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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
WILLIAM A. WHITAKER
Captain, USAF
Project Officer

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

Claude K. Stambaugh
CLAUDE K. STAMBAUGH
Colonel, USAF
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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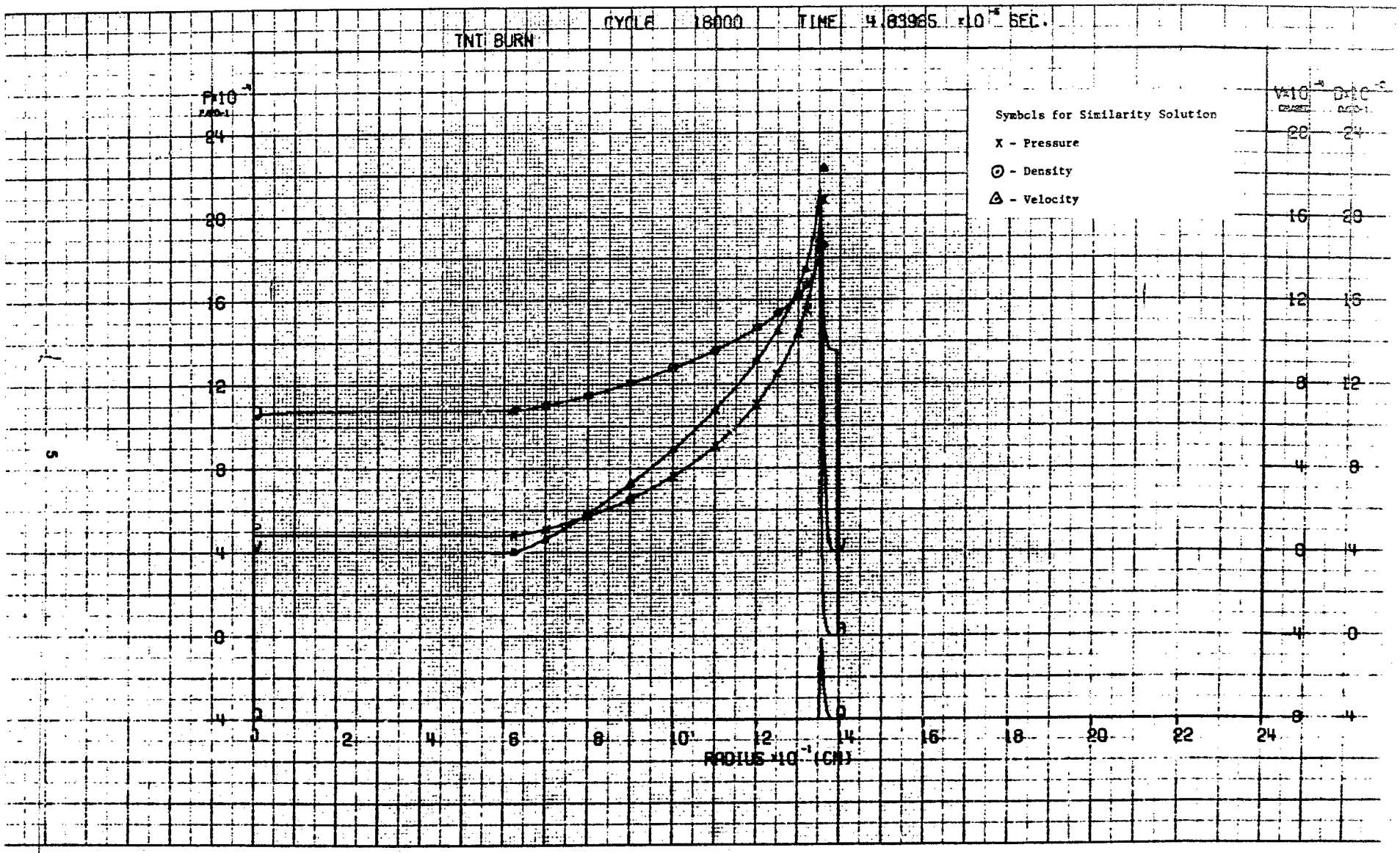
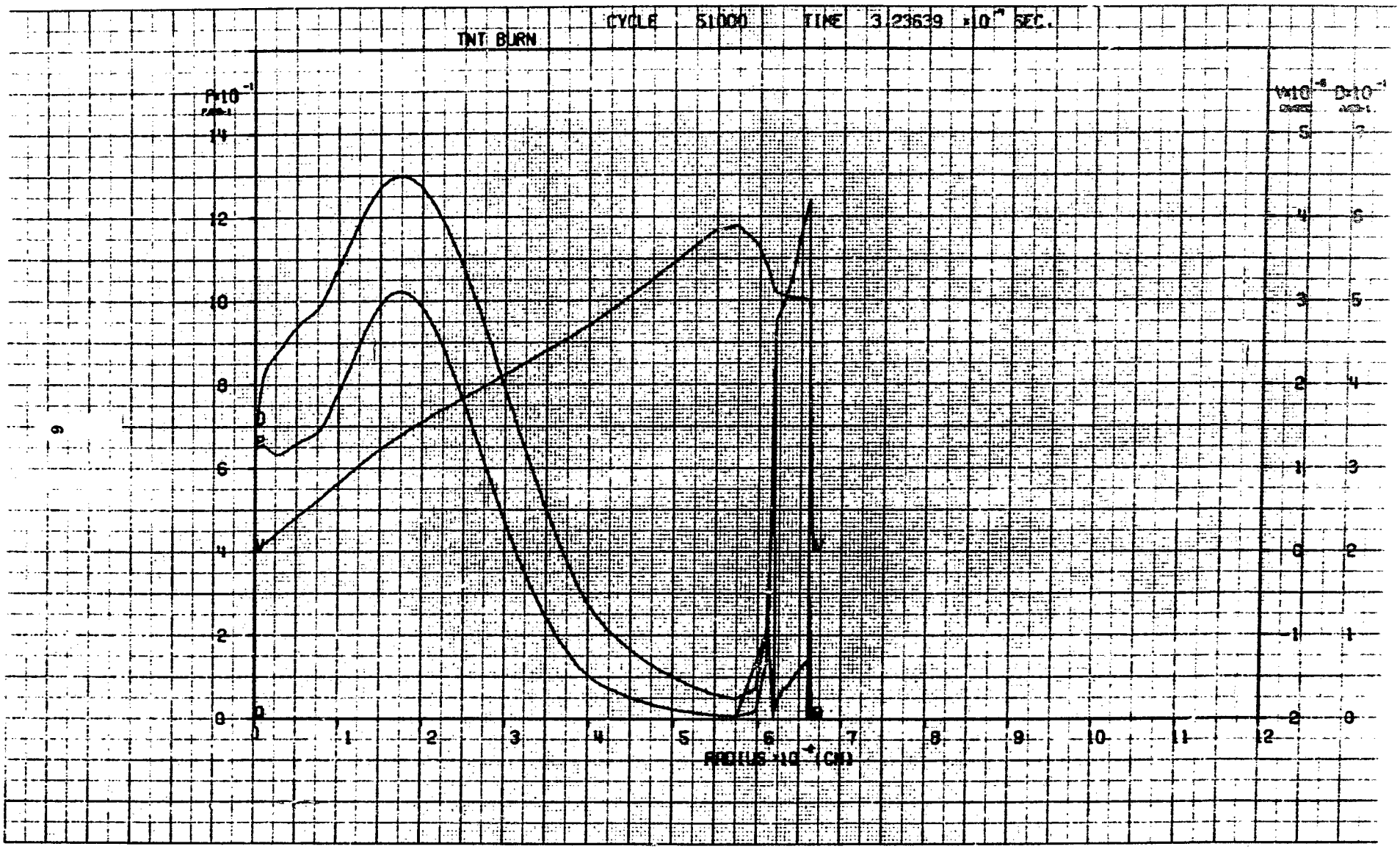
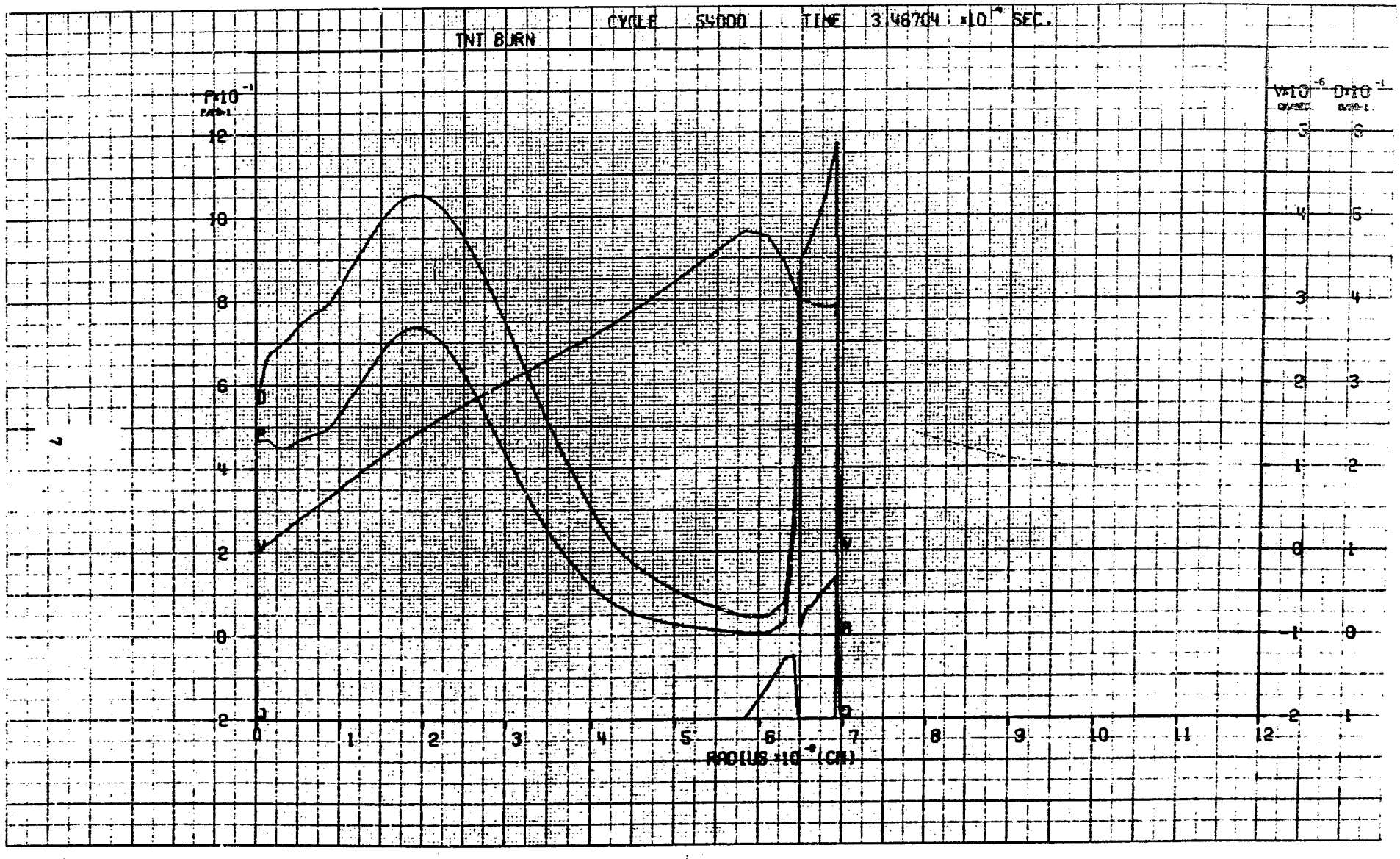
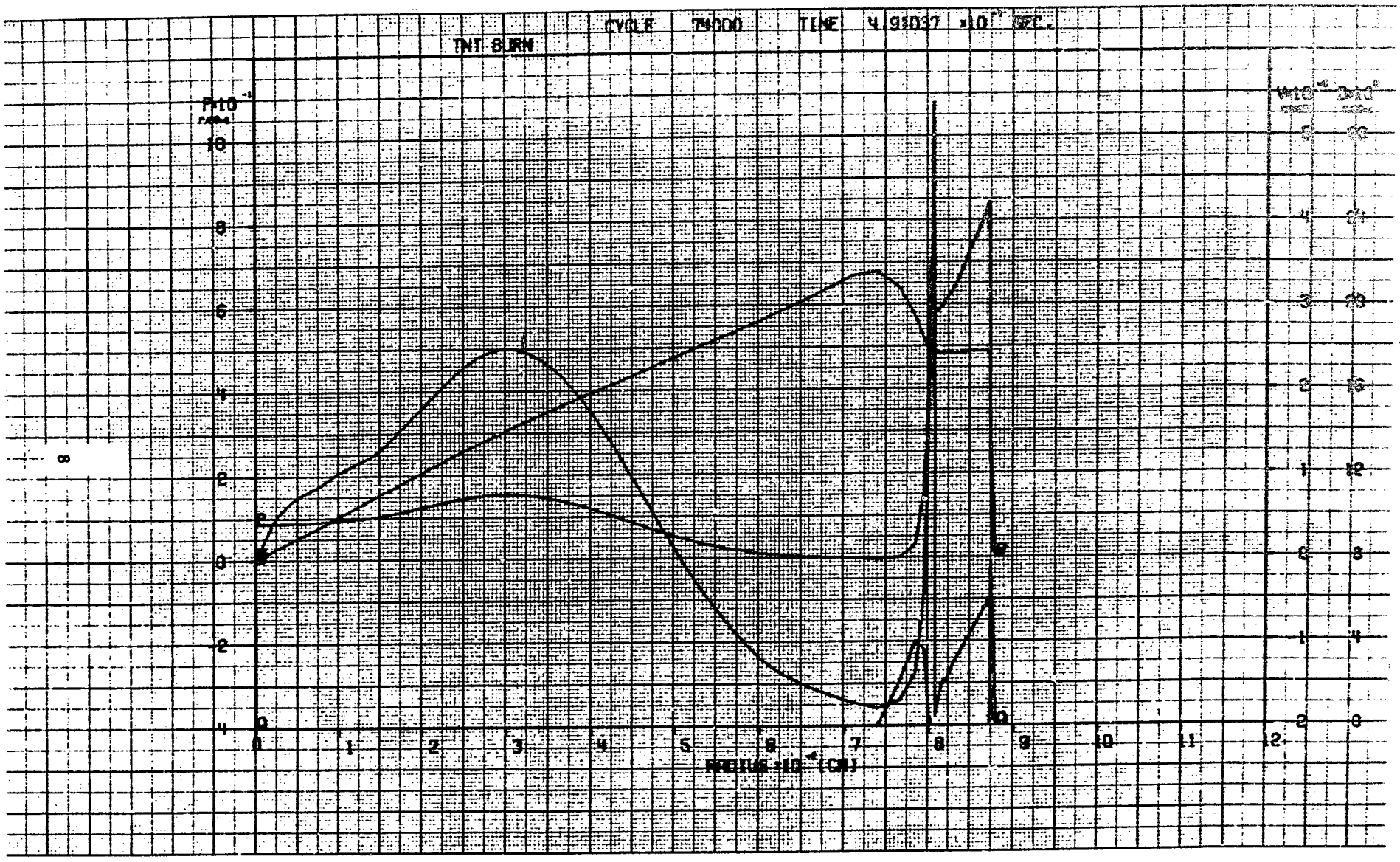
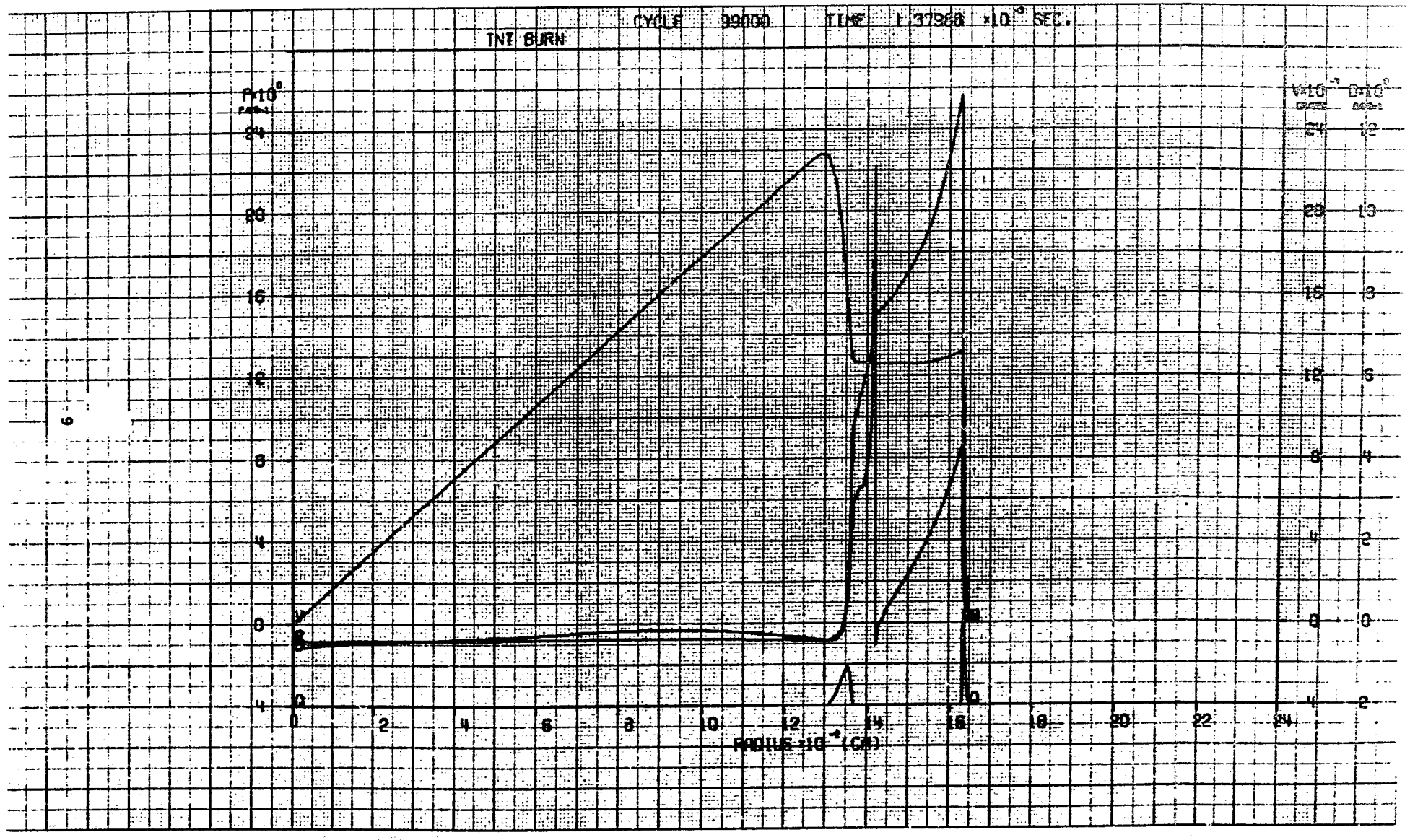
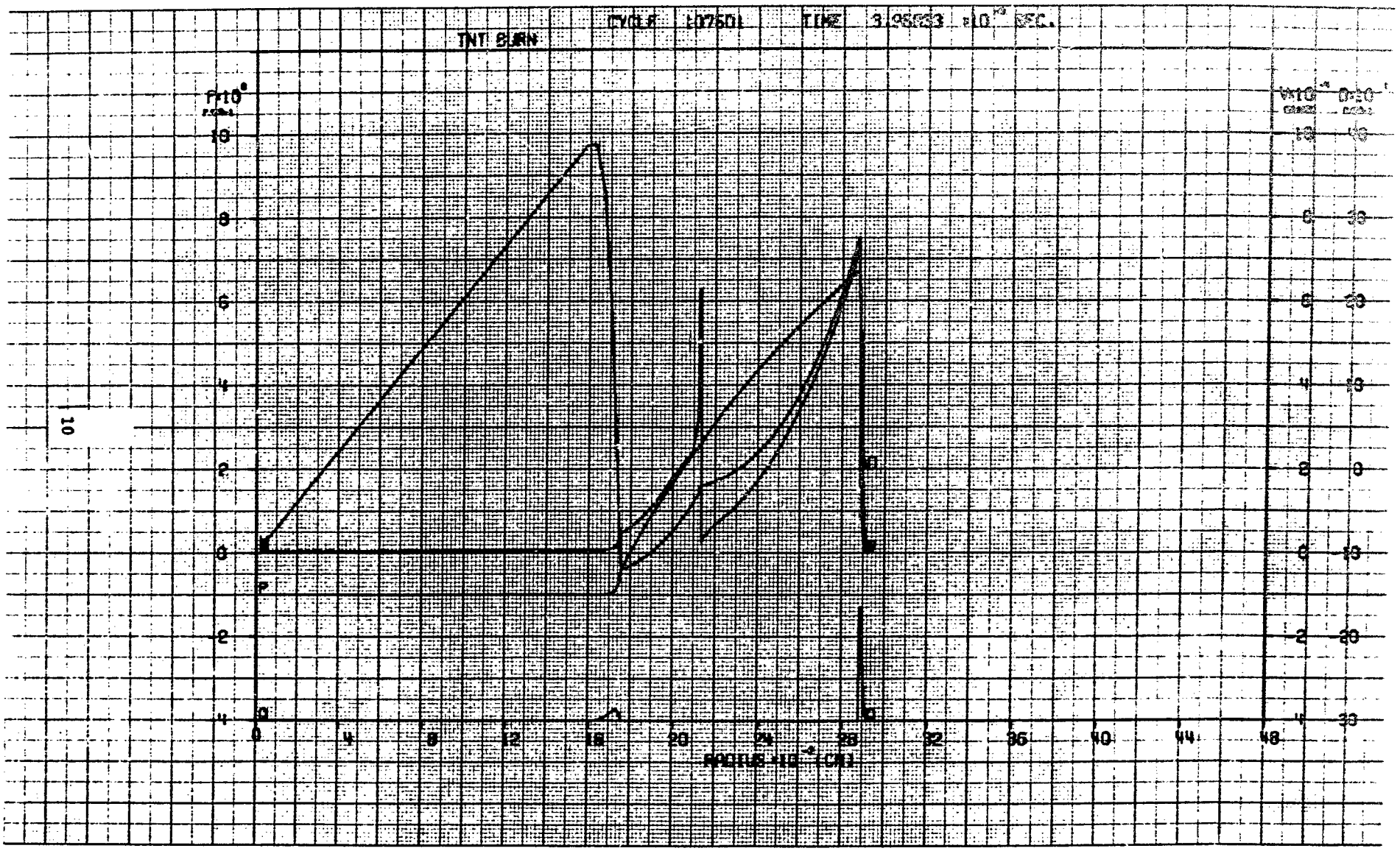

CYCLE 18000 TIME 4.89985 ×10⁻⁶ SEC.
TNT BURN
P×10⁻⁸
V×10⁻⁶
D×10⁻⁶
Symbols for Similarity Solution
X - Pressure
⊙ - Density
△ - Velocity
RADIUS ×10⁻¹ (CM)

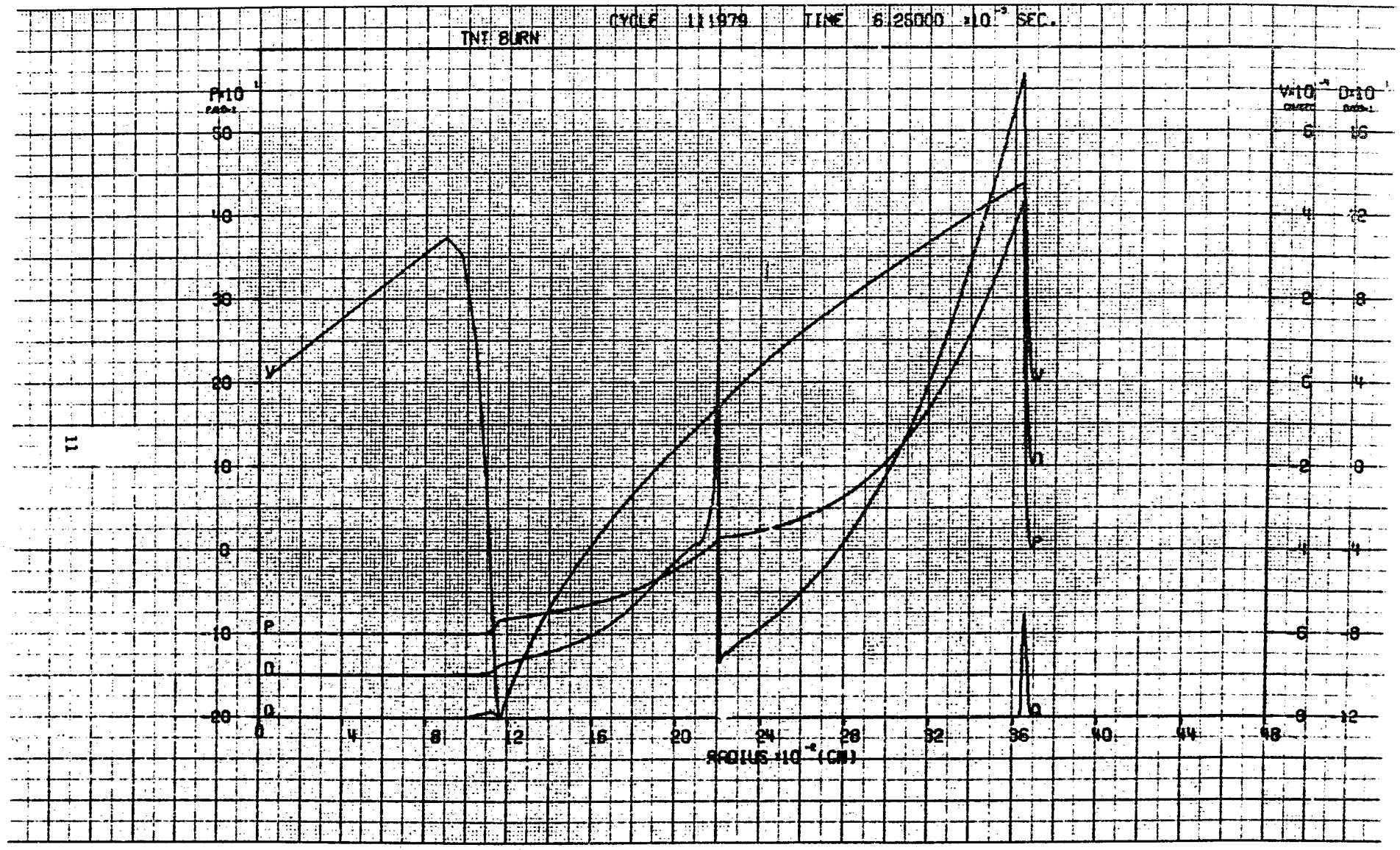

TNT BURN
CYCLE 51000 TIME 3.23639 ×10⁻⁷ SEC.
P×10⁻¹
V×10⁻⁶
D×10⁻¹
RADIUS ×10⁻⁴ (CM)

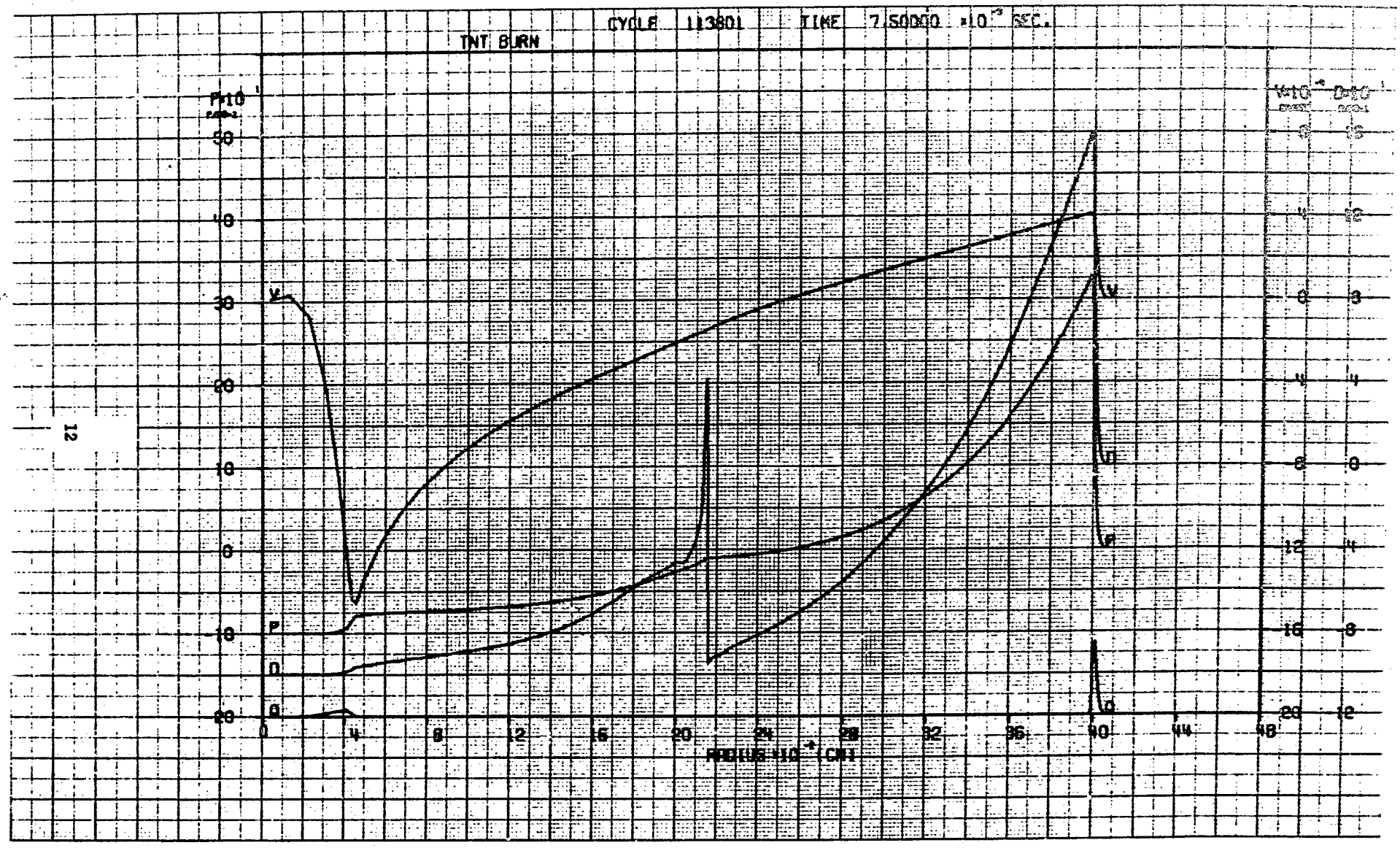

CYCLE 54000 TIME 3.46704 ×10⁻⁴ SEC.
TNT BURN
P×10⁻¹
V×10⁻⁶
D×10⁻¹
RADIUS ×10⁻⁴ (CM)

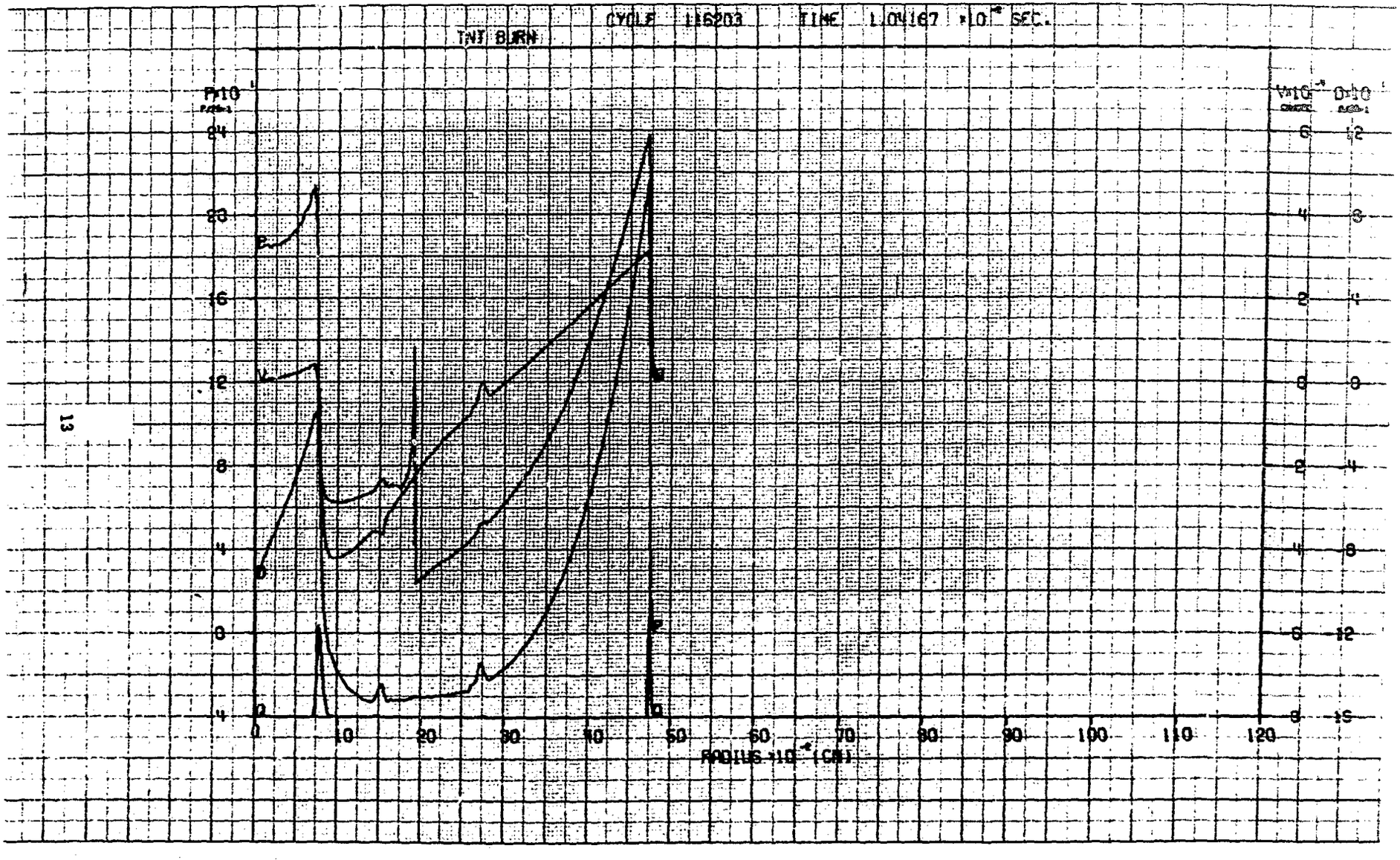

TNT BURN
CYCLE 74000 TIME 4.91037 ×10⁻⁷ SEC.
P×10⁻¹
10
8
6
4
2
0
-2
-4
0
1
2
3
4
5
6
7
8
9
10
11
12
RADIUS ×10⁻⁴ (CM)

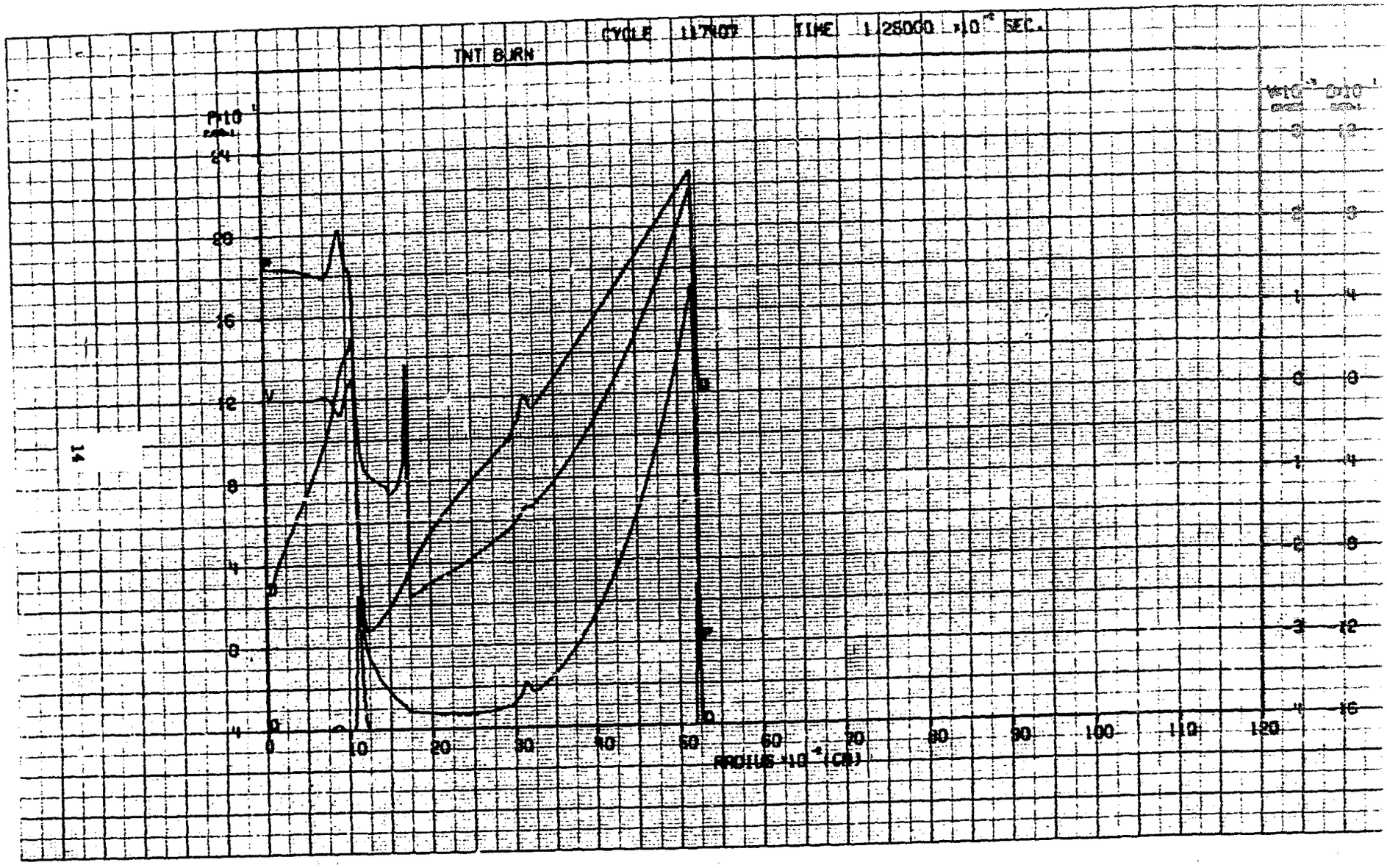

TNT BURN
CYCLE 99000
TIME 1.37968 ×10⁻³ SEC.
P×10⁶
V×10⁻⁷
D×10⁶
RADIUS ×10⁻⁴ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24

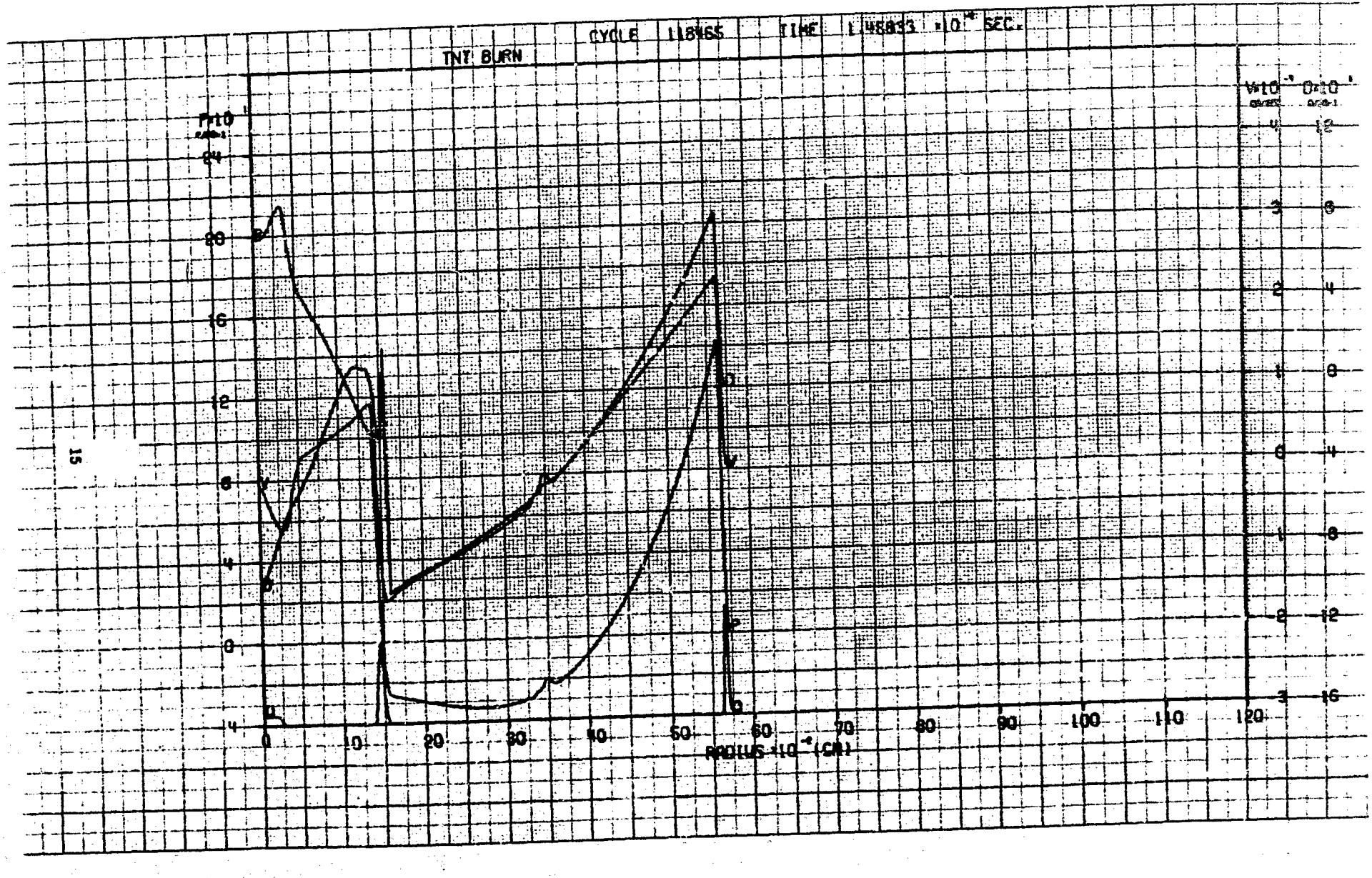

TNT BURN
CYCLE 107601
TIME 3.95633 ×10⁻⁴ SEC.
P×10⁸
10
8
6
4
2
0
-2
-4
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁴ (CM)
V×10⁻⁴
D×10⁻¹
10
8
6
4
2
0
-2
-4
10
0
-10
-20
-30

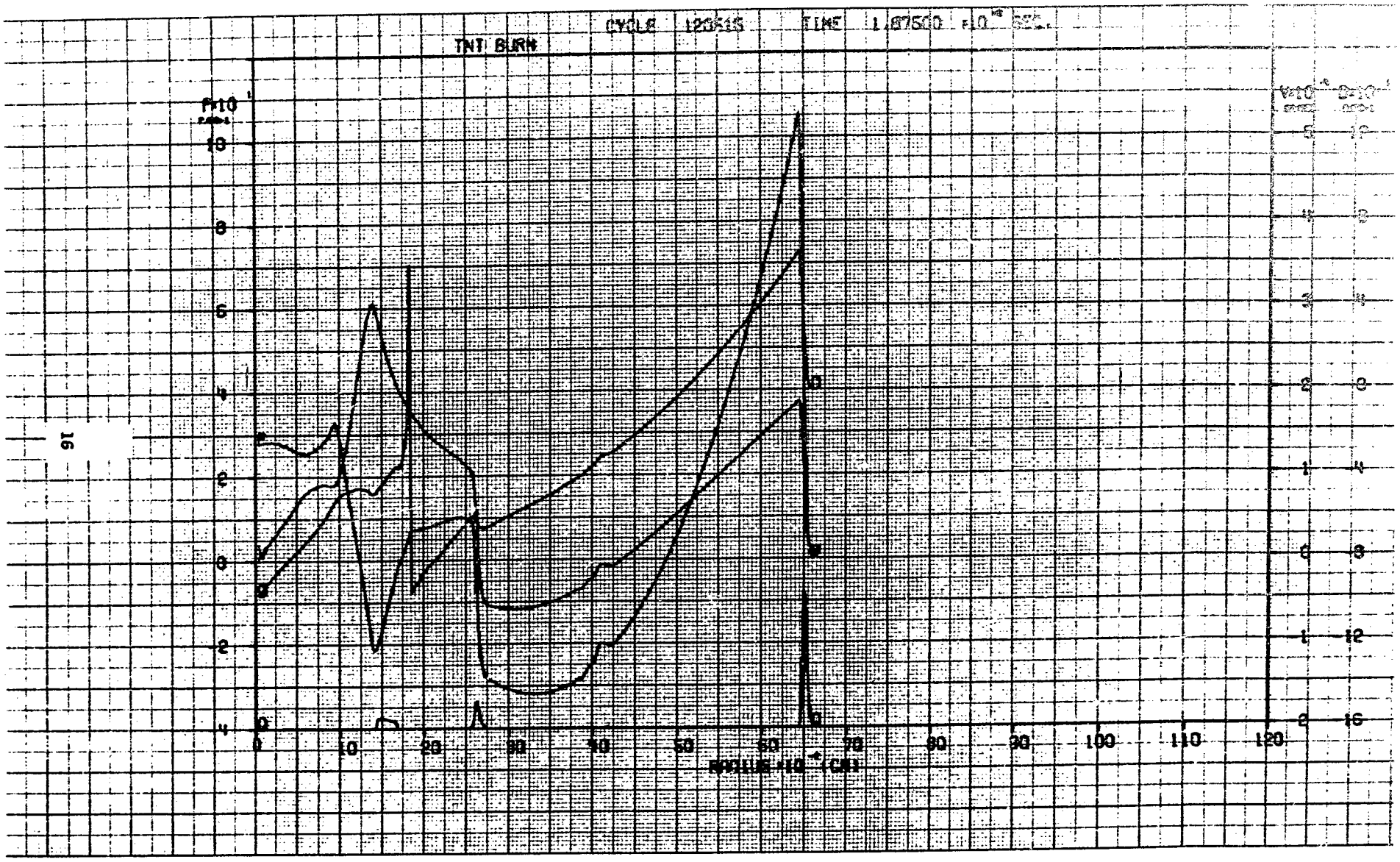

CYCLE 11 1979 TIME 6.25000 ×10⁻⁹ SEC.
TNT BURN
P×10¹
V×10⁻⁸
D×10¹
50
40
30
20
10
0
10
20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁸ (CM)
V
D
P

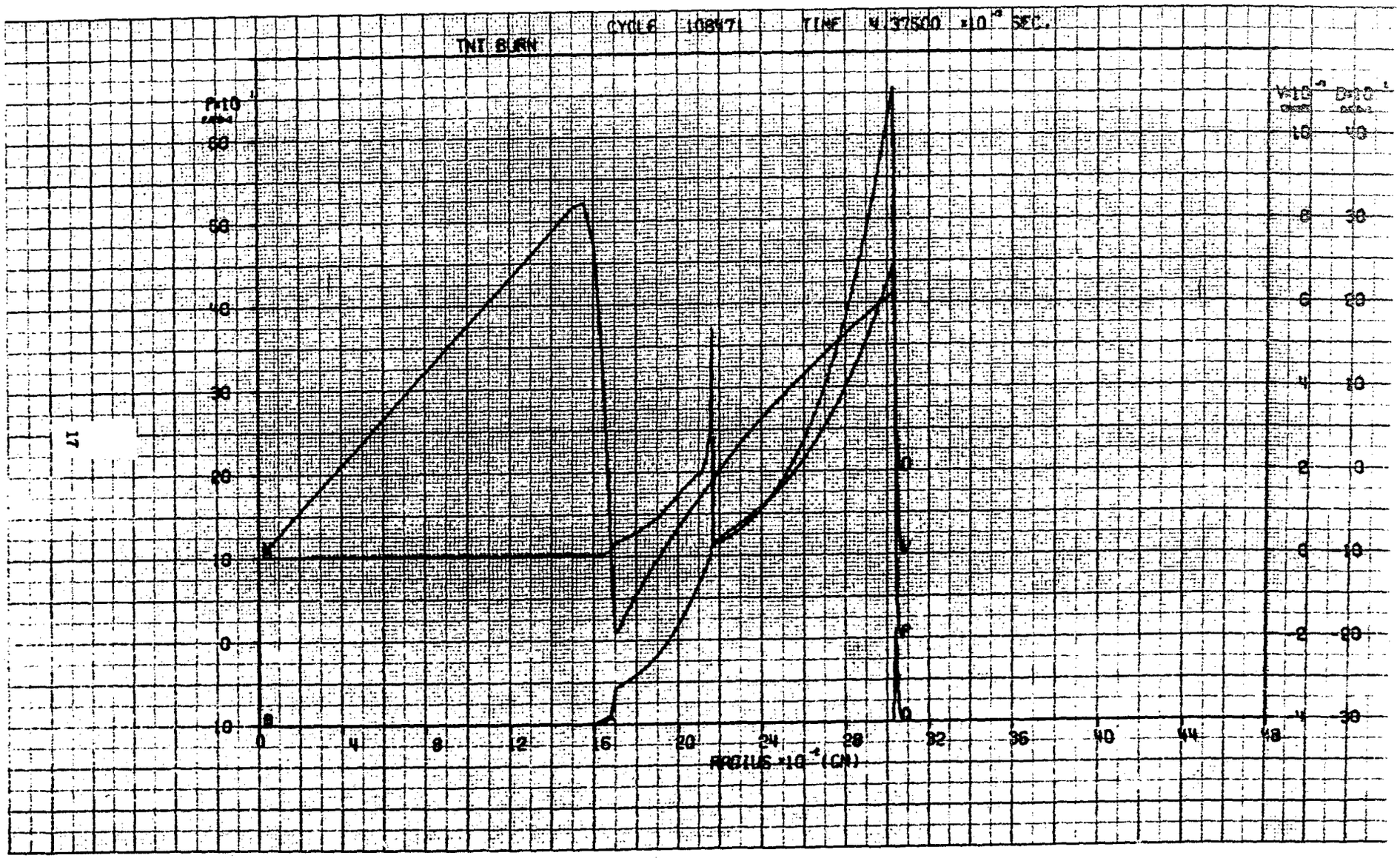

TNT BURN
CYCLE 113801 TIME 7.50000 ×10⁻³ SEC.
P×10⁻¹
50
40
30
20
10
0
-10
-20
V
P
D
Q
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻¹ (CM)
W×10⁻² gm/cc
D×10⁻¹ gm/cc
0
16
4
12
8
3
12
4
16
0
20
-4
24
-8
28
-12
32

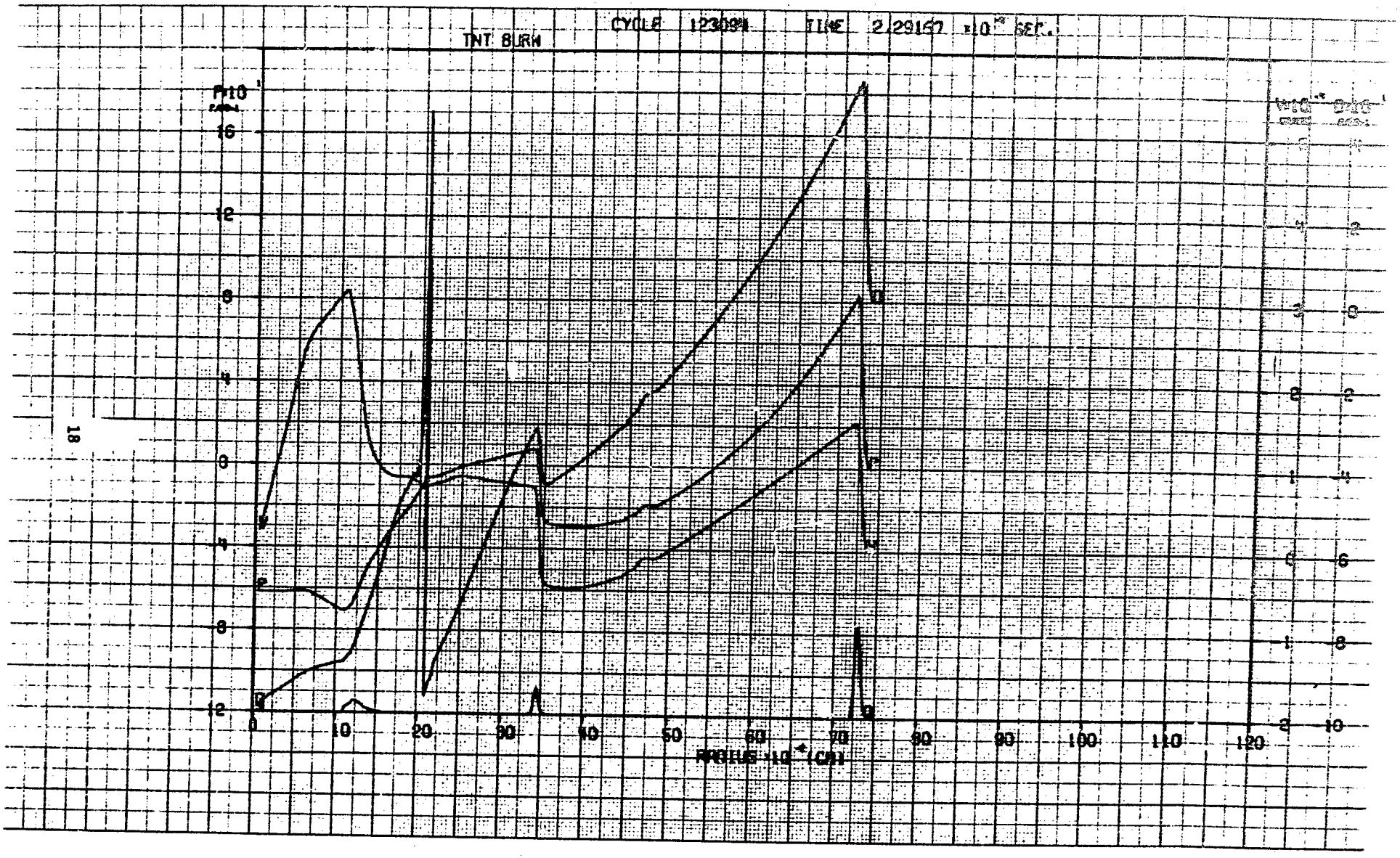

TNT BURN
CYCLE 116203
TIME 1.04167 ×10⁻⁸ SEC.
P×10¹
V×10⁻⁸
D×10¹
RADIUS ×10⁻⁸ (CM)

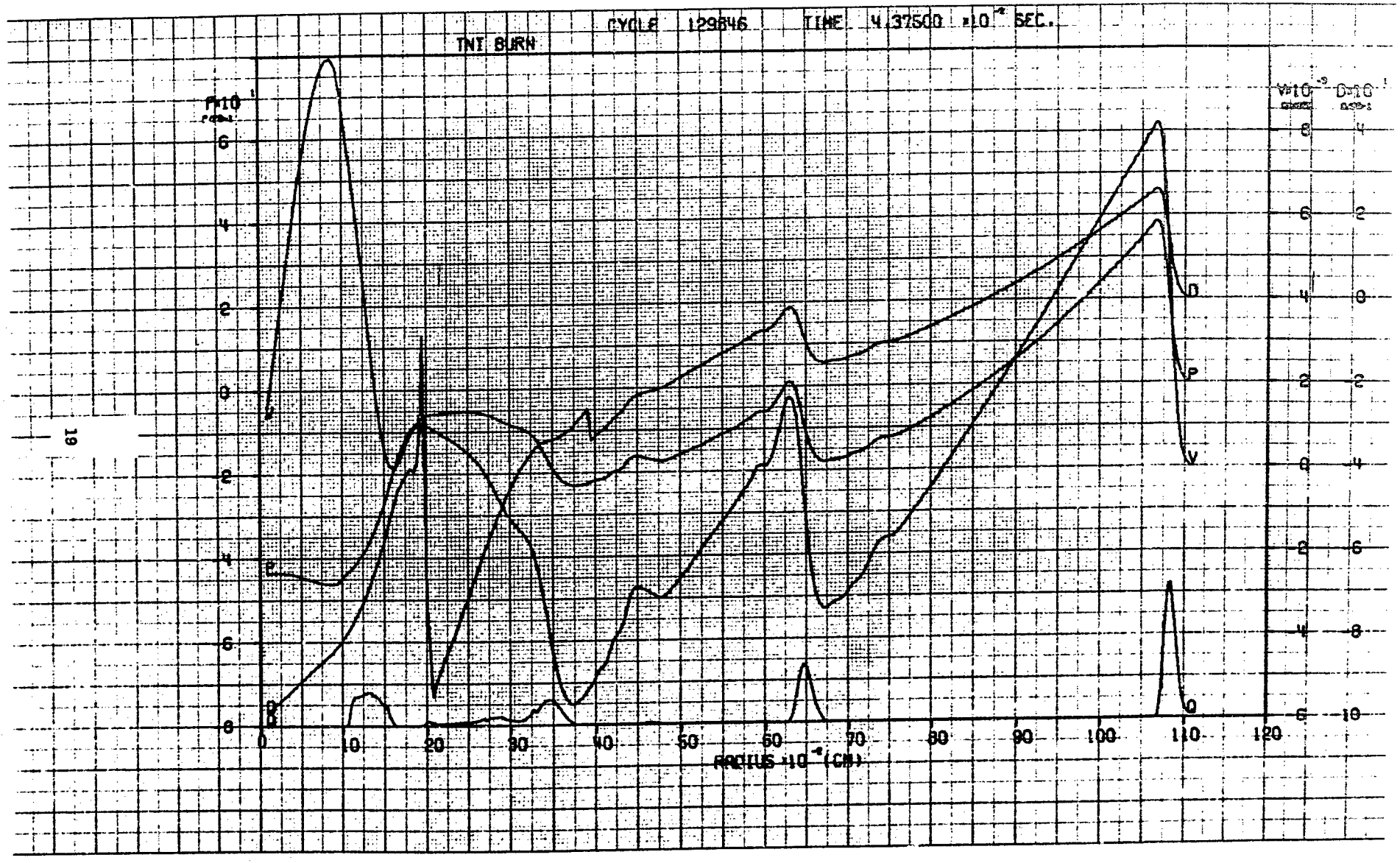

TNT BURN
CYCLE 117907
TIME 1.25000 ×10⁻⁴ SEC.
P×10¹
24
20
16
12
8
4
0
4
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻⁴ (CM)
V×10⁻¹
D×10¹
3
12
2
8
1
4
0
0
-1
-4
-2
-8
-3
-12
-4
-16

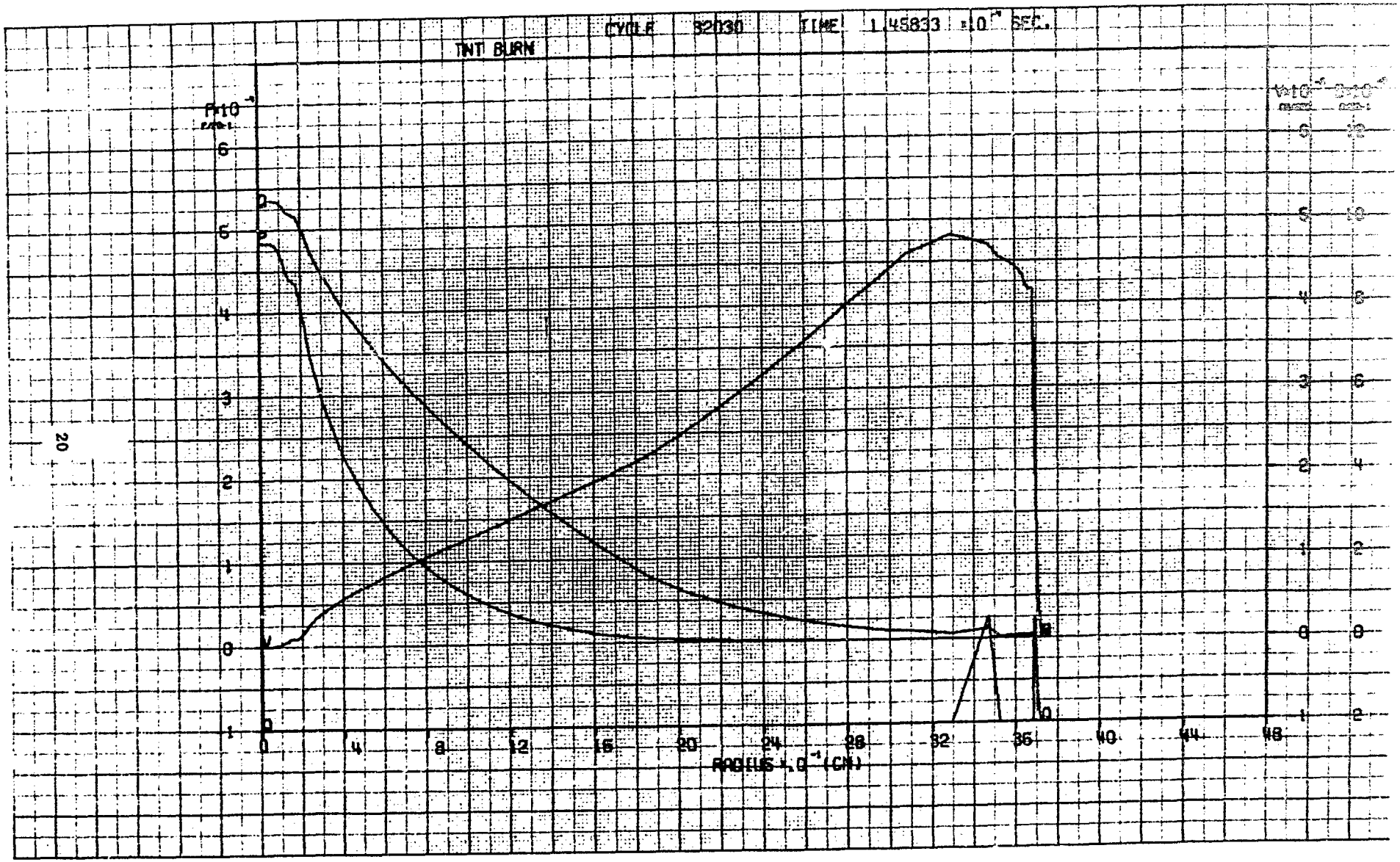

TNT BURN
CYCLE 118465
TIME 1.46833 ×10⁻⁴ SEC.
P×10¹
24
20
16
12
8
4
0
-4
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻⁴ (CM)
V×10⁻⁴
U×10¹
4
3
2
1
0
-1
-2
-3
12
8
4
0
-4
-8
-12
-16

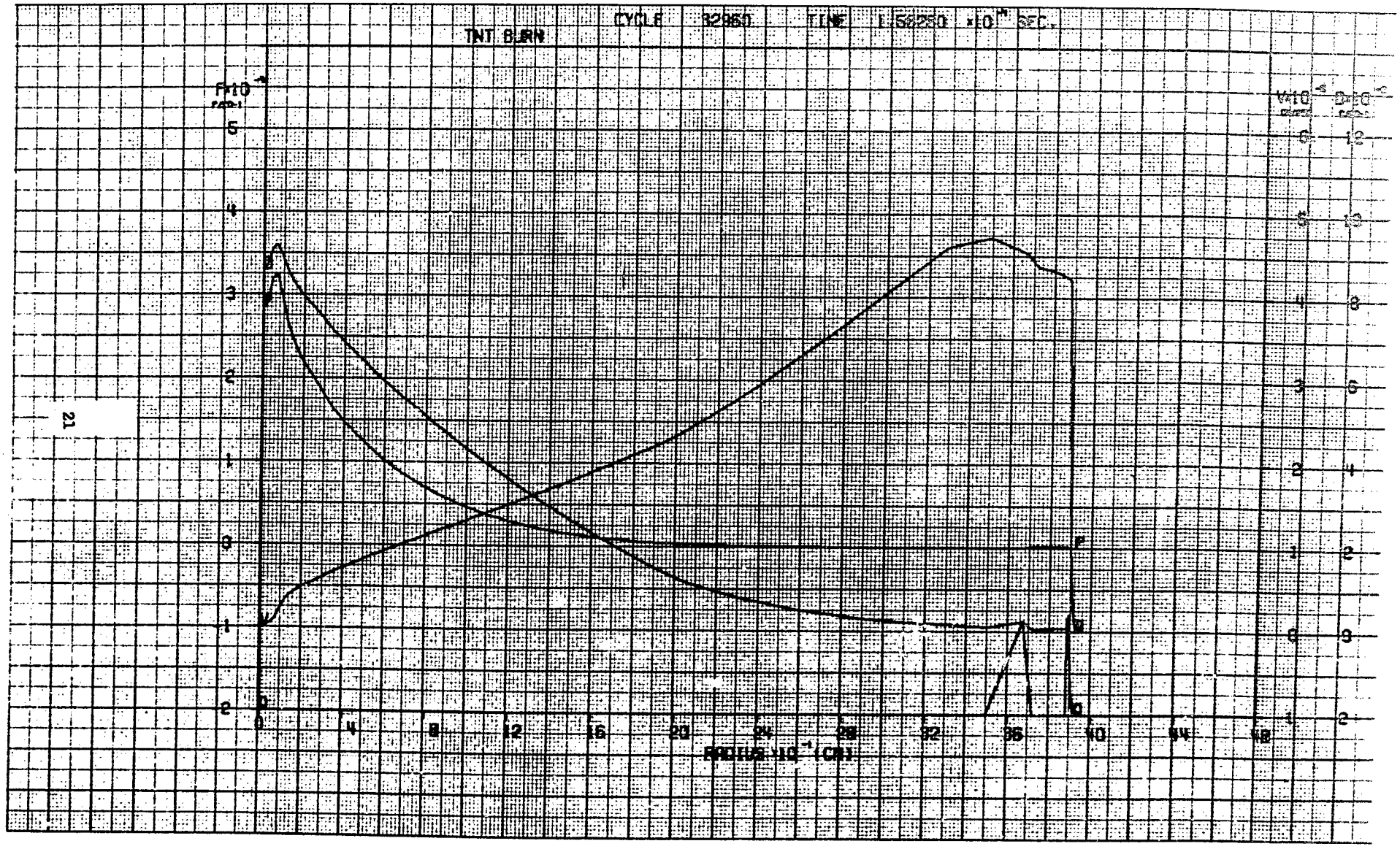

TNT BURN
CYCLE 120515
TIME 1.87500 ×10⁻⁸ SEC.
P×10¹
PSIA
10
8
6
4
2
0
-2
-4
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10⁻⁴ (CM)
V×10⁻⁶
CM/SEC
D×10¹
GM/CC
5
4
3
2
1
0
-1
-2
16
14
12
10
8
6
4
2

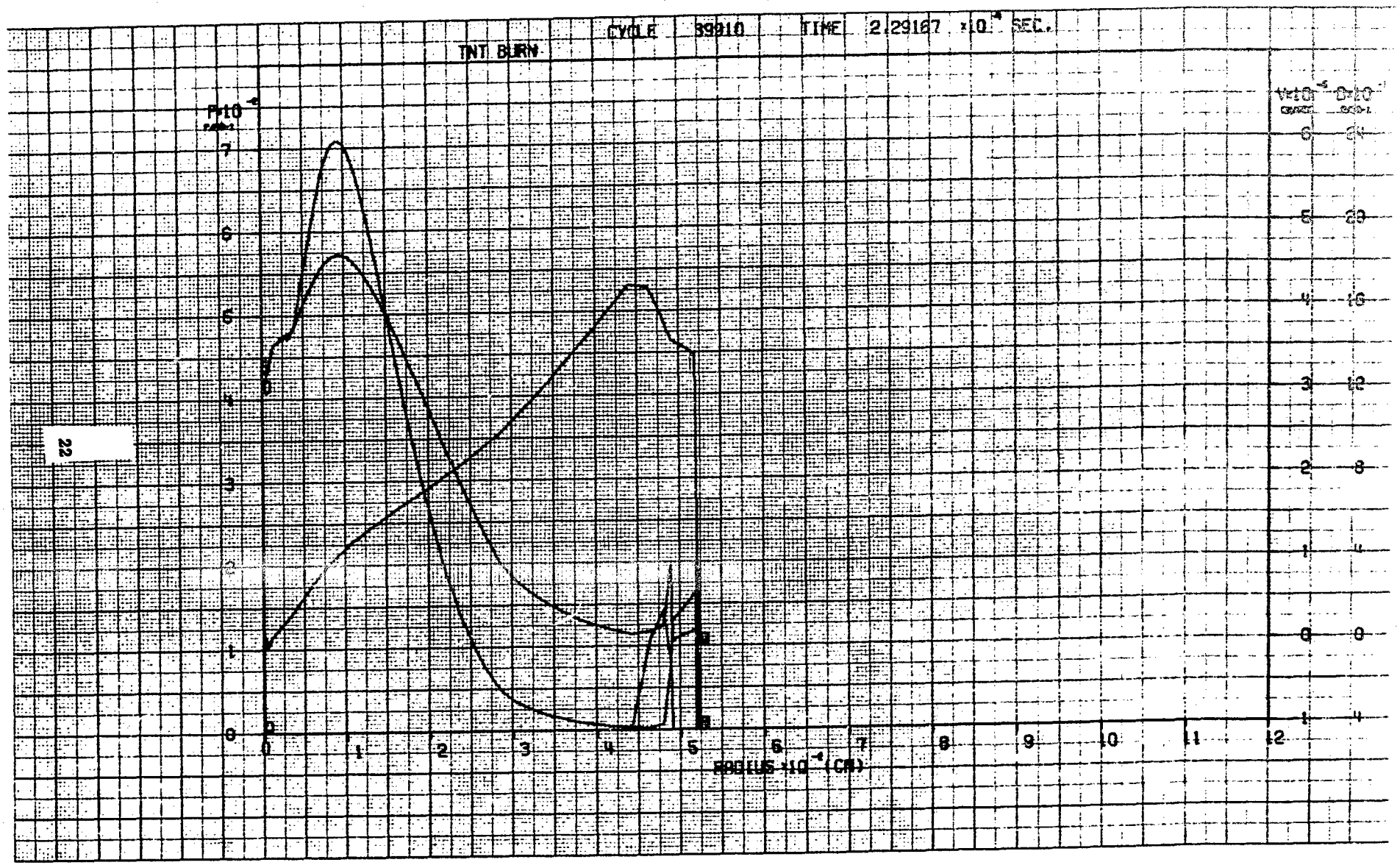

TNT BURN
CYCLE 108471
TIME 4.37500 ×10^-8 SEC.
P×10^1 (atm)
V×10^-5 (cm/sec)
D×10^-1 (gm/cm^3)
RADIUS ×10^-1 (CM)

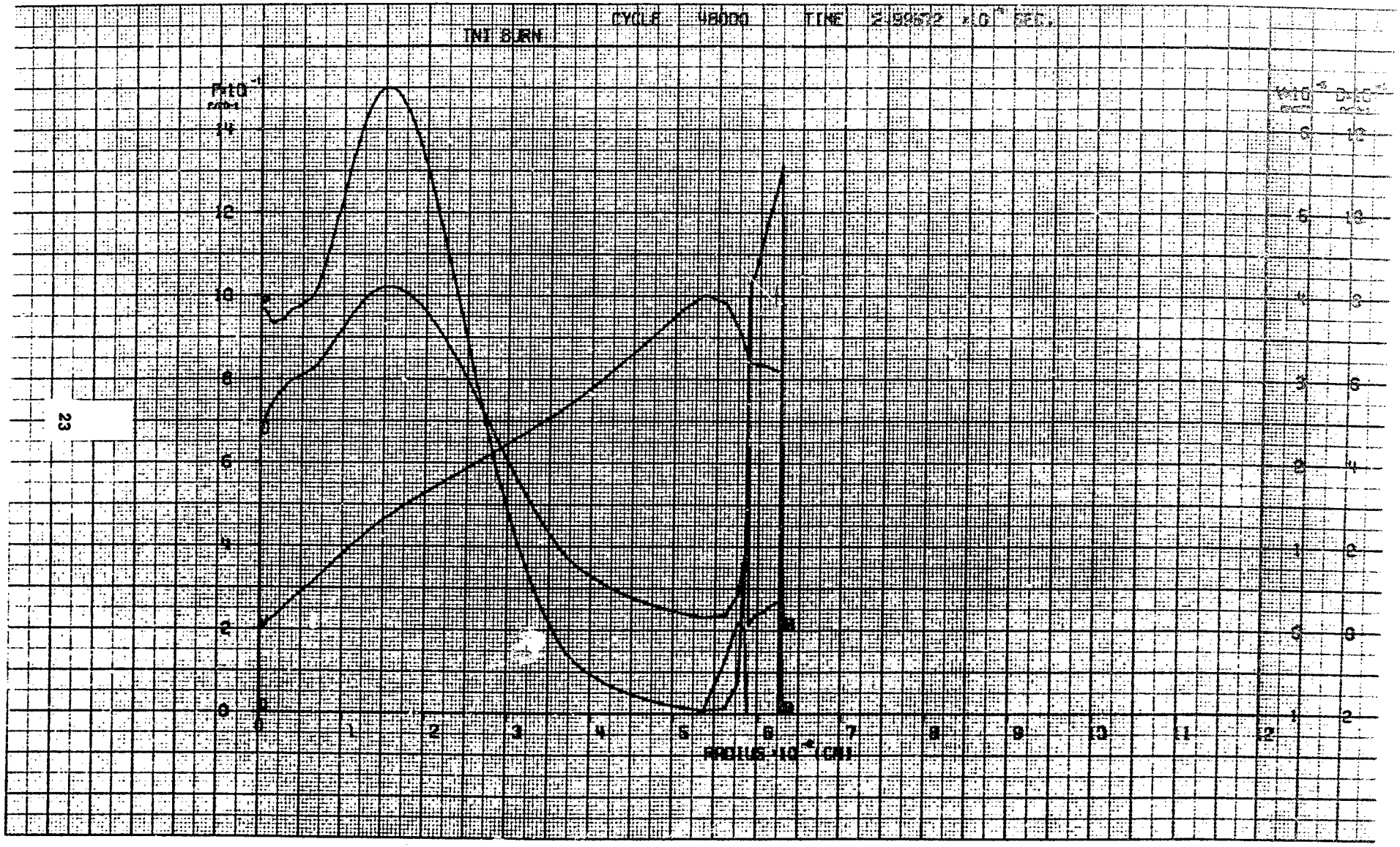

TNT BURN
CYCLE
TIME
16
12
8
4
0
-4
-8
-12
0
10
20
30
40
50
60
70
80
90
100
110
120

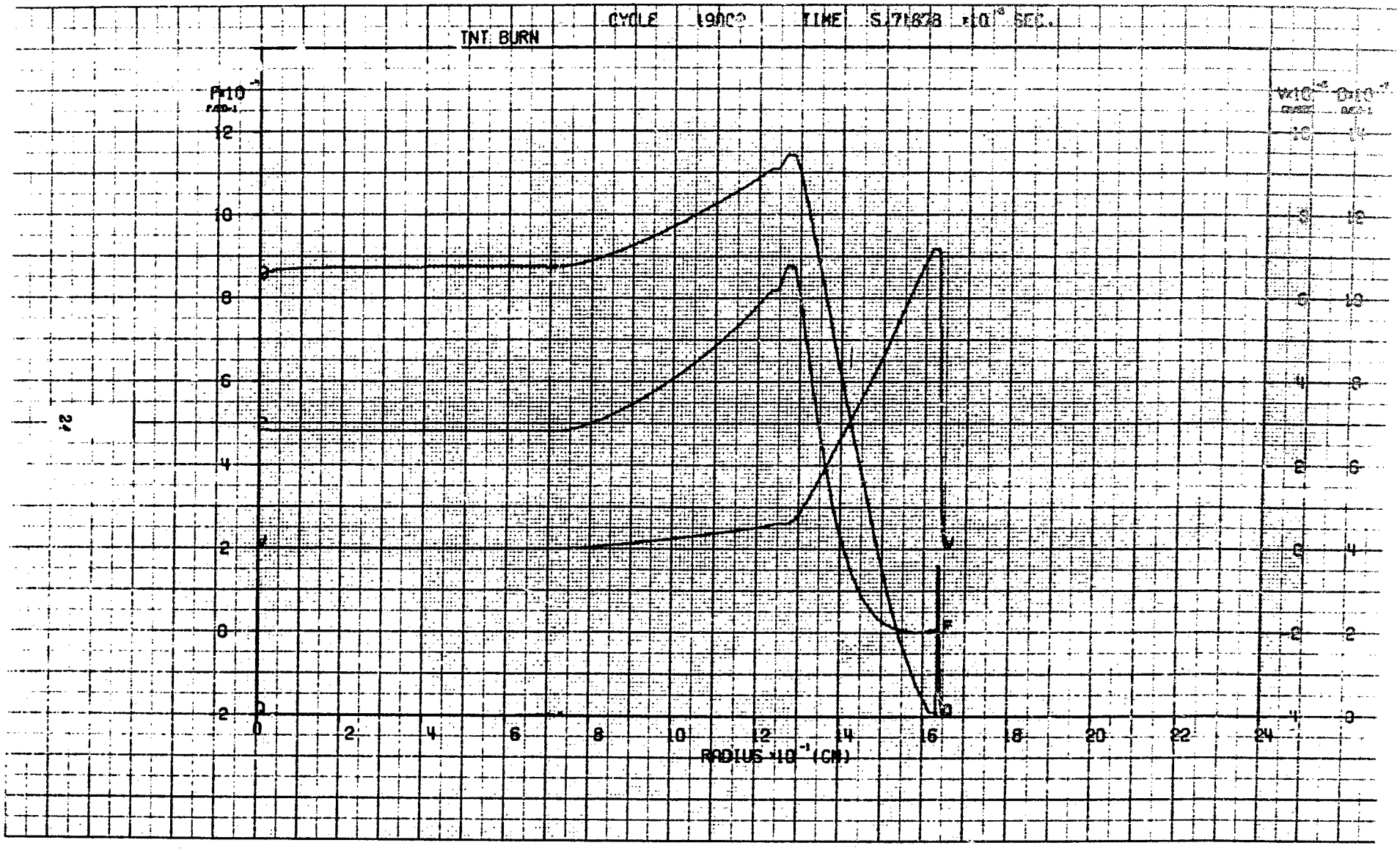

CYCLE 129846 TIME 4.37500 ×10⁻⁸ SEC.
TNT BURN
P×10¹
V×10⁻⁹ D×10¹
D
P
V
RADIUS ×10⁻⁸ (CM)
0 10 20 30 40 50 60 70 80 90 100 110 120

