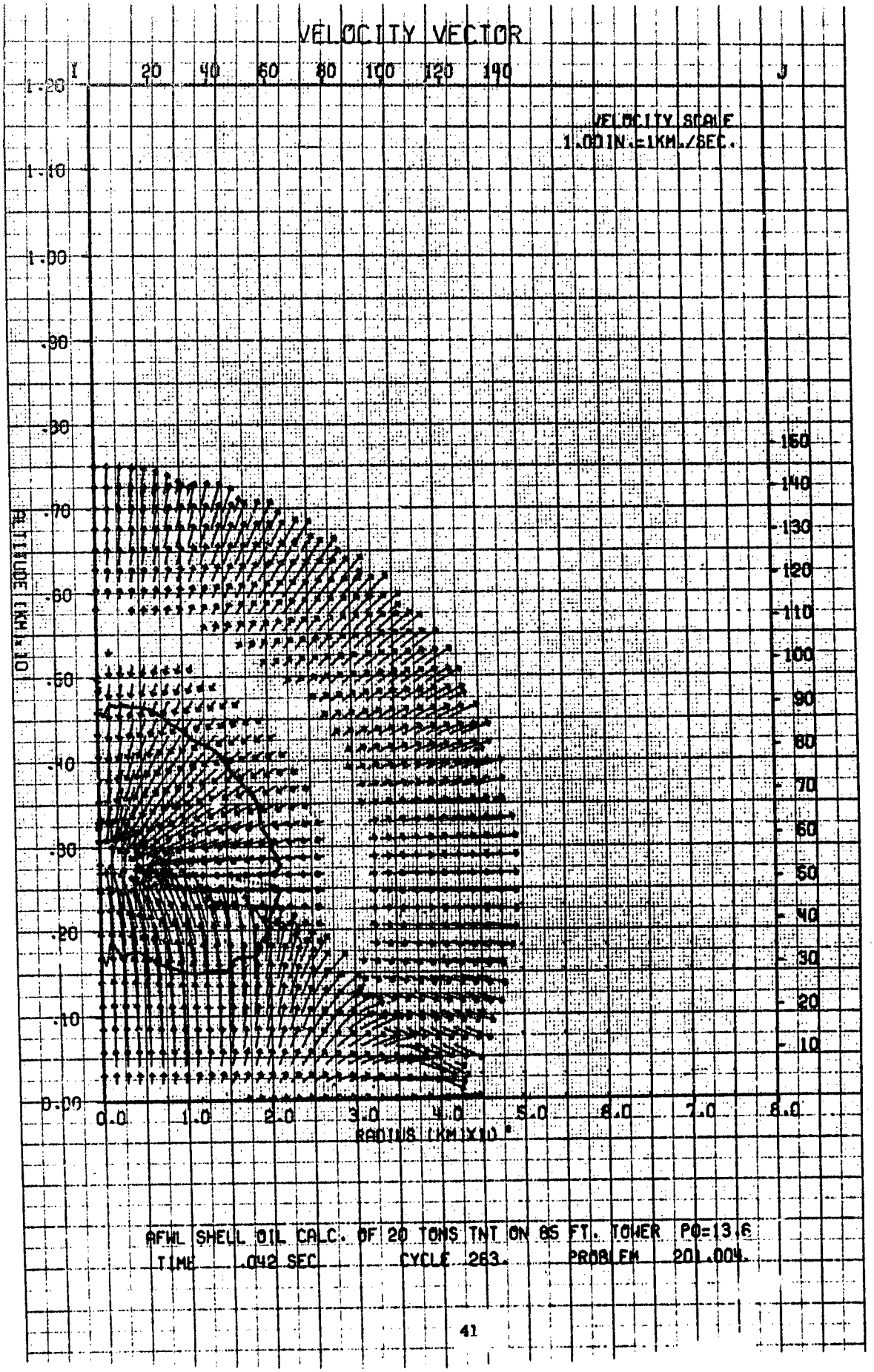

PRESSURE
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1 - -4.00,10 ¶
2 - -2.00,10 ¶
3 - 0.00,10 ¶
4 - 2.00,10 ¶
5 - 4.00,10 ¶
6 - 6.00,10 ¶
7 - 8.00,10 ¶
8 - 10.00,10 ¶
9 - 1.20,10 ¶
10 - 1.40,10 ¶
11 - 1.60,10 ¶
12 - 1.80,10 ¶
13 - 2.00,10 ¶
14 - 2.20,10 ¶
15 - 2.40,10 ¶
16 - 2.80,10 ¶
ALTITUDE (KM)X10
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .019 SEC CYCLE 111. PROBLEM 201.009

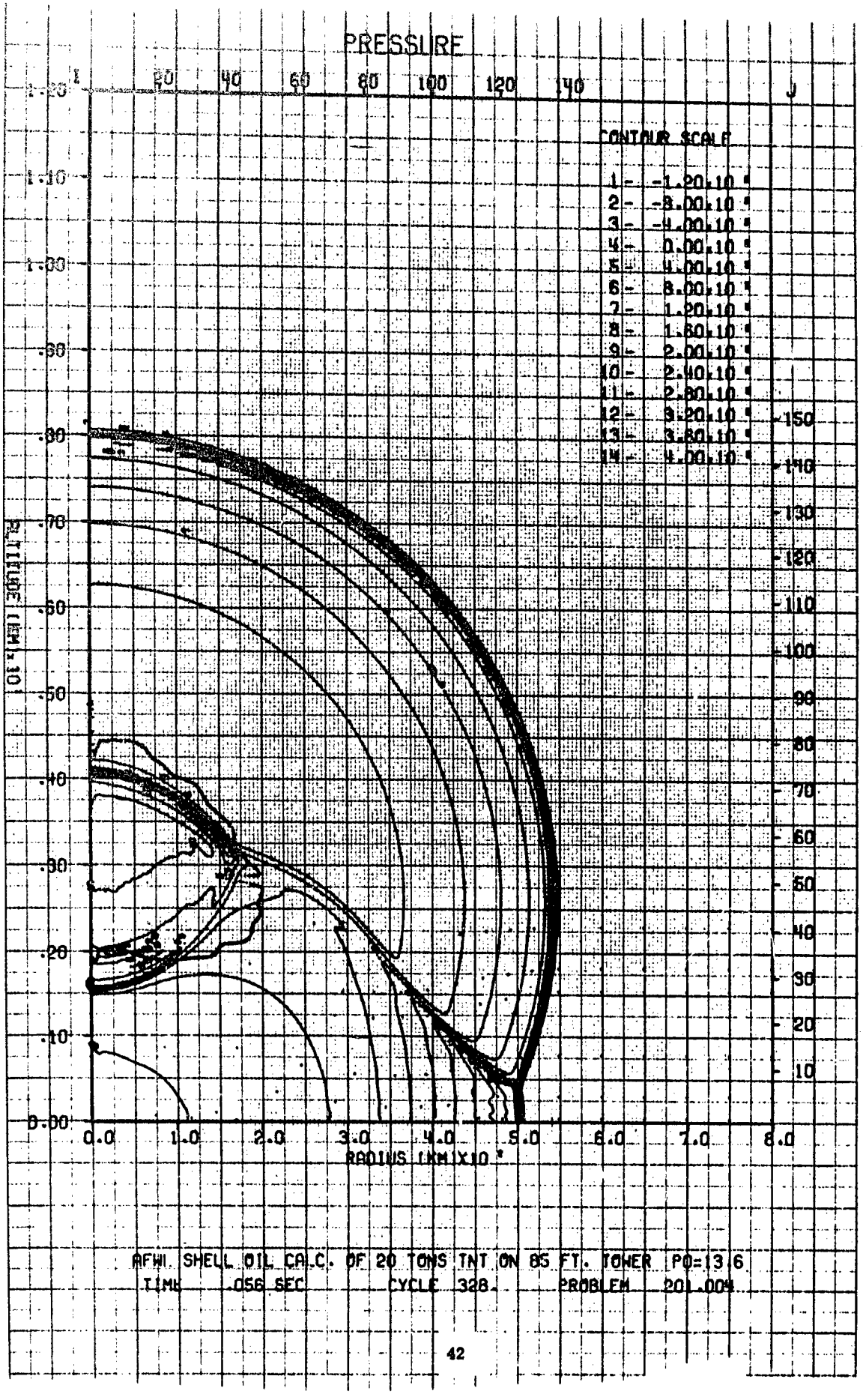

DENSITY
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1 - -4.00x10⁻¹
2 - -3.00x10⁻¹
3 - -2.00x10⁻¹
4 - -1.00x10⁻¹
5 - 0.00x10⁻⁰
6 - 1.00x10⁻¹
7 - 2.00x10⁻¹
8 - 3.00x10⁻¹
9 - 4.00x10⁻¹
10 - 5.00x10⁻¹
11 - 6.00x10⁻¹
12 - 7.00x10⁻¹
13 - 8.00x10⁻¹
14 - 9.00x10⁻¹
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM X10)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X10⁵)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.5
TIME .019 SEC CYCLE 111. PROBLEM 201.009

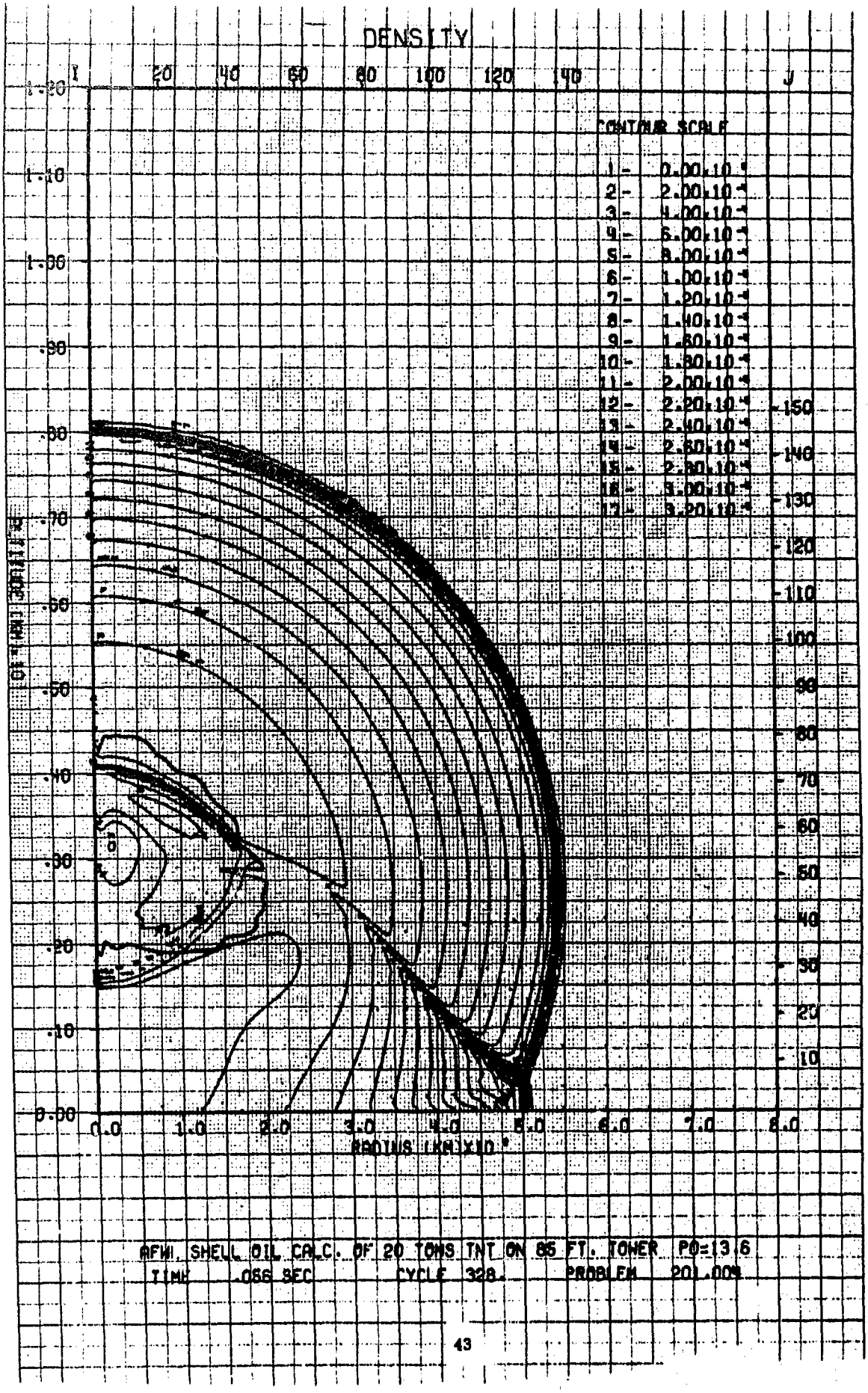

VELOCITY VECTOR
I
20
40
60
80
100
120
140
J
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM)X10
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .019 SEC CYCLE 111 PROBLEM 201.005

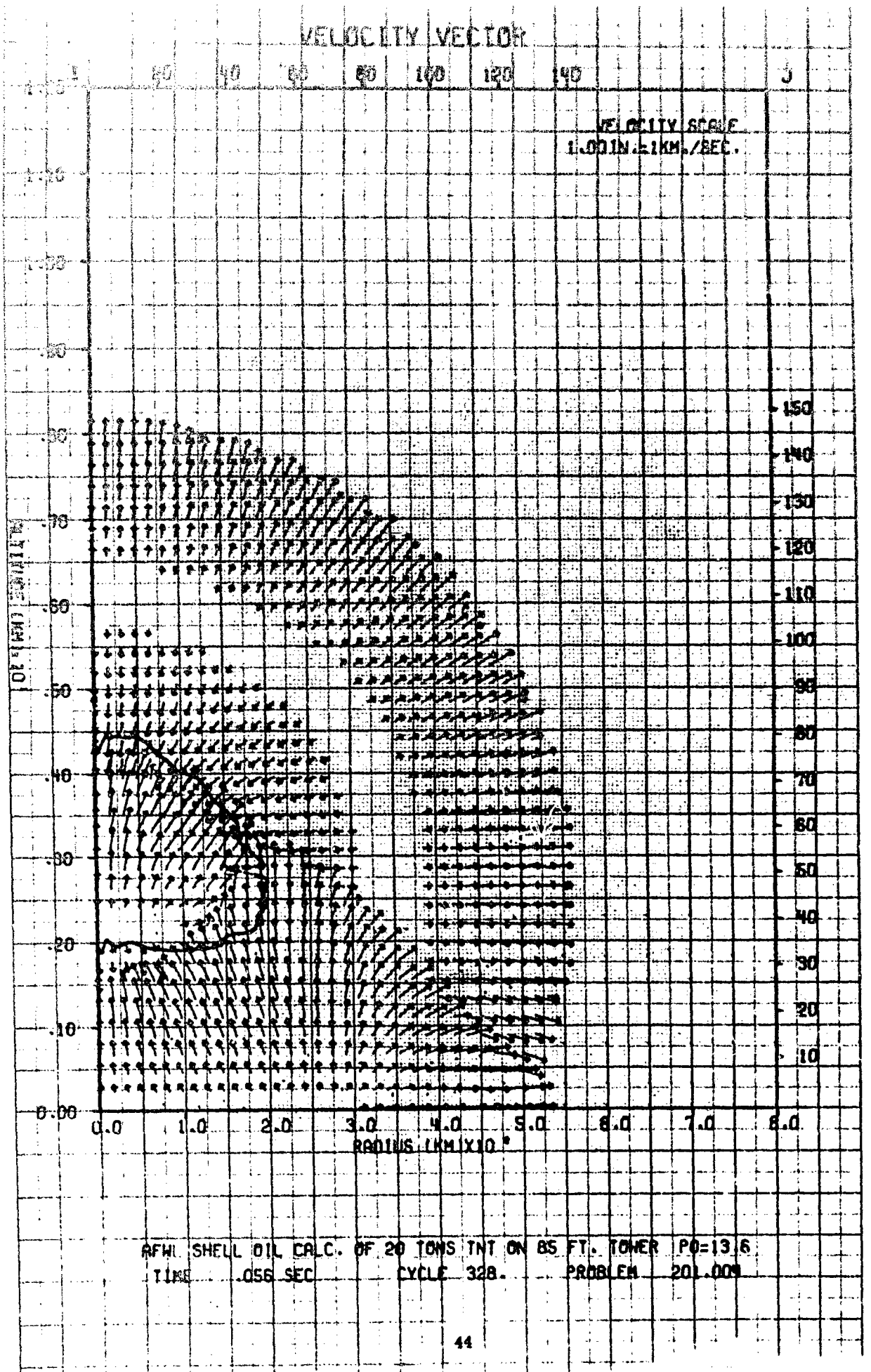

PRESSURE
CONTOUR SCALE
1.- 0.00x10
2.- 4.00x10
3.- 8.00x10
4.- 1.20x10
5.- 1.60x10
6.- 2.00x10
7.- 2.40x10
8.- 2.80x10
9.- 3.20x10
10.- 3.60x10
11.- 4.00x10
12.- 4.40x10
13.- 4.80x10
14.- 5.20x10
15.- 5.60x10
16.- 6.00x10
ALTITUDE (KM)x10
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS INT ON 85 FT. TOWER P0=13.6
TIME .042 SEC CYCLE 263. PROBLEM 201.004

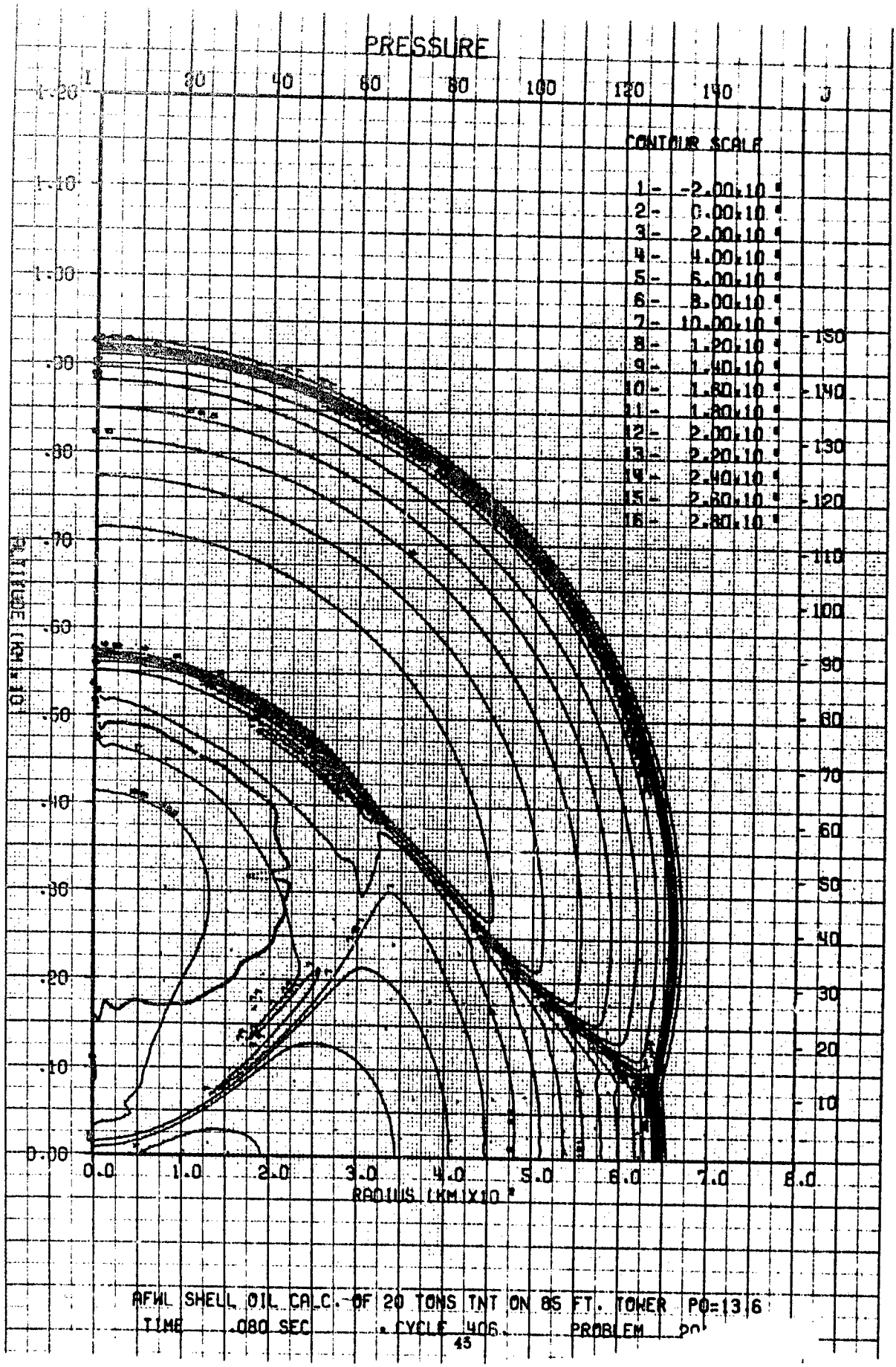

DENSITY
CONTOUR SCALE
1 - 4.00x10⁻⁴
2 - 6.00x10⁻⁴
3 - 8.00x10⁻⁴
4 - 1.00x10⁻³
5 - 1.20x10⁻³
6 - 1.40x10⁻³
7 - 1.60x10⁻³
8 - 1.80x10⁻³
9 - 2.00x10⁻³
10 - 2.20x10⁻³
11 - 2.40x10⁻³
12 - 2.60x10⁻³
13 - 2.80x10⁻³
14 - 3.00x10⁻³
15 - 3.20x10⁻³
16 - 3.40x10⁻³
17 - 3.60x10⁻³
18 - 3.80x10⁻³
19 - 4.00x10⁻³
ALTITUDE (KM x 10³)
RADIUS (KM X10³)
RFWI. SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .042 SEC CYCLE 283. PROBLEM 201.009

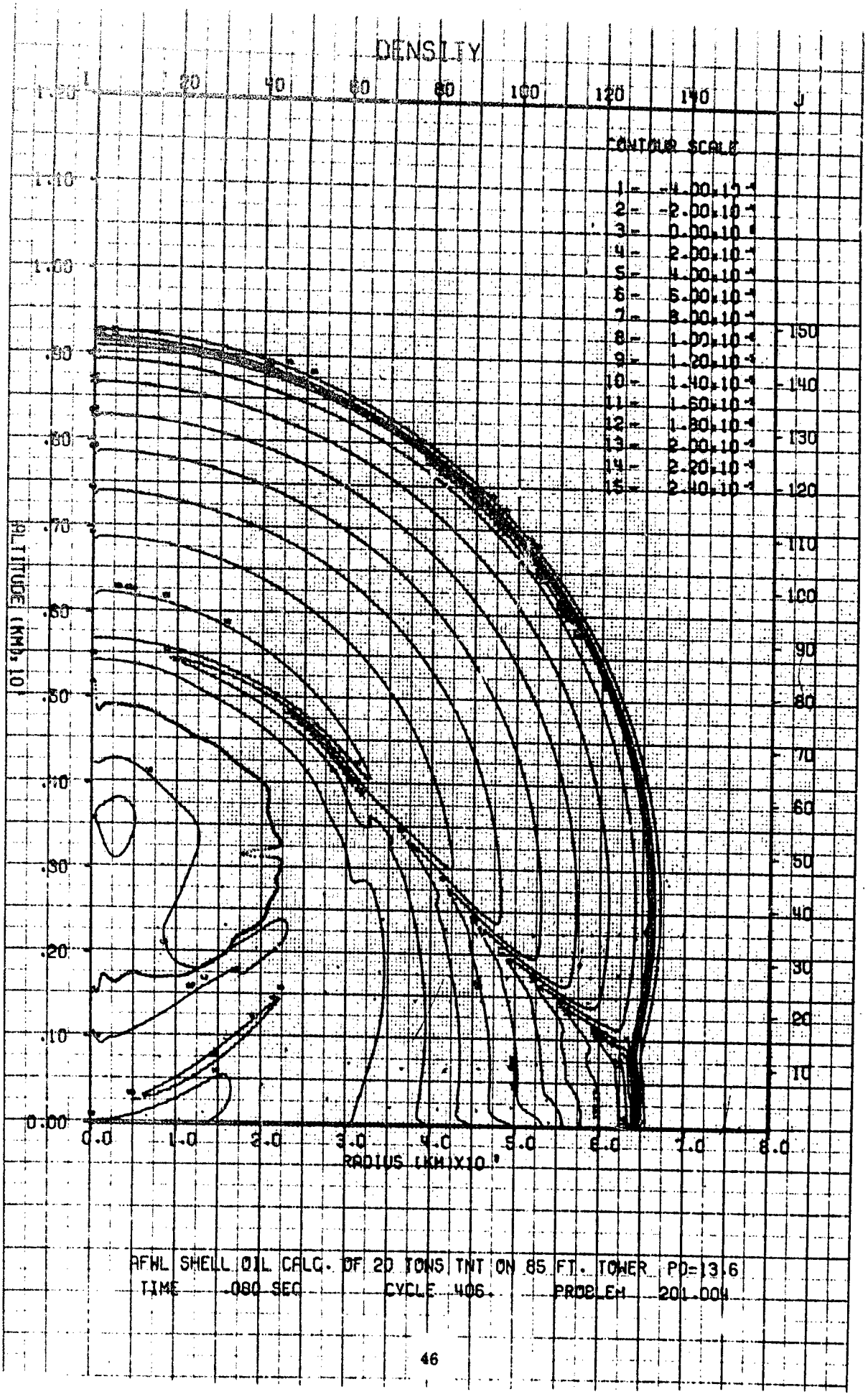

VELOCITY VECTOR
I
20
40
60
80
100
120
140
J
VELOCITY SCALE
1.00 IN.=1KM./SEC.
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM*10)
160
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X10)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .042 SEC CYCLE 263. PROBLEM 201.004.

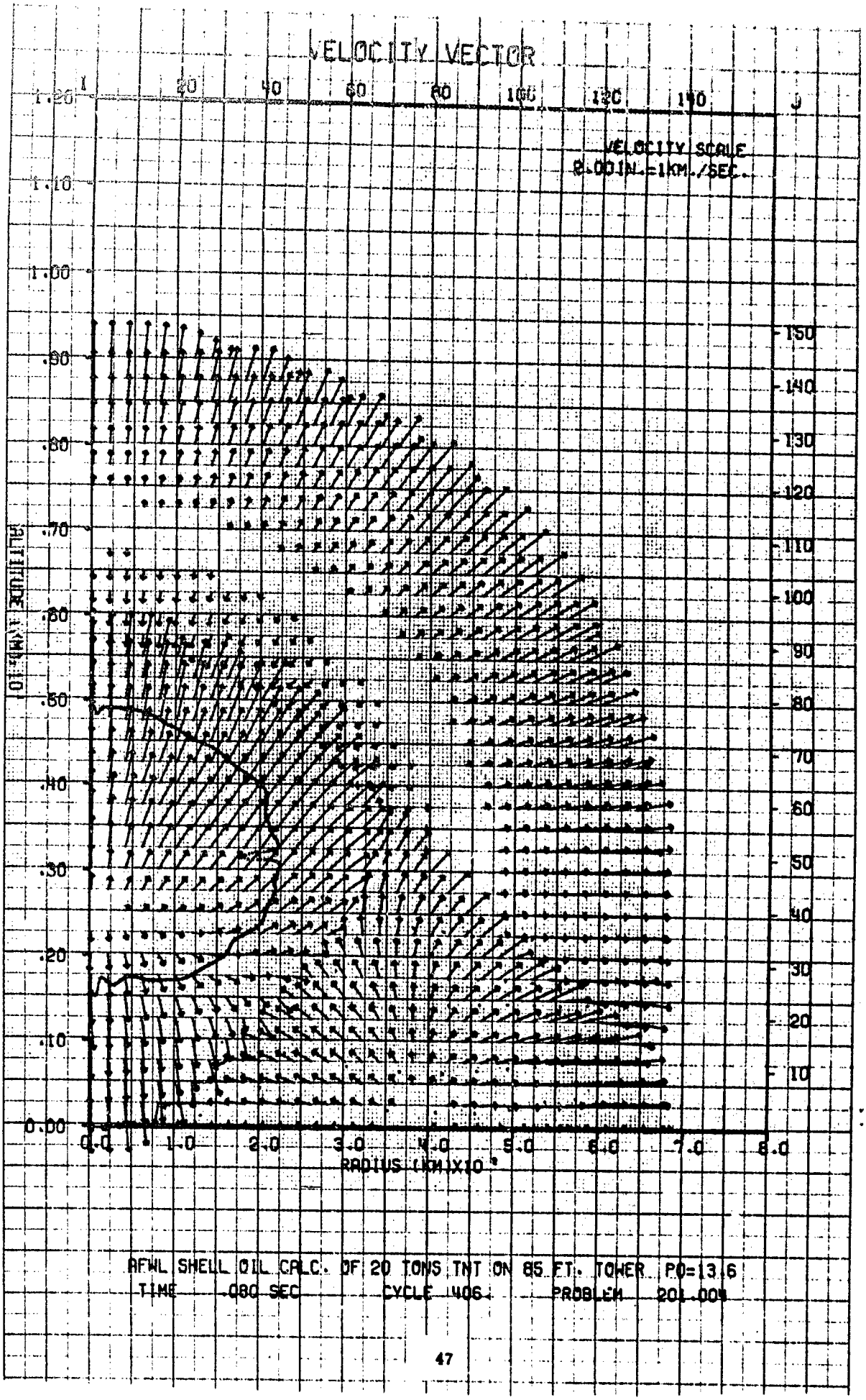

PRESSURE
20
40
60
80
100
120
140
CONTOUR SCALE
1 - -1.20,10 4
2 - -8.00,10 3
3 - -4.00,10 3
4 - 0.00,10 0
5 - 4.00,10 3
6 - 8.00,10 3
7 - 1.20,10 4
8 - 1.60,10 4
9 - 2.00,10 4
10 - 2.40,10 4
11 - 2.80,10 4
12 - 3.20,10 4
13 - 3.80,10 4
14 - 4.00,10 4
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM x 10)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X10)
AFWL SHELL OIL CA.C. OF 20 TONS TNT ON 85 FT. TOWER PO=13 6
TIME .056 SEC CYCLE 328. PROBLEM 201.004

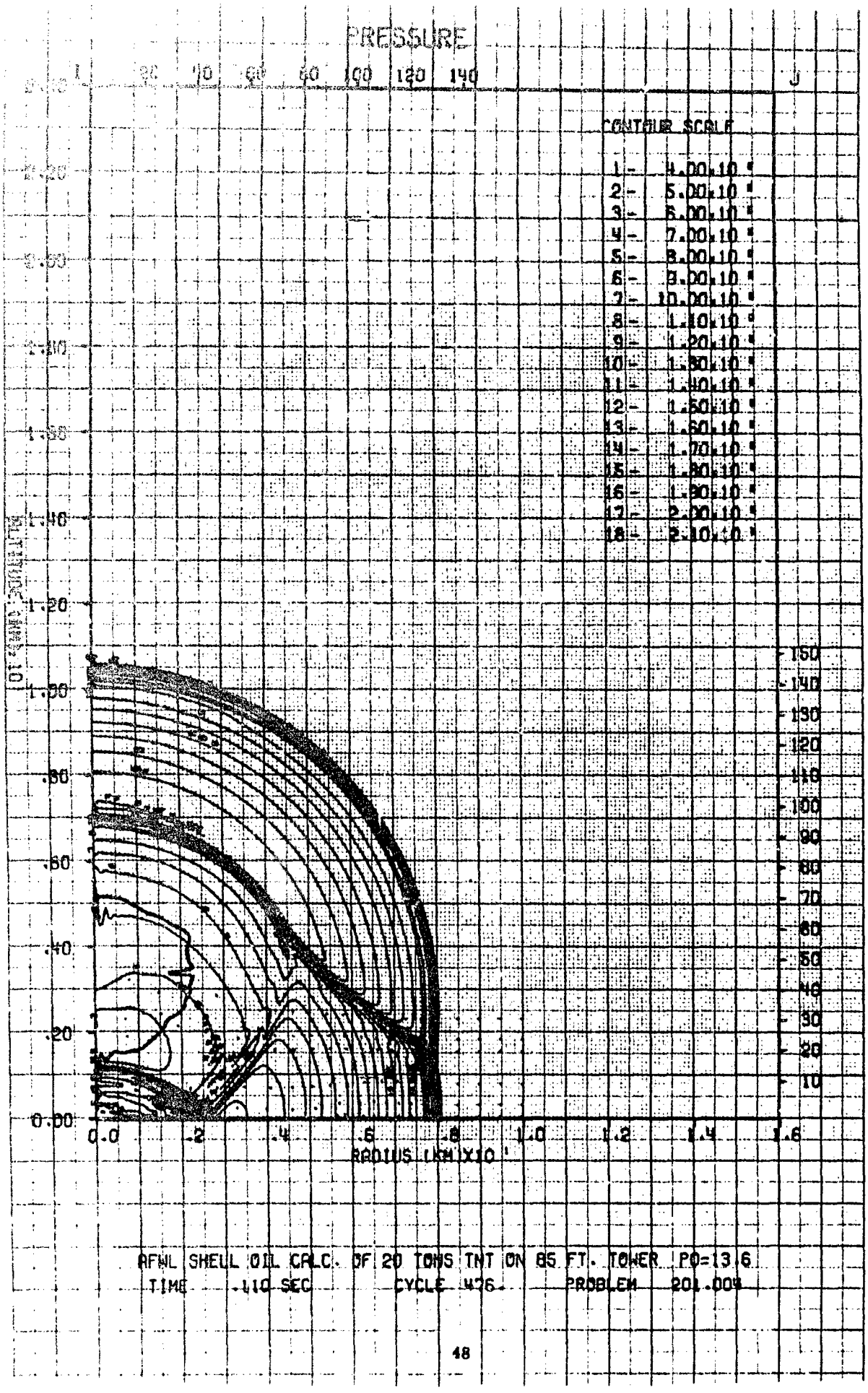

DENSITY
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1 - 0.00,10⁻⁴
2 - 2.00,10⁻⁴
3 - 4.00,10⁻⁴
4 - 6.00,10⁻⁴
5 - 8.00,10⁻⁴
6 - 1.00,10⁻³
7 - 1.20,10⁻³
8 - 1.40,10⁻³
9 - 1.60,10⁻³
10 - 1.80,10⁻³
11 - 2.00,10⁻³
12 - 2.20,10⁻³
13 - 2.40,10⁻³
14 - 2.60,10⁻³
15 - 2.80,10⁻³
16 - 3.00,10⁻³
17 - 3.20,10⁻³
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM.X10)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM.X10)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .066 SEC CYCLE 328. PROBLEM 201.009

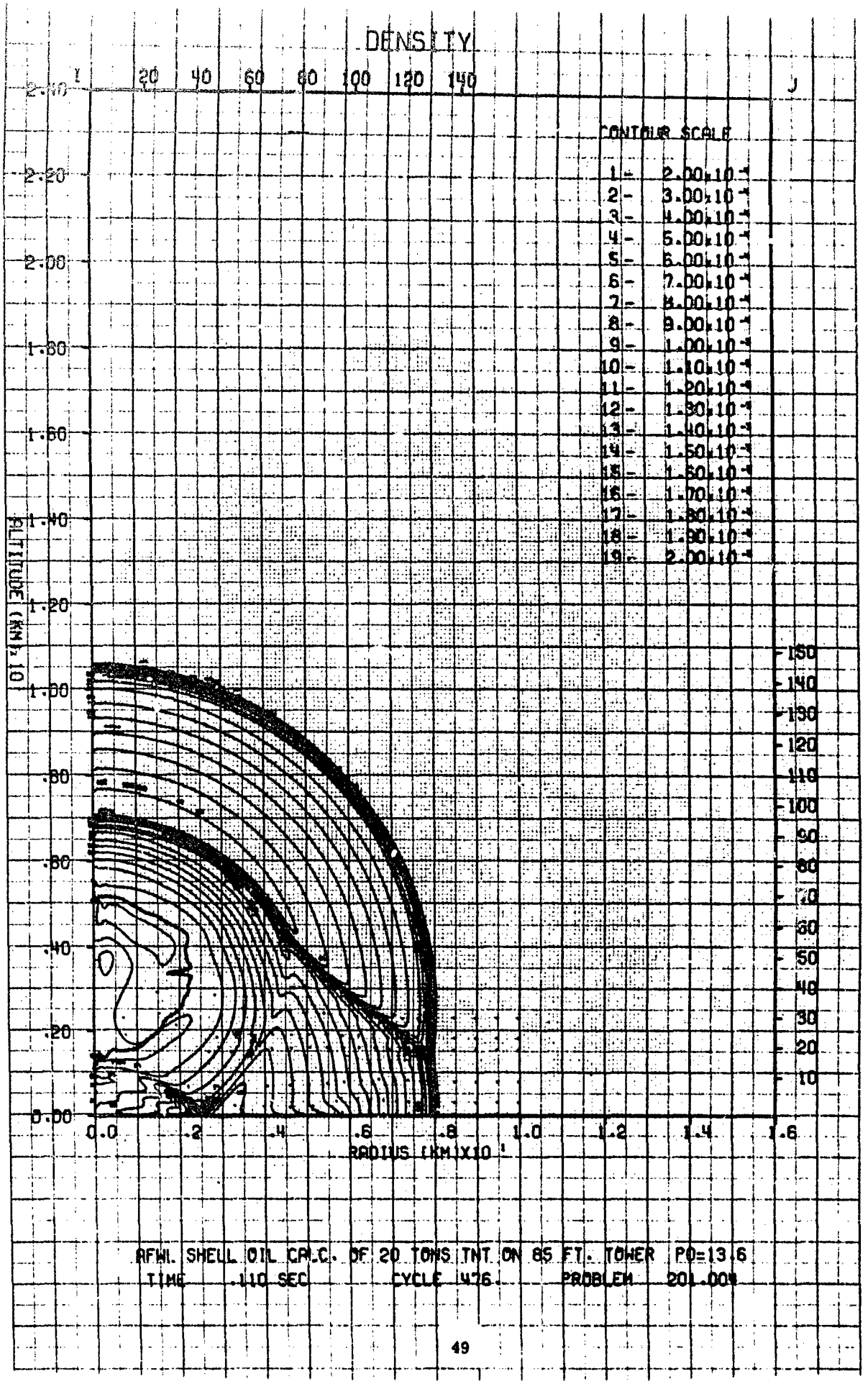

VELOCITY VECTOR
VELOCITY SCALE
1.00IN.=1KM./SEC.
ALTITUDE (KM)X10
RADIUS (KM)X10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .056 SEC CYCLE 328. PROBLEM 201.009

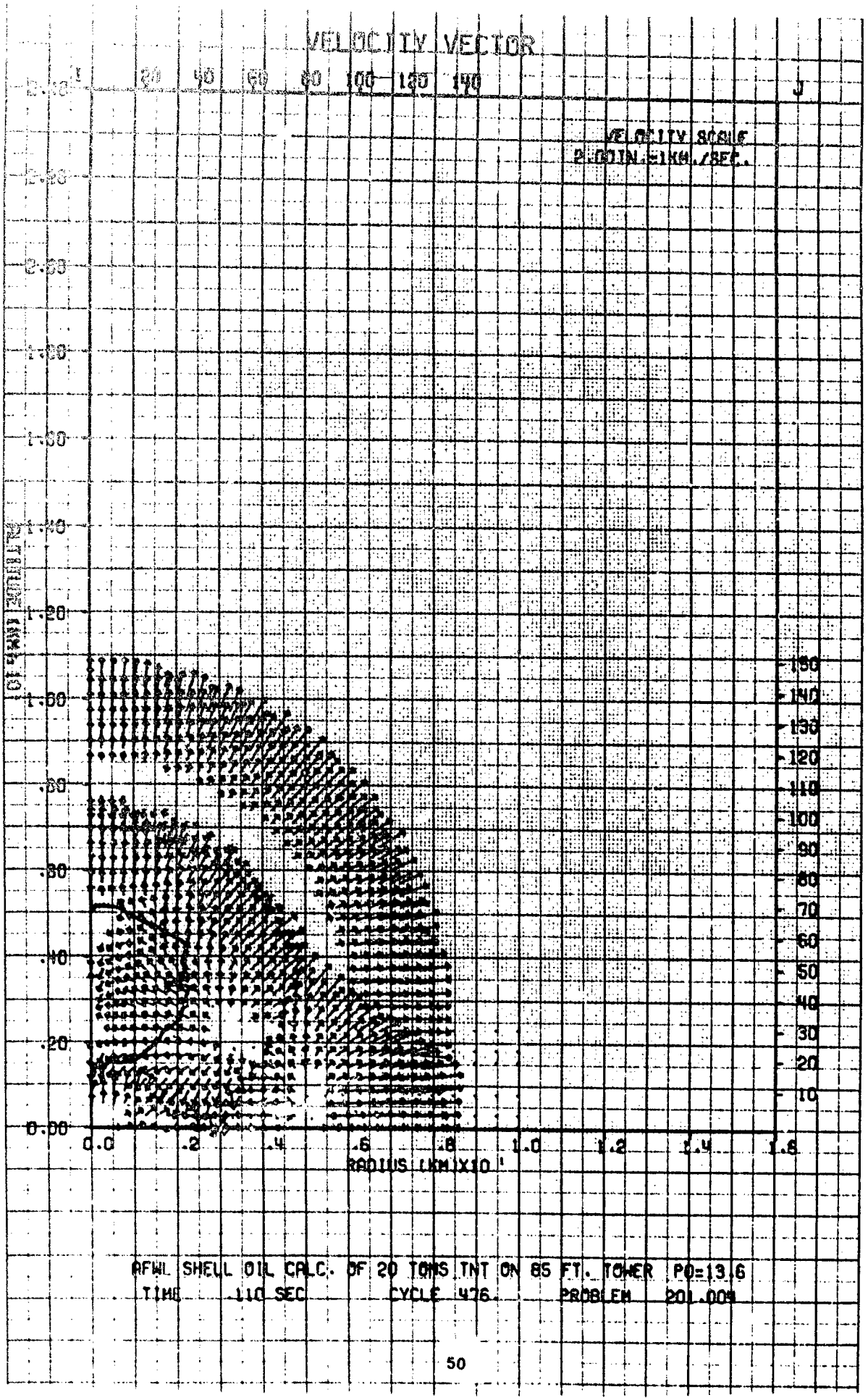

PRESSURE
CONTOUR SCALE
1- -2.00,10
2- 0.00,10
3- 2.00,10
4- 4.00,10
5- 6.00,10
6- 8.00,10
7- 10.00,10
8- 1.20,10
9- 1.40,10
10- 1.60,10
11- 1.80,10
12- 2.00,10
13- 2.20,10
14- 2.40,10
15- 2.60,10
16- 2.80,10
ALTITUDE (KM X10)
RADIUS (KM X10)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .080 SEC • CYCLE 406 PROBLEM 20

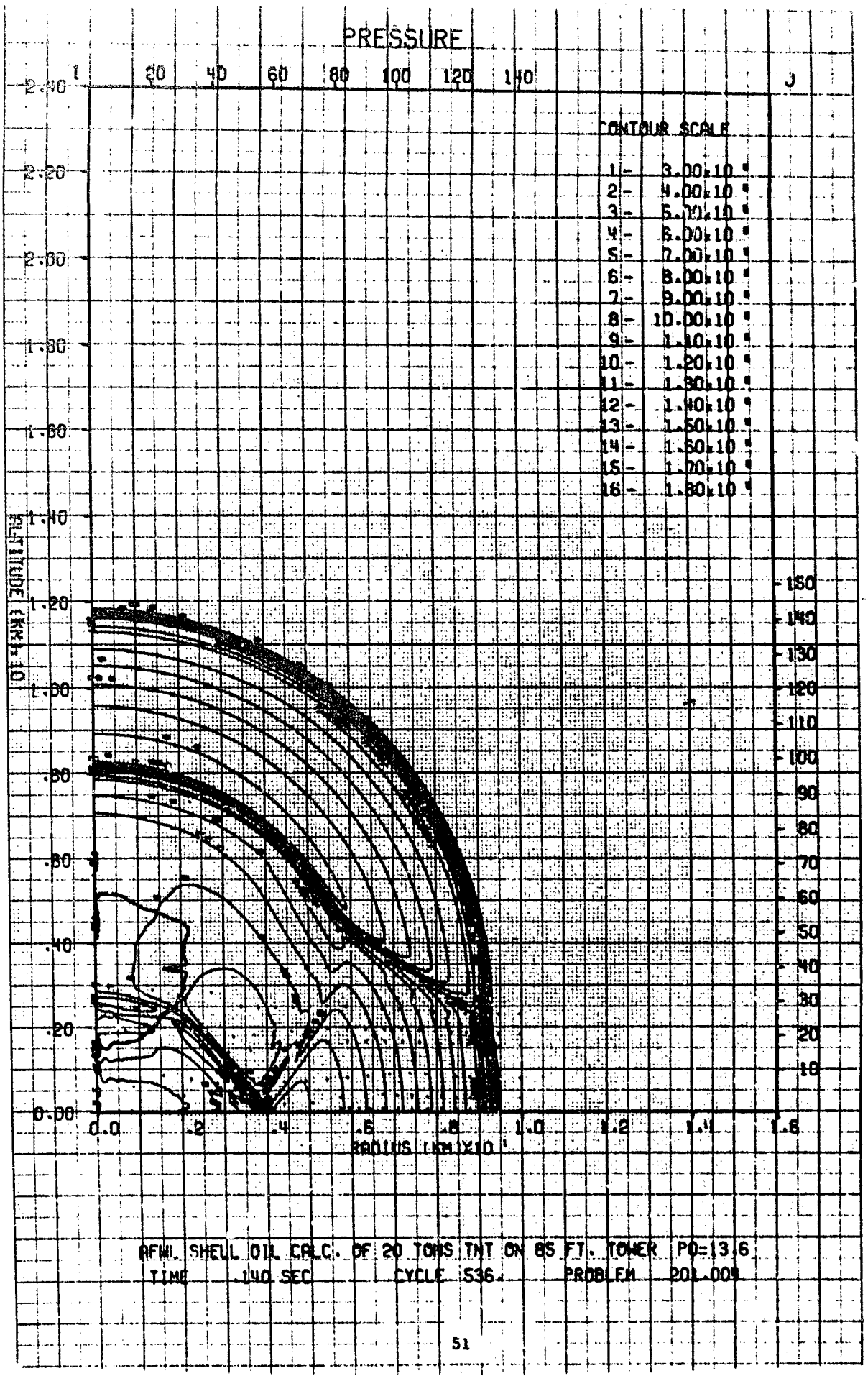

DENSITY
CONTOUR SCALE
1 = -1.00,10-1
2 = -2.00,10-1
3 = 0.00,10-1
4 = 2.00,10-1
5 = 4.00,10-1
6 = 6.00,10-1
7 = 8.00,10-1
8 = 1.00,10-1
9 = 1.20,10-1
10 = 1.40,10-1
11 = 1.60,10-1
12 = 1.80,10-1
13 = 2.00,10-1
14 = 2.20,10-1
15 = 2.40,10-1
ALTITUDE (KM*10)
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .080 SEC CYCLE 406. PROBLEM 201-004

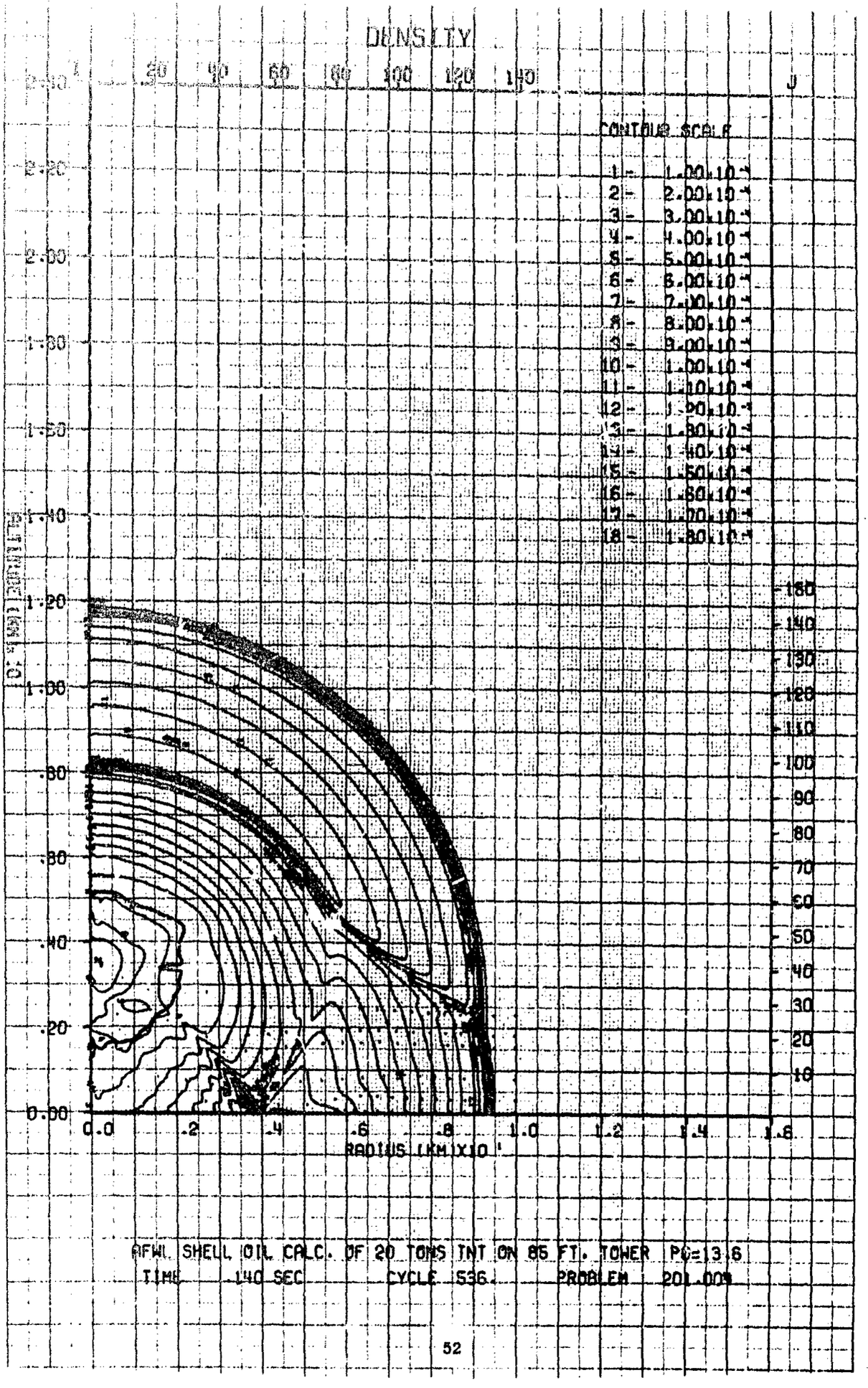

VELOCITY VECTOR
VELOCITY SCALE
0.001N.=1KM./SEC.
ALTITUDE (KM X10)
RADIUS (KM X10)
RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .080 SEC CYCLE 1406 PROBLEM 201.005

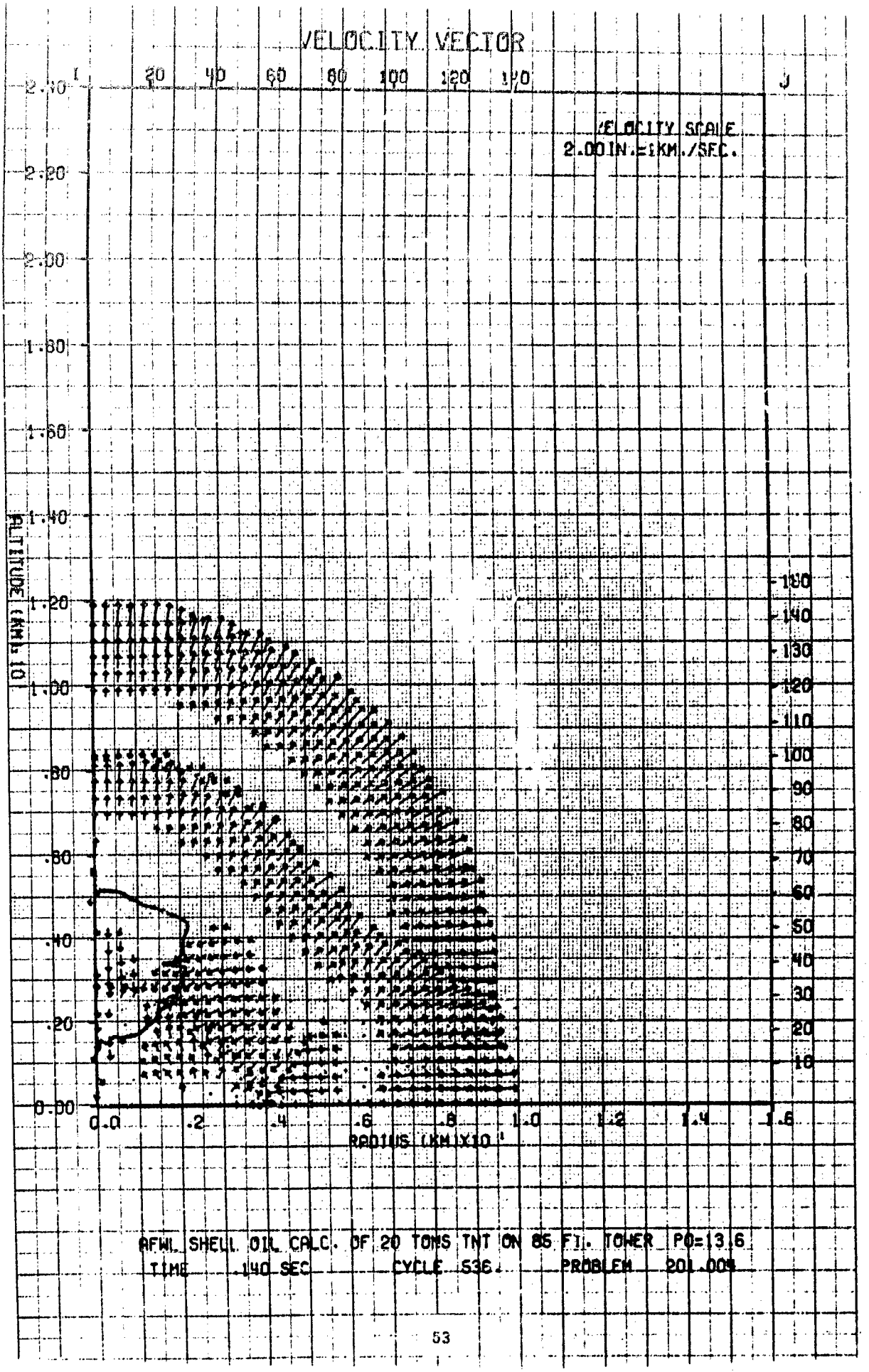

PRESSURE
CONTOUR SCALE
1 - 4.00x10 ⁴
2 - 5.00x10 ⁴
3 - 6.00x10 ⁴
4 - 7.00x10 ⁴
5 - 8.00x10 ⁴
6 - 9.00x10 ⁴
7 - 10.00x10 ⁴
8 - 1.10x10 ⁵
9 - 1.20x10 ⁵
10 - 1.30x10 ⁵
11 - 1.40x10 ⁵
12 - 1.50x10 ⁵
13 - 1.60x10 ⁵
14 - 1.70x10 ⁵
15 - 1.80x10 ⁵
16 - 1.90x10 ⁵
17 - 2.00x10 ⁵
18 - 2.10x10 ⁵
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0.00
0.0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
RADIUS (KM X10 ¹)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .410 SEC CYCLE 476 PROBLEM 201.004

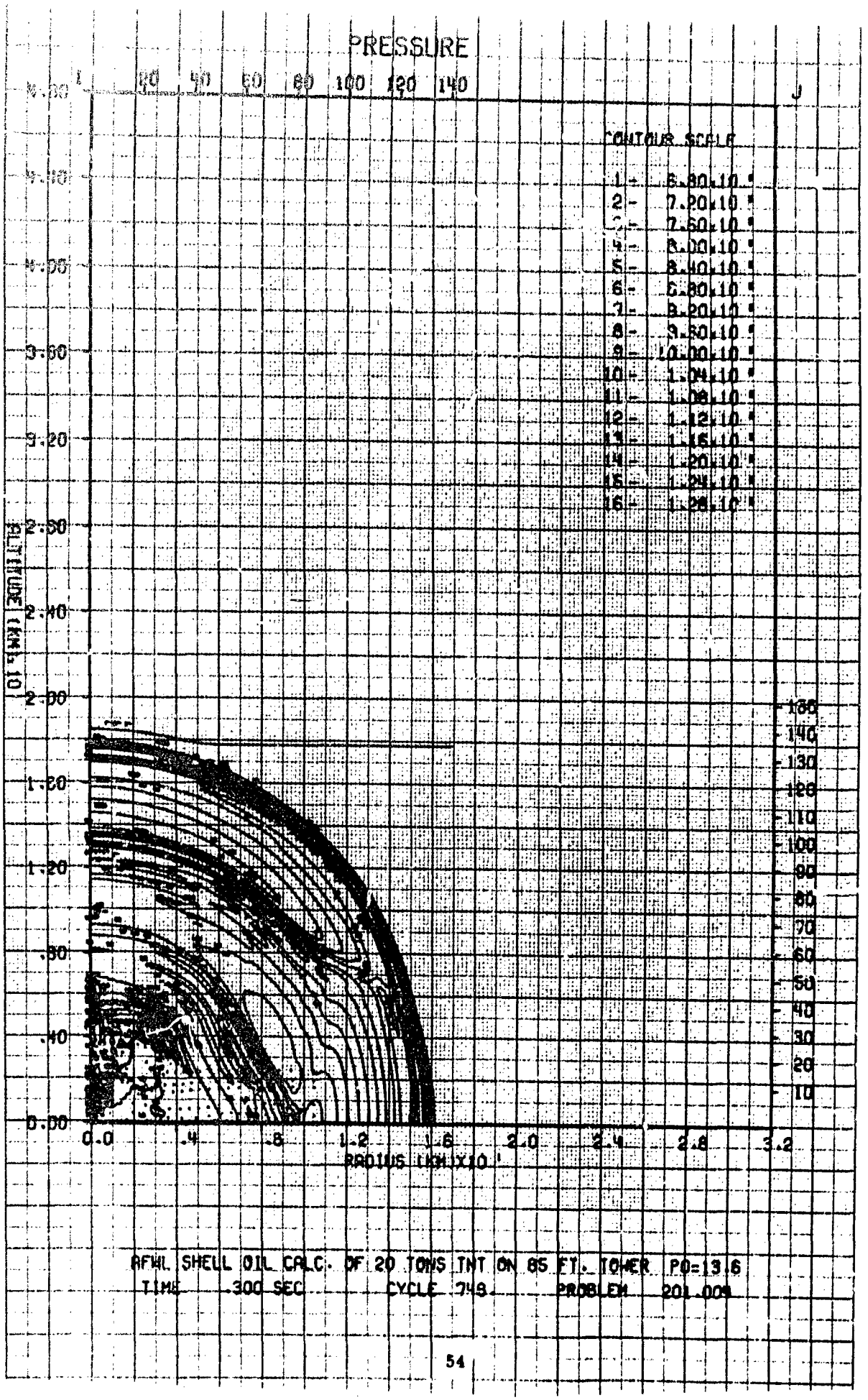

DENSITY
CONTOUR SCALE
1 - 2.00x10⁻⁴
2 - 3.00x10⁻⁴
3 - 4.00x10⁻⁴
4 - 5.00x10⁻⁴
5 - 6.00x10⁻⁴
6 - 7.00x10⁻⁴
7 - 8.00x10⁻⁴
8 - 9.00x10⁻⁴
9 - 1.00x10⁻³
10 - 1.10x10⁻³
11 - 1.20x10⁻³
12 - 1.30x10⁻³
13 - 1.40x10⁻³
14 - 1.50x10⁻³
15 - 1.60x10⁻³
16 - 1.70x10⁻³
17 - 1.80x10⁻³
18 - 1.90x10⁻³
19 - 2.00x10⁻³
ALTITUDE (KM)X10
RADIUS (KM)X10
RFWI. SHELL OIL CR.C. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .110 SEC CYCLE 476. PROBLEM 201.004

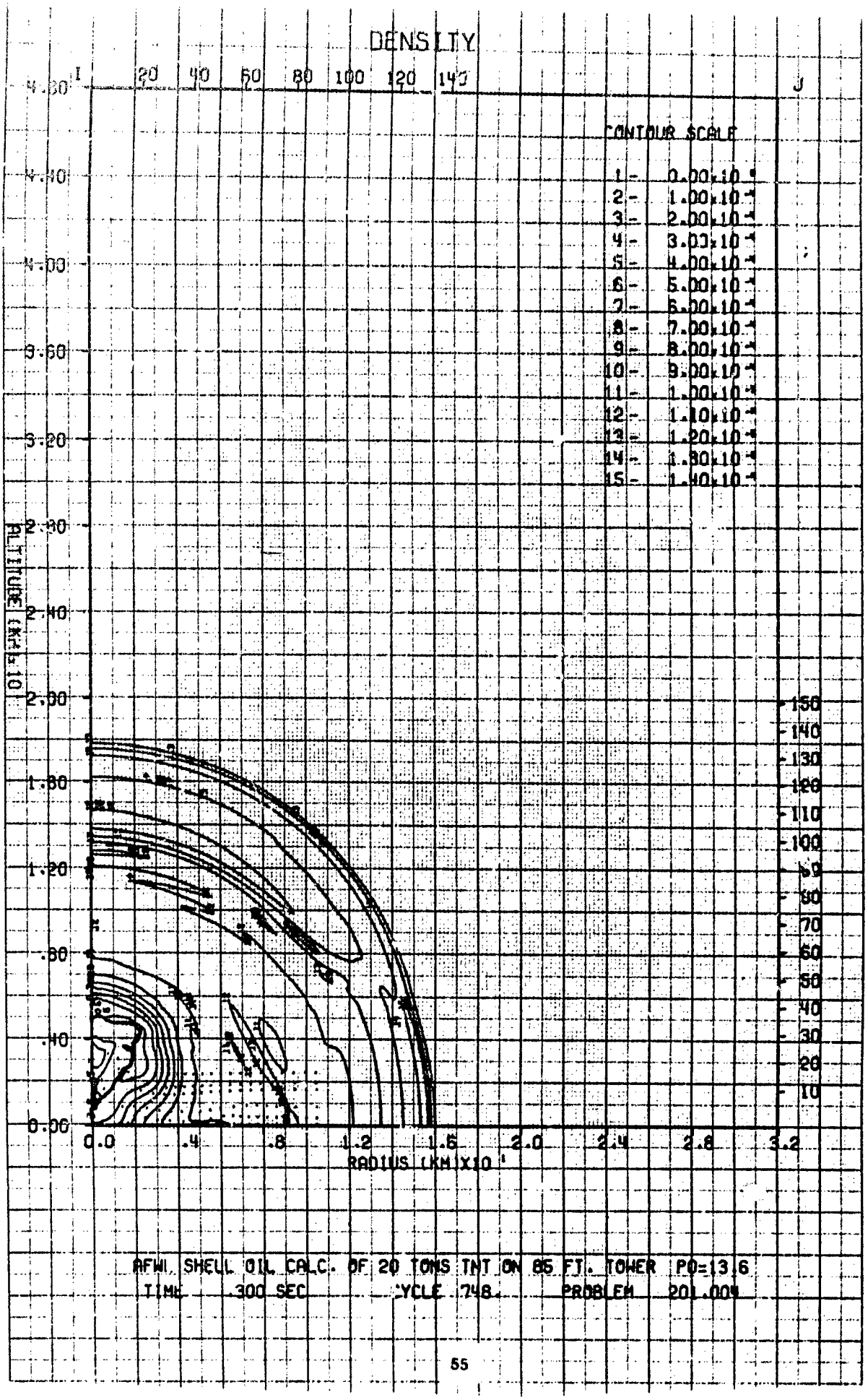

VELOCITY VECTOR
VELOCITY SCALE
2.00IN.=1KM./SEC.
ALTITUDE (KM X 10)
RADIUS (KM X 10)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .110 SEC CYCLE 476. PROBLEM 201.009

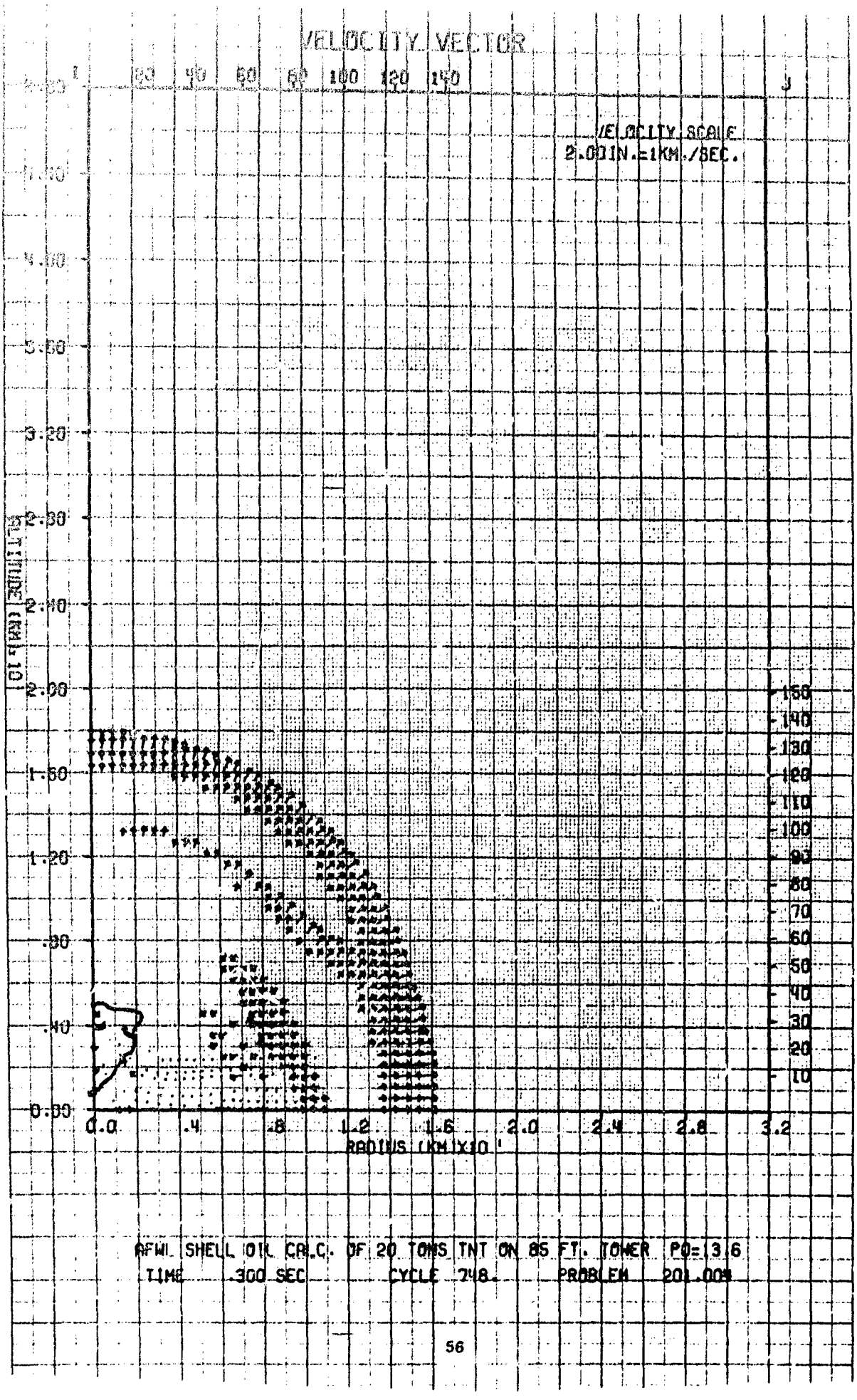

PRESSURE
CONTOUR SCALE
1- 3.00x10
2- 4.00x10
3- 5.00x10
4- 6.00x10
5- 7.00x10
6- 8.00x10
7- 9.00x10
8- 10.00x10
9- 1.10x10
10- 1.20x10
11- 1.30x10
12- 1.40x10
13- 1.50x10
14- 1.60x10
15- 1.70x10
16- 1.80x10
ALTITUDE (KM X10)
RADIUS (KM X10)
RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .140 SEC CYCLE 536. PROBLEM 201.009


DENSITY
CONTOUR SCALE
1 - 1.00x10
2 - 2.00x10
3 - 3.00x10
4 - 4.00x10
5 - 5.00x10
6 - 6.00x10
7 - 7.00x10
8 - 8.00x10
9 - 9.00x10
10 - 1.00x10
11 - 1.10x10
12 - 1.20x10
13 - 1.30x10
14 - 1.40x10
15 - 1.50x10
16 - 1.60x10
17 - 1.70x10
18 - 1.80x10
J
180
140
130
120
110
100
90
80
70
60
50
40
30
20
10
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0.00
0.0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS INT ON 85 FT. TOWER PO=13.6
TIME .140 SEC CYCLE 536. PROBLEM 201.009


VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
ALTITUDE (KM X10)
RADIUS (KM X10)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .140 SEC CYCLE 536 PROBLEM 201.004


PRESSURE
CONTOUR SCALE
1 - 6.80x10
2 - 7.20x10
3 - 7.60x10
4 - 8.00x10
5 - 8.40x10
6 - 8.80x10
7 - 9.20x10
8 - 9.60x10
9 - 10.00x10
10 - 1.04x10
11 - 1.08x10
12 - 1.12x10
13 - 1.16x10
14 - 1.20x10
15 - 1.24x10
16 - 1.28x10
ALTITUDE (KM)x10
RADIUS (KM)X10
RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .300 SEC CYCLE 748 PROBLEM 201.009


DENSITY
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1- 0.00x10⁻⁴
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- 1.00x10⁻³
12- 1.10x10⁻³
13- 1.20x10⁻³
14- 1.30x10⁻³
15- 1.40x10⁻³
ALTITUDE (KM)X10¹
4.80
4.40
4.00
3.60
3.20
2.80
2.40
2.00
1.80
1.20
.80
.40
0.00
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
RADIUS (KM)X10¹
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .300 SEC CYCLE 748. PROBLEM 201.004



AFWL SHELL OIL CR.C. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .300 SEC CYCLE 748. PROBLEM 201.009

SHELL Tracings

This part contains the tracings recorded at each test station of overpressure, dynamic pressure overpressure impulse, dynamic pressure impulse and velocity resulting from the TNT detonation. These are SHELL-OIL results.

Table I gives the location of each test station.

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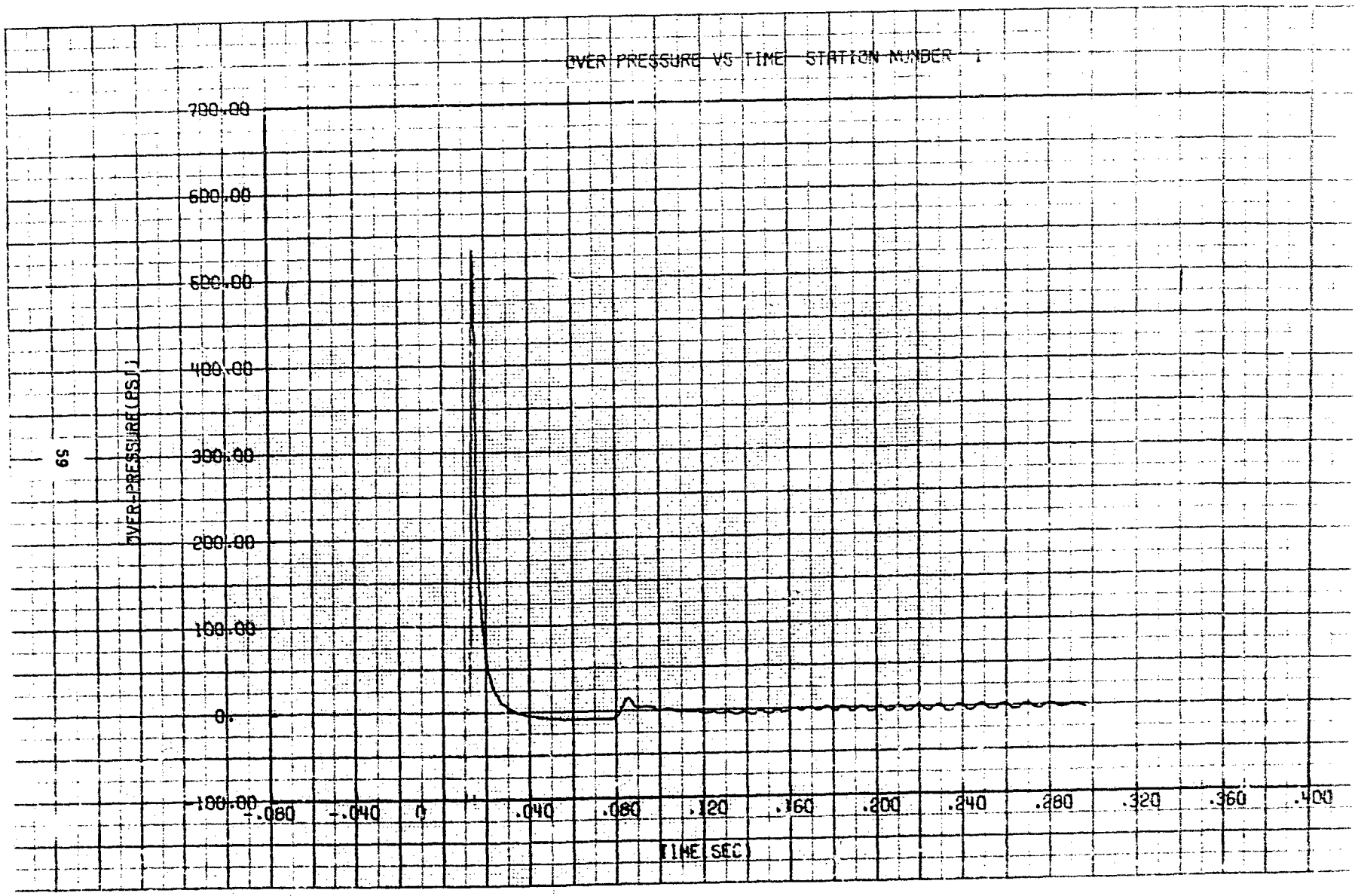
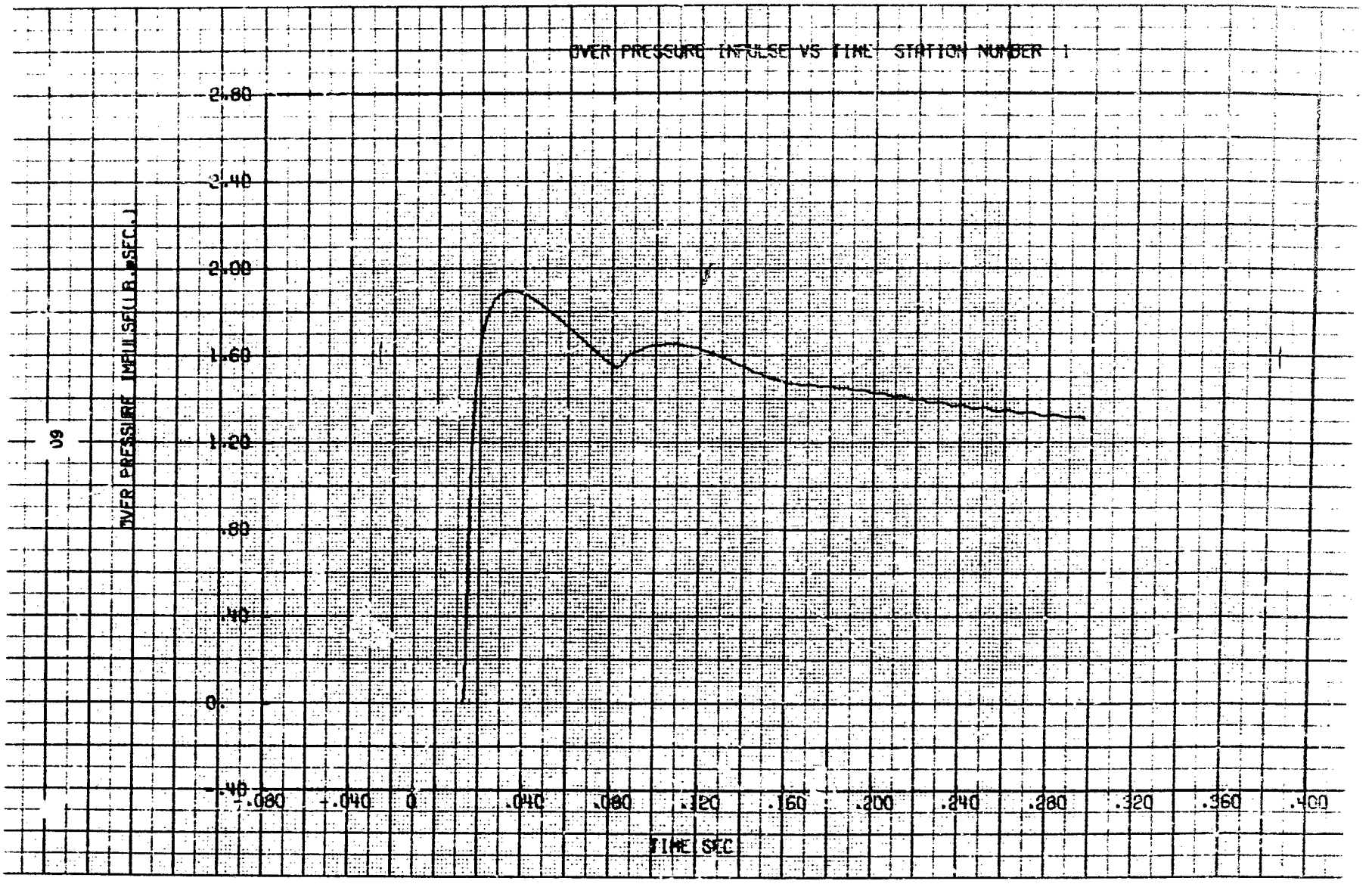
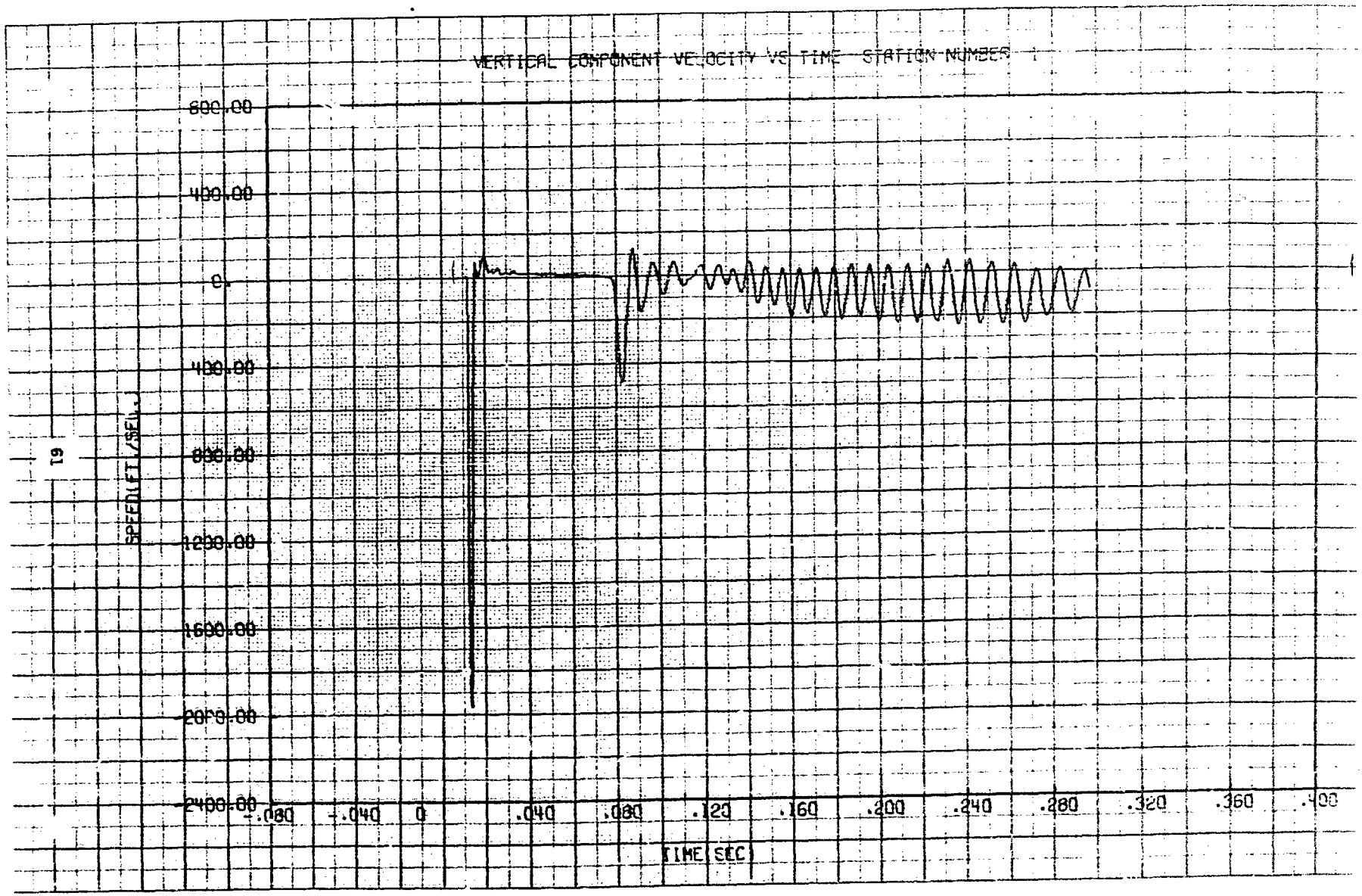
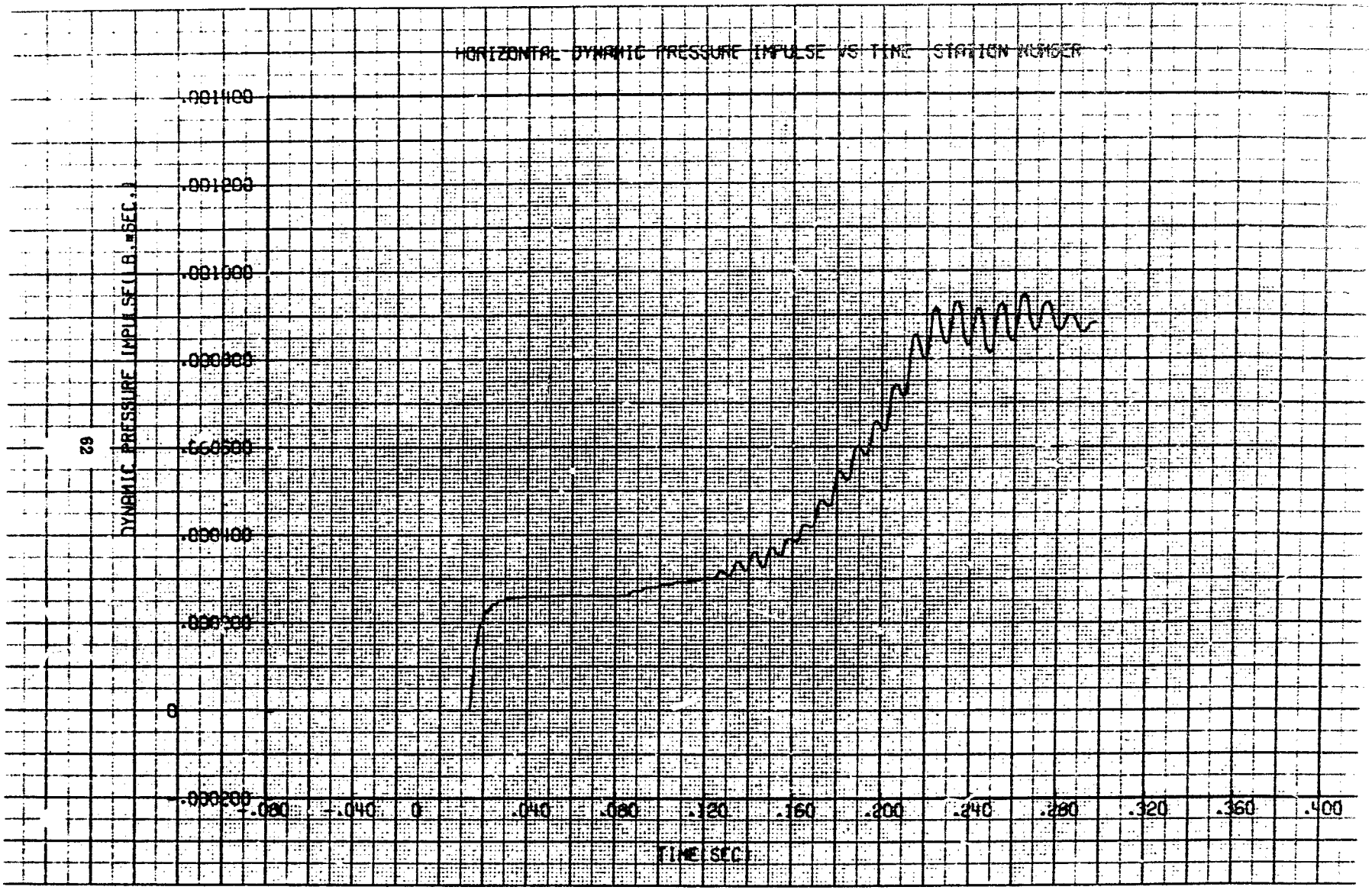
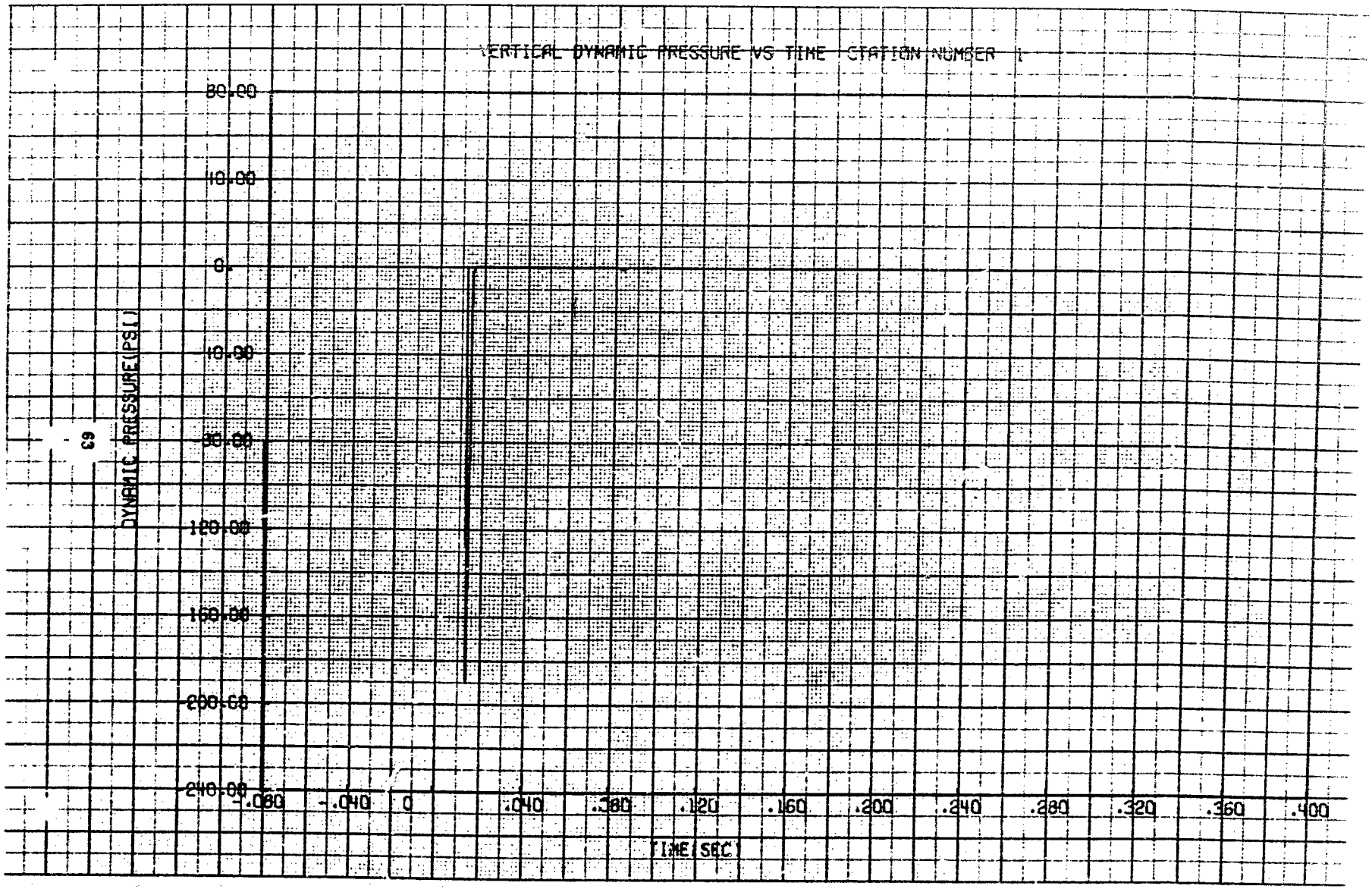
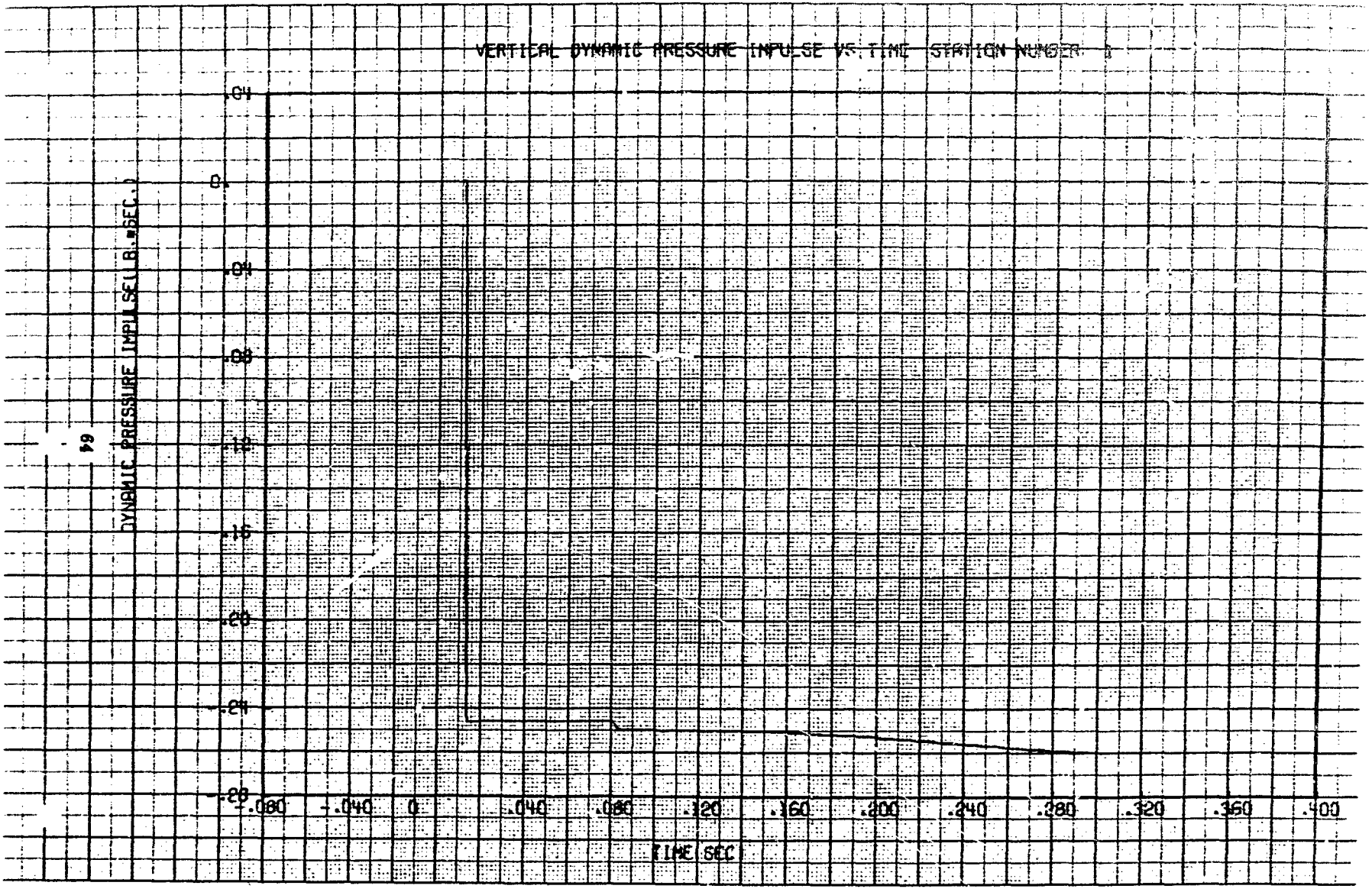

OVER PRESSURE VS TIME STATION NUMBER 1
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

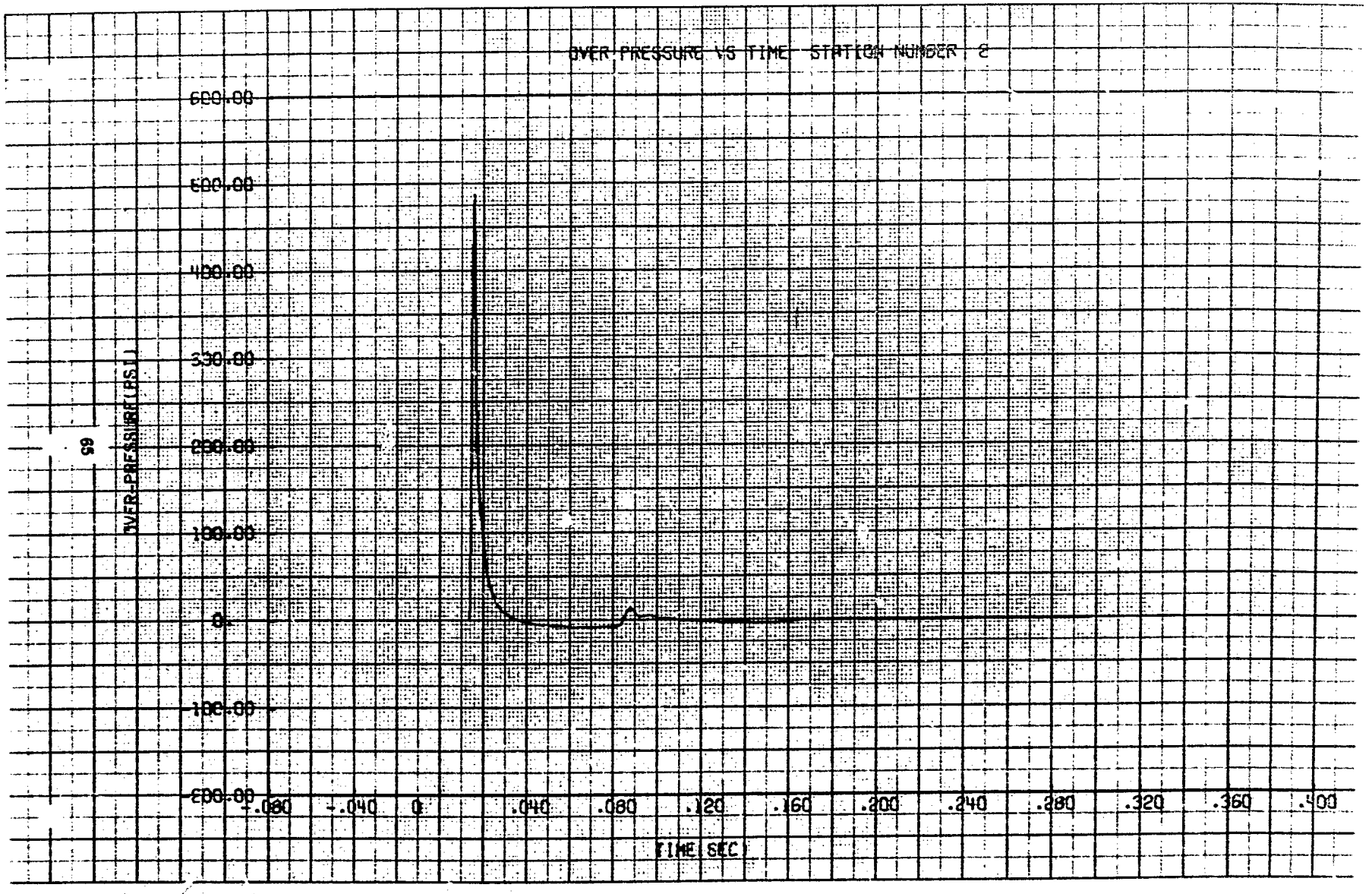

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 1
OVER PRESSURE IMPULSE(LB.*SEC.)
2.80
2.40
2.00
1.60
1.20
.80
.40
0
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

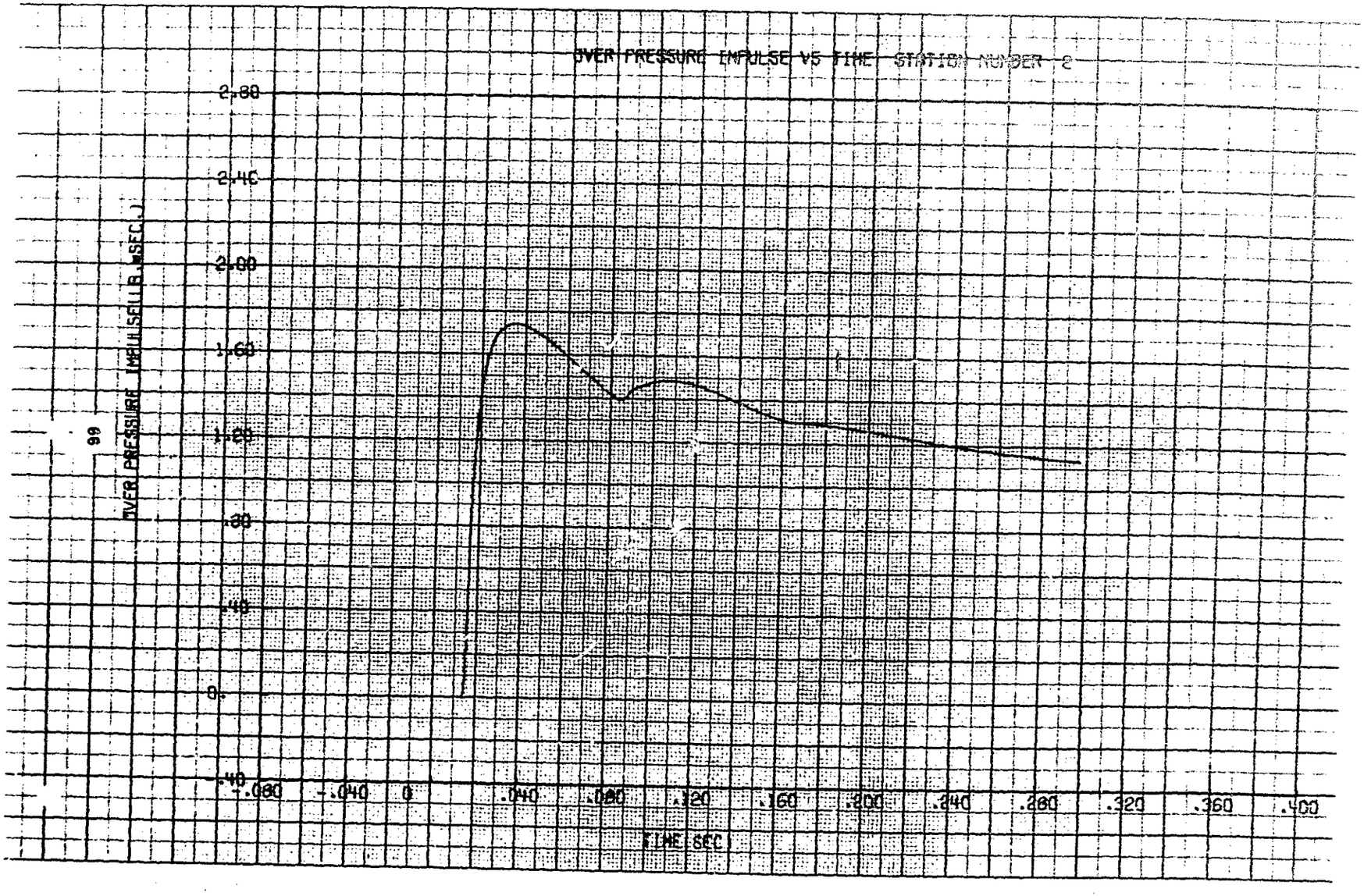

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 1
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
-2400.00
SPEED(FT/SEC)
19
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

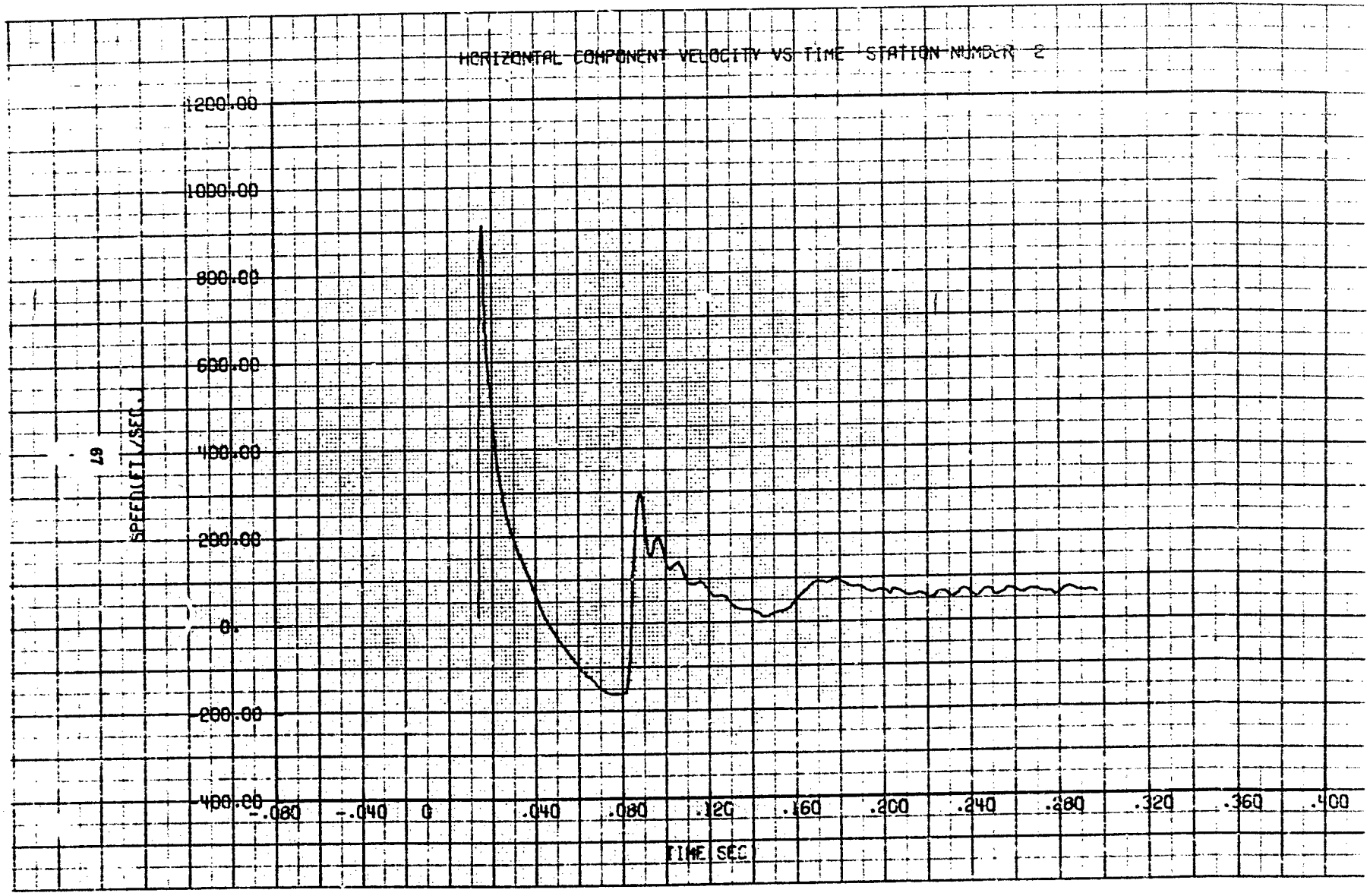

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
.001400
.001200
.001000
.000800
.000600
.000400
.000200
0
-.000200
DYNAMIC PRESSURE IMPULSE (LB.*SEC.)
29
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

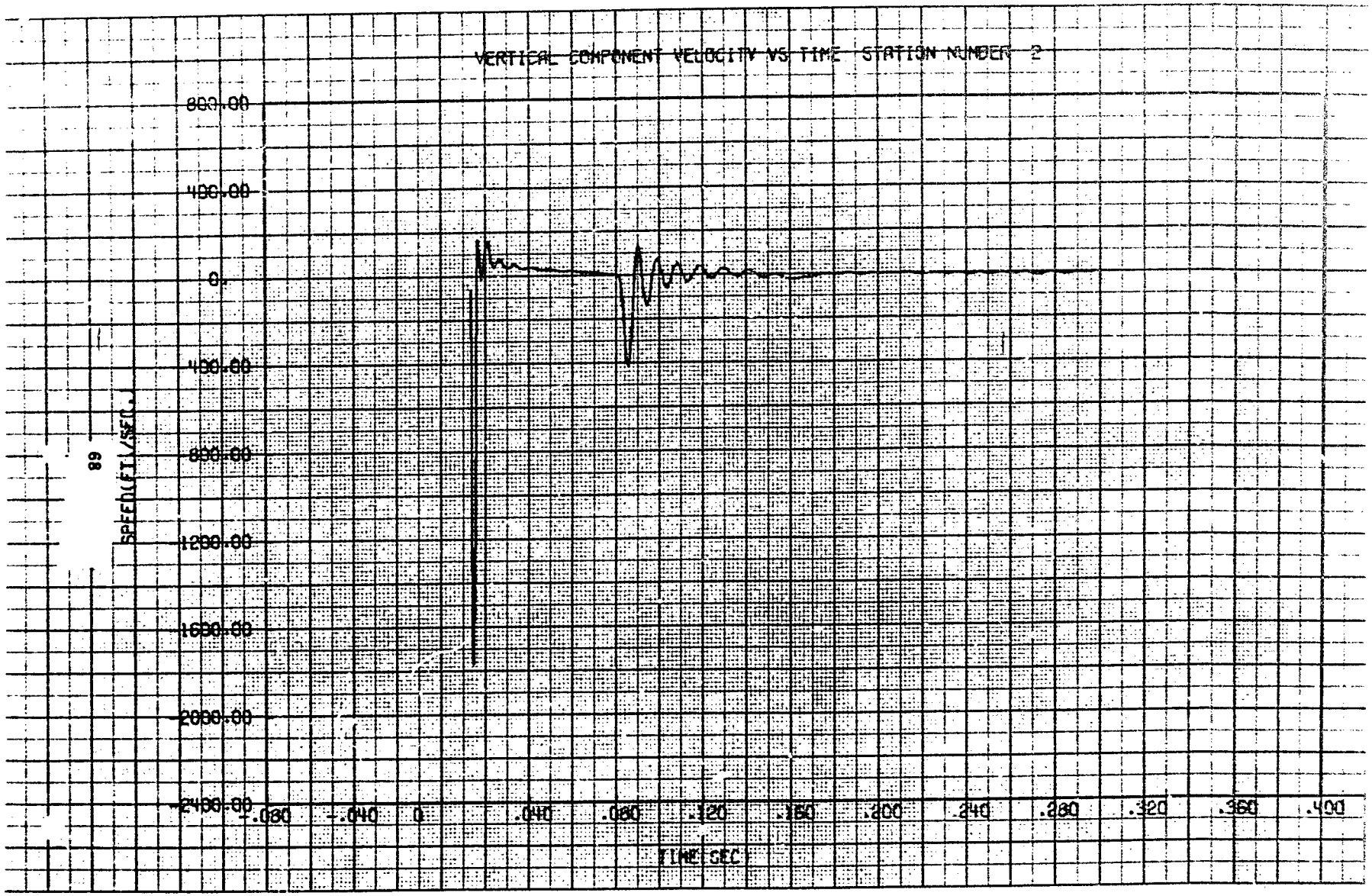

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 1
80.00
40.00
0.
-40.00
-80.00
-120.00
-160.00
-200.00
-240.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

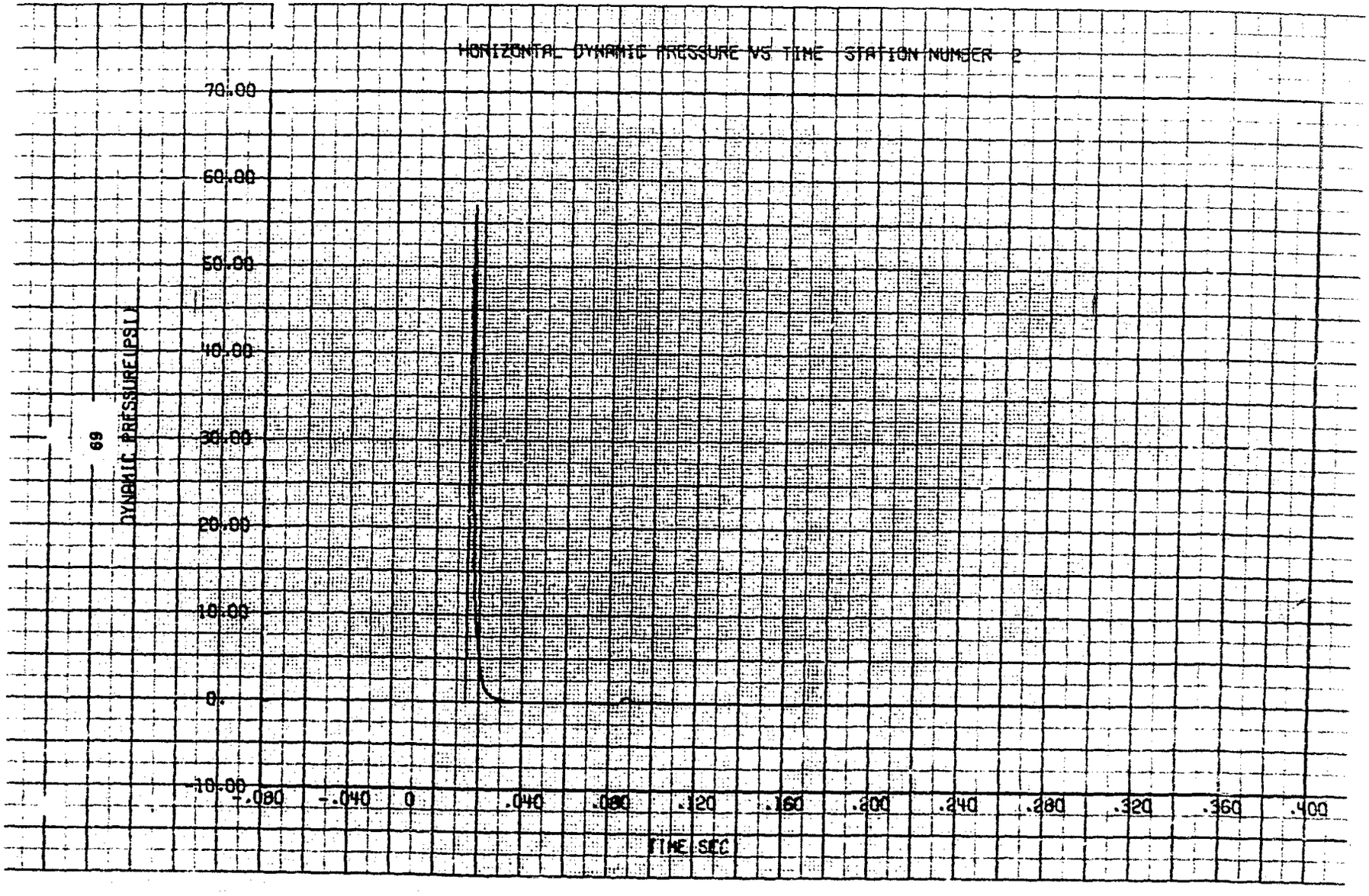

VERTICAL DYNAMIC PRESSURE IMPULSE VS. TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE (LB.*SEC.)
.04
0.
-.04
-.08
-.12
-.16
-.20
-.24
-.28
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

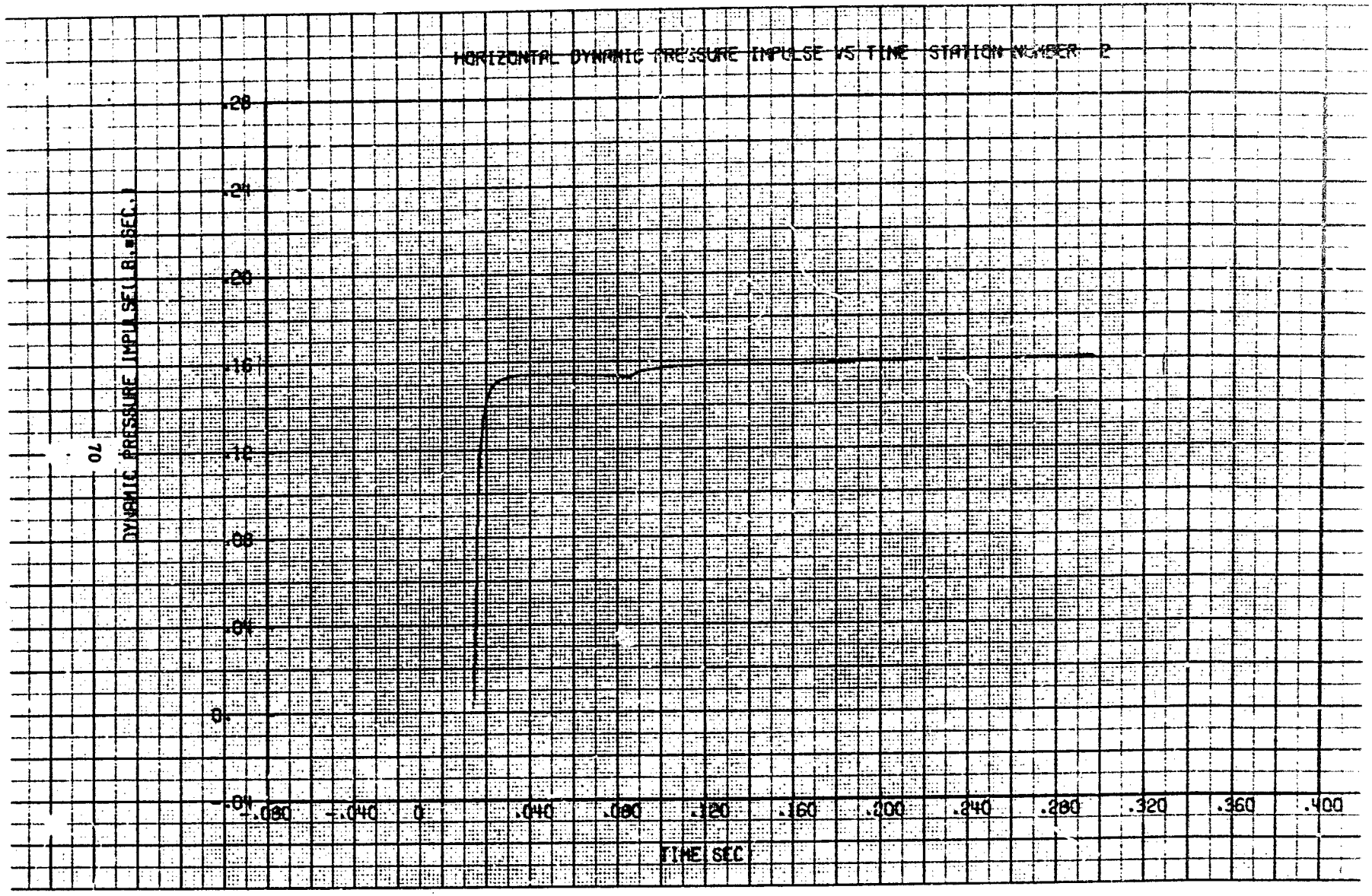

OVER PRESSURE VS TIME STATION NUMBER 8
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
OVER-PRESSURE(LBS/)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

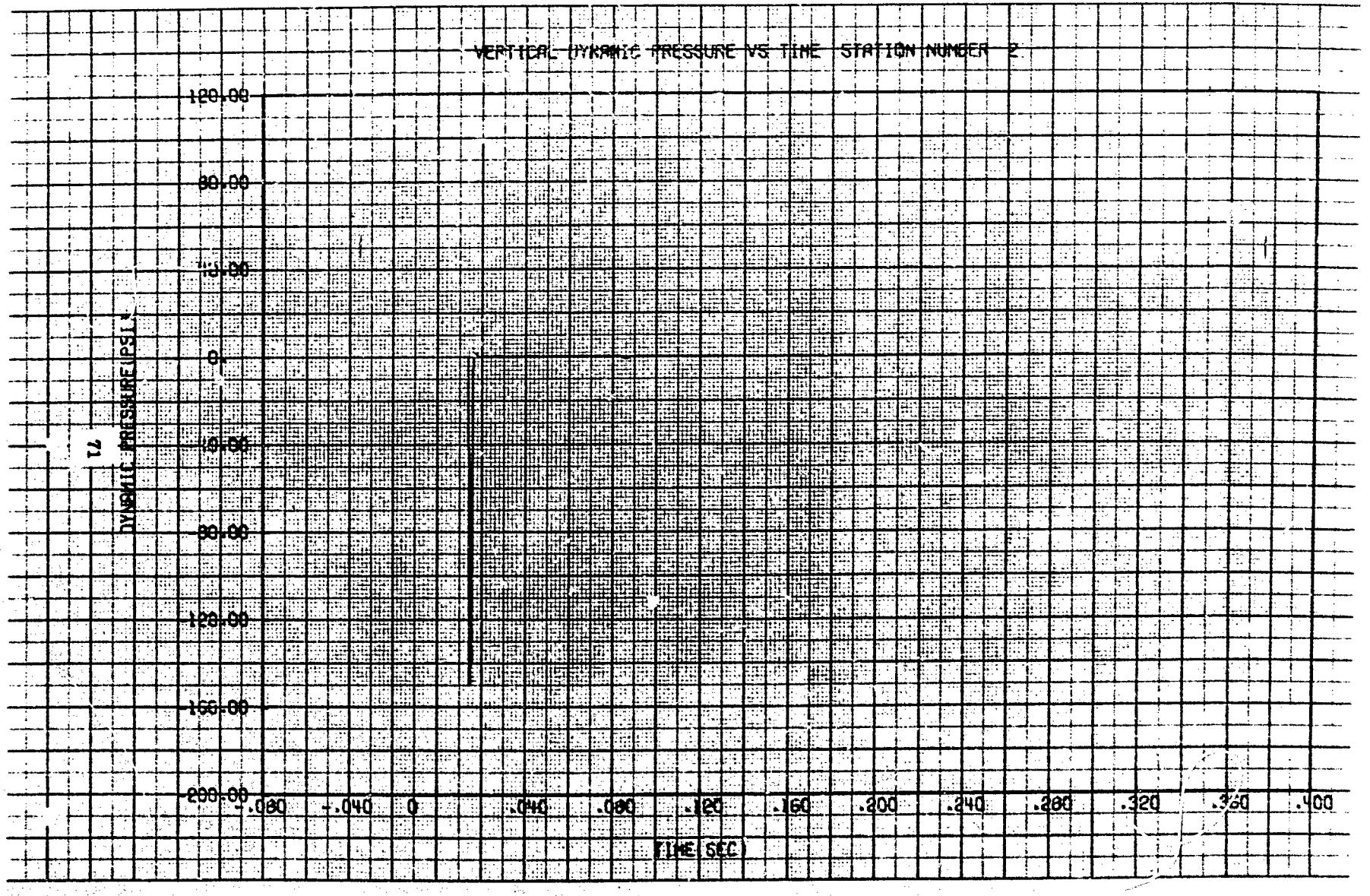

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 2
OVER PRESSURE IMPULSE(LB./SEC.)
99
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

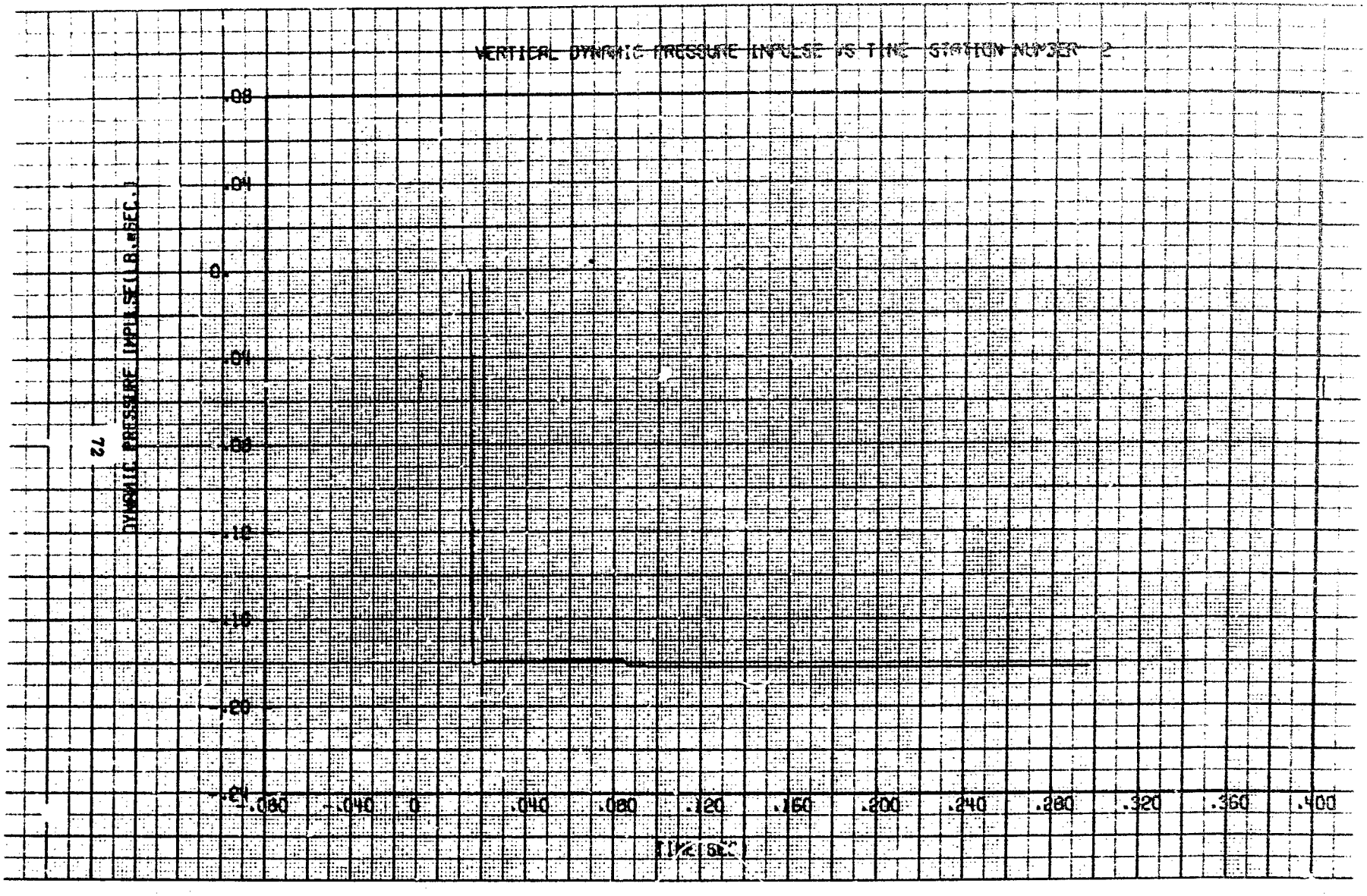

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

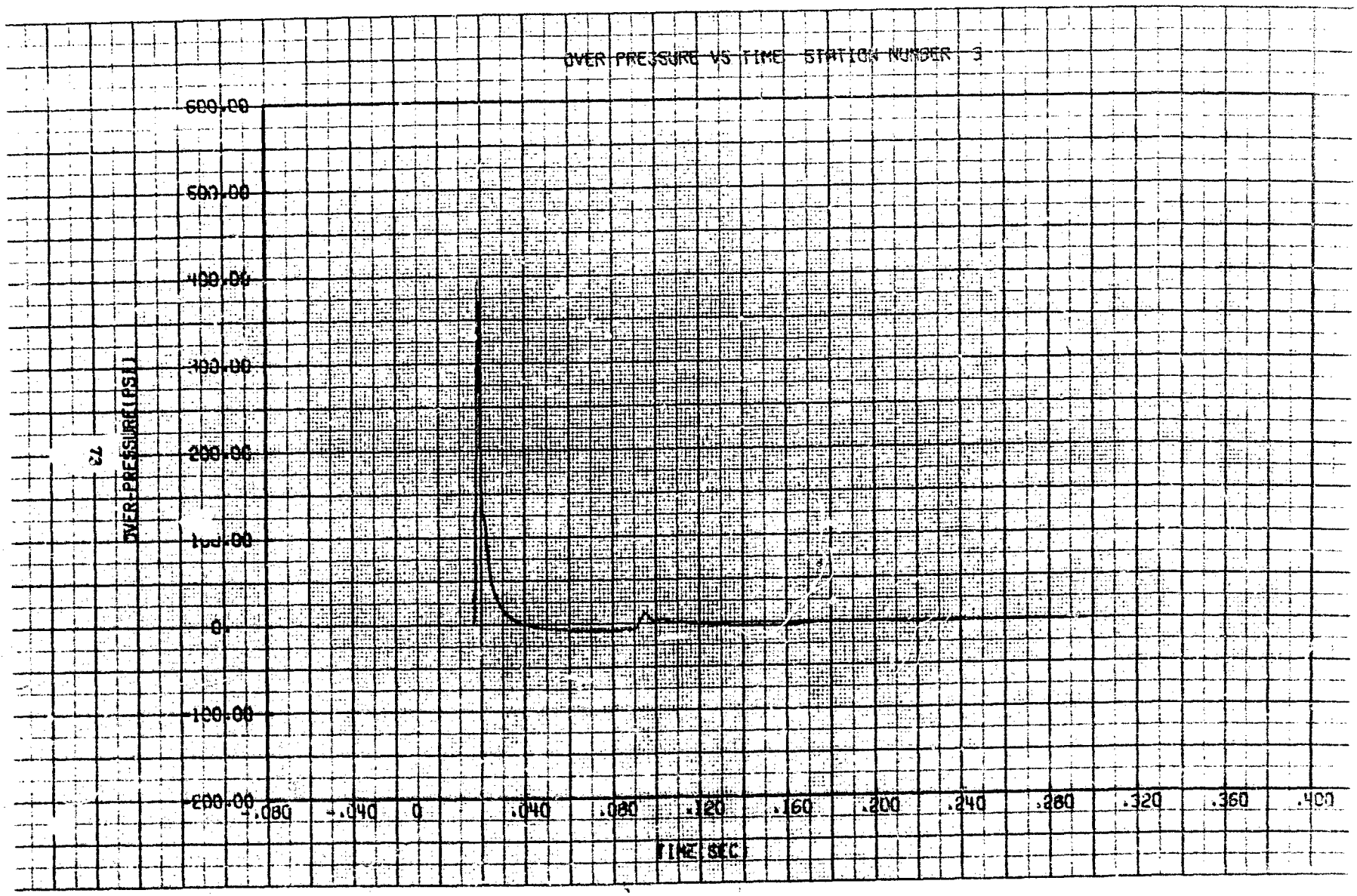

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
-2400.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
68

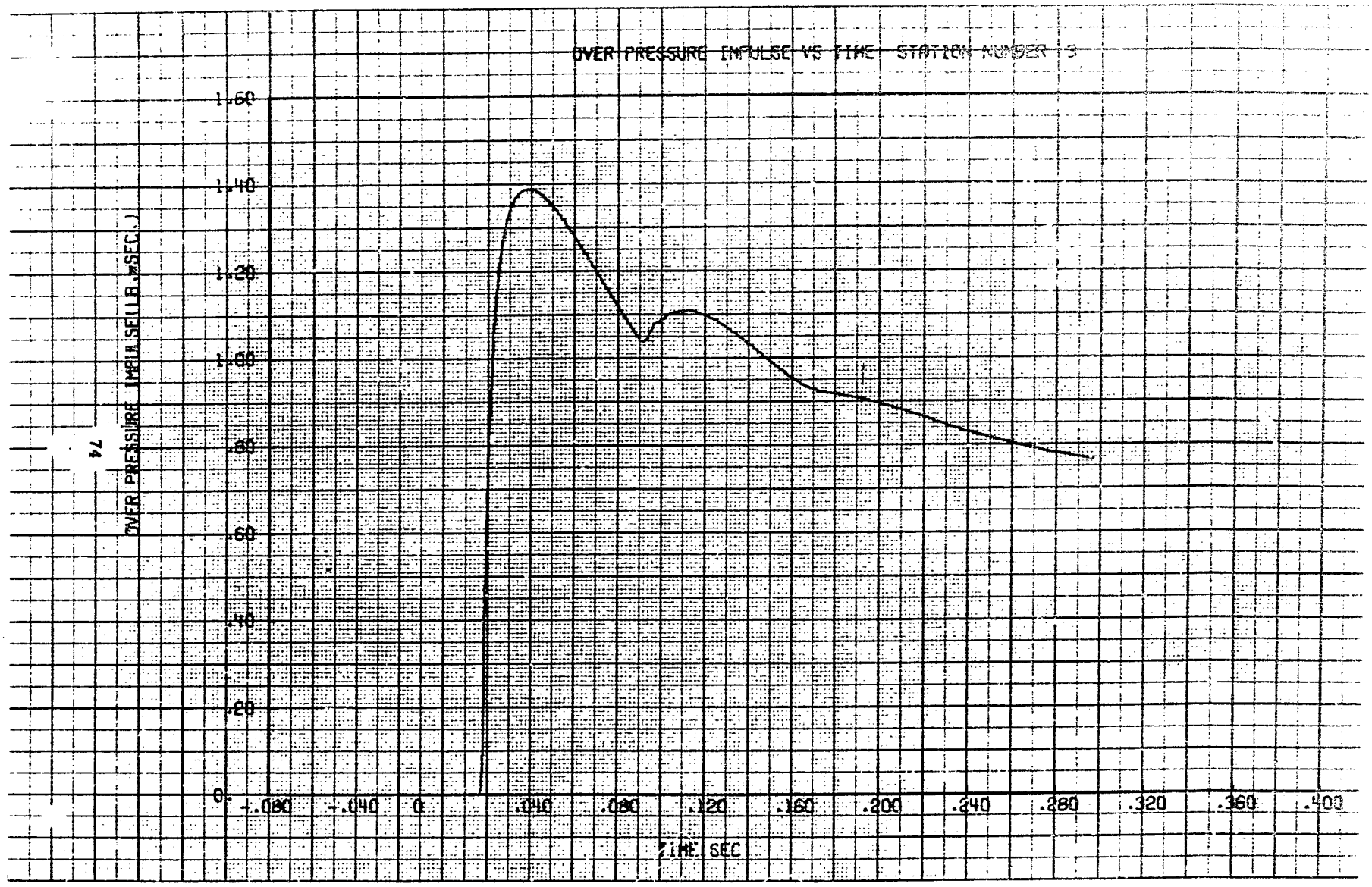

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 2
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
69
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

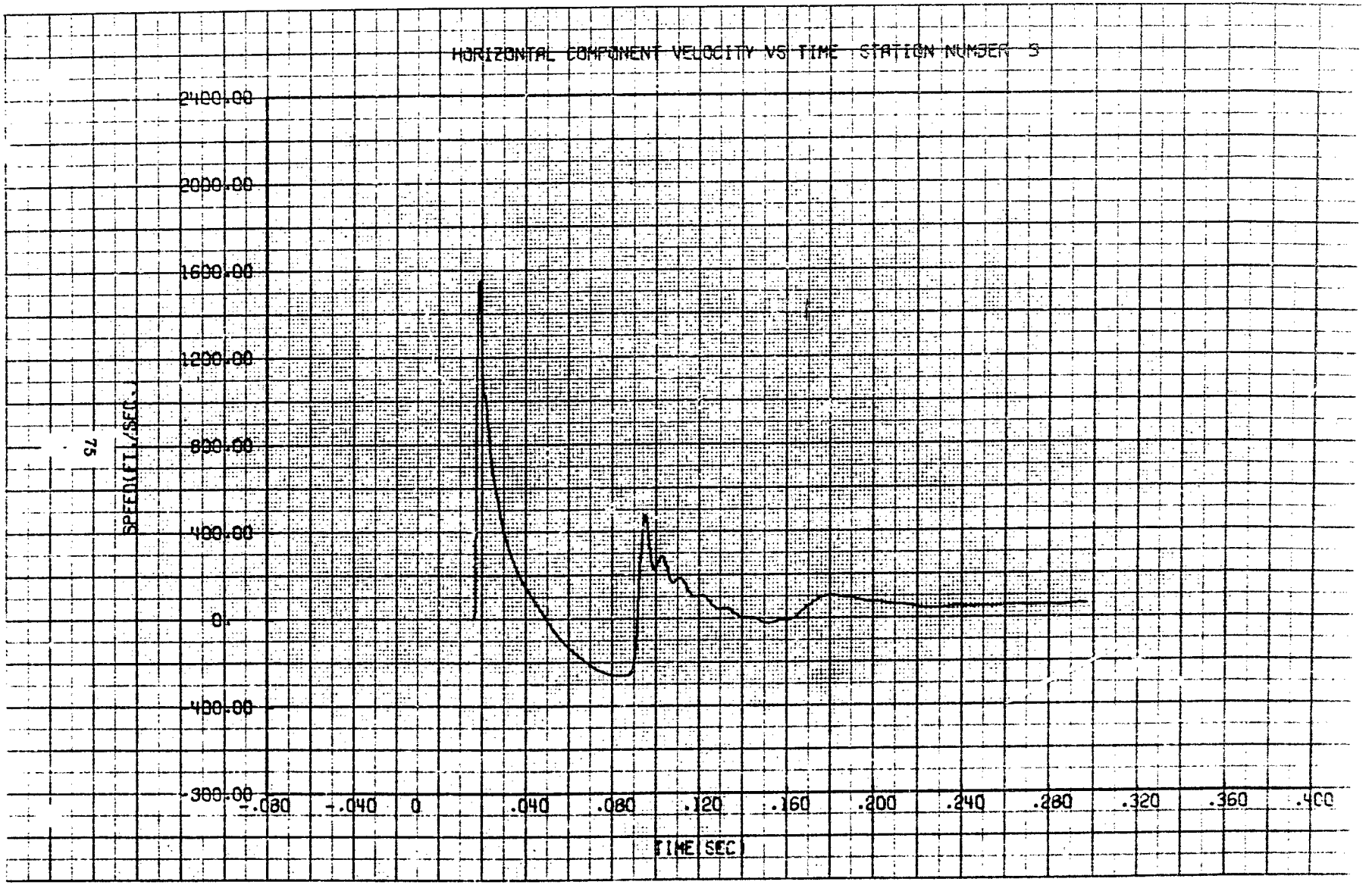

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

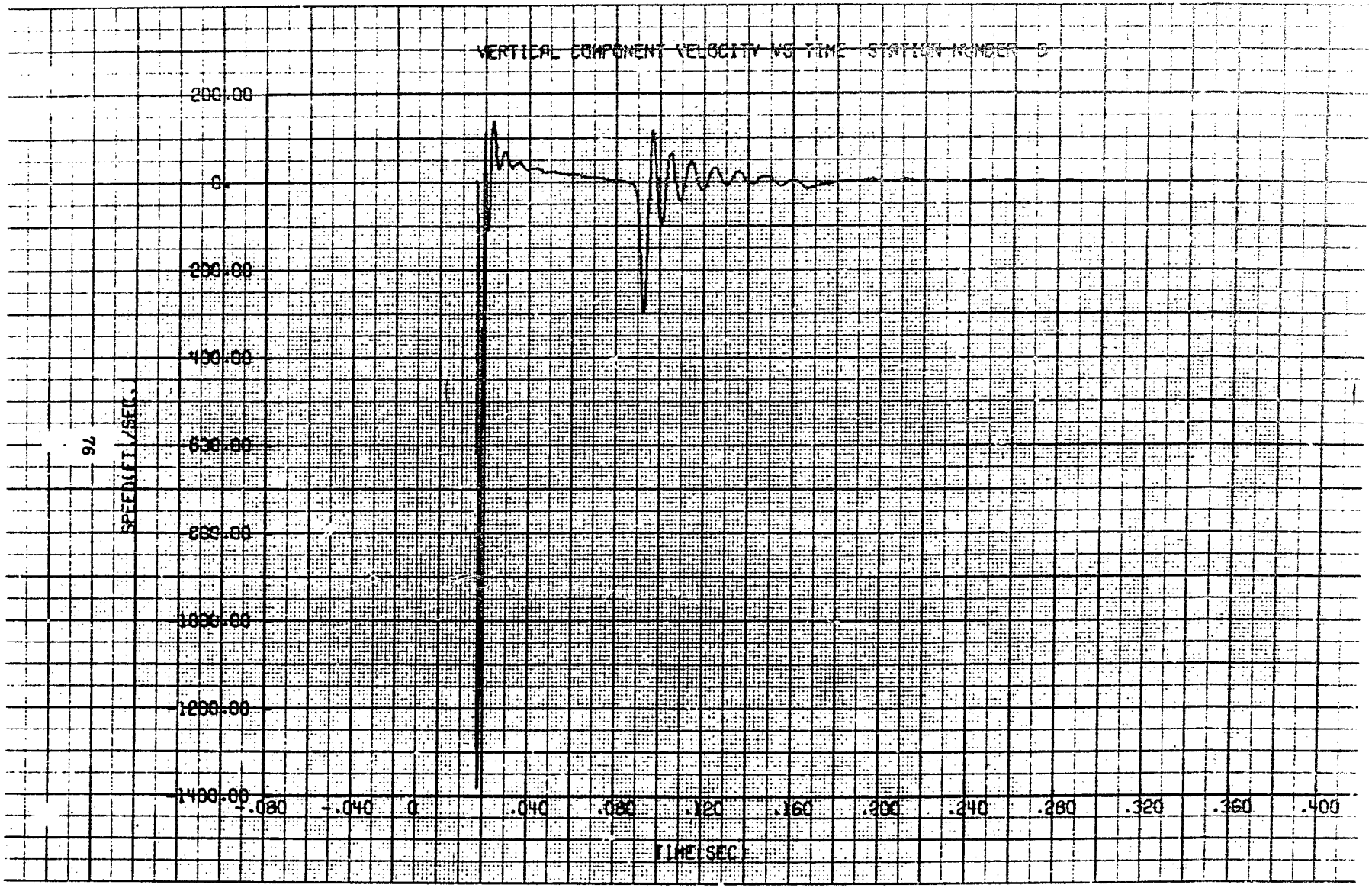

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 2
120.00
80.00
40.00
0
-40.00
-80.00
-120.00
-160.00
-200.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC)

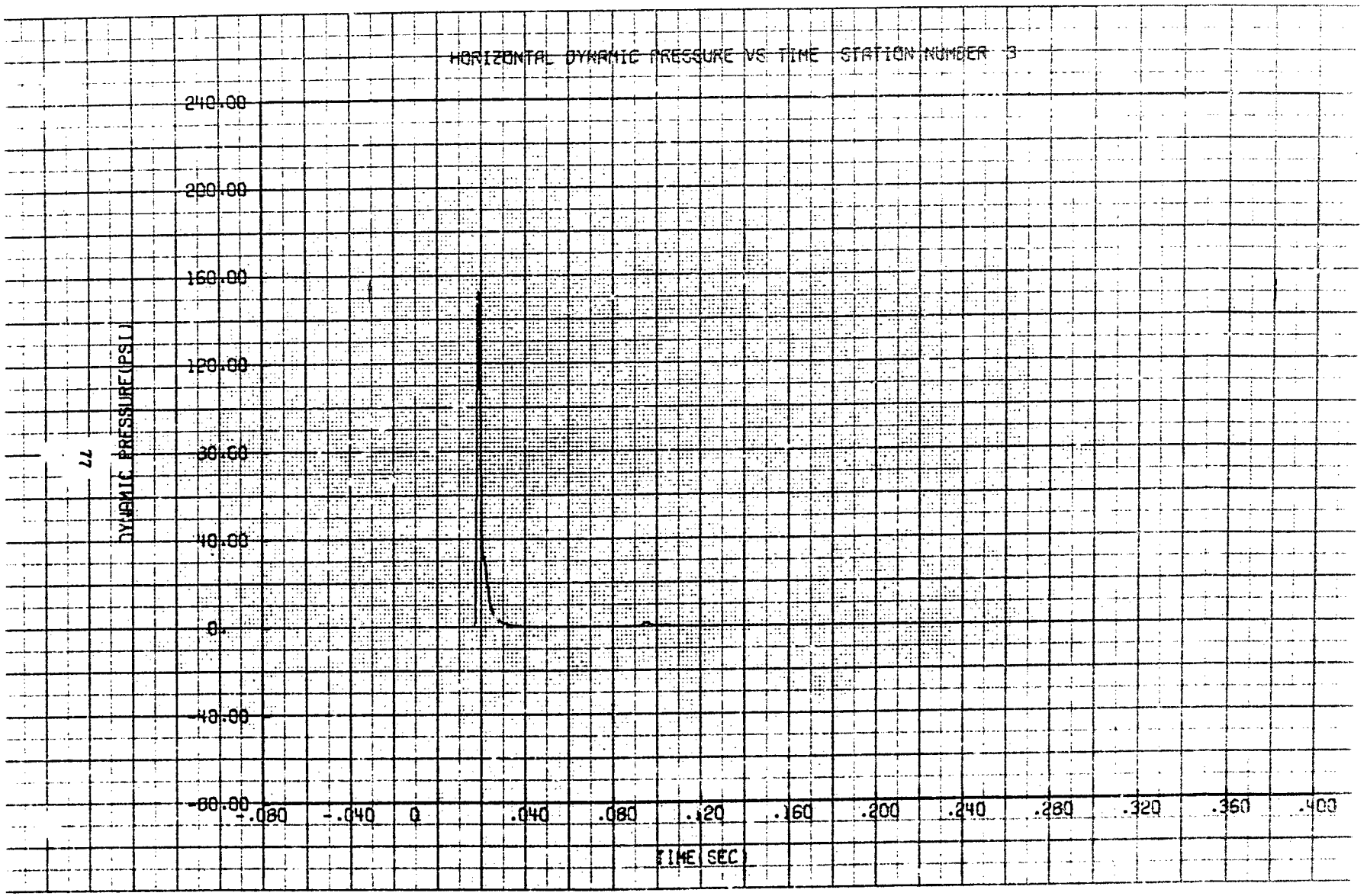

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE IMPULSE (LB.-SEC.)
.08
.04
0
-.04
-.08
-.12
-.16
-.20
-.24
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC.)