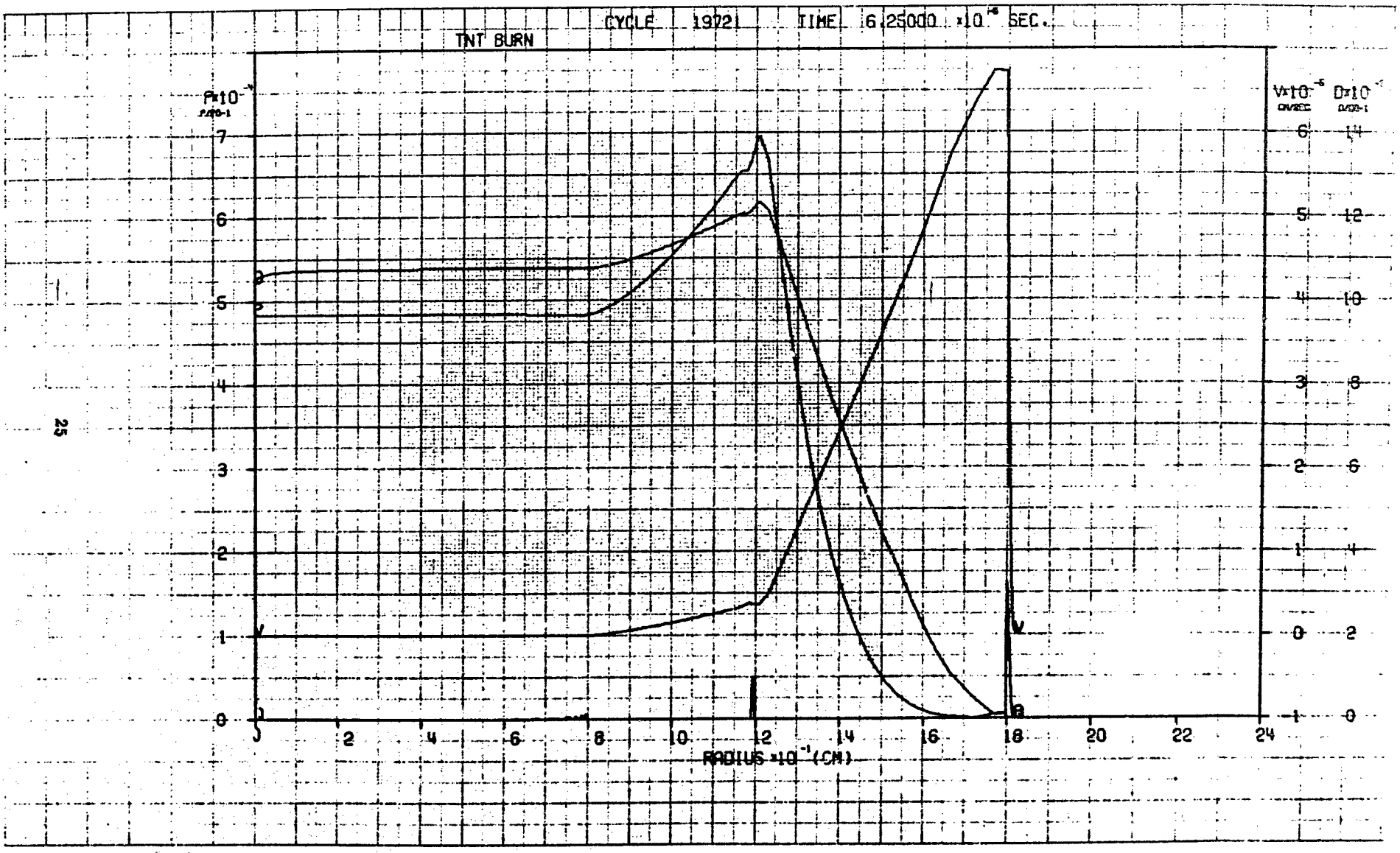

TNT BURN
CYCLE 32030
TIME 1.45833 ×10⁻⁷ SEC.
P×10⁻⁷
RADIUS ×10⁻¹ (CM)
0
4
8
12
16
20
24
28
32
36
40
44
48

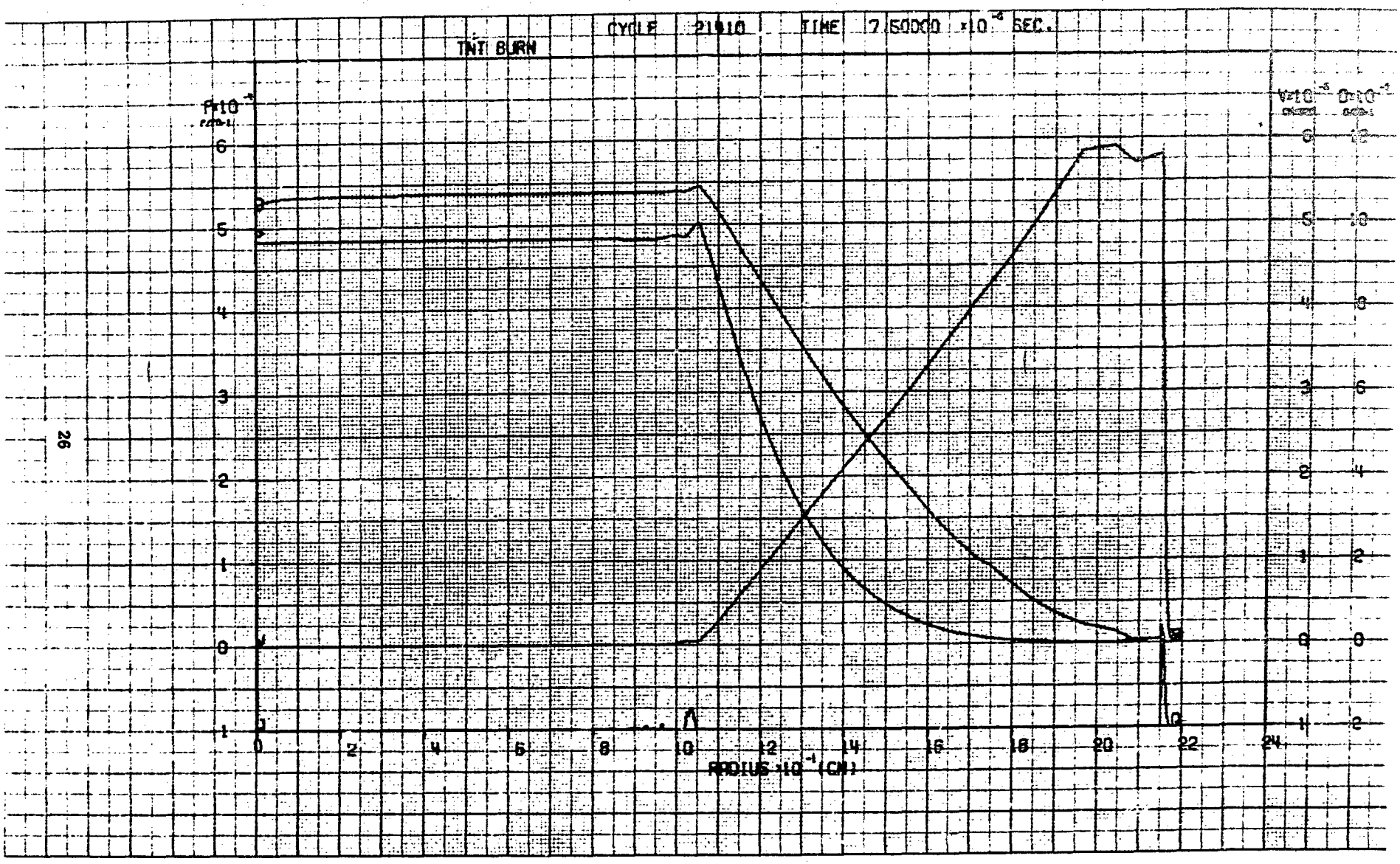

TNT BURN
CYCLE 32950
TIME 1.58250 x10^-4 SEC.
F x10^-1 (GM/CM^2)
V x10^-1 (CM/SEC)
D x10^-1 (GM/CM^3)
RADIUS x10^-1 (CM)

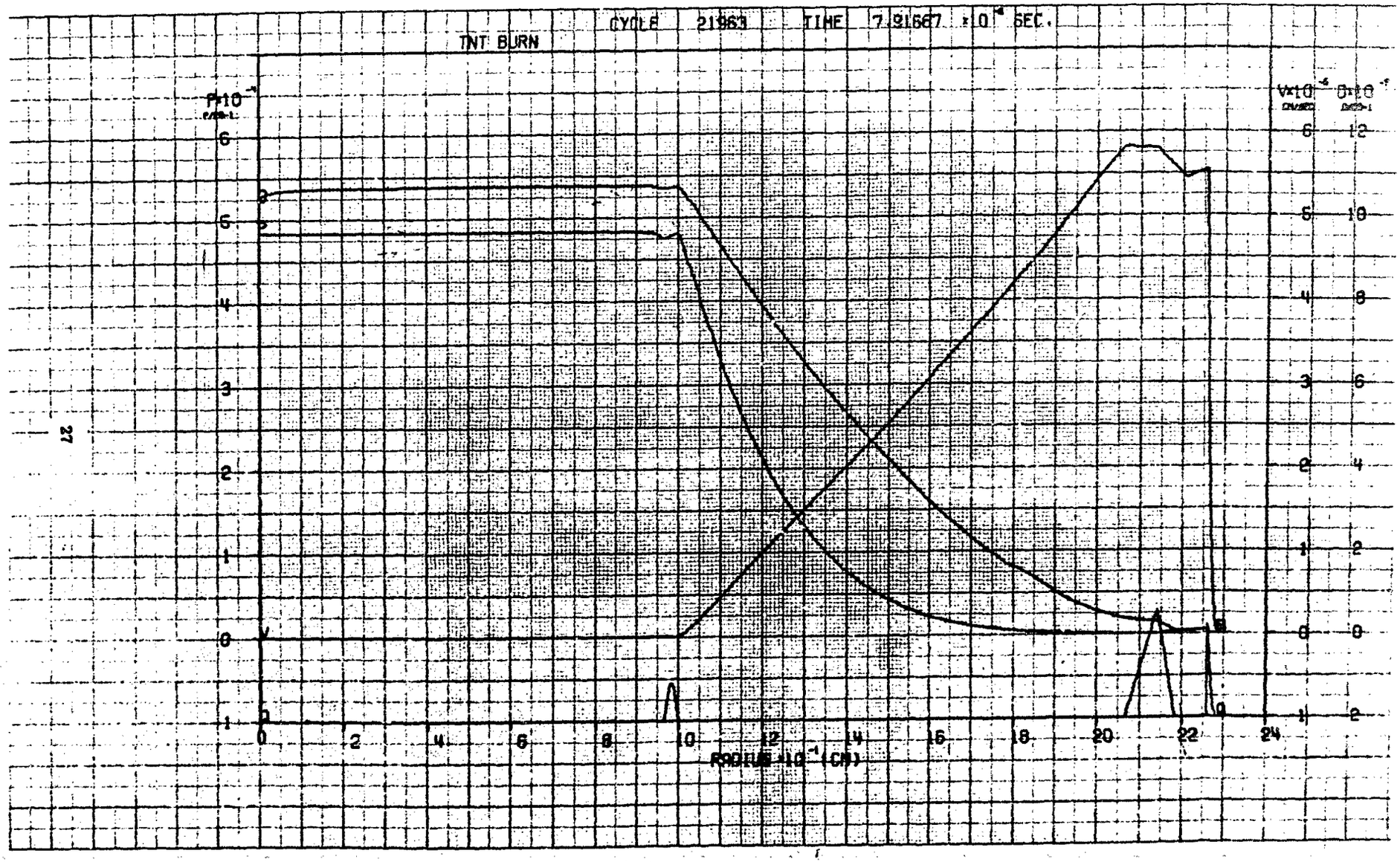

CYCLE 39910 TIME 2.29167 ×10⁻⁴ SEC.
TNT BURN
P×10⁻⁴
RADIUS ×10⁻⁴ (CM)

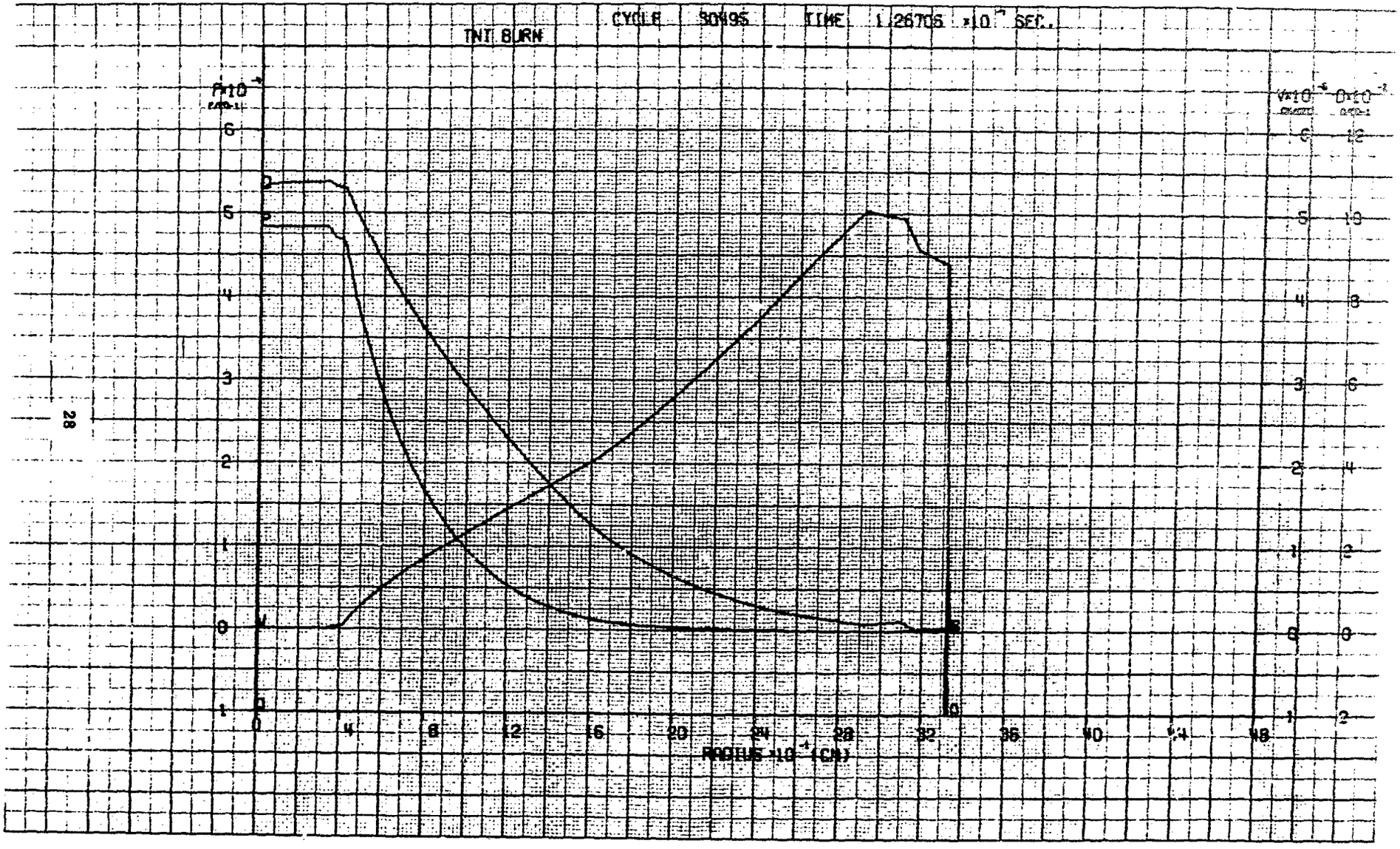

TNT BURN
CYCLE 48000
TIME 2.59572 x10^0 SEC.
F*10^-1
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
11
12
R*10^-4 (CM)

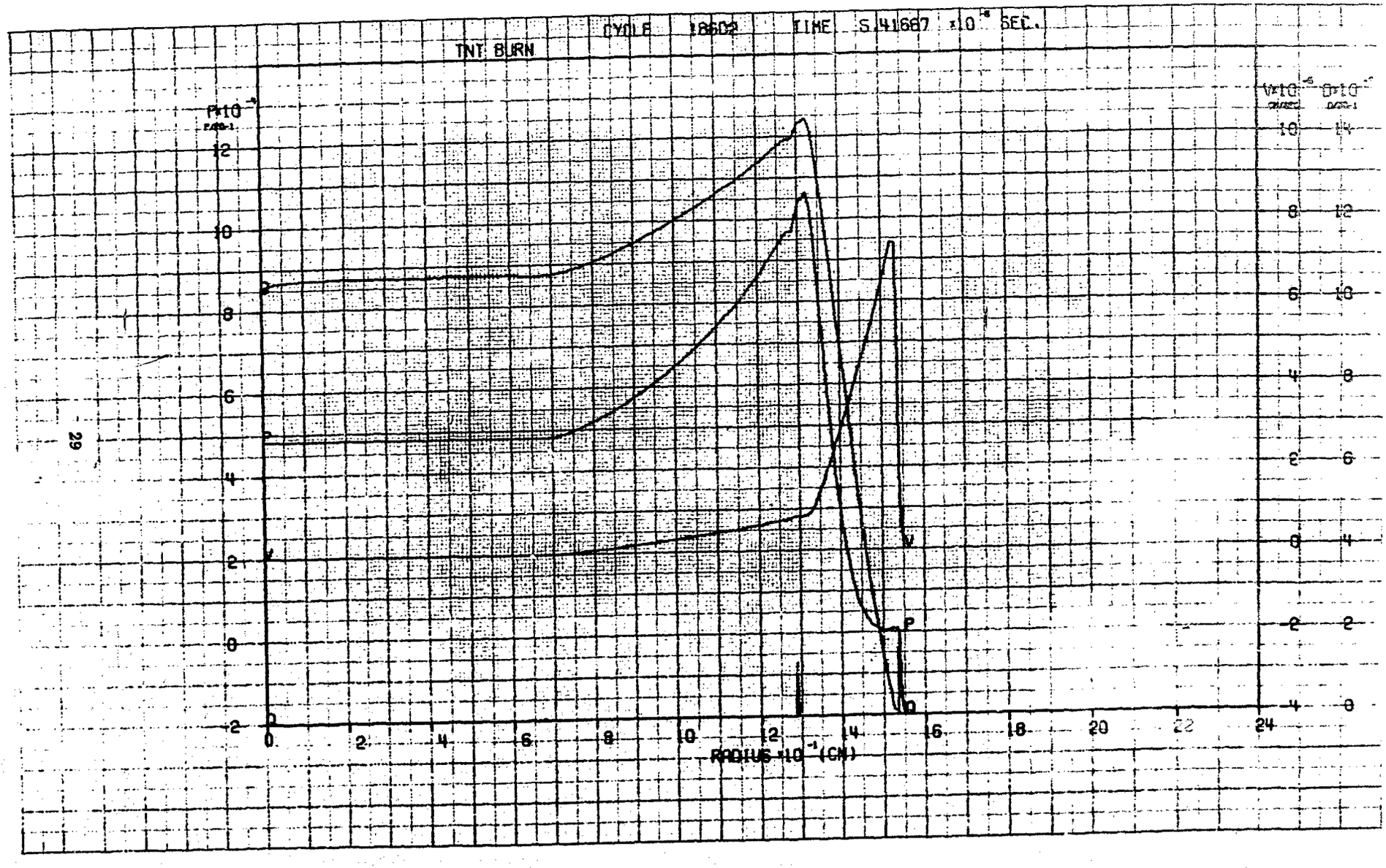

CYCLE 19000 TIME 5.71823 ×10⁻⁸ SEC.
TNT BURN
P×10⁻¹
12
10
8
6
4
2
0
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10⁻¹ (CM)


CYCLE 1972 TIME 6.25000 ×10⁻⁶ SEC.
TNT BURN
P×10⁻⁴
V×10⁻⁶
D×10⁻¹
RADIUS ×10⁻¹ (CM)


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


TNT BURN
CYCLE 21963 TIME 7.21667 ×10⁻⁴ SEC.
P×10⁻⁷
V×10⁻⁶
ρ×10⁻¹
RADIUS×10⁻¹ (CM)


TNT BURN
CYCLE 30495 TIME 1.26705 ×10⁻⁷ SEC.
P×10⁻⁷
V×10⁻⁶
D×10⁻²
RADIUS ×10⁻⁴ (CM)


TNT BURN
CYCLE 18602 TIME 5.41667 x10^-8 SEC.
P*10^-9
RADIUS *10^-1 (CM)
V*10^-6
D*10^-1
0
2
4
6
8
10
12
14
16
18
20
22
24

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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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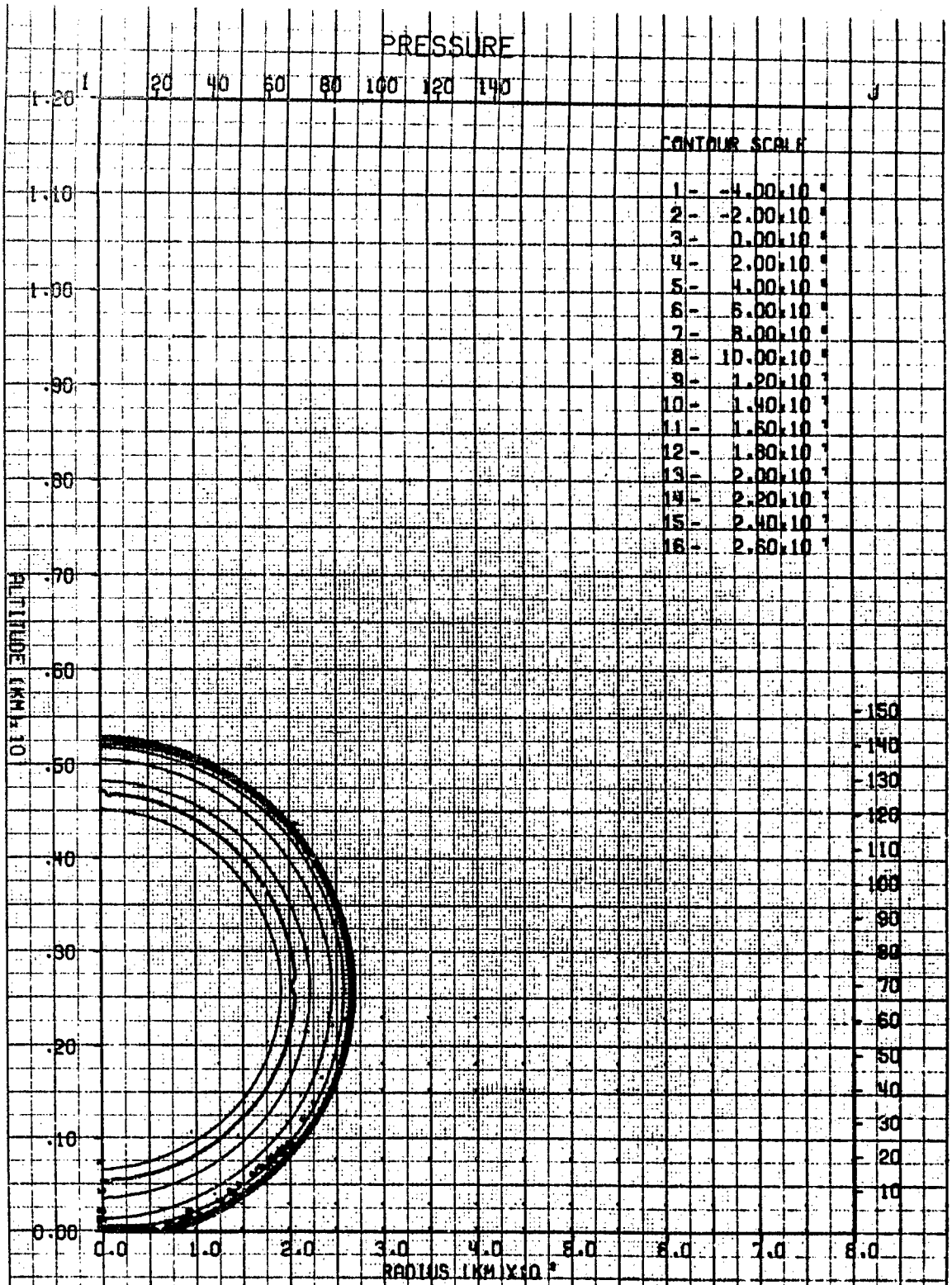
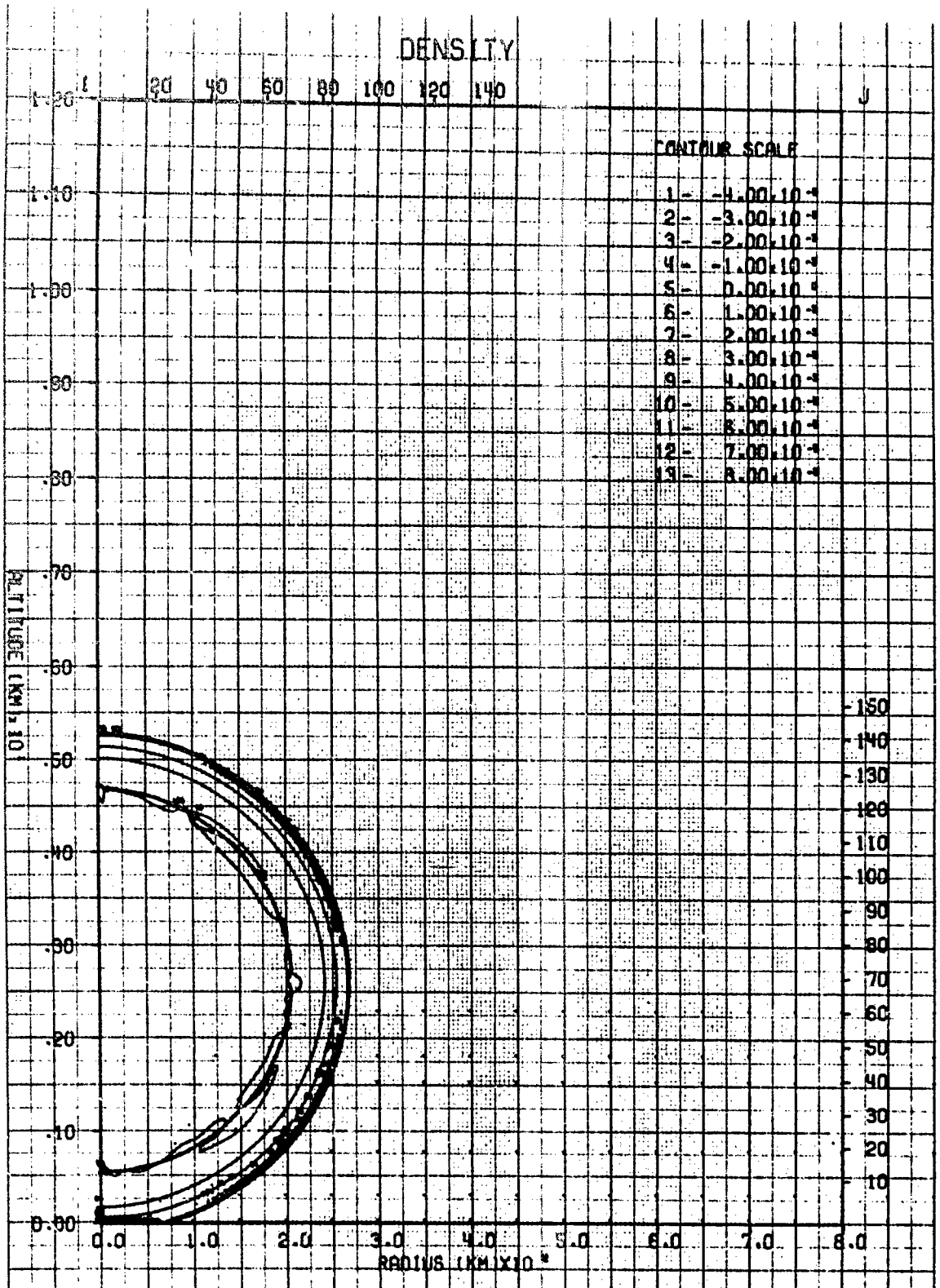
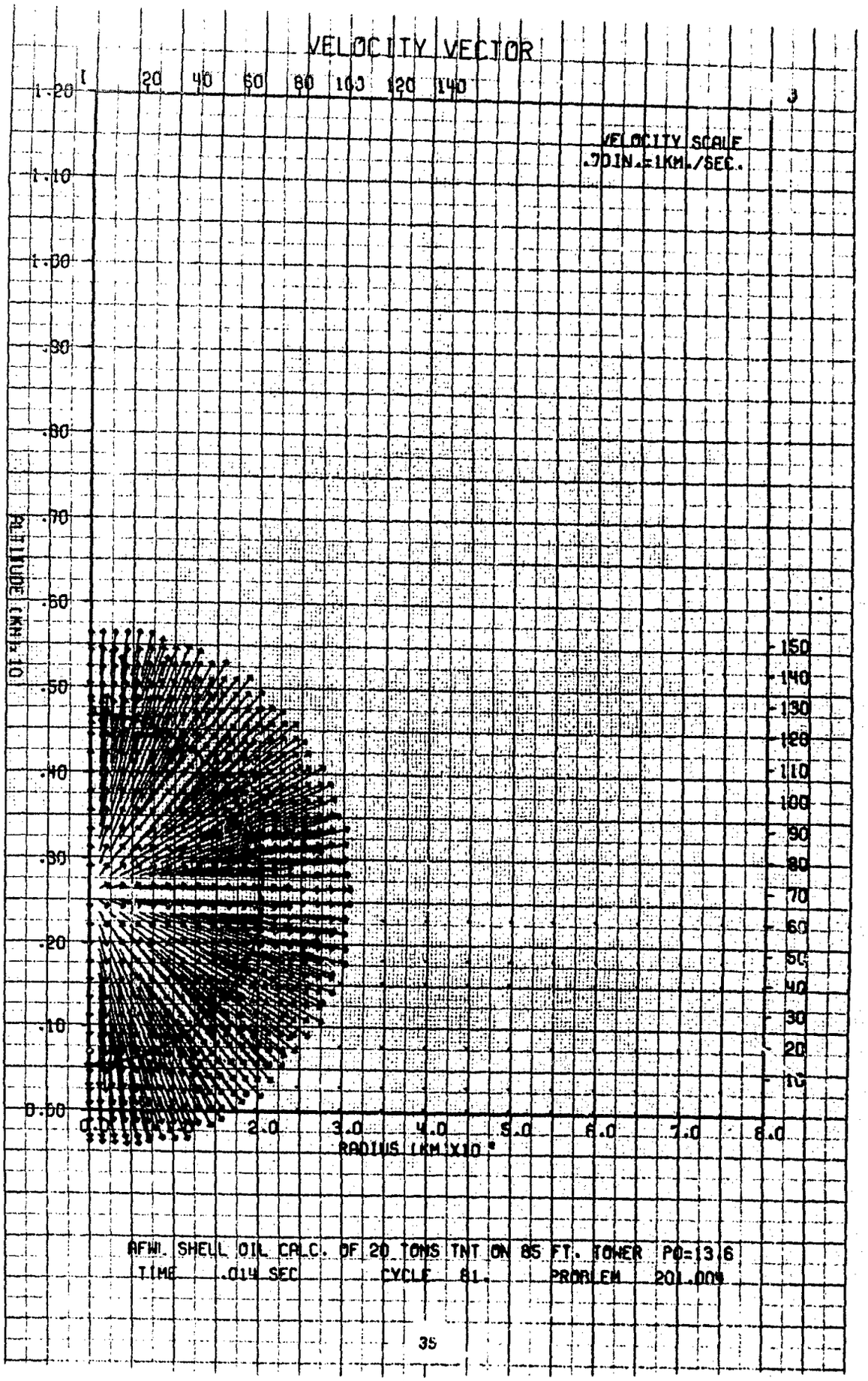
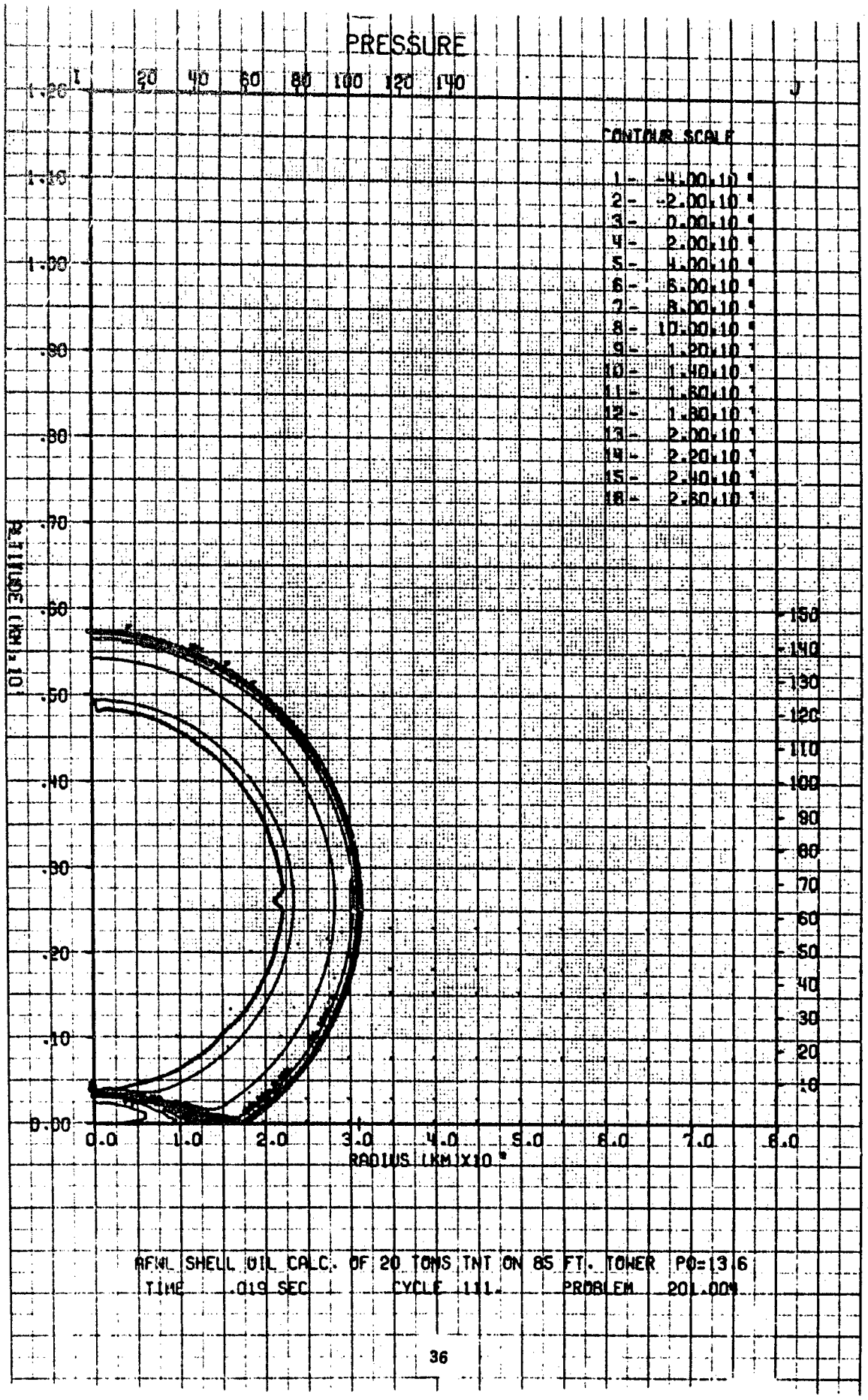


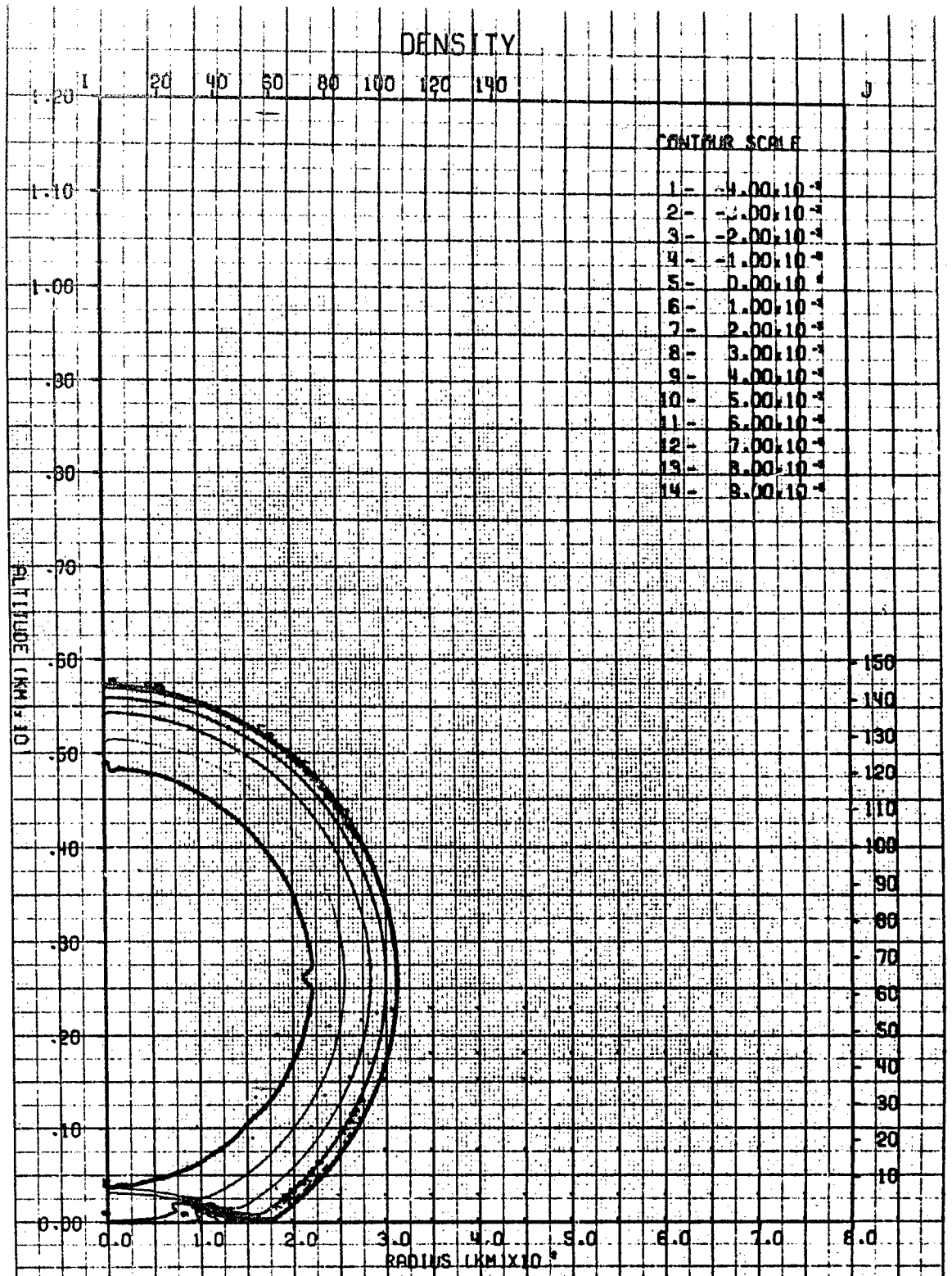
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .014 SEC CYCLE 81. PROBLEM 201.004

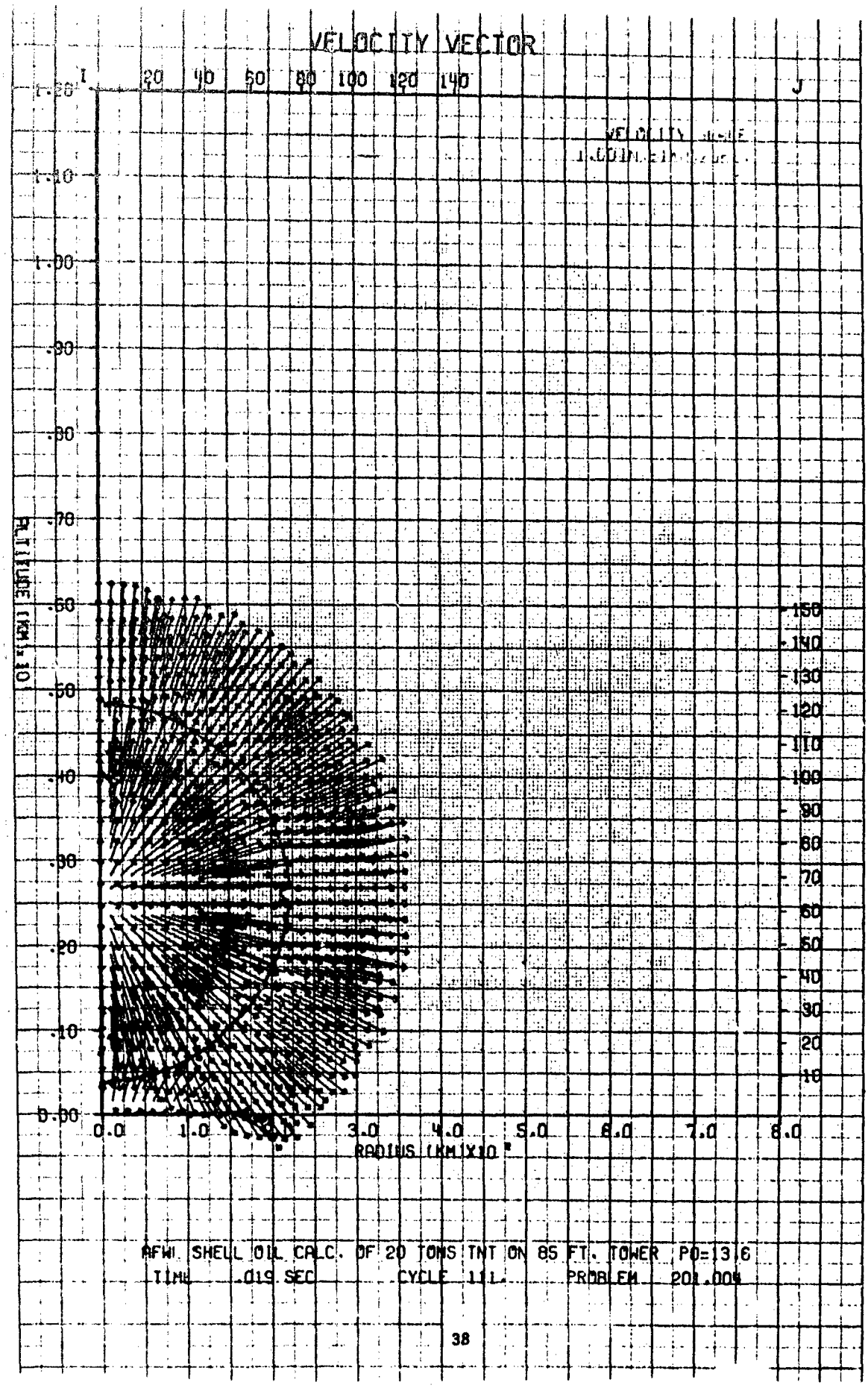


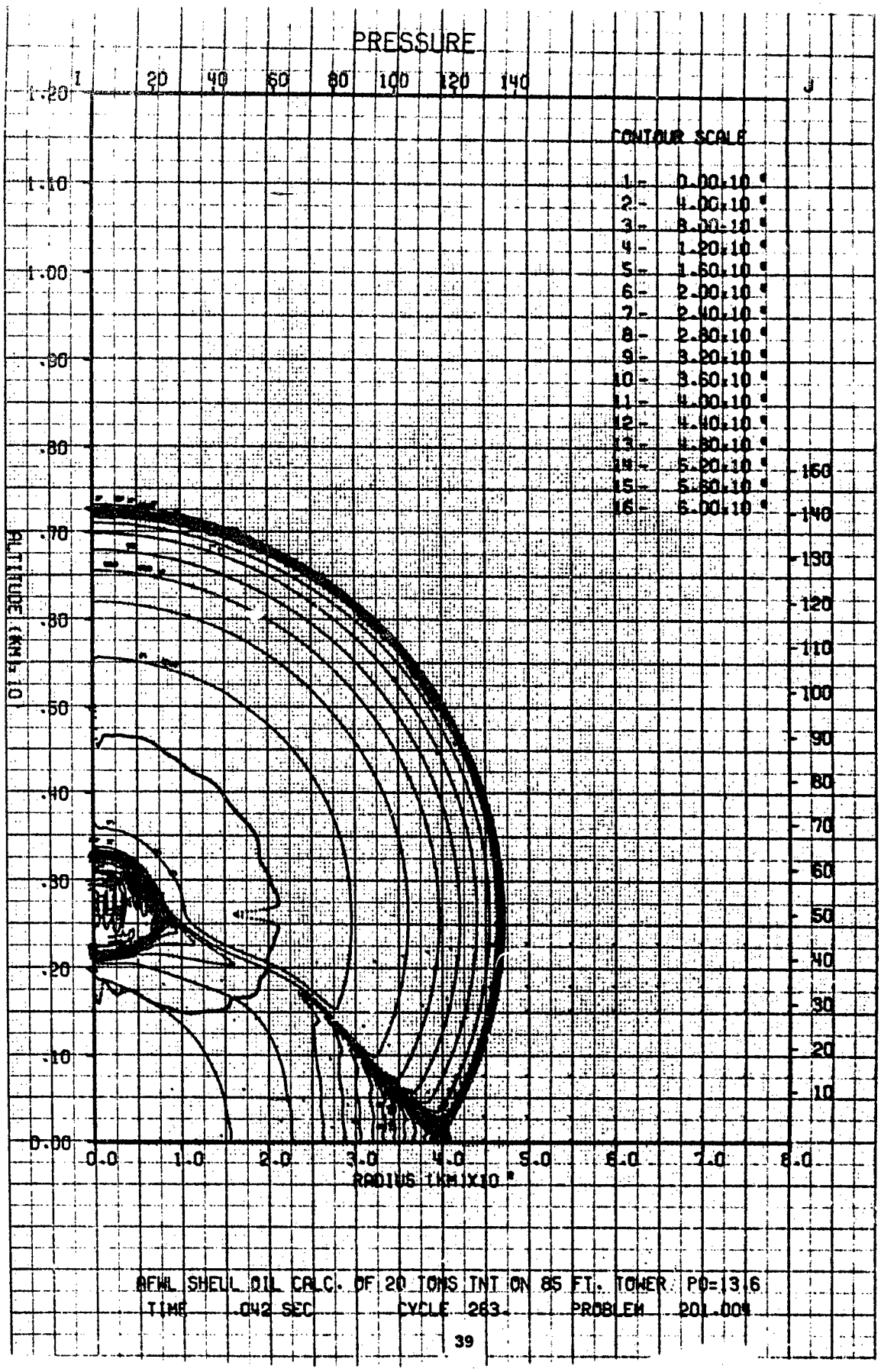
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .014 SEC CYCLE 81. PROBLEM 201.004

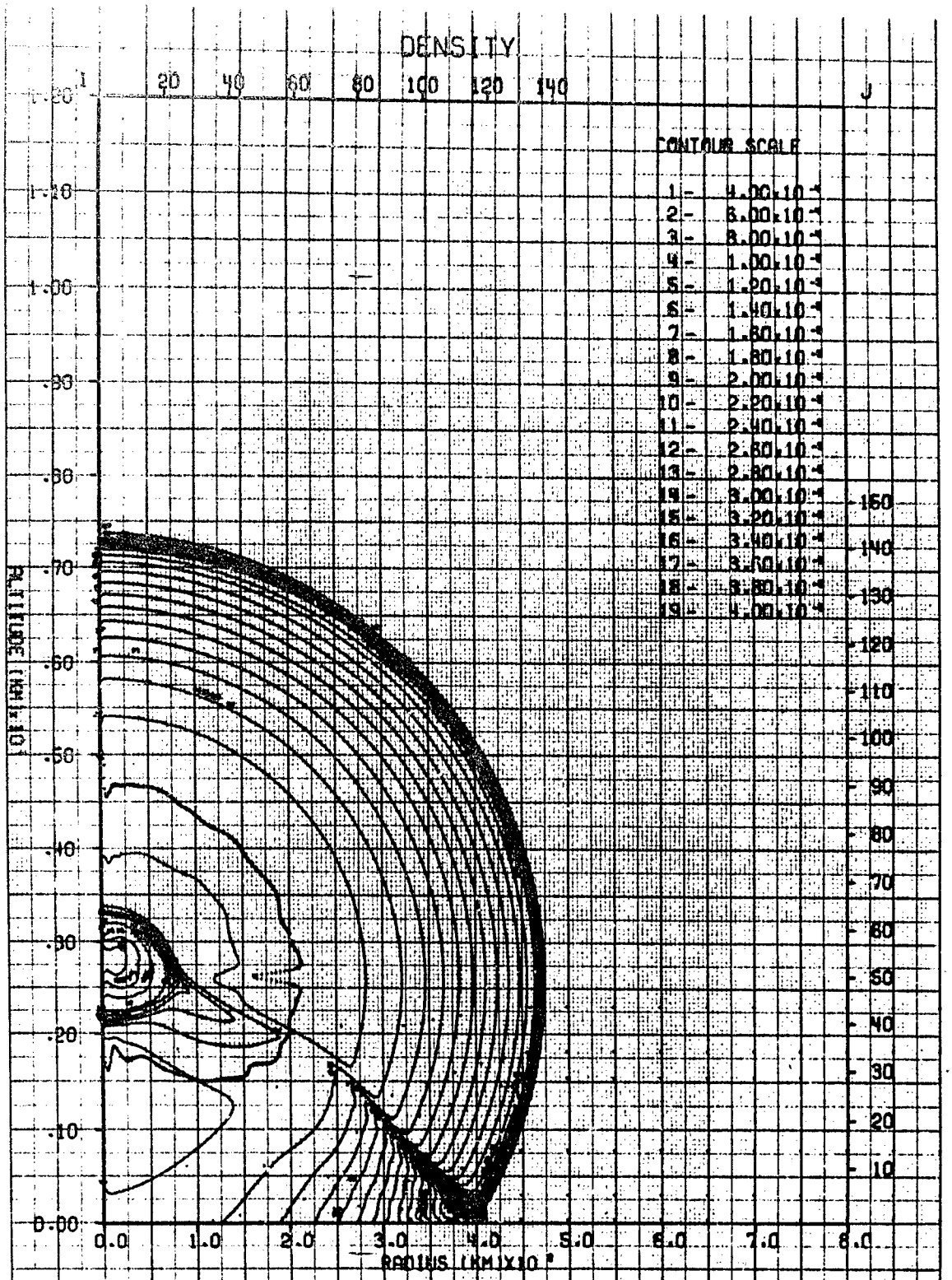

VELOCITY VECTOR
VELOCITY SCALE
.7DIN.=1KM./SEC.
ALTITUDE (KM)x10
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER P0=13.6
TIME .014 SEC CYCLE 81. PROBLEM 201.009


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 - 2.60,10
HEIGHT (KM)X10
1.20
1.10
1.00
.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
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 .019 SEC CYCLE 111. PROBLEM 201.004

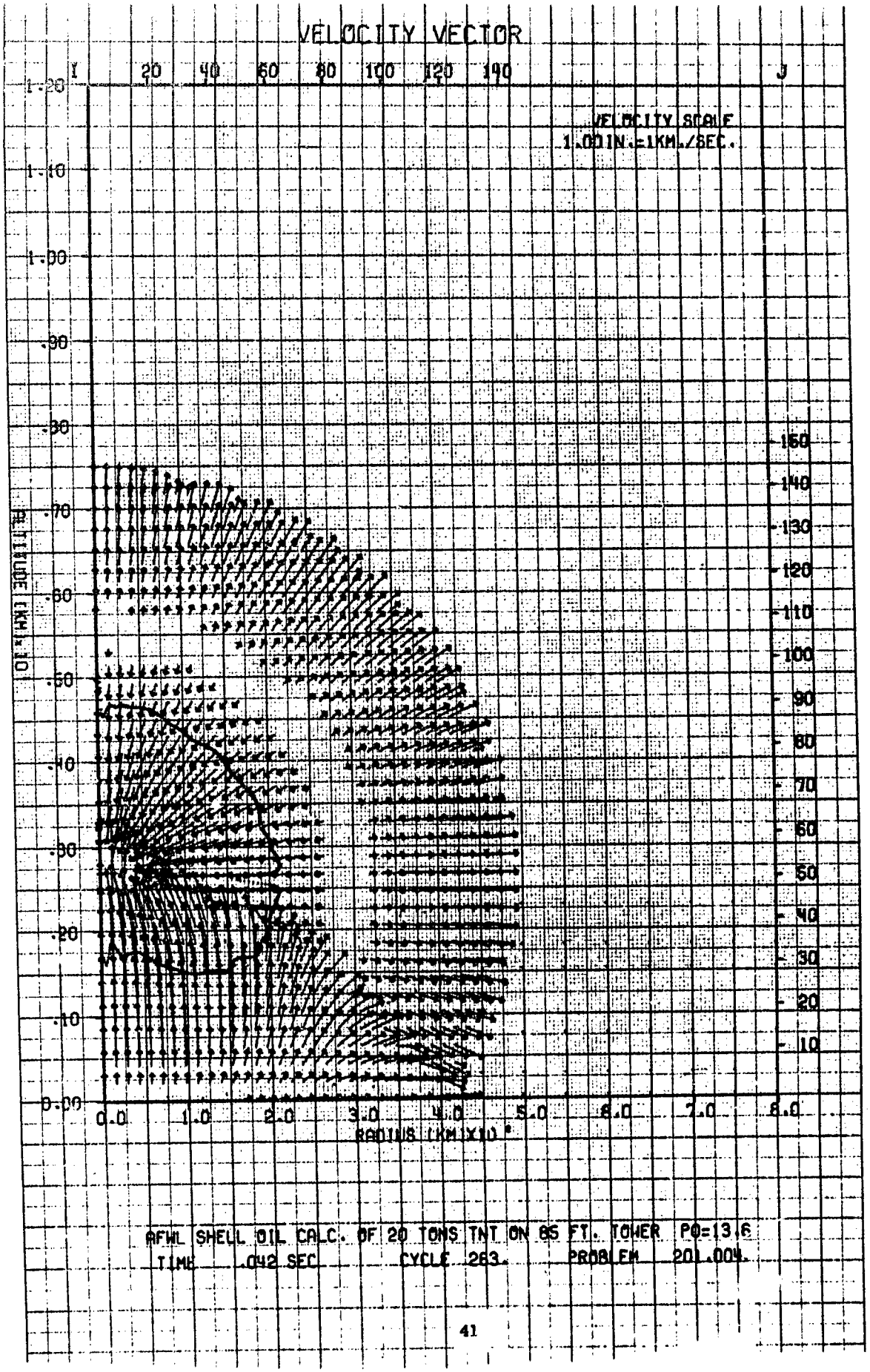

DENSITY
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1- -4.00x10⁻⁴
2- -3.00x10⁻⁴
3- -2.00x10⁻⁴
4- -1.00x10⁻⁴
5- 0.00x10⁻⁴
6- 1.00x10⁻⁴
7- 2.00x10⁻⁴
8- 3.00x10⁻⁴
9- 4.00x10⁻⁴
10- 5.00x10⁻⁴
11- 6.00x10⁻⁴
12- 7.00x10⁻⁴
13- 8.00x10⁻⁴
14- 9.00x10⁻⁴
ALTITUDE (KM X10)
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.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 PO=13.5
TIME .019 SEC CYCLE 111. PROBLEM 201.009

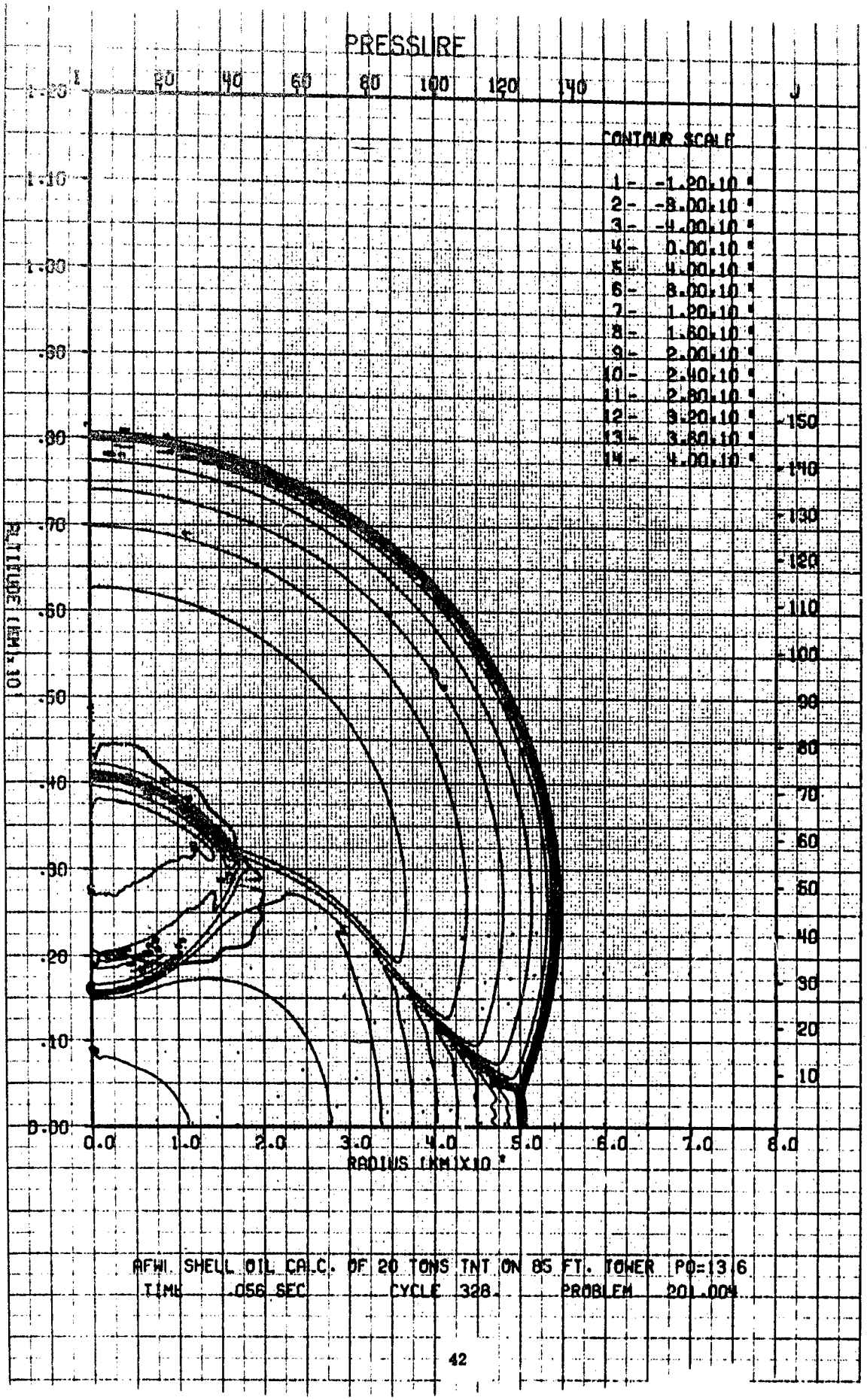

VELOCITY VECTOR
I
20 40 60 80 100 120 140
J
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0.00
ALTITUDE (KM)x10
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
RADIUS (KM)X10
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .019 SEC CYCLE 111. PROBLEM 201.004

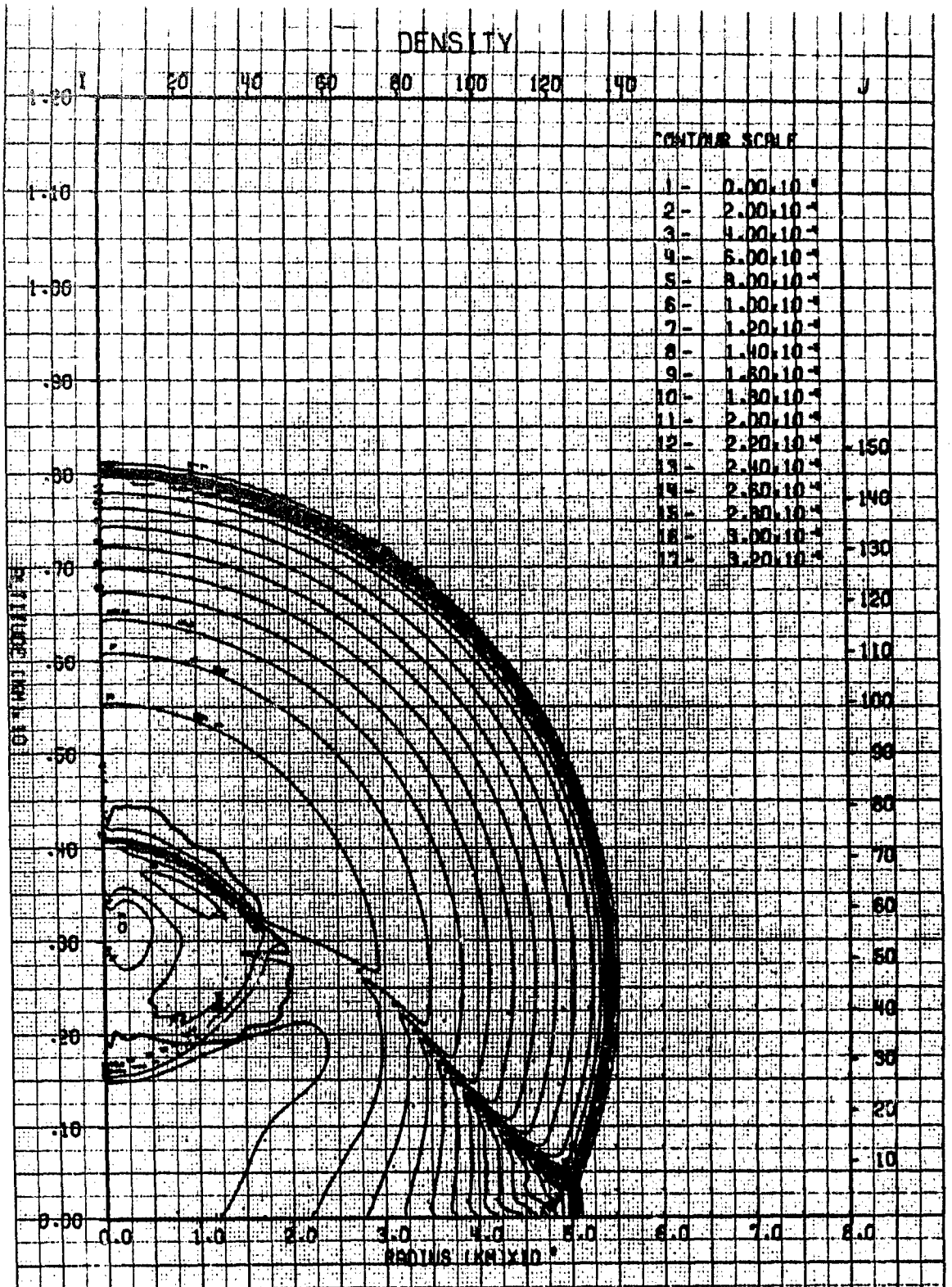

PRESSURE
I
20
40
60
80
100
120
140
J
CONTOUR SCALE
1- 0.00x10
2- 4.00x10
3- 8.00x10
4- 1.20x10
5- 1.60x10
6- 2.00x10
7- 2.40x10
8- 2.80x10
9- 3.20x10
10- 3.60x10
11- 4.00x10
12- 4.40x10
13- 4.80x10
14- 5.20x10
15- 5.60x10
16- 6.00x10
ALTITUDE (KM)
RADIUS (KM)X10
AFWL SHELL OIL CALC. OF 20 TONS INT ON 85 FT. TOWER PO=13.6
TIME .042 SEC CYCLE 263. PROBLEM 201.004



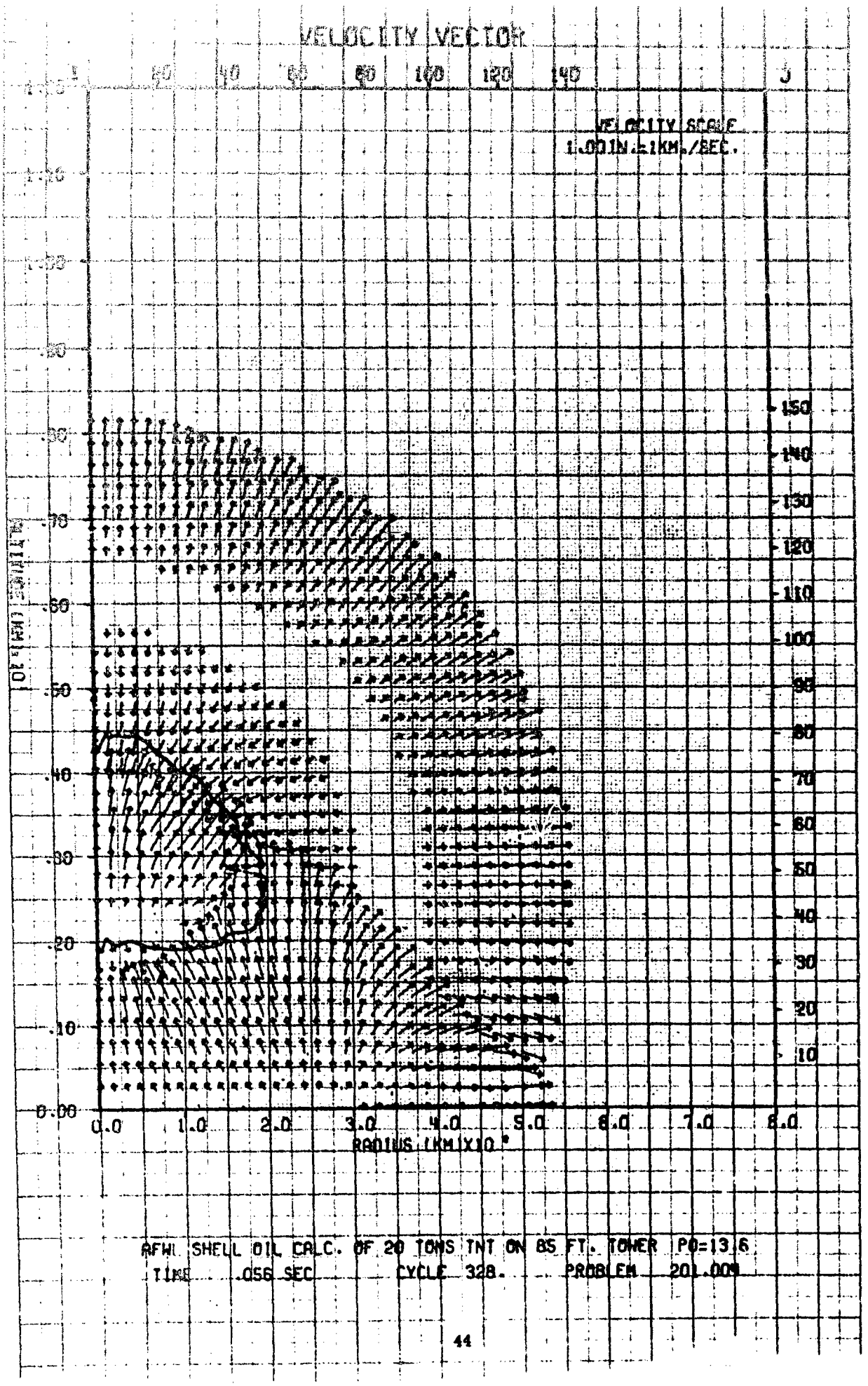
RFWI. SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .042 SEC CYCLE 283. PROBLEM 201.009


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 X10)
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 PO=13.6
TIME .042 SEC CYCLE 263. PROBLEM 201.004.