OVER PRESSURE VS TIME STATION NUMBER 3
OVER-PRESSURE(PSI)
600.00
500.00
400.00
300.00
200.00
100.00
0
-100.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

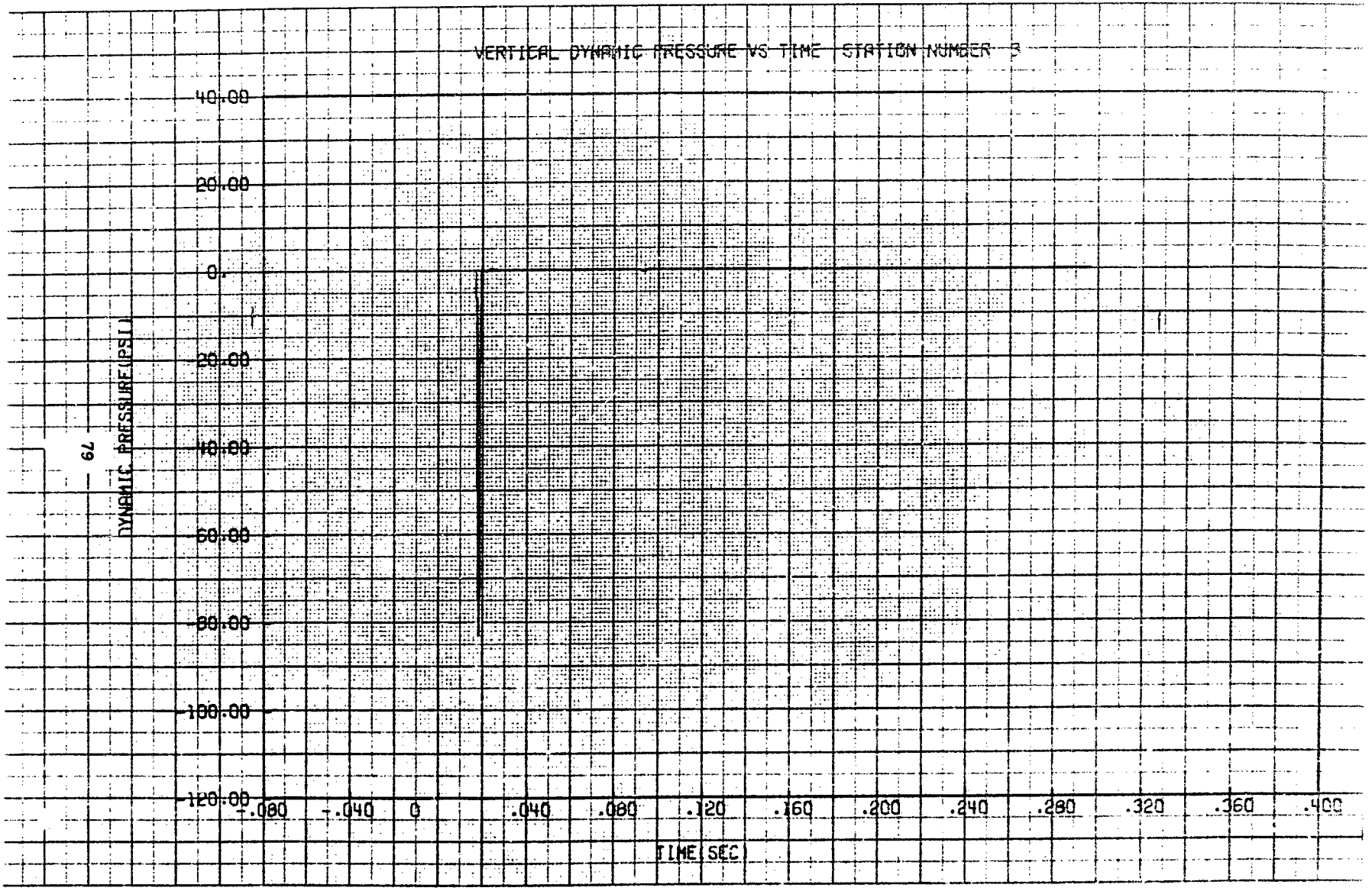

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 3
OVER PRESSURE IMPULSE (LB.-SEC./IN.²)
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

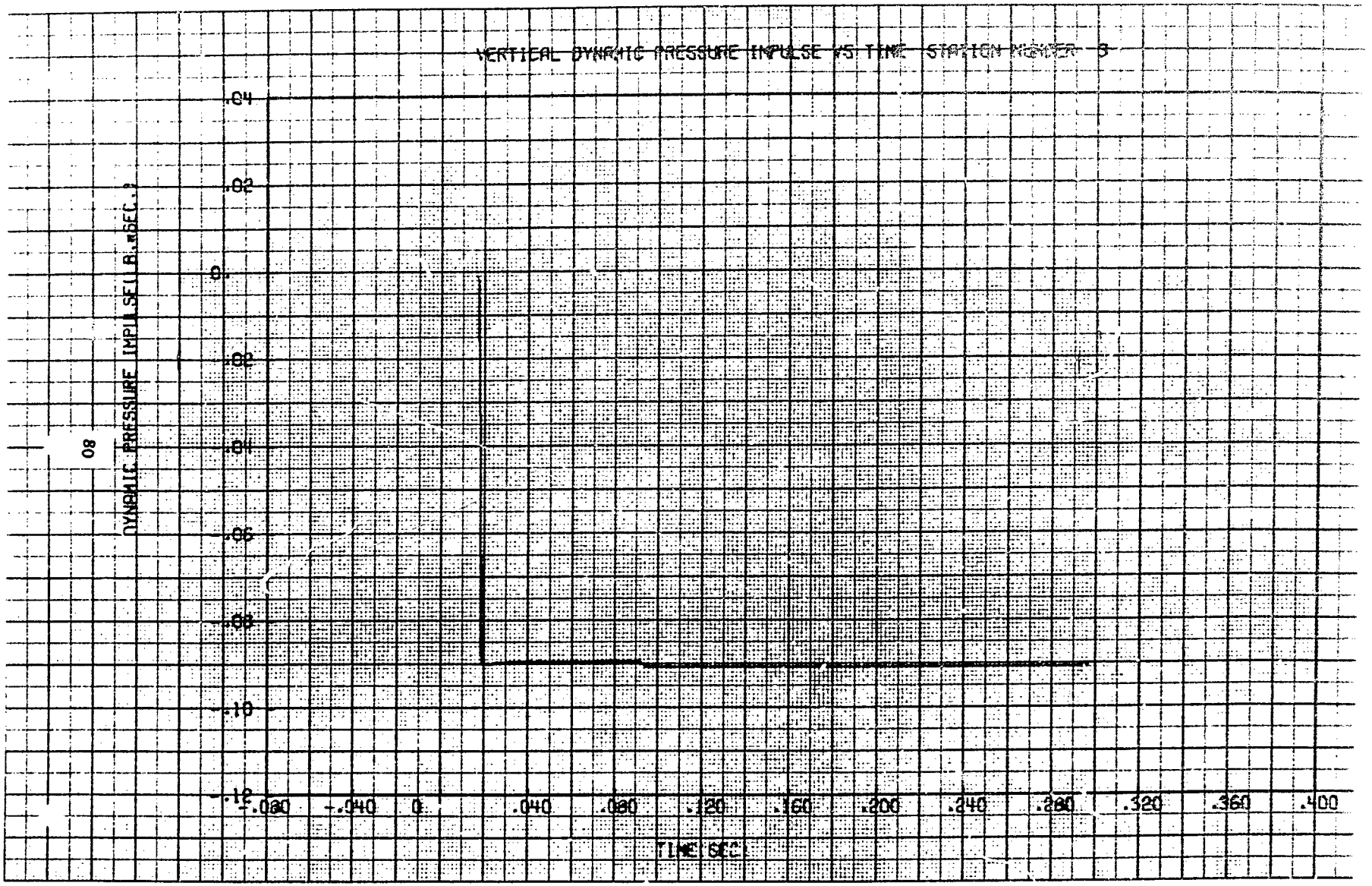

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

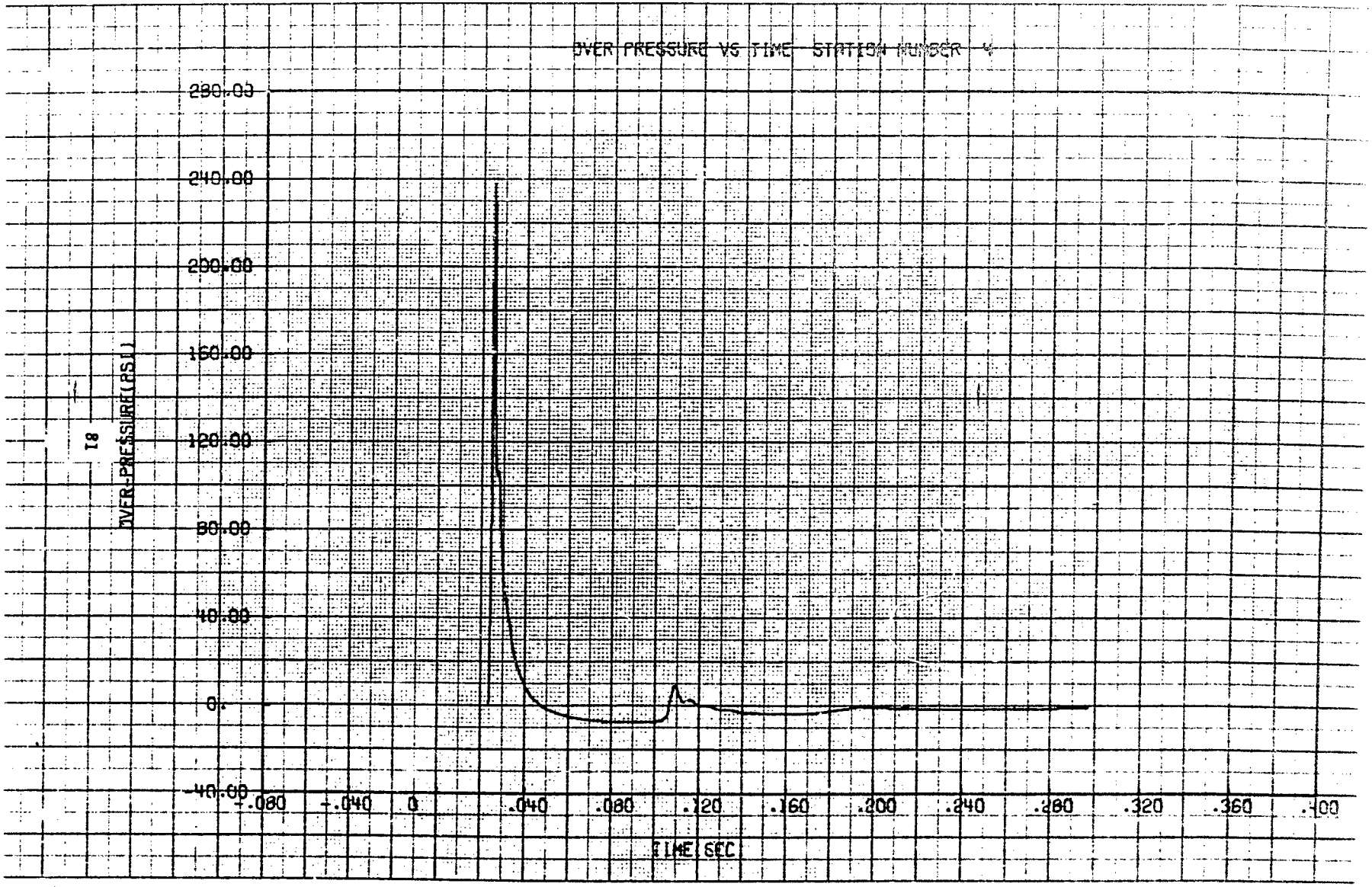

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
-1400.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

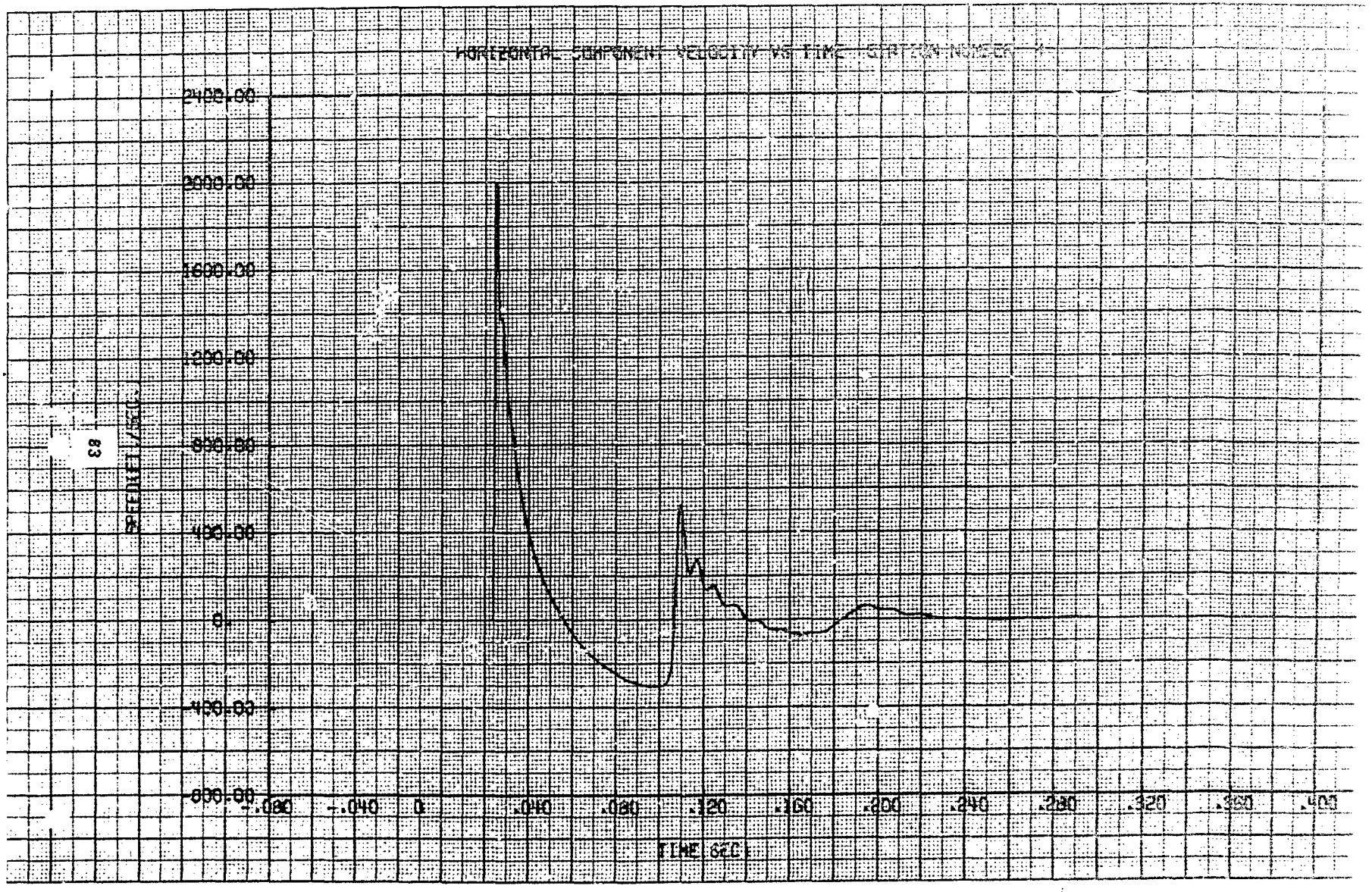
HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STARTING AT 0.000
DYNAMIC PRESSURE IMPULSE (LB.-SEC./SQ.IN.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
-.080
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

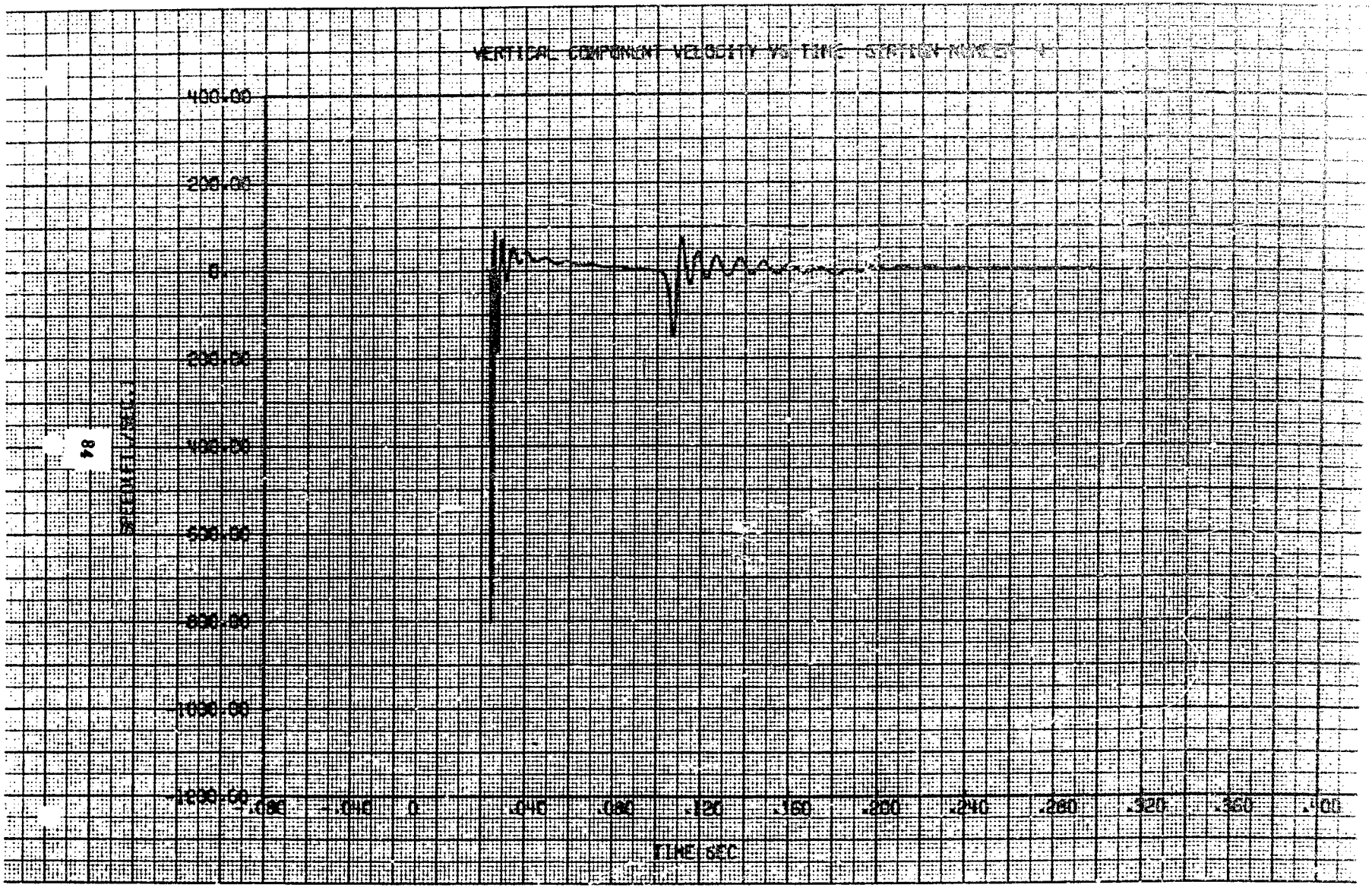

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
40.00
20.00
0.
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

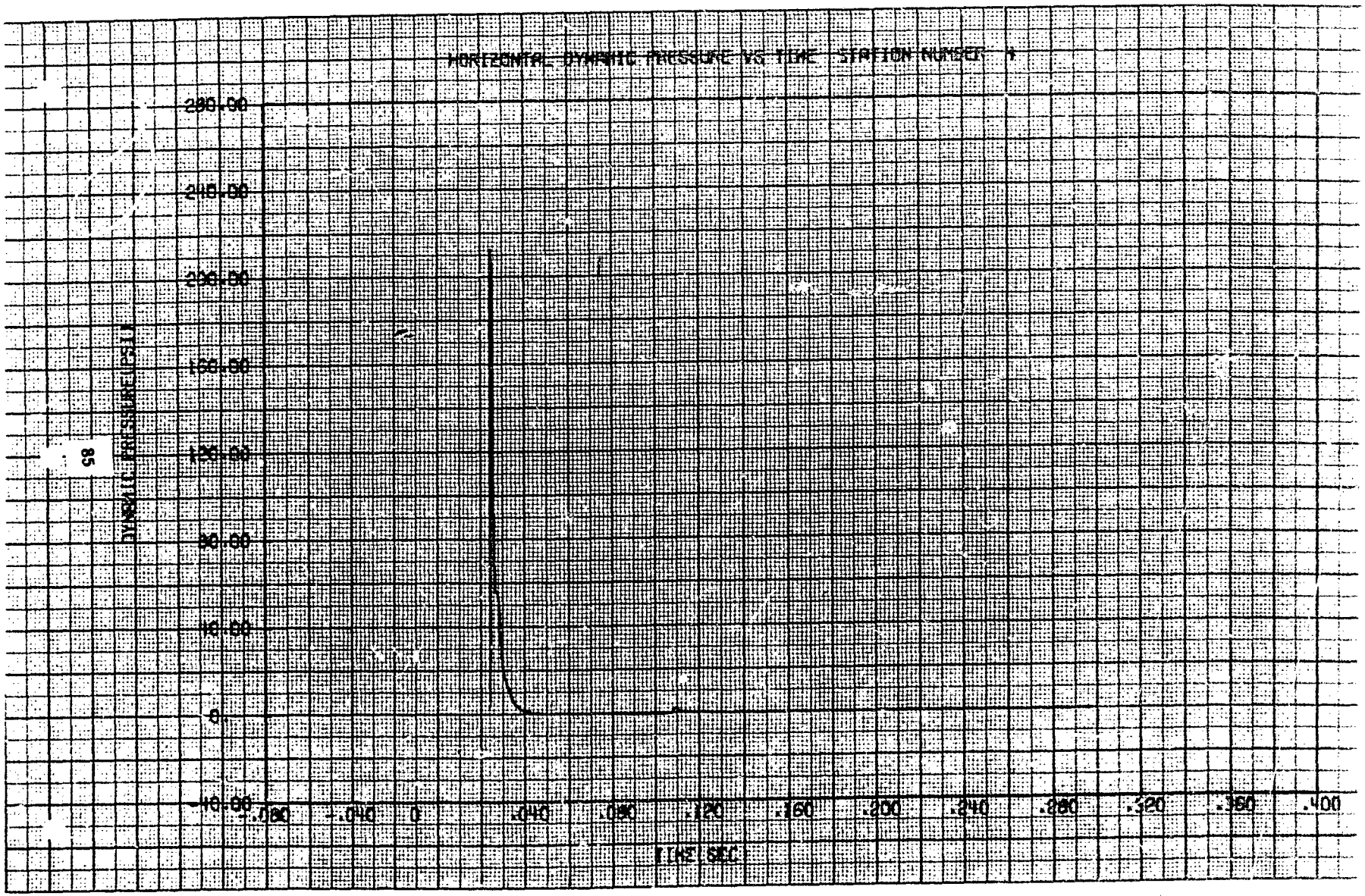

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
.04
.02
0
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.
DYNAMIC PRESSURE IMPULSE LB.-SEC./
80


OVER PRESSURE VS TIME STATION NUMBER 4
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
OVER-PRESSURE(PSI)
81

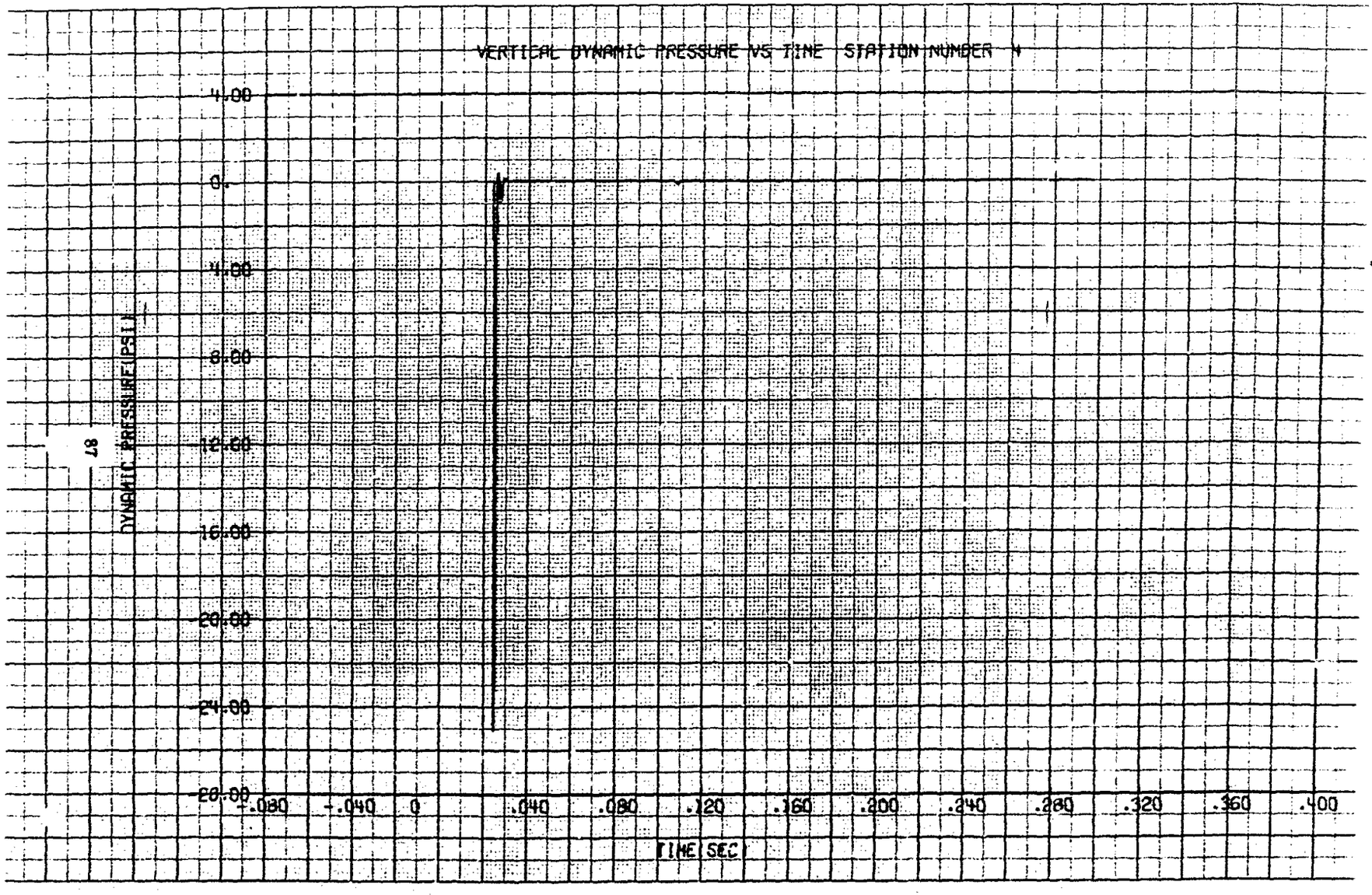
82

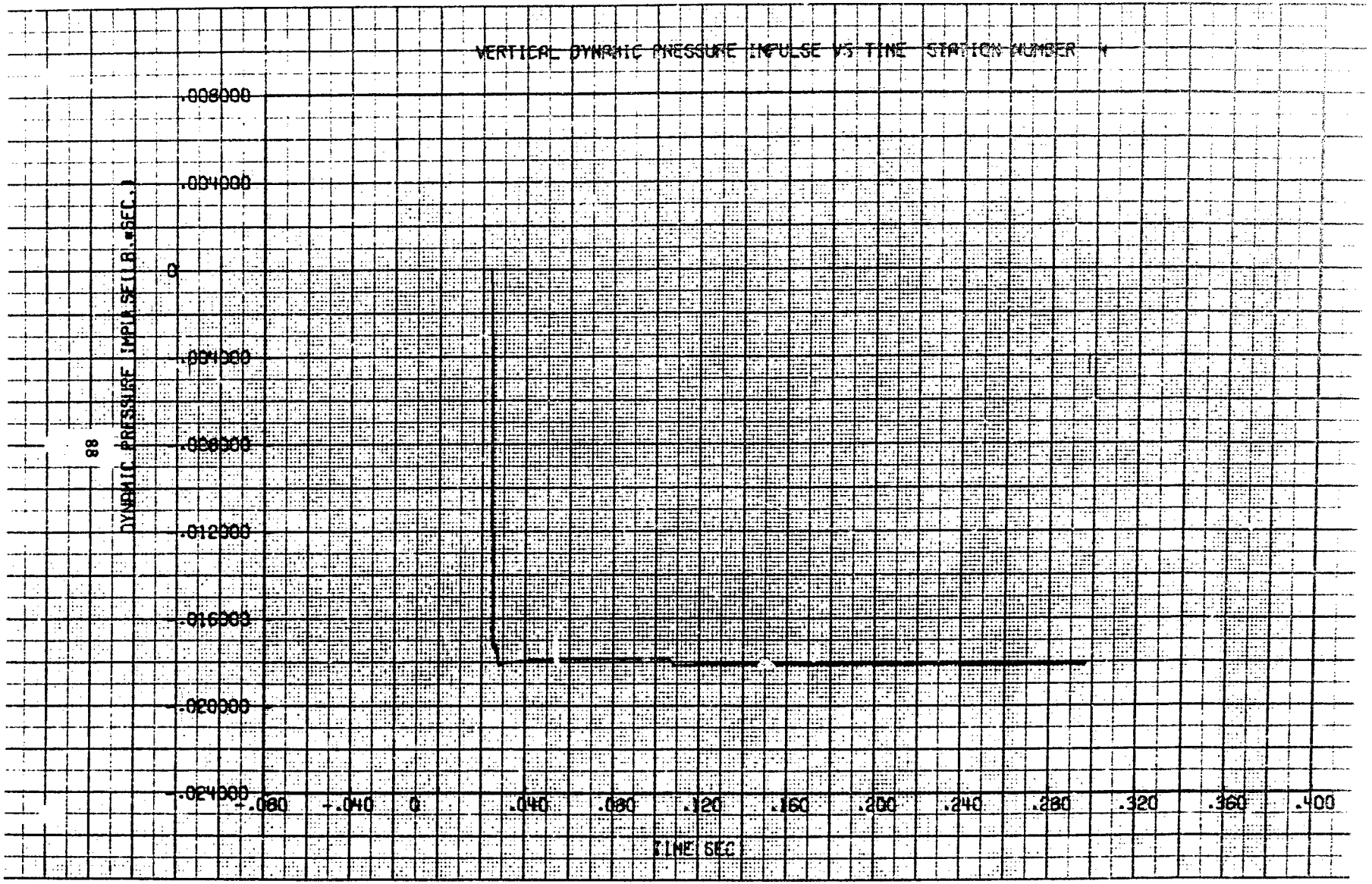

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
VELOCITY FEET/SEC
83

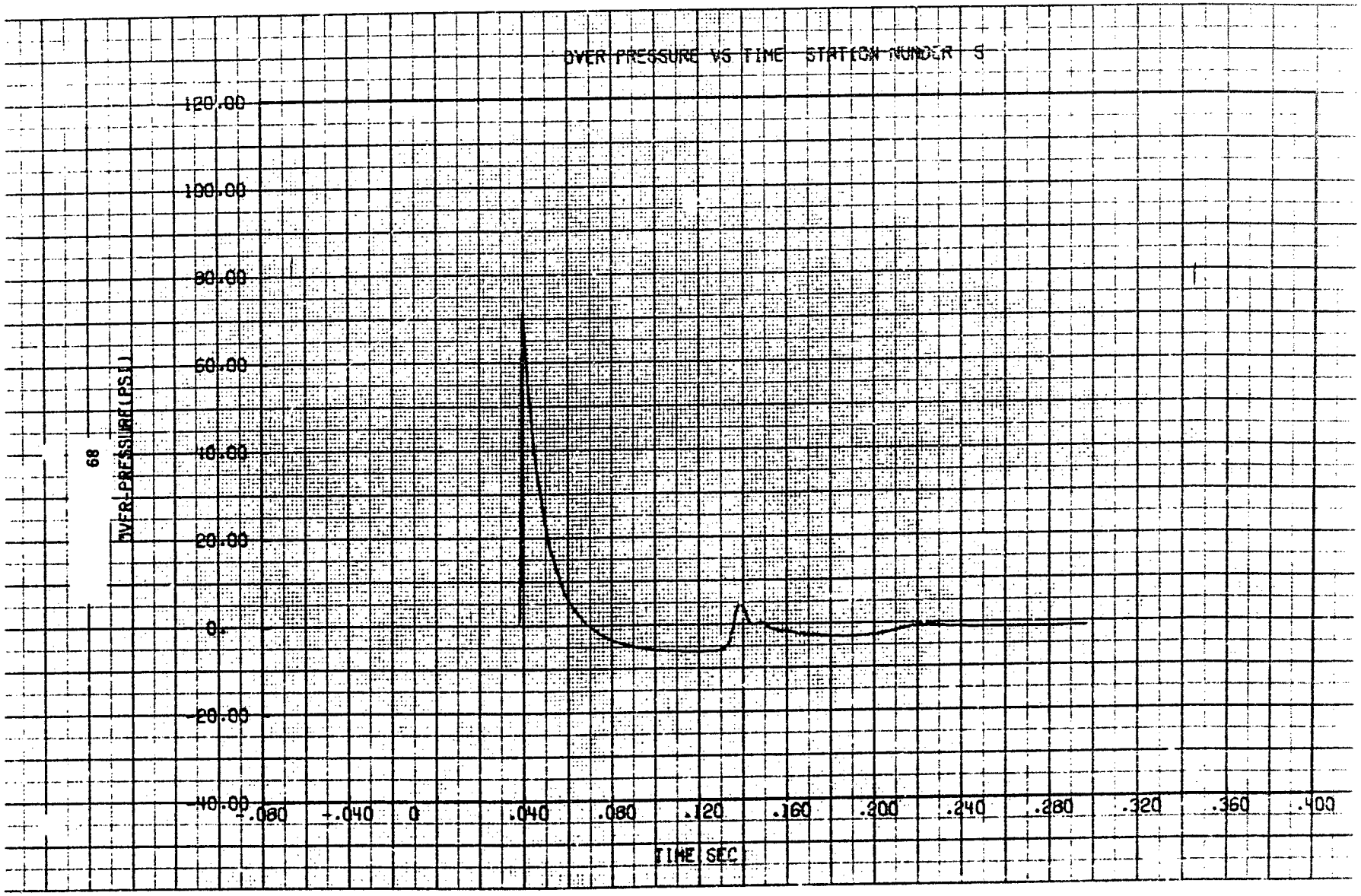

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 4
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
84


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 4
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
HORIZONTAL PRESSURE PSF
85

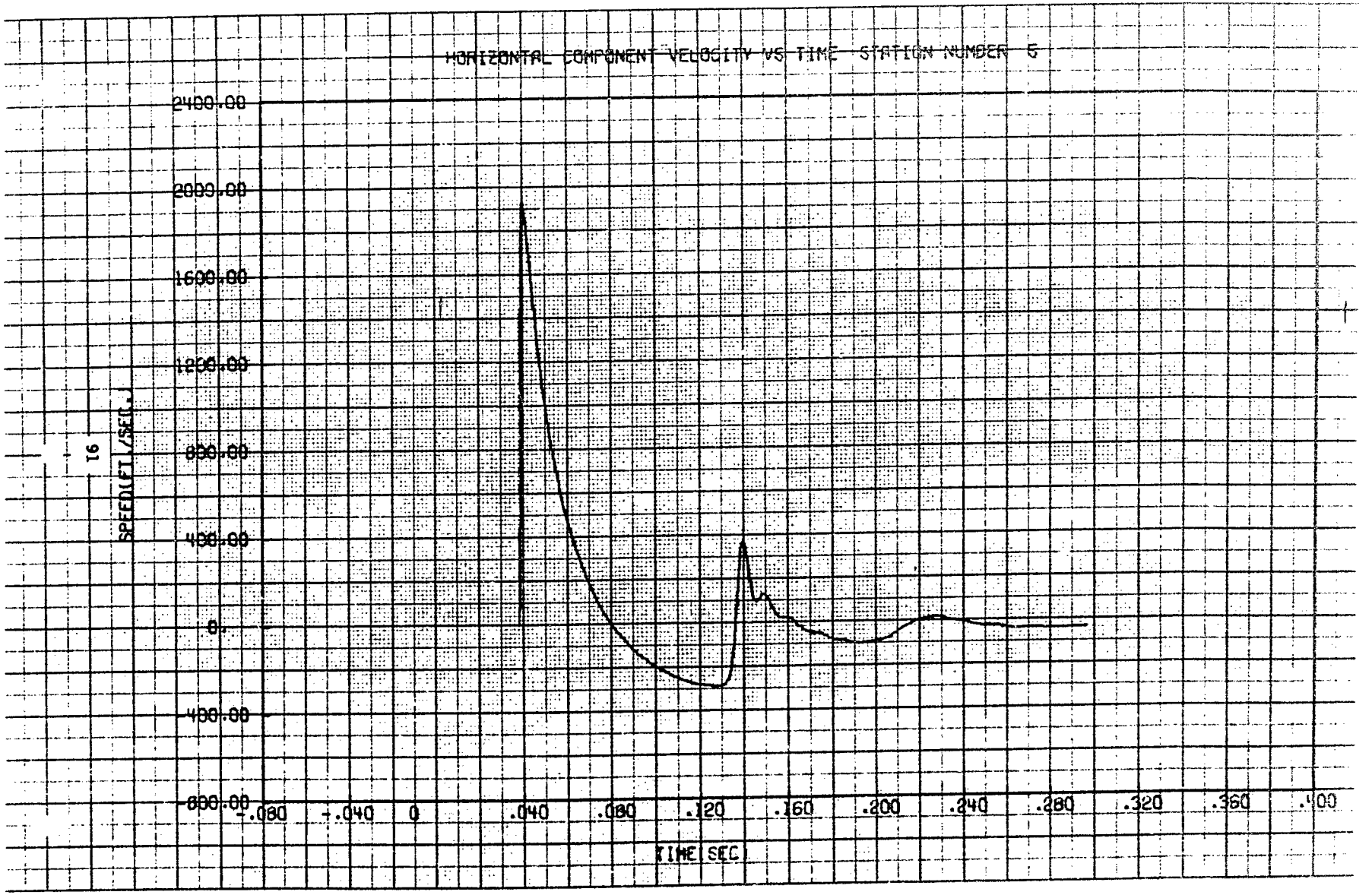
HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION
DYNAMIC PRESSURE IMPULSE (LB./SEC./IN.²)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

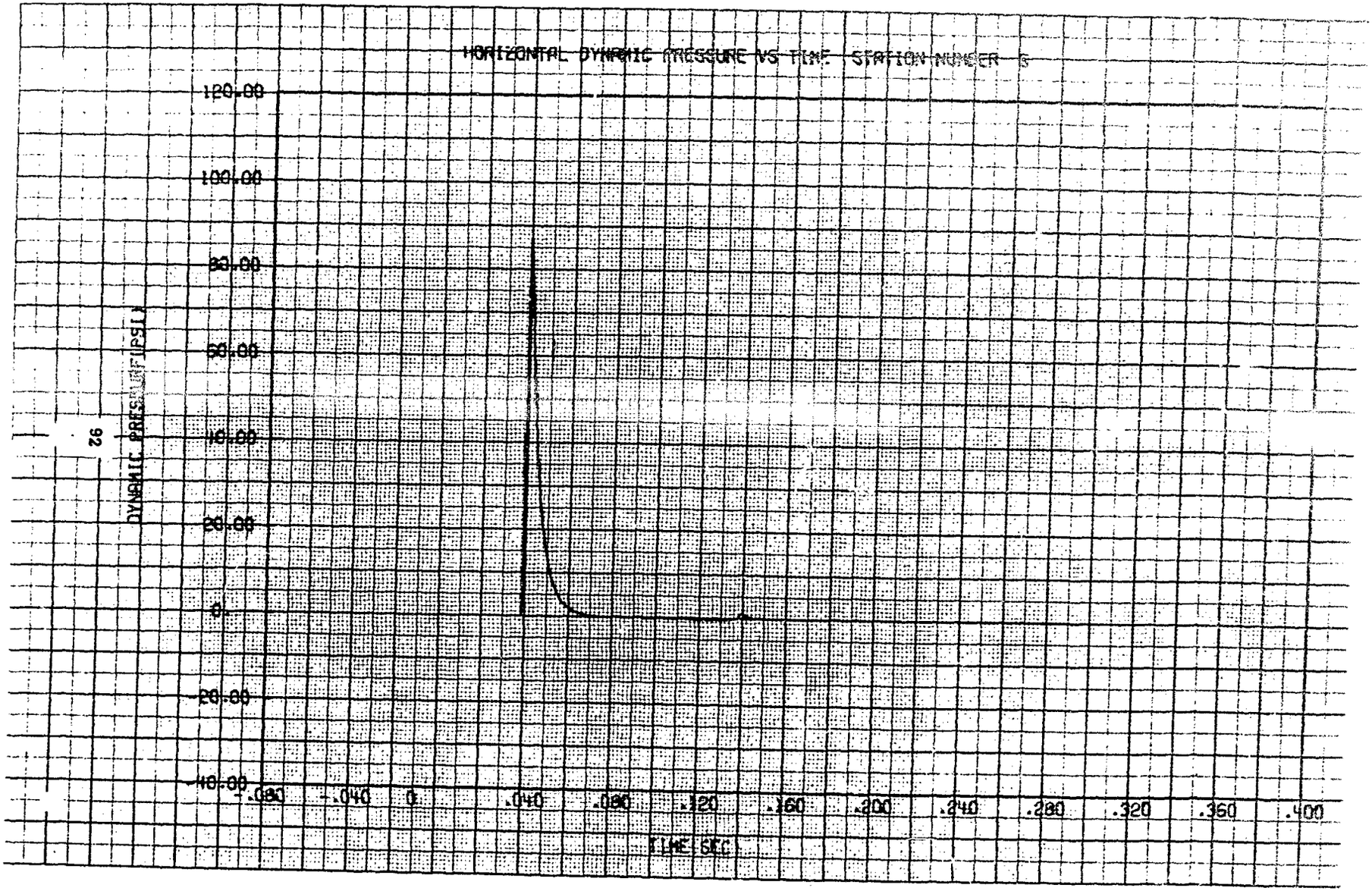

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE(PSI)
87
4.00
0.
-4.00
-8.00
-12.00
-16.00
-20.00
-24.00
-28.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

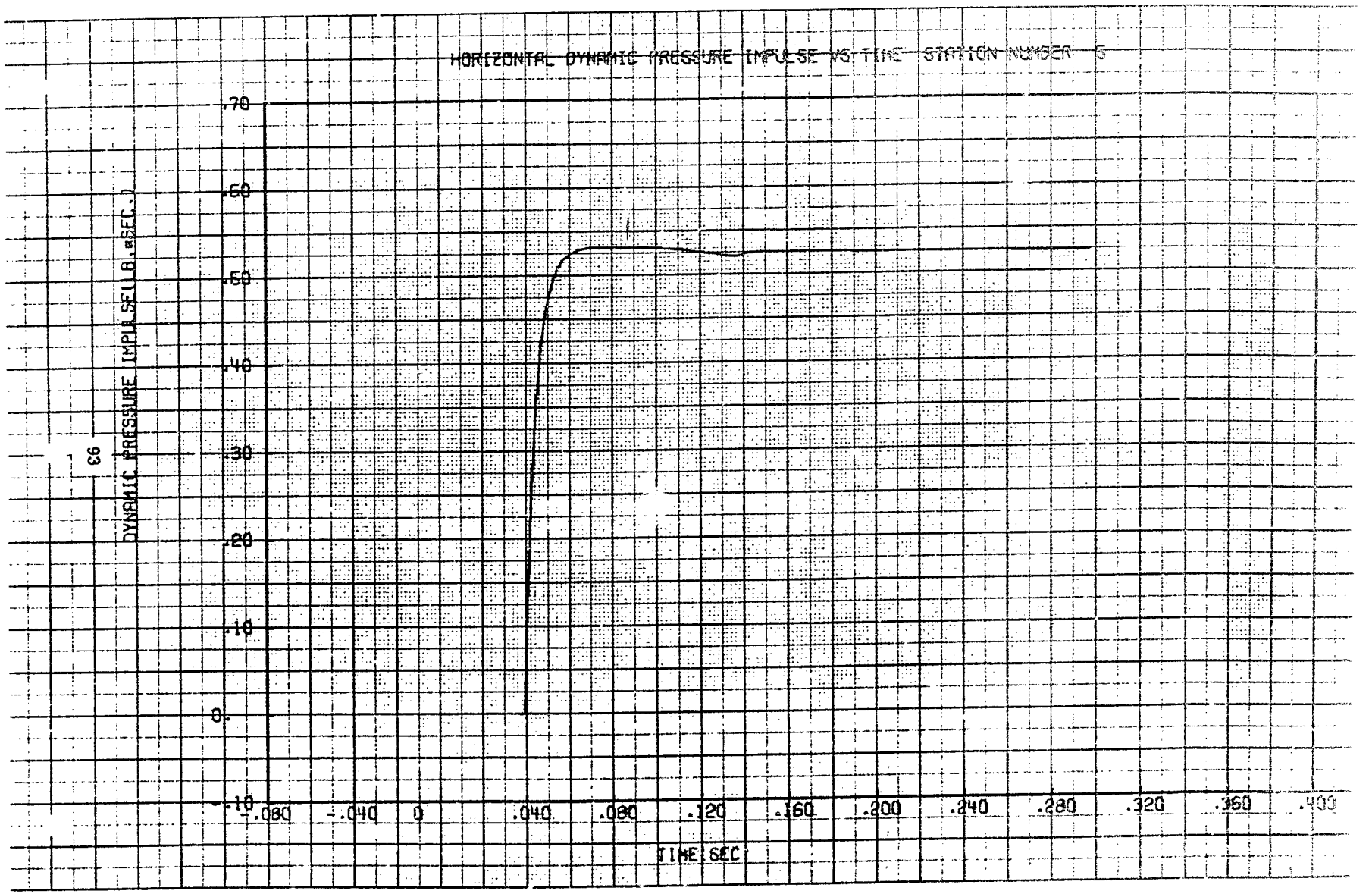

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.008000
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

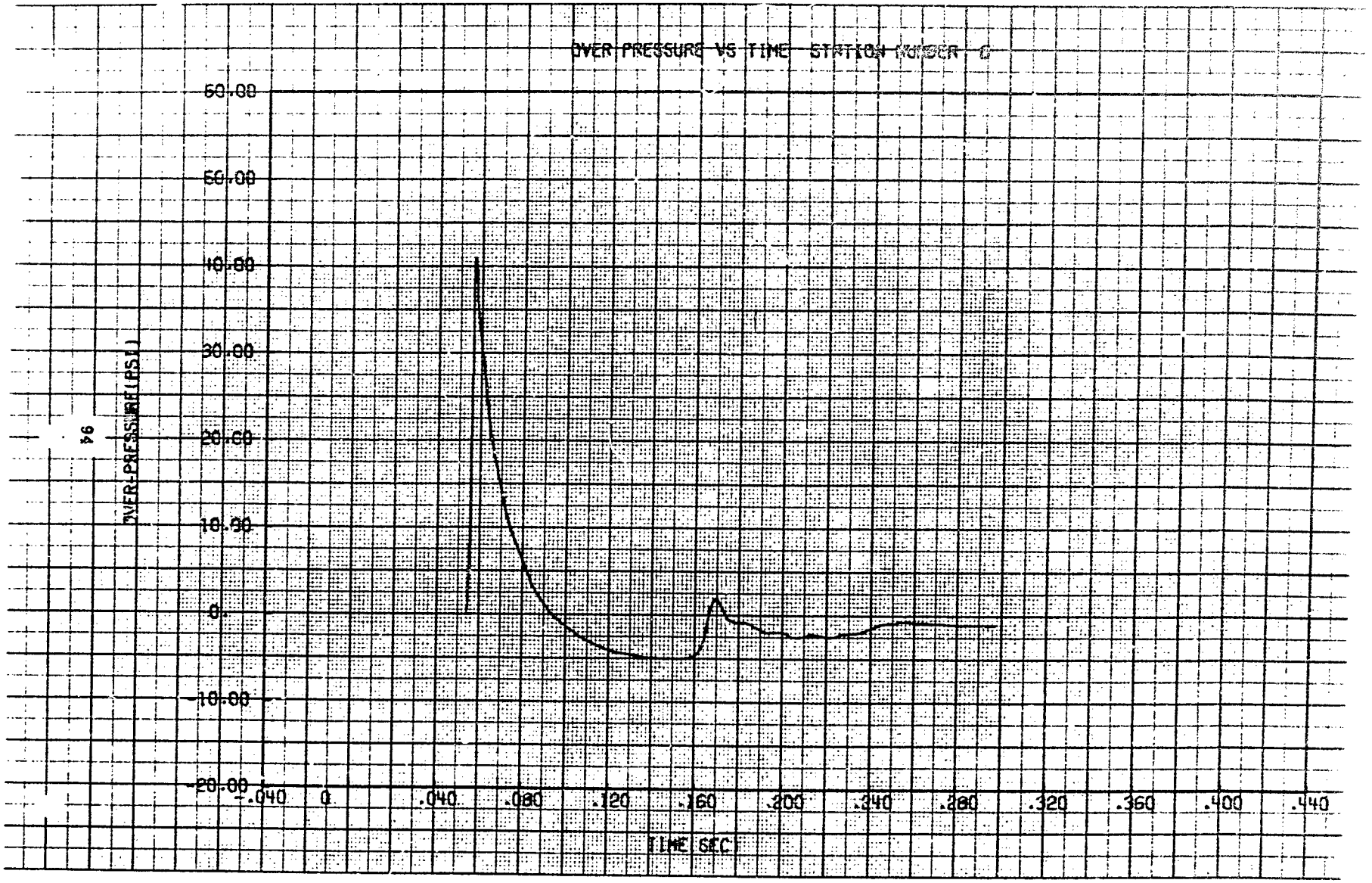

OVER PRESSURE VS TIME STATION NUMBER 5
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
OVER-PRESSURE (P.S.F.)
68
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

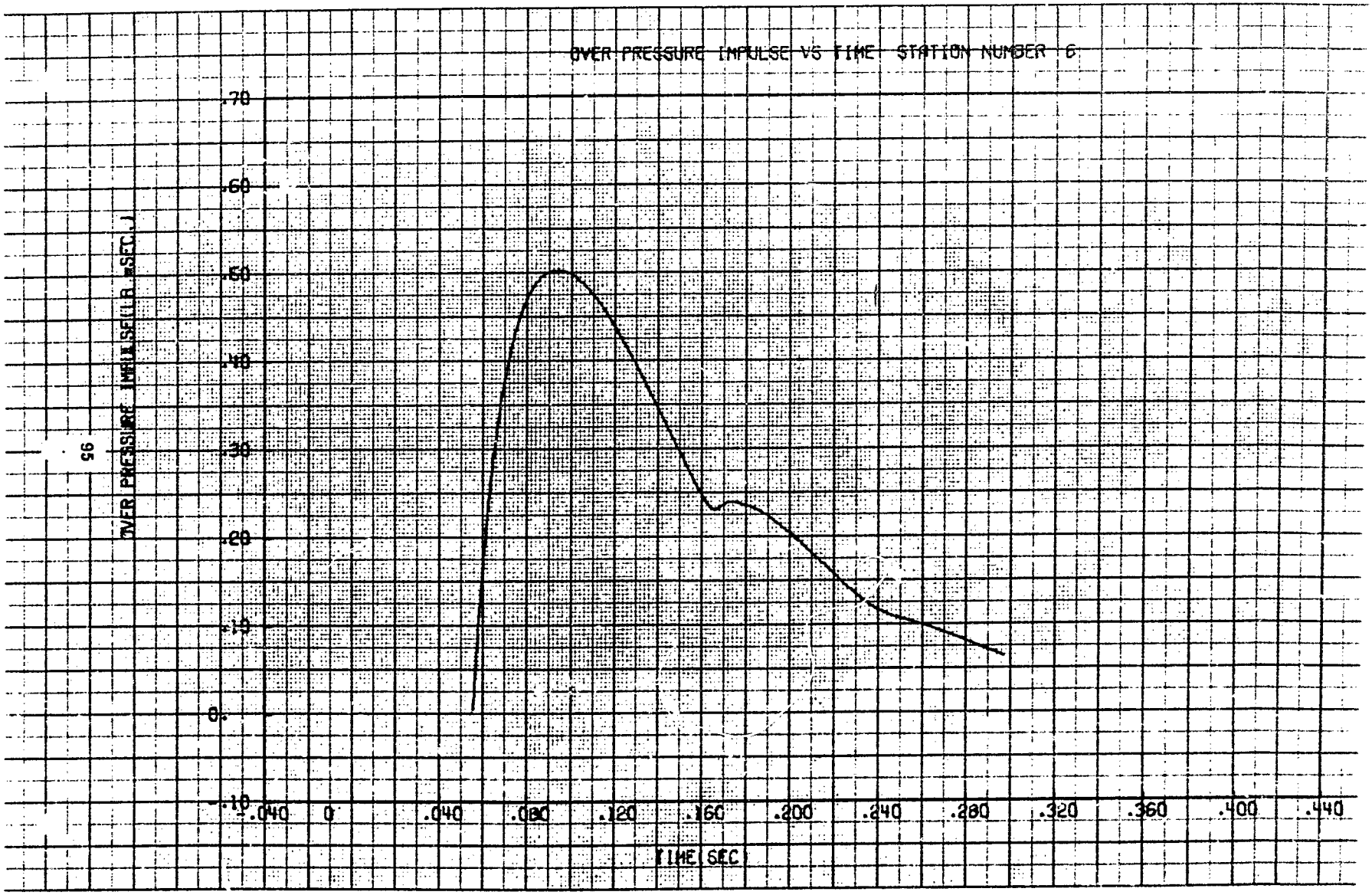
OVER PRESSURE (IMPULSE VS TIME) STATION NUMBER 5
OVER PRESSURE (METRIC LBS./SQ. FT.)
90
70
60
50
40
30
20
10
0
-10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

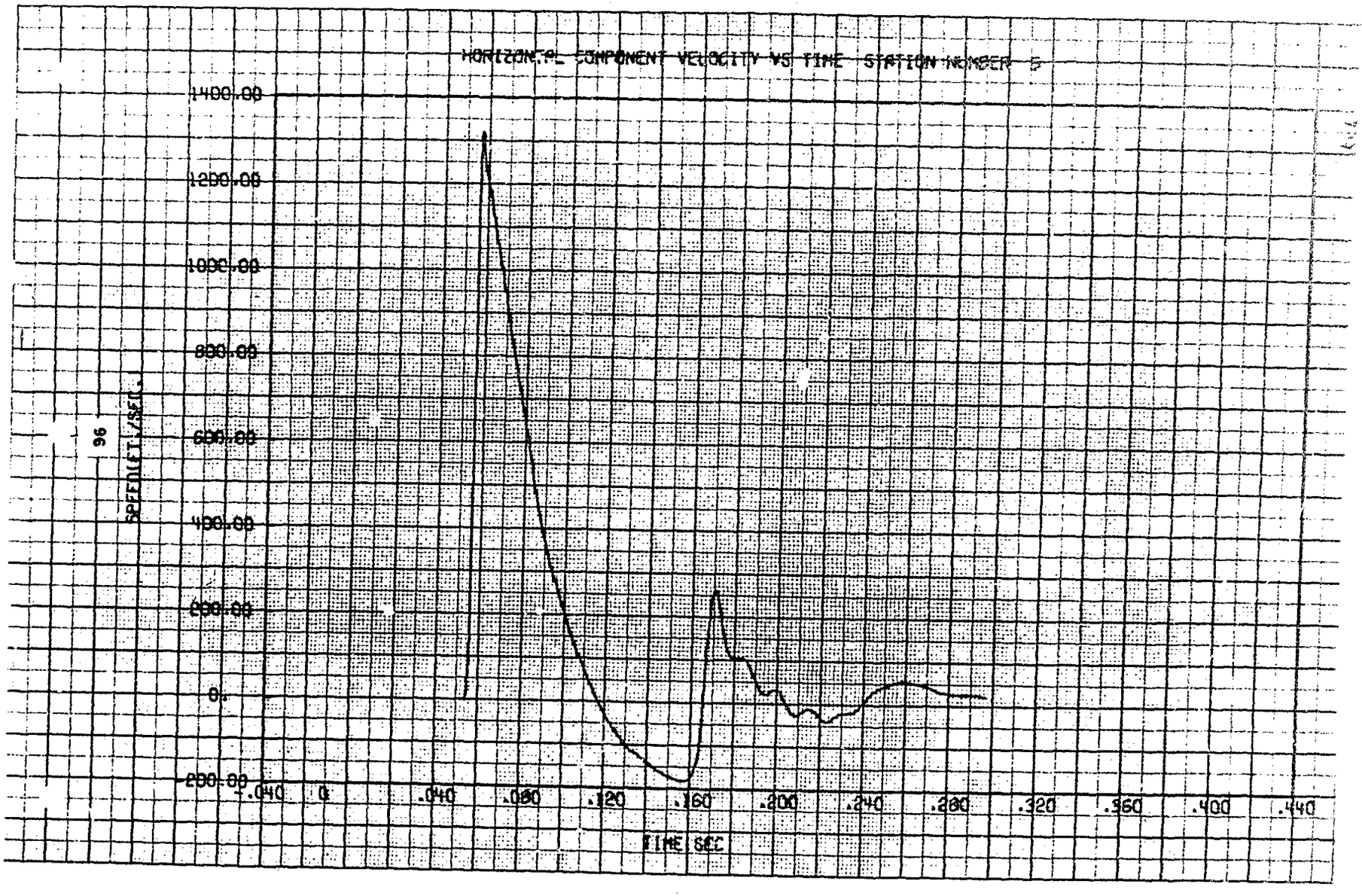

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 6
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

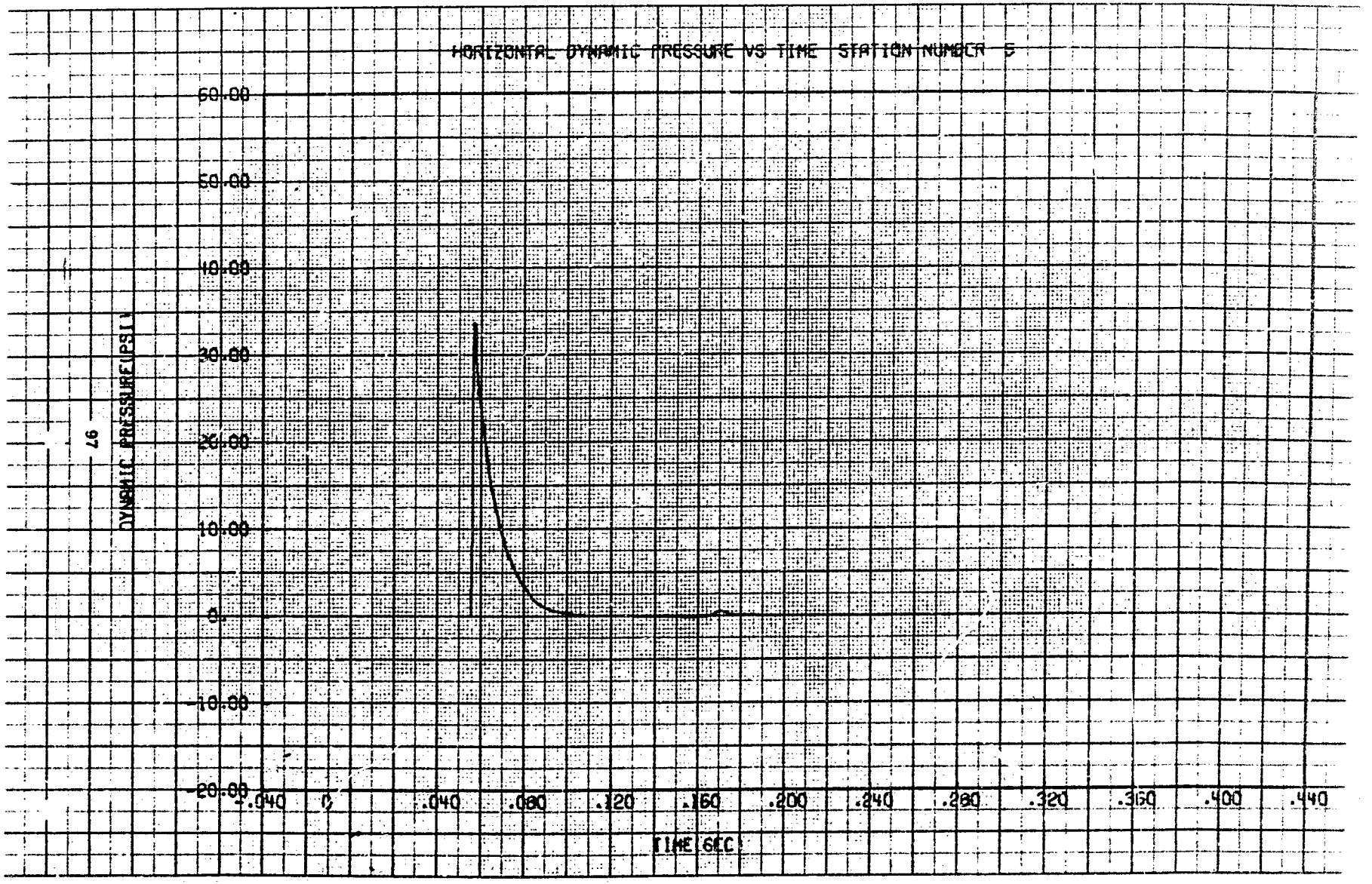

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 6
120.00
100.00
80.00
60.00
40.00
20.00
0
-20.00
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
92

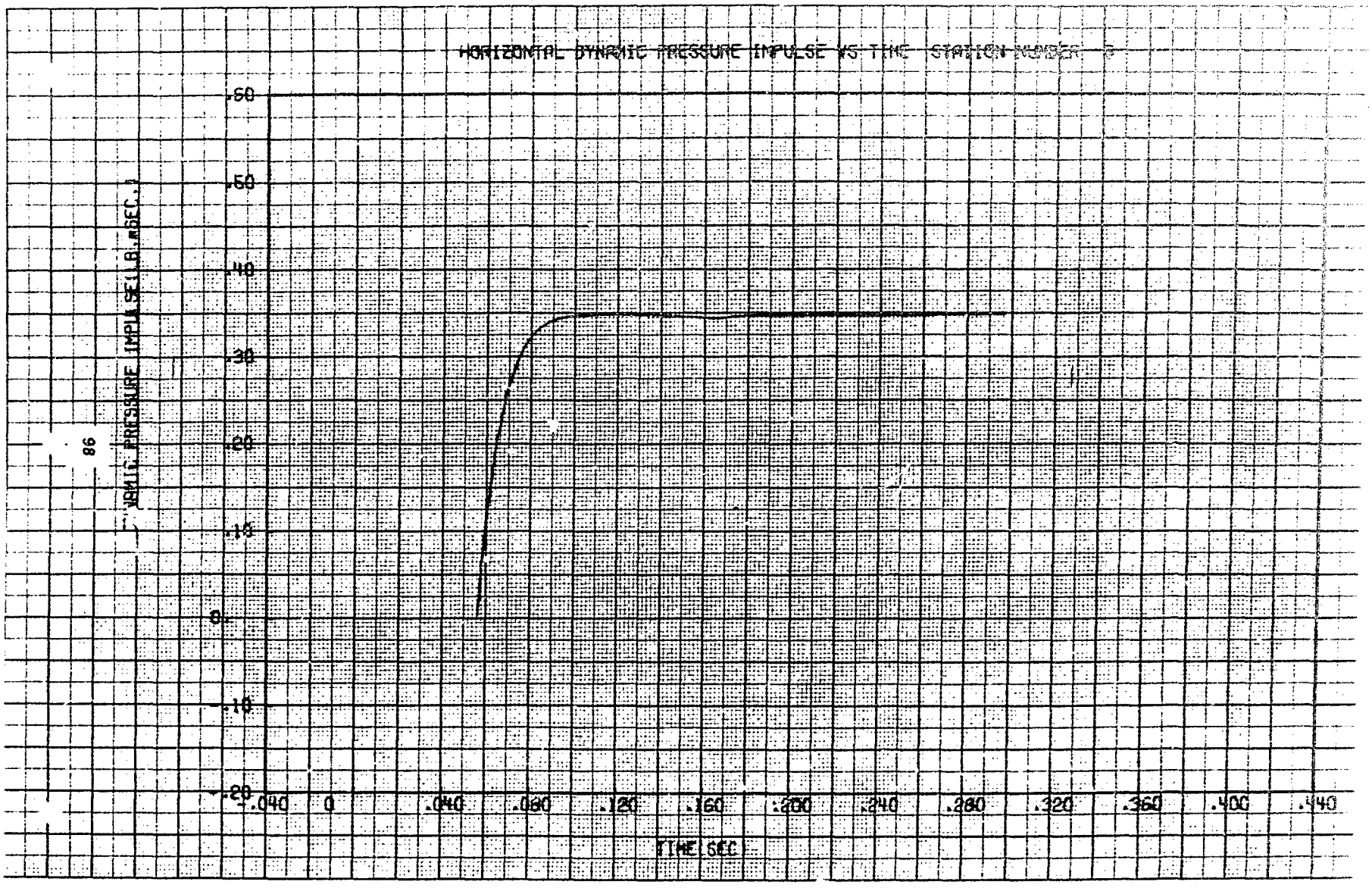

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
93
E6

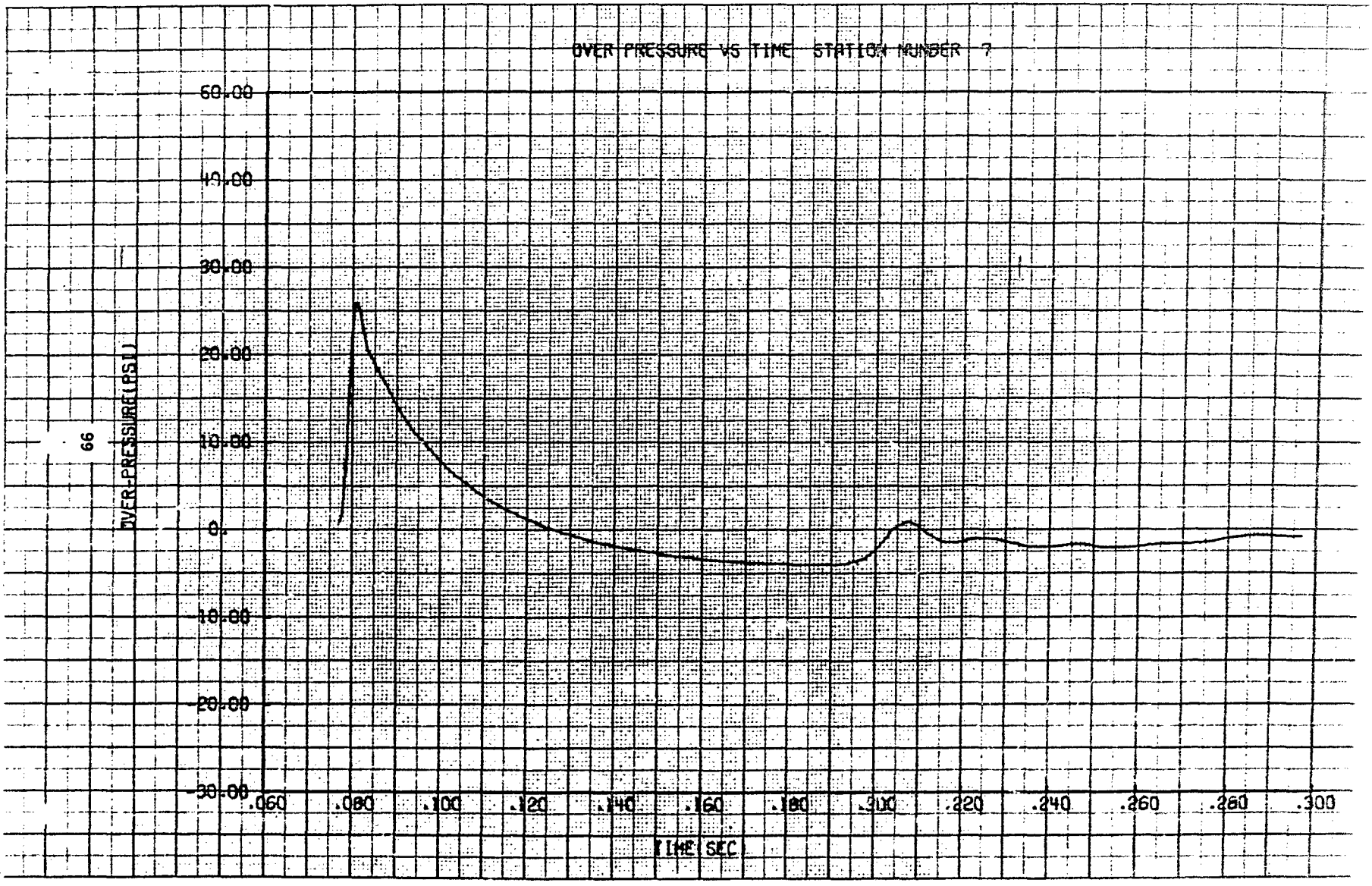

OVER PRESSURE VS TIME STATION NUMBER 6
OVER-PRESSURE (PSI)
94
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

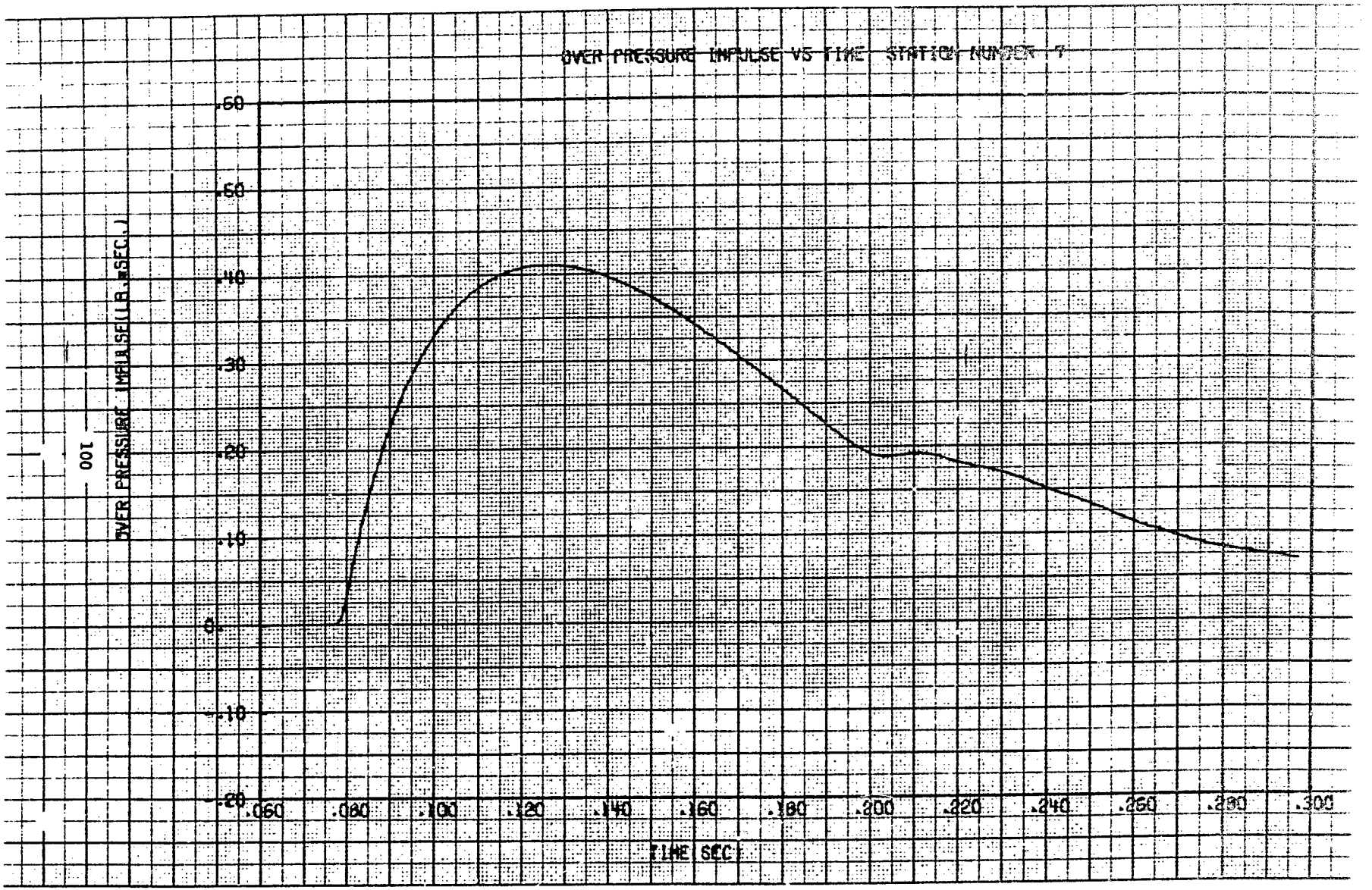

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 6
OVER PRESSURE IMPULSE (LB-SEC/SQ.FT)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

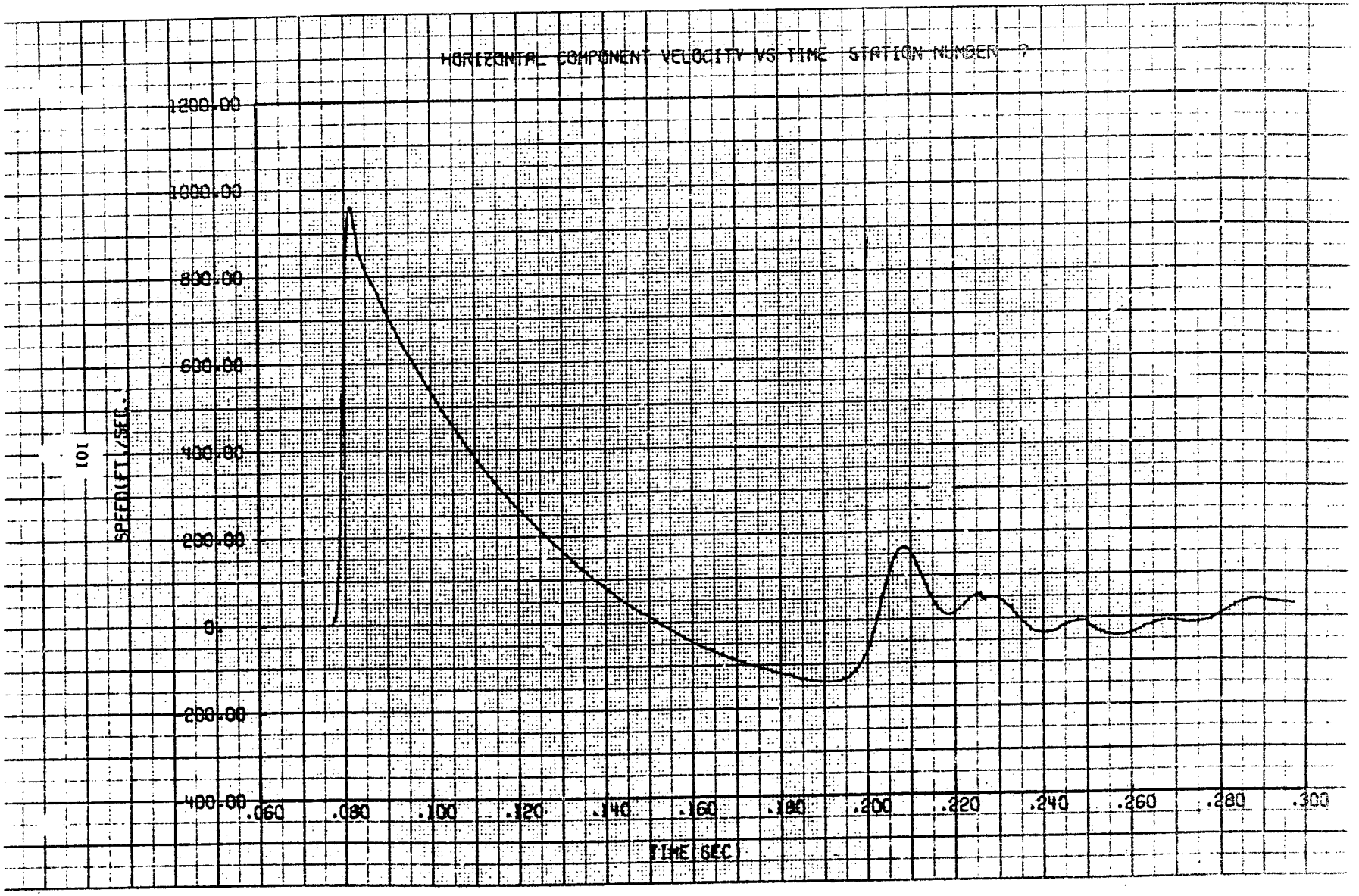

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT./SEC.)
96
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

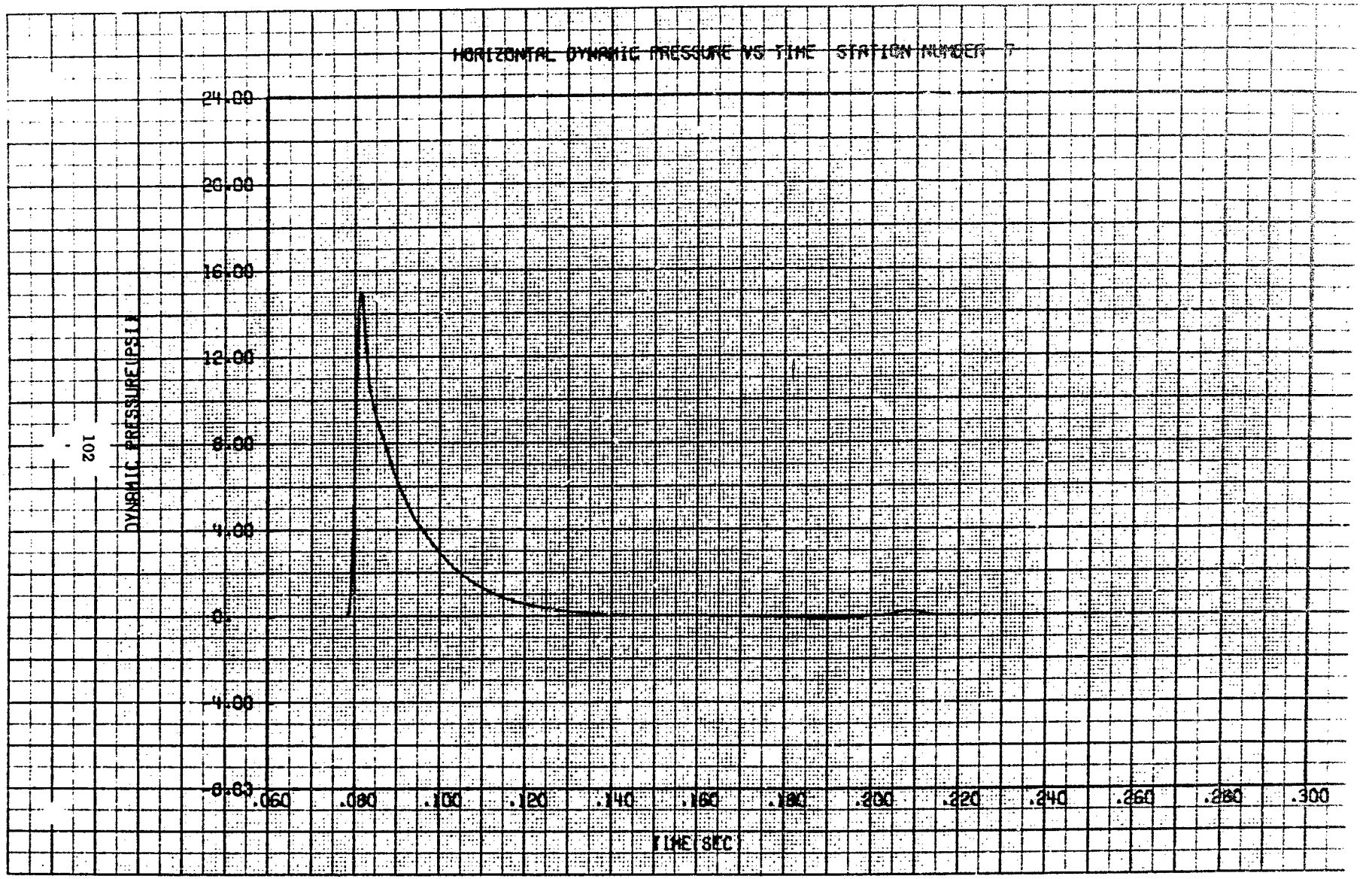

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
60.00
50.00
40.00
30.00
20.00
10.00
0
-10.00
-20.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

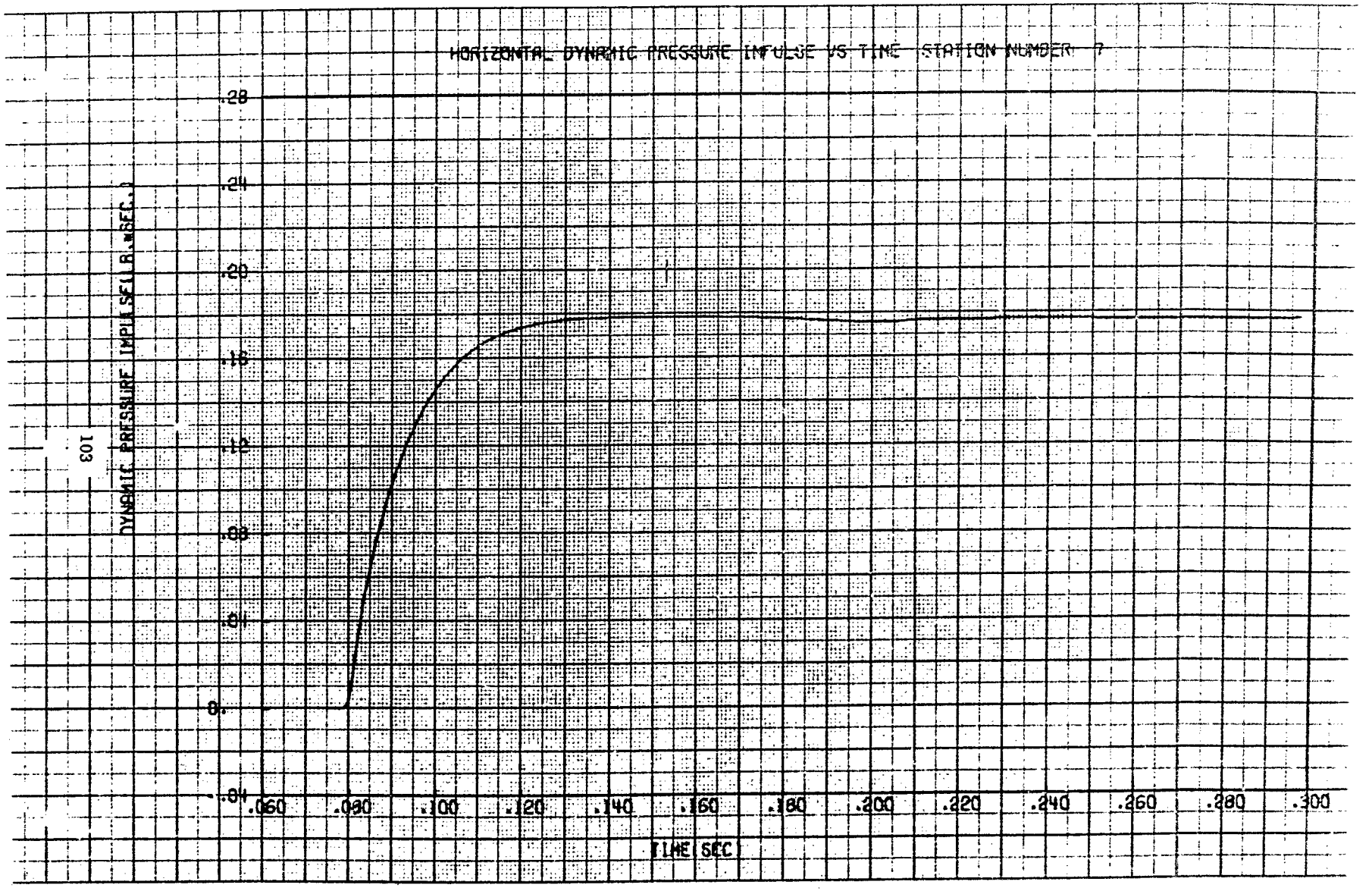

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 6
DYNAMIC PRESSURE IMPULSE (LB.-SEC.)
.80
.60
.40
.30
.20
.10
0
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

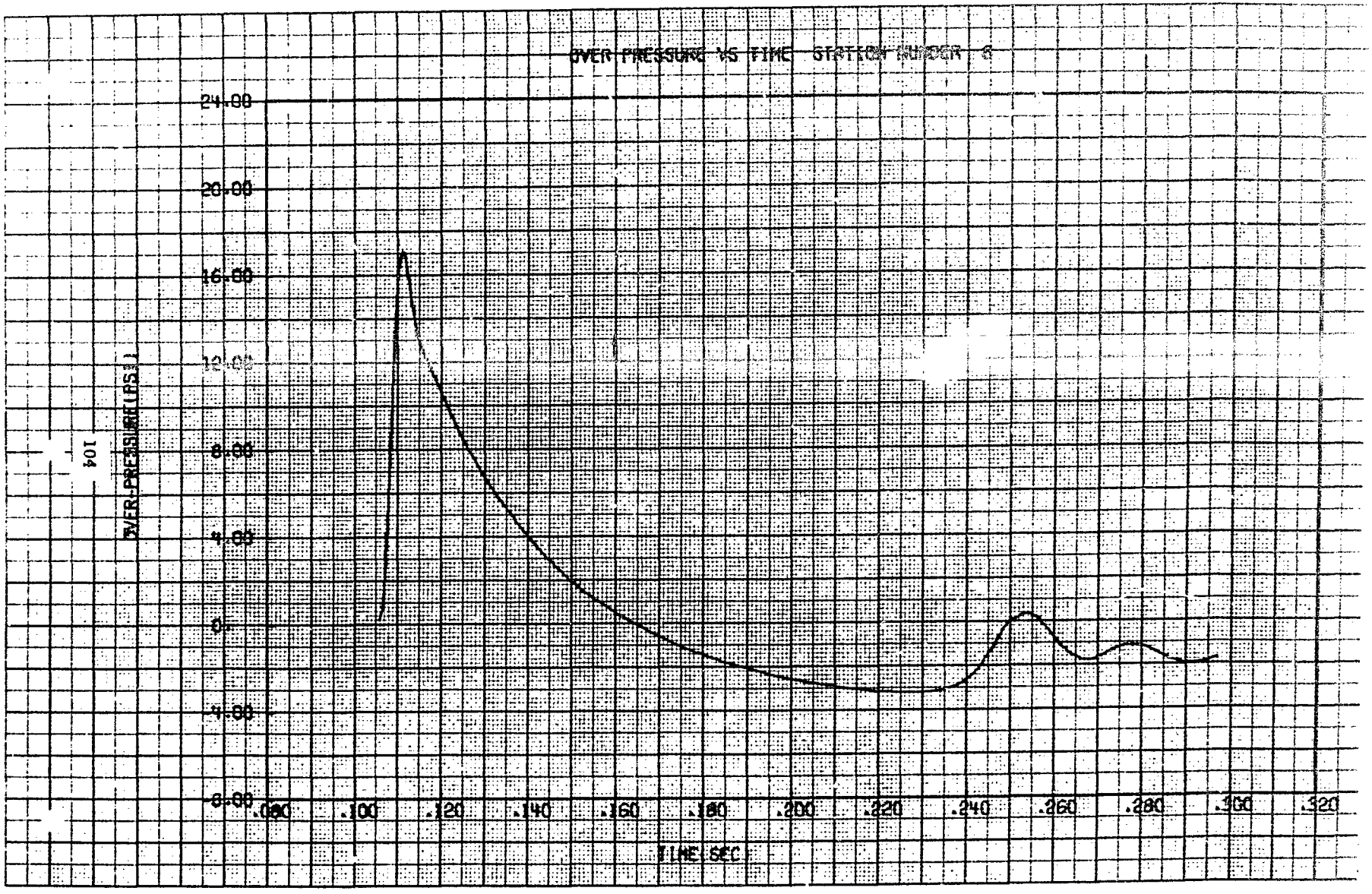

OVER PRESSURE VS TIME STATION NUMBER 7
OVER-PRESSURE(PSI)
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

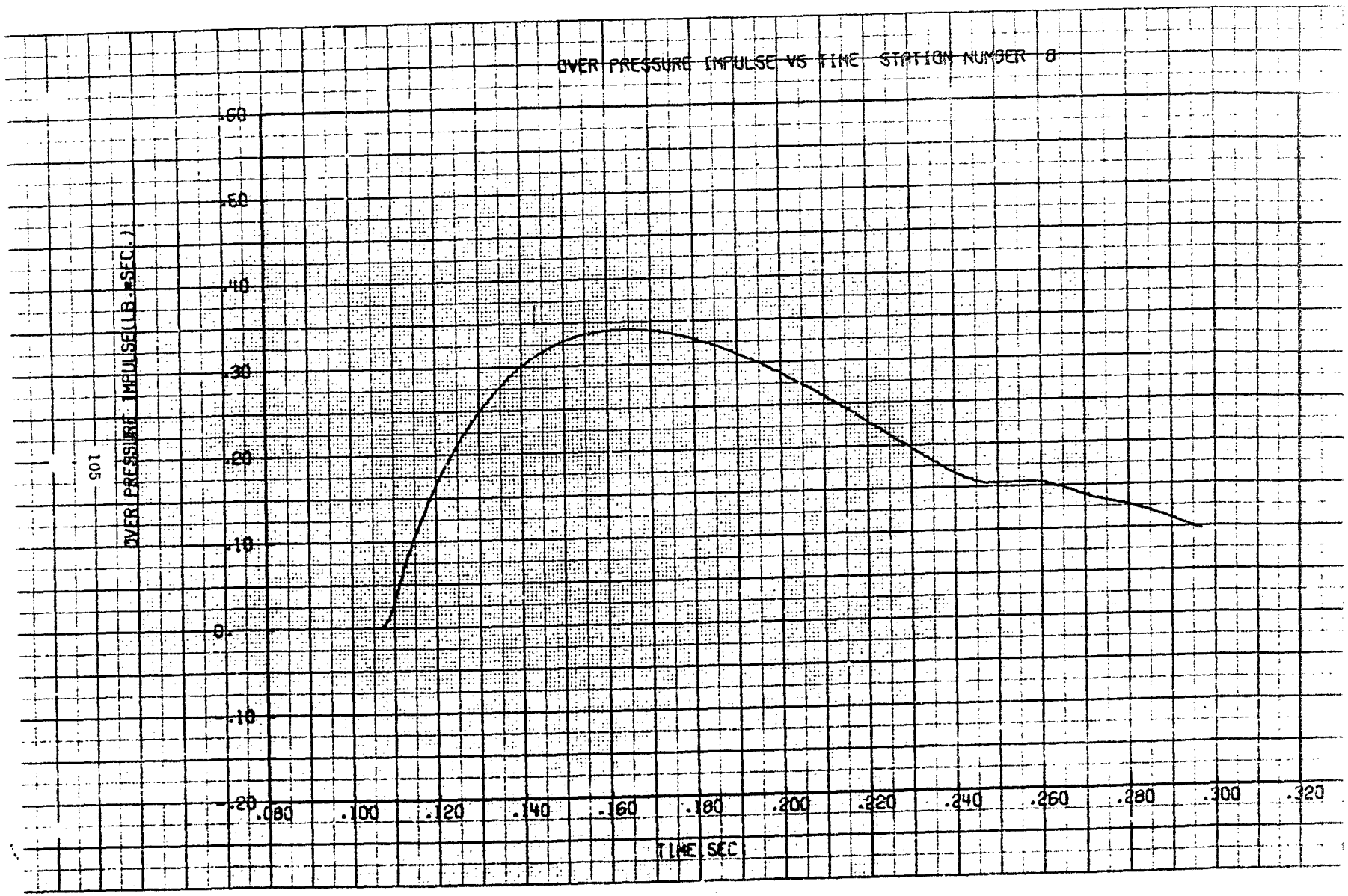

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 7
OVER PRESSURE IMPULSE(LB.*SEC.)
100
60
50
40
30
20
10
0
-10
-20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

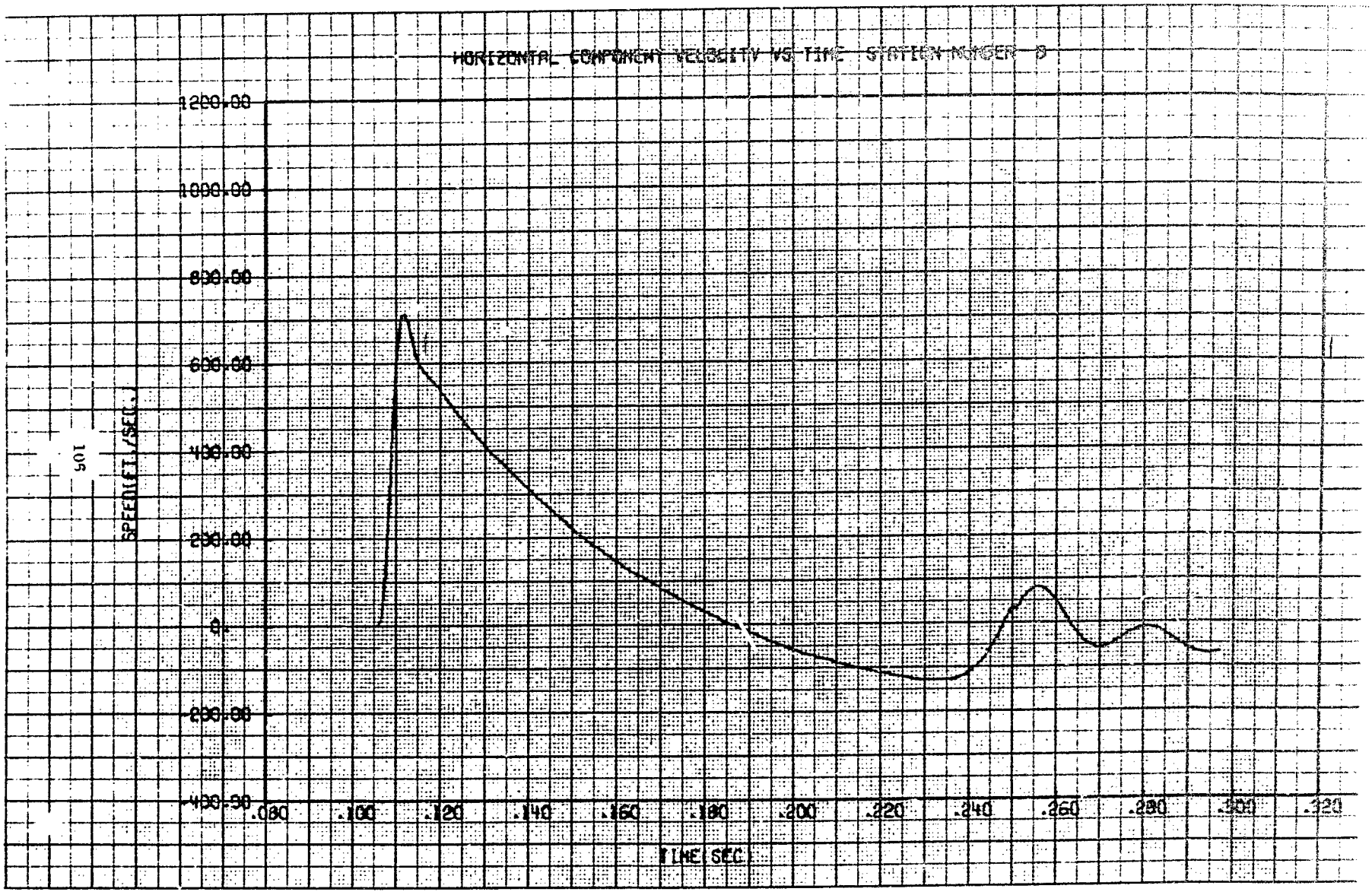

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 7
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
101
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

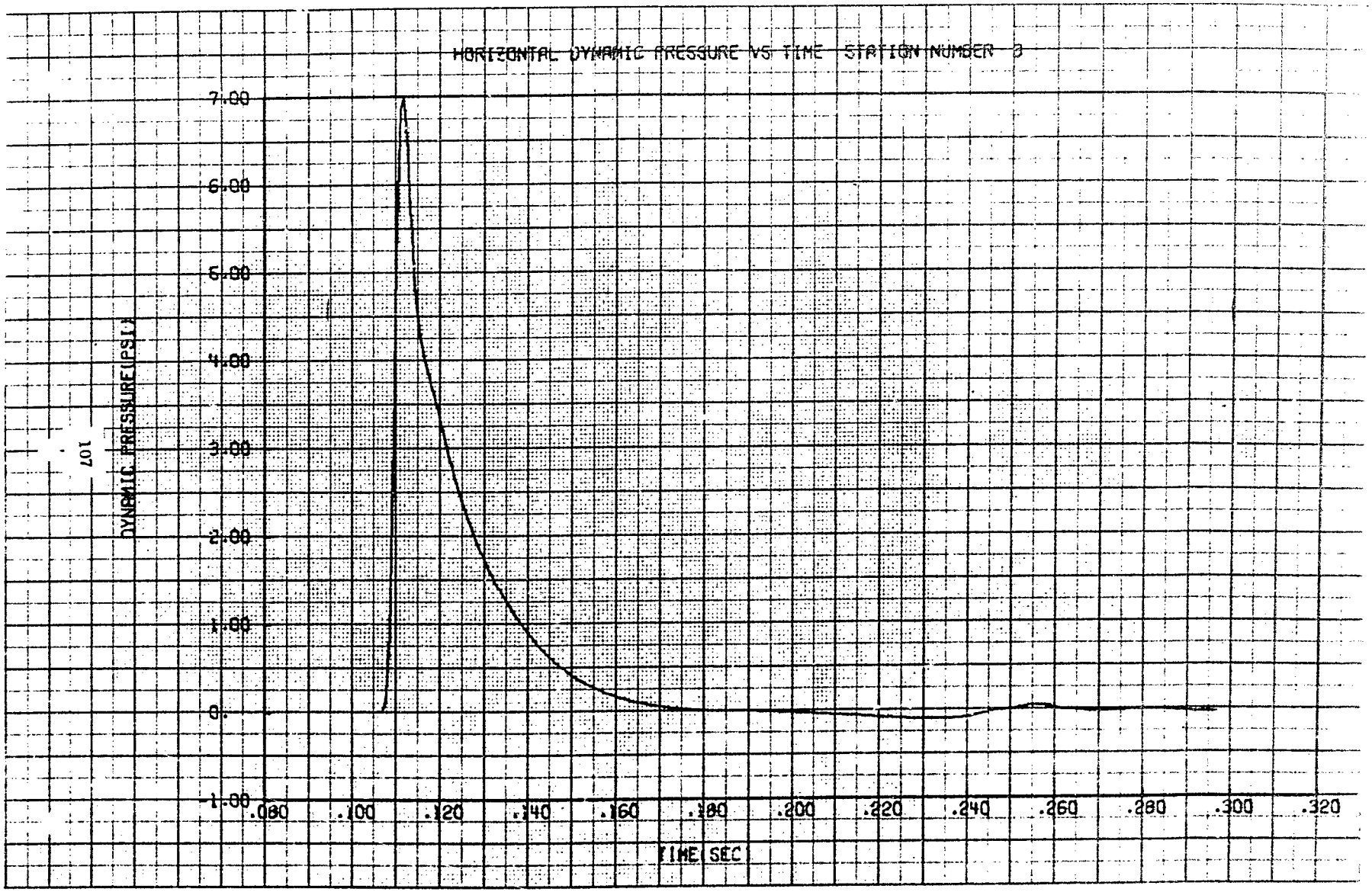

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE(PSI)
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.03
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

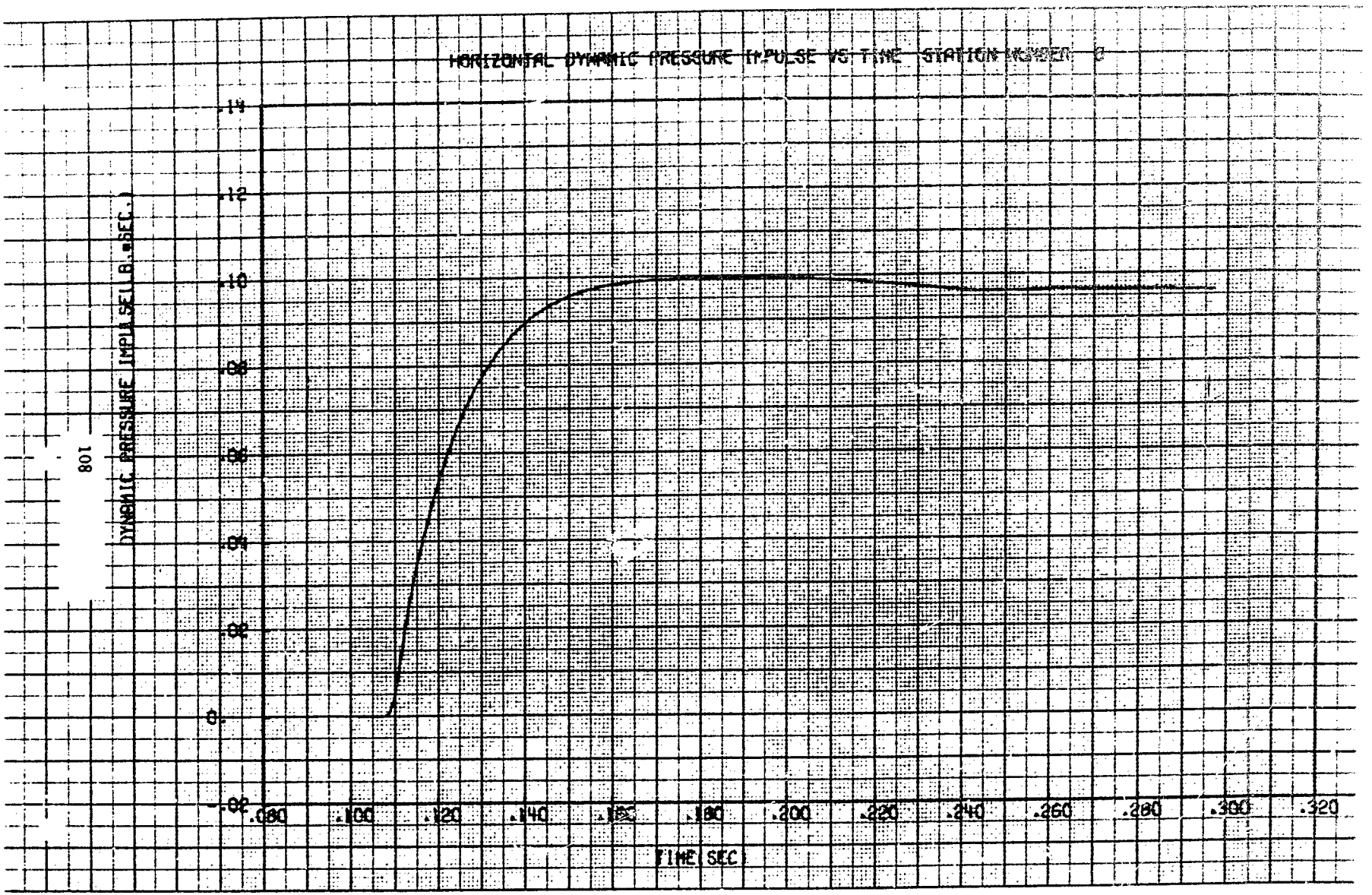

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE IMPULSE(LB./SEC.)
10³
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

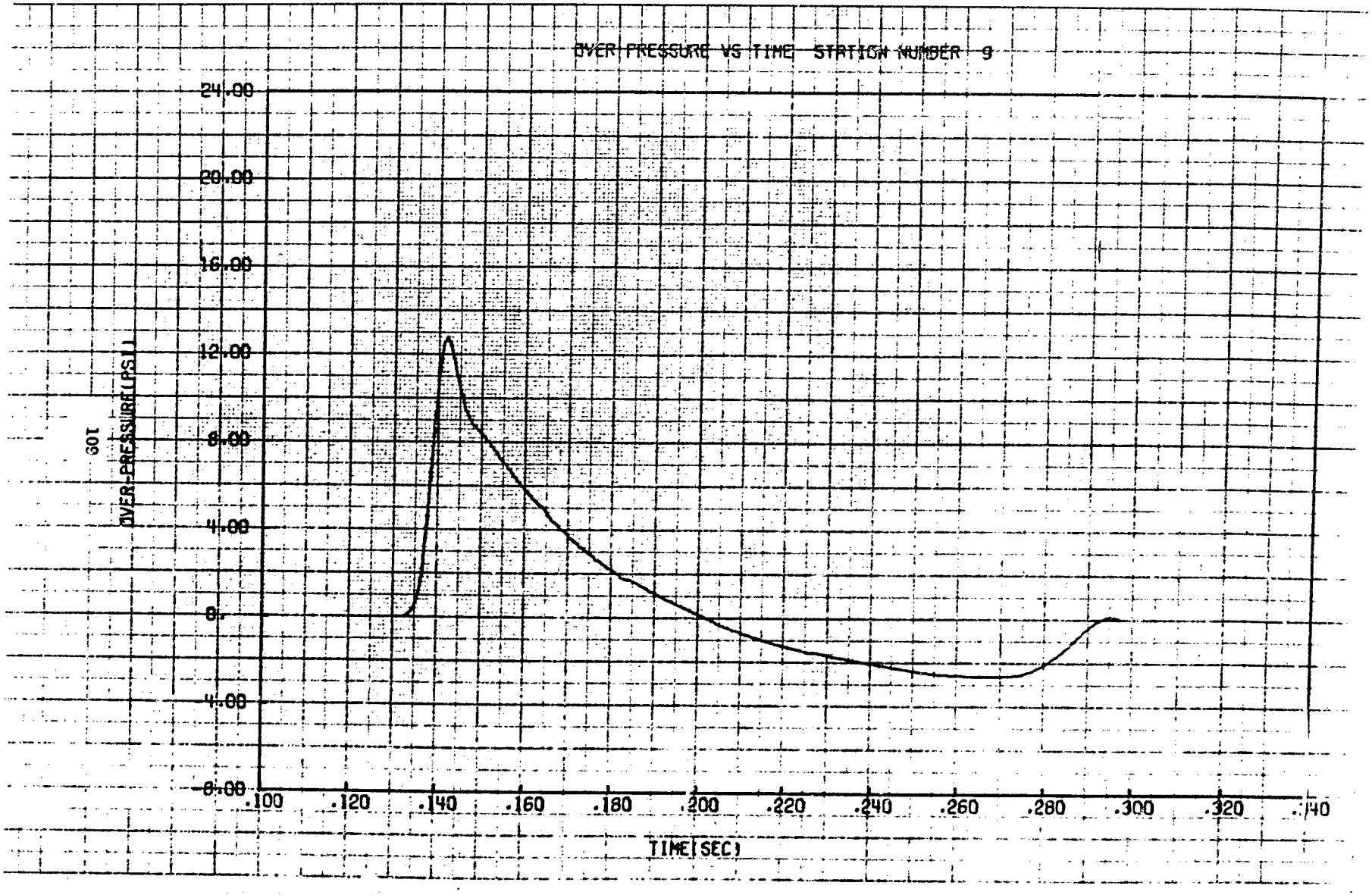

OVER PRESSURE VS TIME STATION NUMBER 6
24.00
20.00
16.00
12.00
8.00
4.00
0
-4.00
-8.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC
OVER-PRESSURE (LBS/
104

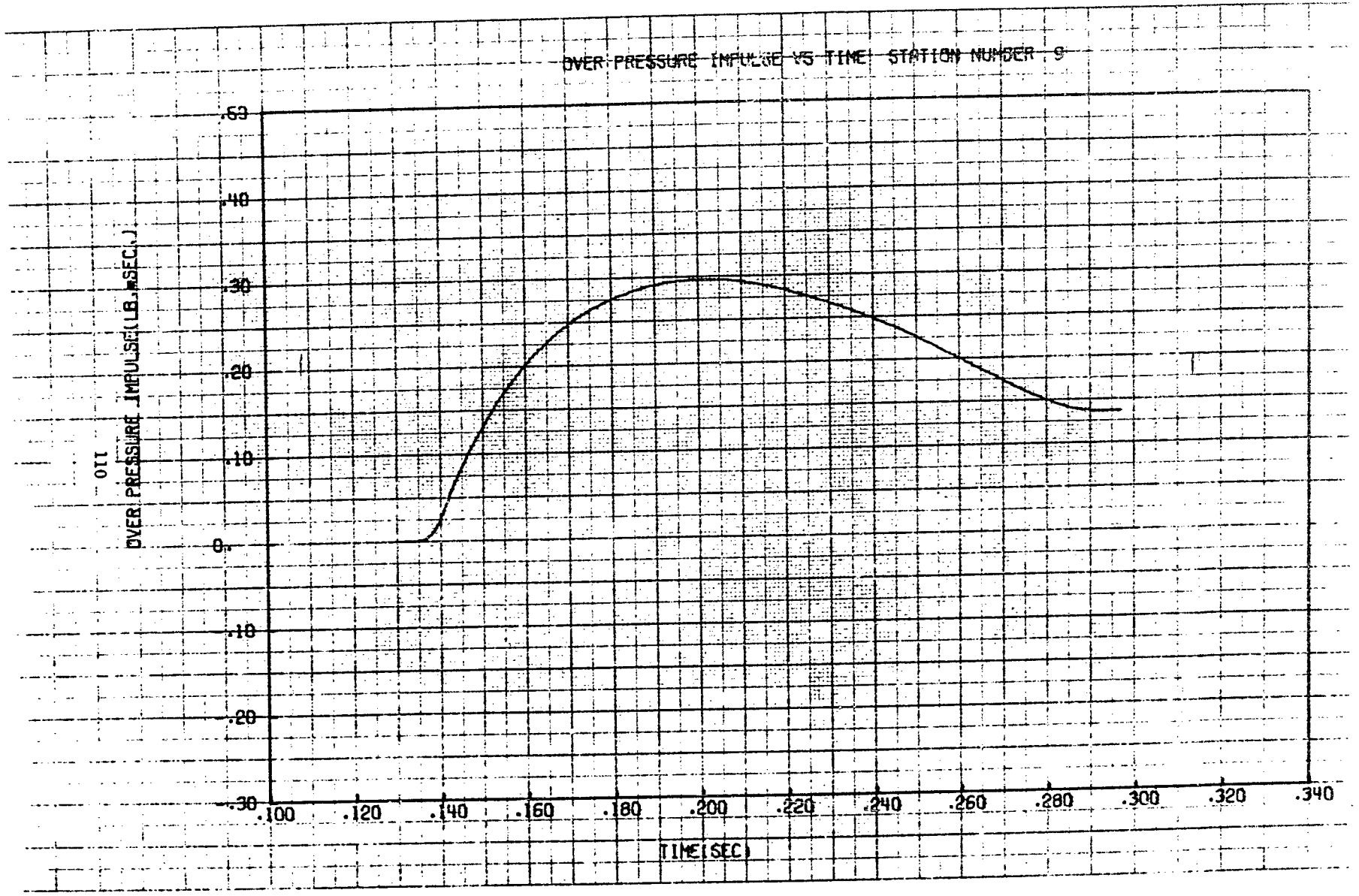

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 8
OVER PRESSURE IMPULSE(LB.*SEC.)
105
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

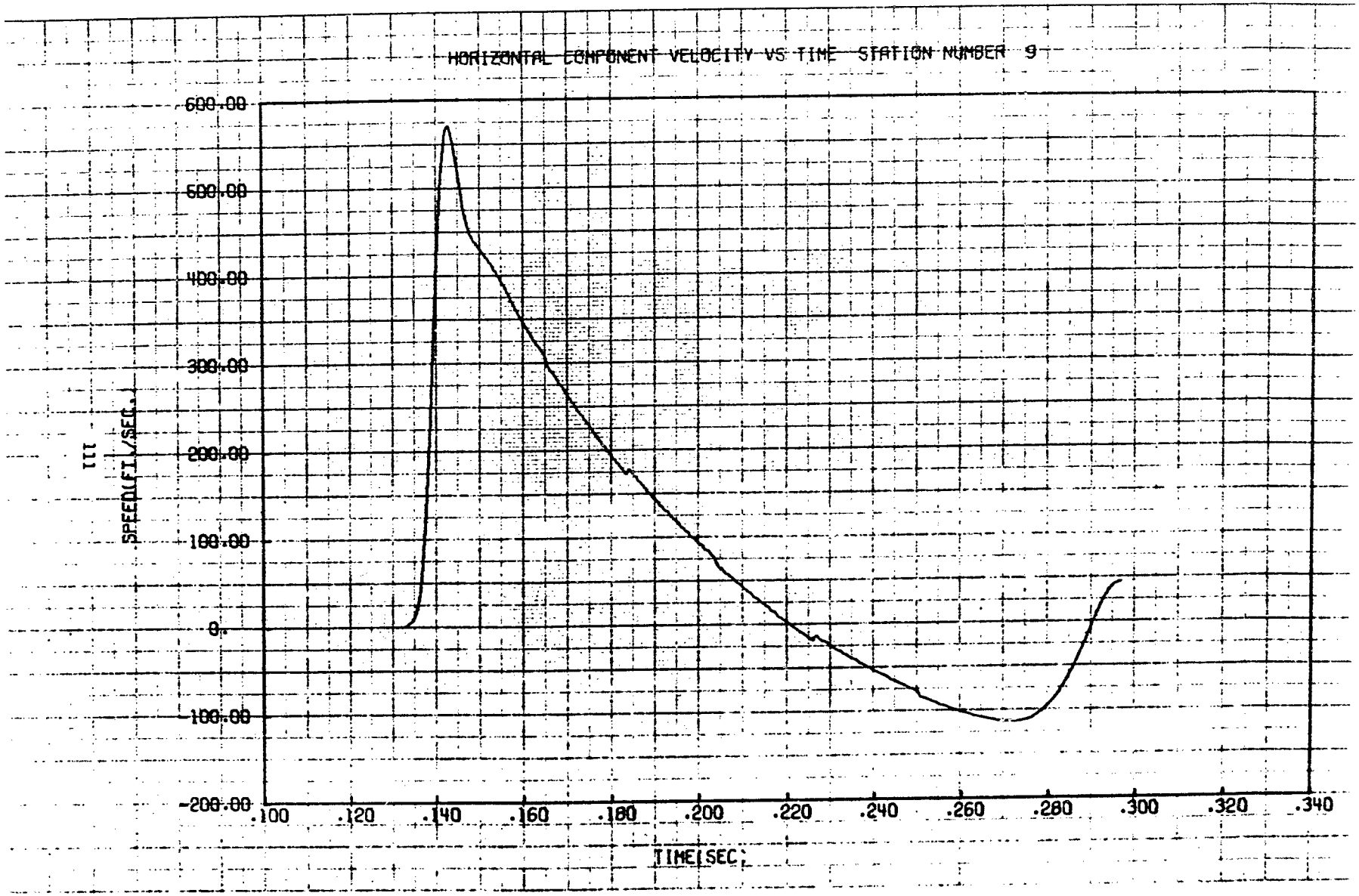

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)
SPEED(FT/SEC)
105

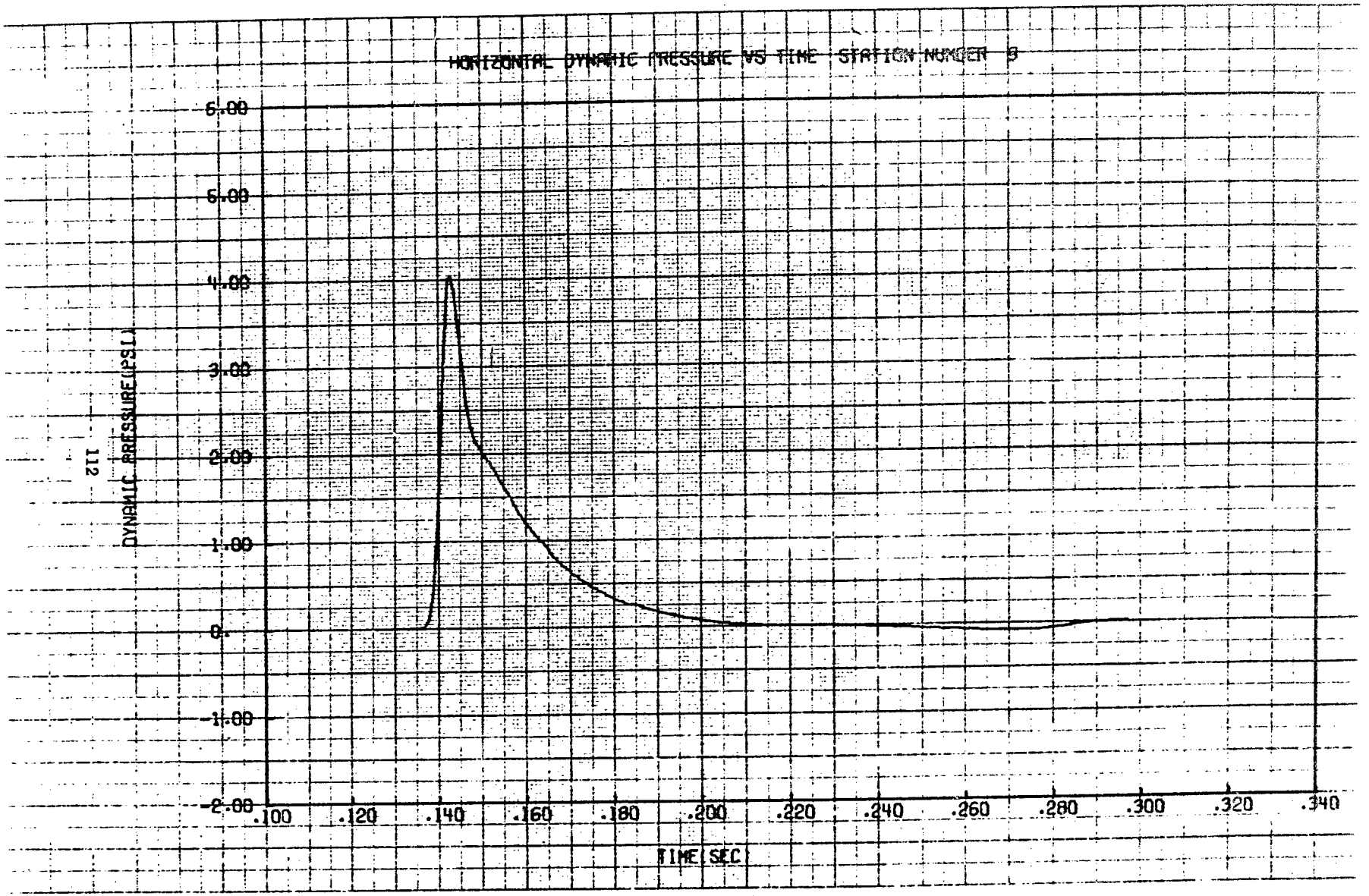

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE(PSI)
107
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

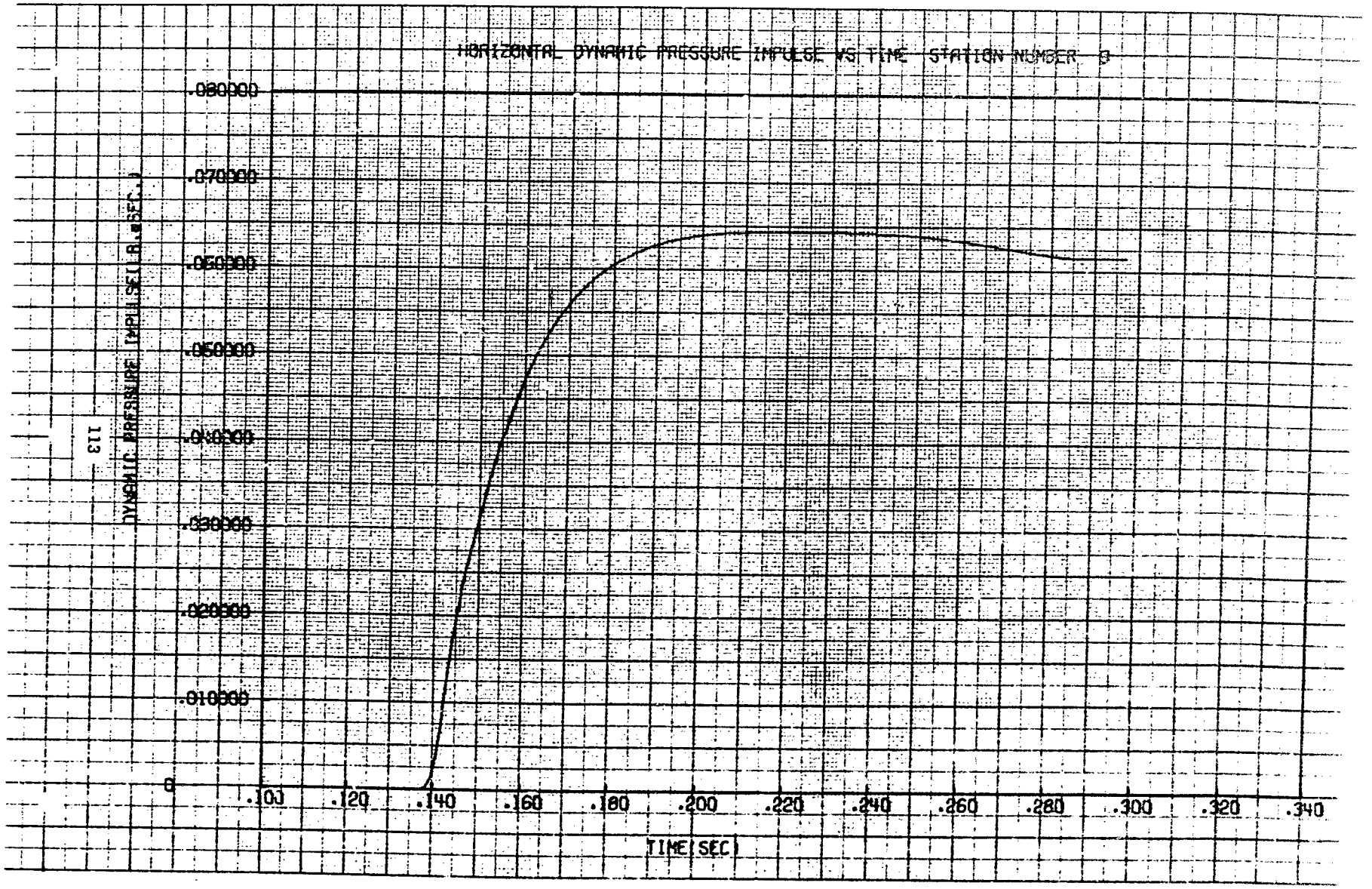

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 0
DYNAMIC PRESSURE IMPULSE(LB./SEC.)
10⁸
.14
.12
.10
.08
.06
.04
.02
0
-.02
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

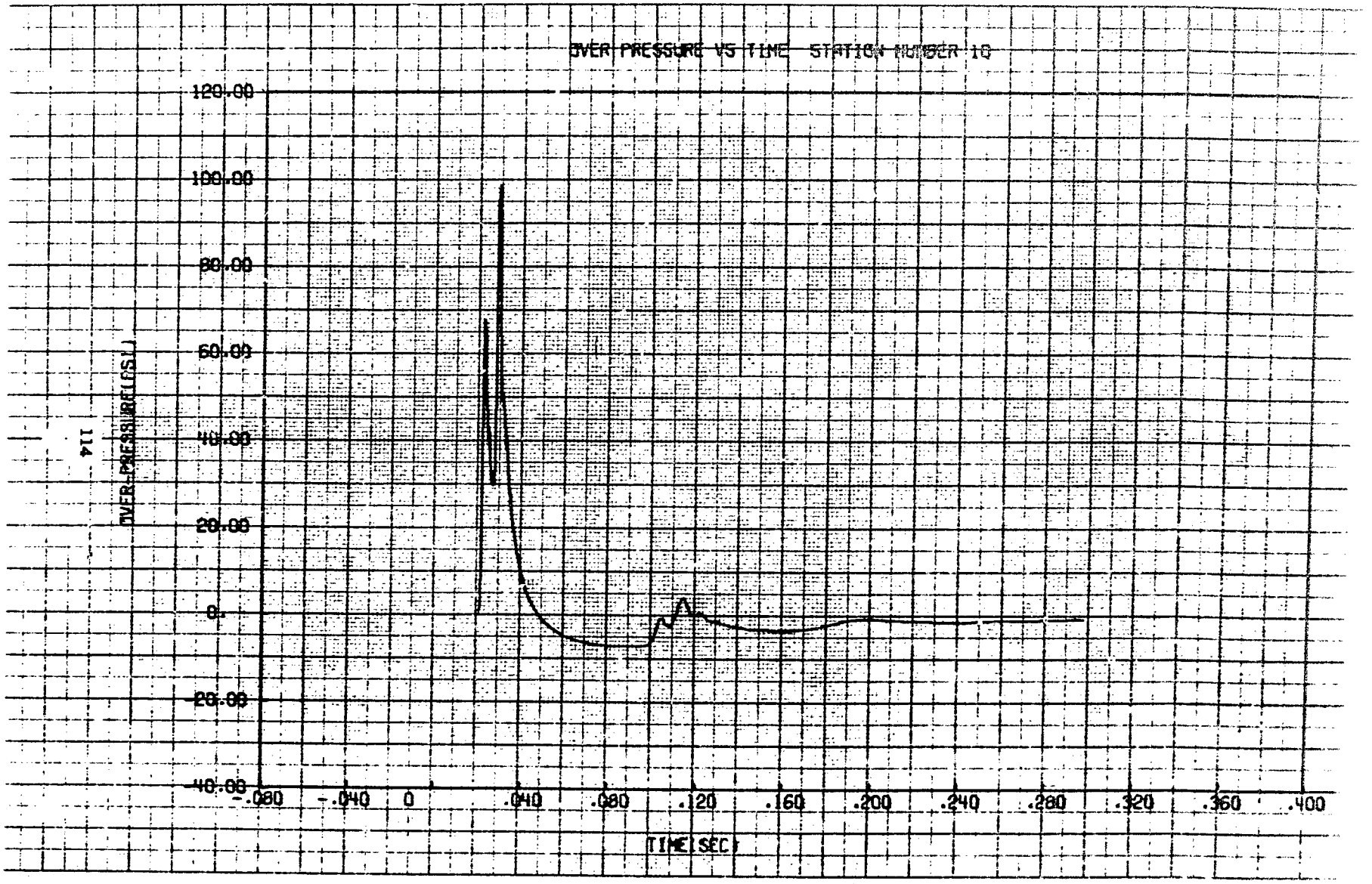

OVER PRESSURE VS TIME STATION NUMBER 9
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)
OVER-PRESSURE(LBS/I)
301

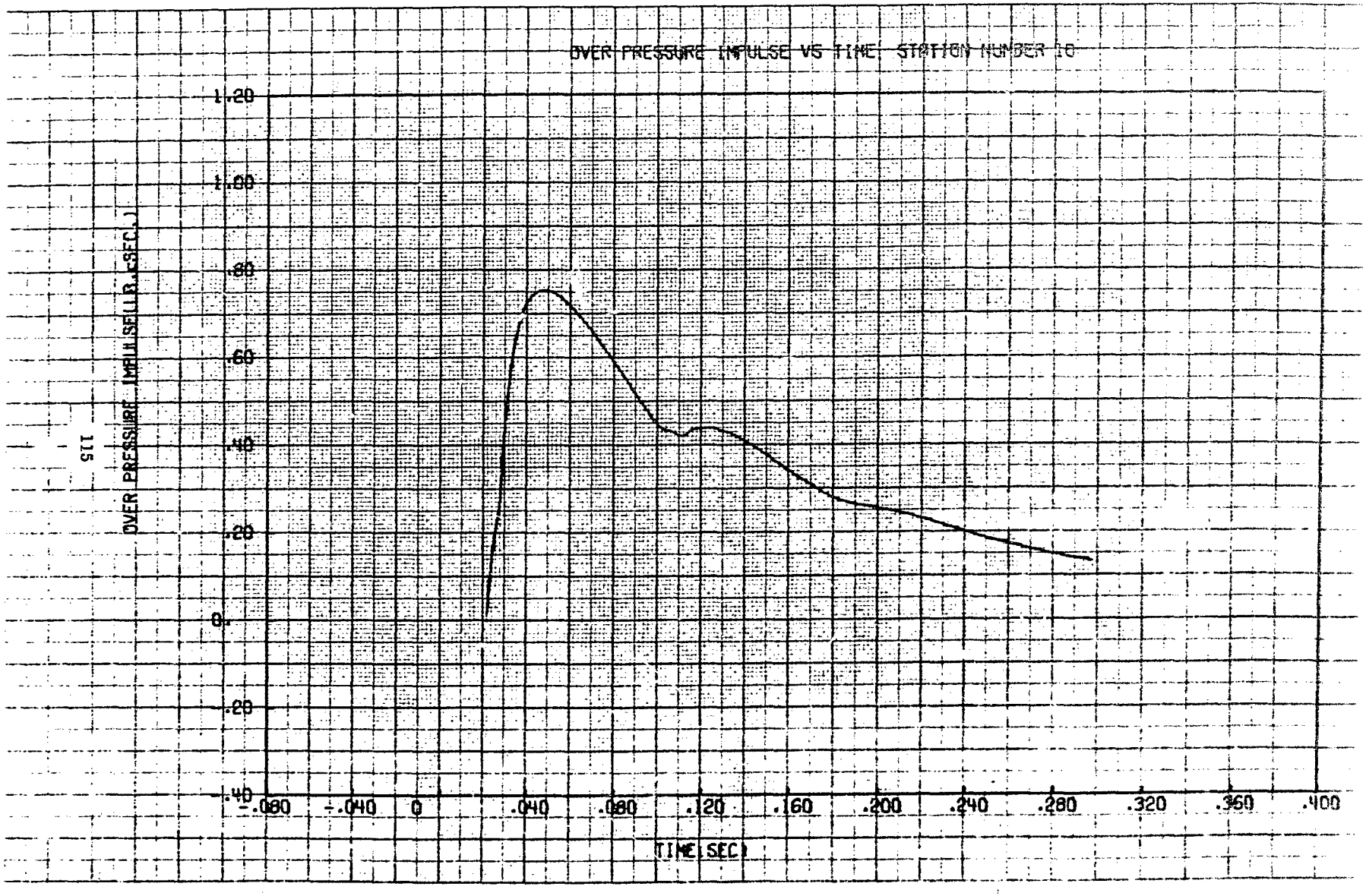

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 9
OVER PRESSURE IMPULSE(LB.*SEC.)
.50
.40
.30
.20
.10
0
-.10
-.20
-.30
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

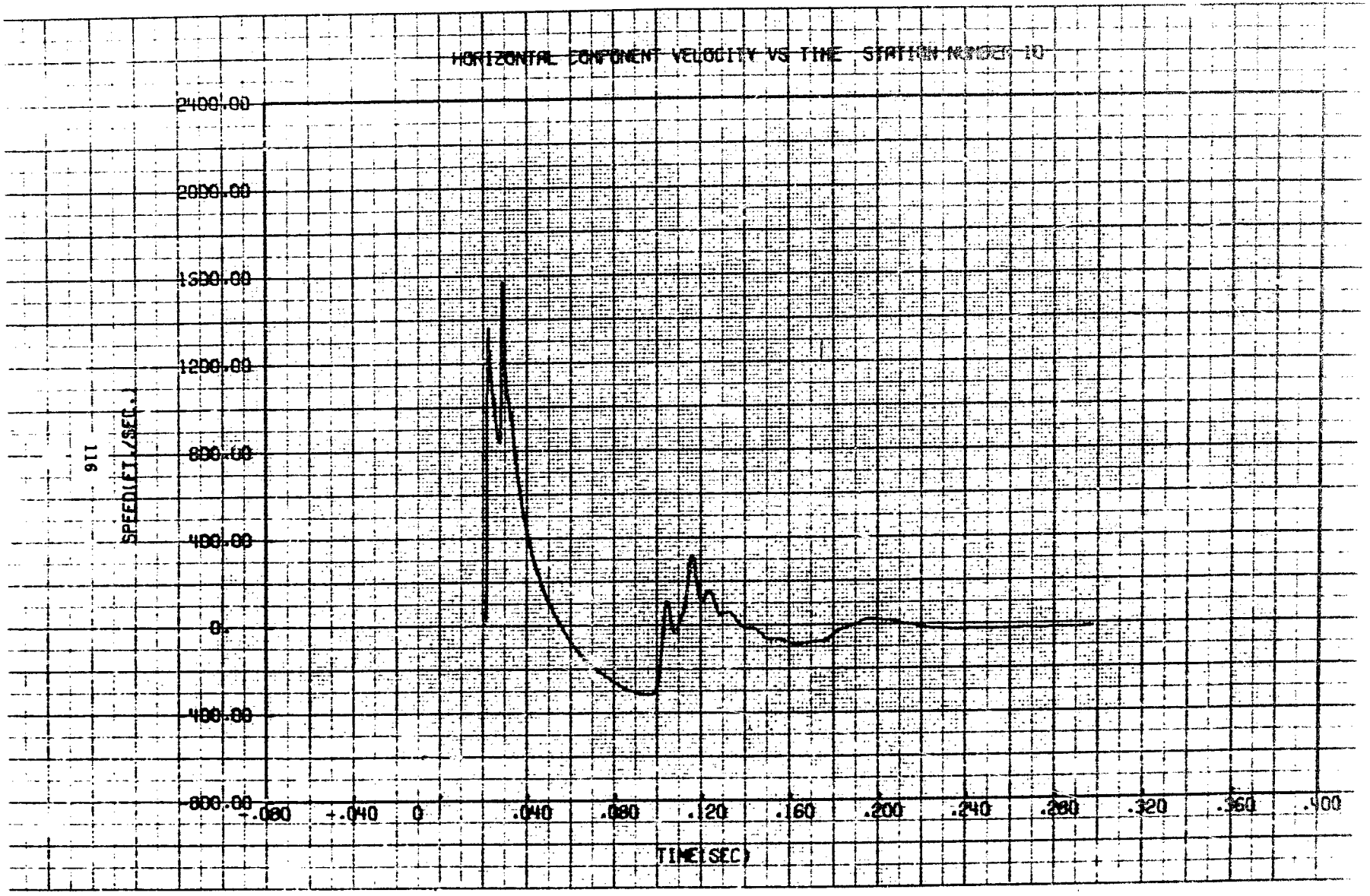

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
SPEED(FT/SEC)
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

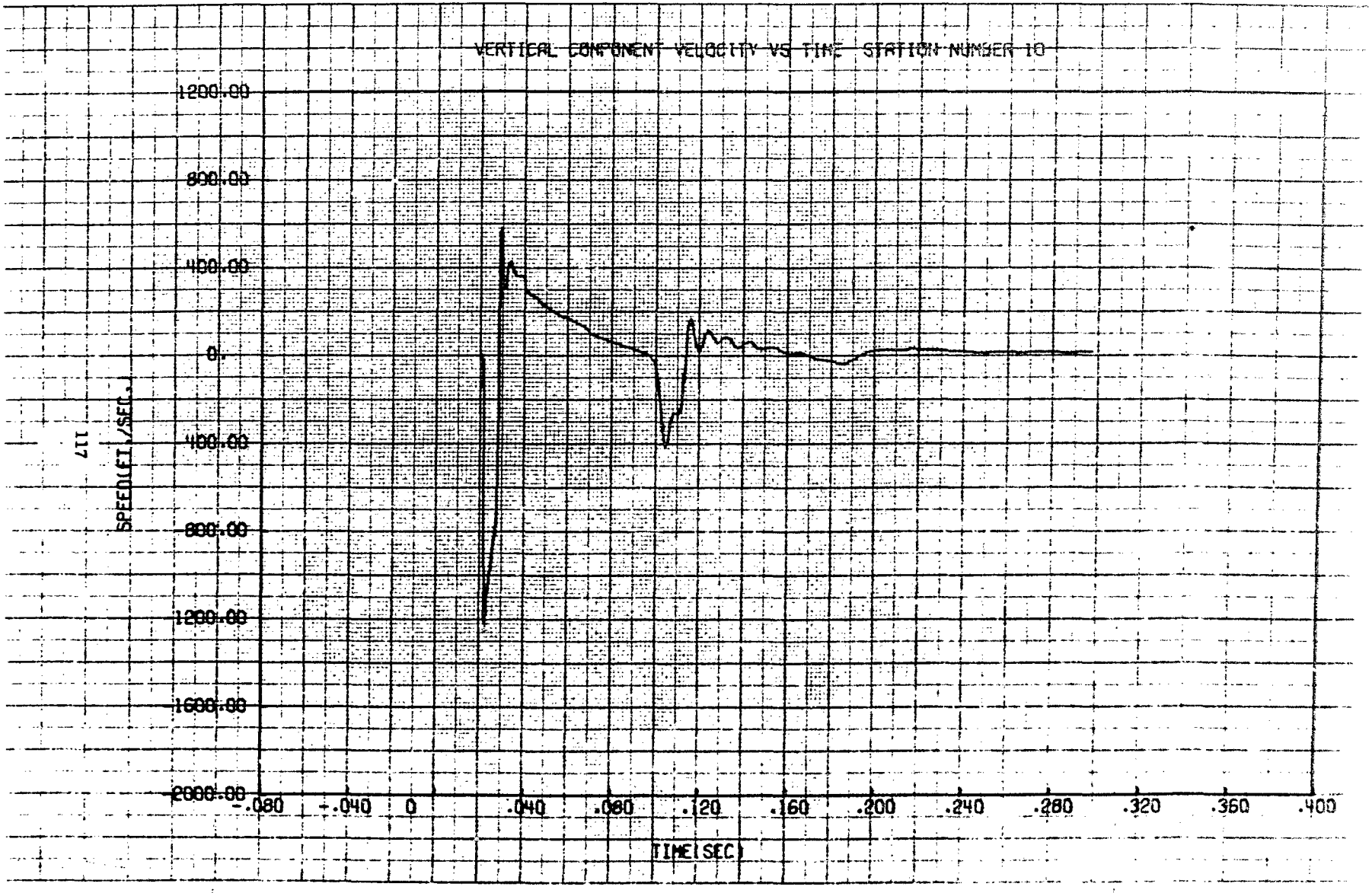

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 8
DYNAMIC PRESSURE(PSI)
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
-2.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

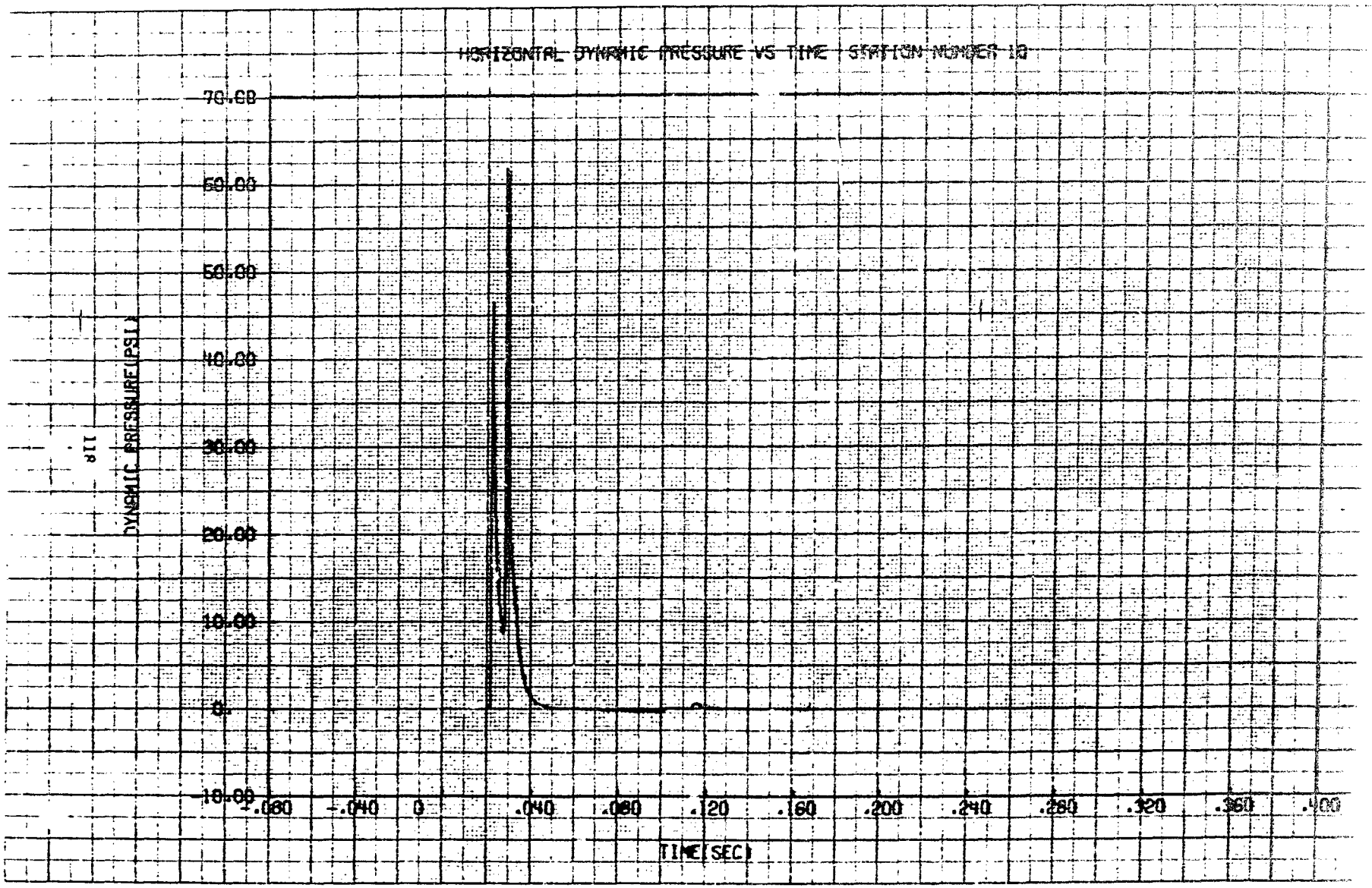

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
.080000
.070000
.060000
.050000
.040000
.030000
.020000
.010000
0
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)

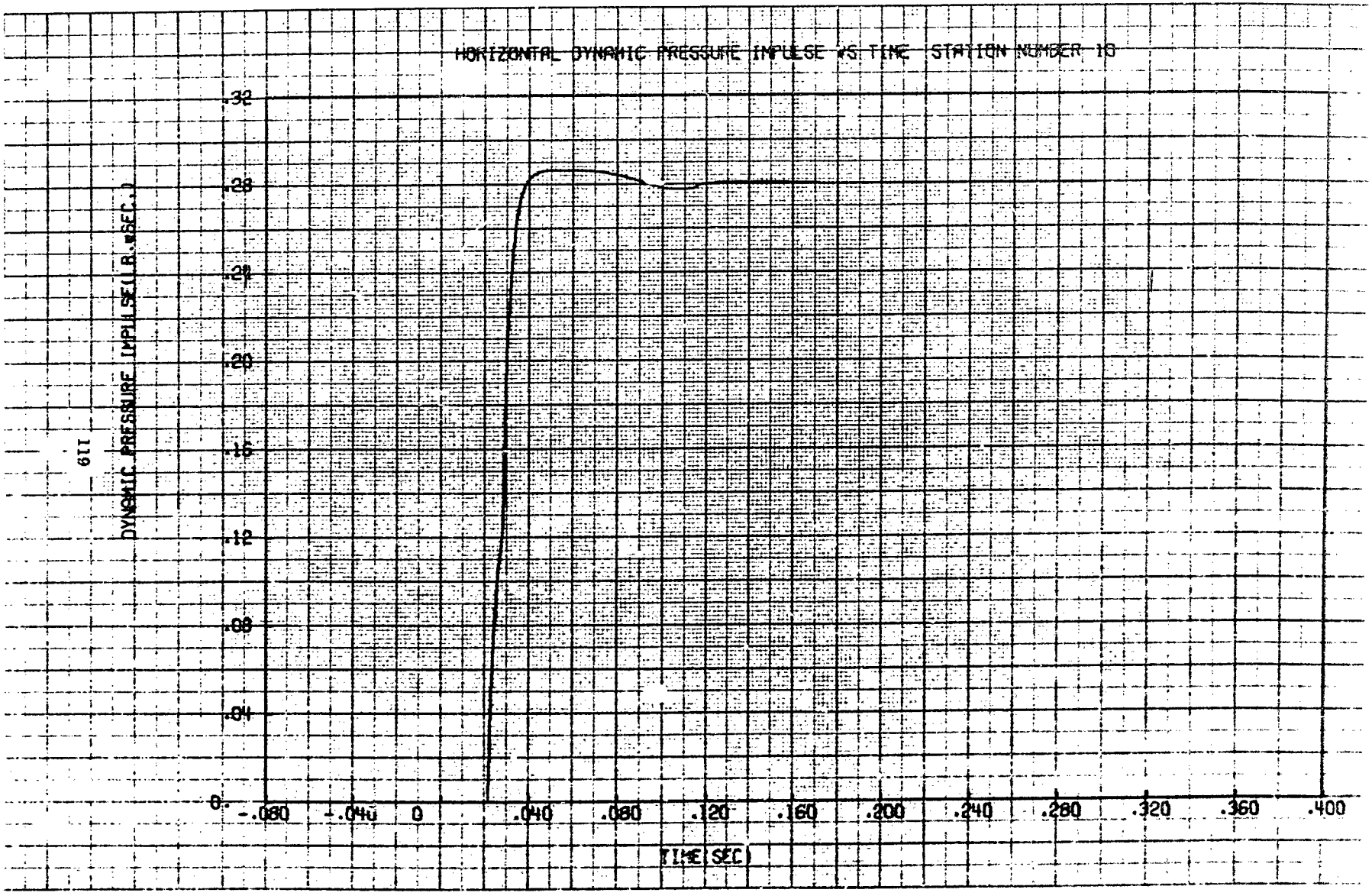

OVER PRESSURE VS TIME STATION NUMBER 10
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
OVER PRESSURE(PSI)

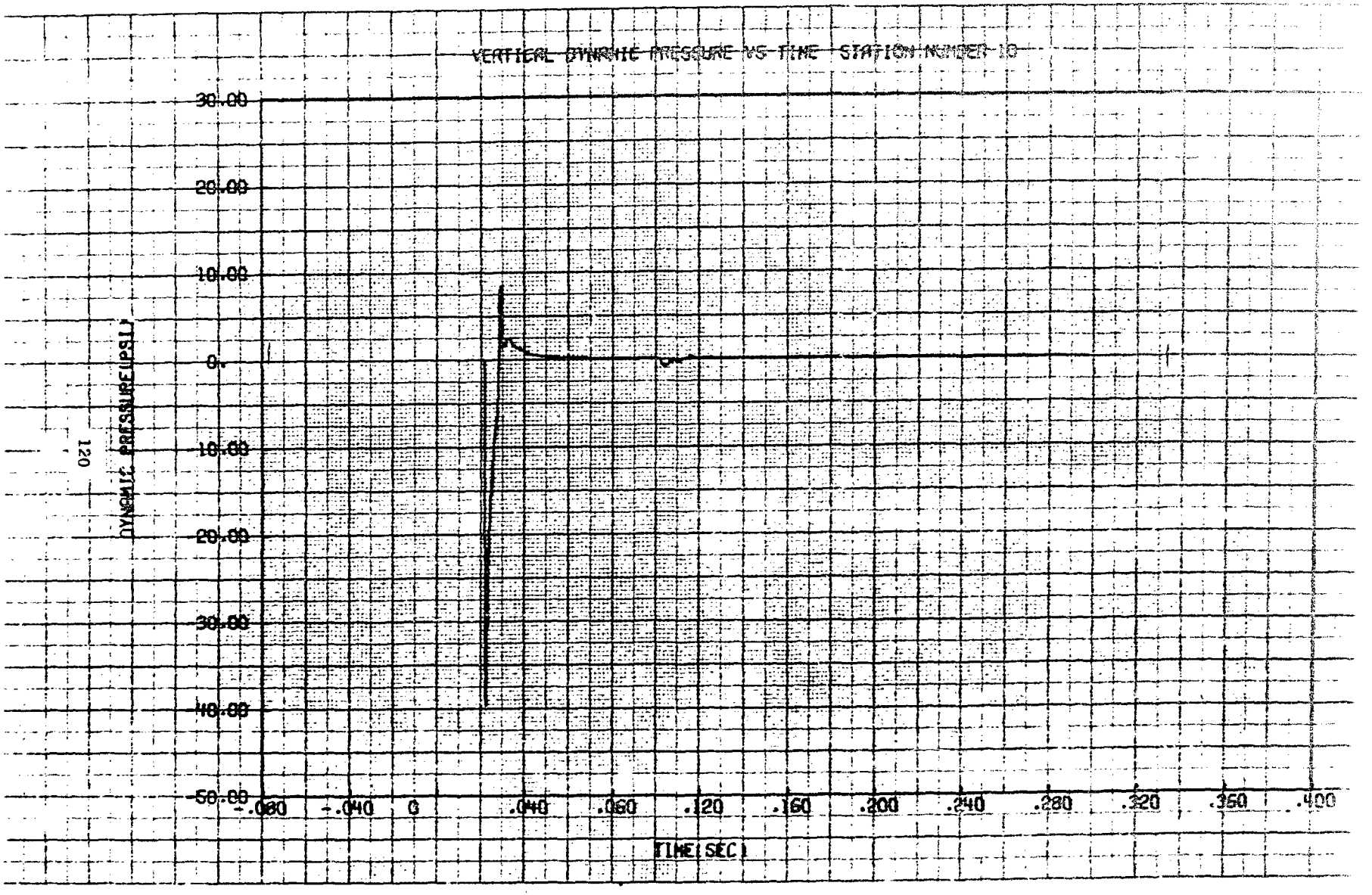

OVER PRESSURE IMPULSE VS TIME, STATION NUMBER 10
OVER PRESSURE IMPULSE (LB./SEC.)
1.20
1.00
.80
.60
.40
.20
0
-.20
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

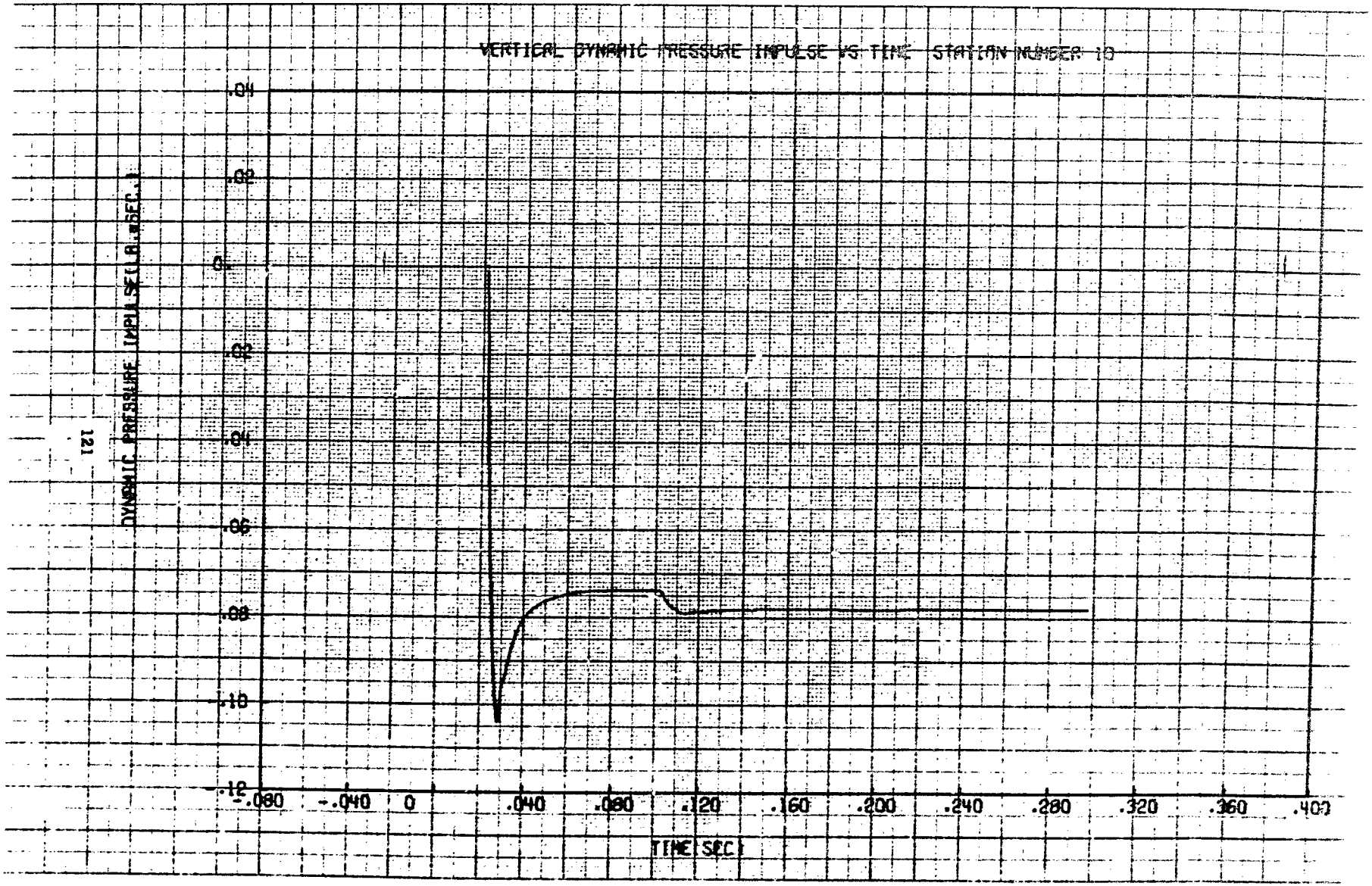

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
116
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

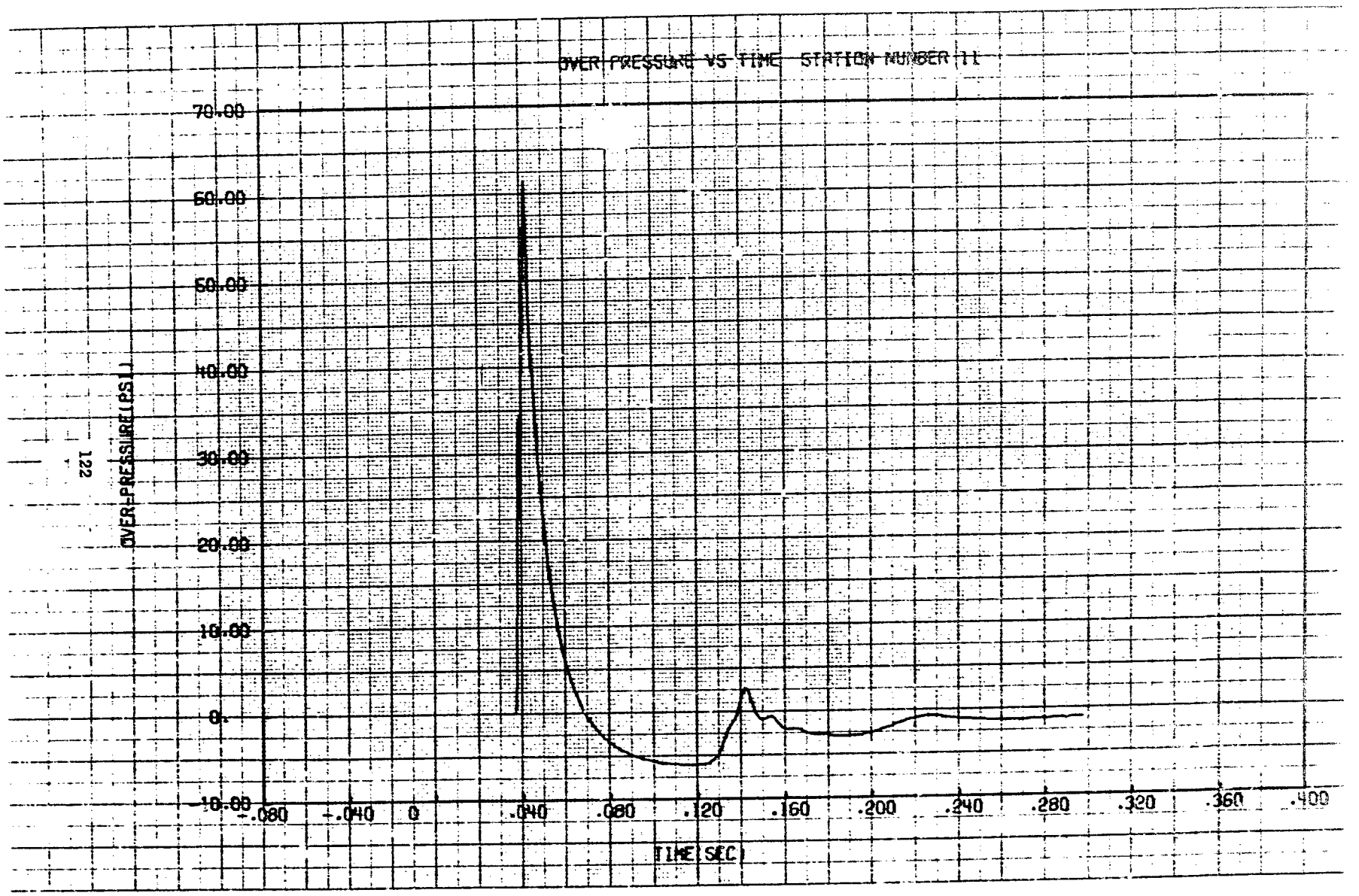

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
SPEED(FT/SEC.)
117
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

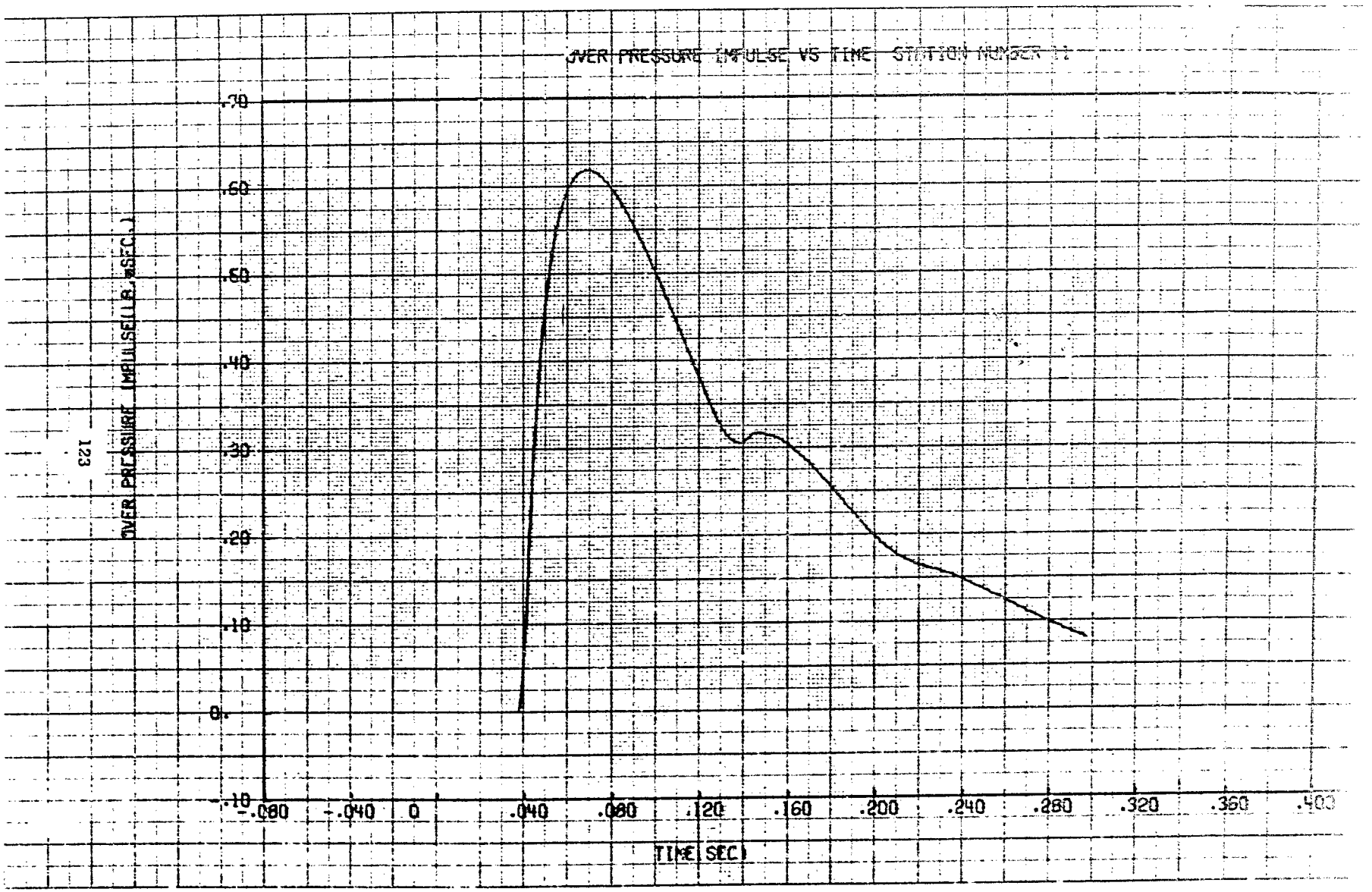

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

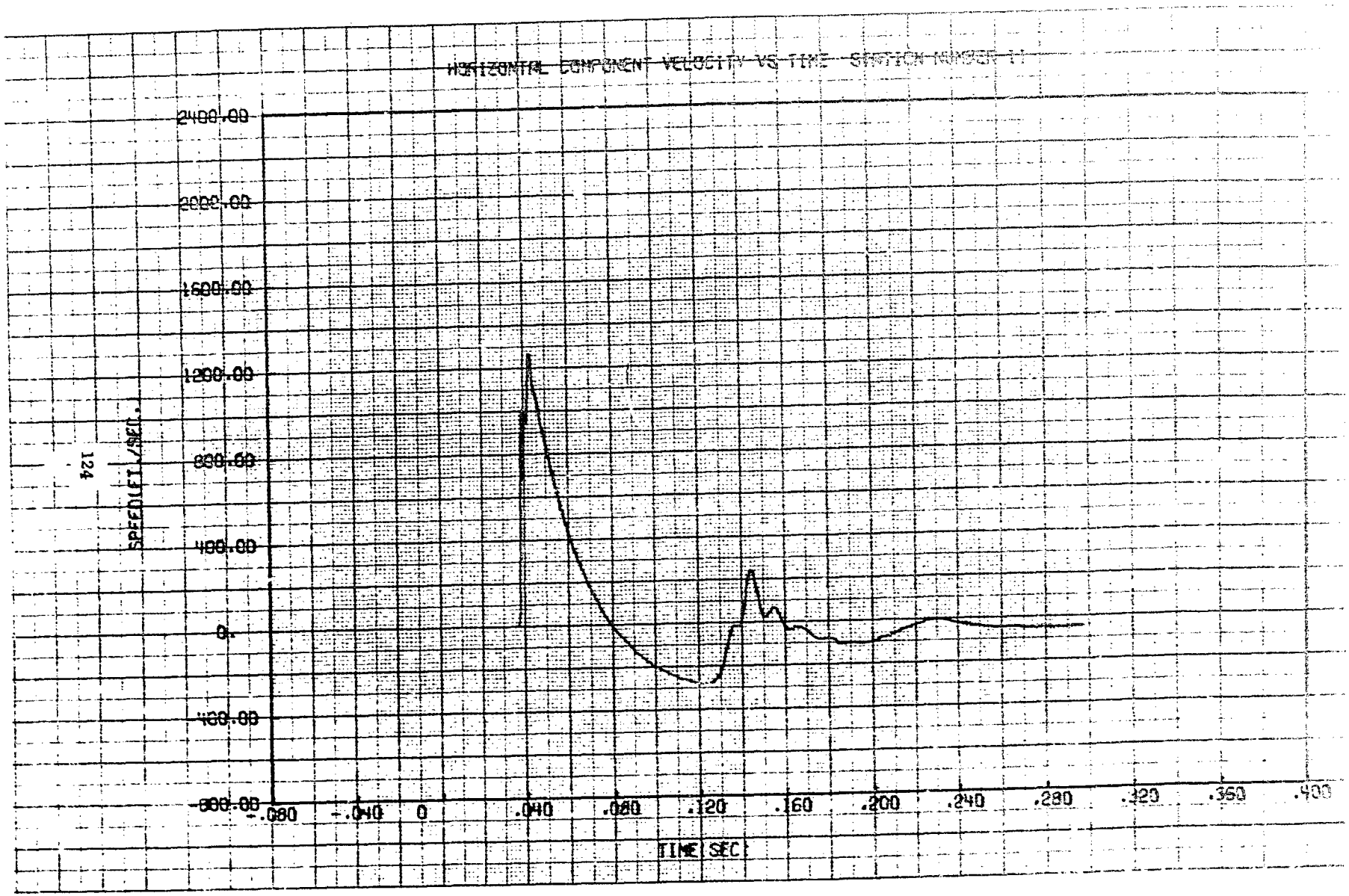

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE (LB./SEC.)
611
.32
.28
.24
.20
.16
.12
.08
.04
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

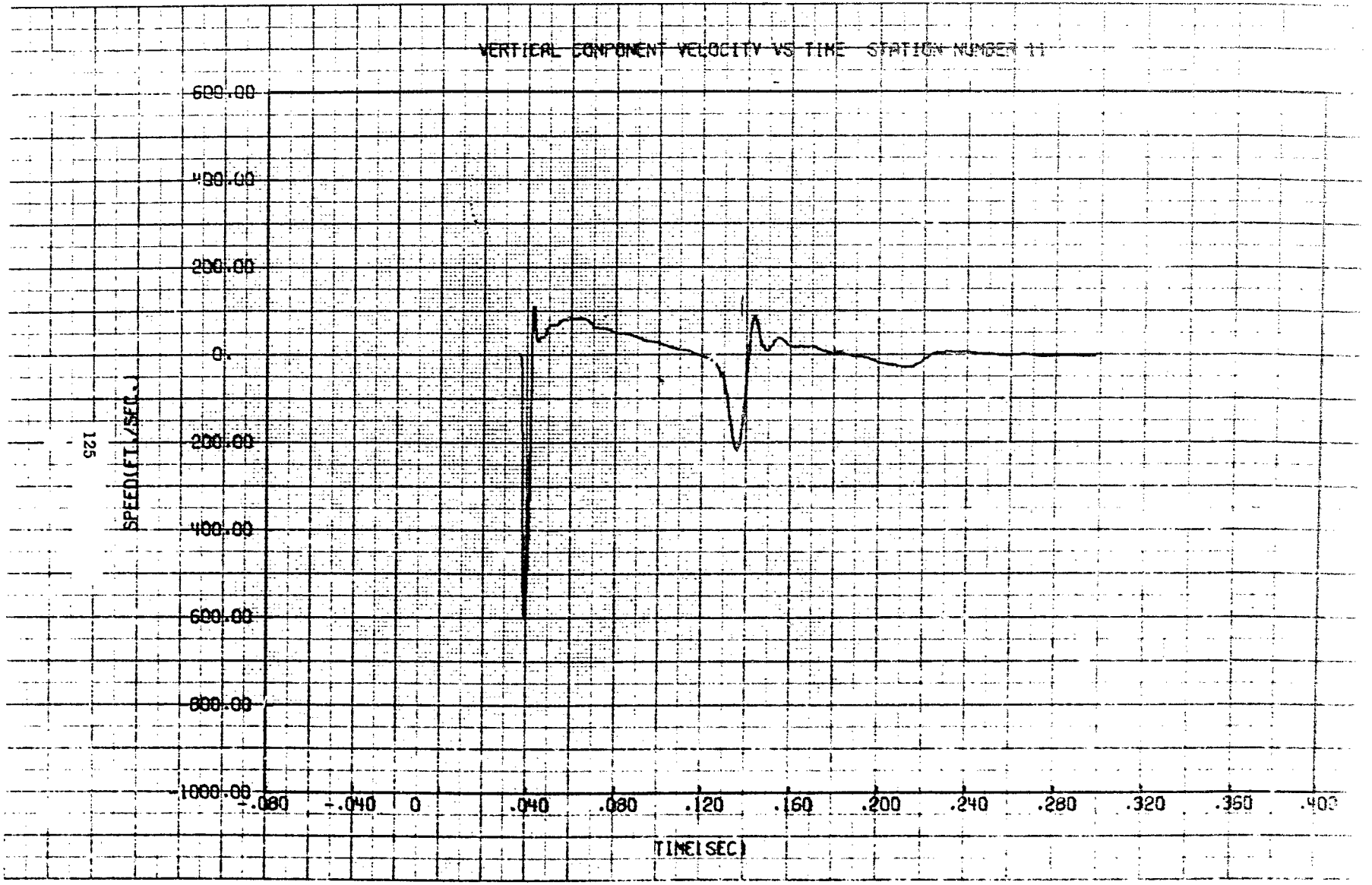

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

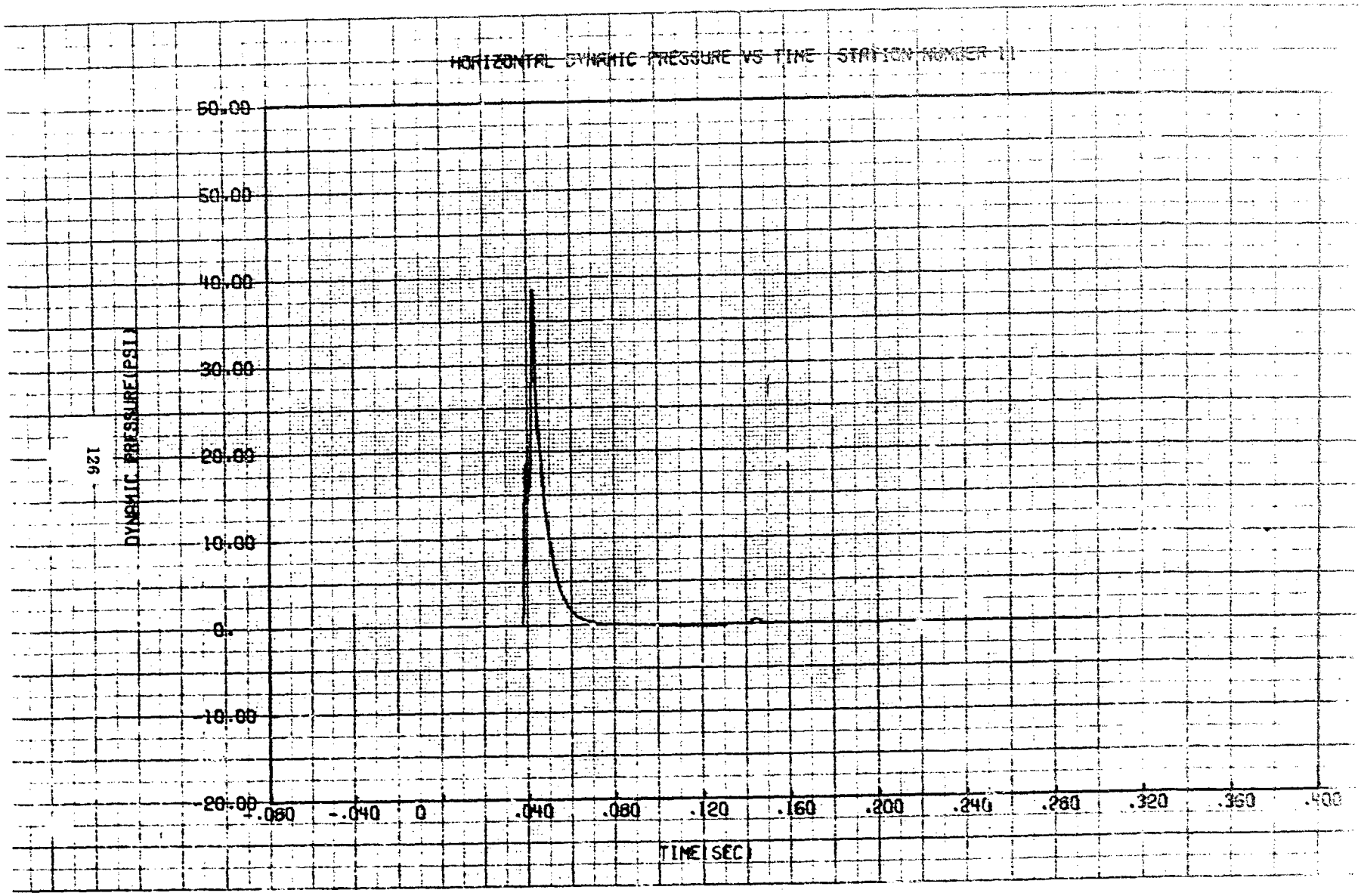

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE (LB.SEC.)
121
.04
.02
0
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

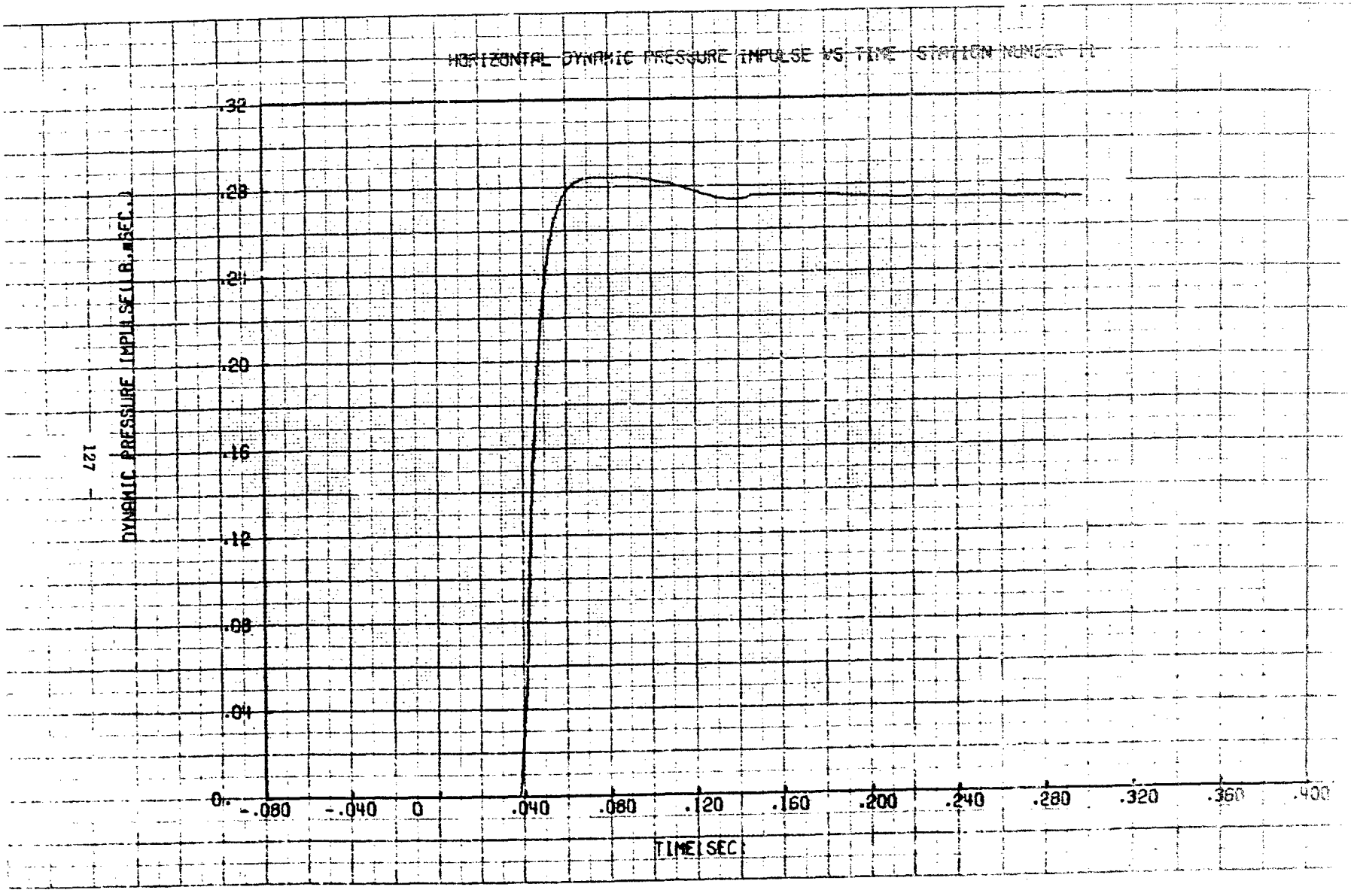

OVER PRESSURE VS TIME STATION NUMBER 11
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

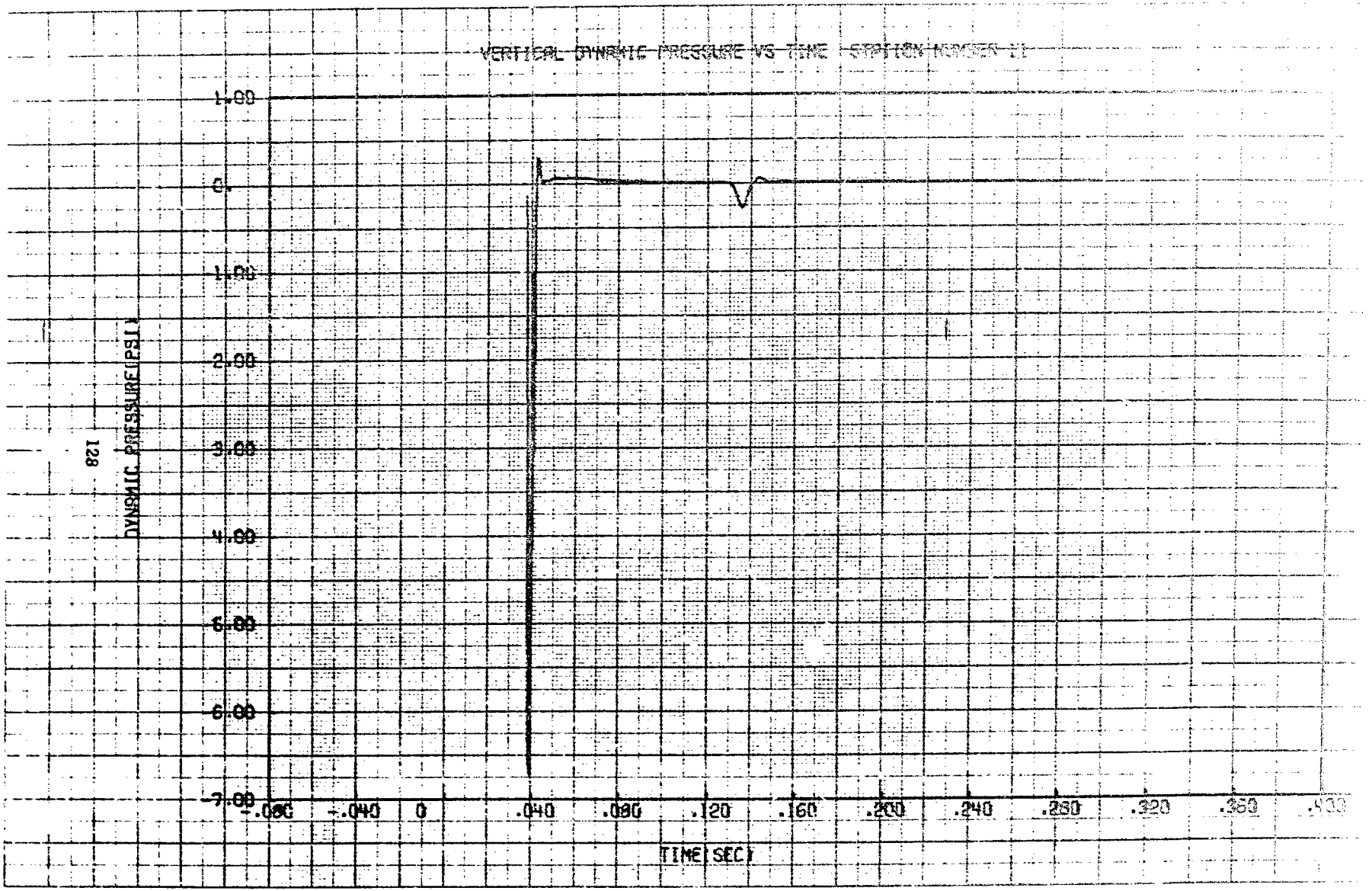

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 11
OVER PRESSURE (IMPULSE/LB./SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC)

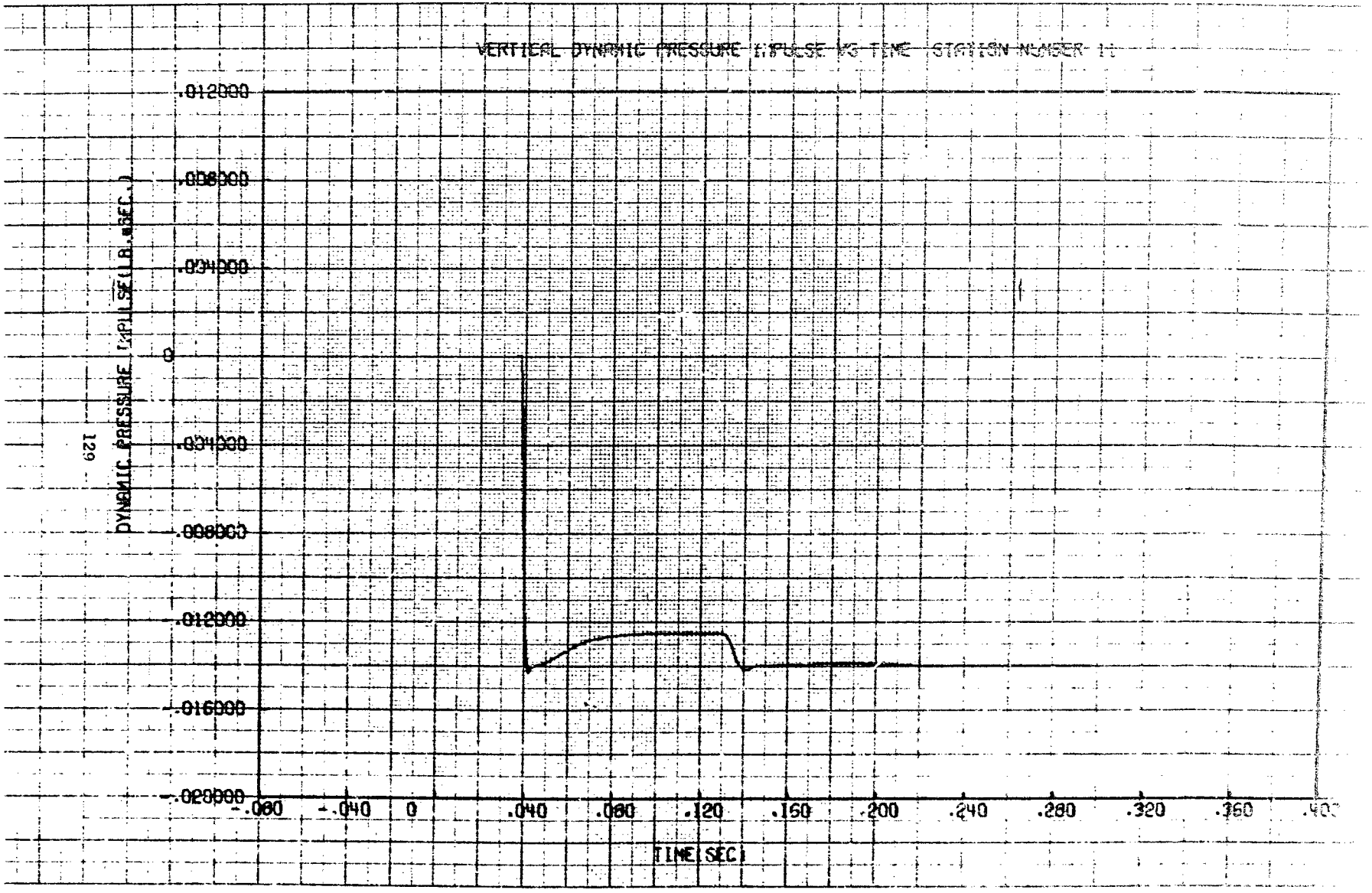

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
SPEED(FT/SEC)
124

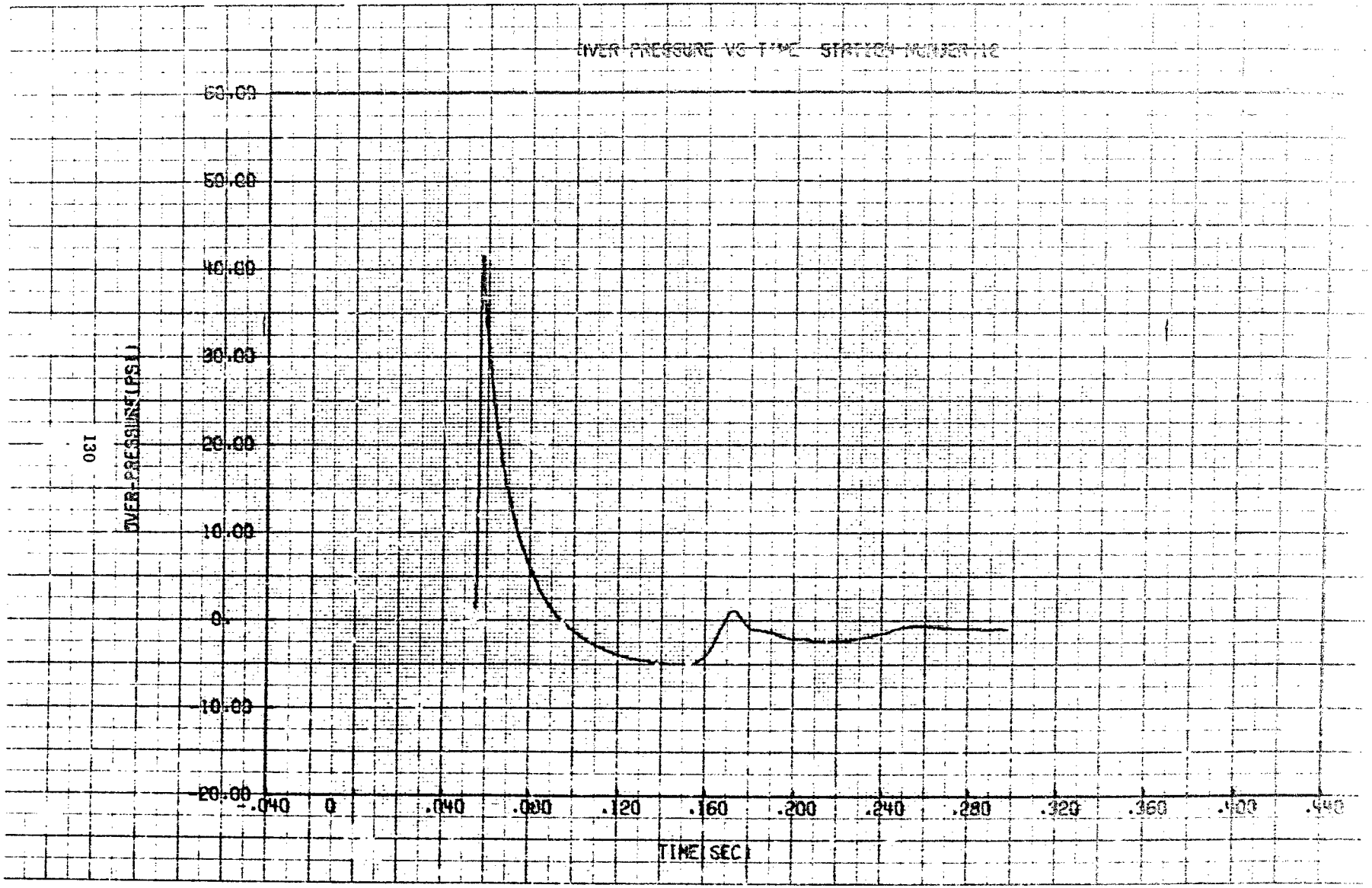

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

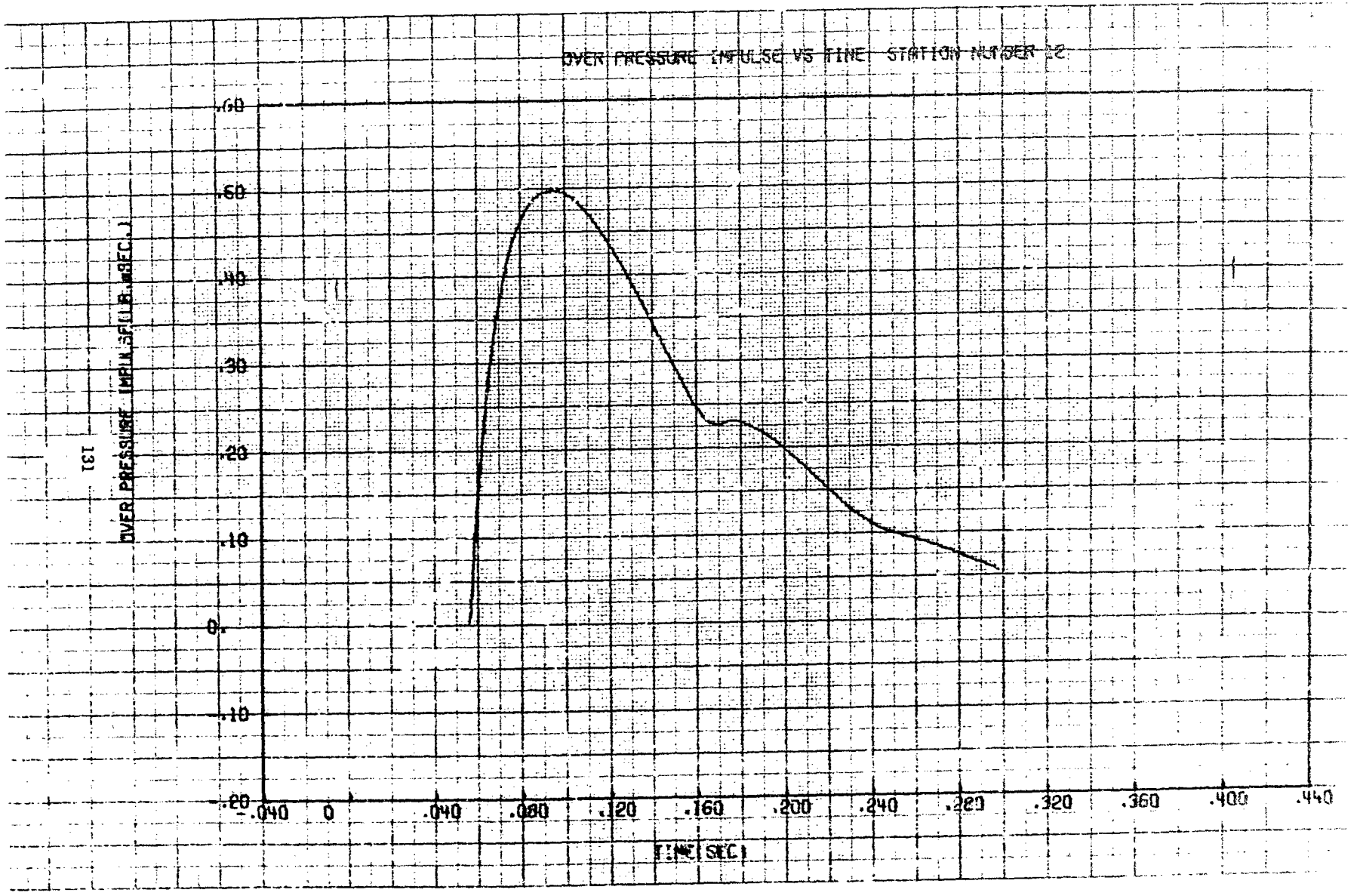

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
DYNAMIC PRESSURE(PSI)
126
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

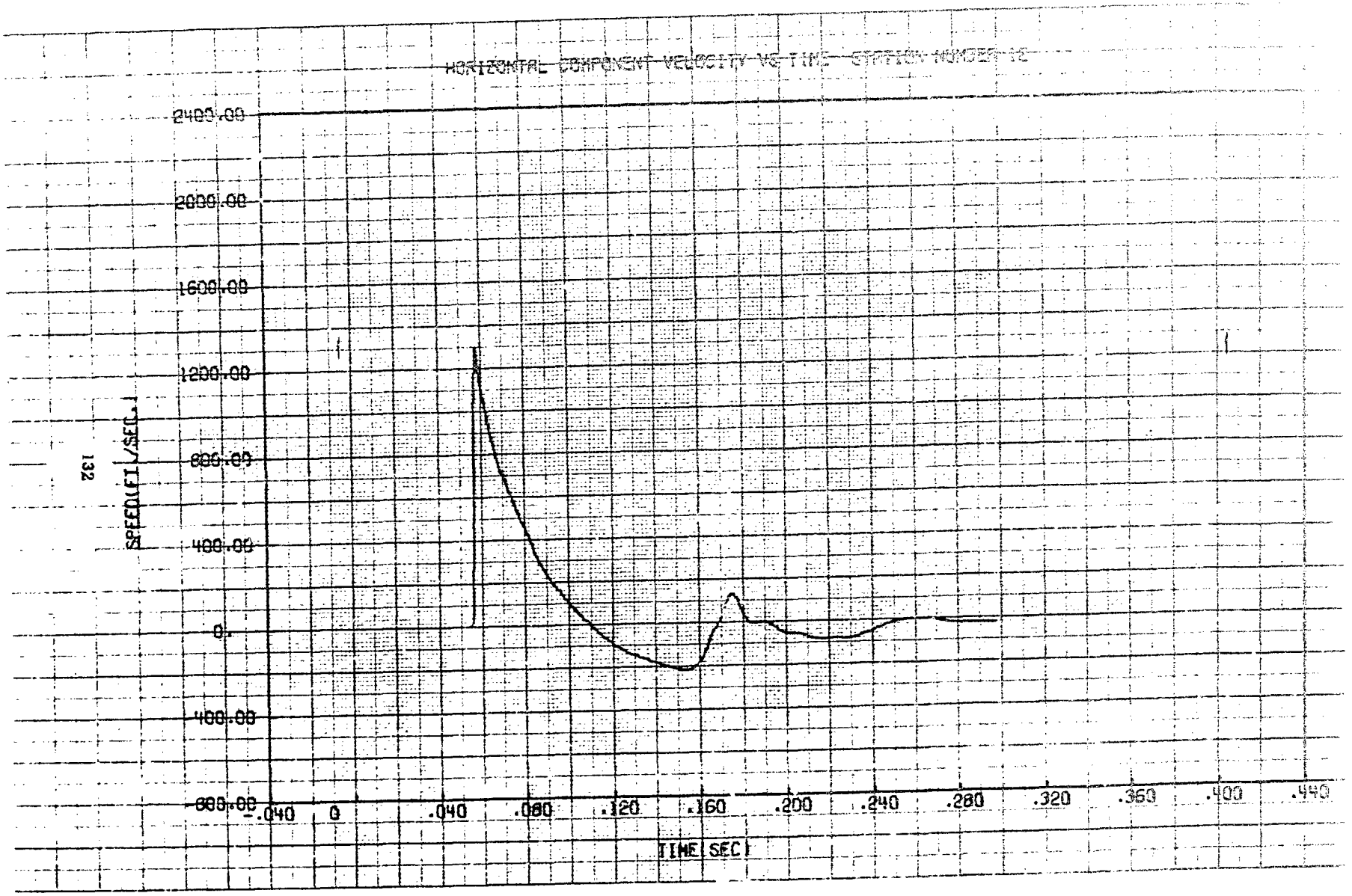

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 11
DYNAMIC PRESSURE IMPULSE (LB.-SEC.)
127
.32
.28
.24
.20
.16
.12
.08
.04
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

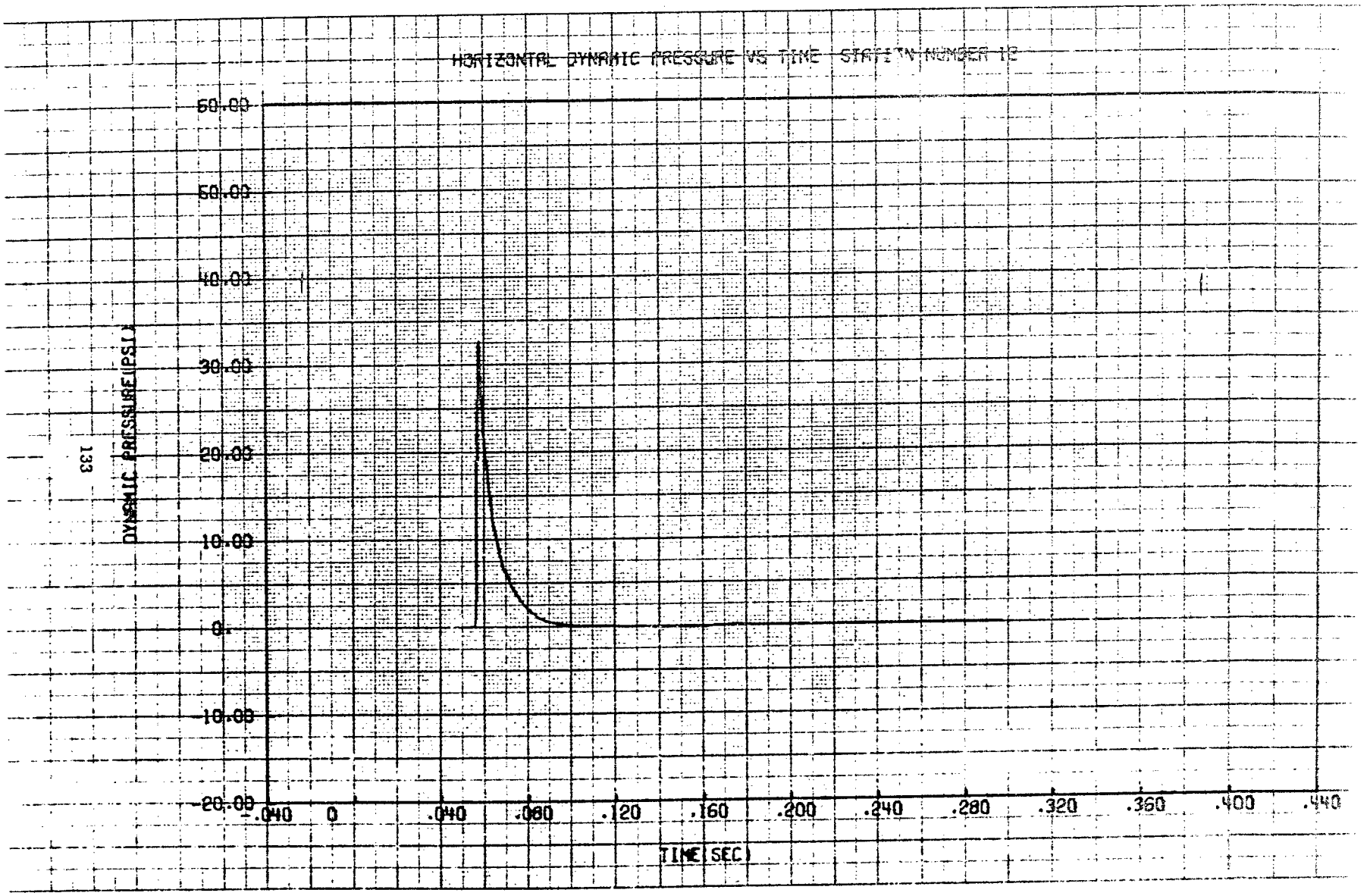

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
1.00
0.
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME SEC)
DYNAMIC PRESSURE(PSI)

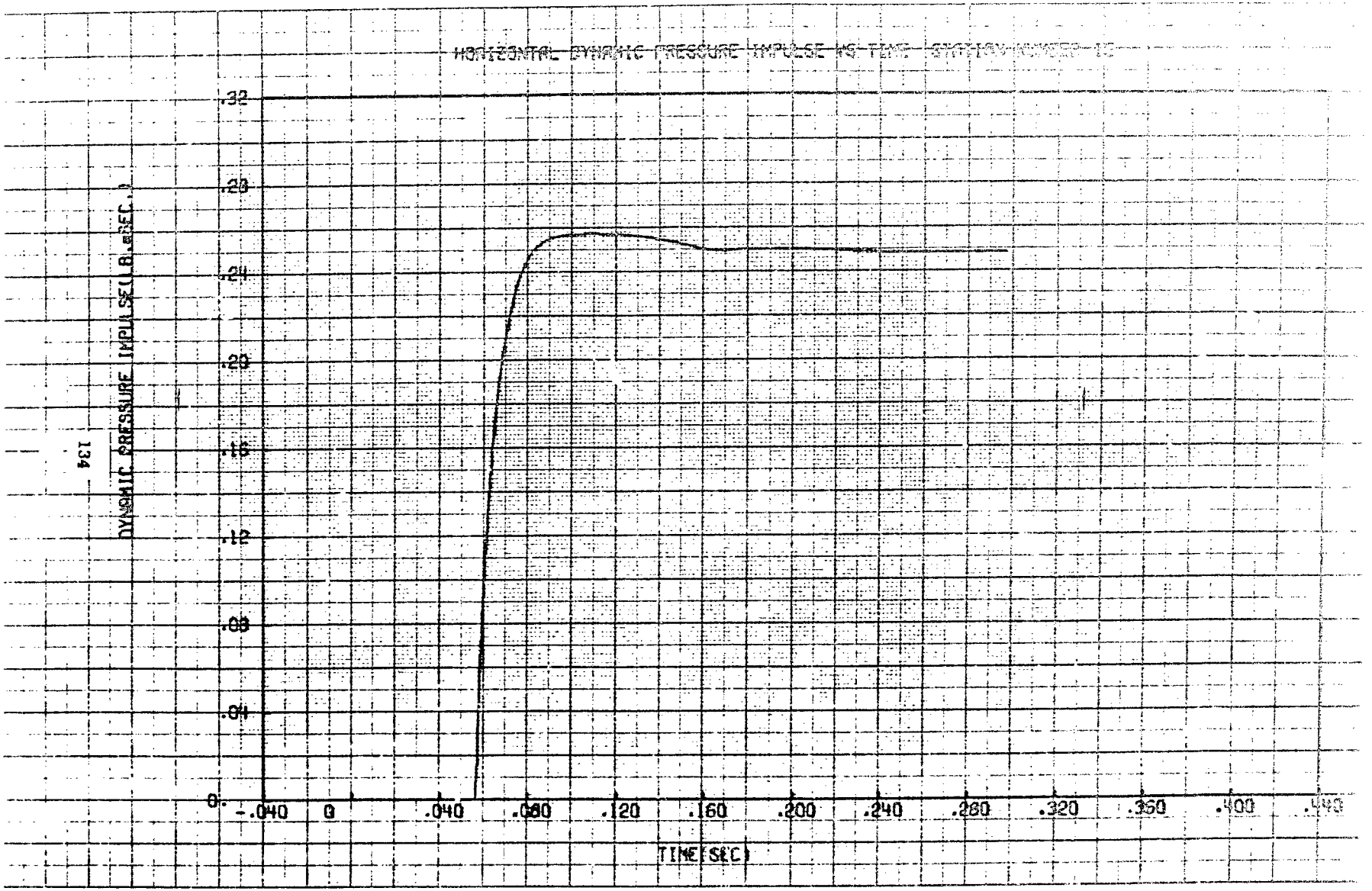

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 11
.012000
.008000
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
DYNAMIC PRESSURE IMPULSE(LB.SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME(SEC)

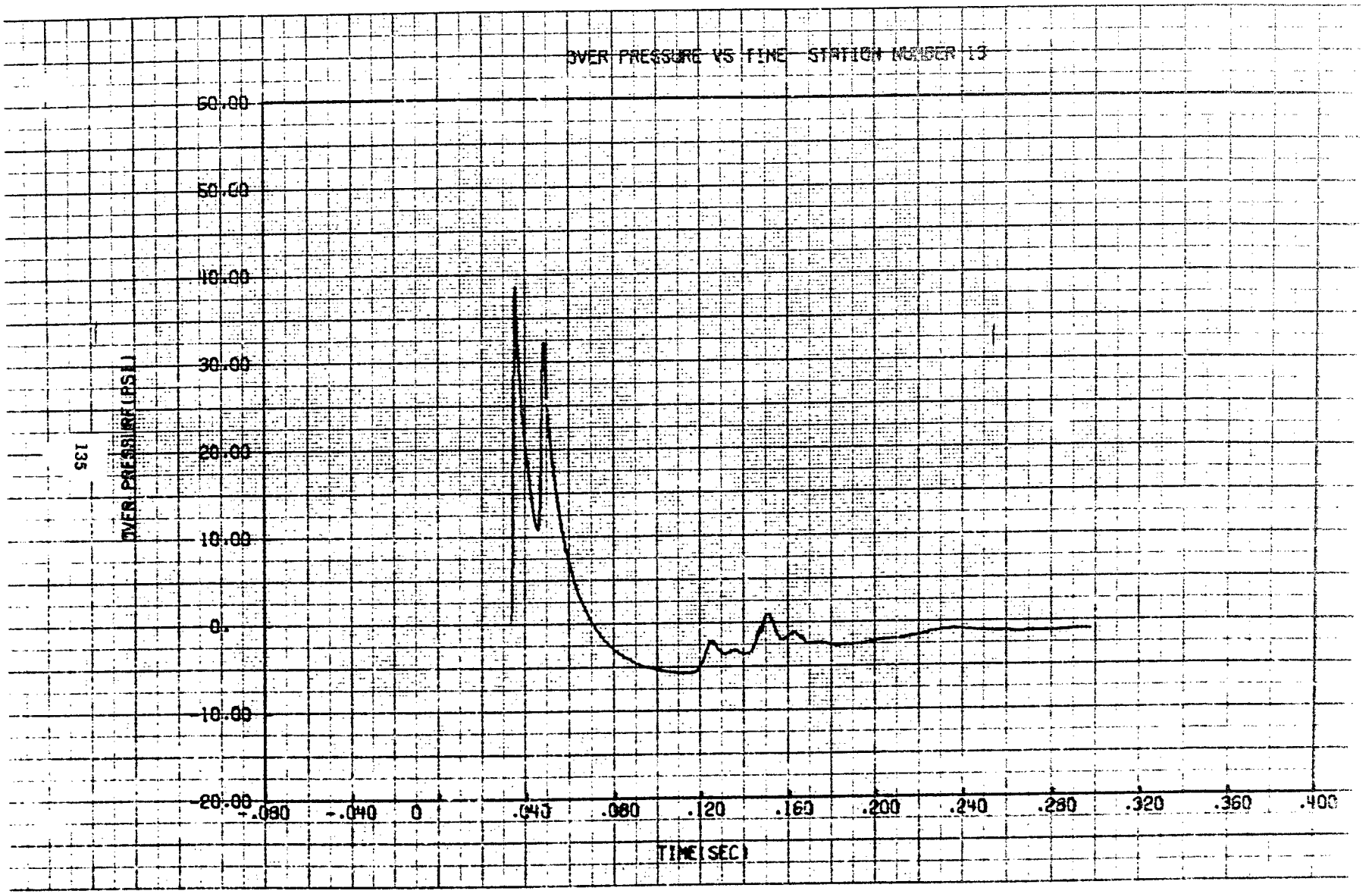

OVER PRESSURE VS TIME STATION NUMBER 12
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
130
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

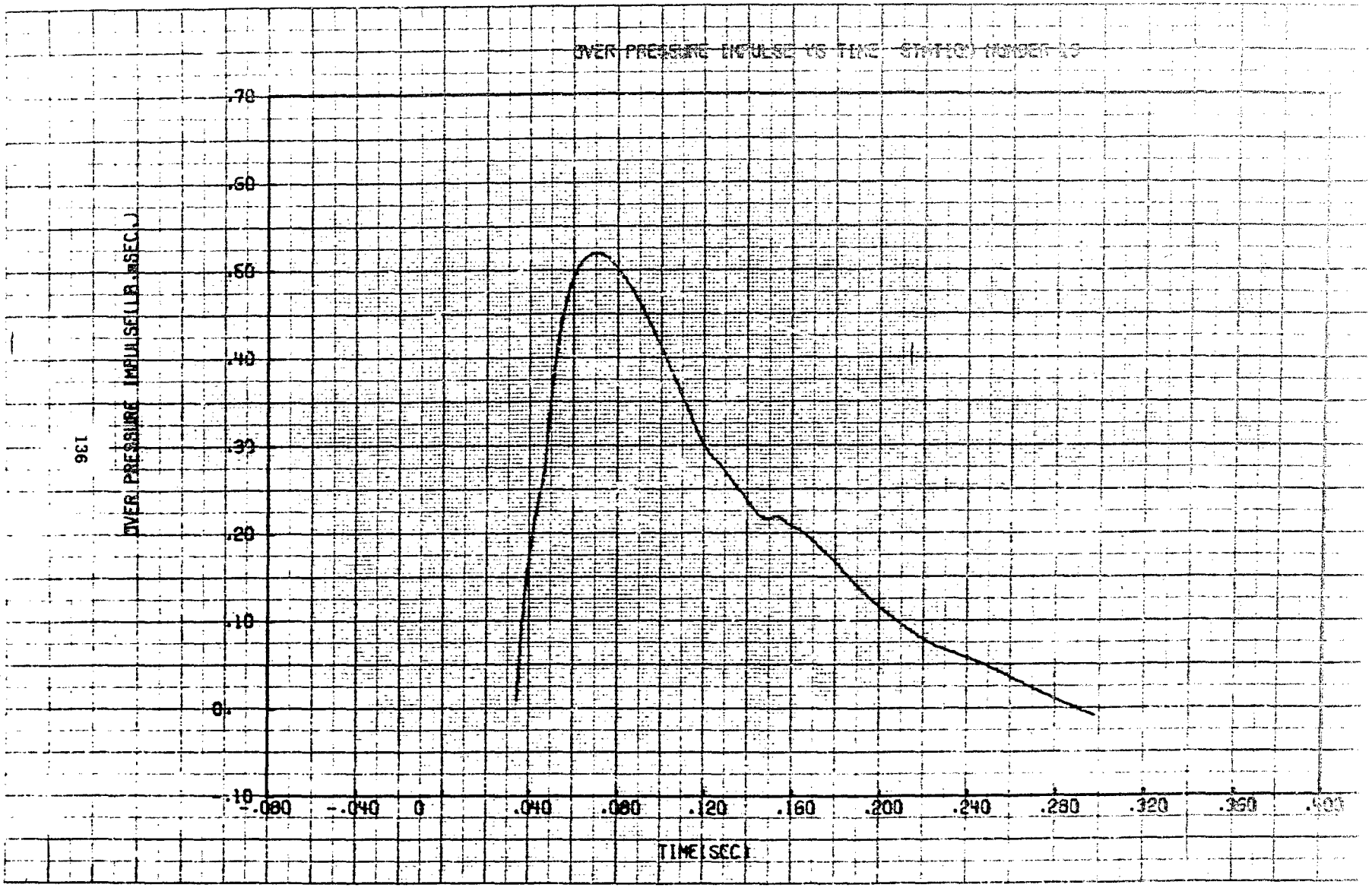

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 12
OVER PRESSURE IMPULSE(LB.mSEC.)
131
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

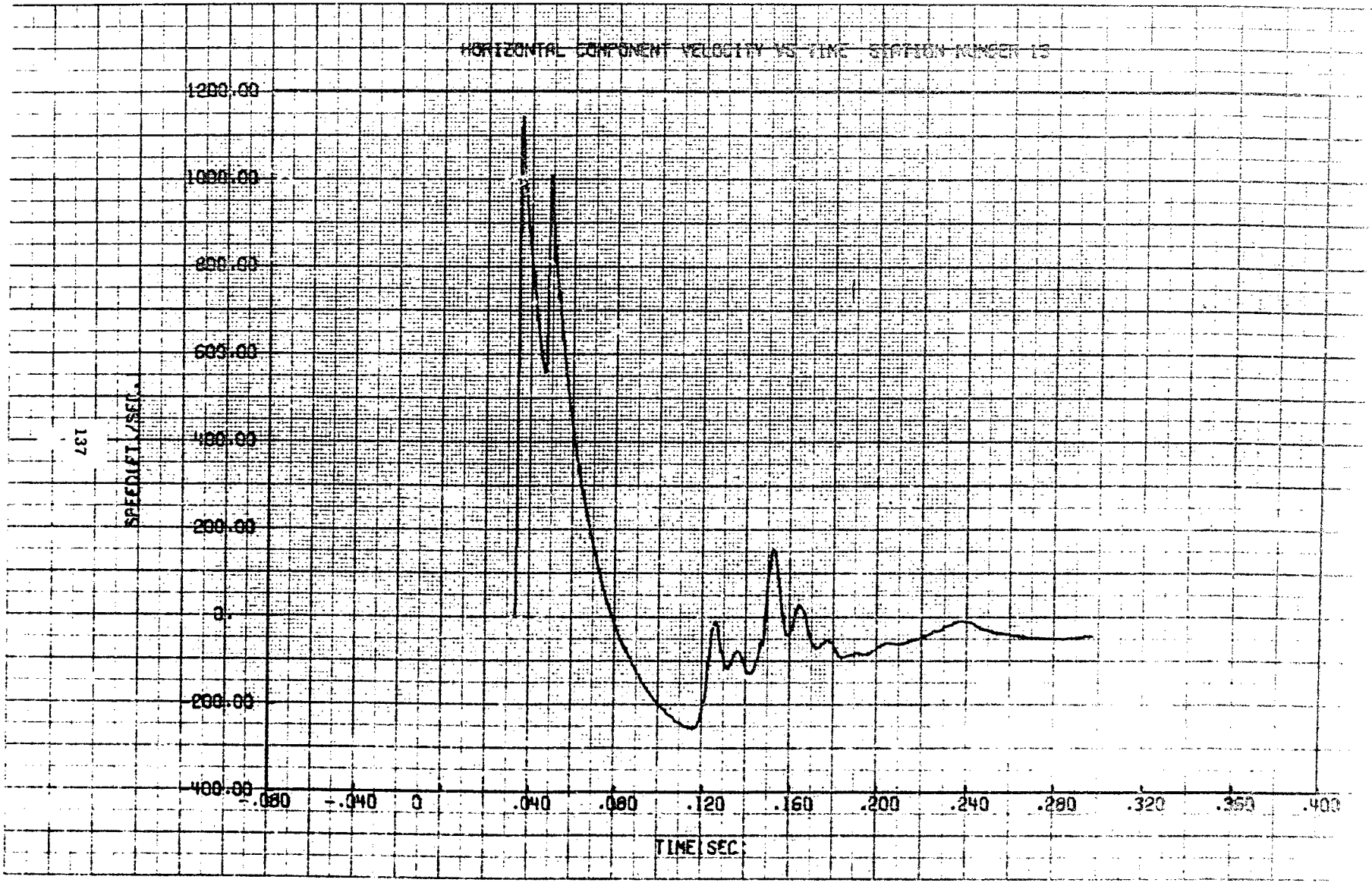

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 15
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC)


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 12
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
DYNAMIC PRESSURE(PSIA
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

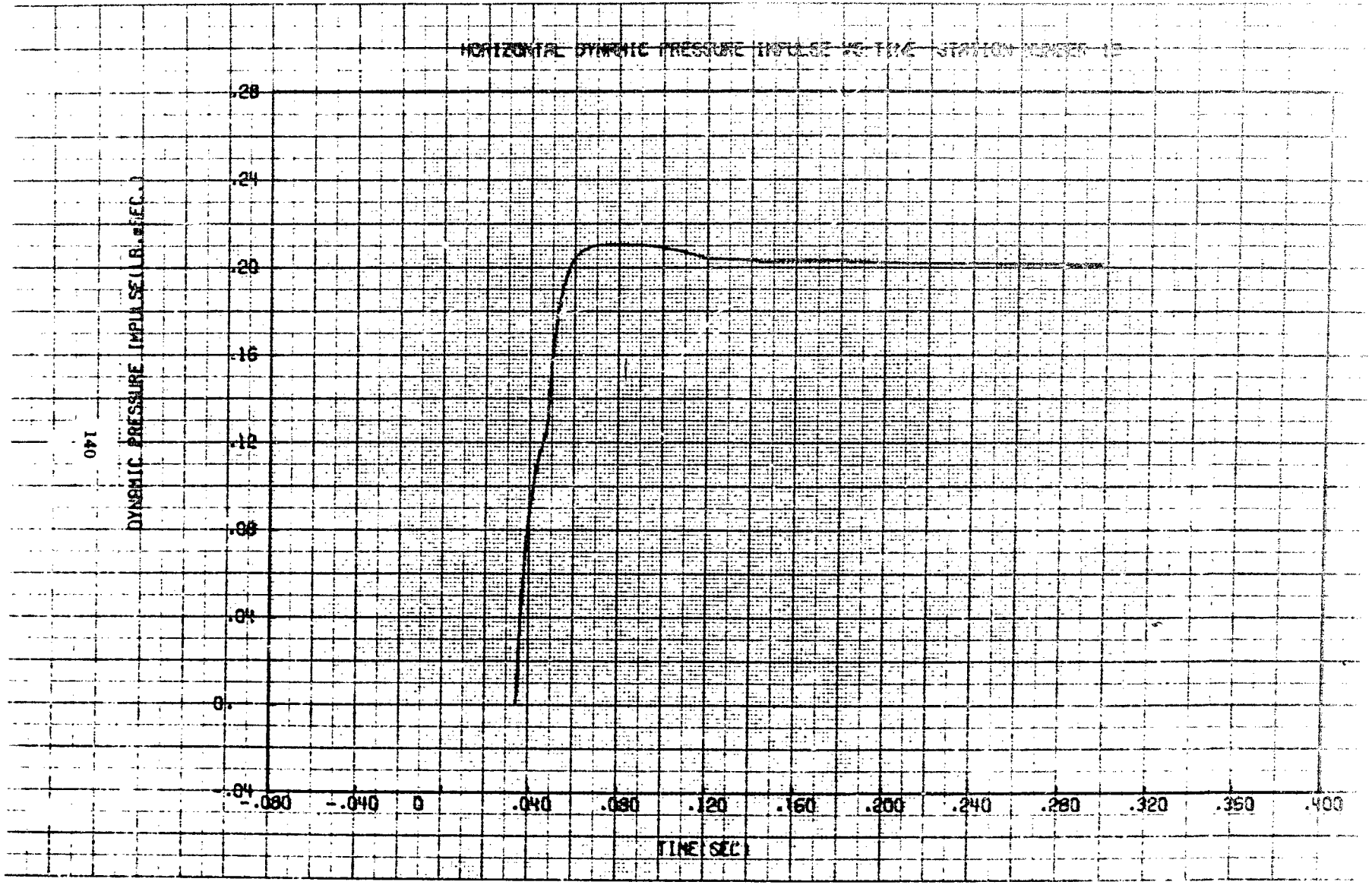

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME - STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE (LB.-SEC./
.32
.28
.24
.20
.16
.12
.08
.04
0
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

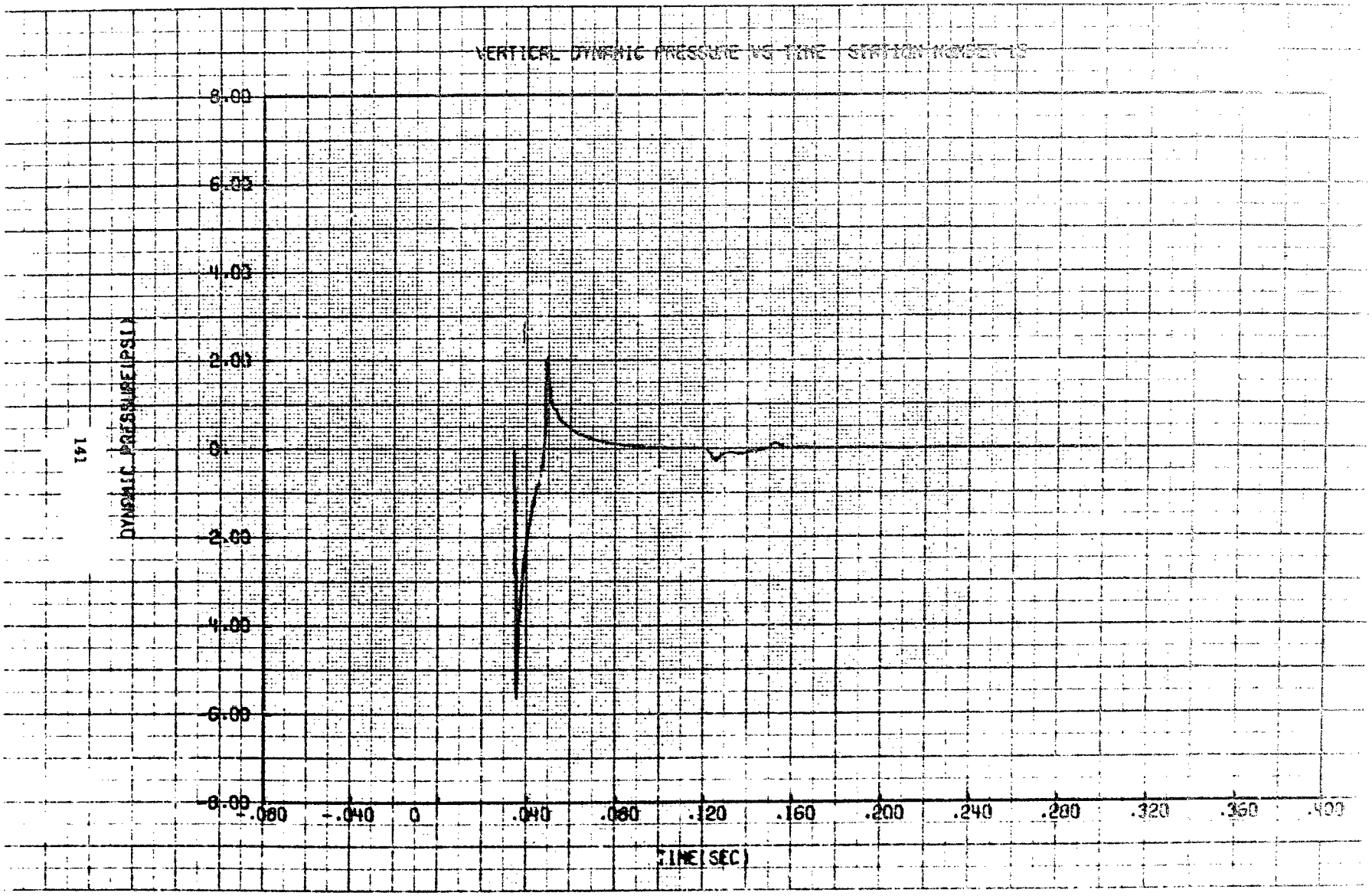

OVER PRESSURE VS TIME STATION NUMBER 13
50.00
40.00
30.00
20.00
10.00
0
-10.00
-20.00
OVER PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

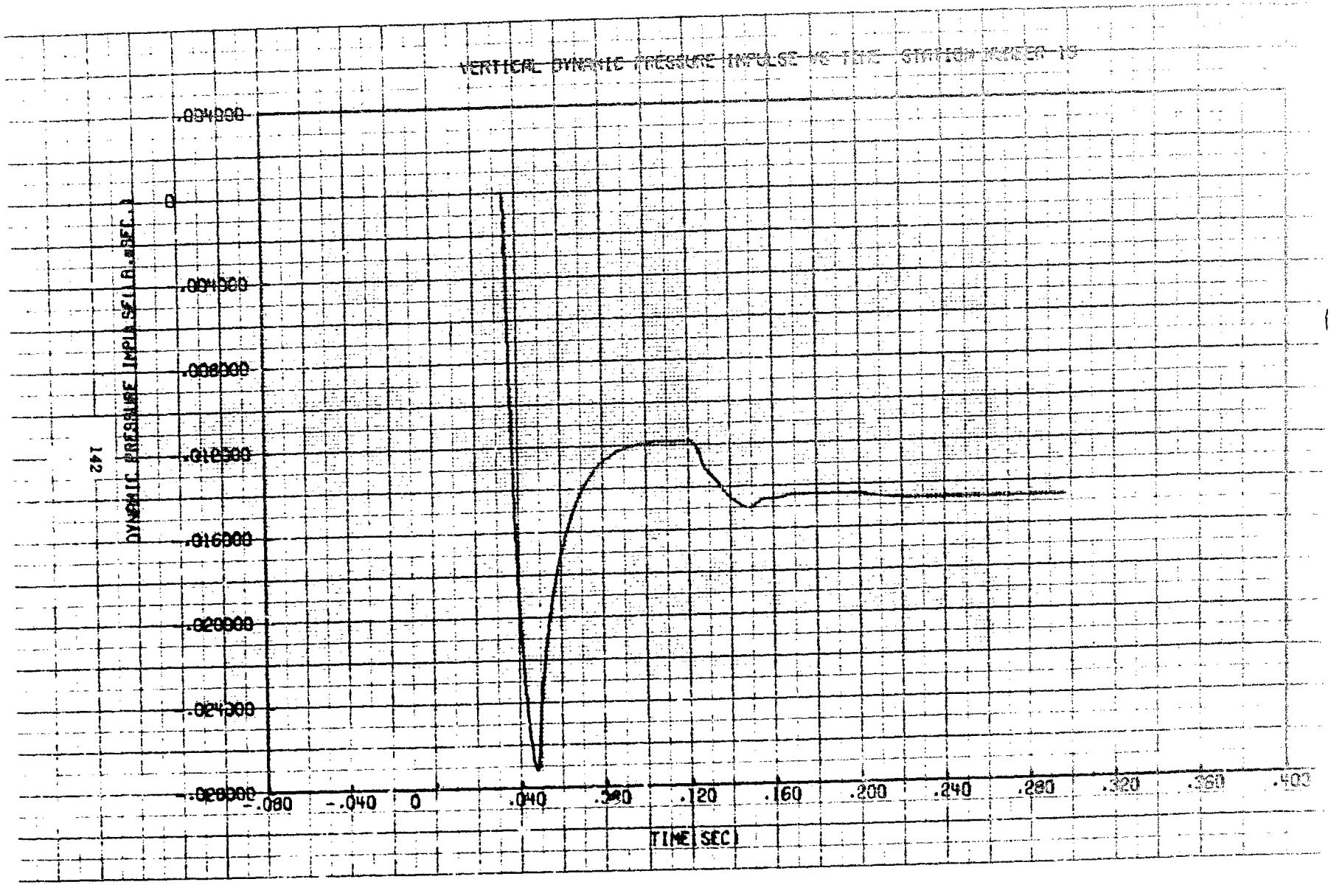

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 13
OVER PRESSURE IMPULSE(LB.mSEC.)
136
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

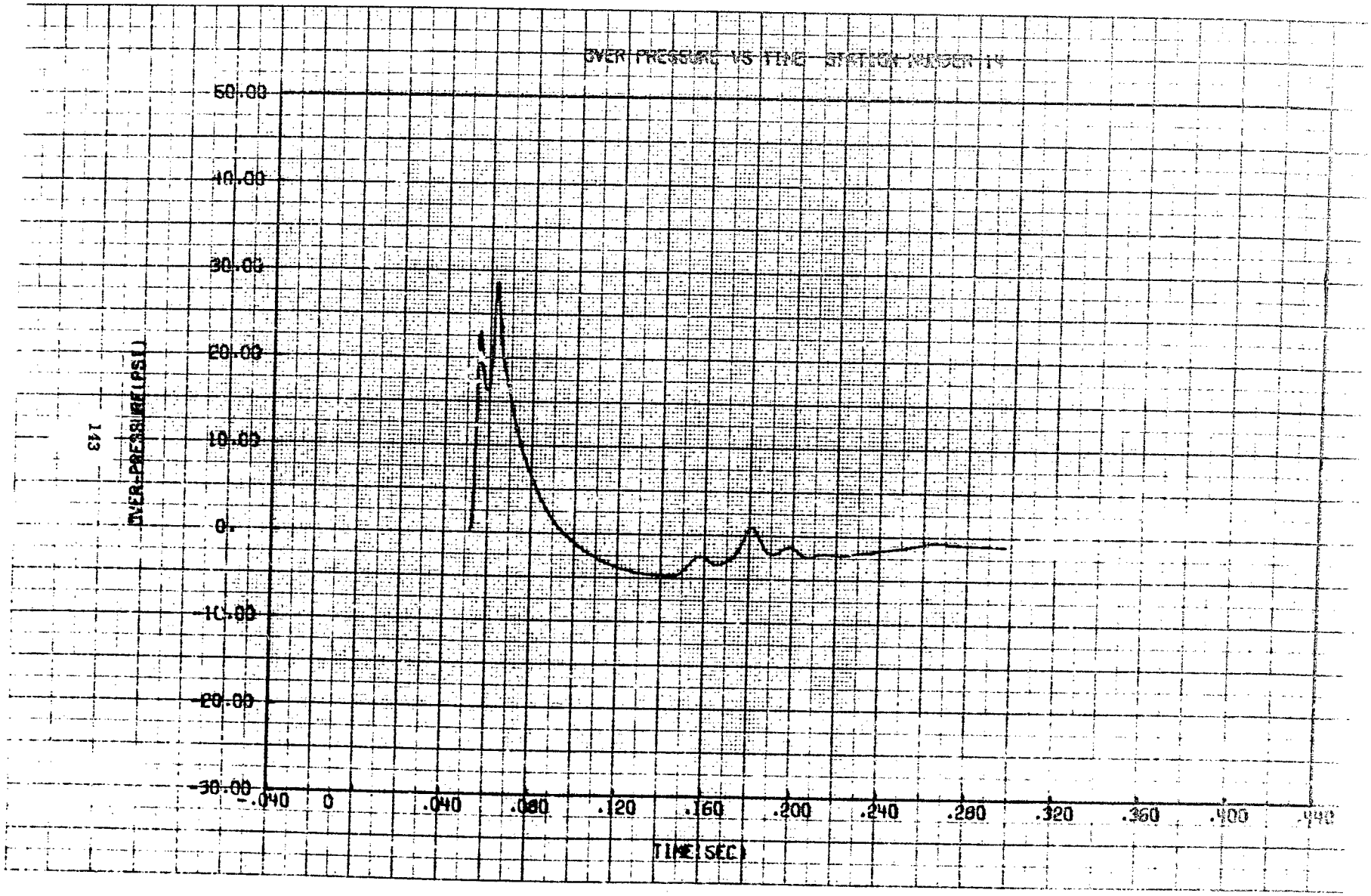

HORIZONTAL COMPONENT VELOCITY VS TIME SECTION NUMBER 15
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED FT/SEC
137
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

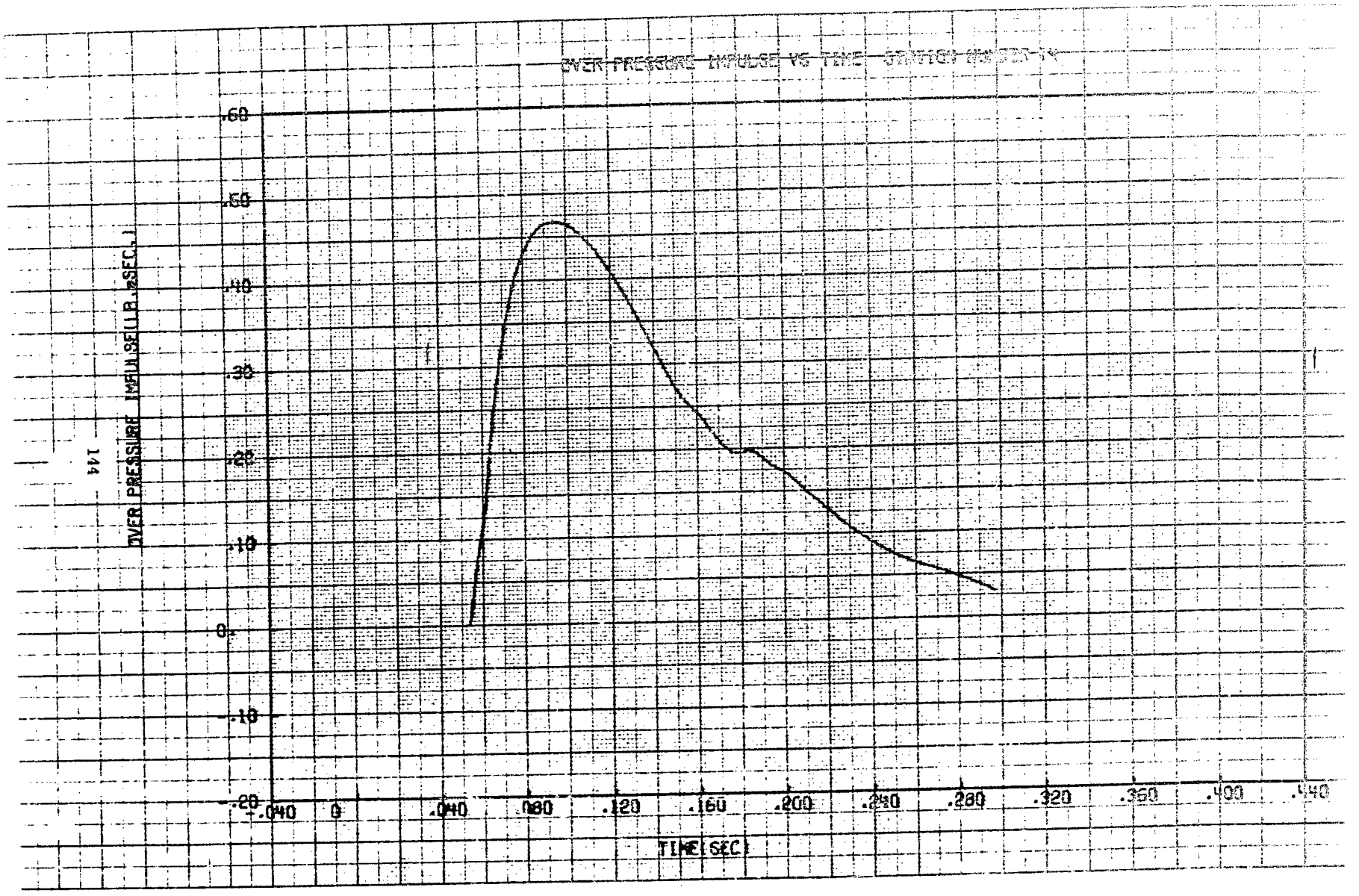
HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NO. 2
DYNAMIC PRESSURE(PSIA)
TIME(SEC)
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

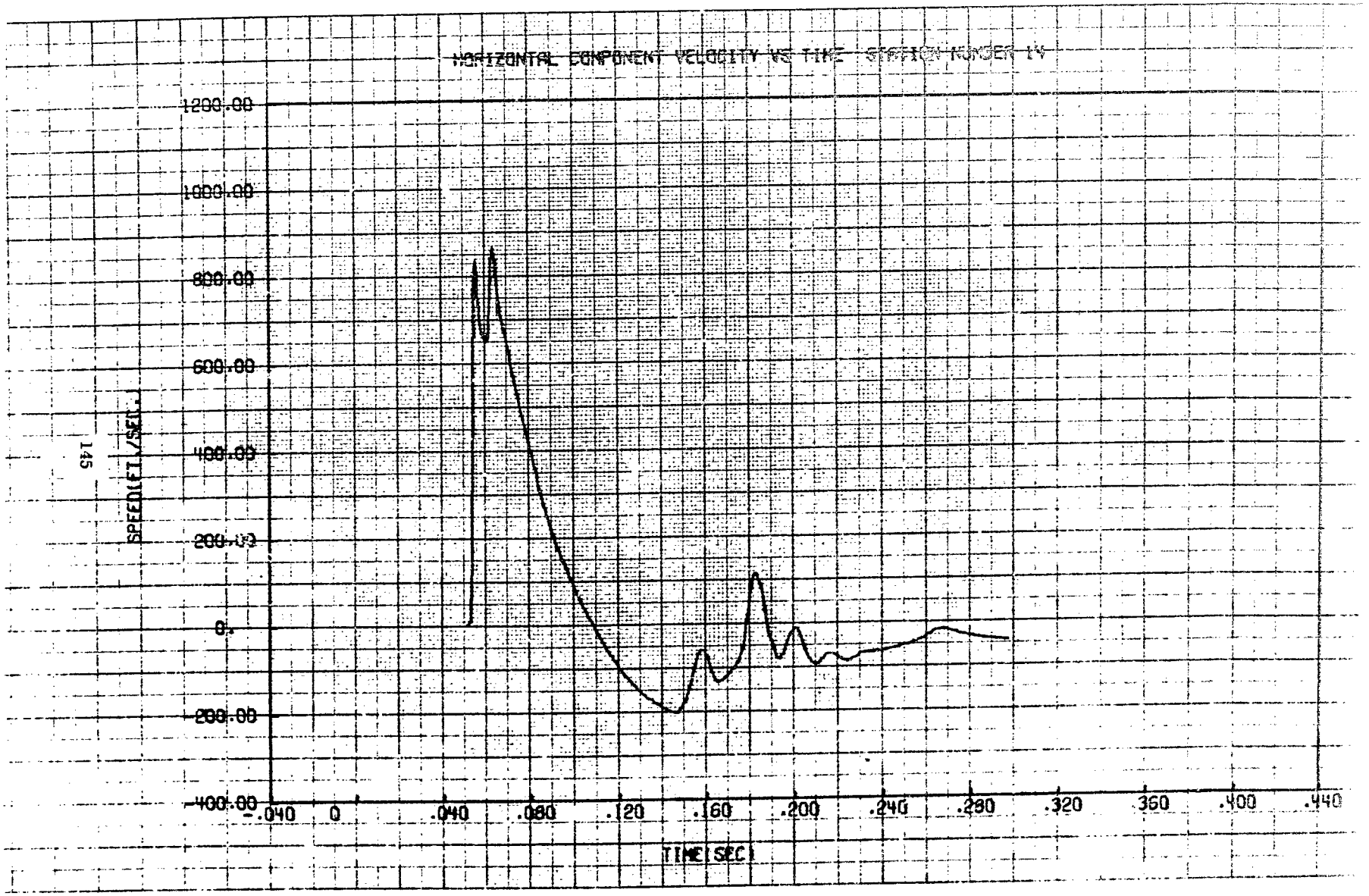

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE (LB.-SEC./FT.²)
140
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC.)

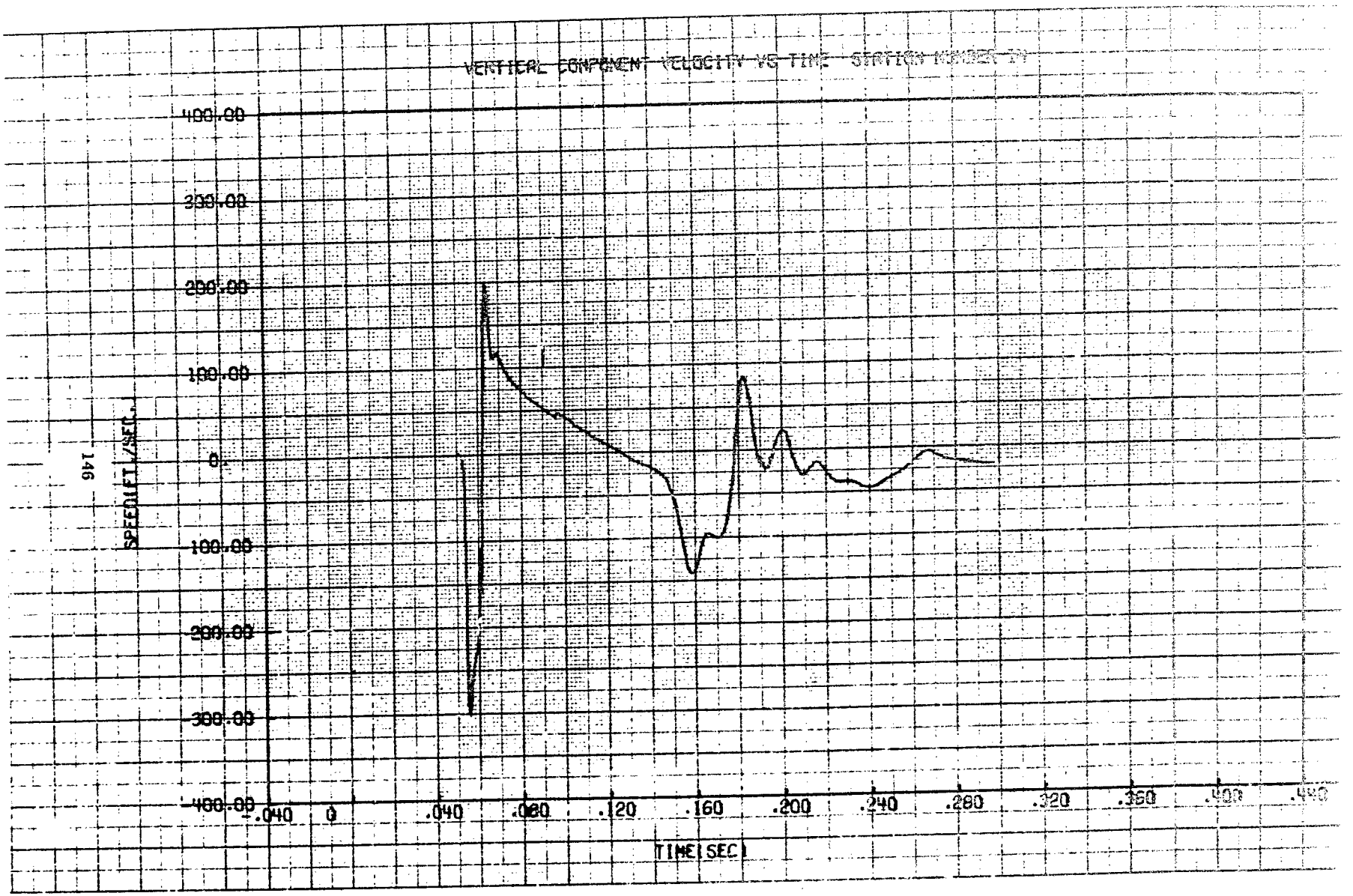

VERTICAL DYNAMIC PRESSURE VS TIME STATION NO.2E-1S
8.00
6.00
4.00
2.00
0
-2.00
-4.00
-6.00
-8.00
DYNAMIC PRESSURE(PSIA)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

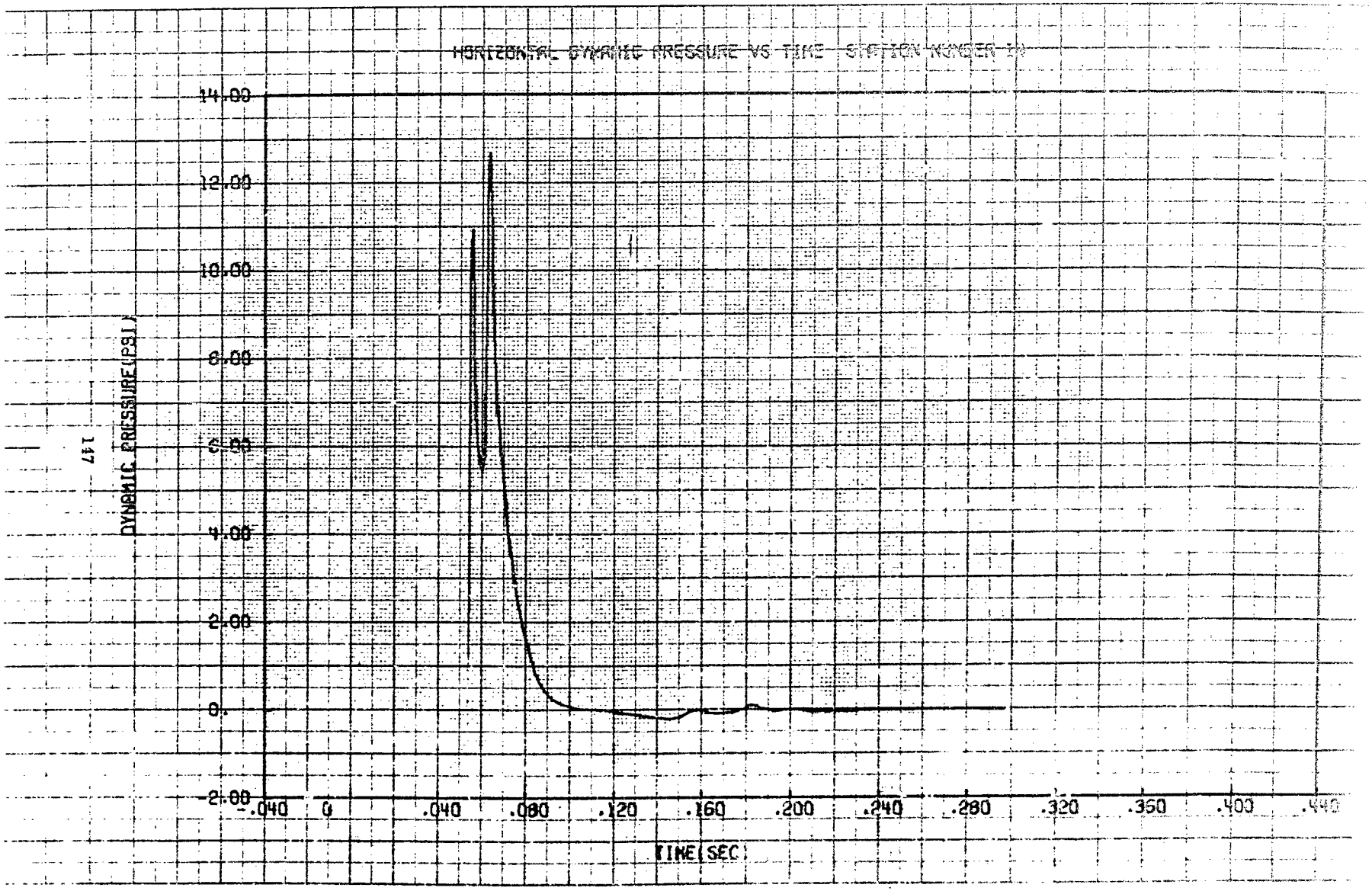

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 19
DYNAMIC PRESSURE IMPULSE (LB./SEC.)
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.028000
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
142

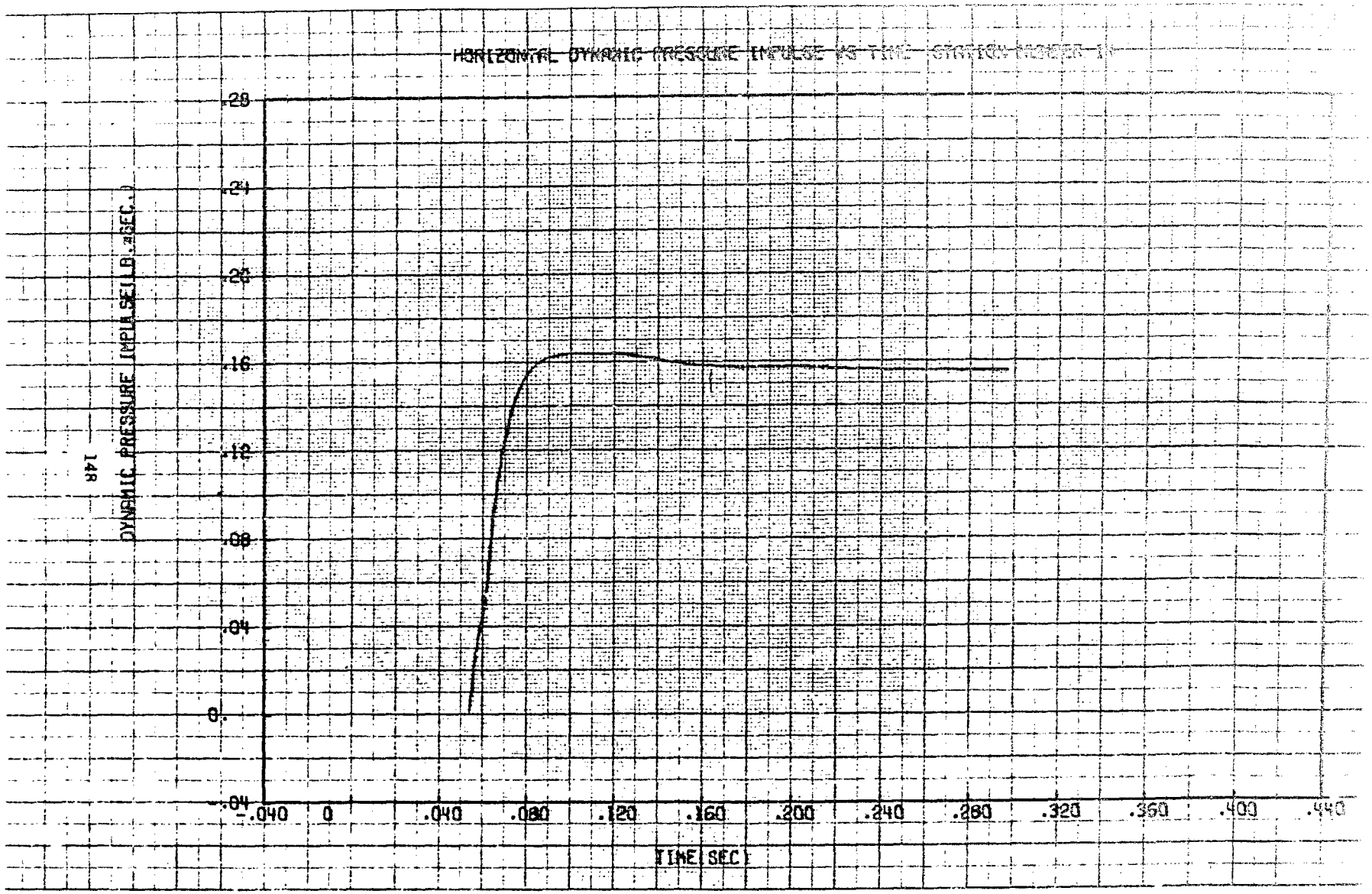

OVER PRESSURE VS TIME STATION NUMBER 14
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
OVER-PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

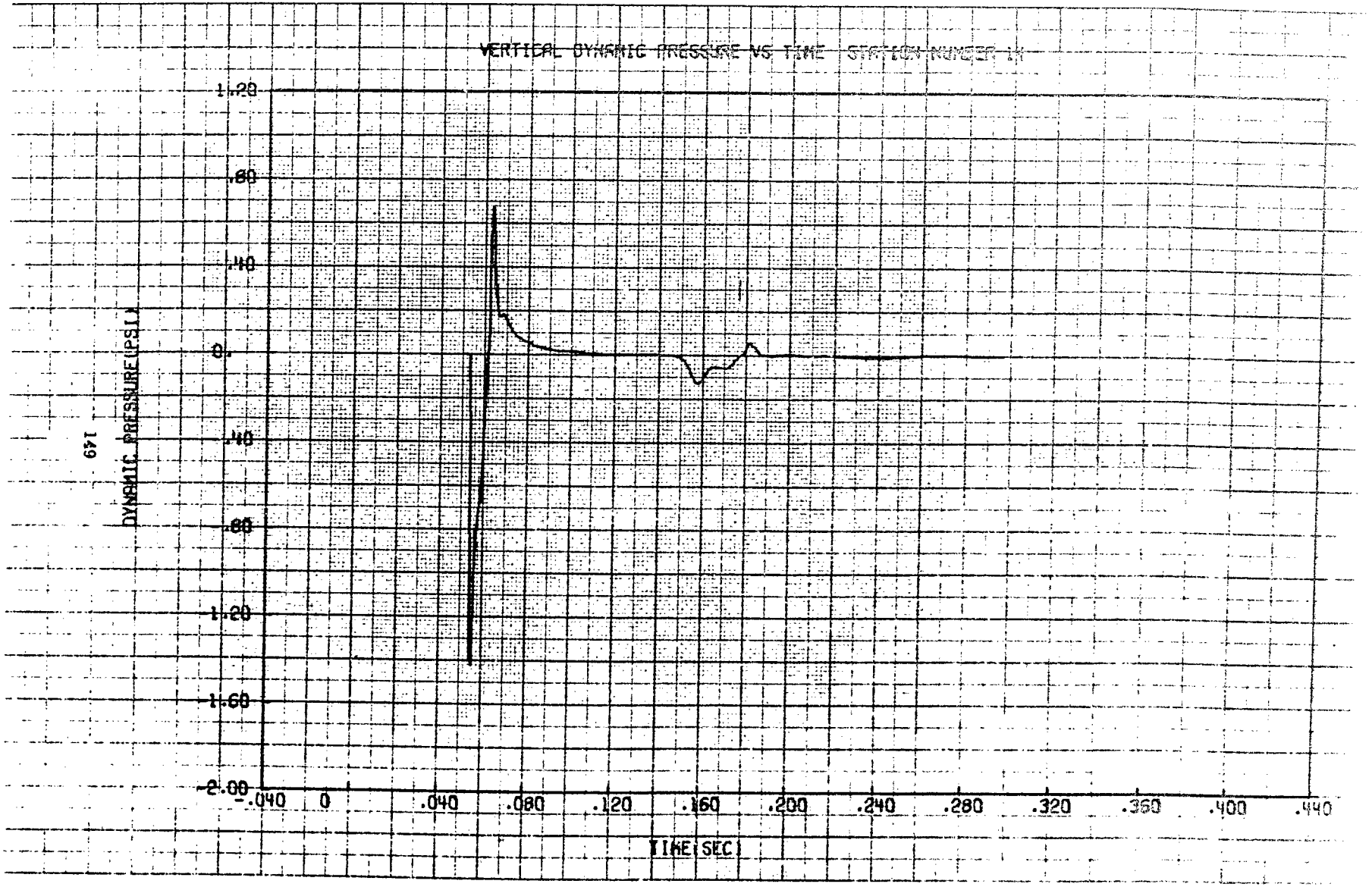

OVER PRESSURE IMPULSE VS TIME
.60
.50
.40
.30
.20
.10
0
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)
OVER PRESSURE IMPULSE(LB.-SEC./
144


HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 14
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

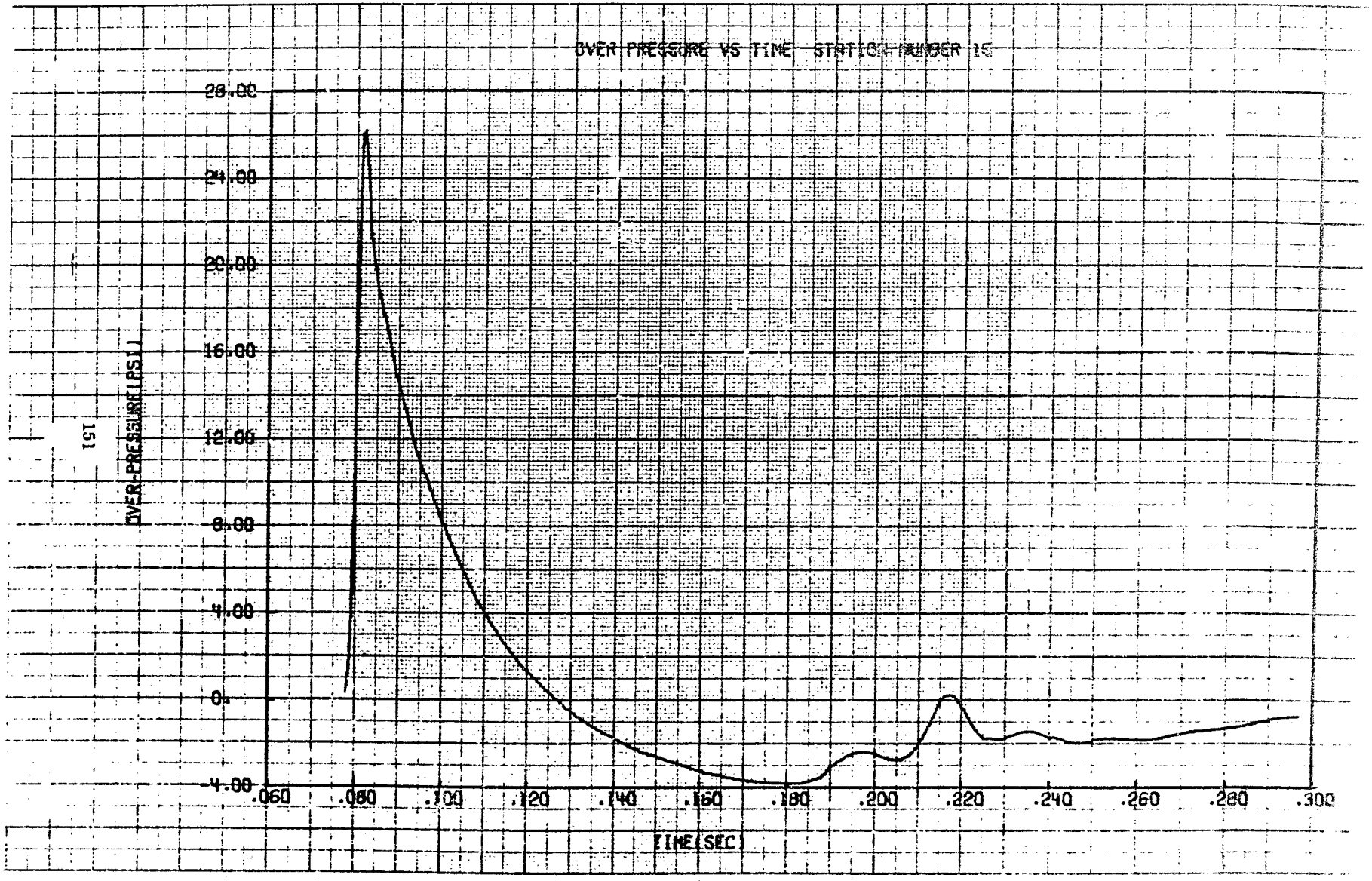

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 27
400.00
300.00
200.00
100.00
0
-100.00
-200.00
-300.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

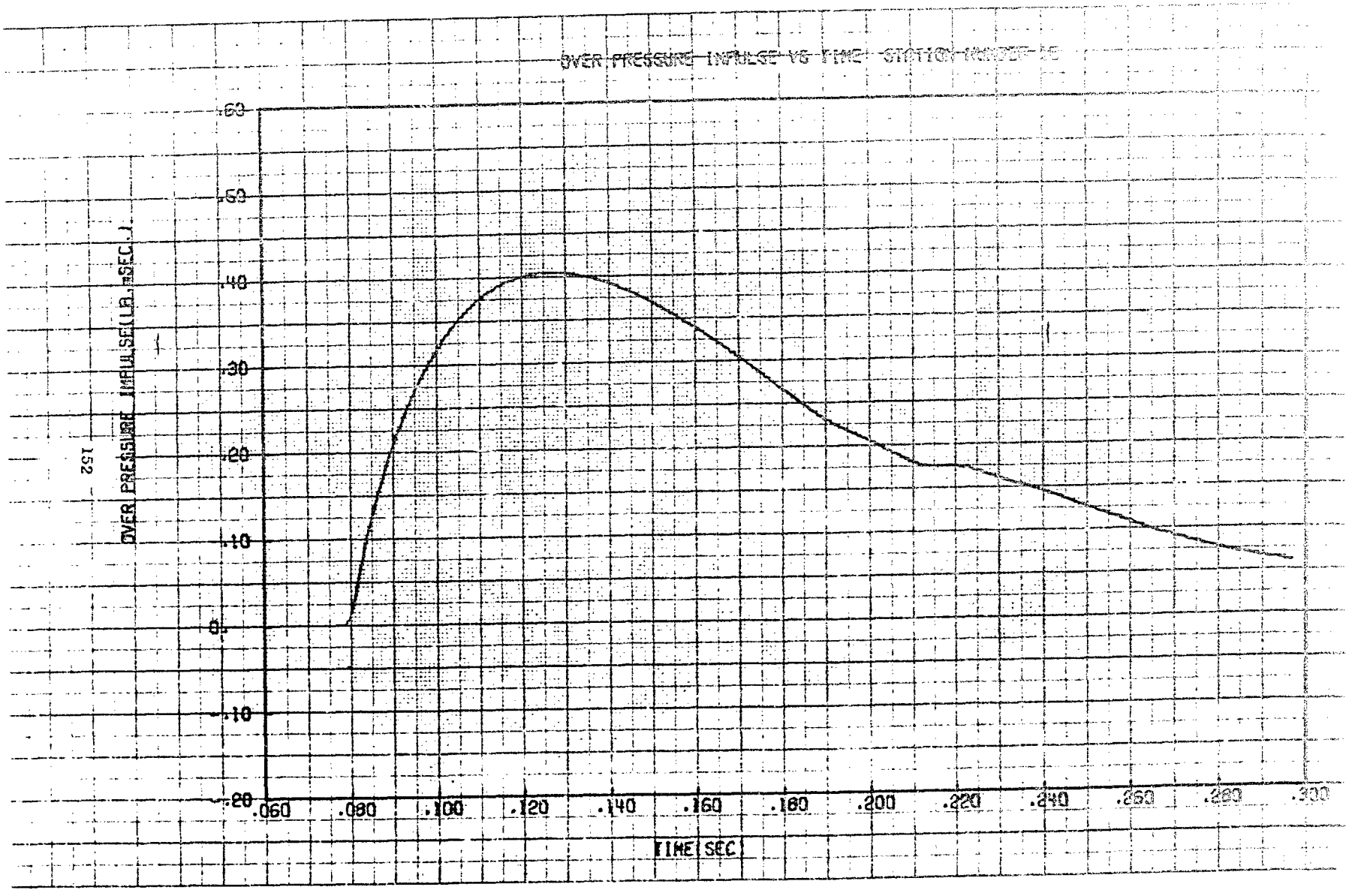

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

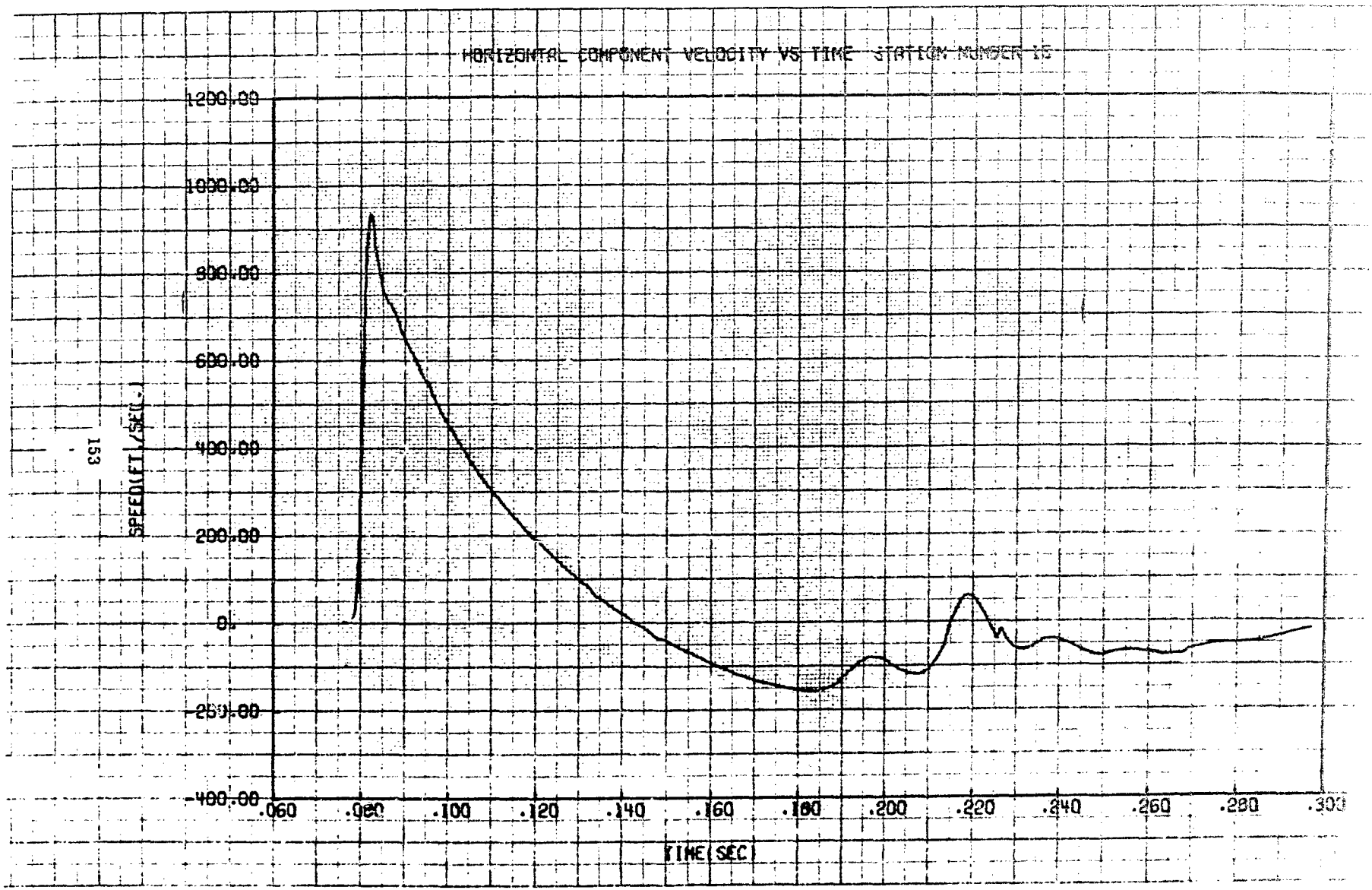

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE (LB.SEC/LB.SEC.)
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

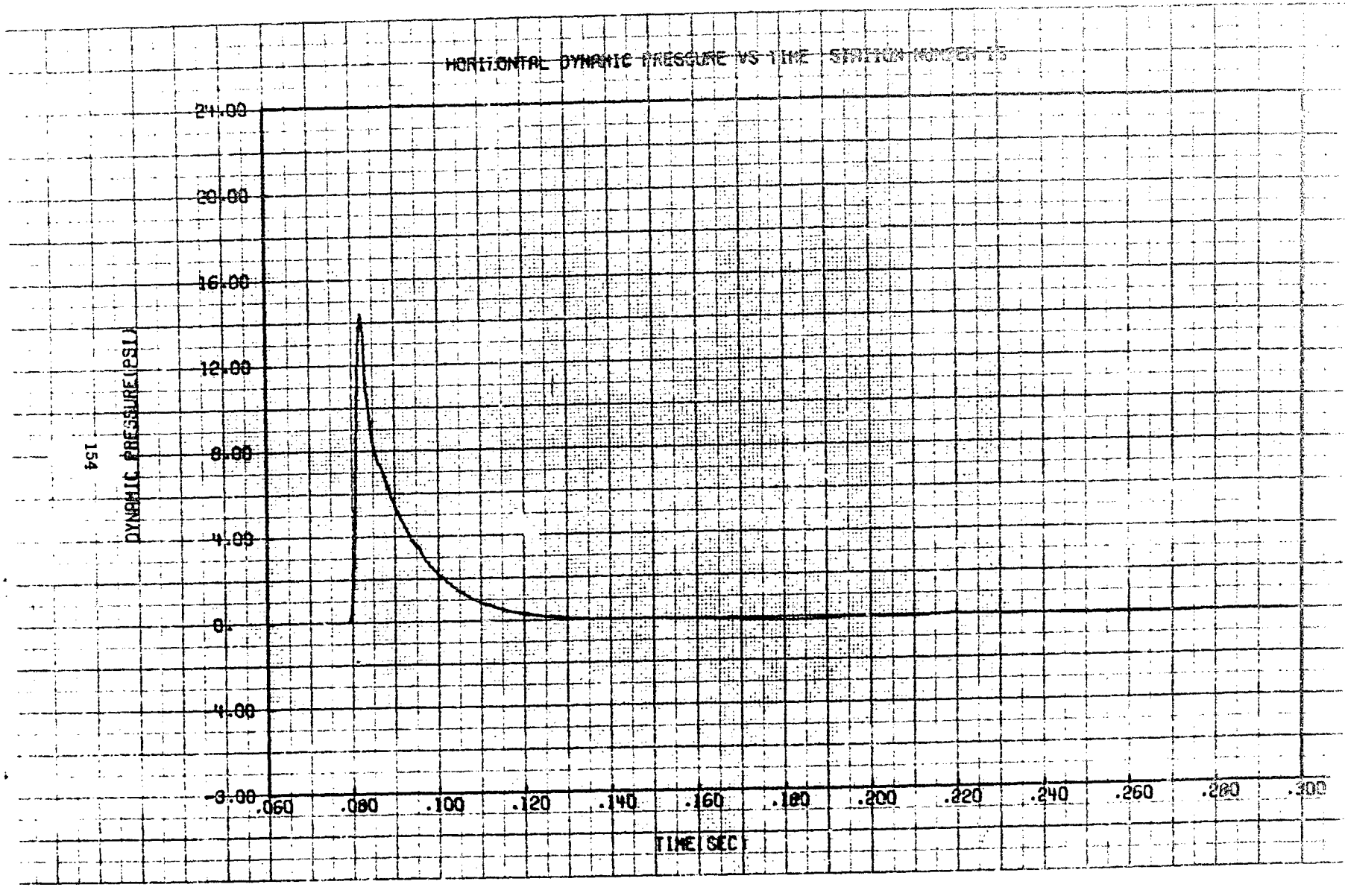

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 14
1.20
.80
.40
0.
-.40
-.80
-1.20
-1.60
-2.00
DYNAMIC PRESSURE(PSIA
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

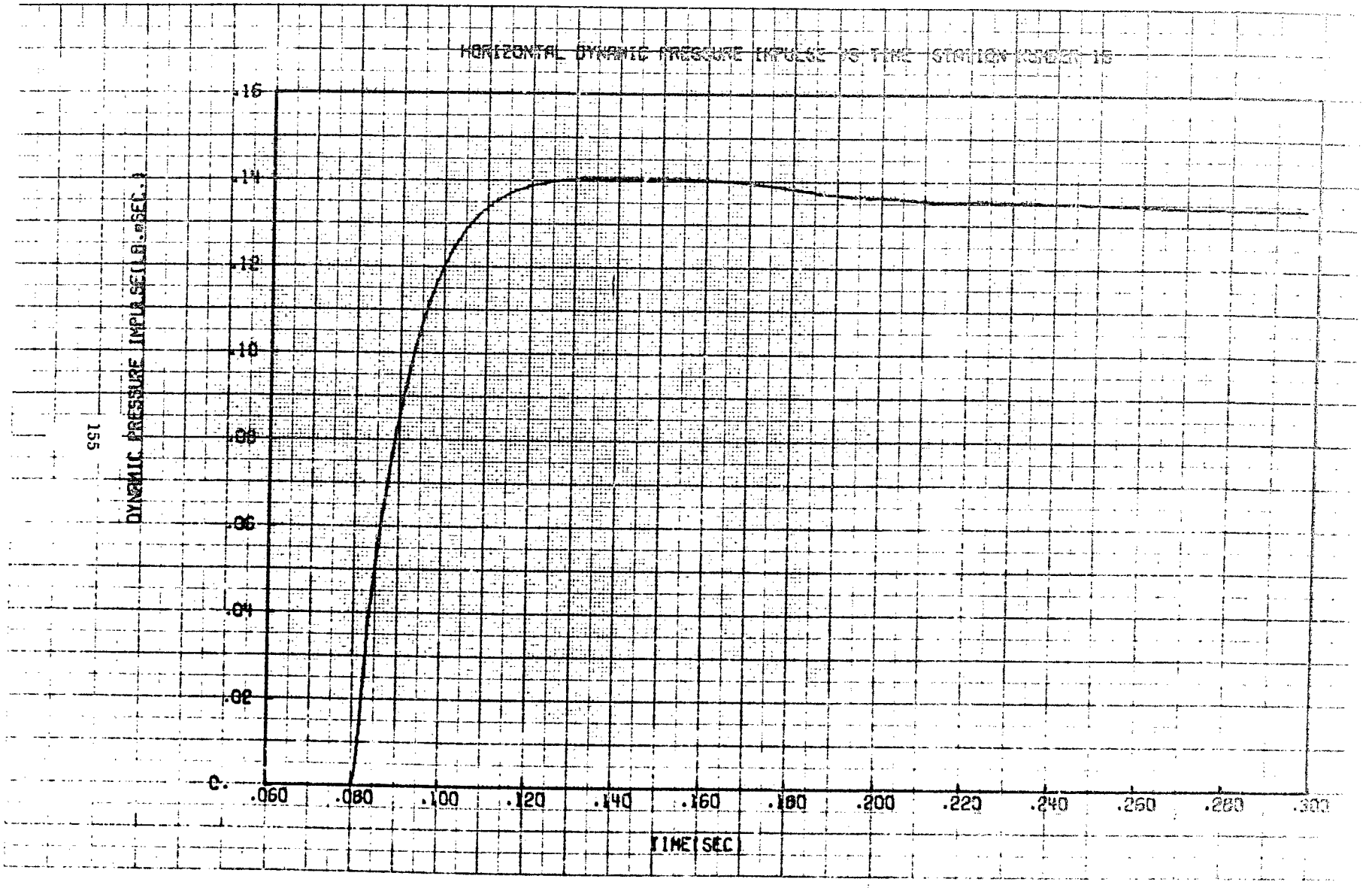
VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION 5
DYNAMIC PRESSURE (MPA.SEC) (LB./IN.²-SEC.)
TIME (SEC)
.020
.010
0
-.010
-.020
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440

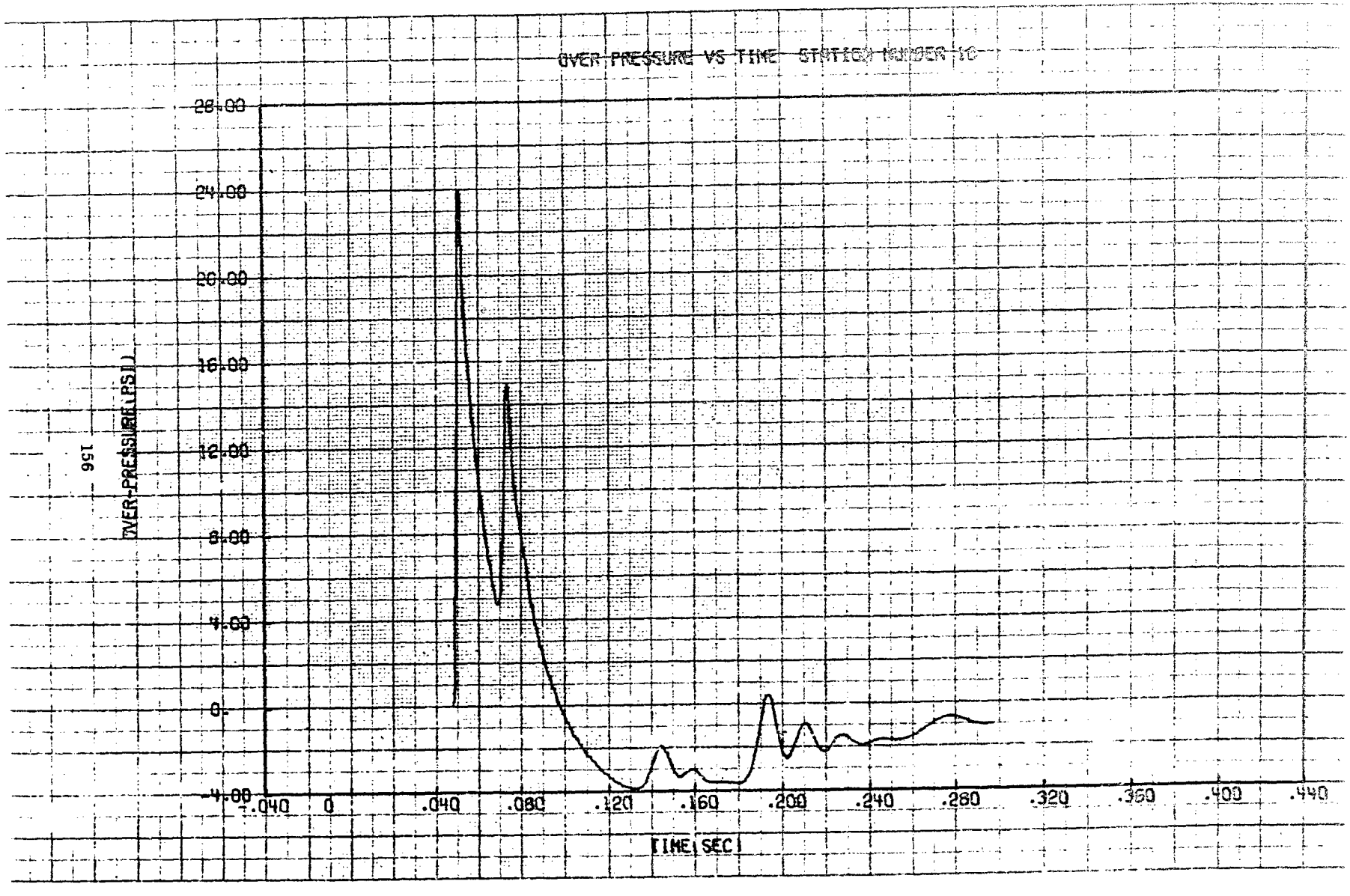

OVER PRESSURE VS TIME STATION NUMBER 15
OVER-PRESSURE(PSI)
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

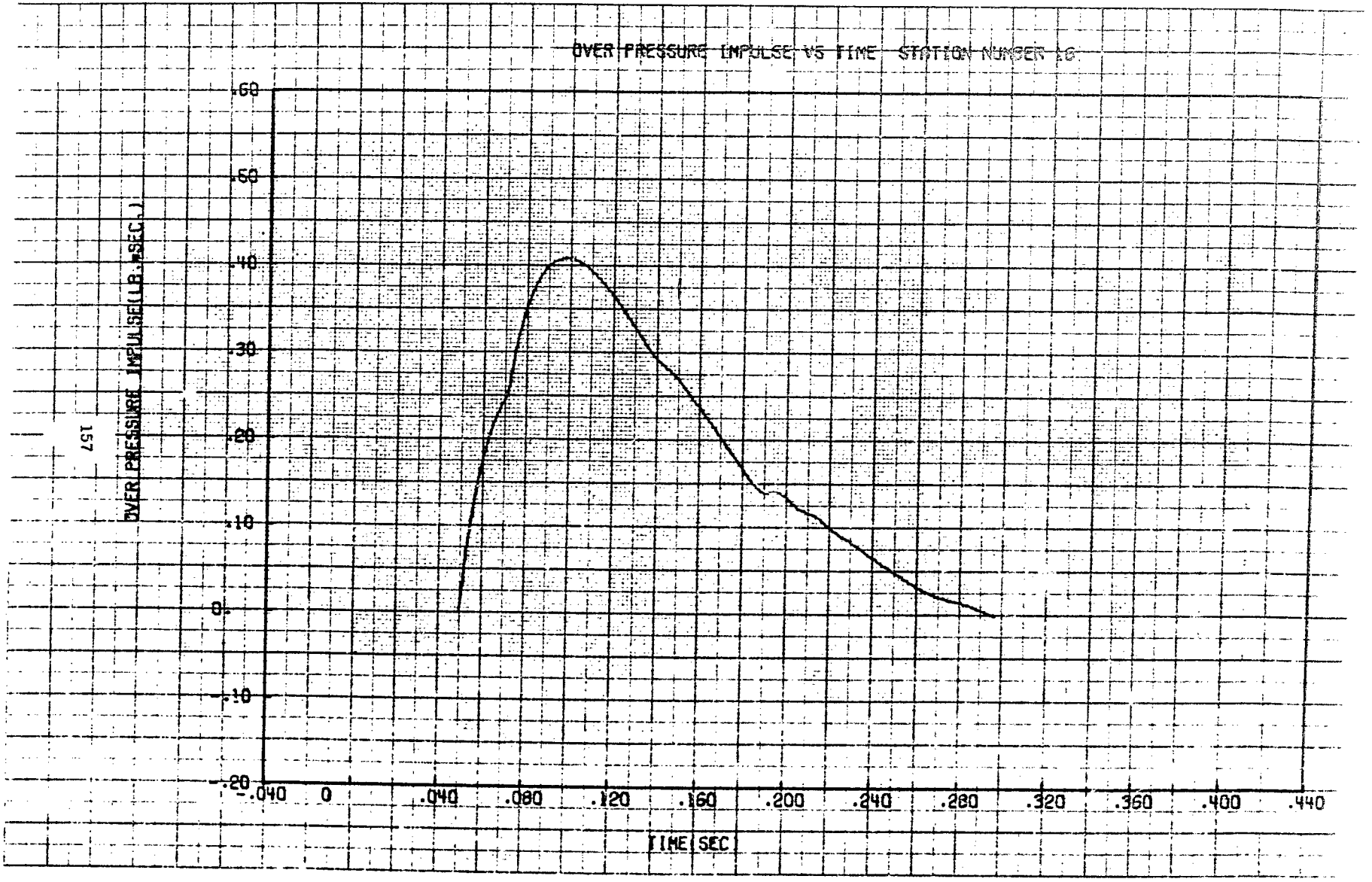

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 15
OVER PRESSURE IMPULSE (LB./SEC.)
.60
.50
.40
.30
.20
.10
0
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

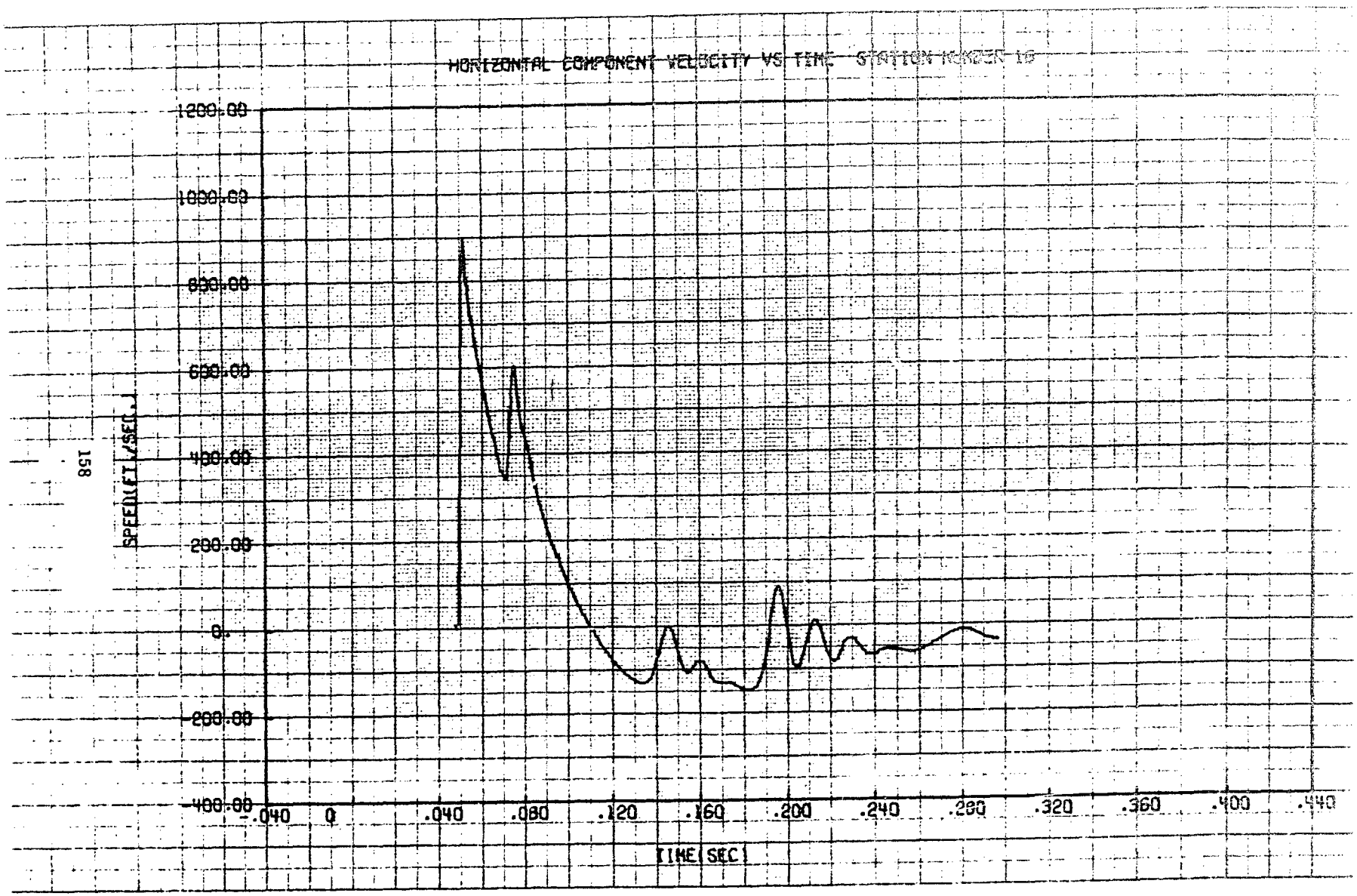

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 15
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

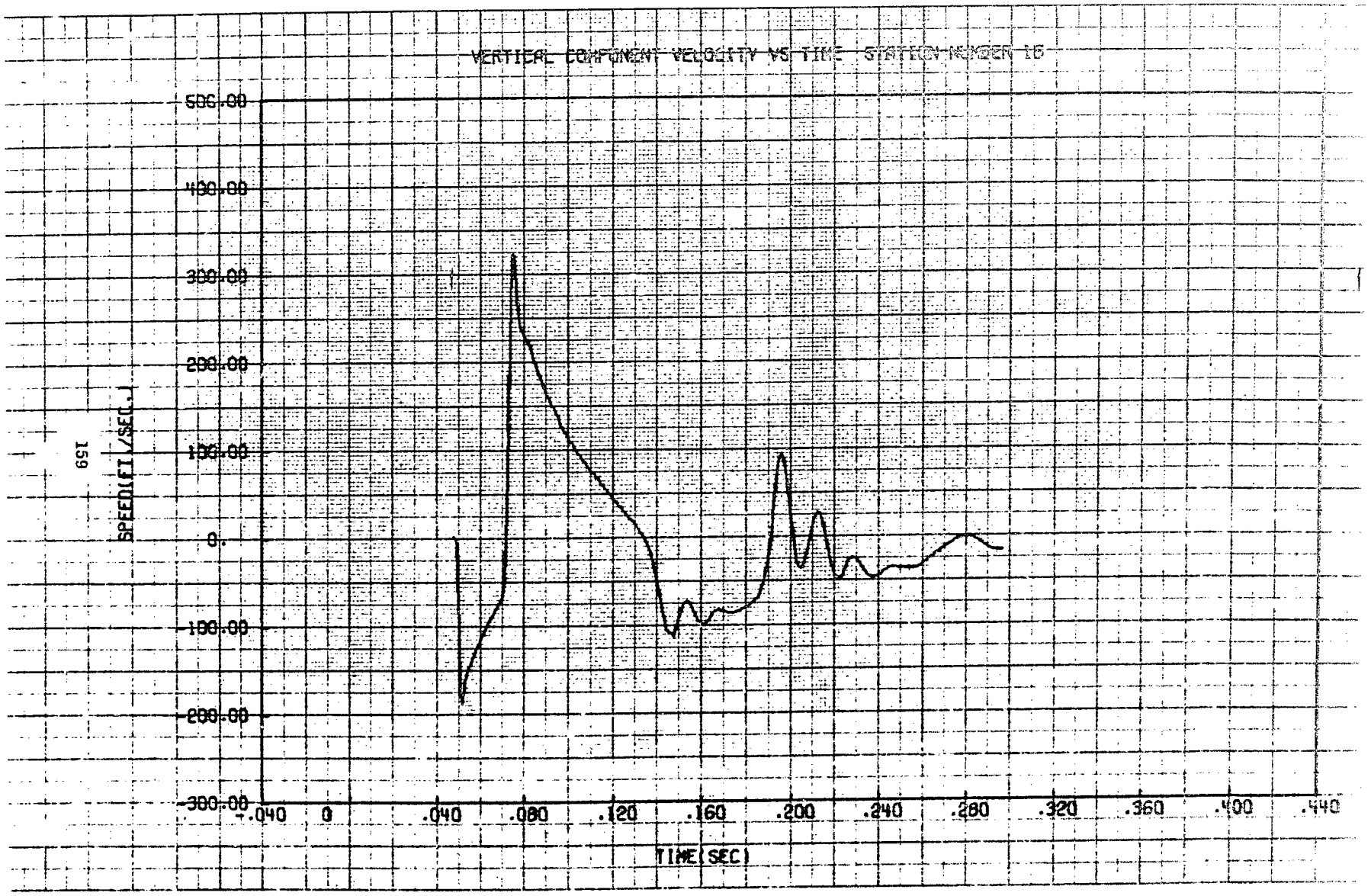

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 15
24.00
20.00
16.00
12.00
8.00
4.00
0.
-3.00
DYNAMIC PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

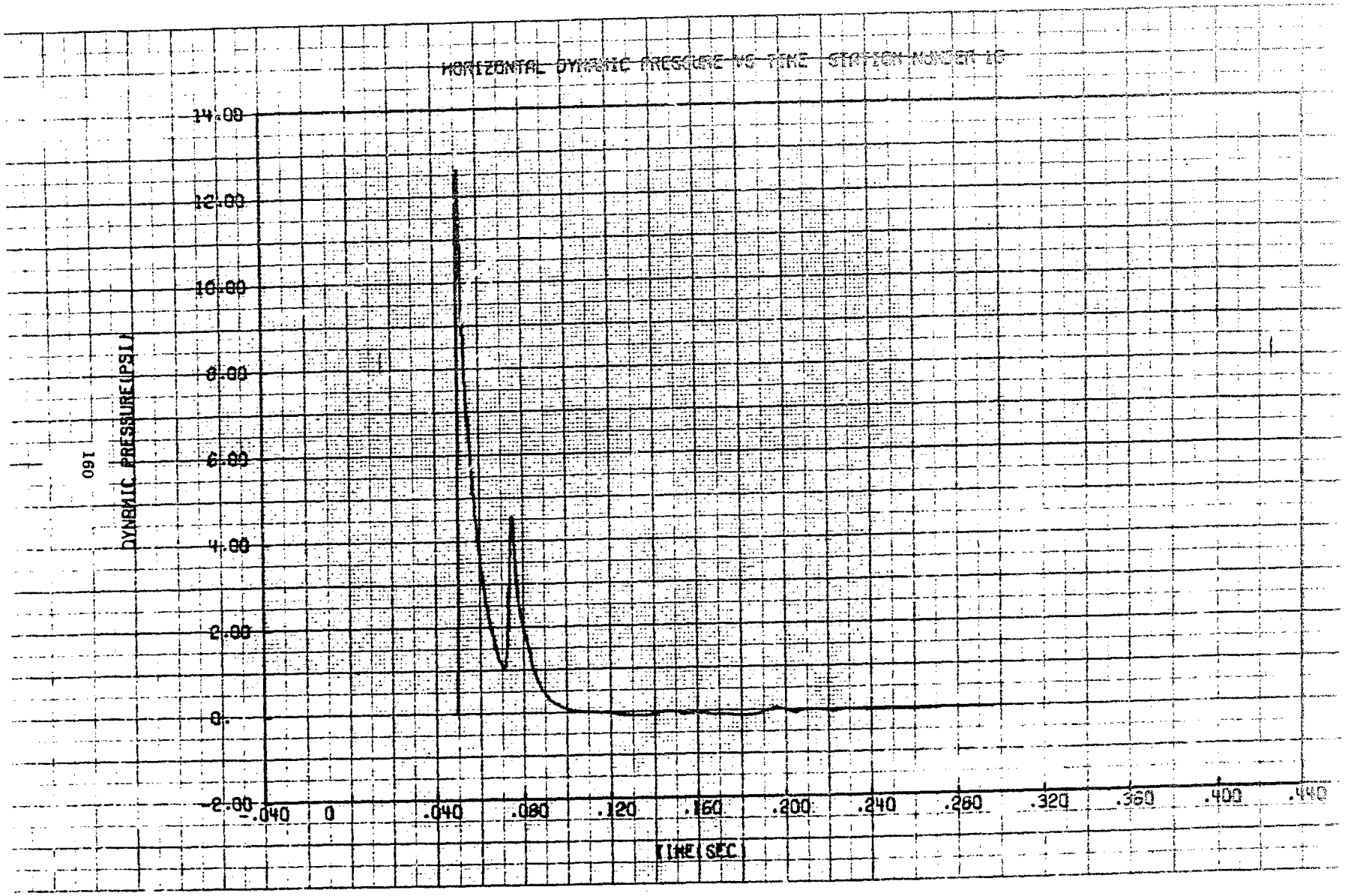

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
155
.16
.14
.12
.10
.08
.06
.04
.02
0.
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

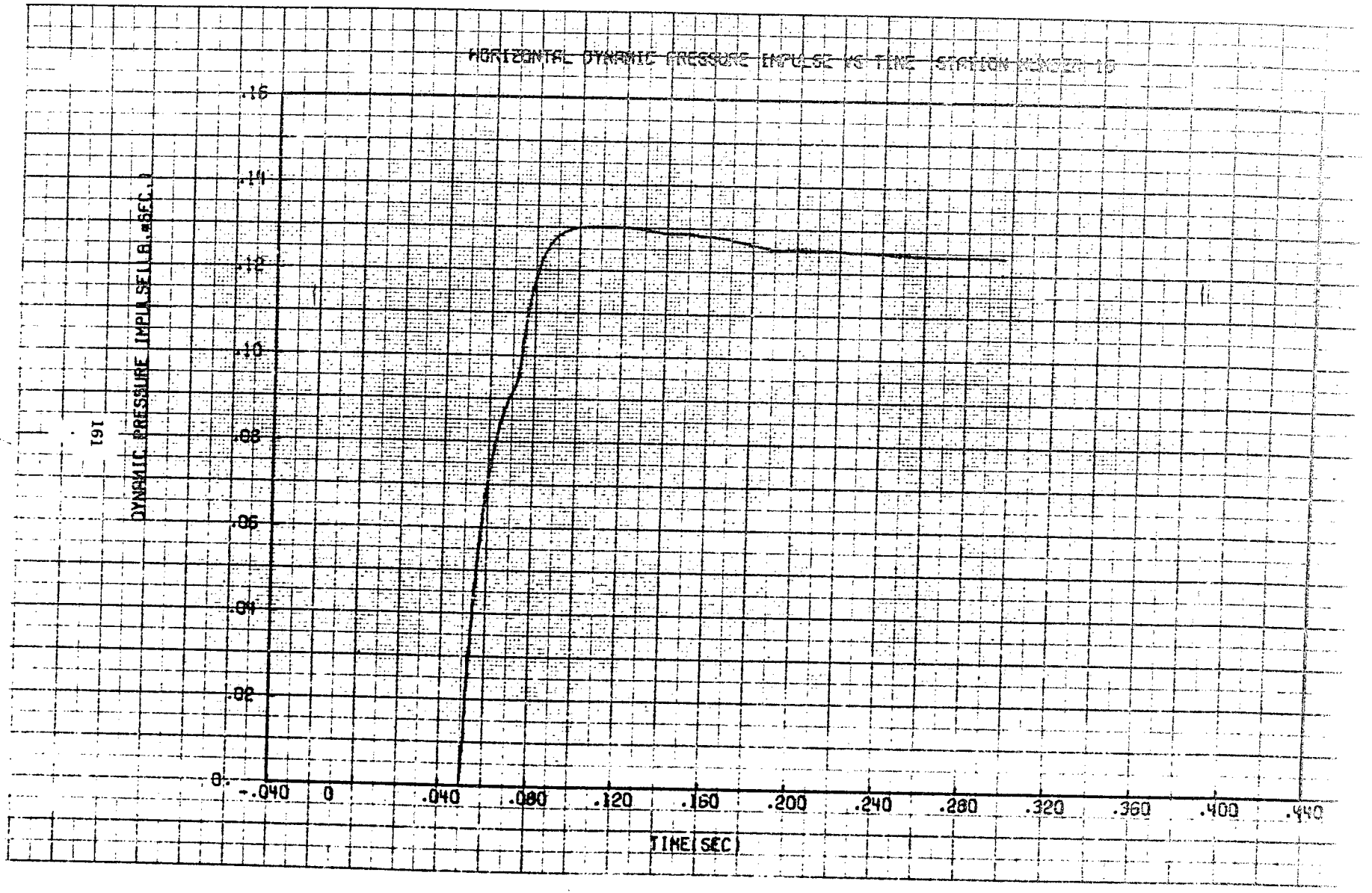

OVER PRESSURE VS TIME STATION NUMBER 10
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0
-4.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)
OVER-PRESSURE (LBS/SQ IN)