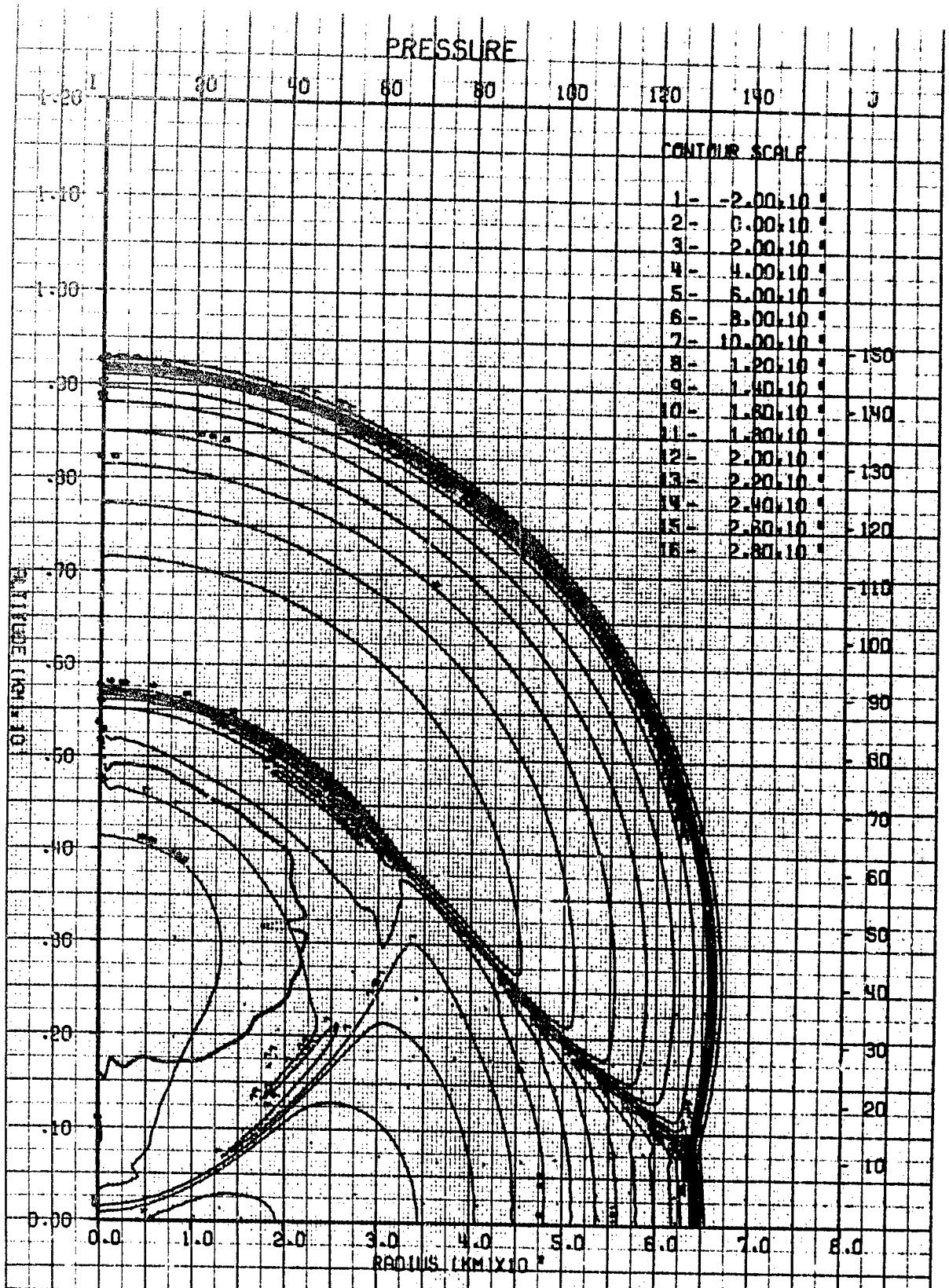

PRESSURE
CONTOUR SCALE
1 - -1.20,10 5
2 - -8.00,10 4
3 - -4.00,10 4
4 - 0.00,10 4
5 - 4.00,10 4
6 - 8.00,10 4
7 - 1.20,10 5
8 - 1.60,10 5
9 - 2.00,10 5
10 - 2.40,10 5
11 - 2.80,10 5
12 - 3.20,10 5
13 - 3.60,10 5
14 - 4.00,10 5
ELEVATION (KM)x10
RADIUS (KM)X10 4
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13 6
TIME .056 SEC CYCLE 328. PROBLEM 201.004



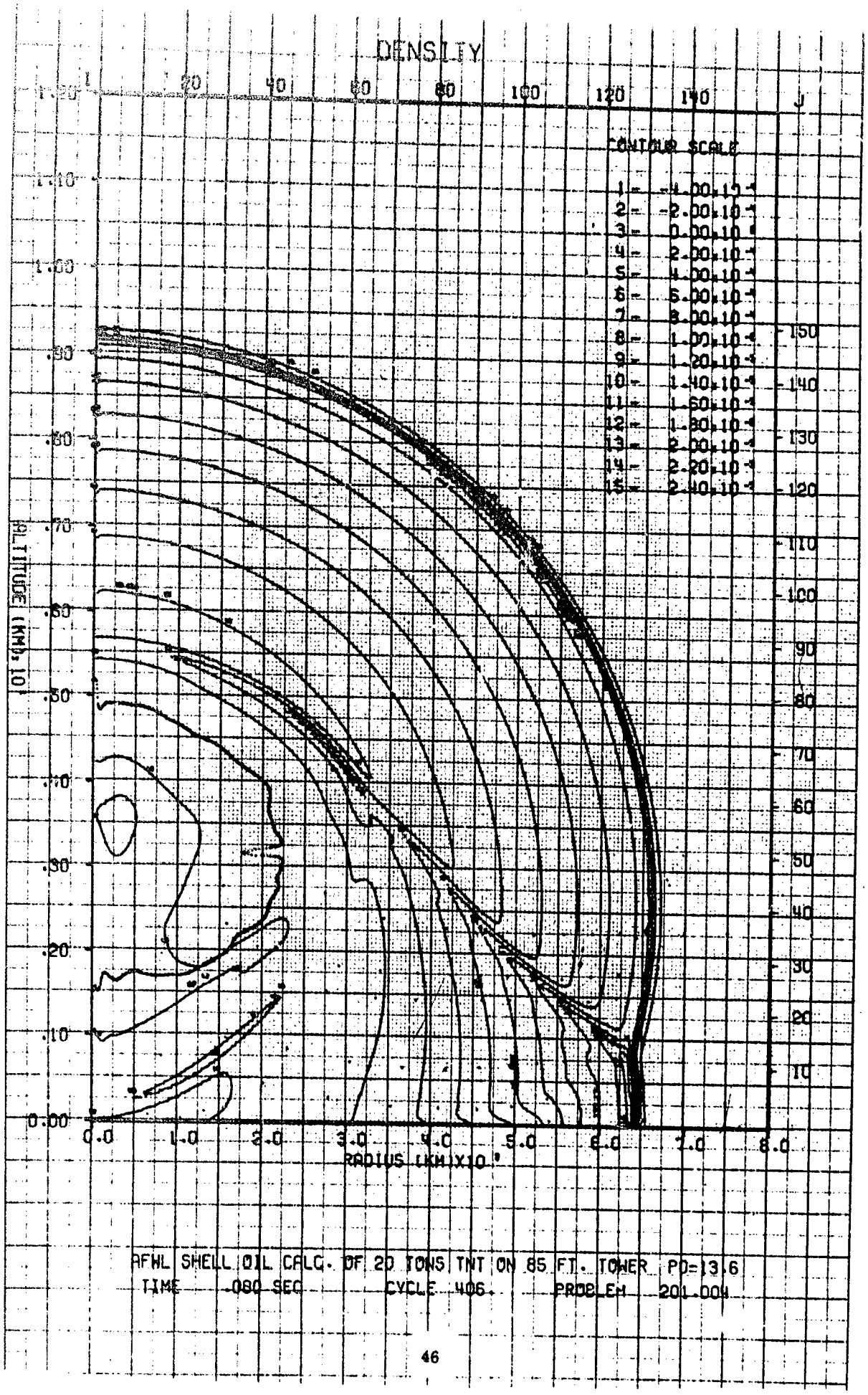
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .056 SEC CYCLE 328. PROBLEM 201.009

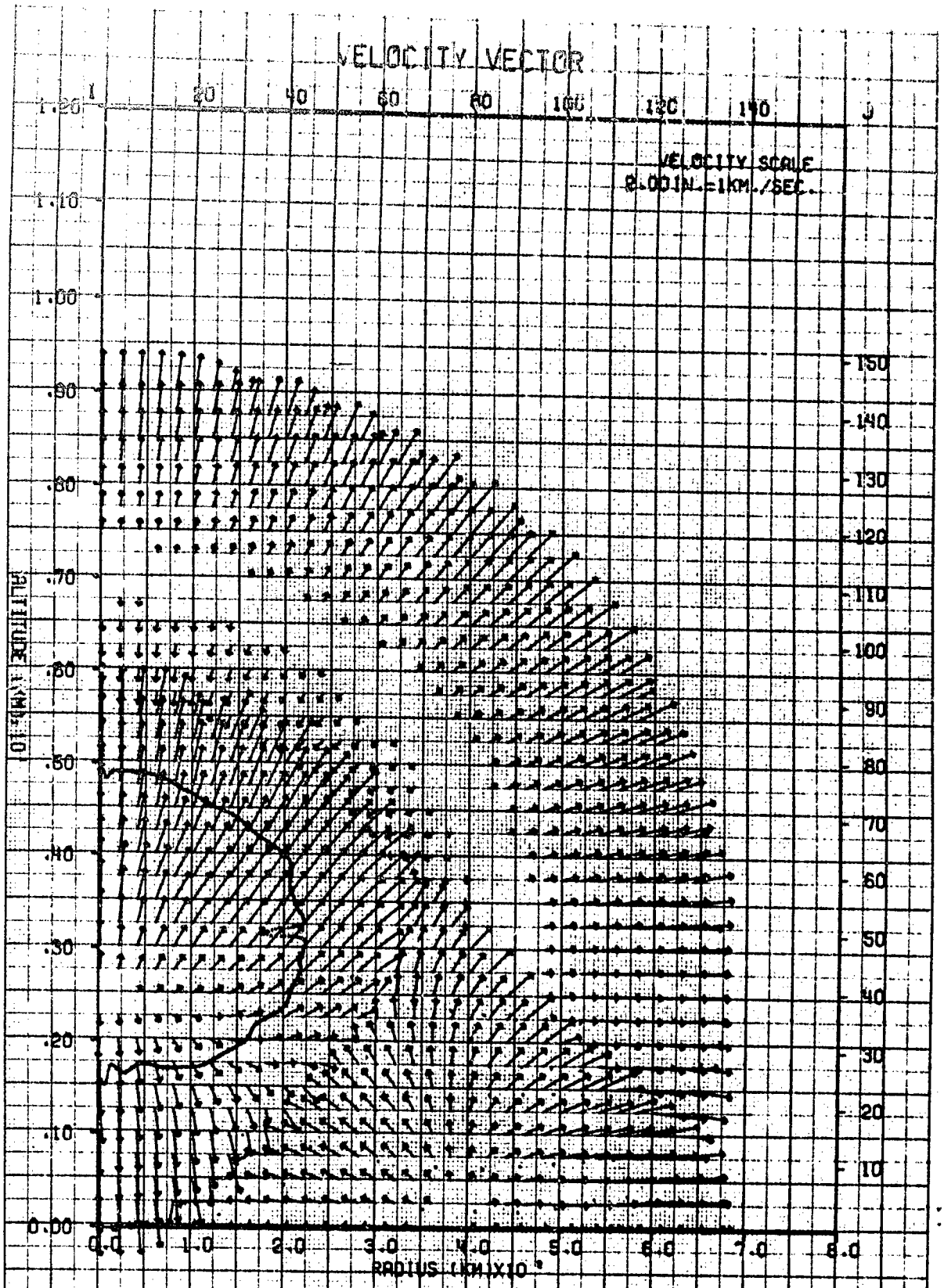


RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .056 SEC CYCLE 328. PROBLEM 201.009

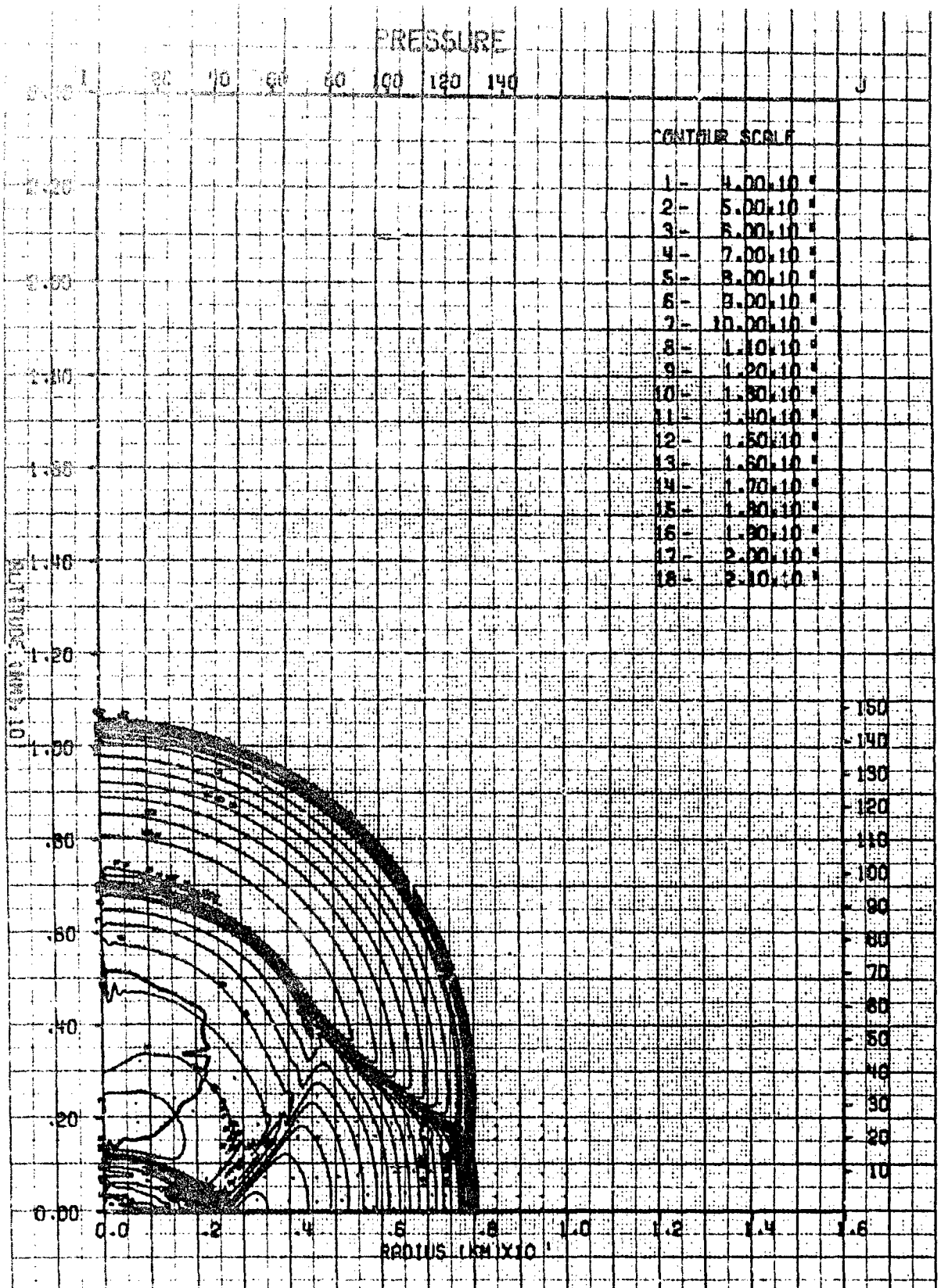


AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .080 SEC . CYCLE 406. PROBLEM 20

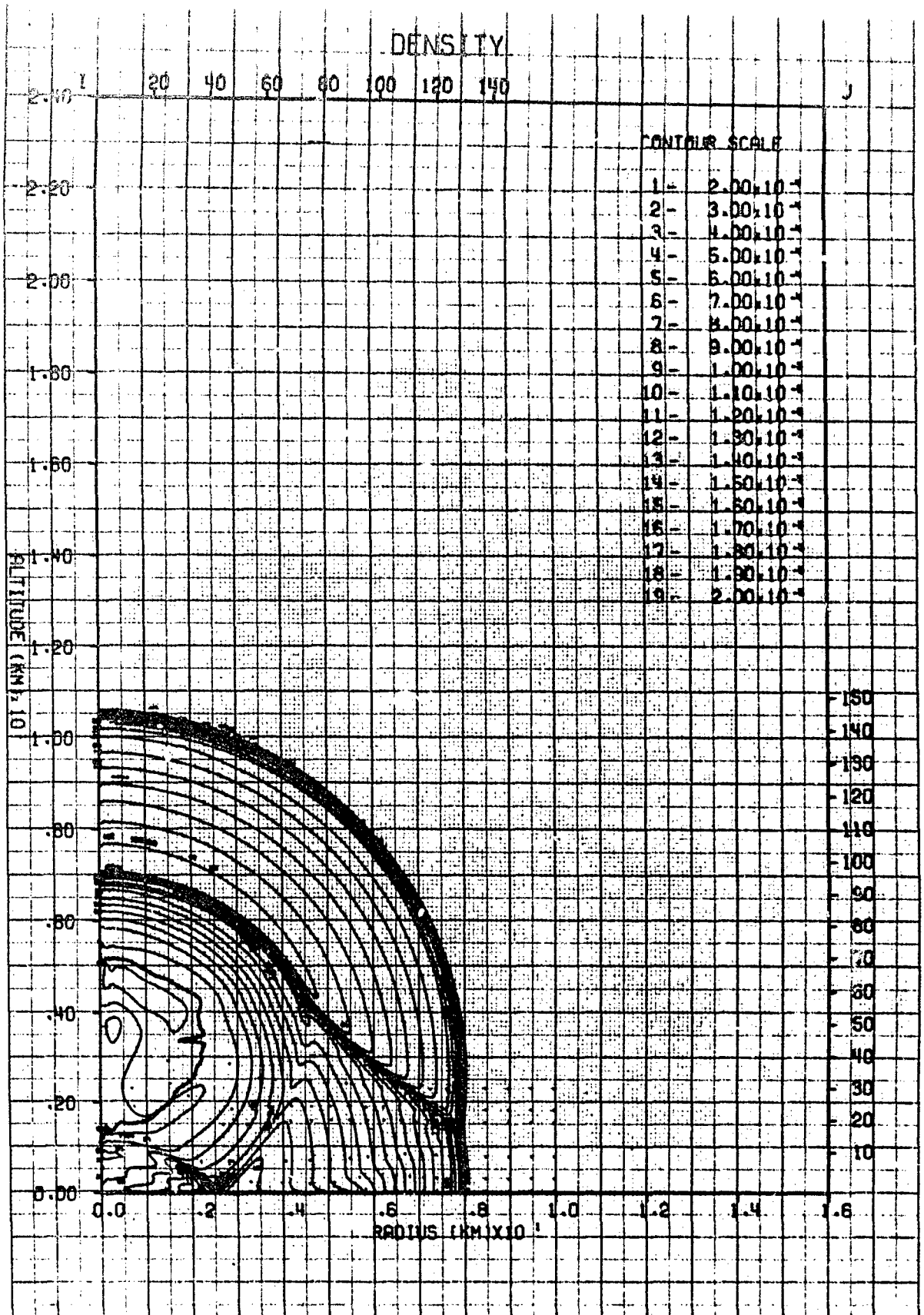

DENSITY
CONTOUR SCALE
1 - -1.00,10-1
2 - -2.00,10-1
3 - 0.00,10-1
4 - 2.00,10-1
5 - 4.00,10-1
6 - 6.00,10-1
7 - 8.00,10-1
8 - 1.00,10-1
9 - 1.20,10-1
10 - 1.40,10-1
11 - 1.60,10-1
12 - 1.80,10-1
13 - 2.00,10-1
14 - 2.20,10-1
15 - 2.40,10-1
ALTITUDE (KM,10)
RADIUS (KM)X10
J
AFWL SHELL OIL CALC. OF 20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



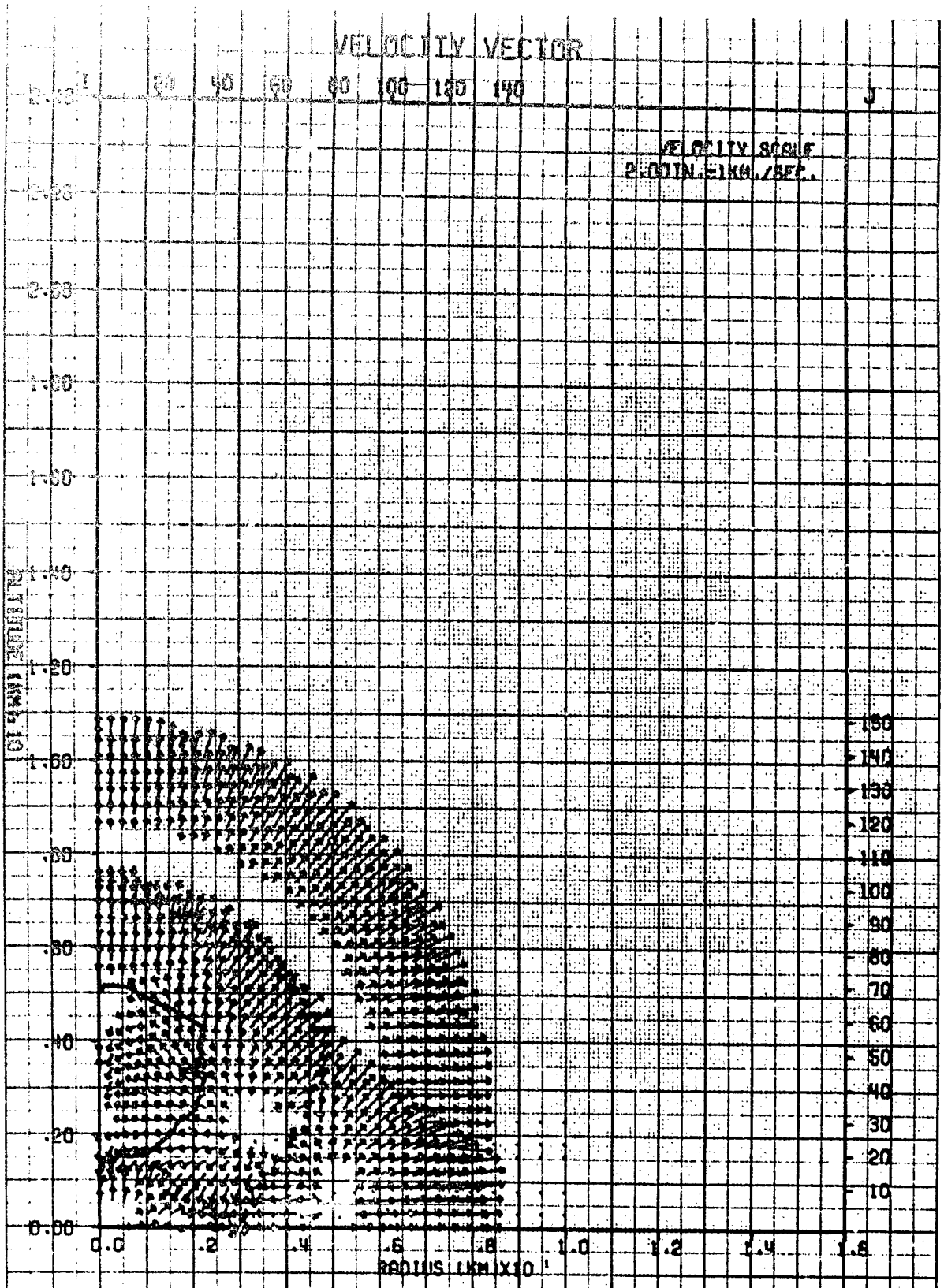
RFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .080 SEC CYCLE 1406 PROBLEM 201.009



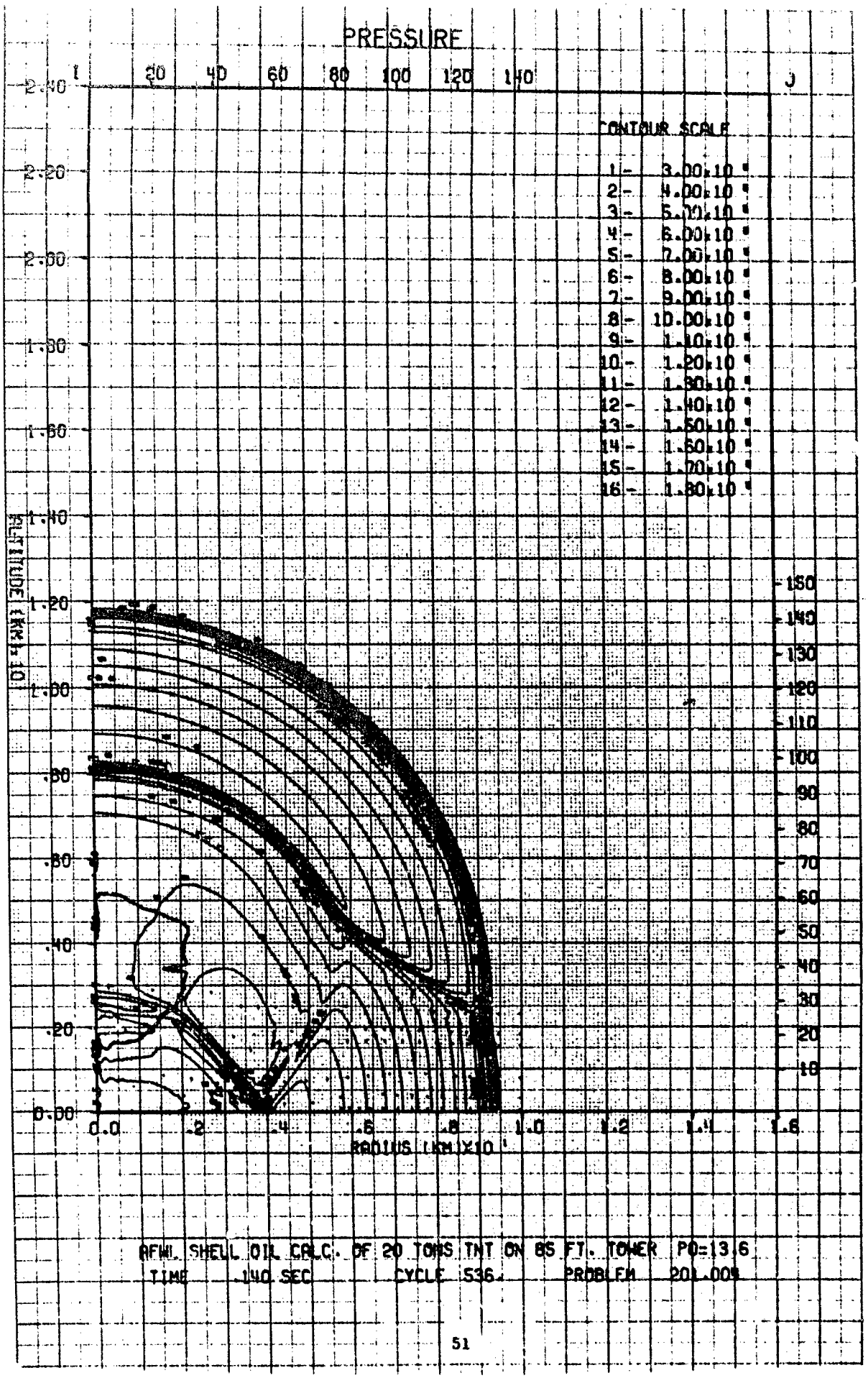
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .110 SEC CYCLE 476 PROBLEM 201.004

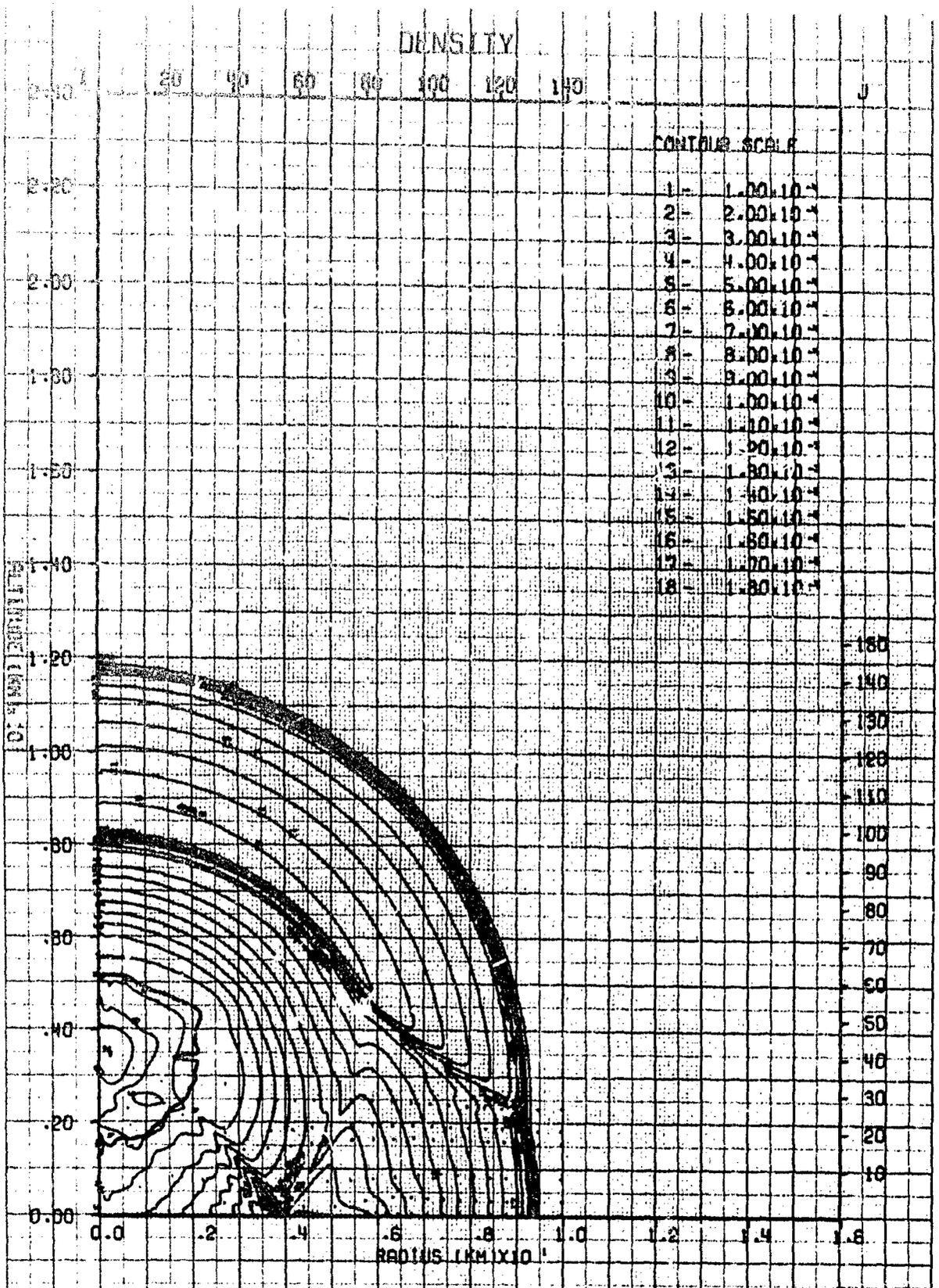


RFWL SHELL OIL CR.C. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .110 SEC CYCLE 476. PROBLEM 201.004

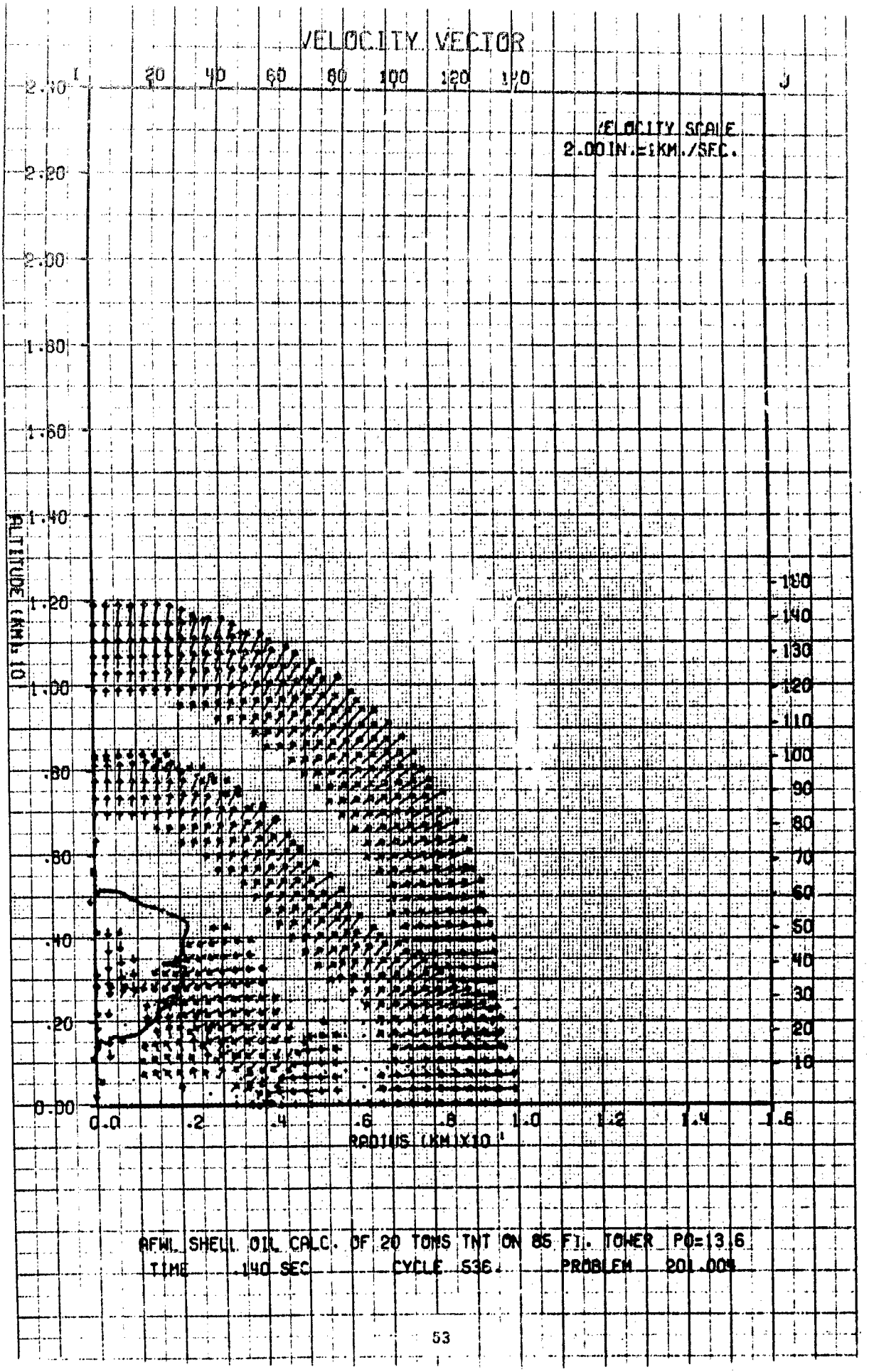


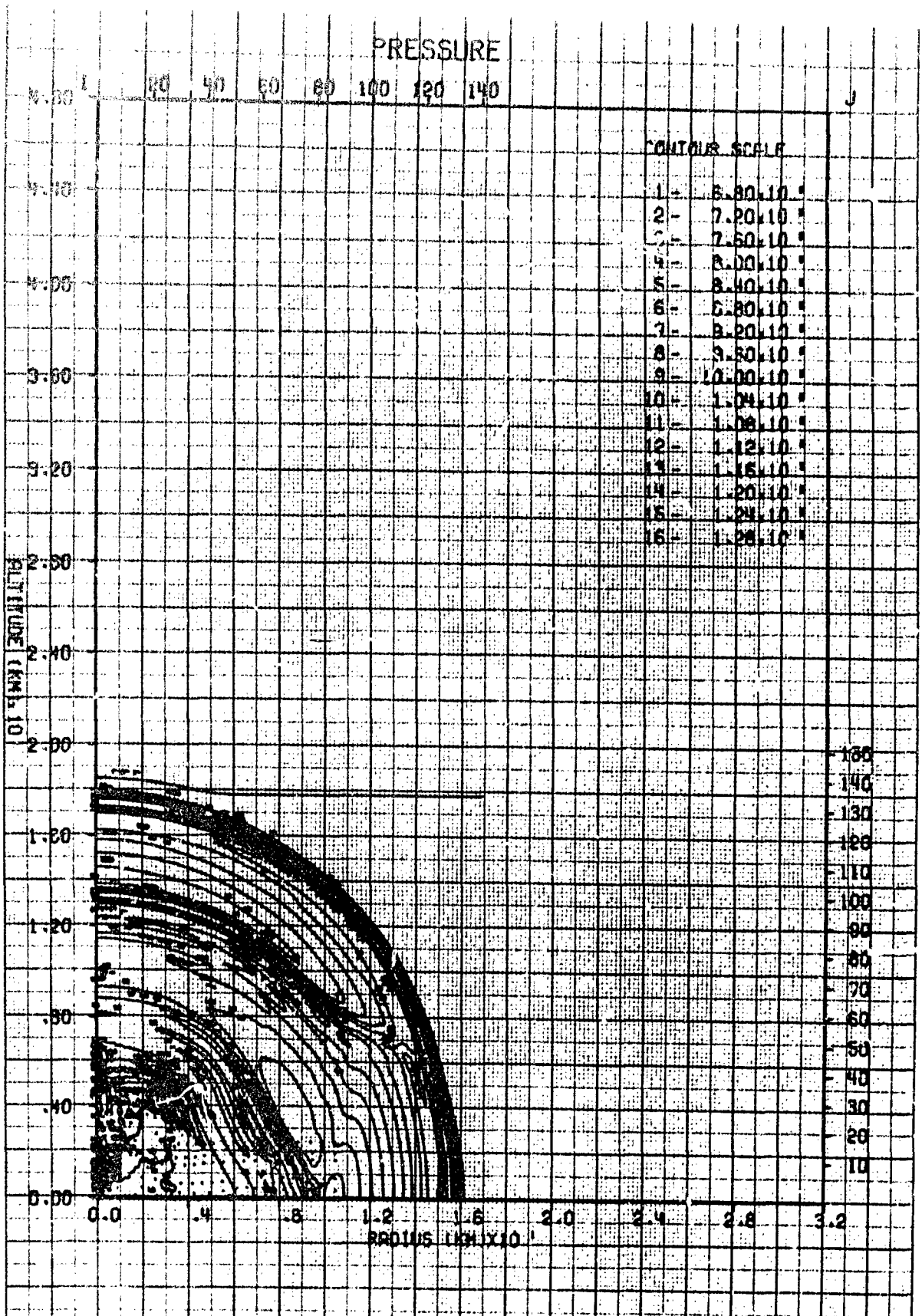
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .110 SEC CYCLE 476. PROBLEM 201.009

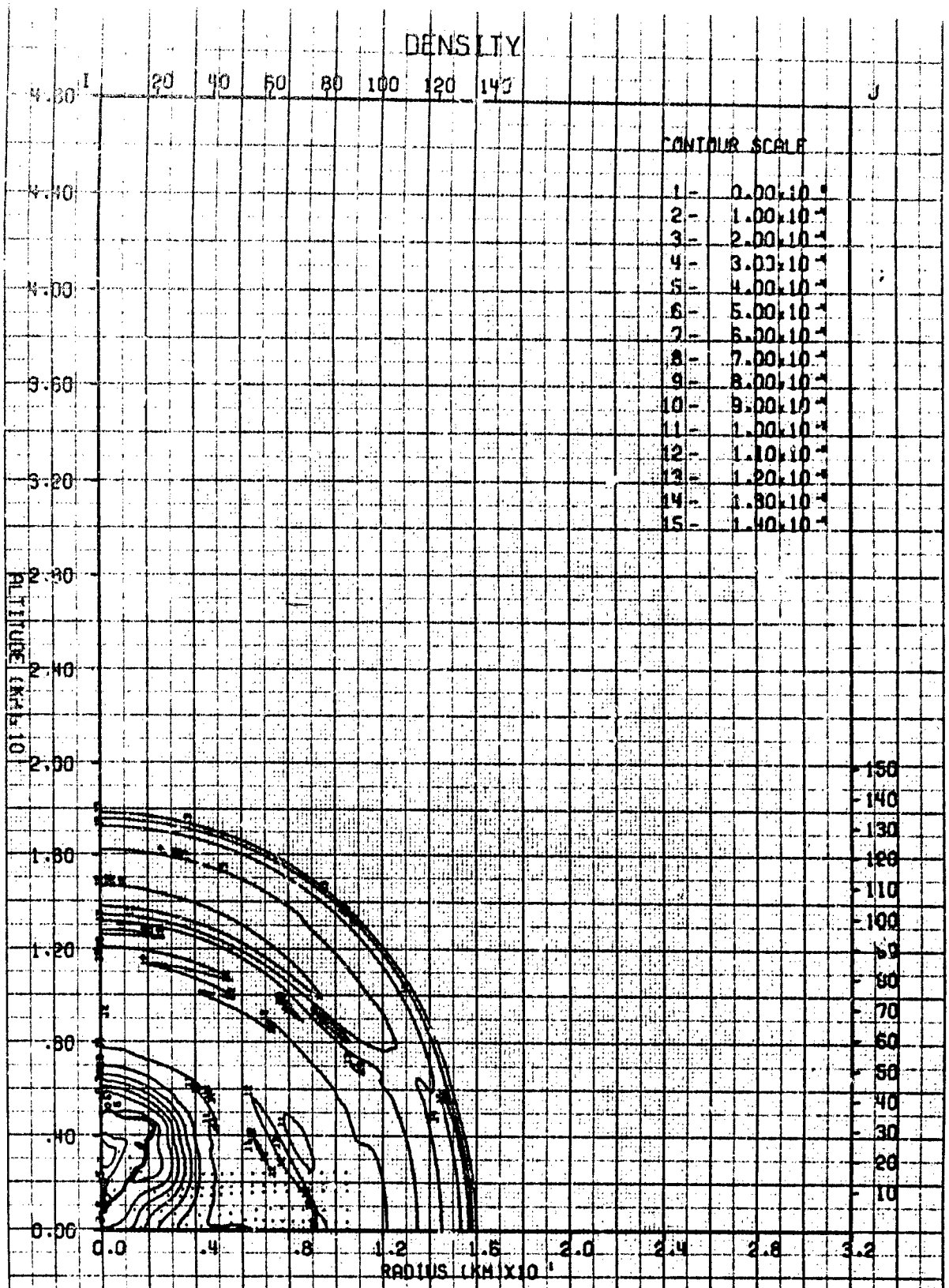

PRESSURE
CONTOUR SCALE
1 - 3.00x10
2 - 4.00x10
3 - 5.00x10
4 - 6.00x10
5 - 7.00x10
6 - 8.00x10
7 - 9.00x10
8 - 10.00x10
9 - 1.10x10
10 - 1.20x10
11 - 1.30x10
12 - 1.40x10
13 - 1.50x10
14 - 1.60x10
15 - 1.70x10
16 - 1.80x10
ALTITUDE (KM)
RADIUS (KM)
AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER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



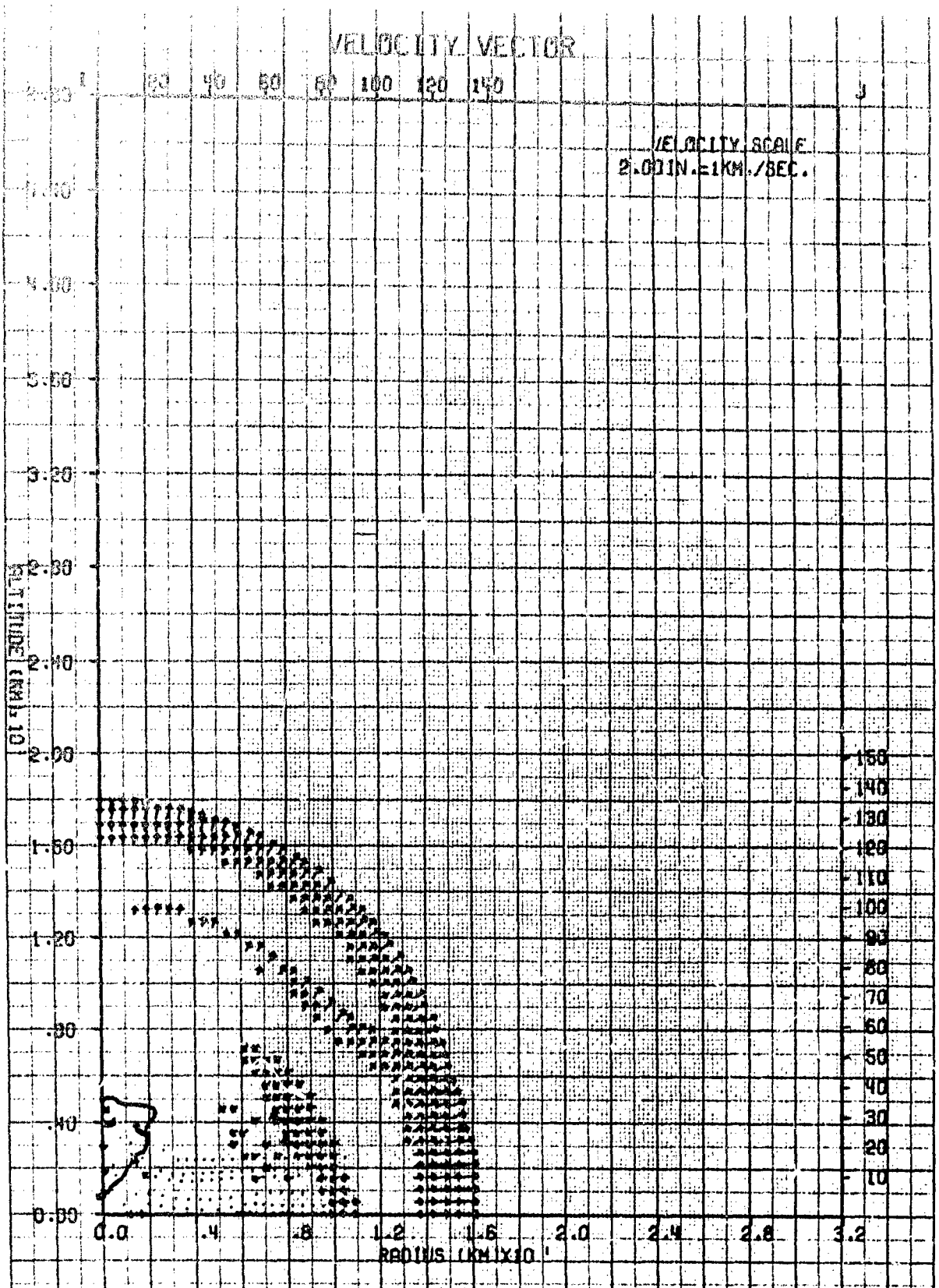
AFWL SHELL OIL CALC. OF 20 TONS INT ON 85 FT. TOWER P0=13.6
TIME .140 SEC CYCLE 536. PROBLEM 201.009


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 PO=13.6
TIME .140 SEC CYCLE 536. PROBLEM 201.009


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 PO=13.6
TIME .300 SEC CYCLE 748 PROBLEM 201.009



AFWL SHELL OIL CALC. OF 20 TONS TNT ON 85 FT. TOWER PO=13.6
TIME .300 SEC CYCLE 748. PROBLEM 201.004



AFWL SHELL OIL CR.C. OF 20 TONS TNT ON 85 FT. TOWER PO=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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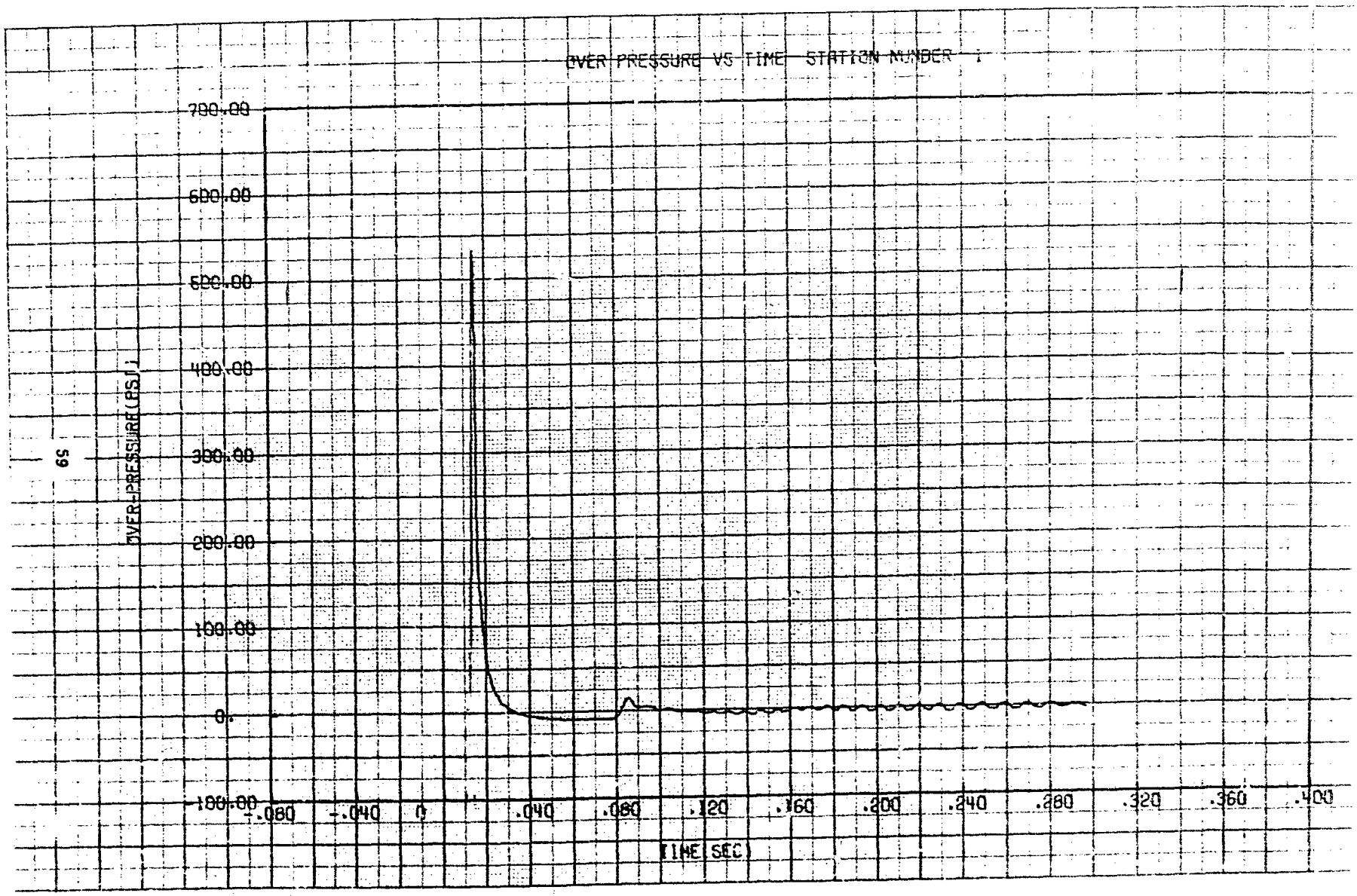
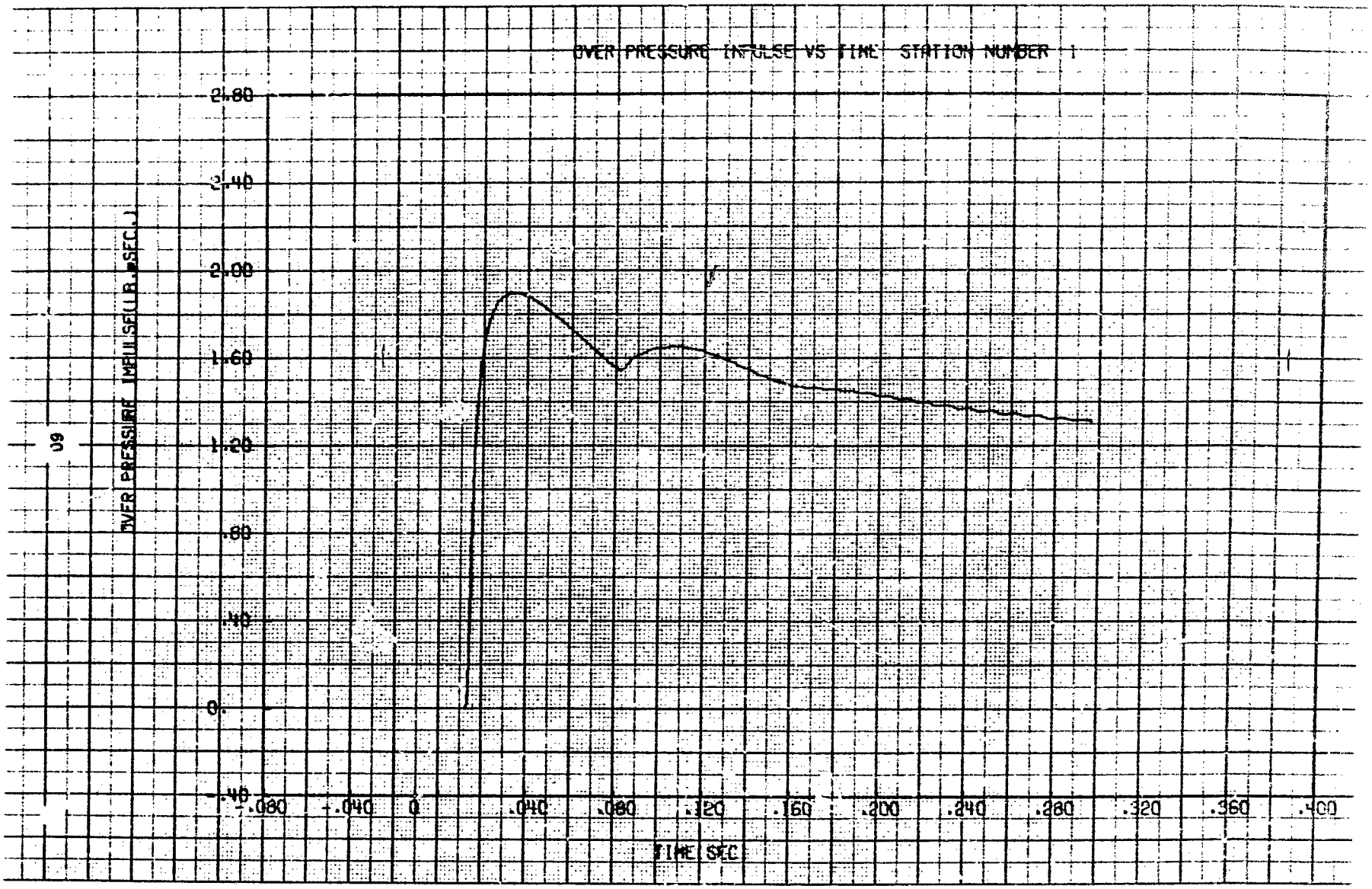
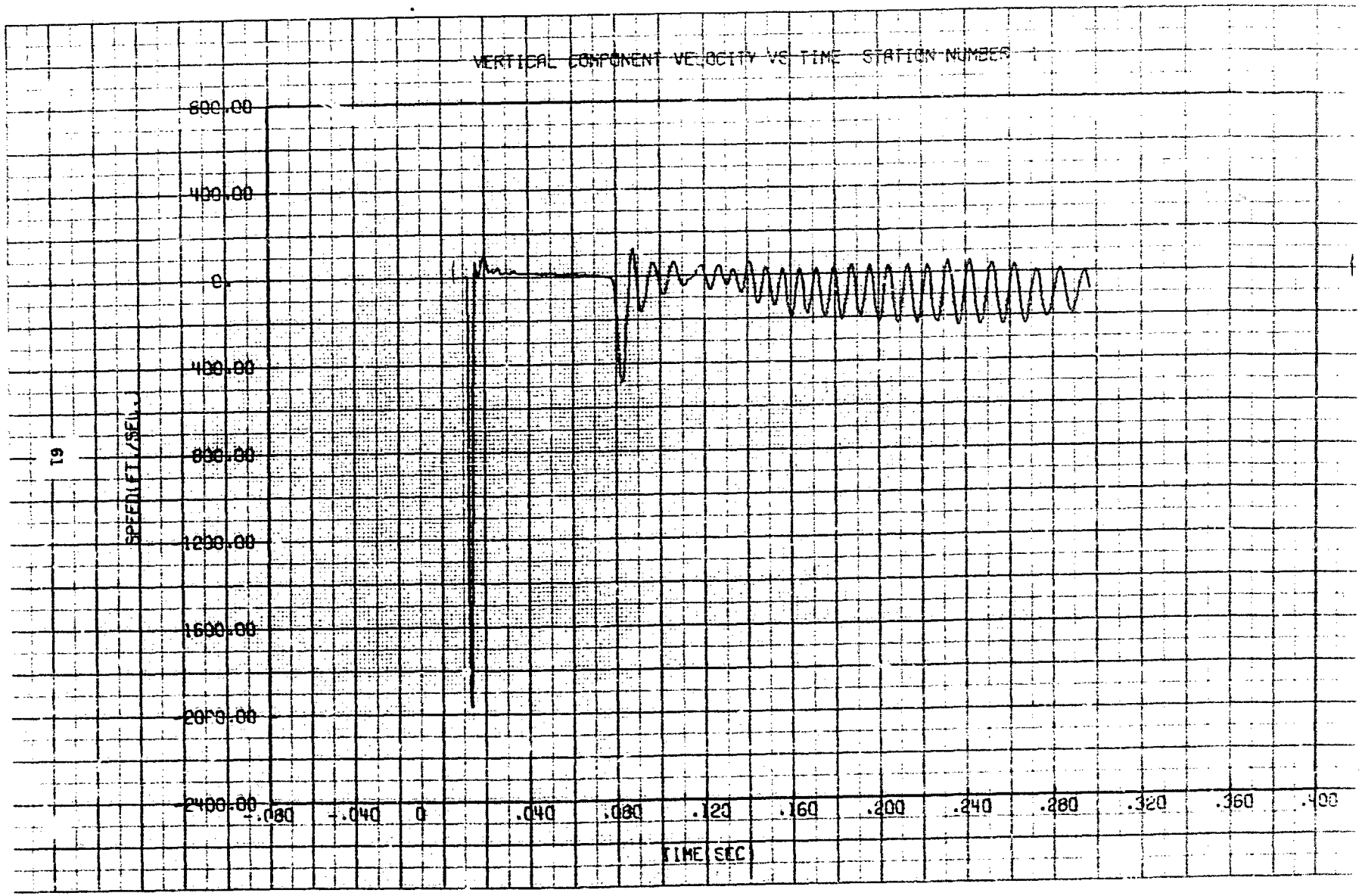
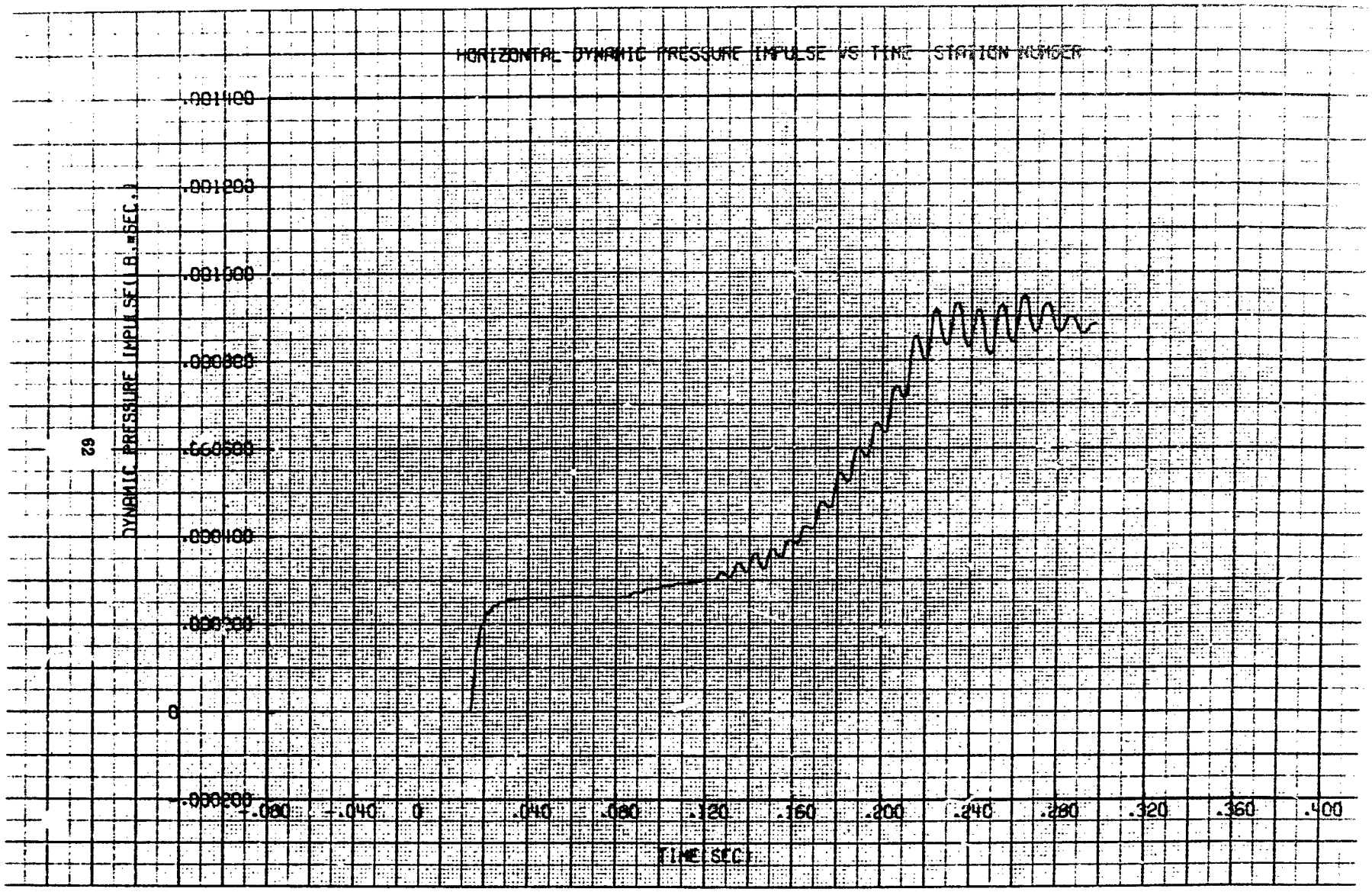
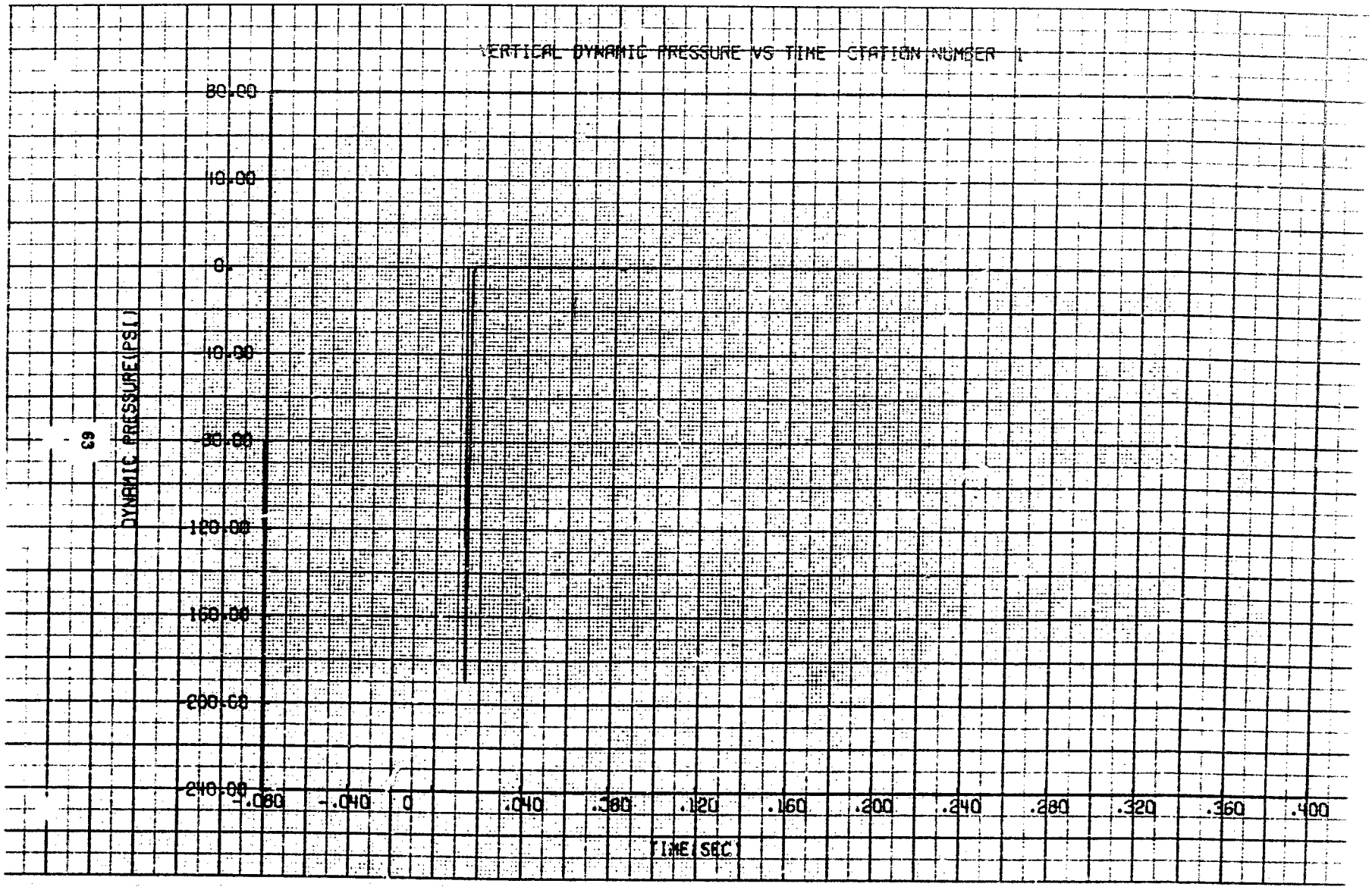
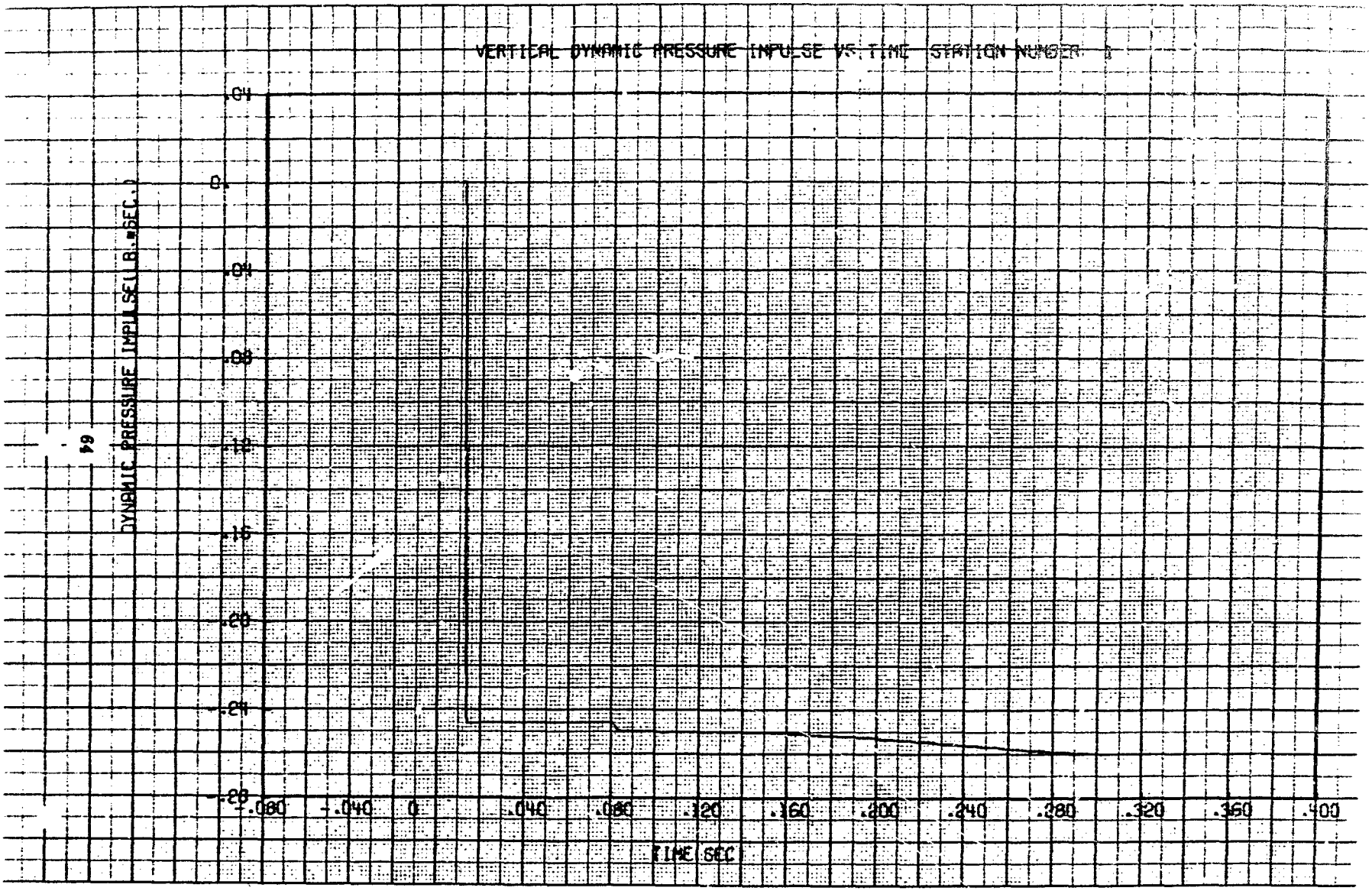

OVER PRESSURE VS TIME STATION NUMBER 1
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
OVER-PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

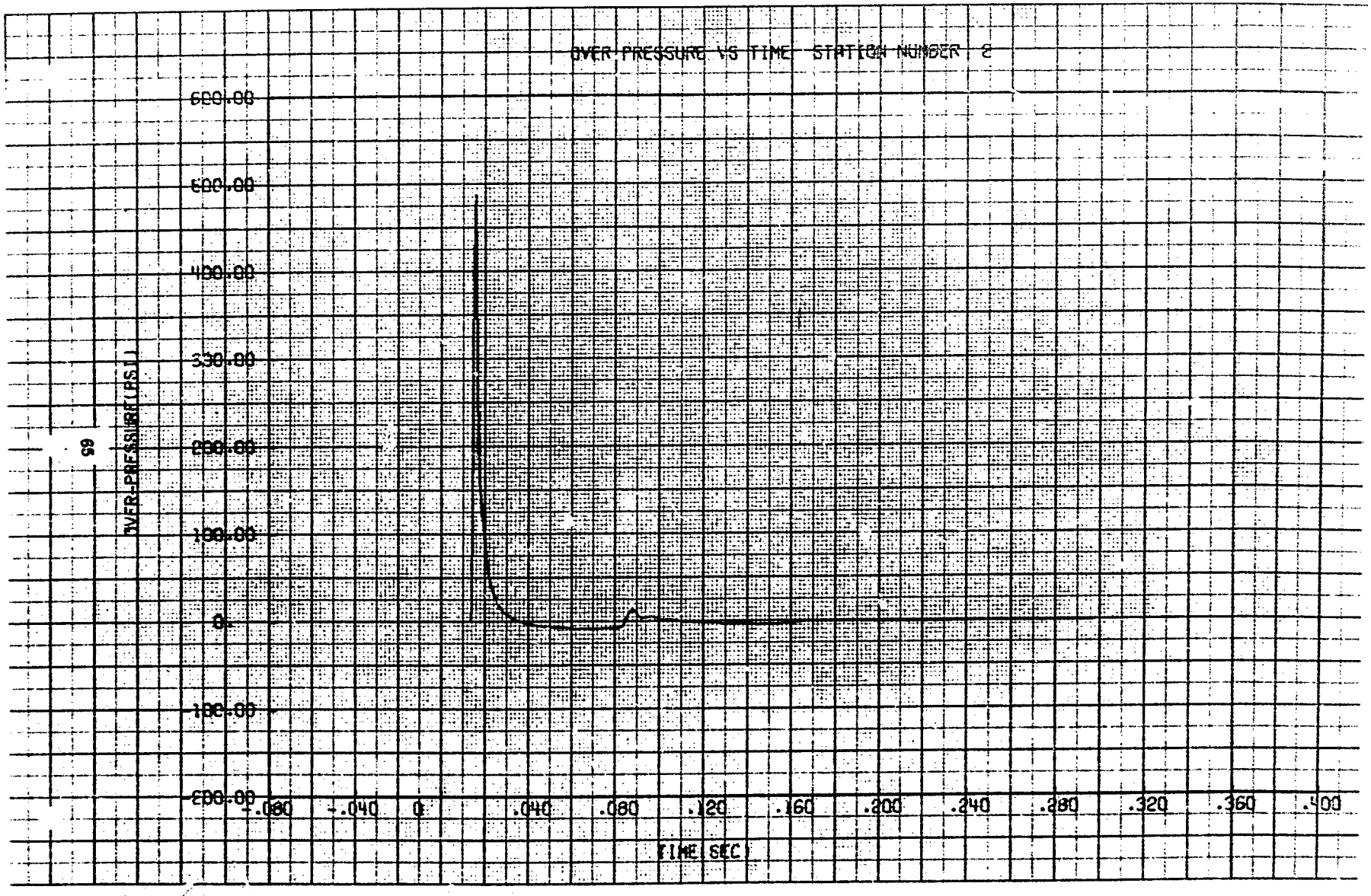

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 1
OVER PRESSURE IMPULSE(LB.*SEC.)
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

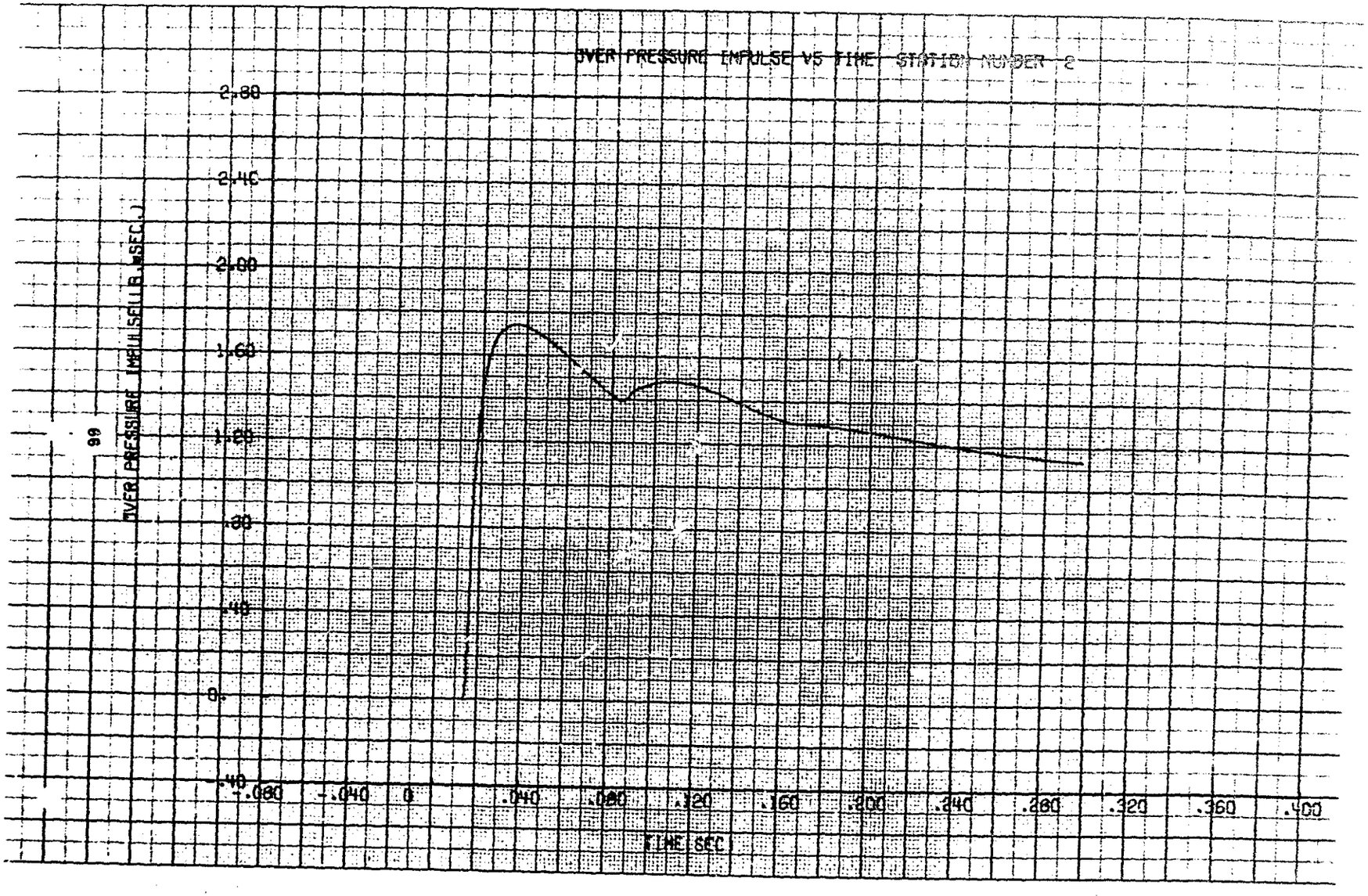

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 1
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
-2400.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
SPEED(FT/SEC)

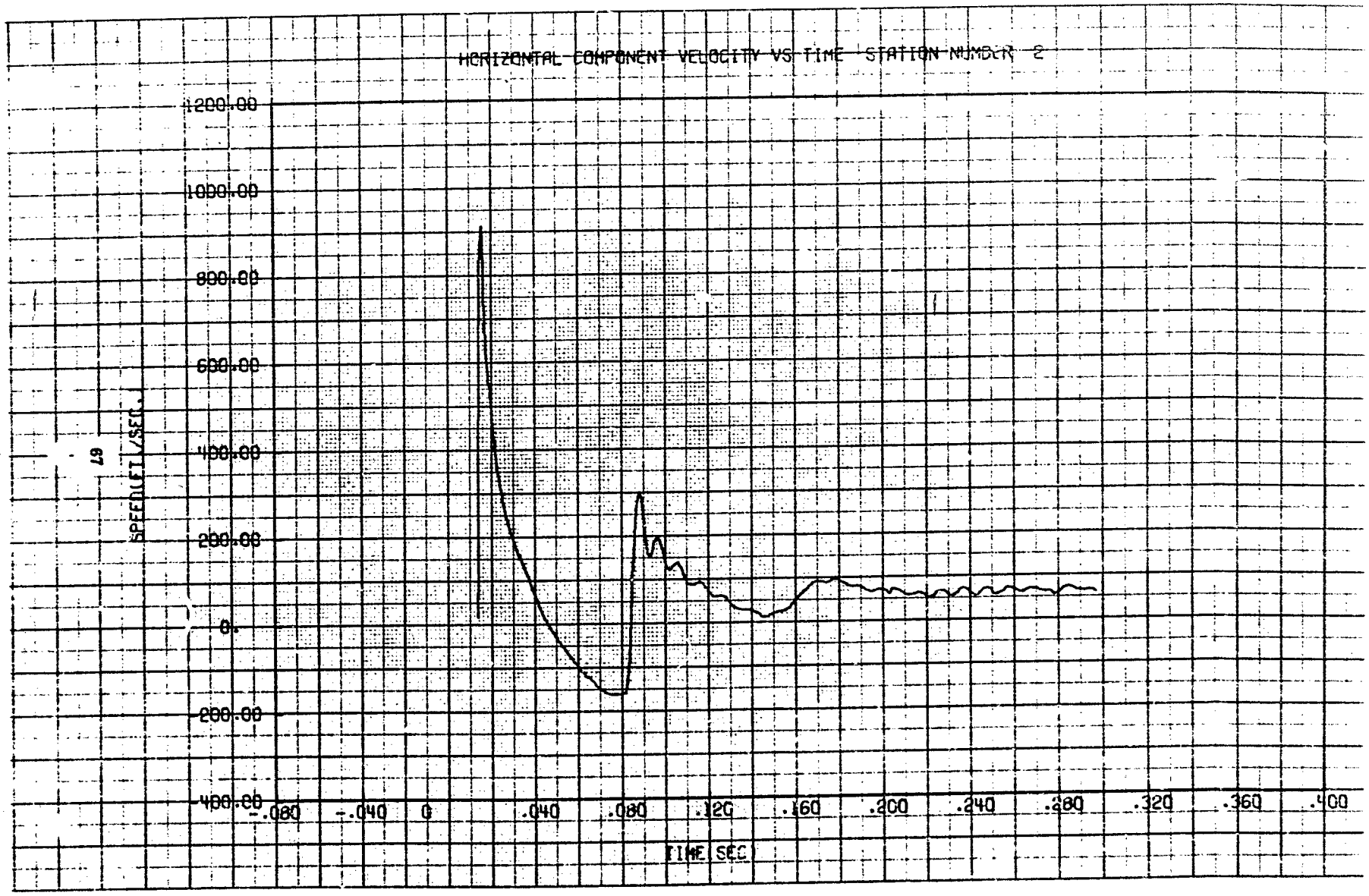

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.001400
.001200
.001000
.000800
.000600
.000400
.000200
0
-.000200
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

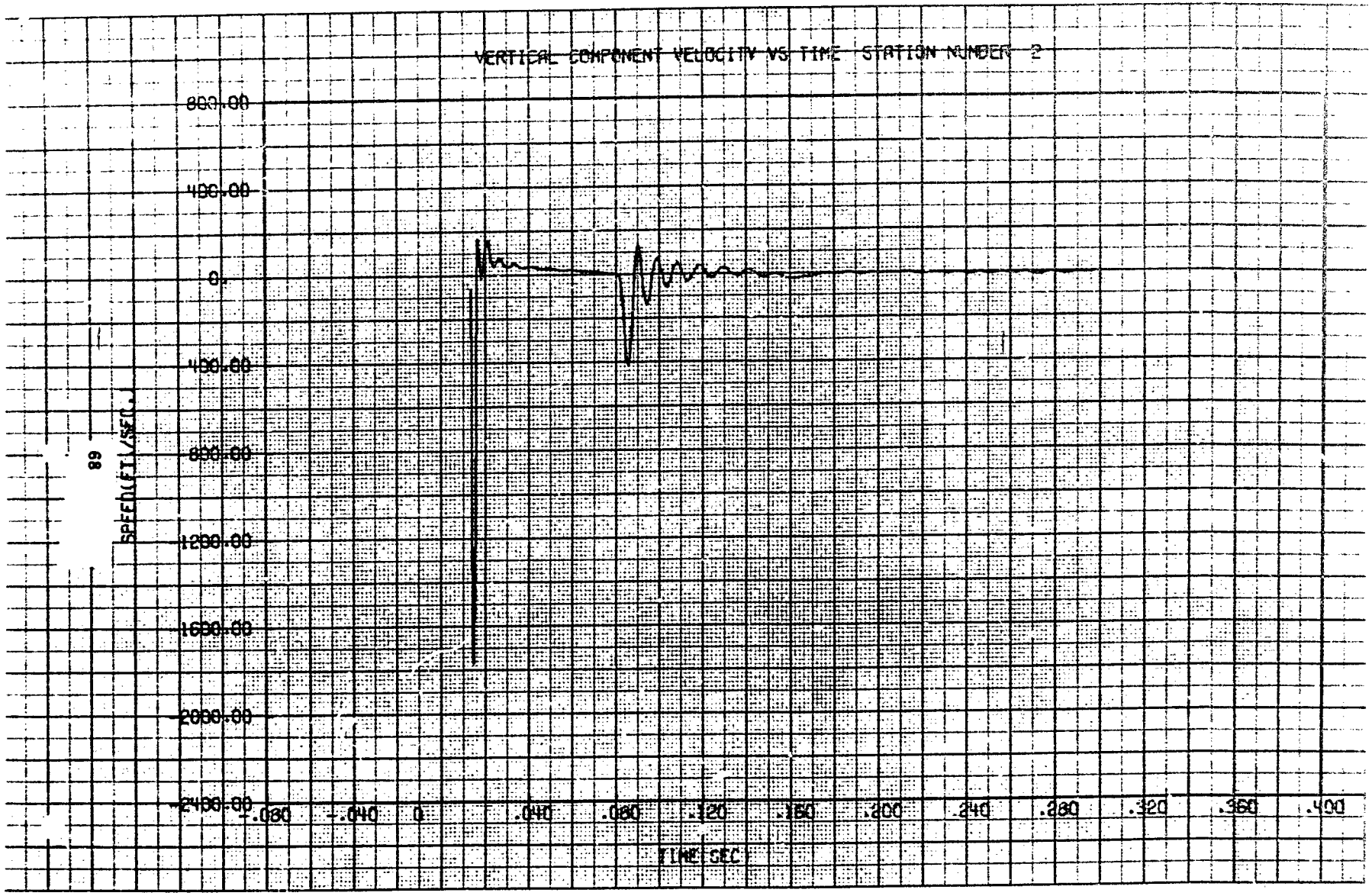

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 1
80.00
40.00
0.
-40.00
-80.00
-120.00
-160.00
-200.00
-240.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

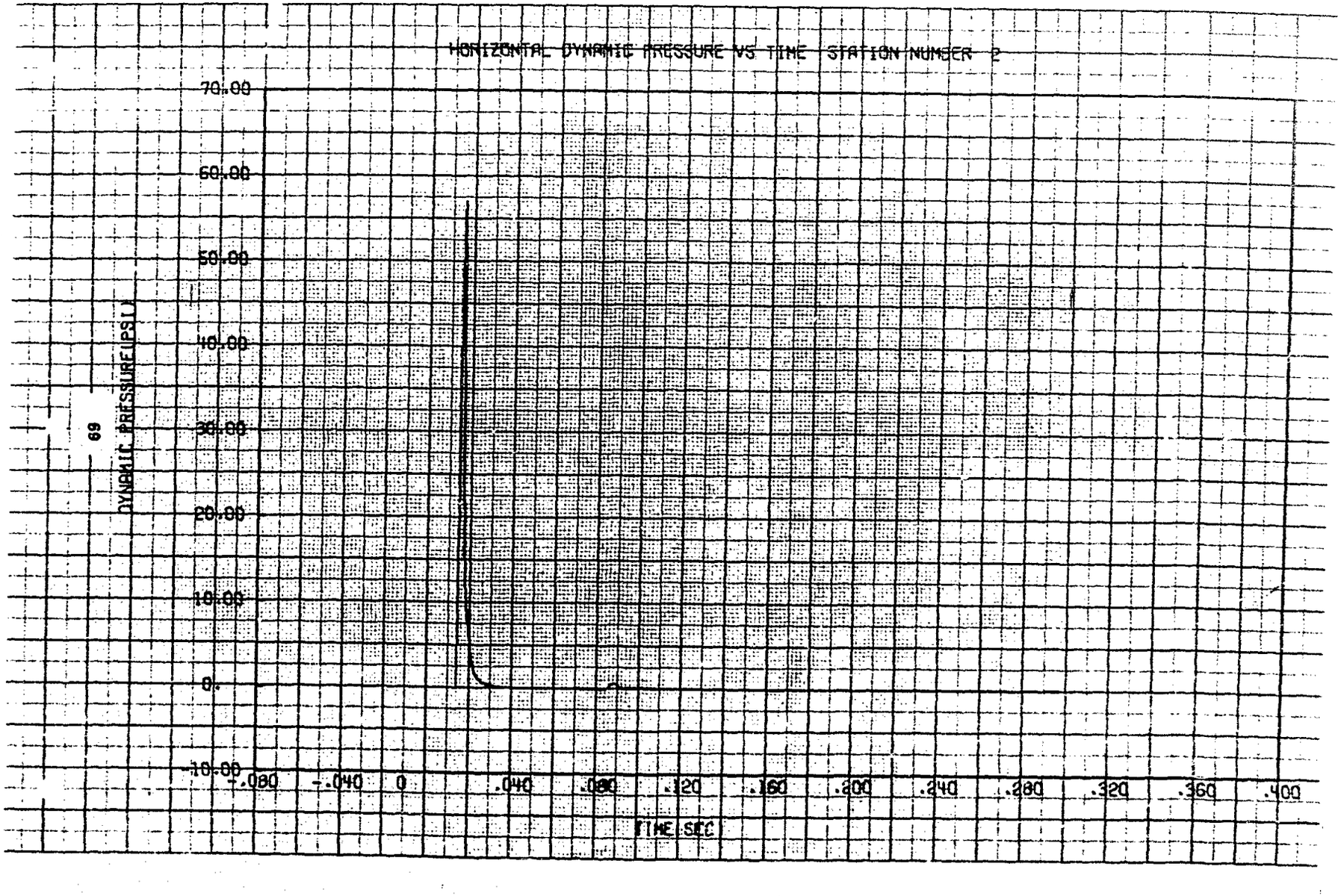

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.04
0.
-.04
-.08
-.12
-.16
-.20
-.24
-.28
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