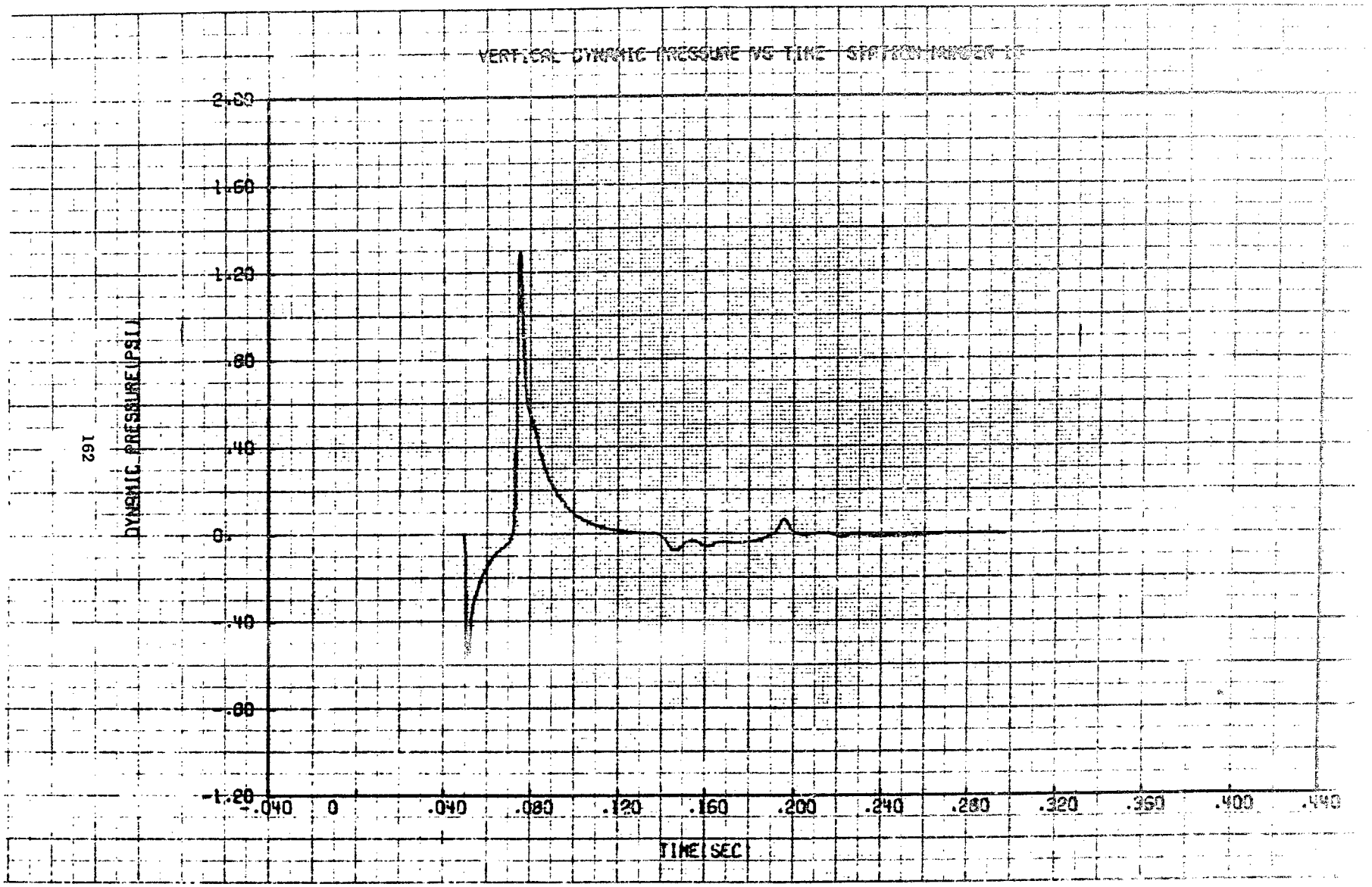

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 16
OVER PRESSURE IMPULSE(LB.-MSEC.)
157
60
50
40
30
20
10
0
-10
-20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

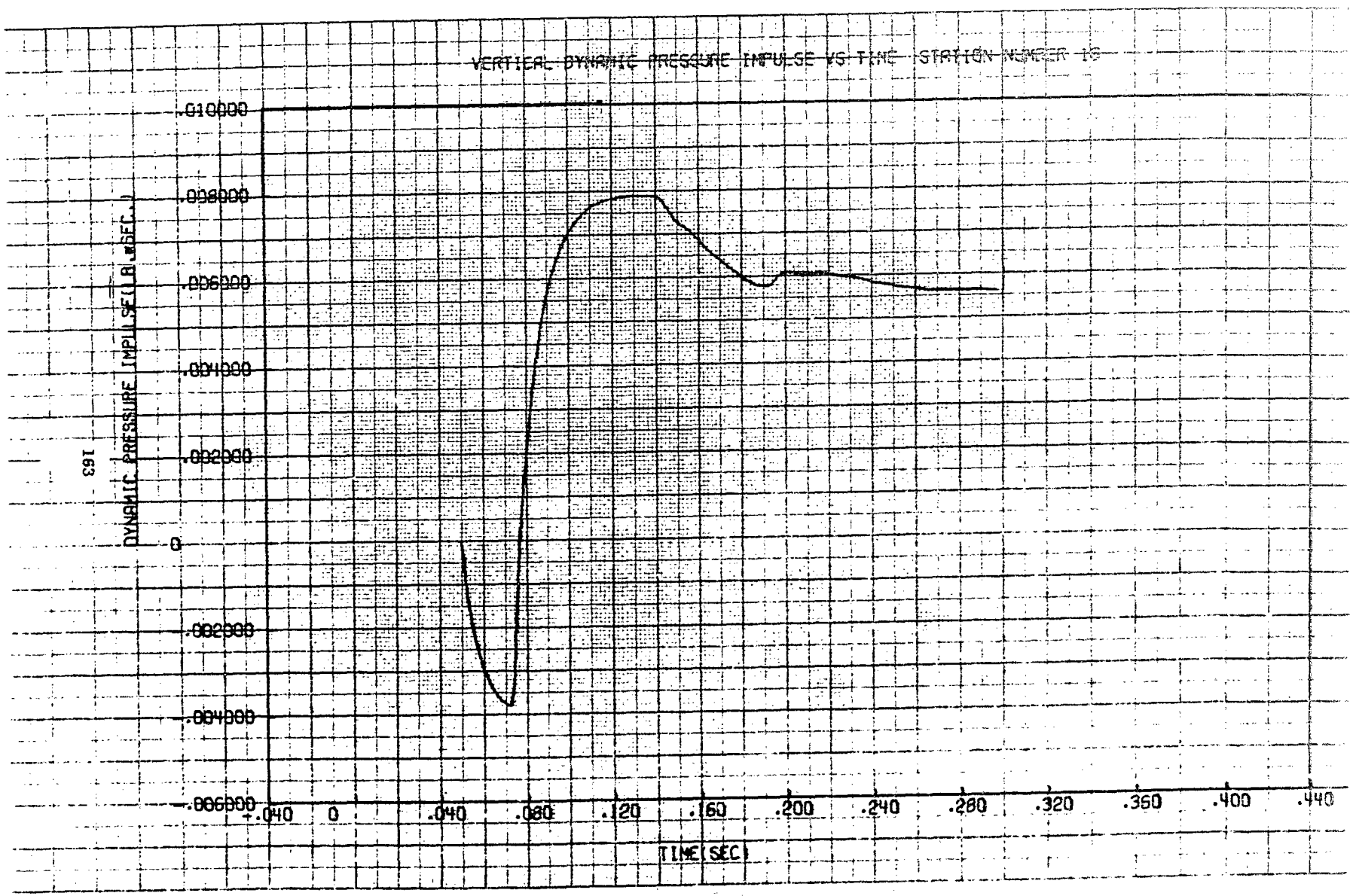

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 16
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

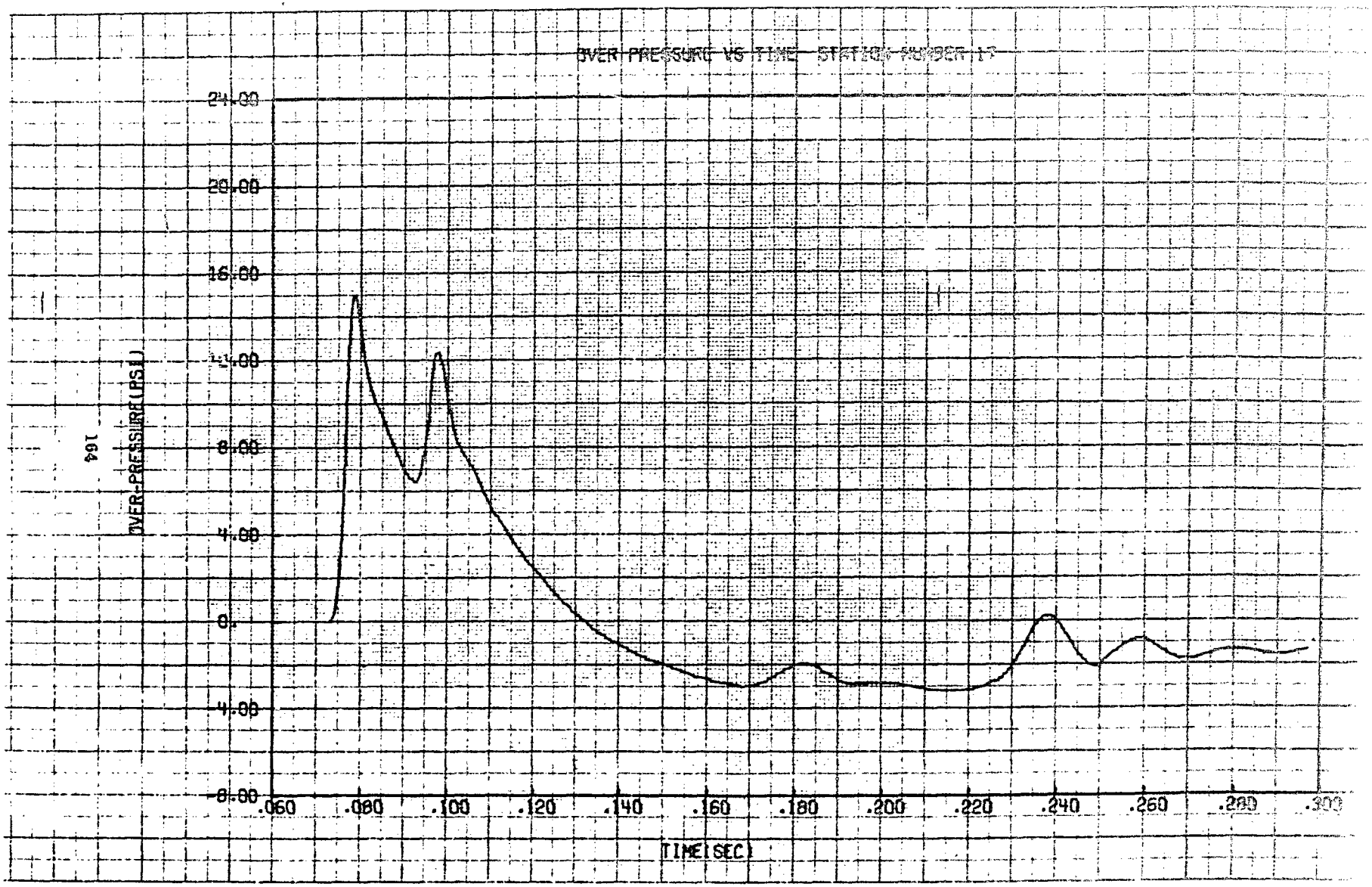

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 16
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
SPEED(FT/SEC.)
159
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

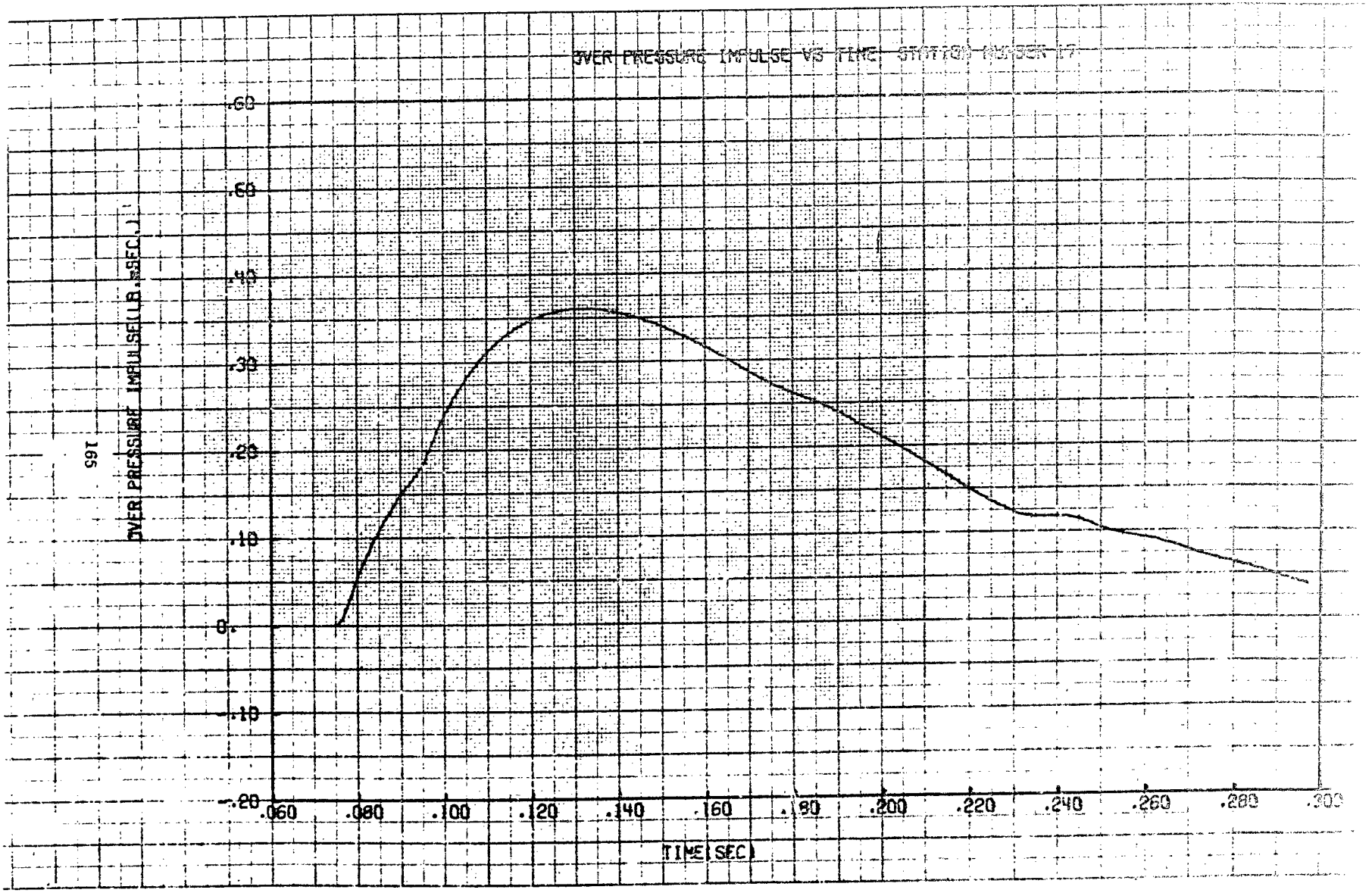

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 16
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
DYNAMIC PRESSURE(PSI)
160
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

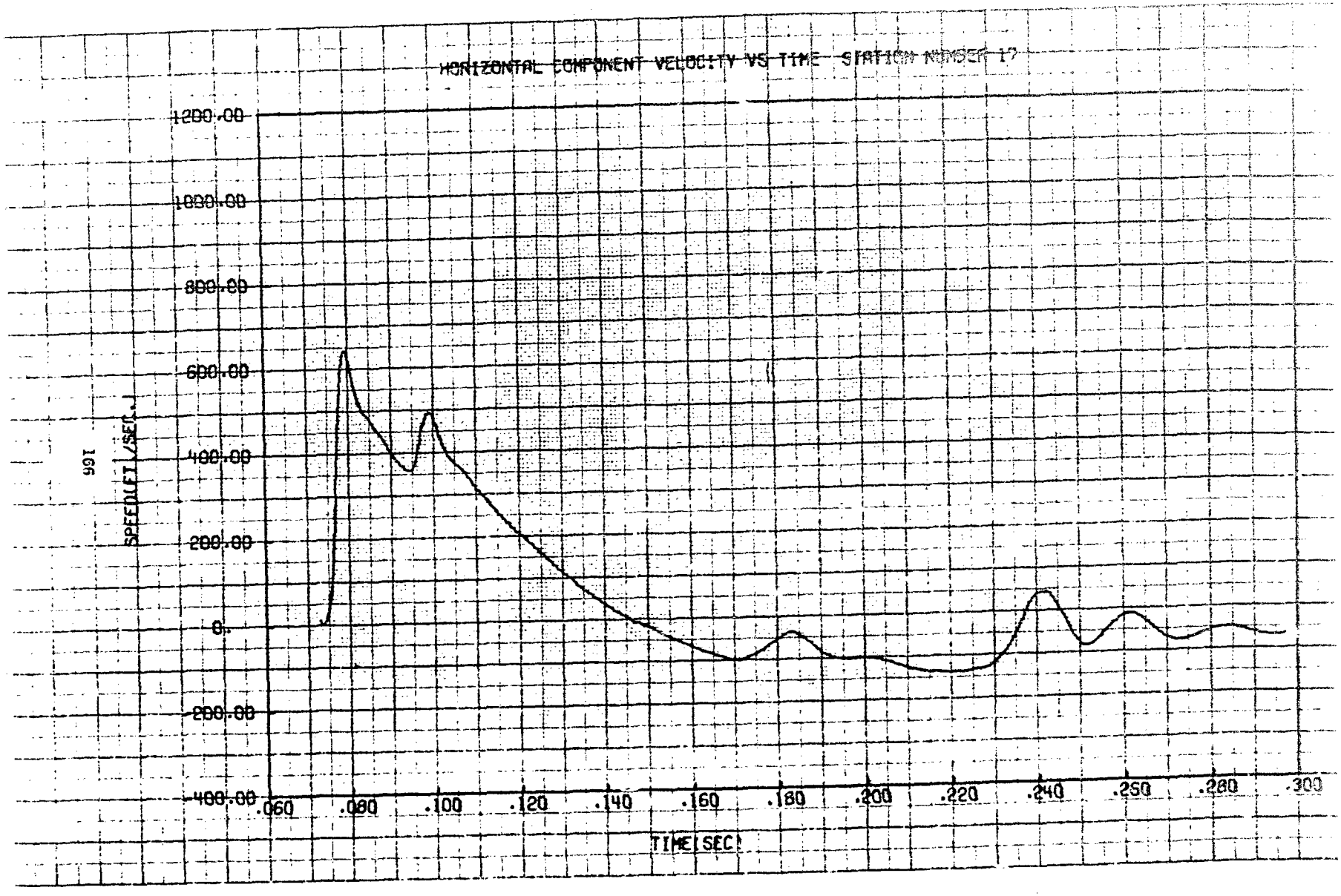

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION KENOZA 10
DYNAMIC PRESSURE IMPULSE (LB./SEC.)
.16
.14
.12
.10
.08
.06
.04
.02
0
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

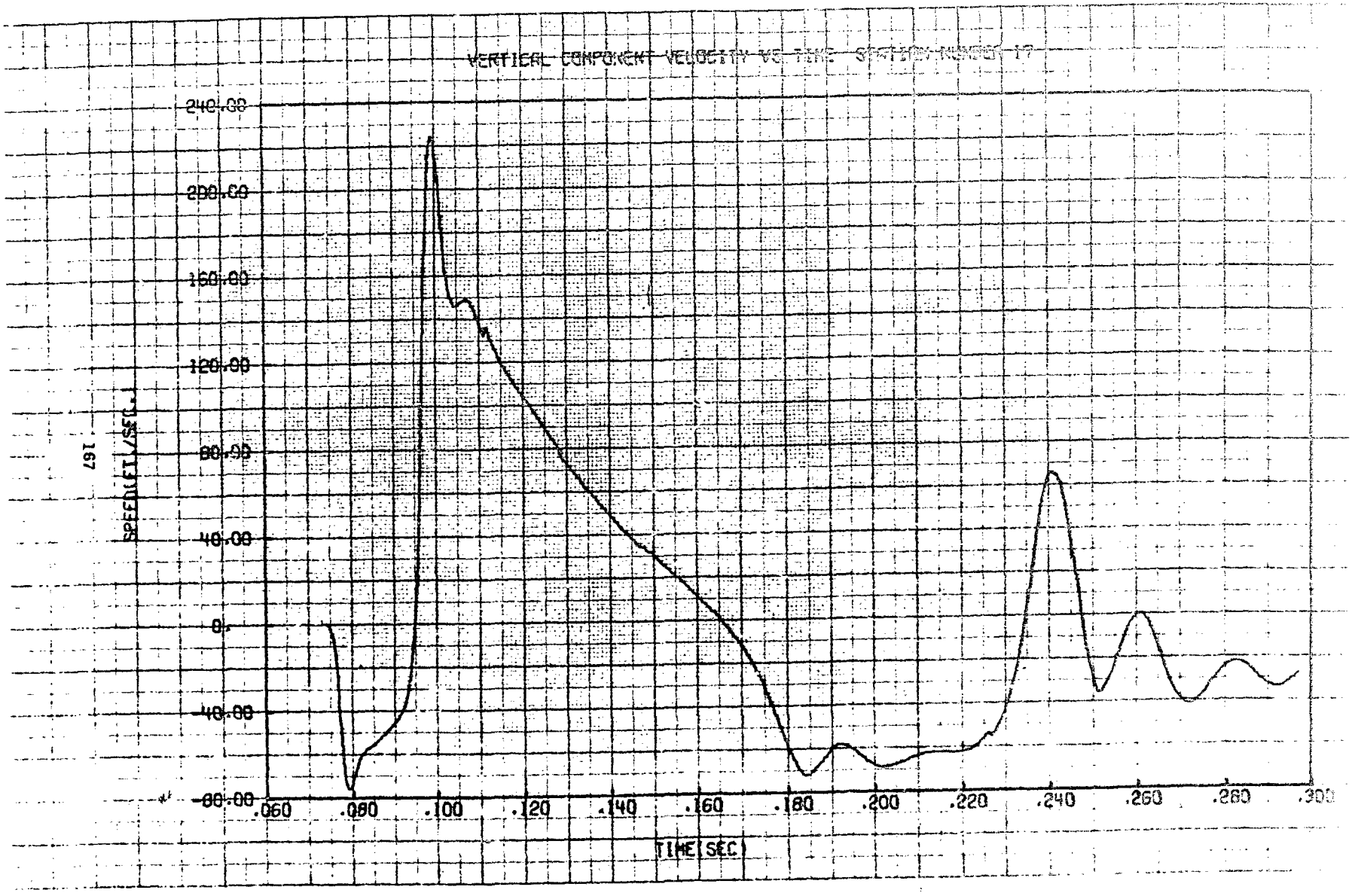

VERTICAL DYNAMIC PRESSURE VS TIME SPITFIRE MODEL 1F
2.00
1.60
1.20
.80
.40
0
-.40
-.80
-1.20
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

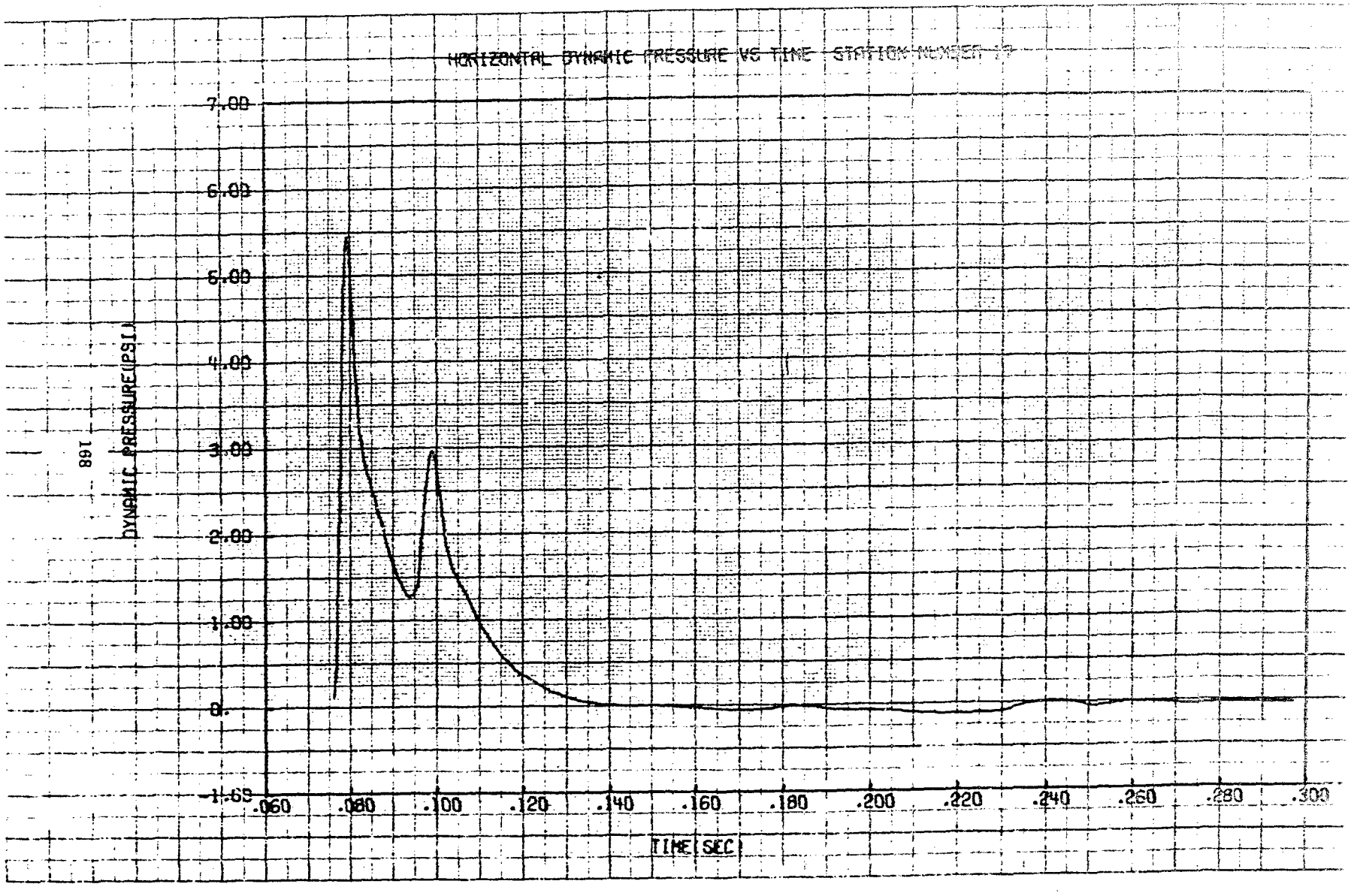

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 16
.010000
.008000
.006000
.004000
.002000
0
-.002000
-.004000
-.006000
DYNAMIC PRESSURE IMPULSE (LB-SEC/...)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

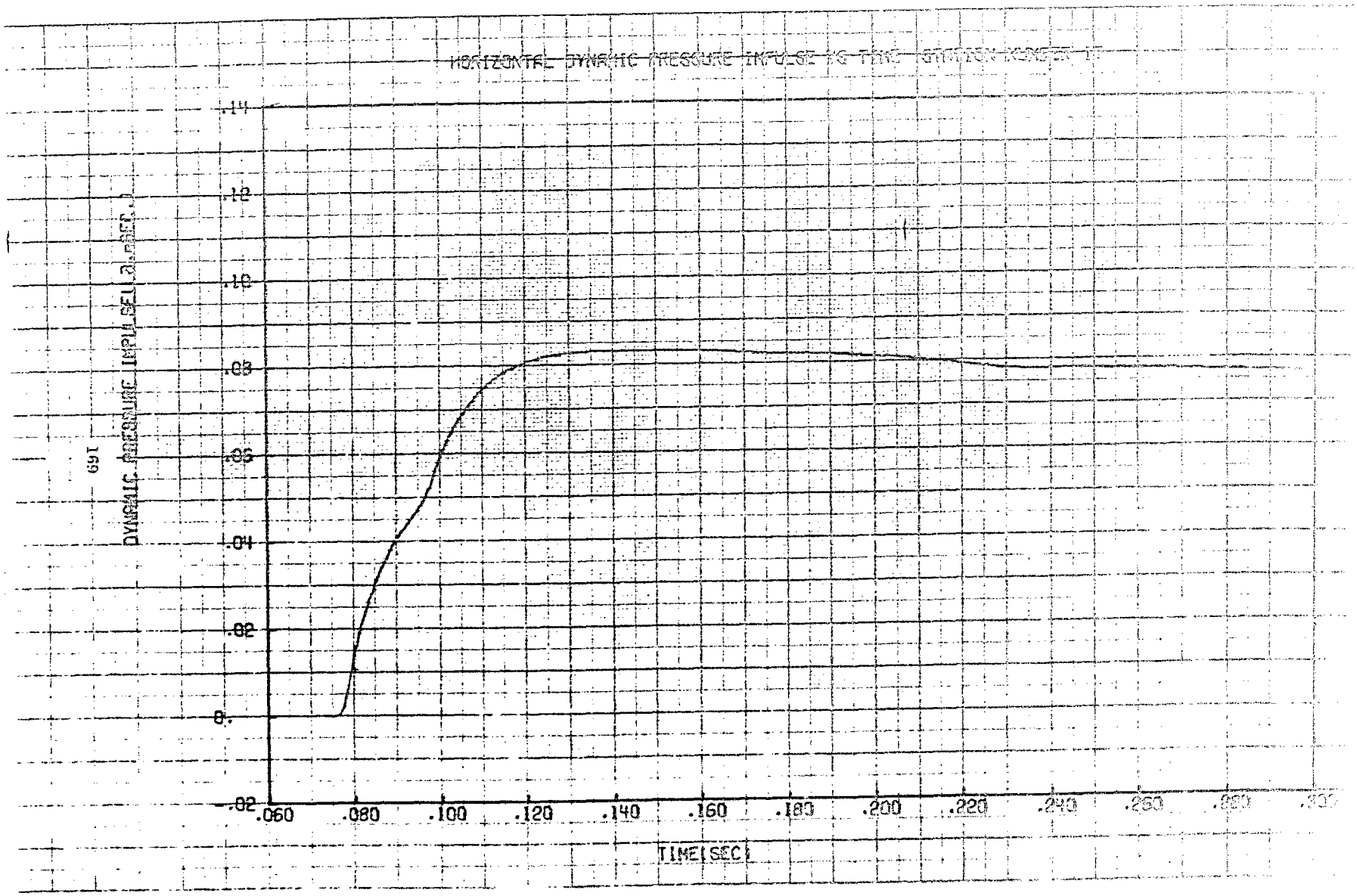

OVER PRESSURE VS TIME STATION NUMBER 17
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE(LBS/
164
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

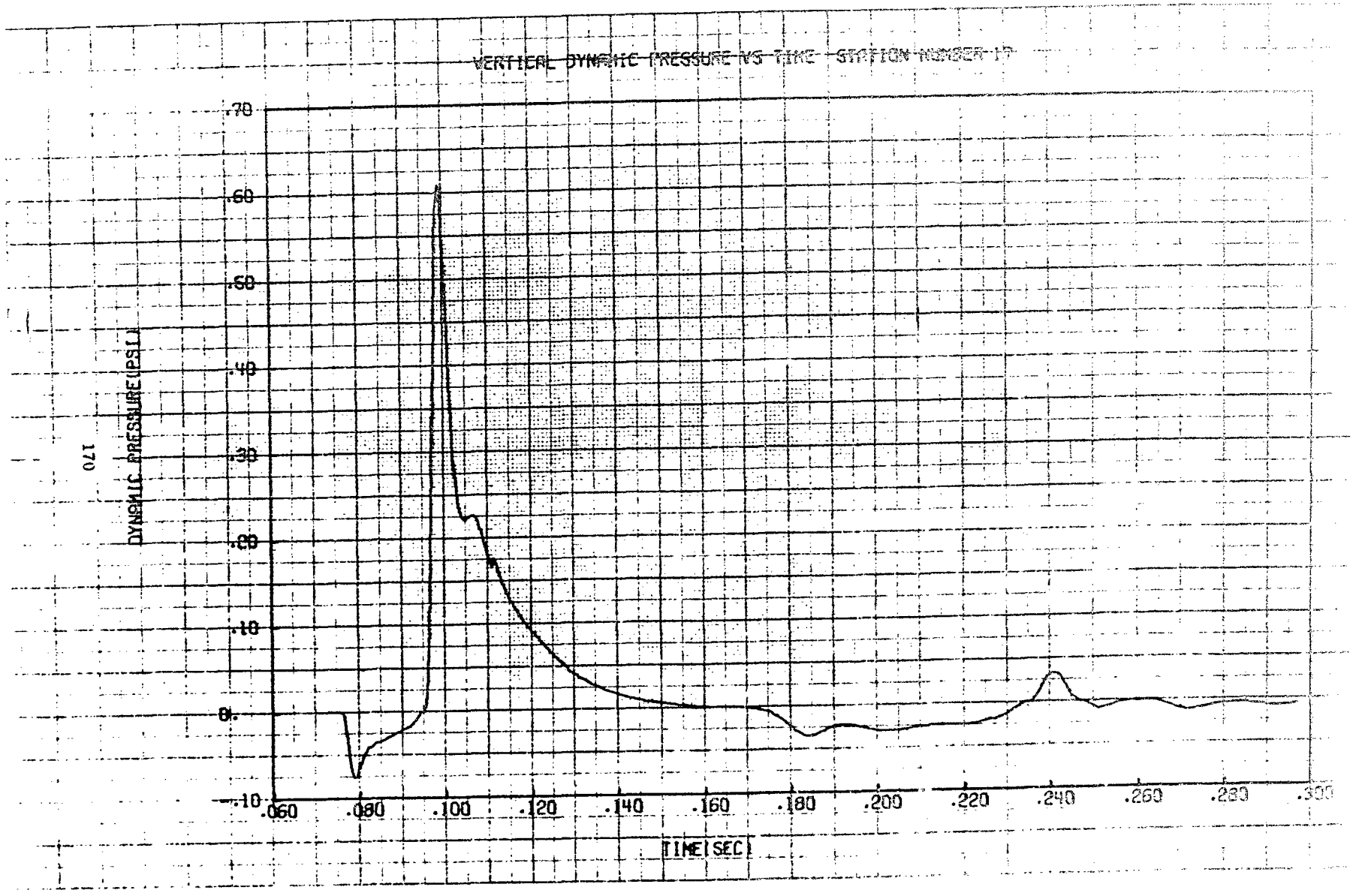

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 17
OVER PRESSURE IMPULSE(LB.-SEC.)
165
.60
.50
.30
.20
.10
0
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

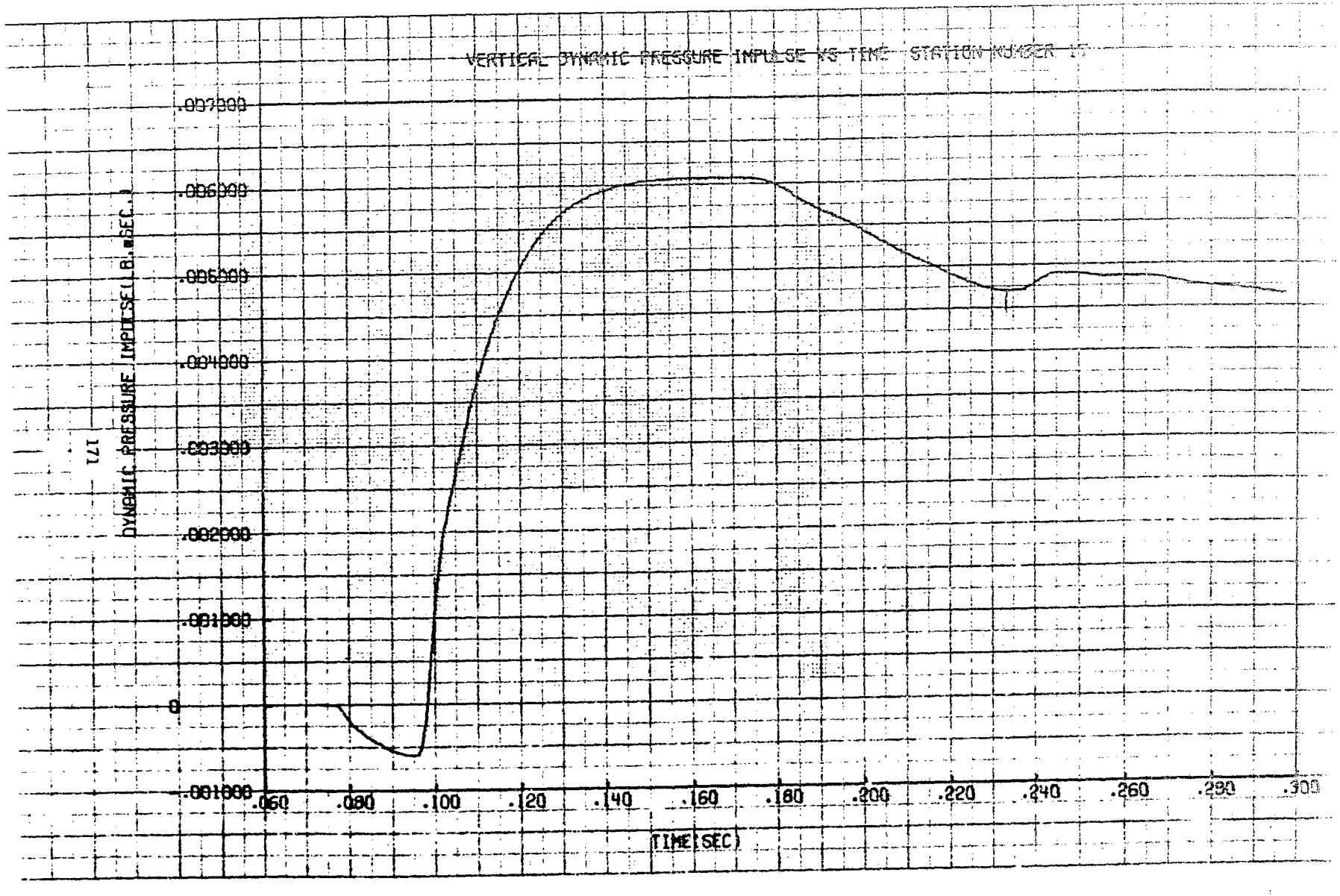

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
165
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

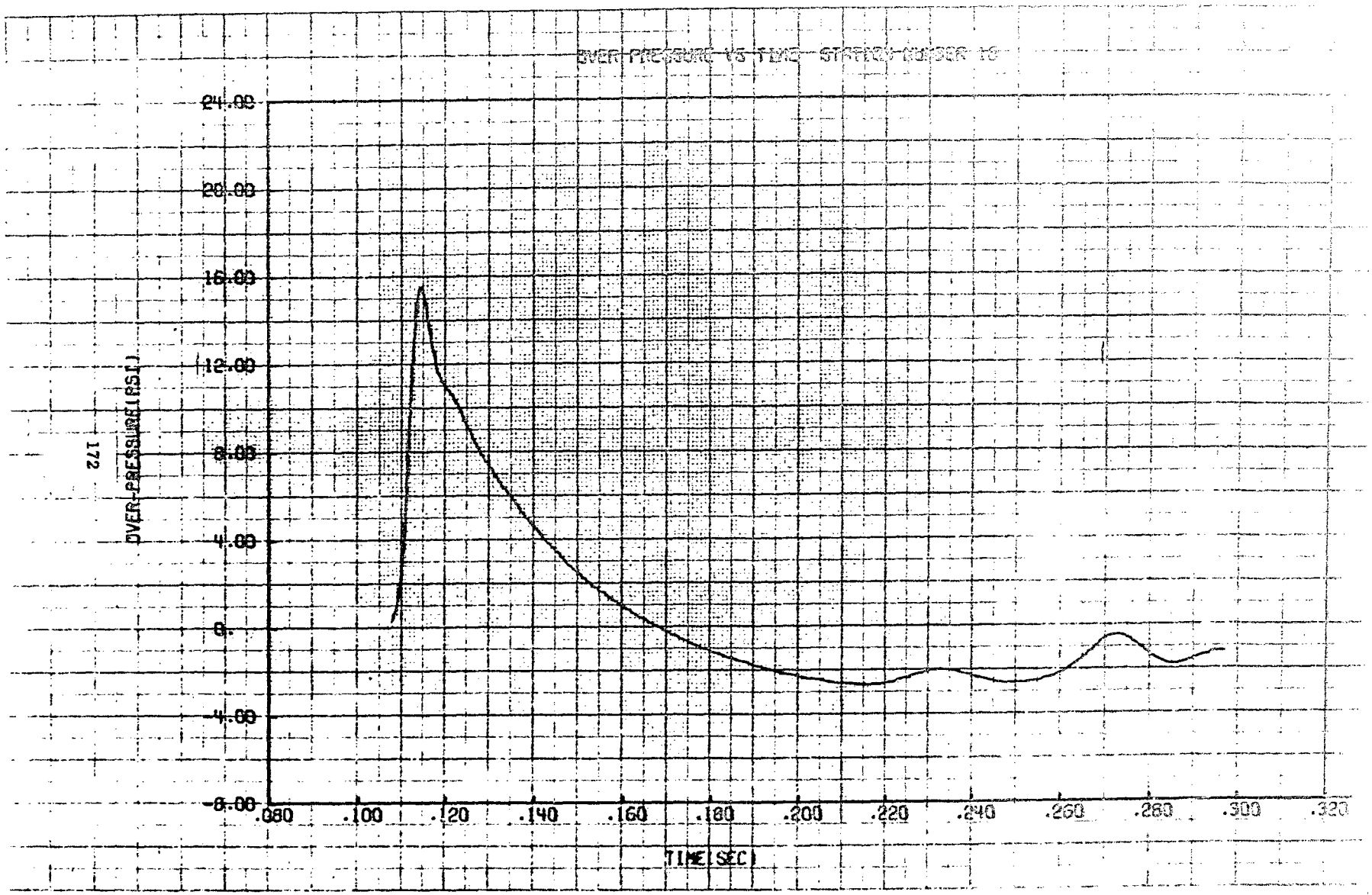

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
VELOCITY(cm/sec)
167

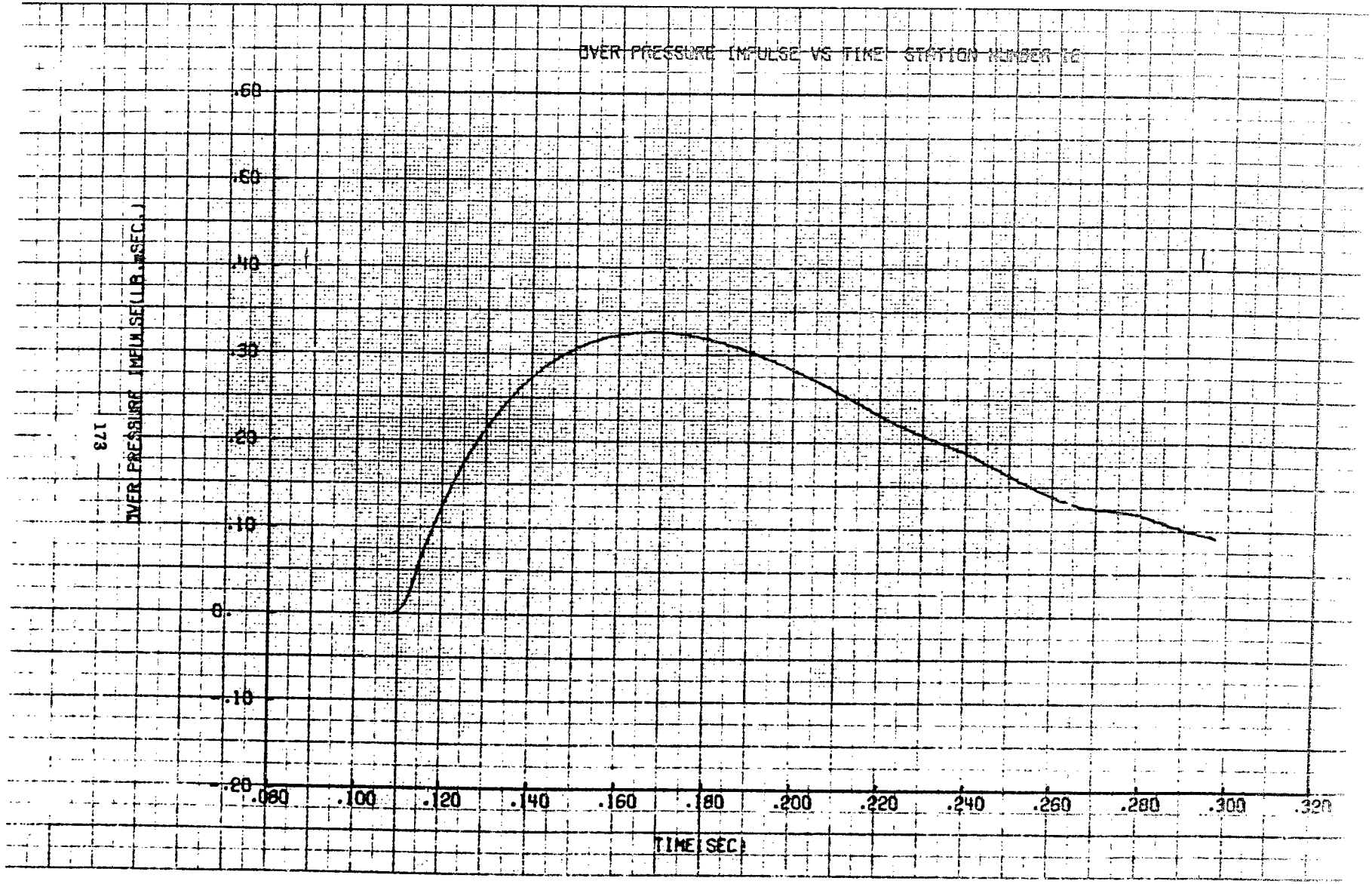

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 19
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.69
DYNAMIC PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

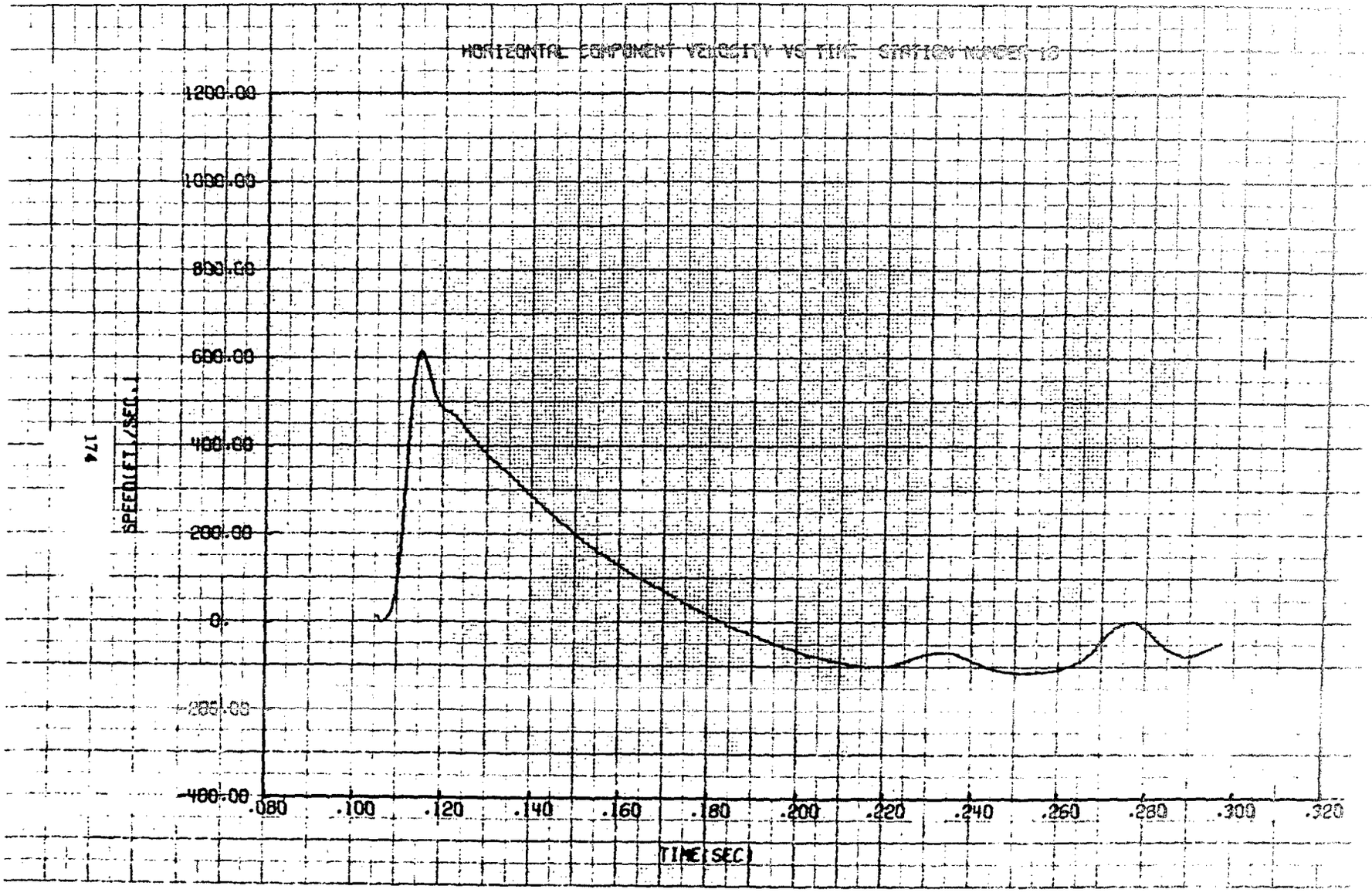

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN.**2)
.14
.12
.10
.08
.06
.04
.02
0.
-.02
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
TIME (SEC)

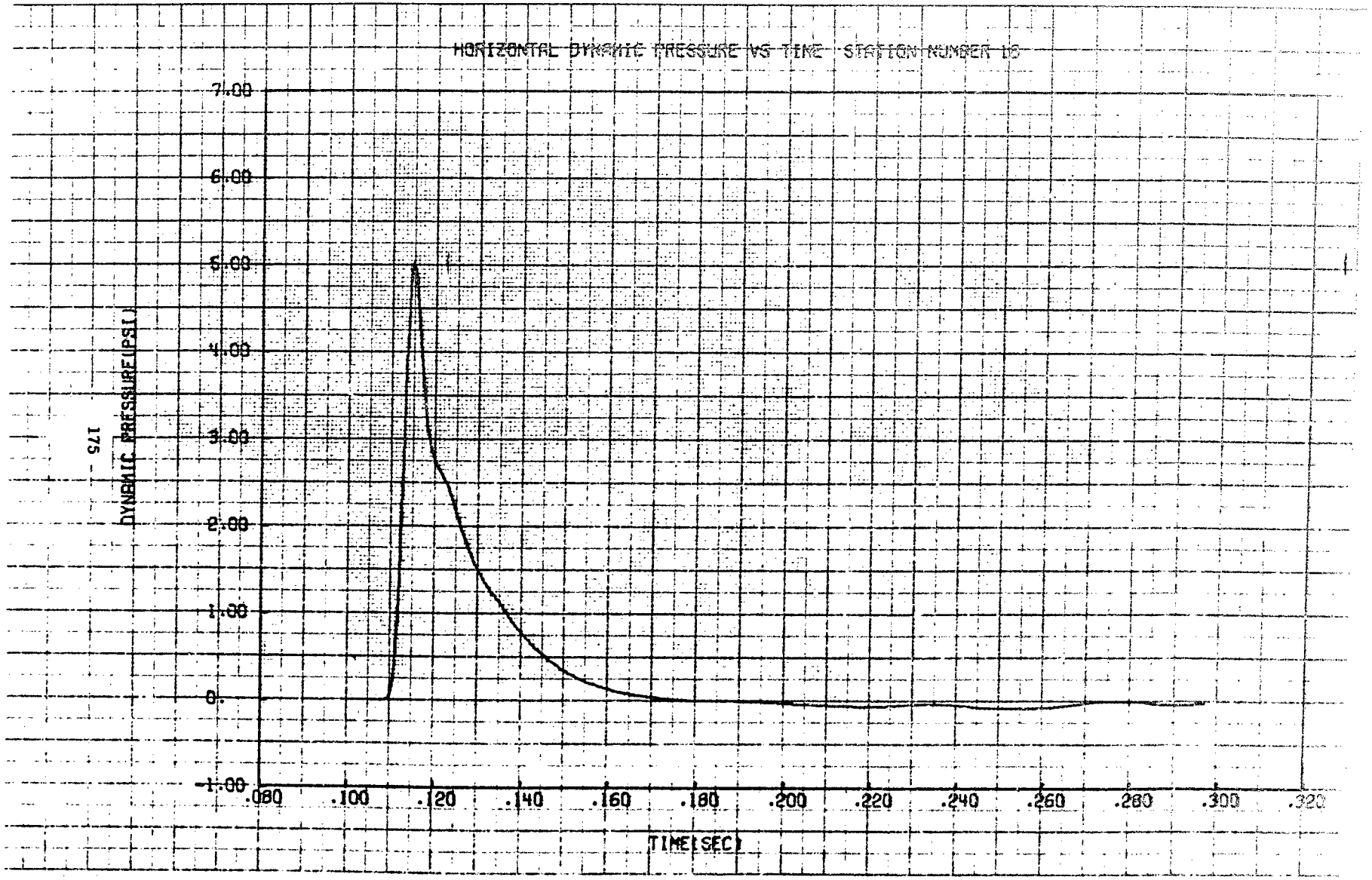

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE(PSI)
170
.70
.60
.50
.40
.30
.20
.10
0.
-.10
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

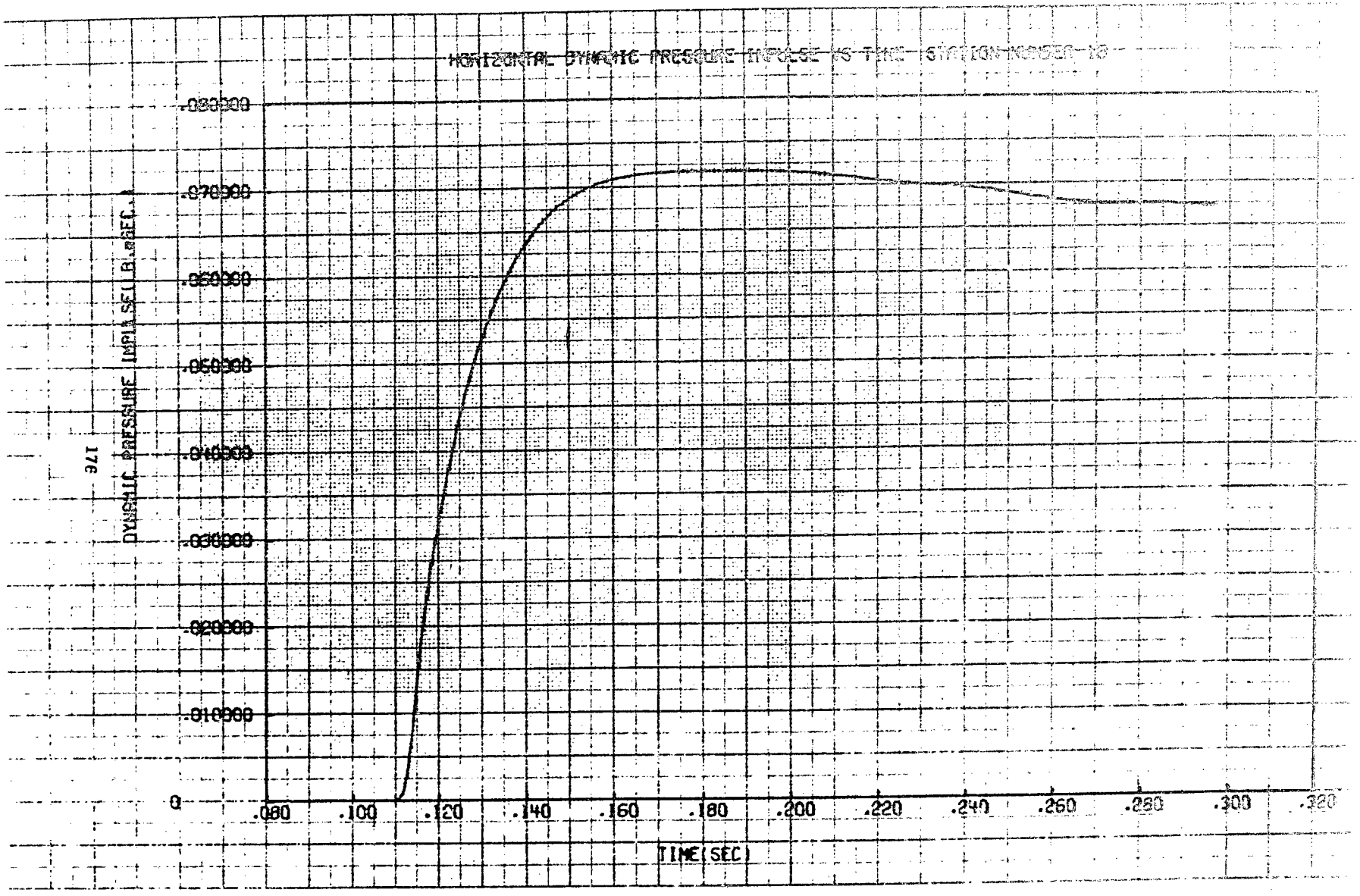

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 17
.007000
.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
DYNAMIC PRESSURE IMPULSE(LB./SQ.IN.-SEC.)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)


OVER PRESSURE VS TIME STATION NUMBER 10
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE(PSI)
172
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)


OVER PRESSURE IMPULSE VS TIME- STATION NUMBER 12
OVER PRESSURE IMPULSE (LB.-SEC.)
173
.60
.50
.40
.30
.20
.10
0
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)

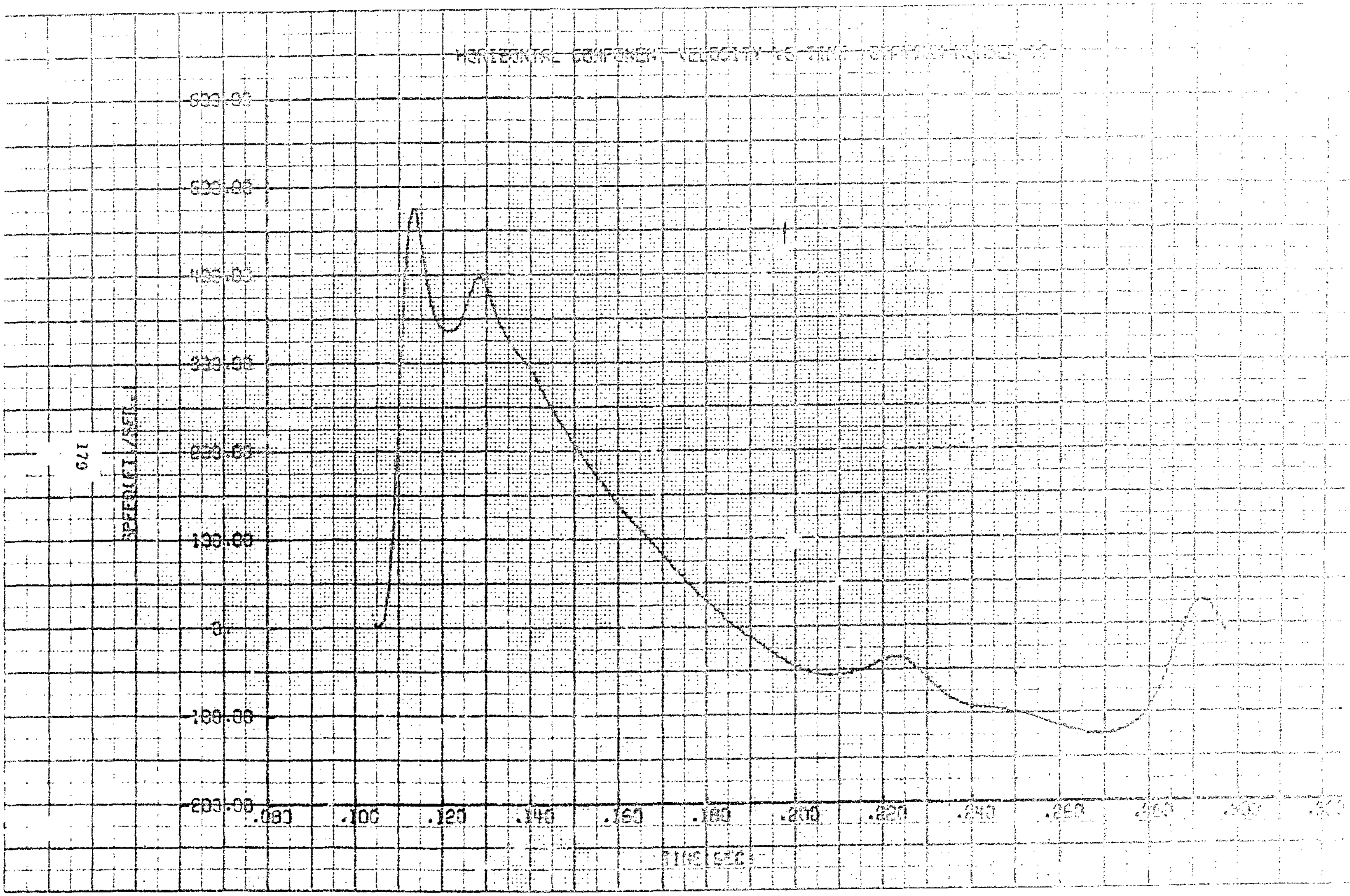

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 13
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT./SEC.)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

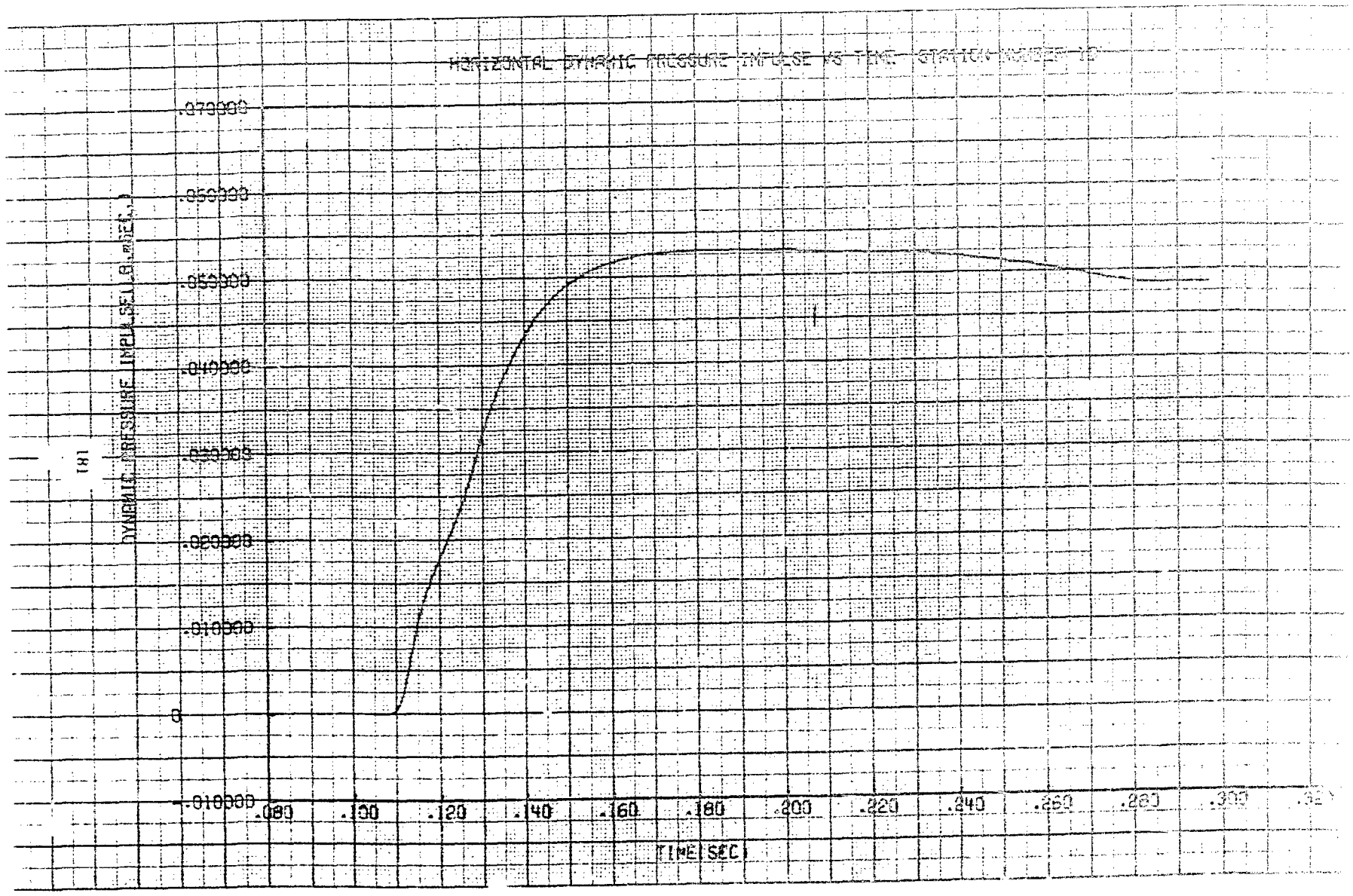

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 18
DYNAMIC PRESSURE(PSI)
175
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
.080000
.070000
.060000
.050000
.040000
.030000
.020000
.010000
0
DYNAMIC PRESSURE IMPULSE (LB-SEC/...)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

OVER PRESSURE VS TIME STATION 10
OVER-PRESSURE (PSI)
12.00
10.00
8.00
6.00
4.00
2.00
0
-2.00
-4.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC


HORIZONTAL COMPONENT VELOCITY VS TIME
SPEED(FT/SEC.)
600.00
500.00
400.00
300.00
200.00
100.00
0
-100.00
-200.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
TIME(SEC)


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
.070000
.050000
.030000
.010000
0
-.010000
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

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SECTION III

THE METHANE CALCULATION

SAP Profiles

This part contains profiles of pressure, density and velocity as calculated by SAP for the methane detonation. This charge, a 1.5 to 1 molar mixture of oxygen and methane, was initially contained in a balloon of 55 ft radius. There are plots for 16 different times.

The first plot contains the profiles describing the flow field behind the detonation front in the methane. Unlike the TNT detonation ambient pressure (13.6 psi) is not negligible; therefore the similarity solution differs from the SAP calculation by approximately 5 percent as can be seen in the first figure. The similarity solution for the methane detonation using the following parameters: detonation velocity, 2.7522×10^5 cm/sec; loading density, 1.07197×10^{-3} gm/cm^3; gamma = 1.2136.

Succeeding plots show the convergence of the rarefaction wave on the origin, the formation and expansion of the free-air shock, and the formation and motion of secondary shocks.

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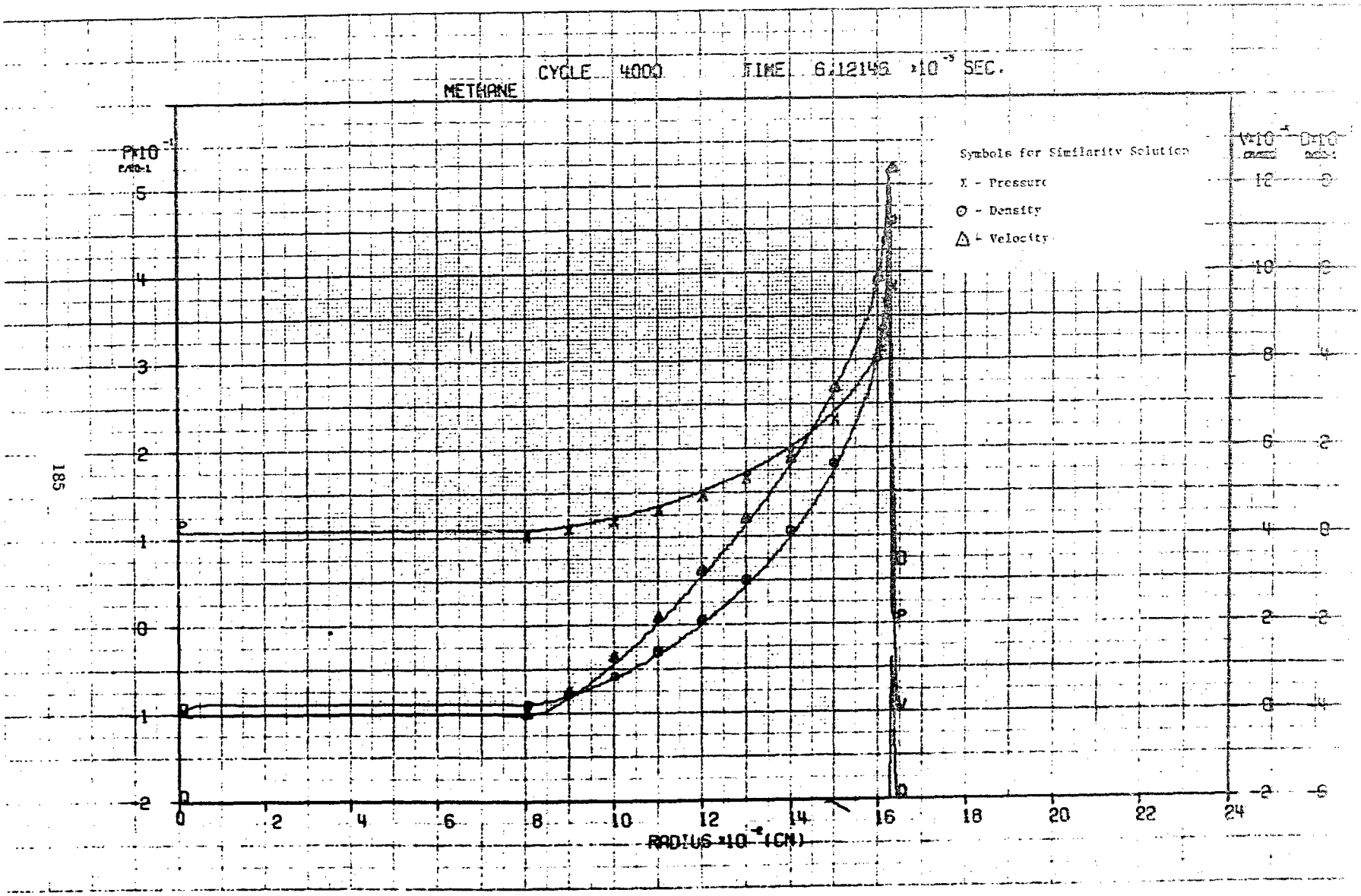
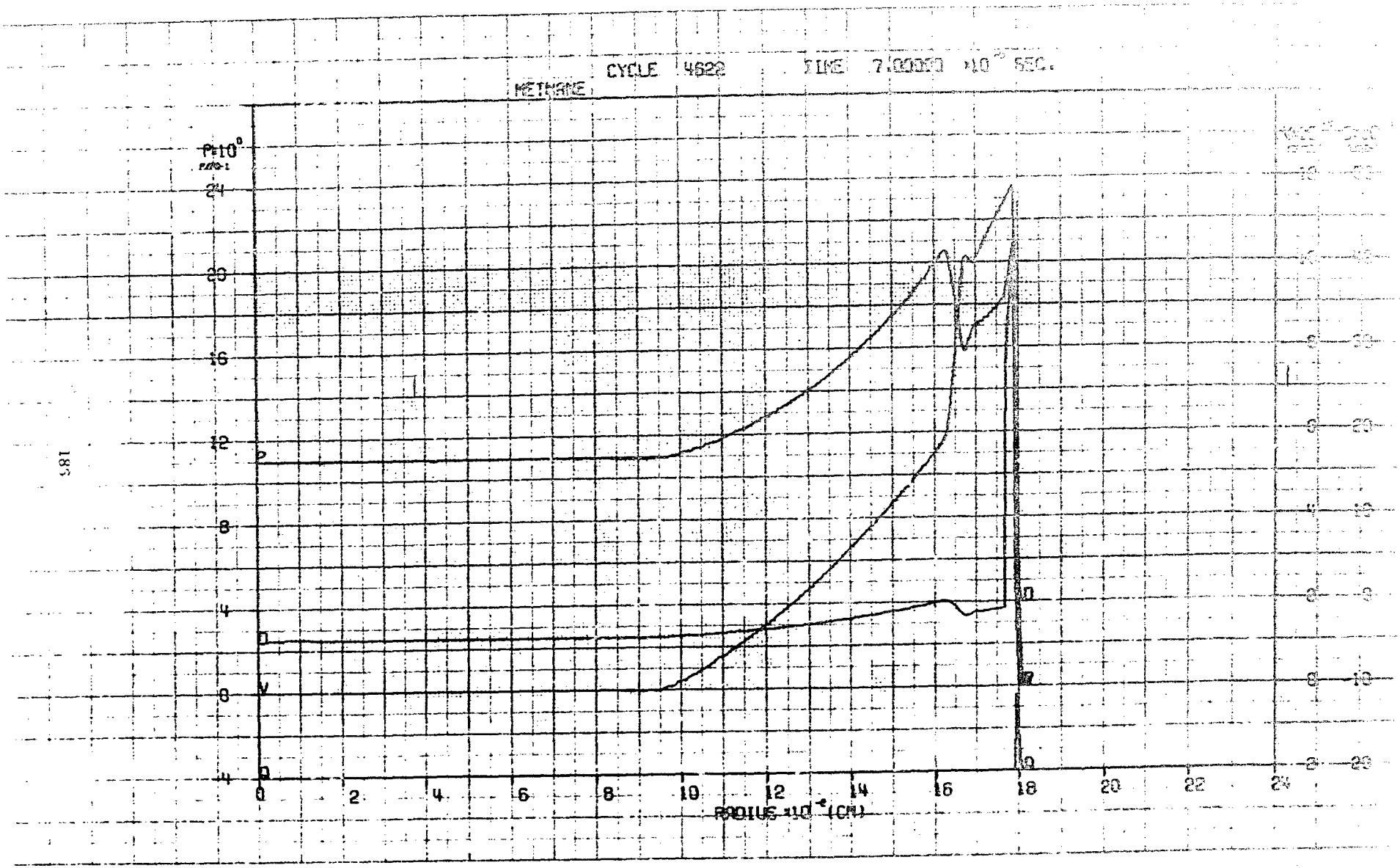
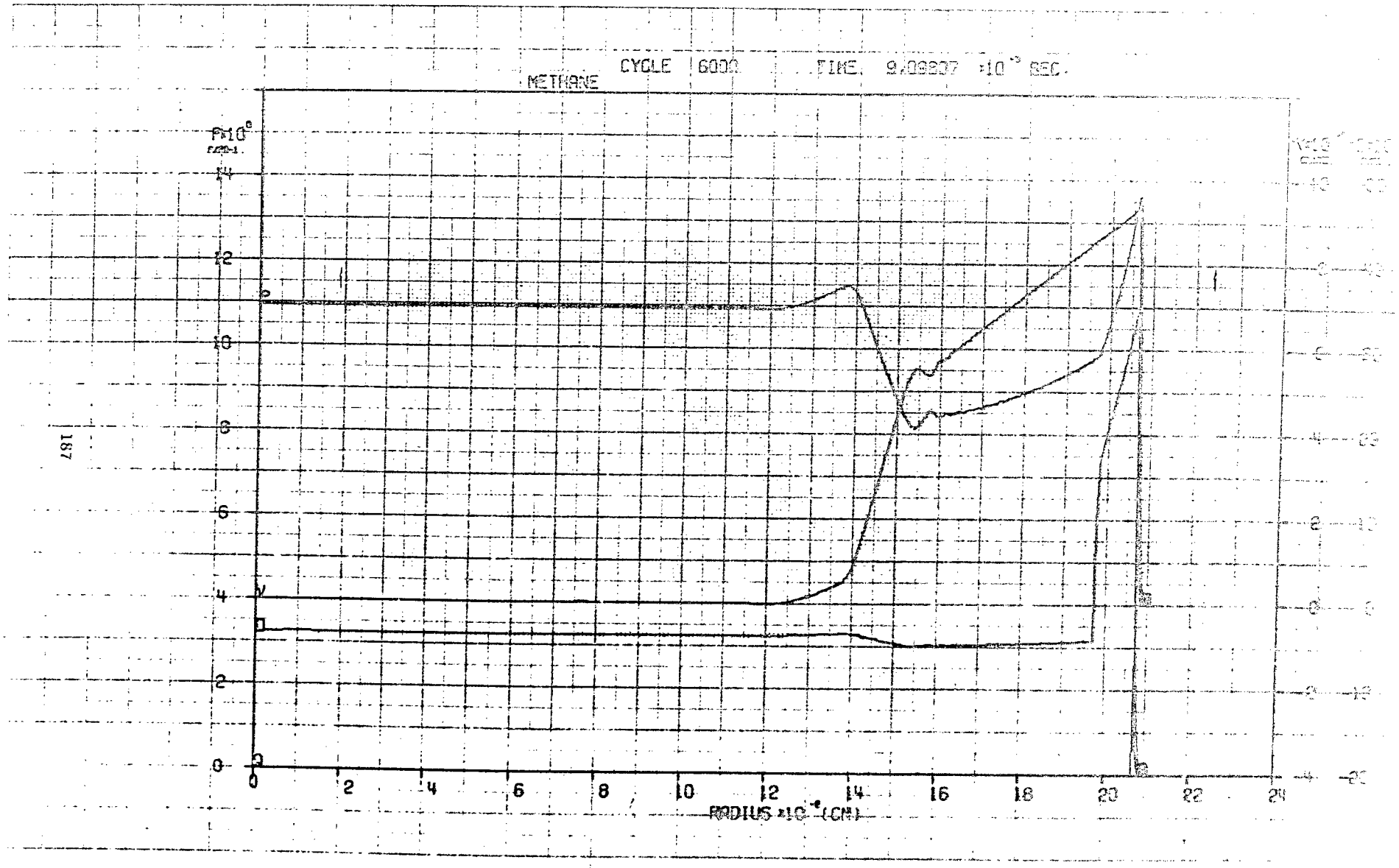
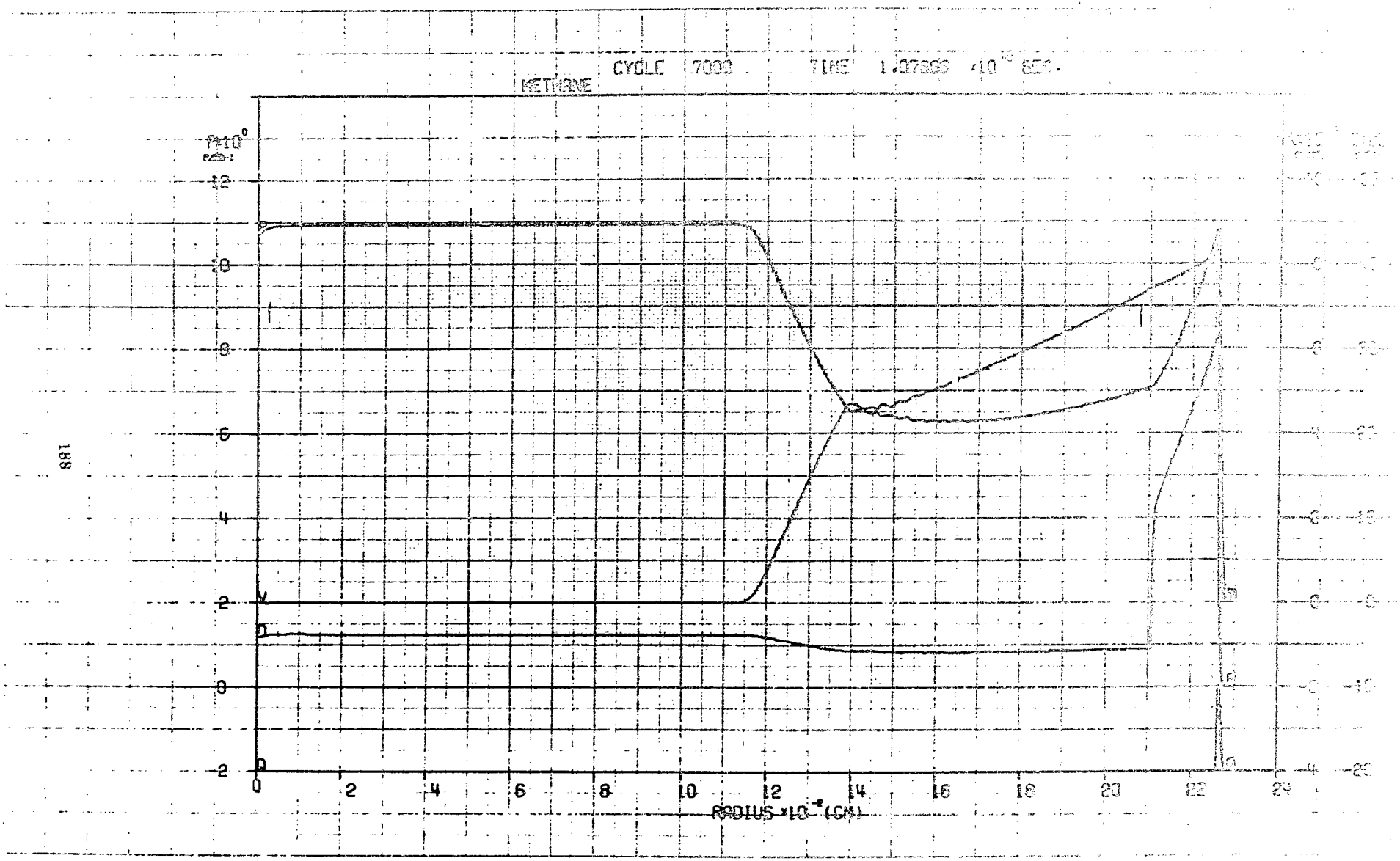
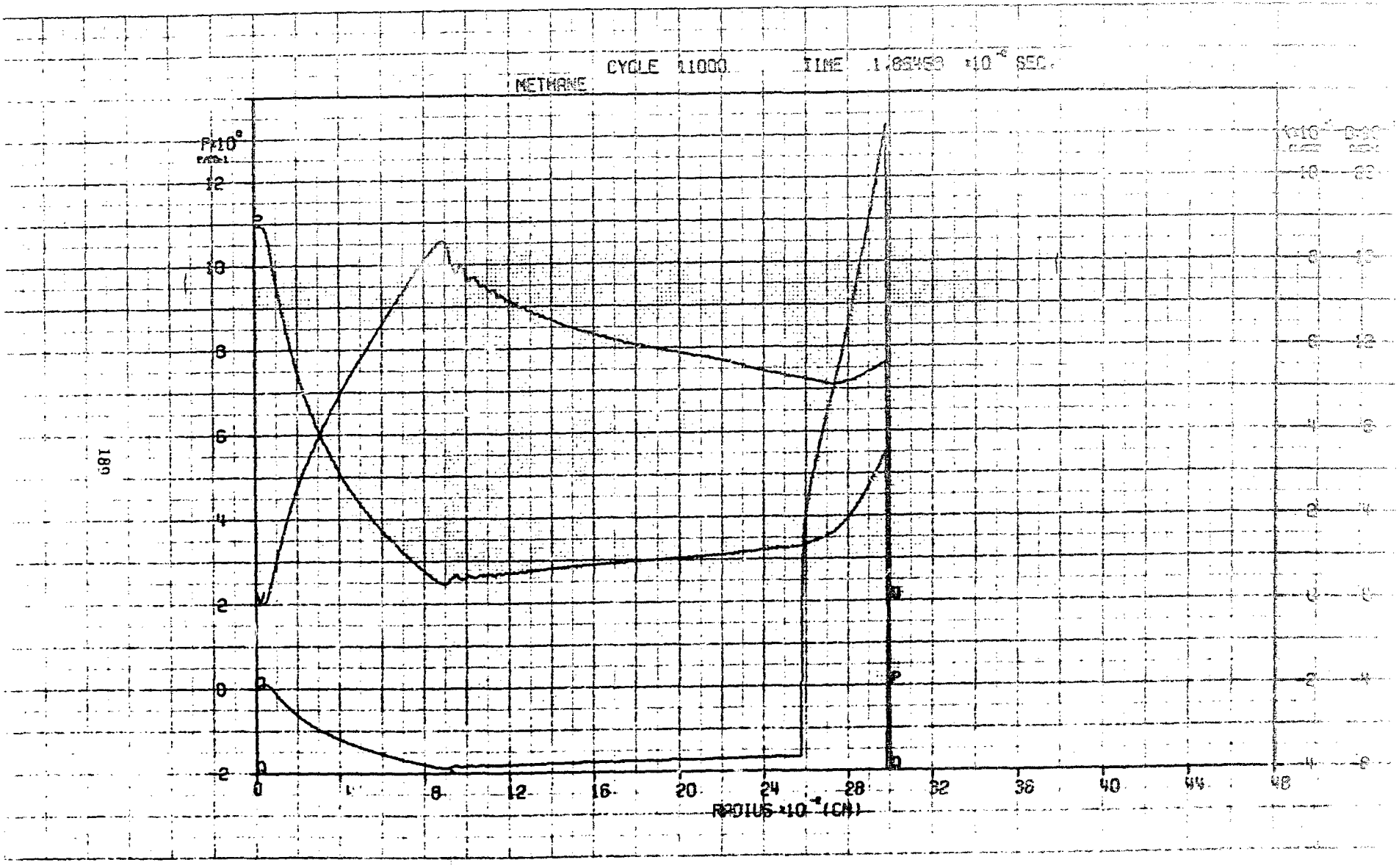
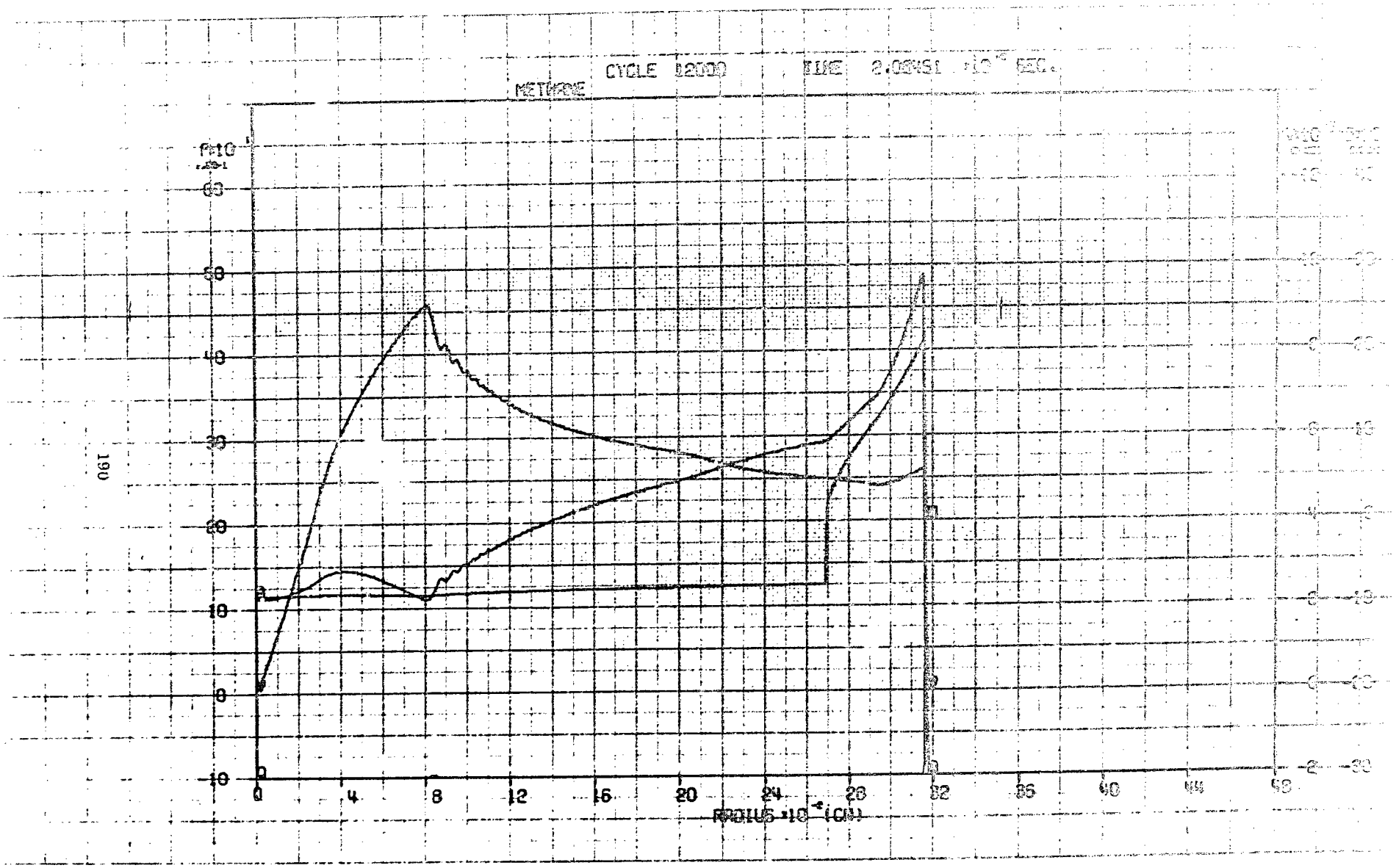

METHANE
CYCLE 4000
TIME 6.12145 ×10⁻⁵ SEC.
Symbols for Similarity Solution
X - Pressure
⊙ - Density
△ - Velocity
P×10⁻⁵ DYNES/CM²
V×10⁻⁴ CM/SEC
D×10 GM/CC
RADIUS ×10⁻² (CM)
0 2 4 6 8 10 12 14 16 18 20 22 24
-2 -1 0 1 2 3 4 5
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12

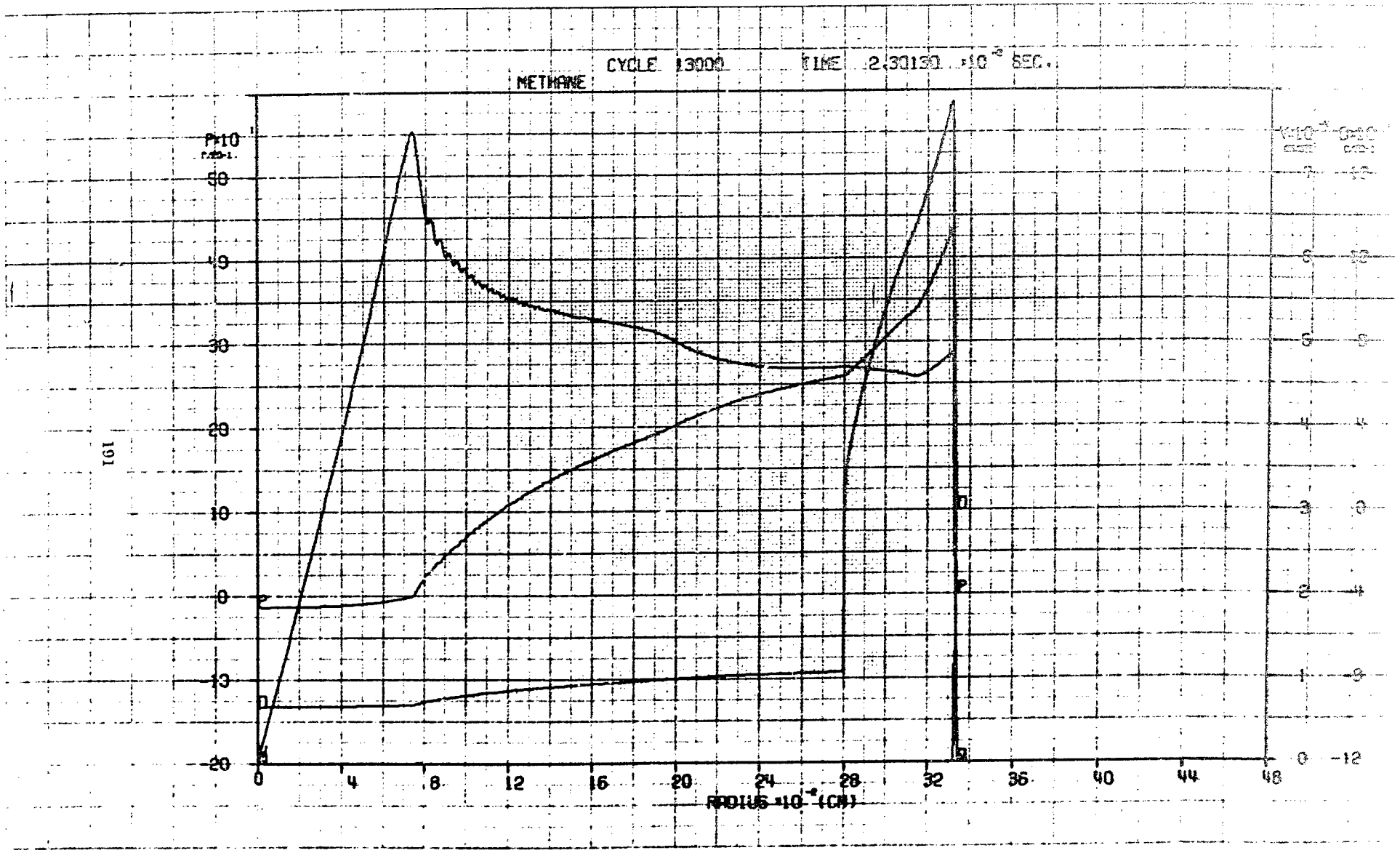

METHANE
CYCLE 4622
TIME 7.00000 ×10⁻⁹ SEC.
P=10⁰
24
20
16
12
8
4
0
4
8
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10⁻⁸ (CM)

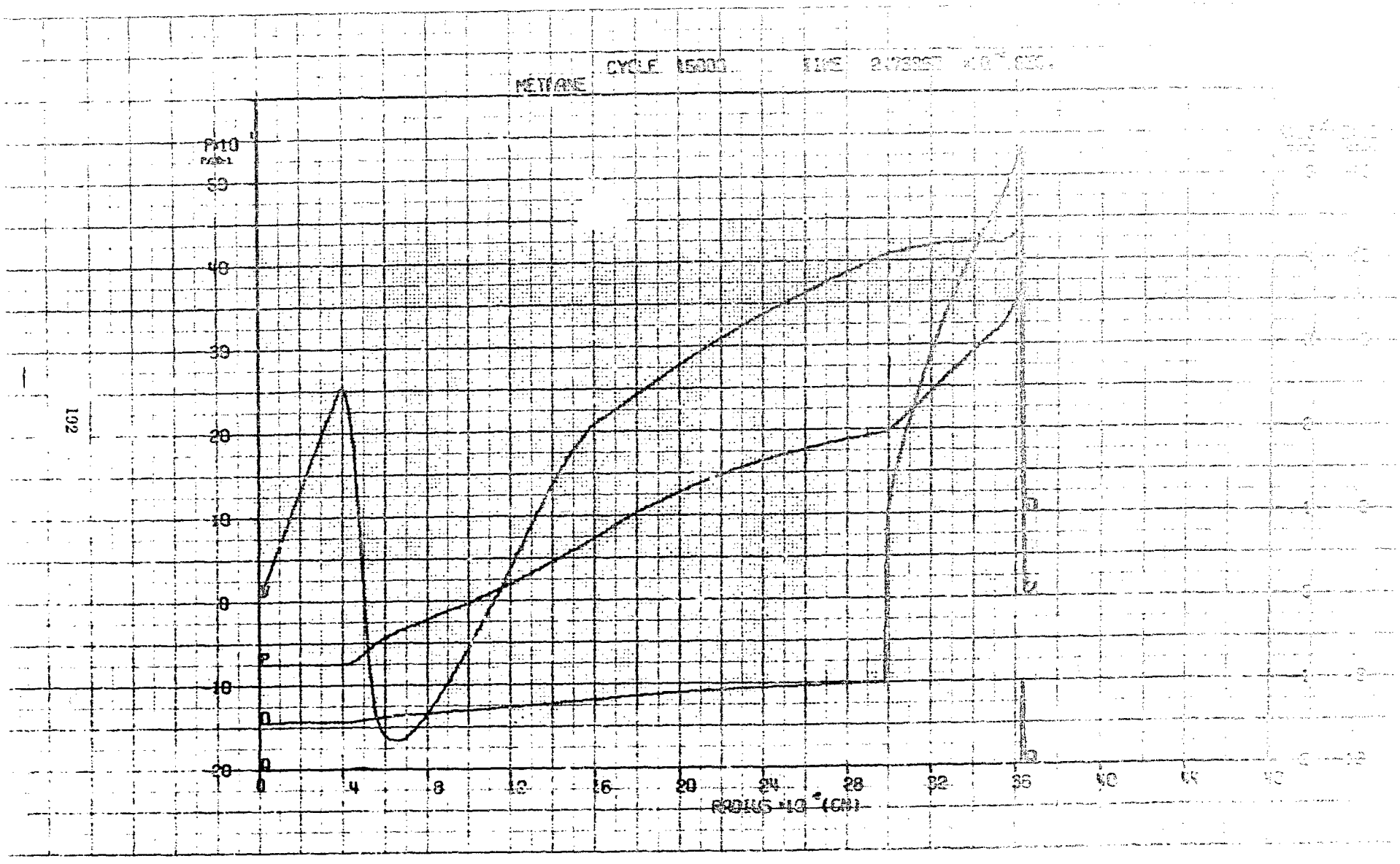

METHANE
CYCLE 6000
TIME 9.09837 ×10⁻⁵ SEC.
P×10⁶
DYNES/CM²
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
RADIUS ×10⁻⁶ (CM)
187

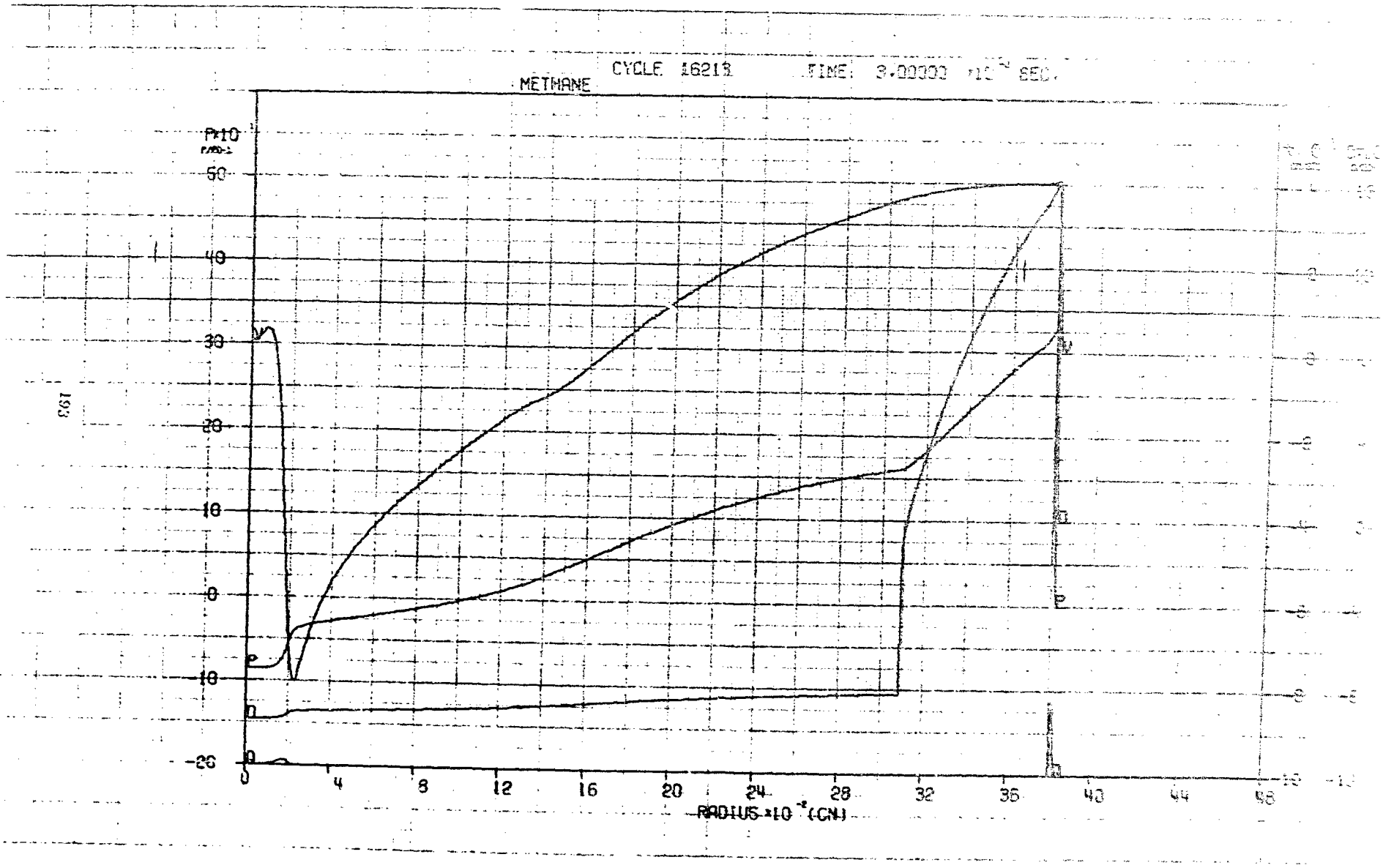

METHANE
CYCLE 7000
RADIUS ×10⁻² (CM)

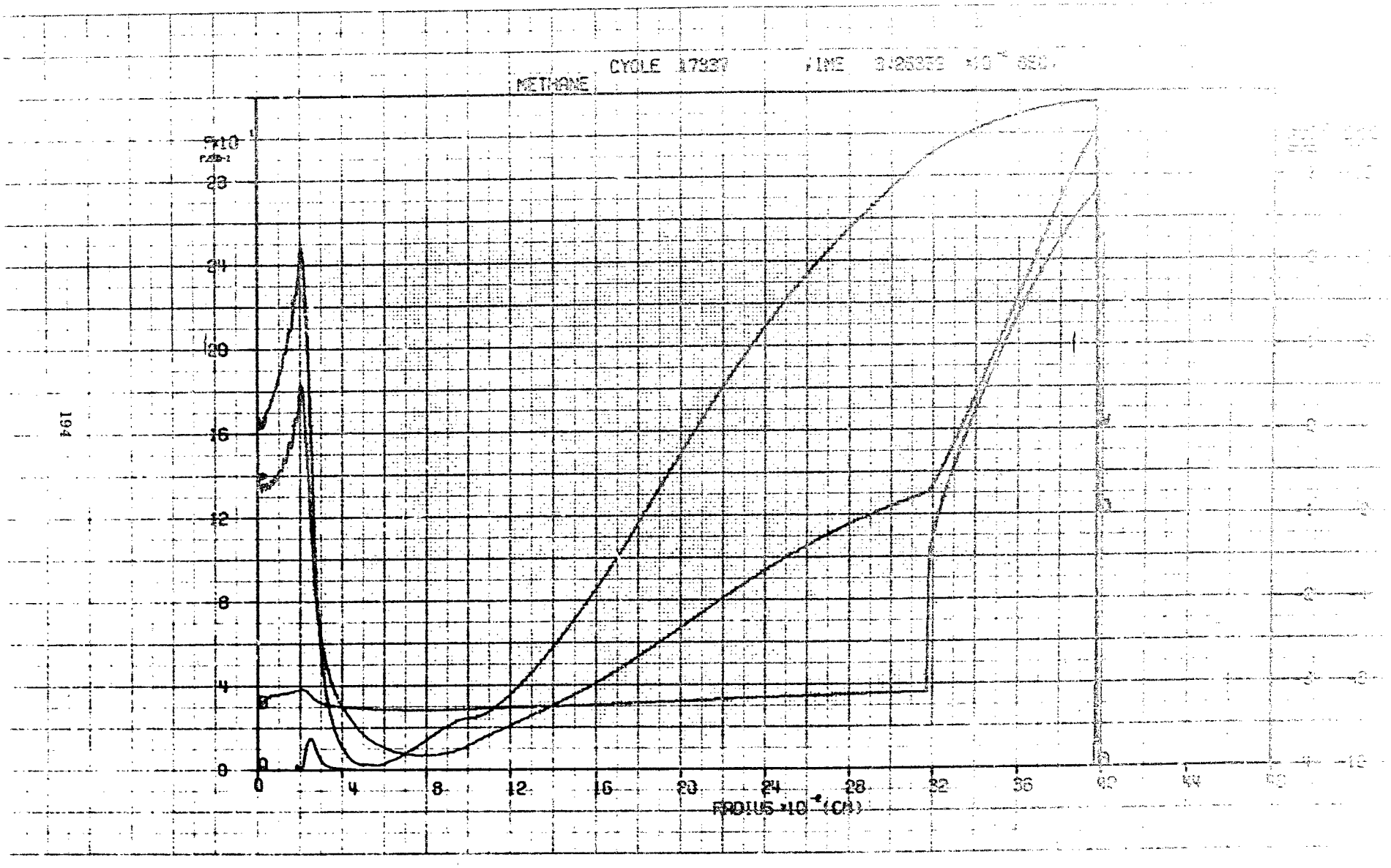

METHANE
CYCLE 11000
TIME 1.865458 ×10⁻⁶ SEC
P×10⁸
12
10
8
6
4
2
0
-2
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁴ (CM)

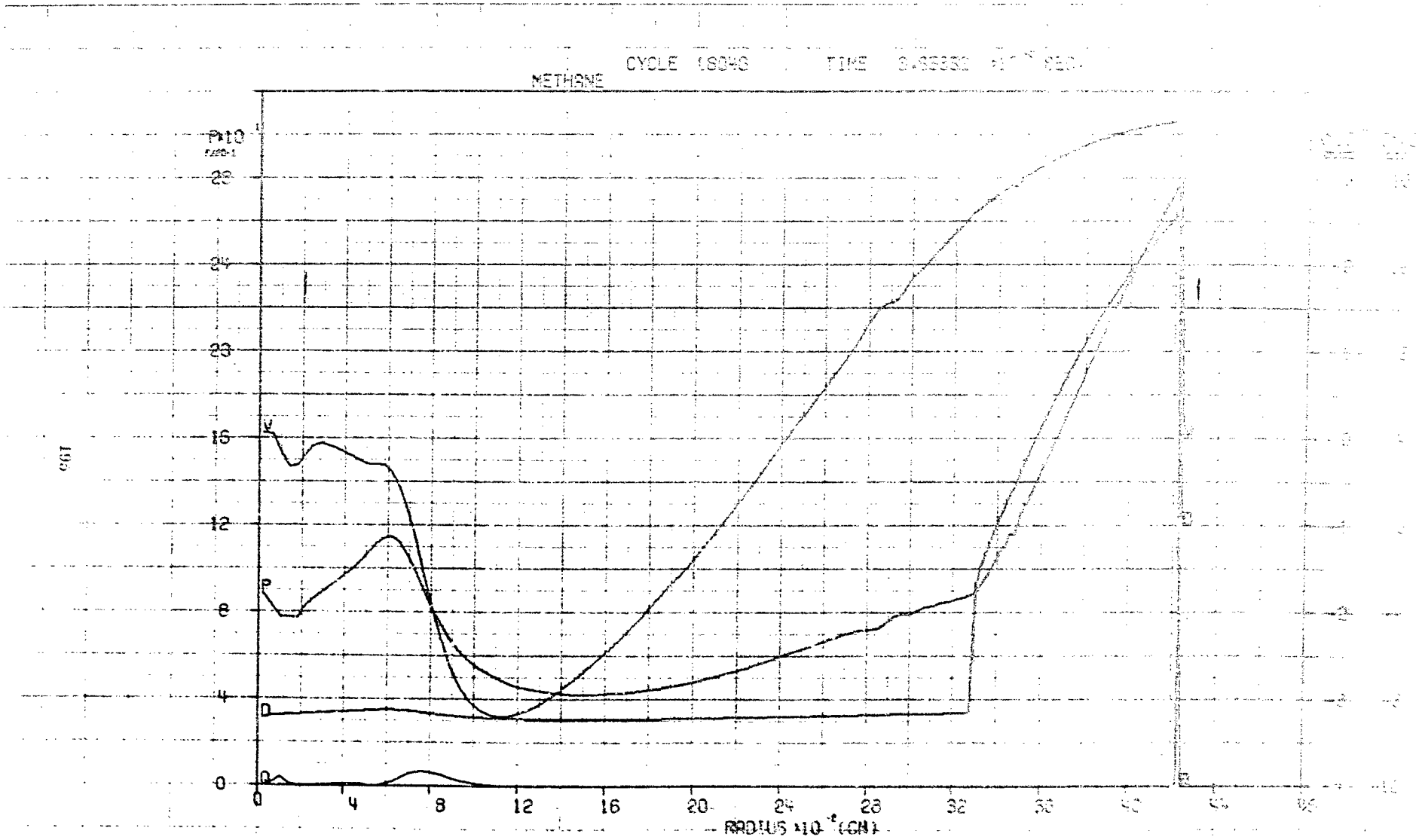

METHANE
CYCLE 12000
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁶ (CM)

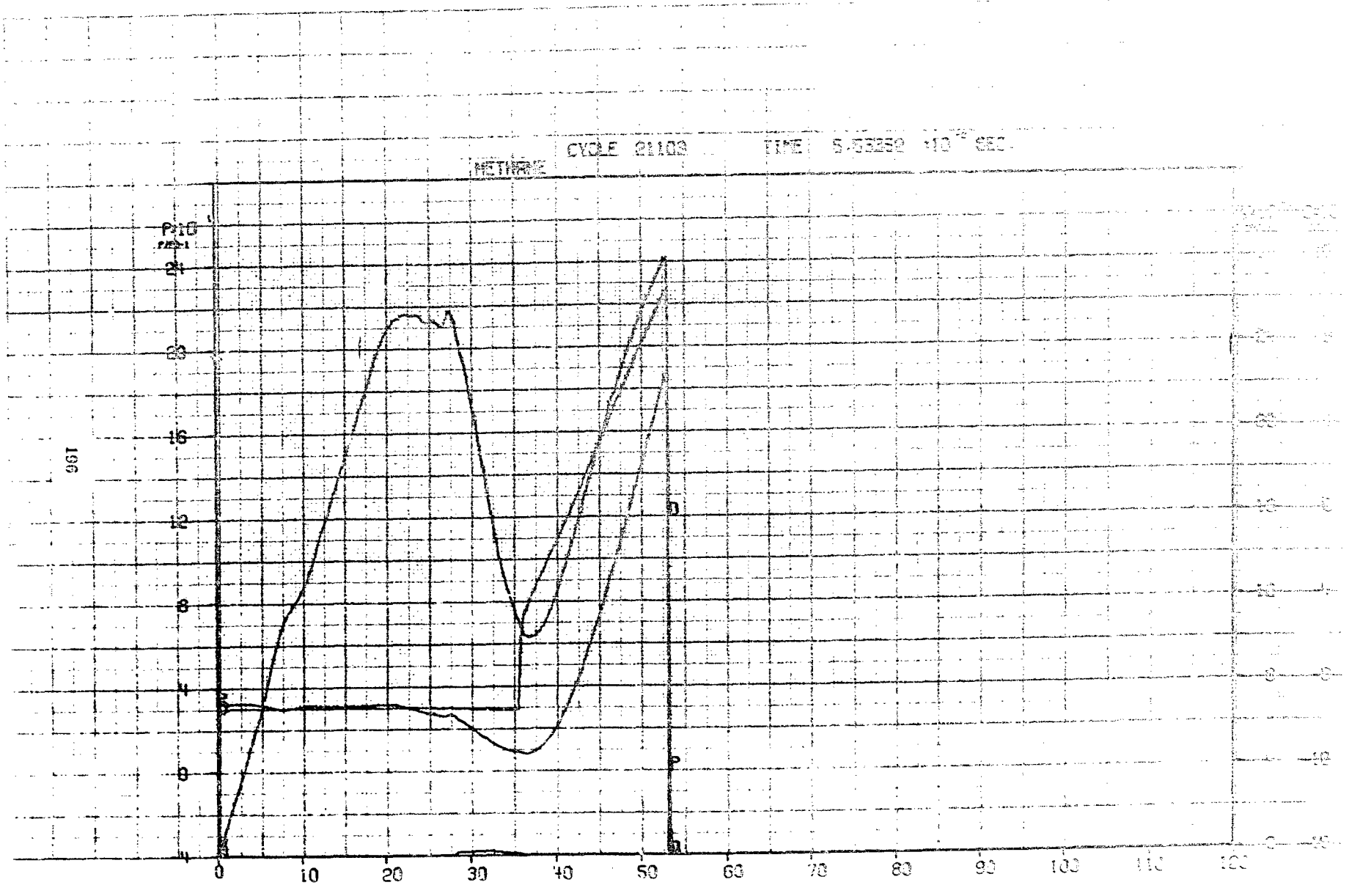

METHANE
CYCLE 13000
TIME 2.30130 ×10⁻³ SEC.
P×10
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)
-12

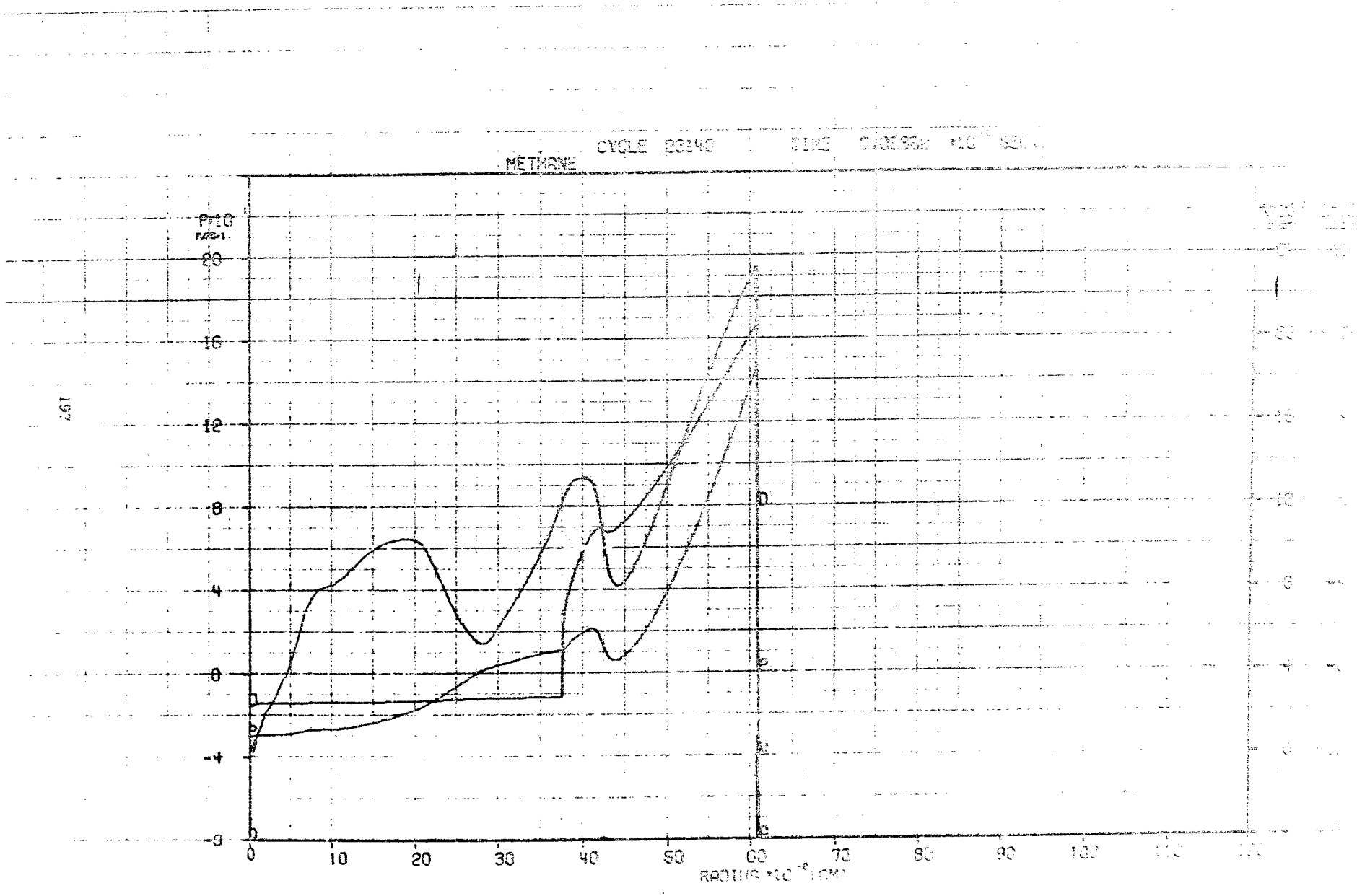

METHANE
CYCLE 15000
P*10
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
RADIUS *10 **(CM)

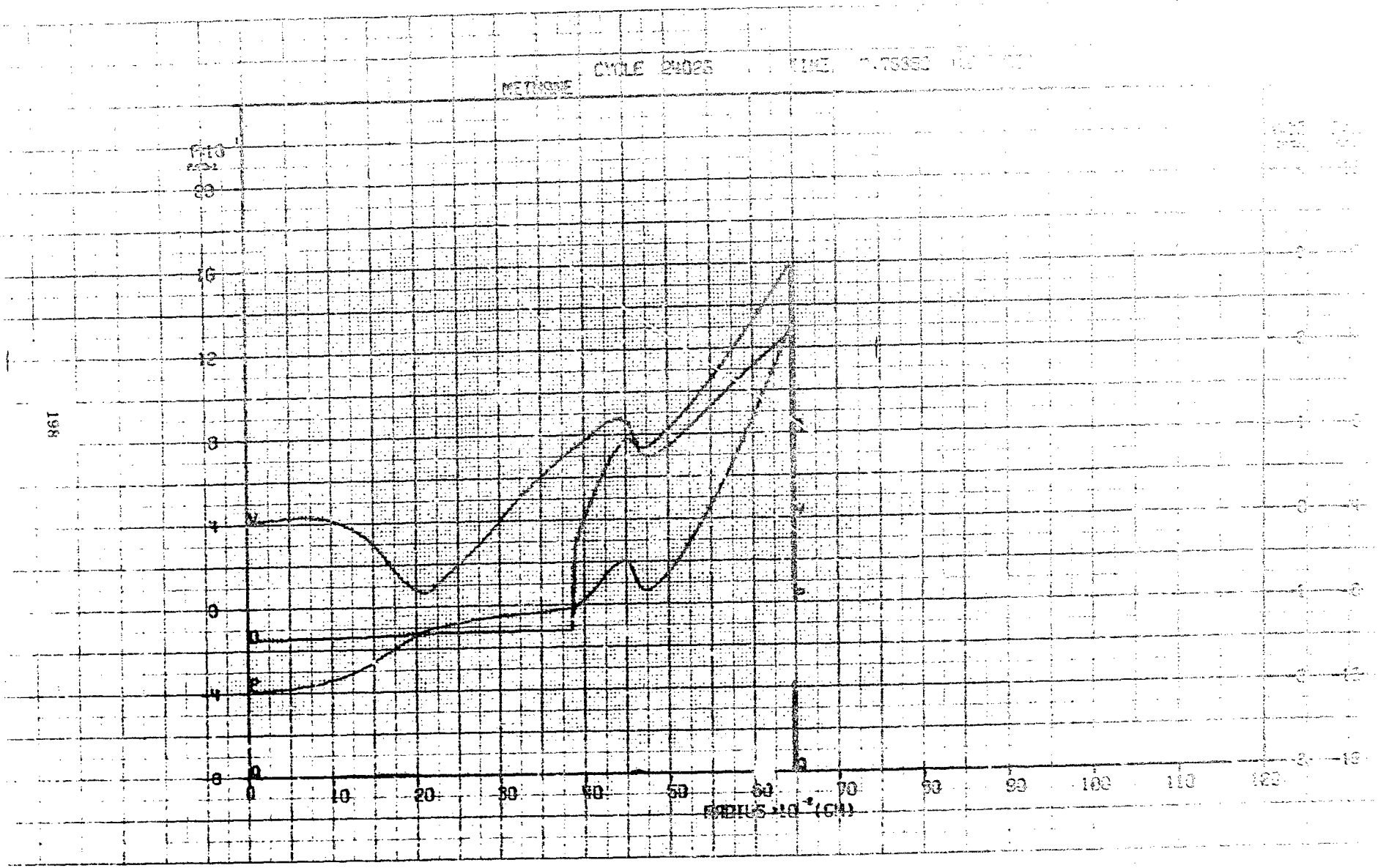

METHANE
CYCLE 16213
TIME 3.00000
PX10
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS x10 -2 (CM)

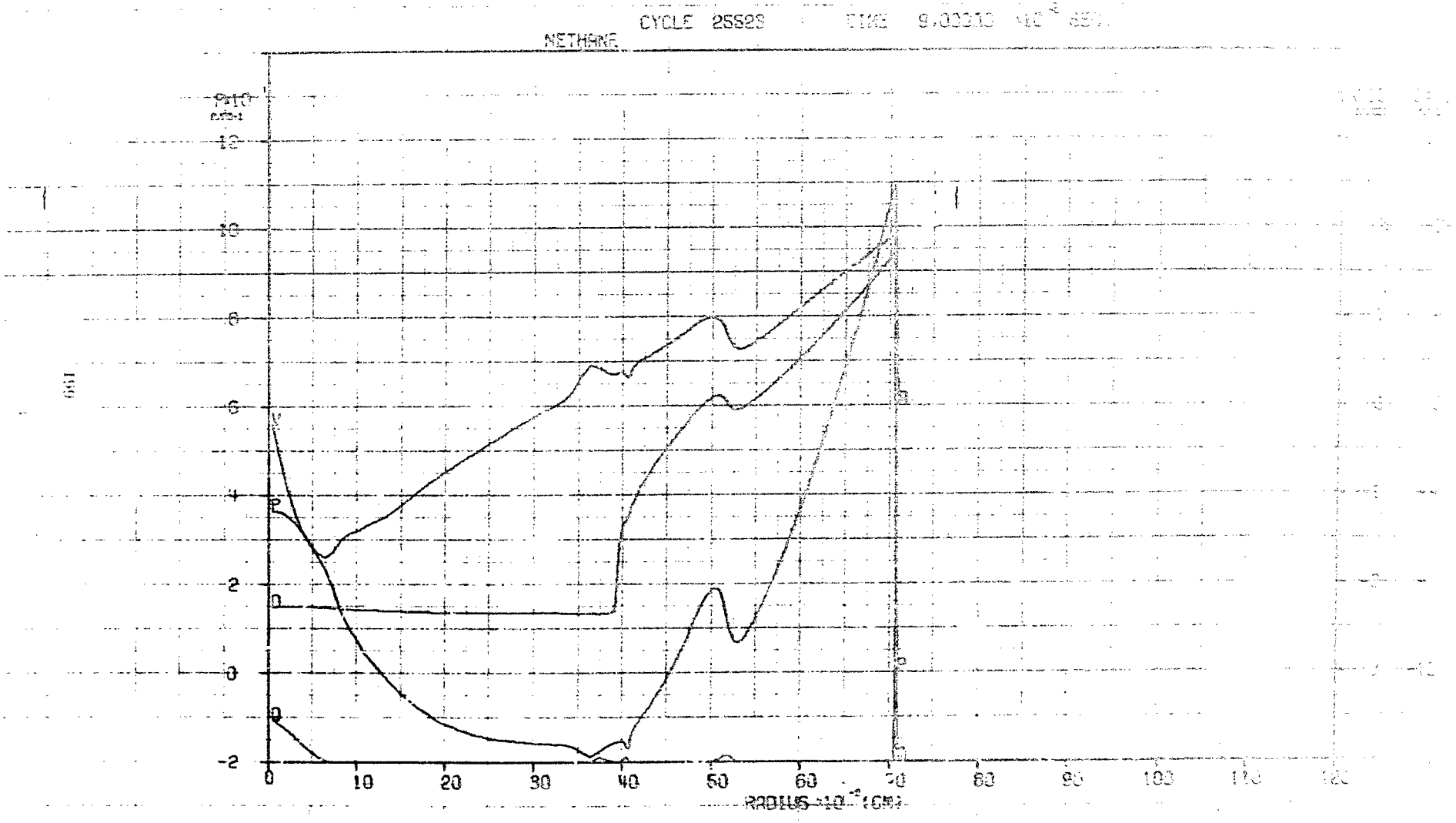

METHANE
CYCLE 17337
TIME
$\times 10^{-1}$
24
20
16
12
8
4
0
0
4
8
12
16
20
24
28
32
36
RADIUS $\times 10^{-8}$ (CM)

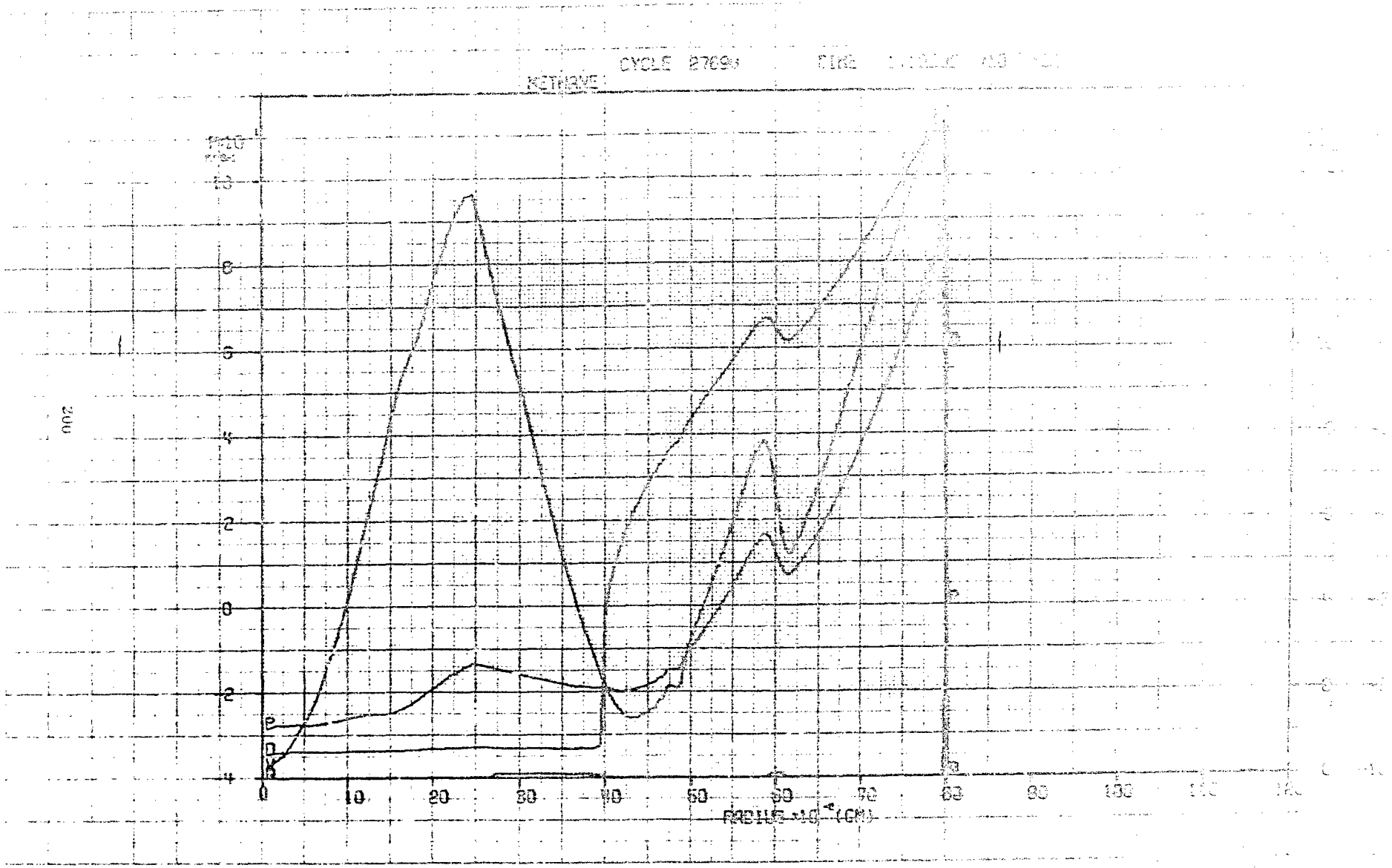

METHANE
CYCLE 1804S
TIME
P*10
20
24
28
16
12
8
4
0
V
P
D
0
4
8
12
16
20
24
28
32
RADIUS *10 **6 (CM)


CYCLE 21103
METHANE
P x 10
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120


METHANE
PFLG
20
16
12
8
4
0
-4
-8
0
10
20
30
40
50
60
70
80
90
100


CYCLE 24025
METHANE
RADIUS $\times 10^{-2}$ (CM)


CYCLE 25523
NETHANE
12
10
8
6
4
2
0
-2
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS


RETRIEVE
CYCLE 2769
0
10
20
30
40
50
60
70
80
90
100
RADIUS ×10⁻⁴(CM)

SHELL Contours and Velocity Vectors

This part contains pressure and density contours and velocity vector plots of the results of the SHELL-OIL calculation of the Methane detonation. There are plots for eight different times.

The first plot shows the reflection of the free-air shock at the ground. Subsequent plots show the formation and movement of the triple point and mach stem. The heavy black line on each plot shows the location of the massless trace particles which represent the methane-air interface at that time.

The numbers along the top of each plot represent the horizontal index of each cell of the mesh used in the calculation. The numbers along the right edge of the plot refer to vertical indices. The number associated with each contour line represents a value for that line appearing in the upper right-hand corner of each contour plot. The velocity vector scale is similarly given in the upper right-hand corner of each velocity vector plot.