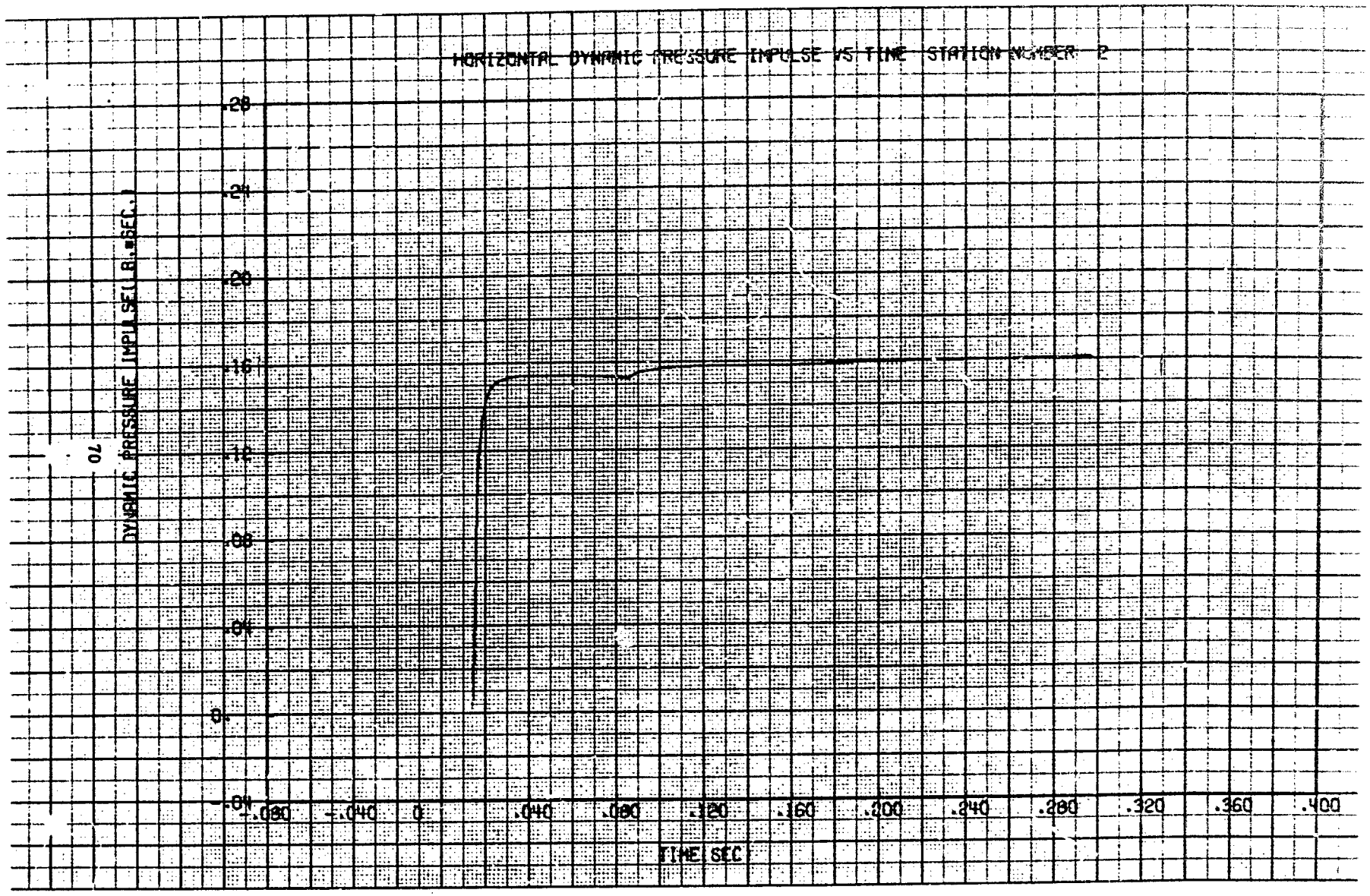

OVER PRESSURE VS TIME STATION NUMBER 2
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

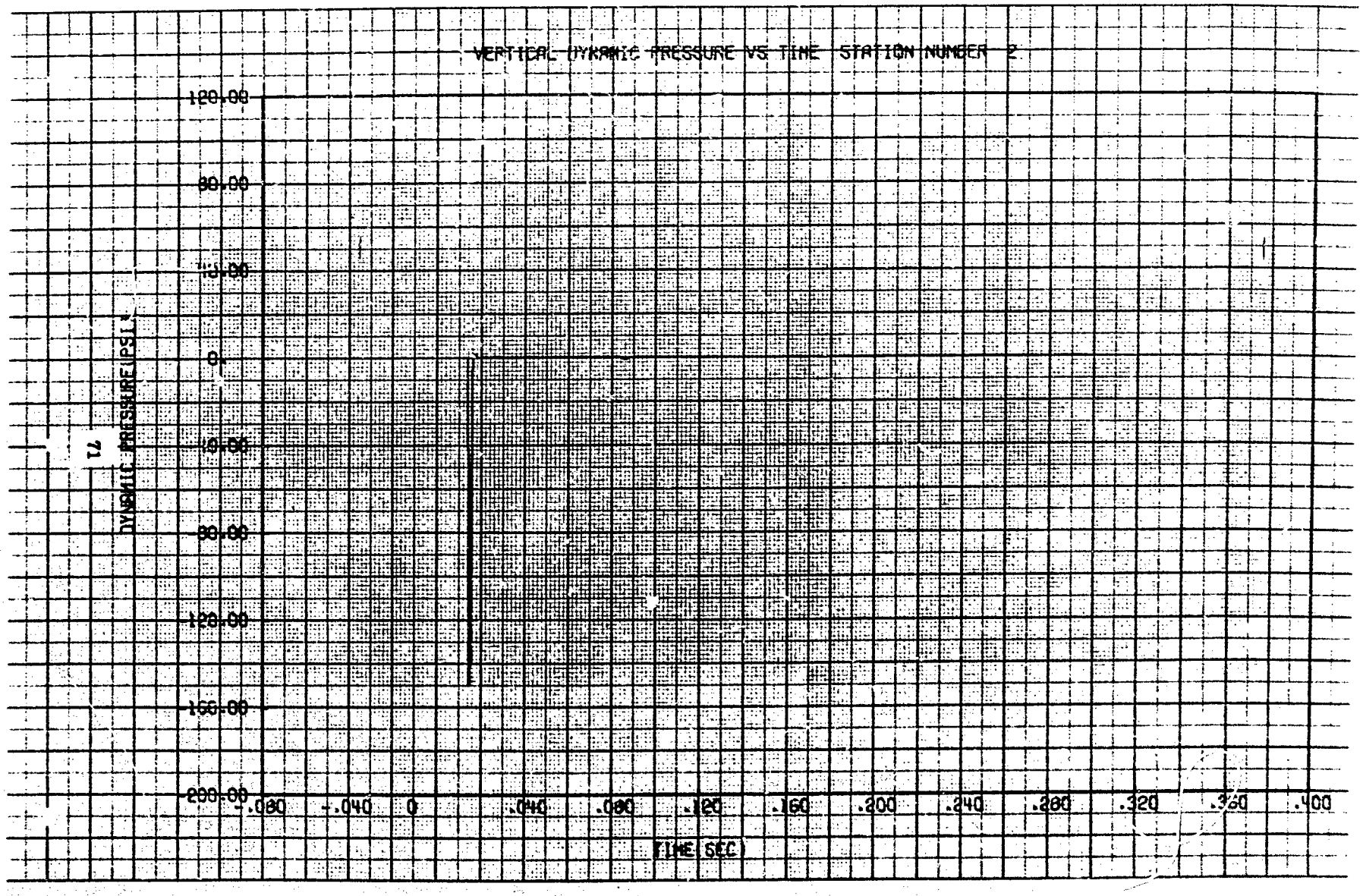

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 2
OVER PRESSURE IMPULSE(LB.*SEC.)
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

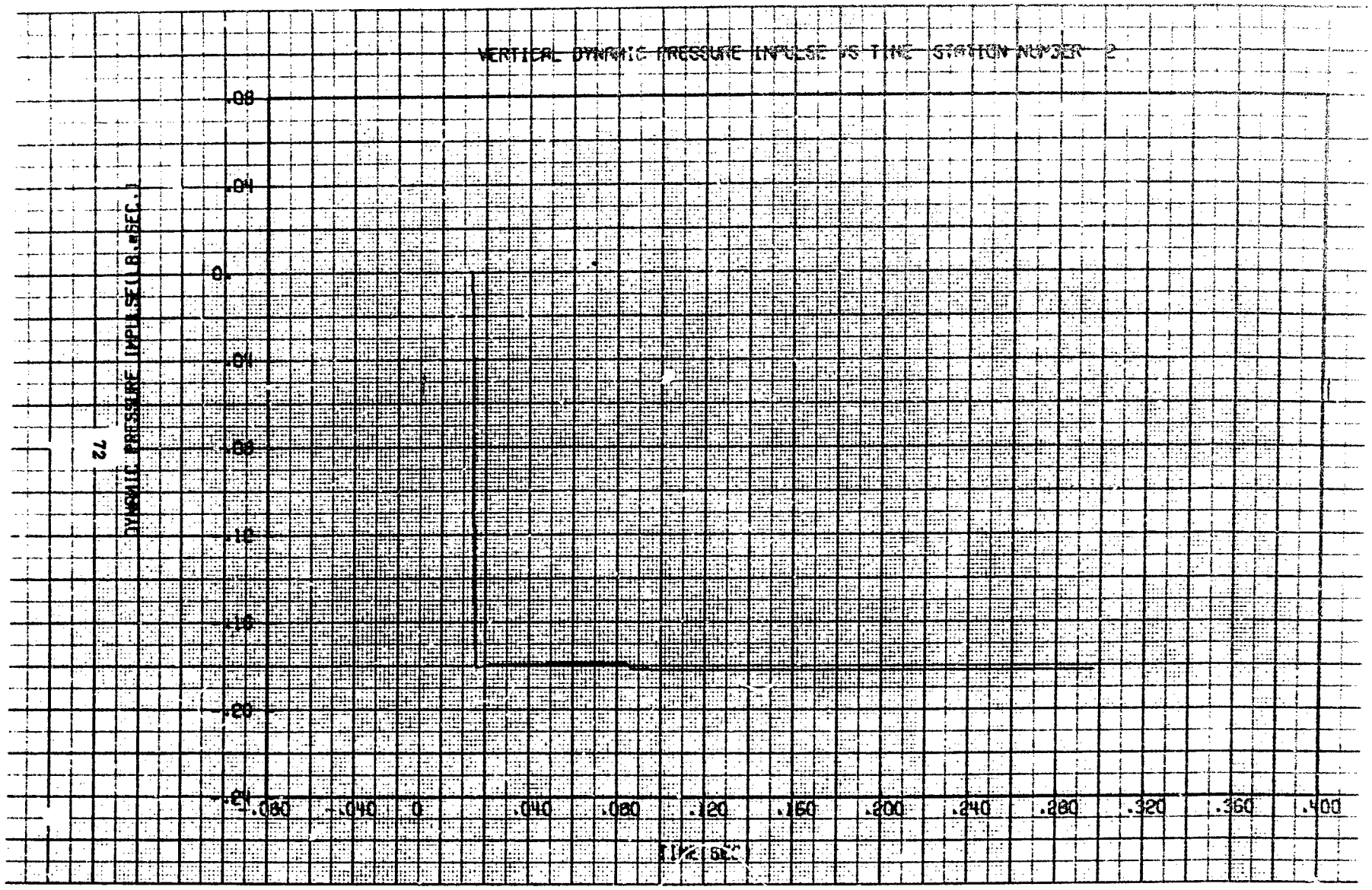

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

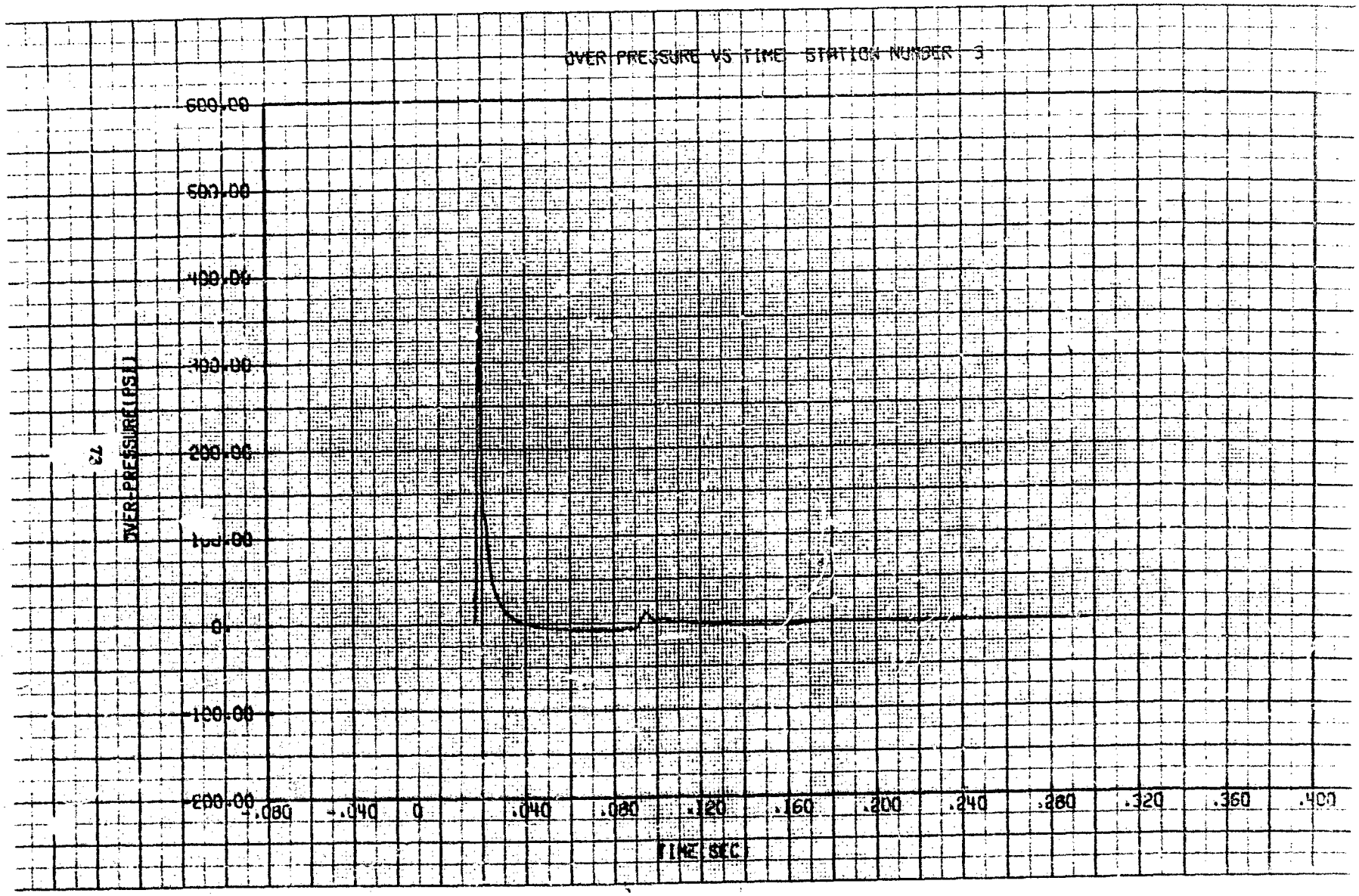

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
-2400.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

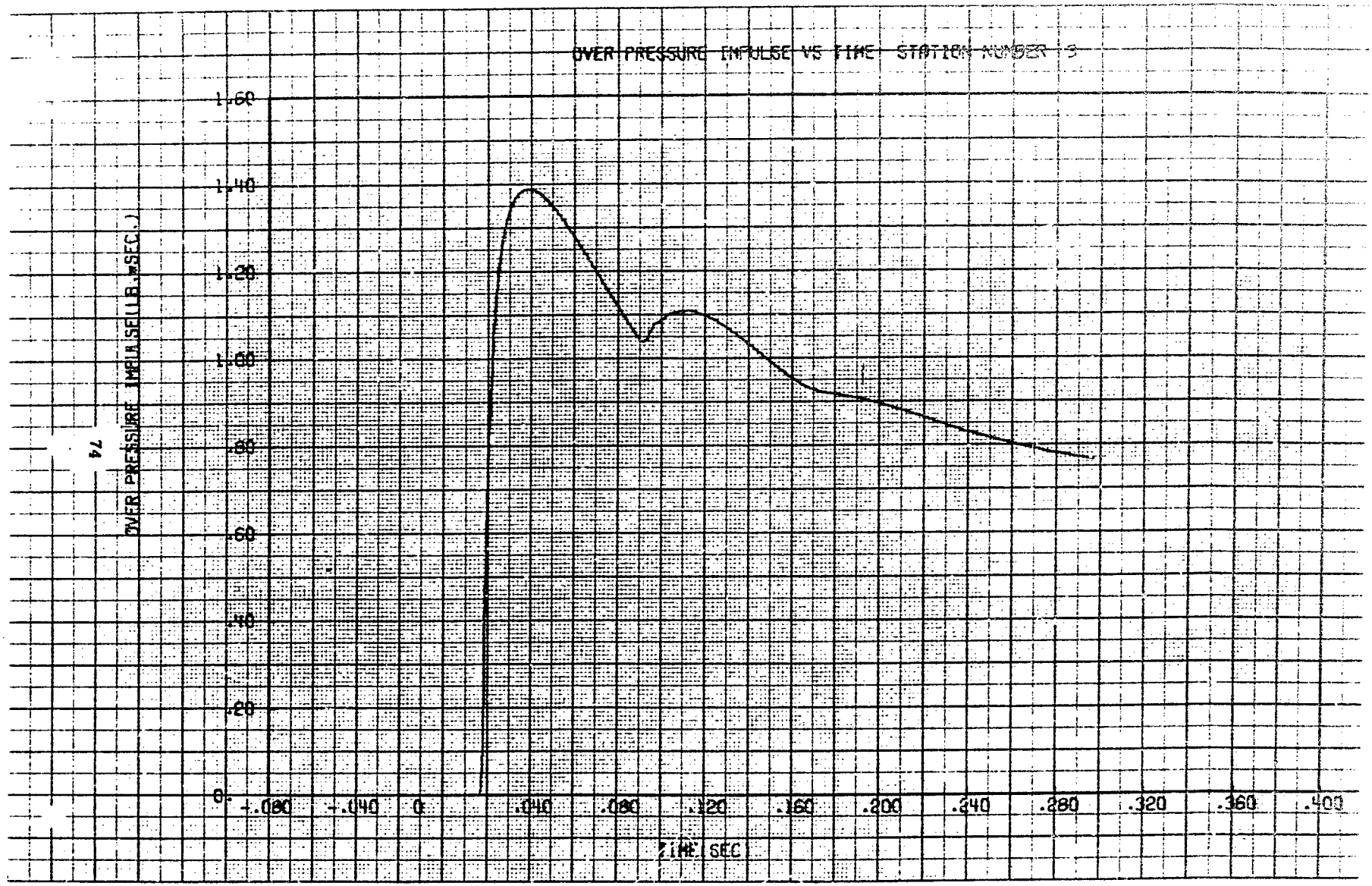

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE(PSI)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

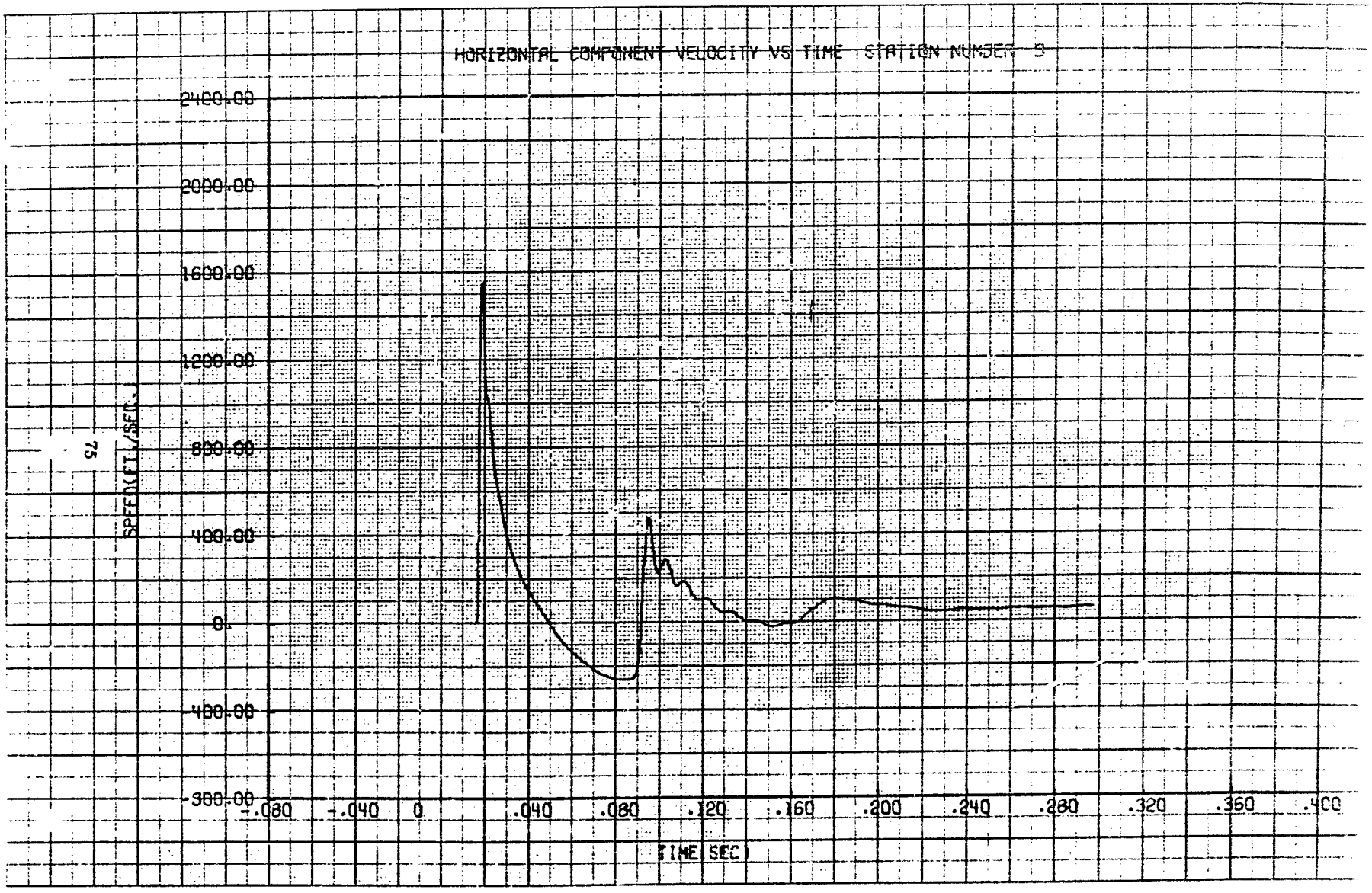

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

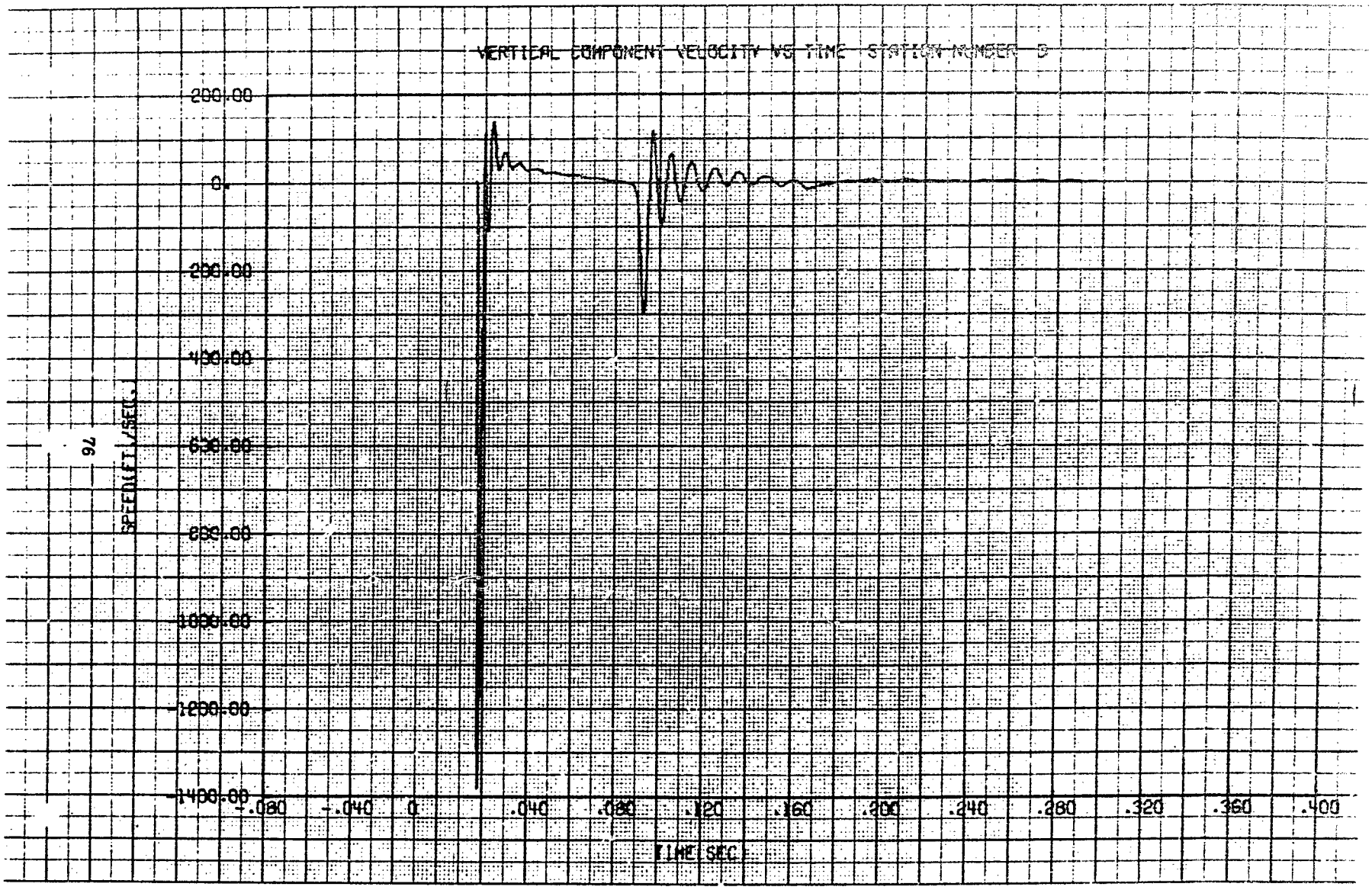

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE(PSI)
120.00
80.00
40.00
0
-40.00
-80.00
-120.00
-160.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

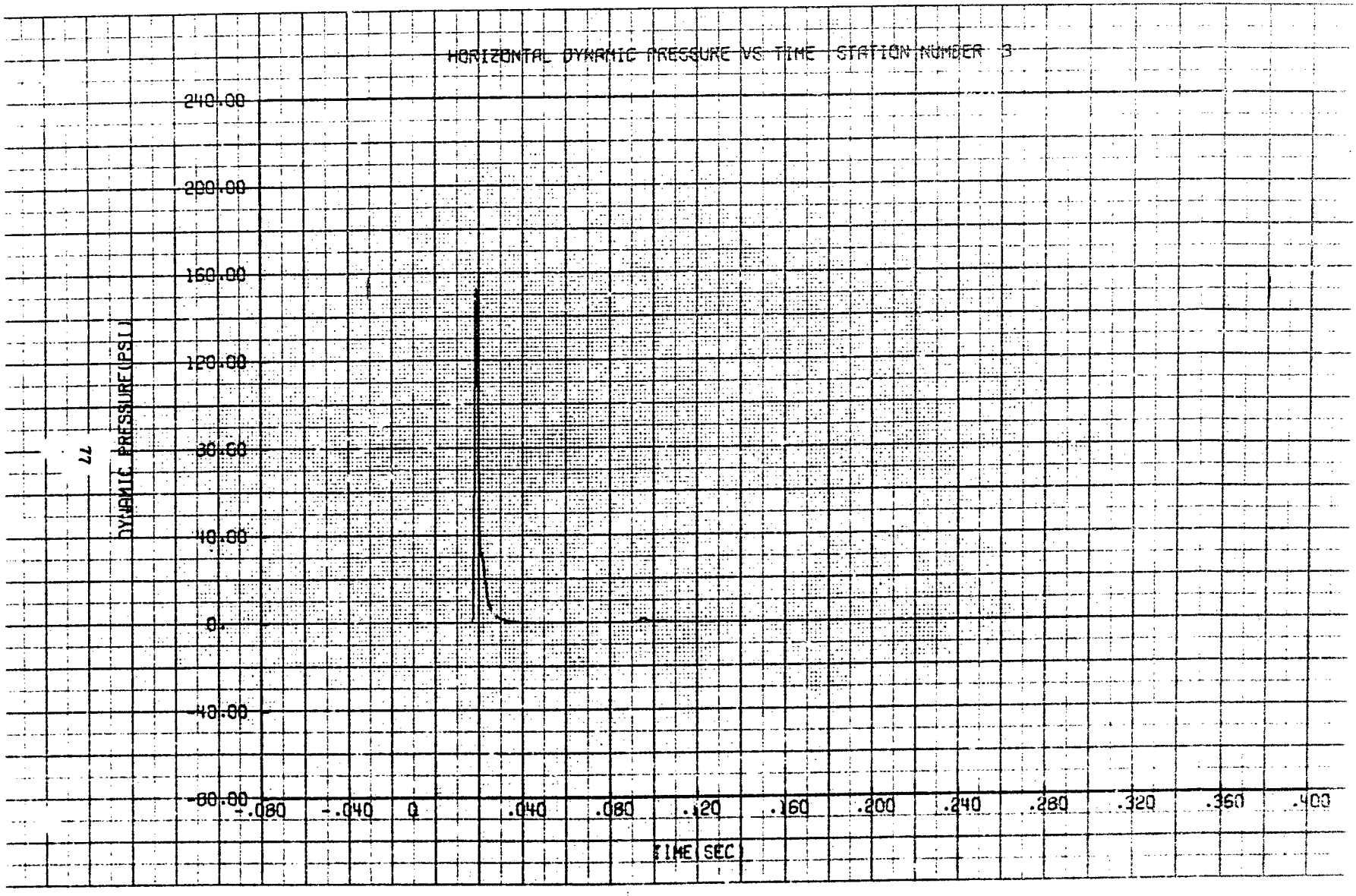

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
DYNAMIC PRESSURE IMPULSE(LB.SEC.)
.08
.04
0
-.04
-.08
-.12
-.16
-.20
-.24
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

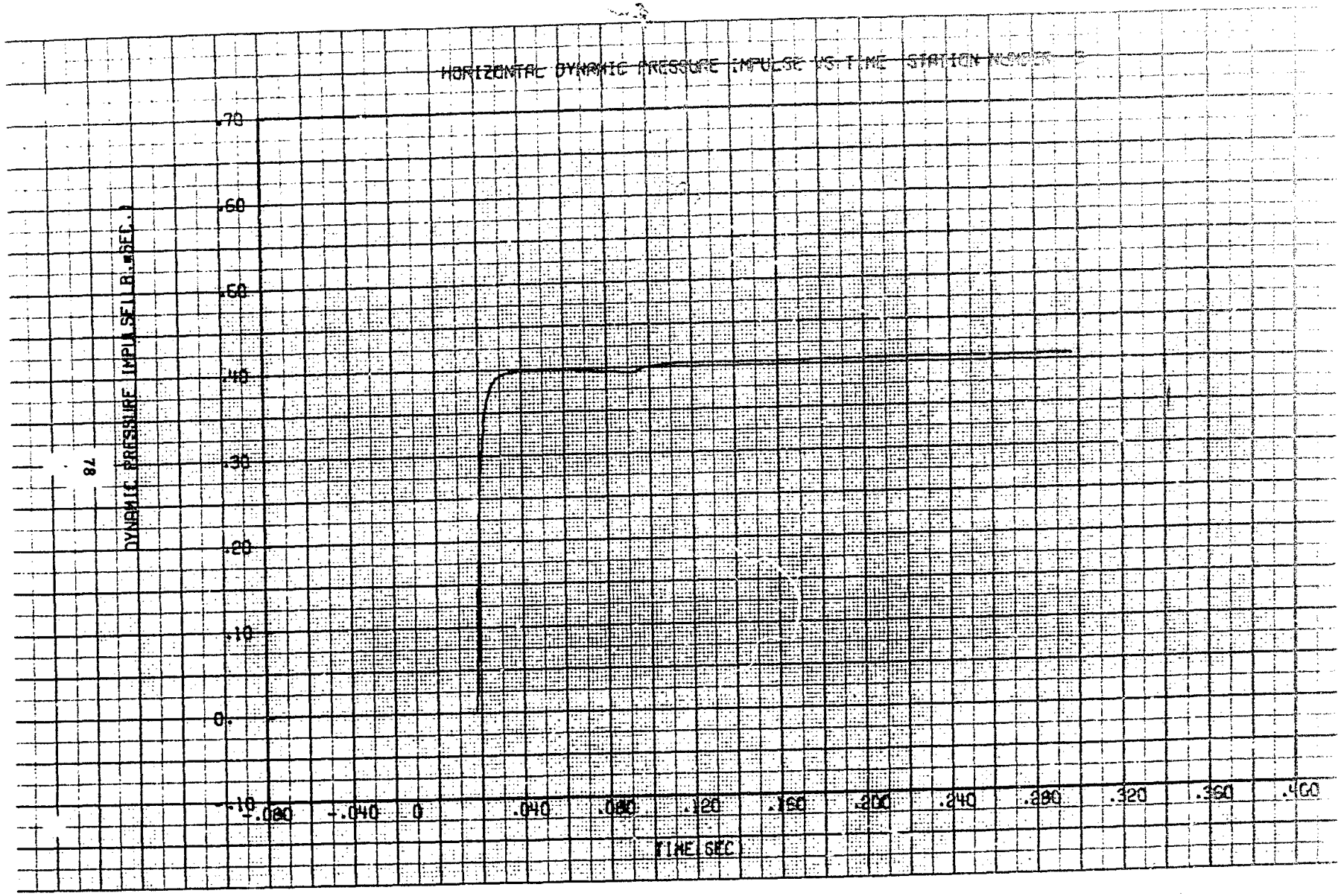

OVER PRESSURE VS TIME STATION NUMBER 3
OVER-PRESSURE (PSI)
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

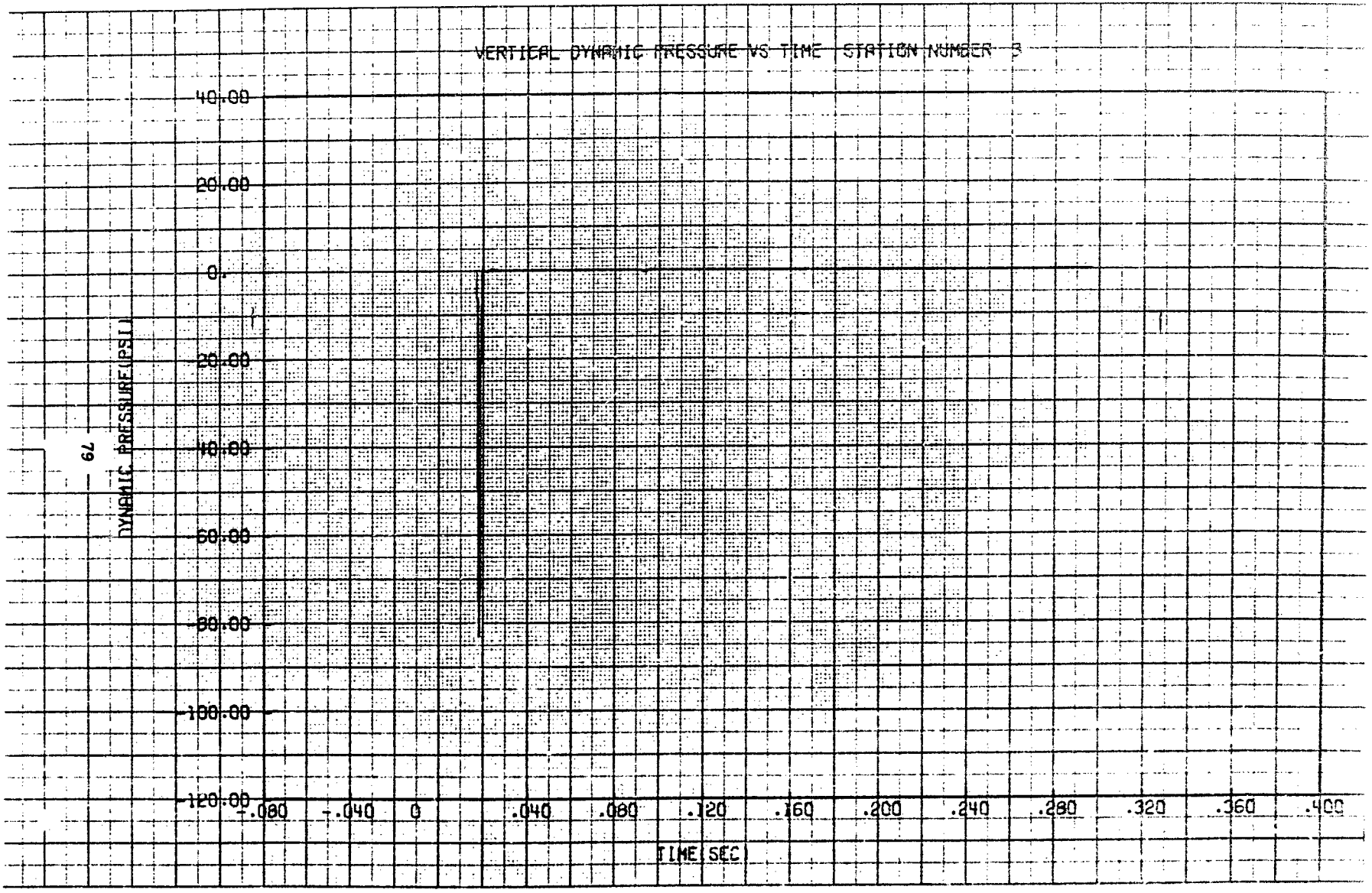

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 3
OVER PRESSURE IMPULSE(LB.*SEC.)
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

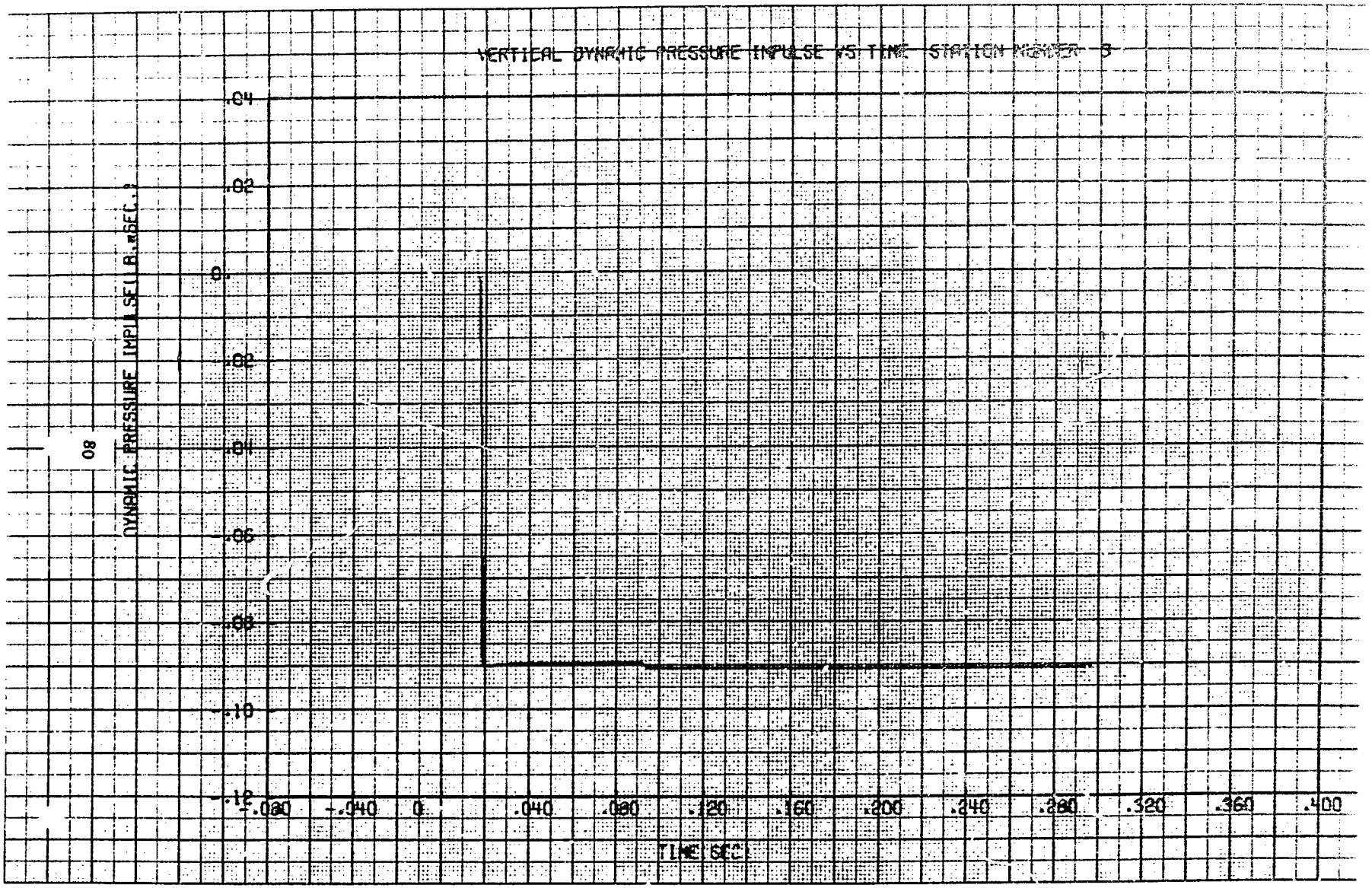

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 3
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

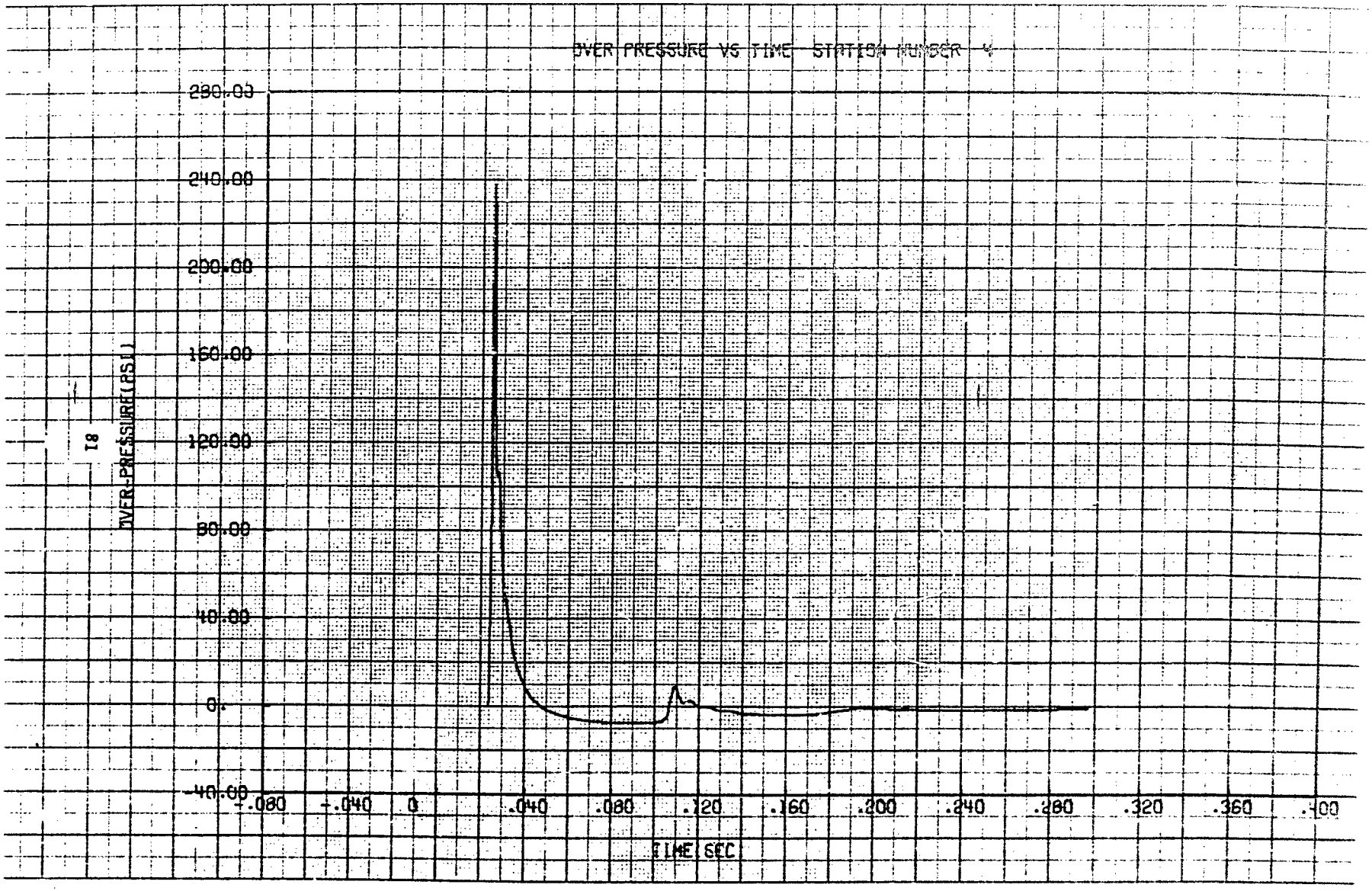

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER D
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
-1400.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC


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)

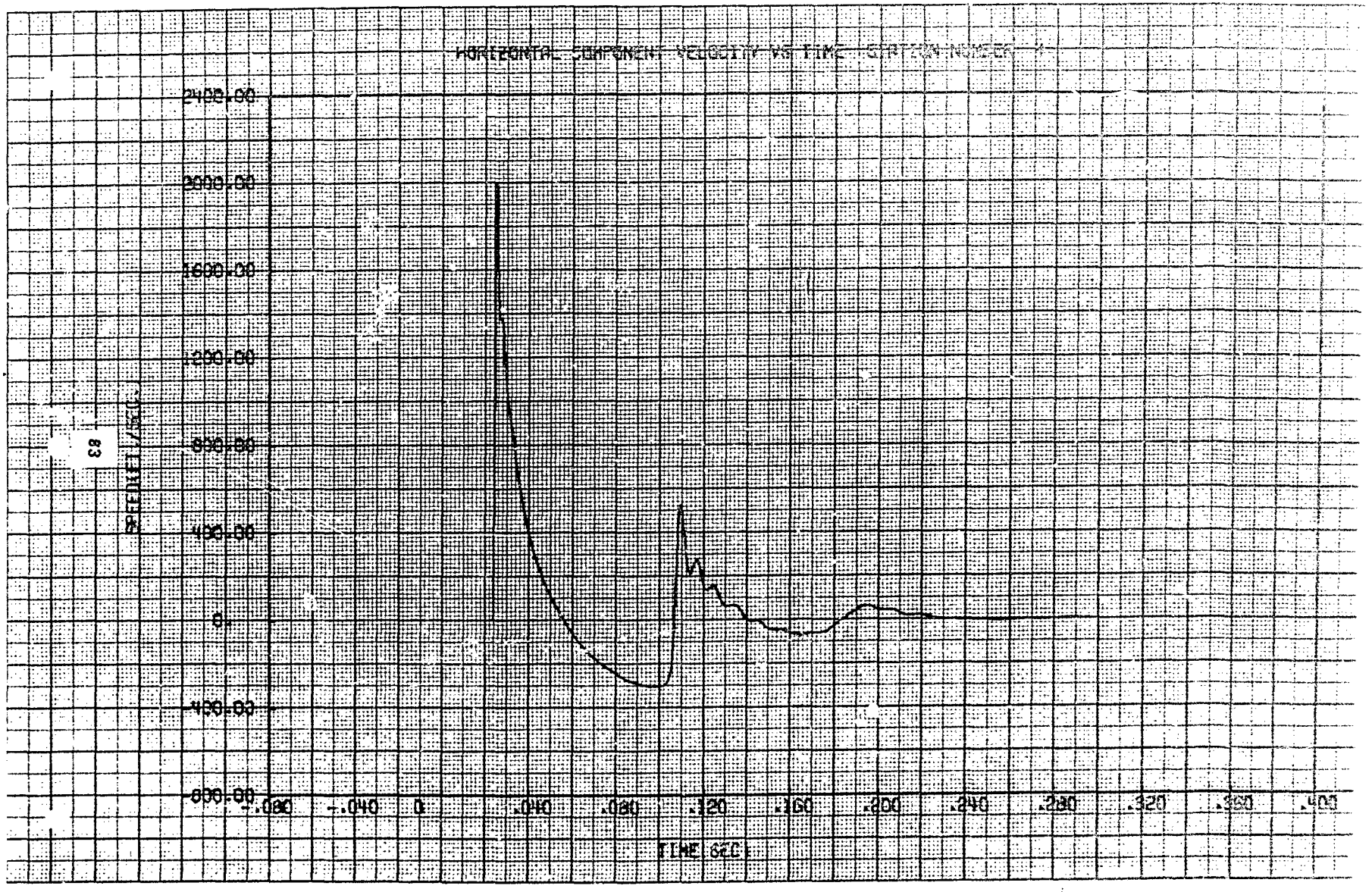

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE (LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

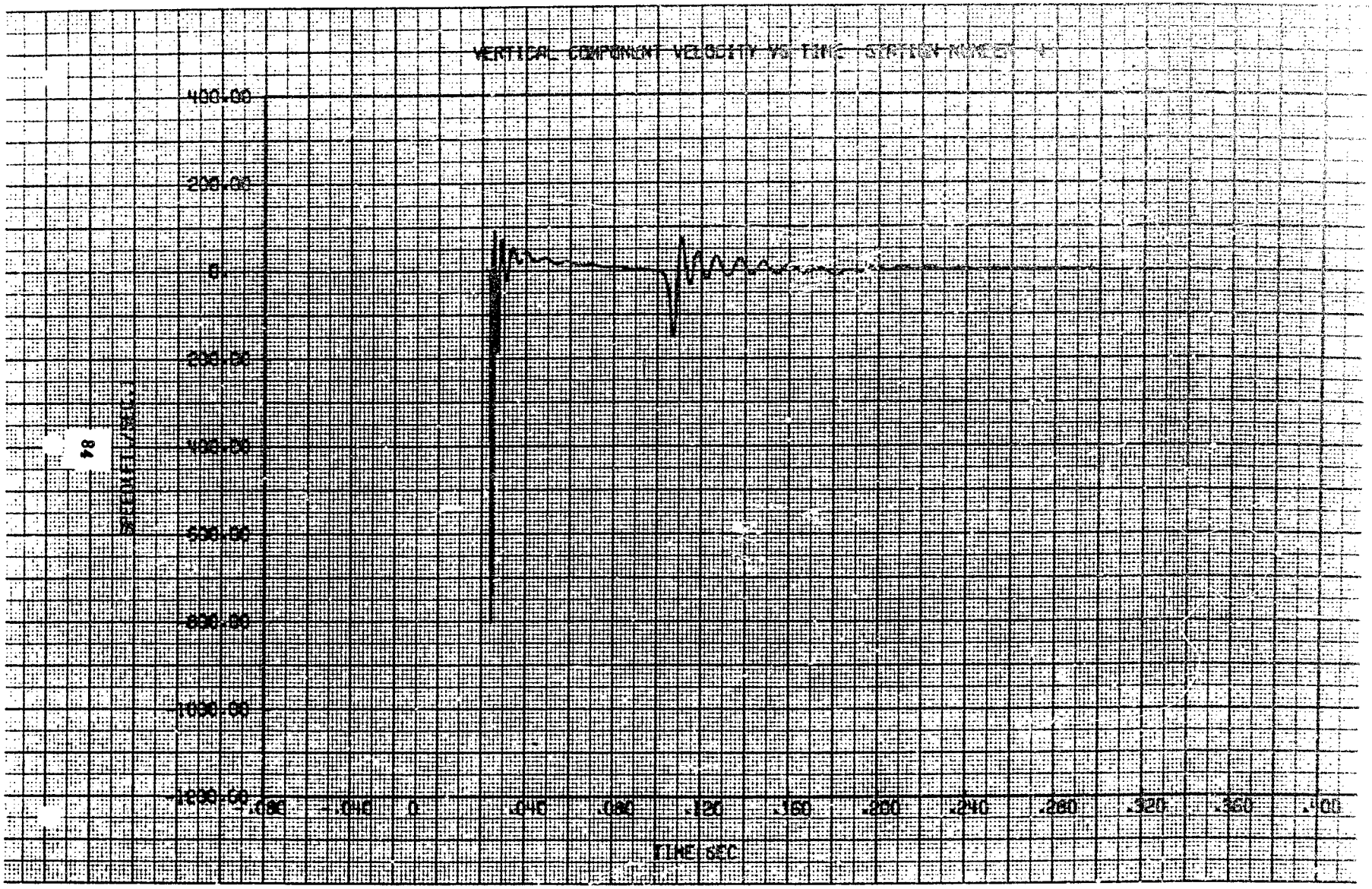

VERTICAL DYNAMIC PRESSURE VS TIME (STATION NUMBER 3)
40.00
20.00
0.
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

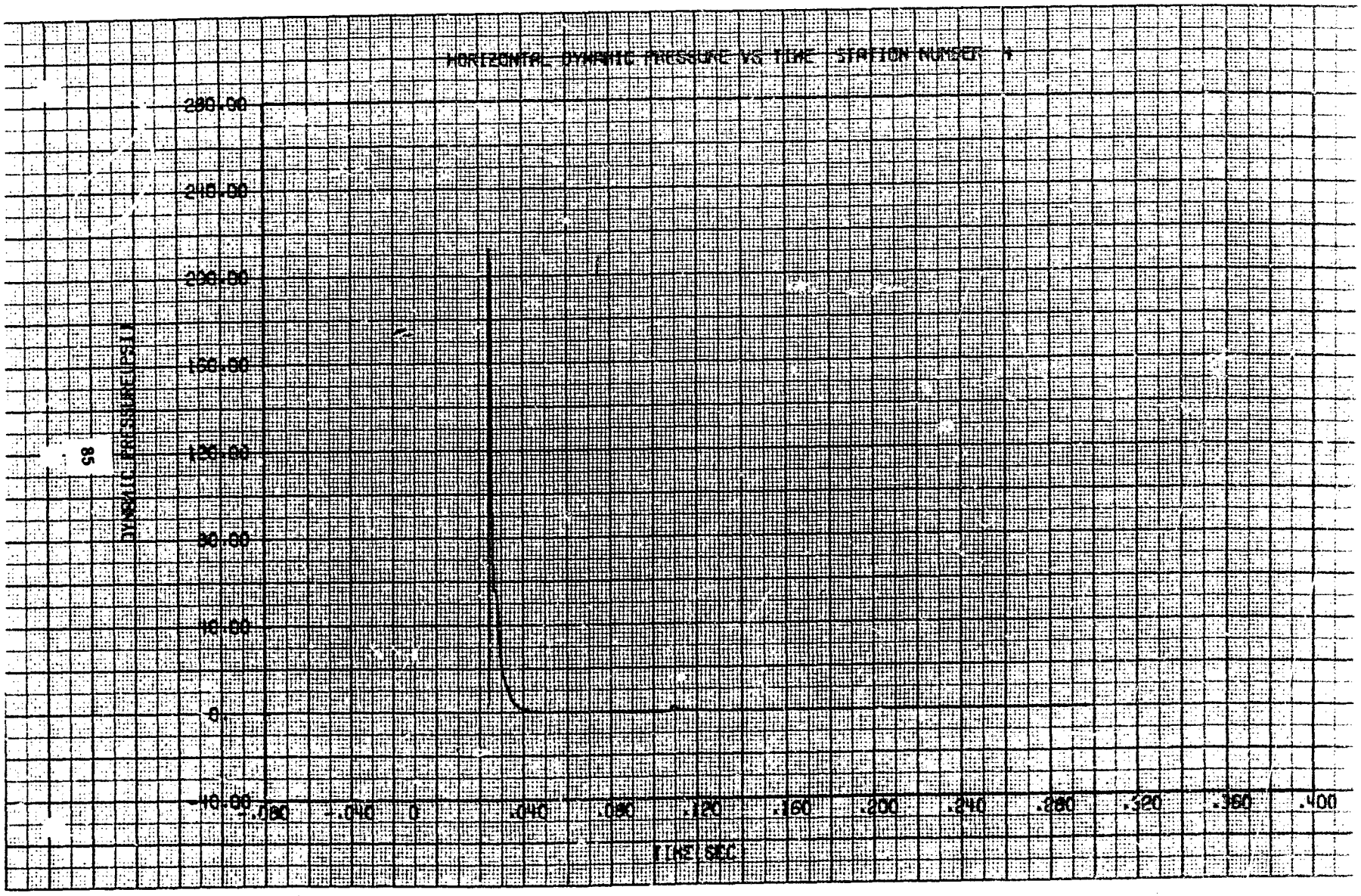

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.04
.02
0.
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

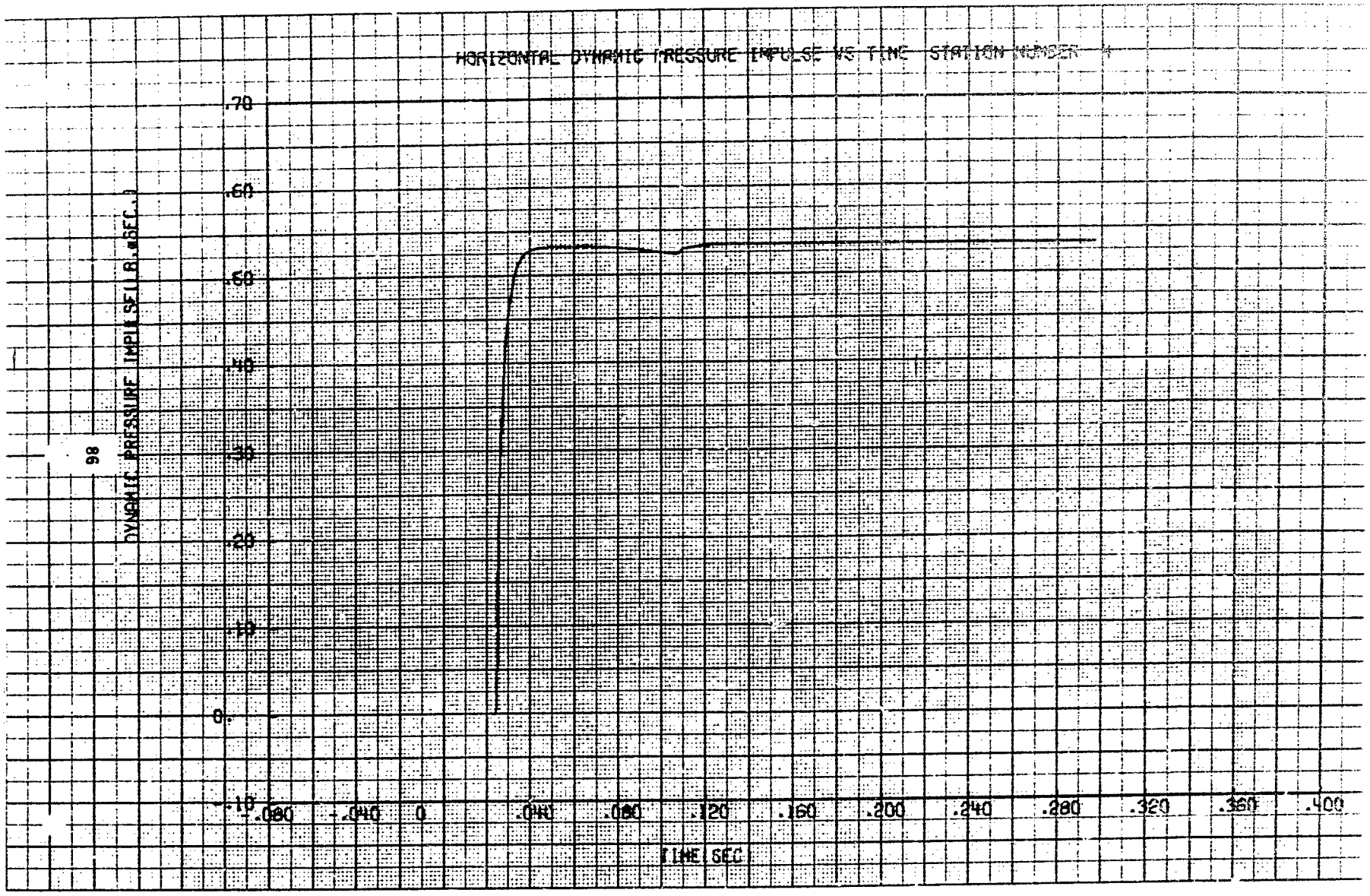

OVER PRESSURE VS TIME STATION NUMBER 4
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

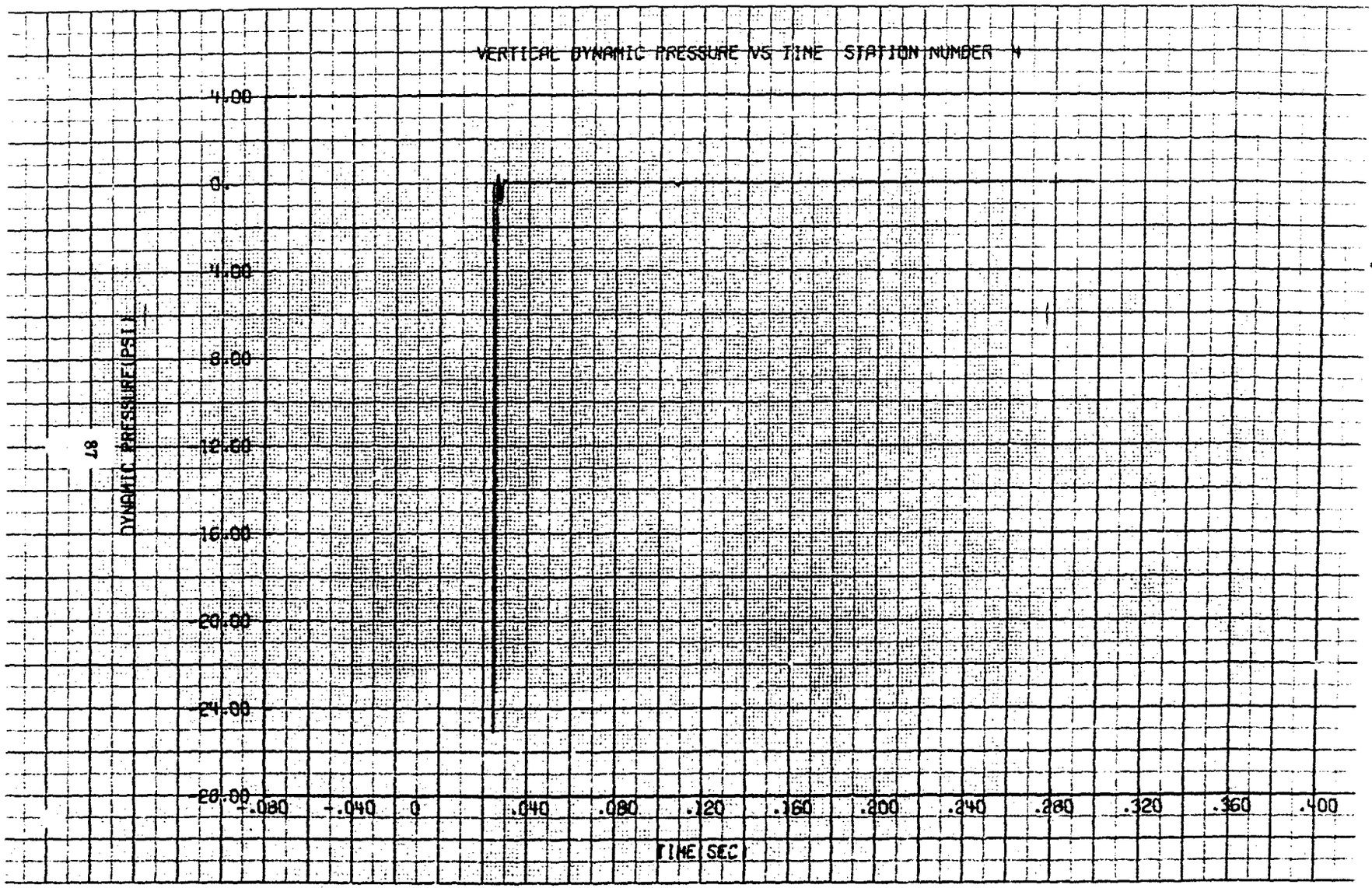
OVER PRESSURE (PSI)
TIME (SEC)
1.40
1.20
1.00
.80
.60
.40
.20
0
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

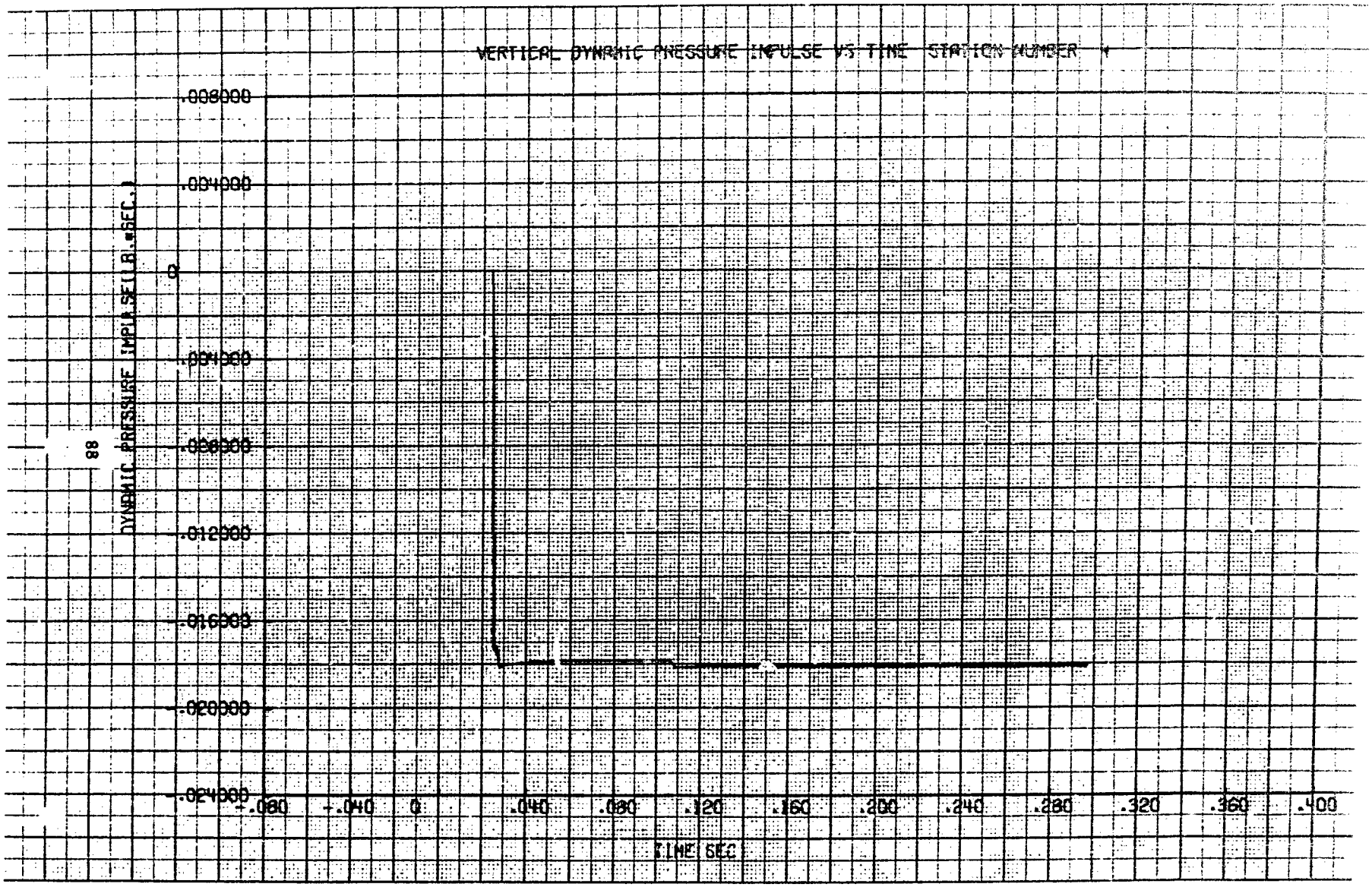

HORIZONTAL COMPONENT VELOCITY VS TIME (SPIKE NOISE)
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.080
-.040
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
VELOCITY FEET/SEC

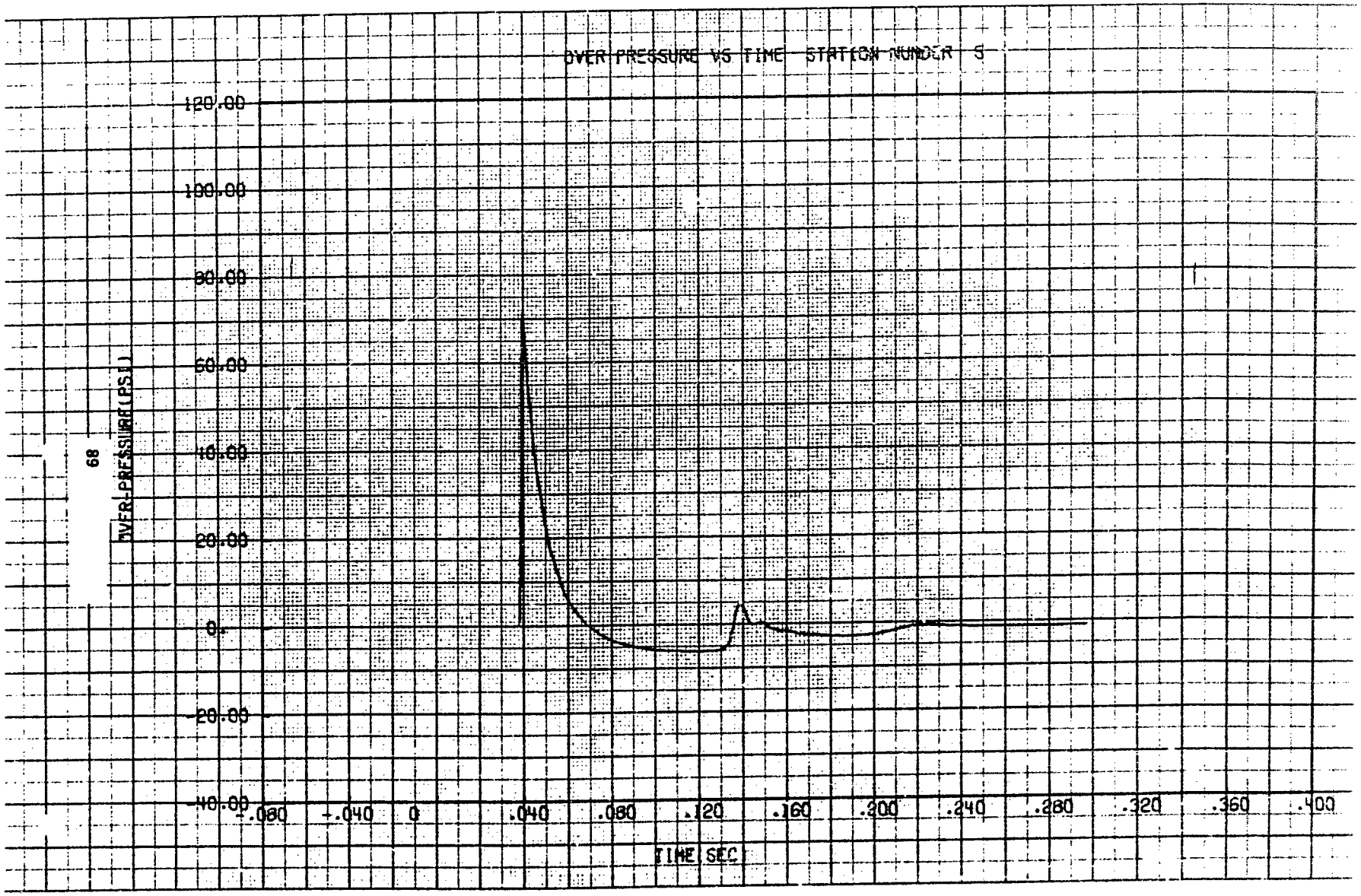

VERTICAL COMPONENT VELOCITY VS TIME
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

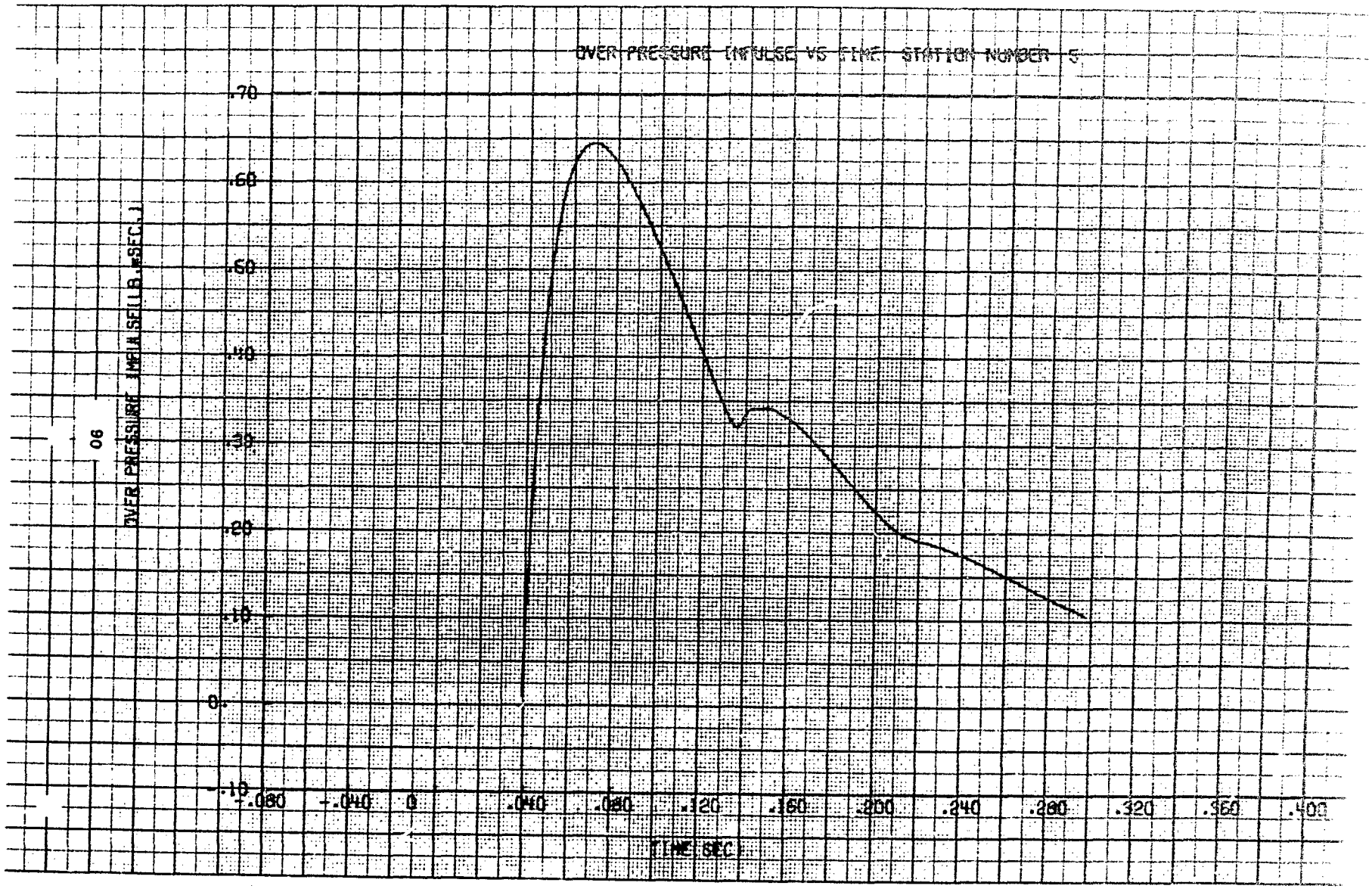

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE LBS/FT
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

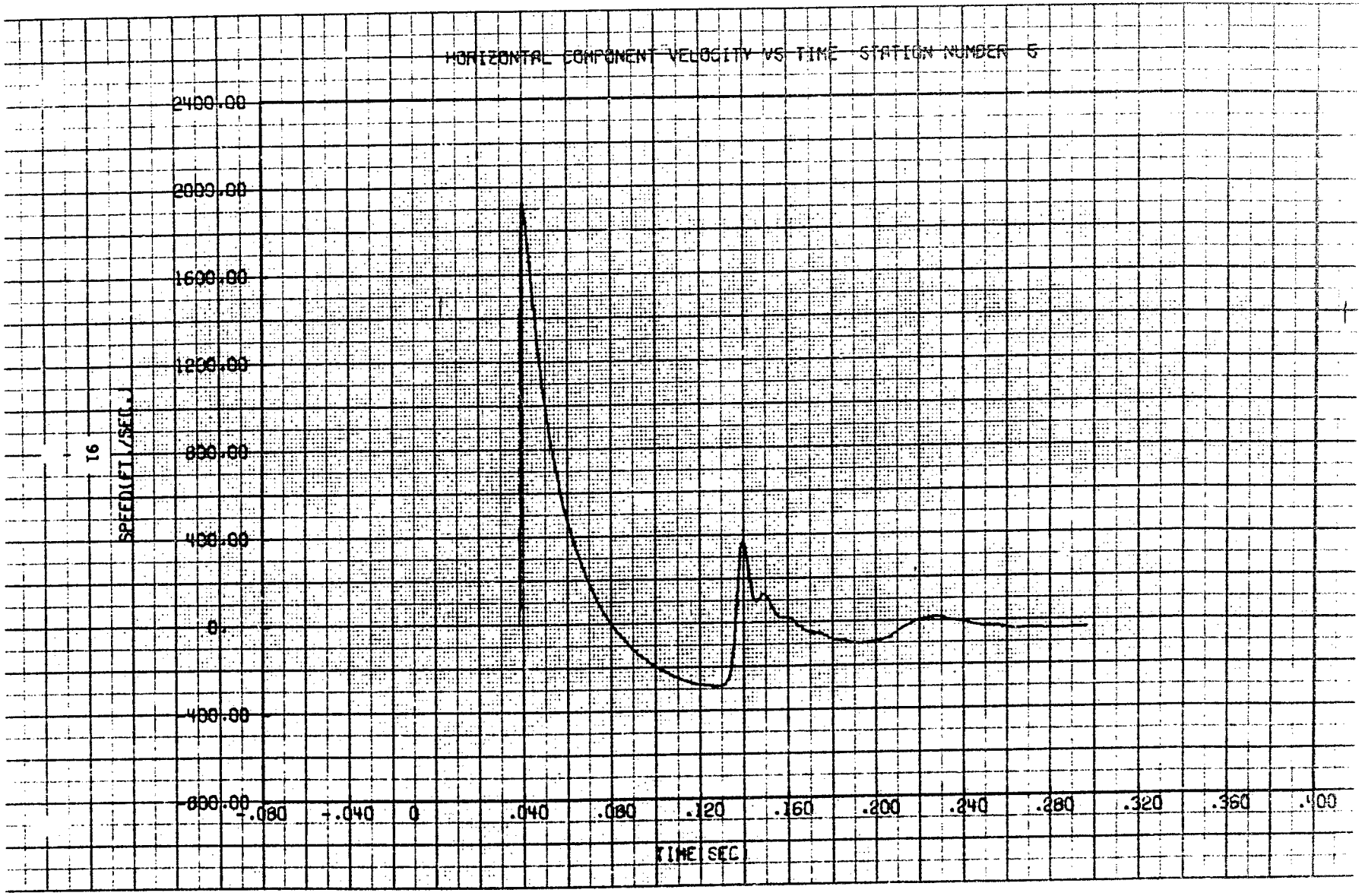

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

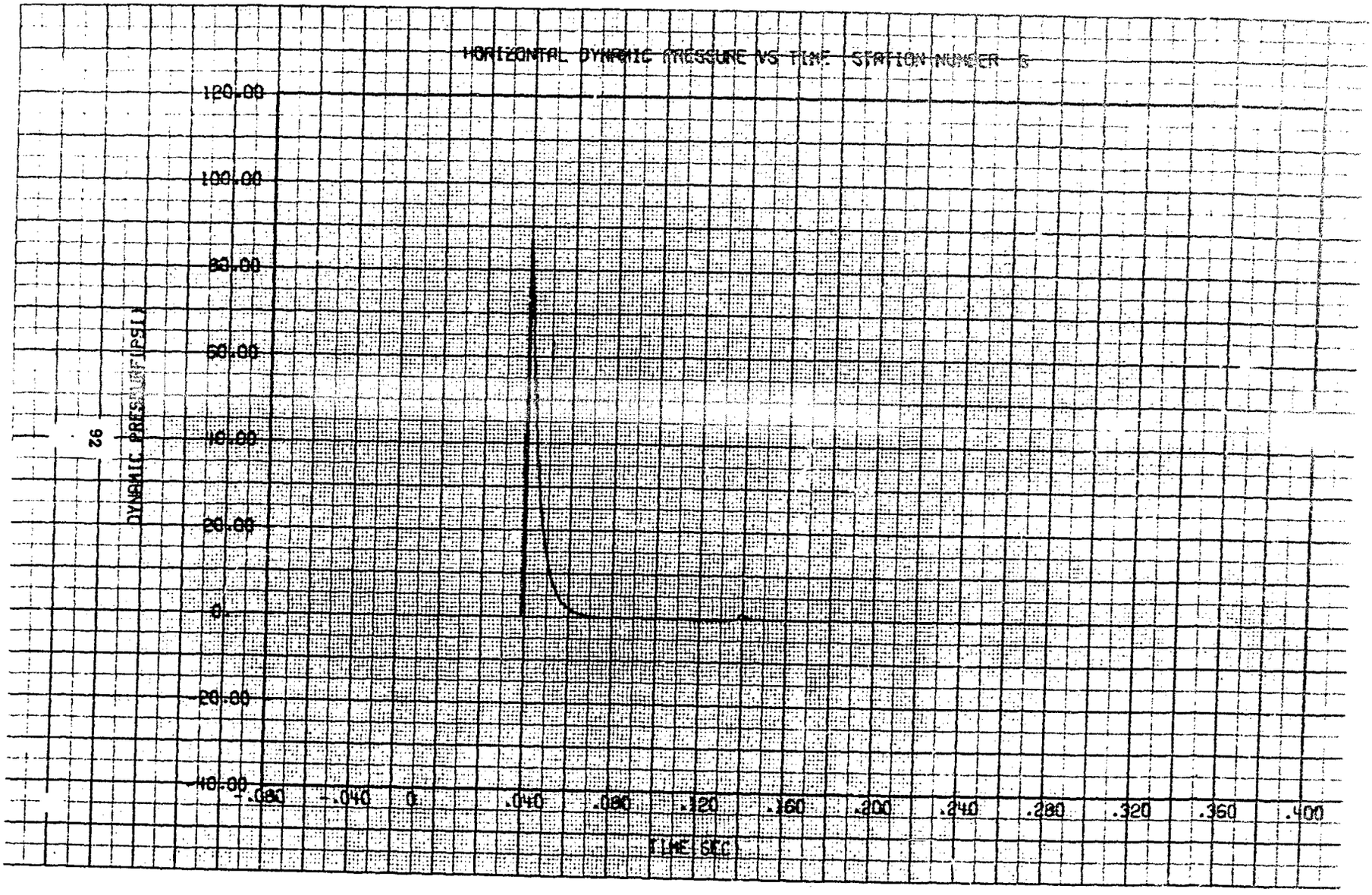

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE(PSI)
4.00
0.
-4.00
-8.00
-12.00
-16.00
-20.00
-24.00
-28.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

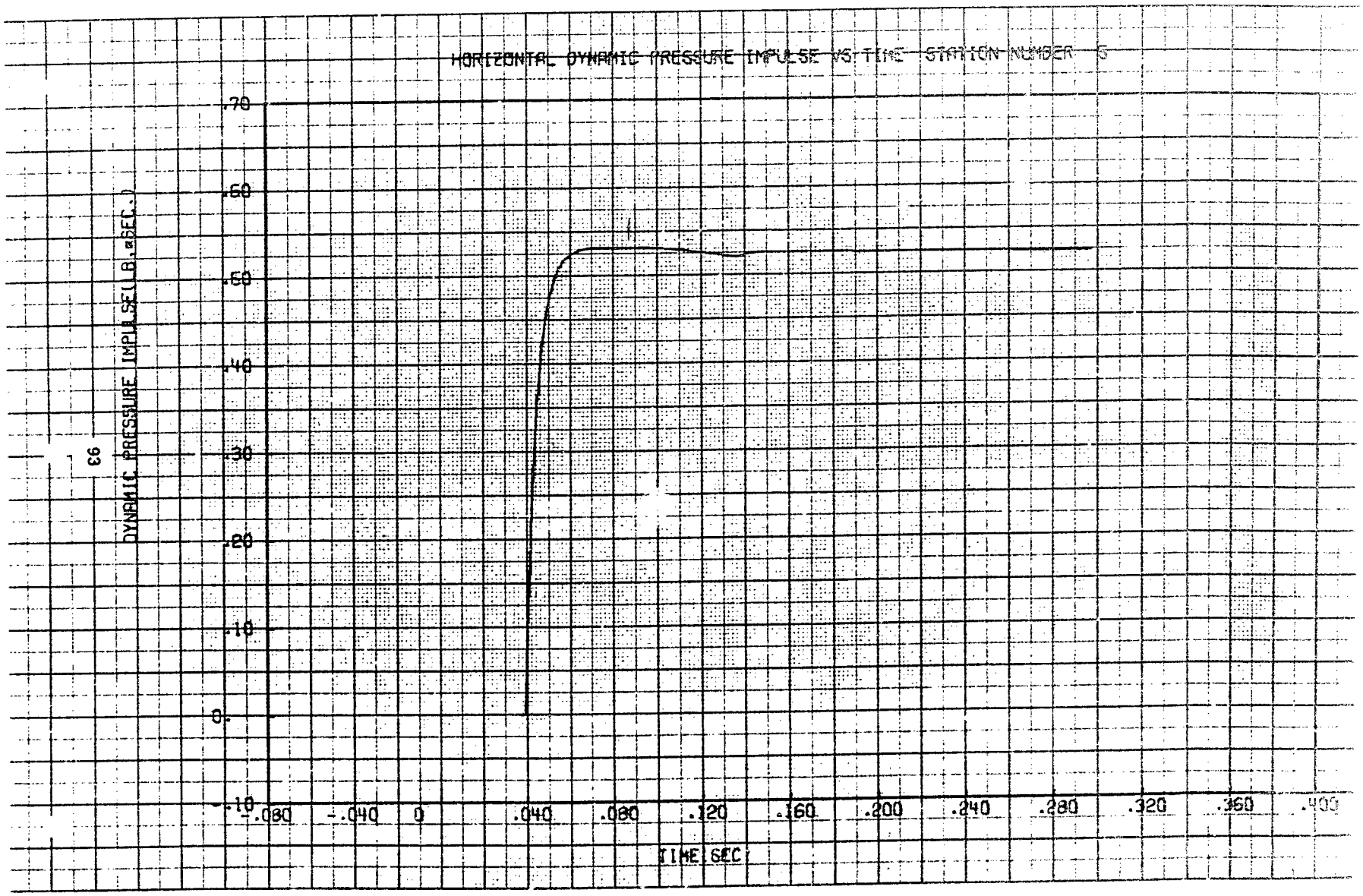

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.008000
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

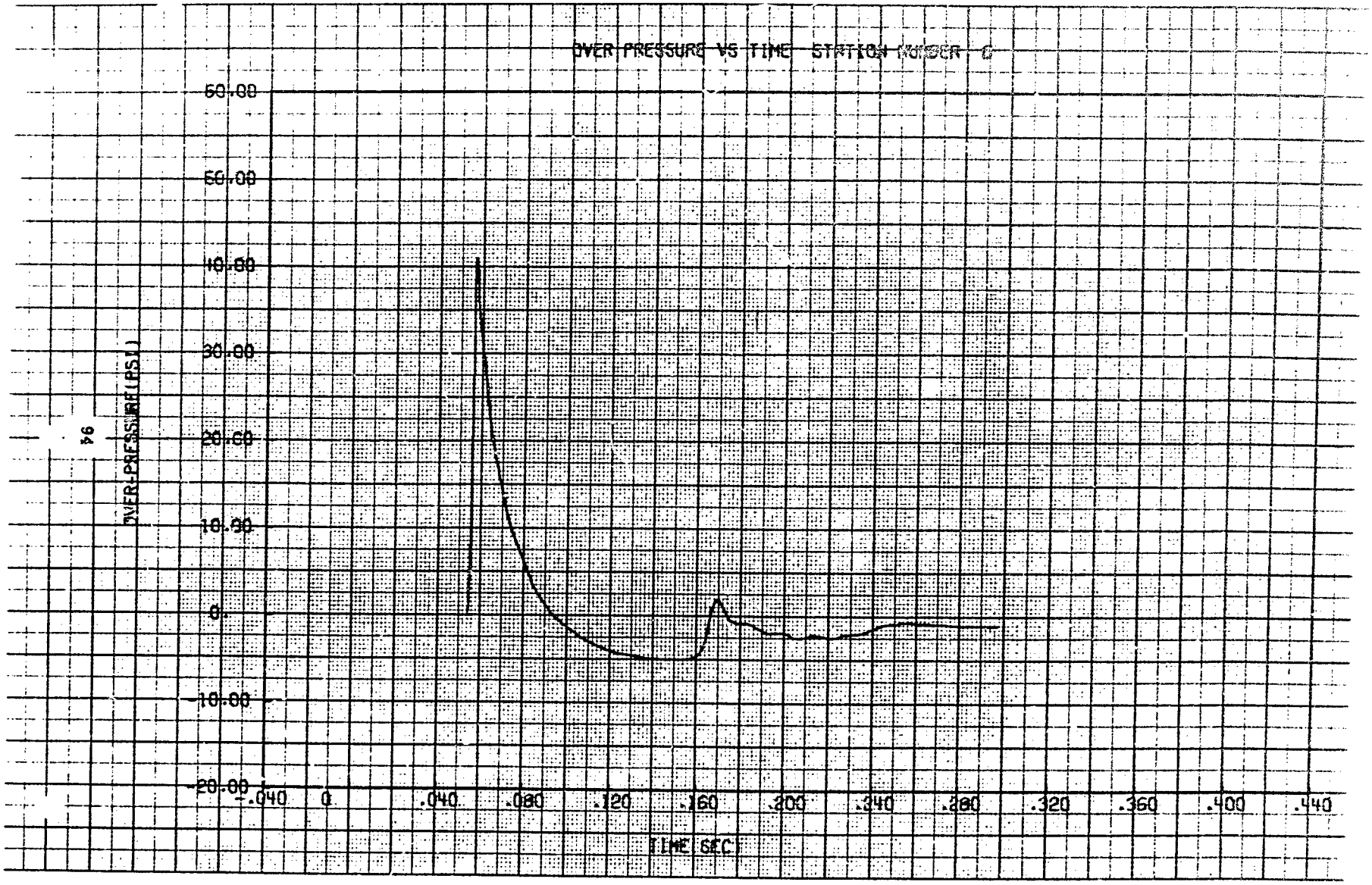

OVER PRESSURE VS TIME STATION NUMBER 5
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

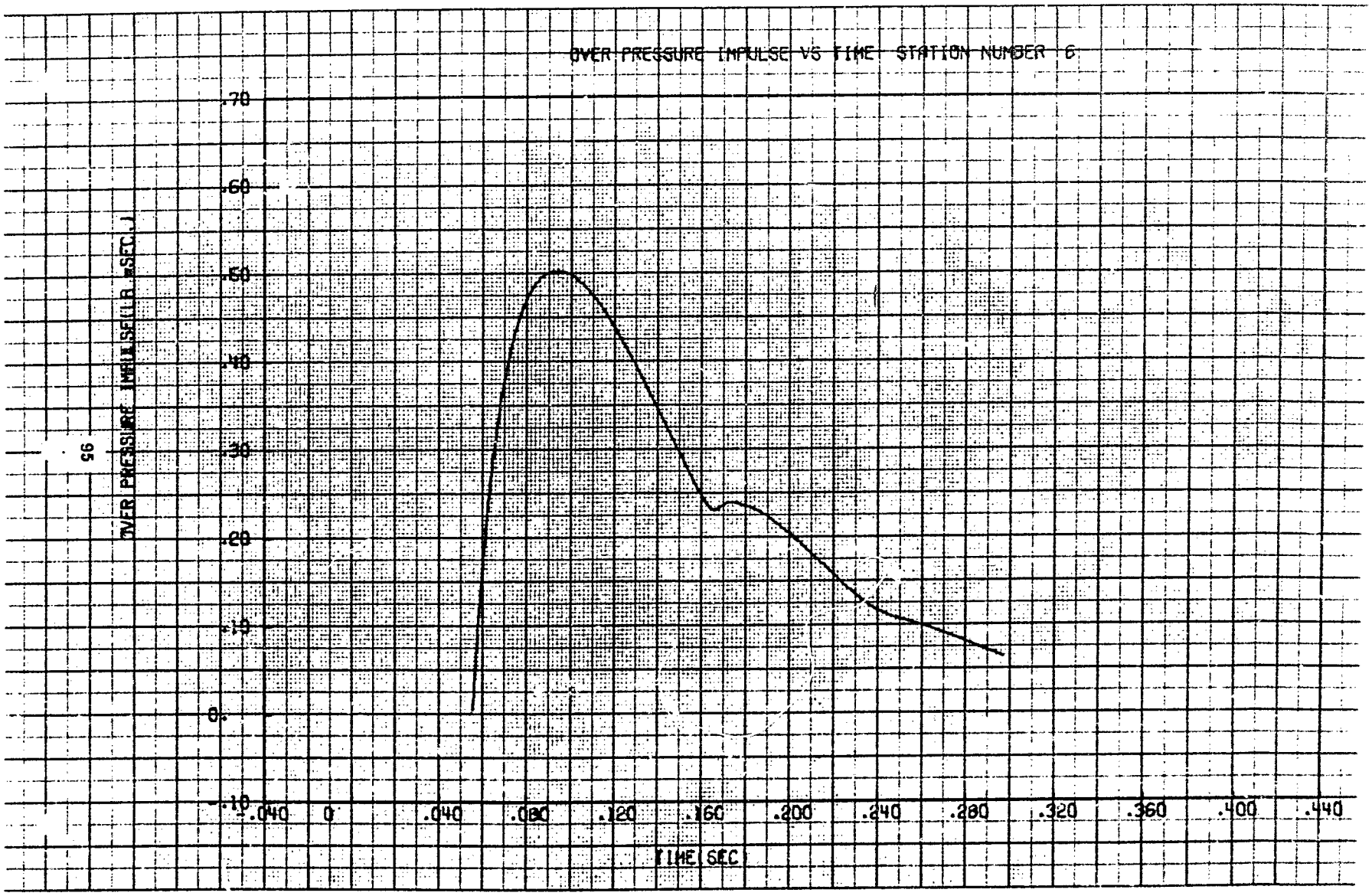

OVER PRESSURE IMPULSE VS TIME, STATION NUMBER 5
OVER PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

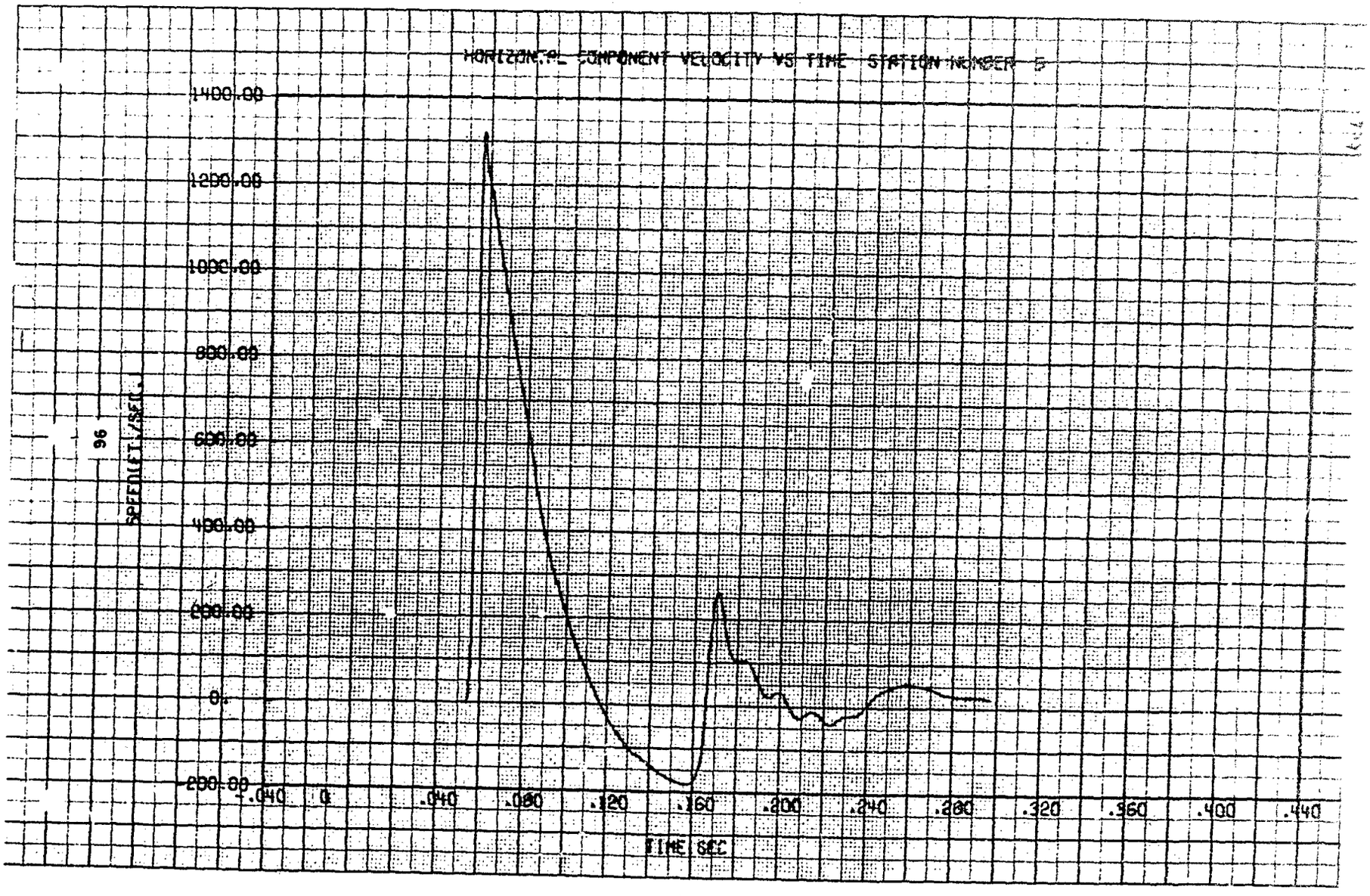

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 6
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

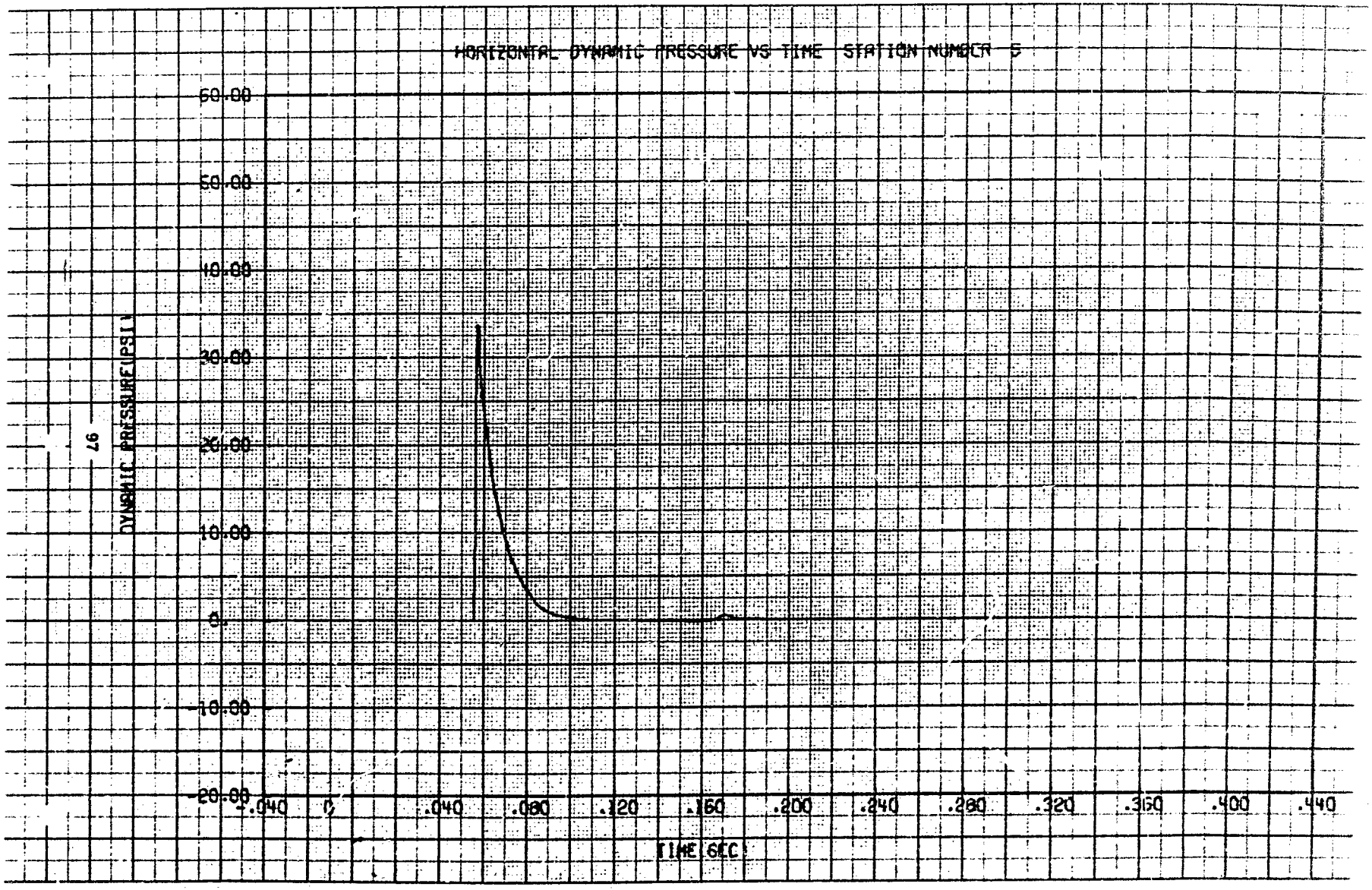

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE (PSI)
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
-.080
-.040
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC


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


OVER PRESSURE VS TIME STATION NUMBER 6
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
.440
TIME SEC


OVER PRESSURE IMPULSE VS TIME STATION NUMBER 6
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 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.)
-.040
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE(PSI)
60.00
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

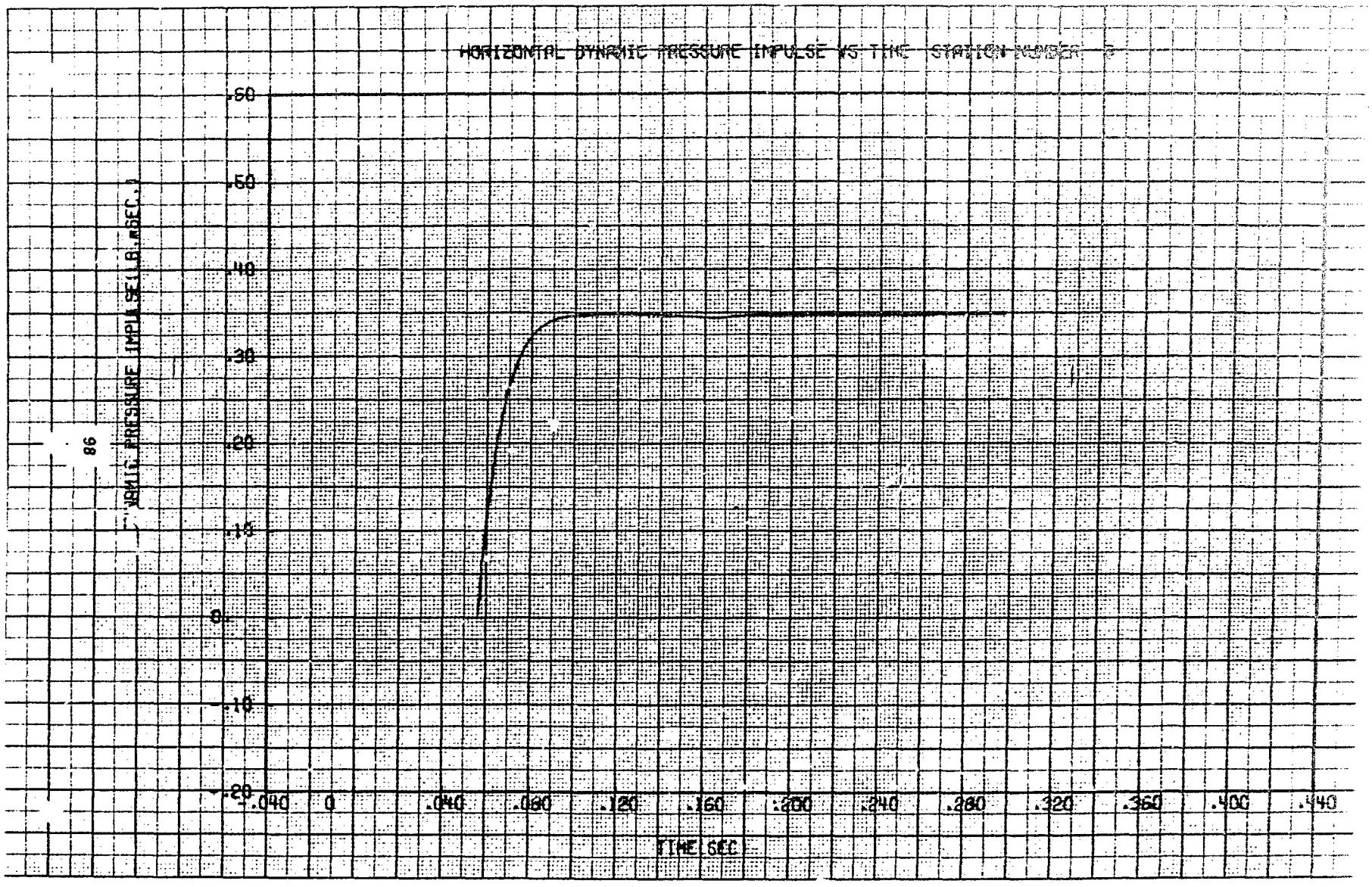
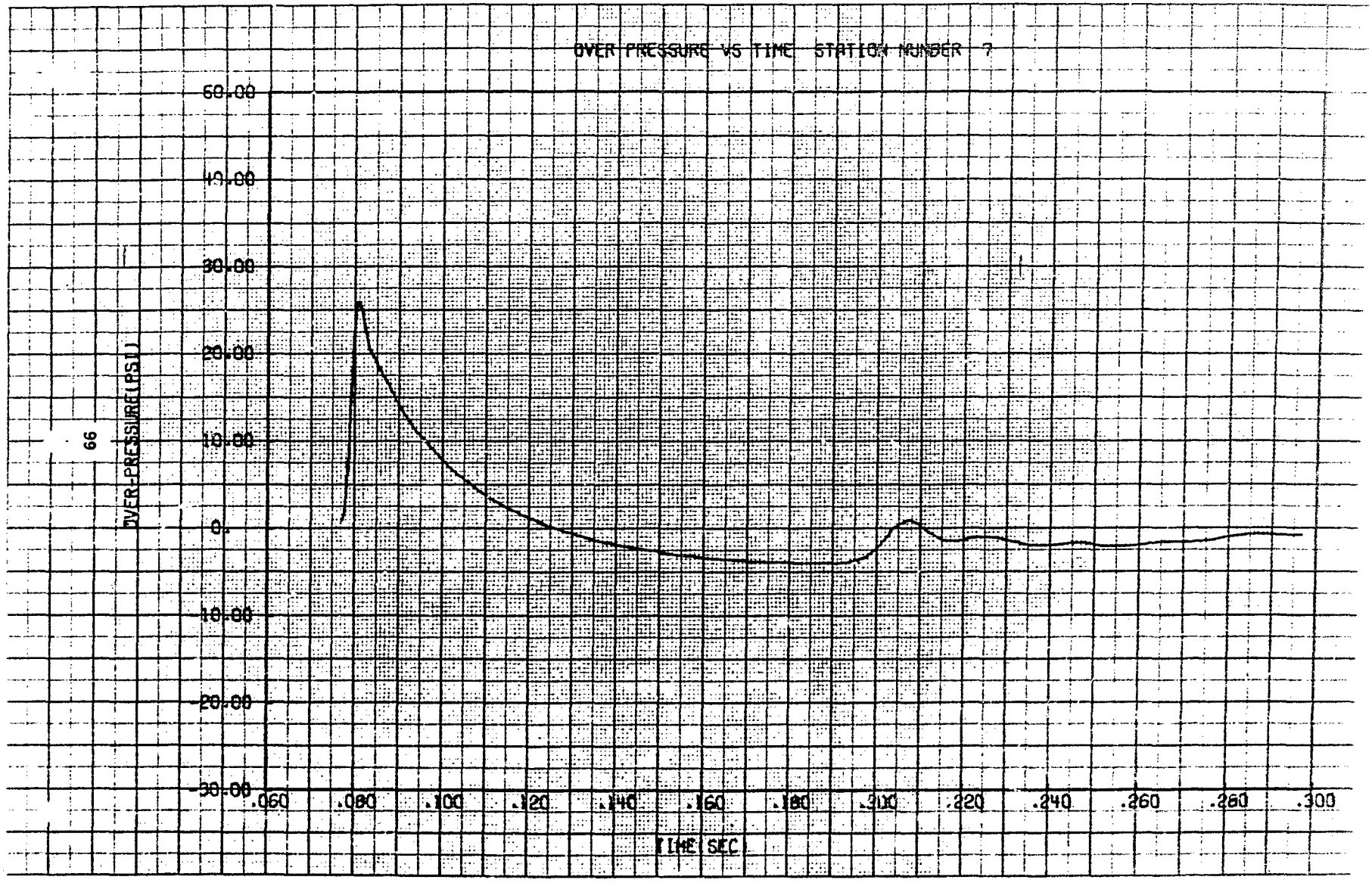
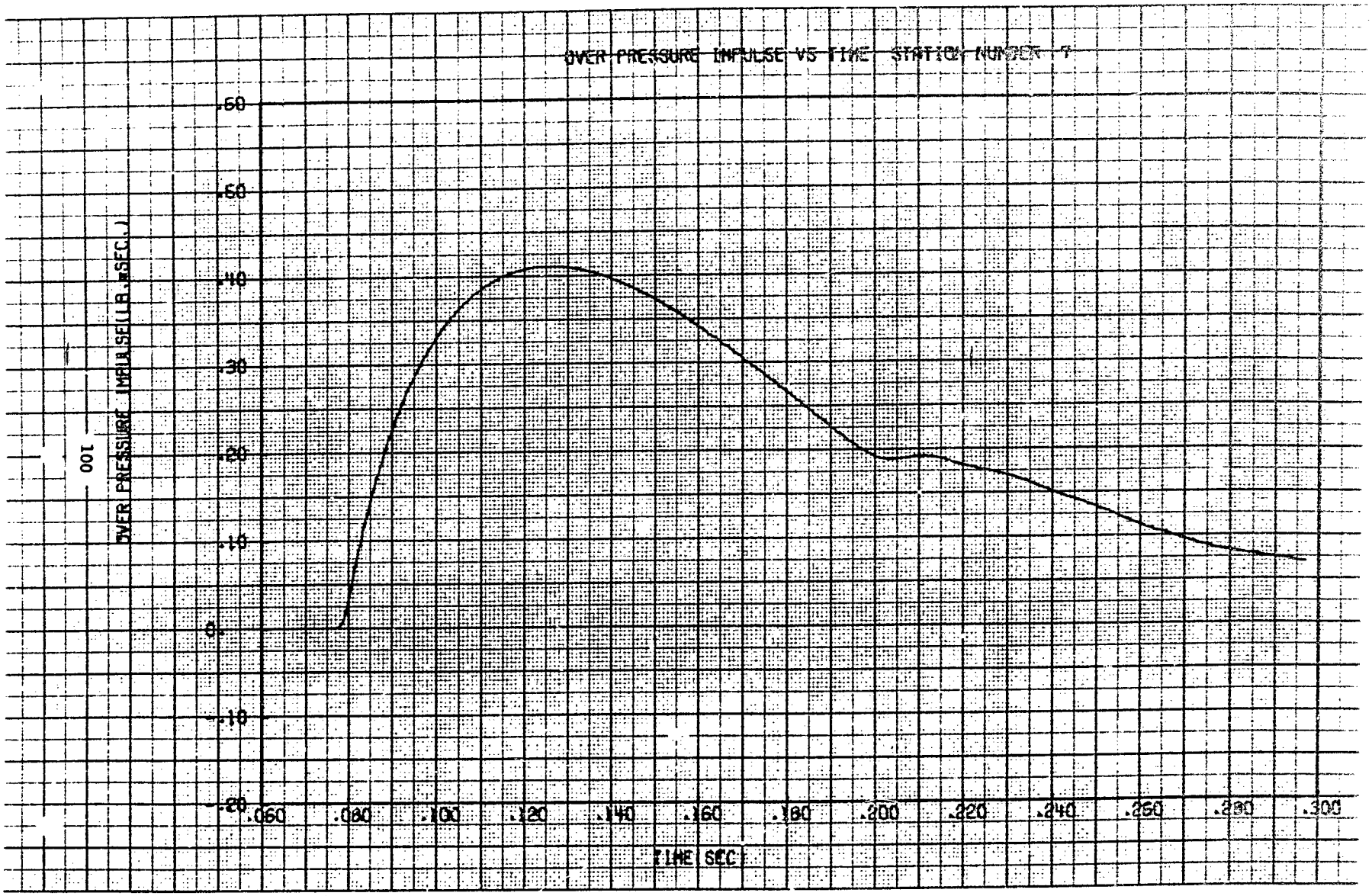
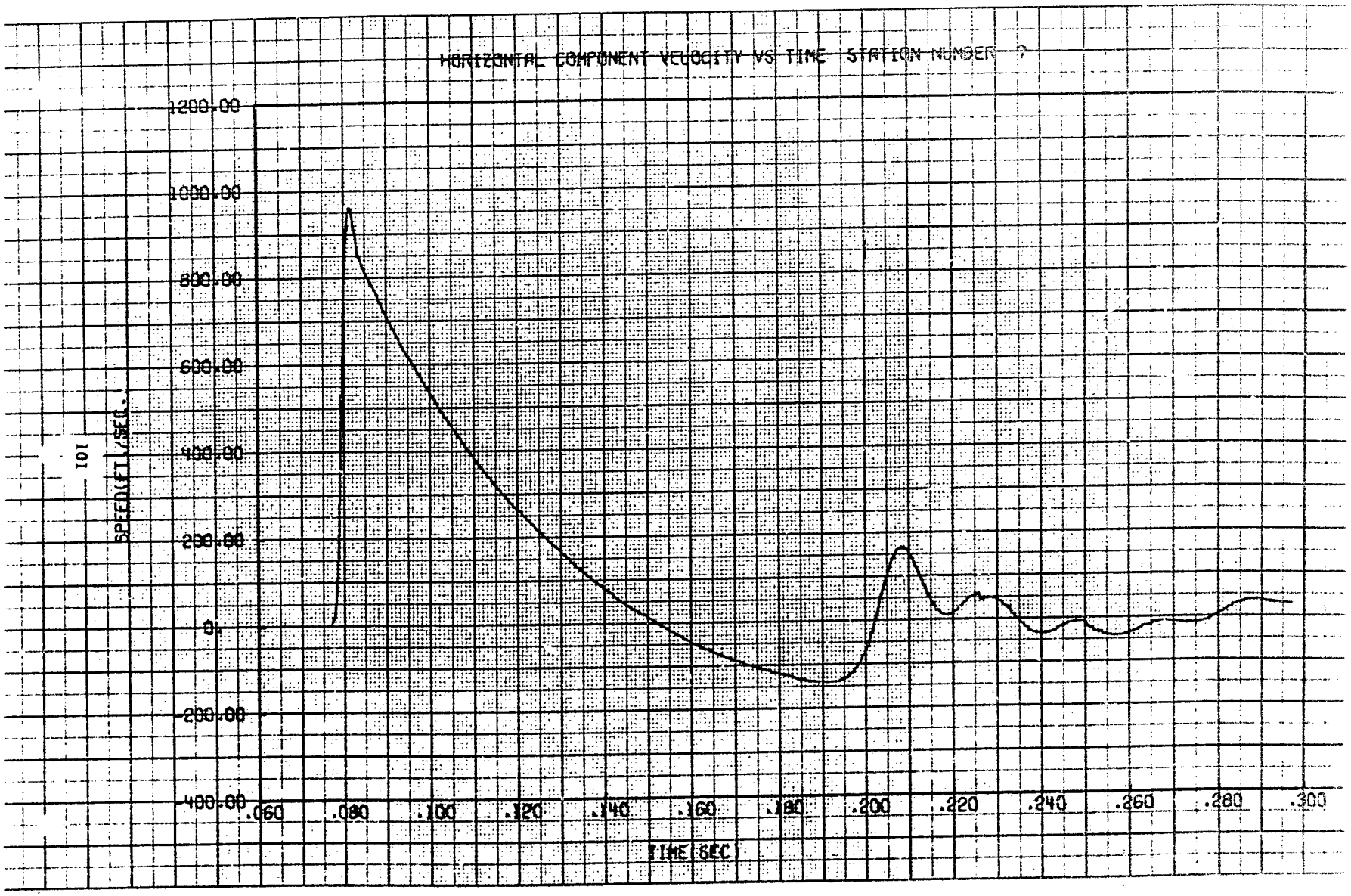
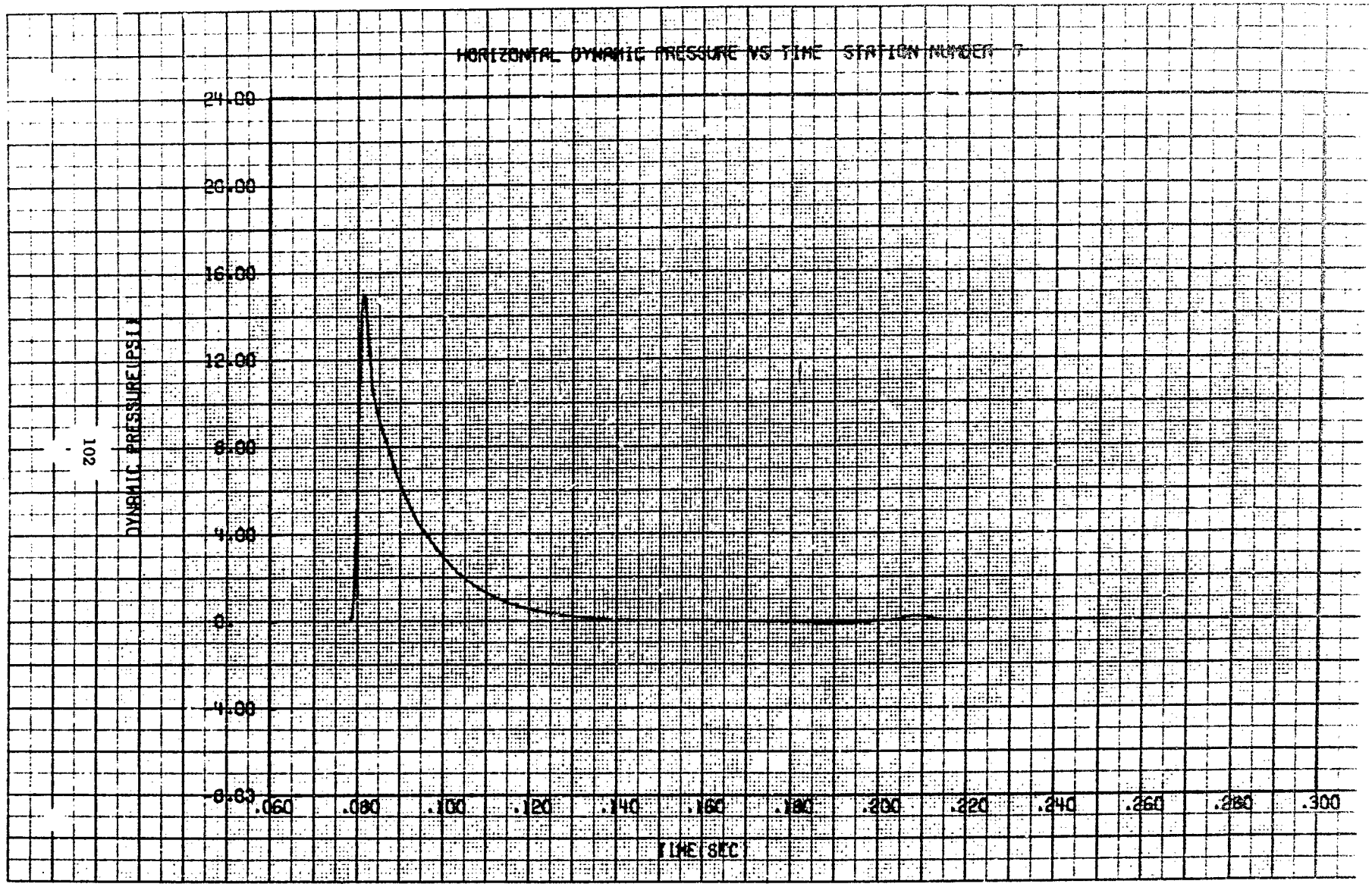

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE (LB.MSEC.)
.60
.50
.40
.30
.20
.10
0
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC

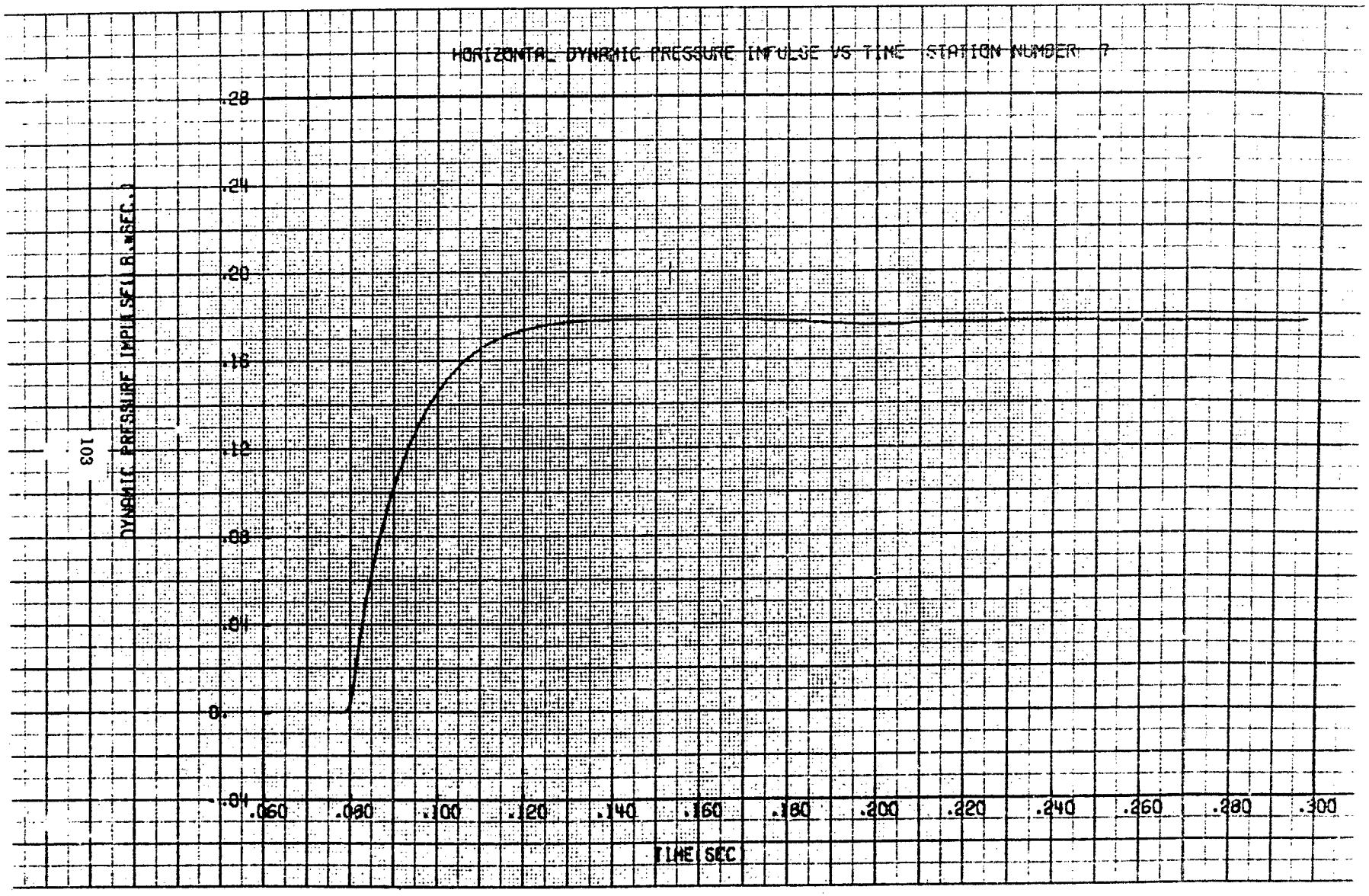
FIG. 86

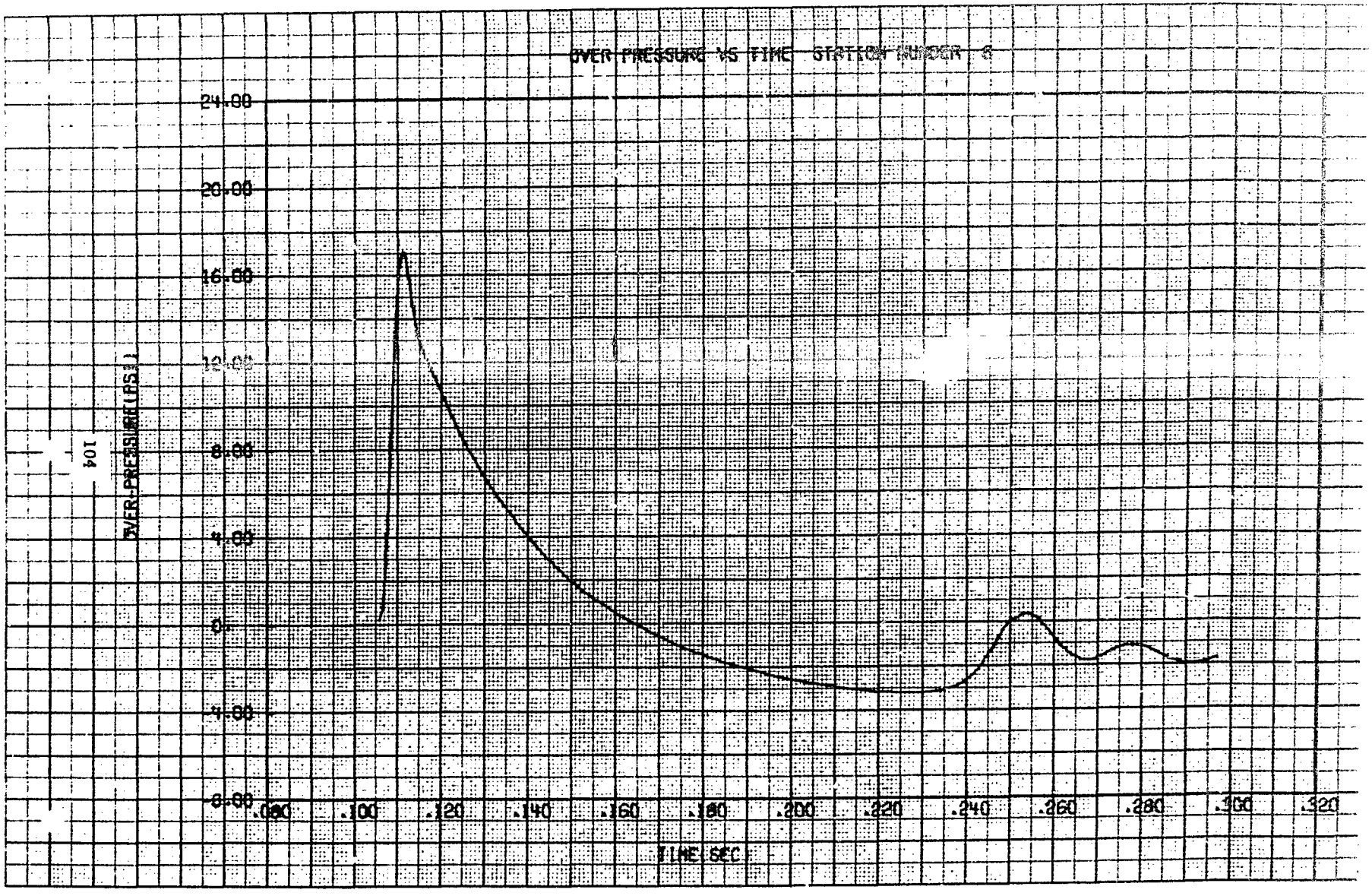

OVER PRESSURE VS TIME STATION NUMBER 7
OVER-PRESSURE(PSI)
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

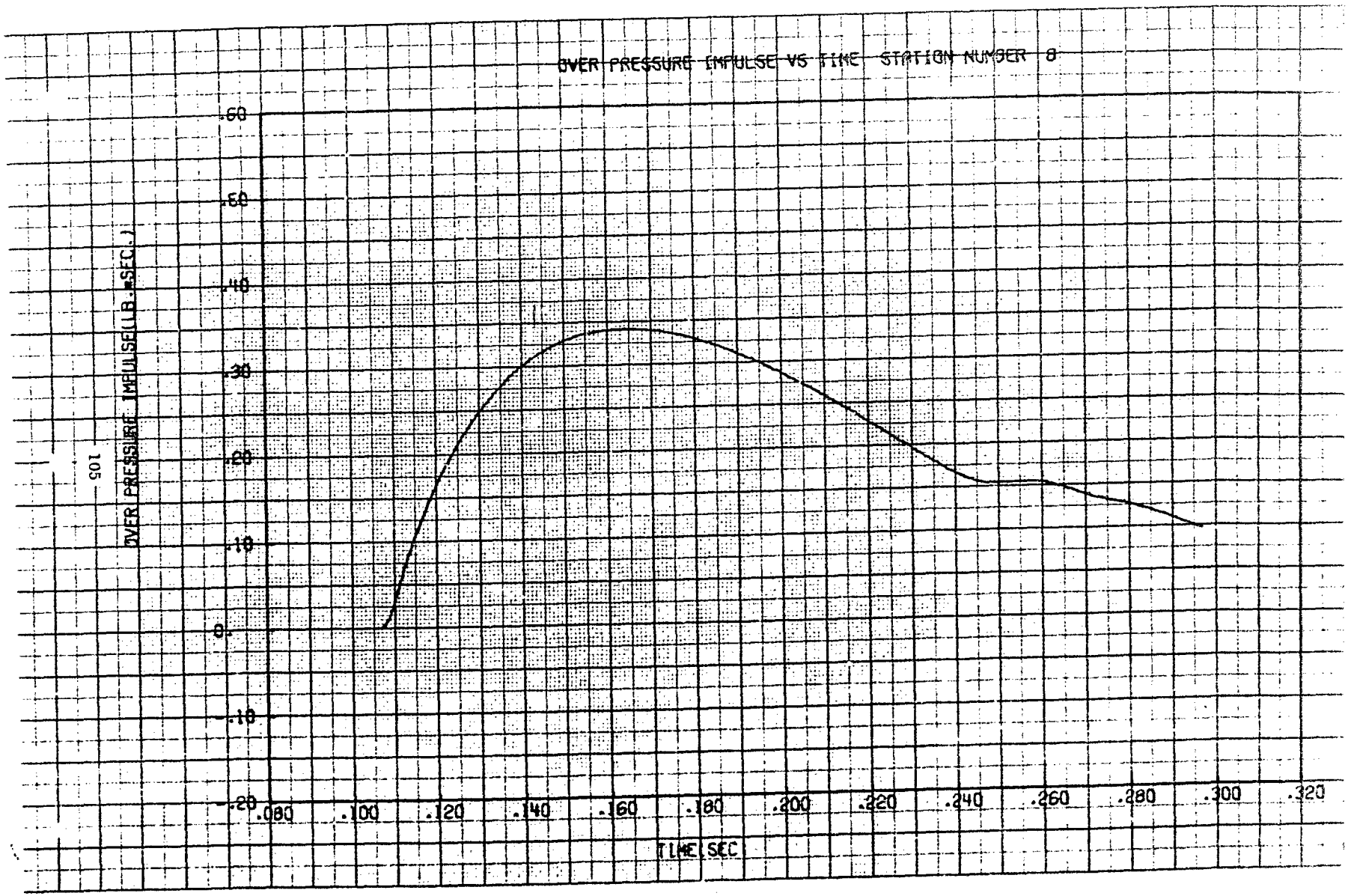

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 7
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

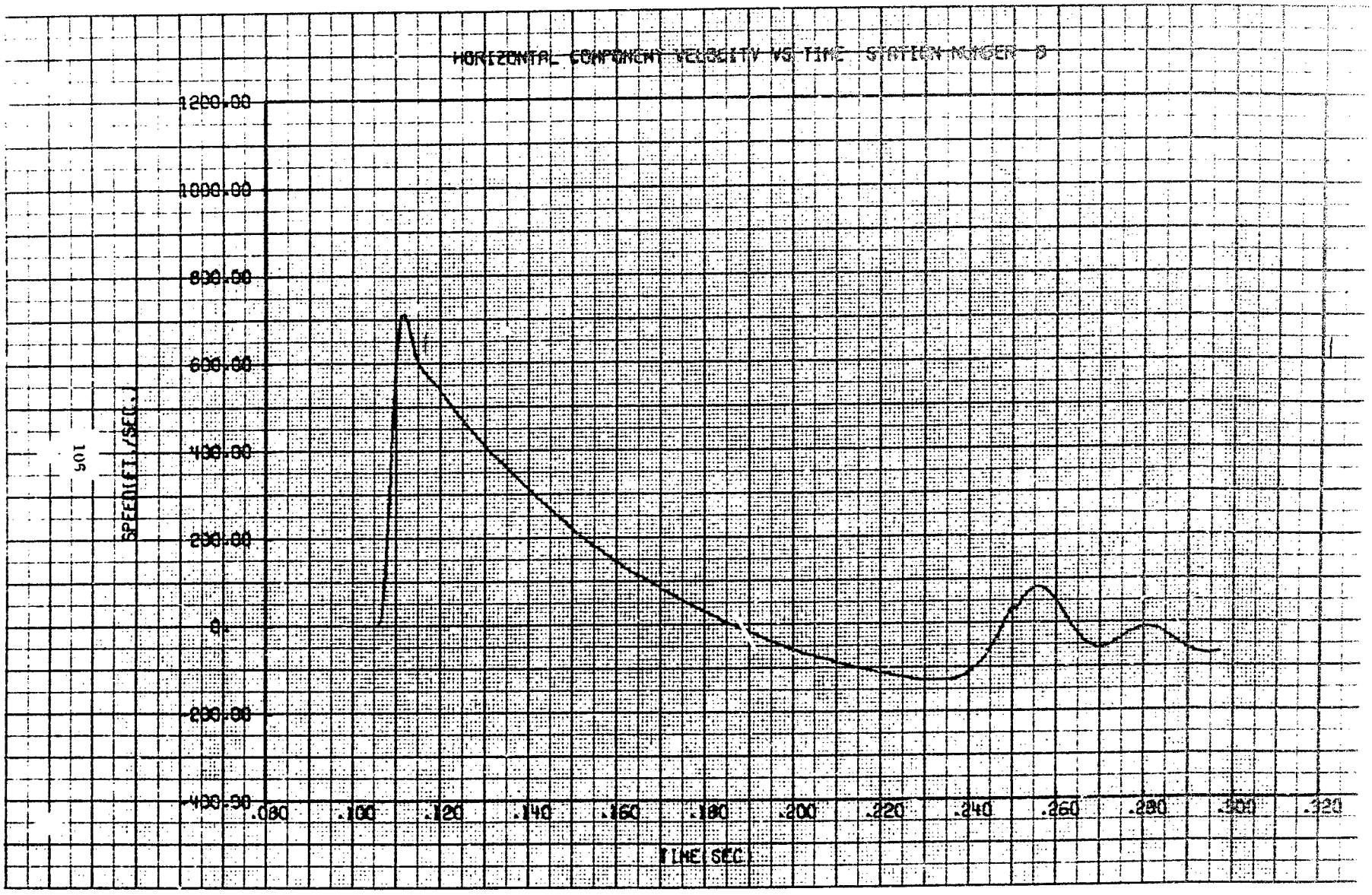

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 7
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC.)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

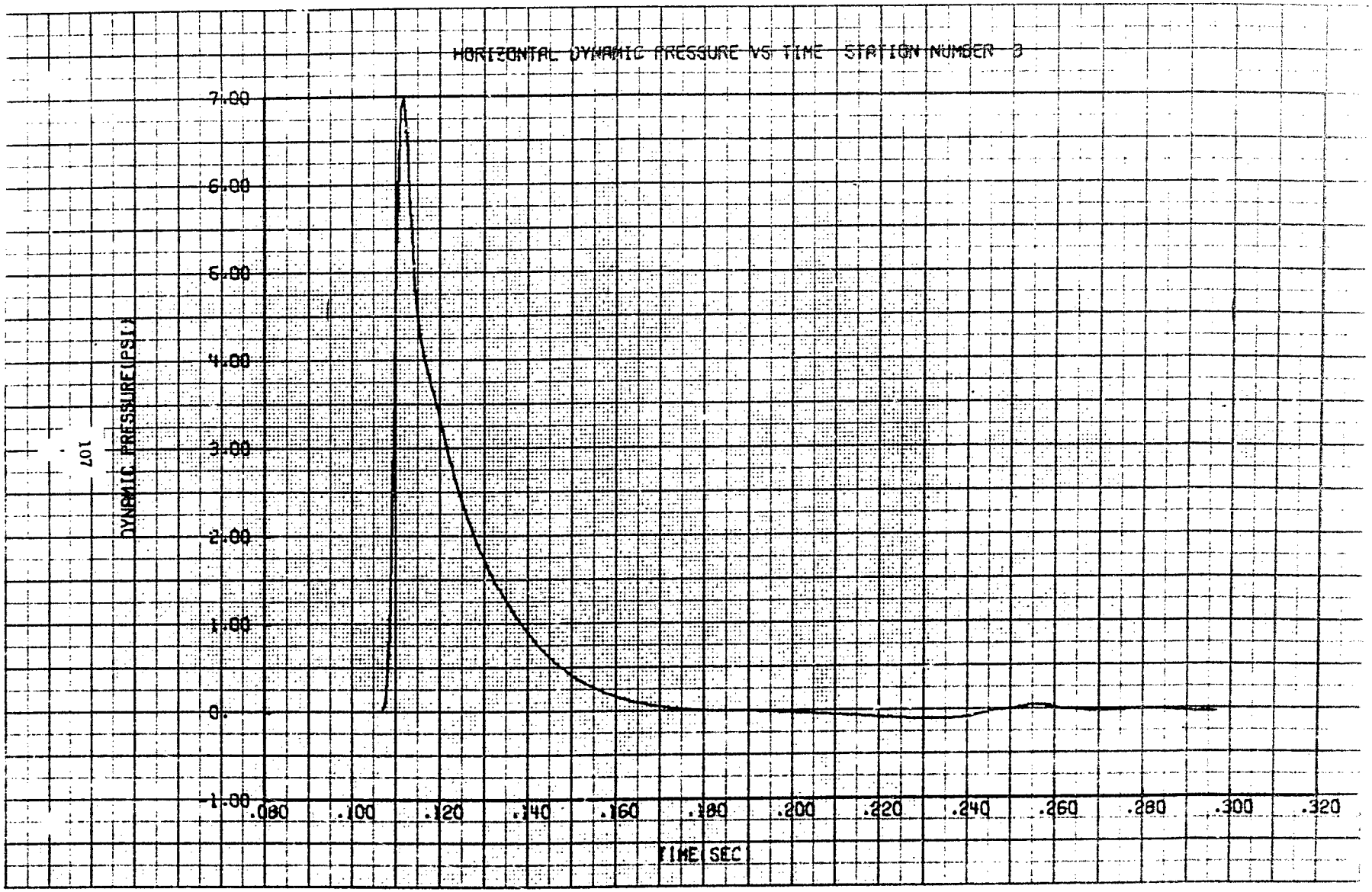

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE(PSI)
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

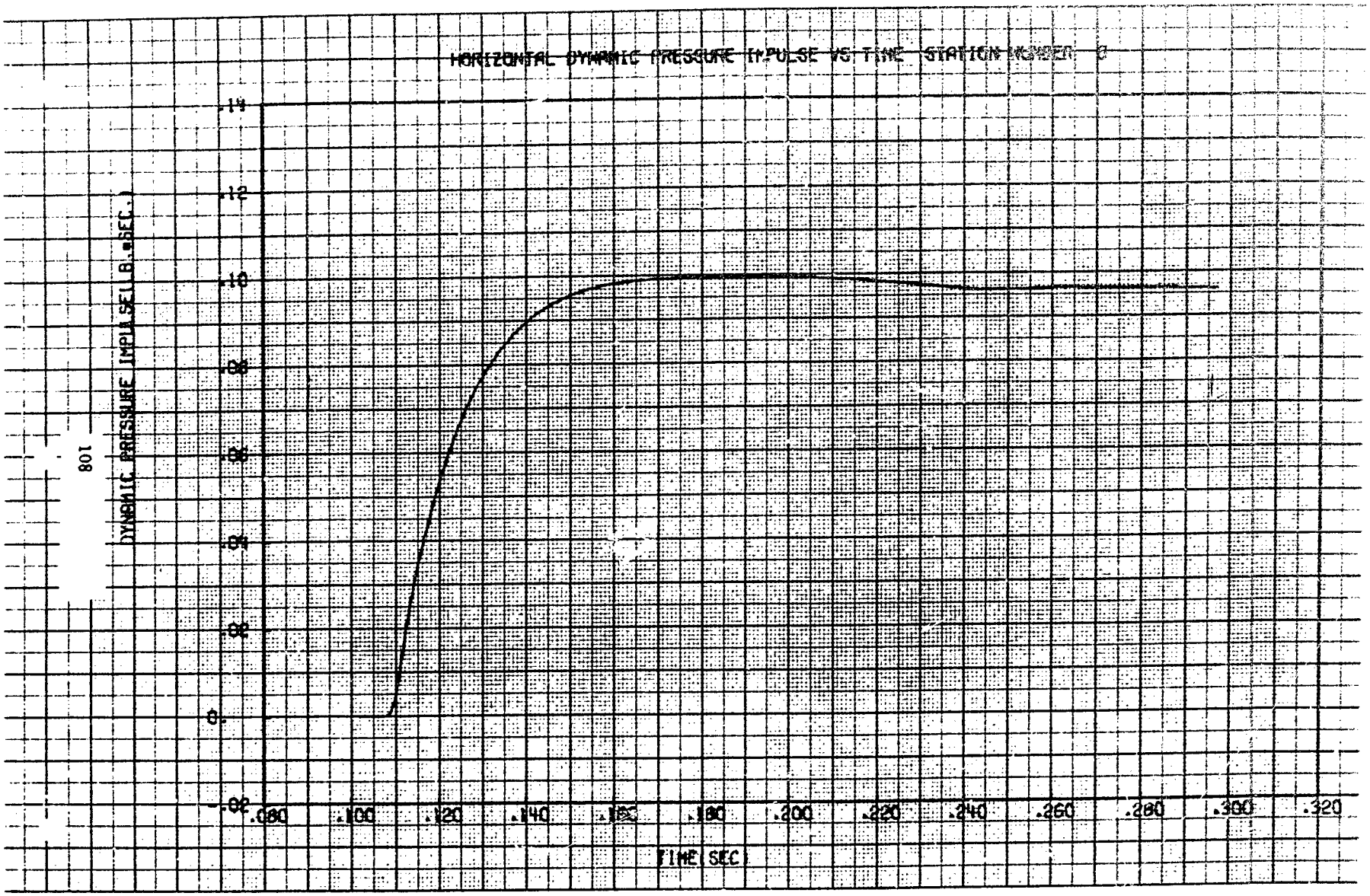

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME SEC

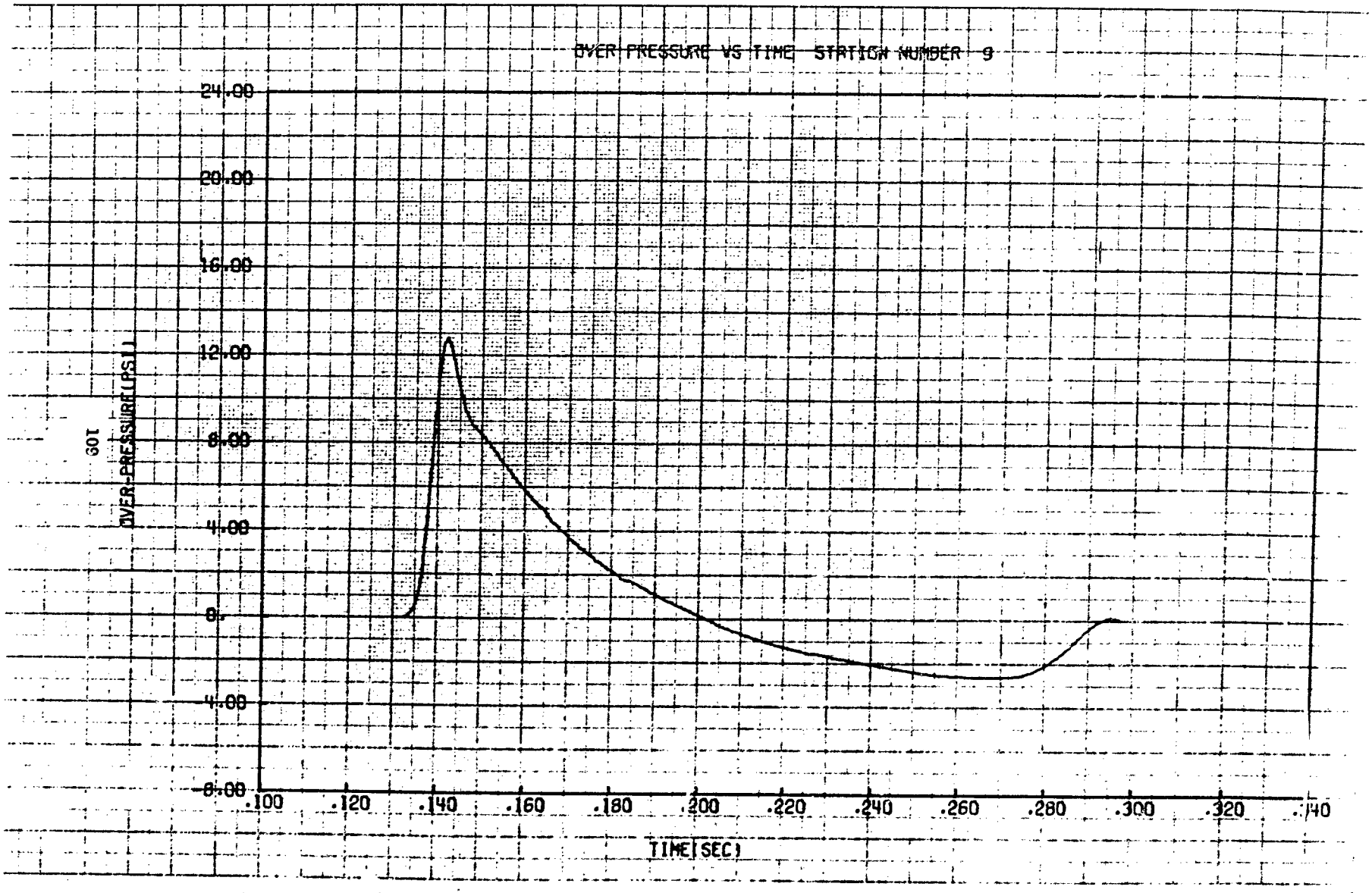

OVER PRESSURE VS TIME STATION NUMBER 6
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE (PSI)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC

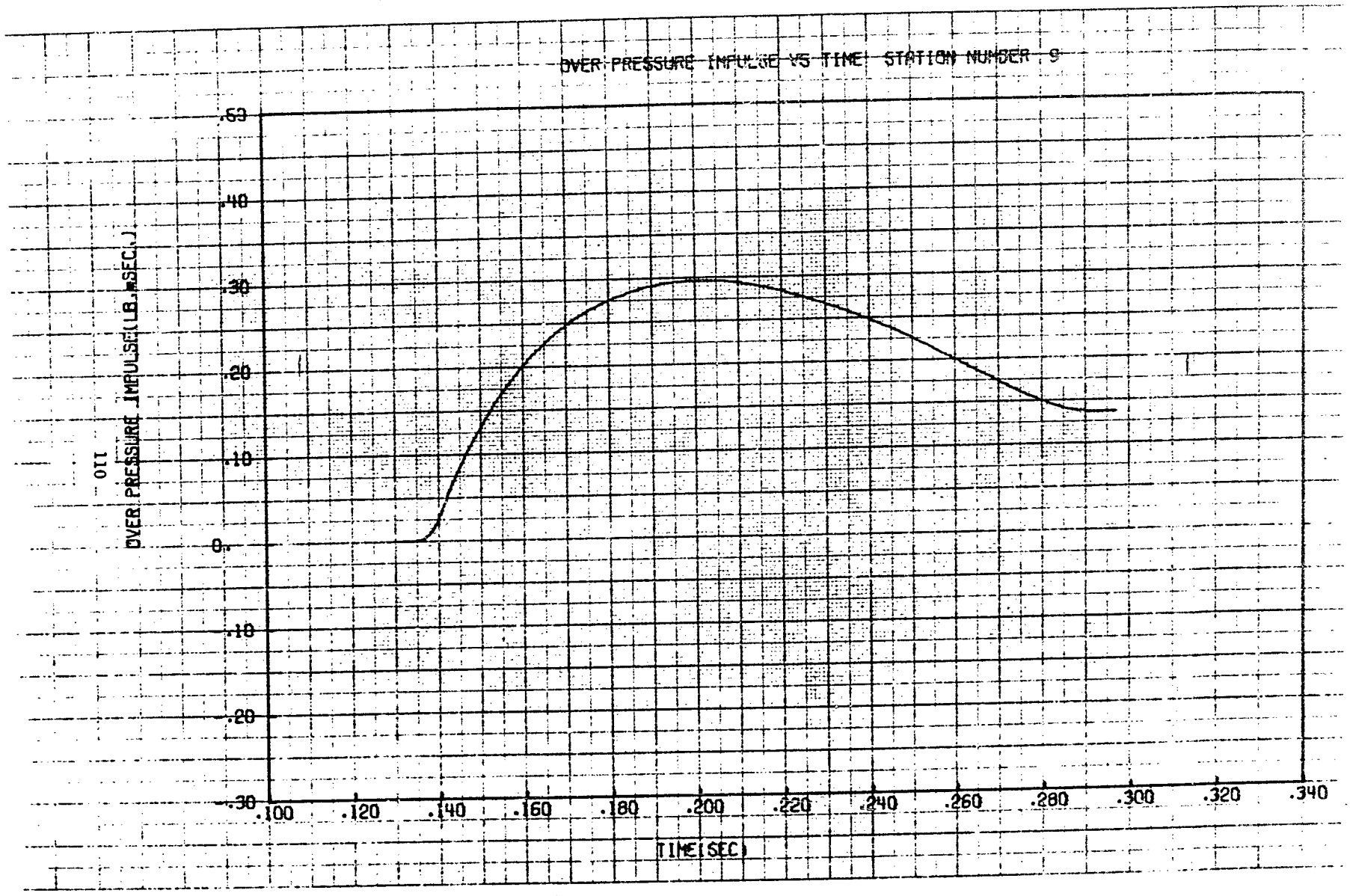

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 8
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME SEC

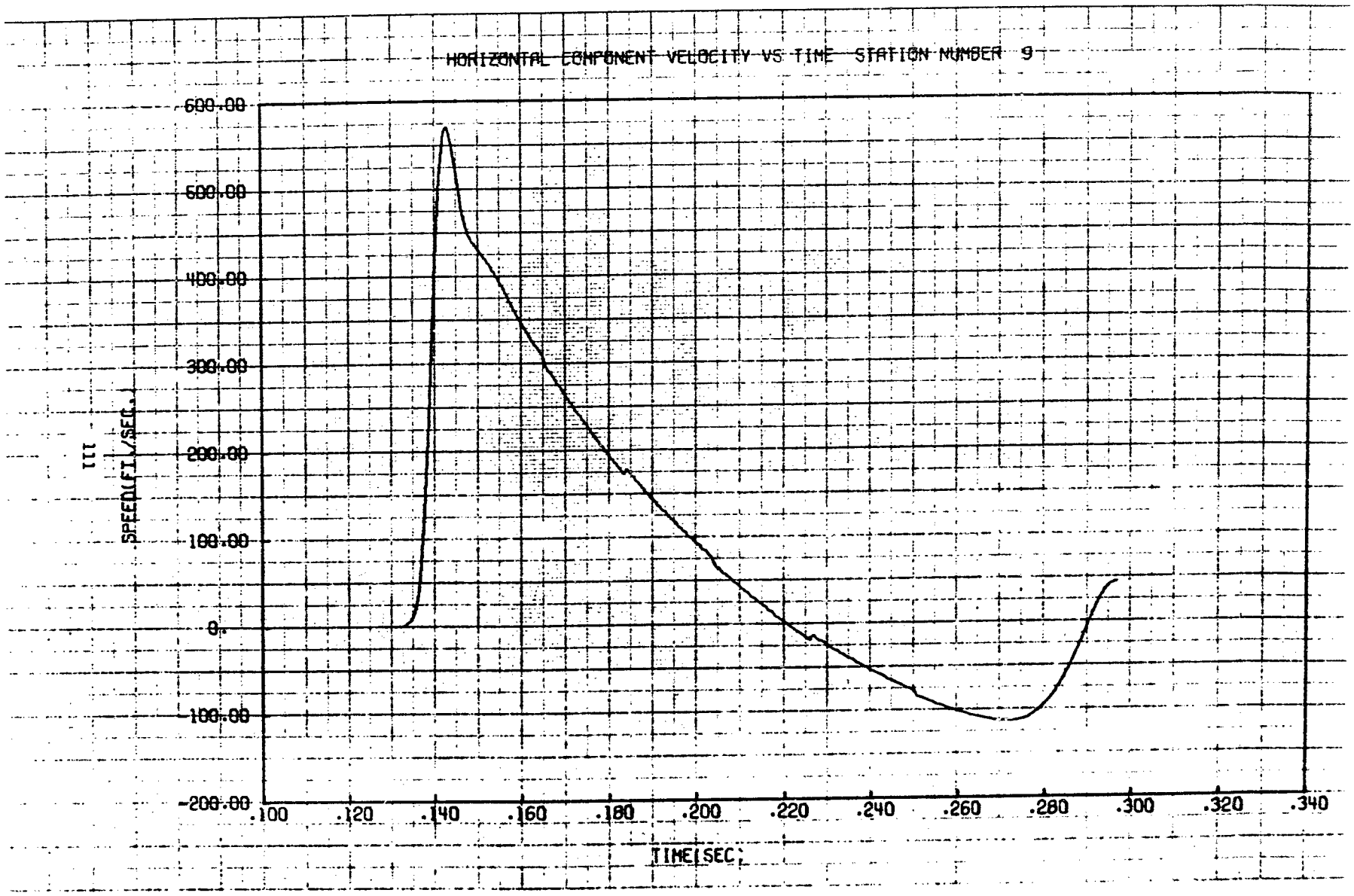

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT./SEC.)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC.)