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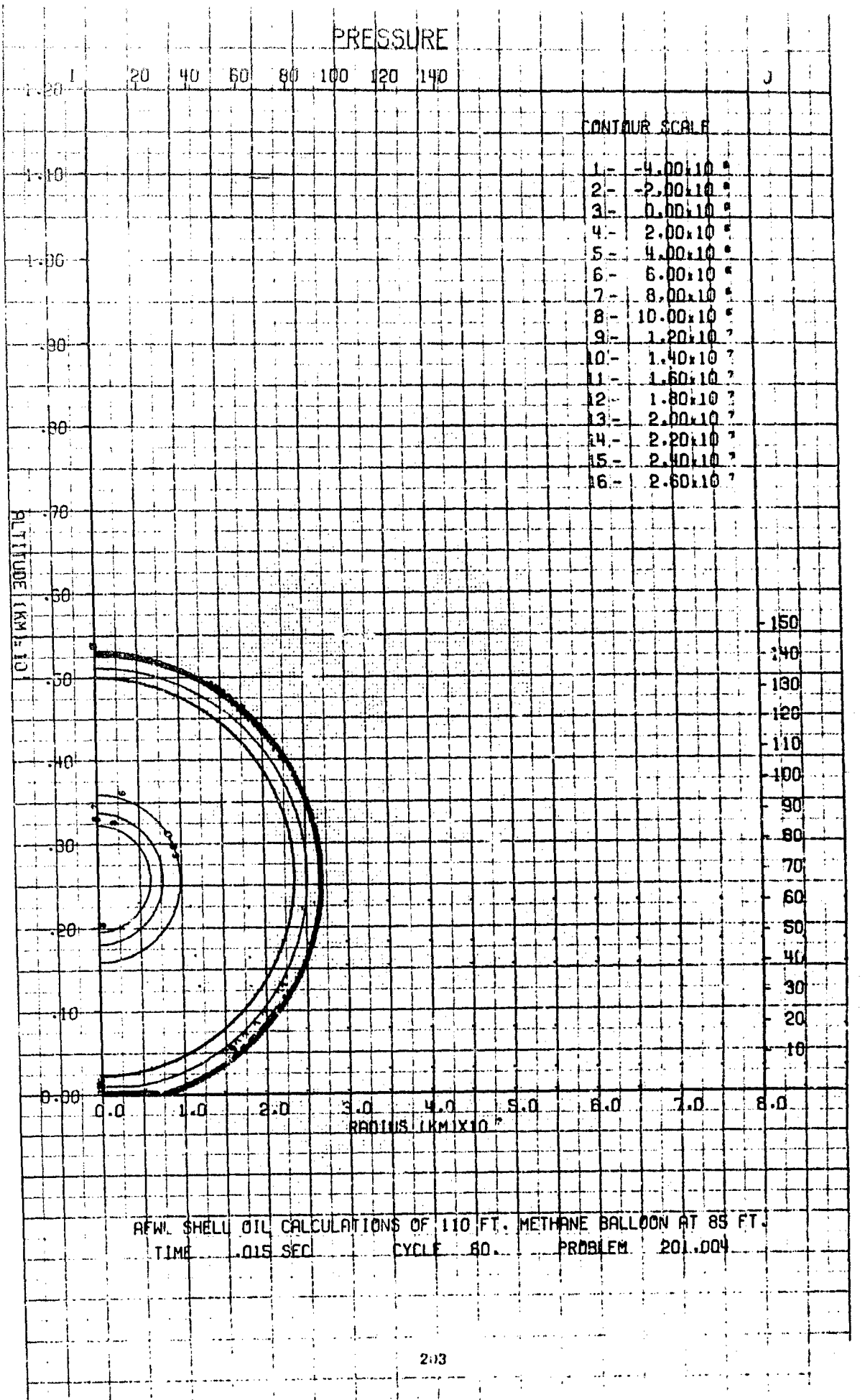
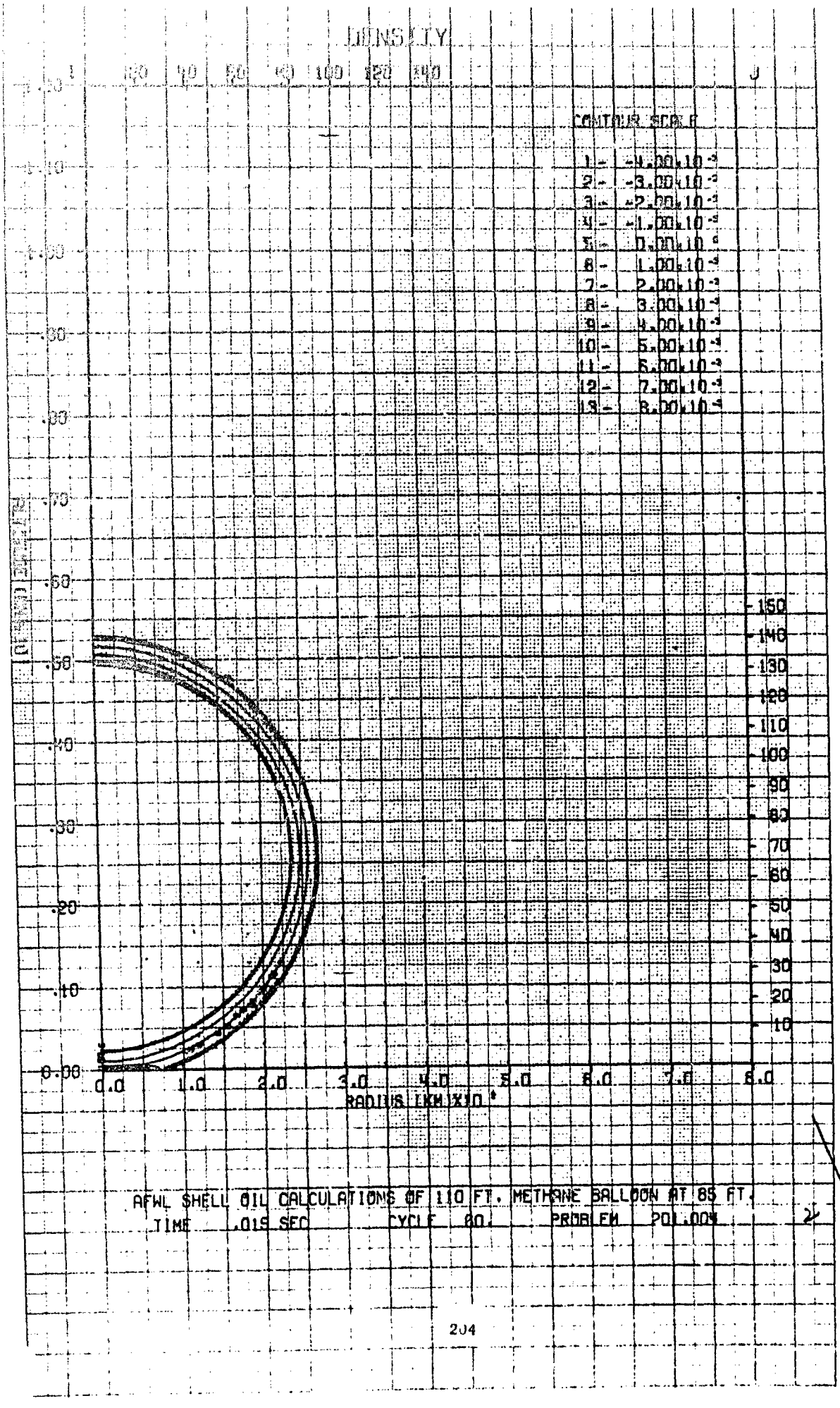
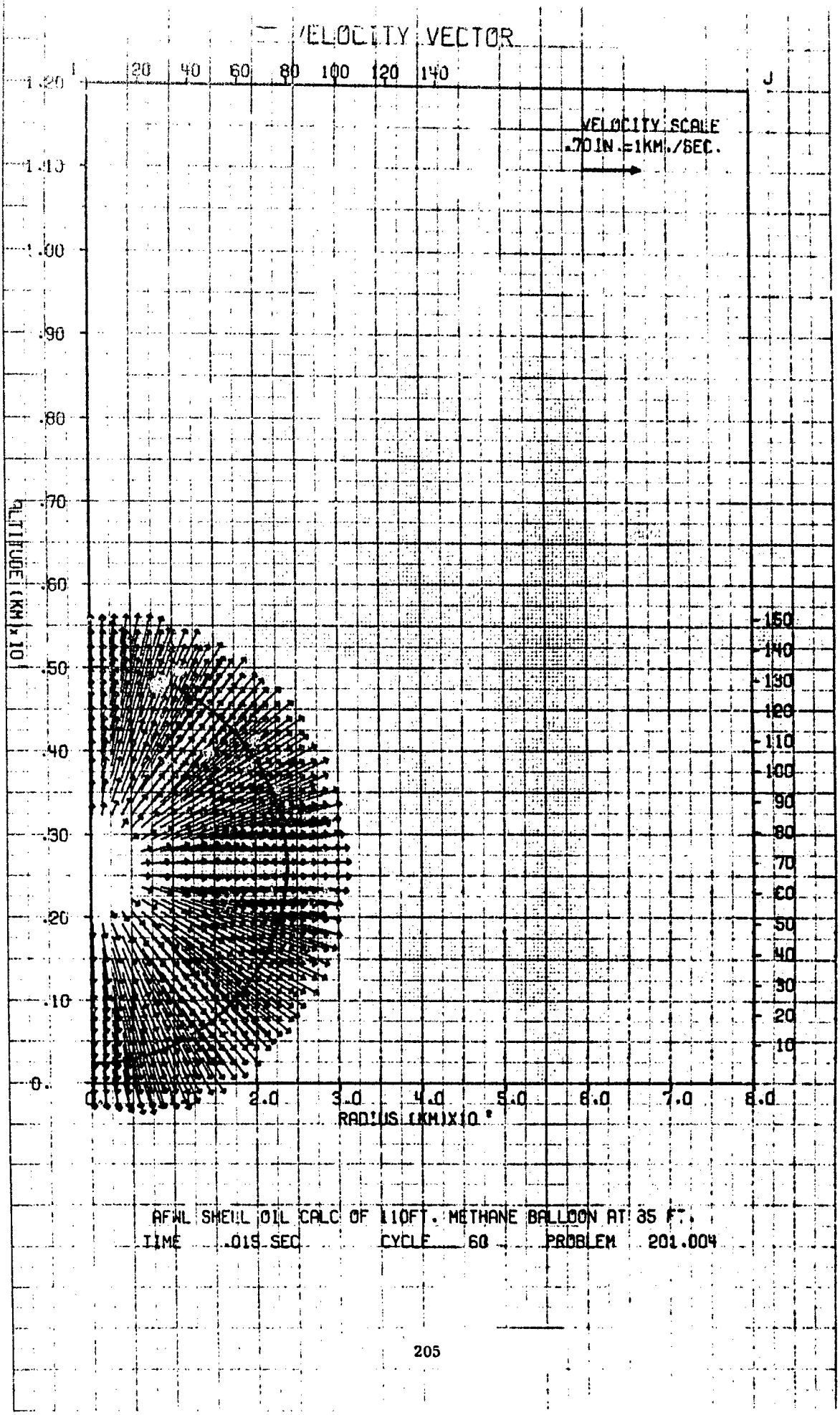
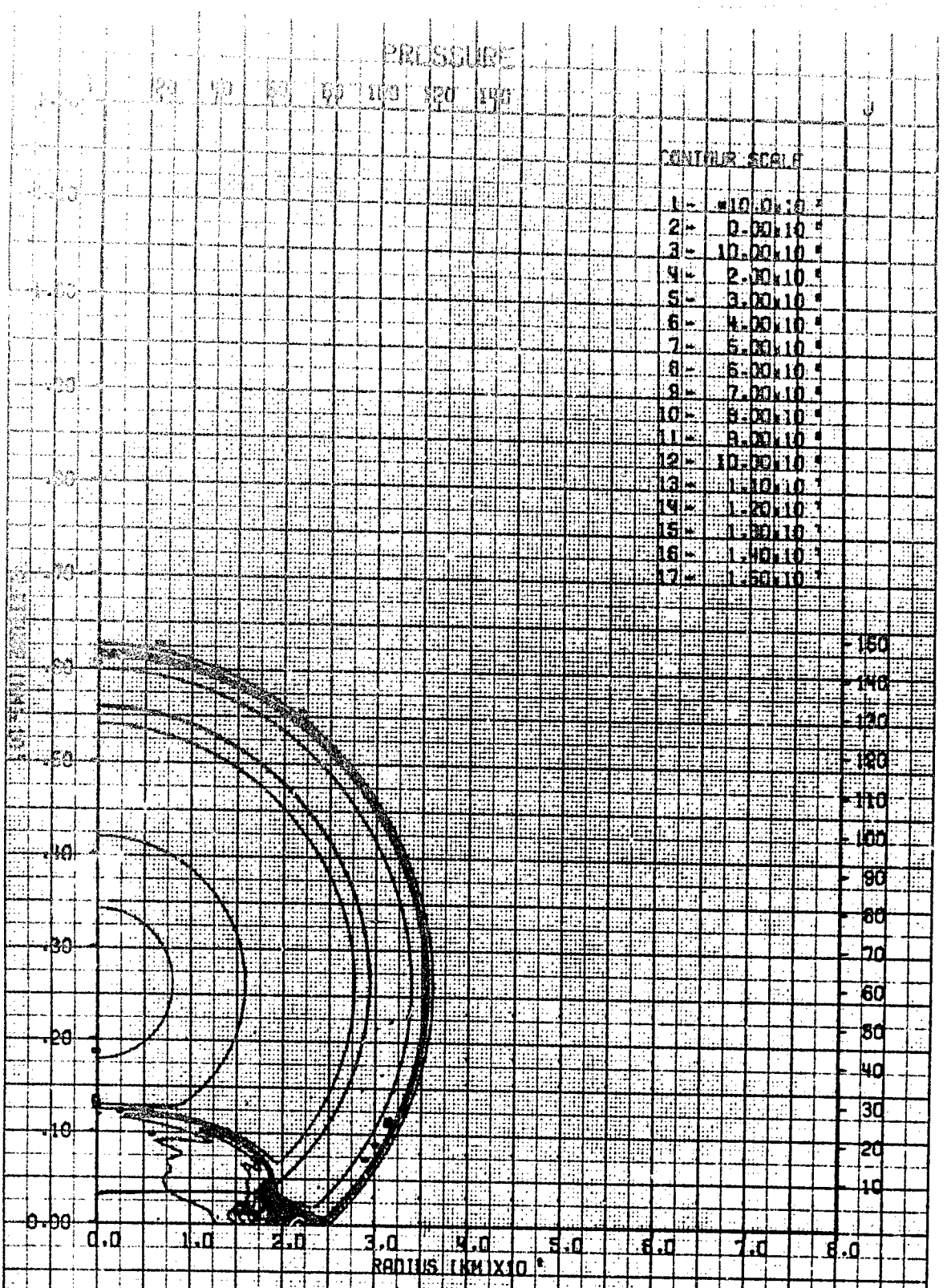
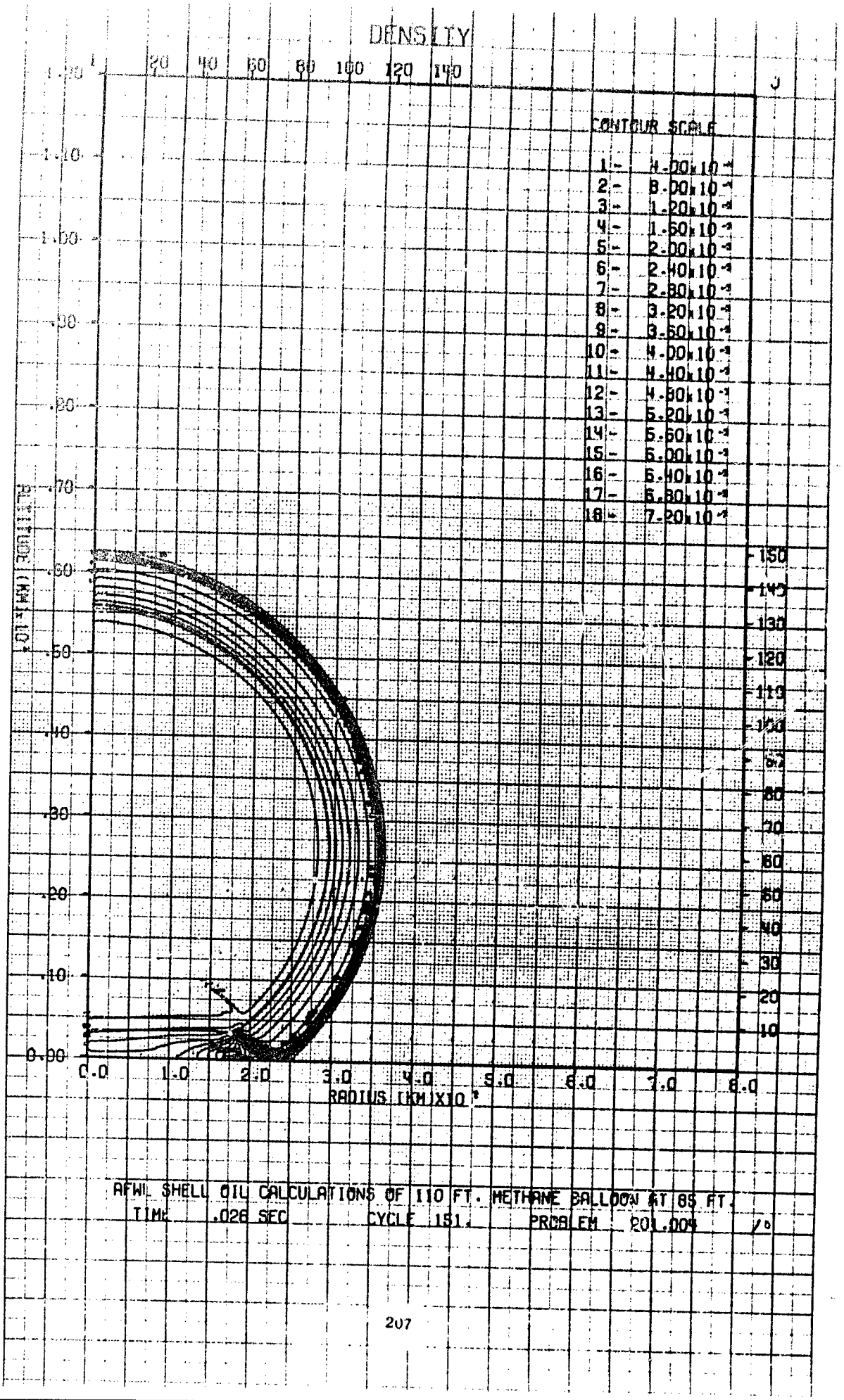
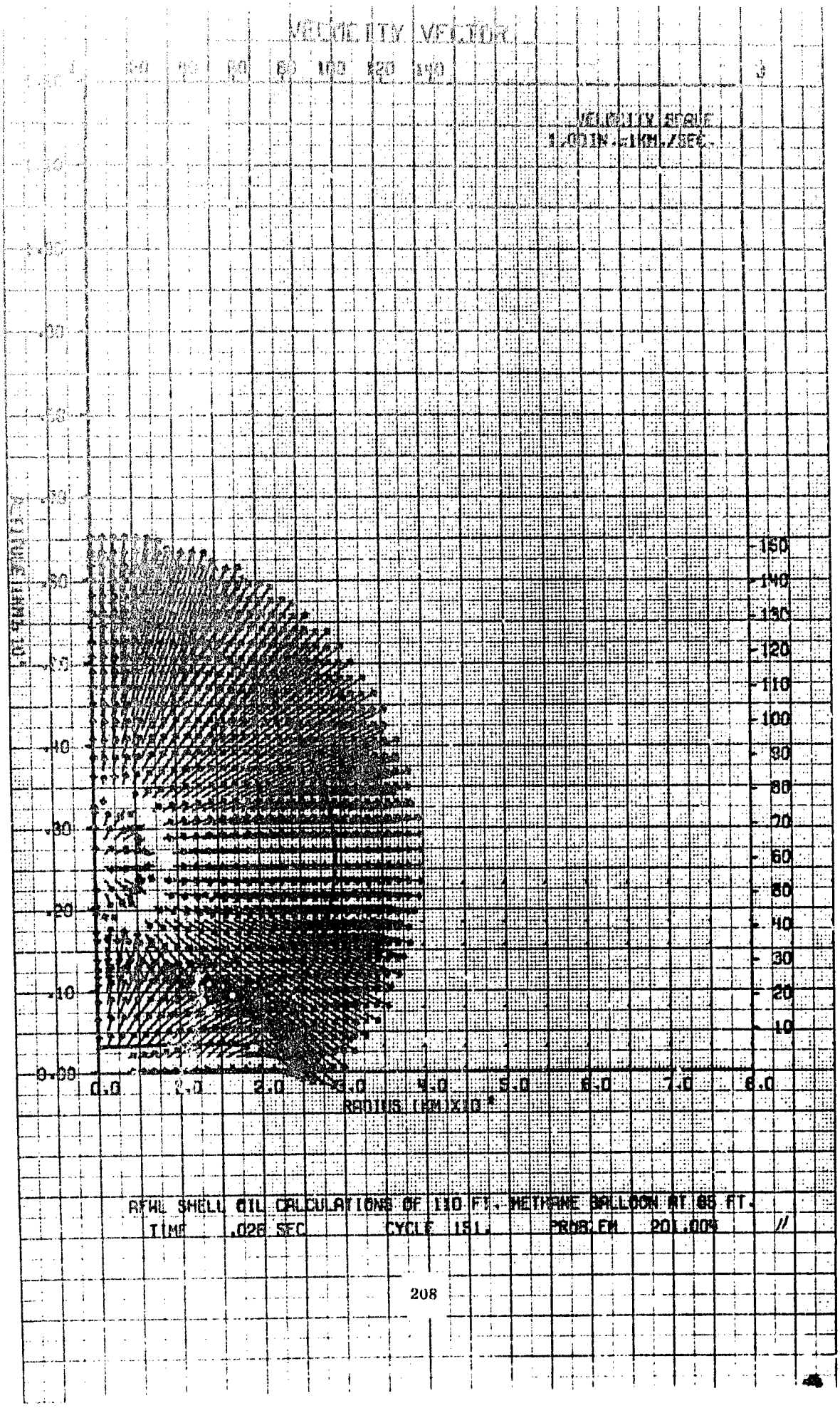

PRESSURE
CONTOUR SCALE
1 - -4.00x10 8
2 - -2.00x10 8
3 - 0.00x10 8
4 - 2.00x10 8
5 - 4.00x10 8
6 - 6.00x10 8
7 - 8.00x10 8
8 - 10.00x10 8
9 - 1.20x10 9
10 - 1.40x10 9
11 - 1.60x10 9
12 - 1.80x10 9
13 - 2.00x10 9
14 - 2.20x10 9
15 - 2.40x10 9
16 - 2.60x10 9
ALTITUDE (KM)=10
RADIUS (KM)X10
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .015 SEC CYCLE 80. PROBLEM 201.004

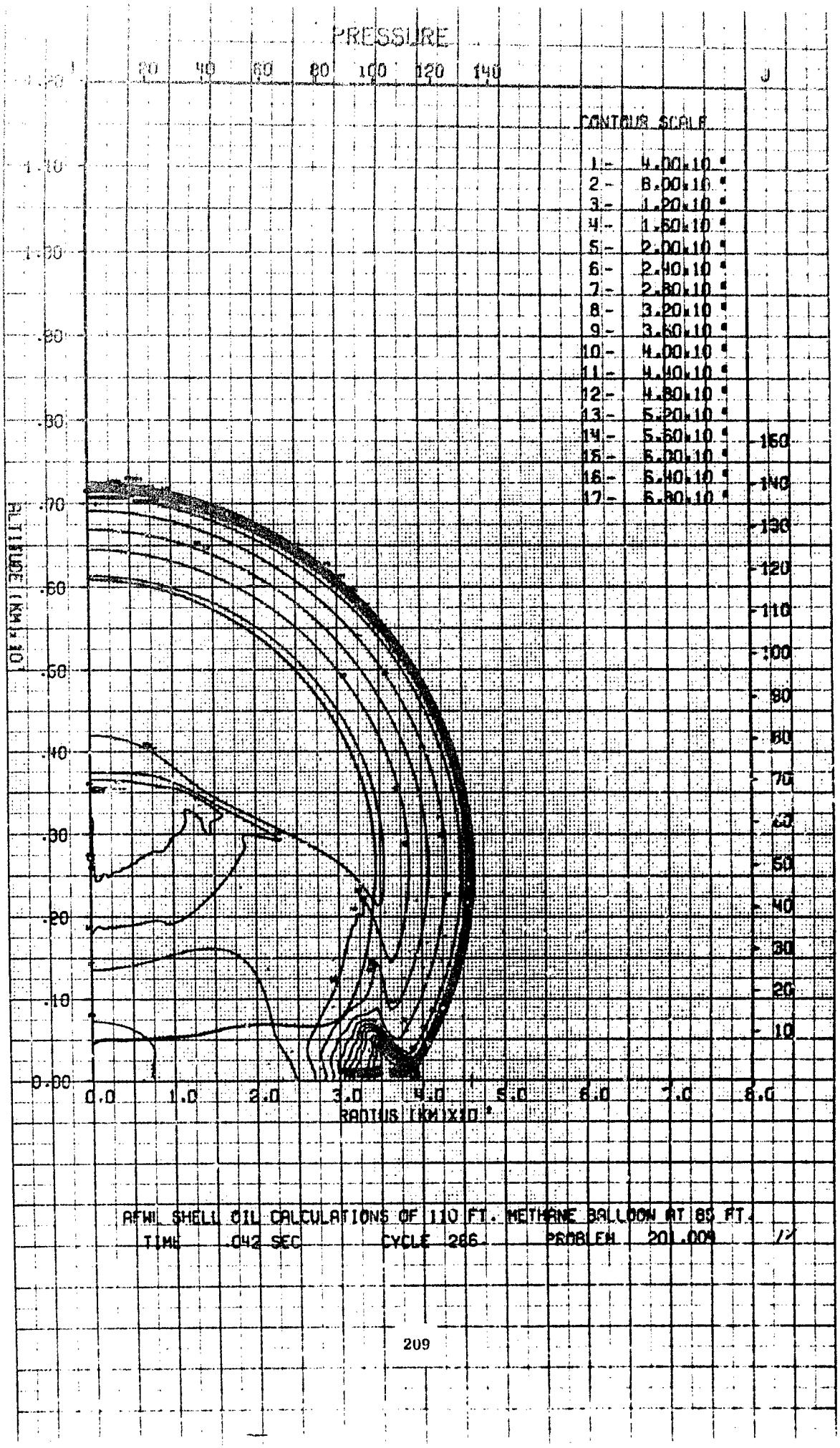

DENSITY
CONTOUR SCALE
1 - -4.00,10-3
2 - -3.00,10-3
3 - -2.00,10-3
4 - -1.00,10-3
5 - 0.00,10-3
6 - 1.00,10-3
7 - 2.00,10-3
8 - 3.00,10-3
9 - 4.00,10-3
10 - 5.00,10-3
11 - 6.00,10-3
12 - 7.00,10-3
13 - 8.00,10-3
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X10)
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .015 SEC CYCLE 80. PROBLEM POL.004

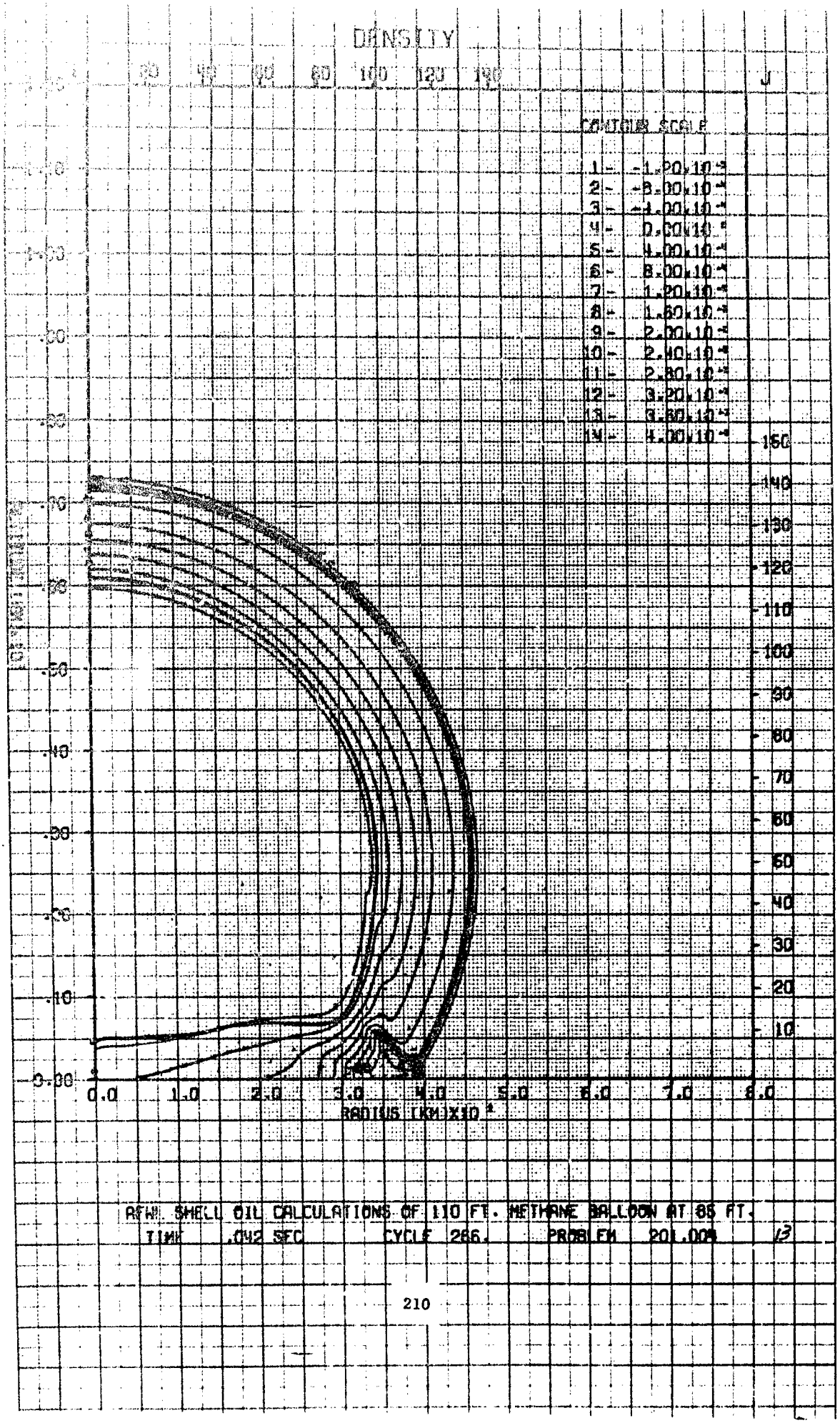

VELOCITY VECTOR
VELOCITY SCALE
.70 IN. = 1KM./SEC.
ALTITUDE (KM) x 10
RADIUS (KM) X10
AFWL SHELL OIL CALC OF 110FT. METHANE BALLOON AT 35 FT.
TIME .015 SEC CYCLE 60 PROBLEM 201.004

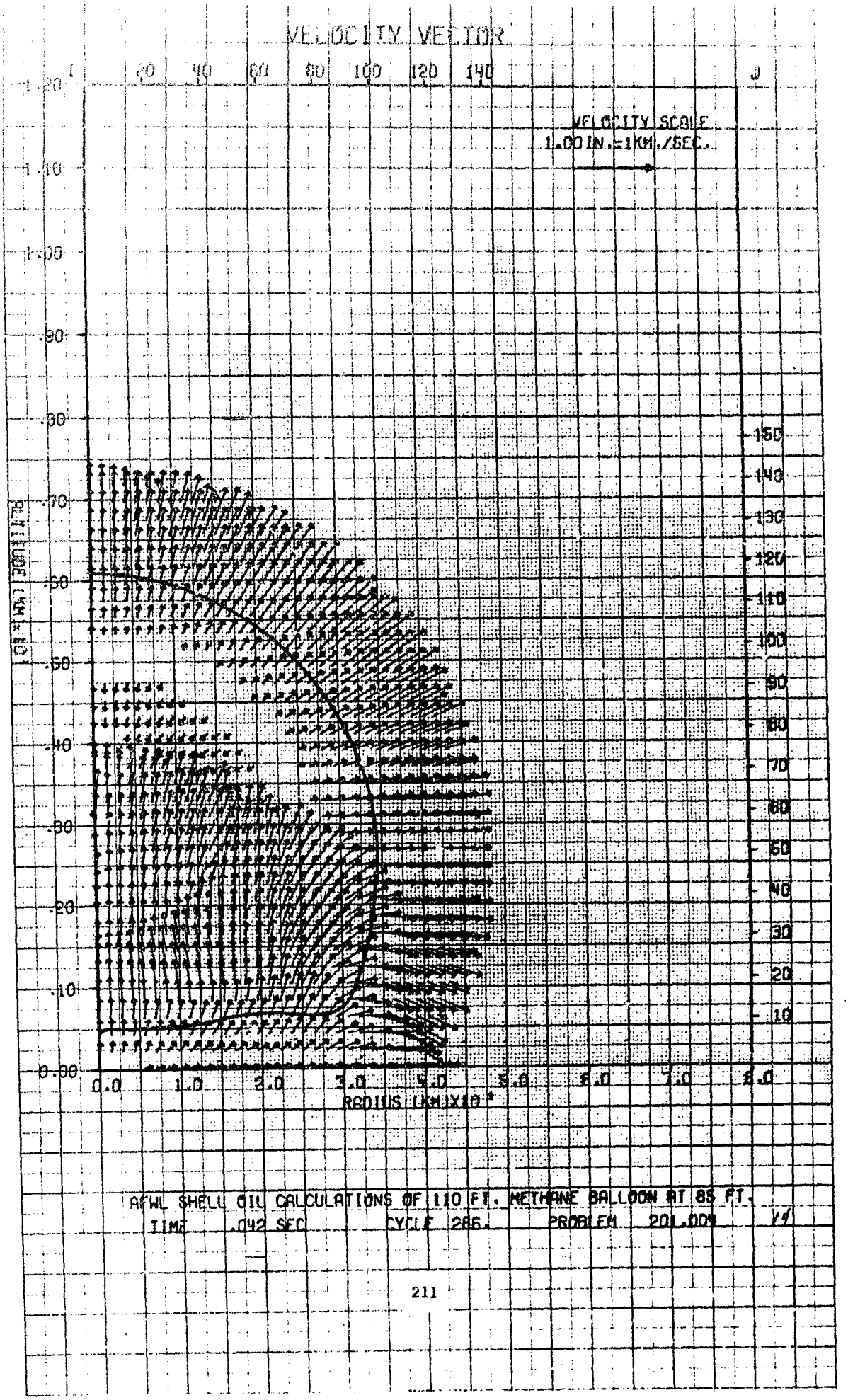

PRESSURE
CONTOUR SCALE
1 = 10.00x10
2 = 0.00x10
3 = 10.00x10
4 = 2.00x10
5 = 3.00x10
6 = 4.00x10
7 = 5.00x10
8 = 6.00x10
9 = 7.00x10
10 = 8.00x10
11 = 9.00x10
12 = 10.00x10
13 = 1.10x10
14 = 1.20x10
15 = 1.30x10
16 = 1.40x10
17 = 1.50x10
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .026 SEC CYCLE 151 PROBLEM 201.004
9

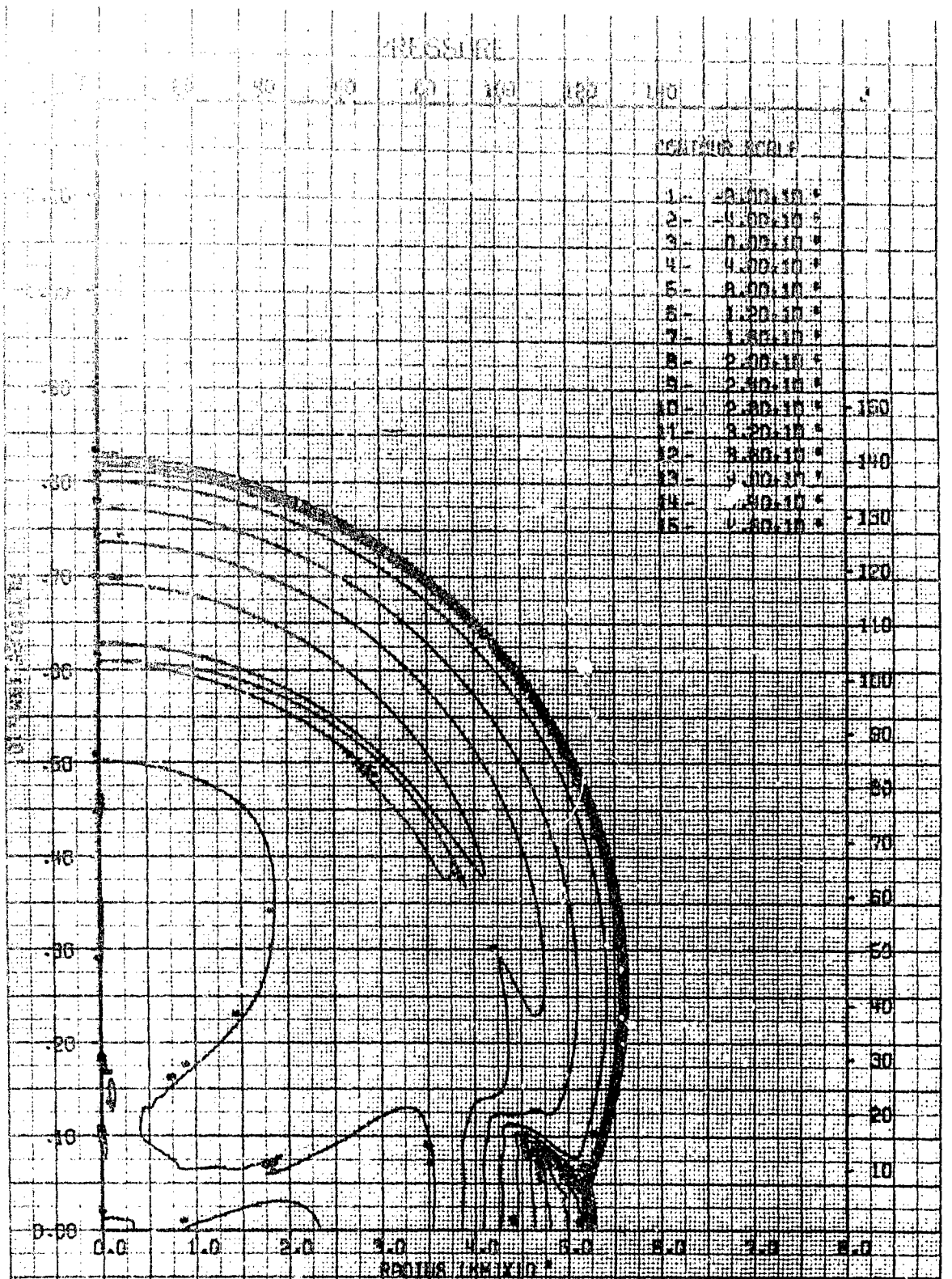

DENSITY
CONTOUR SCALE
1 - 4.00x10⁻⁴
2 - 8.00x10⁻⁴
3 - 1.20x10⁻³
4 - 1.60x10⁻³
5 - 2.00x10⁻³
6 - 2.40x10⁻³
7 - 2.80x10⁻³
8 - 3.20x10⁻³
9 - 3.60x10⁻³
10 - 4.00x10⁻³
11 - 4.40x10⁻³
12 - 4.80x10⁻³
13 - 5.20x10⁻³
14 - 5.60x10⁻³
15 - 6.00x10⁻³
16 - 6.40x10⁻³
17 - 6.80x10⁻³
18 - 7.20x10⁻³
ALTITUDE (KM)X10³
RADIUS (KM)X10³
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .026 SEC CYCLE 151. PROBLEM 201.004


VELOCITY VECTOR
VELOCITY SCALE
1.00IN.=1KM./SEC.
ALTITUDE (KM)
RADIUS (KM)X10*
0.00
2.0
4.0
6.0
8.0
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
RFHL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 65 FT.
TIME .028 SEC CYCLE 151. PROBLEM 201.00%

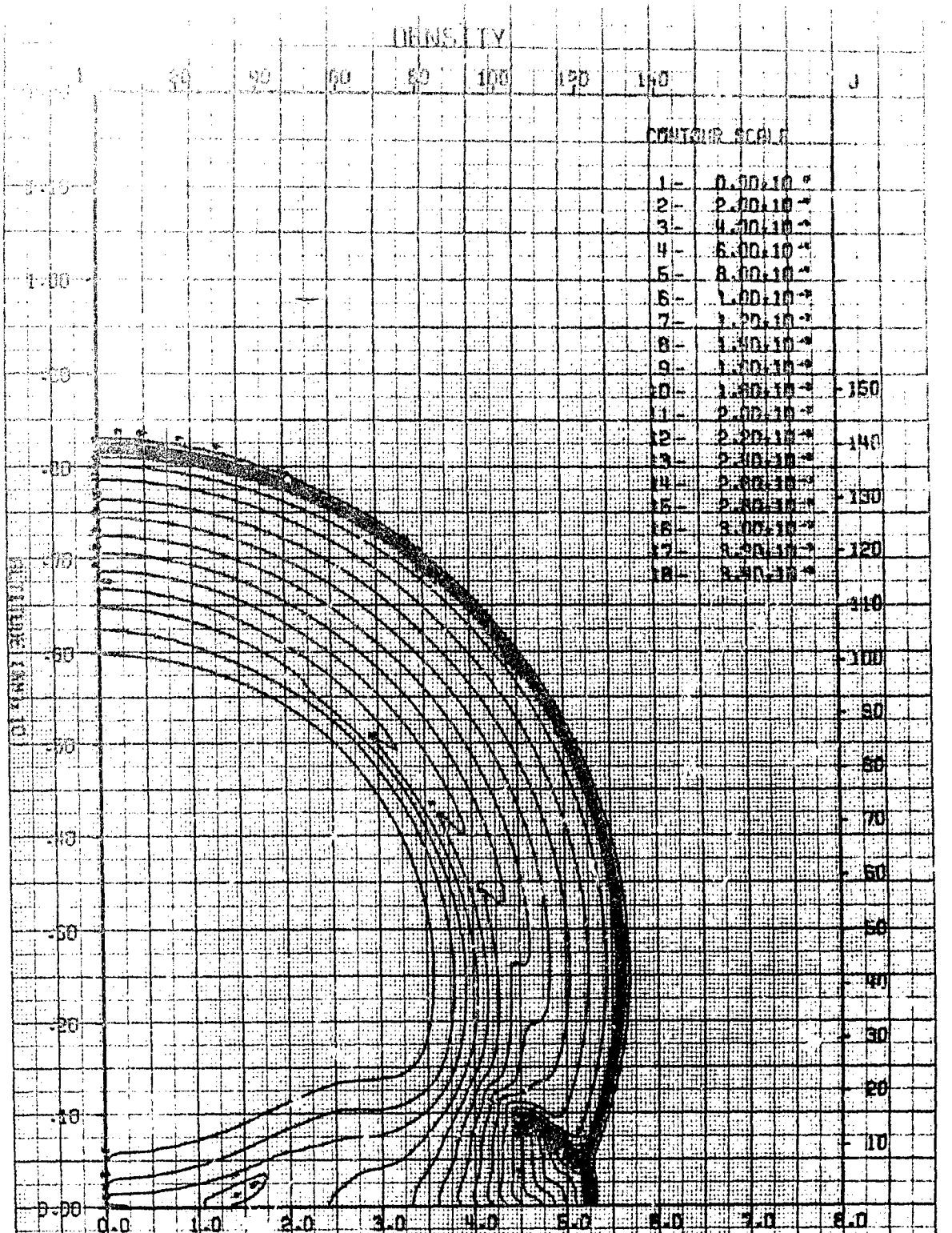

PRESSURE
20
40
60
80
100
120
140
CONTOUR SCALE
1 - 4.00x10
2 - 8.00x10
3 - 1.20x10
4 - 1.60x10
5 - 2.00x10
6 - 2.40x10
7 - 2.80x10
8 - 3.20x10
9 - 3.60x10
10 - 4.00x10
11 - 4.40x10
12 - 4.80x10
13 - 5.20x10
14 - 5.60x10
15 - 6.00x10
16 - 6.40x10
17 - 6.80x10
ALTITUDE (KM)x10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
1.10
1.20
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 286 PROBLEM 201.009

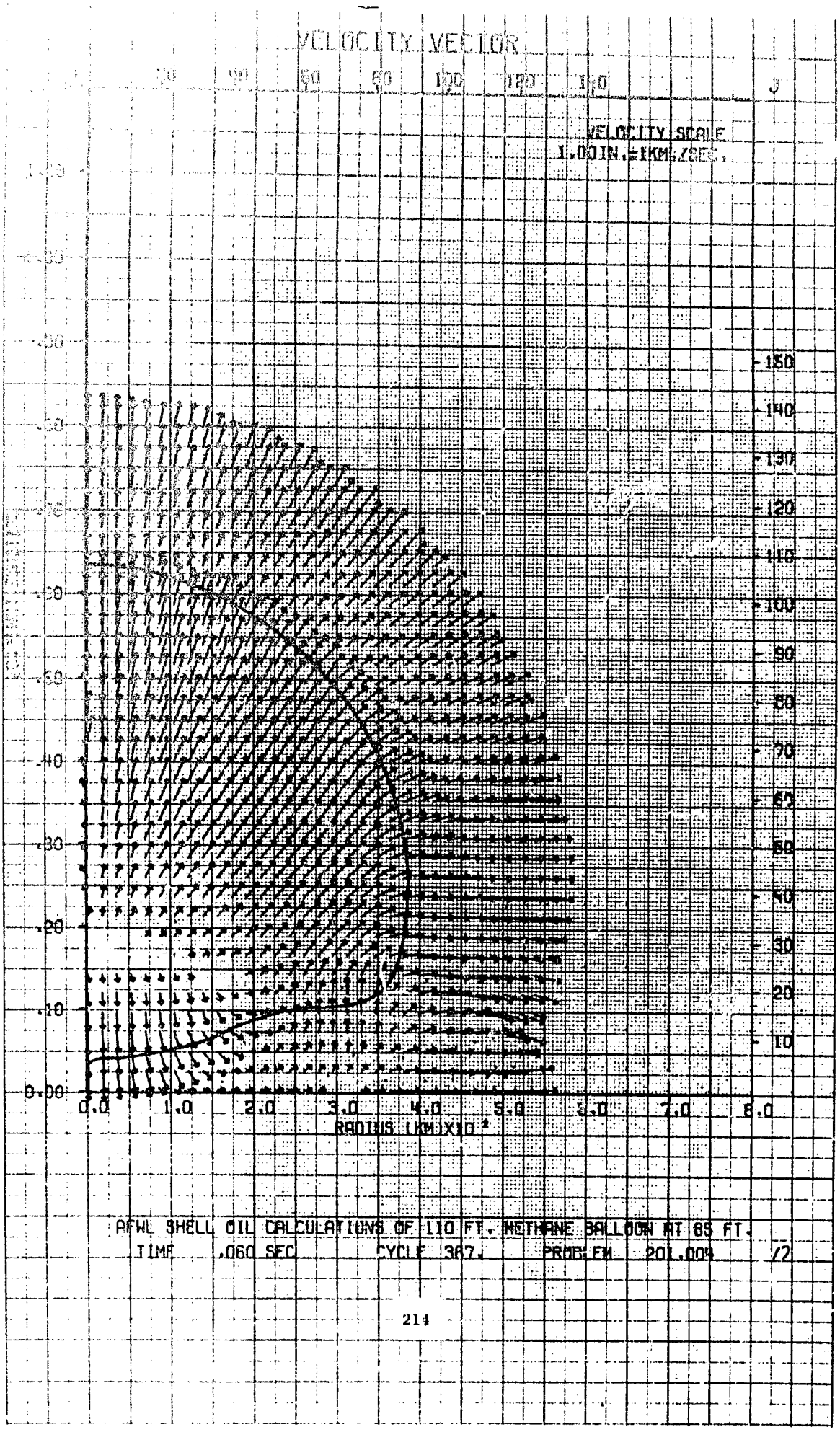

DENSITY
CONTOUR SCALE
1 - -1.20x10⁻³
2 - -8.00x10⁻⁴
3 - -4.00x10⁻⁴
4 - 0.00x10⁻⁴
5 - 4.00x10⁻⁴
6 - 8.00x10⁻⁴
7 - 1.20x10⁻³
8 - 1.60x10⁻³
9 - 2.00x10⁻³
10 - 2.40x10⁻³
11 - 2.80x10⁻³
12 - 3.20x10⁻³
13 - 3.60x10⁻³
14 - 4.00x10⁻³
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM X10⁴)
REM SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 286. PROBLEM 201.004
13

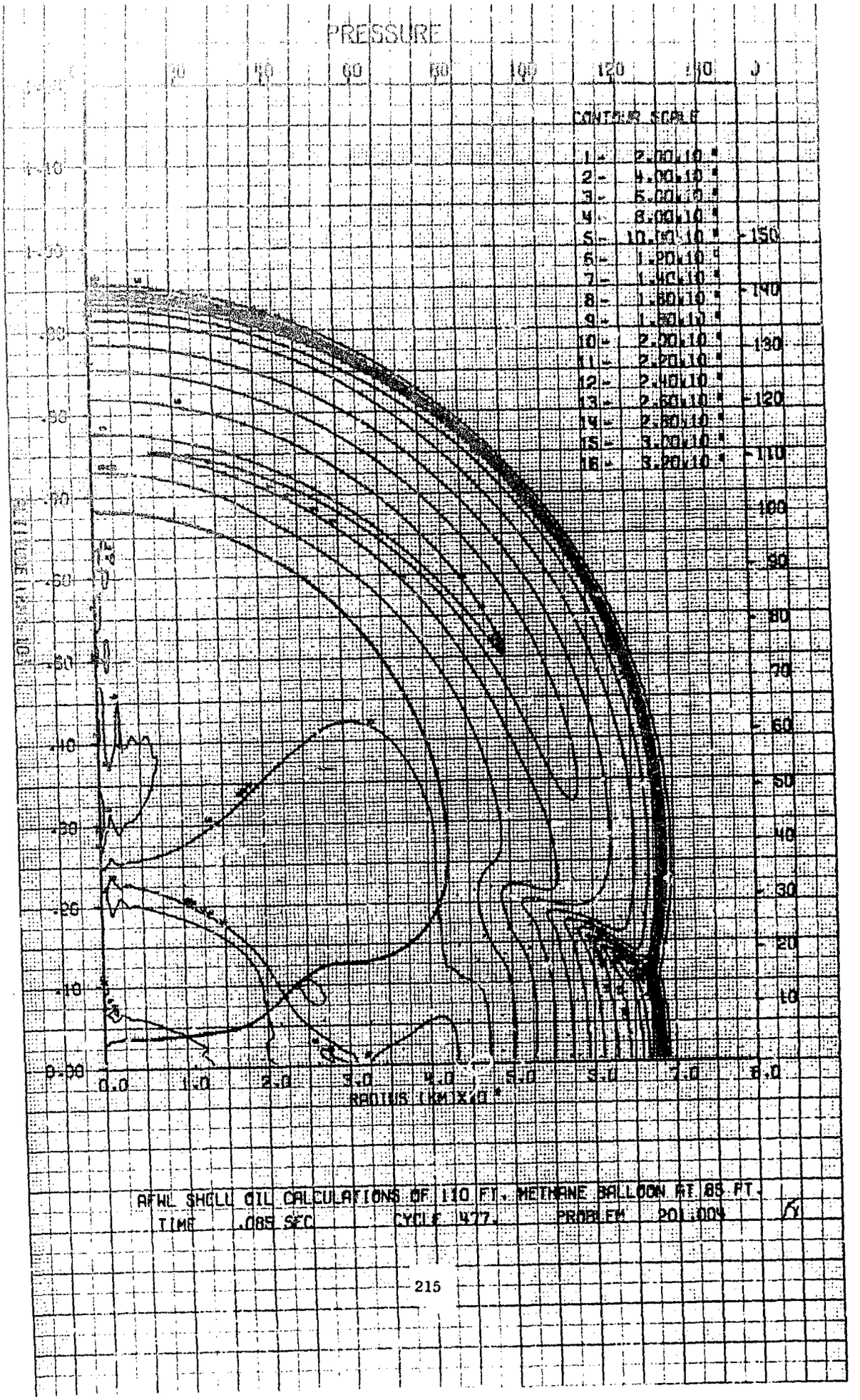

VELOCITY VECTOR
VELOCITY SCALE
1.00 IN.=1KM./SEC.
ALTITUDE (KM)X10
RADIUS (KM)X10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 286. PROBLEM 201.004

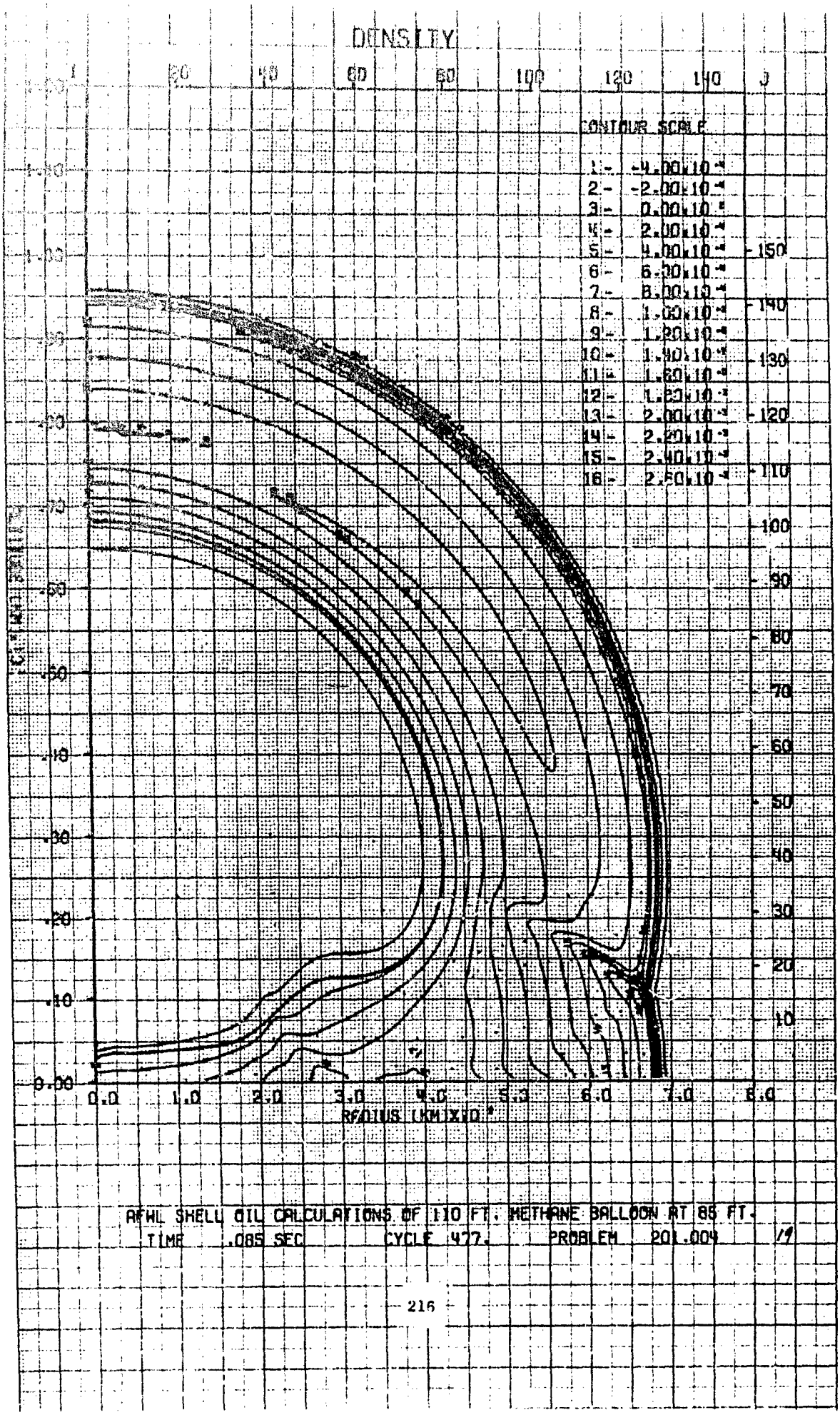


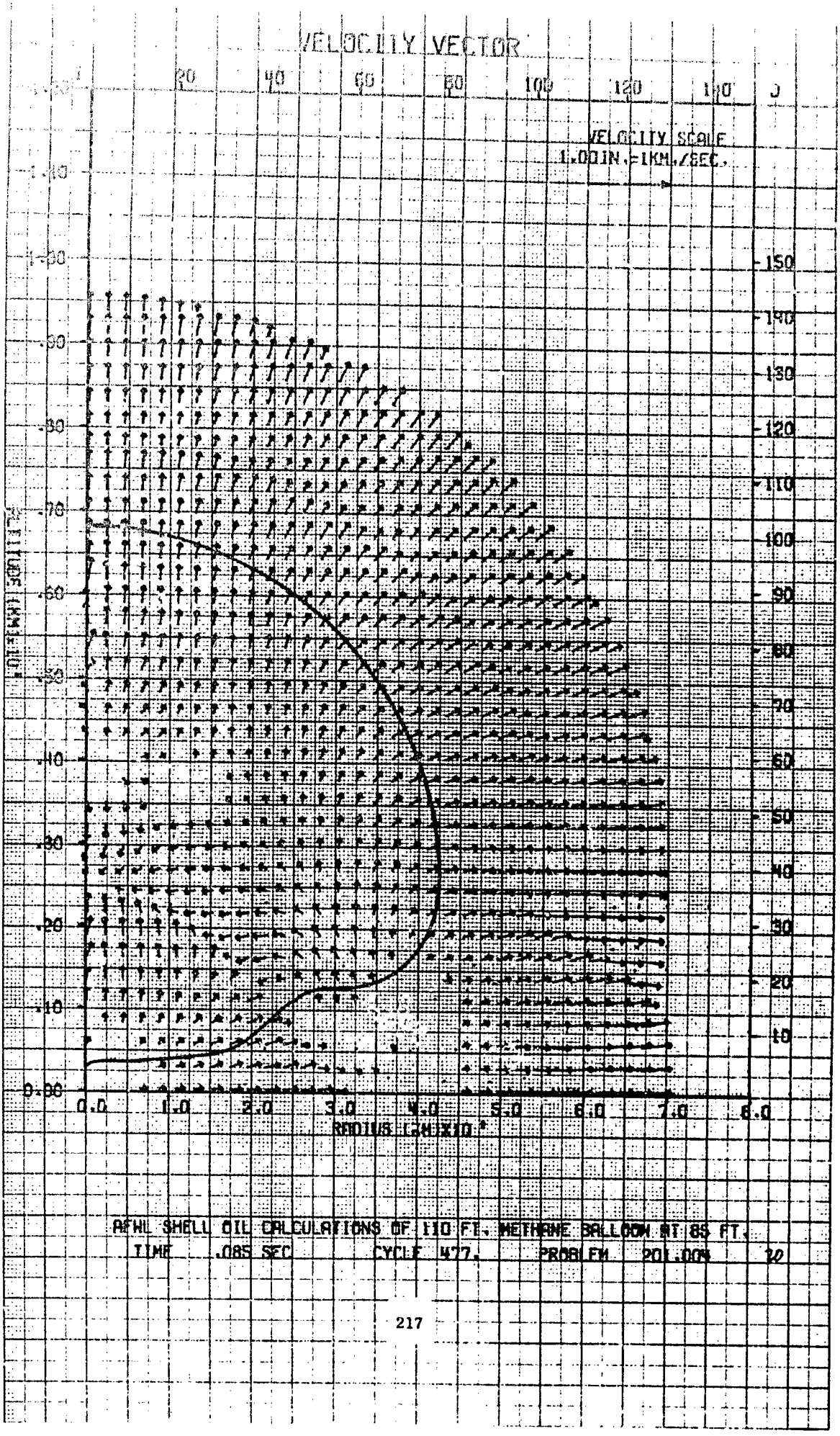
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 86 FT.
TIME .060 SEC CYCLE 387. PROBLEM 20L.MOM

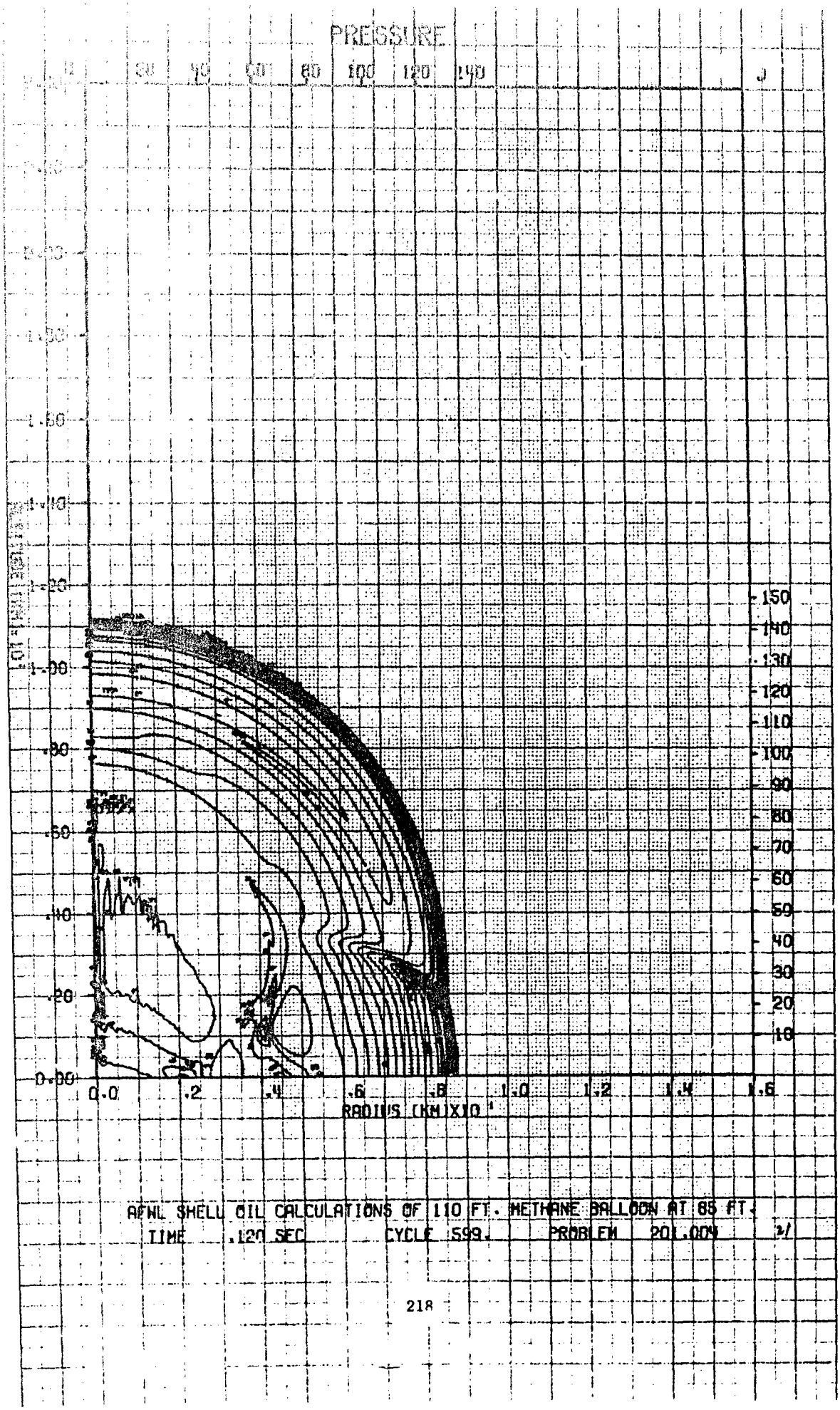

DENSITY
CONTOUR SCALE
1- 0.00,10 -6
2- 2.00,10 -6
3- 4.00,10 -6
4- 6.00,10 -6
5- 8.00,10 -6
6- 1.00,10 -5
7- 1.20,10 -5
8- 1.40,10 -5
9- 1.60,10 -5
10- 1.80,10 -5
11- 2.00,10 -5
12- 2.20,10 -5
13- 2.40,10 -5
14- 2.60,10 -5
15- 2.80,10 -5
16- 3.00,10 -5
17- 3.20,10 -5
18- 3.40,10 -5
ALTITUDE (KM X 10)
RADIUS (KM X 10 *)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .060 SEC CYCLE 367. PROBLEM 201.004

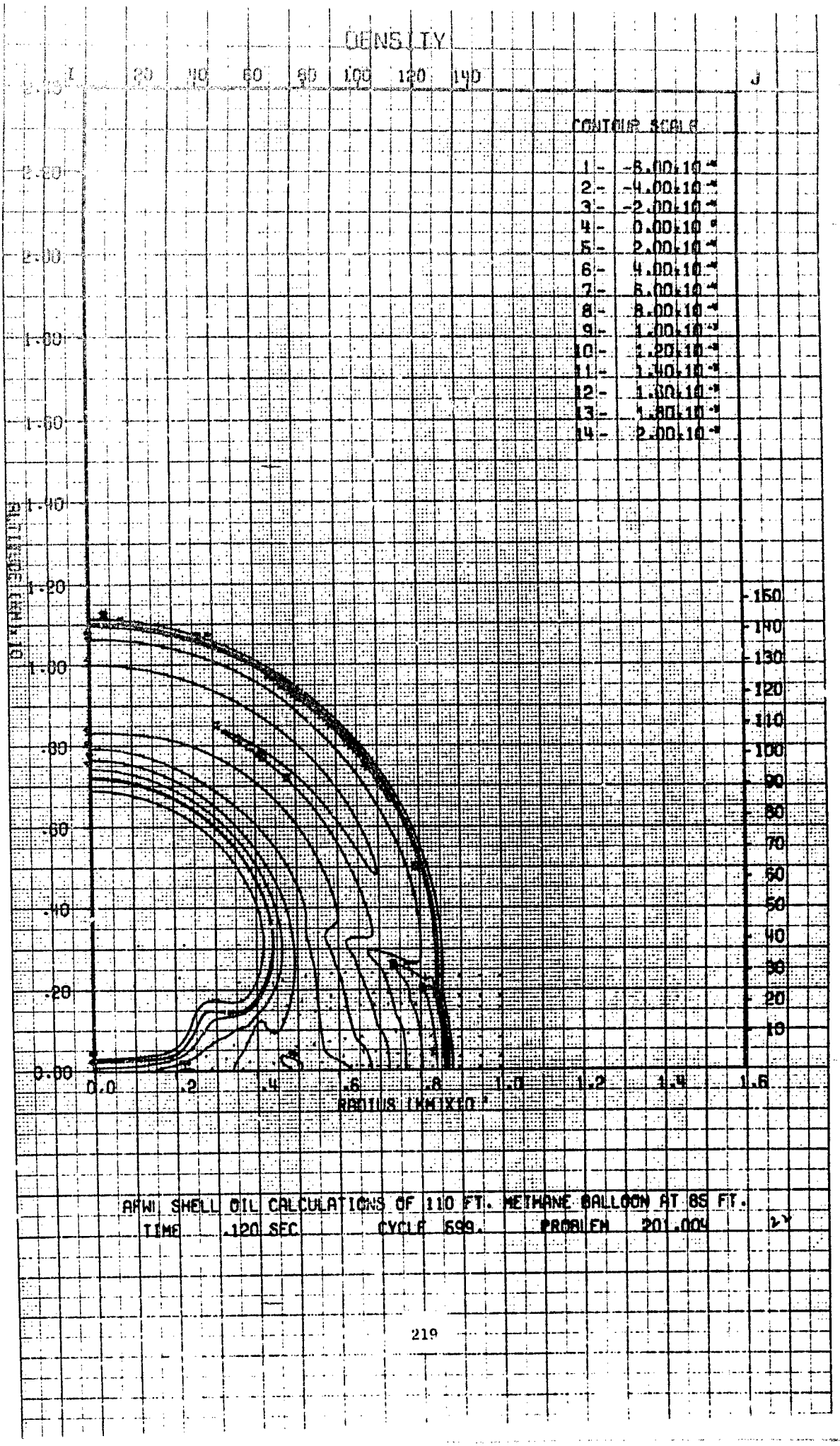

VELOCITY VECTOR
VELOCITY SCALE
1.00IN.=1KM/SEC.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.00
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM)X10²
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 65 FT.
TIME .060 SEC CYCLE 387. PROB.EM 201.004 /2

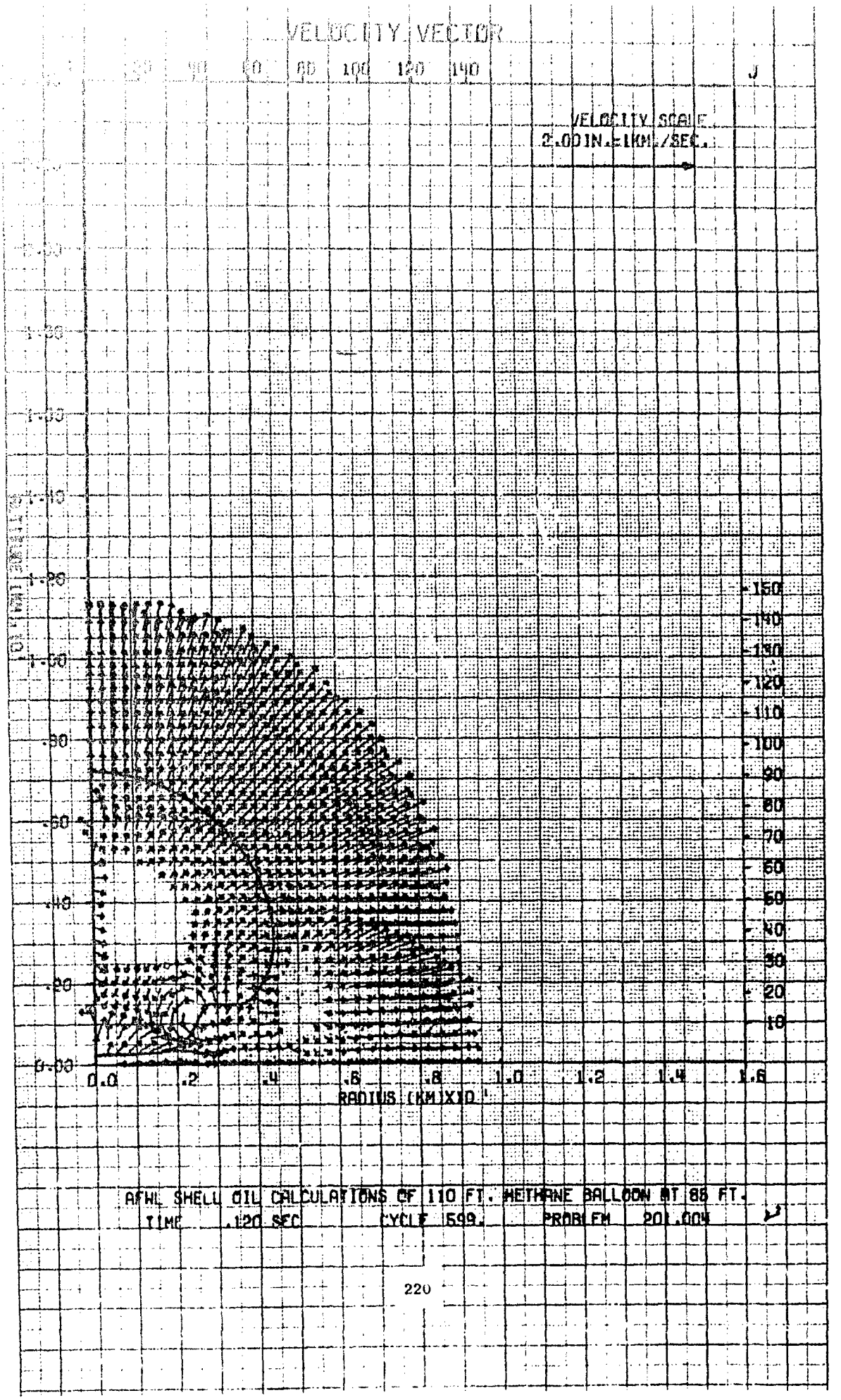

PRESSURE
CONTOUR SCALE
1 - 2.00x10 ⁴
2 - 4.00x10 ⁴
3 - 6.00x10 ⁴
4 - 8.00x10 ⁴
5 - 10.00x10 ⁴
6 - 1.20x10 ⁵
7 - 1.40x10 ⁵
8 - 1.60x10 ⁵
9 - 1.80x10 ⁵
10 - 2.00x10 ⁵
11 - 2.20x10 ⁵
12 - 2.40x10 ⁵
13 - 2.60x10 ⁵
14 - 2.80x10 ⁵
15 - 3.00x10 ⁵
16 - 3.20x10 ⁵
-150
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RADIUS (KM) X10 ⁴
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC
CYCLE 477.
PROBLEM POL.004

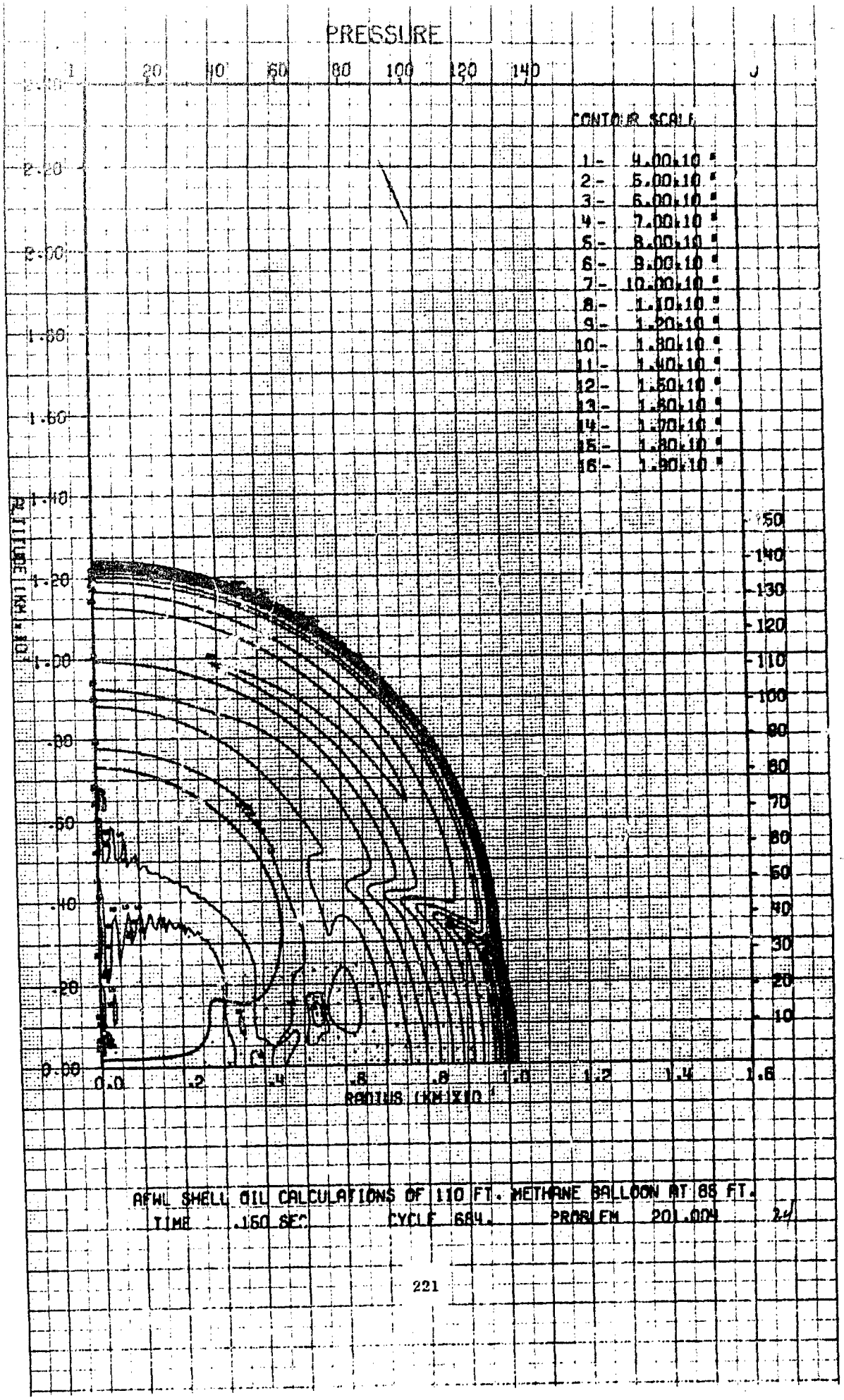

DENSITY
CONTOUR SCALE
1 - -4.00x10 **-4
2 - -2.00x10 **-4
3 - 0.00x10 **-4
4 - 2.00x10 **-4
5 - 4.00x10 **-4
6 - 6.00x10 **-4
7 - 8.00x10 **-4
8 - 1.00x10 **-4
9 - 1.20x10 **-4
10 - 1.40x10 **-4
11 - 1.60x10 **-4
12 - 1.80x10 **-4
13 - 2.00x10 **-4
14 - 2.20x10 **-4
15 - 2.40x10 **-4
16 - 2.60x10 **-4
RADIUS (KM)X10 **
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC CYCLE 477. PROBLEM 201.004

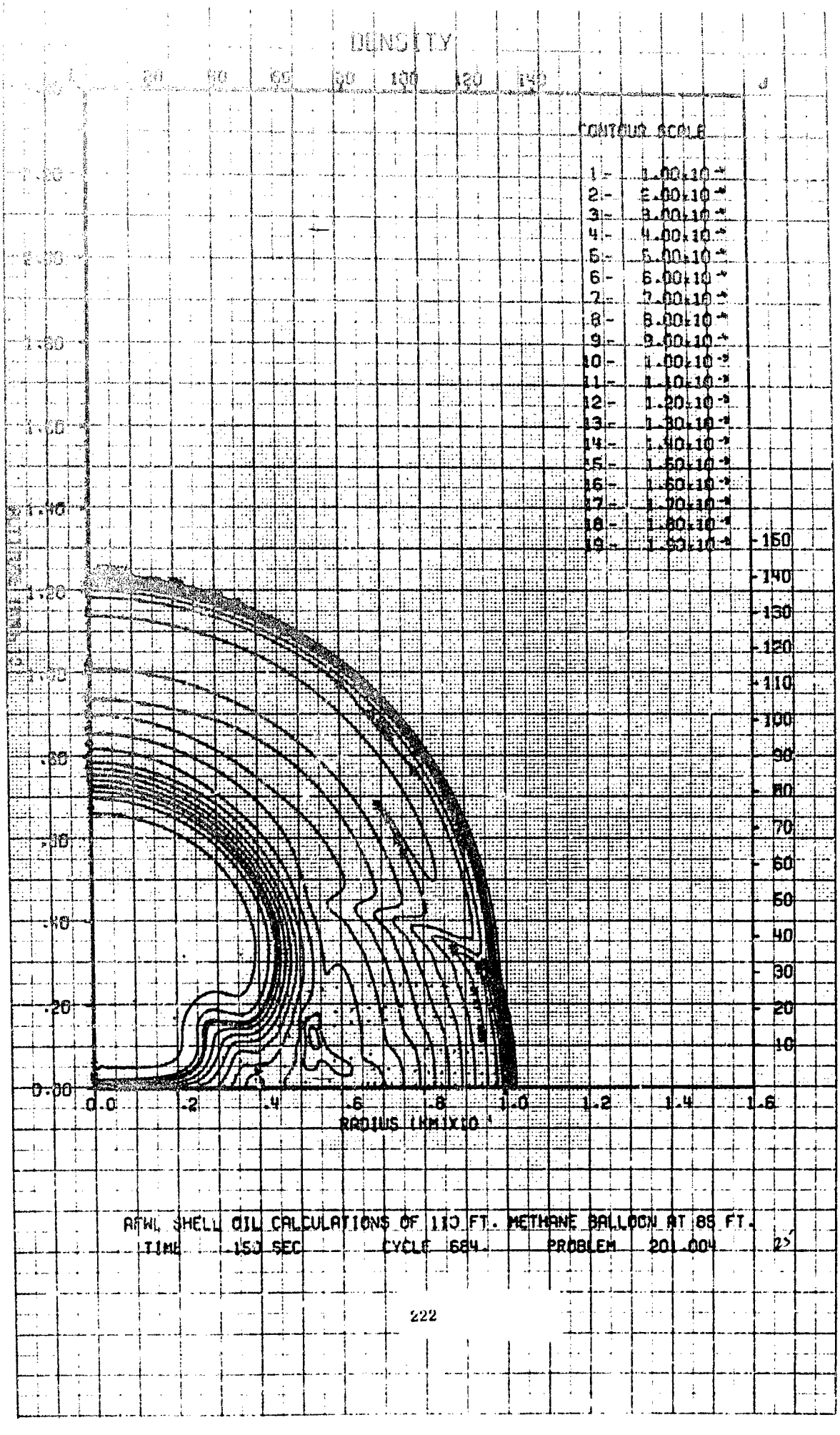

VELOCITY VECTOR
VELOCITY SCALE
1.00IN.=1KM./SEC.
ALTITUDE (KM)X10³
RADIUS (KM)X10³
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC
CYCLE 477.
PROBLEM 201.00%

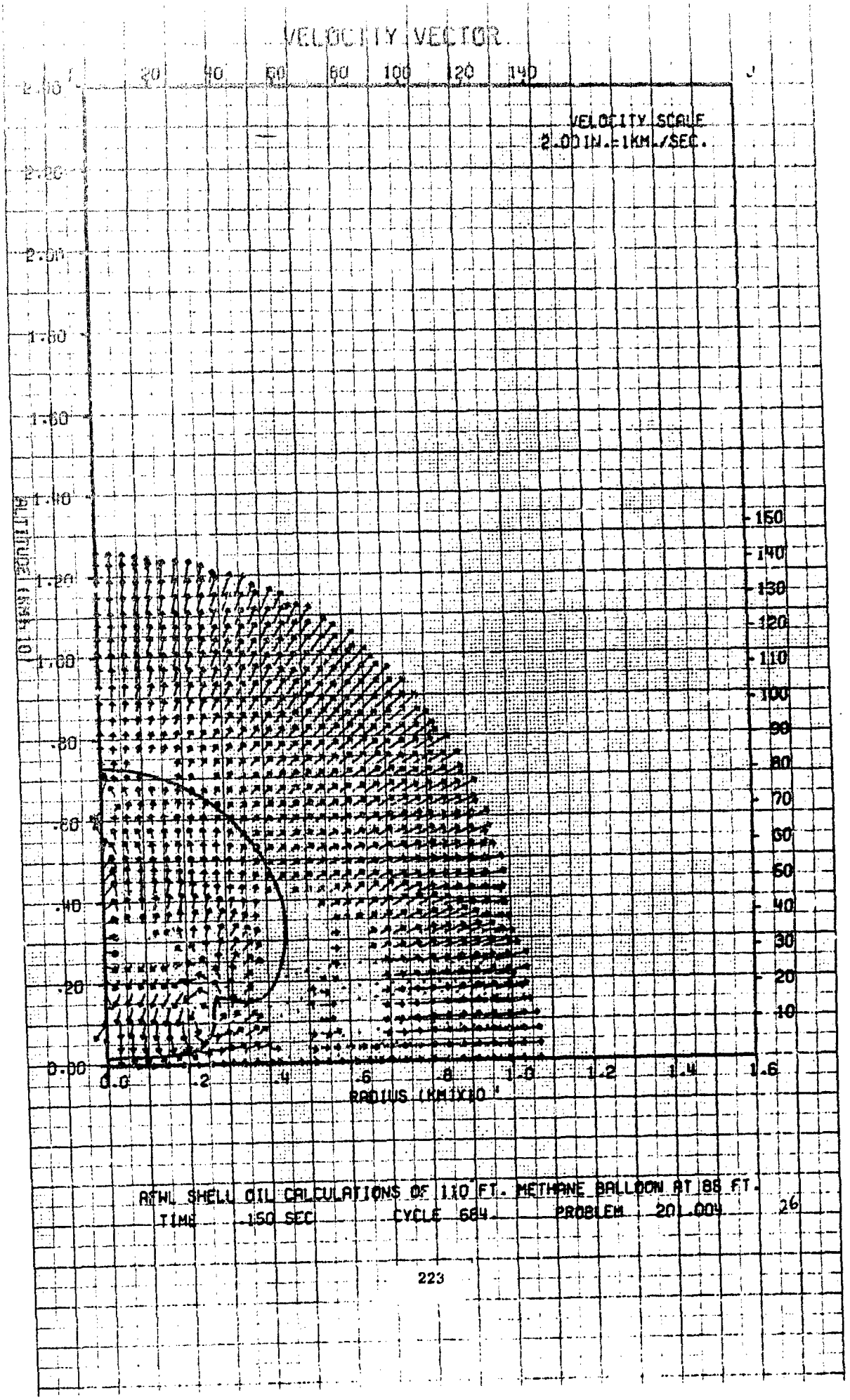

PRESSURE
RADIUS (KM)X10
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004

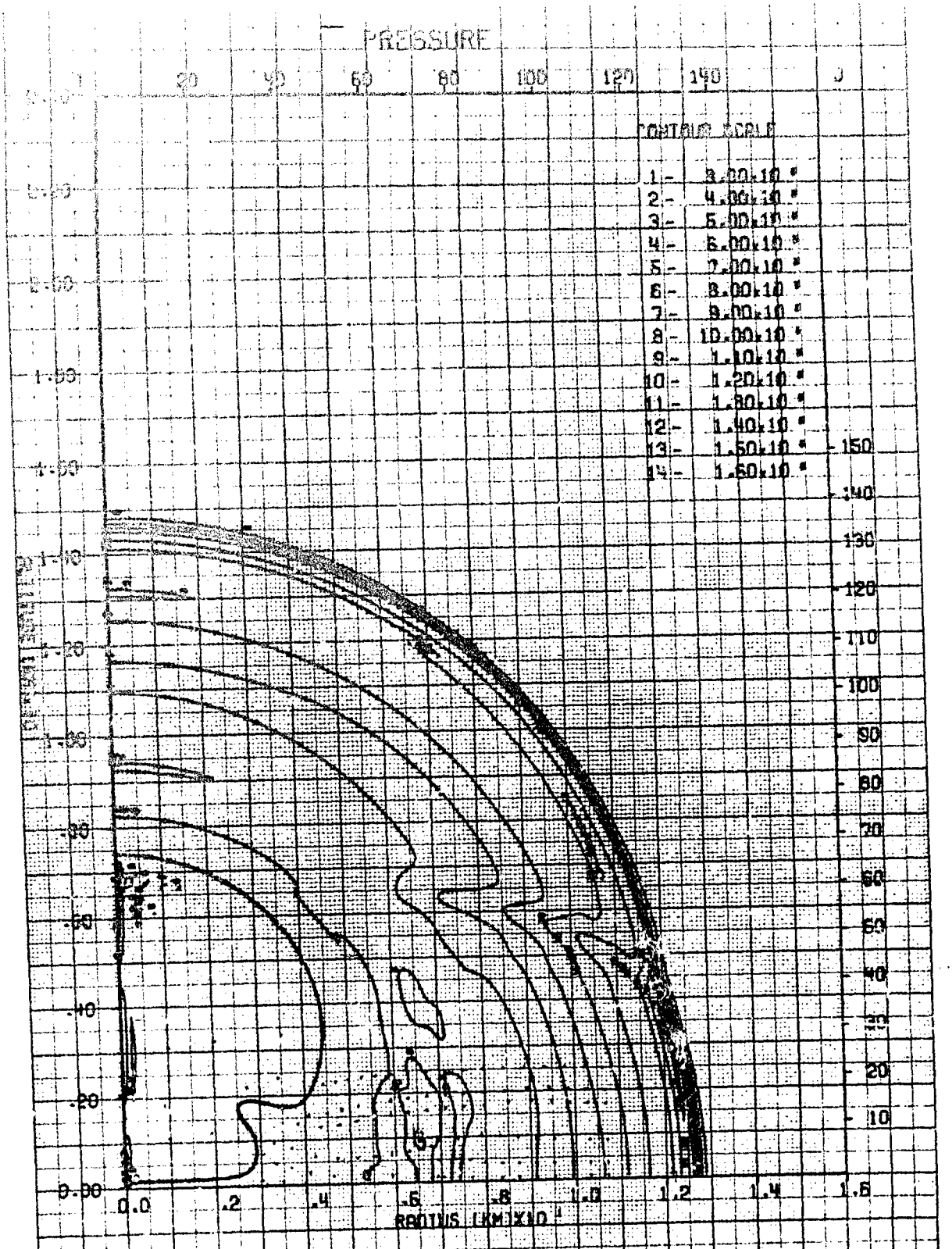

DENSITY
CONTOUR SCALE
1 - -8.00,10 **
2 - -4.00,10 **
3 - -2.00,10 **
4 - 0.00,10 **
5 - 2.00,10 **
6 - 4.00,10 **
7 - 6.00,10 **
8 - 8.00,10 **
9 - 1.00,10 **
10 - 1.20,10 **
11 - 1.40,10 **
12 - 1.60,10 **
13 - 1.80,10 **
14 - 2.00,10 **
RADIUS (MIXED)
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004


VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
RADIUS (KM)X10
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 88 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004

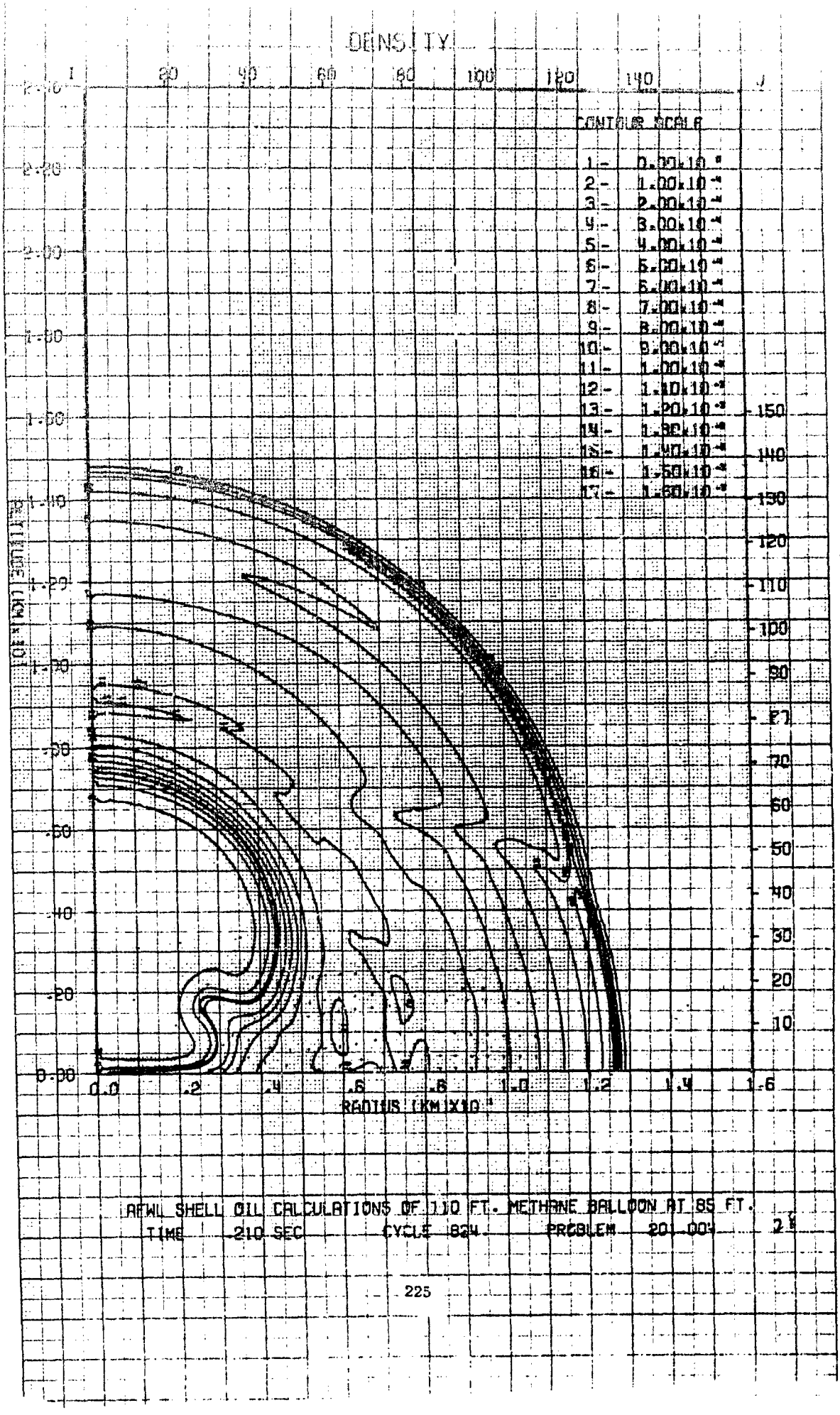

PRESSURE
CONTOUR SCALE
1- 4.00,10
2- 5.00,10
3- 6.00,10
4- 7.00,10
5- 8.00,10
6- 9.00,10
7- 10.00,10
8- 1.10,10
9- 1.20,10
10- 1.30,10
11- 1.40,10
12- 1.50,10
13- 1.60,10
14- 1.70,10
15- 1.80,10
16- 1.90,10
ALTITUDE (KM X10)
RADIUS (KM X10)
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 65 FT.
TIME .150 SEC CYCLE 684. PROBLEM 201.004

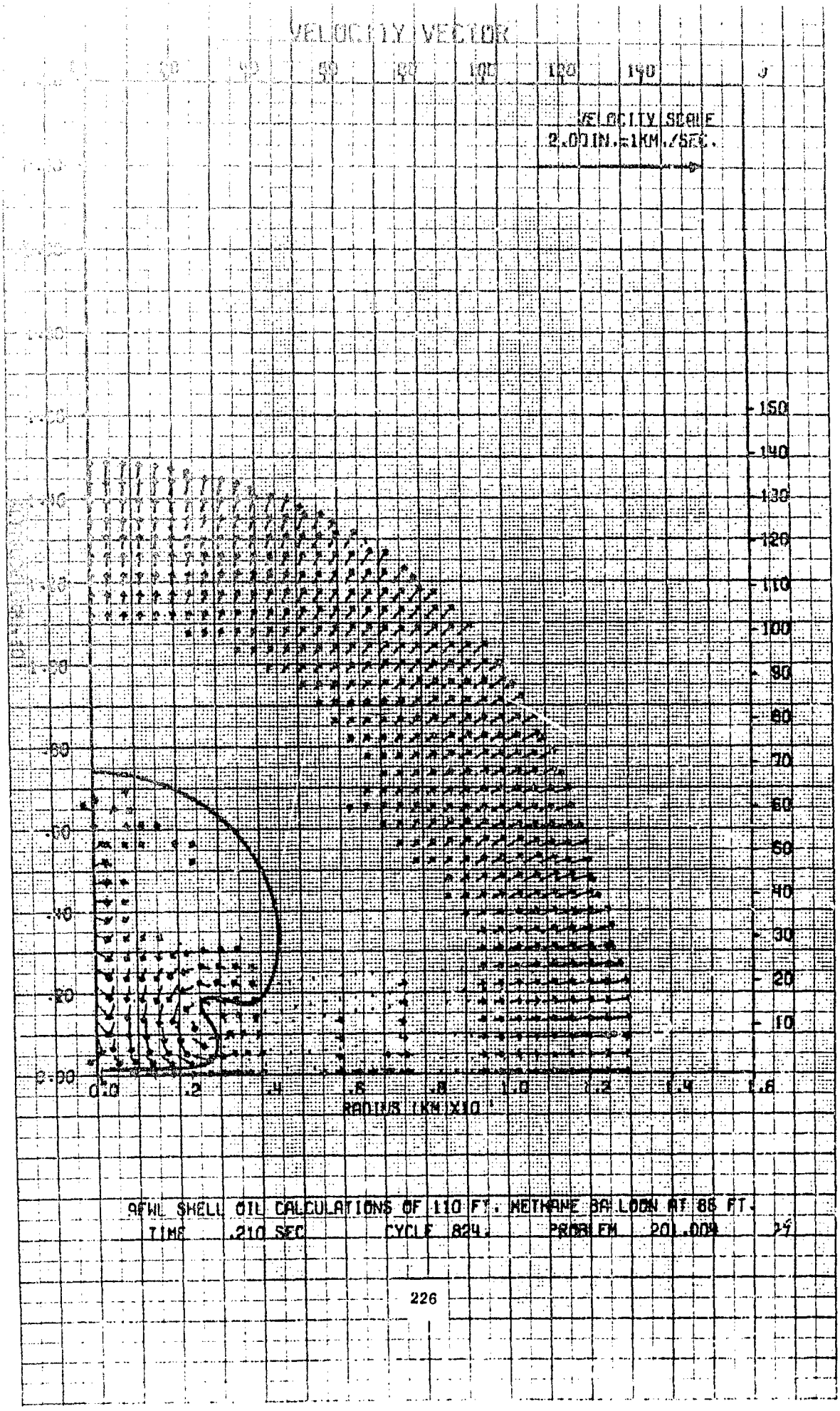

DENSITY
CONTOUR SCALE
1- 1.00x10⁻³
2- 2.00x10⁻³
3- 3.00x10⁻³
4- 4.00x10⁻³
5- 5.00x10⁻³
6- 6.00x10⁻³
7- 7.00x10⁻³
8- 8.00x10⁻³
9- 9.00x10⁻³
10- 1.00x10⁻²
11- 1.10x10⁻²
12- 1.20x10⁻²
13- 1.30x10⁻²
14- 1.40x10⁻²
15- 1.50x10⁻²
16- 1.60x10⁻²
17- 1.70x10⁻²
18- 1.80x10⁻²
19- 1.90x10⁻²
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0.00
0.0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
RADIUS (MMIX10
RFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .150 SEC CYCLE 684 PROBLEM 201.004


VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
ALTITUDE (KM X10)
RADIUS (KM X10)
RSWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 88 FT.
TIME .150 SEC CYCLE 684 PROBLEM 201.004



AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .210 SEC CYCLE 1824. PROBLEM 201.004 27


DENSITY
CONTOUR SCALE
1 - 0.00x10 -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 -3
12 - 1.10x10 -3
13 - 1.20x10 -3
14 - 1.30x10 -3
15 - 1.40x10 -3
16 - 1.50x10 -3
17 - 1.60x10 -3
ALTITUDE (KM)X10 3
RADIUS (KM)X10 3
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .210 SEC CYCLE 824 PROBLEM 20-00


VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
RADIUS (KM X10)
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 86 FT.
TIME .210 SEC CYCLE 824. PROBLEM 201.009

SHELL Tracings

This part contains the tracings recorded at each test station of overpressure, dynamic pressure overpressure impulse, dynamic pressure impulse and velocity resulting from the methane detonation. These are SHELL-OIL results.

Table I gives the location of each test station.

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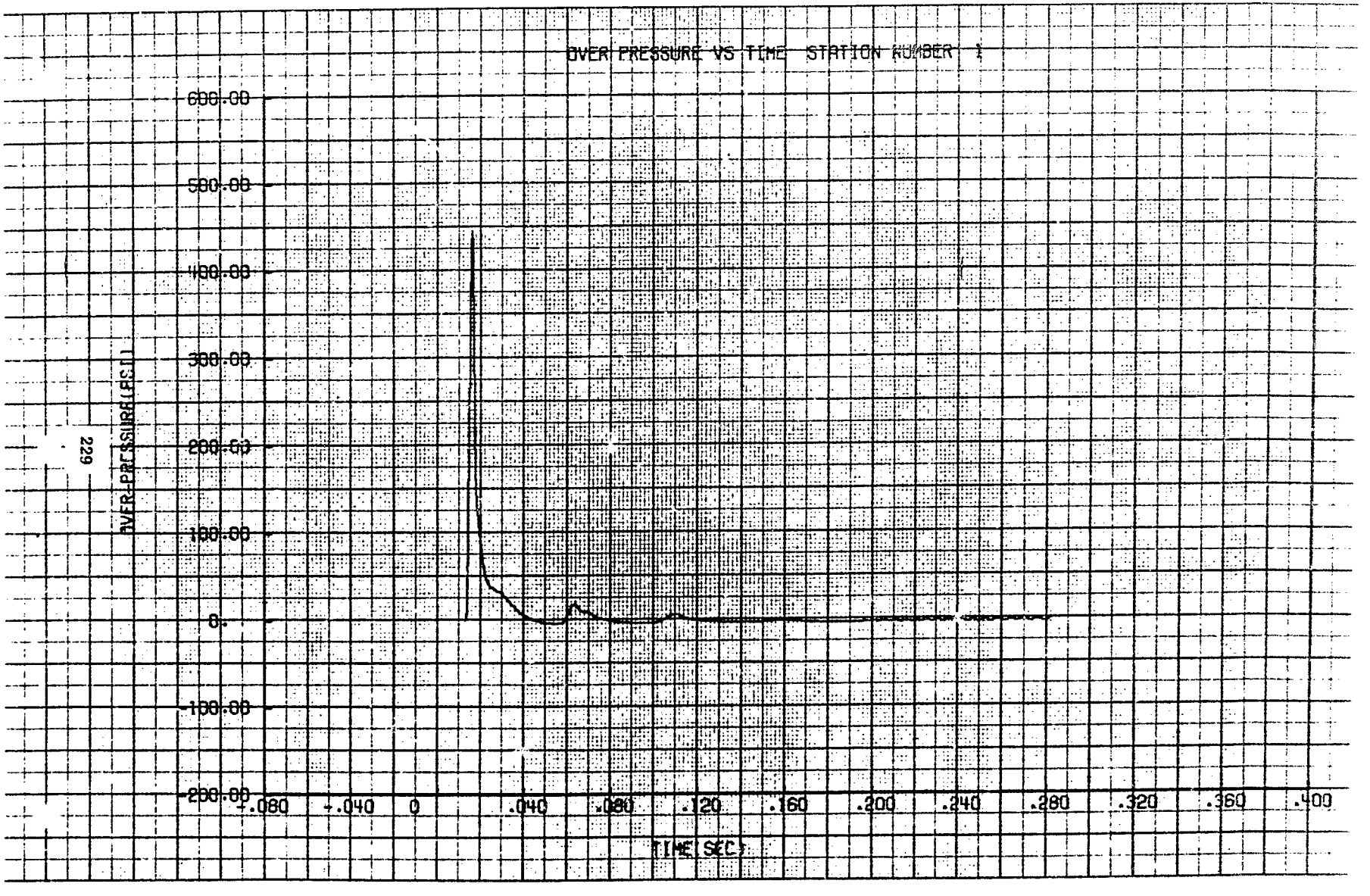
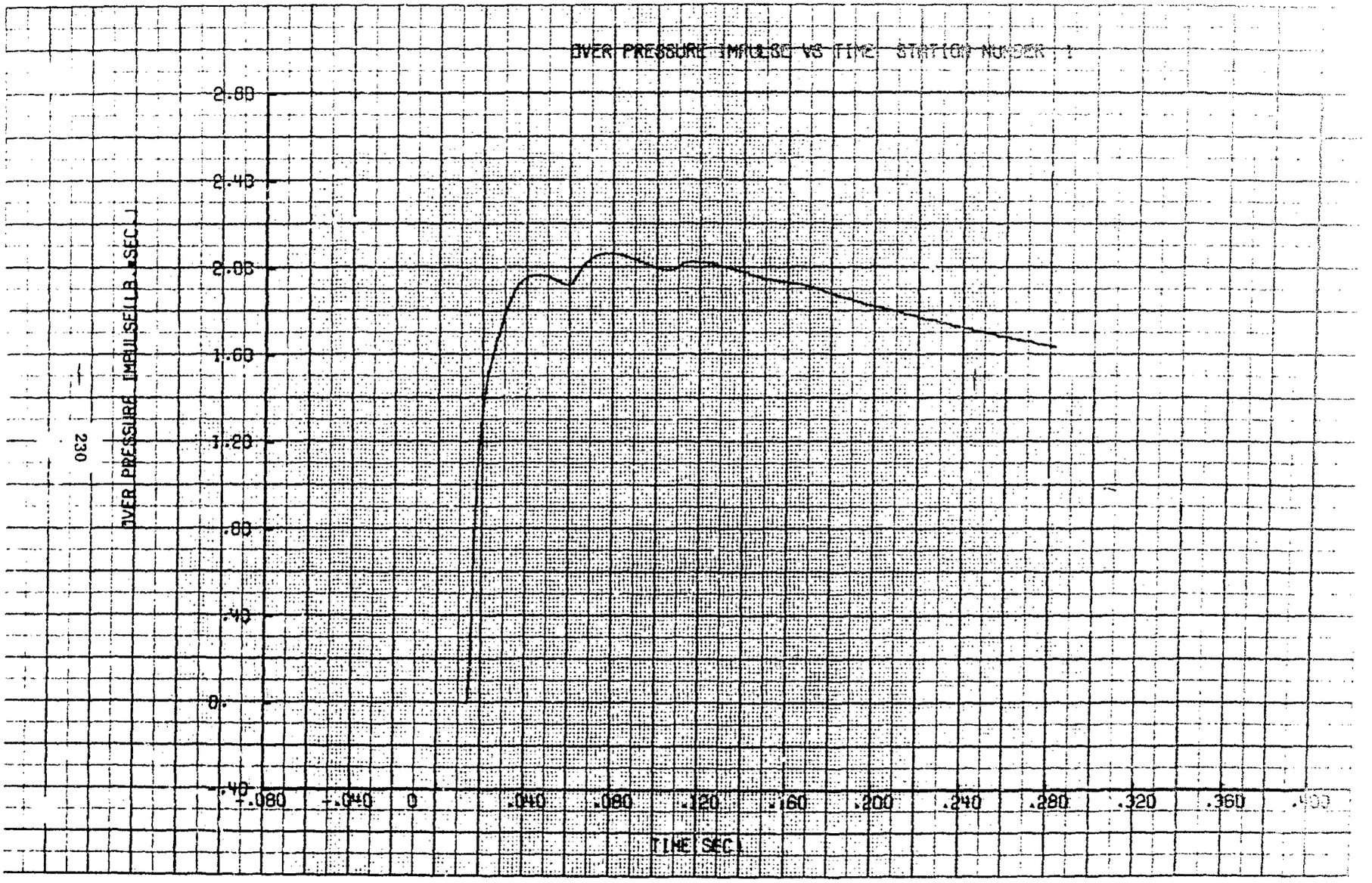
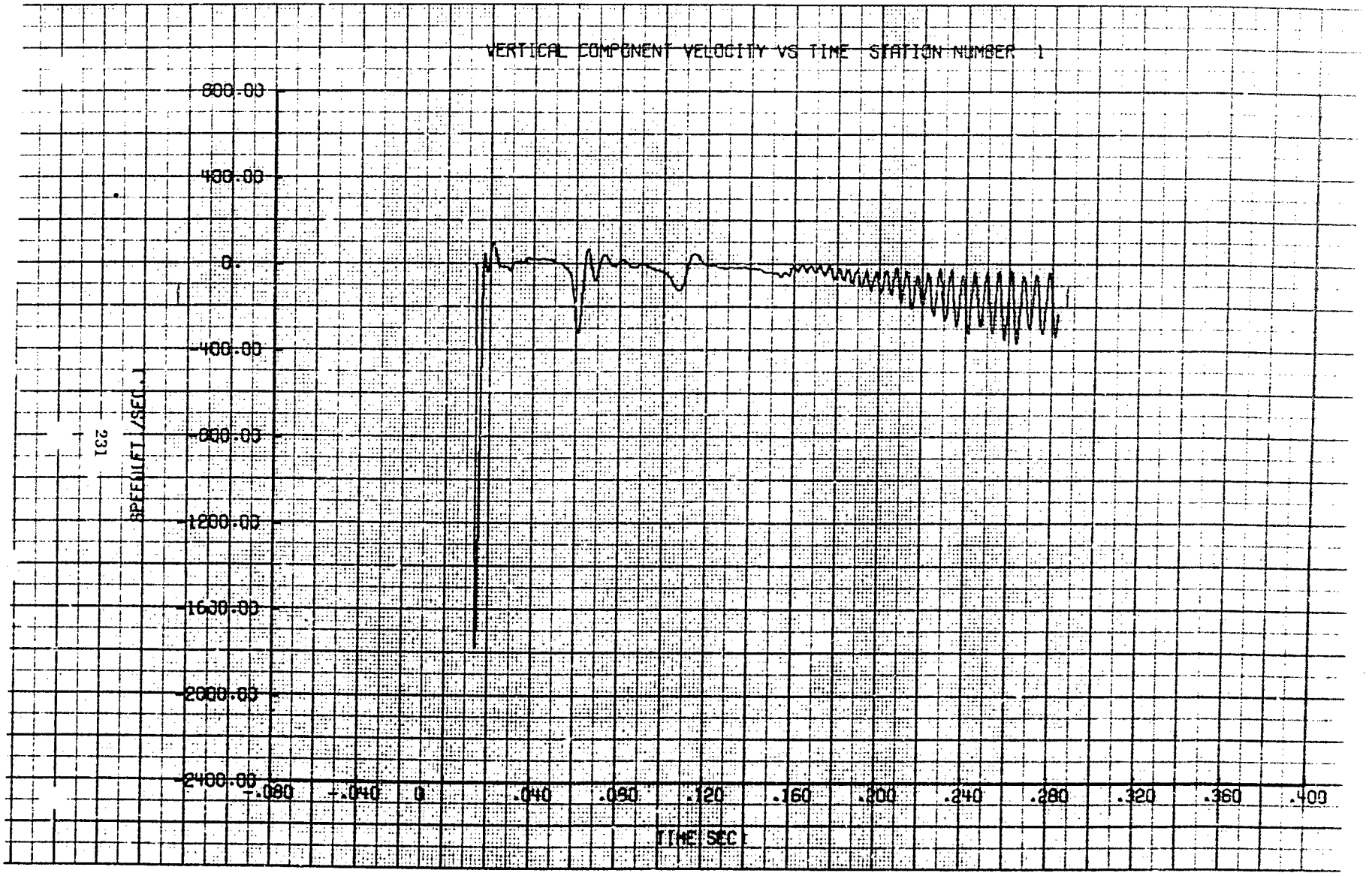
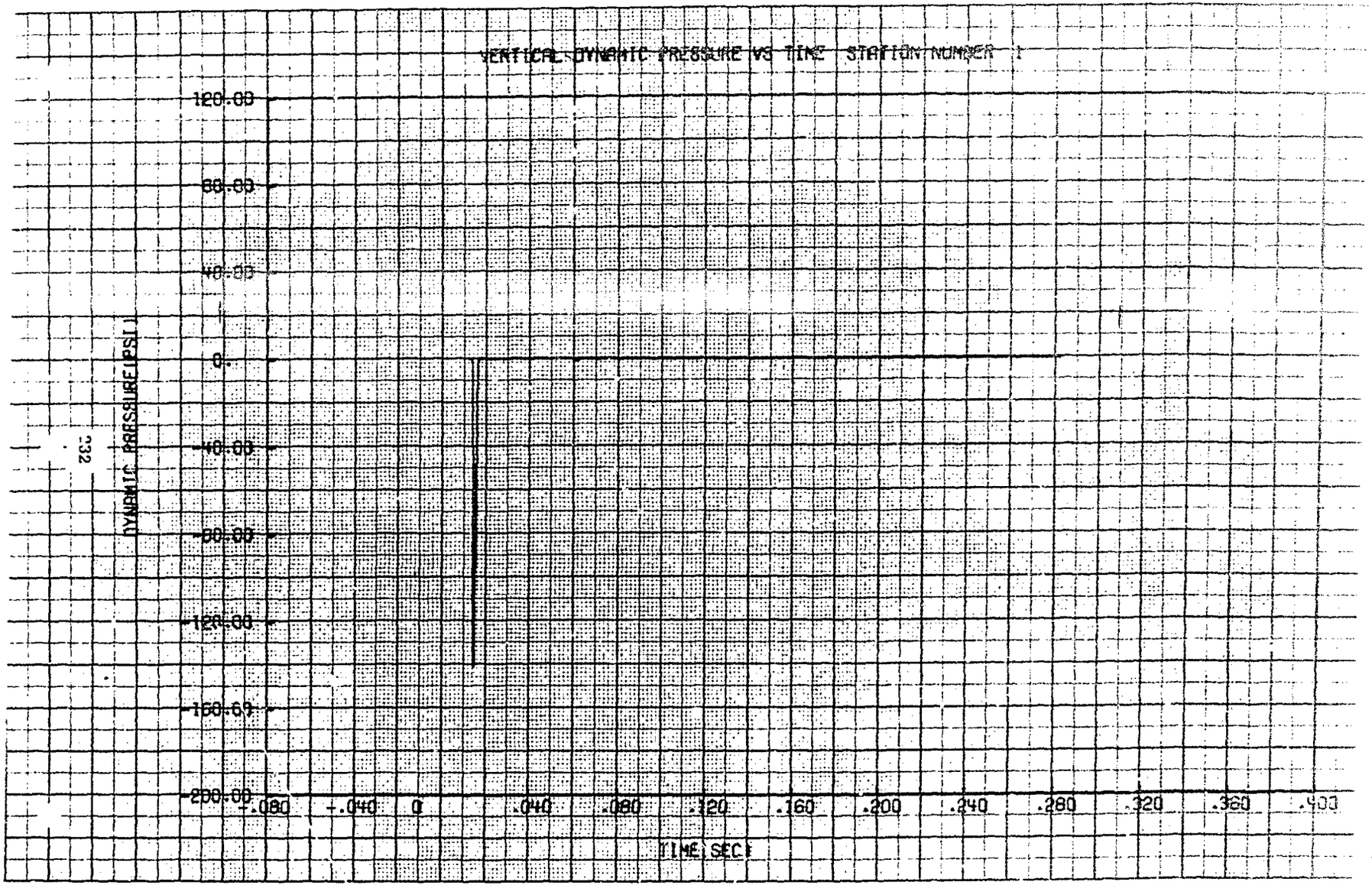
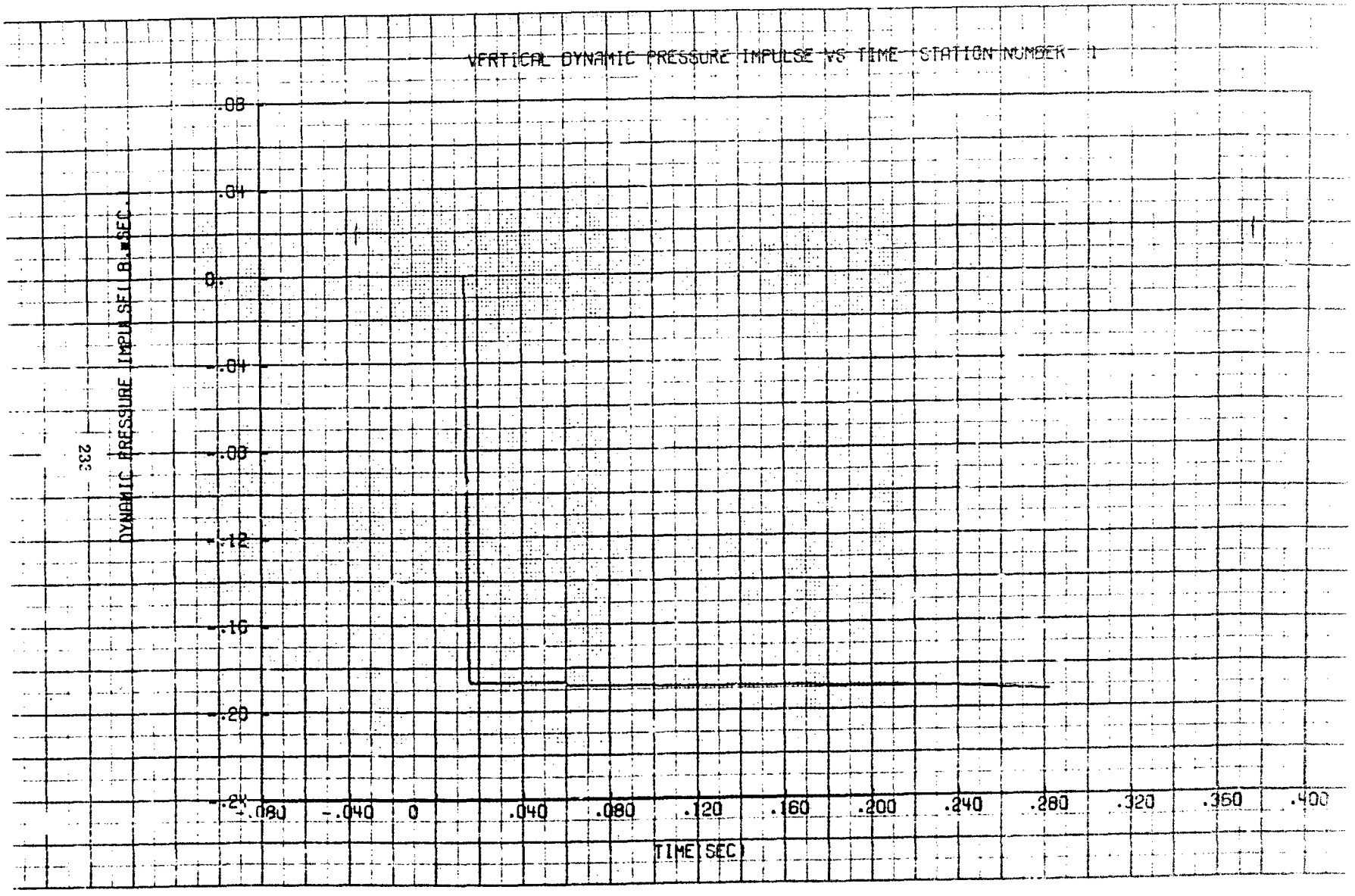
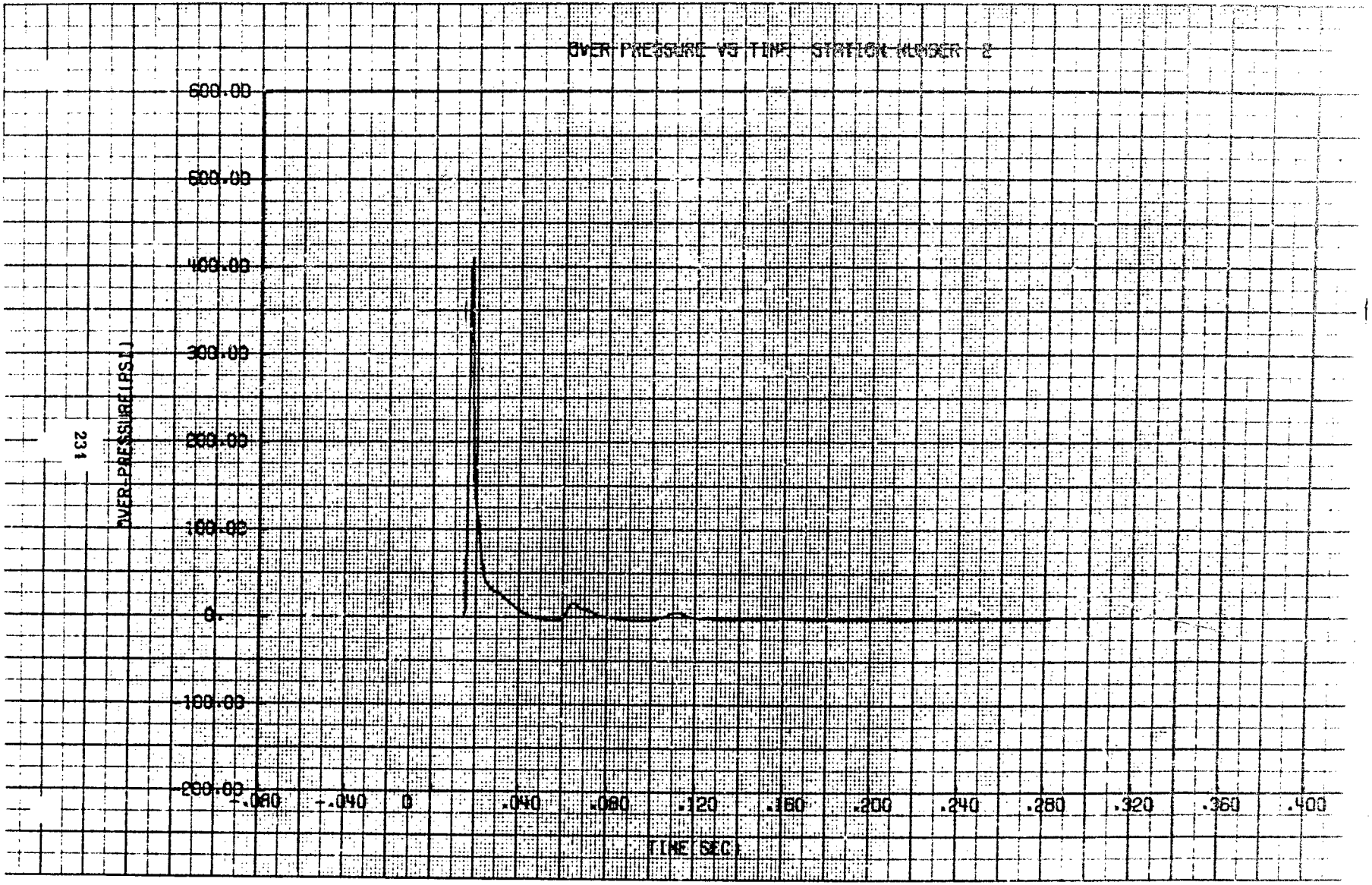

OVER PRESSURE VS TIME STATION NUMBER 1
OVER-PRESSURE(PSID)
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

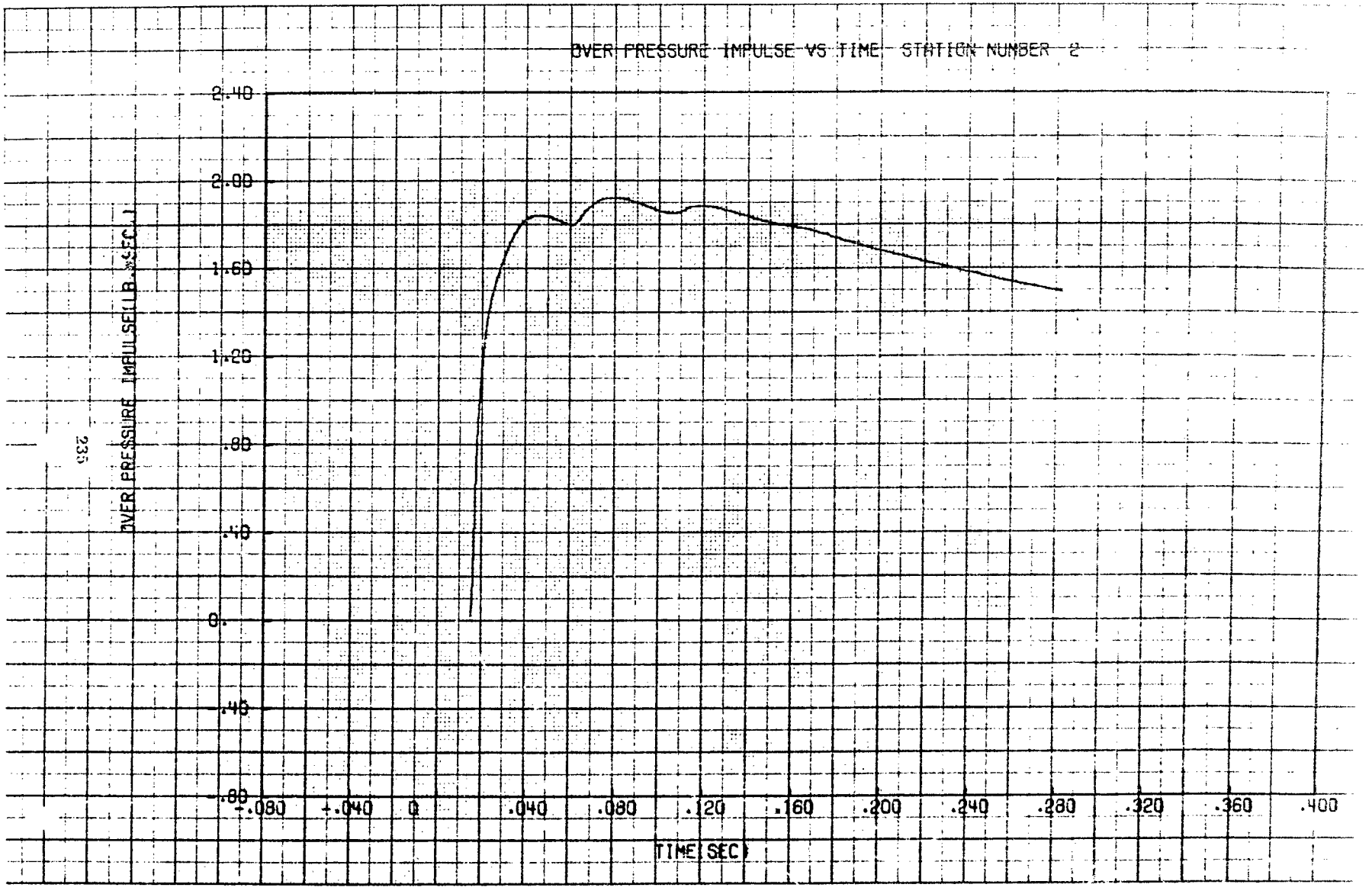

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 1
OVER PRESSURE IMPULSE (LB.-SEC.)
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.
230

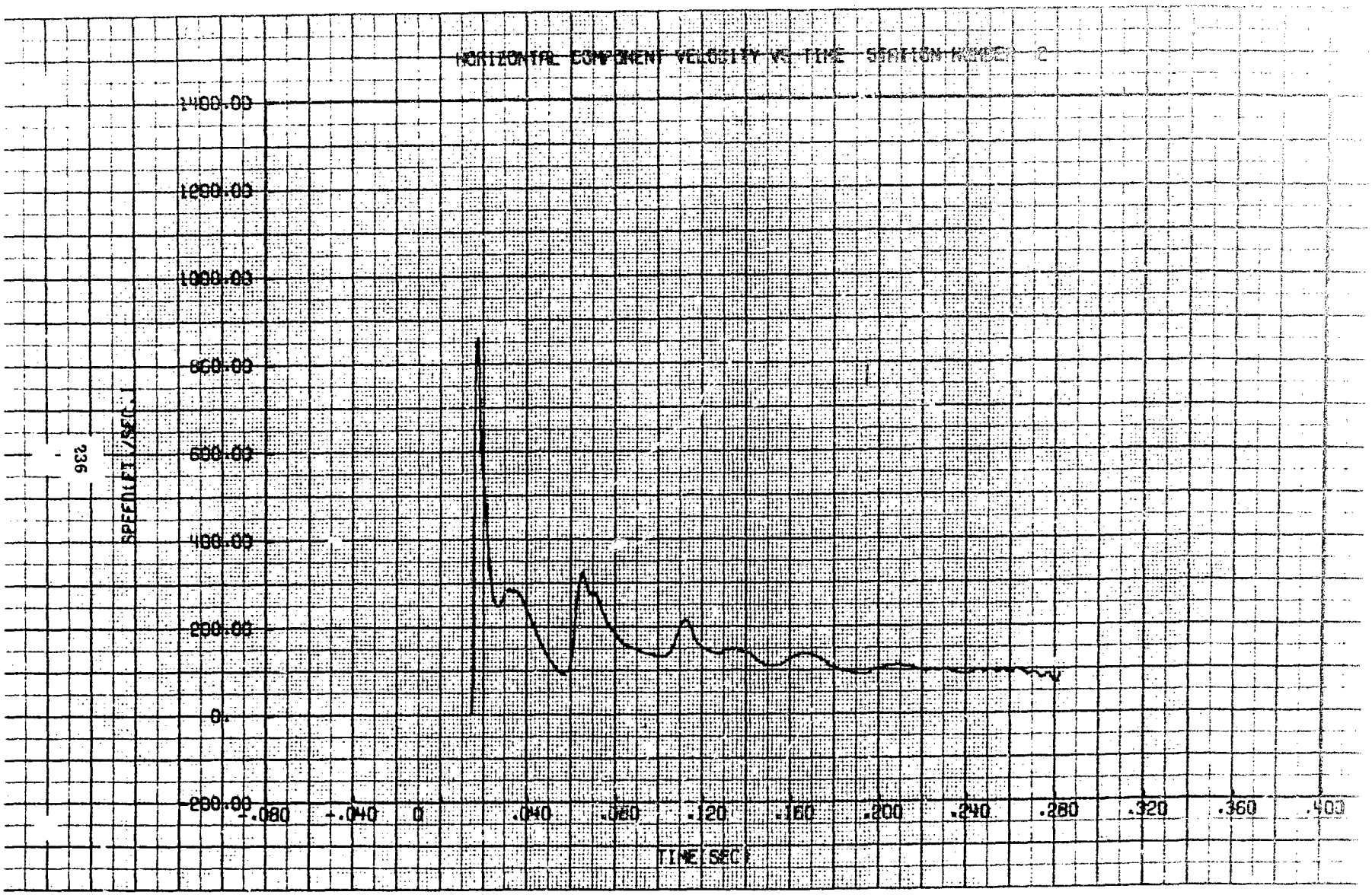

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 1
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
-2400.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
231

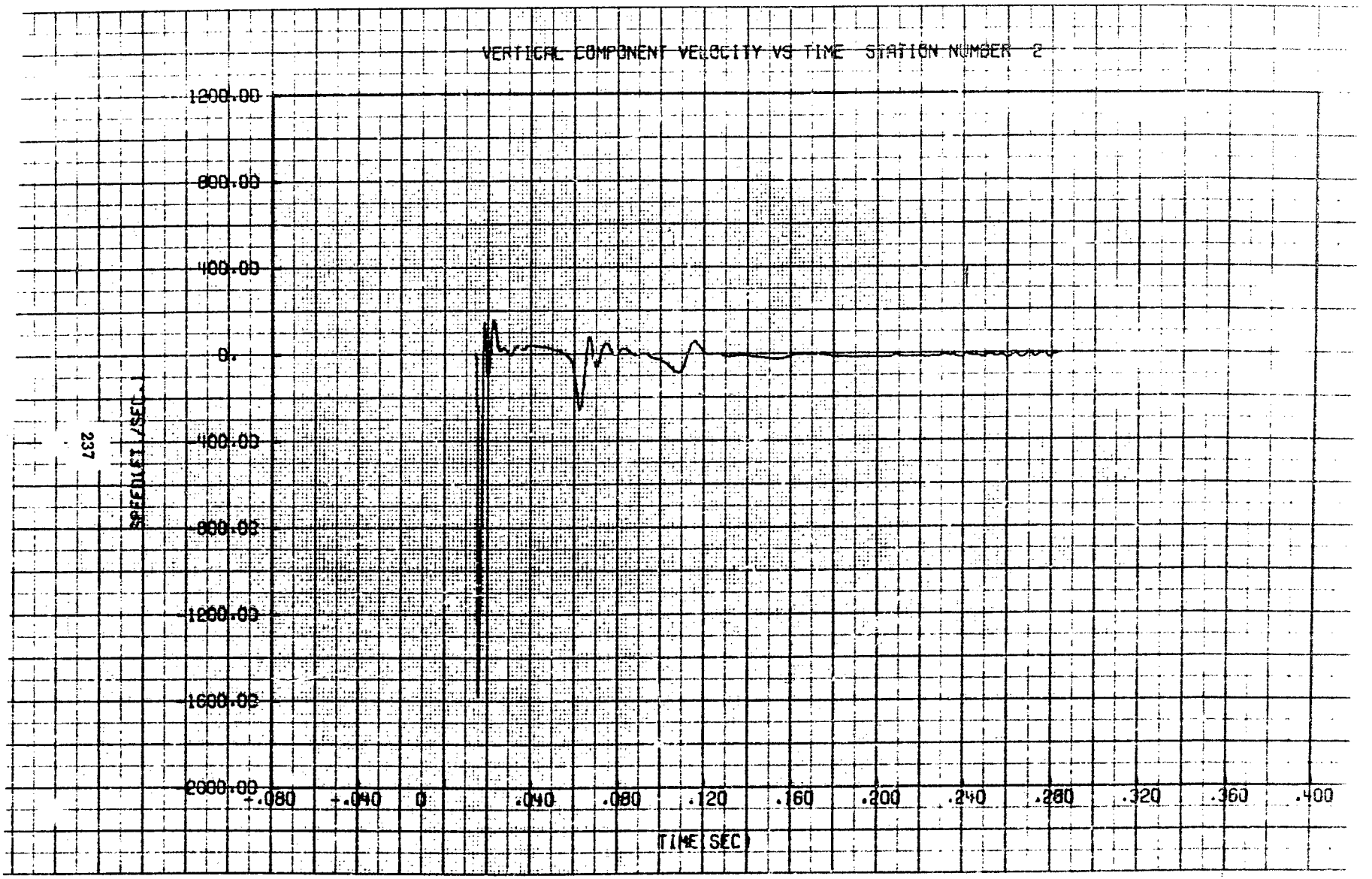

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 1
120.00
80.00
40.00
0.
-40.00
-80.00
-120.00
-160.00
-200.00
DYNAMIC PRESSURE (PSI)
232
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME, SEC

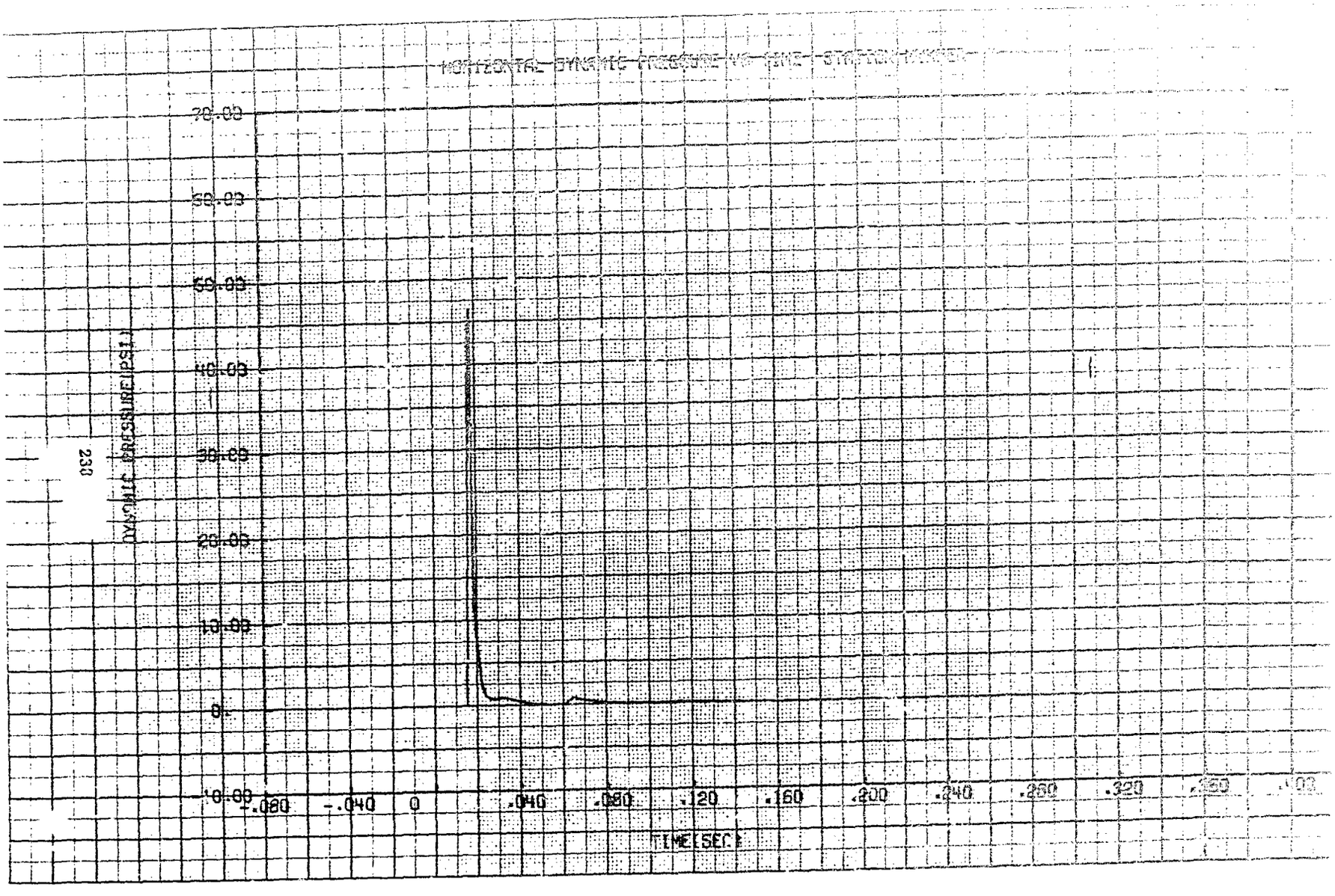

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE LB.-SEC.
.08
.04
0.
-.04
-.08
-.12
-.16
-.20
-.24
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

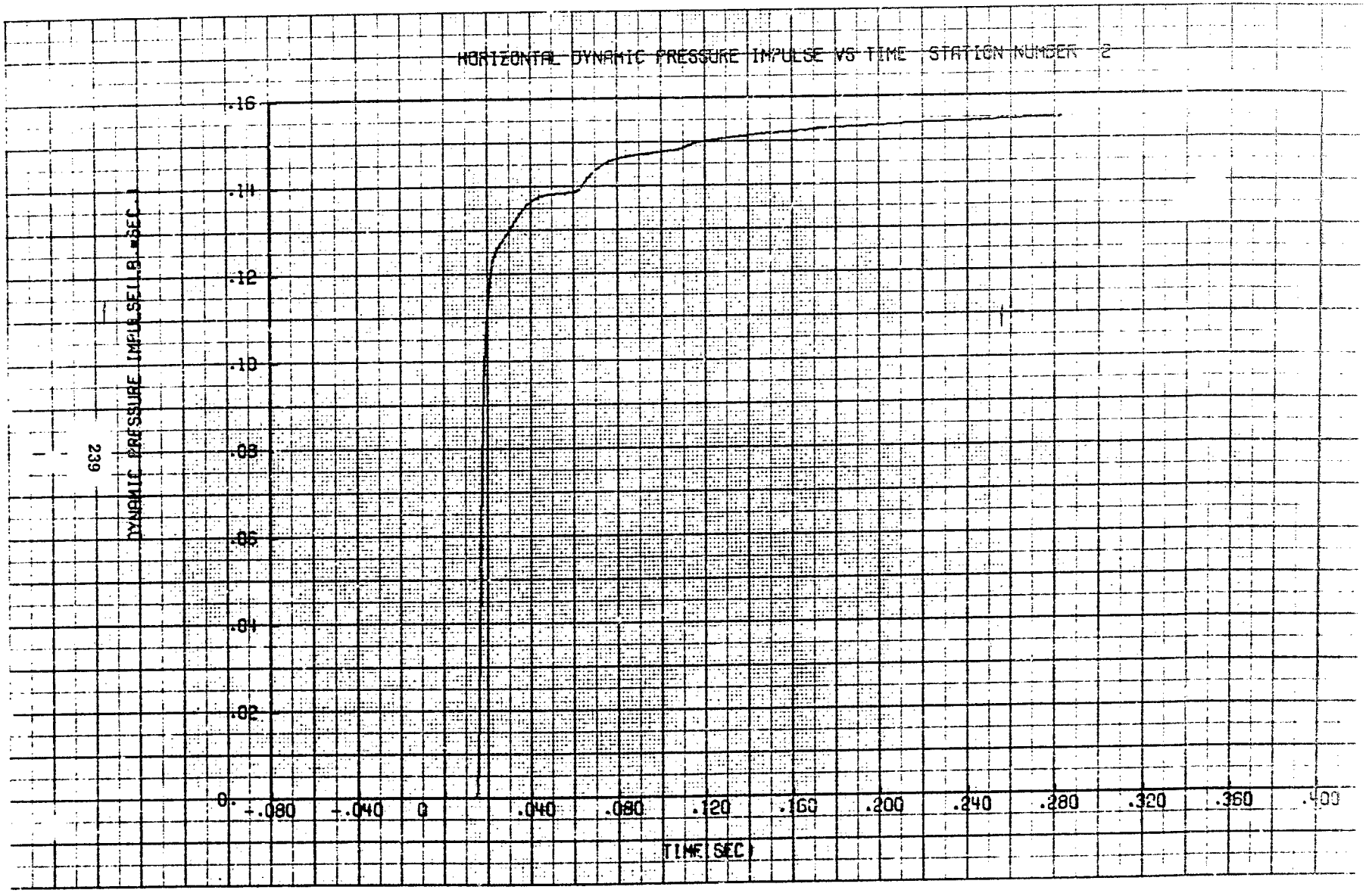

OVER PRESSURE VS TIME STATION NUMBER 2
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
OVER-PRESSURE (PSI)
231

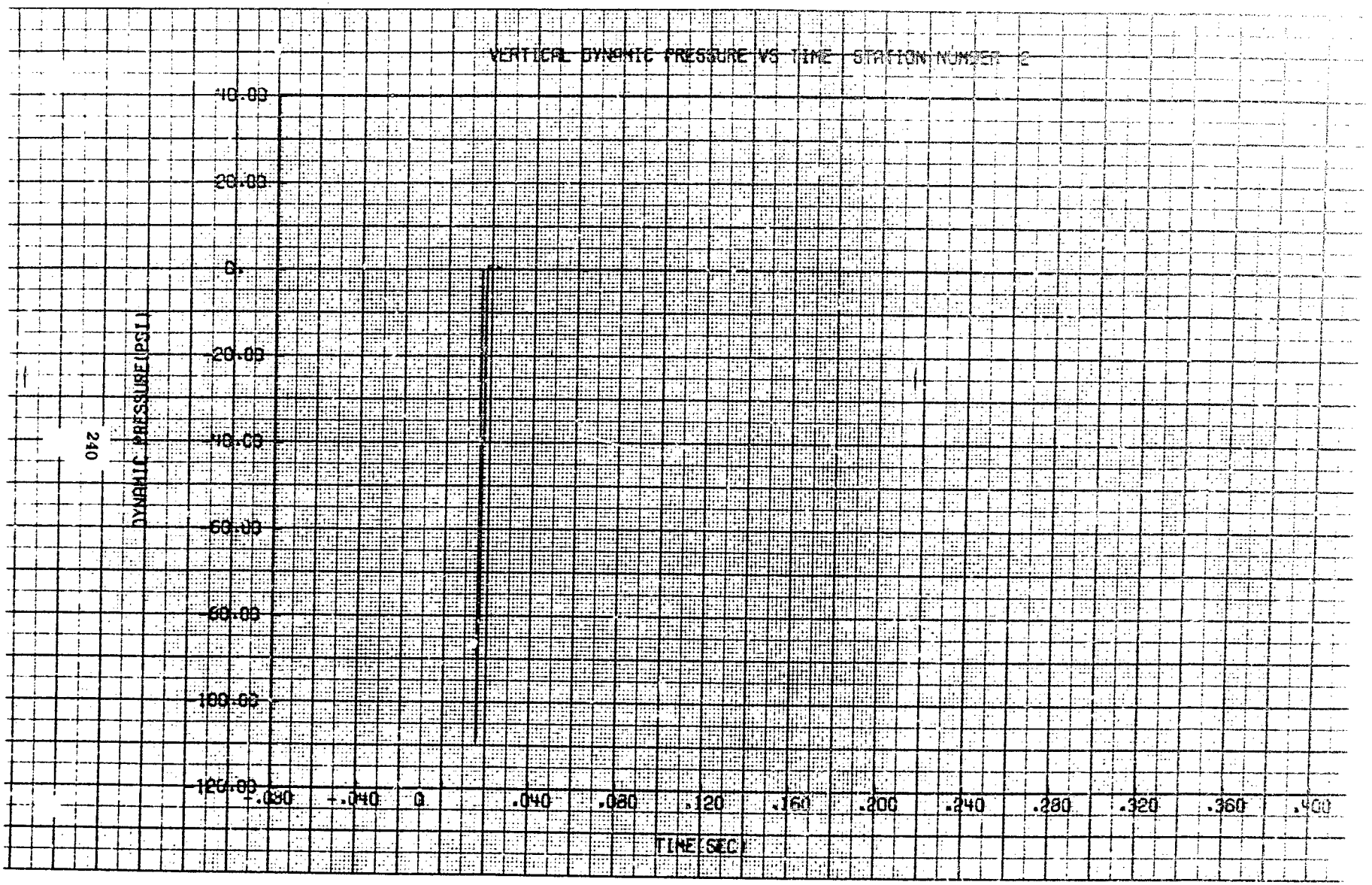

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 2
OVER PRESSURE IMPULSE(LB.*SEC.)
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.80
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

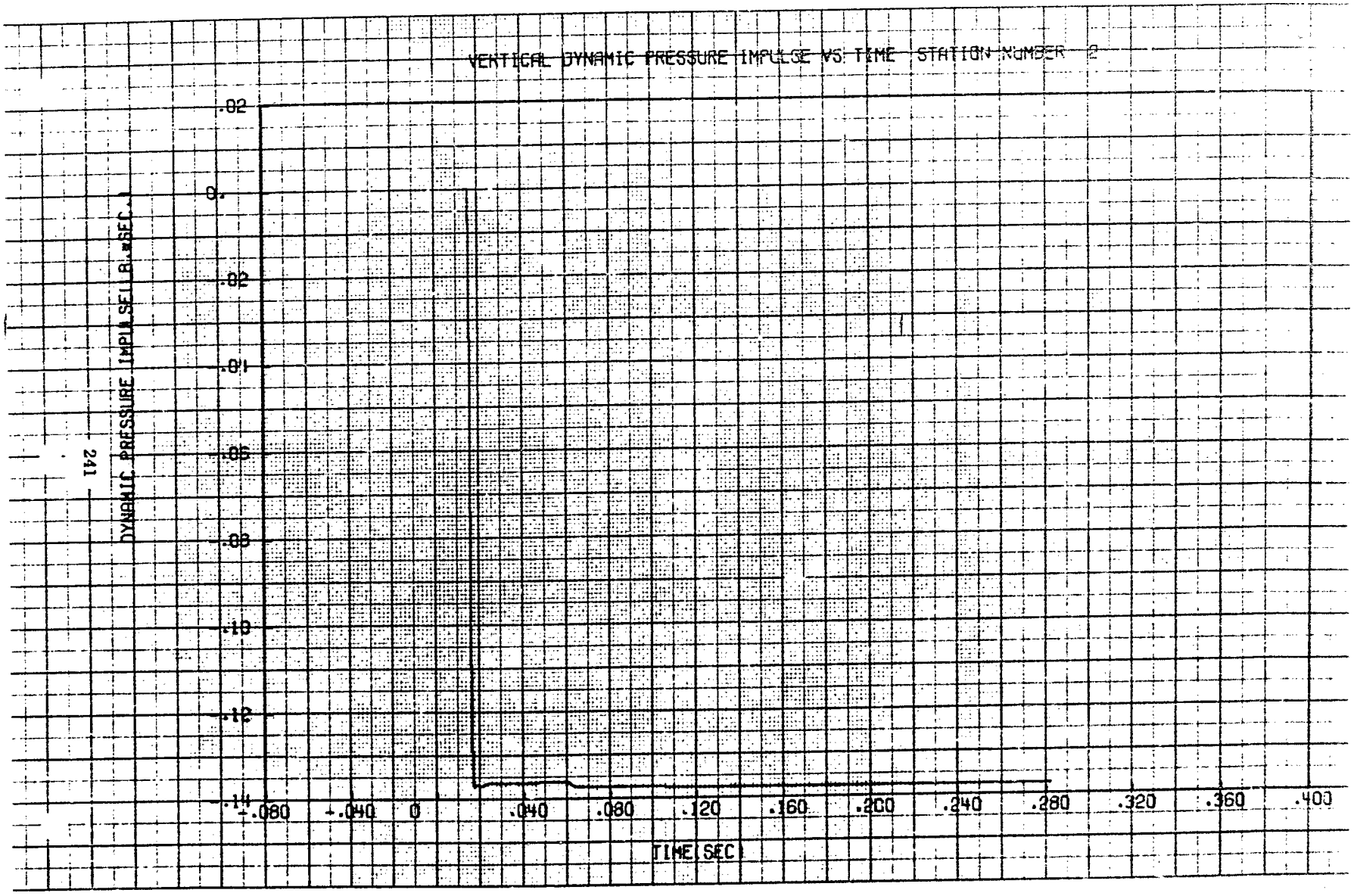

HORIZONTAL COMPONENT VELOCITY VS TIME SECTION NUMBER 2
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
VELOCITY (FEET/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

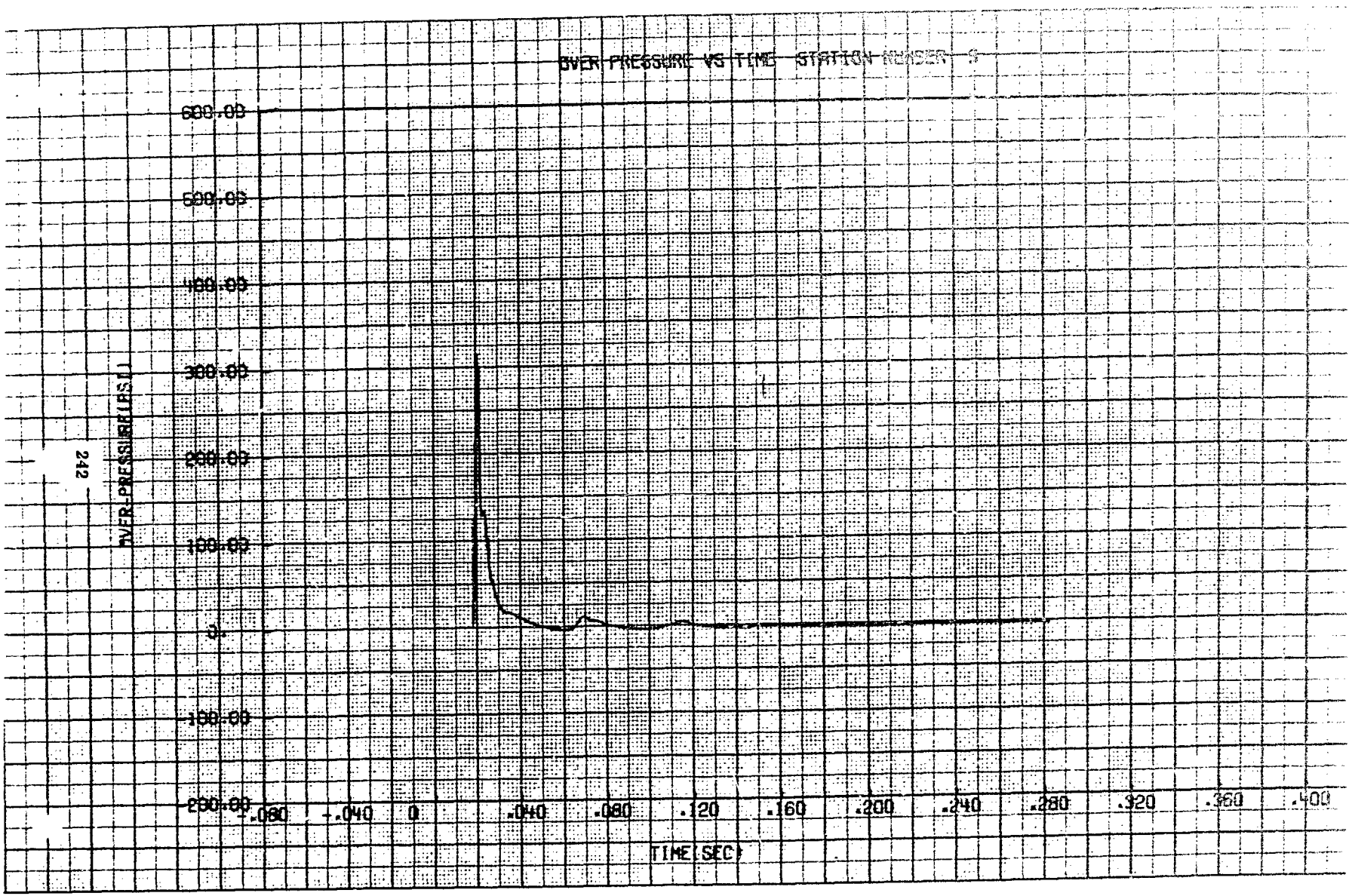

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
+.080
+.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
237

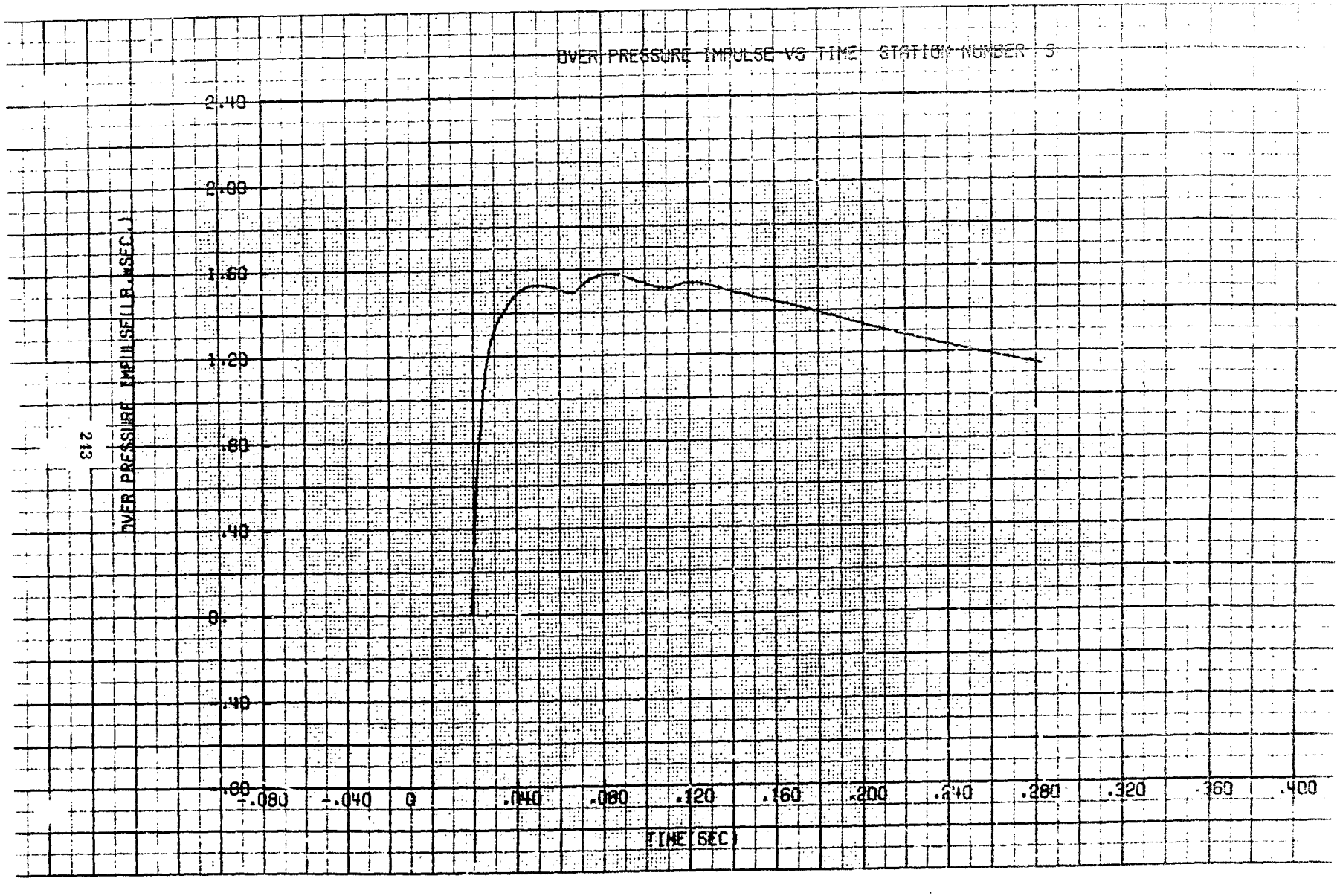

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION XXXXXX
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
230
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

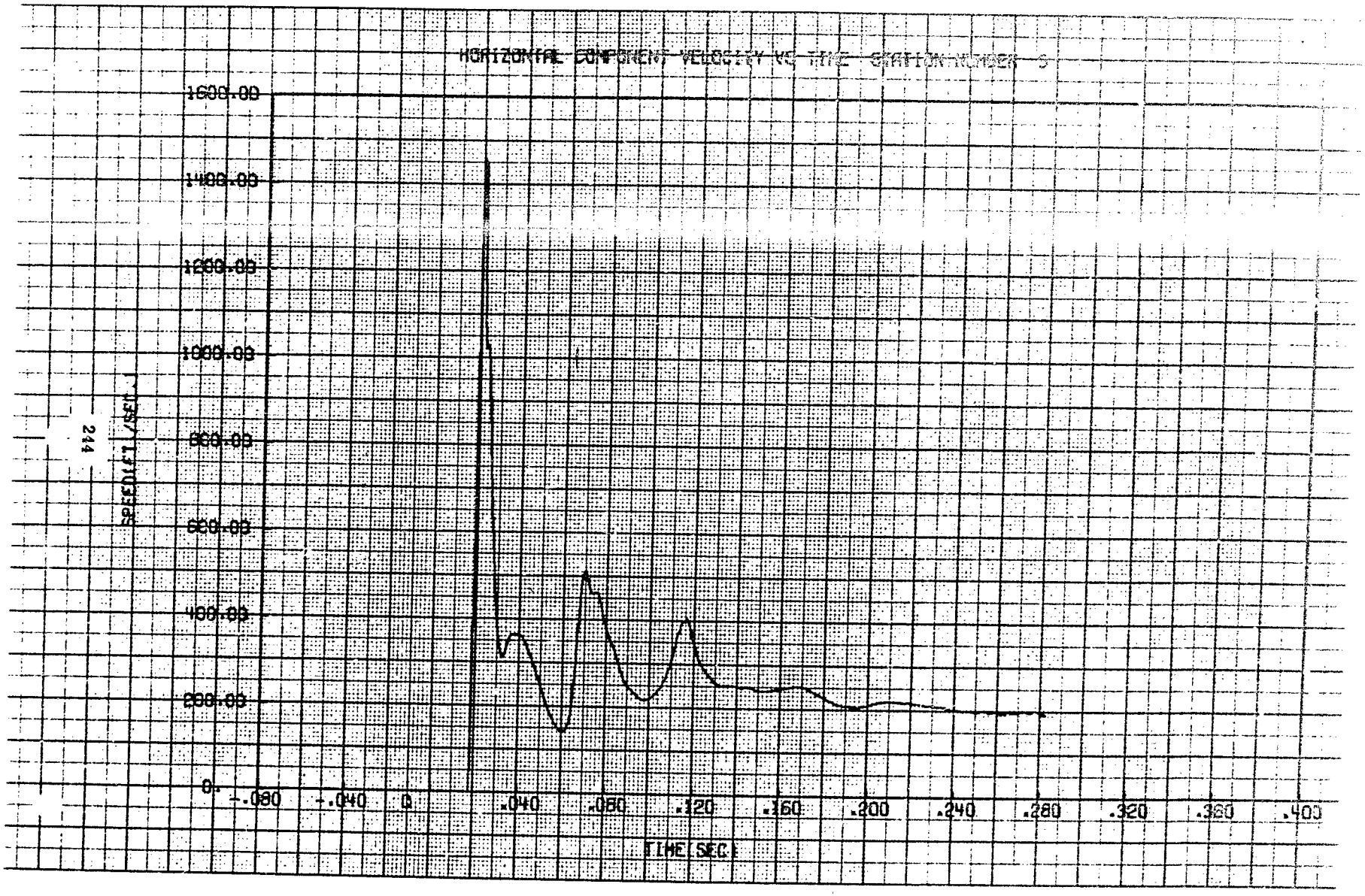

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
.16
.14
.12
.10
.08
.06
.04
.02
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
239
DYNAMIC PRESSURE IMPULSE LB-SEC/IN**2

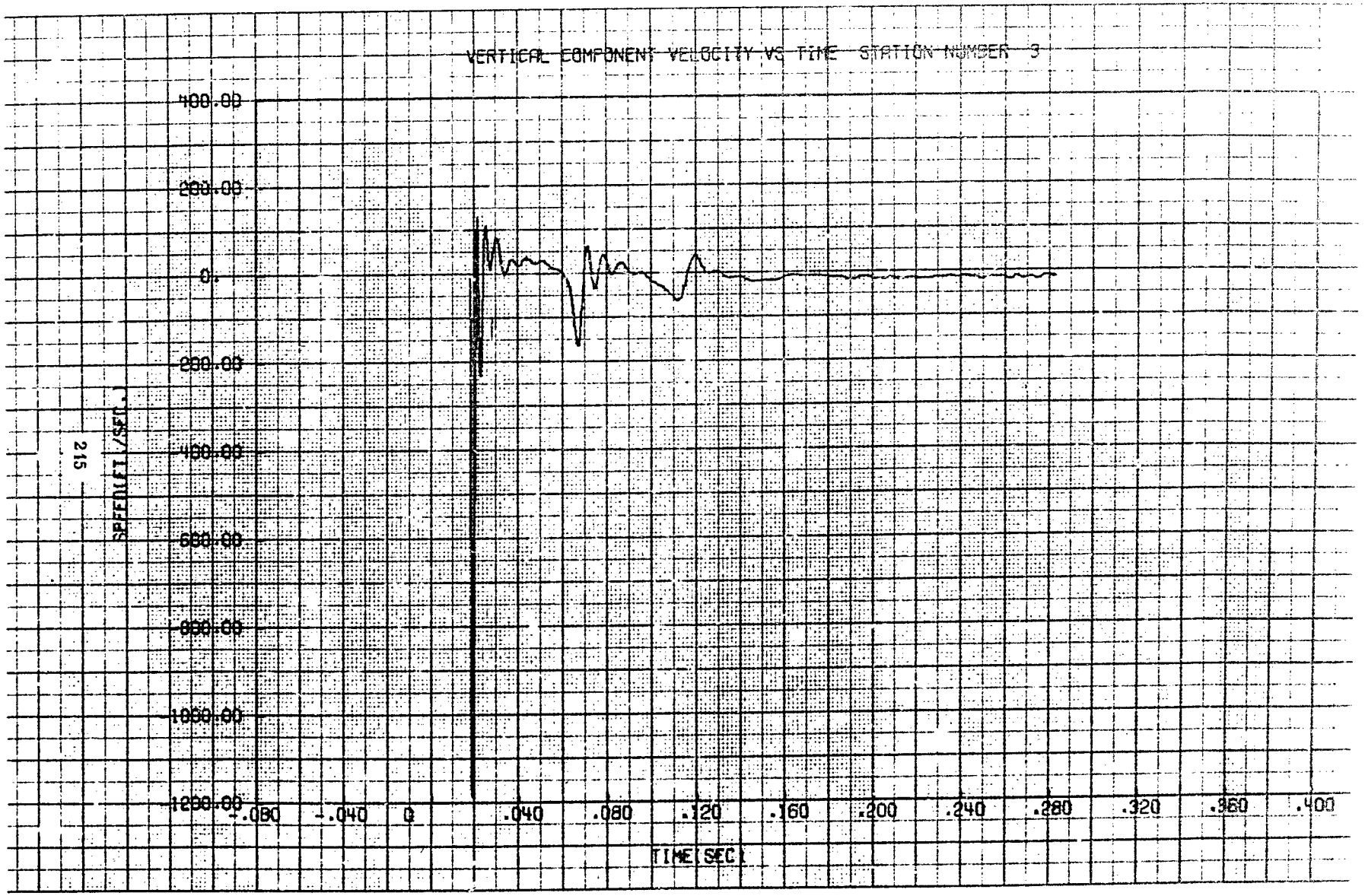

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 12
10.00
20.00
0.
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
DYNAMIC PRESSURE(PSI)
240
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN²)
.02
0
-.02
-.04
-.06
-.08
-.10
-.12
-.14
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