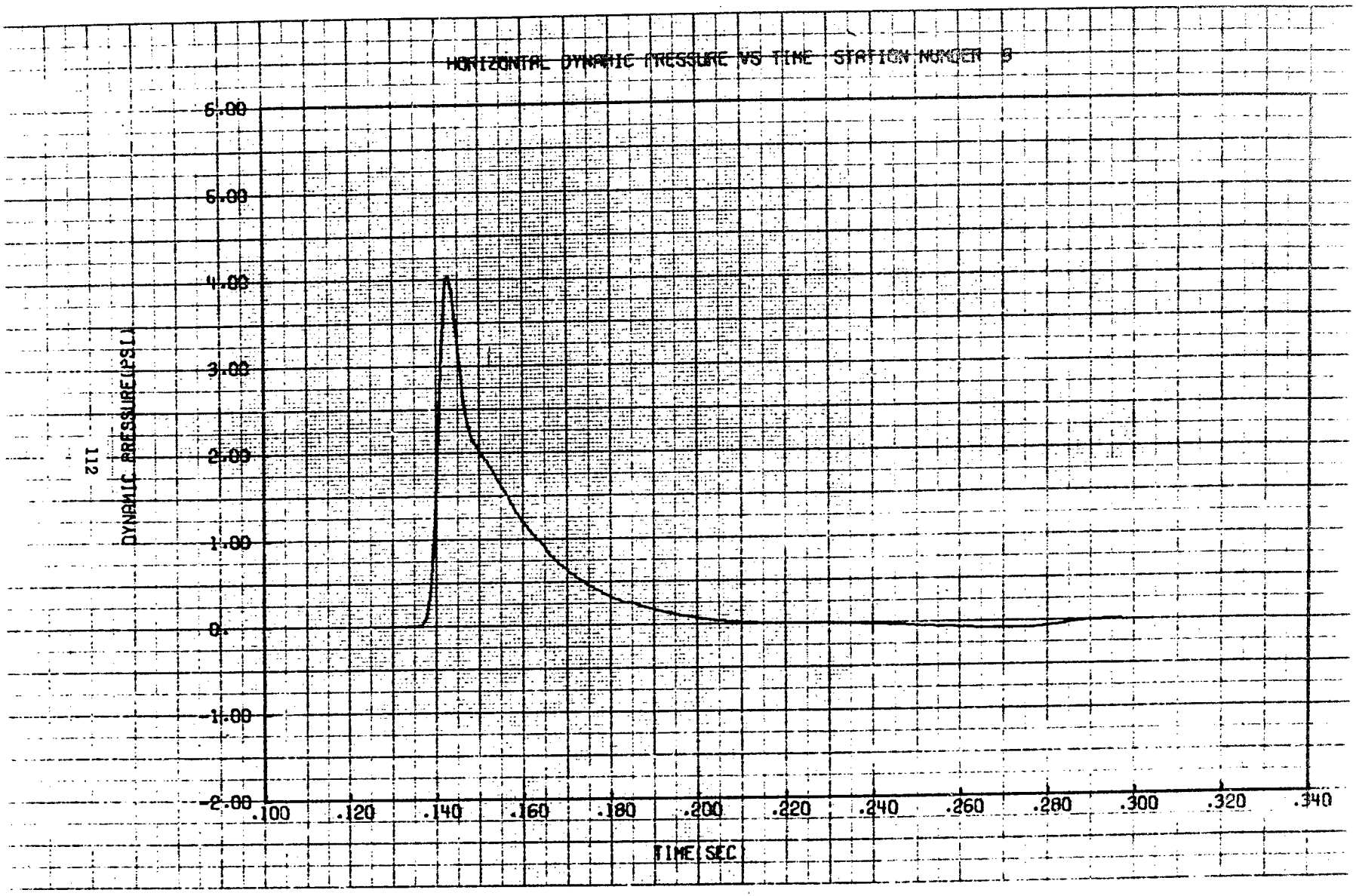

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE(PSI)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

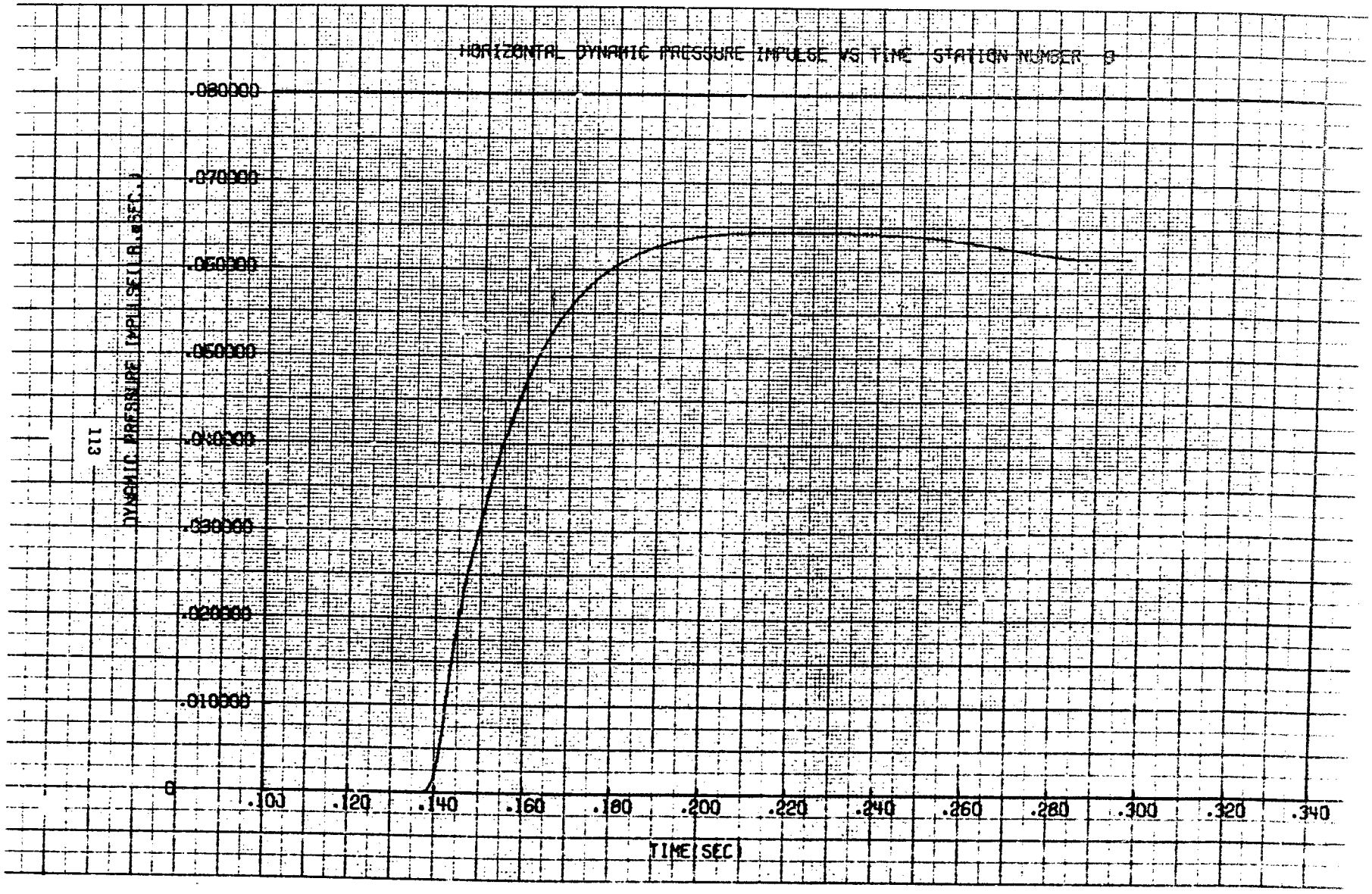

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 0
DYNAMIC PRESSURE IMPULSE(LB.•SEC.)
.14
.12
.10
.08
.06
.04
.02
0.
-.02
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

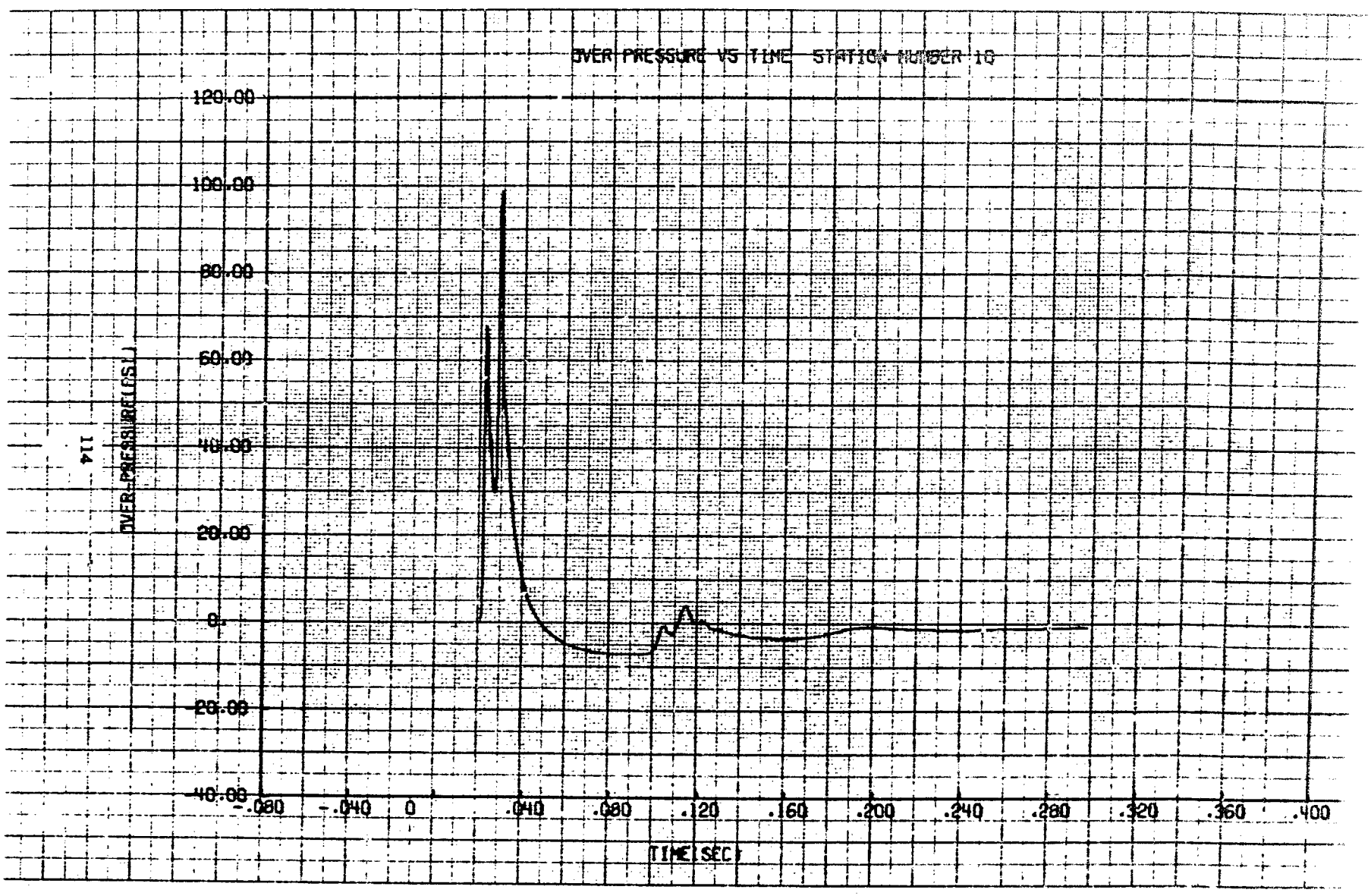

OVER PRESSURE VS TIME STATION NUMBER 9
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE(PSI)
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

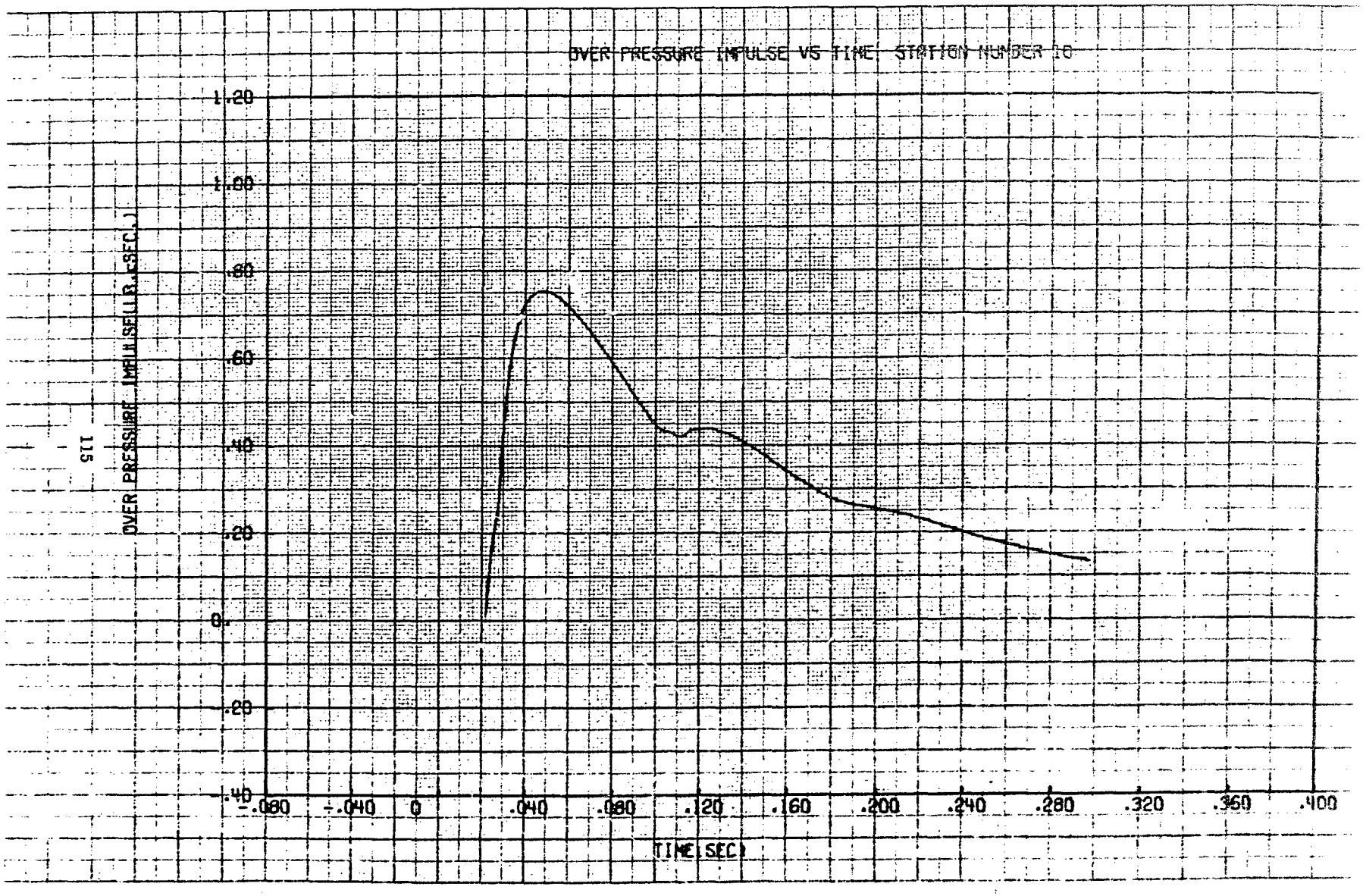

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 9
OVER PRESSURE IMPULSE(LB.*SEC.)
.50
.40
.30
.20
.10
0.
-.10
-.20
-.30
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

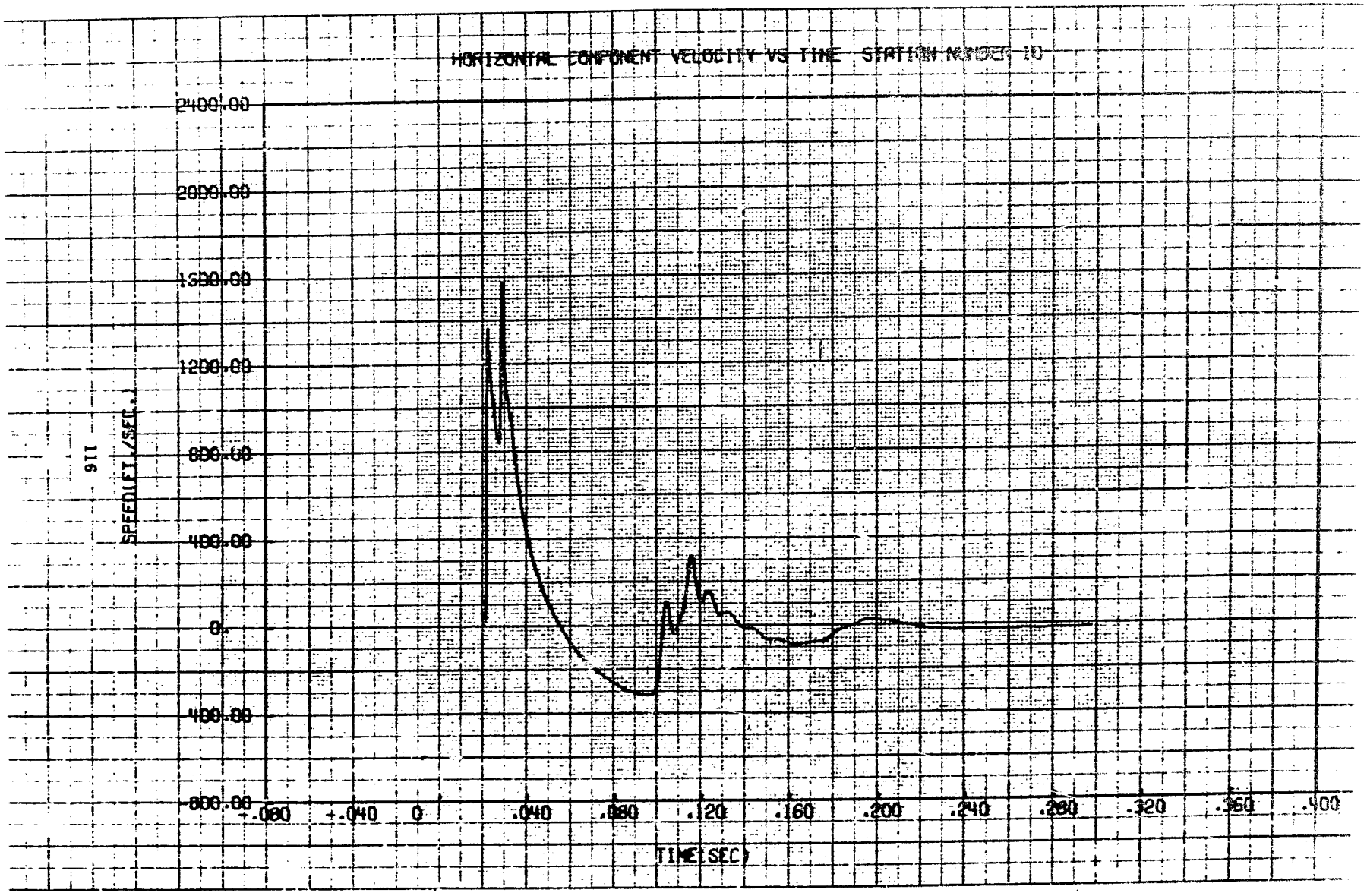

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
SPEED(FT/SEC)
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

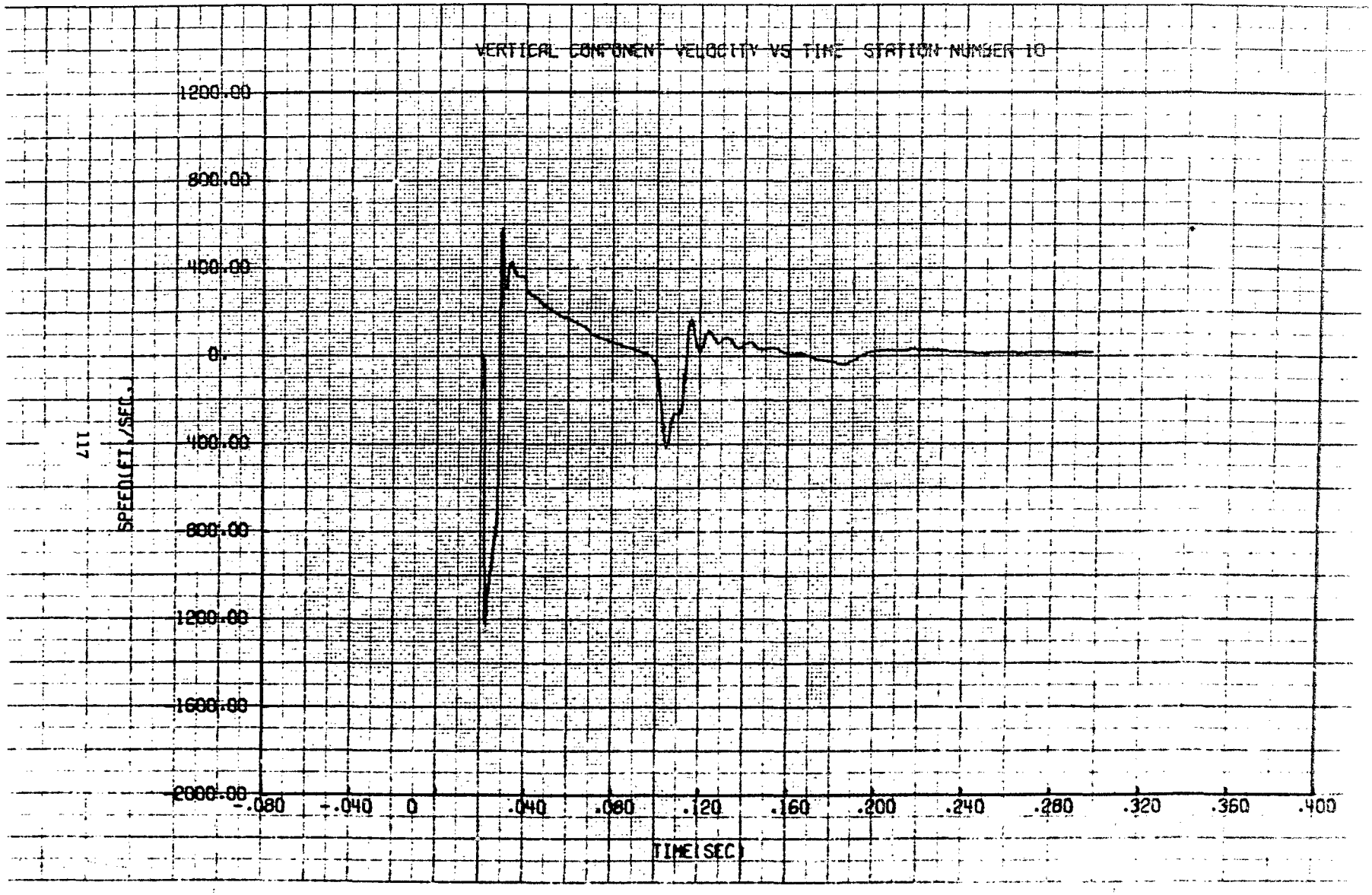

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 8
DYNAMIC PRESSURE(PSI)
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
-2.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

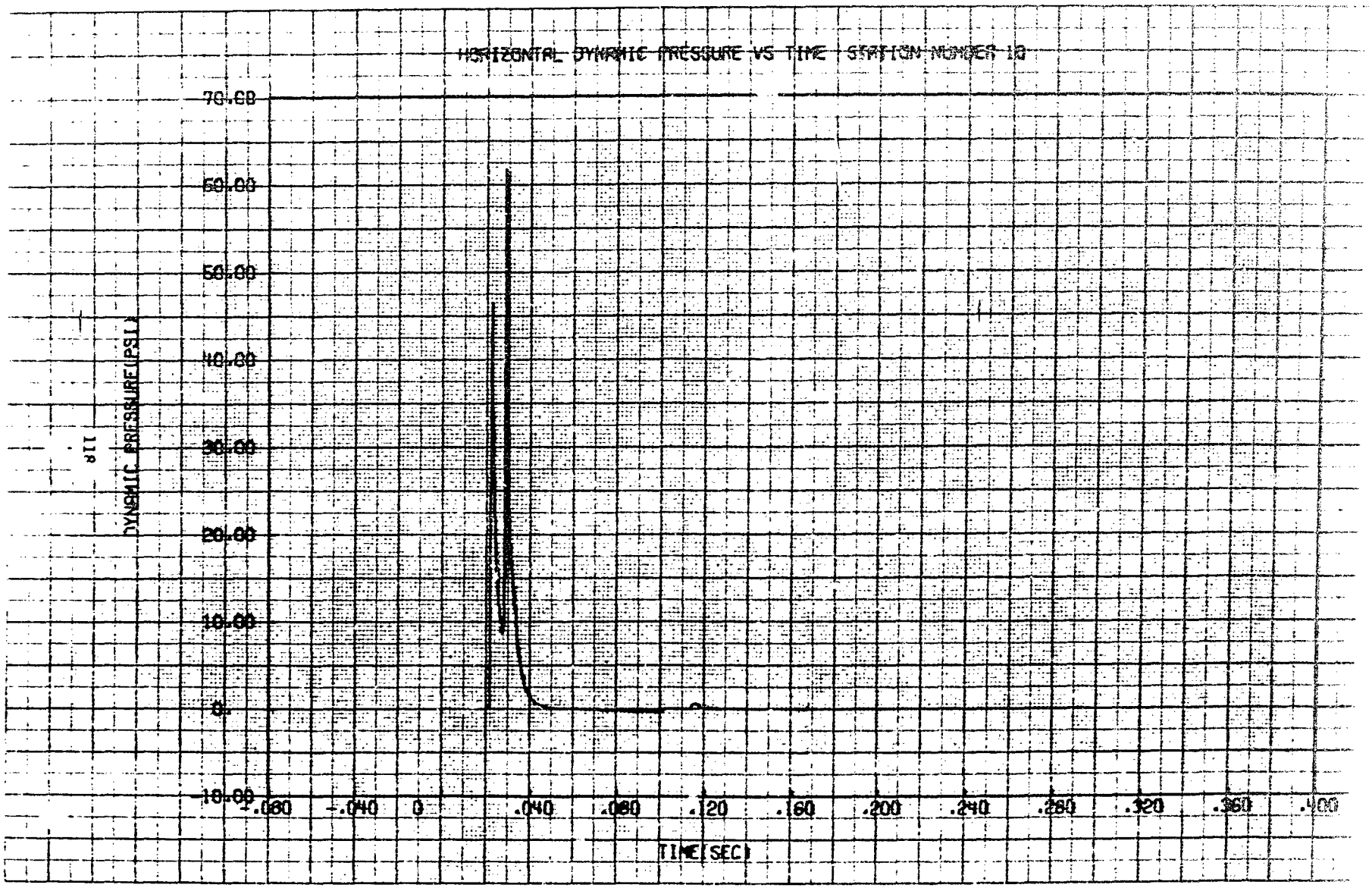

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 9
.080000
.070000
.060000
.050000
.040000
.030000
.020000
.010000
0
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)

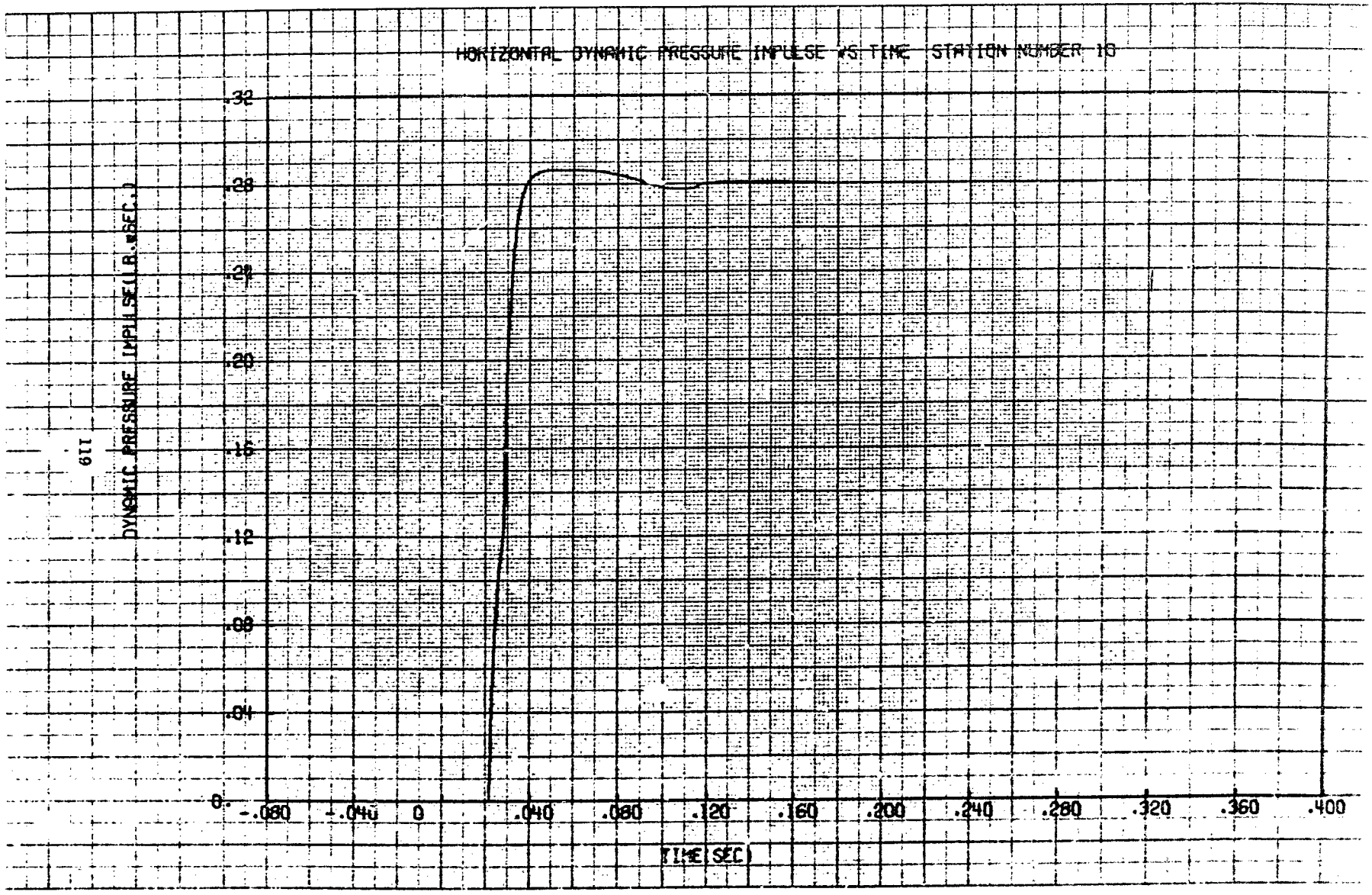

OVER PRESSURE VS TIME STATION NUMBER 10
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
OVER PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

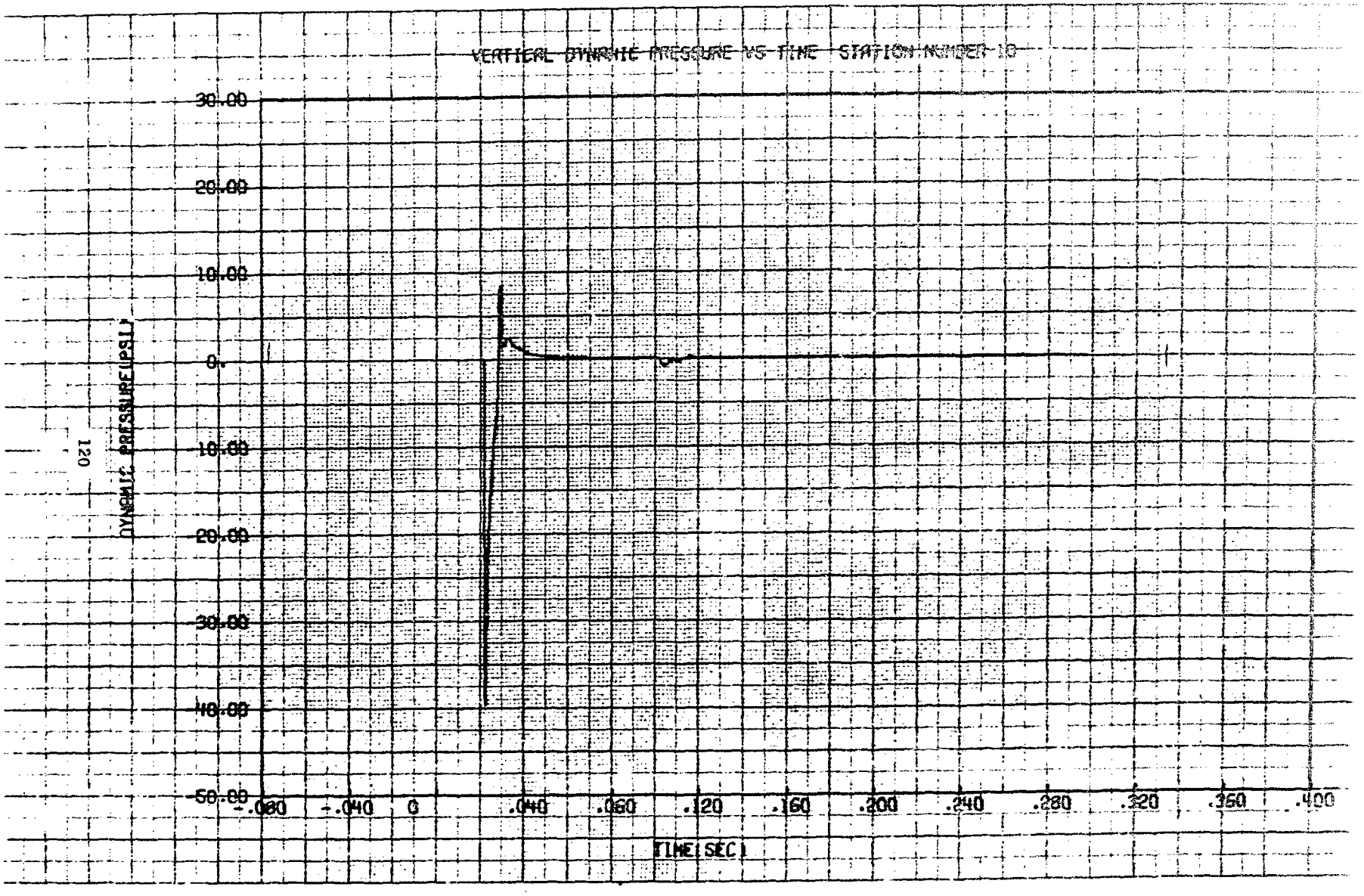

OVER PRESSURE IMPULSE VS TIME, STATION NUMBER 10
OVER PRESSURE IMPULSE(LB.-SEC.)
1.20
1.00
.80
.60
.40
.20
0.
-.20
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

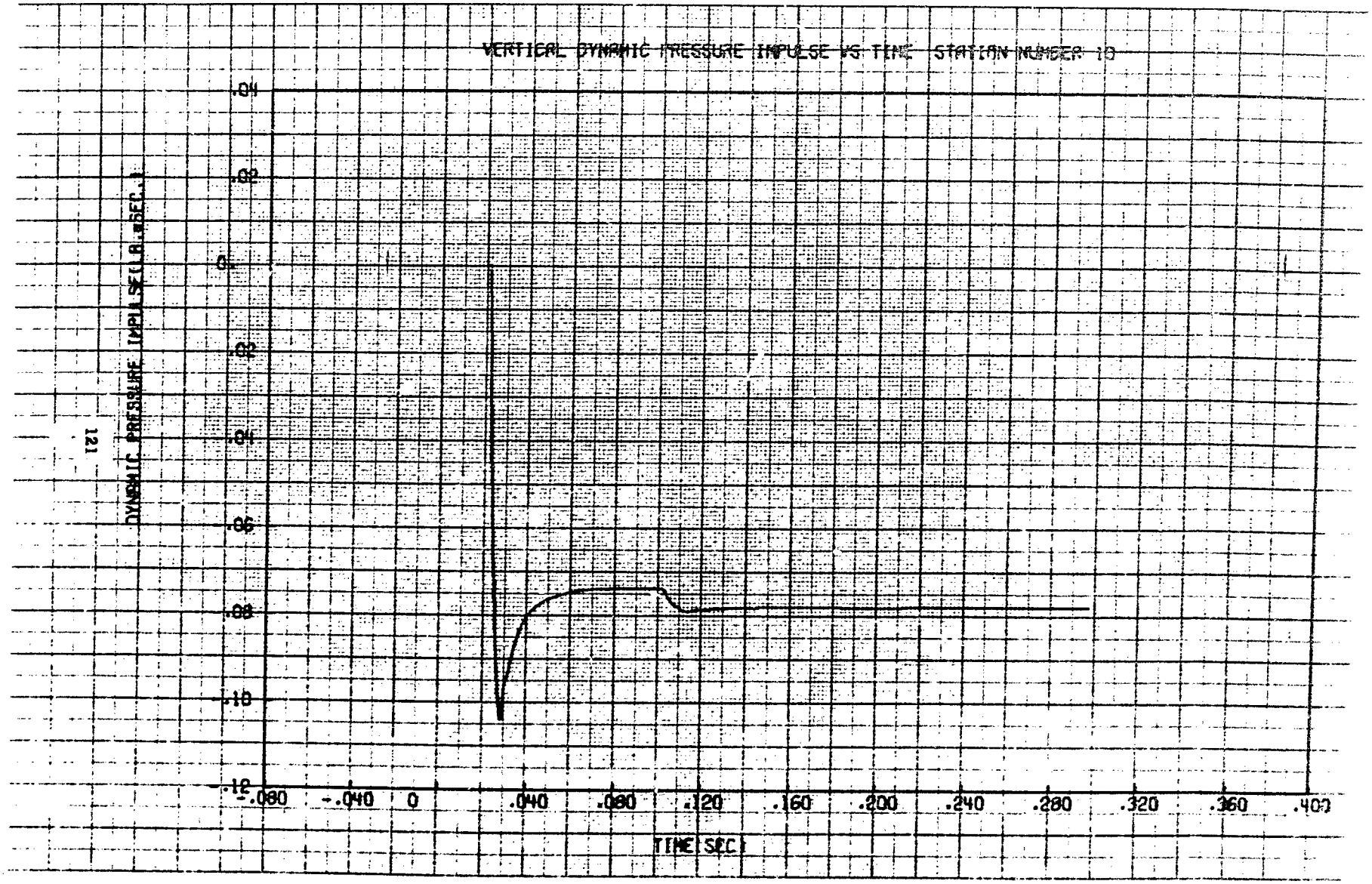

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

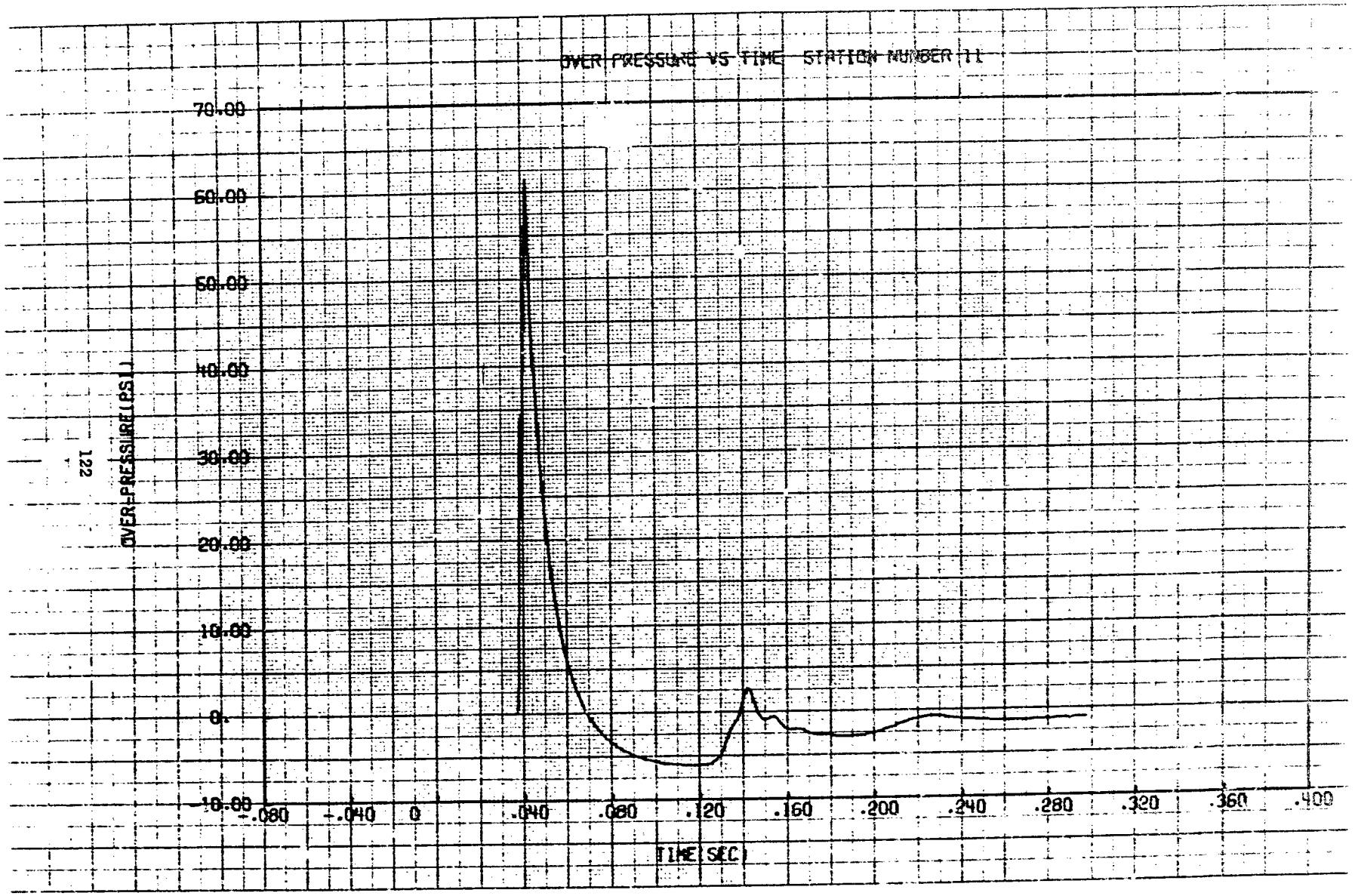

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

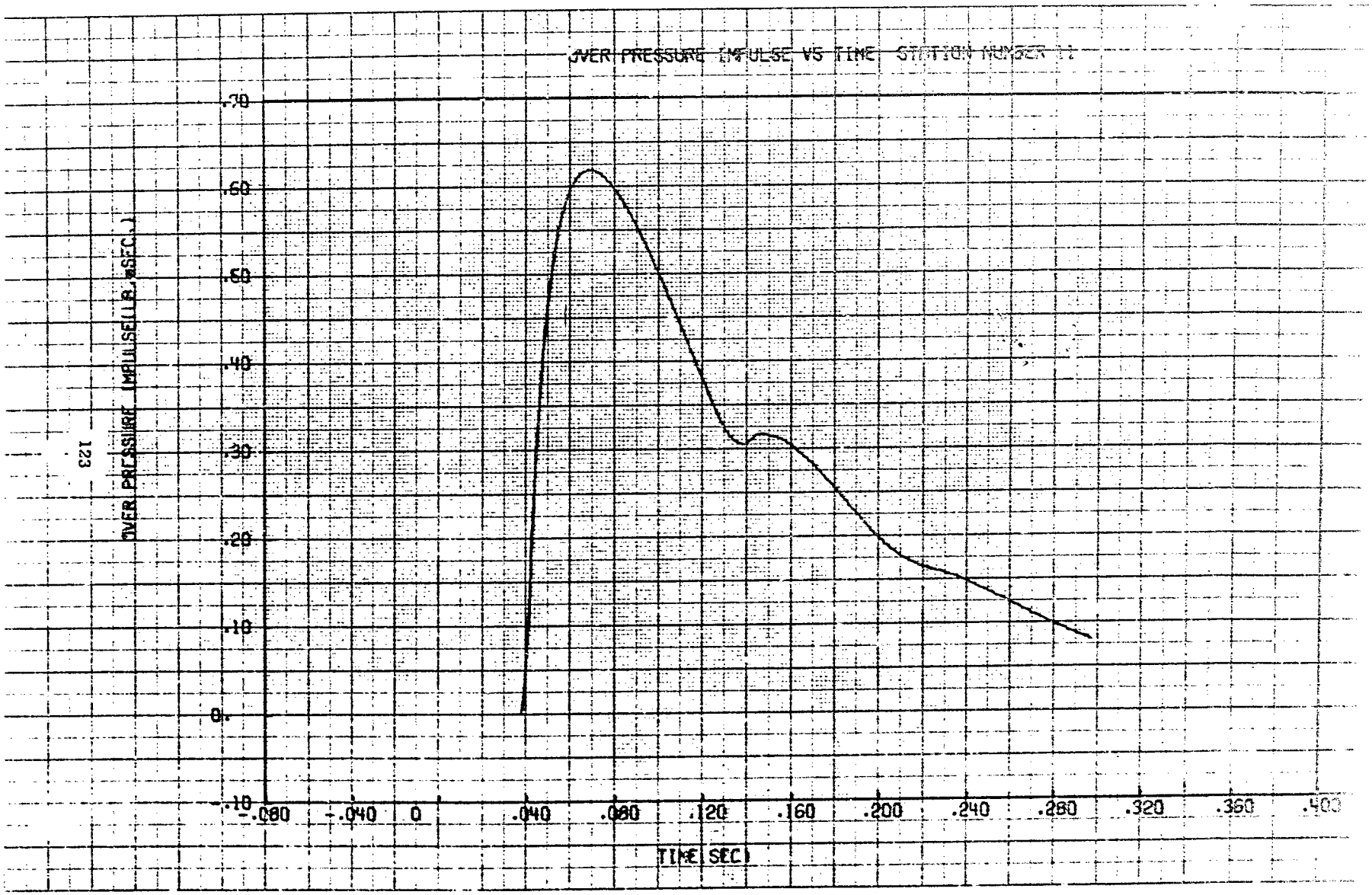

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

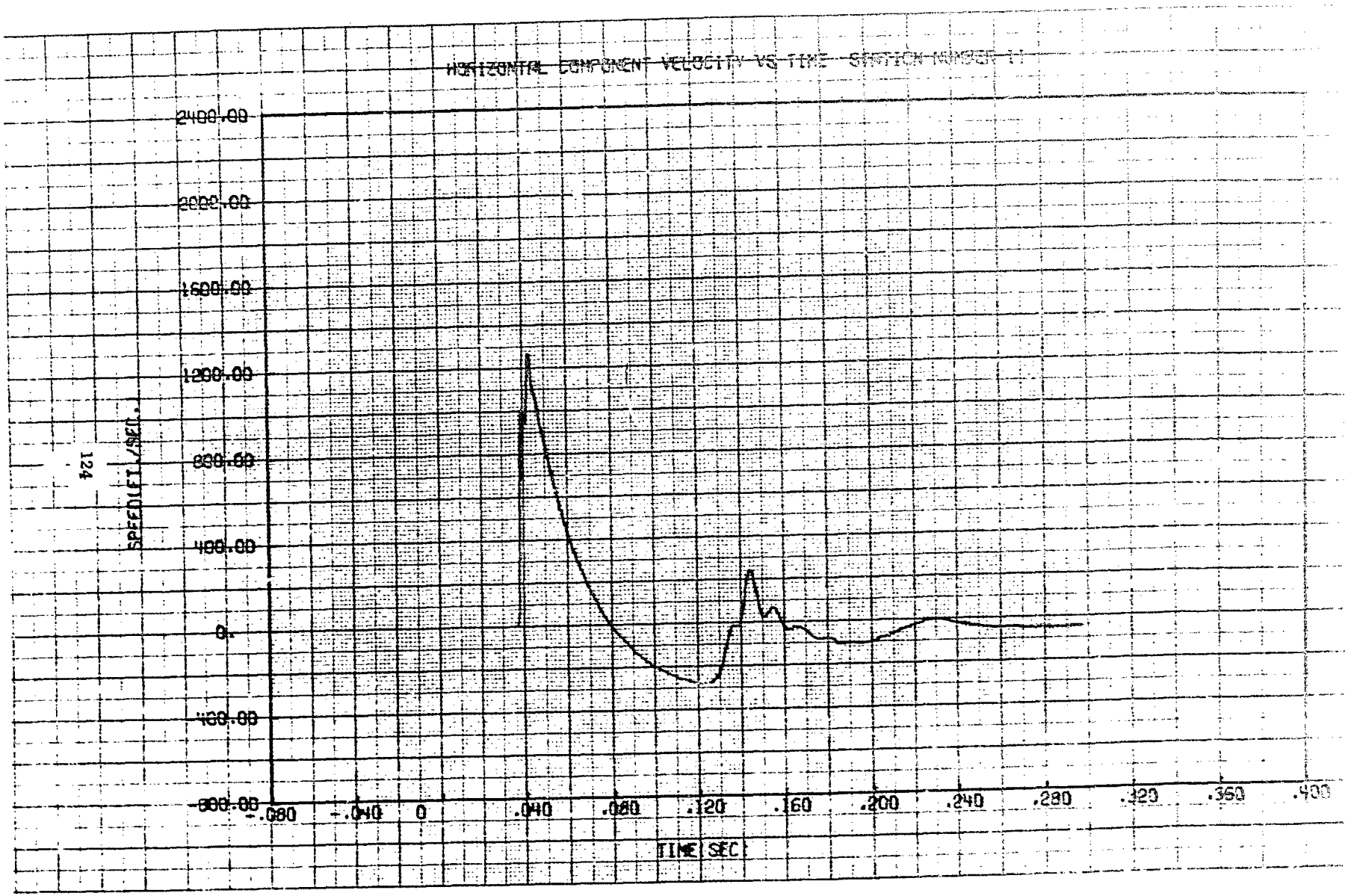

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.32
.28
.24
.20
.16
.12
.08
.04
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

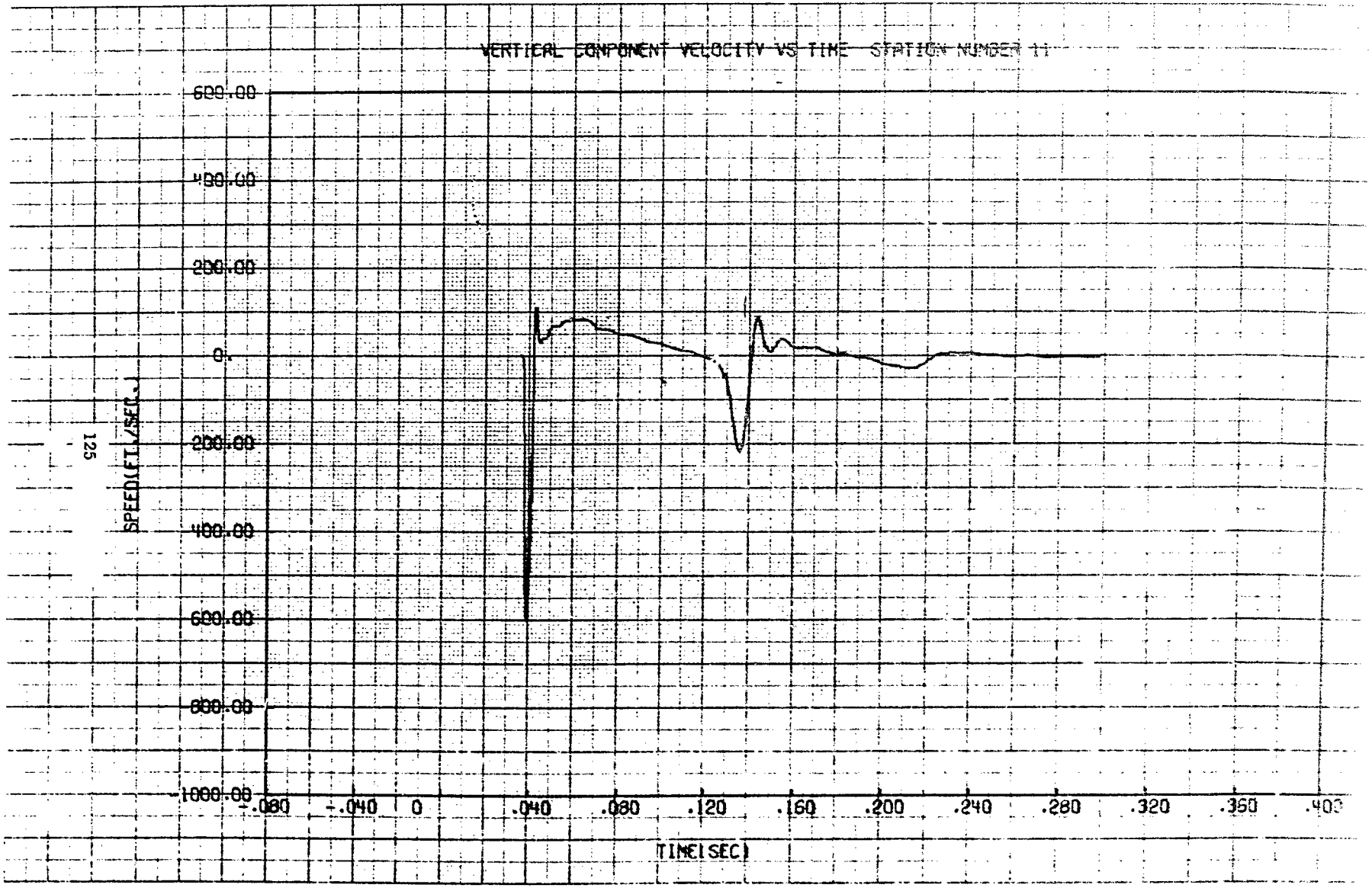

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

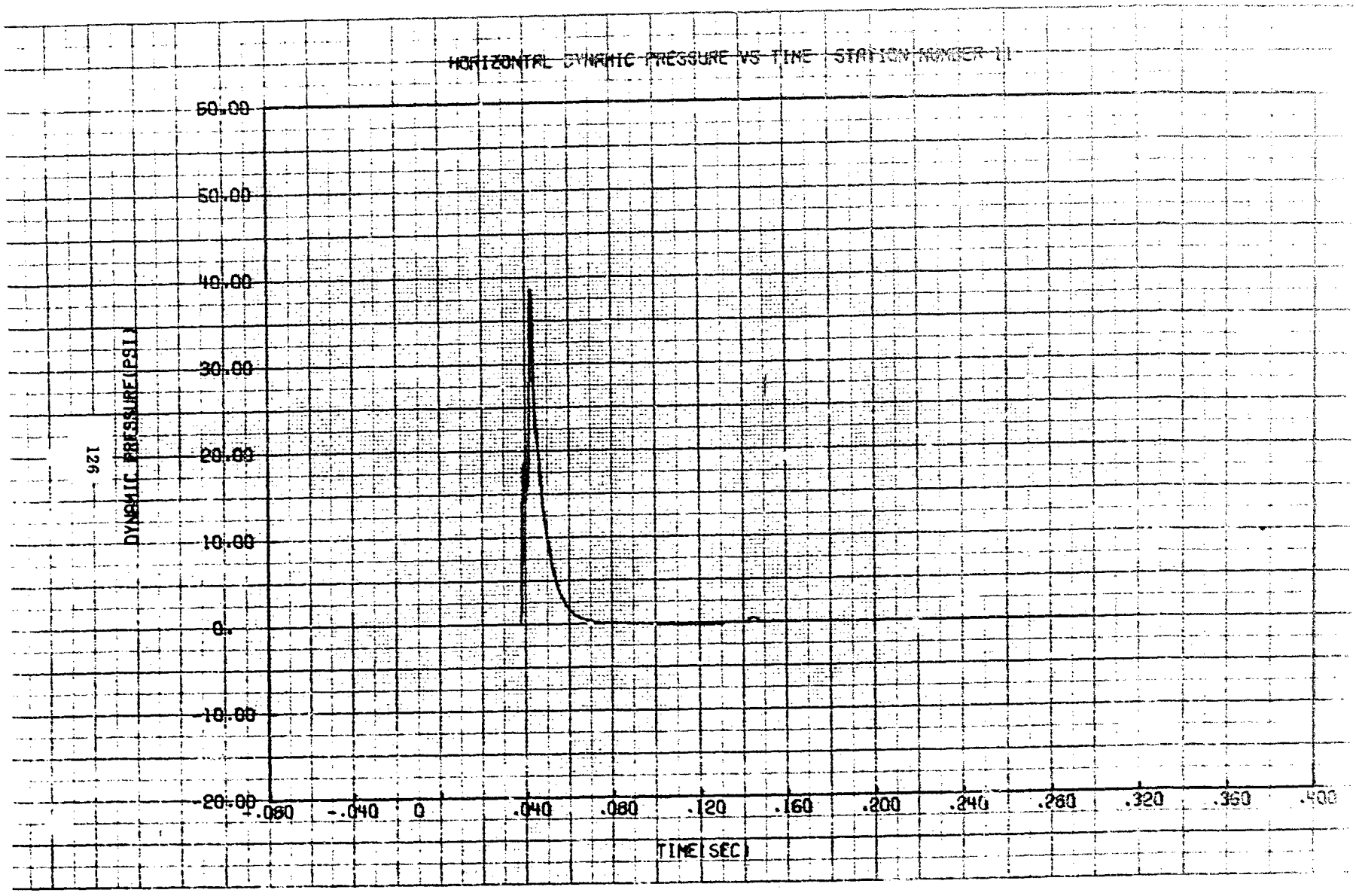

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE (LB.#SEC.)
.04
.02
0
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

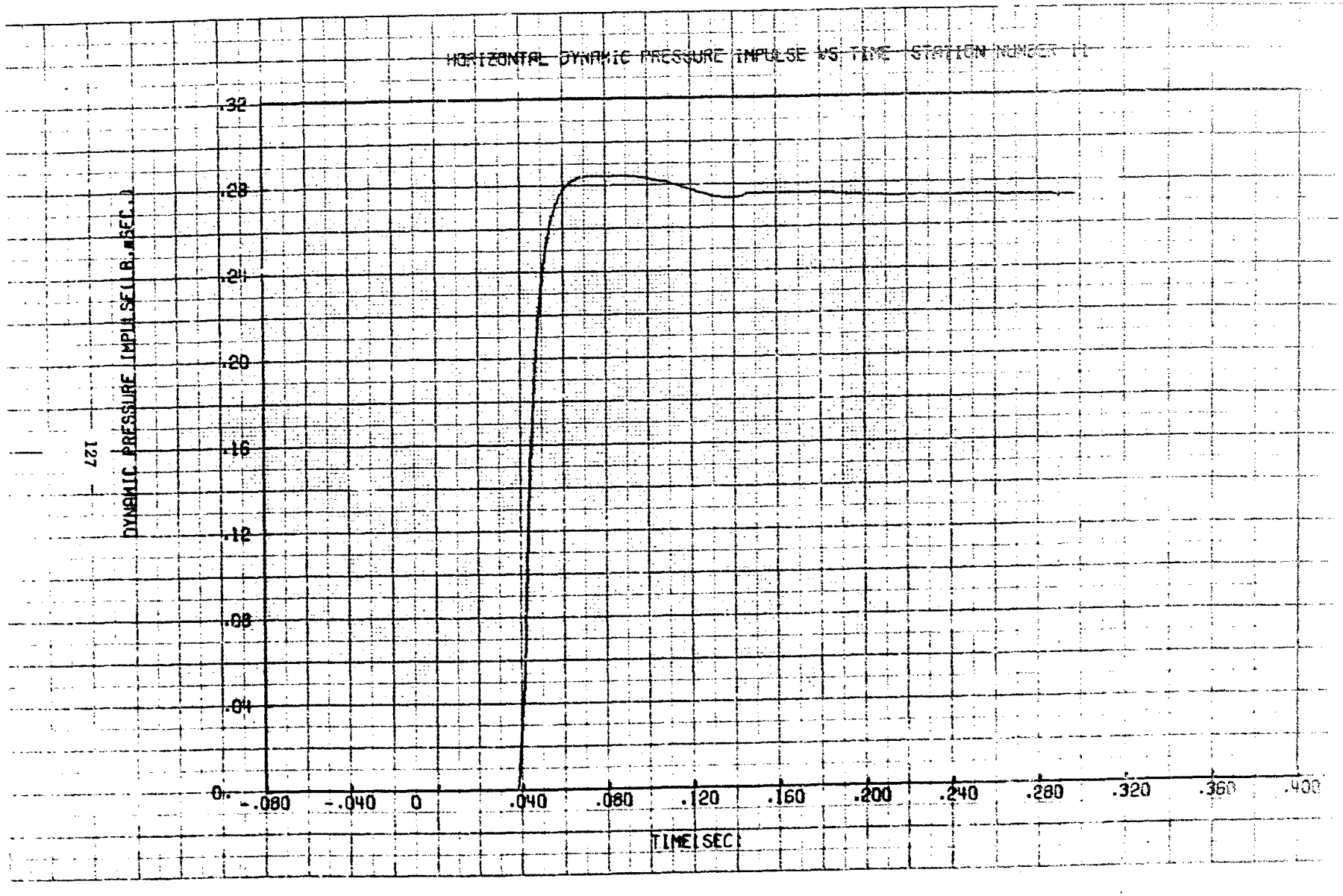

OVER PRESSURE VS TIME STATION NUMBER 11
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

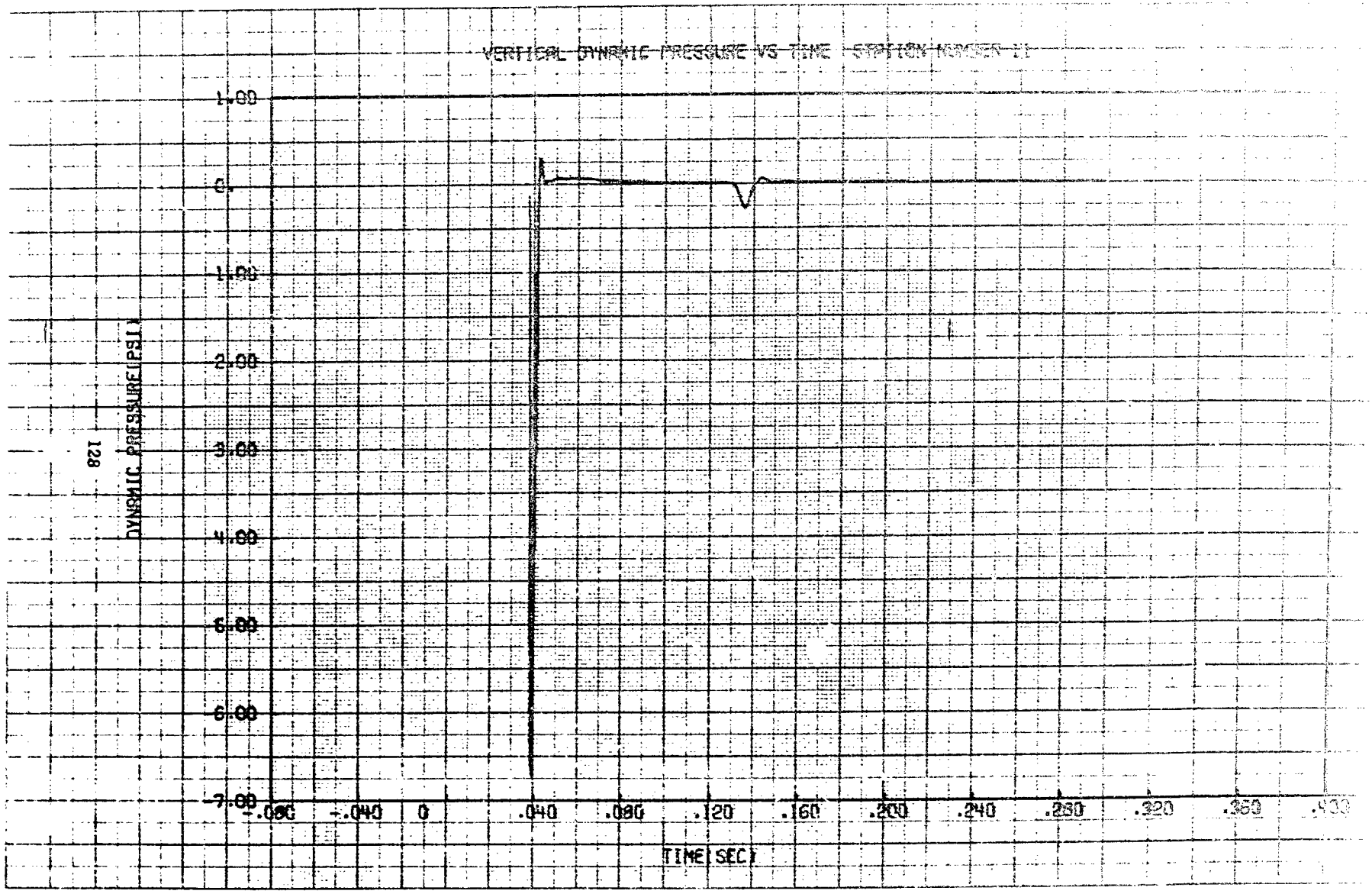

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 11
OVER PRESSURE (IMPULSE(LB.*SEC.))
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

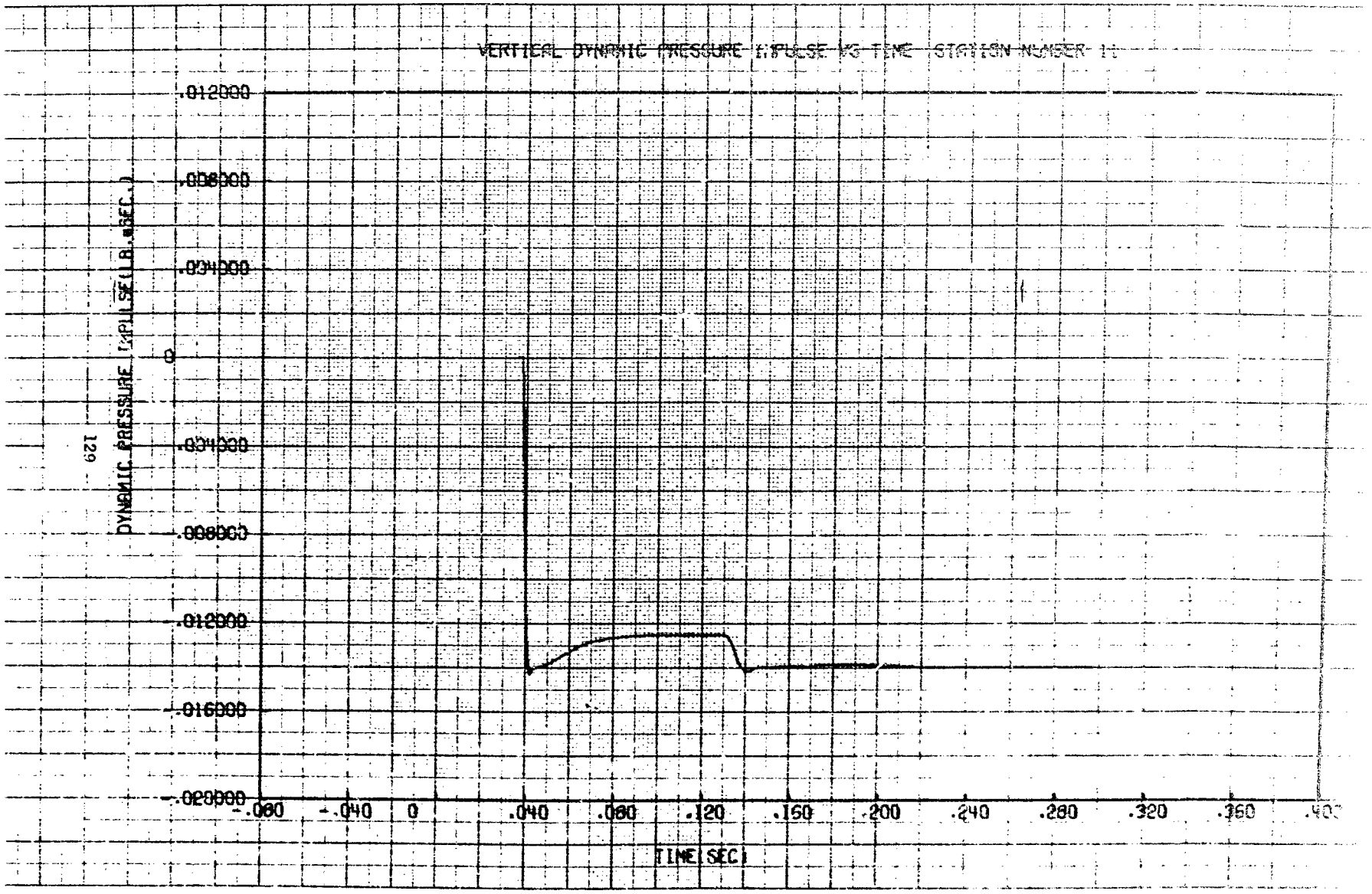

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

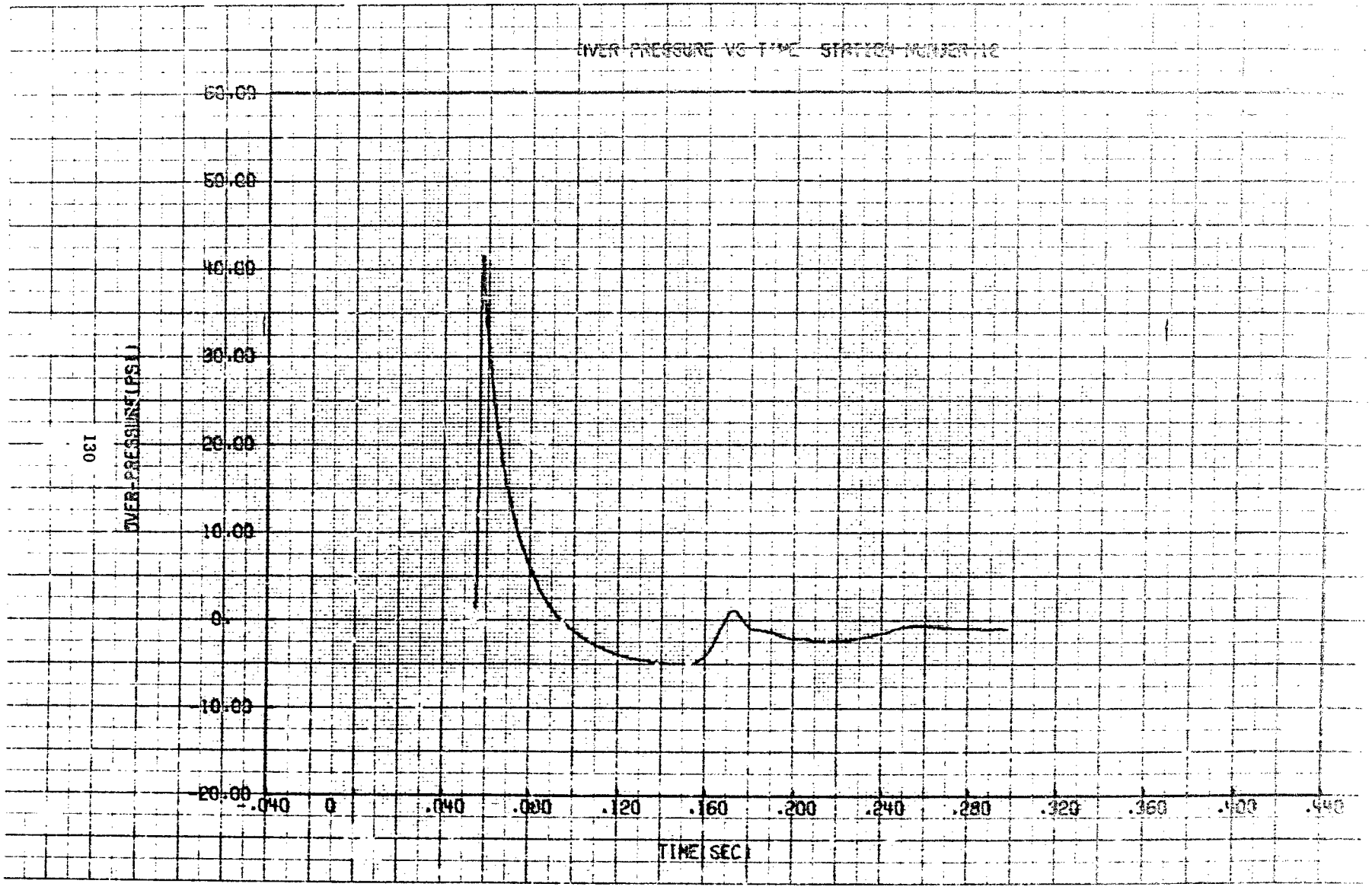

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
SPEED(FT./SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

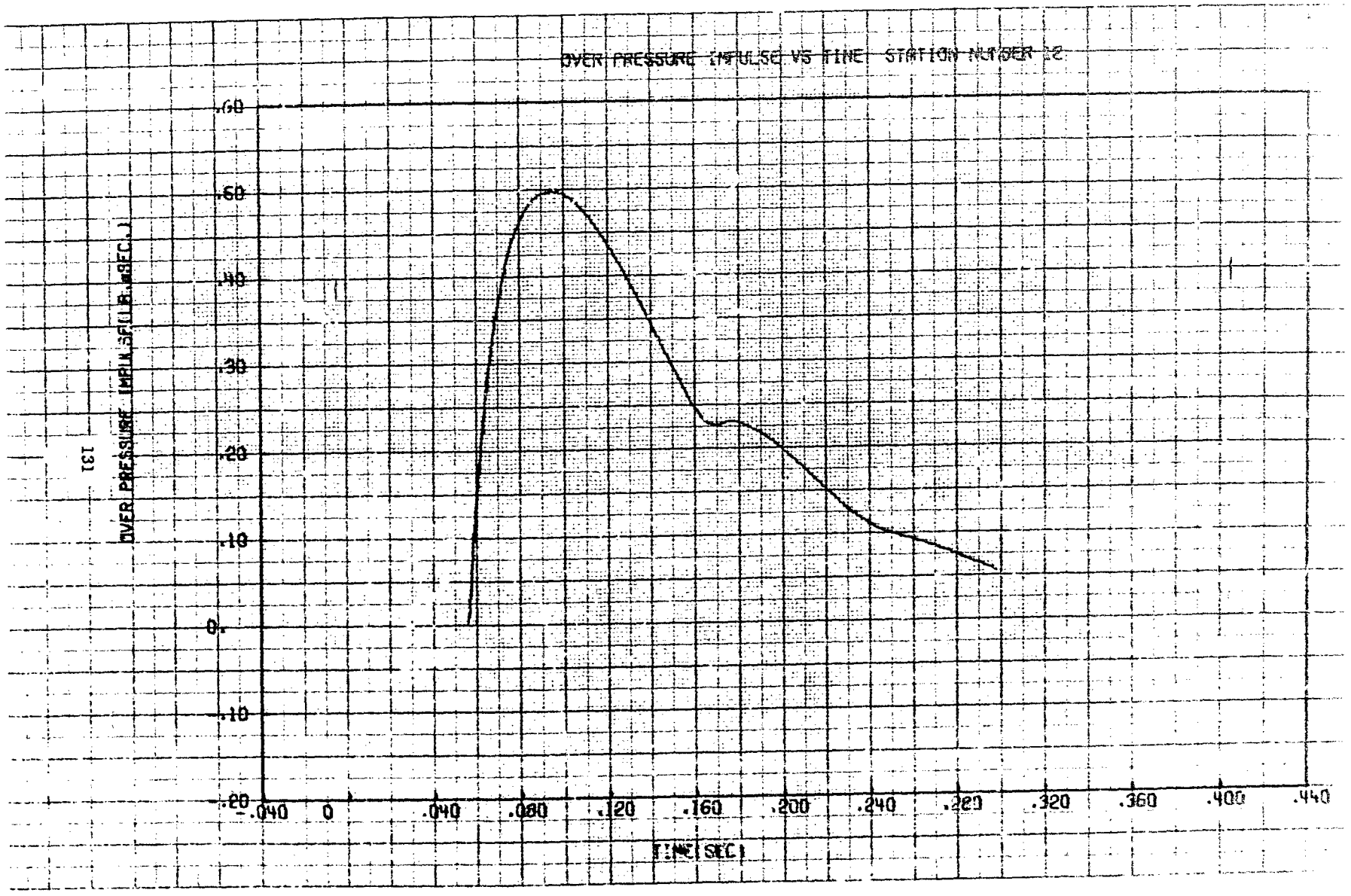

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
DYNAMIC PRESSURE(PSI)
50.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

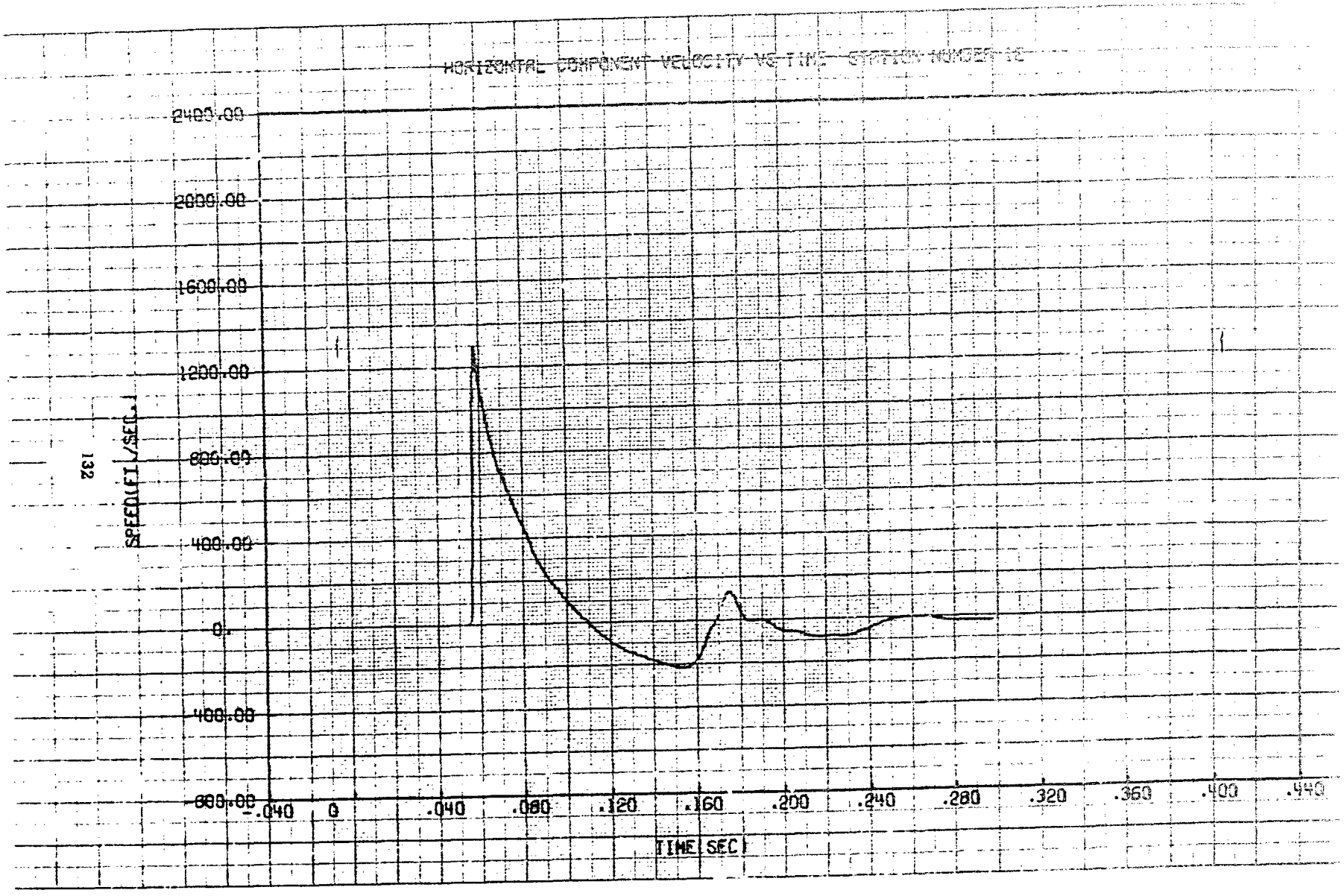

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 11
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.32
.28
.24
.20
.16
.12
.08
.04
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

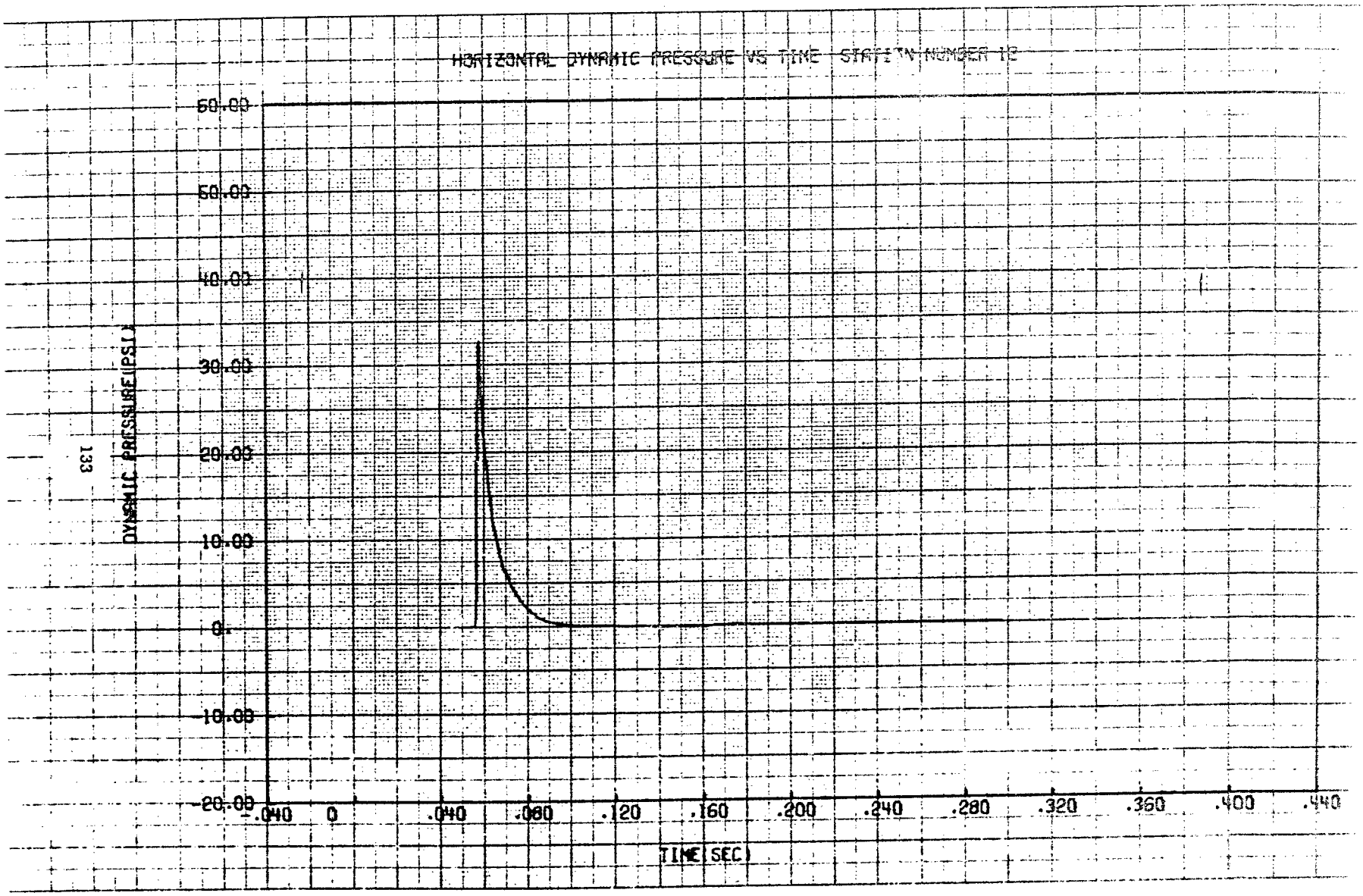

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
1.00
0.
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
DYNAMIC PRESSURE (PSI)

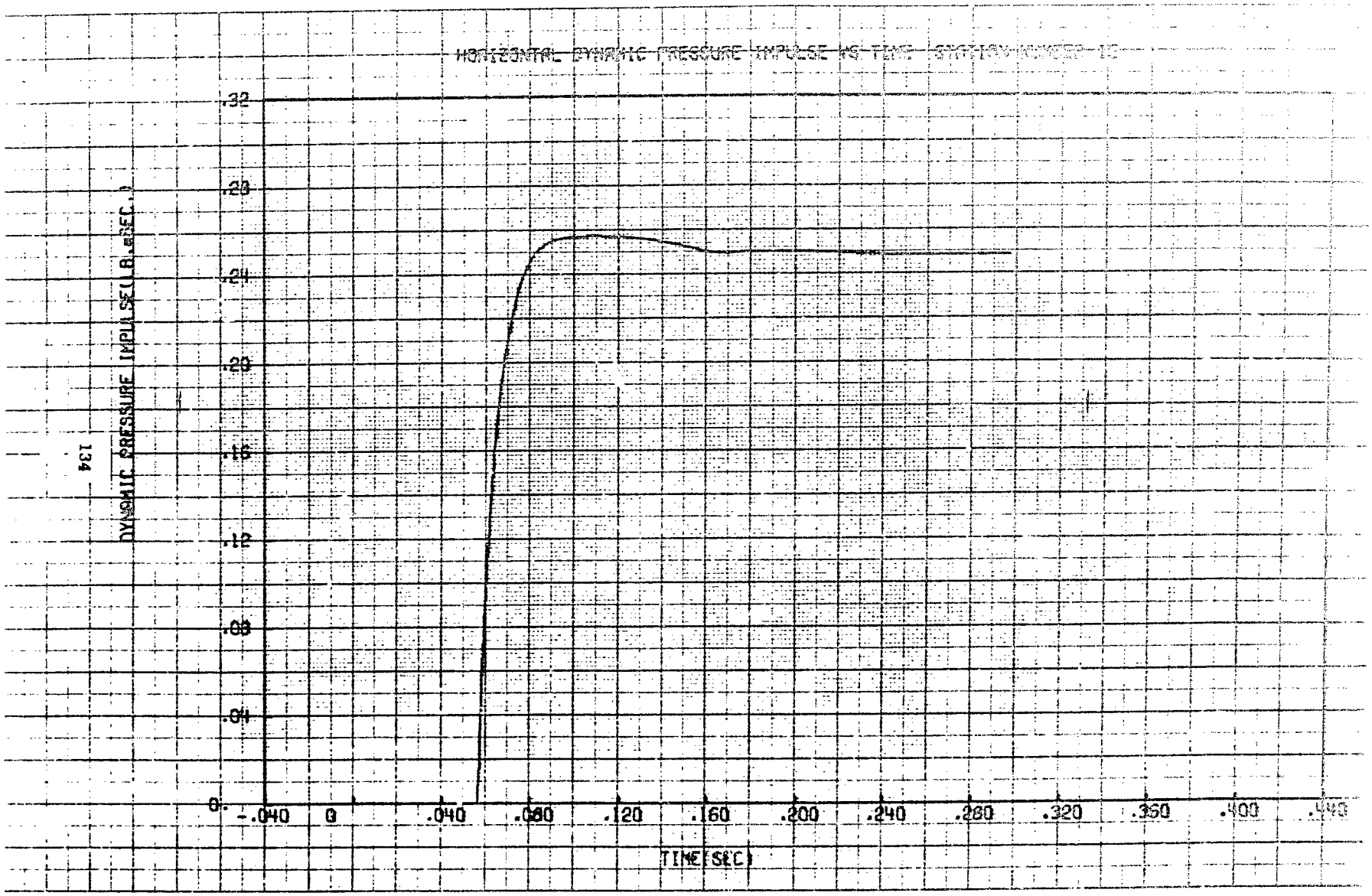

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 11
.012000
.008000
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

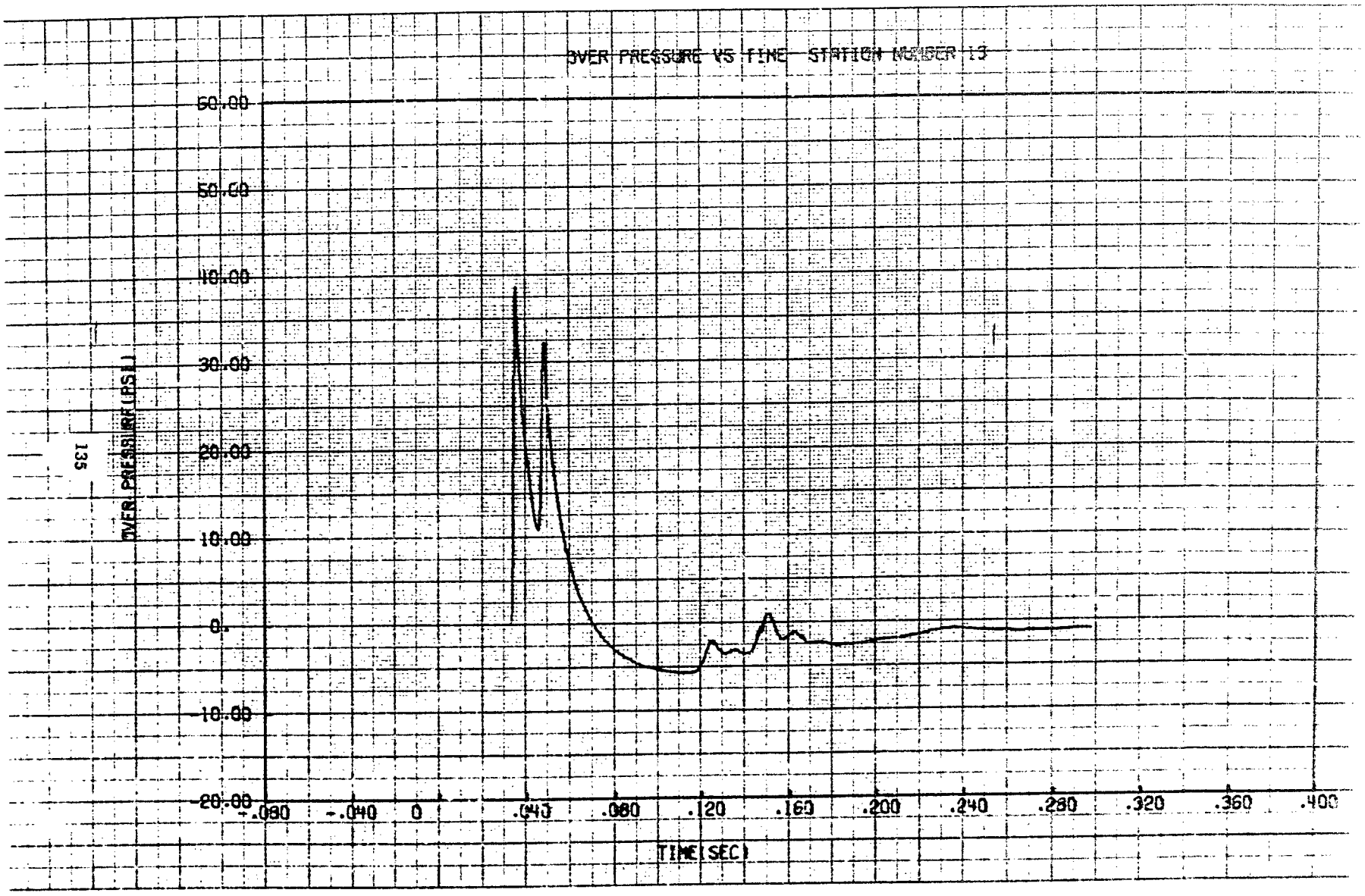

OVER PRESSURE VS TIME STATION NUMBER 16
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

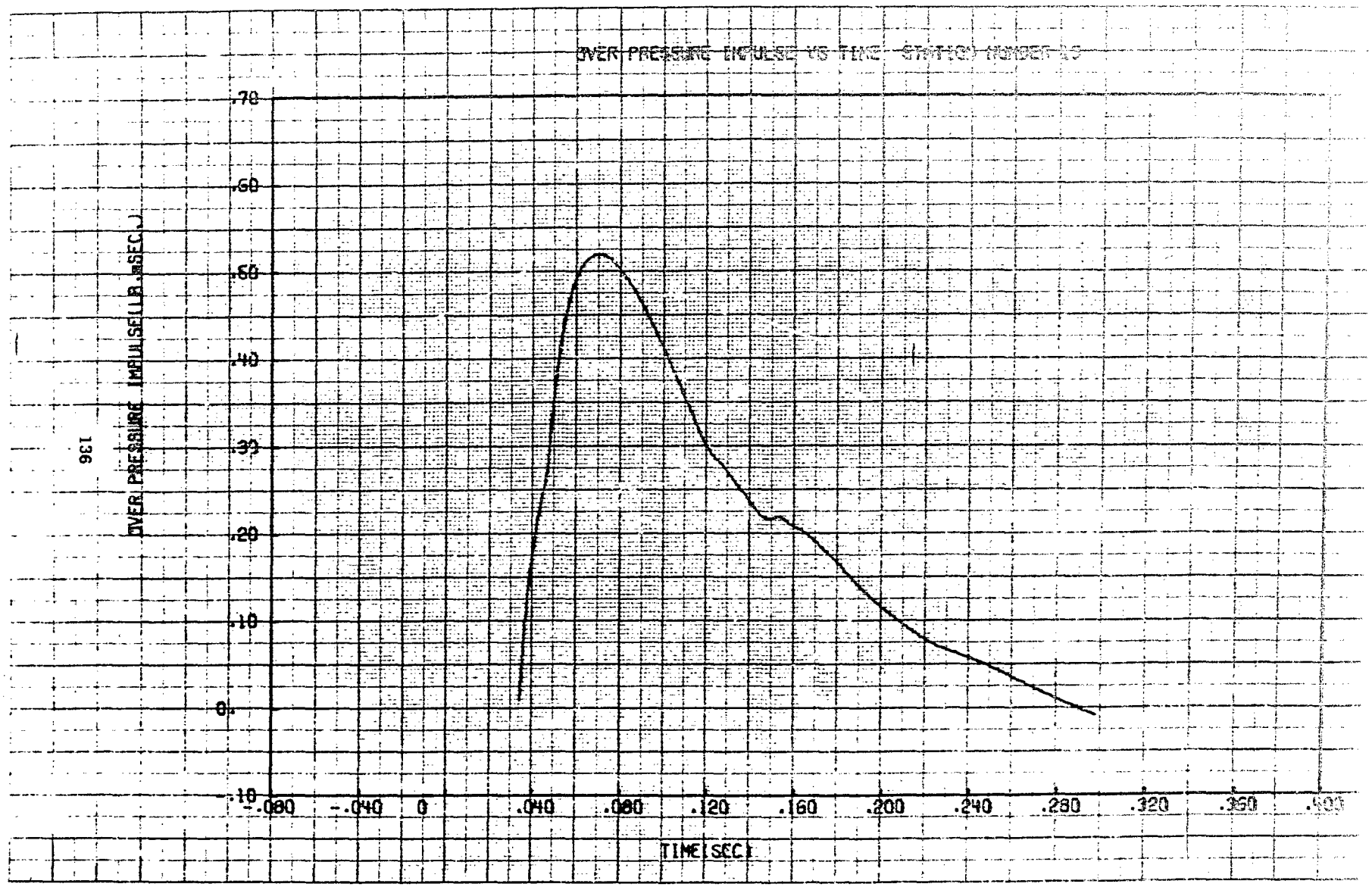

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 12
OVER PRESSURE IMPULSE(LB.mSEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

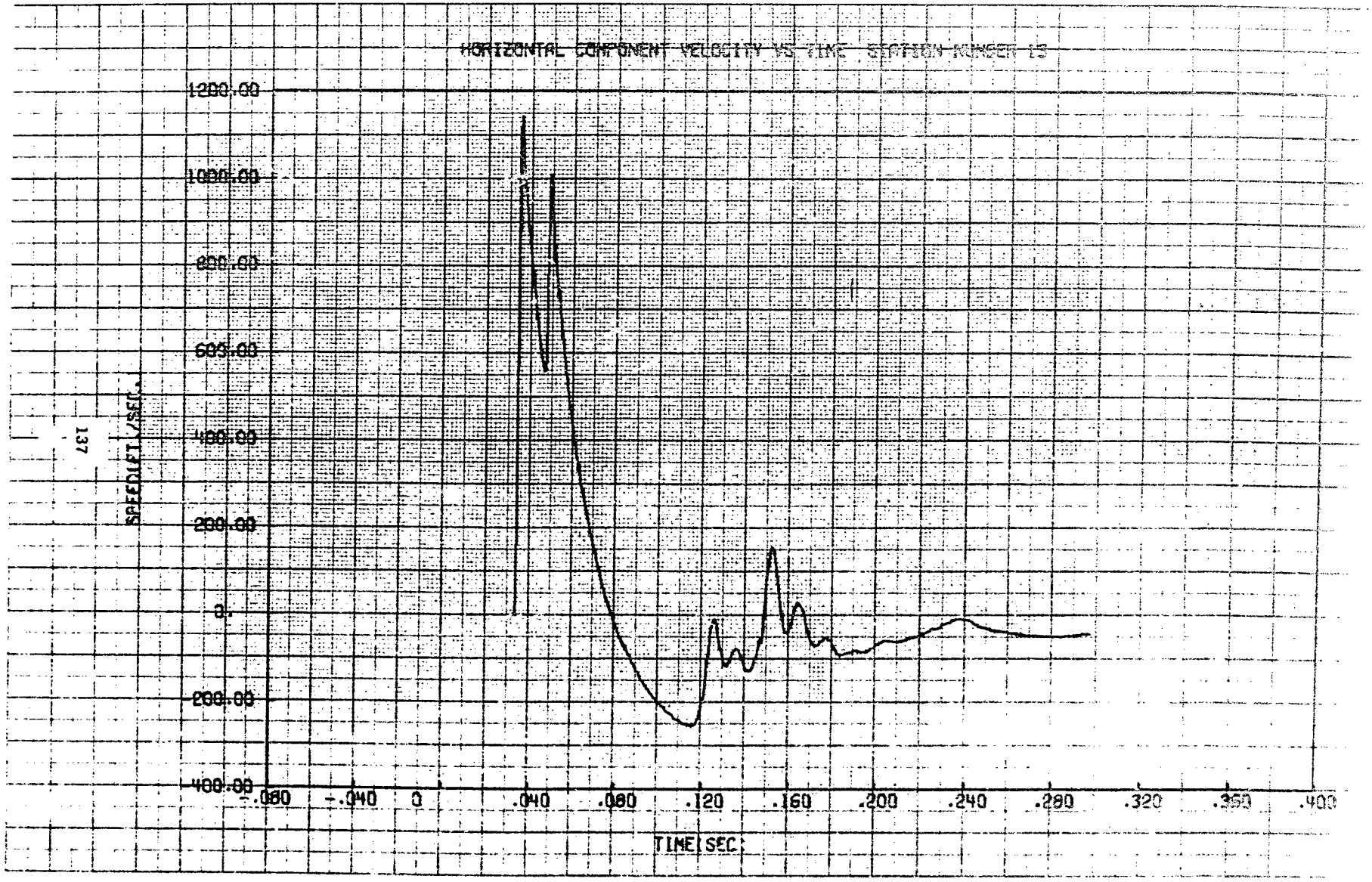

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 16
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC)


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 12
DYNAMIC PRESSURE(PSIA)
60.00
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)

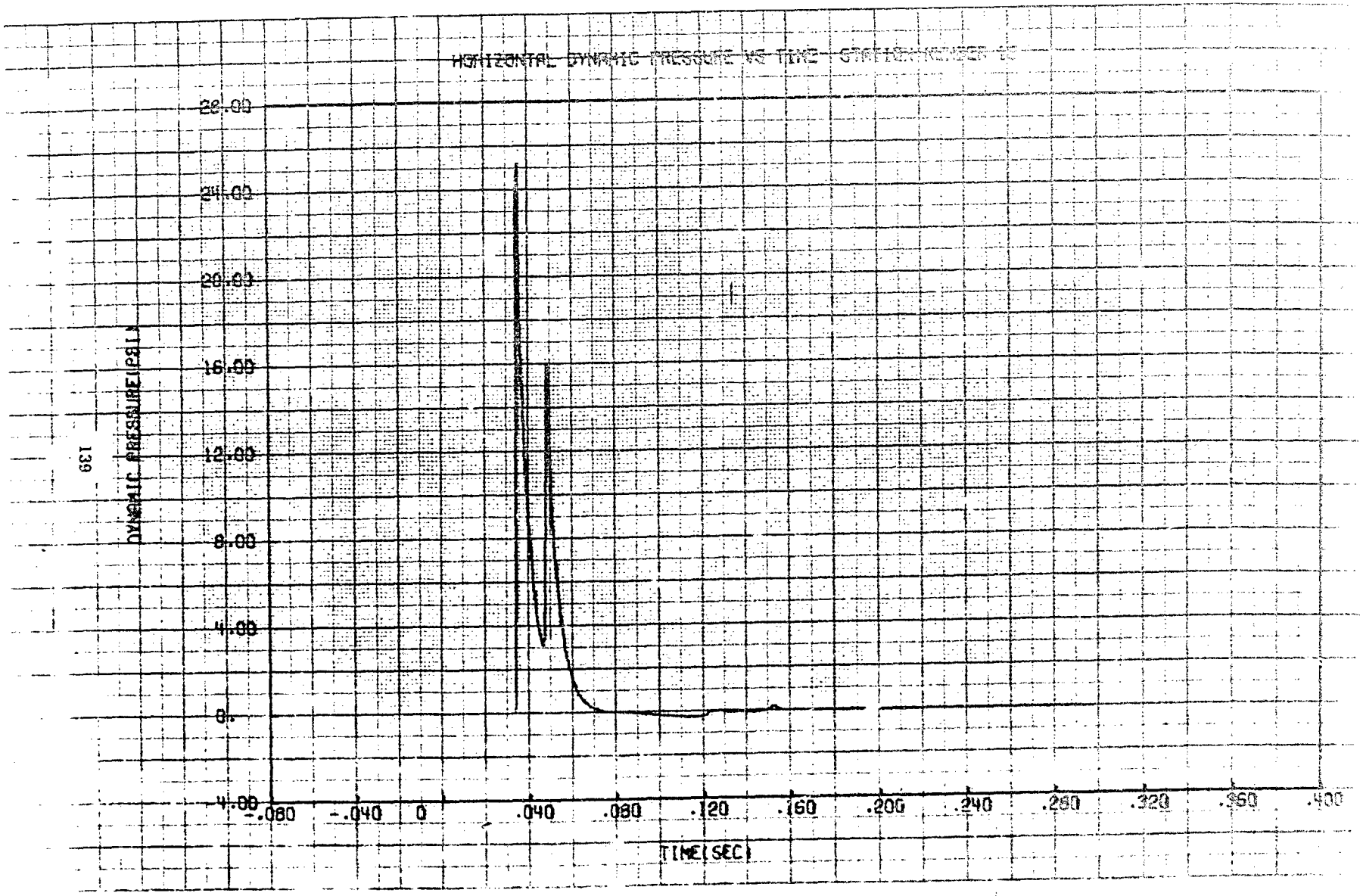

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME (STATION NUMBER 13)
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
.32
.28
.24
.20
.16
.12
.08
.04
0.
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

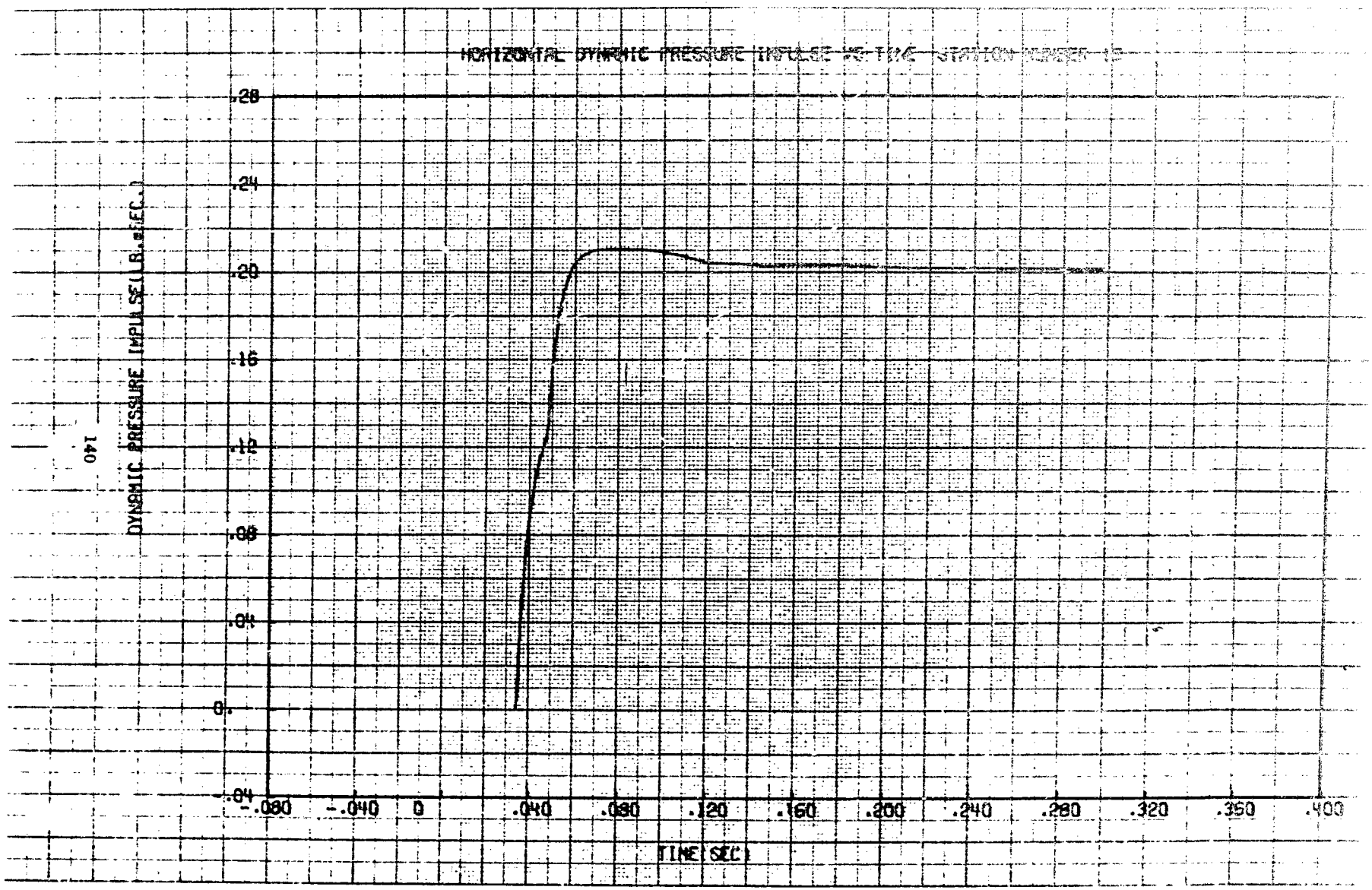

OVER PRESSURE VS TIME STATION NUMBER 13
OVER PRESSURE (PSI)
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

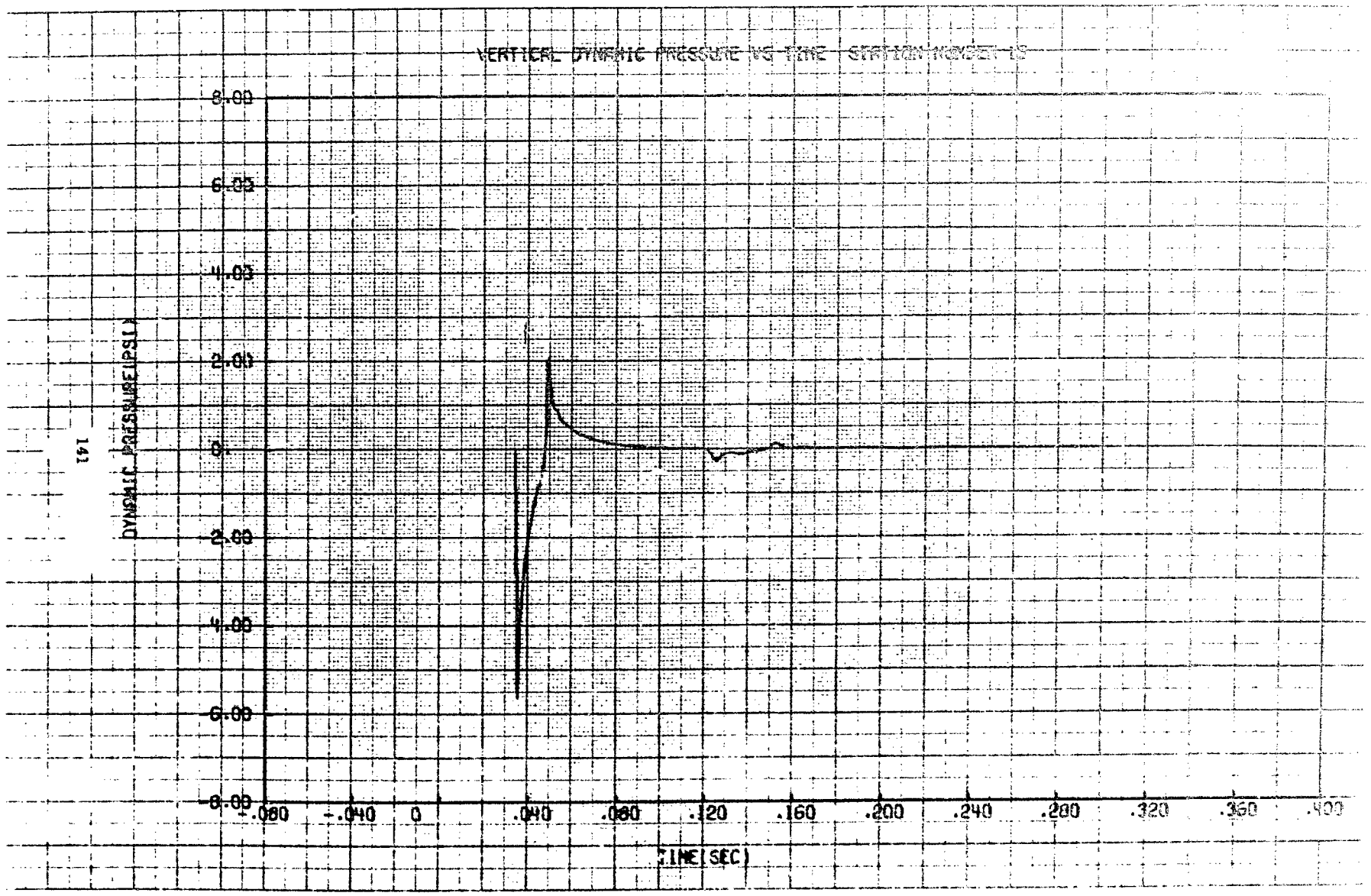

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 10
OVER PRESSURE IMPULSE(LB.mSEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

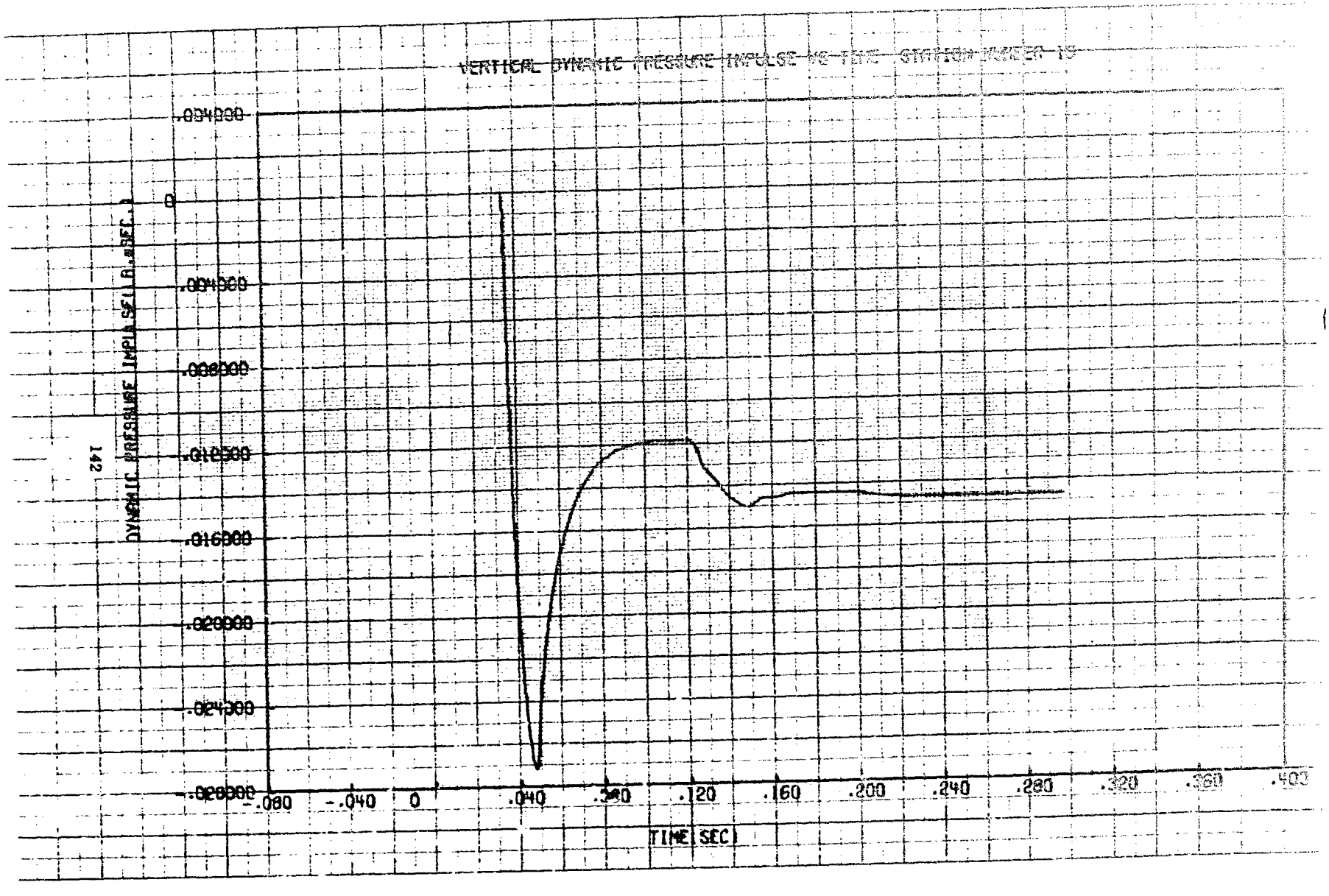

HORIZONTAL COMPONENT VELOCITY VS TIME SECTION NUMBER 13
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

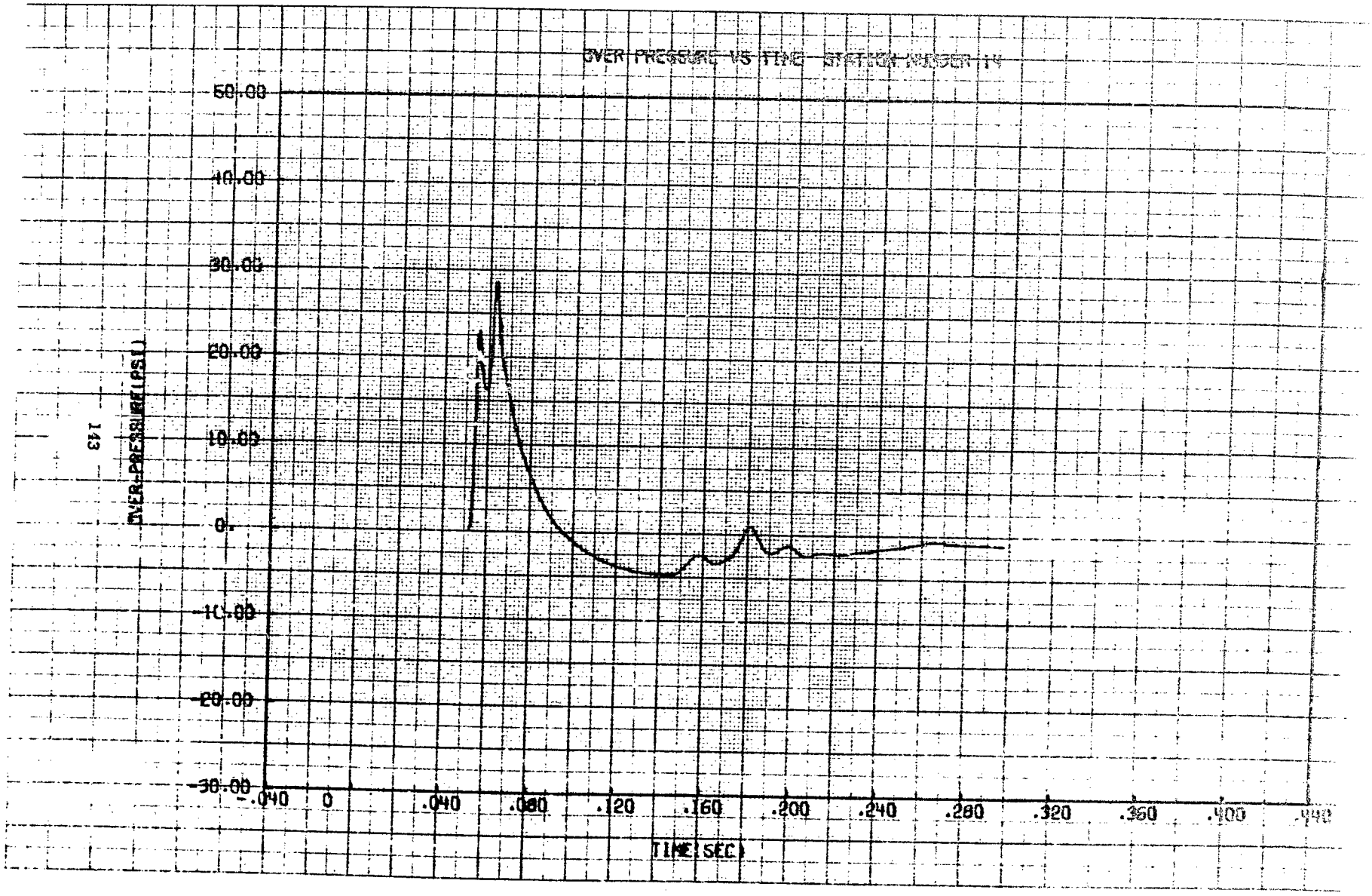
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400

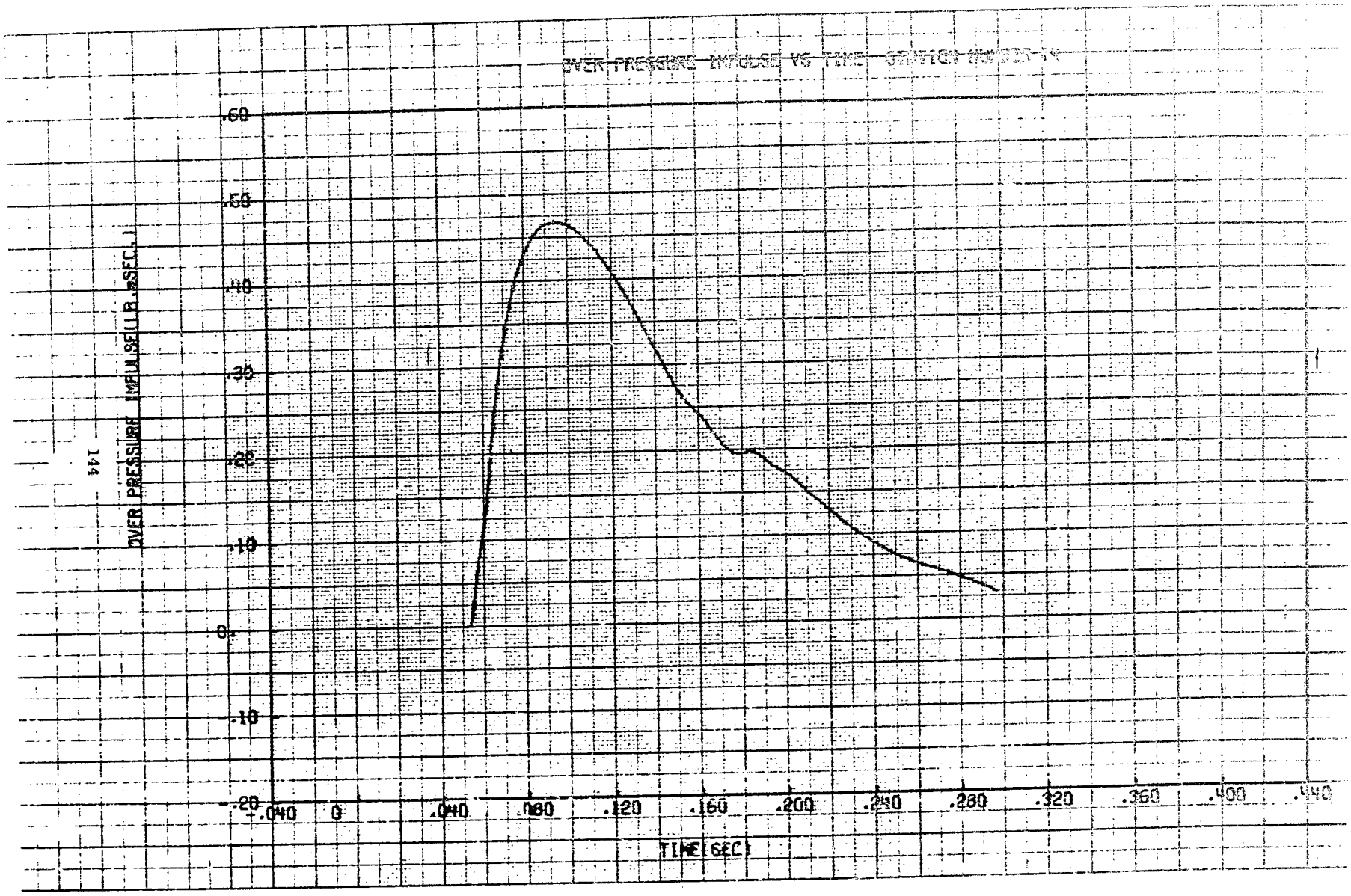

HORIZONTAL DYNAMIC PRESSURE VS TIME
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

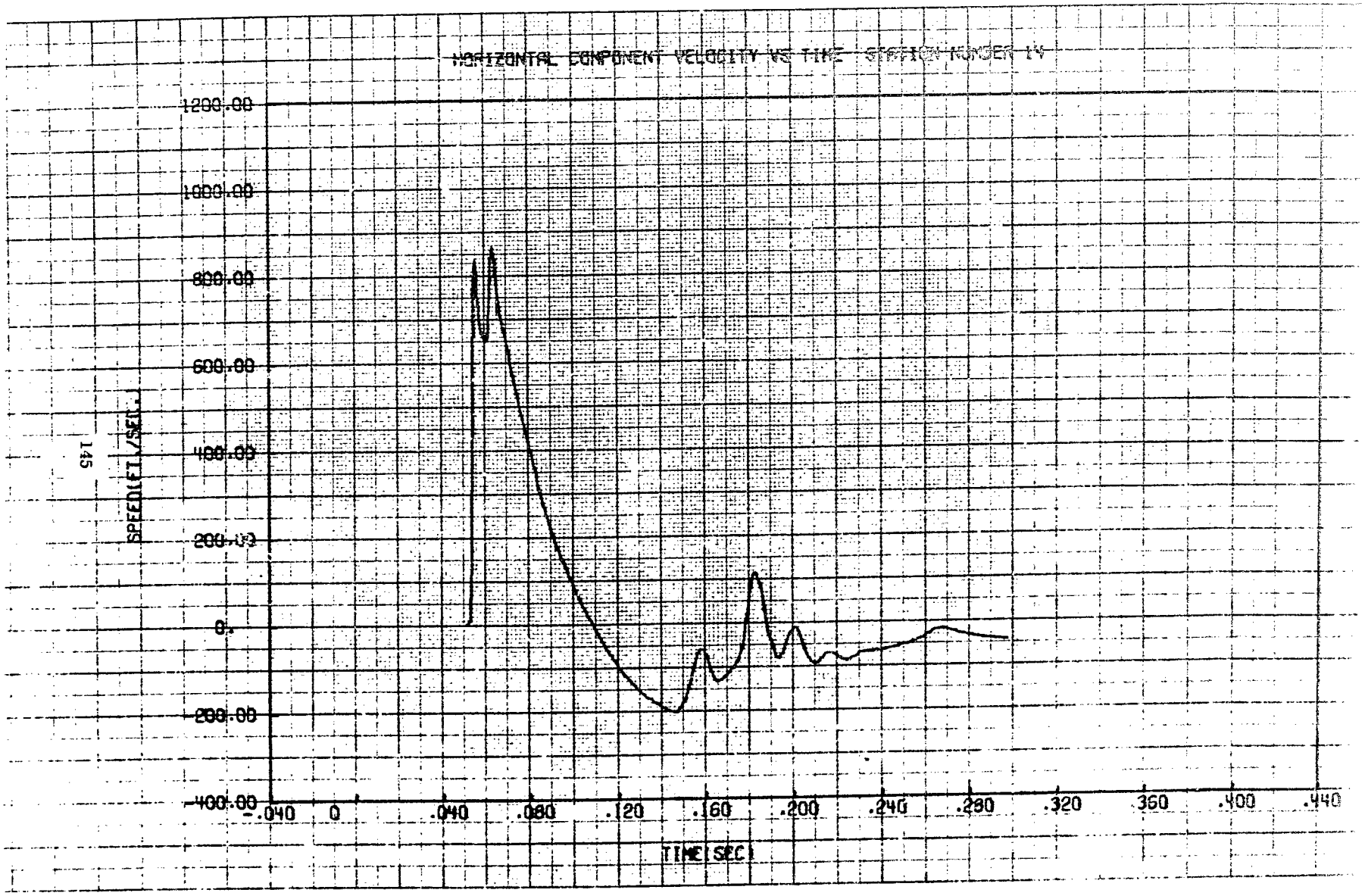

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

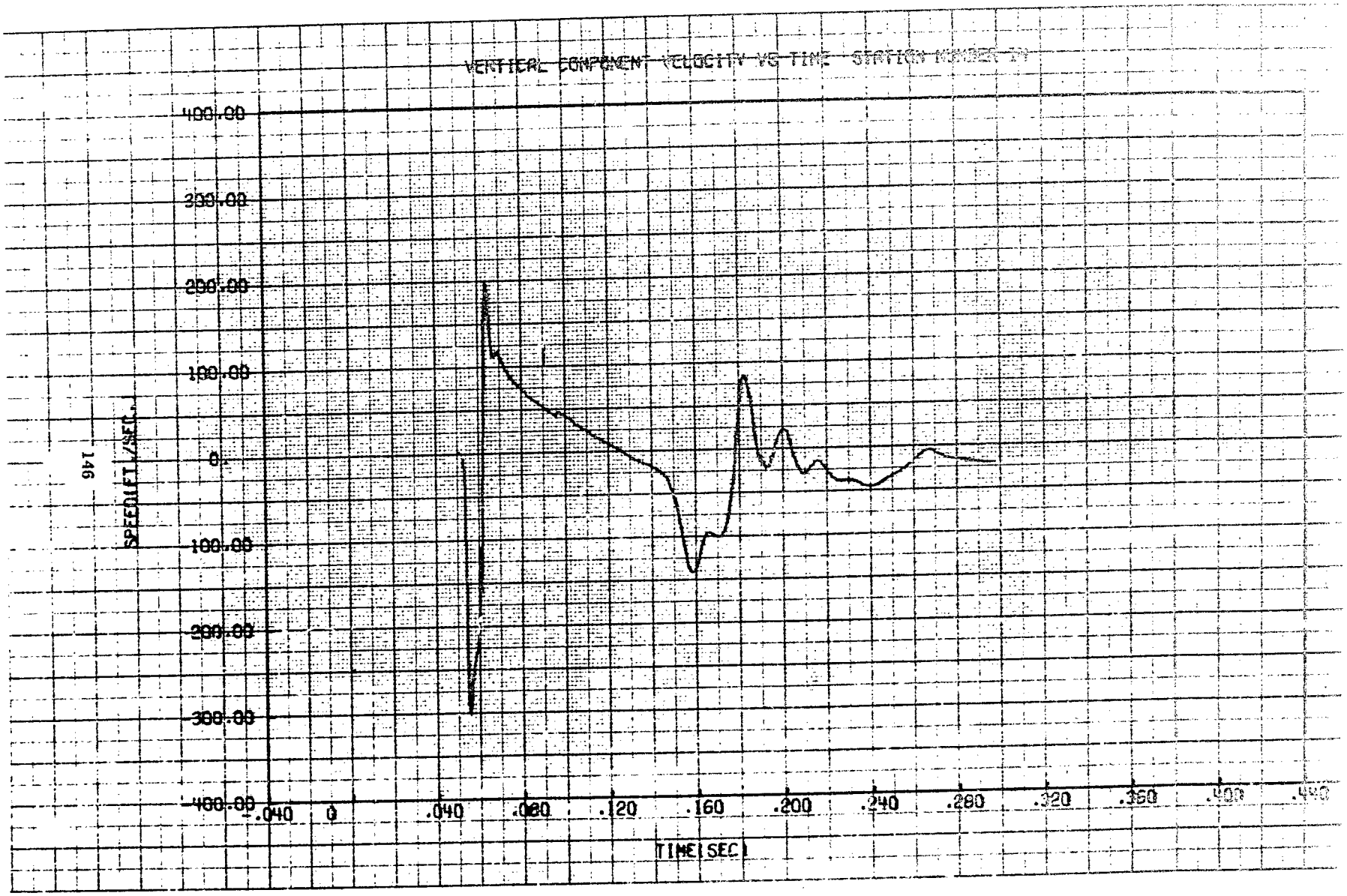

VERTICAL DYNAMIC PRESSURE VS TIME STATION NOZZLE 15
8.00
6.00
4.00
2.00
0.
-2.00
-4.00
-6.00
-8.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

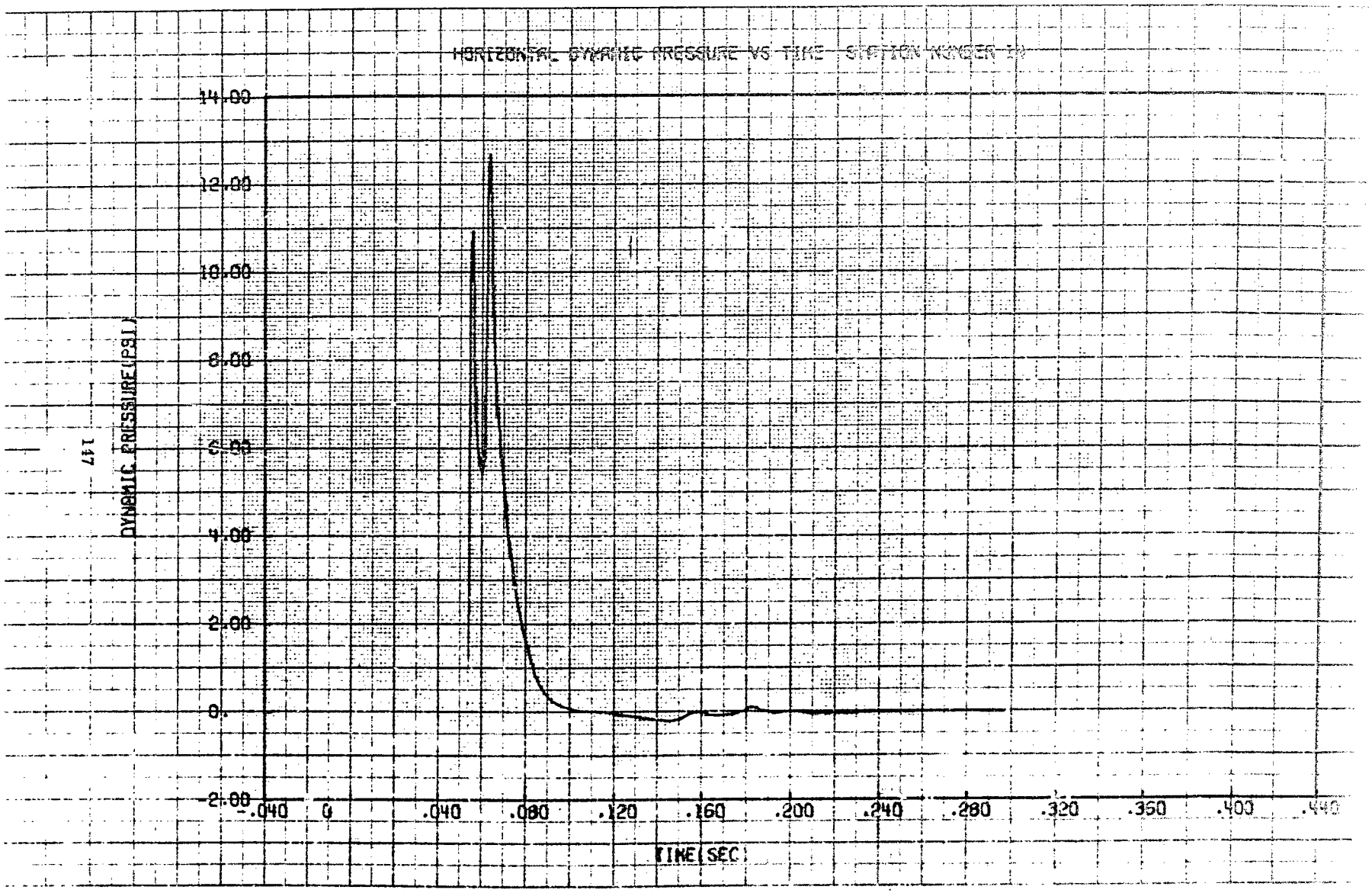

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 19
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.028000
DYNAMIC PRESSURE IMPULSE(LB.-SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

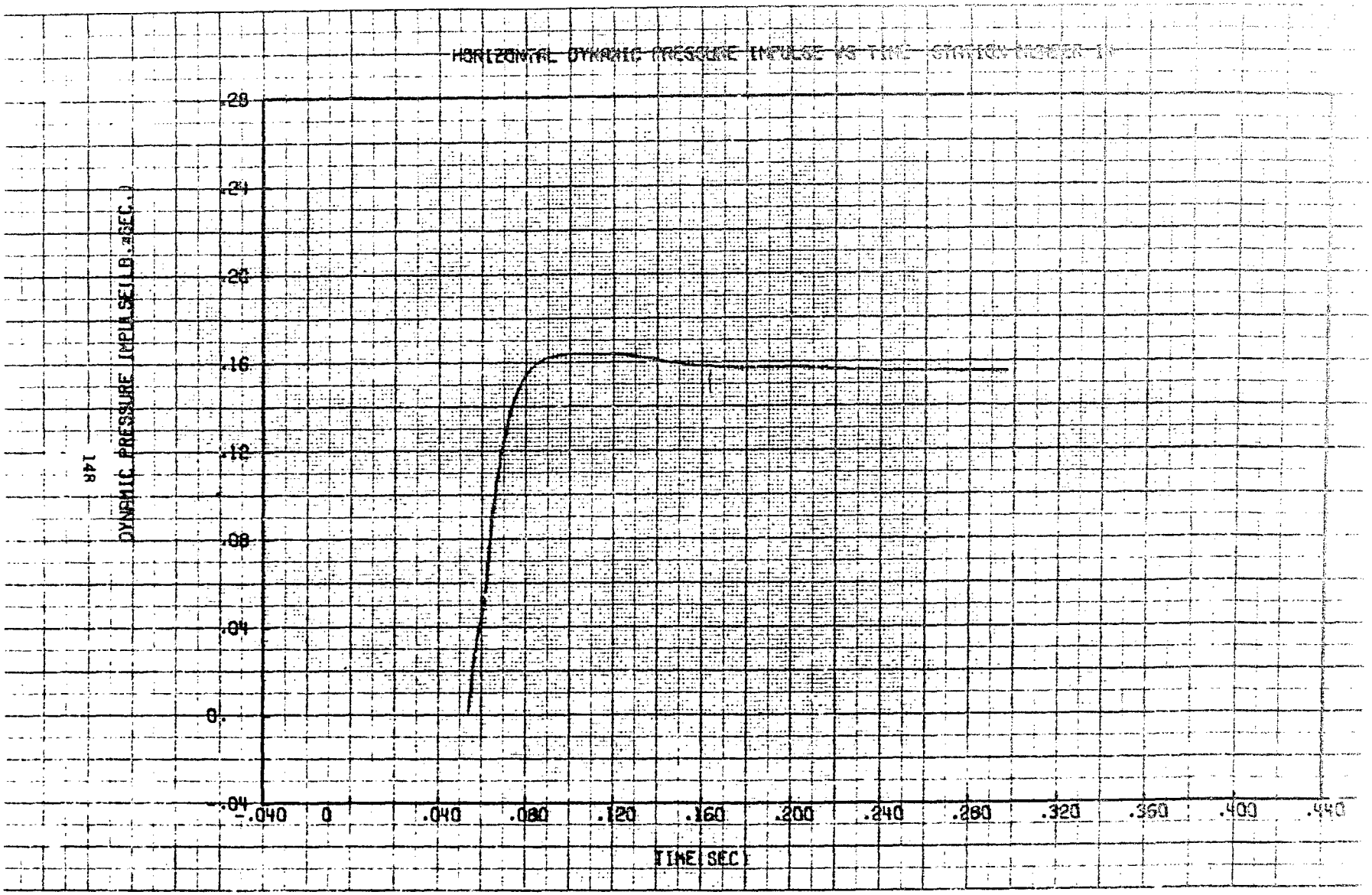

OVER PRESSURE VS TIME STATION NUMBER 14
OVER-PRESSURE(PSI)
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

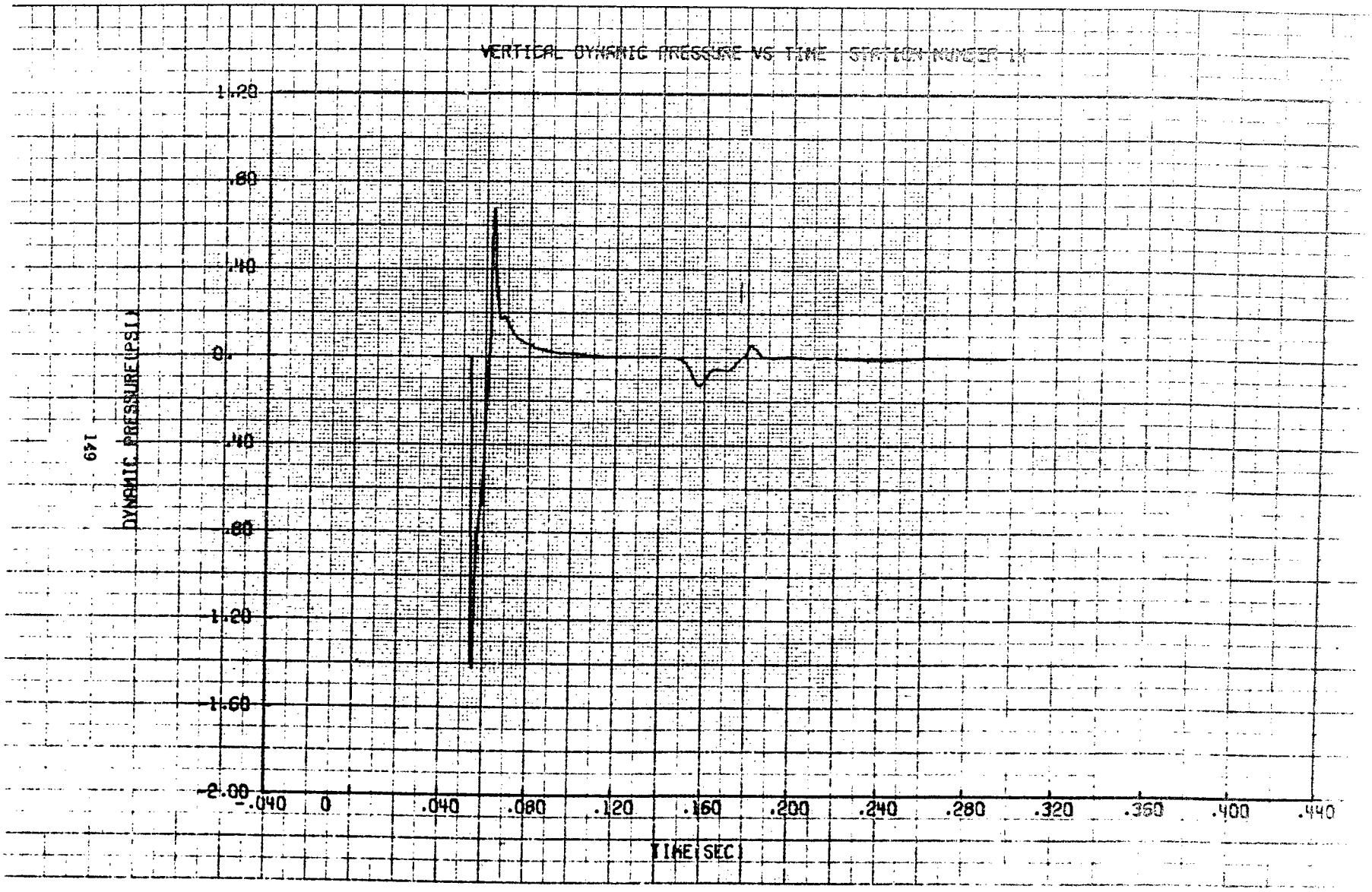

OVER PRESSURE IMPULSE VS TIME
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

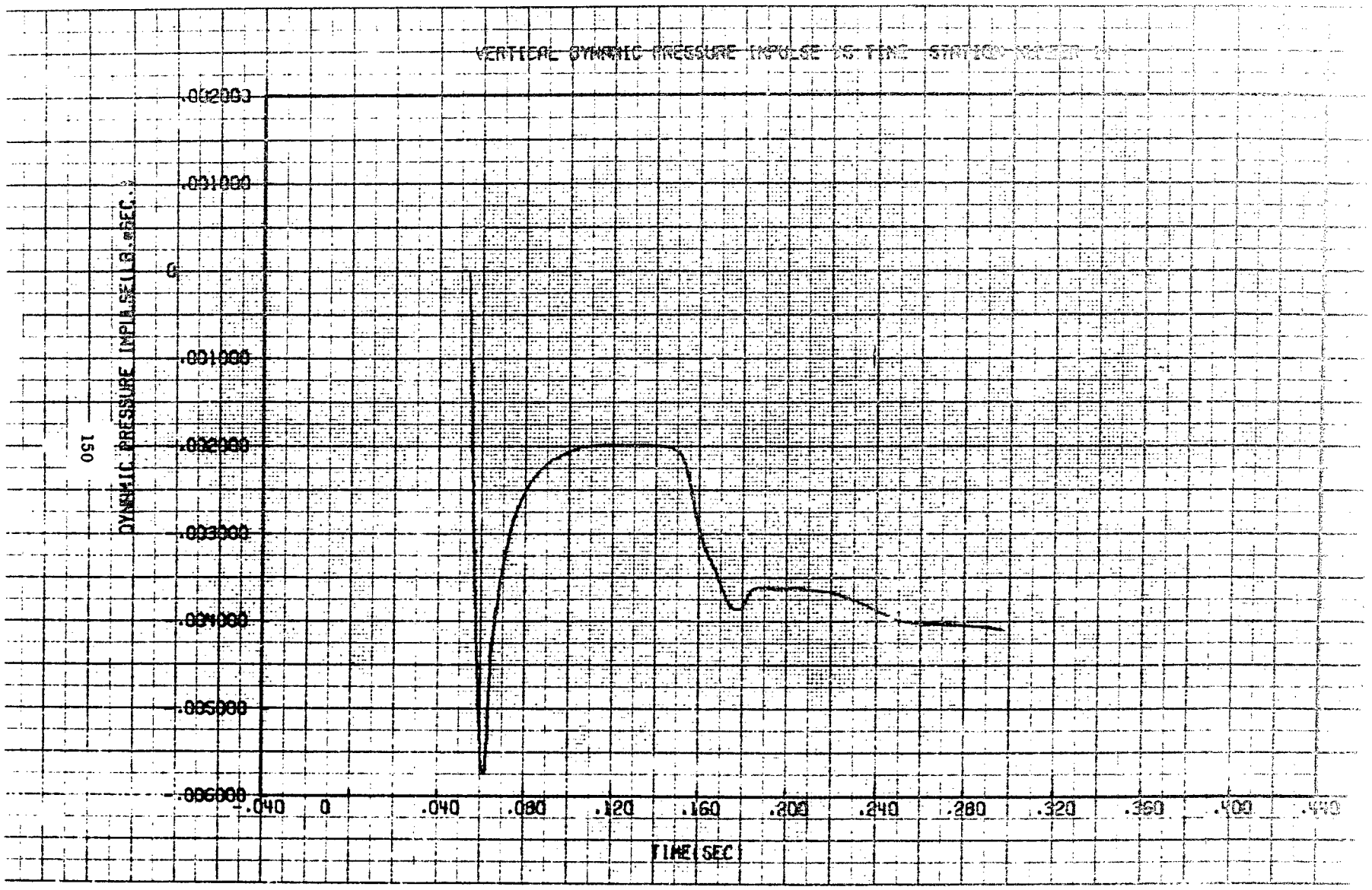

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 14
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

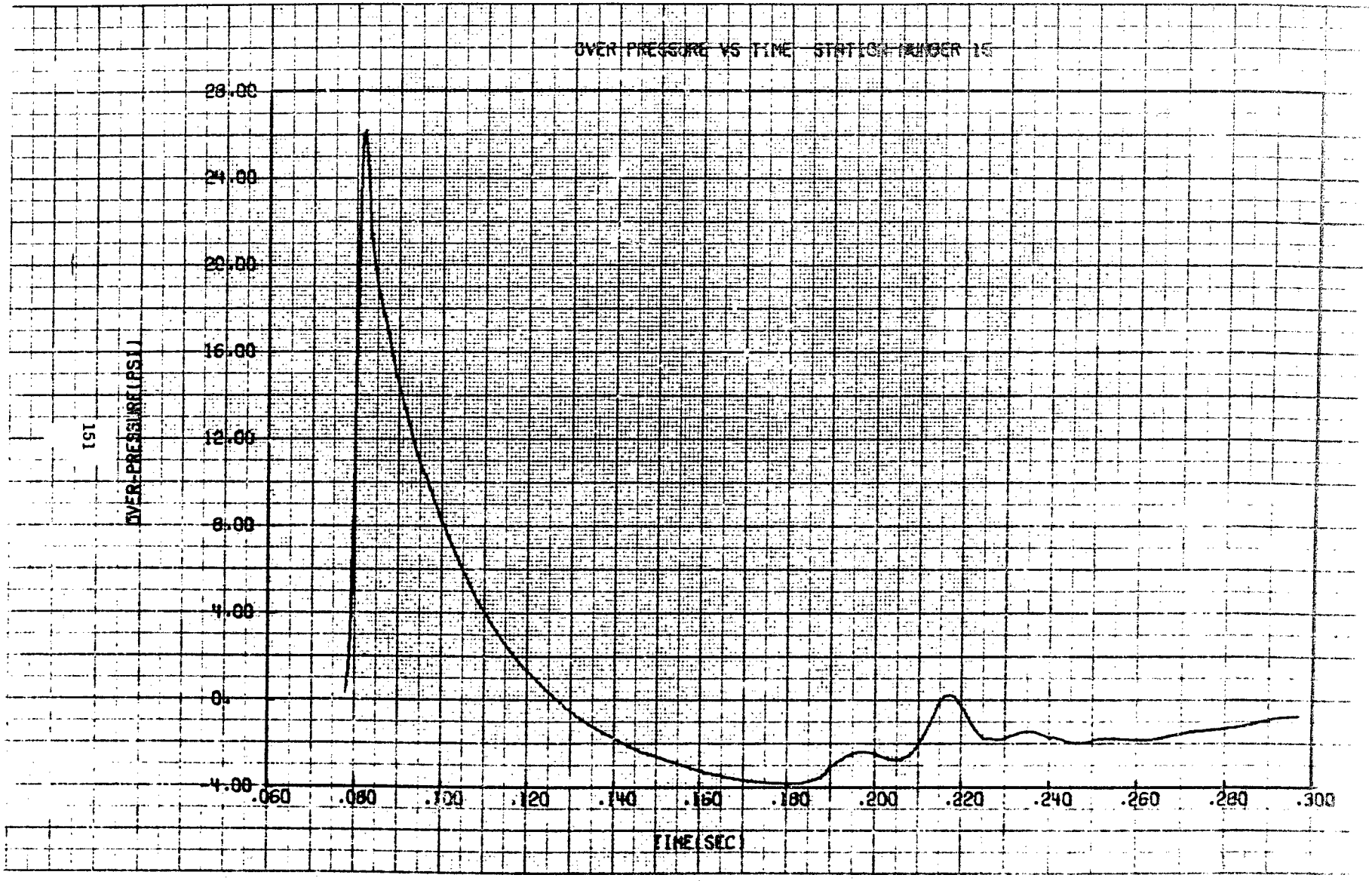

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

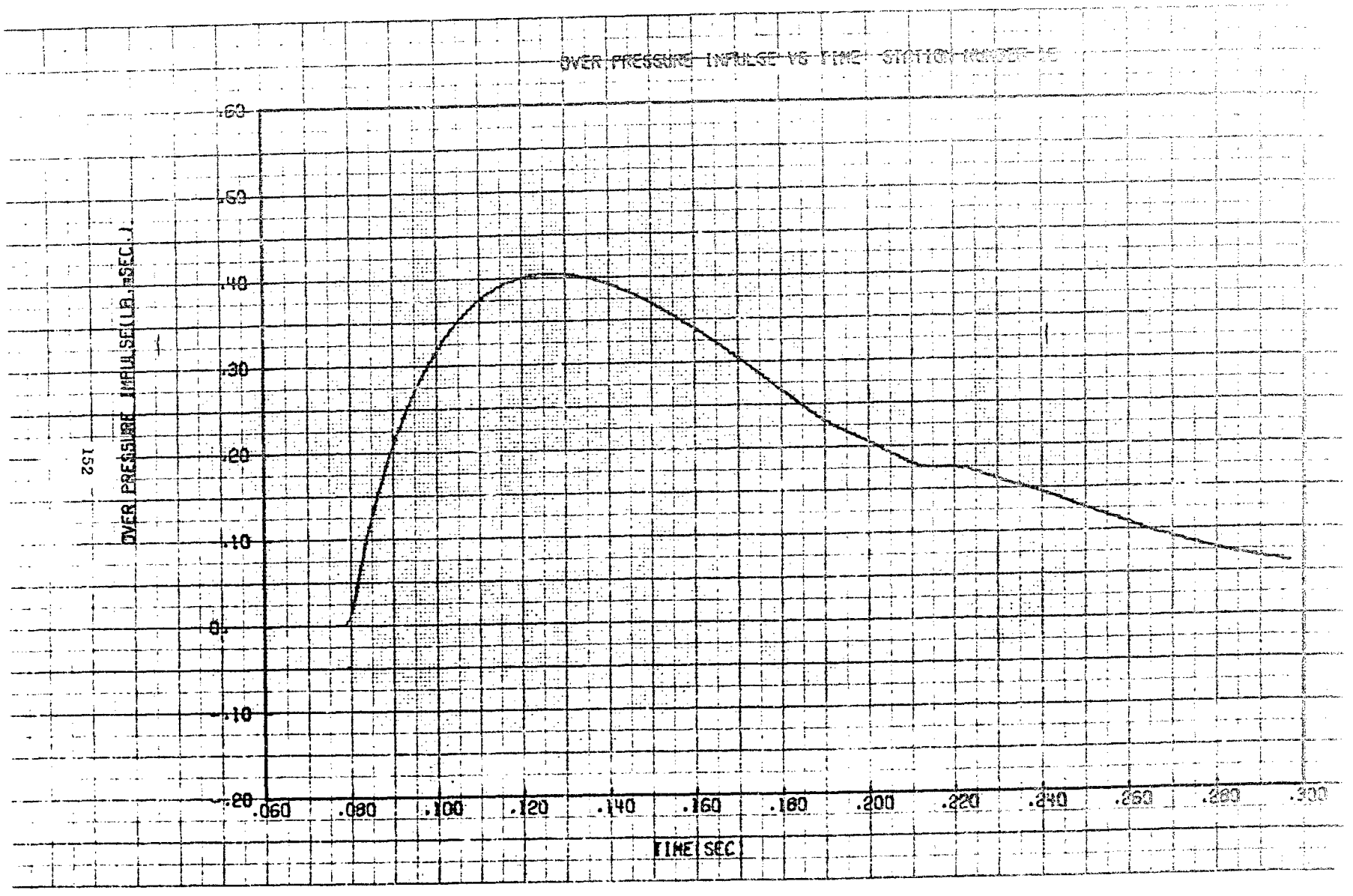

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

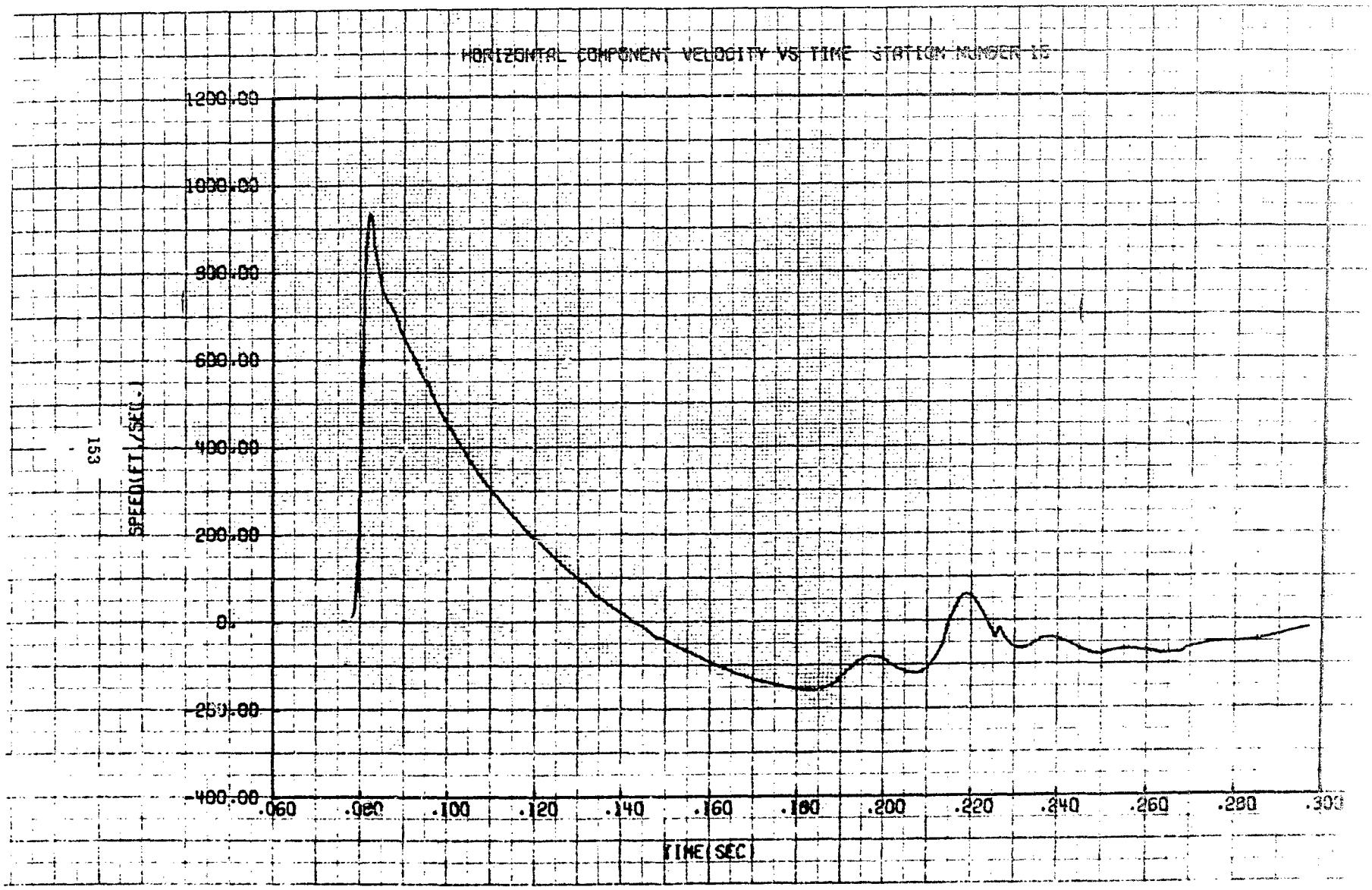

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE (LB.SEC.)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