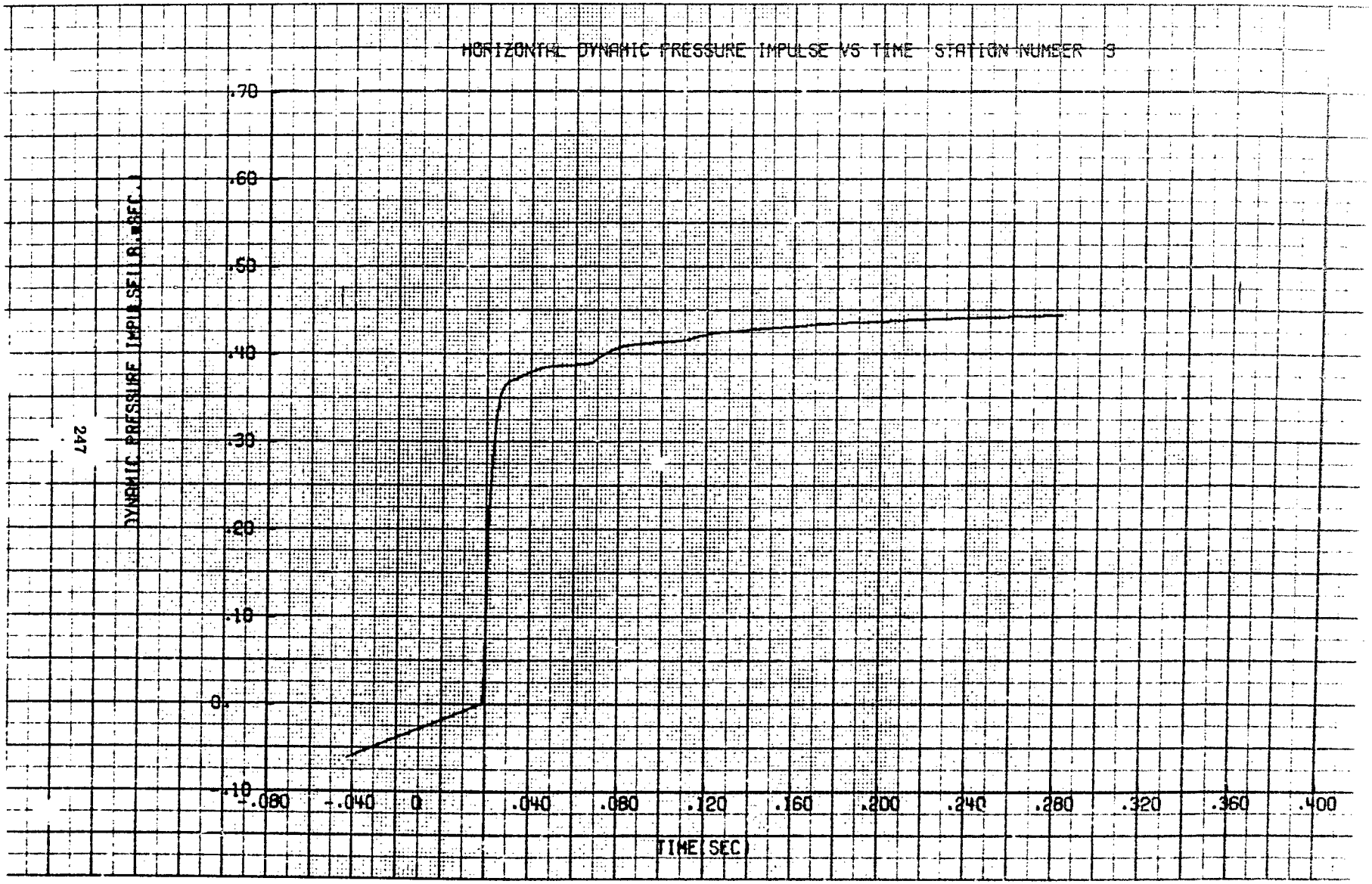

OVER PRESSURE VS TIME STATION NUMBER 9
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
OVER-PRESSURE(LBS/I)
242

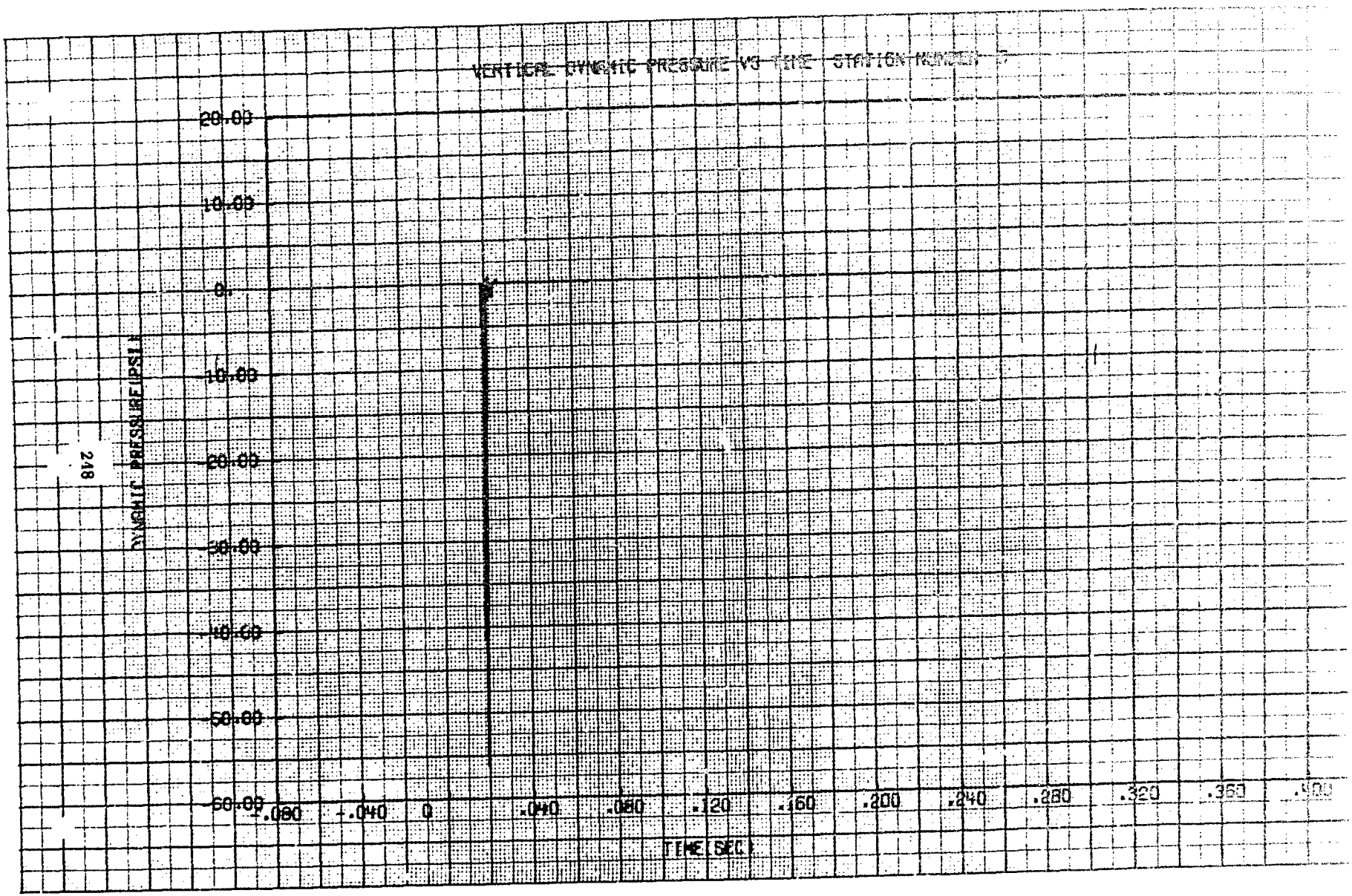

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 3
OVER PRESSURE IMPULSE LB.-SEC./
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.80
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

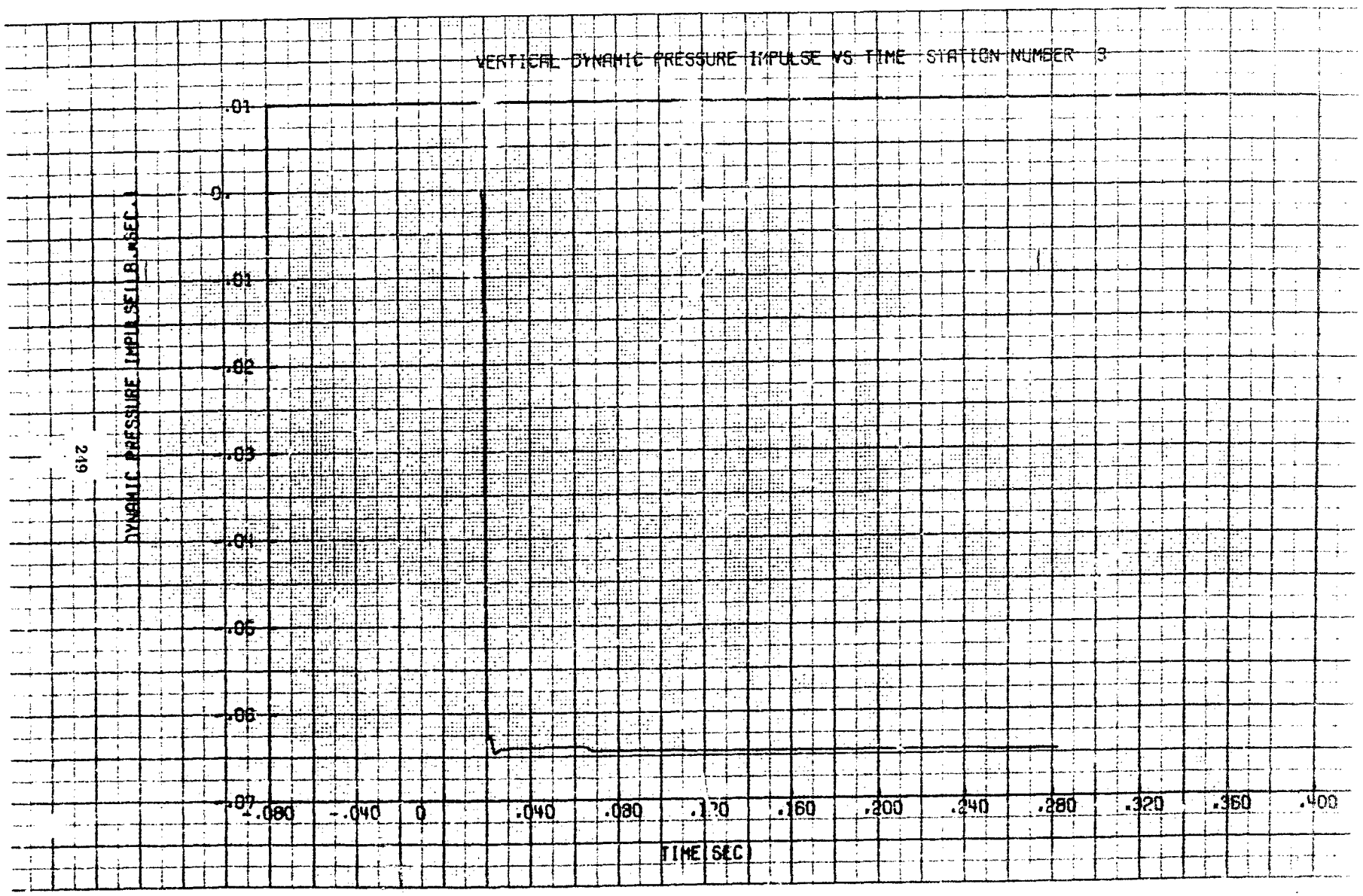

HORIZONTAL CONFIDENCE VELOCITY VS TIME STATION NUMBER 5
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
SPEED(FT/SEC)
244


VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 3
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
SPEED(FT/SEC)

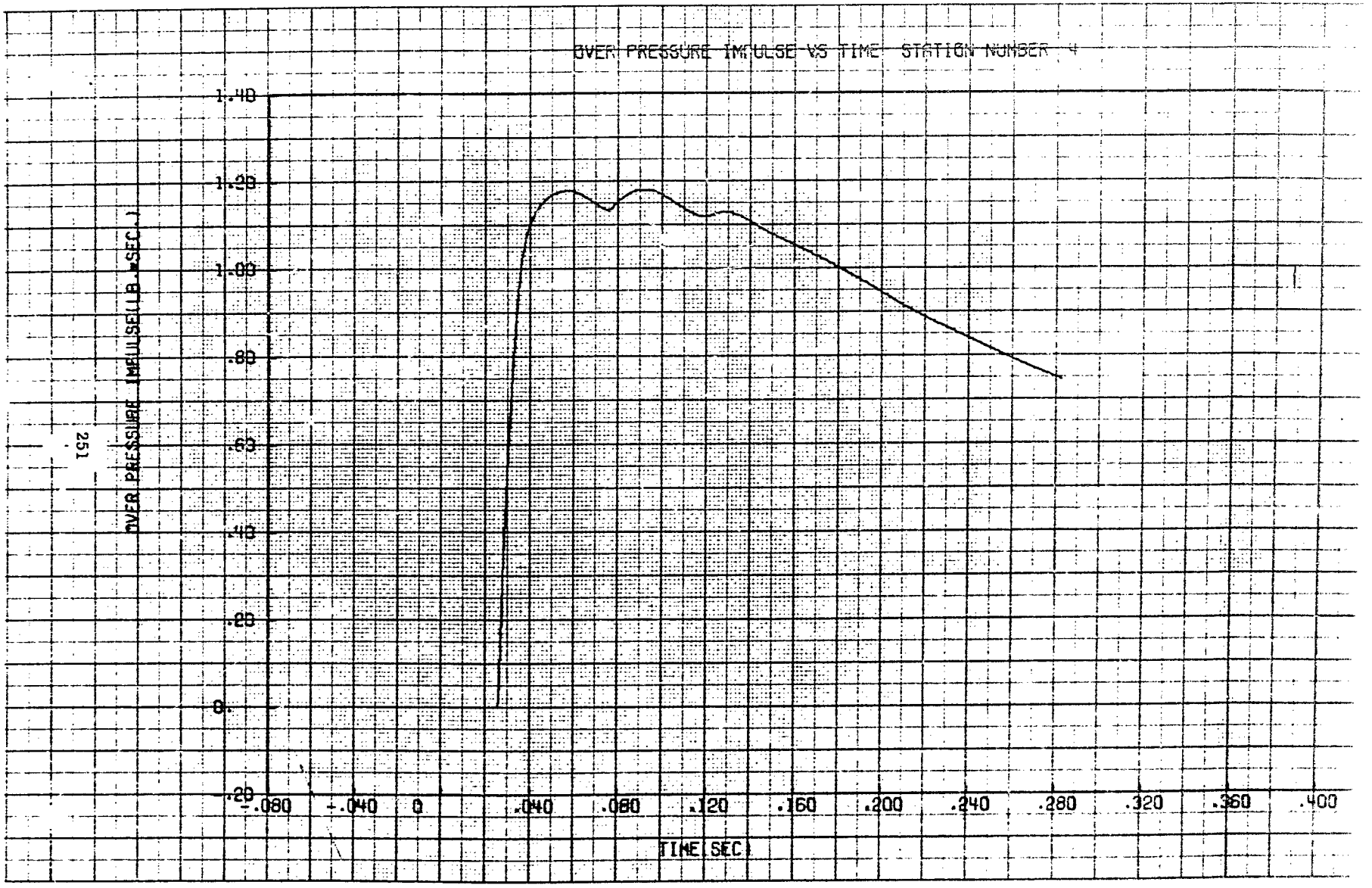
DYNAMIC PRESSURE(PSI)
160.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME SEC

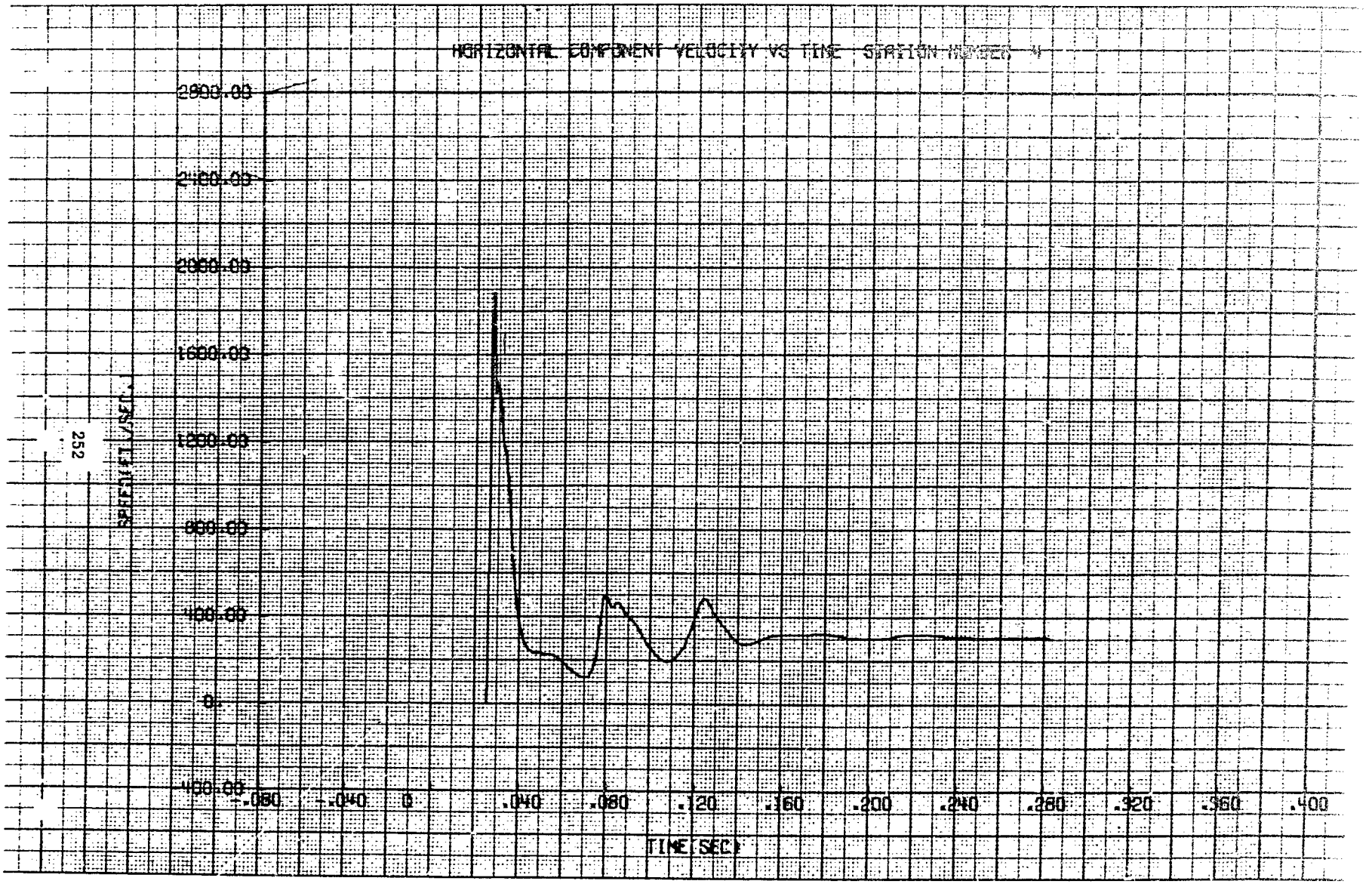

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB./SEC.)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

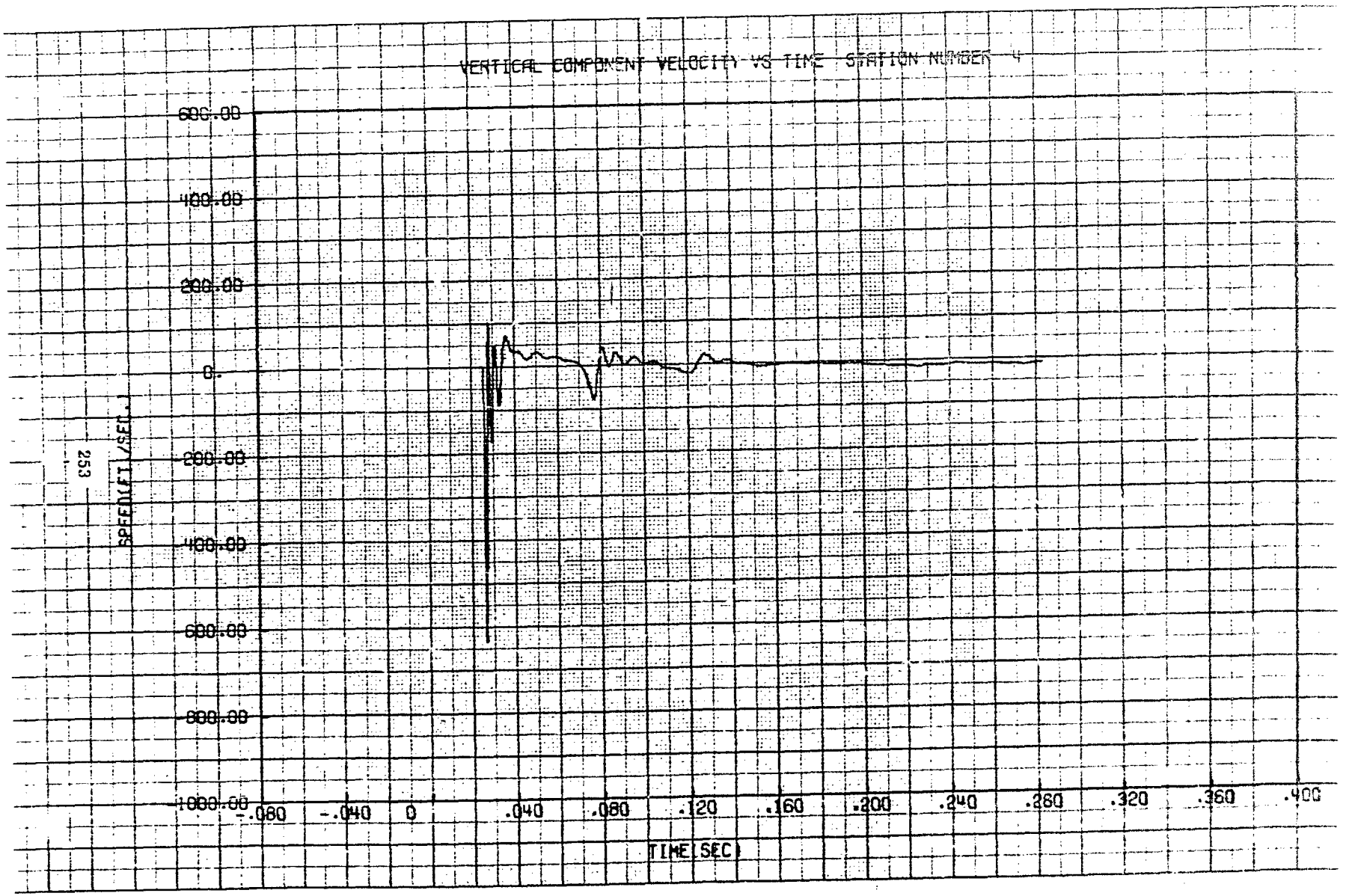

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
248


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB-SEC/...
.01
0.
-.01
-.02
-.03
-.04
-.05
-.06
-.07
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

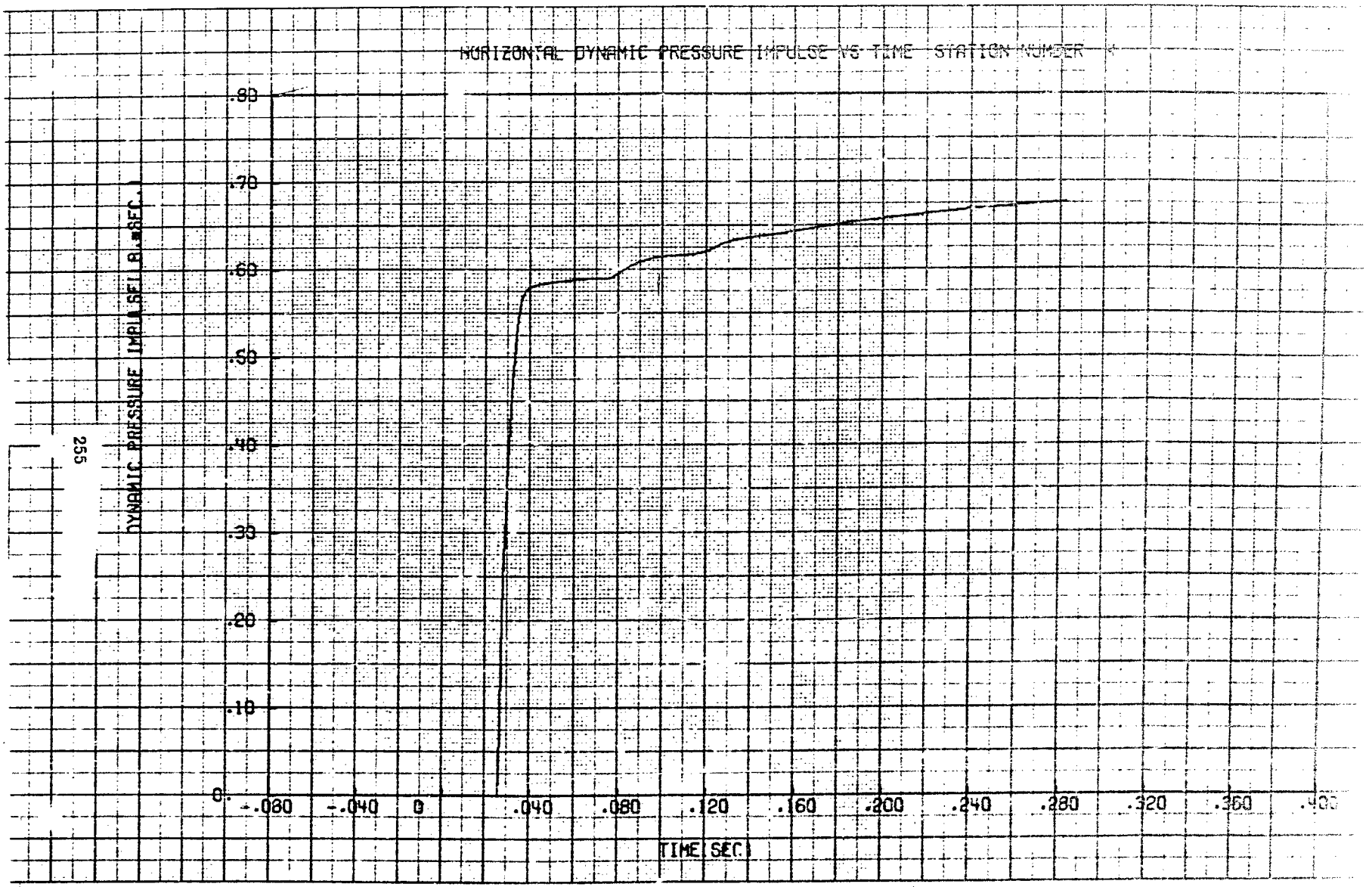
OVER-PRESS [PSI]
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME [SEC]


OVER PRESSURE IMPULSE VS TIME STATION NUMBER 4
OVER PRESSURE IMPULSE(LB.*SEC.)
1.40
1.20
1.00
.80
.60
.40
.20
0.
-.20
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

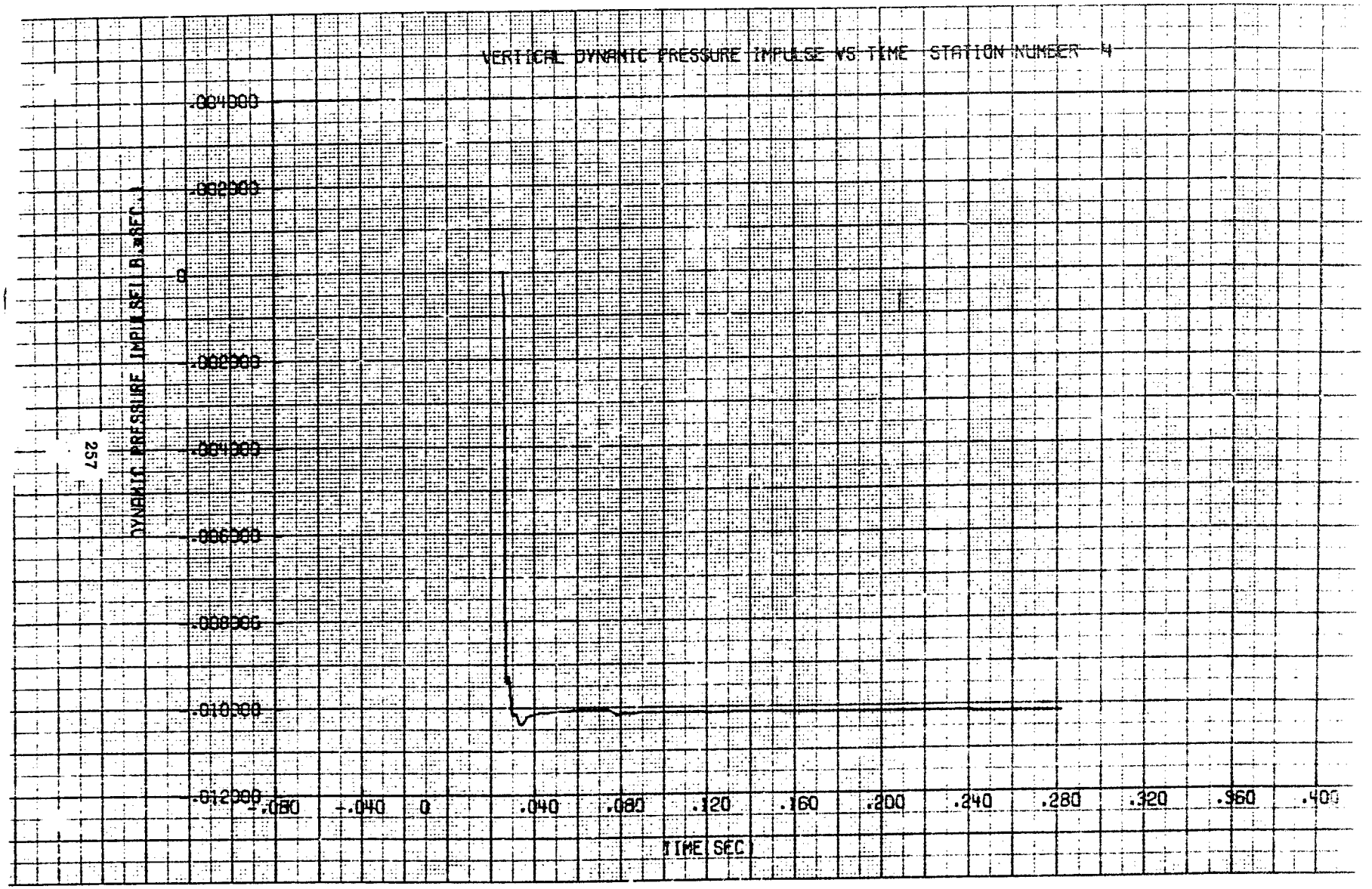

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 4
2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
VELOCITY (FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

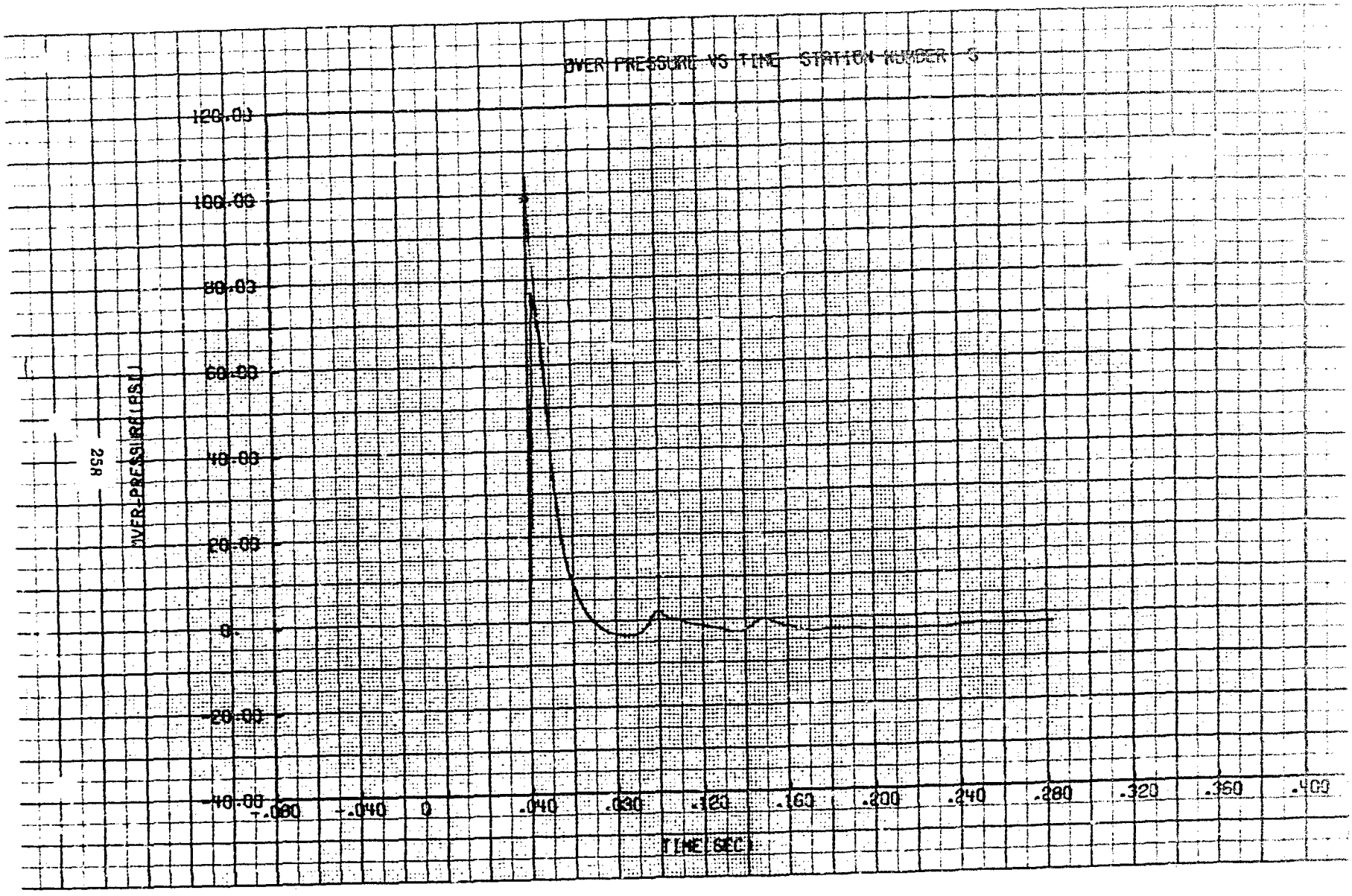

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 4
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
VELOCITY (IN/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

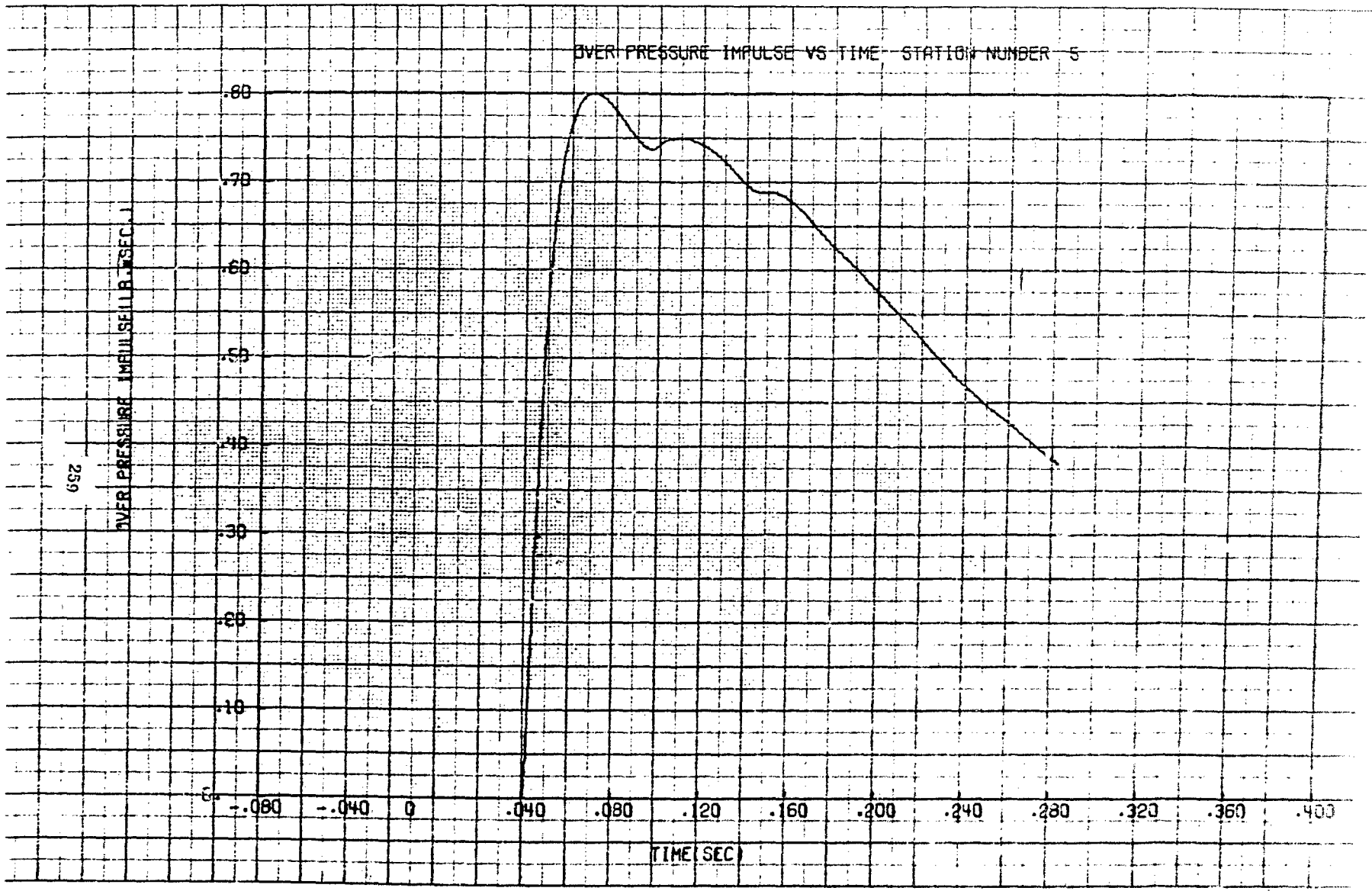
DYNAMIC PRESSURE(PSI)
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME SEC

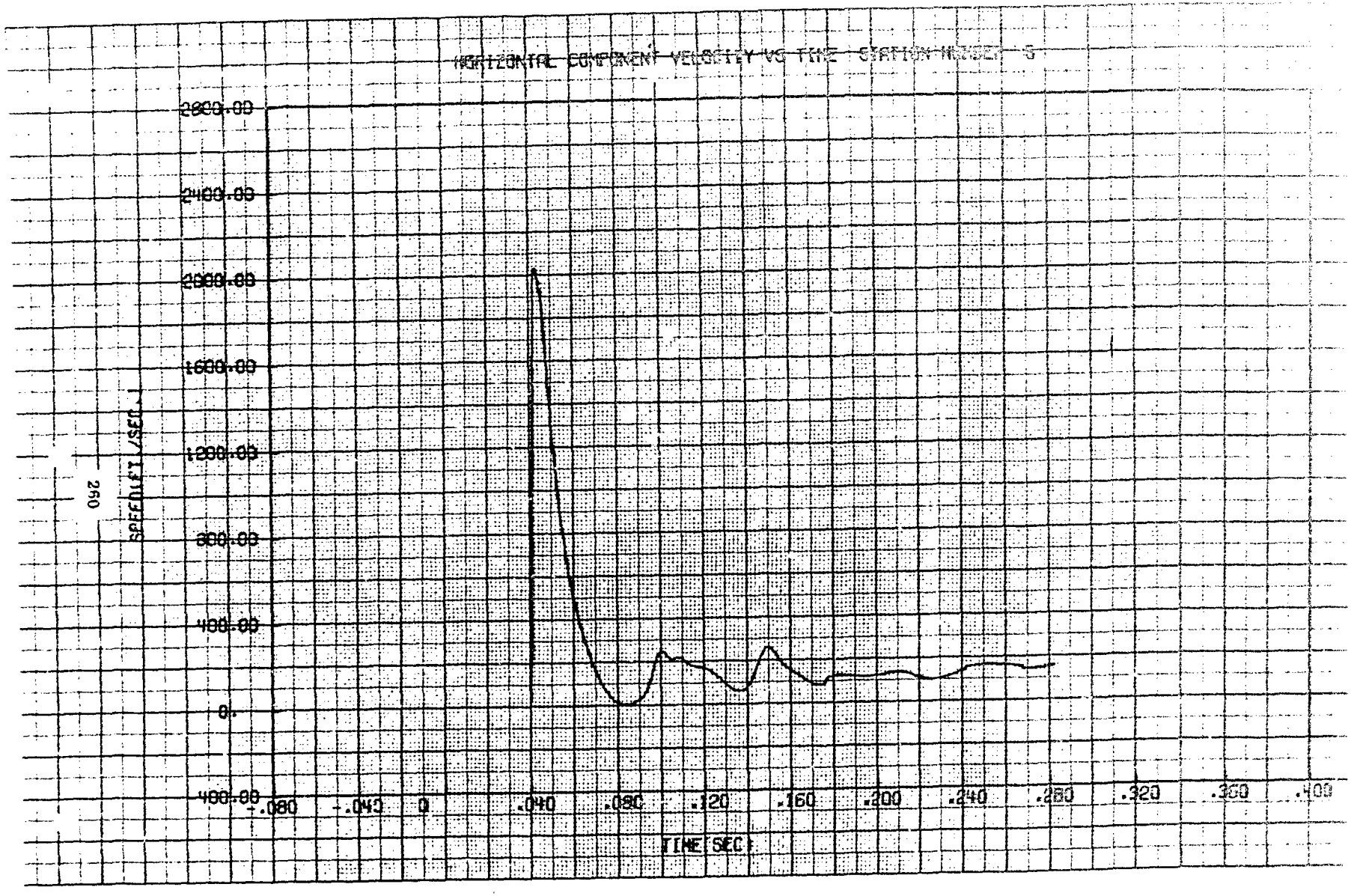

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE (PSI A.*SEC.)
255
.80
.70
.60
.50
.40
.30
.20
.10
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME SEC.

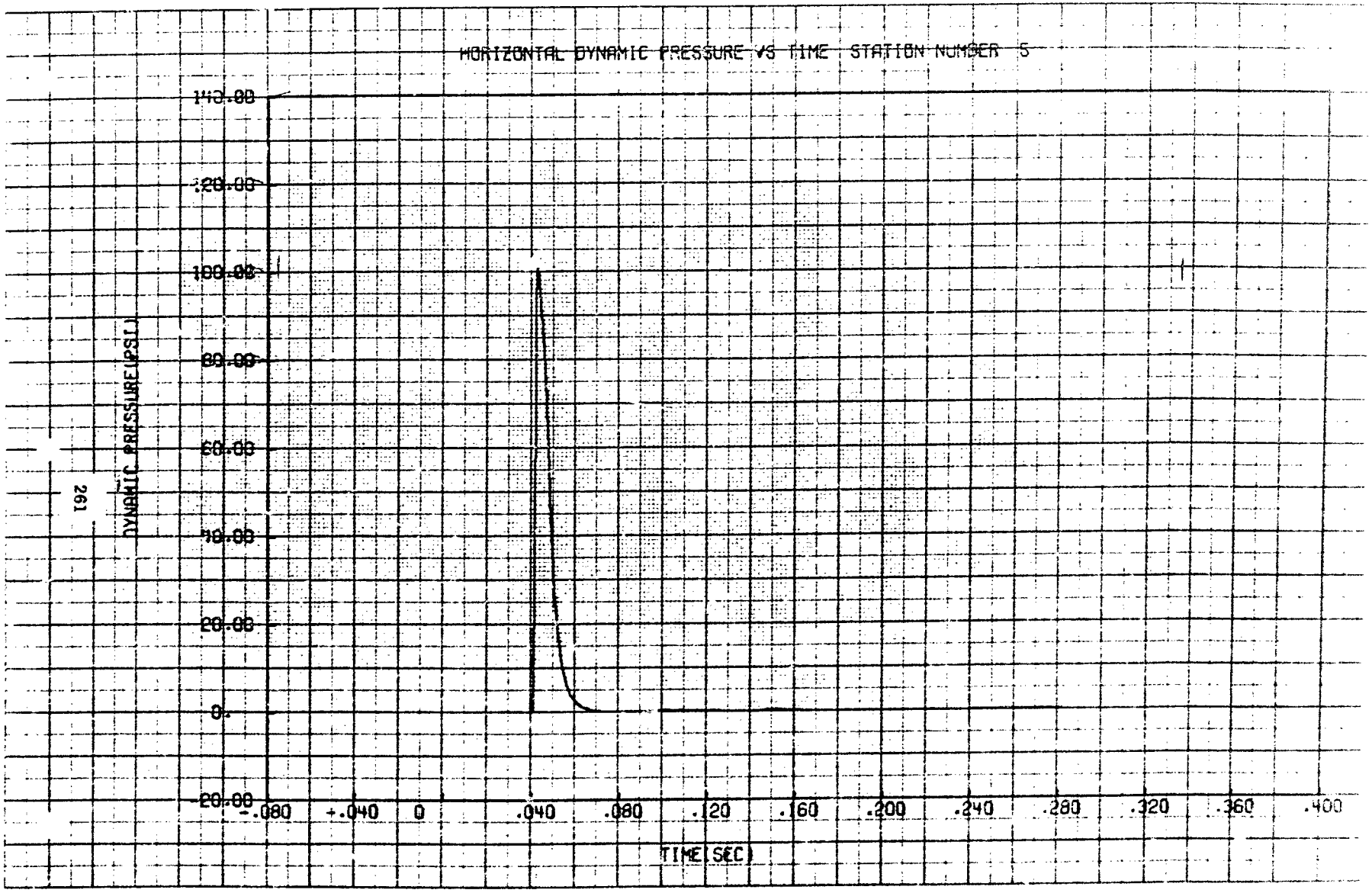
CRITICAL DYNAMIC PRESSURE VS TIME - STATION 1
DYNAMIC PRESSURE (PSI)
TIME SEC)
2.00
0.
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

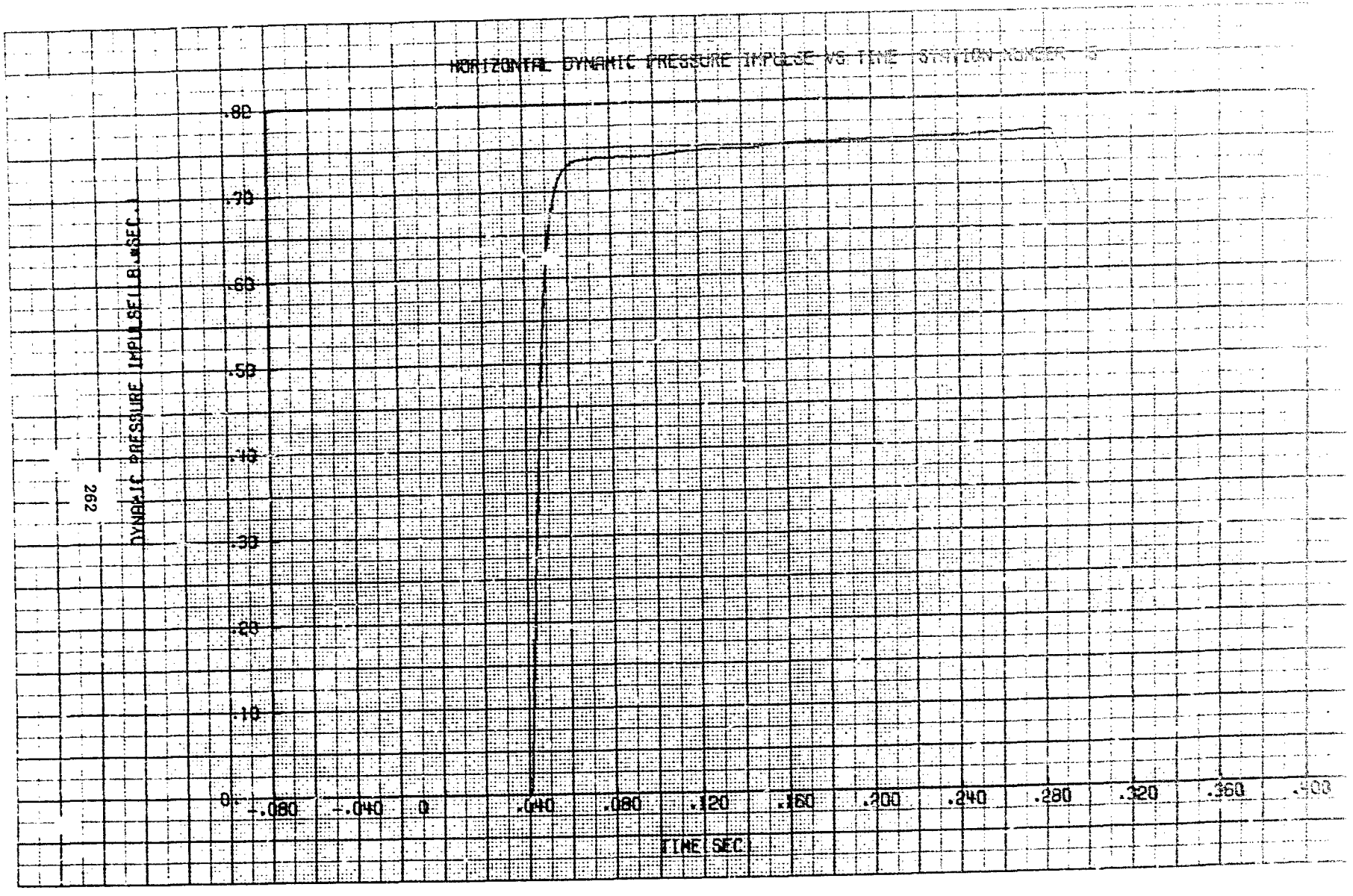

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
.004000
.002000
0
-.002000
-.004000
-.006000
-.008000
-.010000
-.012000
DYNAMIC PRESSURE IMPULSE (LB-SEC/...)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

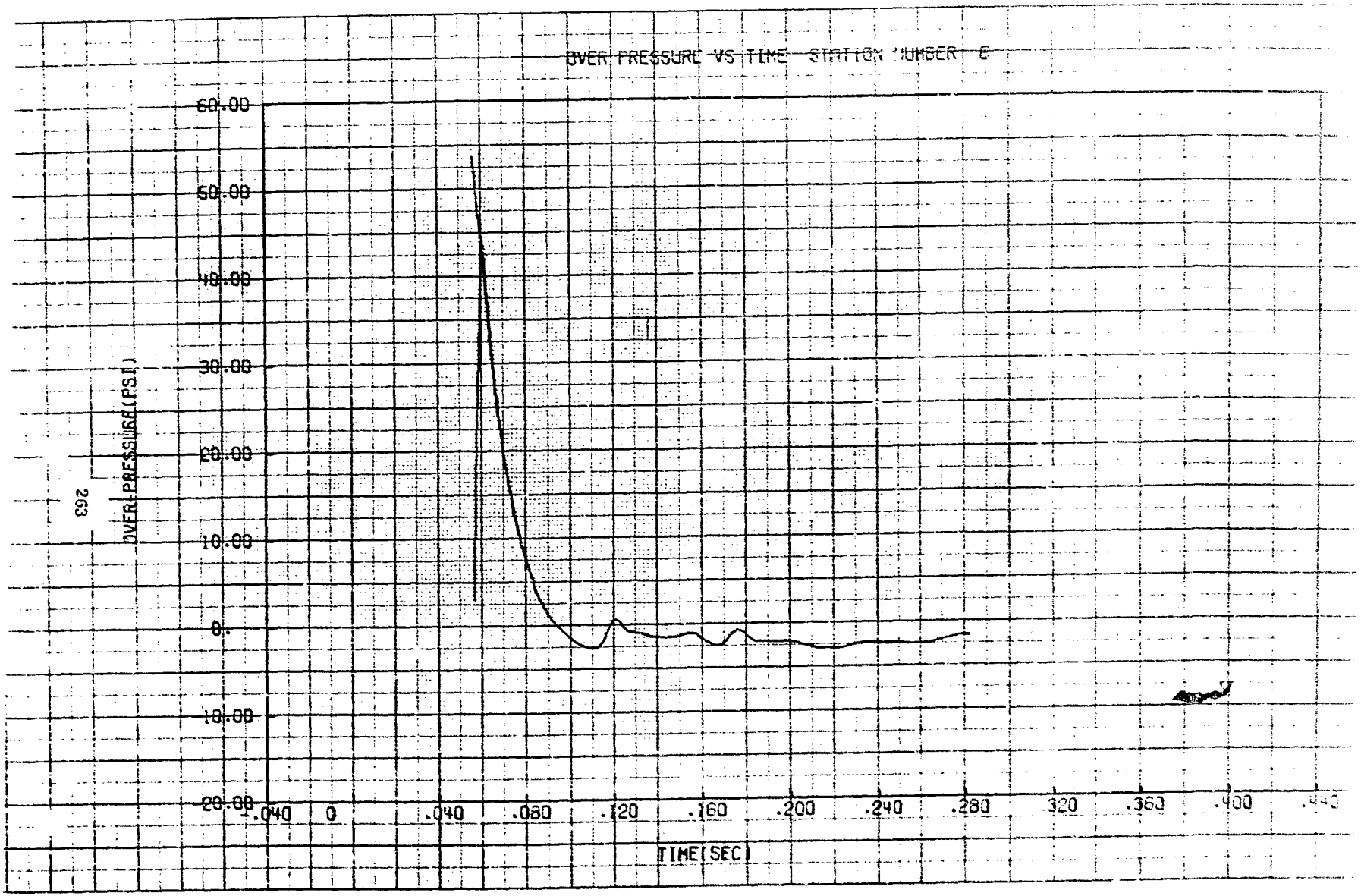

OVER PRESSURE VS TIME STATION NUMBER 5
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
OVER-PRESSURE (PSF)
258
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

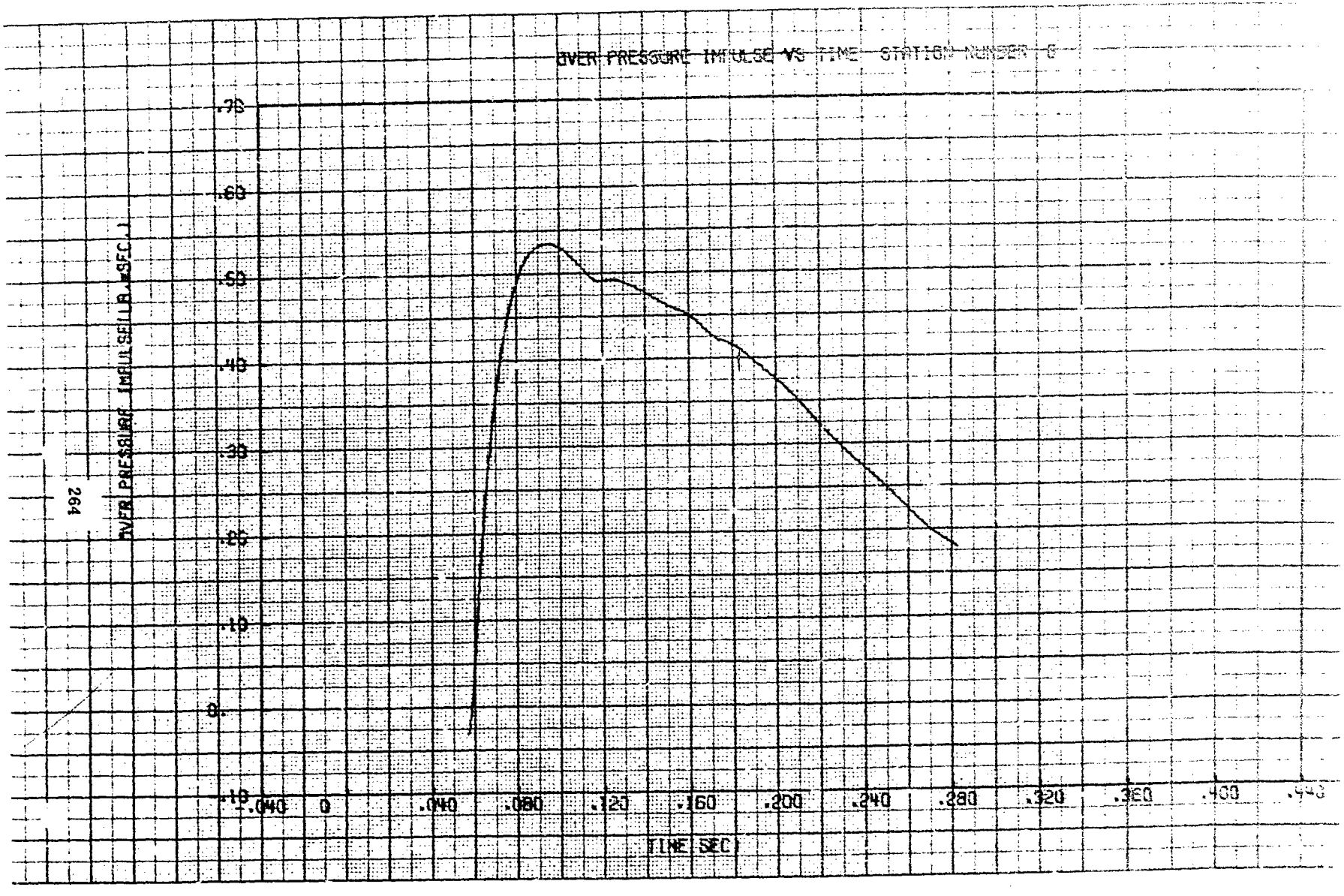

OVER PRESSURE IMPULSE VS TIME- STATION NUMBER 5
OVER PRESSURE IMPULSE (LB-SEC/...
.80
.70
.60
.50
.40
.30
.20
.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

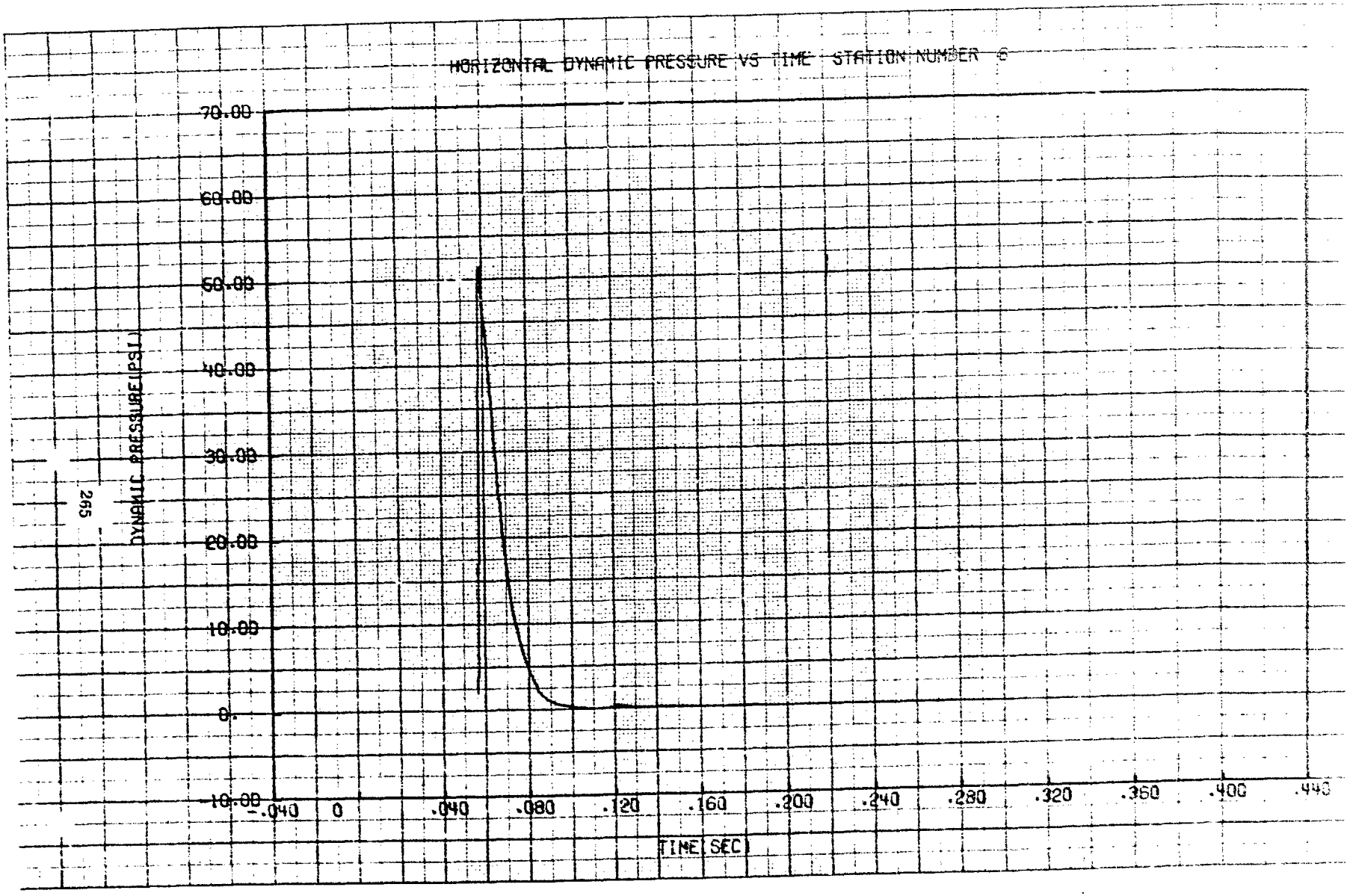

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
SPEED(FT/SEC)
260
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

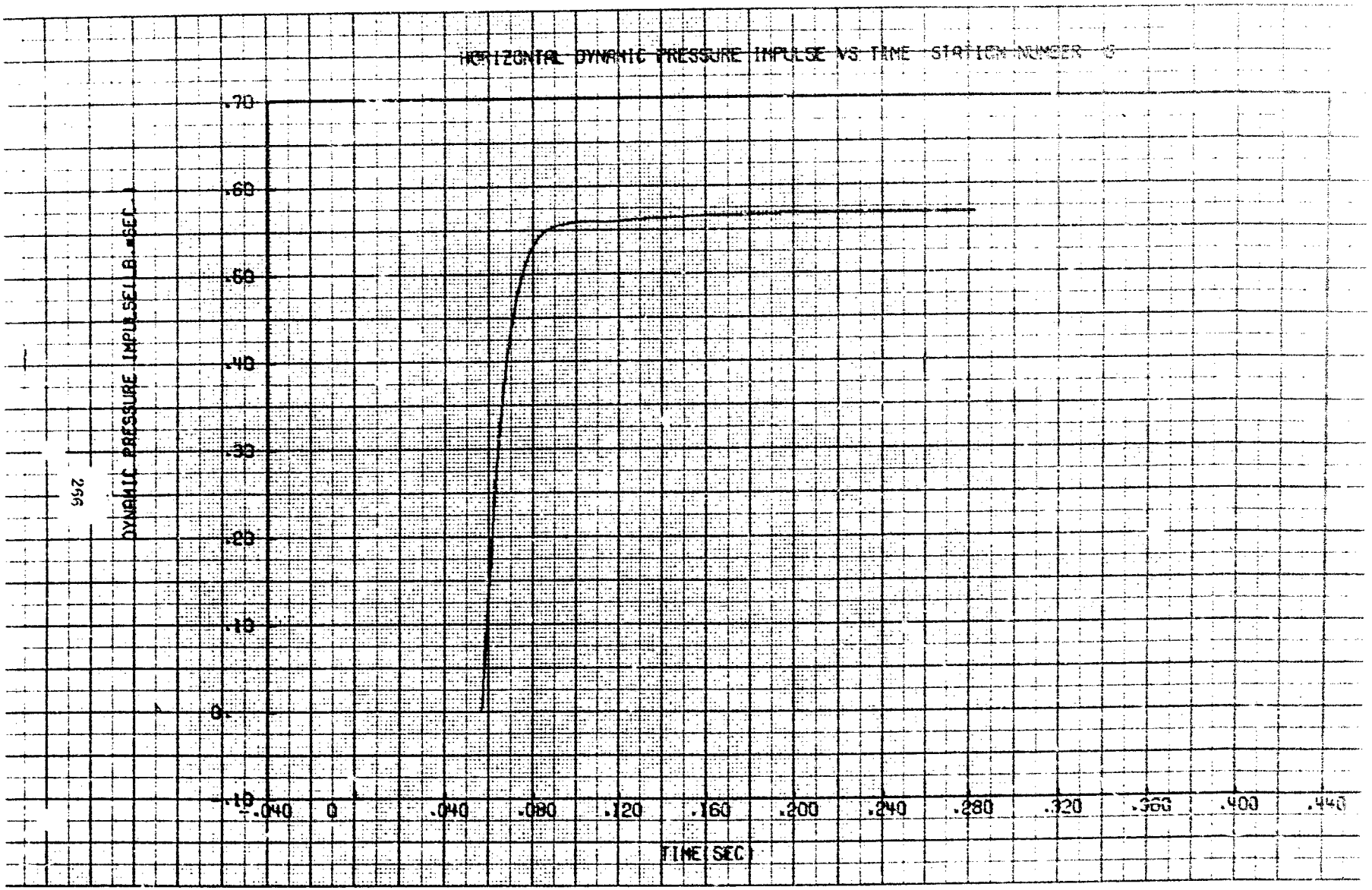

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE(PSI)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-.080
+.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

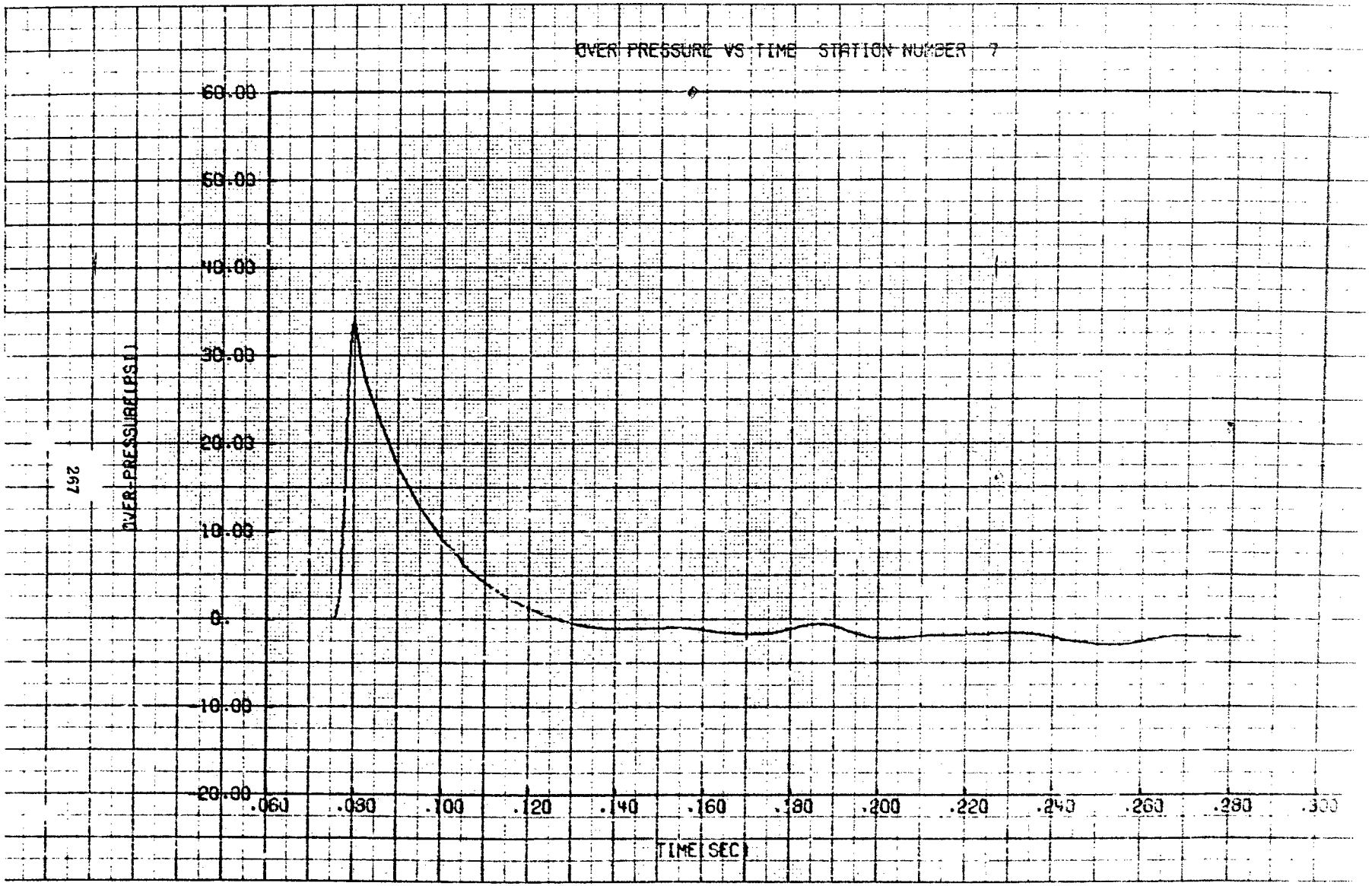

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 5
.80
.70
.60
.50
.40
.30
.20
.10
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME SEC
DYNAMIC PRESSURE IMPULSE LB.*SEC.
262

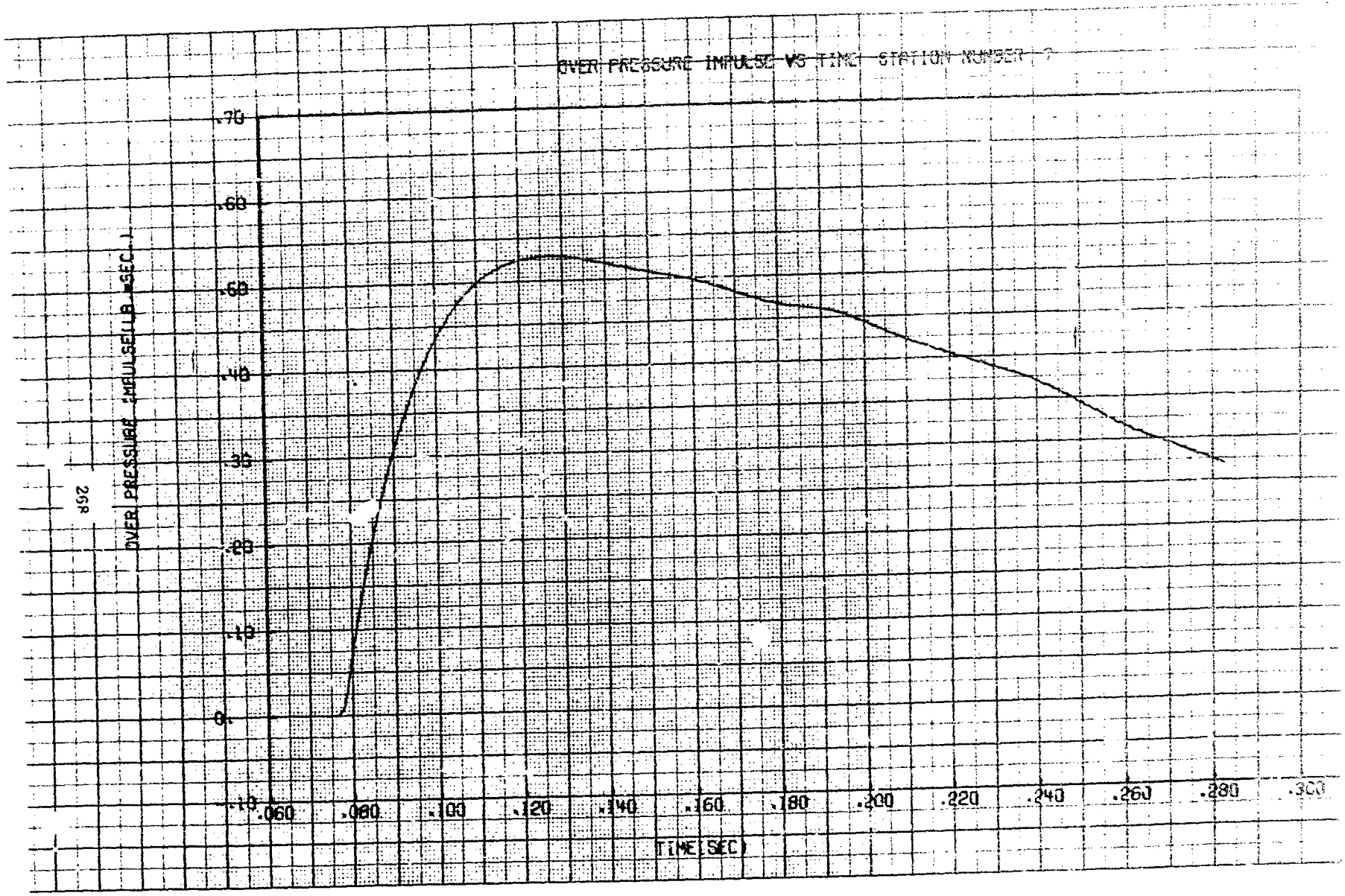

OVER PRESSURE VS TIME STATION NUMBER 8
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

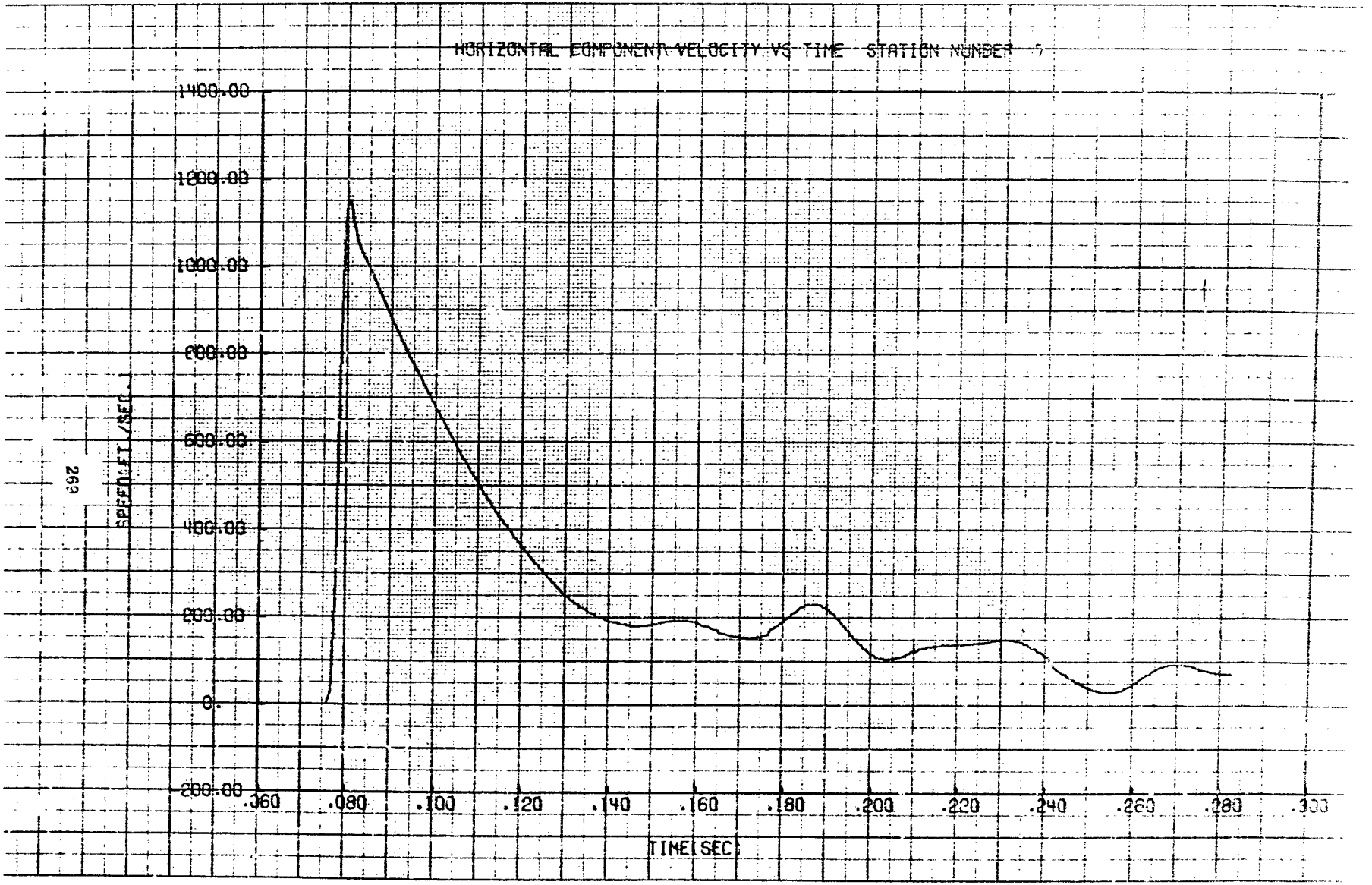

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 0
.75
.60
.50
.10
.30
.05
.10
0
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
OVER PRESSURE IMPULSE LB/SEC
264

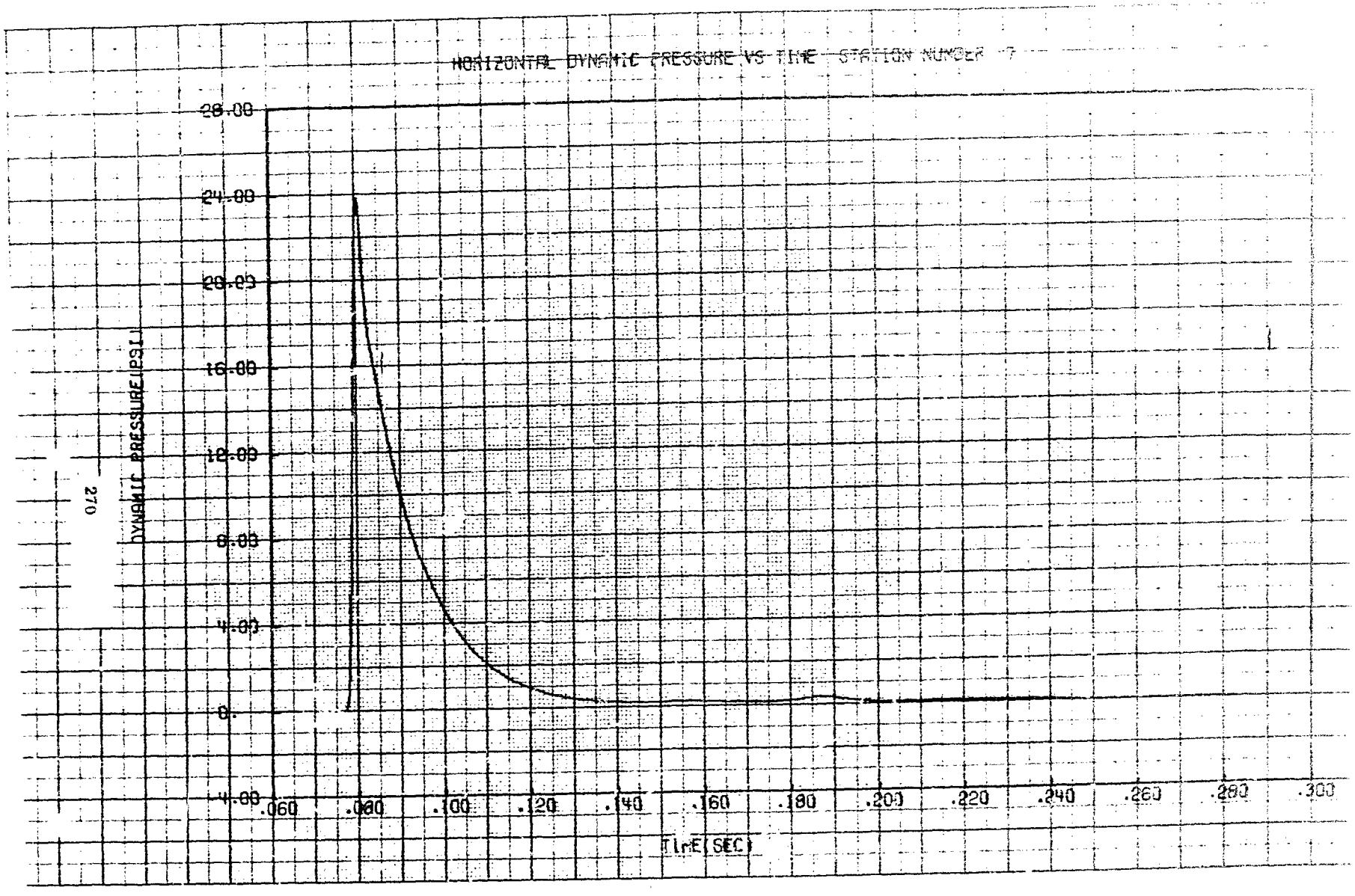

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 6
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
265
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

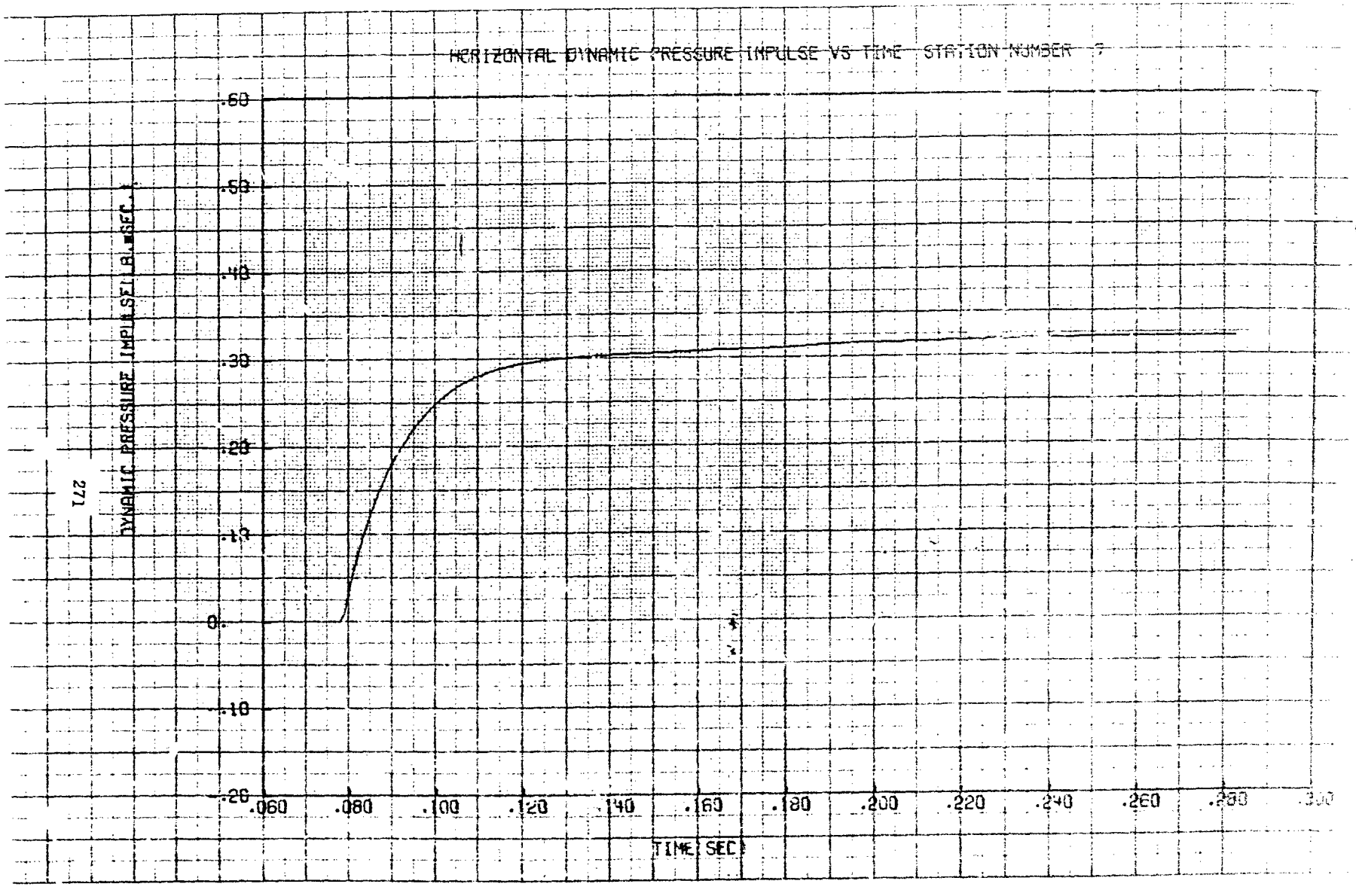

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 6
DYNAMIC PRESSURE IMPULSE(LB-SEC/FT2)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

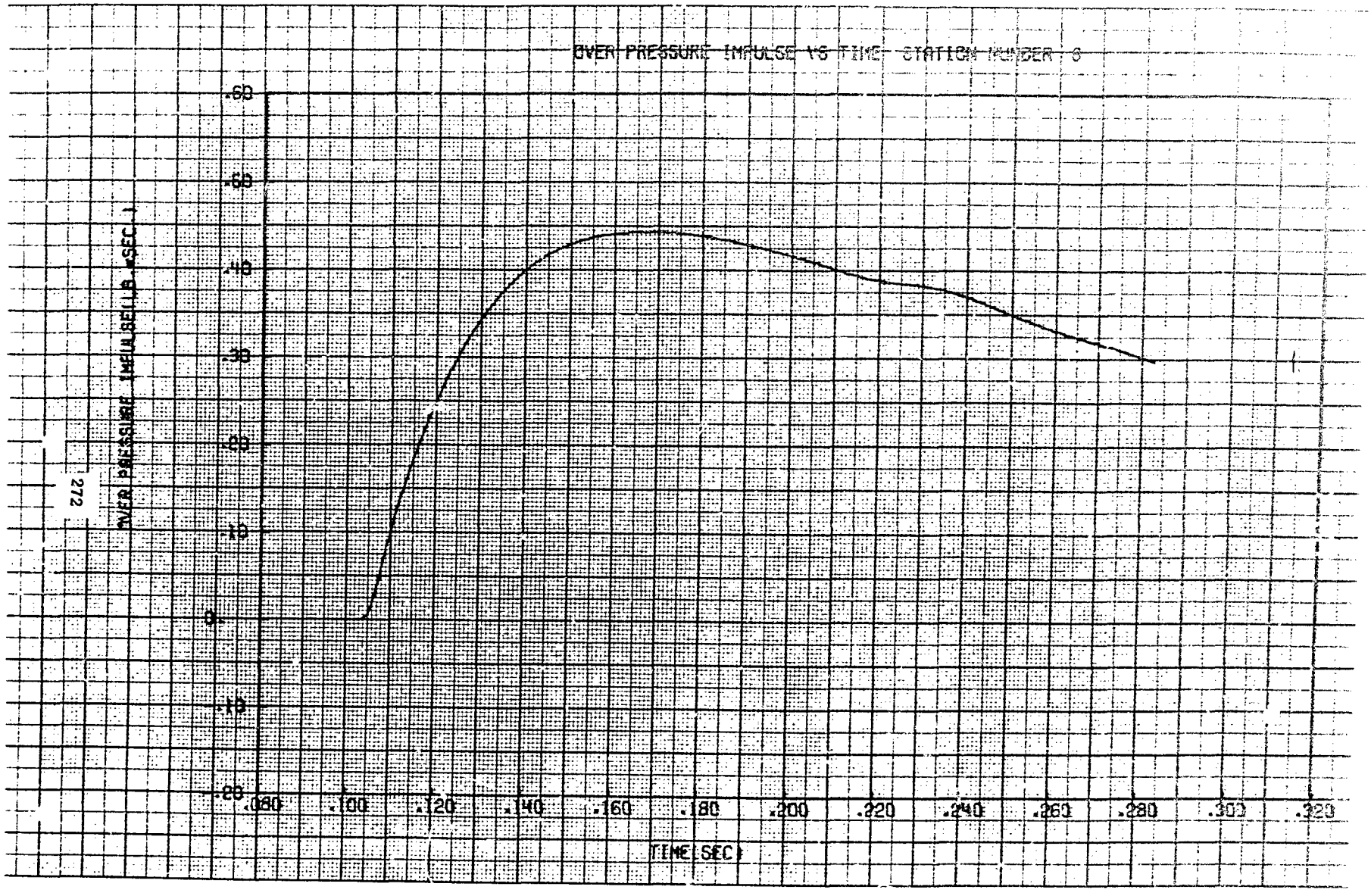

OVER PRESSURE VS TIME STATION NUMBER 7
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

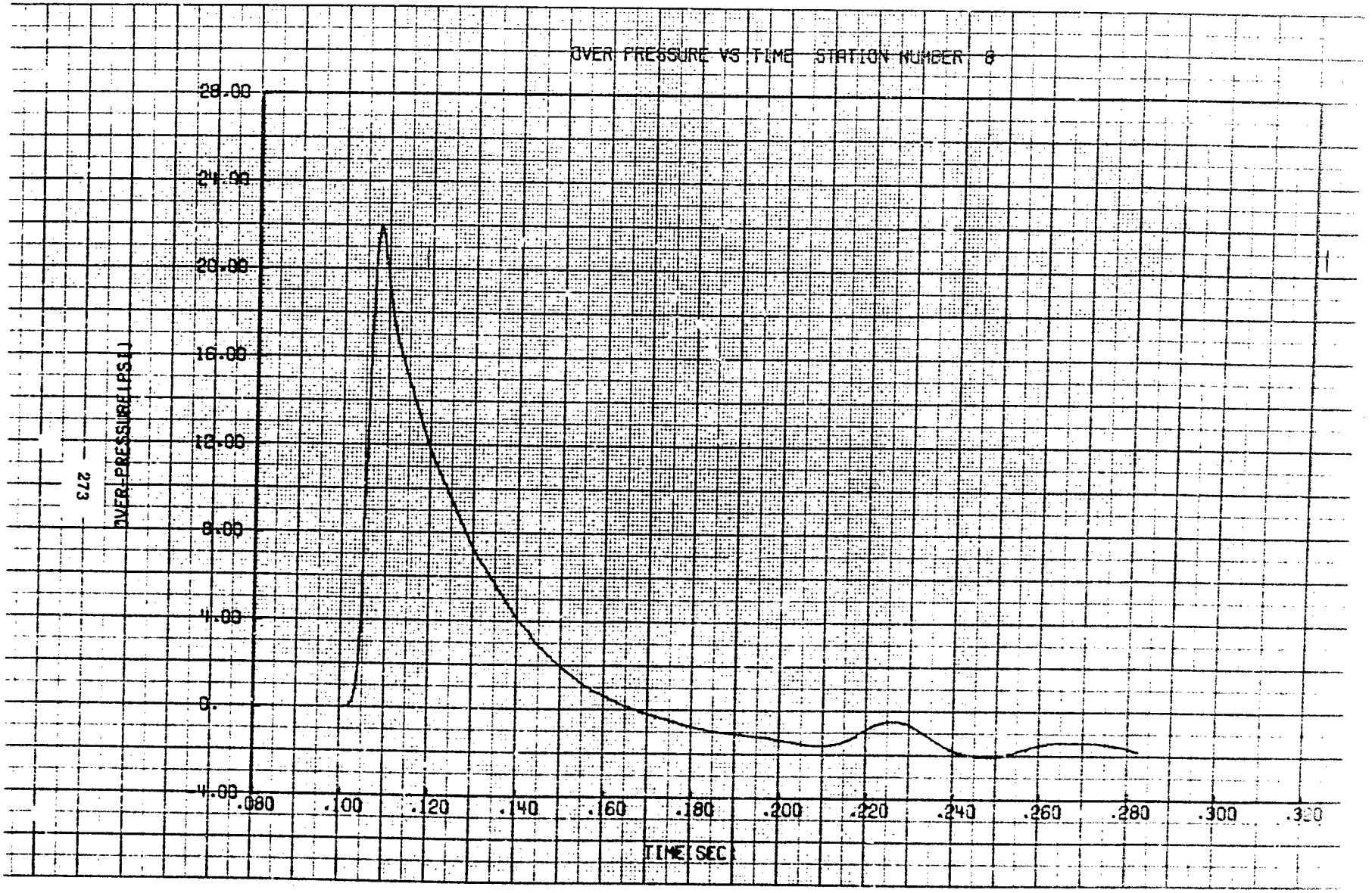

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 7
OVER PRESSURE IMPULSE(LB-SEC/...
.70
.60
.50
.40
.30
.20
.10
0
-.10
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

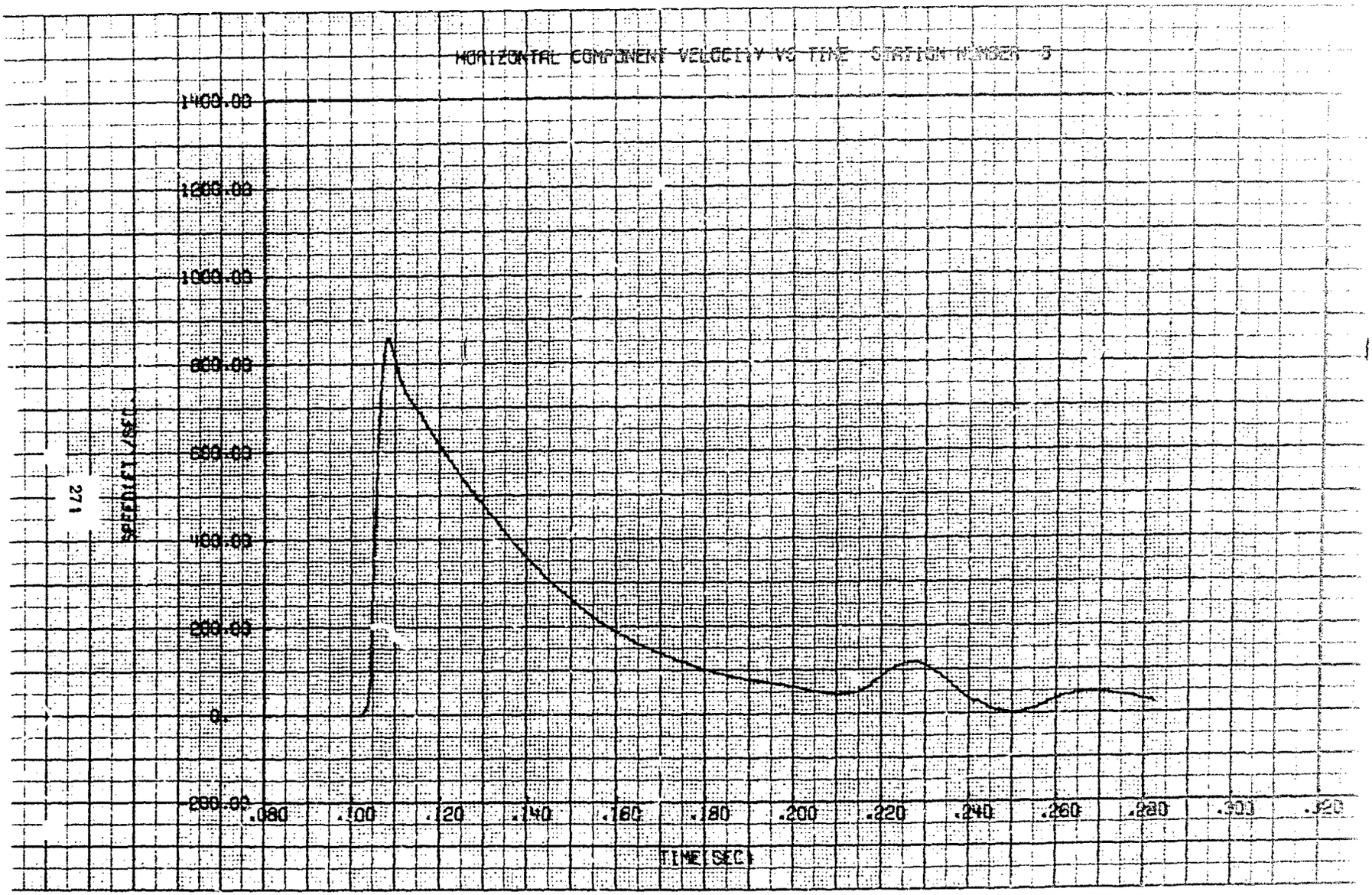

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

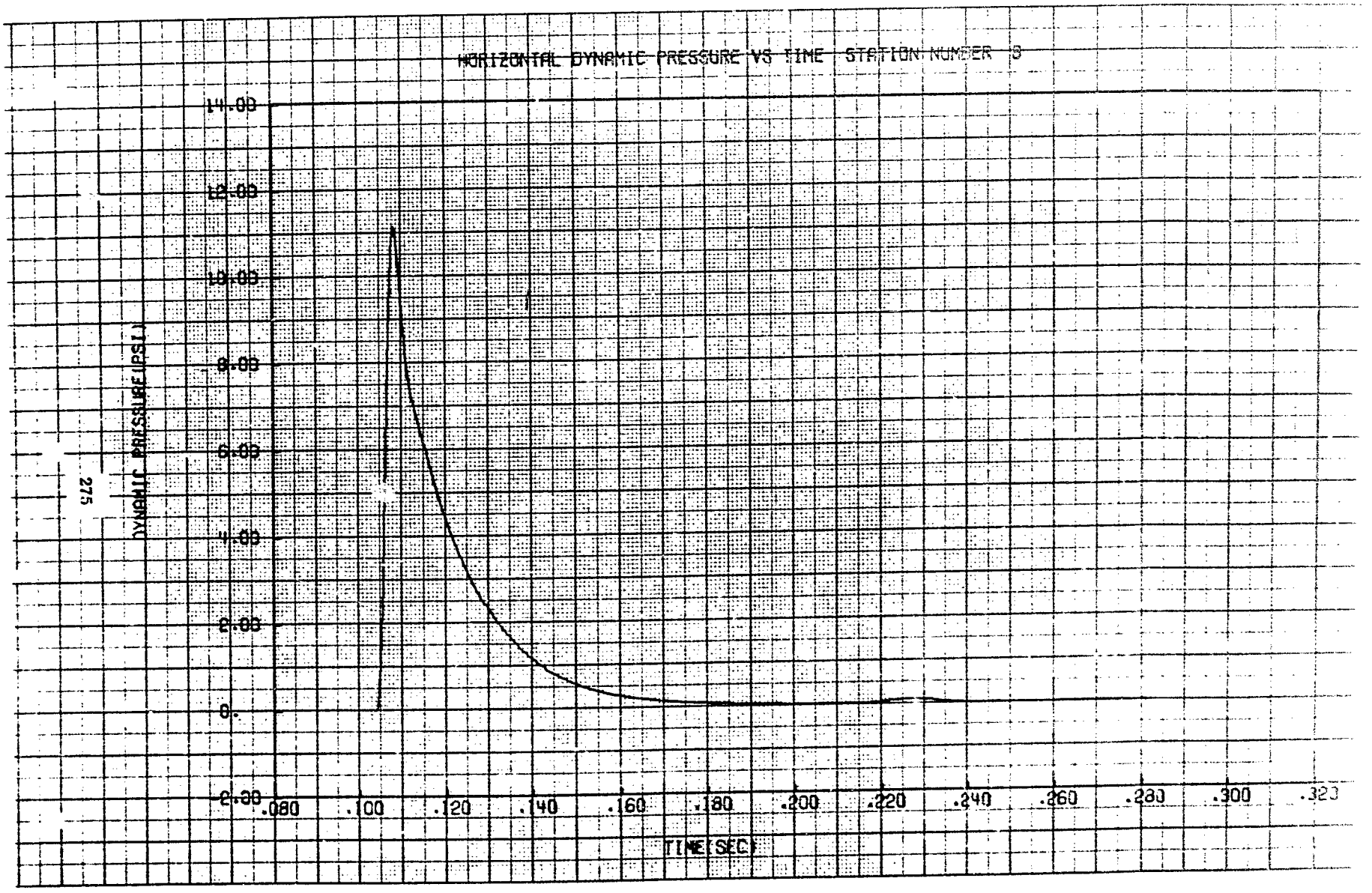

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE(PSI)
270
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

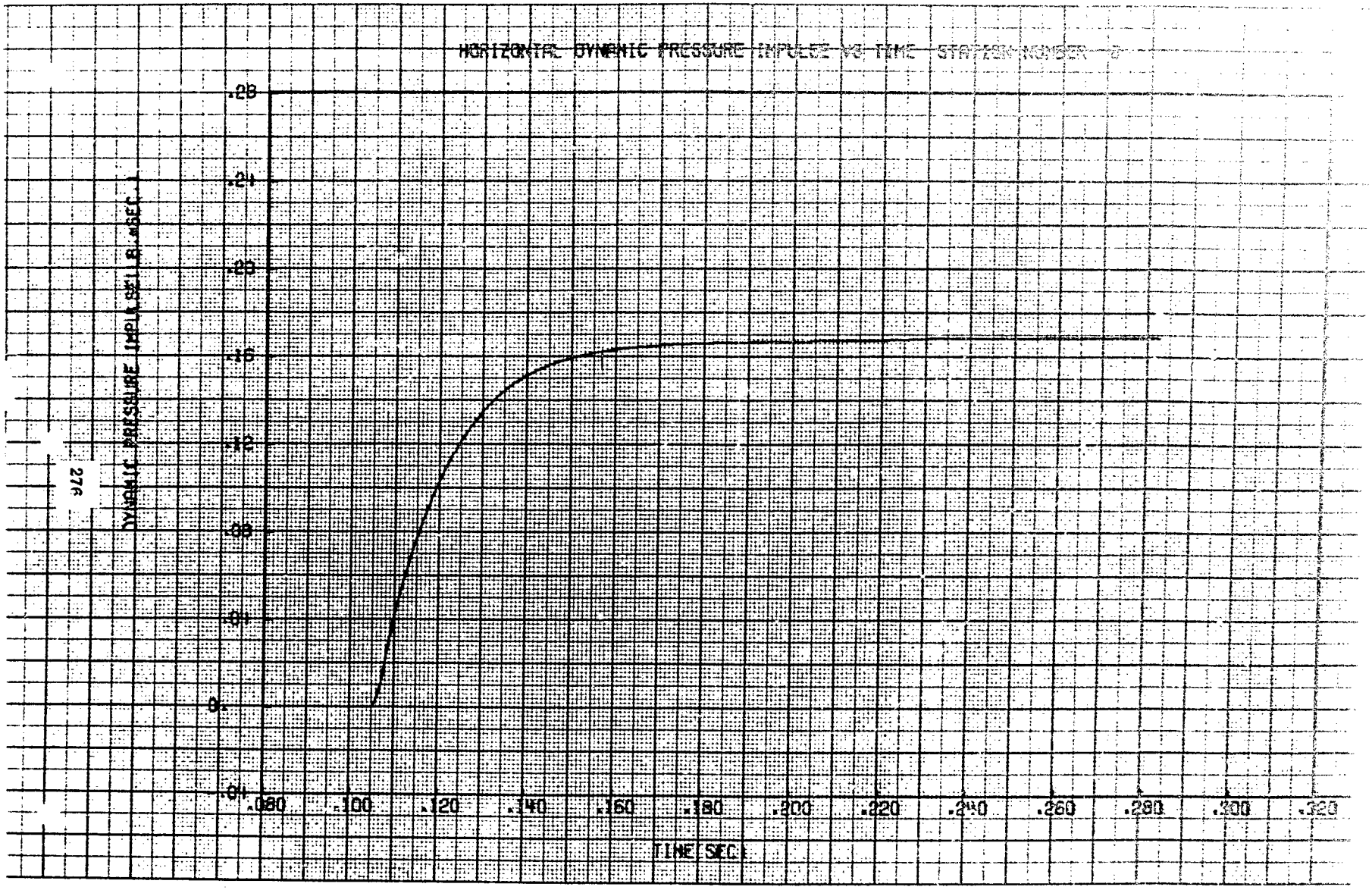

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC)

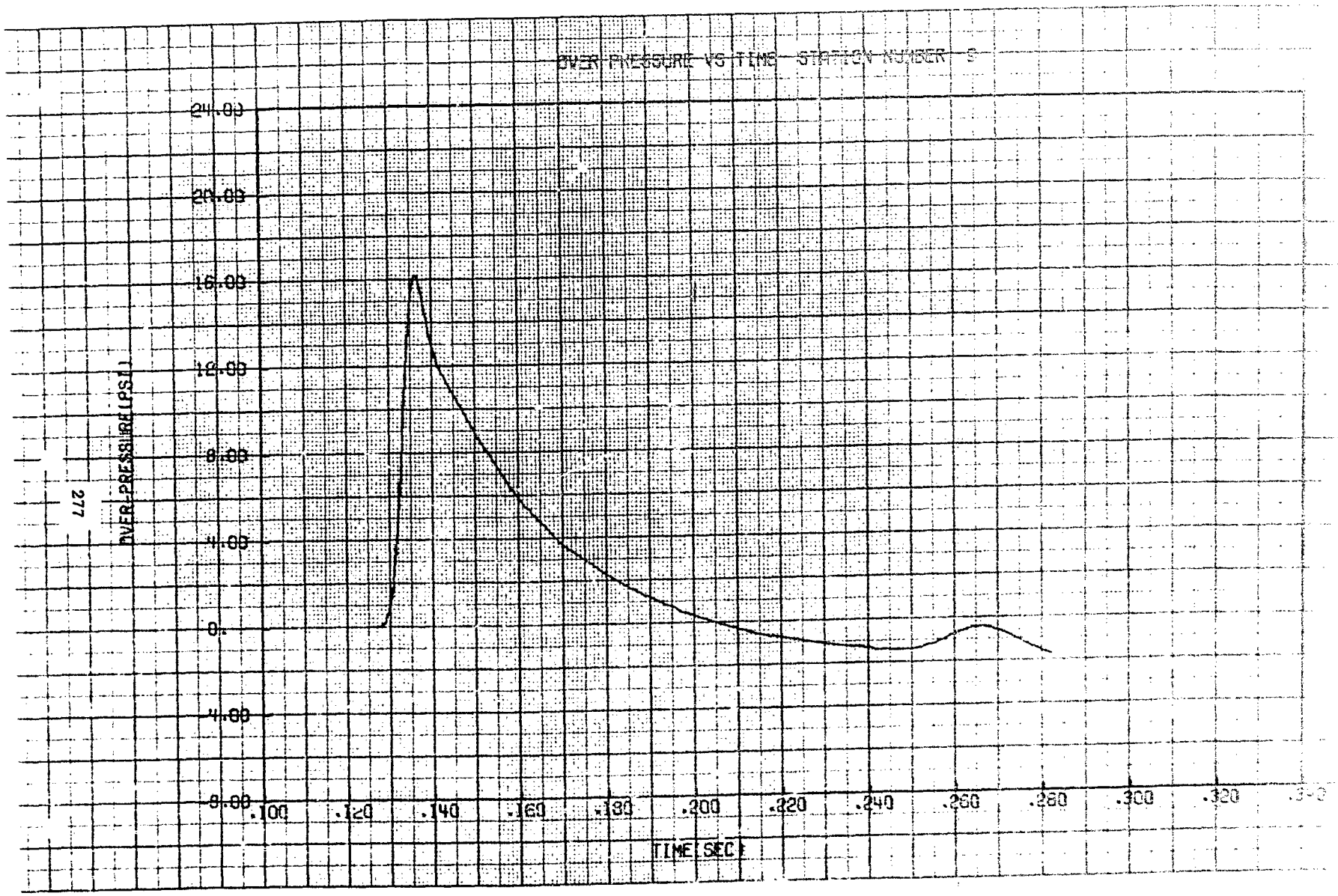

OVER PRESSURE IMPULSE VS TIME- STATION NUMBER 6
.60
.50
.40
.30
.20
.10
0
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC
OVER PRESSURE IMPULSE PSI-SEC


OVER PRESSURE VS TIME STATION NUMBER 8
OVER-PRESSURE(LBS/I)
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

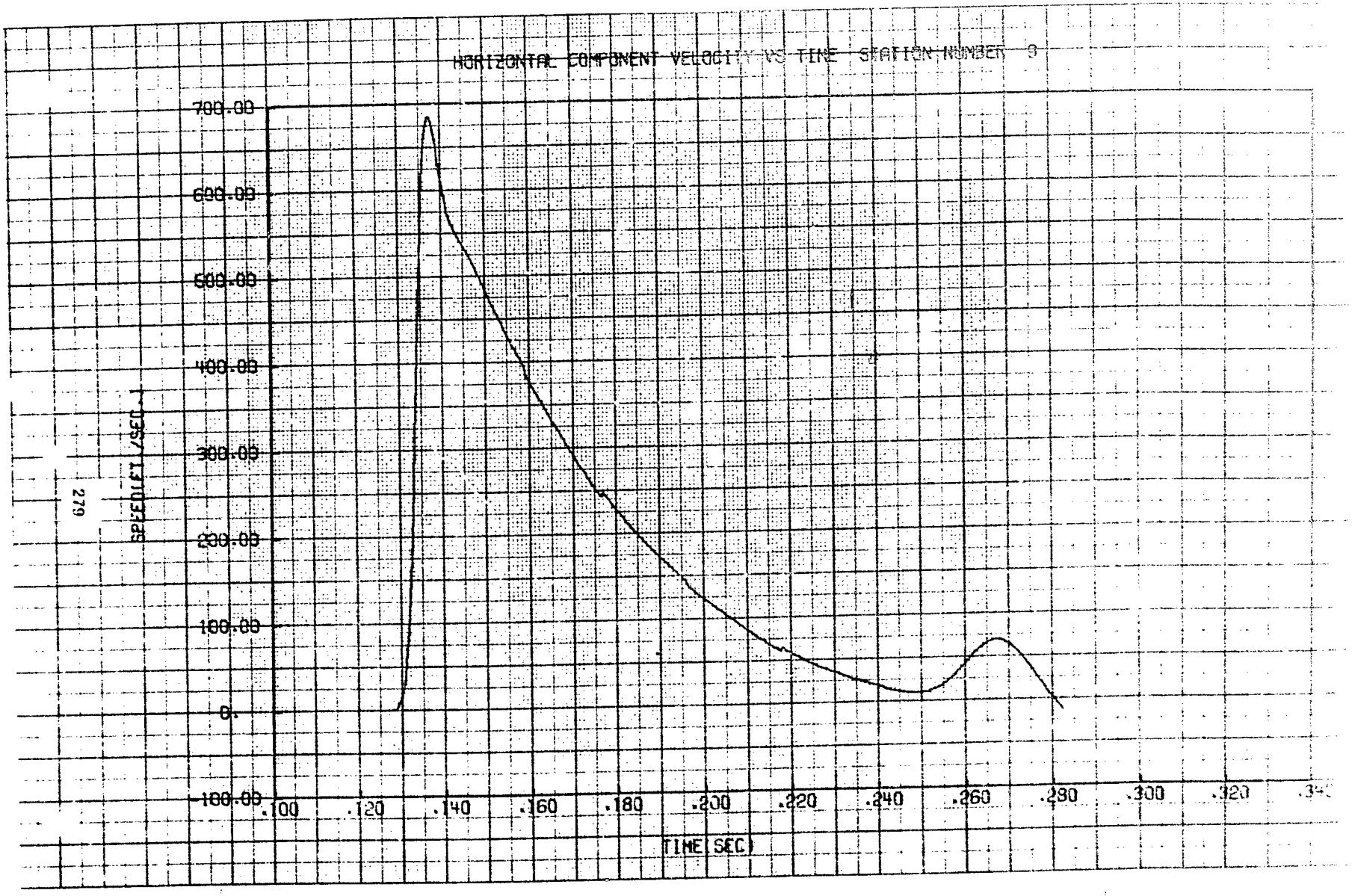

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)
271


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)
DYNAMIC PRESSURE(PSI)
275

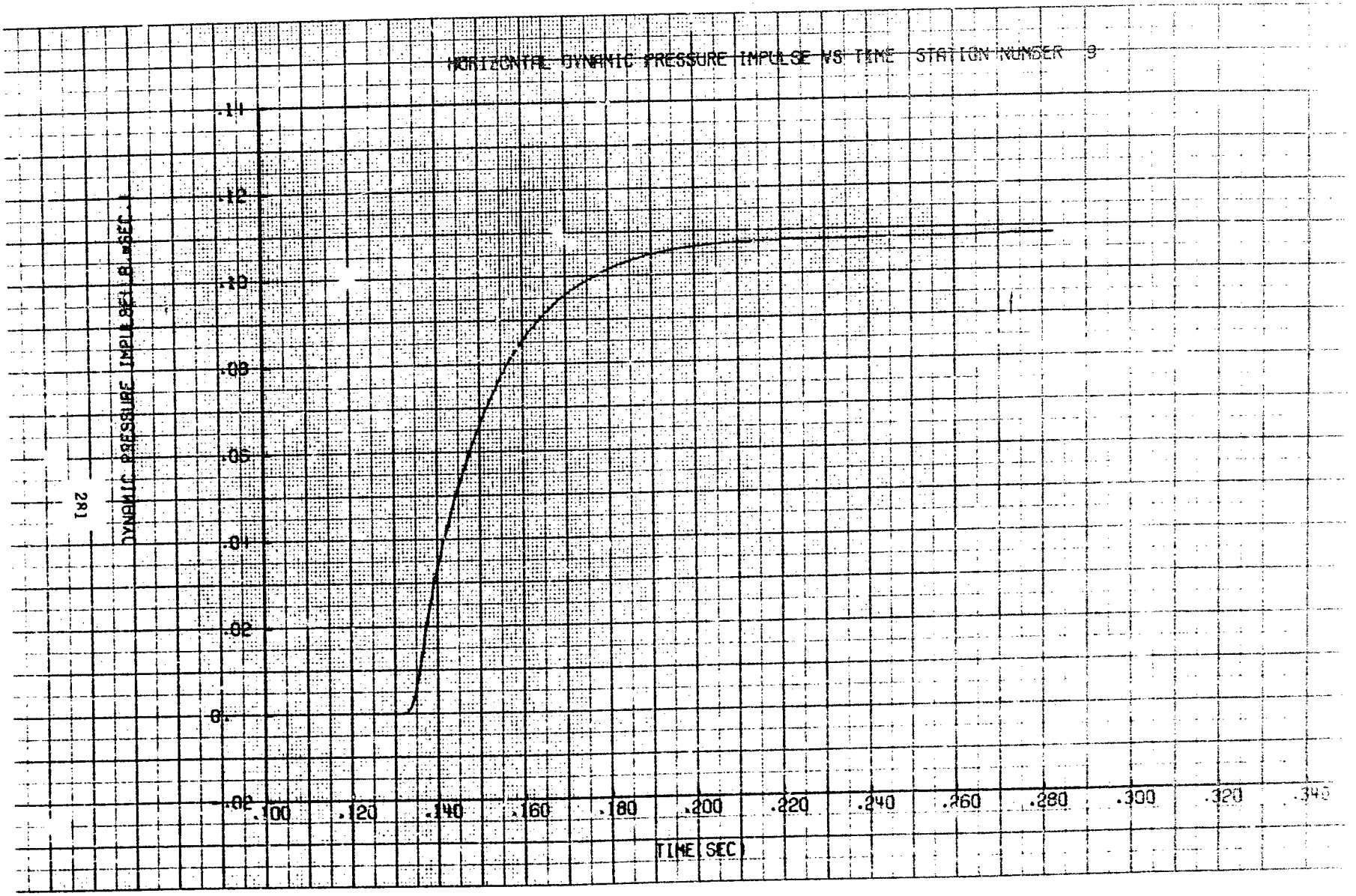

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 6
DYNAMIC PRESSURE IMPULSE (PSI-SEC)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)

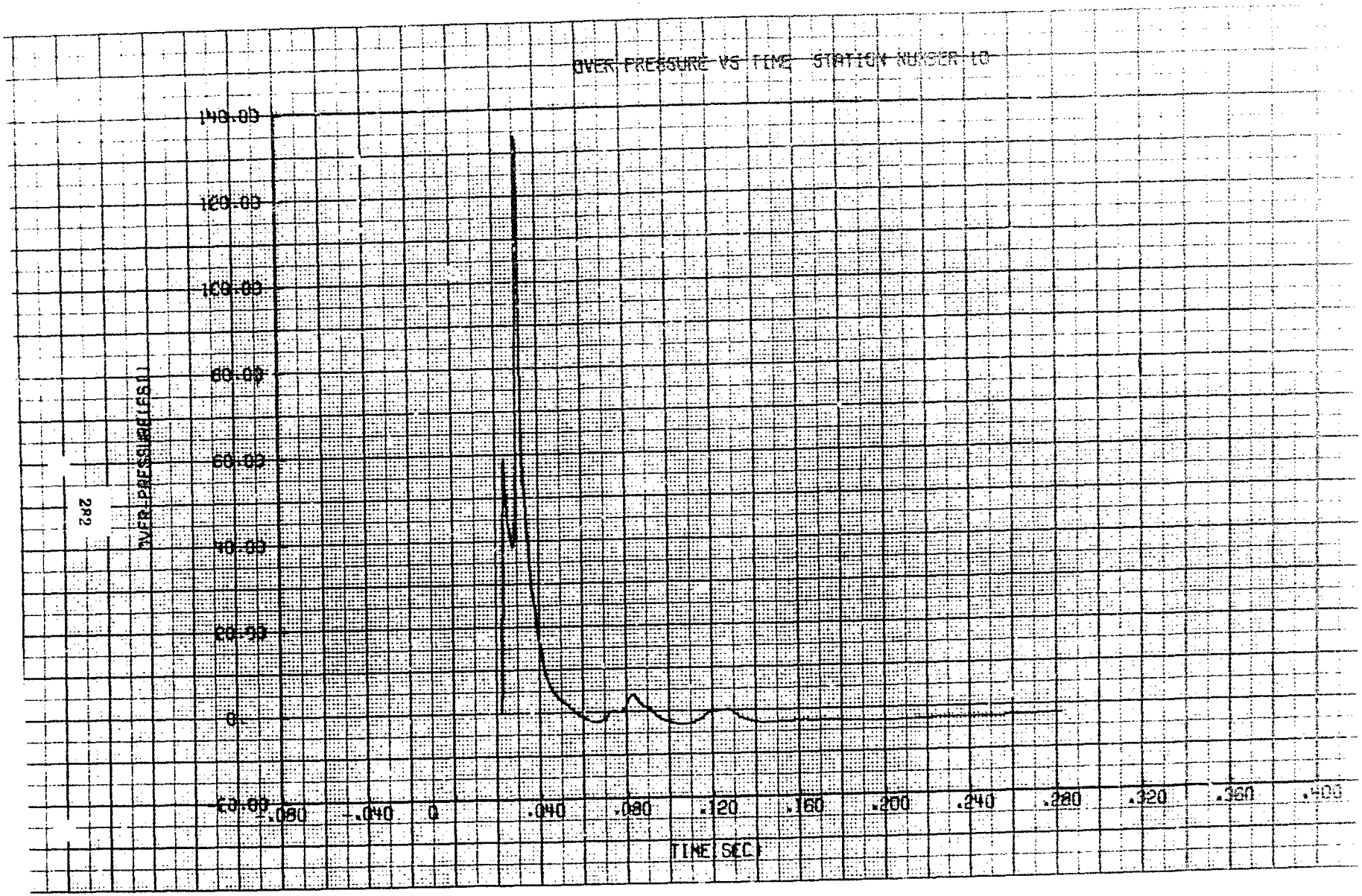

OVER PRESSURE VS TIME STATION NUMBER 5
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVERPRESSURE(PSI)
277
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC

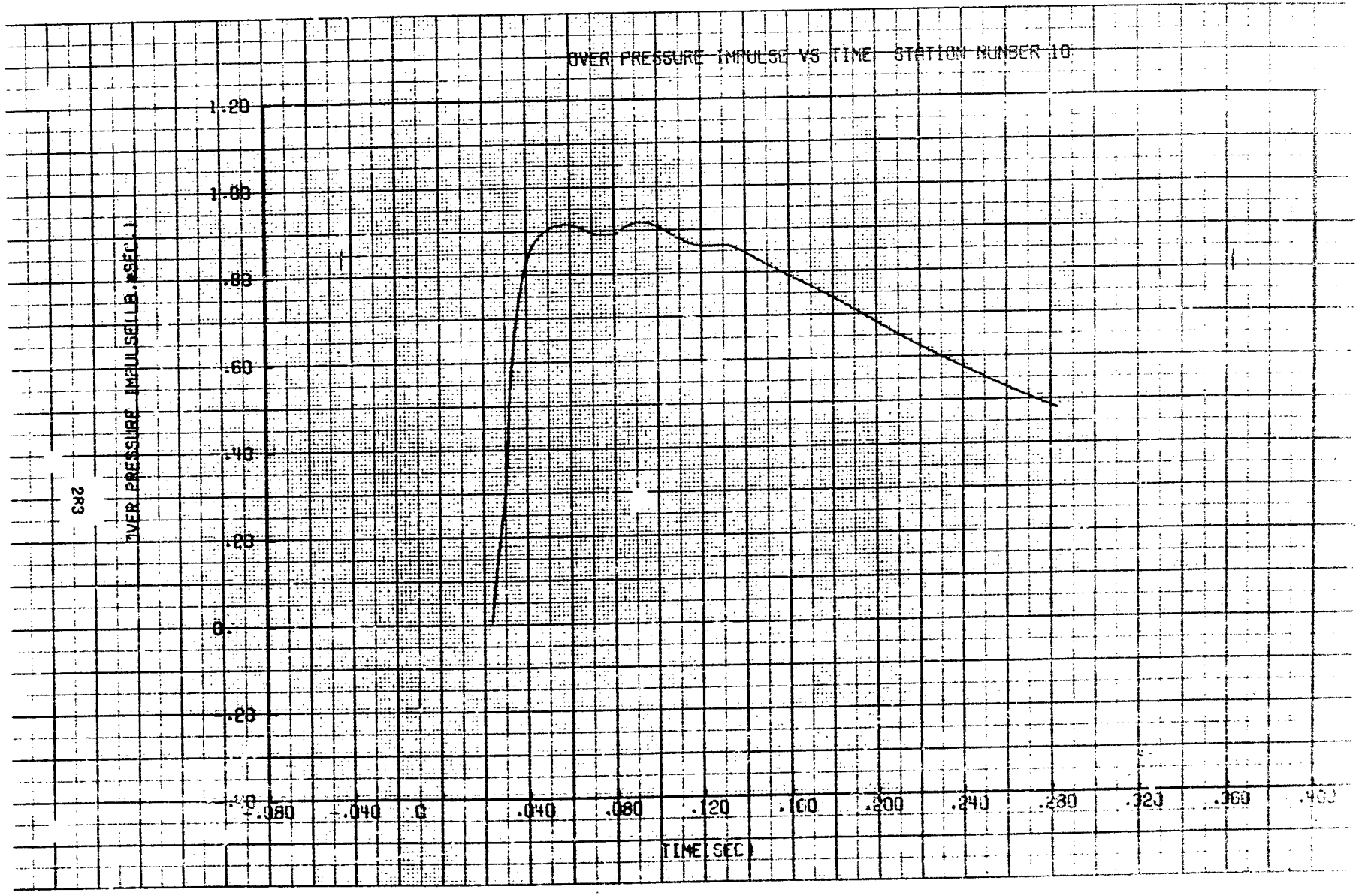
OVER PRESSURE IMPULSE VS TIME, STATION NUMBER 6
OVER PRESSURE IMPULSE (PSI-SEC.)
.60
.50
.40
.30
.20
.10
0
-.10
-.20
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME SEC.

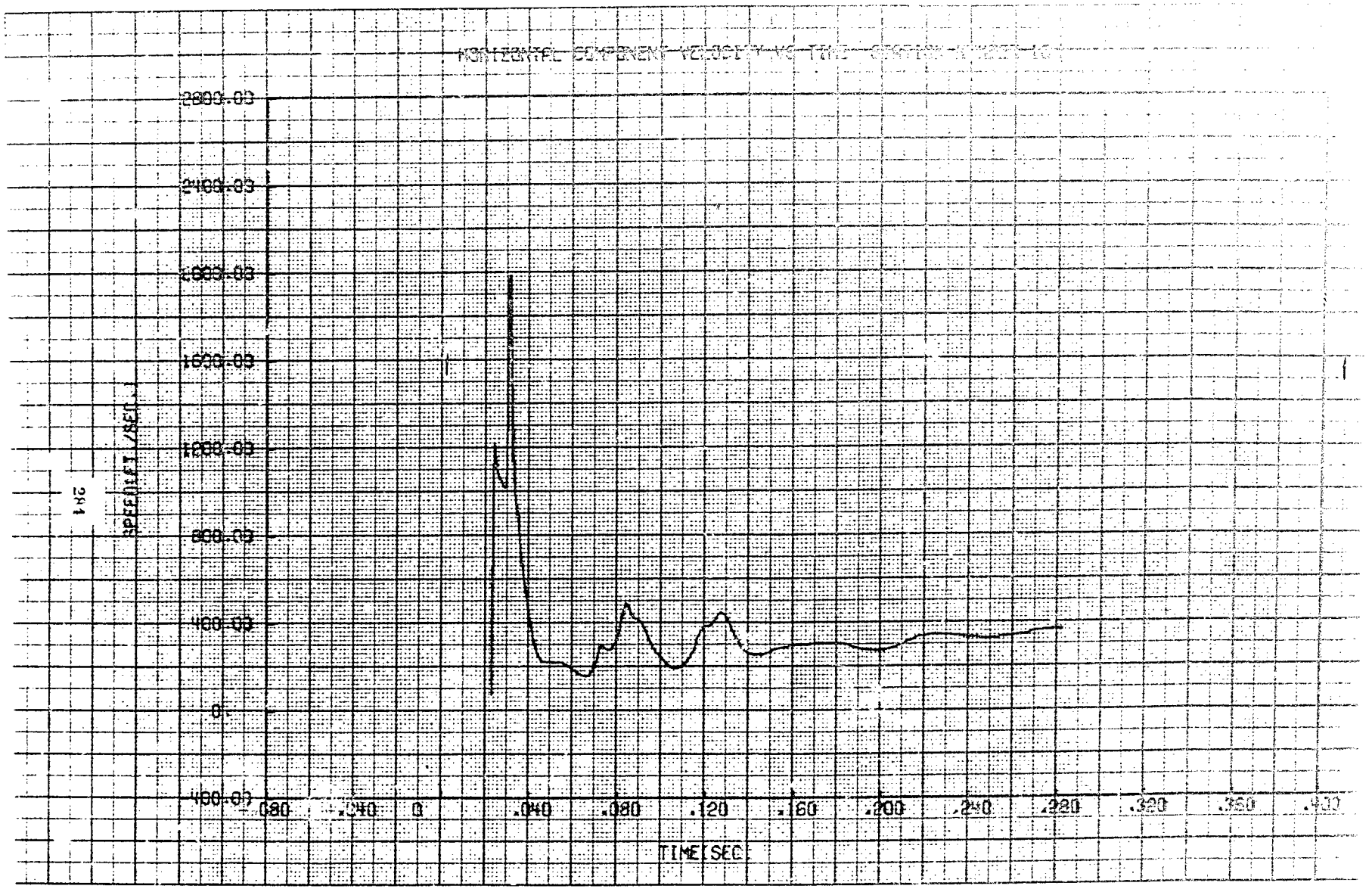

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
SPEED(FT/SEC)
279
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

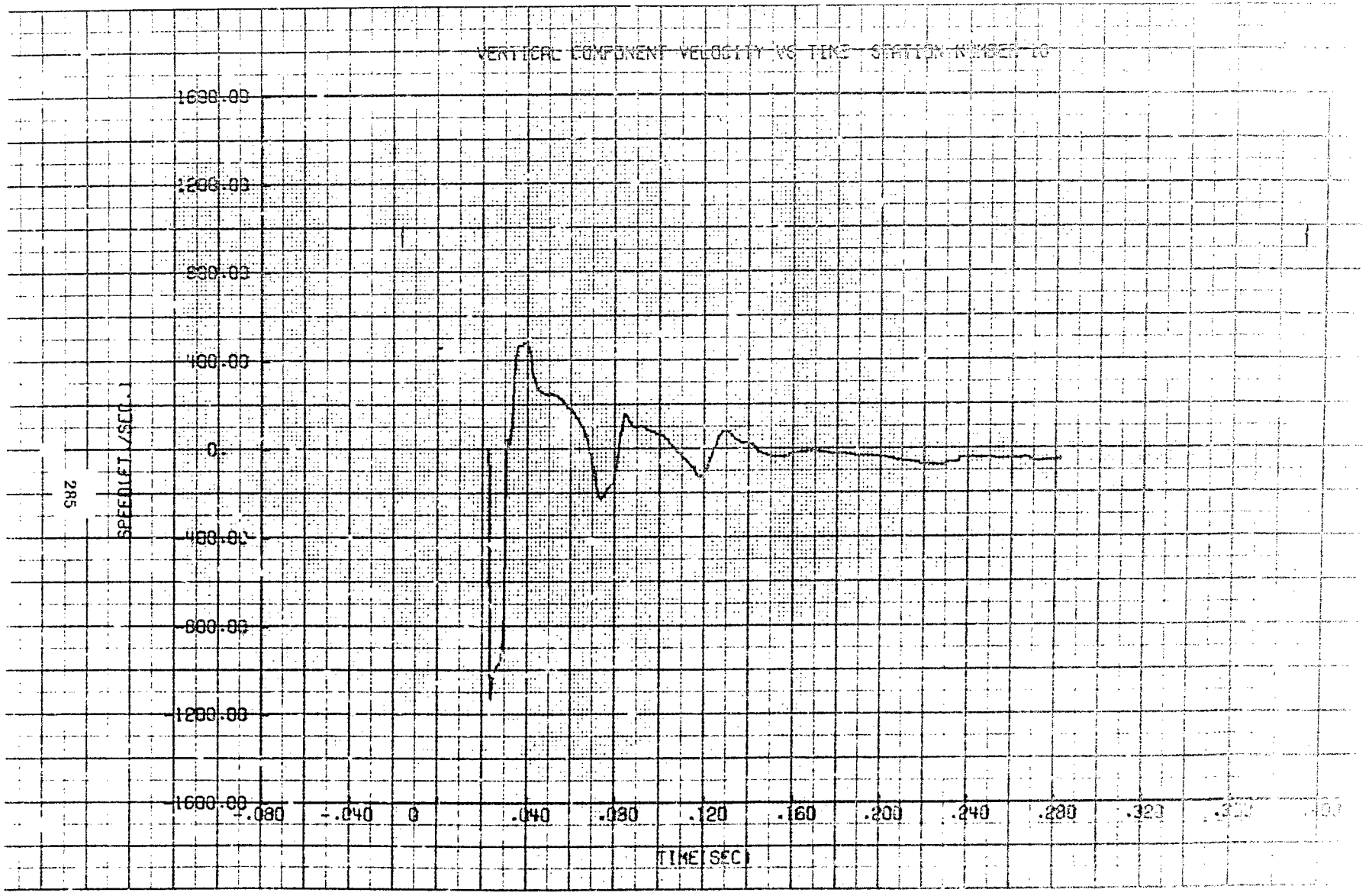
MOUNTAINTOP DYNAMIC PRESSURE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE (PSI)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 9
DYNAMIC PRESSURE IMPULSE (PSI-SEC)
.11
.12
.10
.09
.05
.01
.02
0.
-.02
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME (SEC)

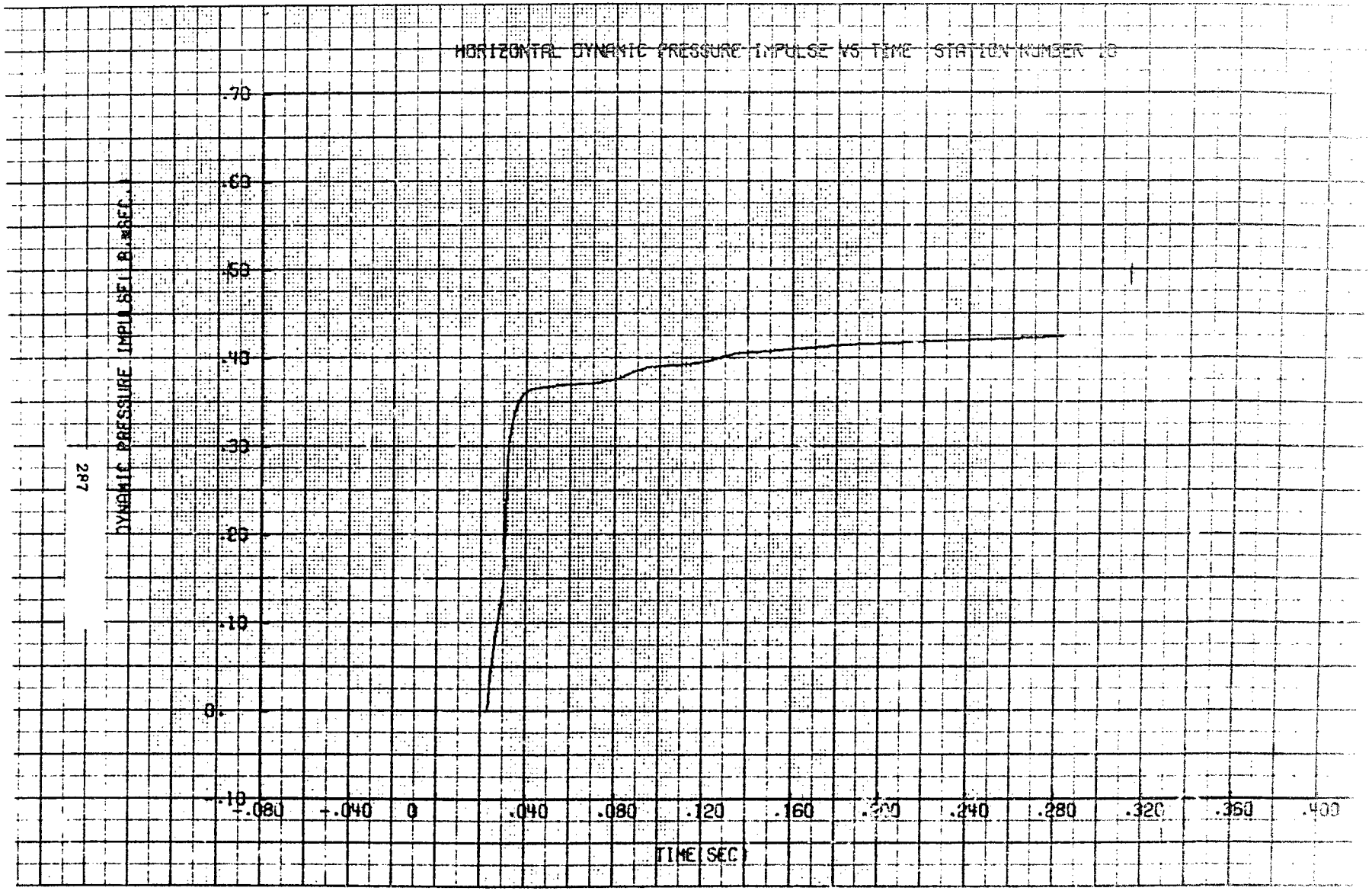

OVER PRESSURE VS TIME STATION NUMBER 10
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0
-20.00
OVER PRESSURE (PSF)
282
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

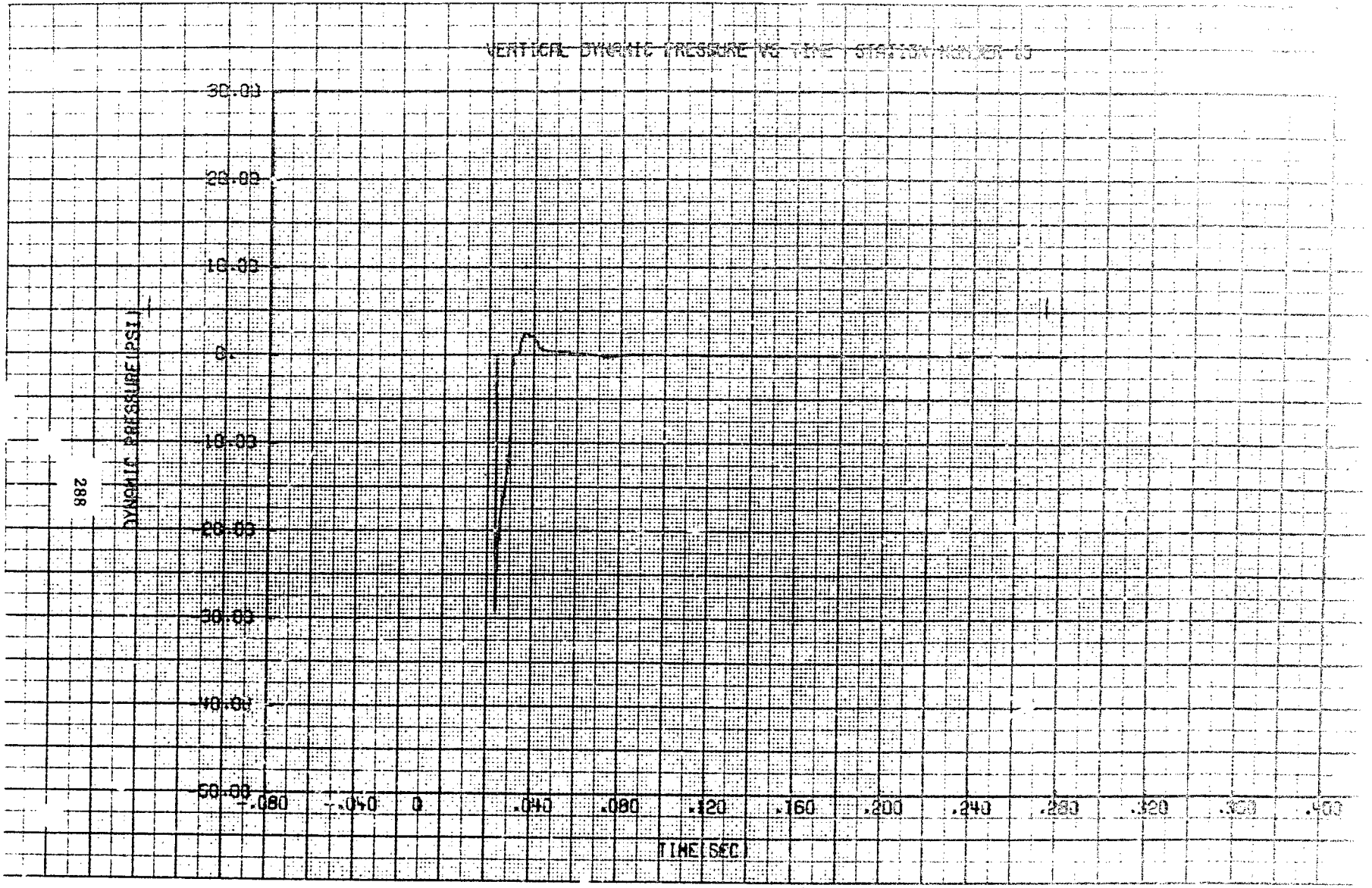

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 10
OVER PRESSURE IMPULSE(LB.*SEC.)
1.20
1.00
.80
.60
.40
.20
0
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME(SEC)

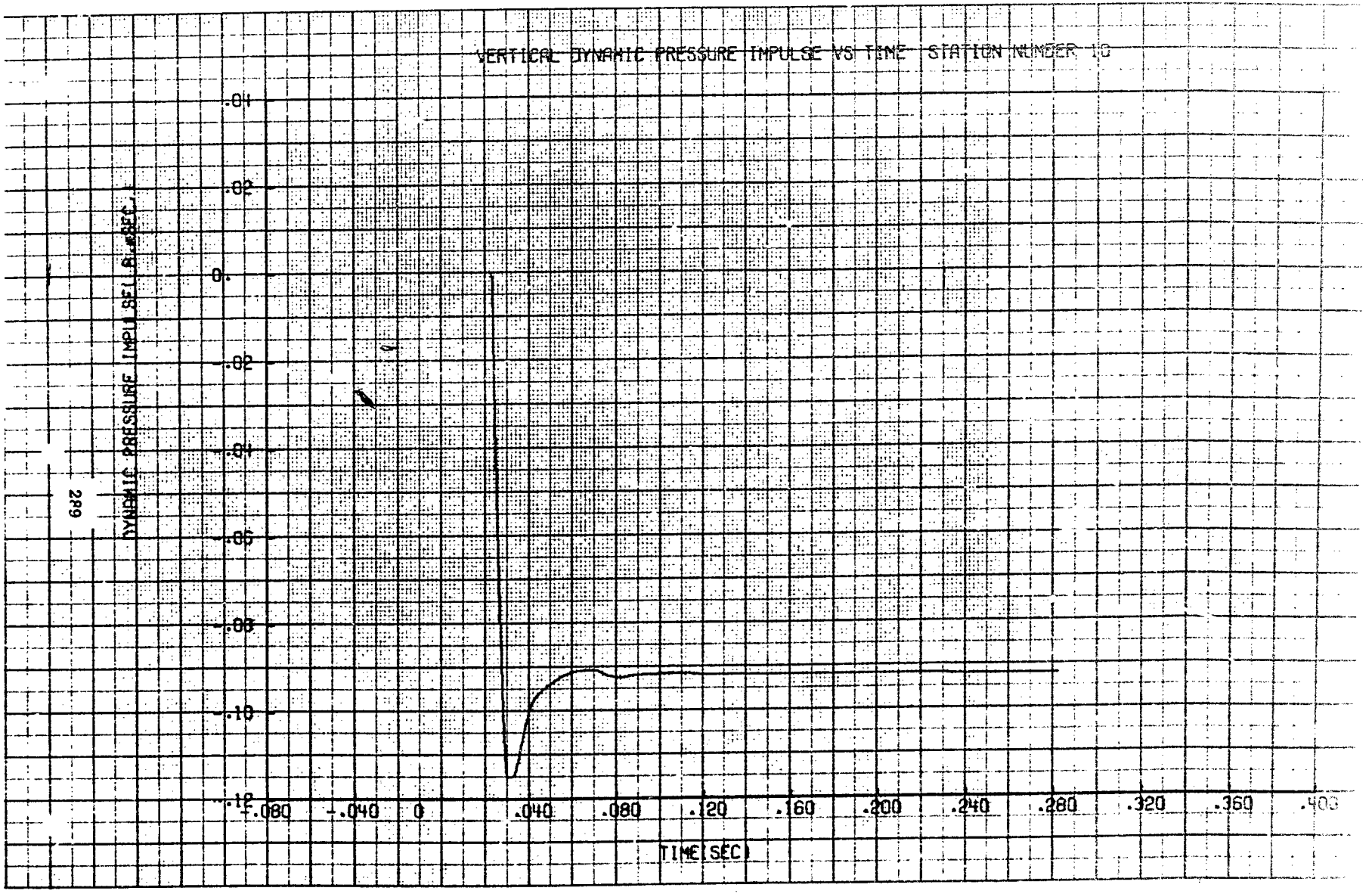

HORIZONTAL COMPONENT VELOCITY VS TIME - SYSTEM TEST 10
2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
SPEED(FT/SEC)
.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

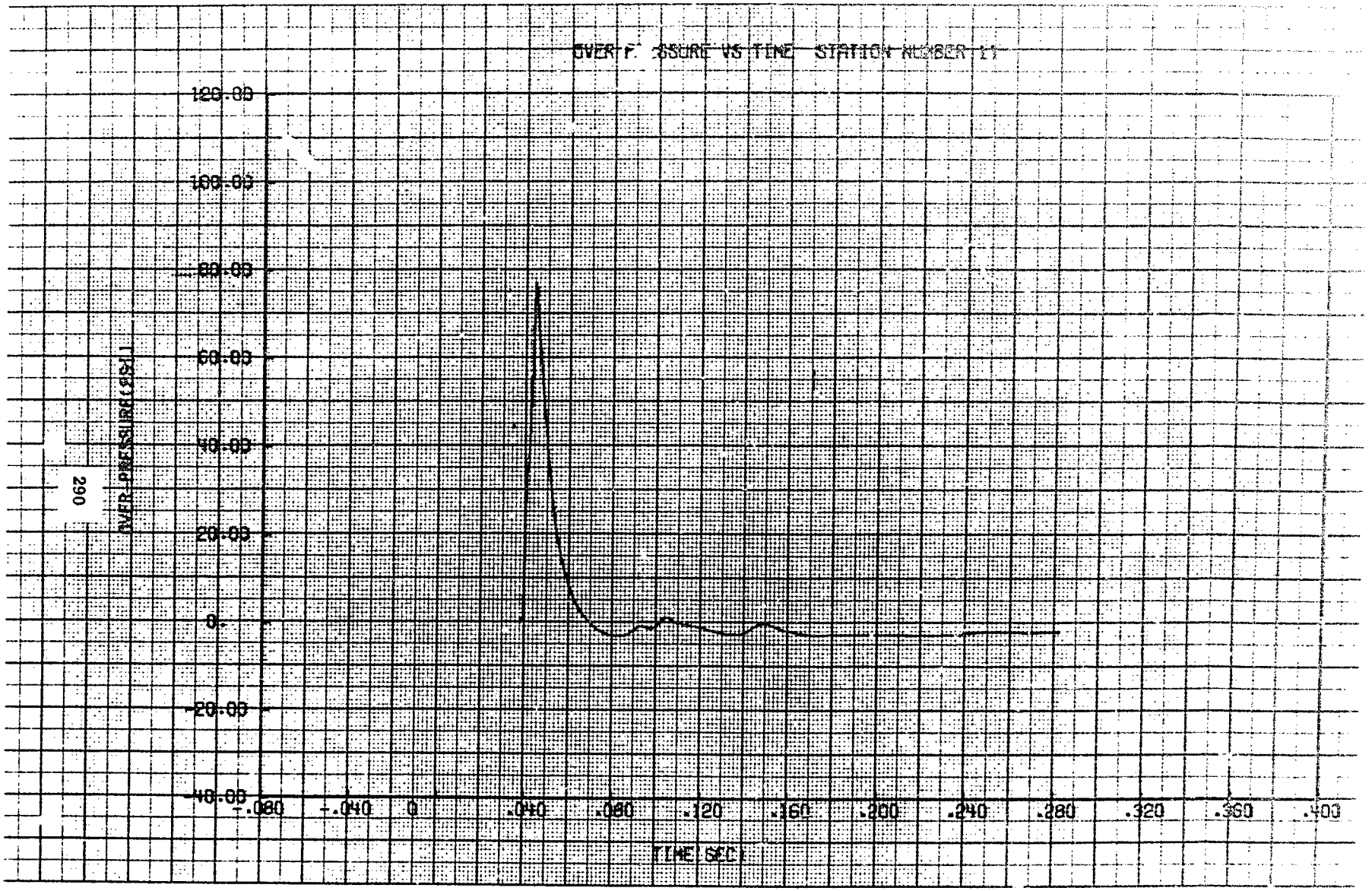

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
1600.00
1200.00
800.00
400.00
0
-400.00
-800.00
-1200.00
-1600.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
TIME(SEC)

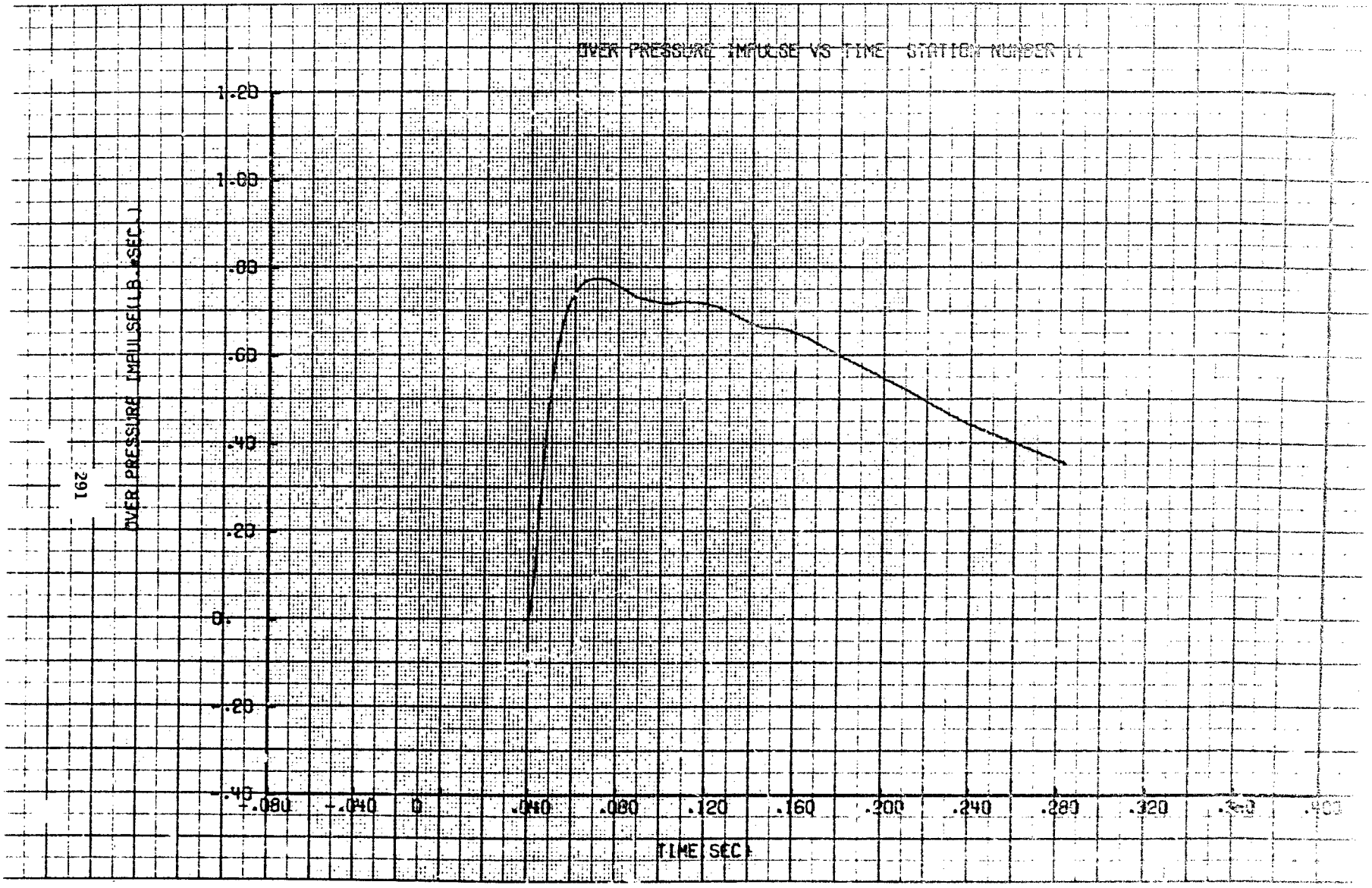
DYNAMIC PRESSURE(PSI)
TIME SEC.
286

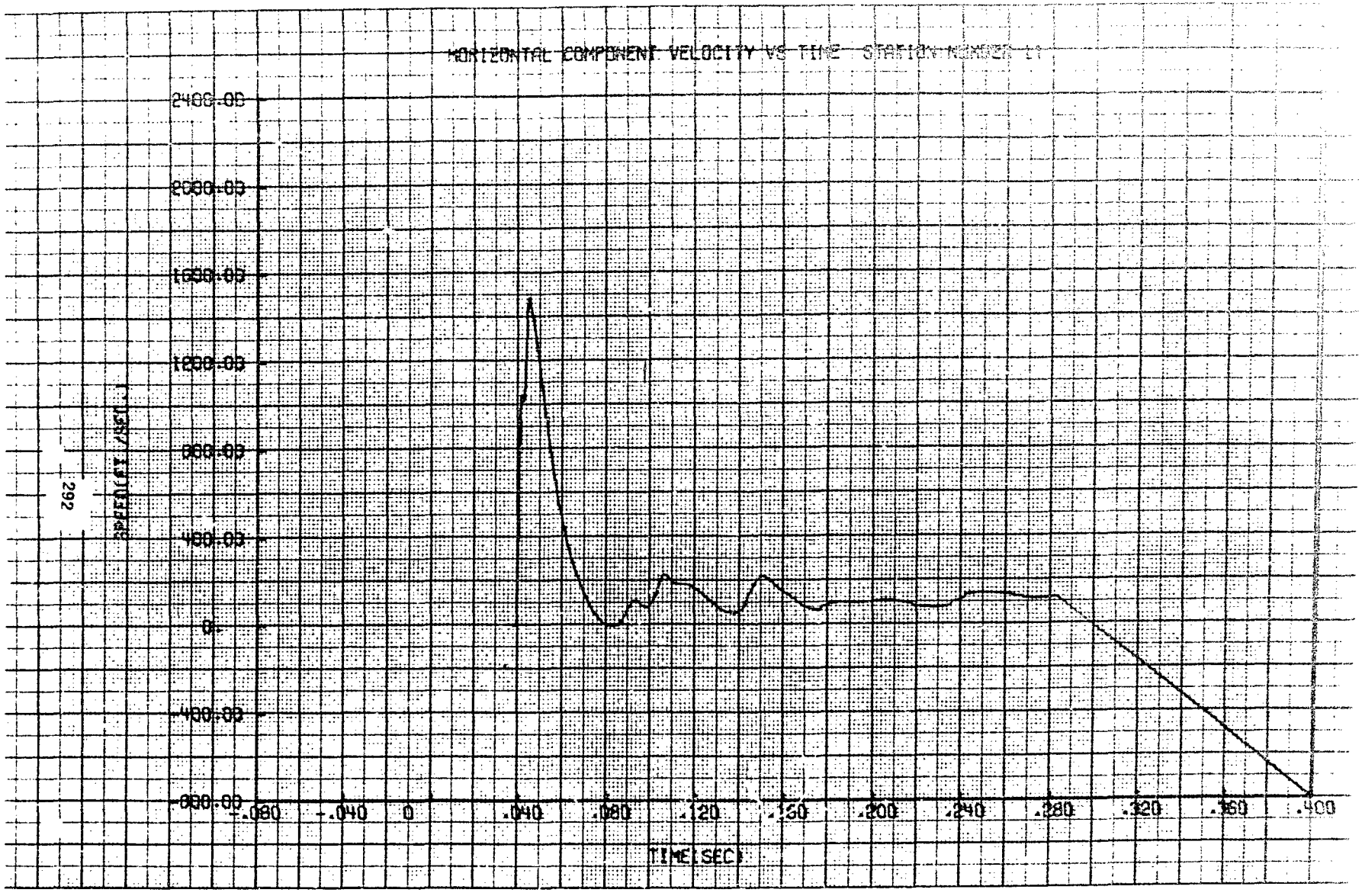

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE(B.*SEC.)
287
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

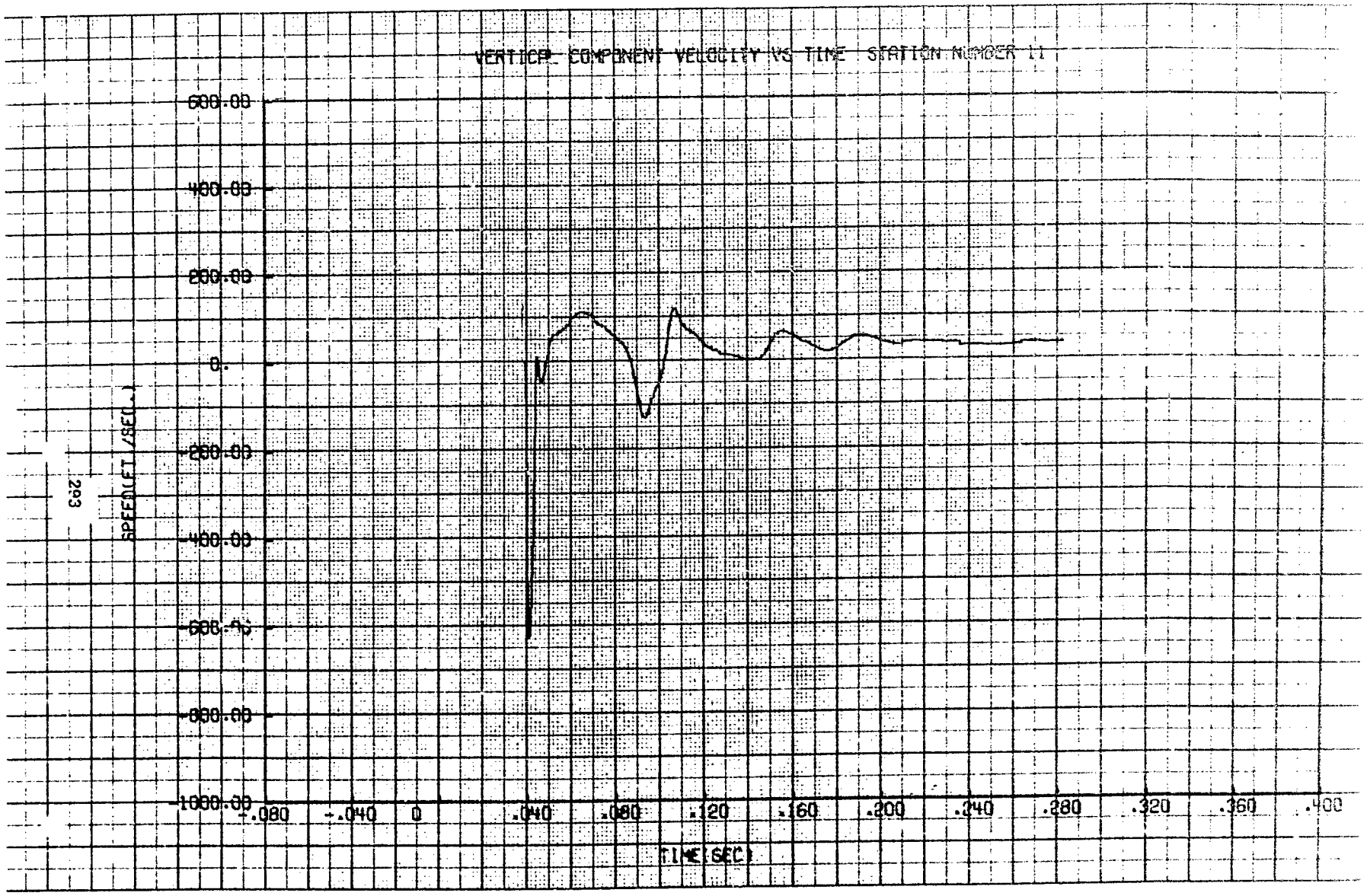

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
DYNAMIC PRESSURE (PSI)
288

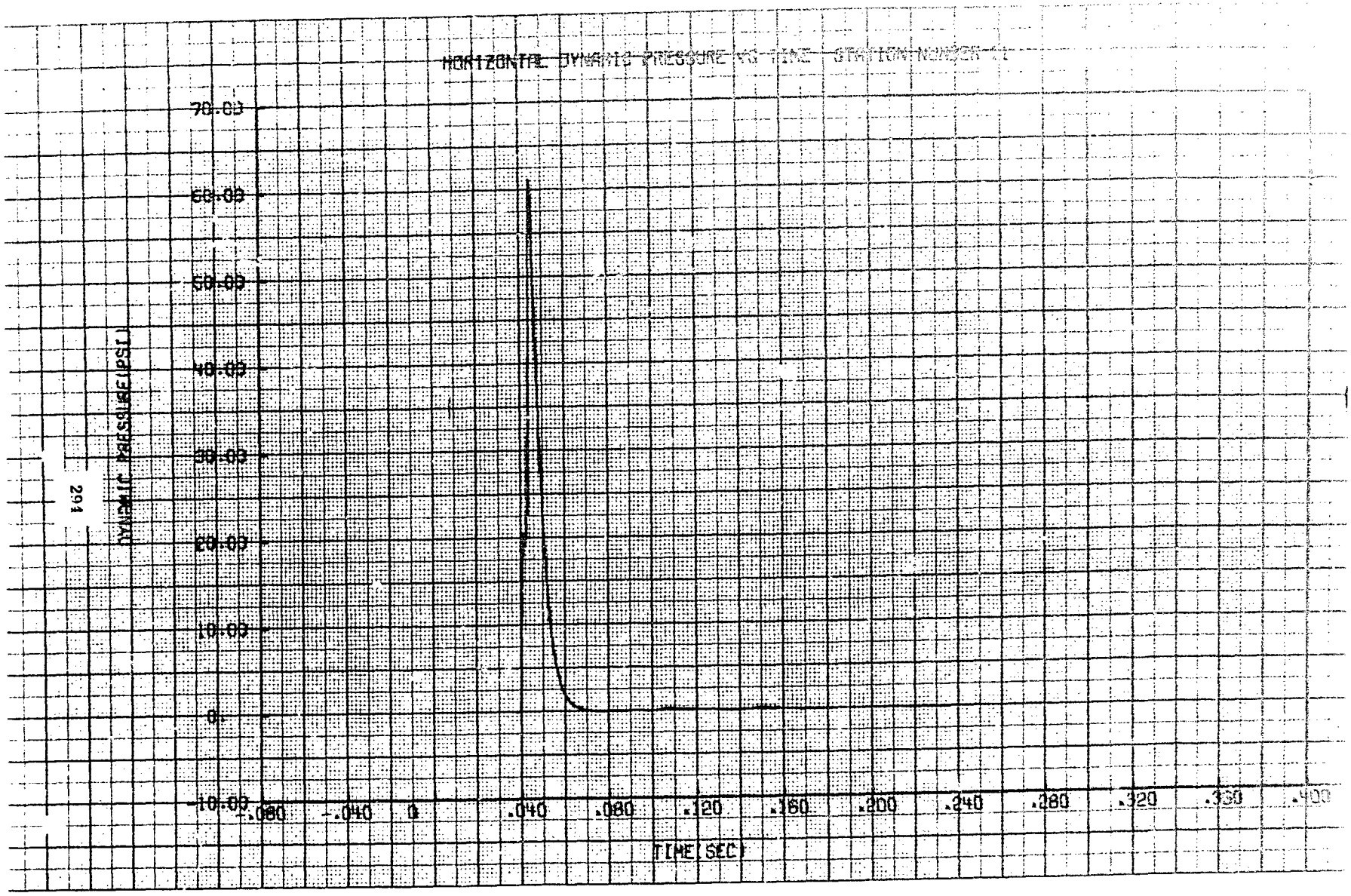

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
.04
.02
0.
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
DYNAMIC PRESSURE IMPULSE (LB-SEC/
289

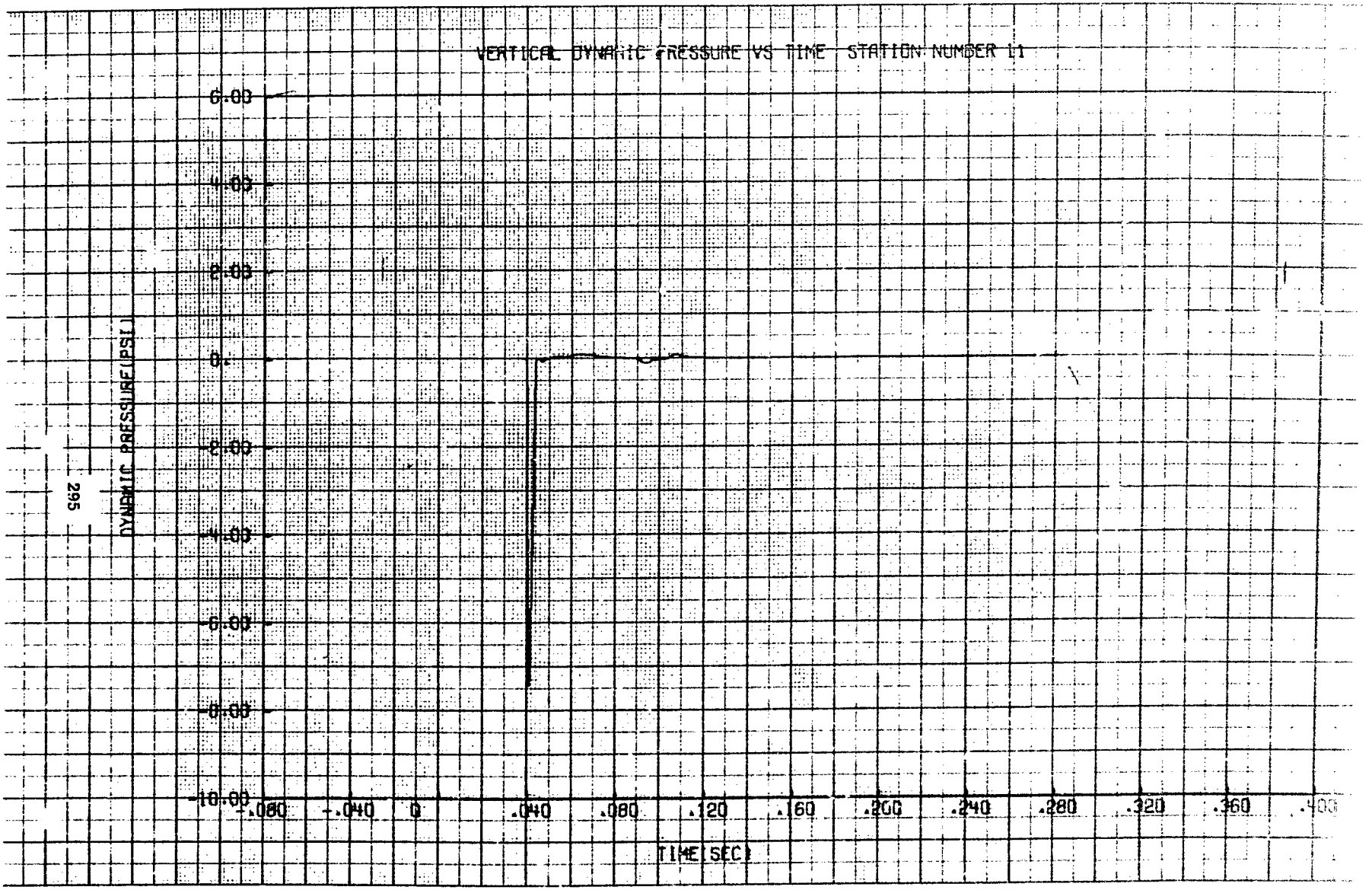

OVERPRESSURE VS TIME STATION NUMBER 11
120.00
100.00
80.00
60.00
40.00
20.00
0
-20.00
-40.00
OVERPRESSURE PSF
290
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC


OVER PRESSURE IMPULSE VS TIME STATION NUMBER 11
OVER PRESSURE IMPULSE(LB.-SEC.)
1.20
1.00
.80
.60
.40
.20
0
-.20
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
TIME SEC.
291

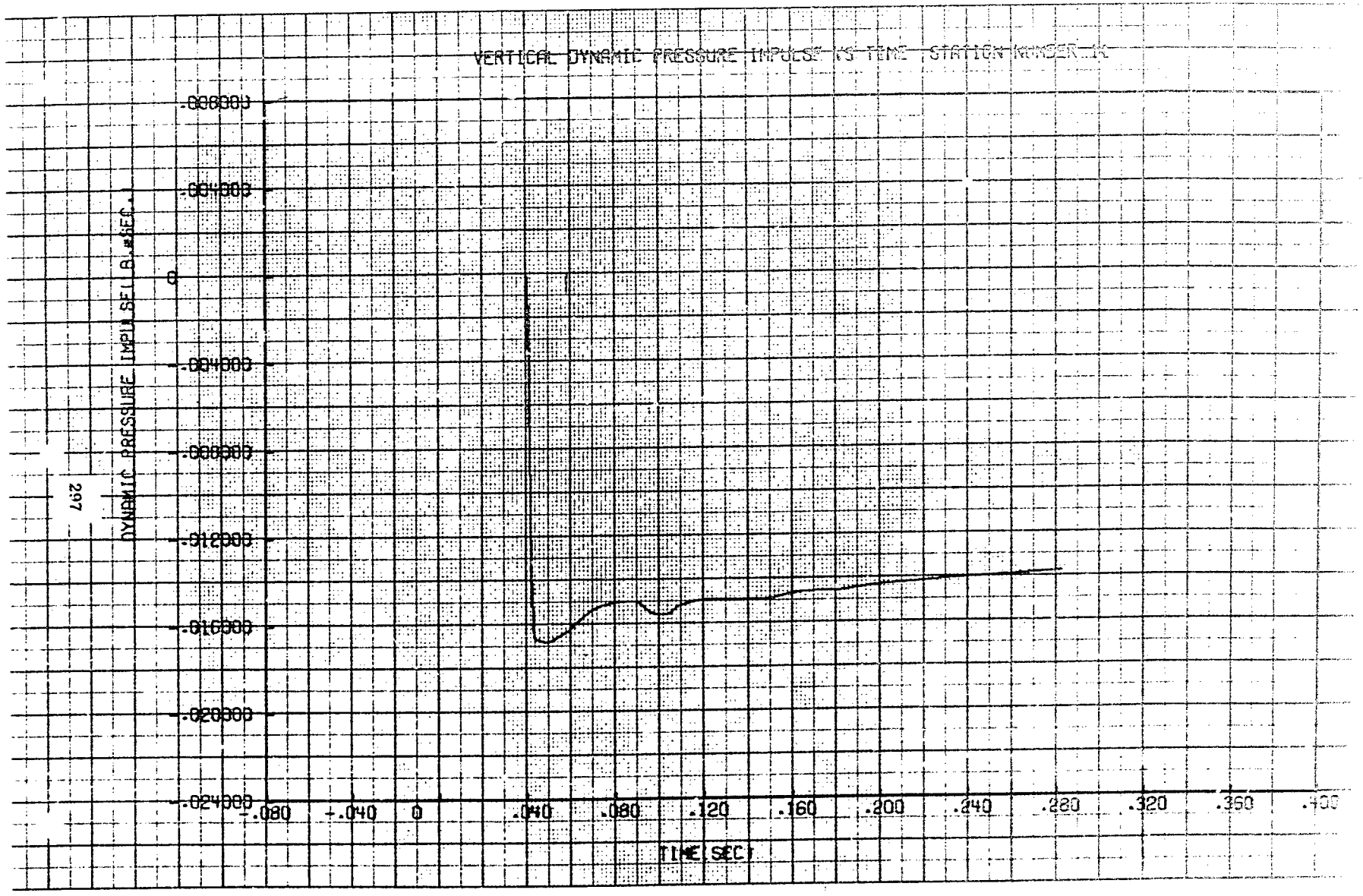

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
VELOCITY(FT/SEC)
292

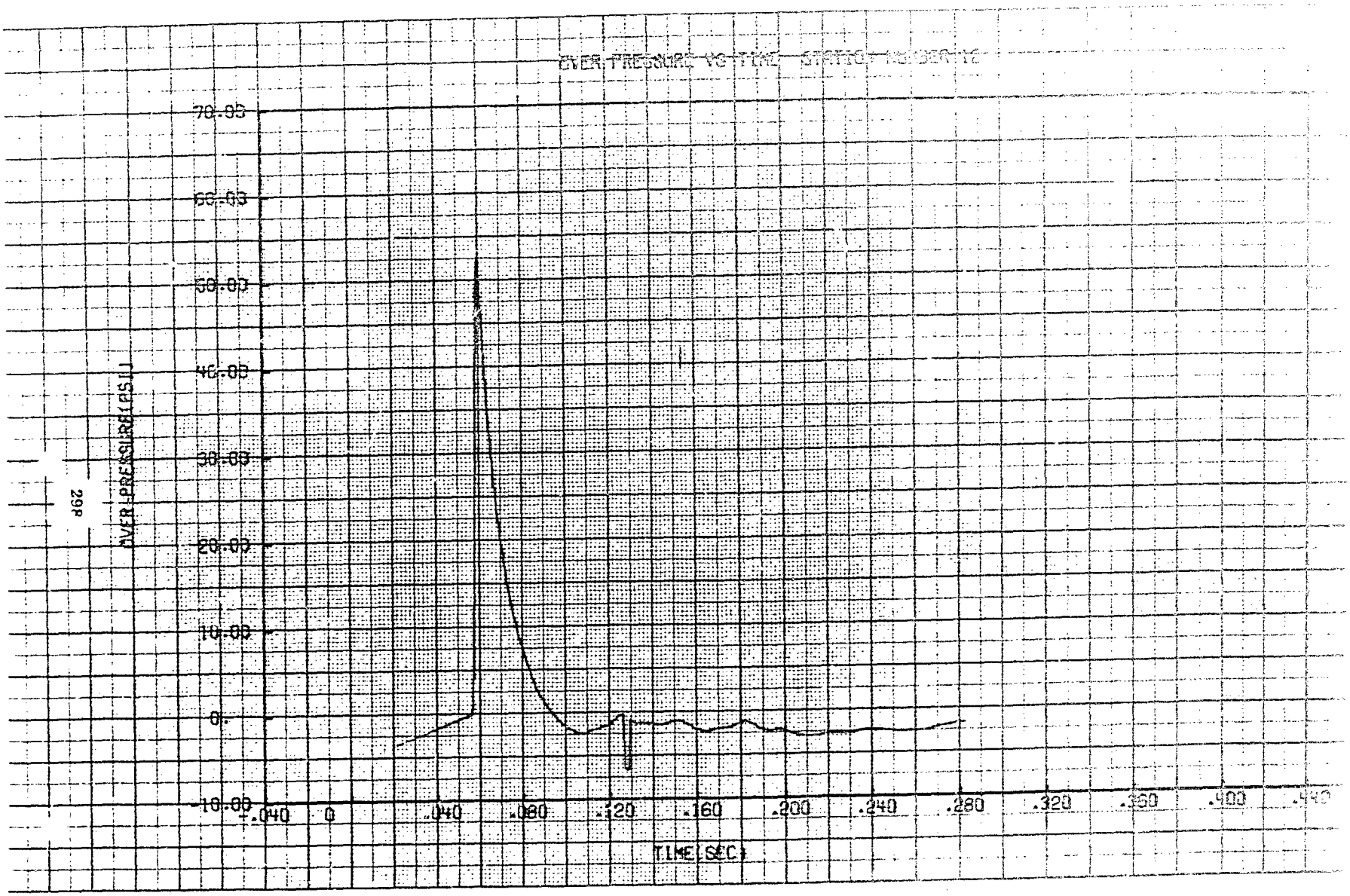

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
293

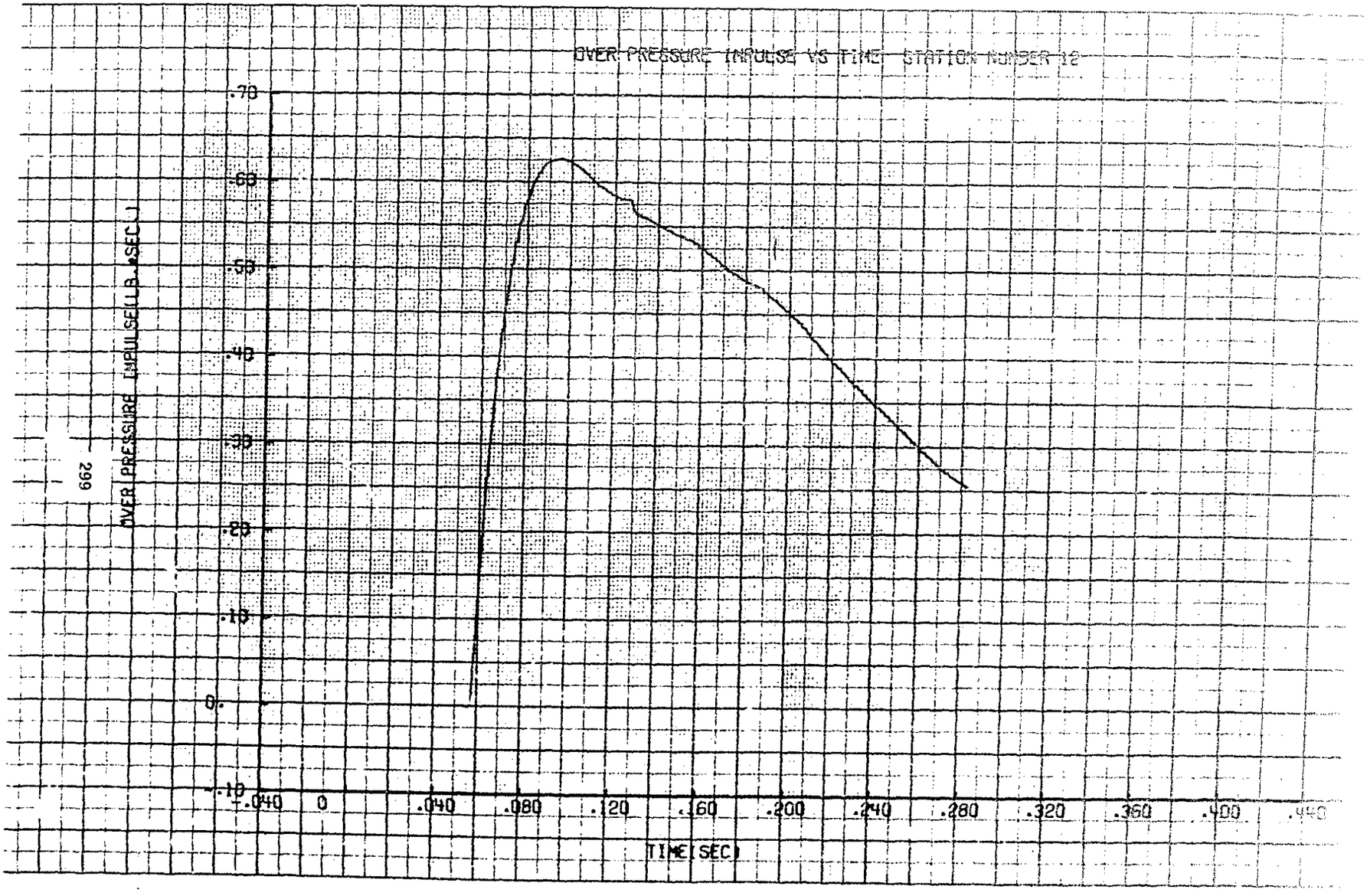

HORIZONTAL DYNAMIC PRESSURE VS TIME - STATION NUMBER 41
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
DYNAMIC PRESSURE (PSF)
294

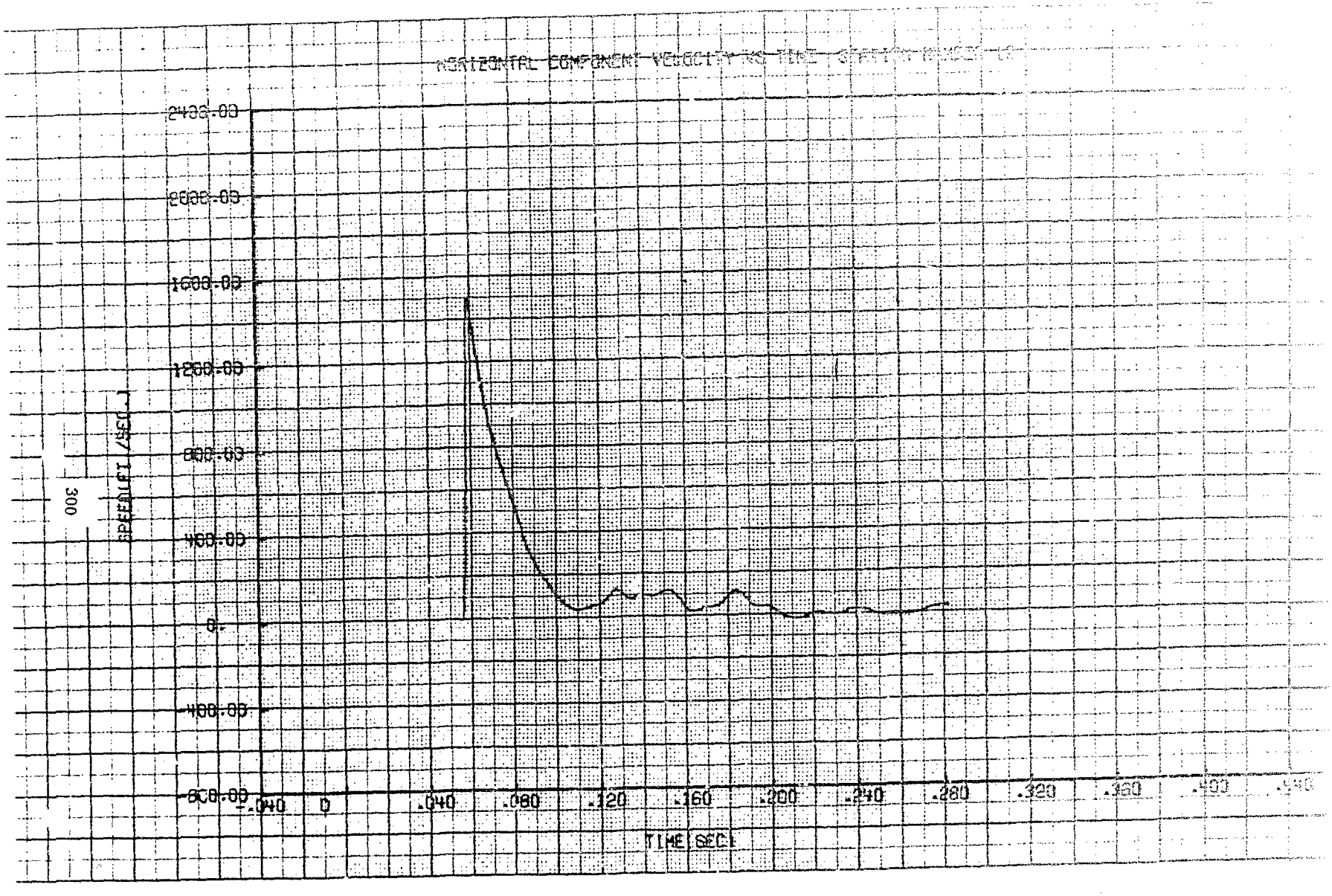

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER L1
6.00
4.00
2.00
0.
-2.00
-4.00
-6.00
-8.00
-10.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

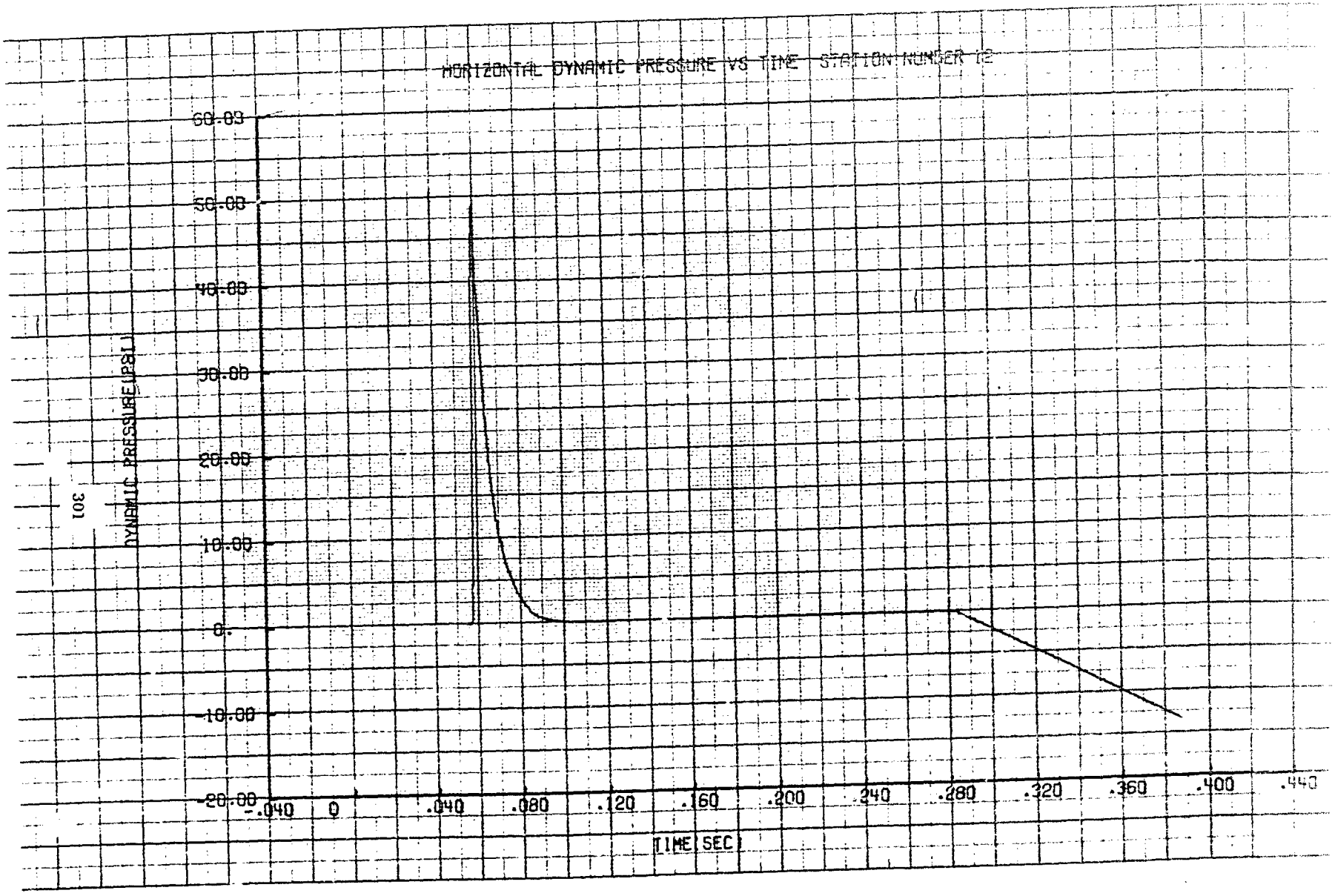
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
TIME SEC.
-20
-6B
-5B
-4B
-3B
-2B
-1B
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

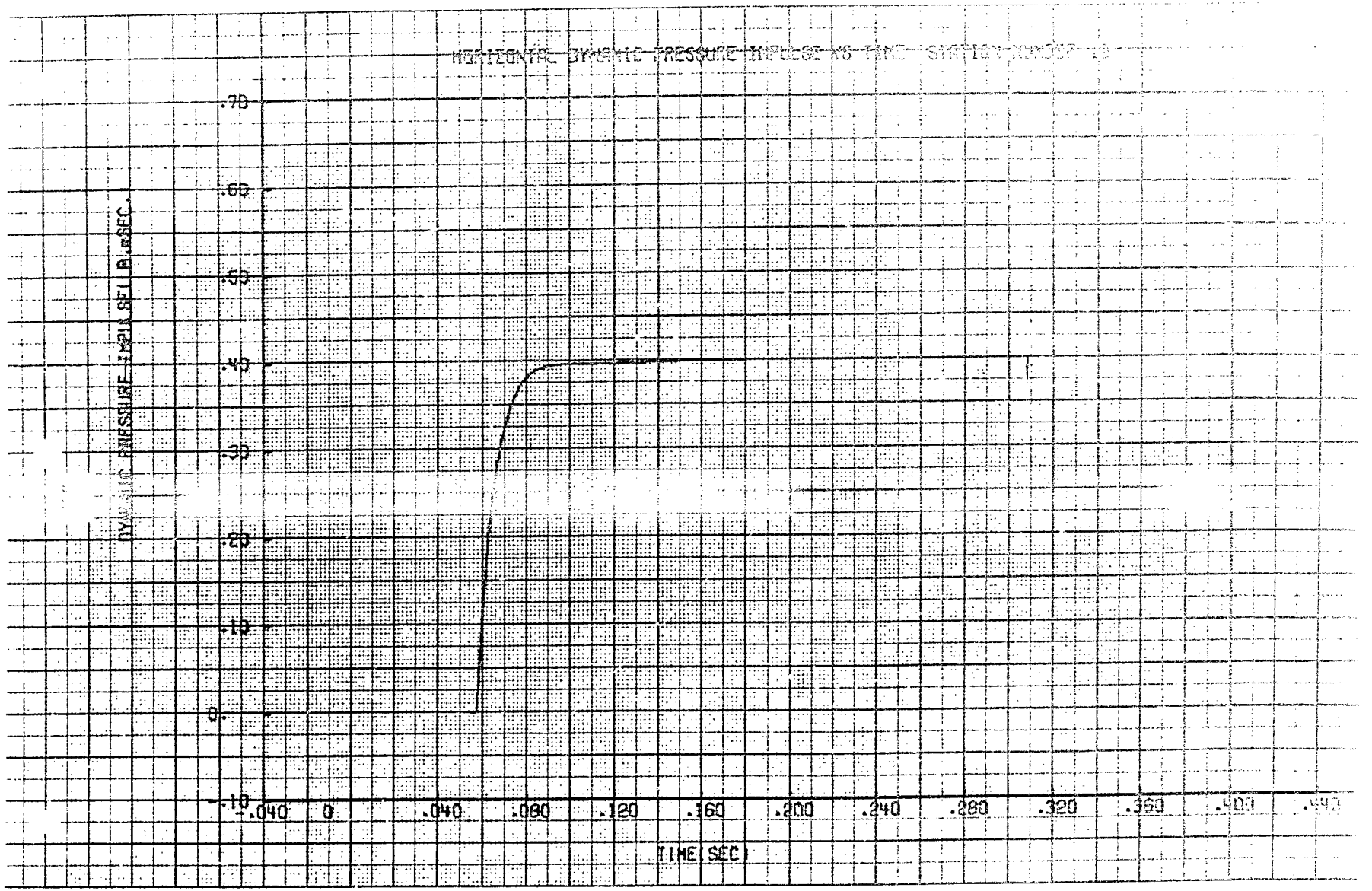

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1K
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN**2)
-.008000
-.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

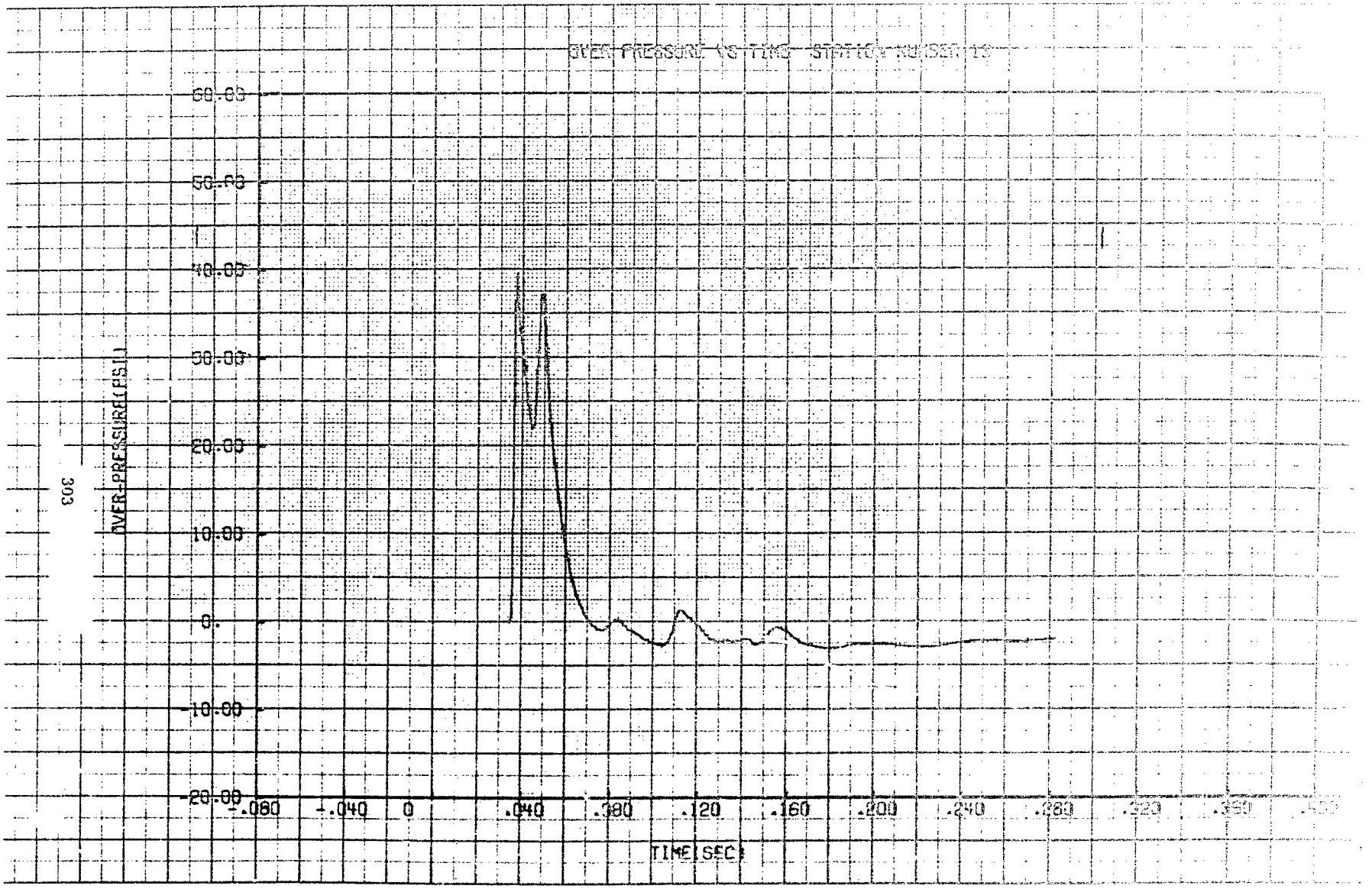

OVER PRESSURE VS TIME STATIC TUNNEL
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
OVER PRESSURE (PSI)
298
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

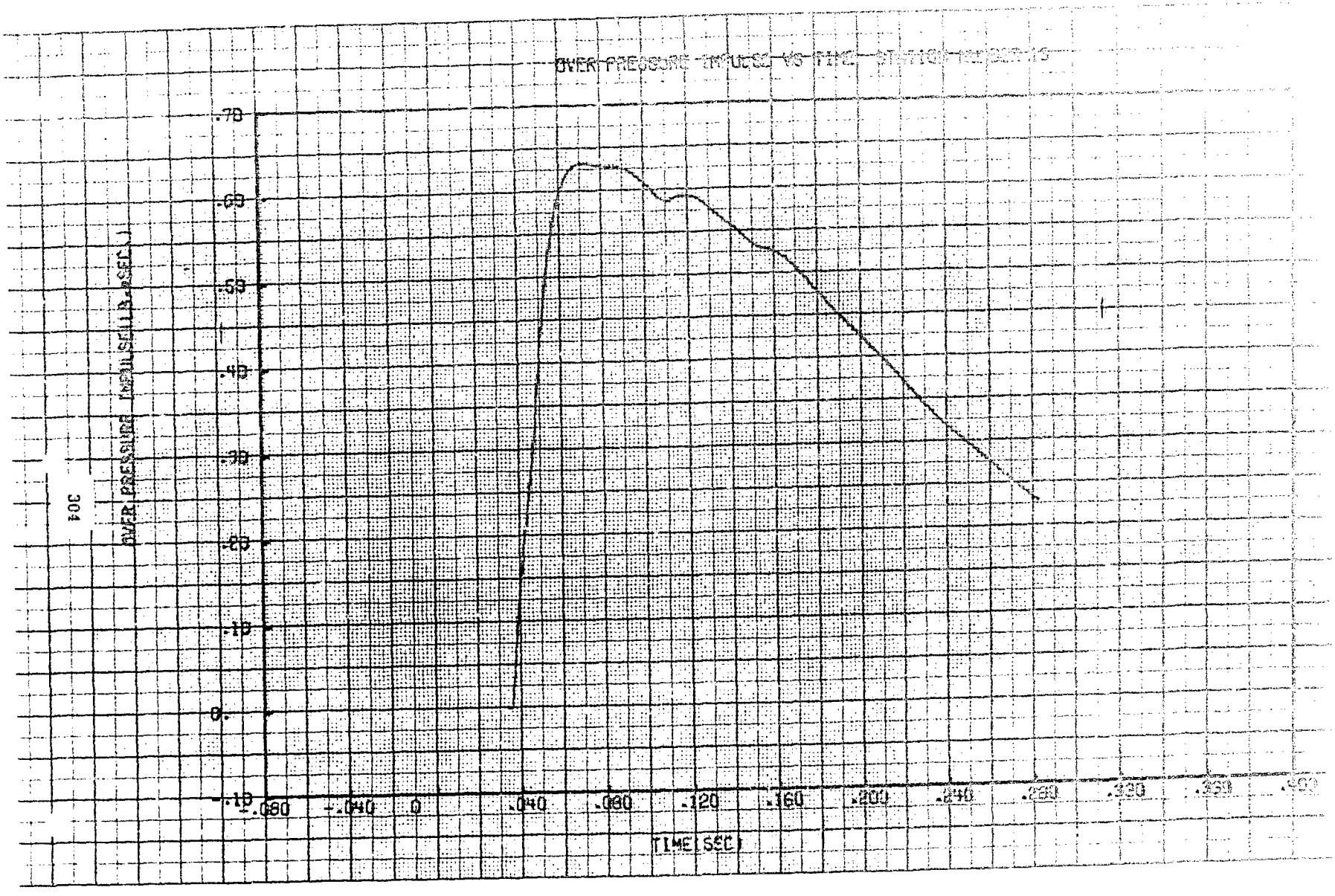

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 12
OVER PRESSURE IMPULSE(LB.-SEC.)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
299

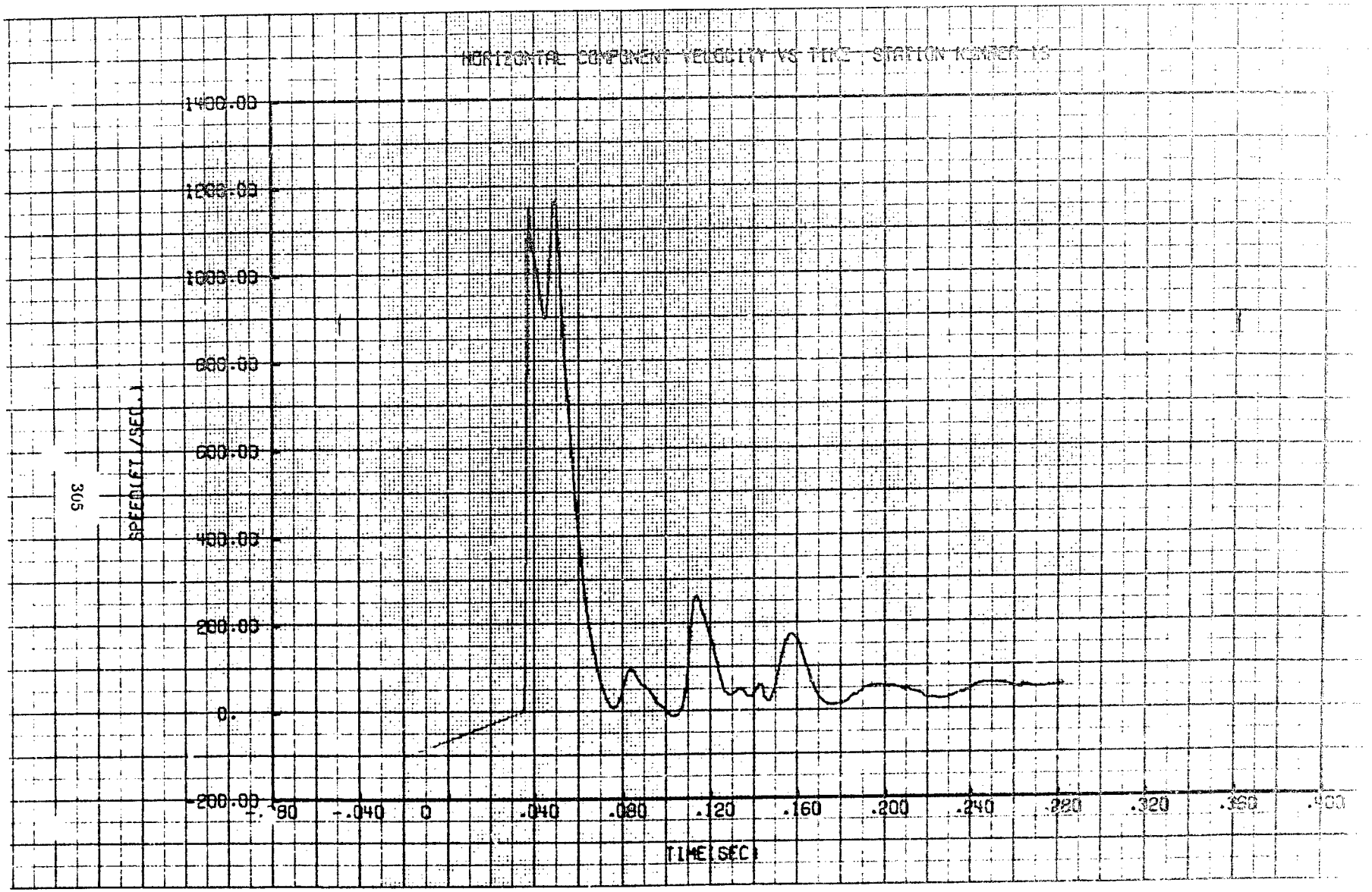

HORIZONTAL COMPONENT VELOCITY VS TIME STATION MINE-1
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC.
300
SPEED FT/SEC.

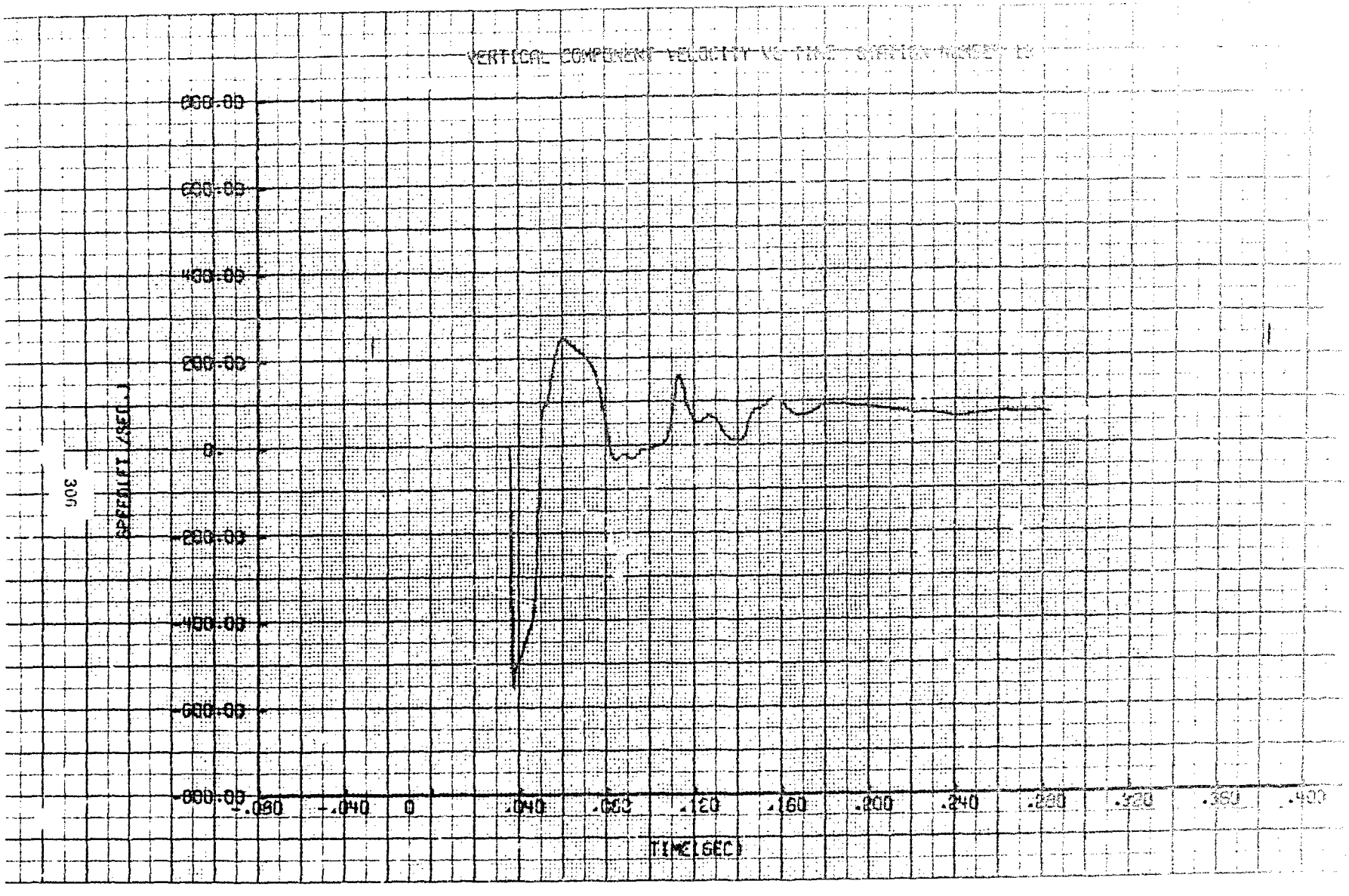

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 12
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)


.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

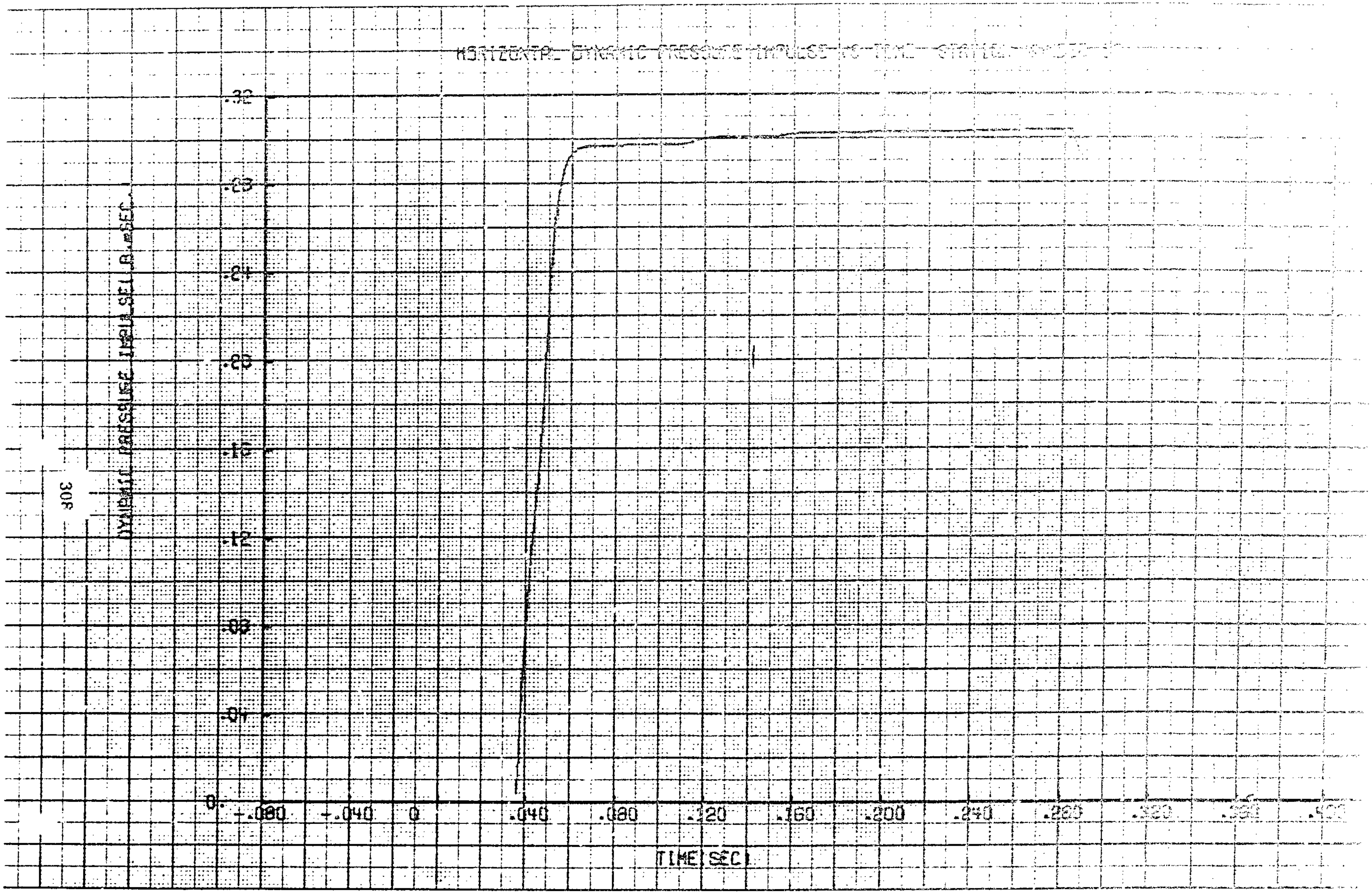

OVER PRESSURE VS TIME STATION NUMBER 19
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSIG)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
TIME(SEC)

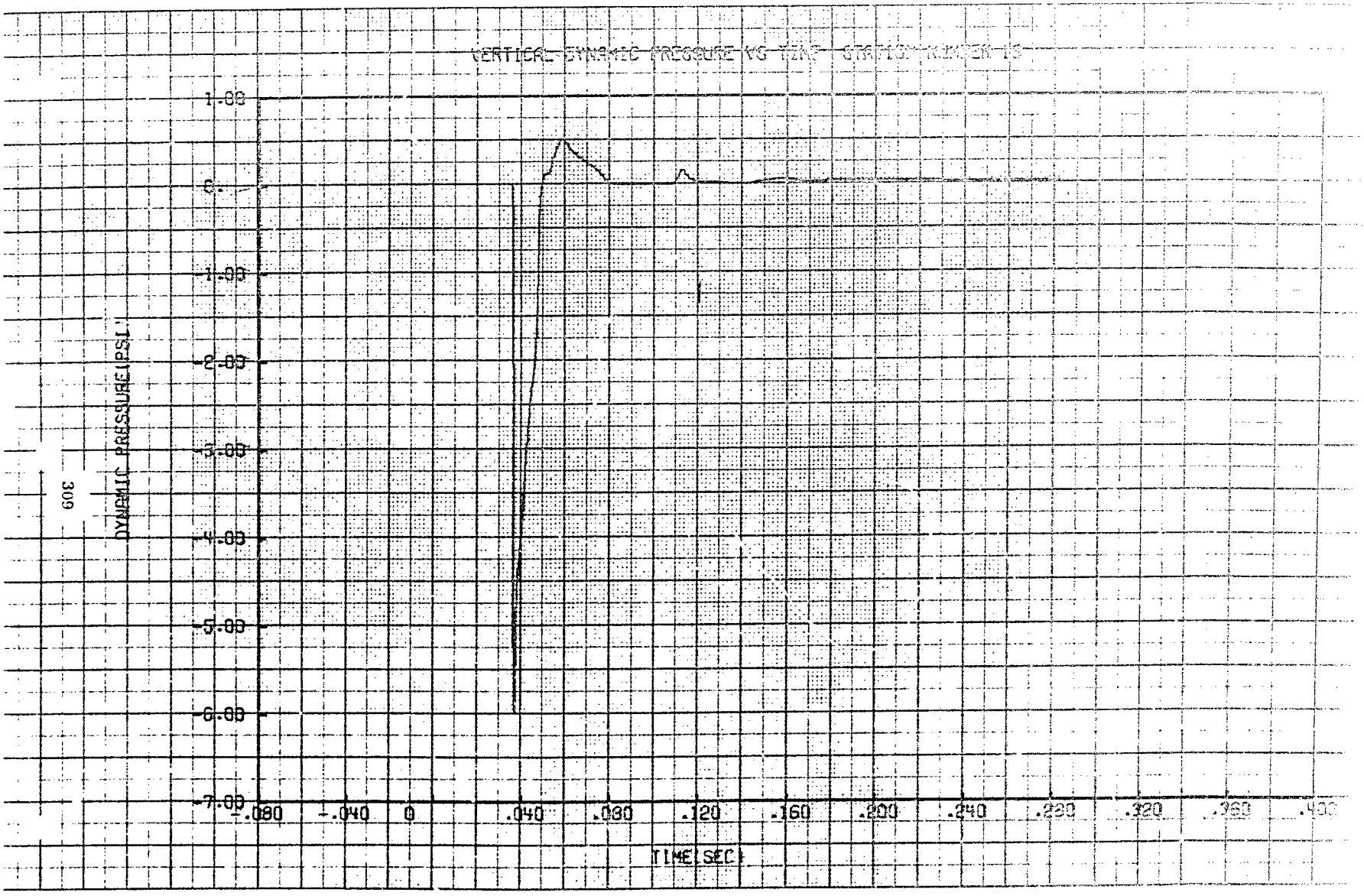

OVER PRESSURE (INCH SCALE=PSI)
.78
.68
.58
.48
.38
.28
.18
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
304


HORIZONTAL COMPONENT VELOCITY VS TIME ; STATION KOBE-YS
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
SPEED(CM/SEC)
305

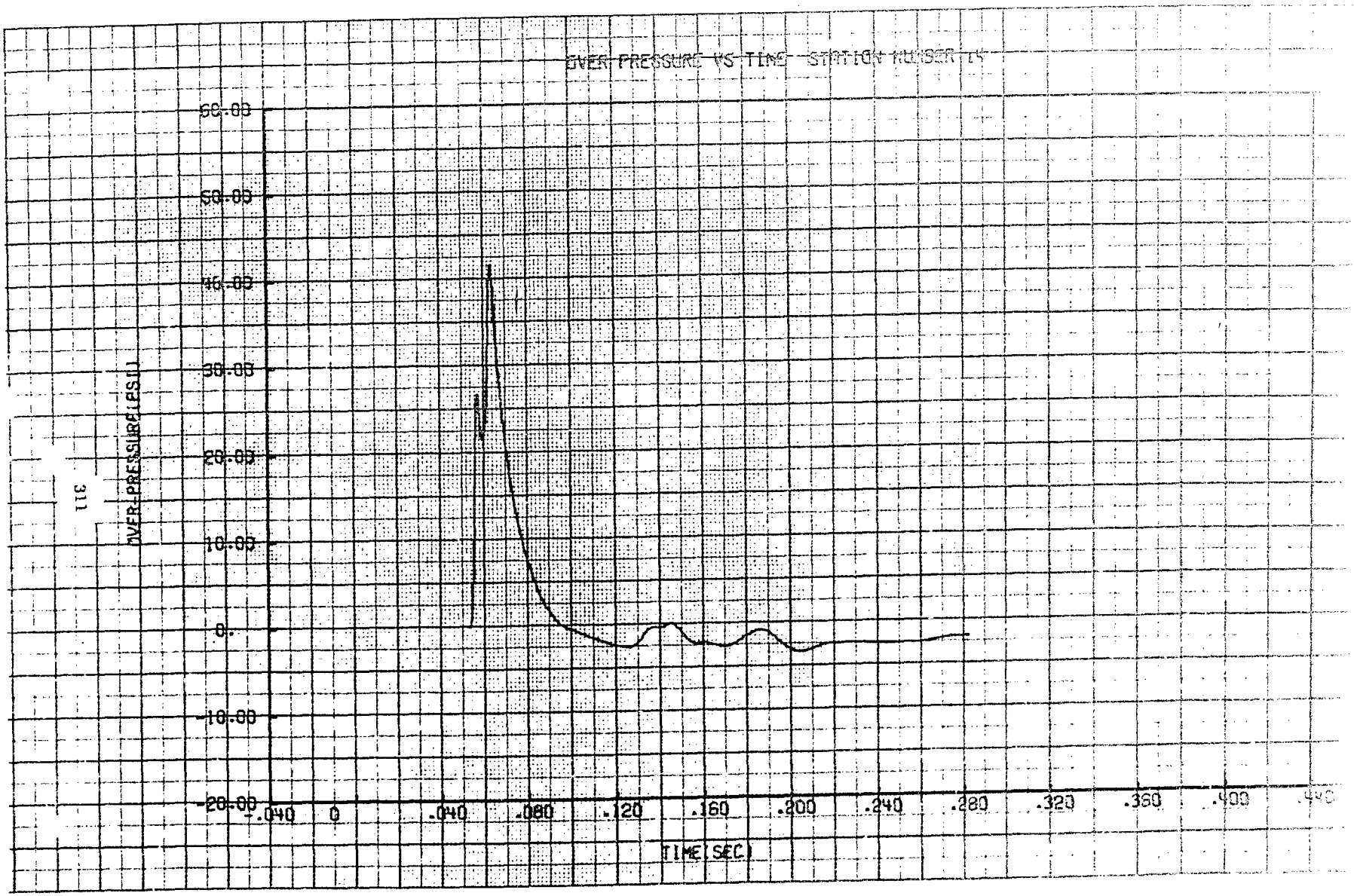

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
306

DYNAMIC PRESSURE(PSI)
TIME SEC
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320

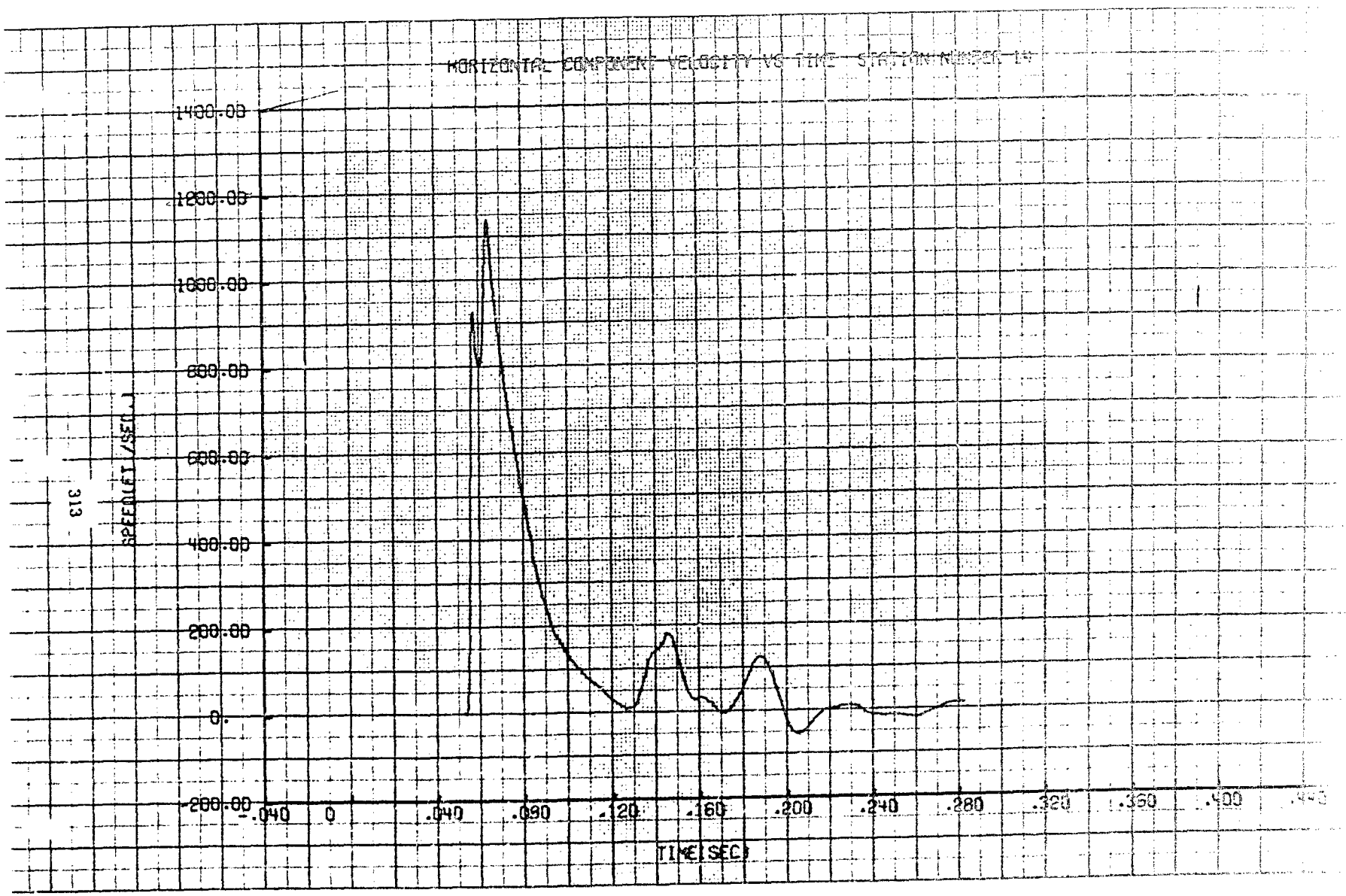

.32
.28
.24
.20
.16
.12
.08
.04
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
TIME (SEC)

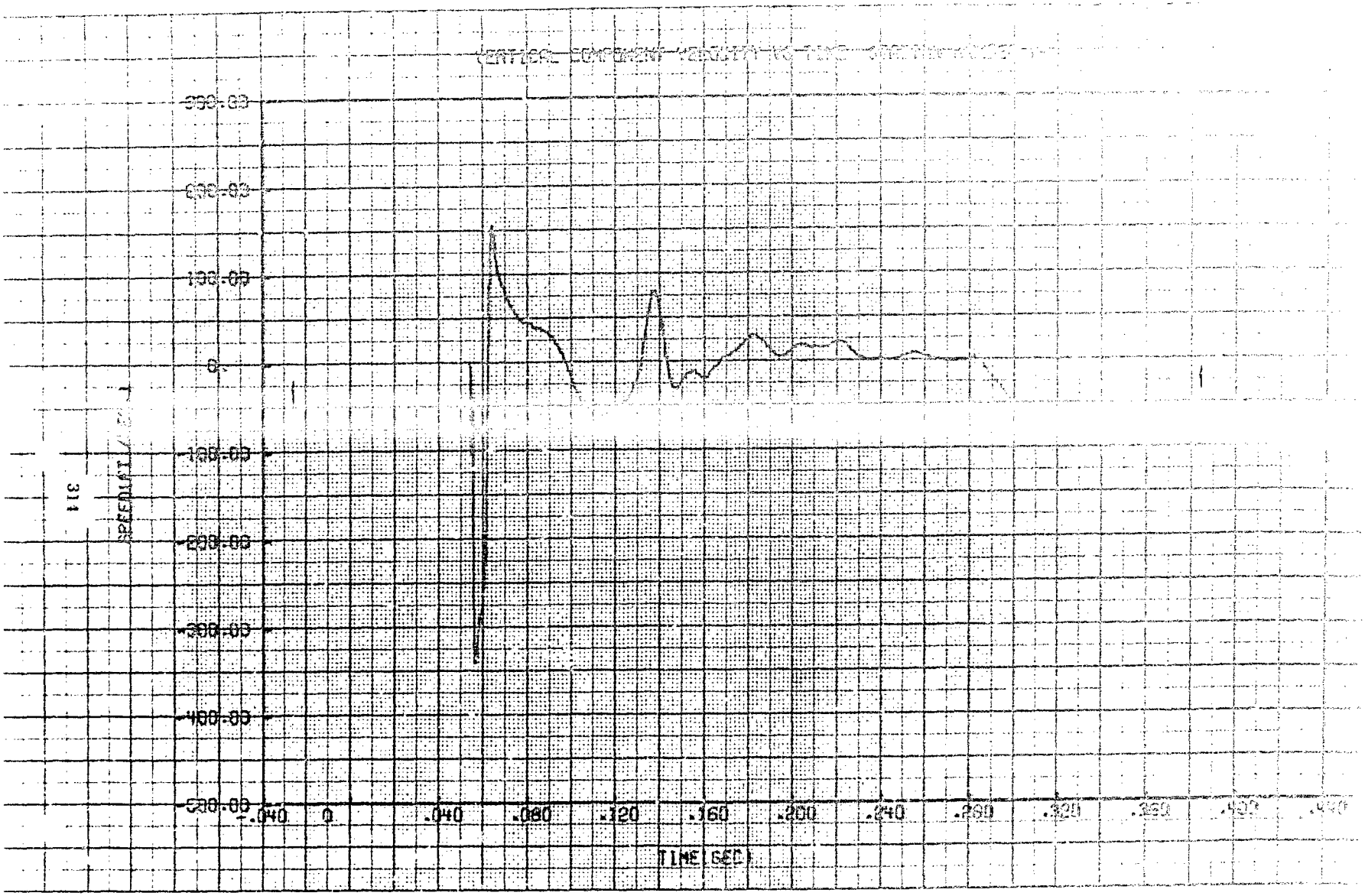

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 15
1.00
0.
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
DYNAMIC PRESSURE(PSI)
309
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

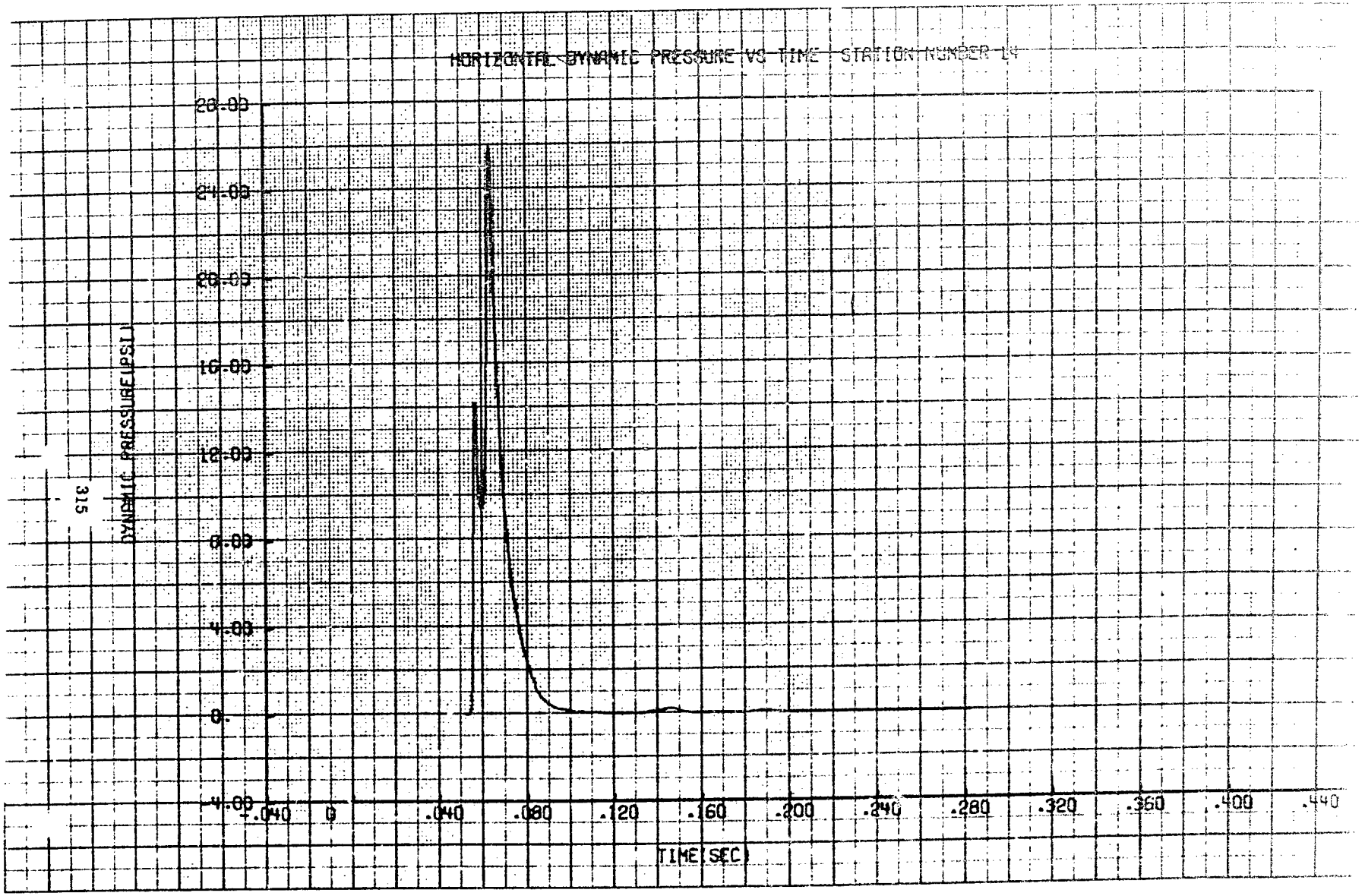
VERTICAL DYNAMIC PRESSURE IMPULSE TO TARGET STATION NO. 10
DYNAMIC PRESSURE IMPULSE P.S.I.-SEC.
TIME/SEC.

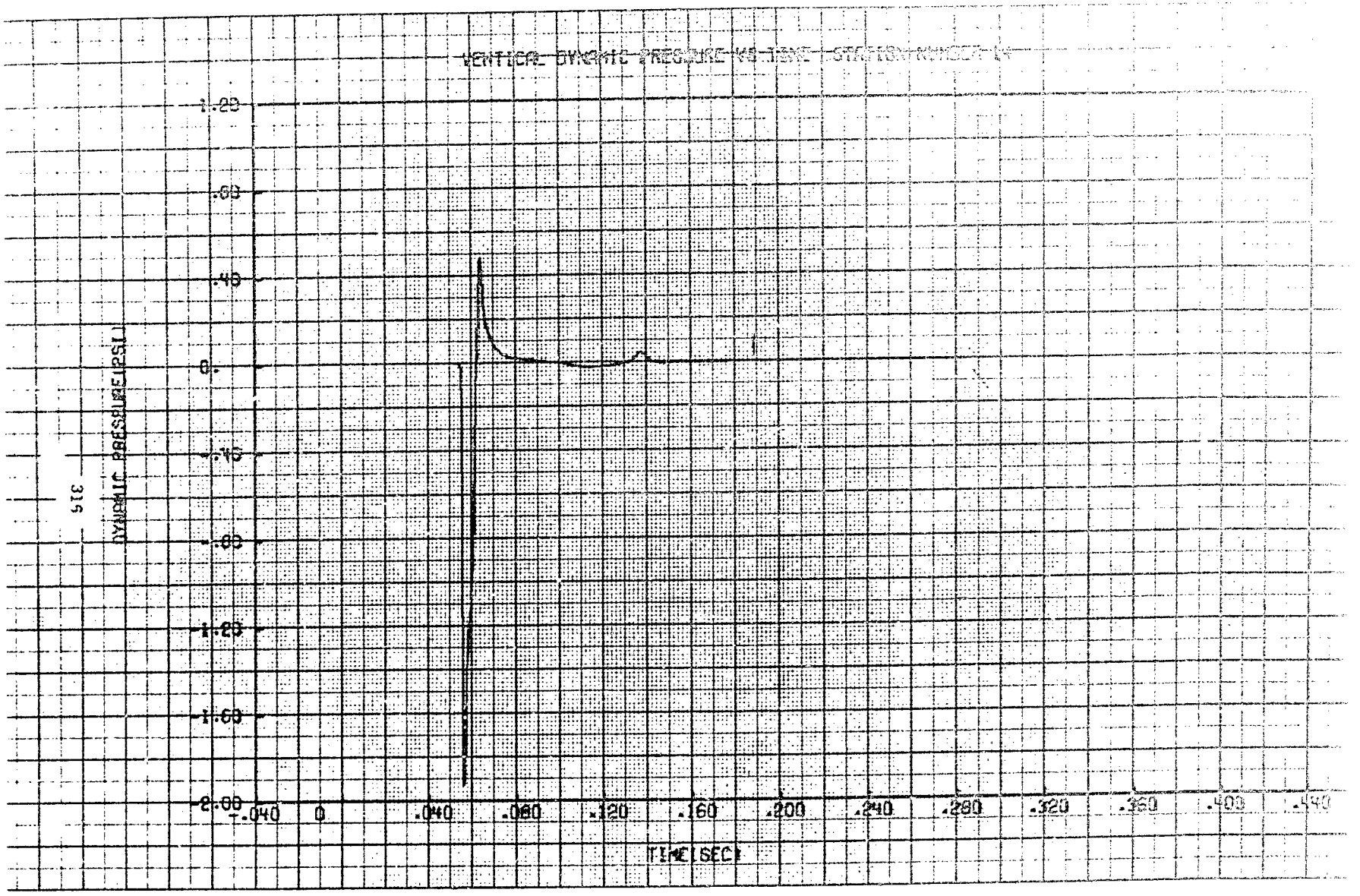

OVER PRESSURE VS TIME STATION NUMBER 14
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
311
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

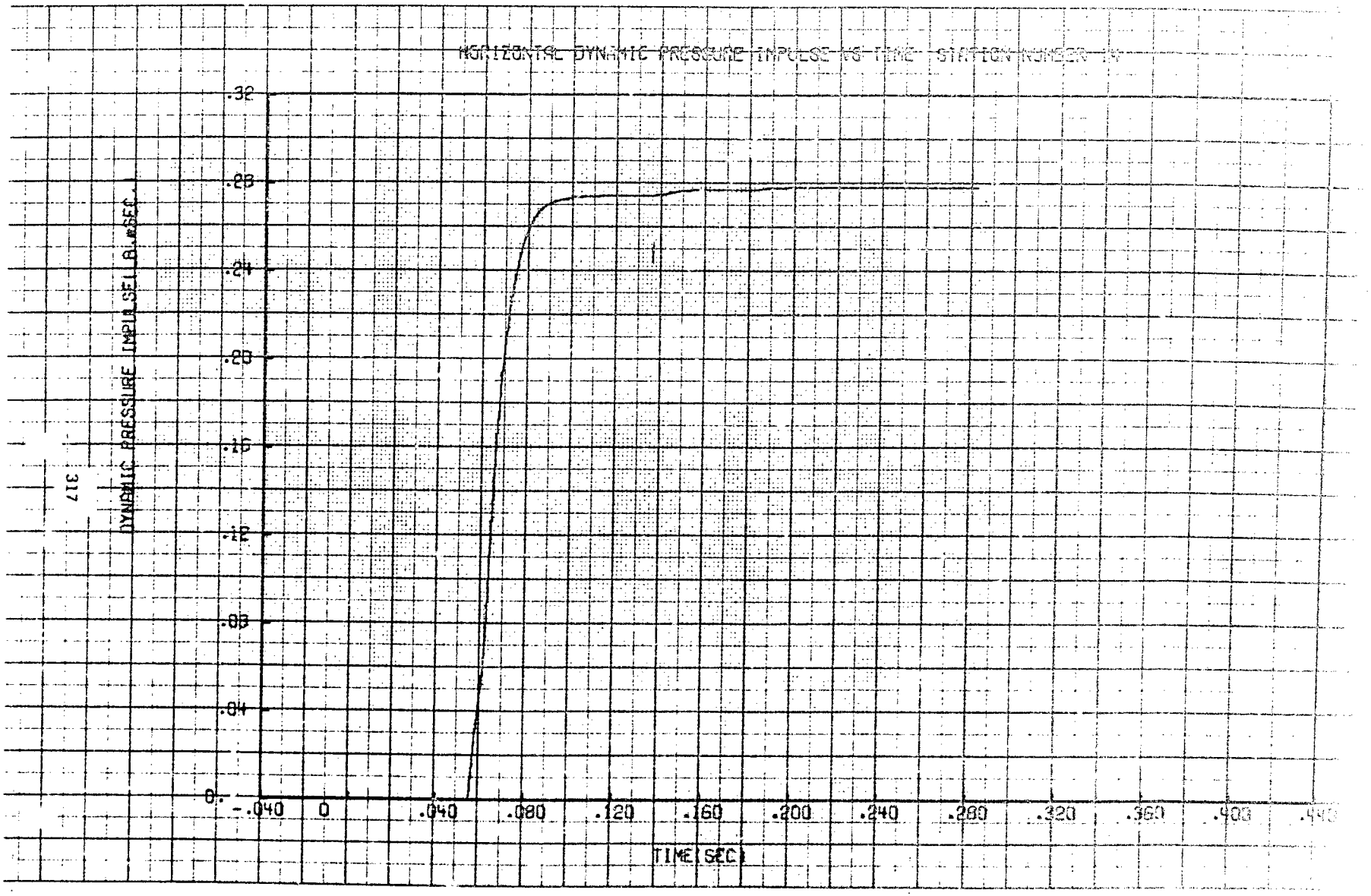
Over Pressure (Pulse Cell 2, Asec 1)


HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 14
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
313
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

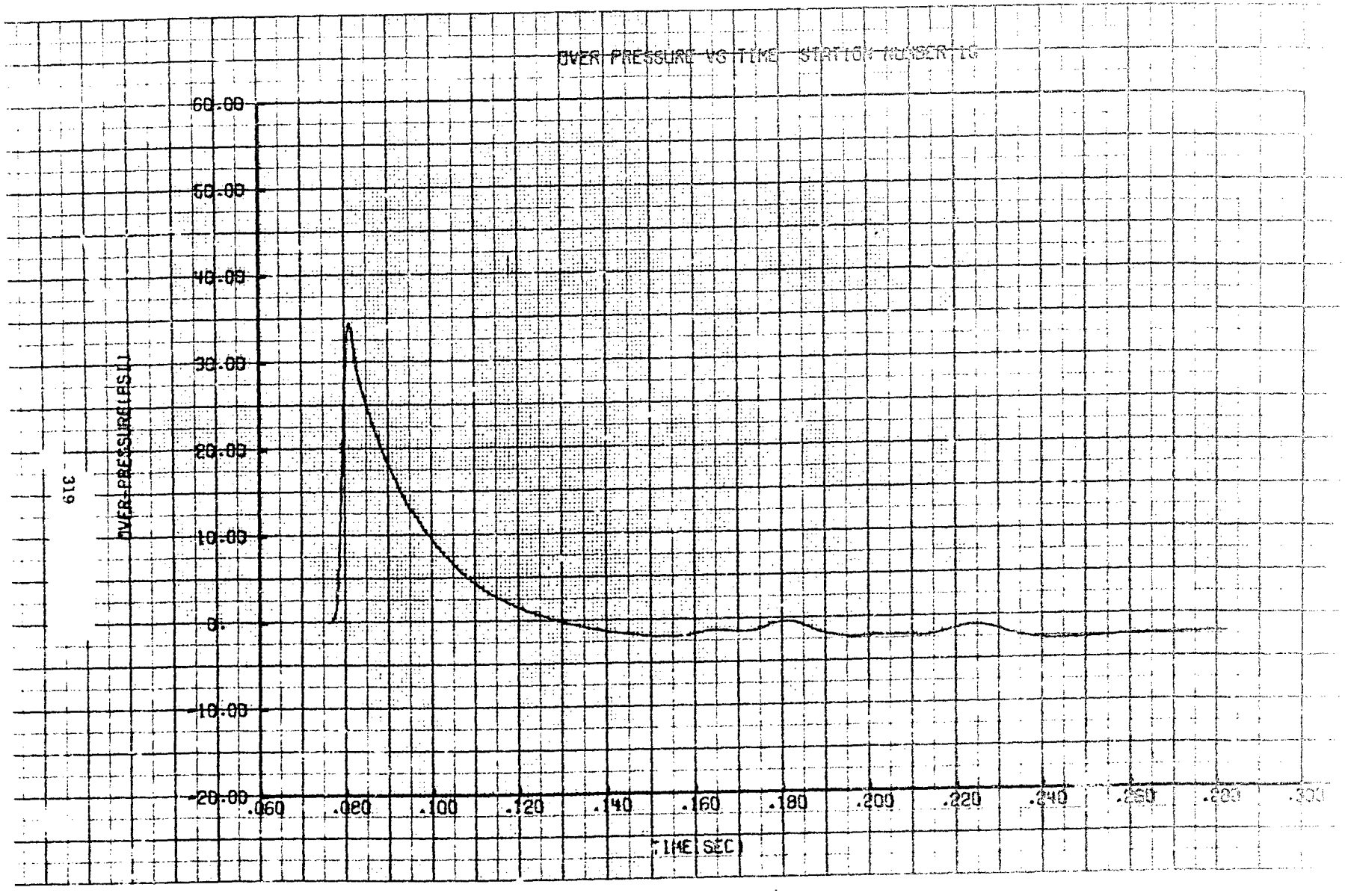

VERTICAL COMPONENT VELOCITY VS TIME STATION 311
-100.00
0.
-200.00
-300.00
-400.00
-500.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)
311
SPEED(FT/SEC)

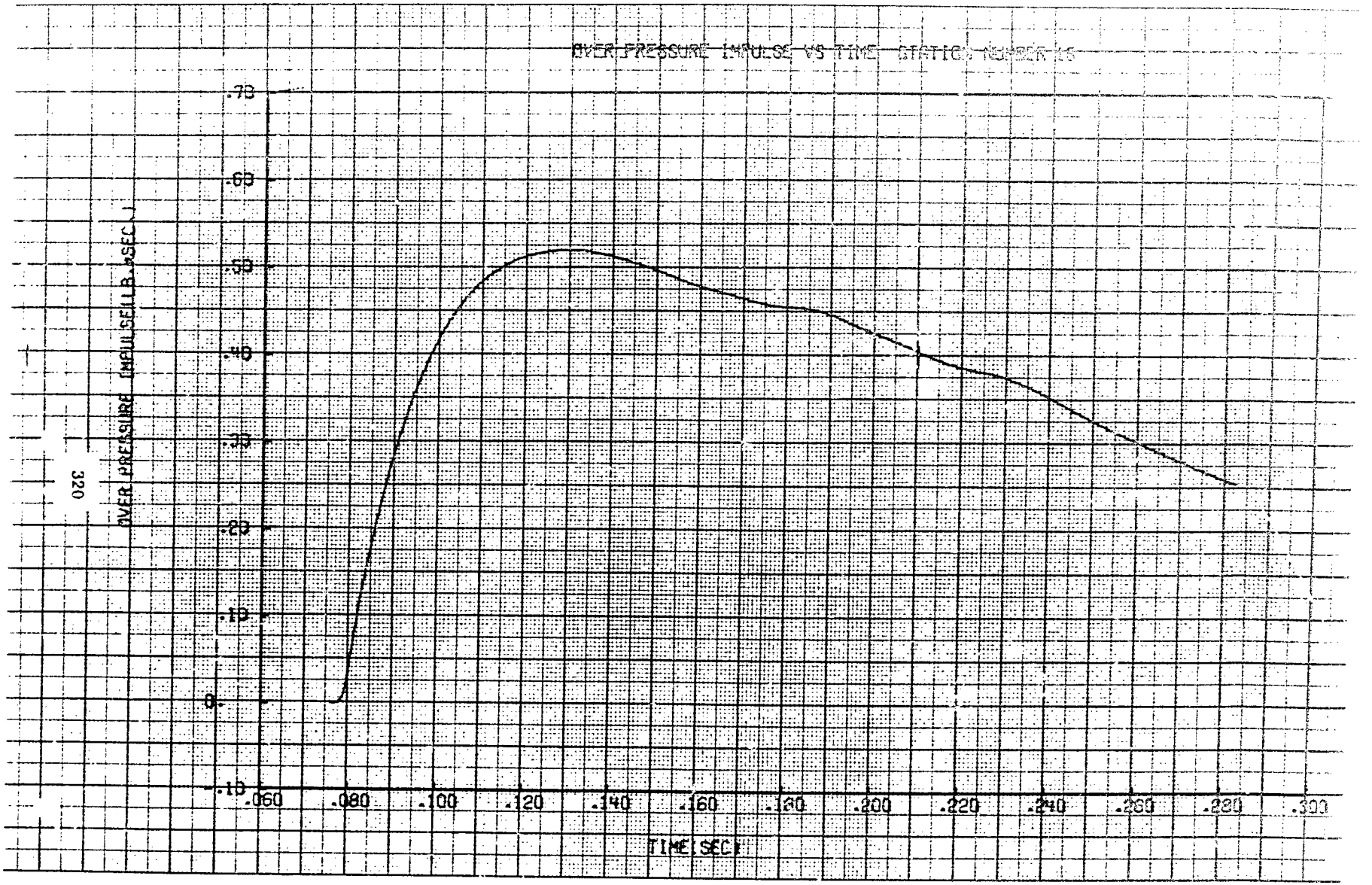

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 14
20.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)
DYNAMIC PRESSURE(PSI)
315

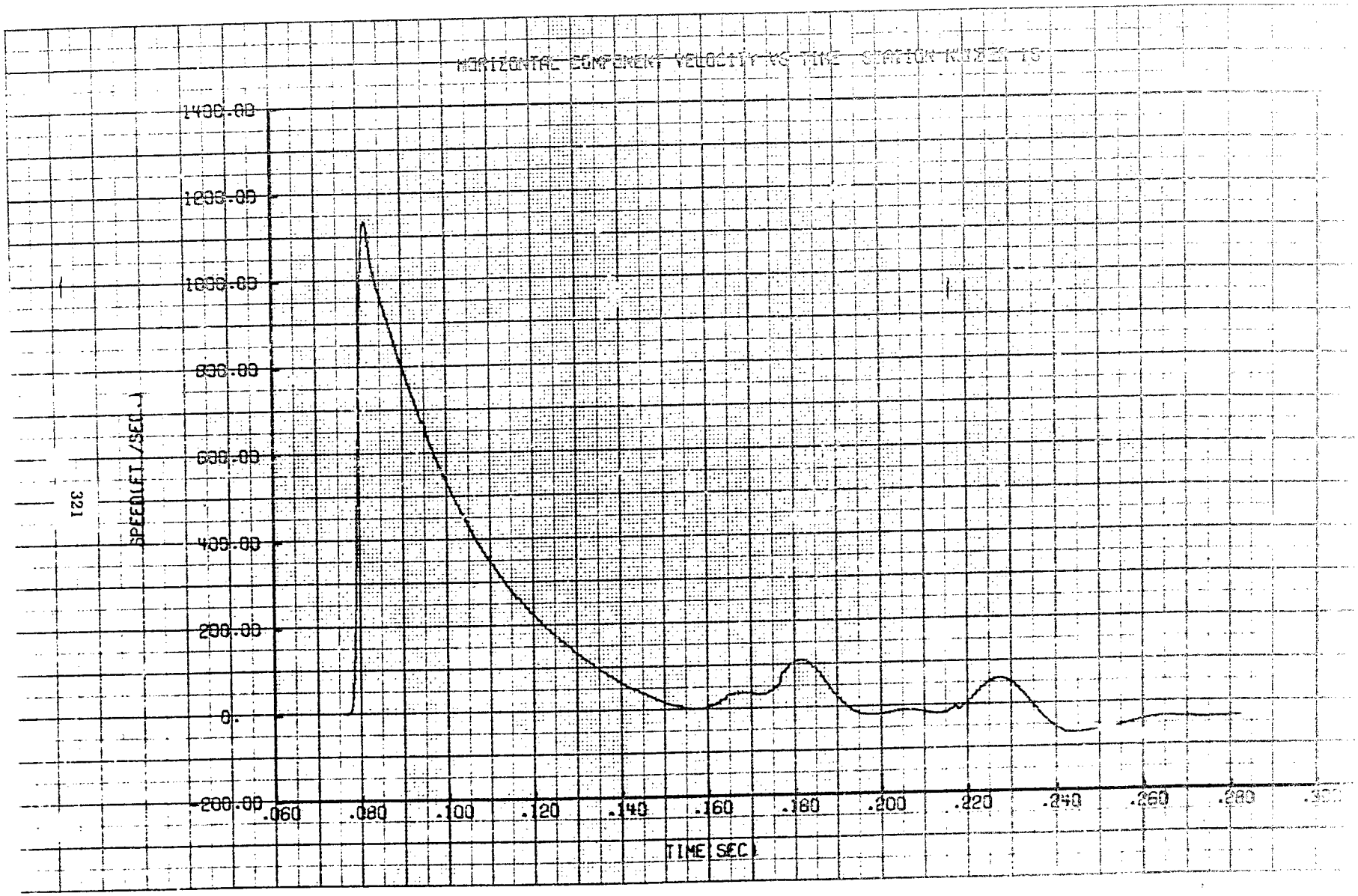

VERTICAL DYNAMIC PRESSURE VS TIME - STATION NINE
1.20
.80
.40
0
-.40
-.80
-1.20
-1.60
-2.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)
DYNAMIC PRESSURE(PSI)
315

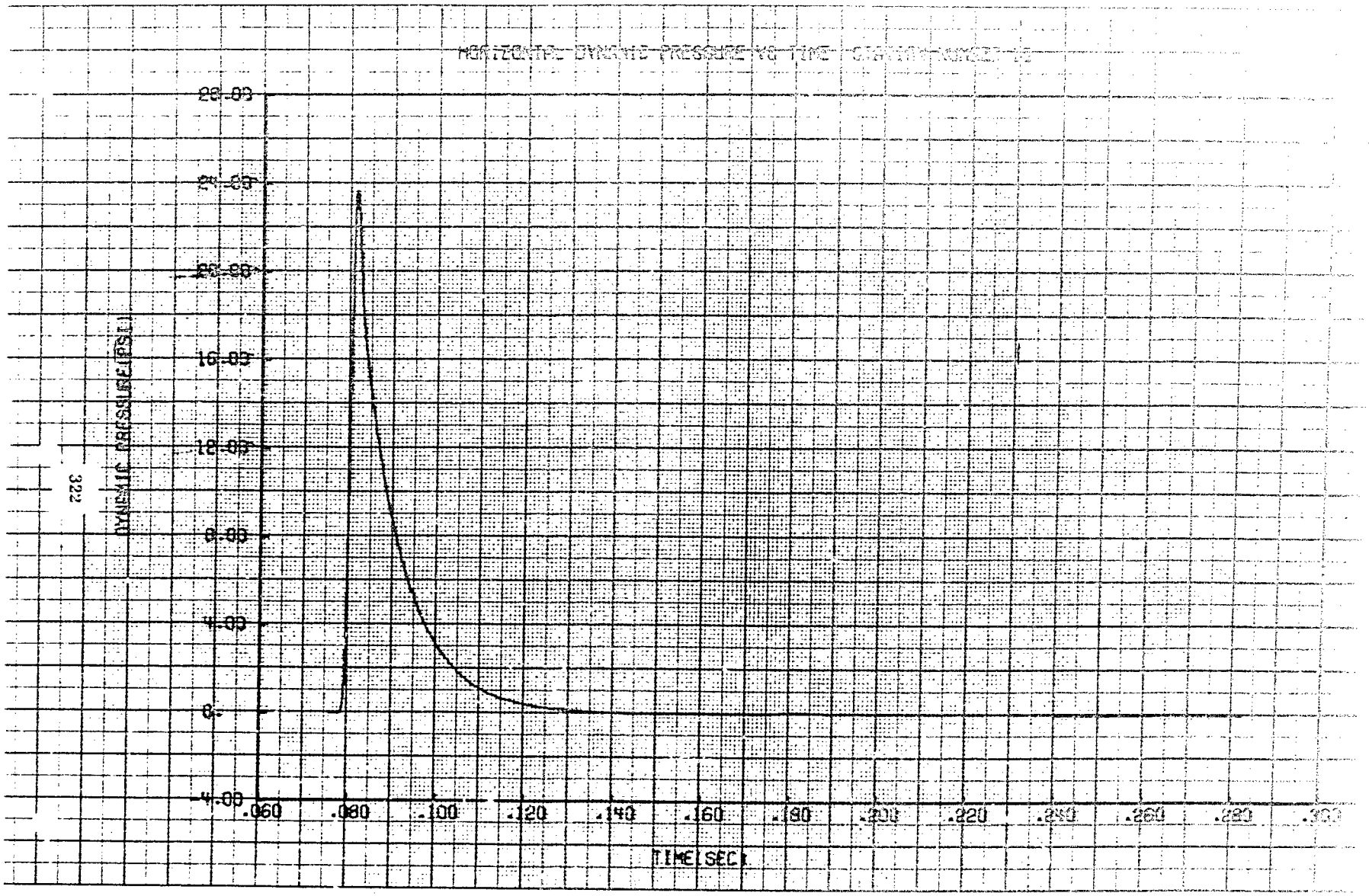

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 14
DYNAMIC PRESSURE IMPULSE (PSI-SEC)
.32
.28
.24
.20
.16
.12
.08
.04
0
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

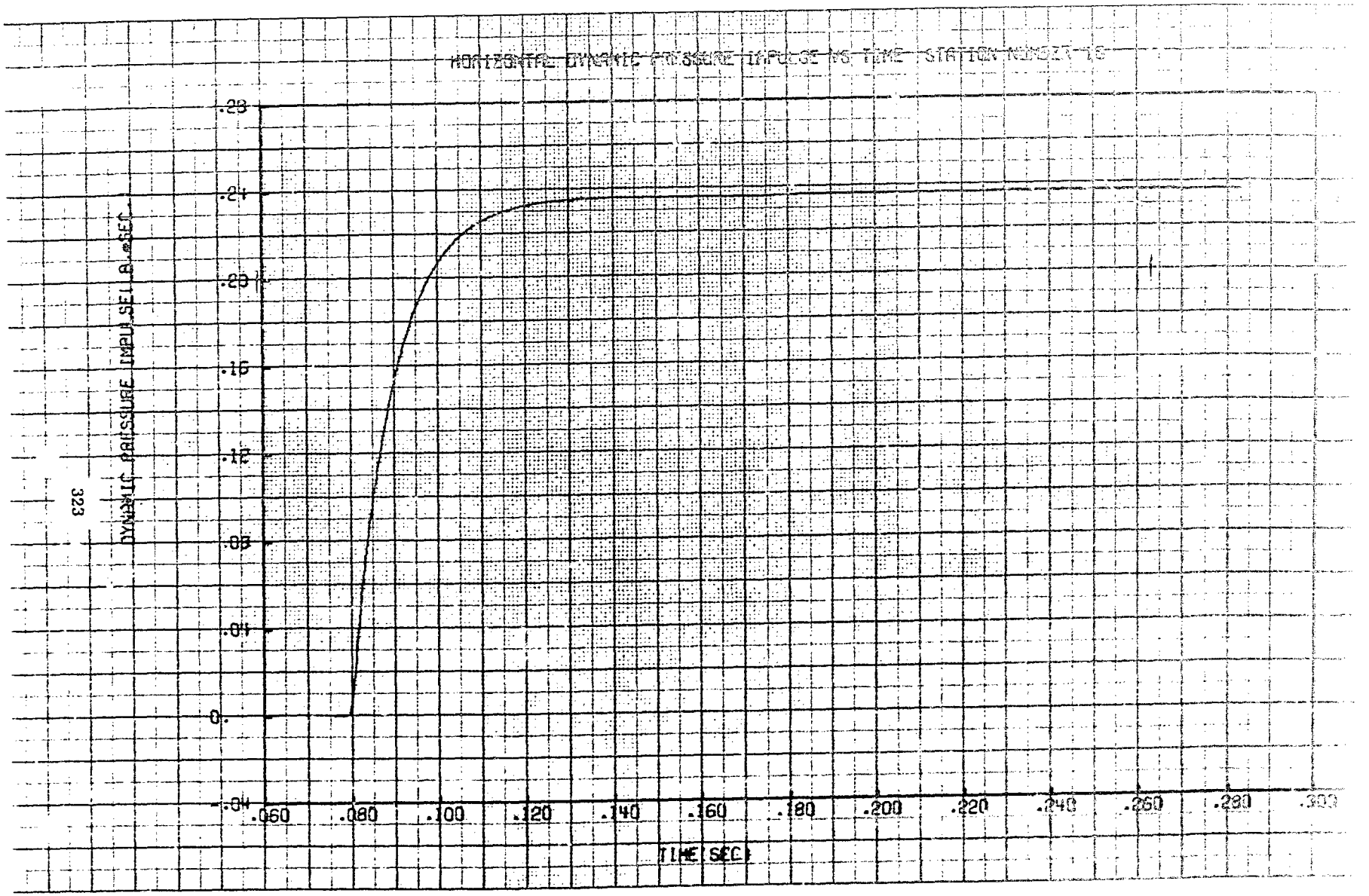
DYNAMIC PRESSURE (PSI)
TIME (SEC)
0.0000
0.0040
0.0080
0.0120
0.0160
0.0200
0.0240
0.0280
0.0320
0.0360
0.0400
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440

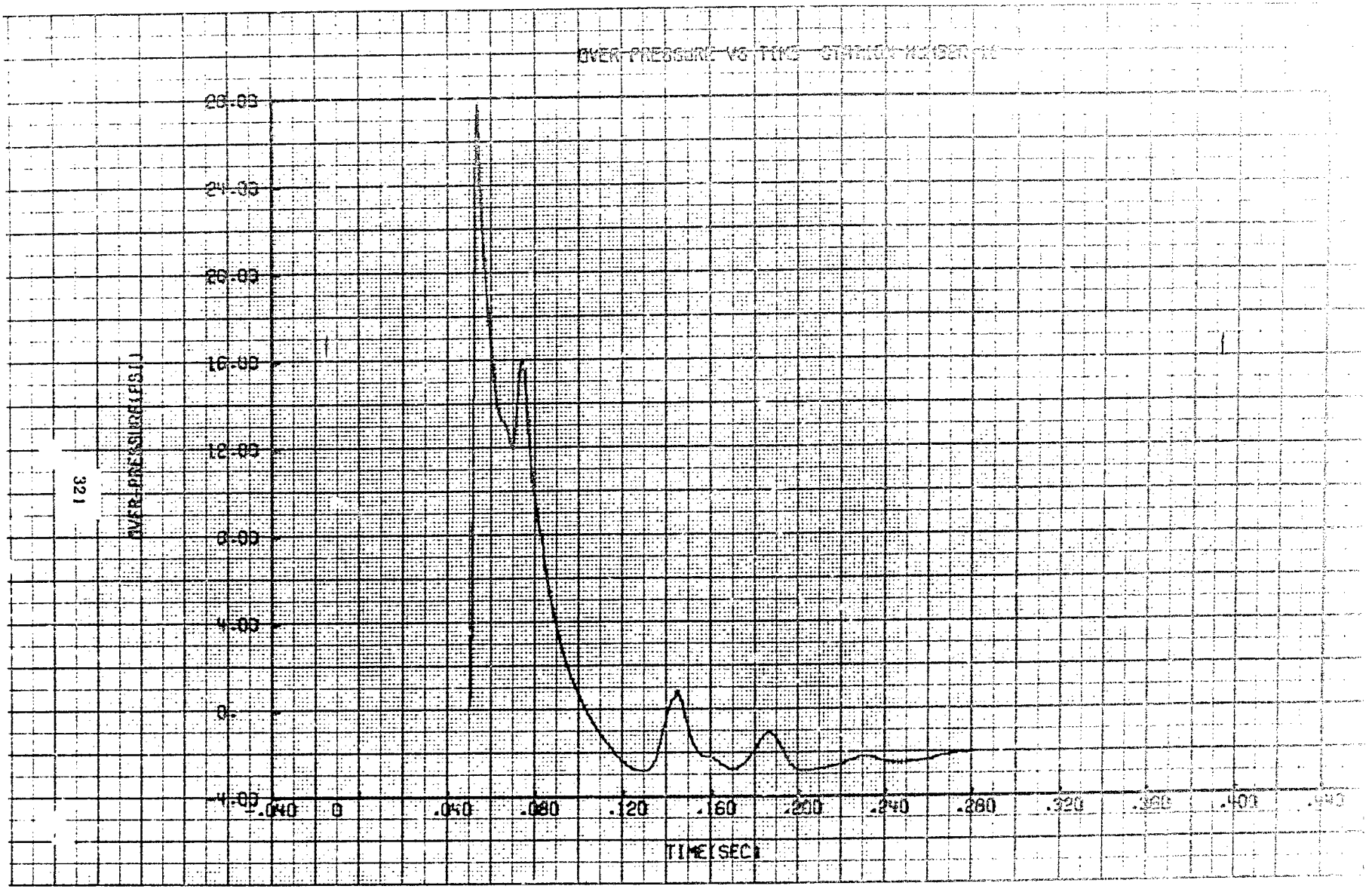

OVER PRESSURE VS TIME STATION NUMBER 16
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(LBS/I)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME SEC

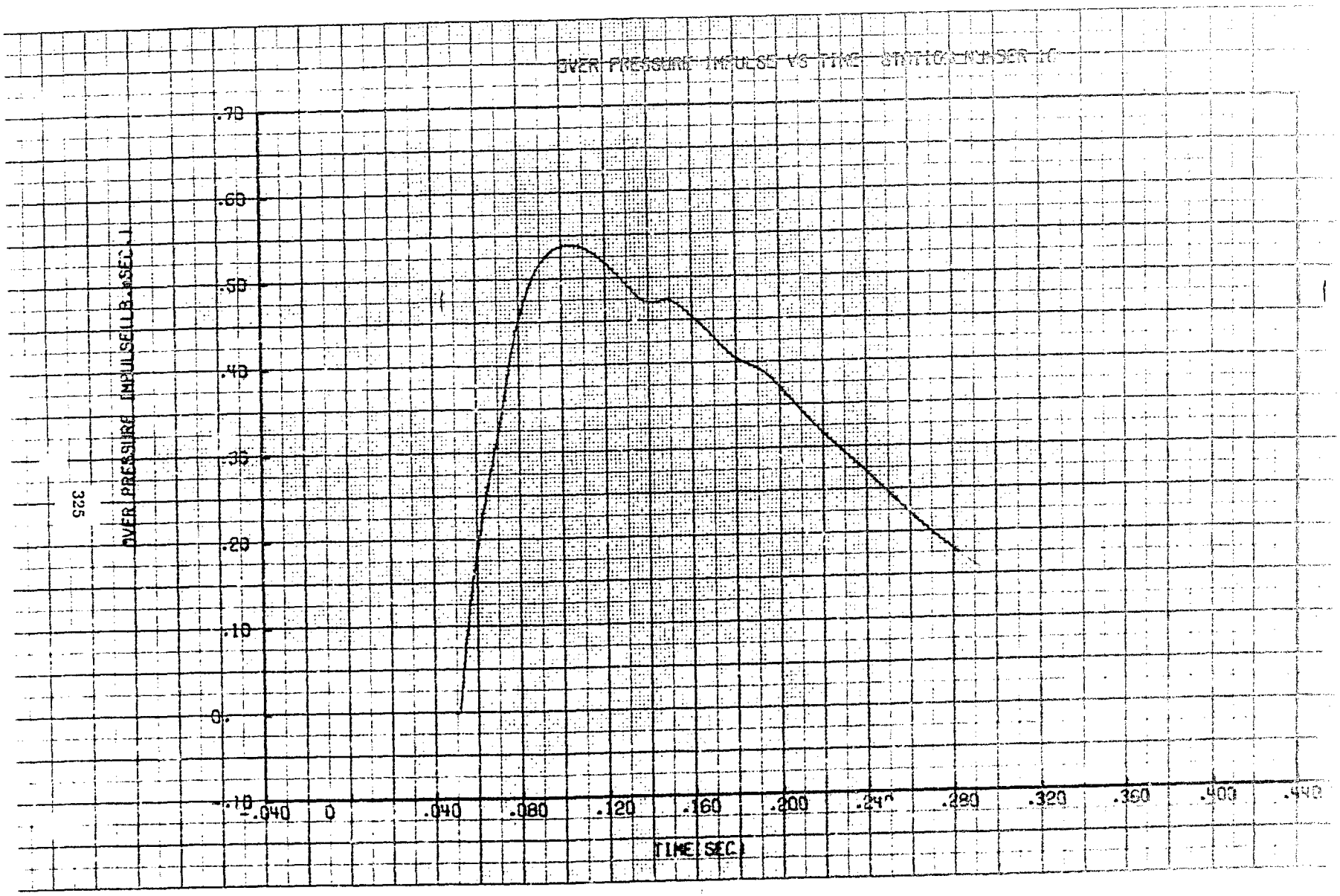

OVERPRESSURE IMPULSE VS TIME STATION NUMBER 16
.70
.60
.50
.40
.30
.20
.10
0
-.10
OVER PRESSURE (IMPULSE/LB.*SEC.)
320
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC.)

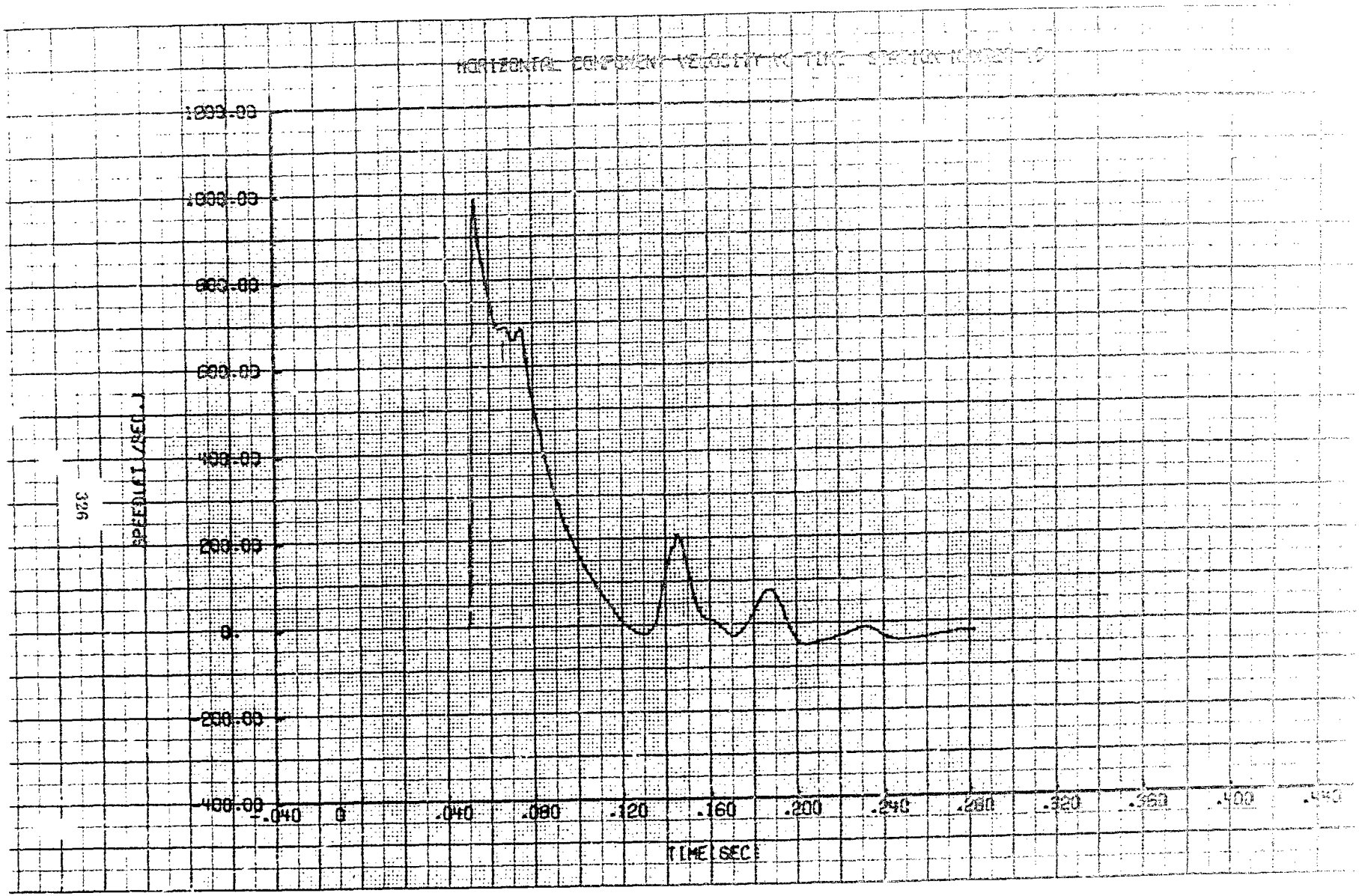

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 15
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)

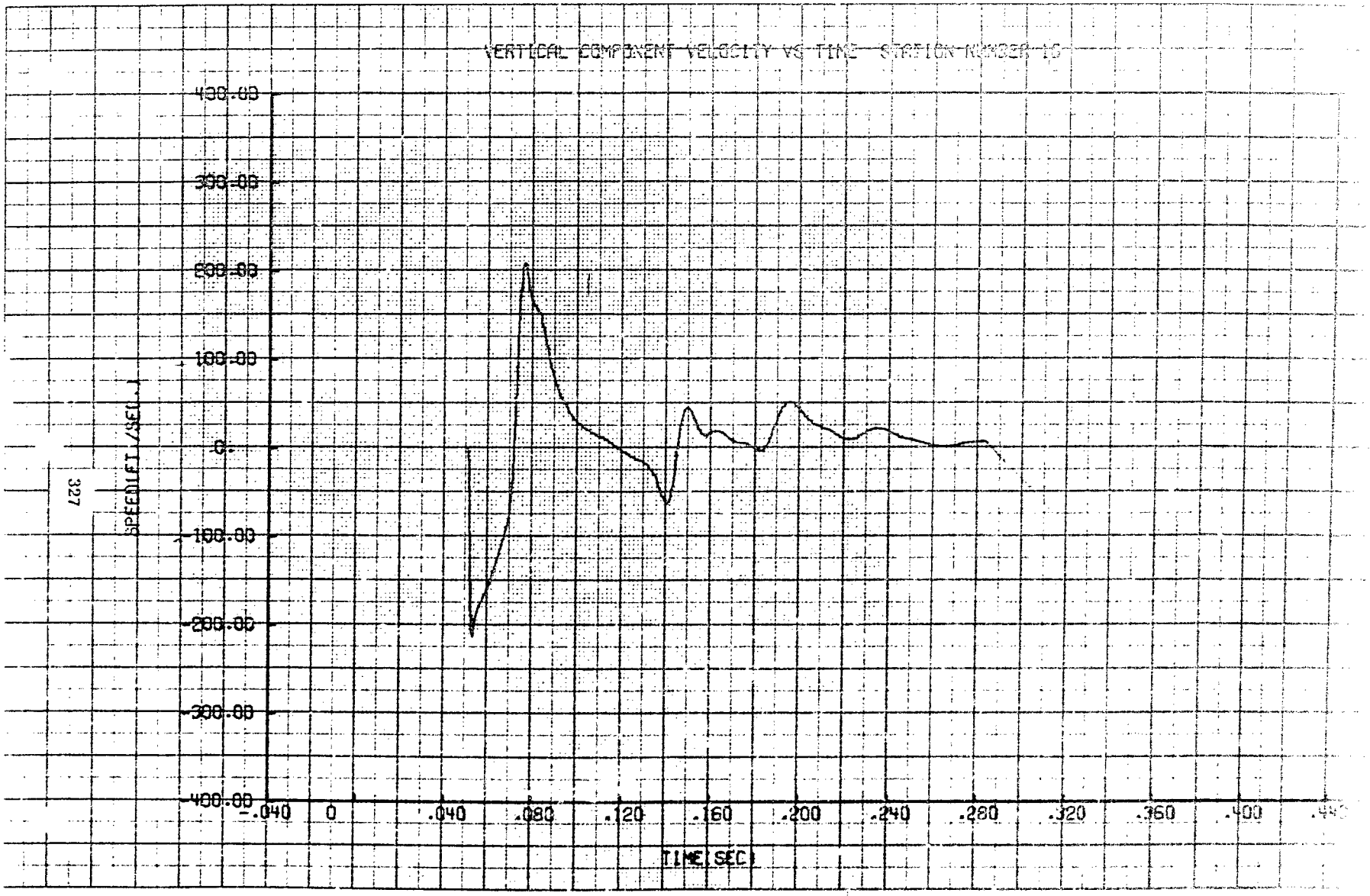

HORIZONTAL DYNAMIC PRESSURE VS TIME - GAGE NUMBER 15
20.00
16.00
12.00
8.00
4.00
0.
-4.00
DYNAMIC PRESSURE(PSI)
322
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

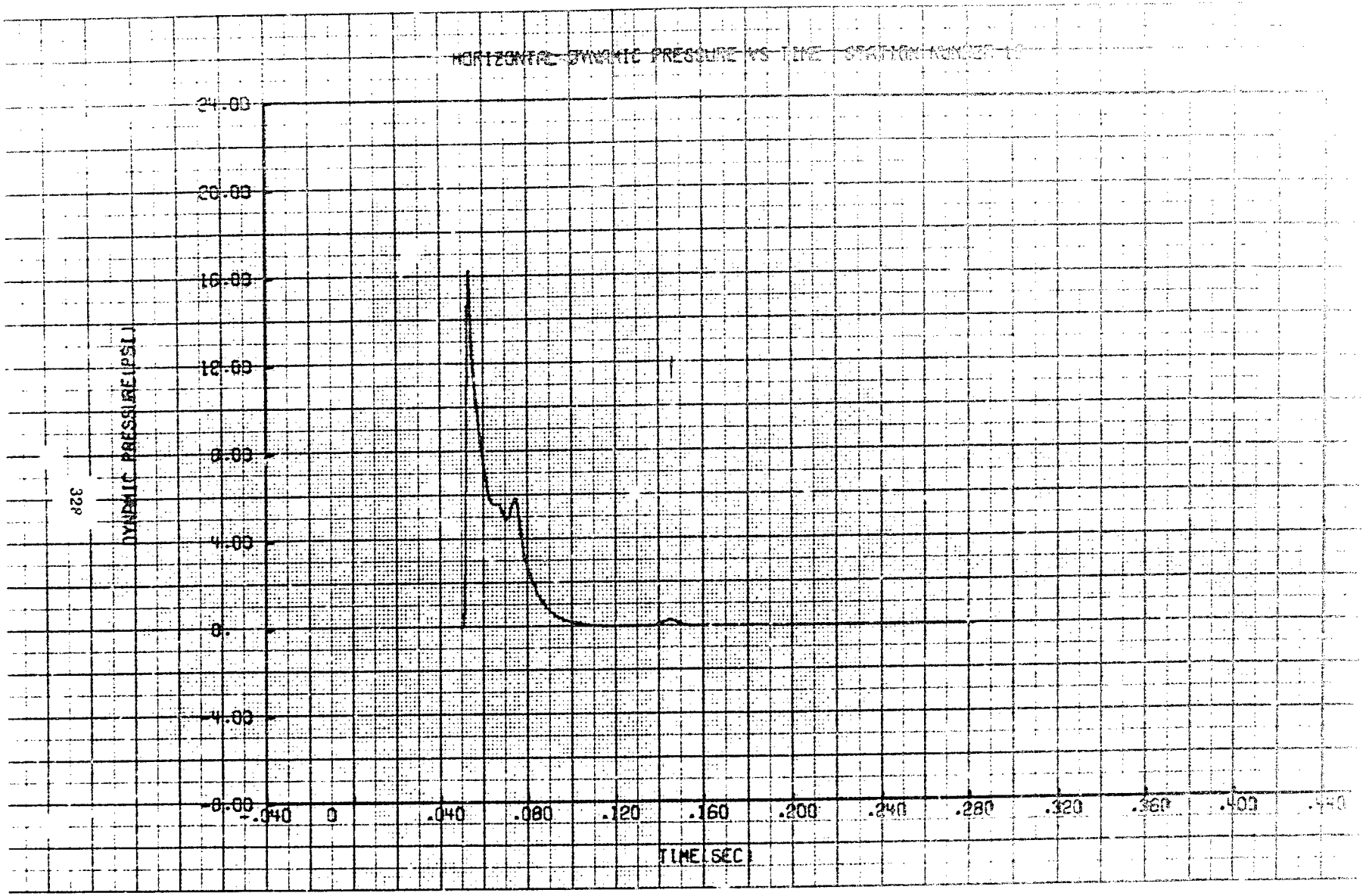

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 16
DYNAMIC PRESSURE IMPULSE LB-SEC/SQ IN
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC)

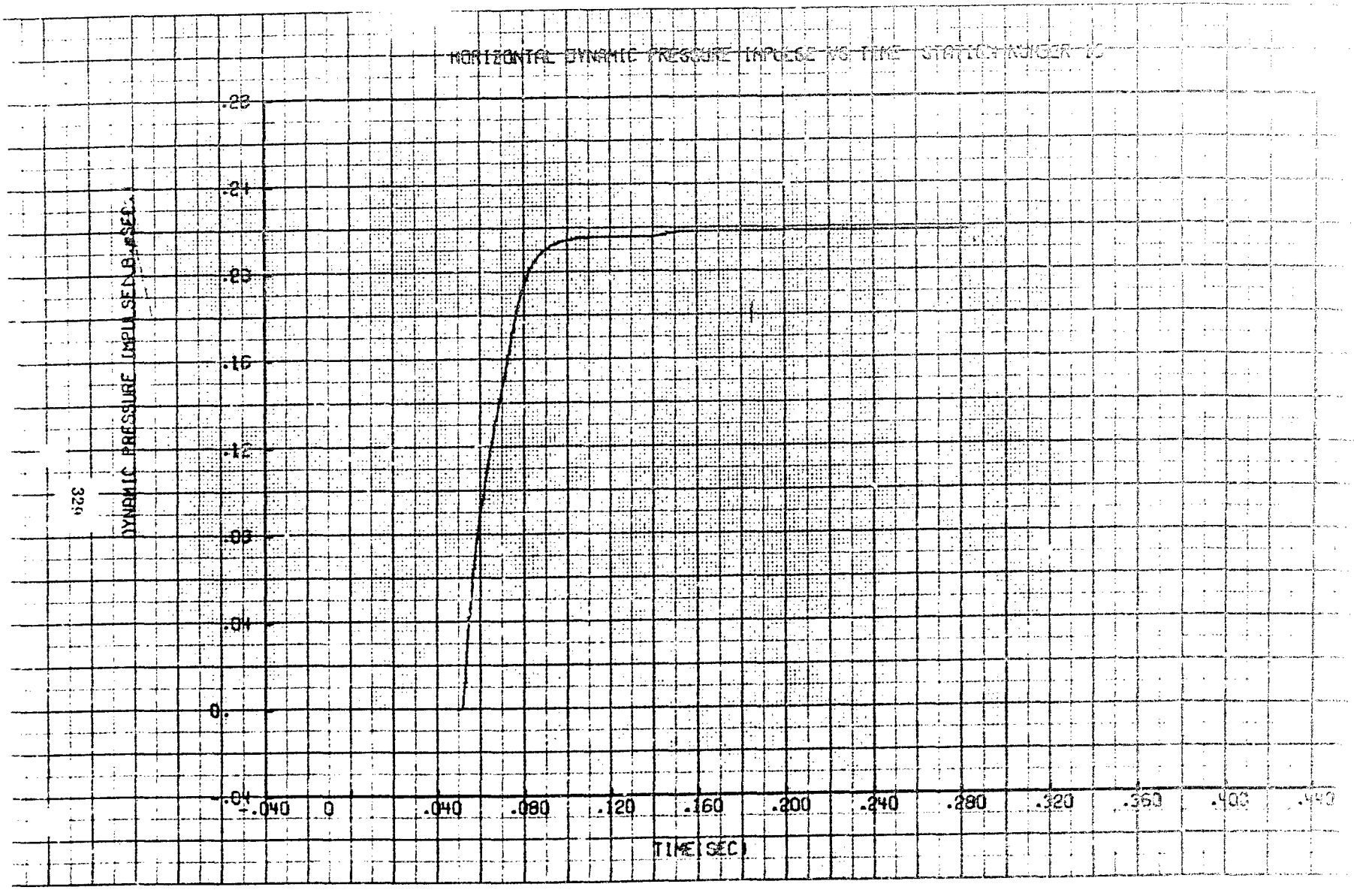

OVER-PRESSURE VS TIME STATION NUMBER 11
OVER-PRESSURE(LBS/SQ.FT.)
24.-03
20.-03
16.-03
12.-03
8.-03
4.-03
0.
-4.-03
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)


OVER PRESSURE IMPULSE VS TIME STATION GAUGE 10
OVER PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC.)

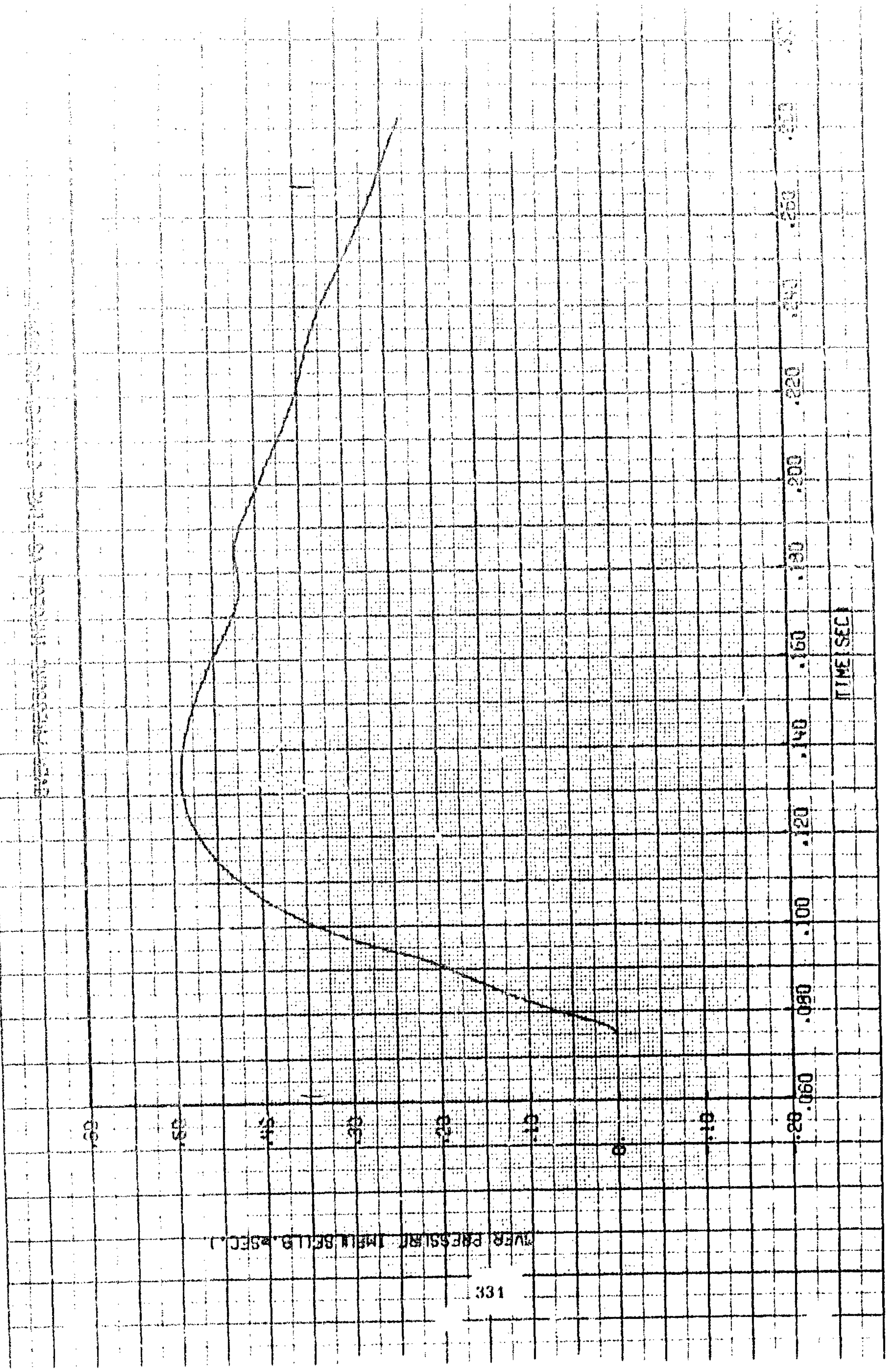

HORIZONTAL EQUIVALENT VELOCITY VS TIME STATION NUMBER 12
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
326

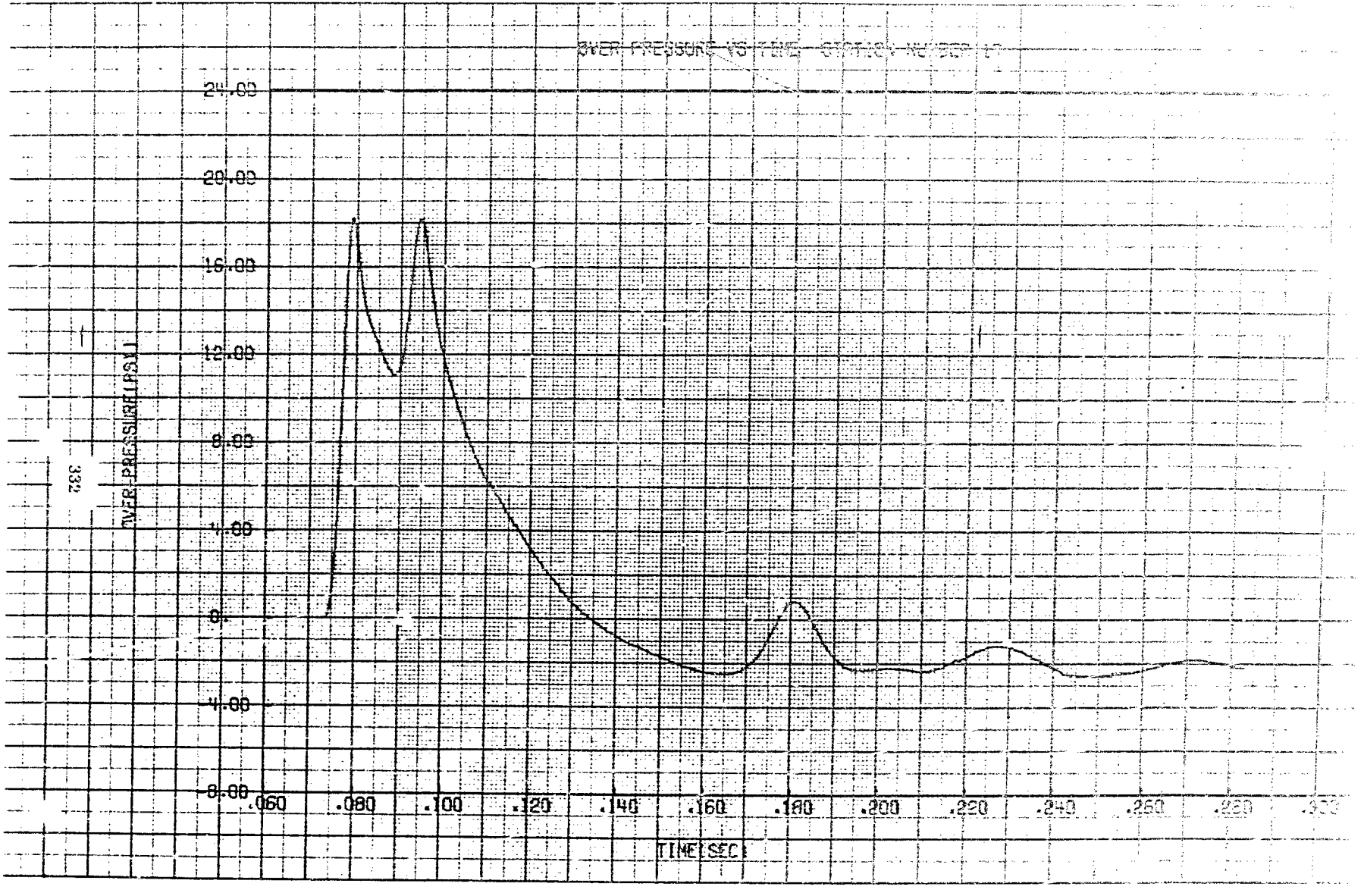

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
-400.00
VELOCITY (FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

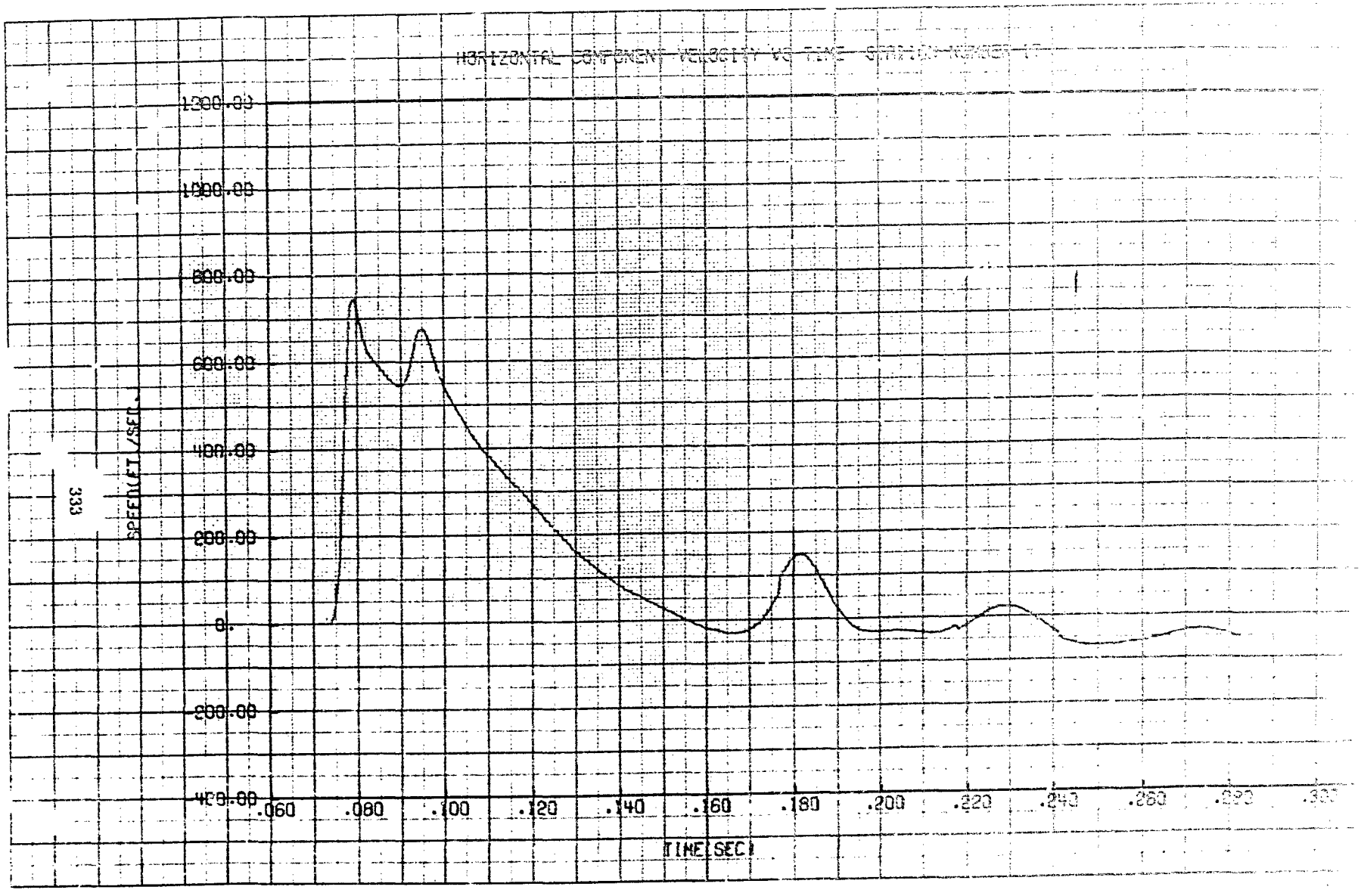

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 6
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
DYNAMIC PRESSURE(PSI)
32P
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

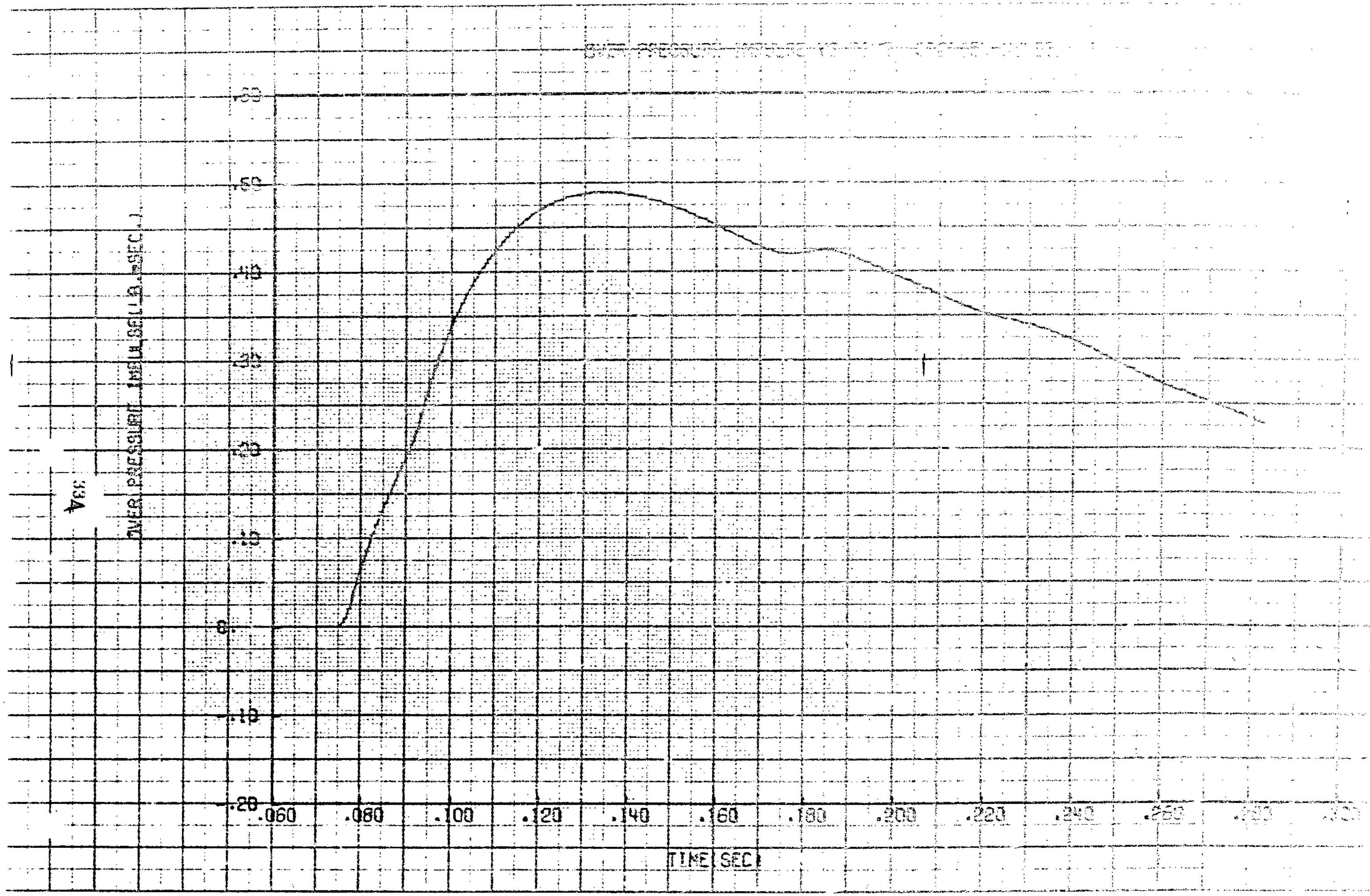

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE (LB./SEC.)
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

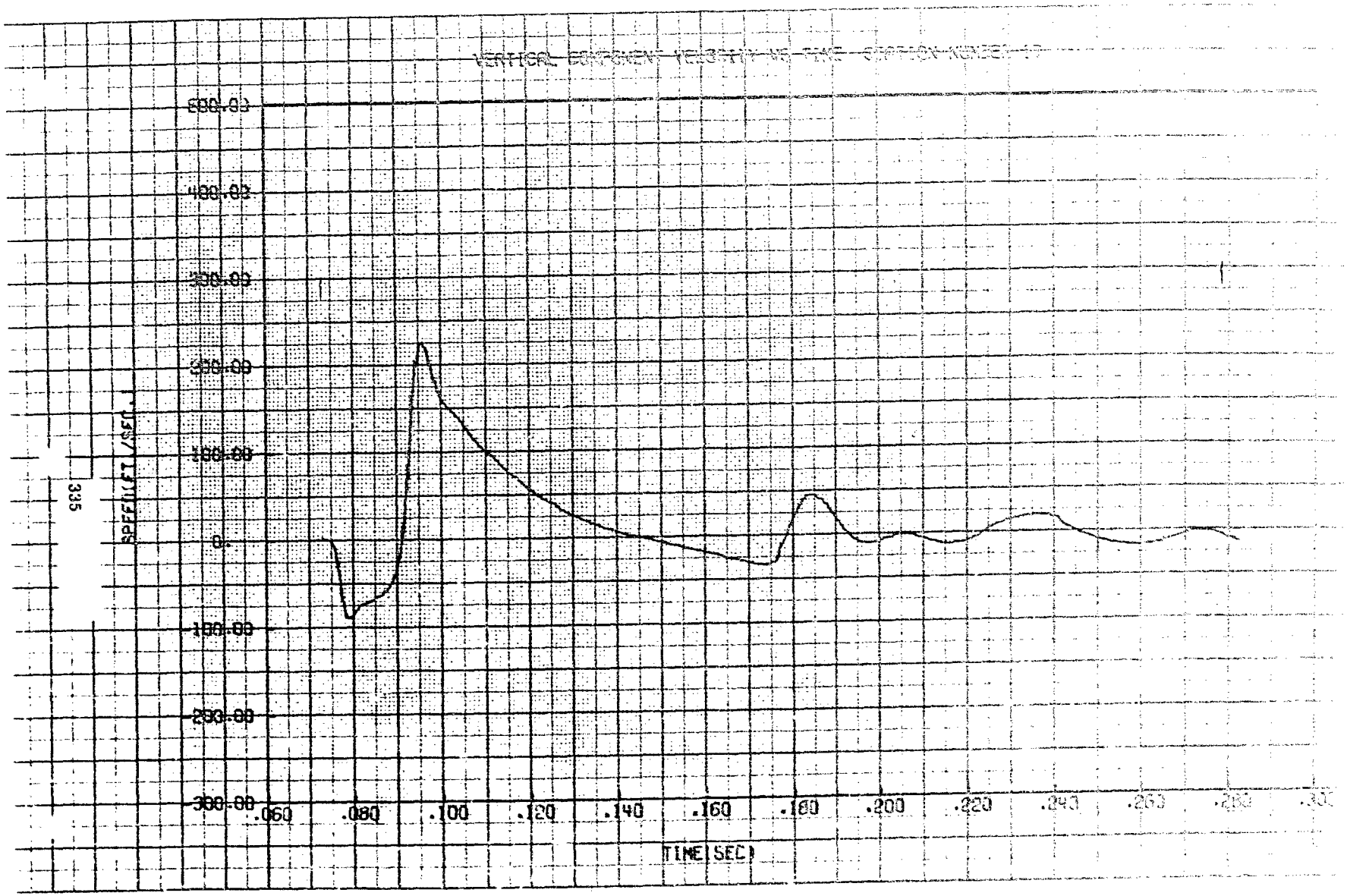
VERTICAL DYNAMIC PRESSURE VS. TIME STABILIZER
DYNAMIC PRESSURE(PSI)
TIME(SEC)
-80.
-60.
-40.
-20.
0.
20.
40.
60.
80.
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

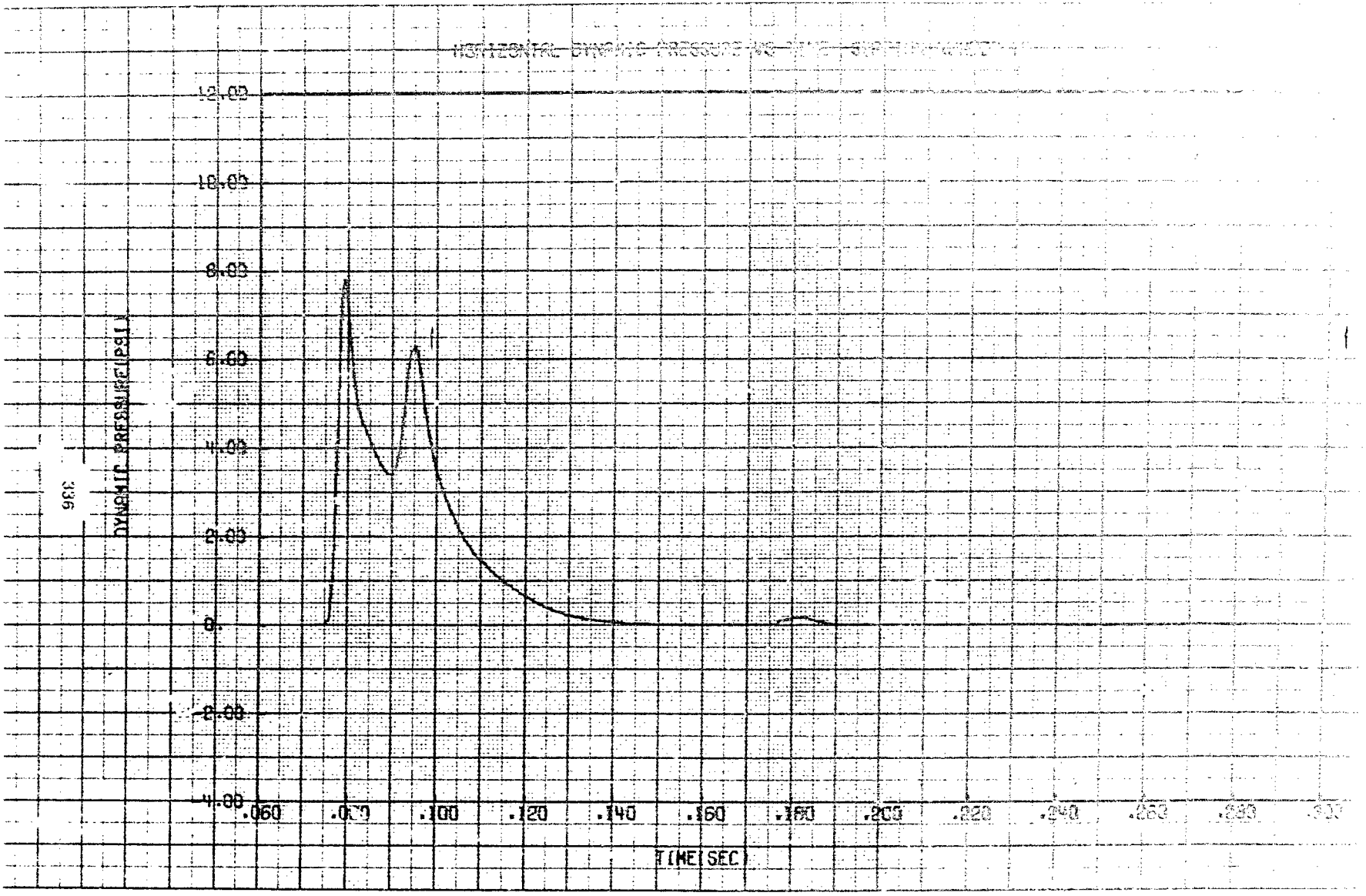

.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME (SEC)


OVER PRESSURE VS TIME STATION NO 332
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER PRESSURE(PSF)
332
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)

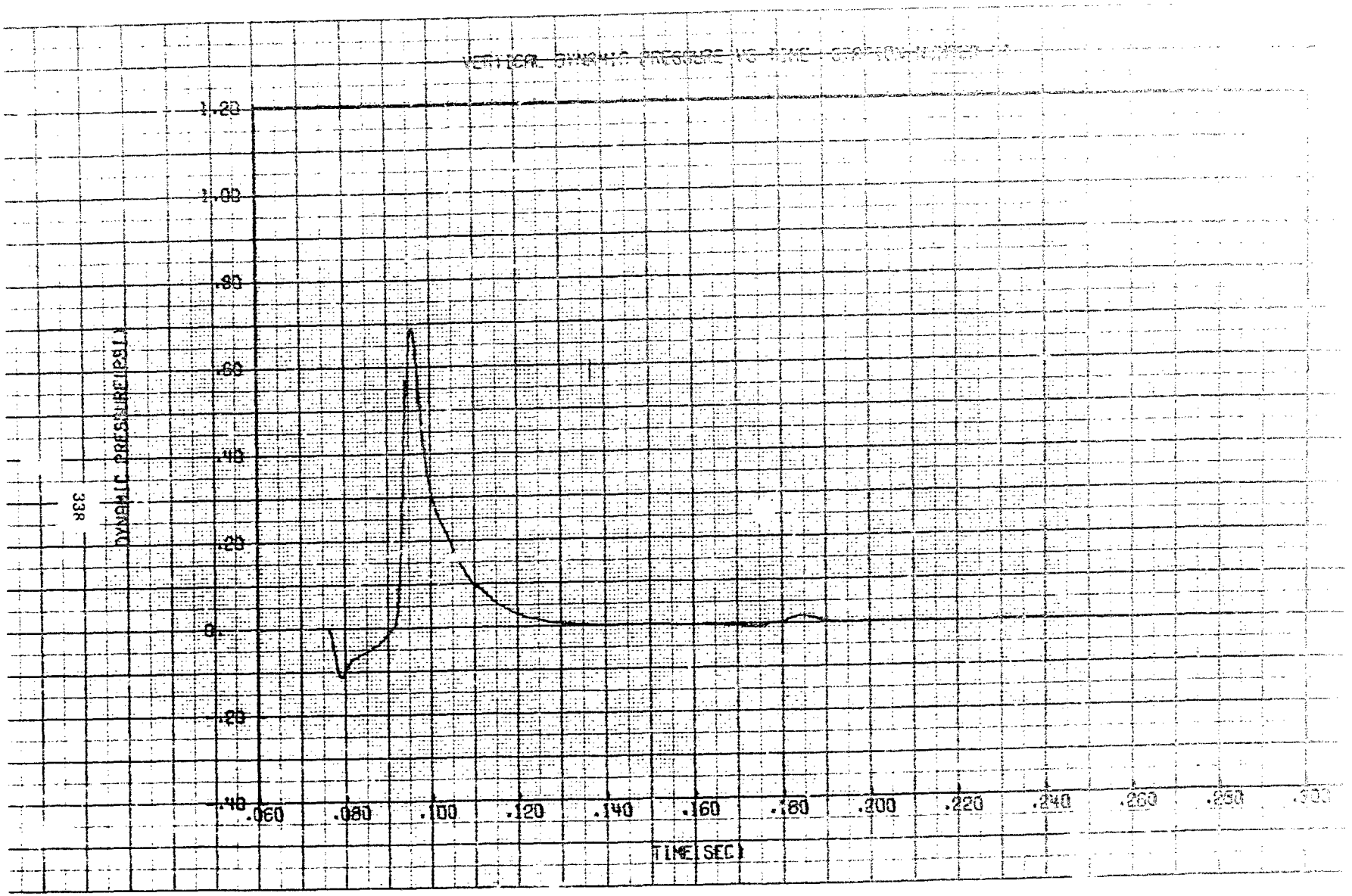

HORIZONTAL COMPONENT VELOCITY VS TIME STATION KRAKET
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
333
SPEED(FT/SEC)

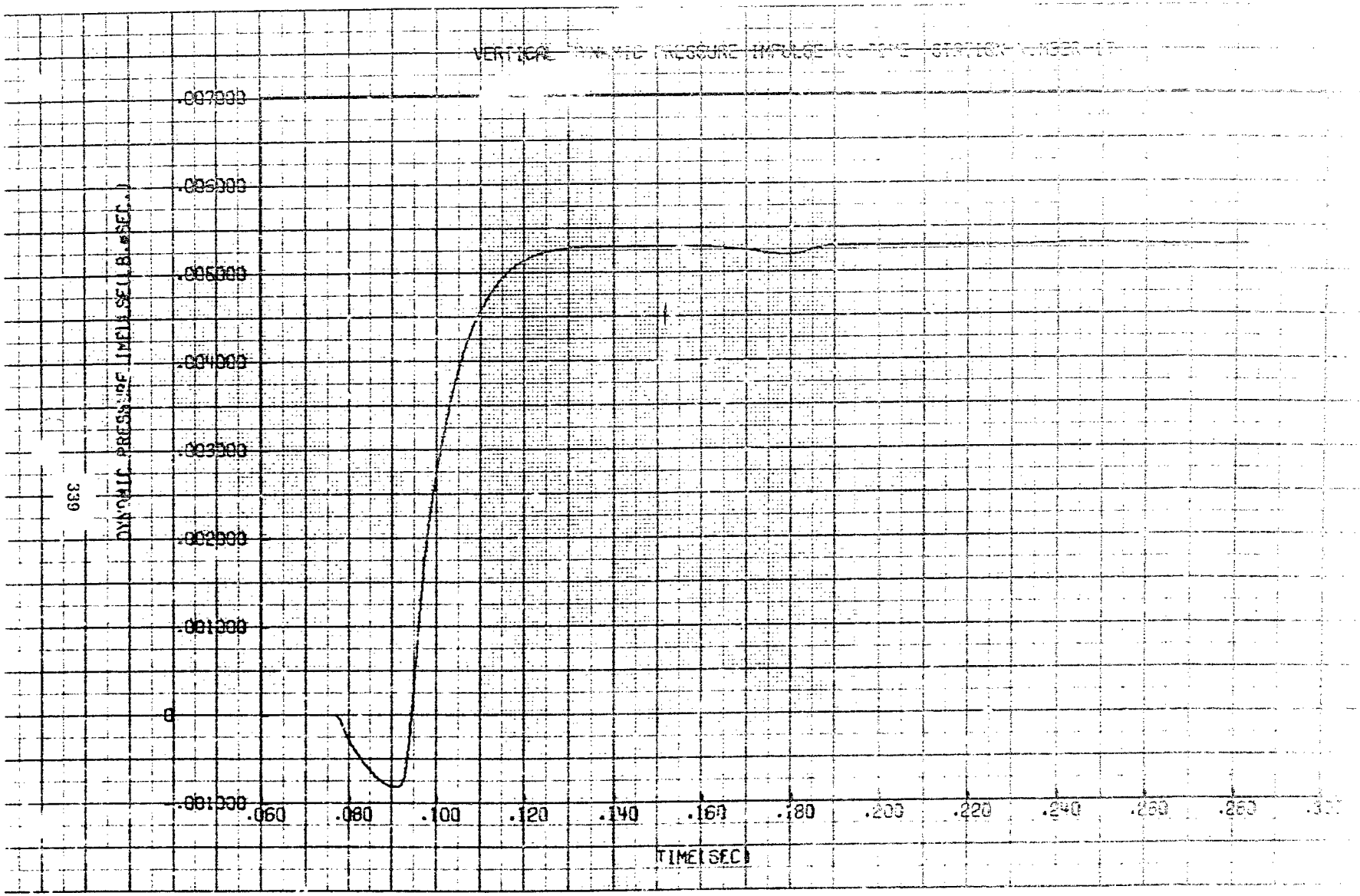

OVER PRESSURE IMPULSE(LB.-SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

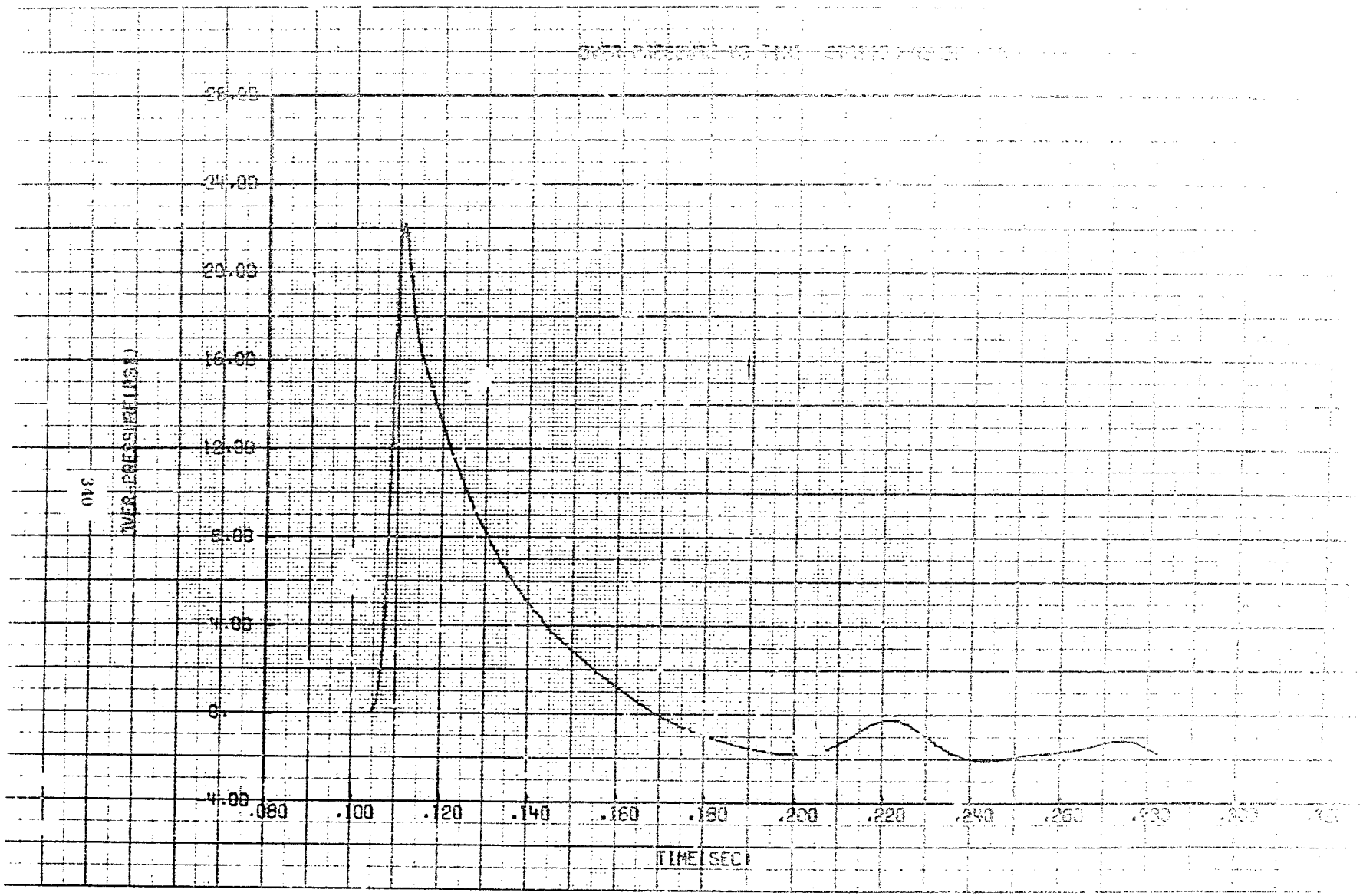

VERTICAL ENTRANCE VELOCITY VS TIME STATION NUMBER 12
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC)
VELOCITY (FPS)
335


12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
-4.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)
DYNAMIC PRESSURE(PSI)
336

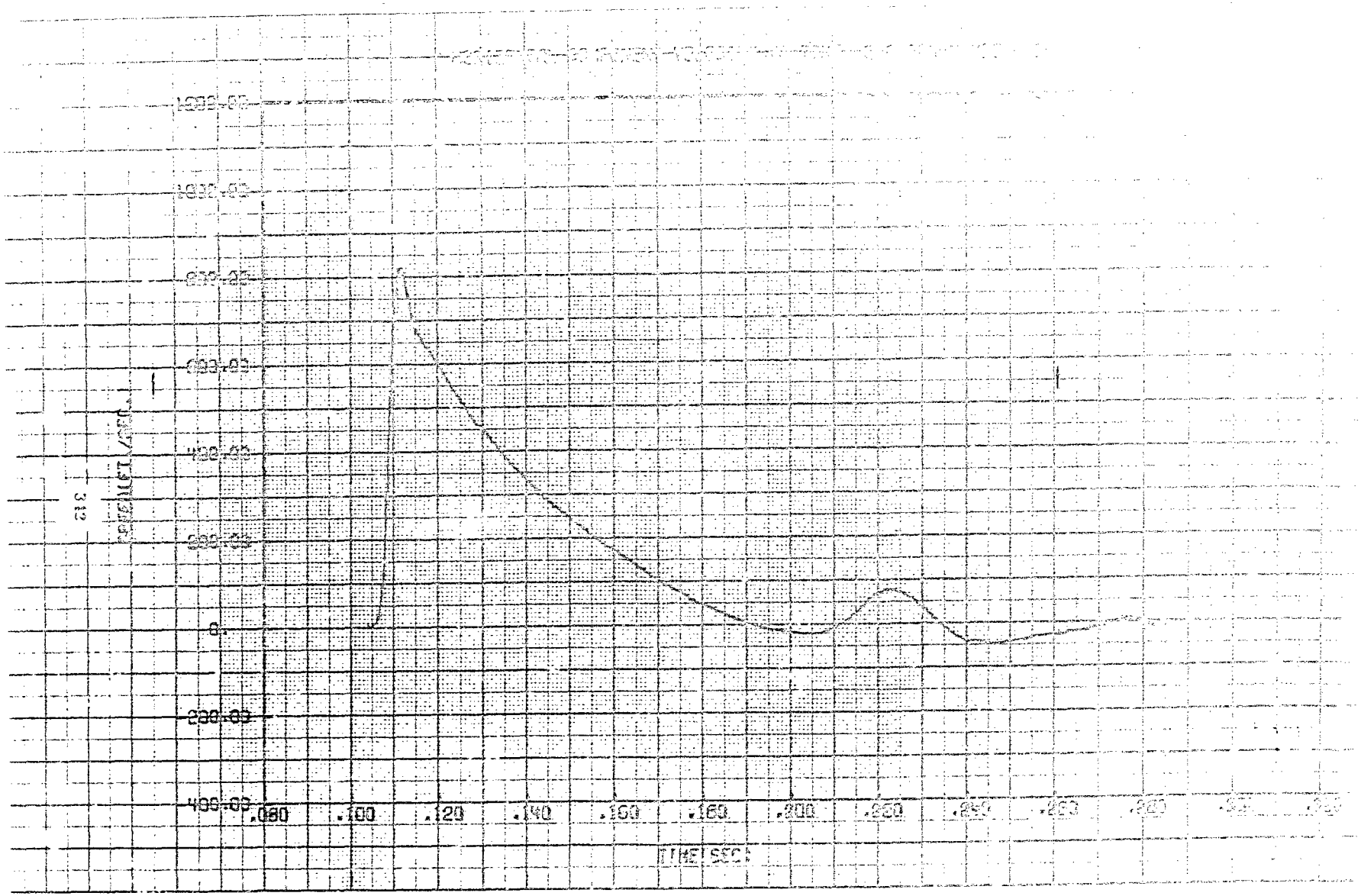
HORIZONTAL DYNAMIC PRESSURE IMPULSE TIME ORIGIN AT NOZZLE
DYNAMIC PRESSURE IMPULSE(LB.*SEC./
.16
.14
.12
.10
.08
.06
.04
.02
0.
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME(SEC)

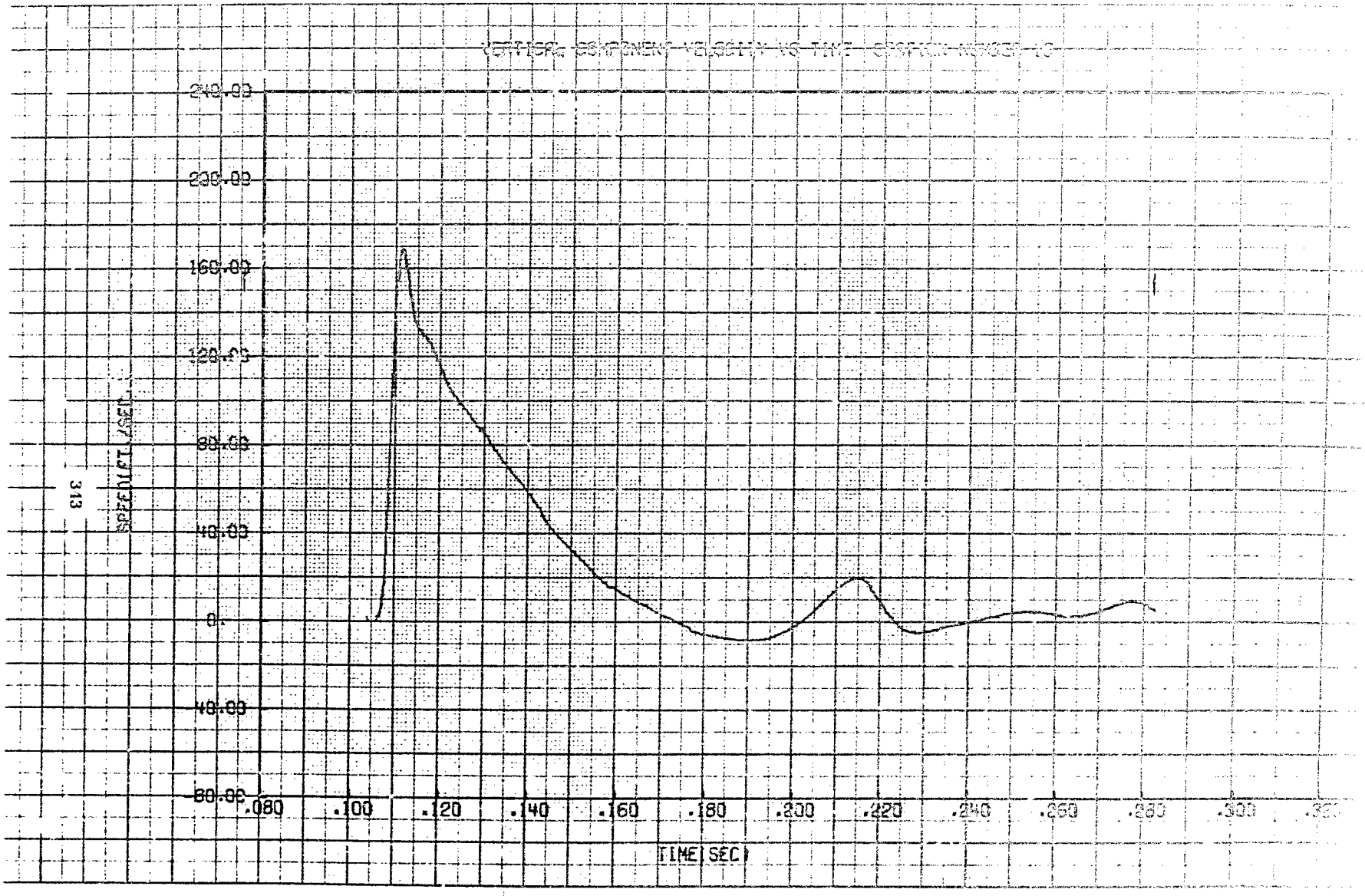

VERTICAL DYNAMIC PRESSURE VS TIME - STATION NUMBER 1
1.20
1.00
.80
.60
.40
.20
0
-.20
-.40
DYNAMIC PRESSURE (PSI)
338
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC)


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
.007000
.005000
.004000
.003500
.002000
.001200
0
-.001000
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)
DYNAMIC PRESSURE IMPULSE(LB-SEC/...)
339

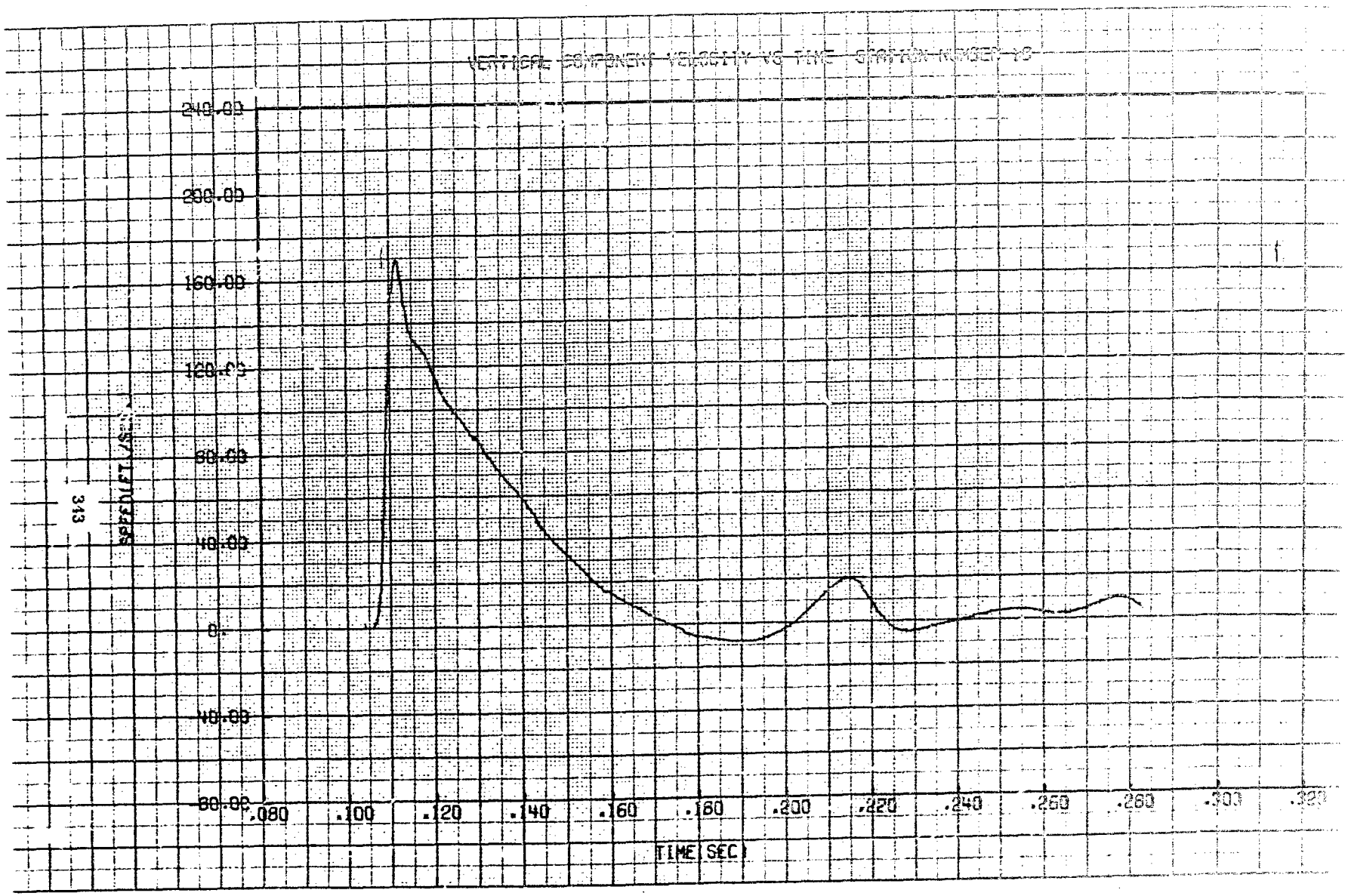

24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME(SEC)
340

OVER PRESSURE IMPULSE VS TIME - STATION 4 GAUGE 3
OVER PRESSURE IMPULSE (PSI-SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.000
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME SEC.


.080
.100
.120
.140
.160
.180
.200
TIME (SEC)


VERTICAL COMPONENT VELOCITY VS TIME EPSILON NOVEMBER 10
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
313

TIME(SEC)
.080
.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
.800
.820
.840
.860
.880
.900
.920
.940
.960
.980
1.000
1.020
1.040
1.060
1.080
2.00
6.
2.00
1.00
.50
.20
.10
.05
.02
.01
.005
.002
.001


VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 43
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)
343

DYNAMIC PRESSURE (PSI)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
TIME (SEC)

DYNAMIC PRESSURE (PSI)
TIME (SEC)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300

DYNAMIC RESPONSE (PSI/PSI @ SEC.)
TIME (SEC.)
.060
.100
.120
.140
.160
.180
.200
.220

DYNAMIC PRESSURE IMPULSE (LB-SEC/IN²)
TIME (SEC)
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
.480
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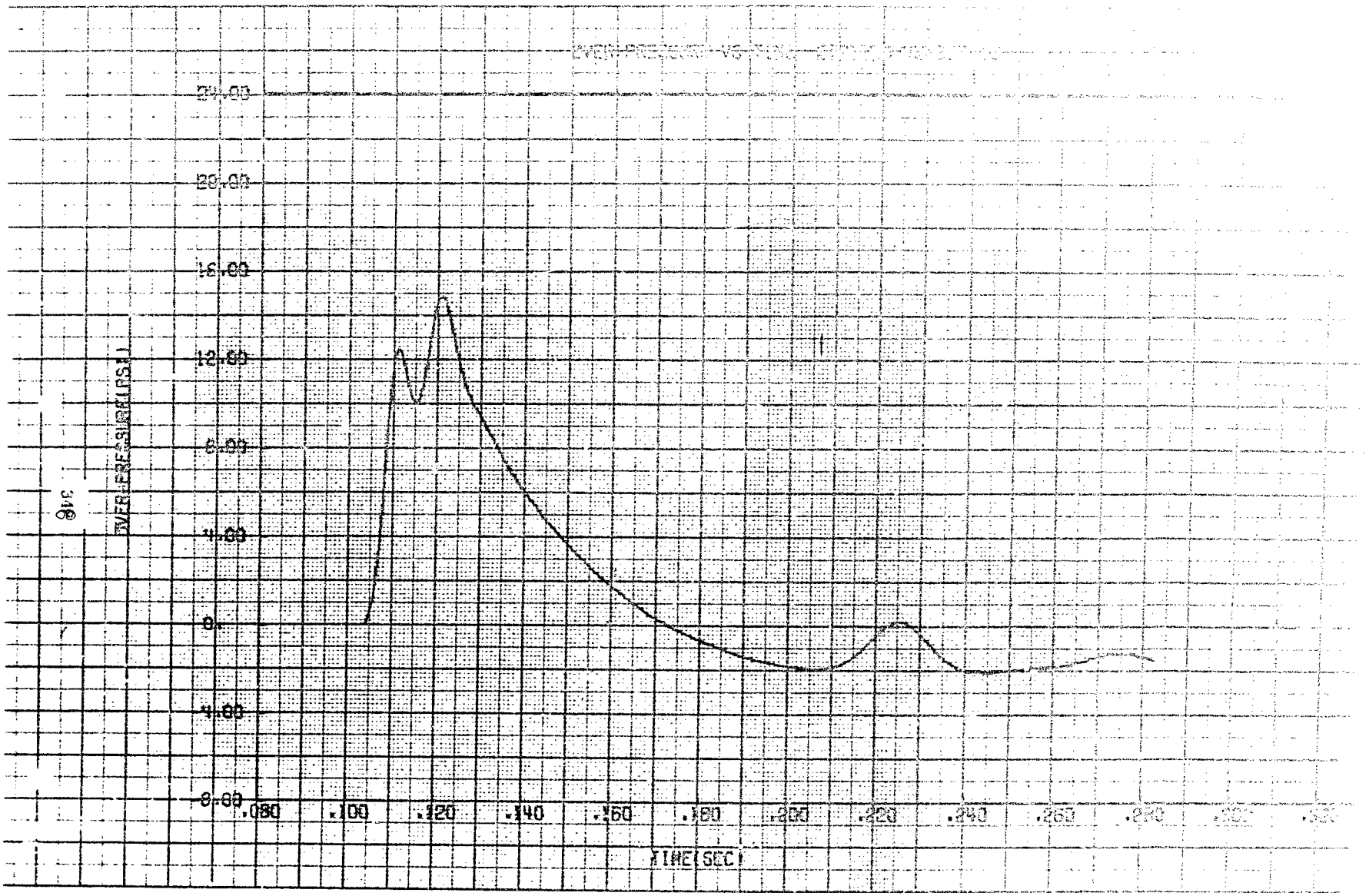
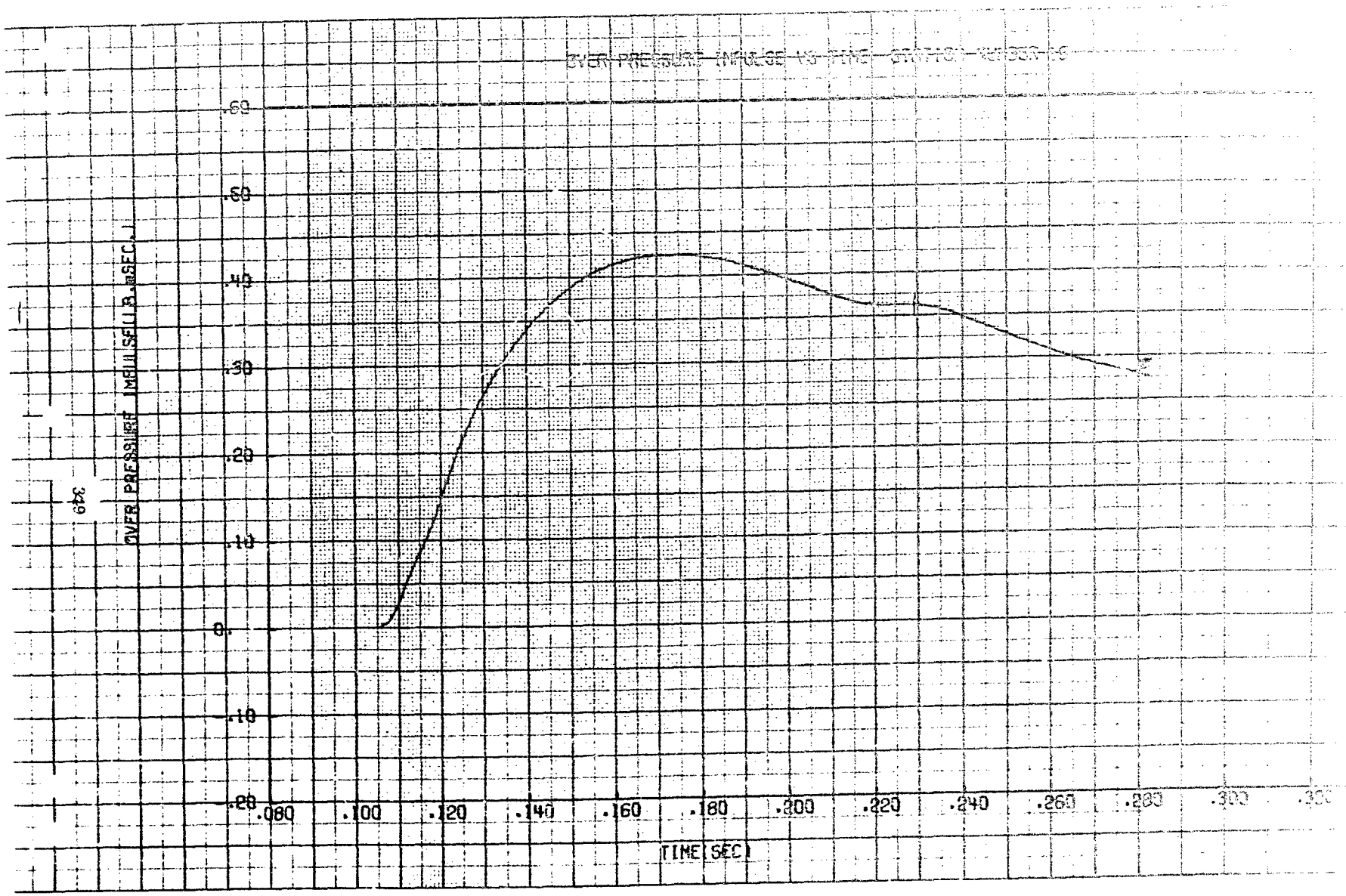
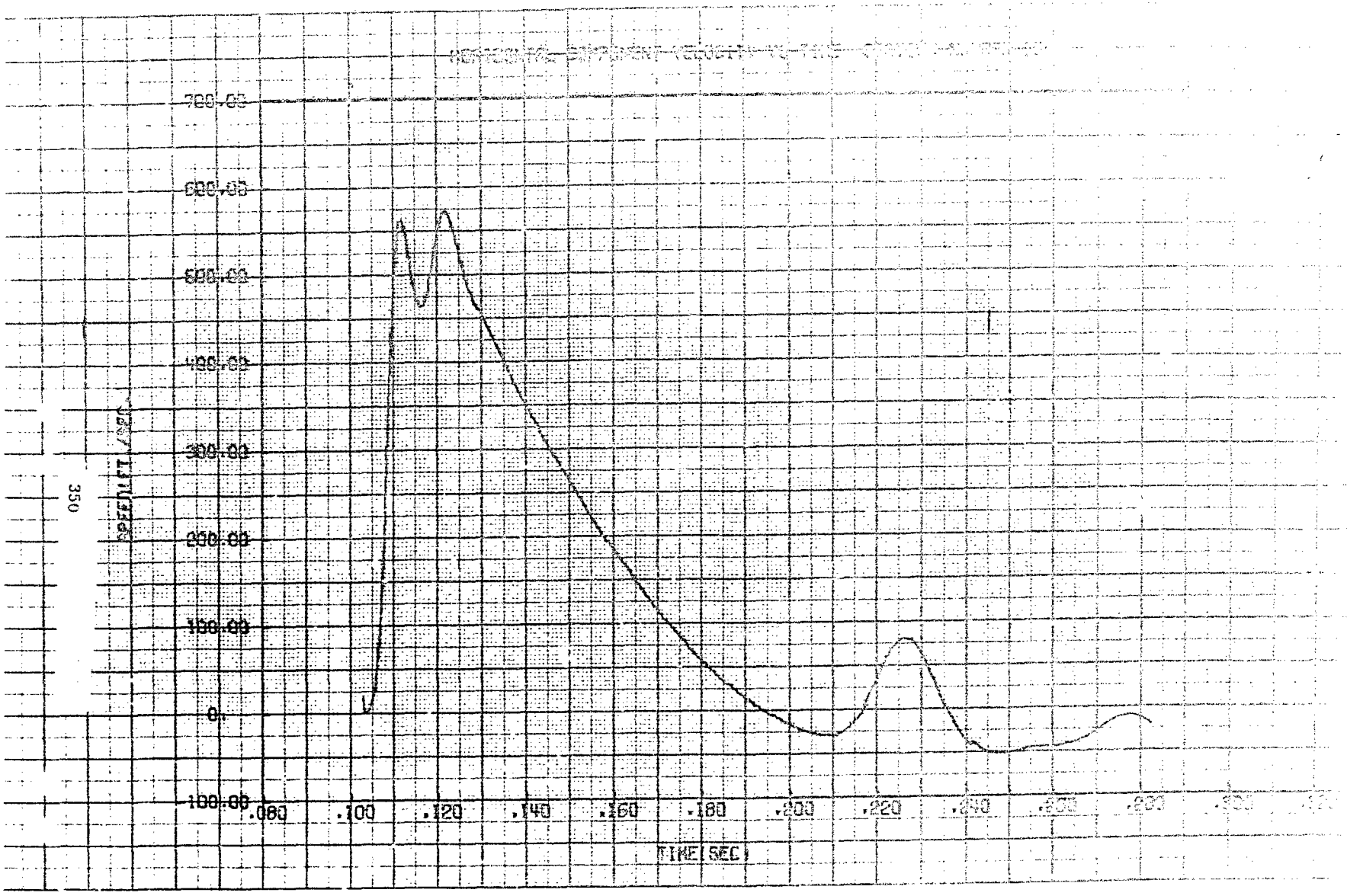
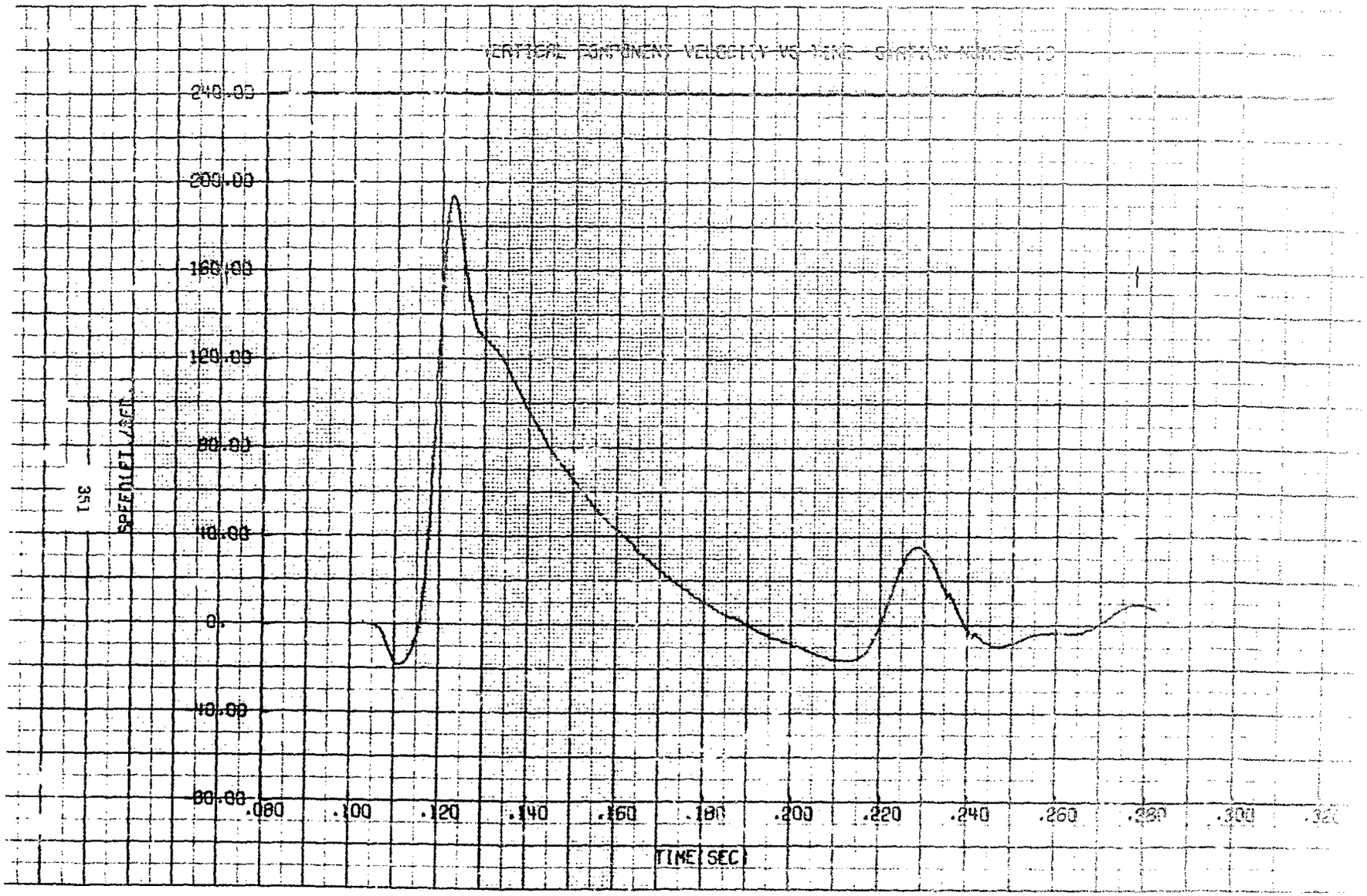
.920
.960
1.000


OVERPRESSURE (PSI)
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
TIME (SEC)

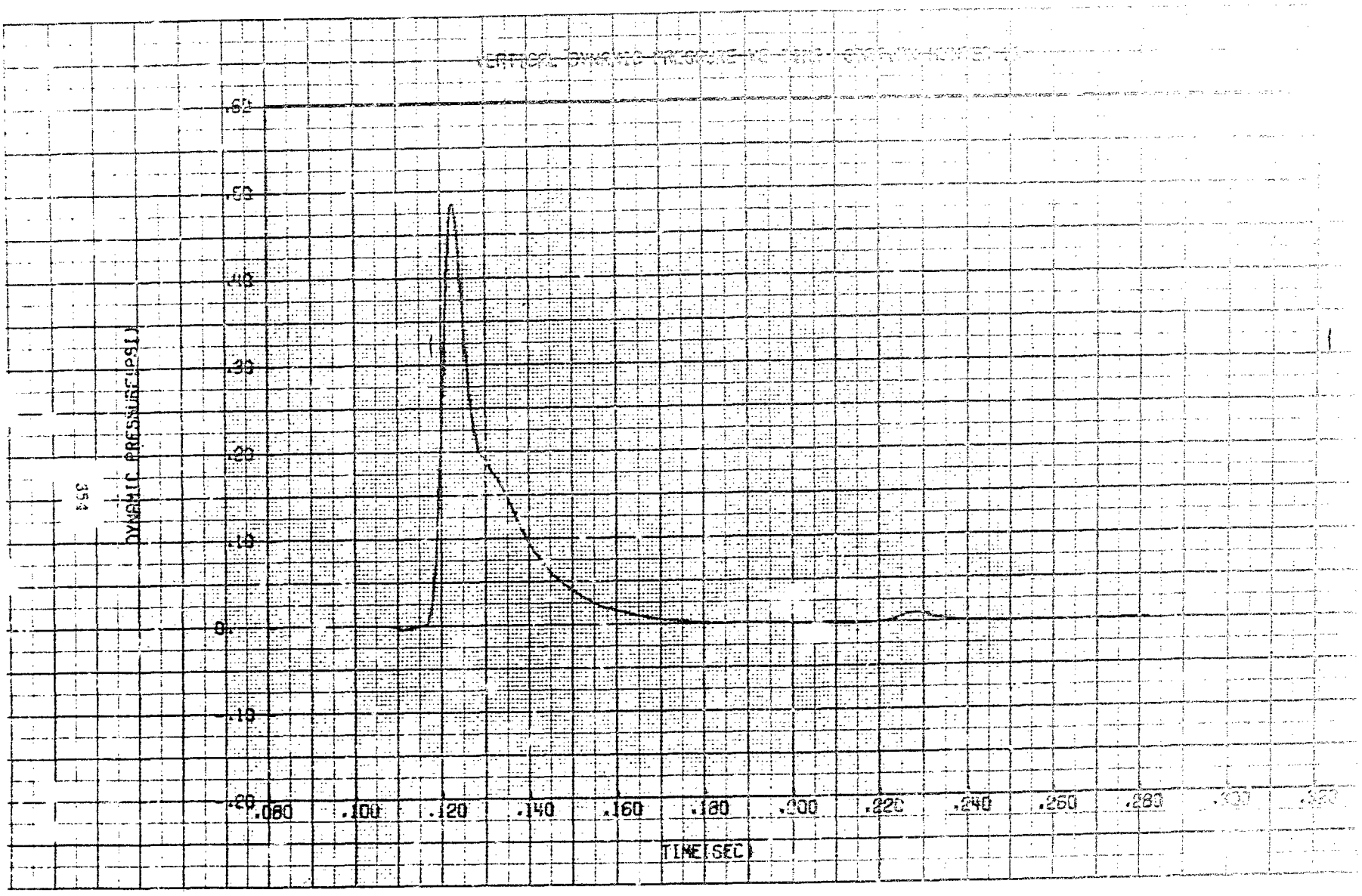

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 16
OVER PRESSURE IMPULSE, PSI-SEC.
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC)

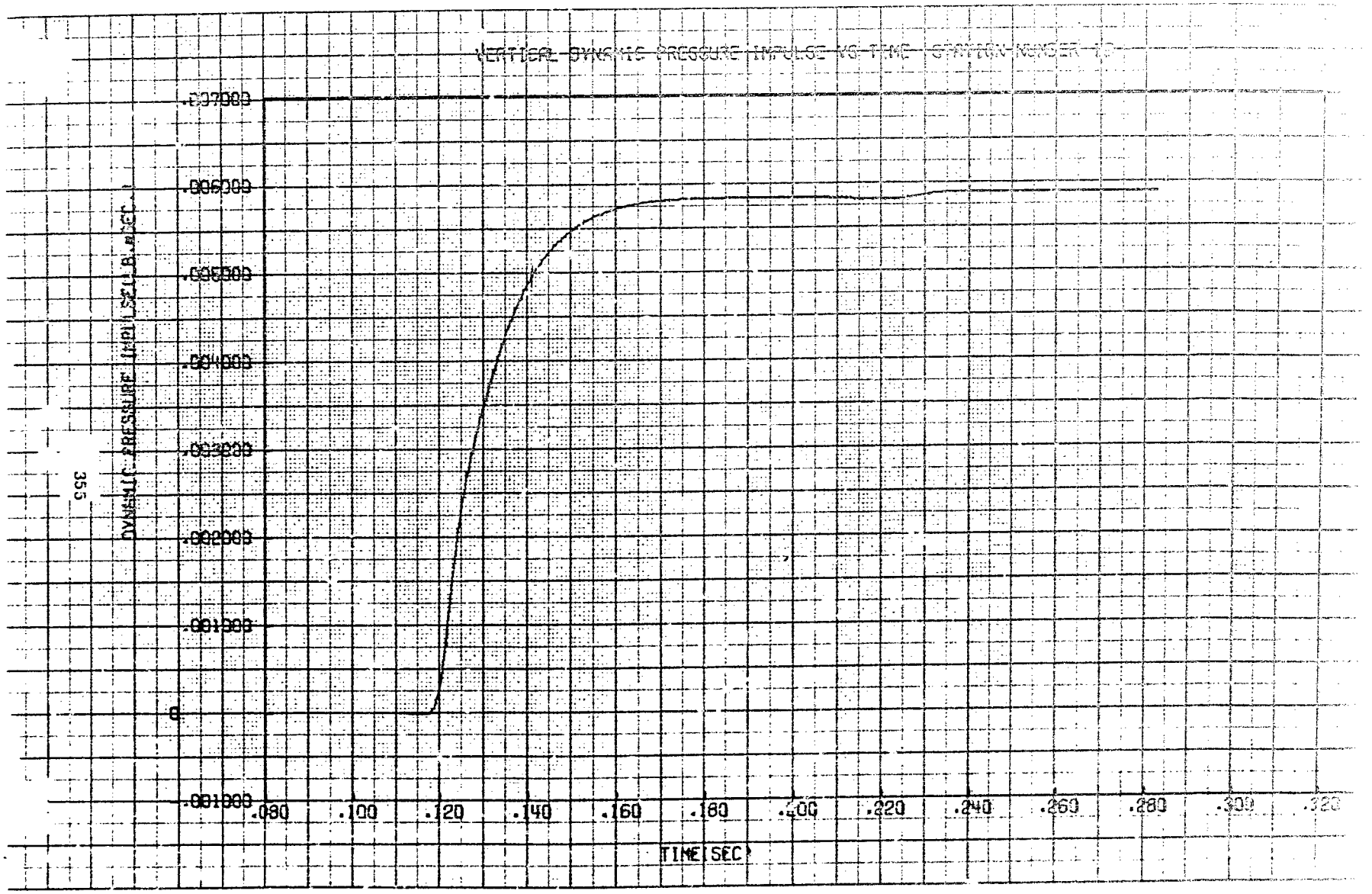

700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
.080
.100
.120
.140
.160
.180
.200
.220
TIME(SEC)
350


VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
351
SPEED(FT/SEC)

DYNAMIC PRESSURE (PSI)
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
-2.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
TIME SEC

DYNAMIC PRESSURE IMPULSE (LB./SEC.)
TIME (SEC)
.11
.12
.15
.03
.05
.01
.02
0.
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280


VERTICAL DYNAMIC PRESSURE FOR FORCE GAUGE
.60
.50
.40
.30
.20
.10
0
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)
DYNAMIC PRESSURE(PSI)
354


VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
.007000
.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)
DYNAMIC PRESSURE IMPULSE(LB.SEC/
355

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Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

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	2b. GROUP

3. REPORT TITLE

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4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

1 September 1965 to 1 June 1966

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

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

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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c. Subtask No. 1.027	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

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13. ABSTRACT

The phenomenology of two atmospheric high-explosive detonation were calculated theoretically. The first was a 20-short-ton spherical charge of TNT (loading density--1.56 gms/cc). The second was a methane-oxygen mixture (mole ratio 1 to 1.5) contained in a 55-ft-radius balloon. Both detonations took place at an altitude of 670 meters (ambient pressure 13.6 psi) with a reflecting surface 85 feet below burst point. The calculations, taken out to 300 milliseconds after detonations, were performed by using SAP, a one-dimensional Lagrangian hydrodynamic code and SHELL-OIL, a two-dimensional pure Eulerian hydrodynamic code. Volume II of this report contains the details of the results in graphical form. Included are pressure and density contours, velocity vector plots, and wave forms for 19 test stations.

DD FORM 1 JAN 64 1473

Unclassified

Security Classification

Unclassified
Security Classification

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Blast Wave						
Shock Reflection						
Mach Reflection						
Triple Point						
HE Detonation, Calculation of						
SAP						
SHELL-OIL						

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SUPPLEMENTARY

INFORMATION

AD- 803 654

DEPARTMENT OF THE AIR FORCE
AF Weapons Laboratory, RTD (AFSC)
Kirtland Air Force Base, New Mexico 87117

12 April 1967

ERRATA

AFWL-TR-66-141, Volume II

"THEORETICAL CALCULATIONS OF THE PHENOMENOLOGY OF H.E. DETONATIONS," Vol. II, Unclassified, November 1966, by William A. Whitaker, Capt, USAF, et al.

1. Replace pages 5 through 29 with the attached pages 5 through 29.

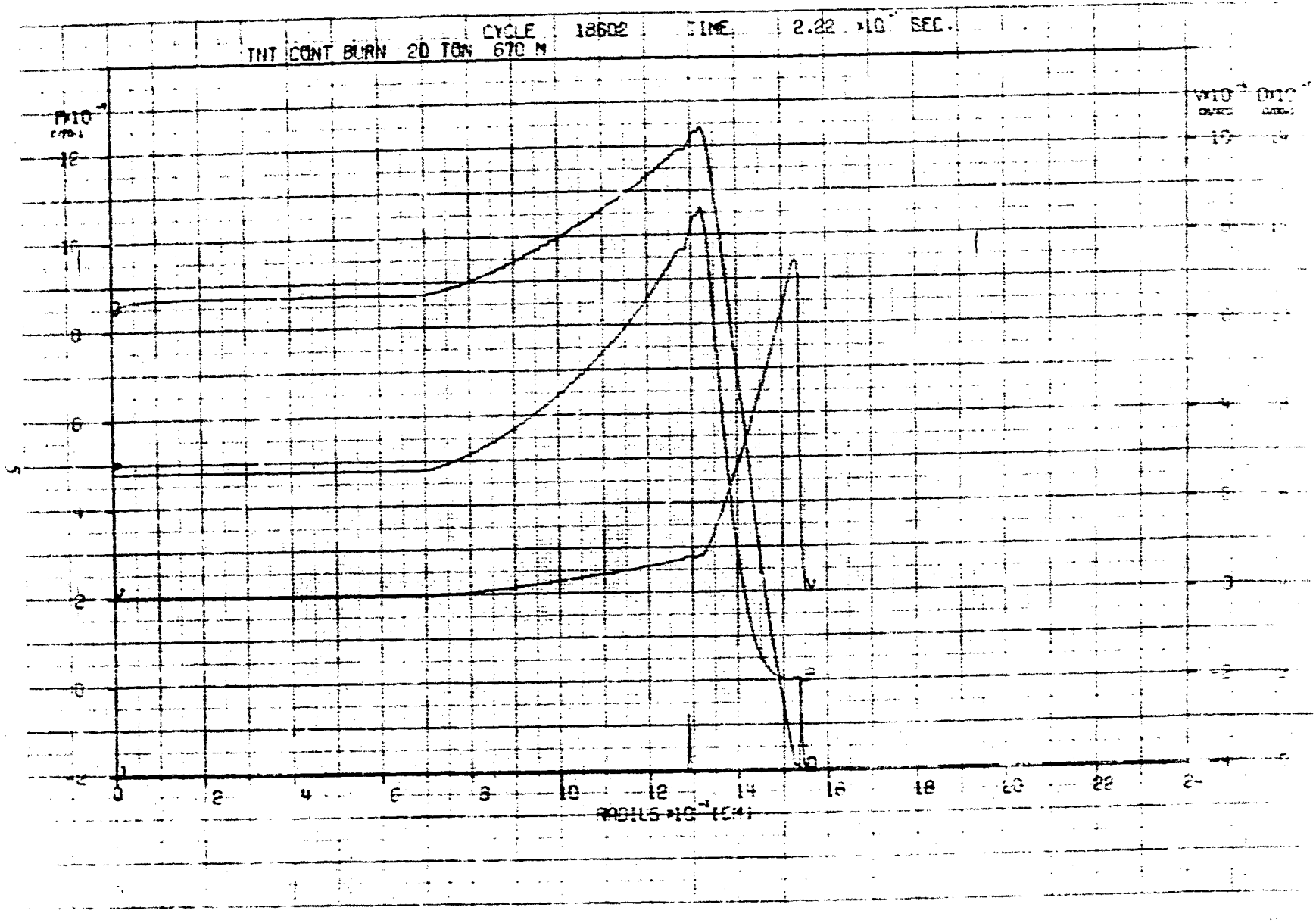
2. The units for the values appearing in the contour scales in Sections II and III are: grams/cm^3 for the density contours and dynes/cm^2 for the pressure contours.

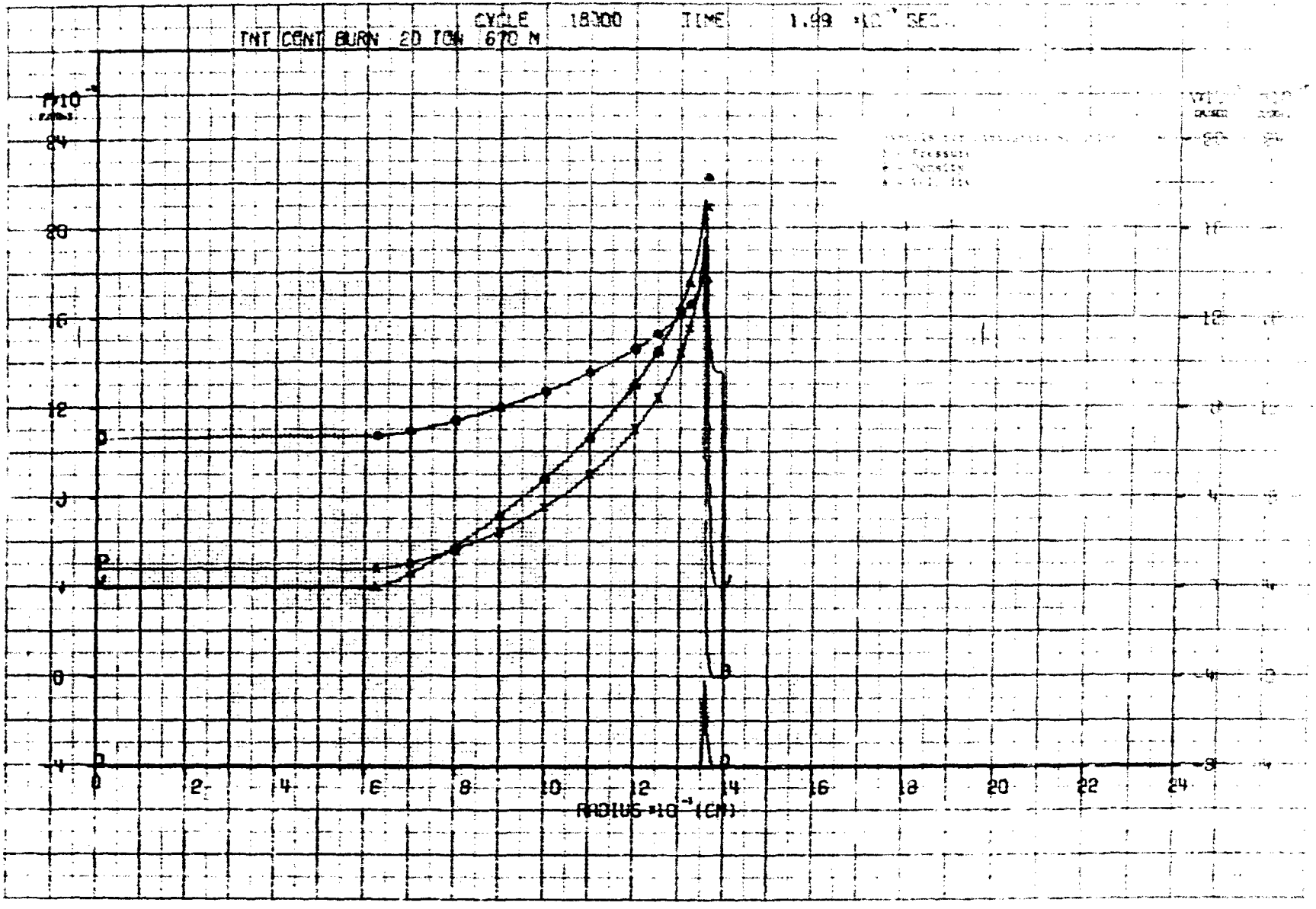
AUTHORITY:

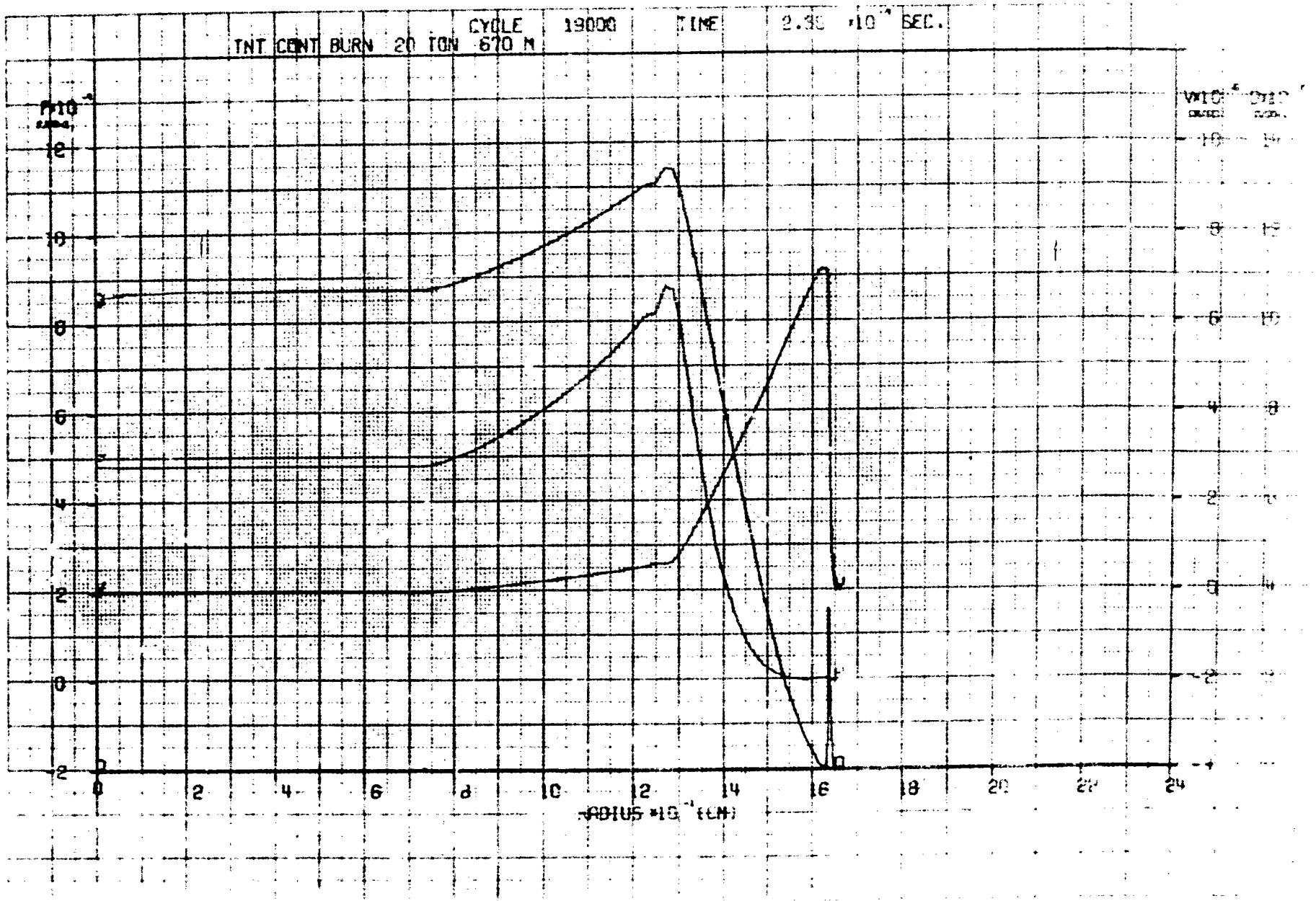
EDWARD A. NAWROCKI
Captain, USAF
4 April 1967

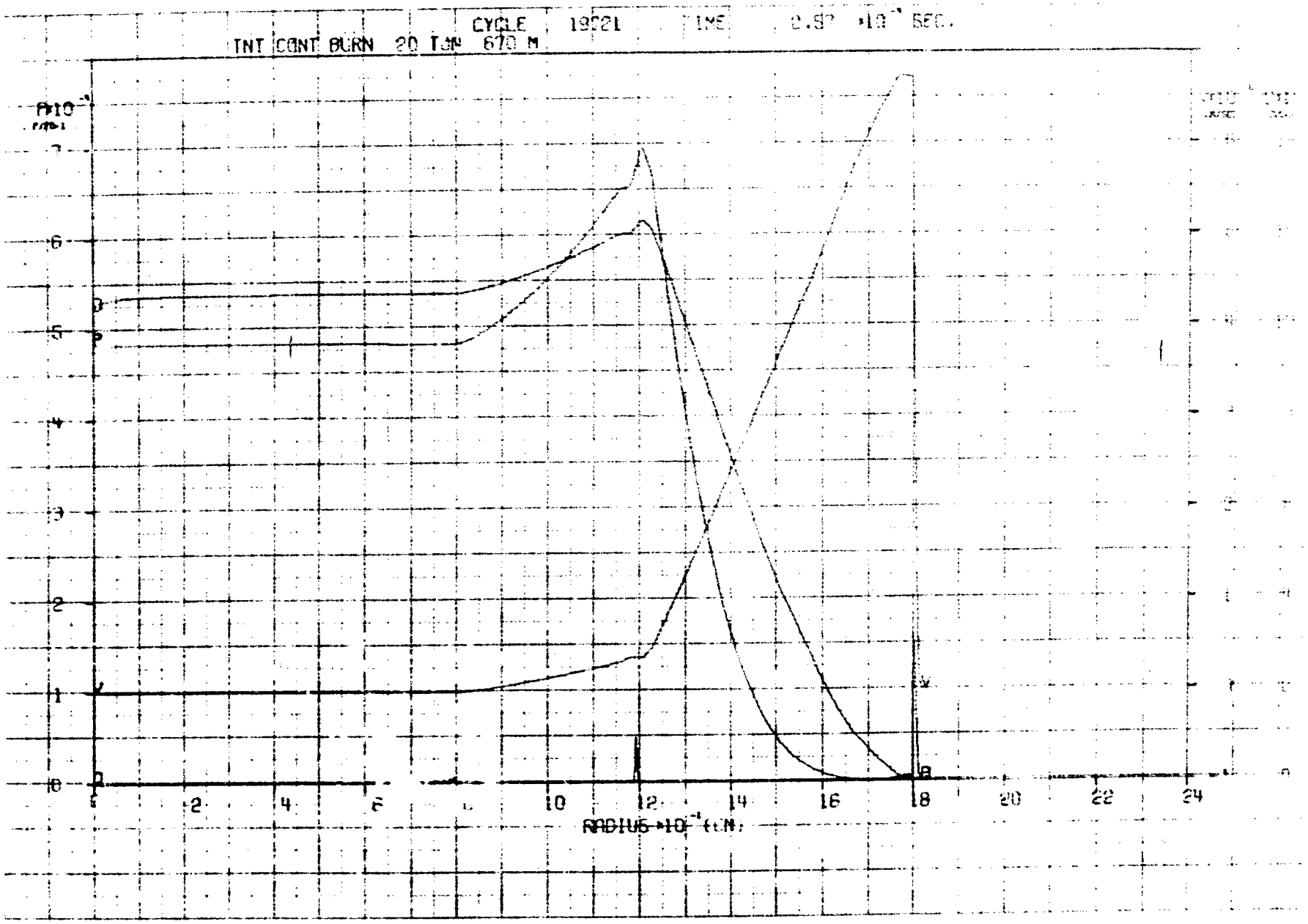
C. W. HAIG
Chief, Reports and Data Branch
Technical Information Division

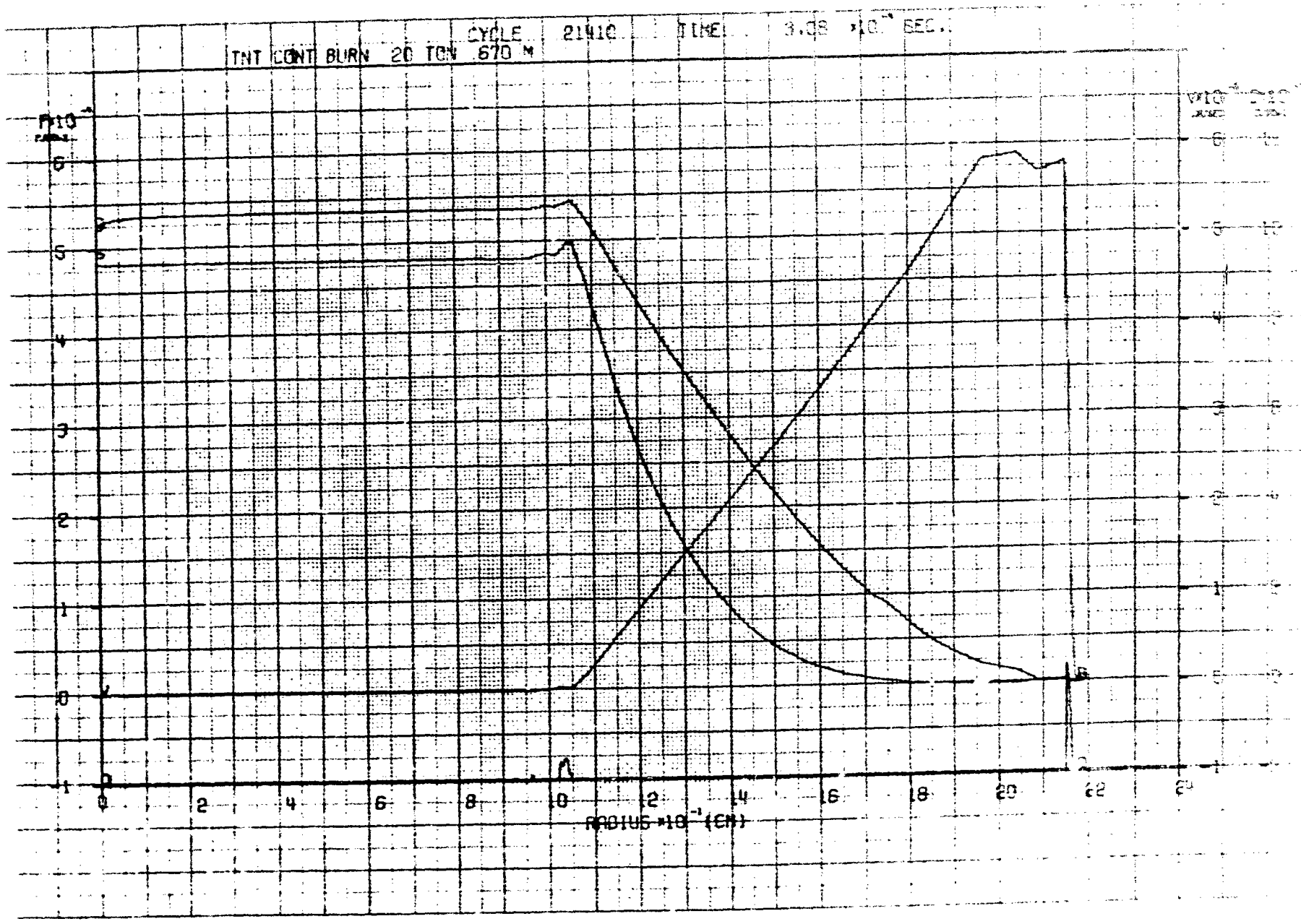
Atch
a/s

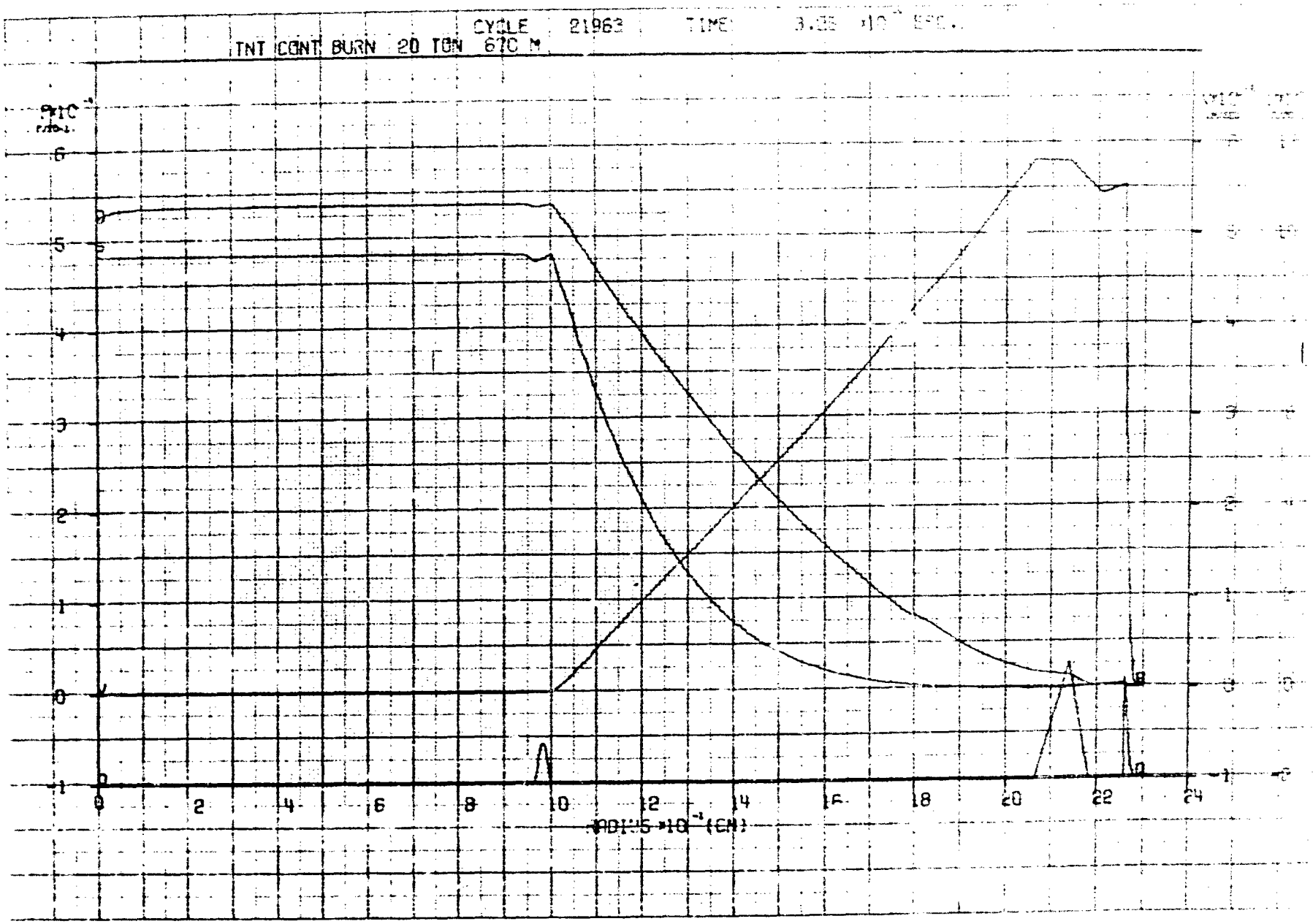

CYCLE 18602 TIME 2.22 ×10 SEC.
TNT CONT BURN 20 TON 670 M
FX10
12
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22

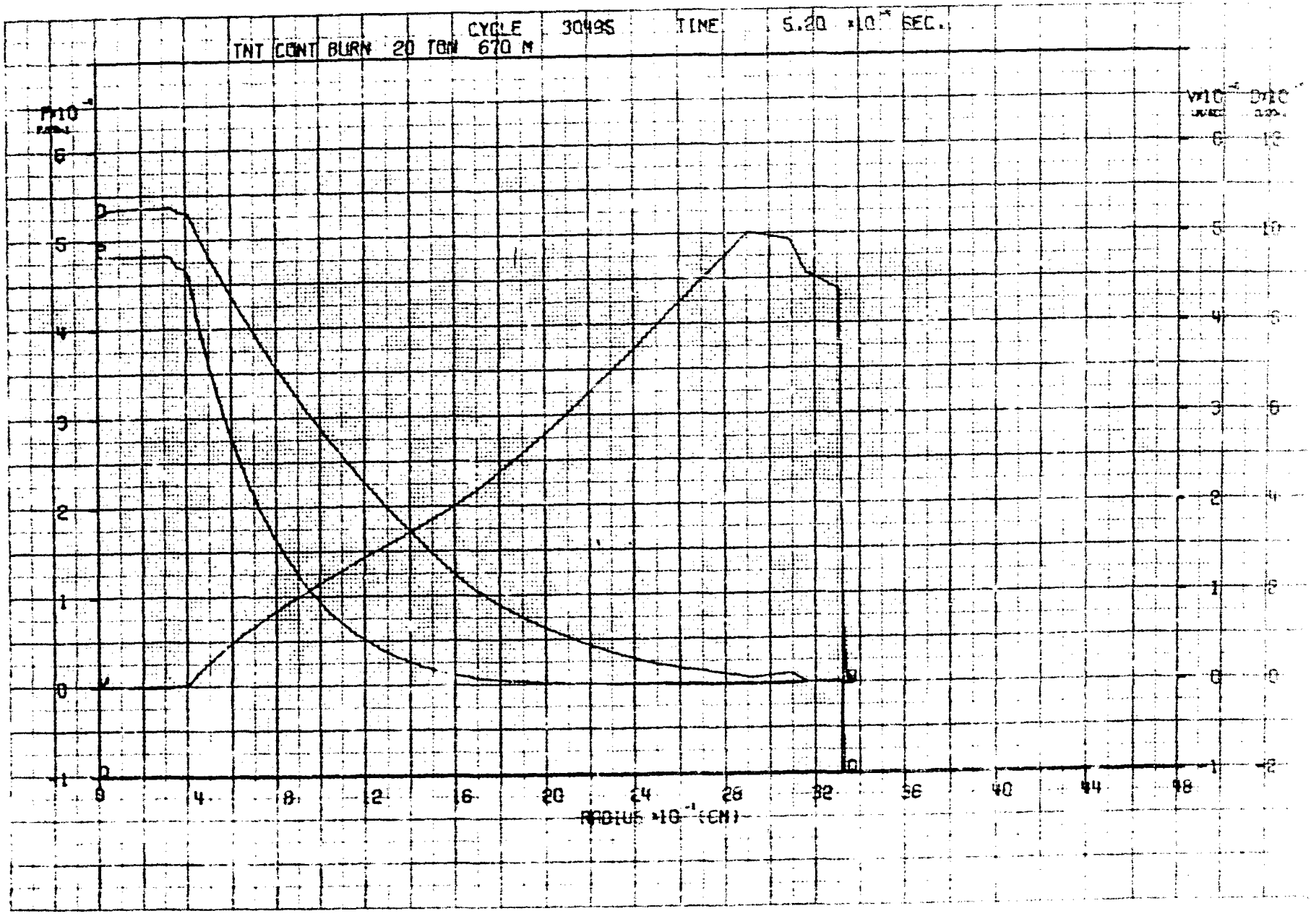

TNT CONT BURN 2D IGN 670 M
CYCLE 18300
TIME 1.99
RADIUS ×10⁻³ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24

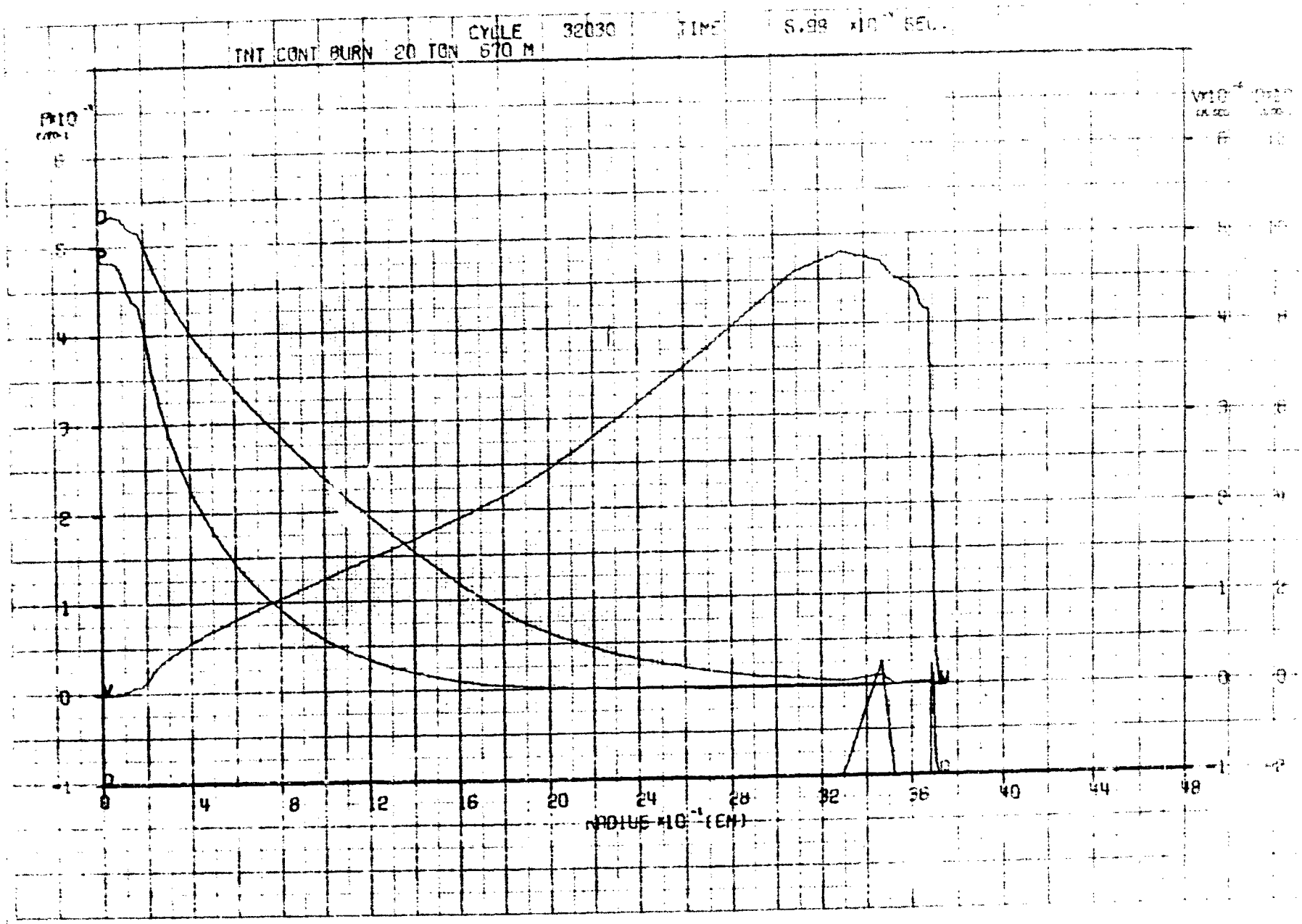

TNT CENT BURN 20 TON 670 M
CYCLE 19000
TIME
SEC.
RADIUS *10⁻¹ (CM)

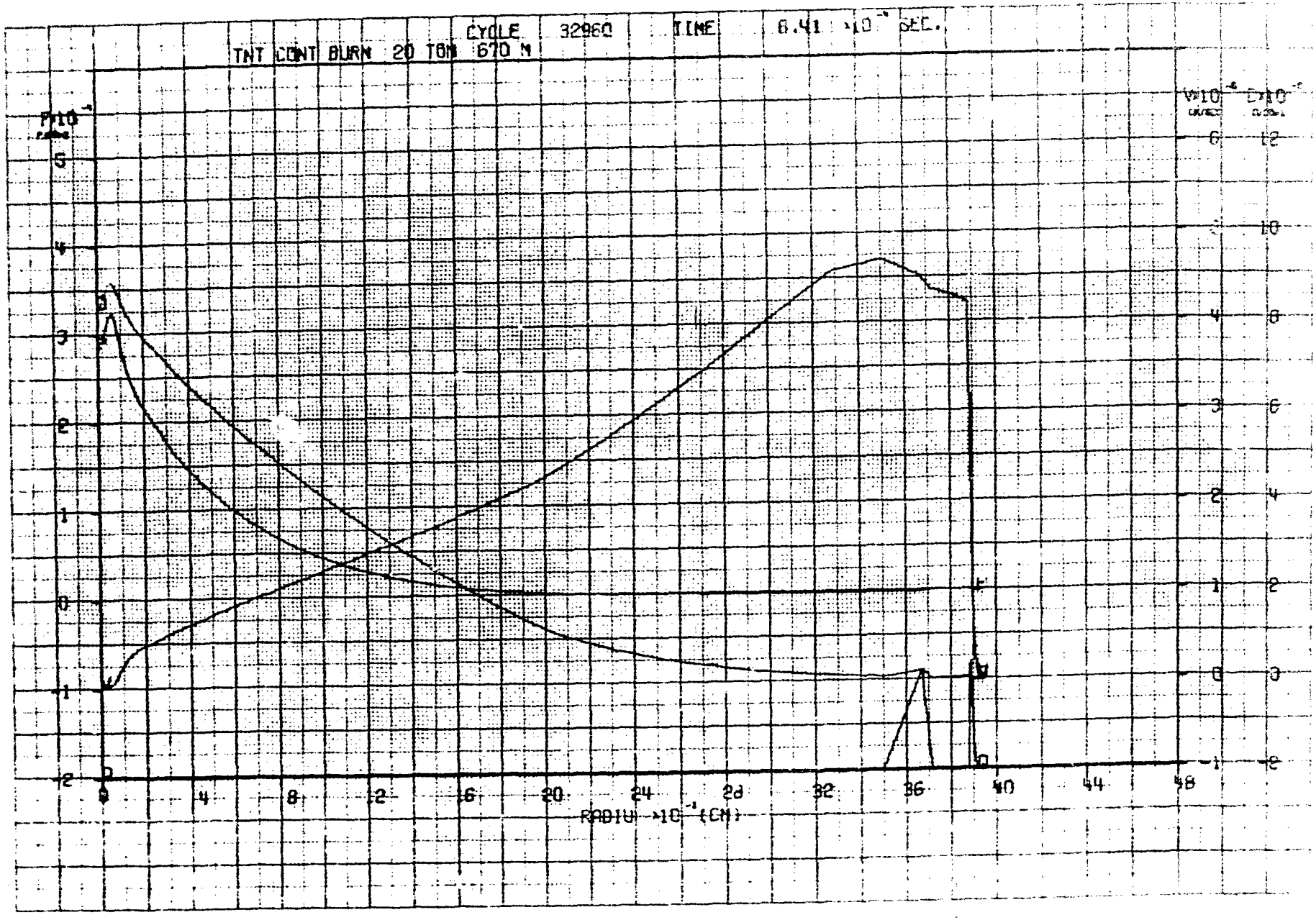

INT CONT BURN 20 TJN 670 M
CYCLE 19221
TIME
SEC.
RADIUS ×10⁻¹ (I.N.)
2
4
6
8
10
12
14
16
18
20
22
24

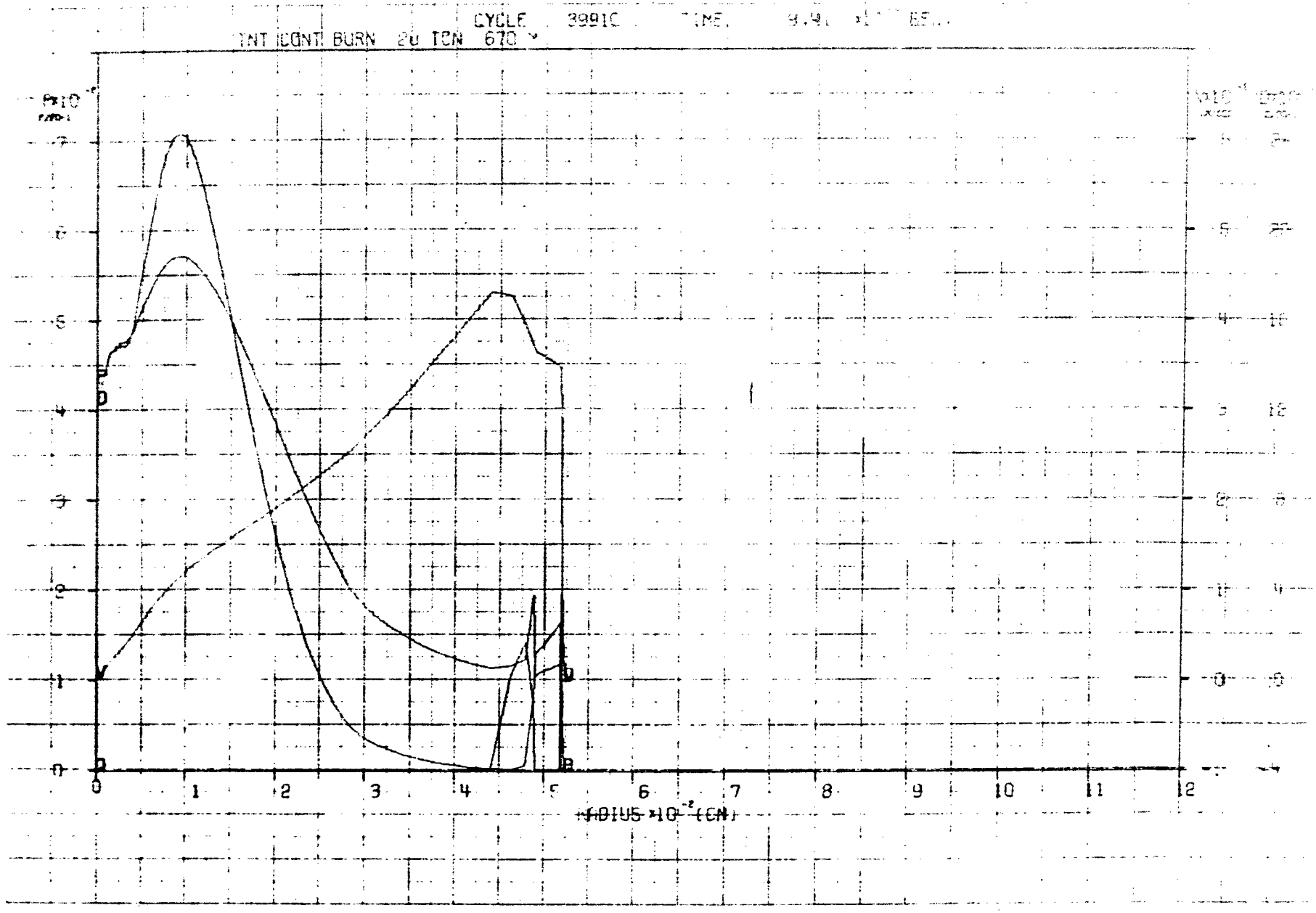

TNT CONT BURN 20 TON 670 M
CYCLE 21410
TIME 3.08 ×10⁻¹ SEC.
P×10⁻¹
RADIUS ×10⁻¹ (CM)

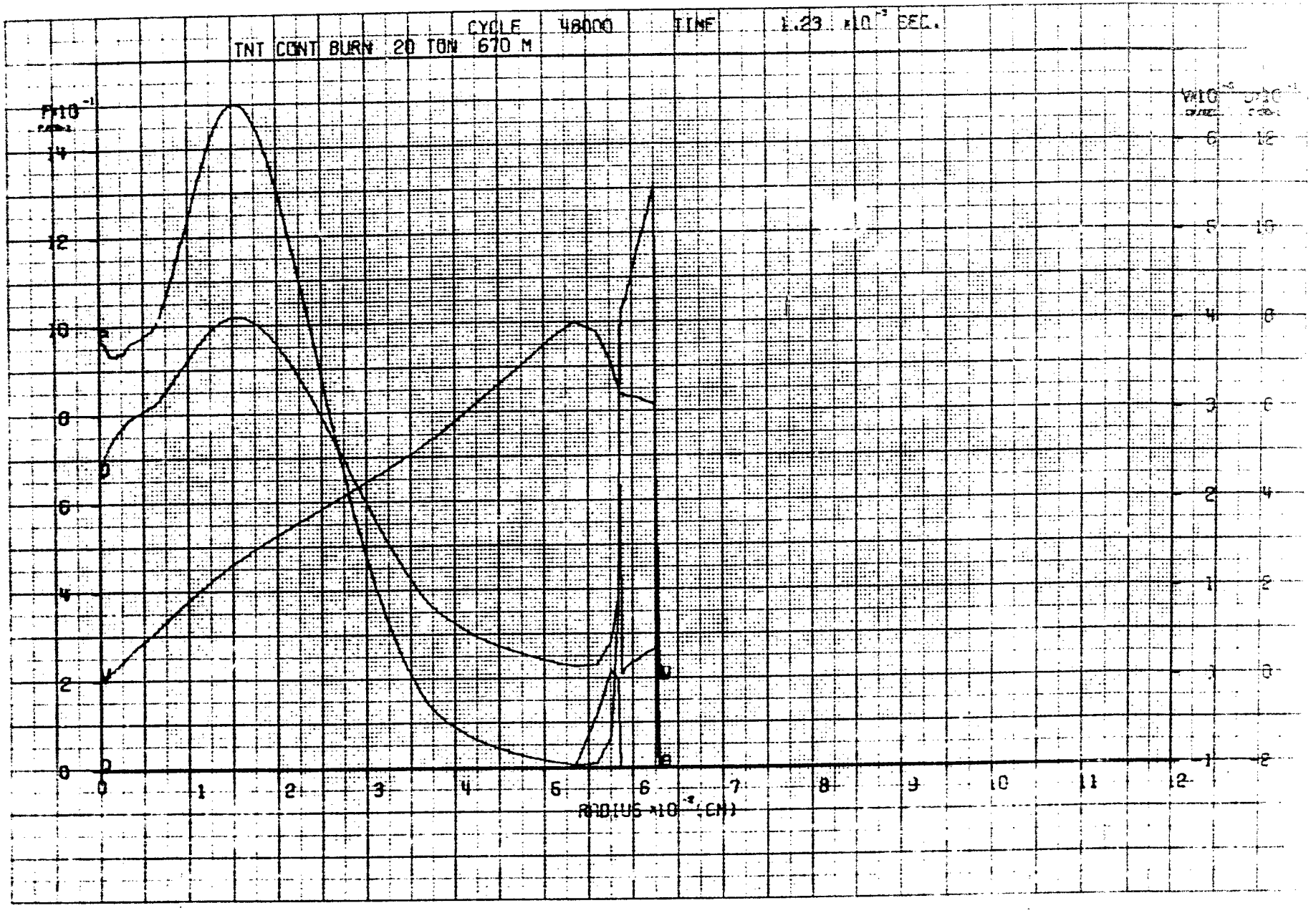

CYCLE 21963
TIME 3.35 ×10⁷ SEC.
TNT CONT BURN 20 TON 670 M
RADIUS ×10⁻¹ (CM)

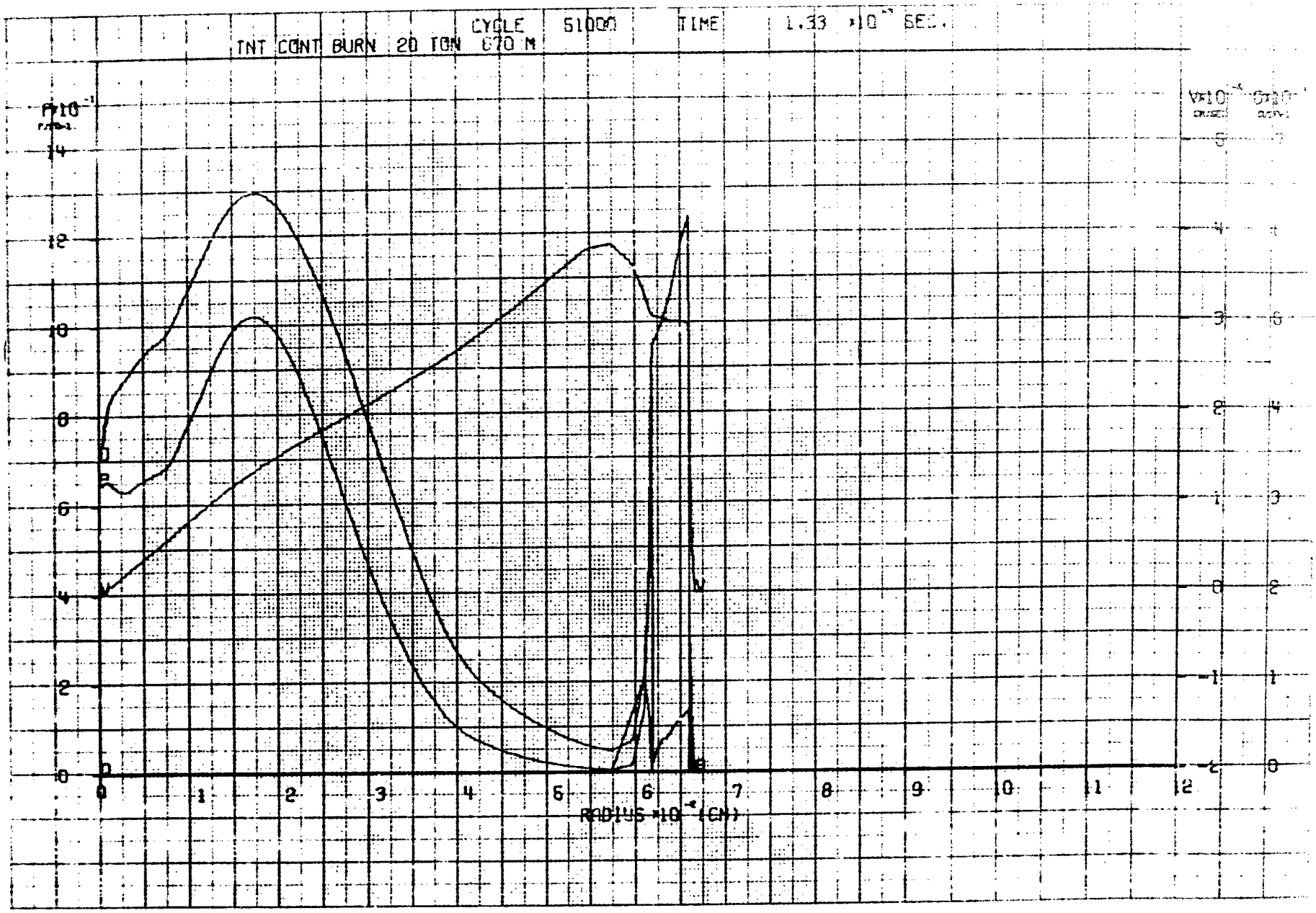

TNT CONT BURN 20 TON 670 M
CYCLE 30495
TIME 5.20 ×10⁻⁴ SEC.
P×10⁻⁴
V×10⁻⁴
D×10⁻⁴
RADIUS ×10⁻¹ (CM)
0
4
8
12
16
20
24
28
32
36
40
44
48

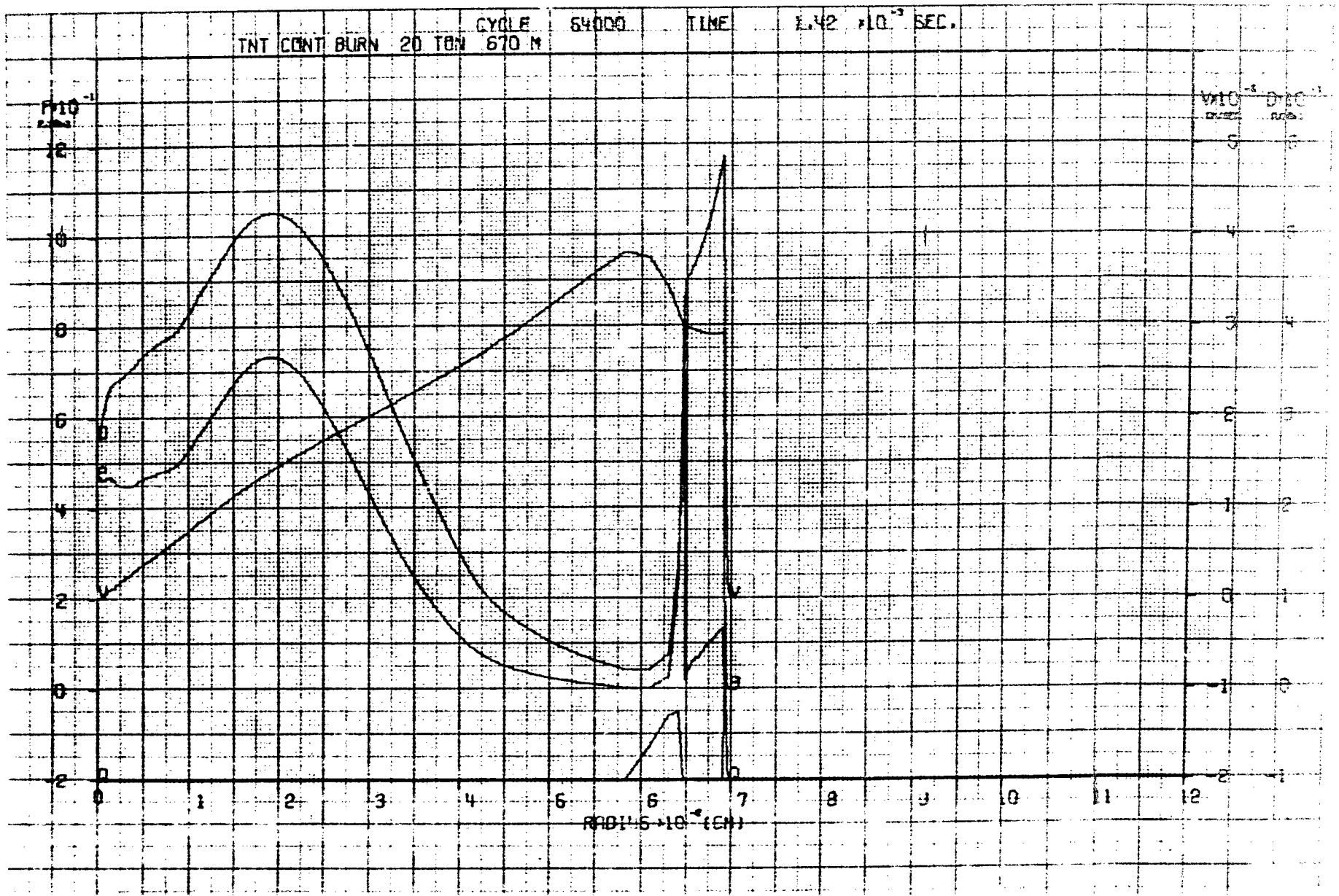

CYCLE 32030
TIME 5.99 ×10
SEC.
TNT CONT BURN 20 TON 670 M
P×10
V×10
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻¹ (CM)

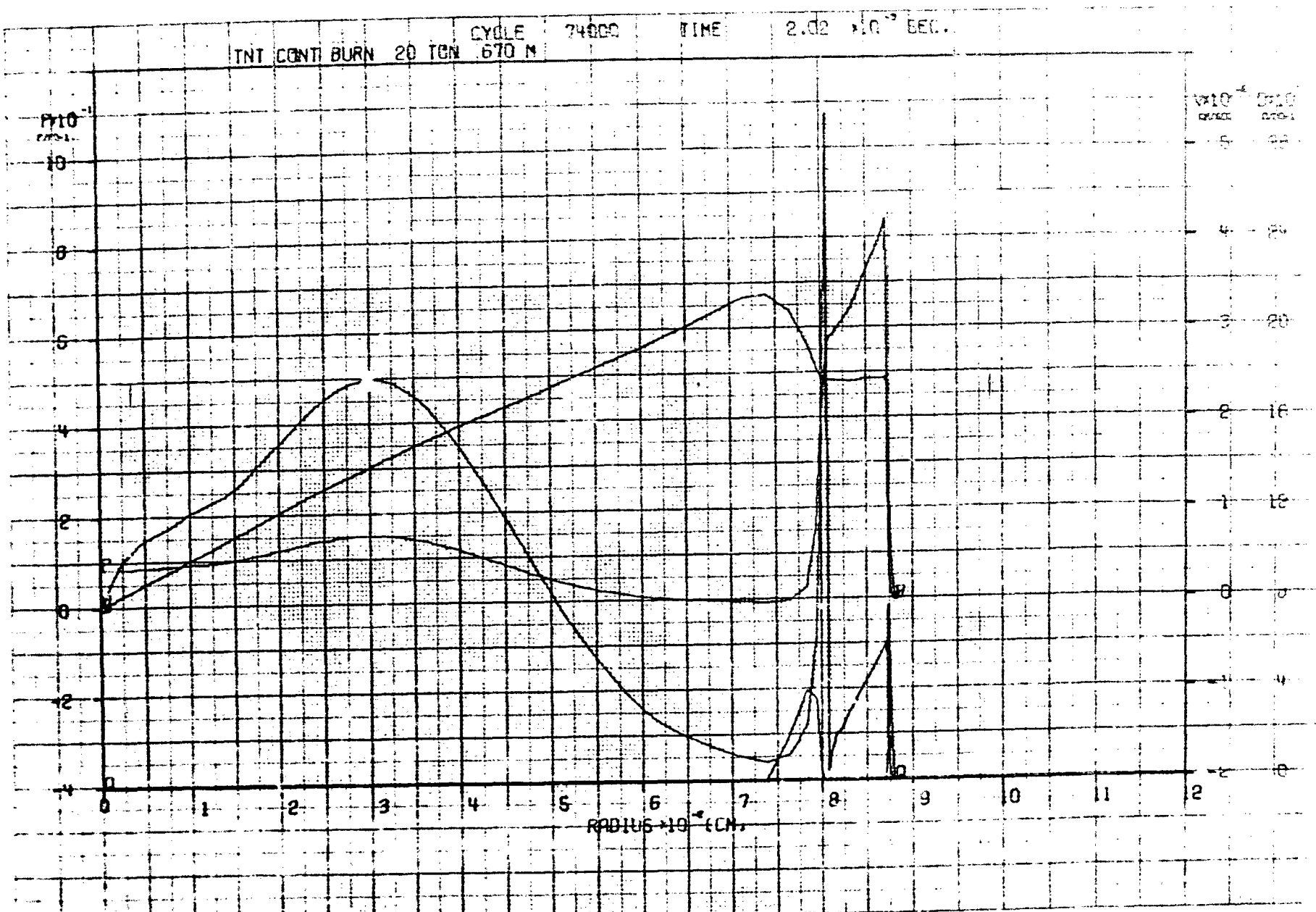

TNT CONT BURN 20 TON 670 M
CYCLE 32960
TIME 8.41 ×10⁻³ SEC.
P×10⁻⁷
V×10⁻⁶
D×10⁻⁶
RADIUS ×10⁻¹ (CM)

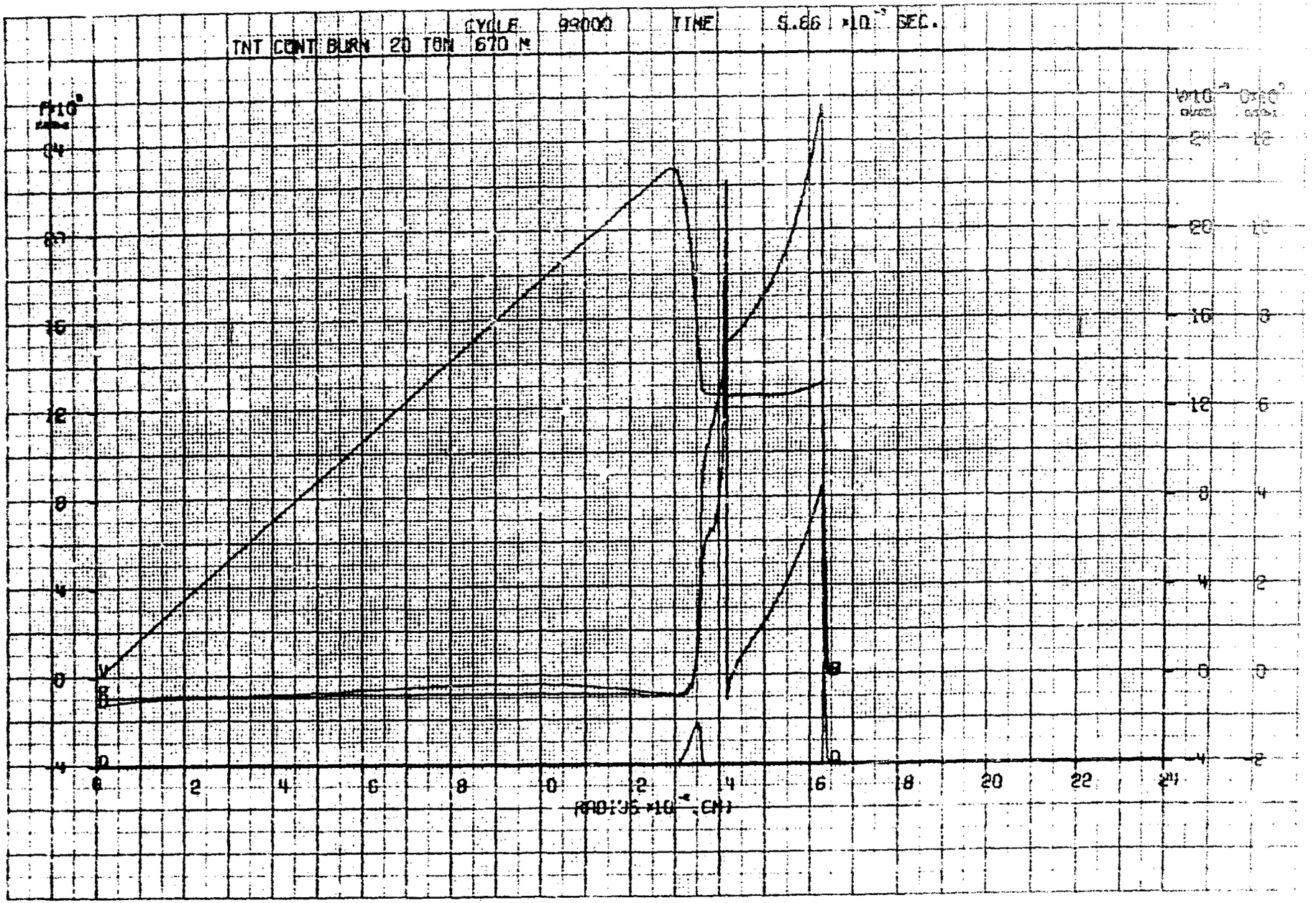

INT (CONT) BURN 20 TON 670
0
1
2
3
4
5
6
7
8
9
10
11
12
RADIUS ×10⁻² (CM)

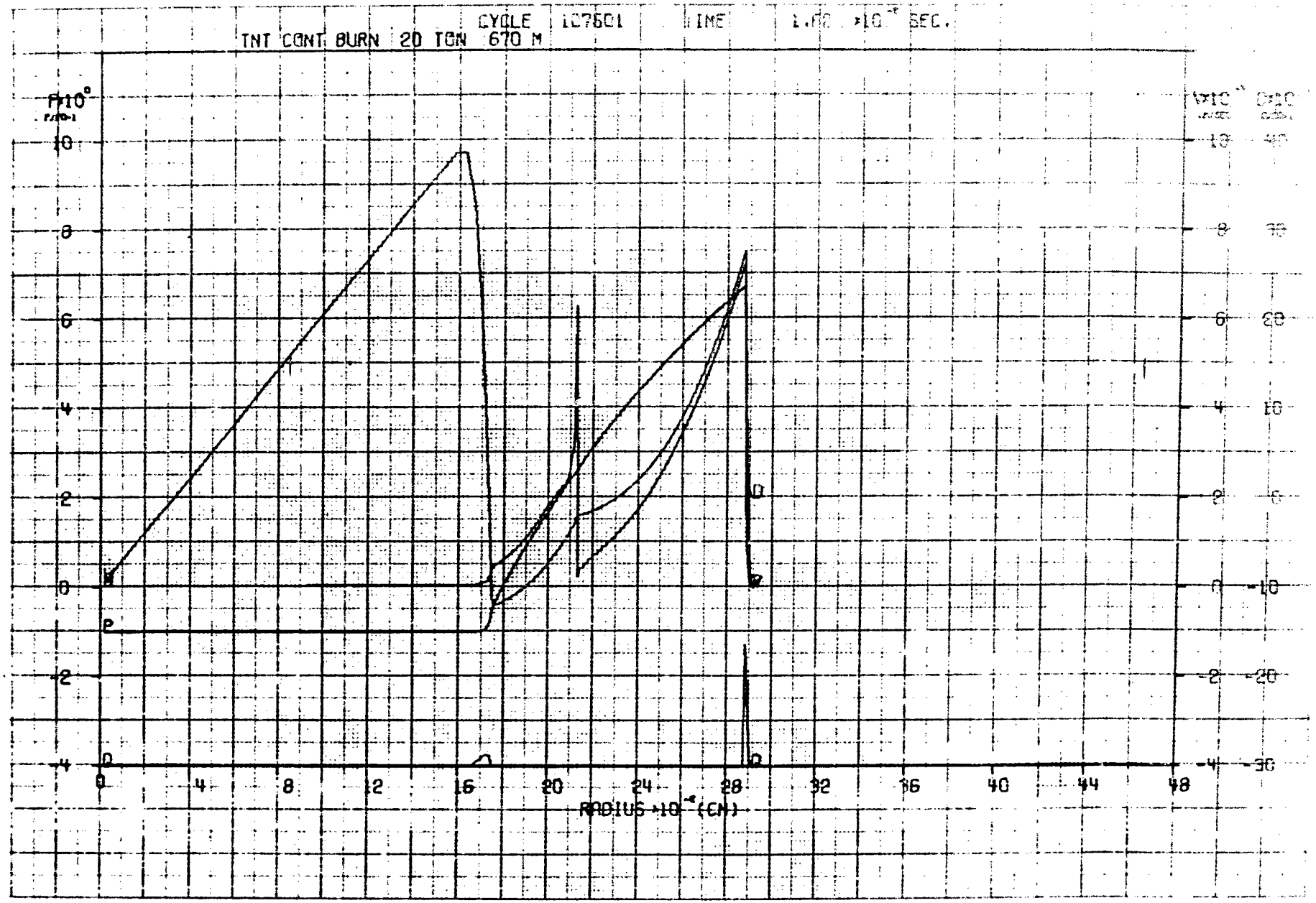

CYCLE 48000 TIME 1.23 ×10⁻³ SEC.
TNT CONT BURN 20 TON 670 M
P×10⁻¹
V×10⁻⁵
RADIUS ×10⁻² (CM)


TNT CONT BURN 20 TON 670 M
CYCLE 51000
TIME 1.33 ×10⁻³ SEC.
P×10⁻¹
V×10⁻⁴
U×10⁻⁴
RADIUS ×10⁻⁴ (CM)

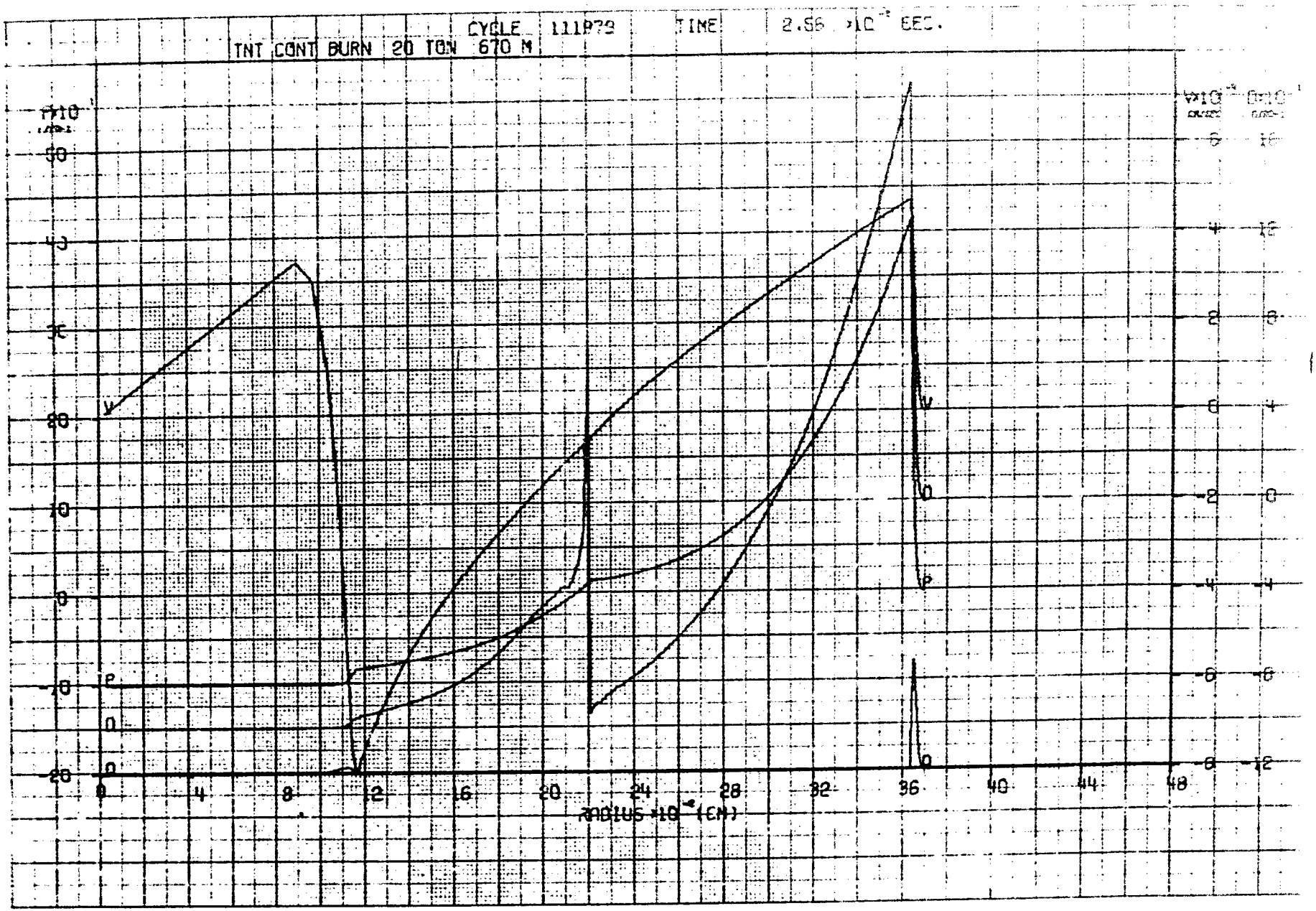

CYCLE 54000 TIME 1.42 ×10⁻³ SEC.
TNT CONT BURN 20 TON 670 M
P×10⁻¹
V×10⁻⁵ D×10⁻¹
RADIUS ×10⁻⁴ (CM)

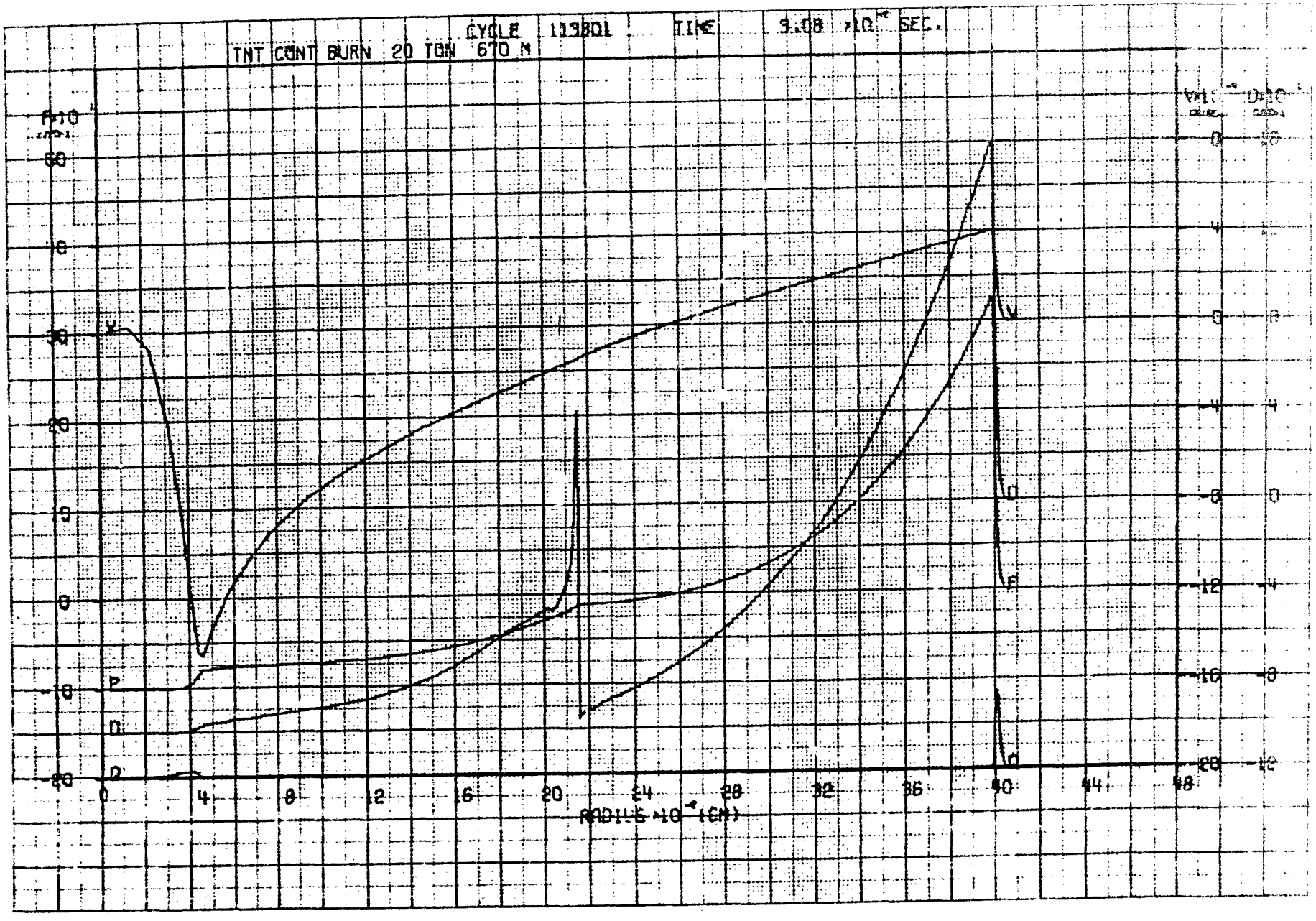

TNT CONT BURN 20 TON .670 M
CYCLE 24000
TIME 2.02 ×10⁻³ SEC.
PY10⁻¹
RADIUS ×10⁻⁴ (CM)
0
1
2
3
4
5
6
7
8
9
10
11
12

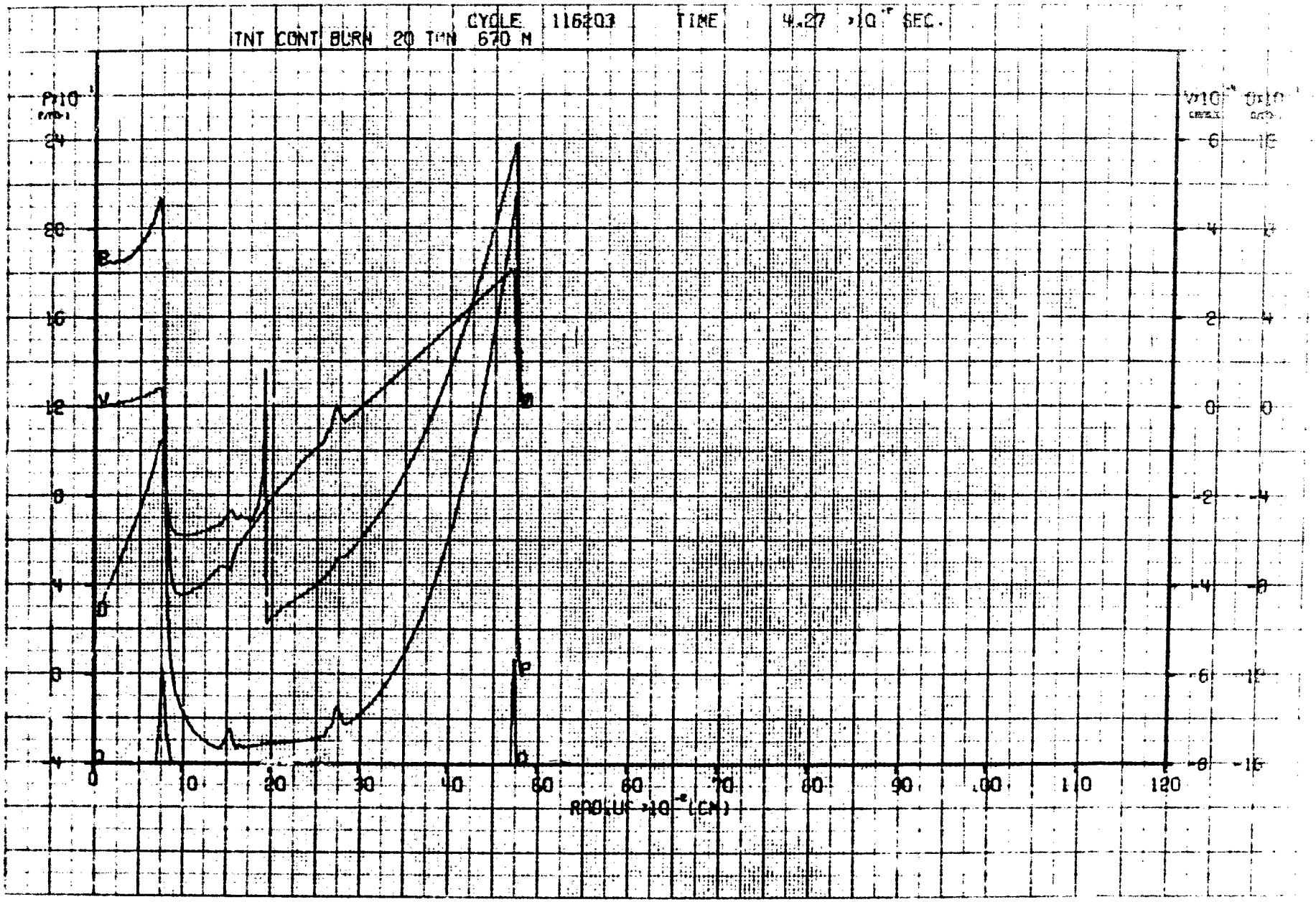

TNT CONT BURN 20 TON 670 M
CYCLE 99000 TIME 5.86 ×10⁻² SEC.
P×10⁶
0
2
4
6
8
0
2
4
6
8
20
22
24
(RADIUS ×10⁻² CM)

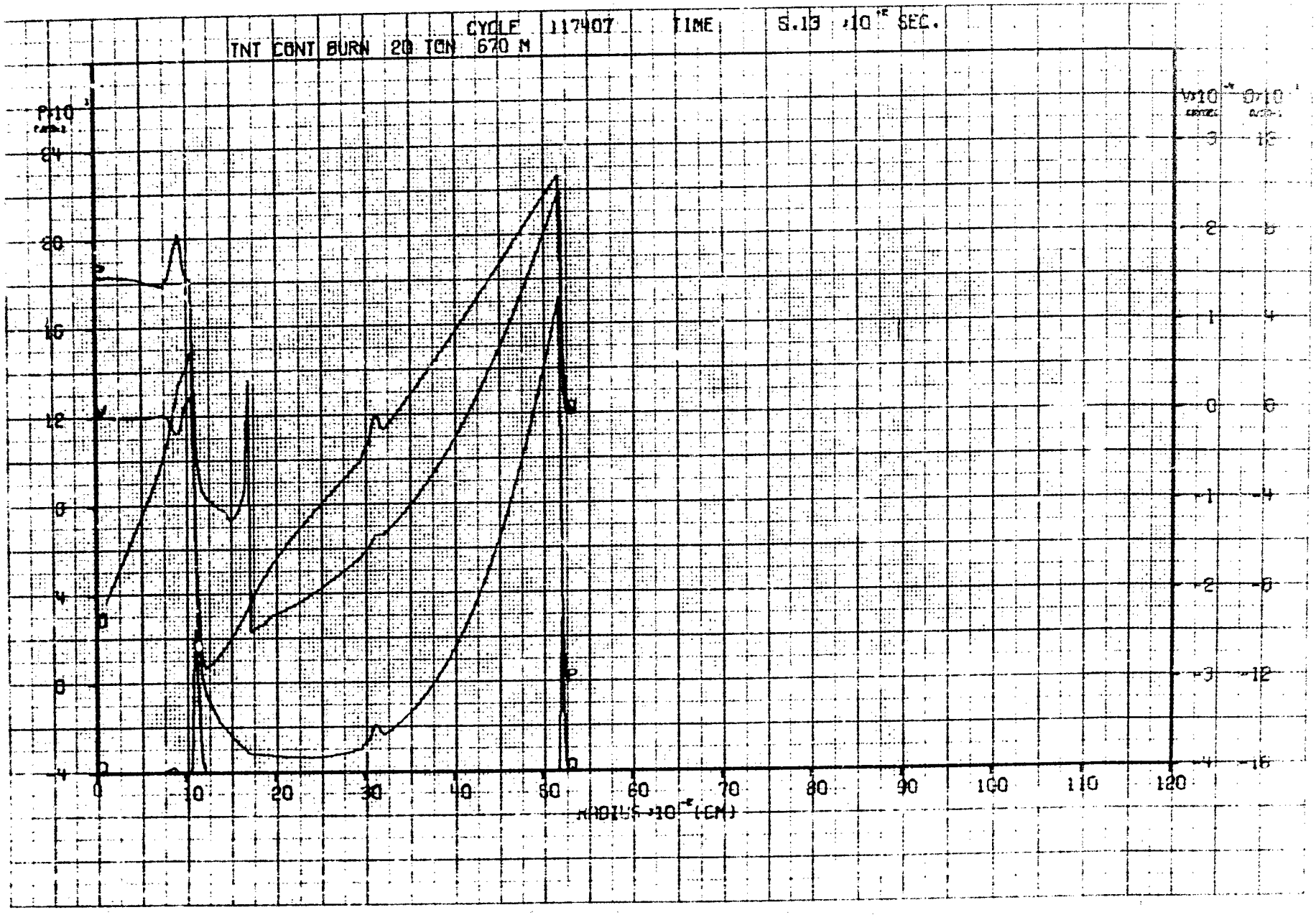

TNT CONT BURN 20 TON 670 M
CYCLE 107501
TIME
SEC.
RADIUS ×10⁻⁶ (CM)

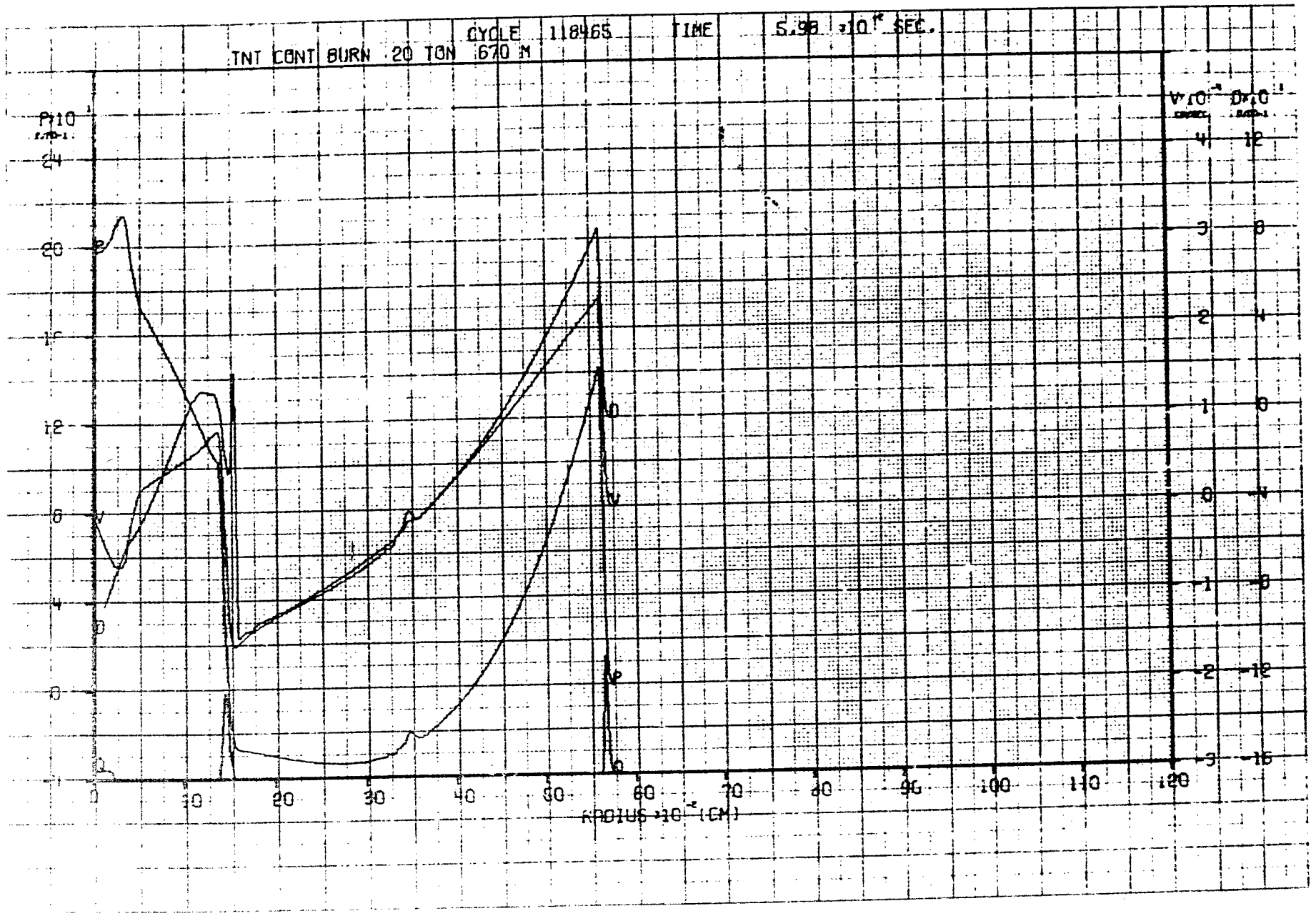
TNT CONT BURN 20 TON 670 M
CYCLE 108471
TIME 1.80 ×10⁻² SEC.
RADIUS ×10⁻² (CM)


TNT CONT BURN 20 TON 670 M
CYCLE 111872
TIME 2.56 ×10⁻⁴ SEC.
RADIUS ×10⁻⁴ (CM)
V
P
0
4
8
12
16
20
24
28
32
36
40
44
48

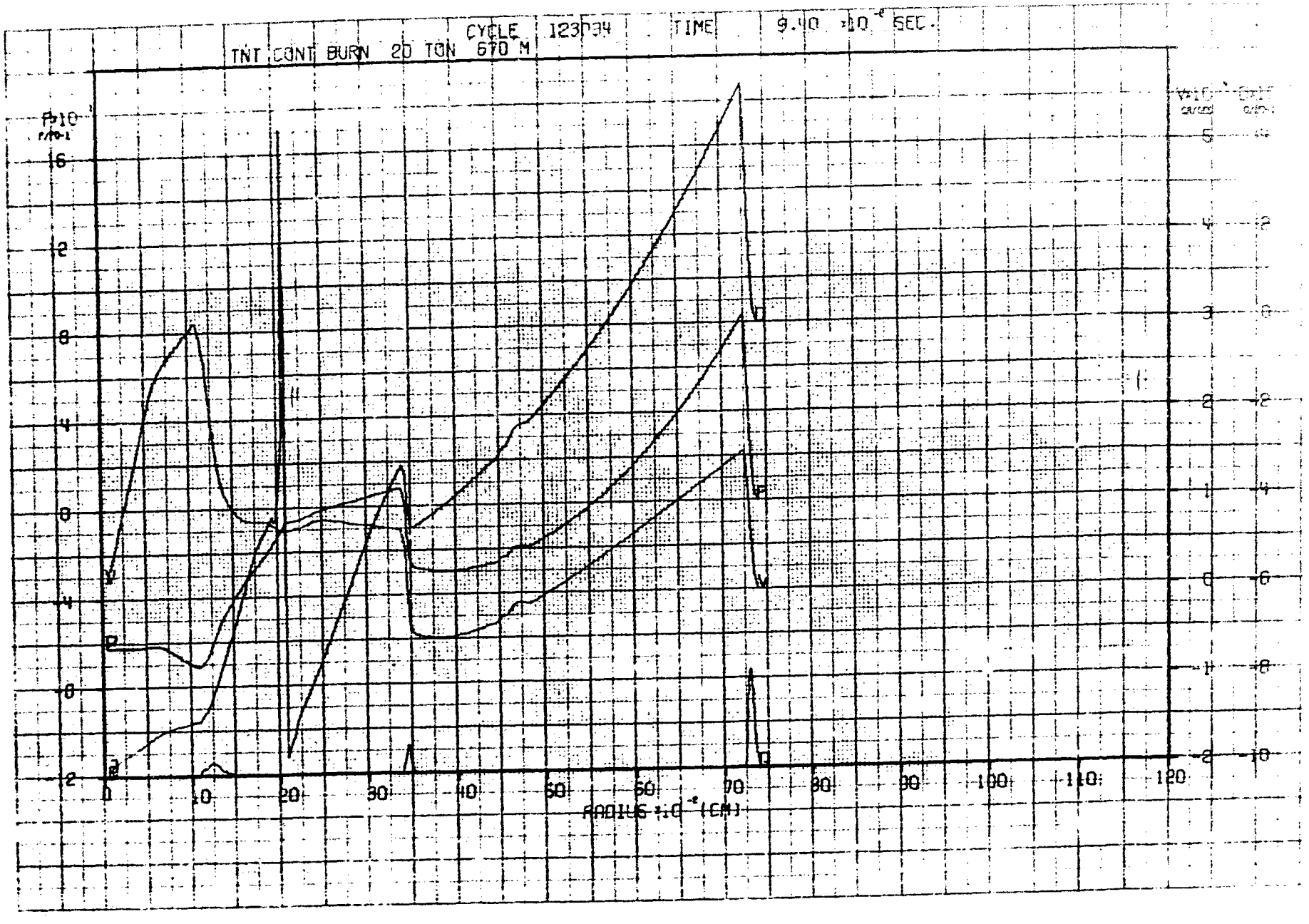

TNT CONT BURN 20 TON 670 M
CYCLE 113801
TIME 9.08 ×10⁻⁴ SEC.
P×10⁻³
V
P
D
Q
RADIUS ×10⁻⁴ (CM)

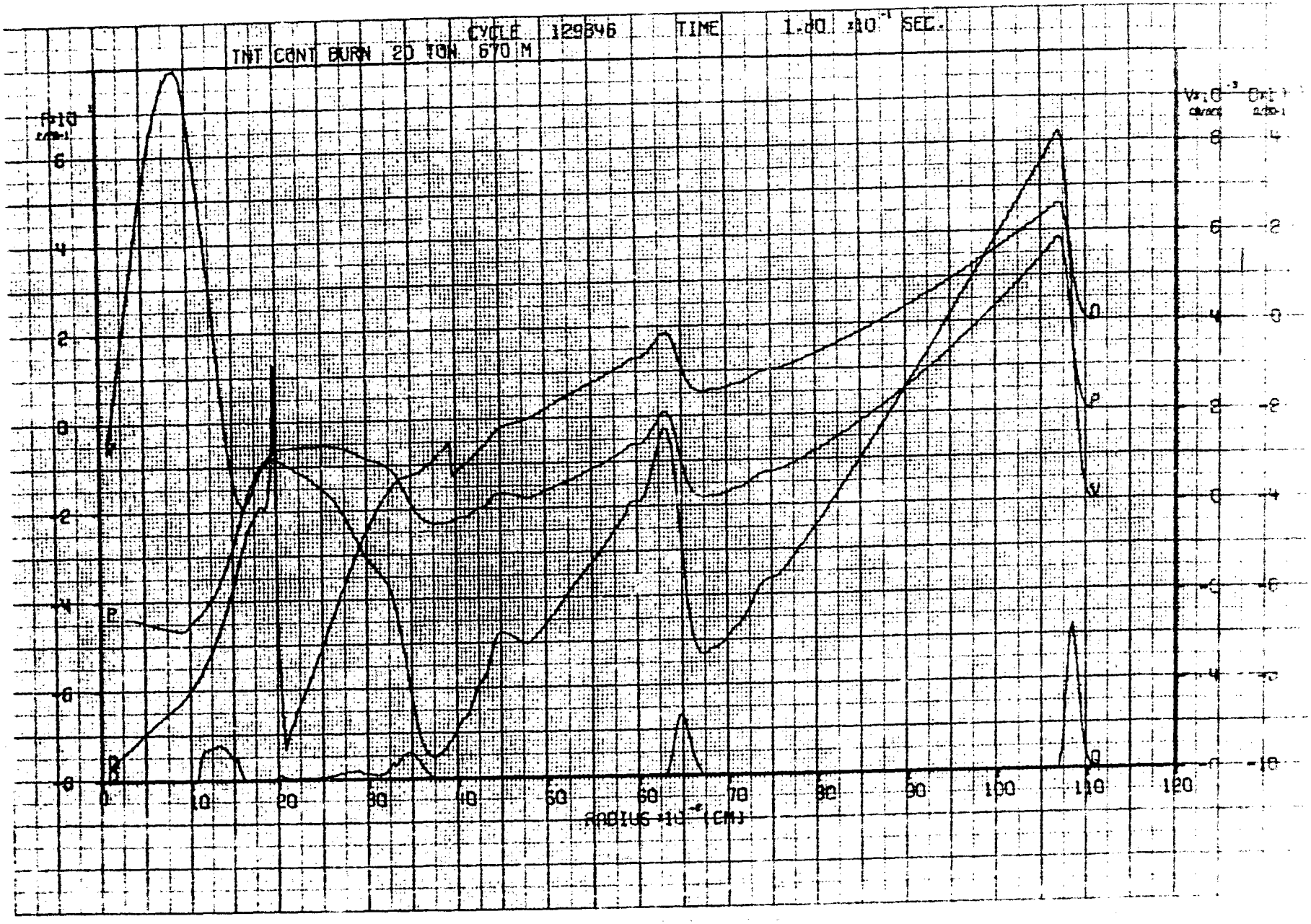

TNT CONT BURN 20 TON 670 M
CYCLE 116203
TIME 4.27 ×10⁻⁶ SEC.
P×10⁻⁶
V×10⁻⁶
U×10⁻⁶
RADIUS ×10⁻⁶ (CM)
0
10
20
30
40
50
60
70
80
90
100
110
120


TNT CONT BURN 20 TON 670 M
CYCLE 117407
TIME 5.13 ×10⁻² SEC.
P×10⁻³ (atm)
V×10⁻⁴ (cm³)
RADIUS ×10⁻² (CM)
0
10
20
30
40
50
60
70
80
90
100
110
120


CYCLE 118465 TIME 5.98 ×10⁻² SEC.
TNT CONT BURN 20 TON 670 M
P×10
V×10⁻⁵
D×10
RADIUS ×10⁻² (CM)
0
10
20
30
40
50
60
70
80
90
100
110
120

INT CONT BURN 20 TON 670 M
CYCLE 120S15
TIME 7.70 ×10⁴ SEC.


TNT CONT BURN 20 TON 670 M
CYCLE 123034
TIME 9.40 ×10⁻⁴ SEC.
RADIUS ×10⁻² (CM)
0
10
20
30
40
50
60
70
80
90
100
110
120


CYCLE 129846
TIME 1.00 x10⁻¹ SEC.
TNT CONT BURN 20 TON 670 M
P x10⁵ dyne/cm²
V x10⁻³ cm/sec
Qx10⁻⁶ gm/cm³
P
V
Q
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS x10⁻⁶ (CM)