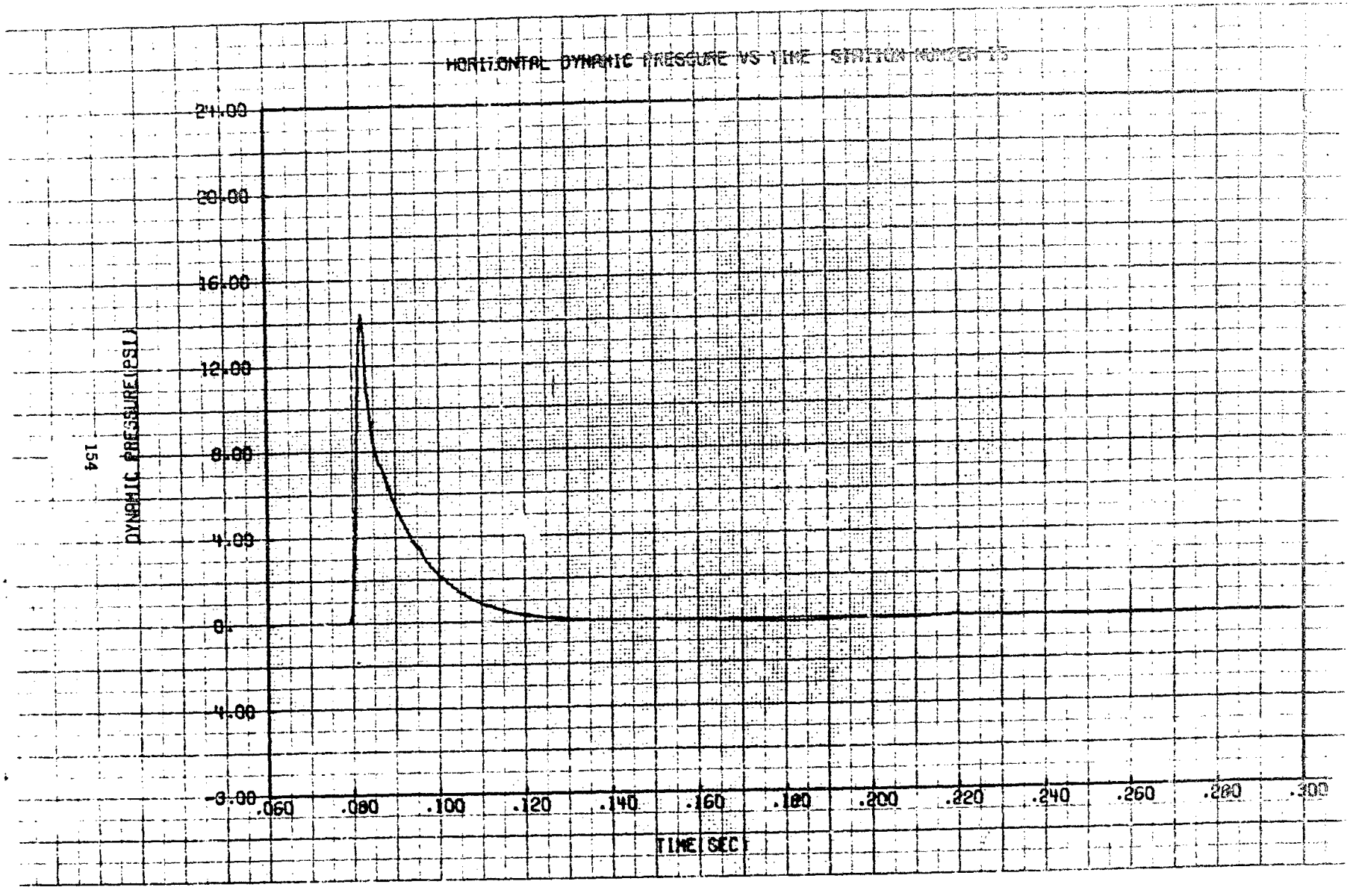

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 14
1.20
.80
.40
0.
-.40
-.80
-1.20
-1.60
-2.00
DYNAMIC PRESSURE(PSIA)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

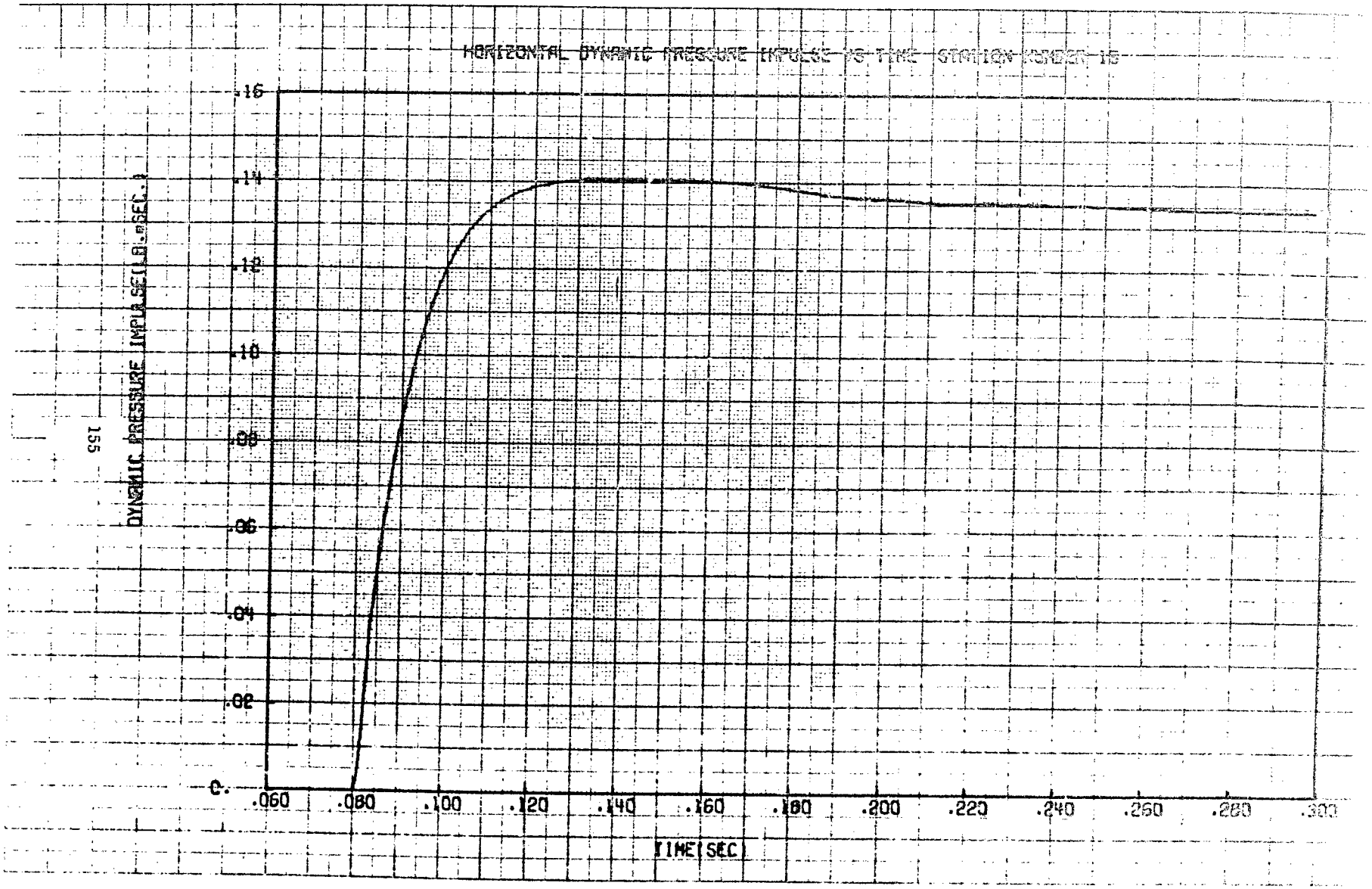

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
.002000
.001000
0
-.001000
-.002000
-.003000
-.004000
-.005000
-.006000
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

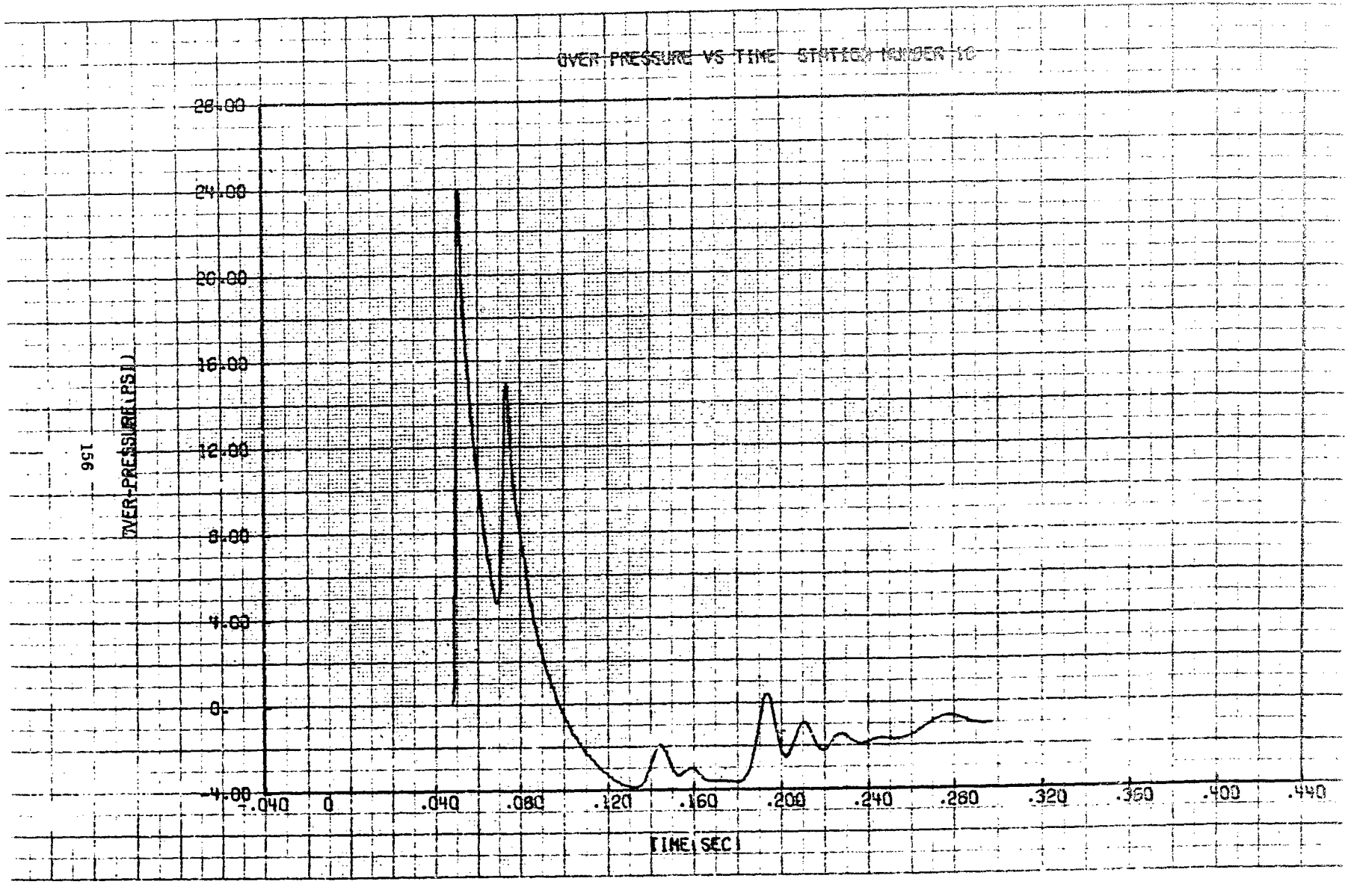

OVER PRESSURE VS TIME STATION NUMBER 15
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
OVER-PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

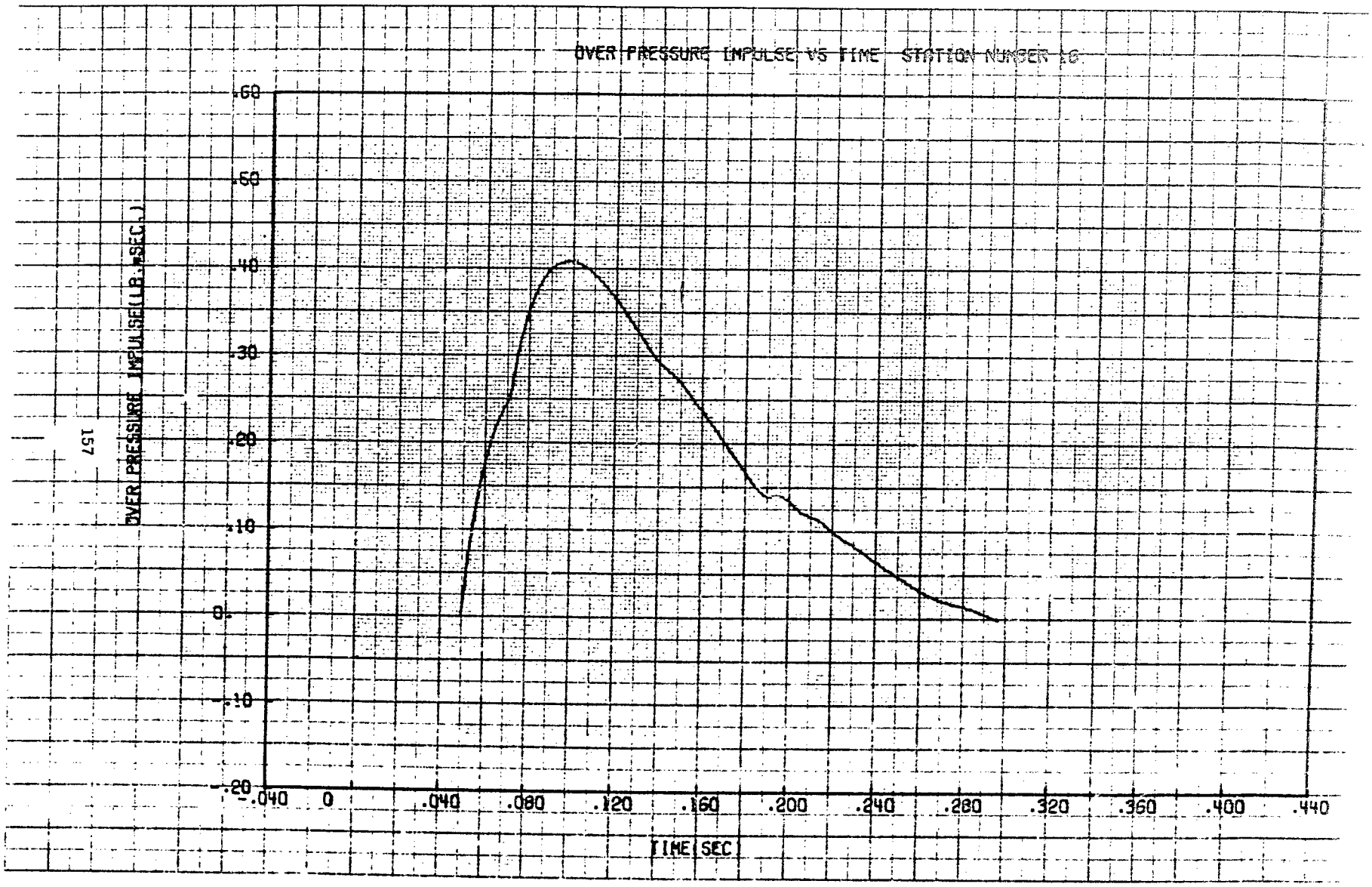

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 15
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

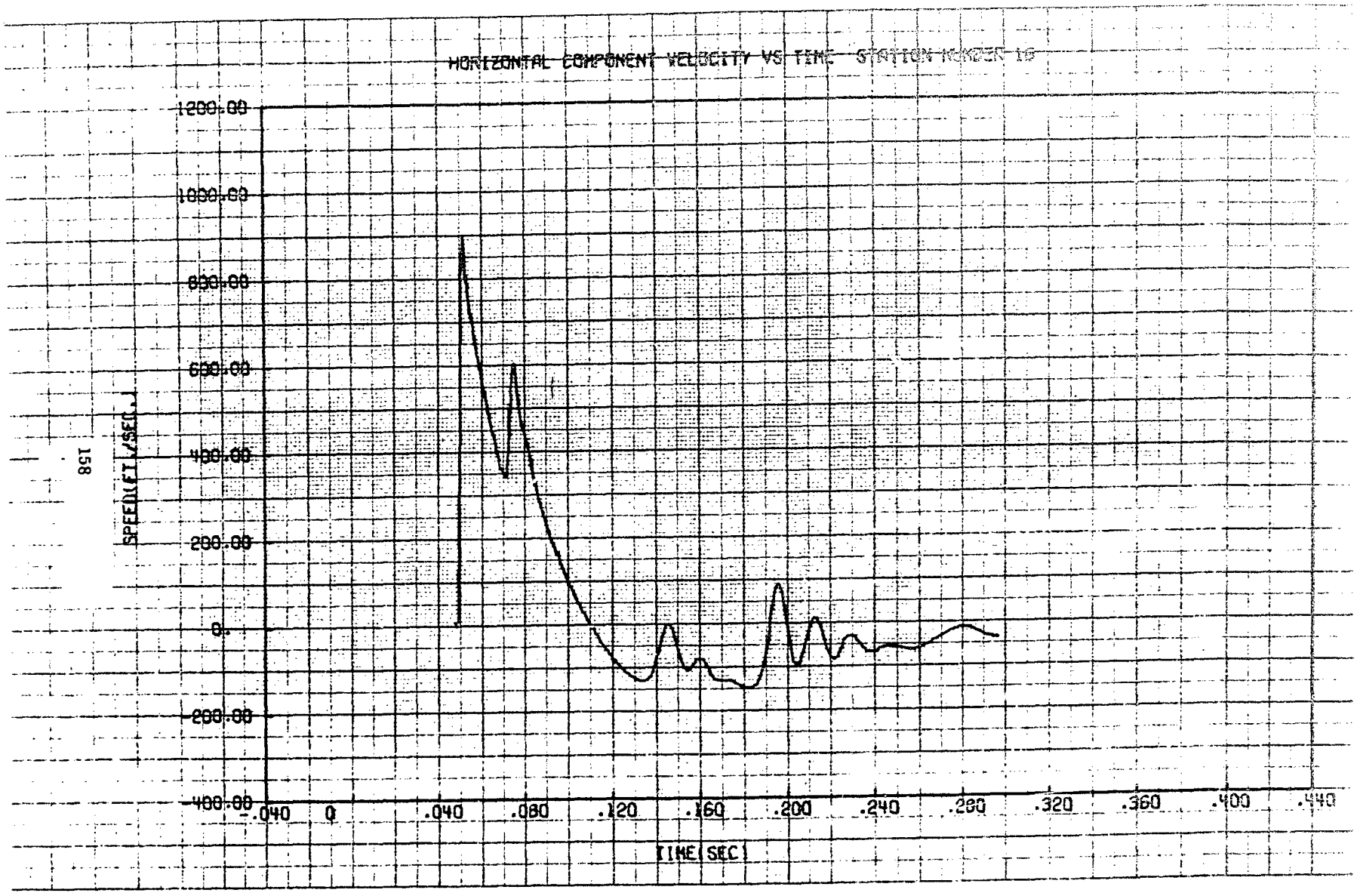

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 15
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

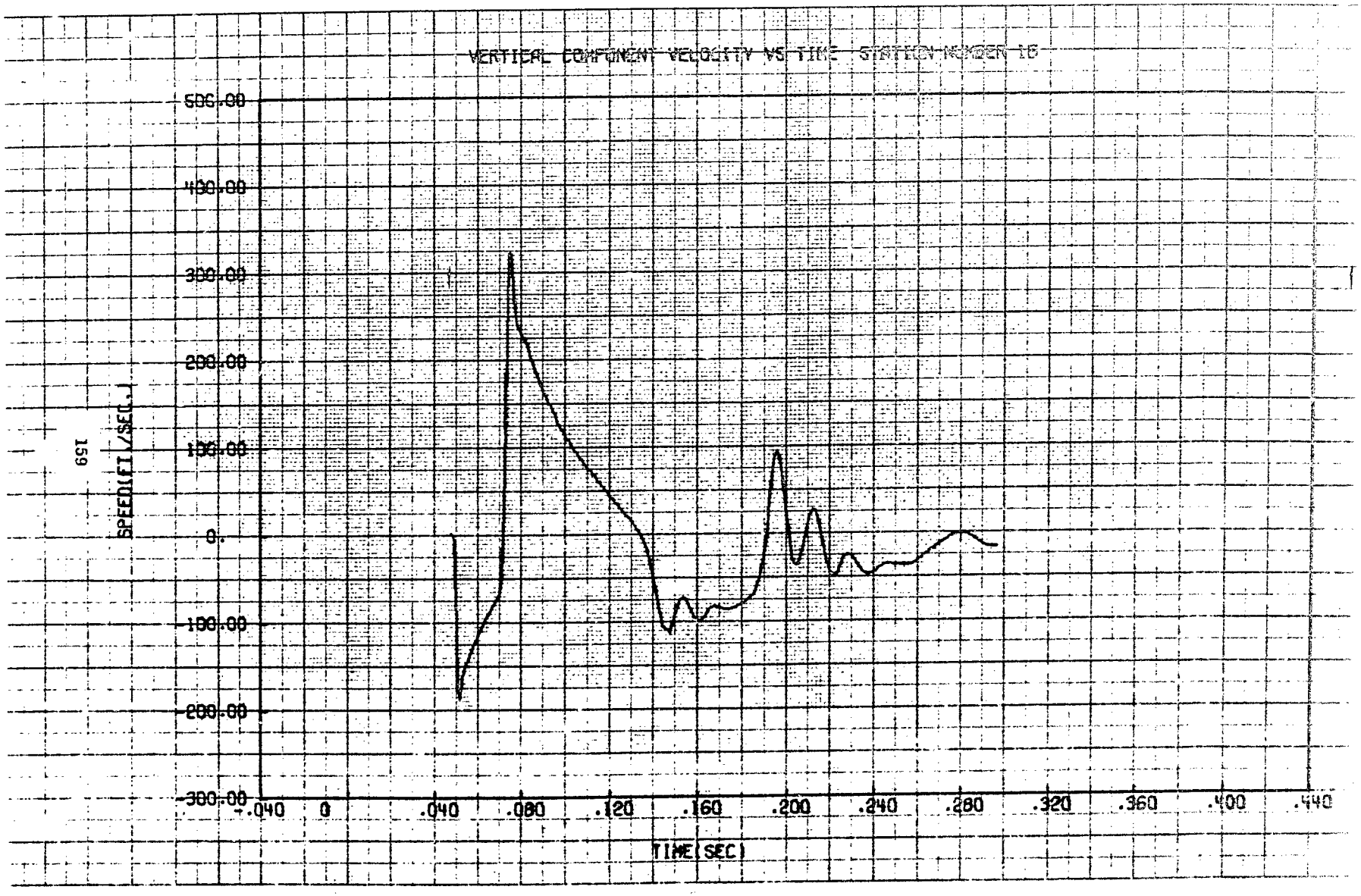

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 15
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
DYNAMIC PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

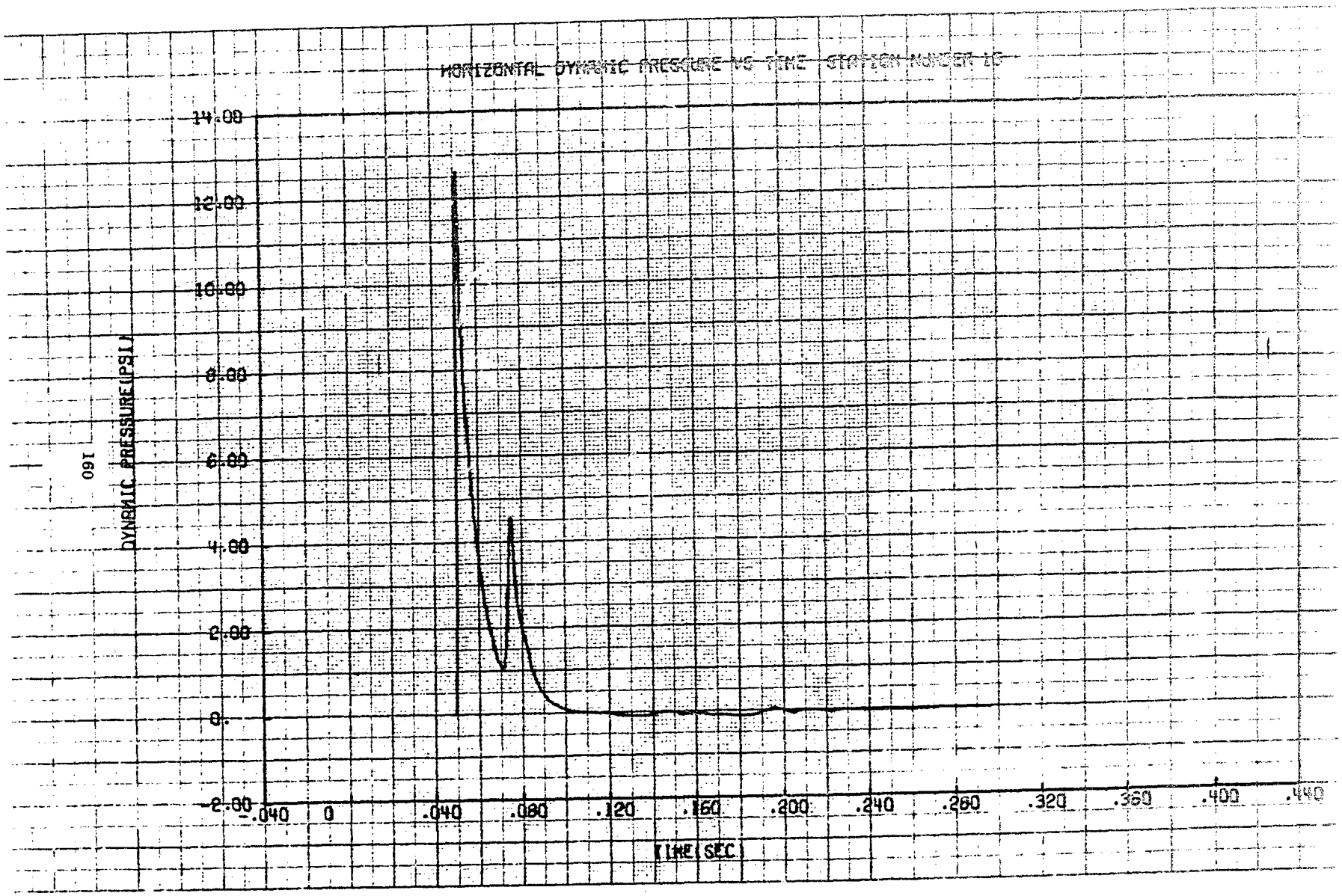

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE(LB.mSEC.)
.16
.14
.12
.10
.08
.06
.04
.02
0.
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

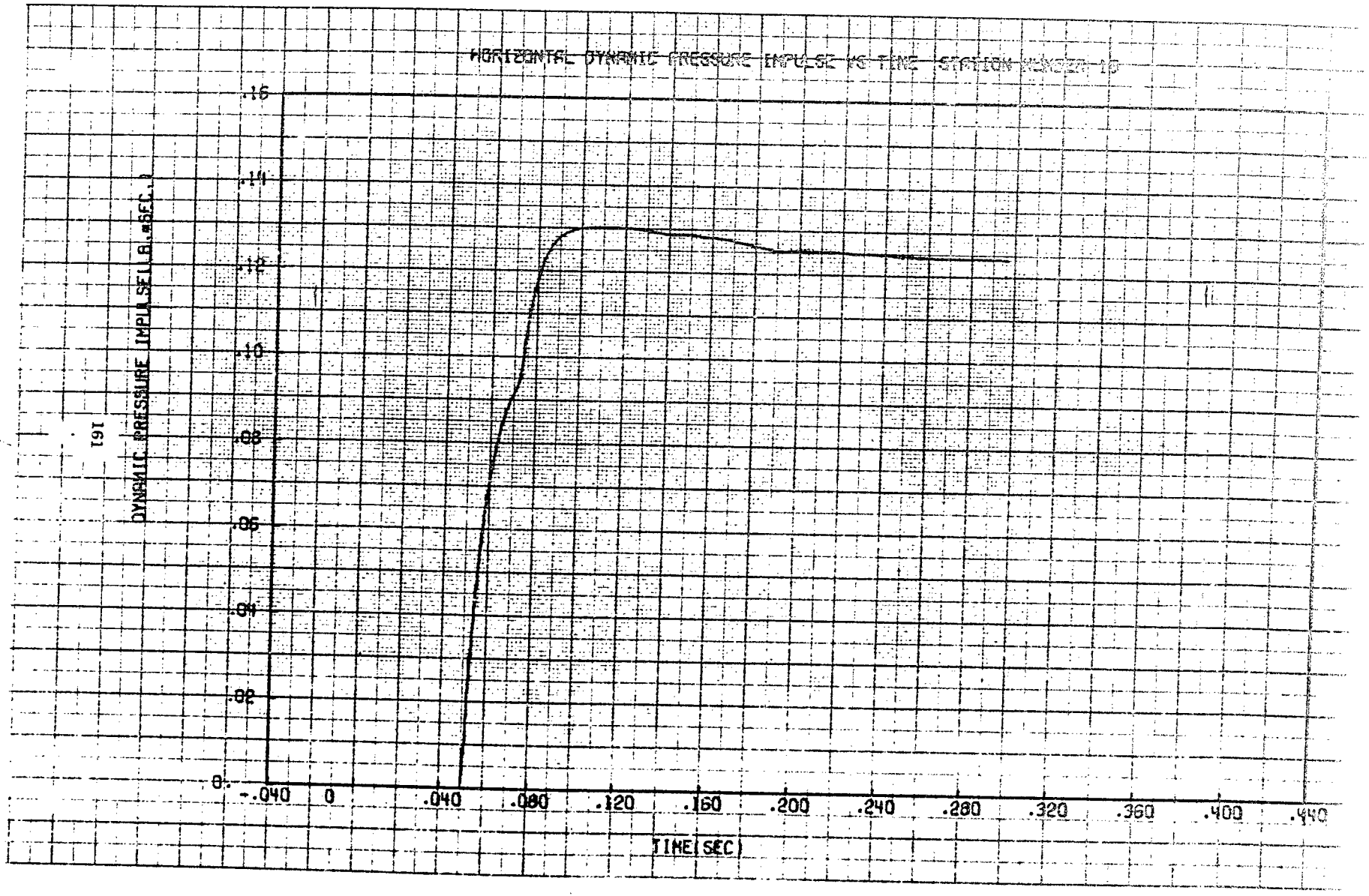

OVER PRESSURE VS TIME STATION NUMBER 10
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
OVER-PRESSURE (PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

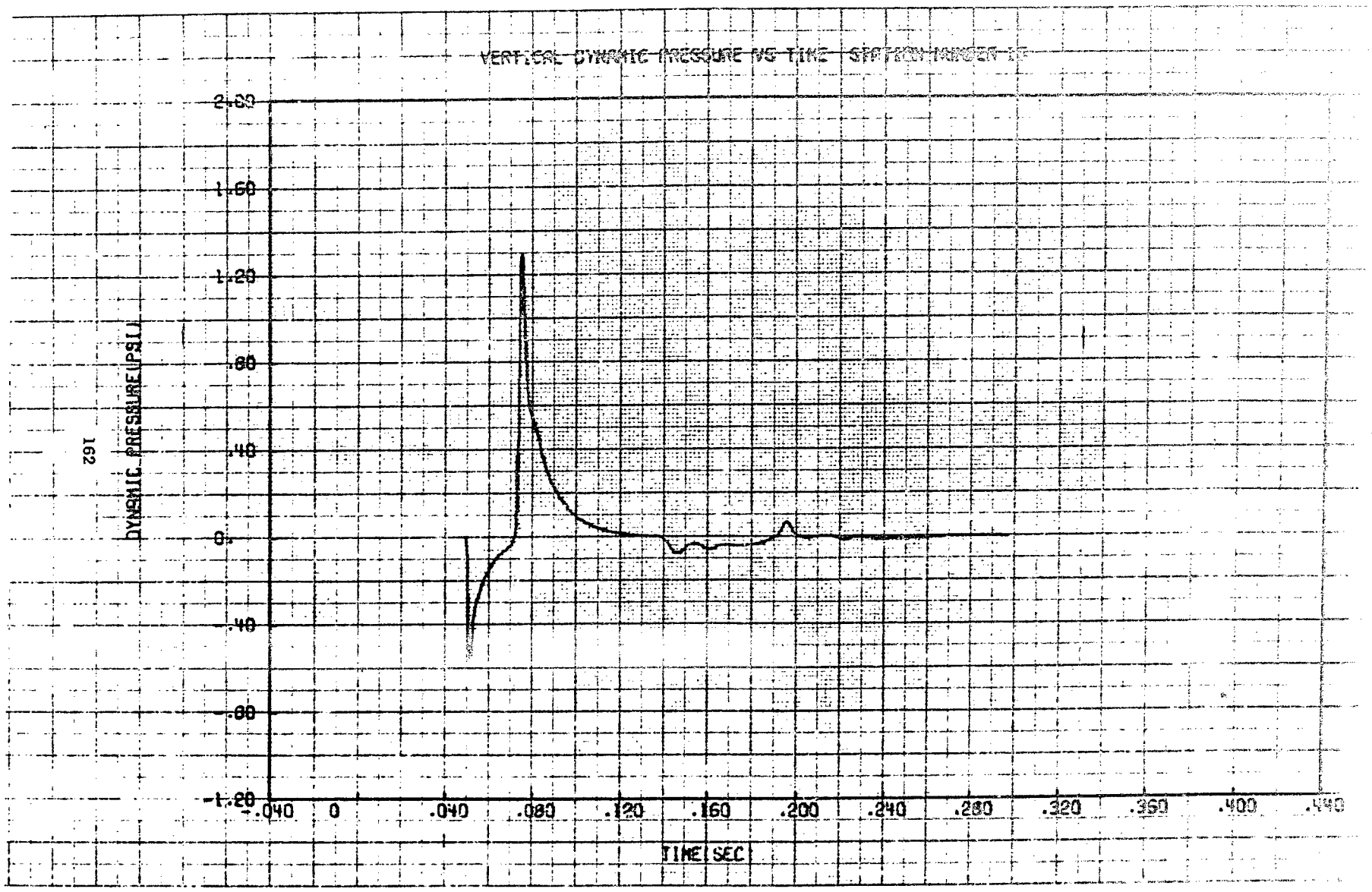

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 16
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0
-.10
-.20
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

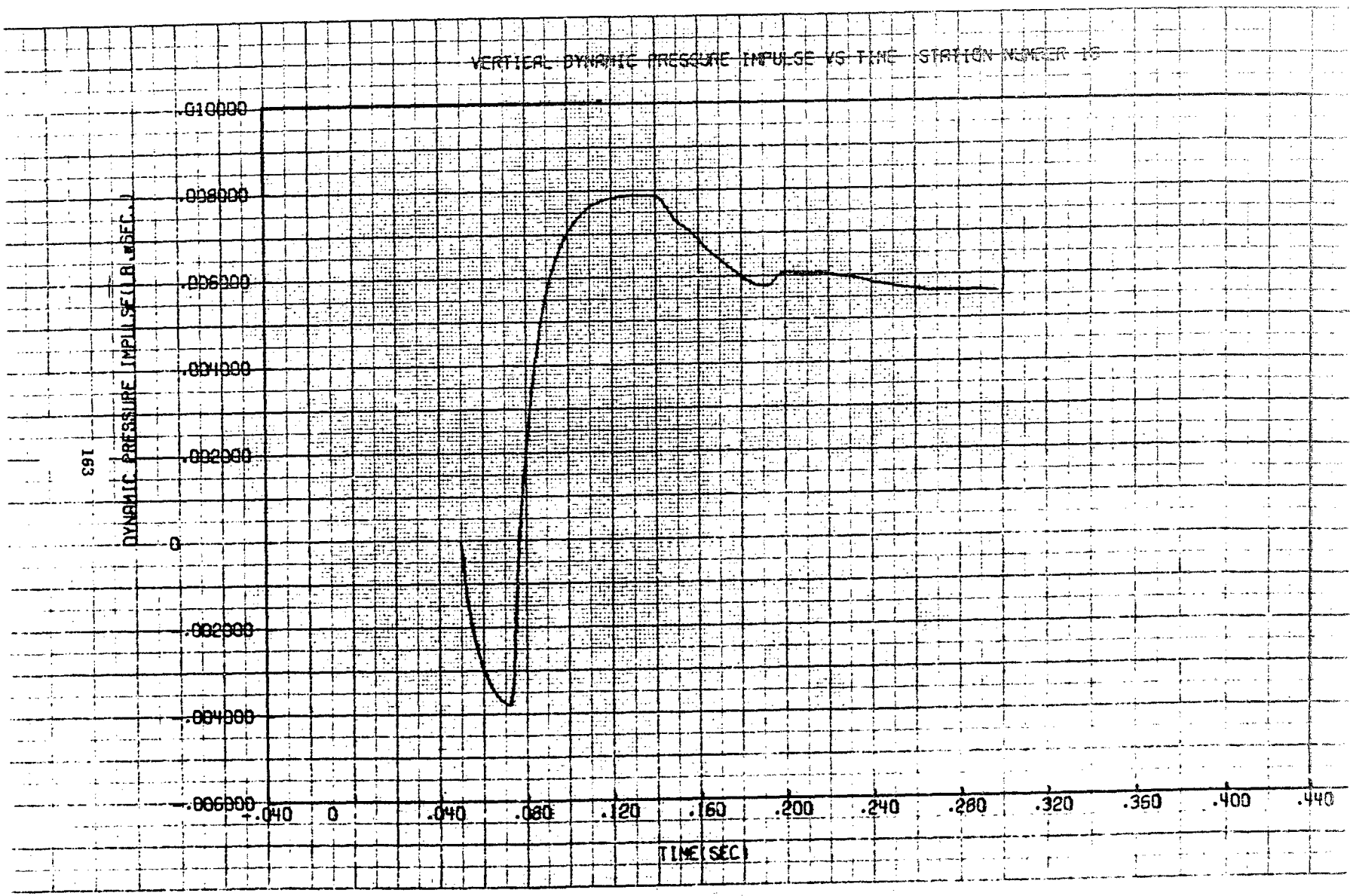

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 16
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

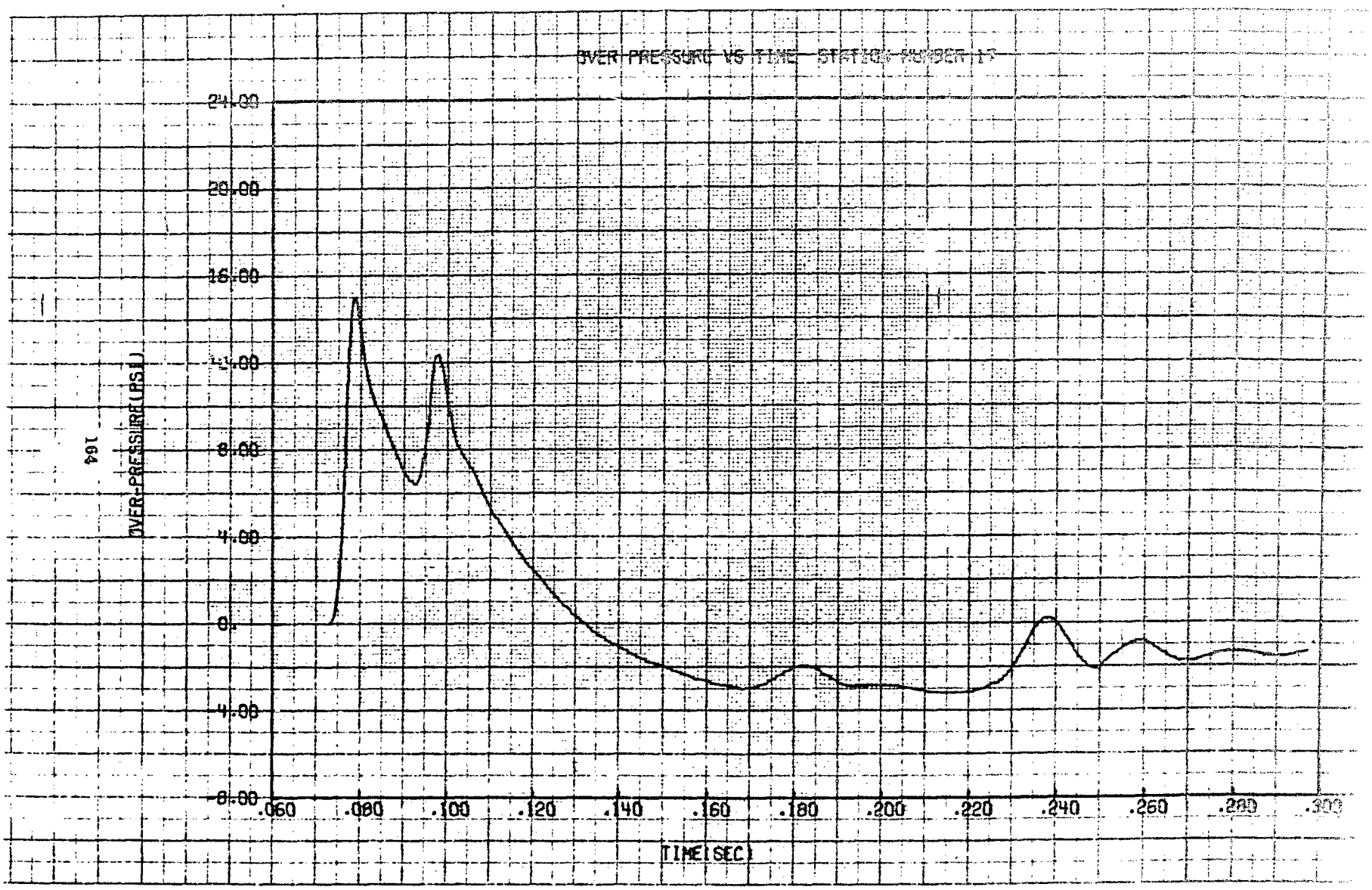

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 16
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
SPEED(FT/SEC.)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

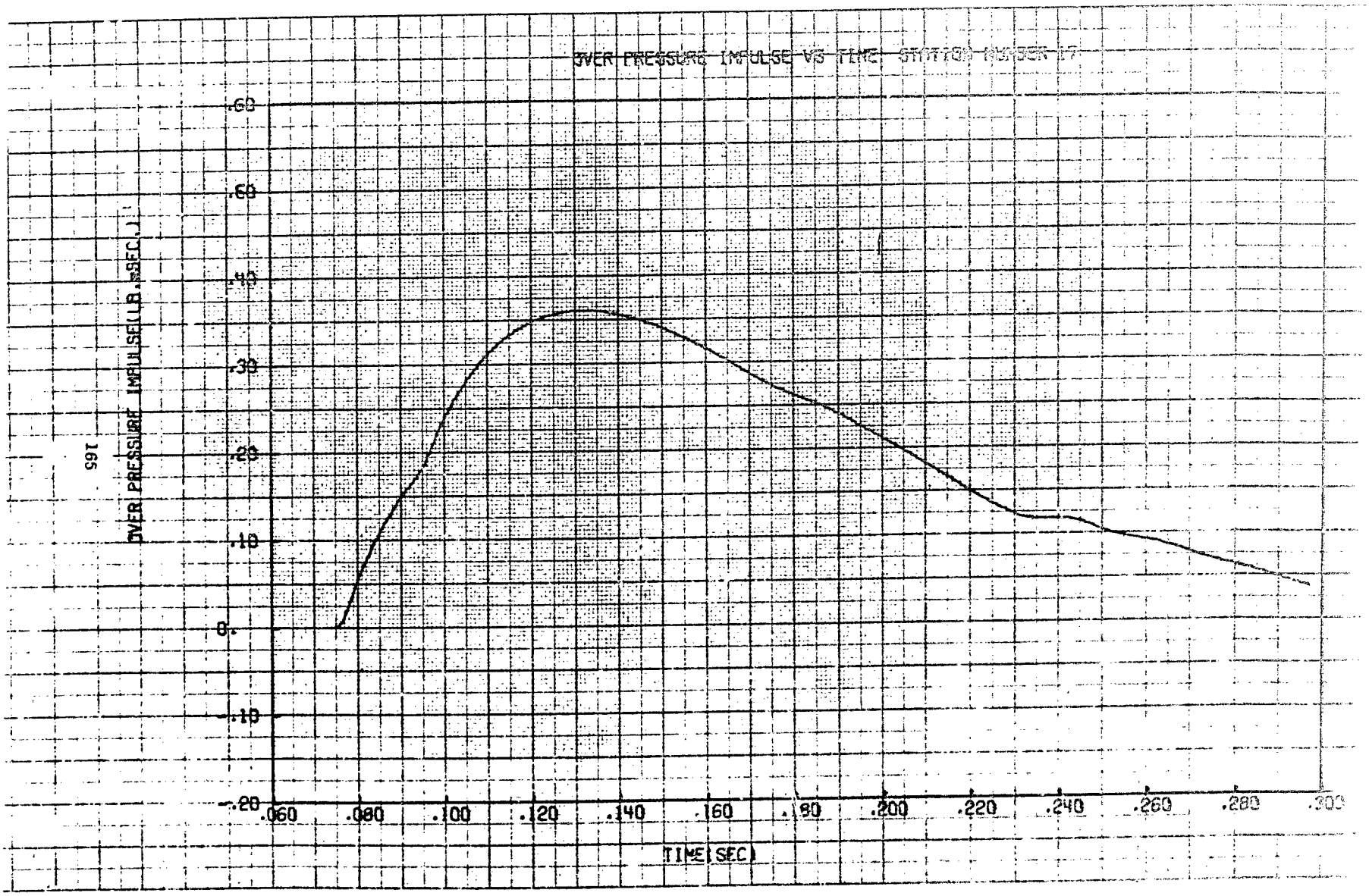

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 16
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

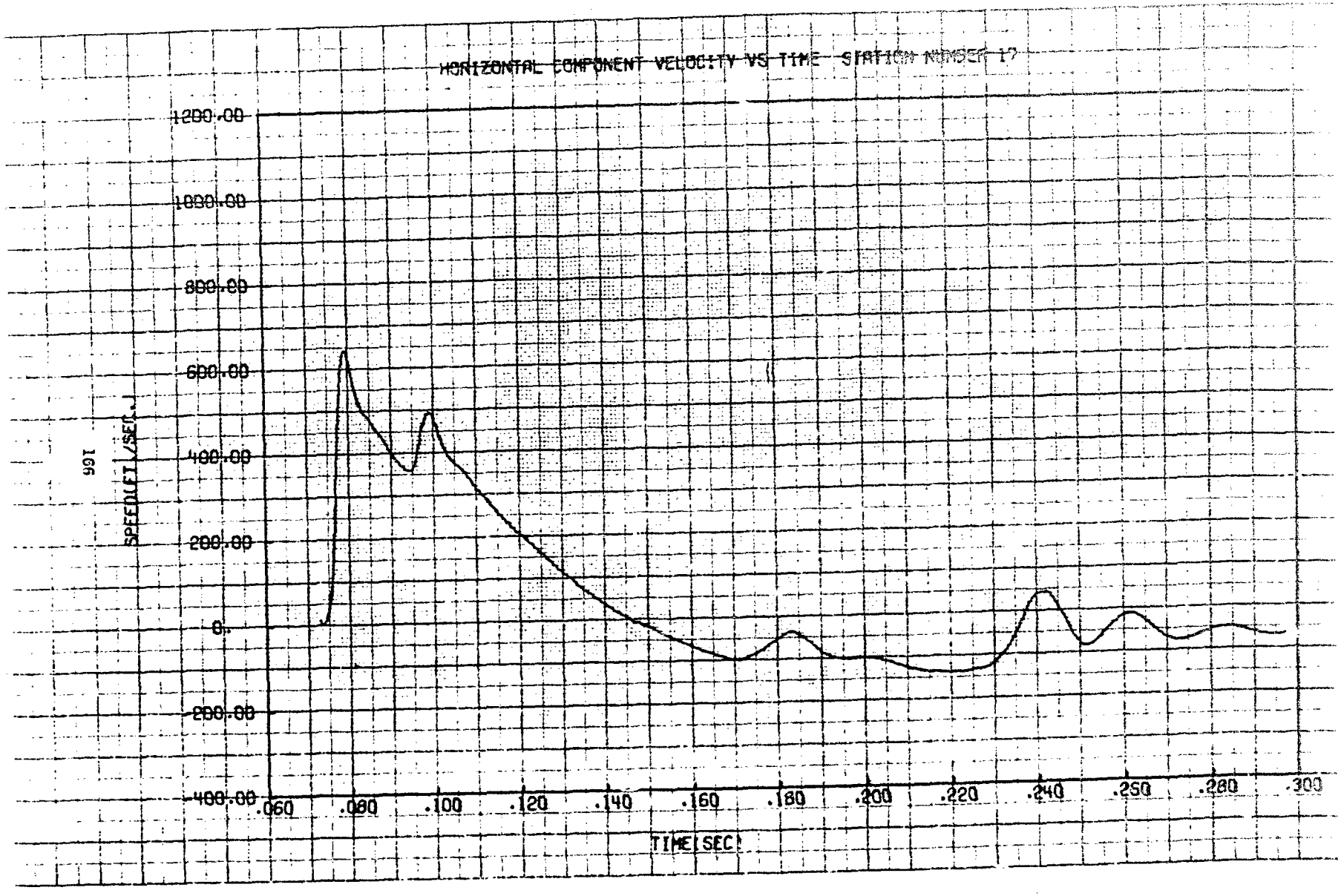

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 16
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.16
.14
.12
.10
.08
.06
.04
.02
0
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

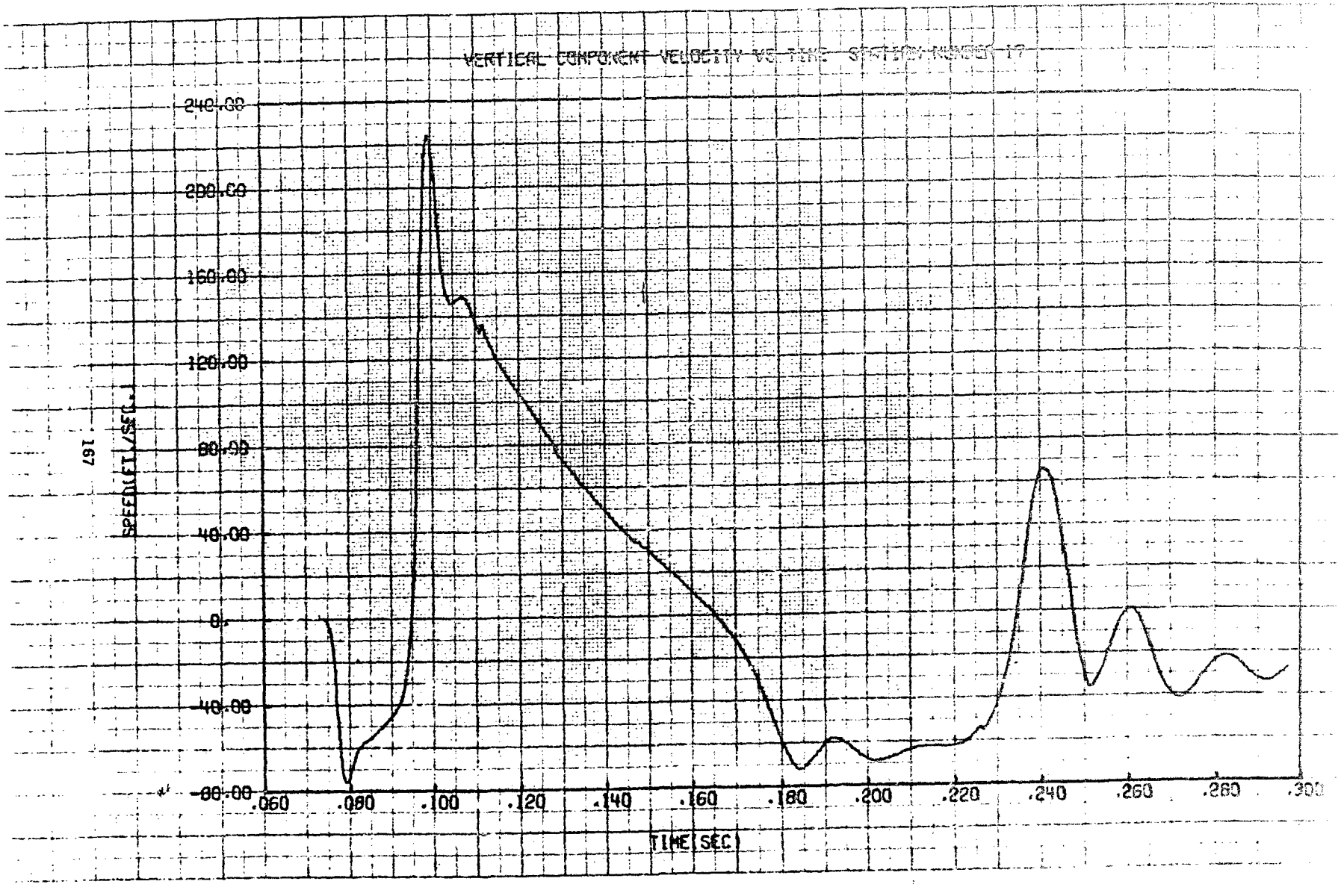

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 17
2.00
1.60
1.20
.80
.40
0.
-.40
-.80
-1.20
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

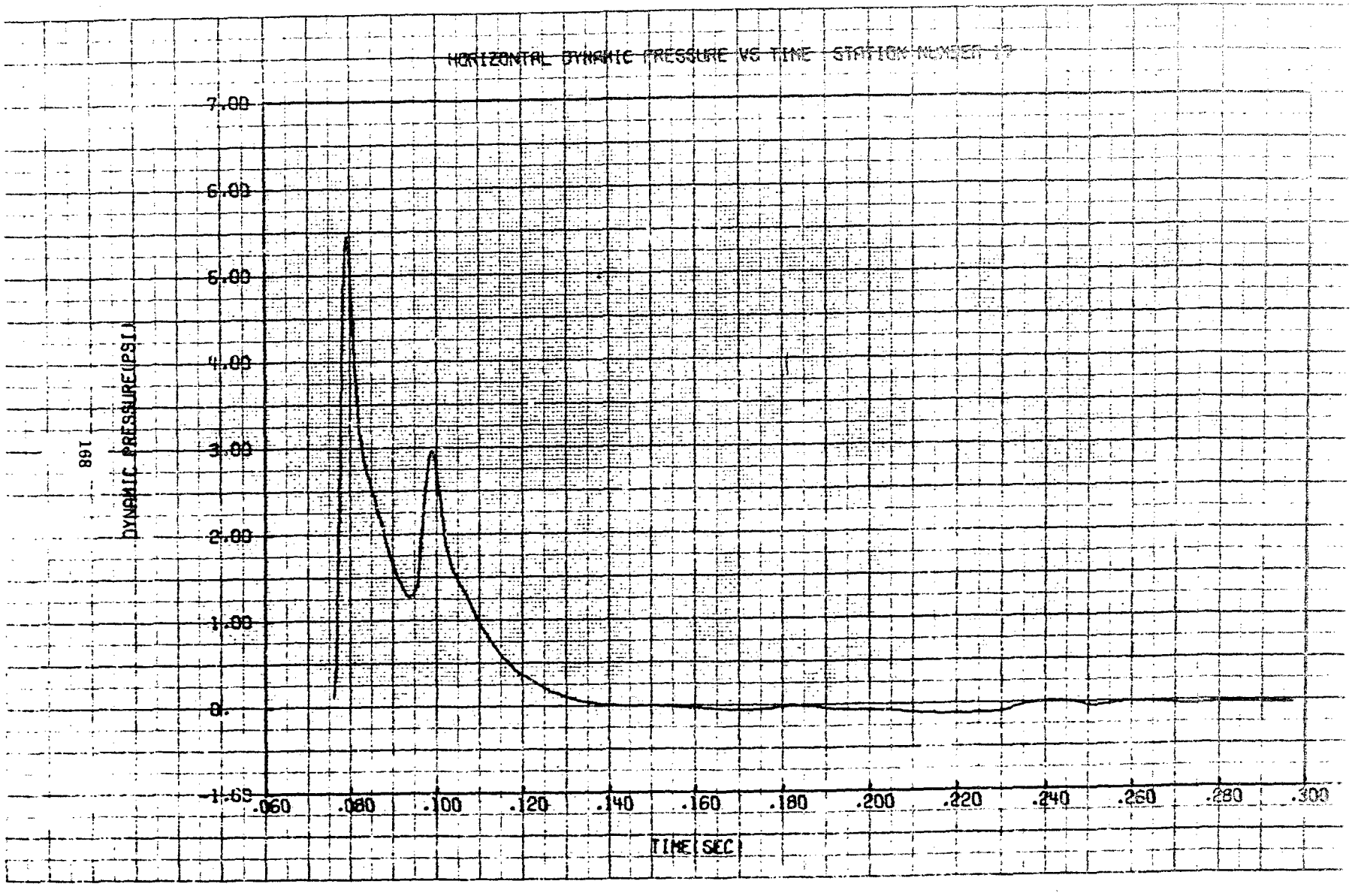

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 15
DYNAMIC PRESSURE IMPULSE(LB-SEC)
.010000
.008000
.006000
.004000
.002000
0
-.002000
-.004000
-.006000
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

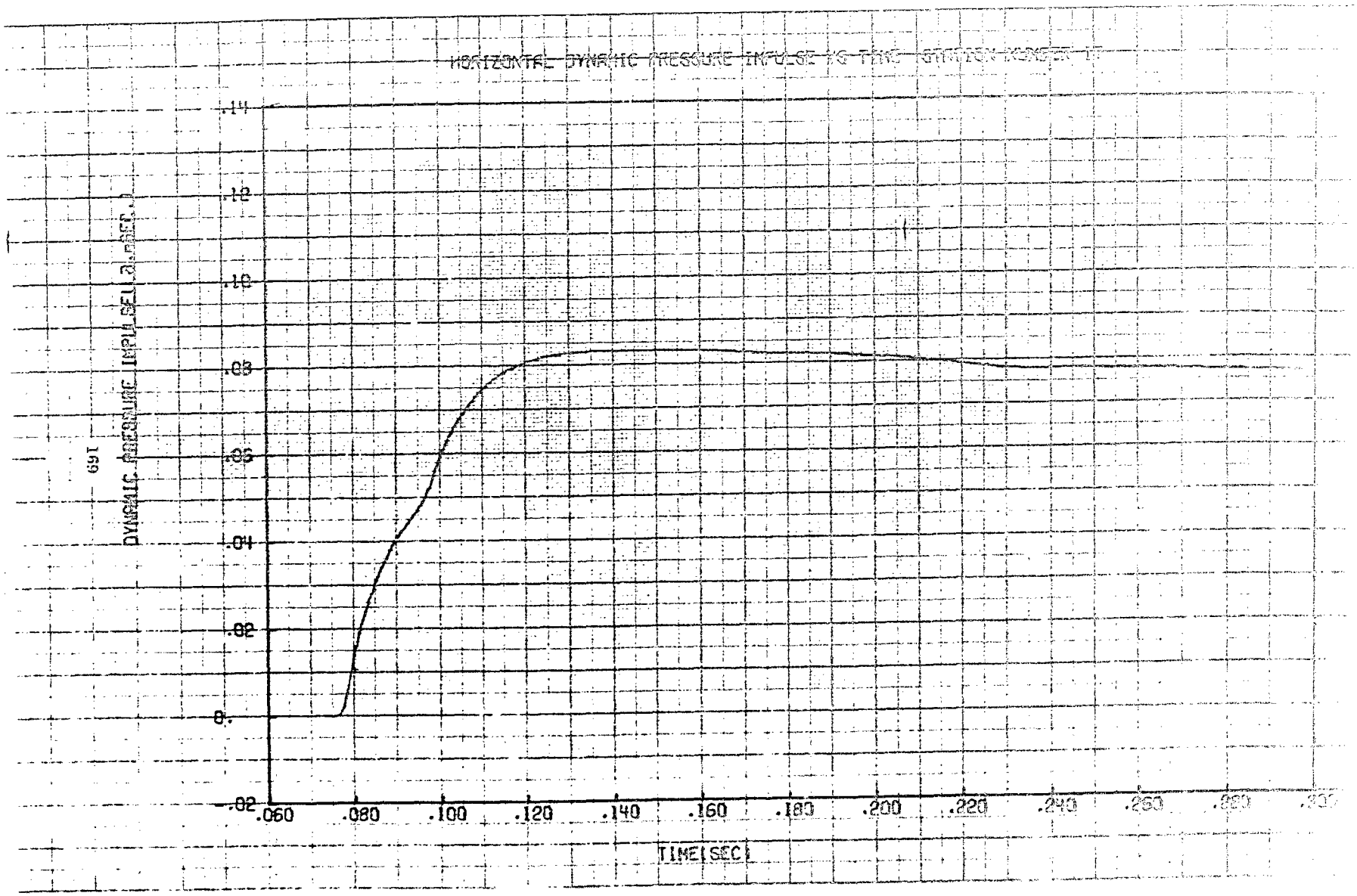

OVER PRESSURE VS TIME STATION NUMBER 17
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE(LBS/)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

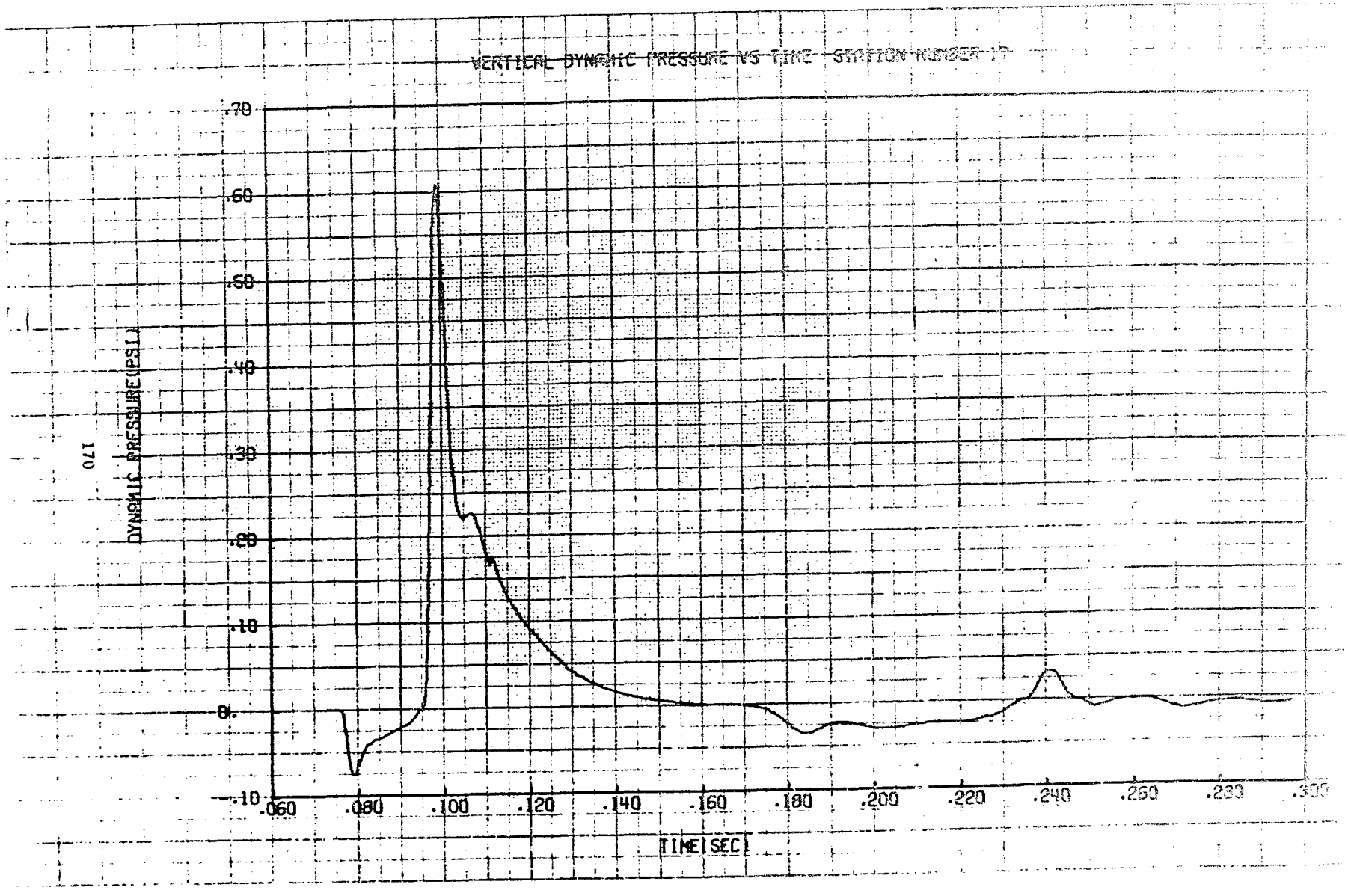

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 17
OVER PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

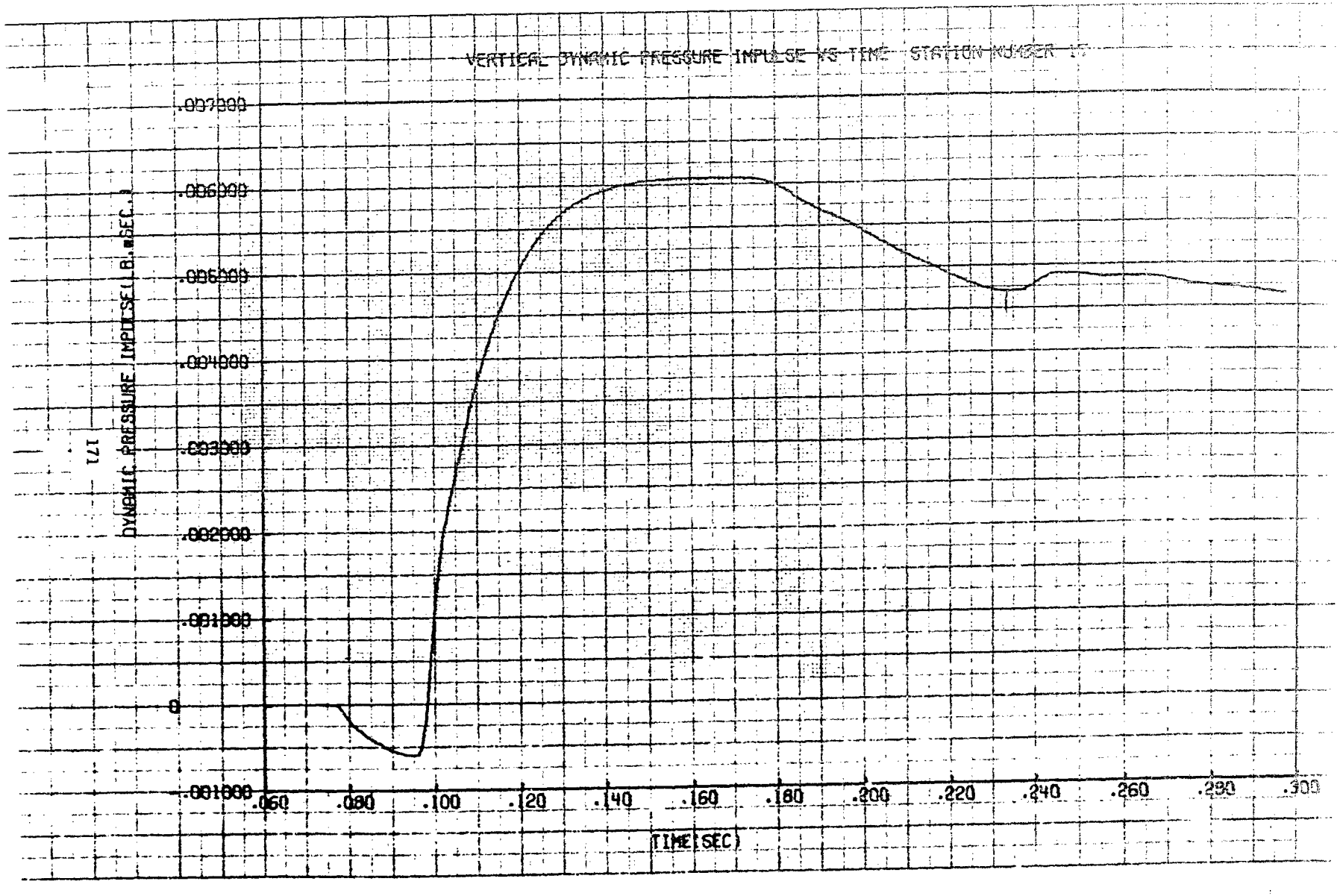

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

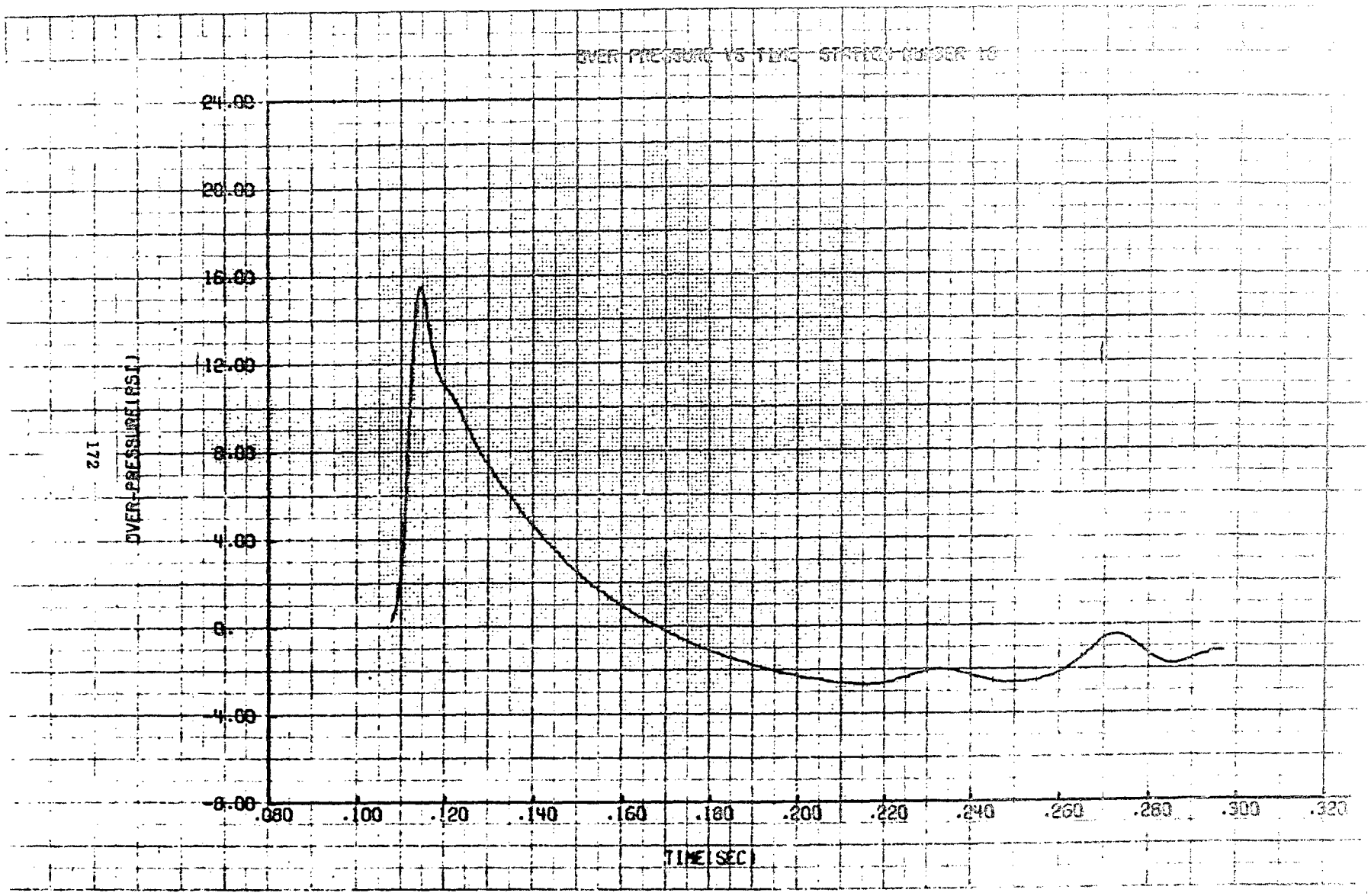

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
FT/SEC/FT/SEC

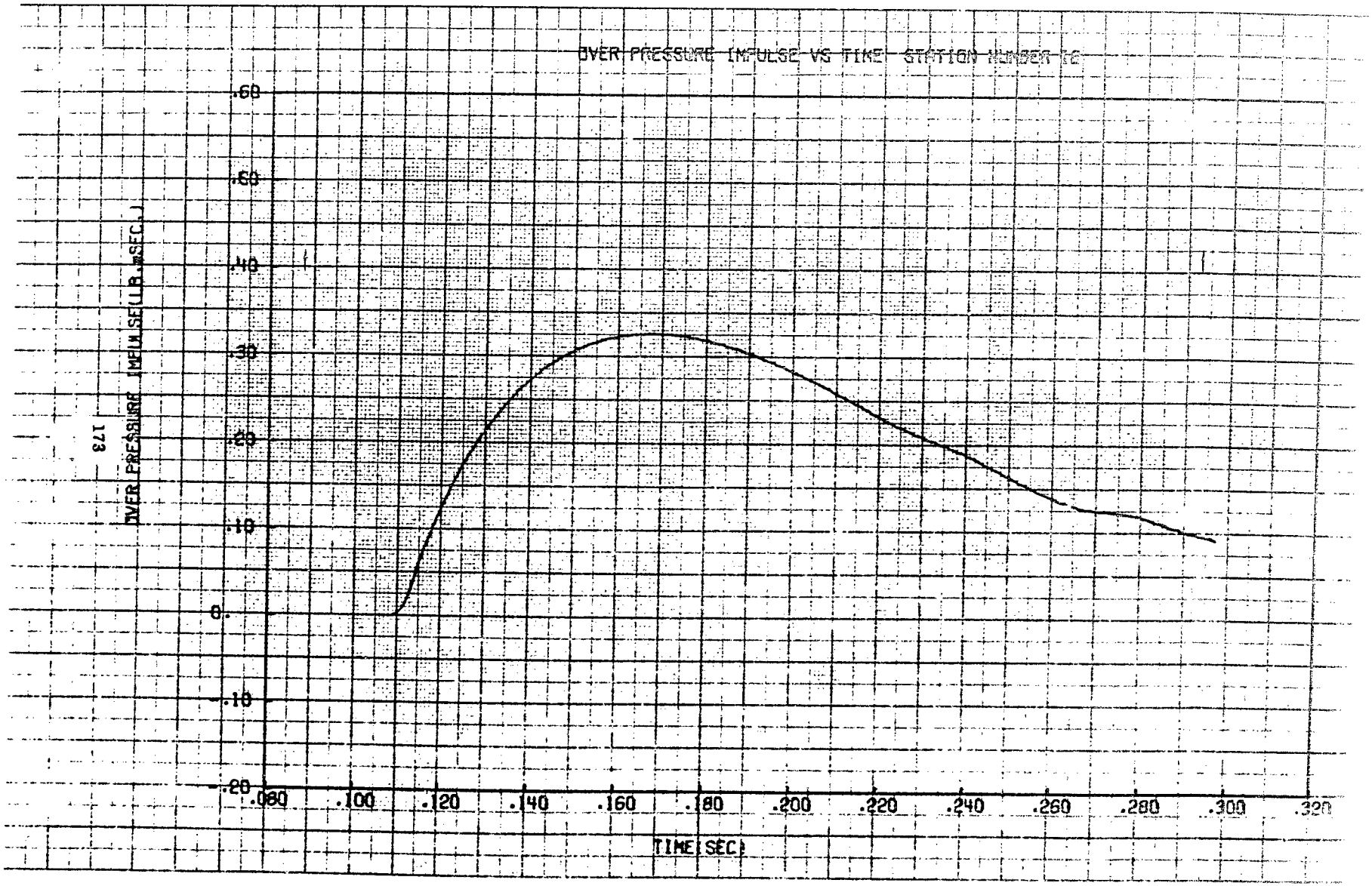

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE(PSI)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

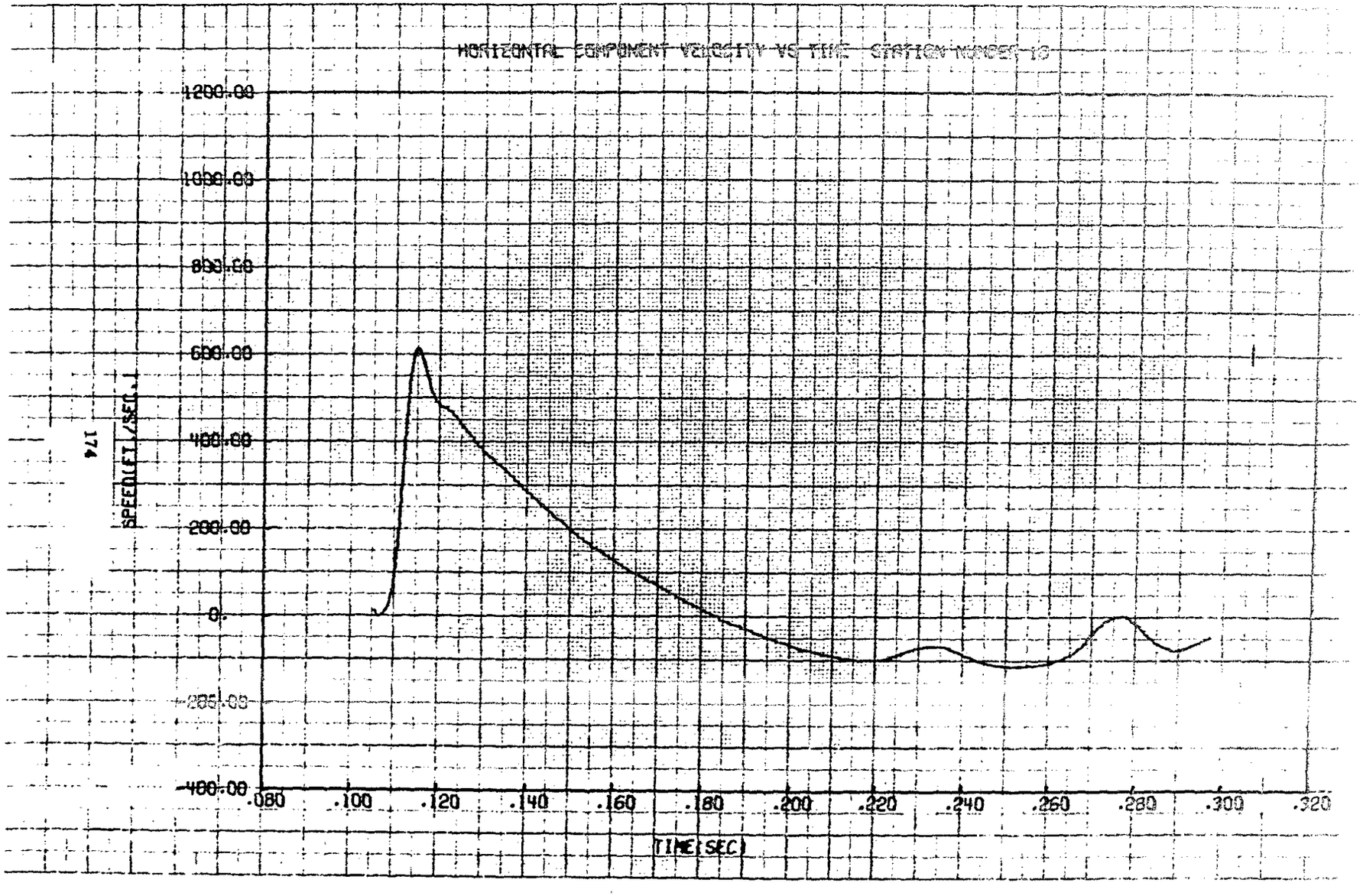

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE IMPULSE(LB-SEC/...)
.14
.12
.10
.08
.06
.04
.02
0.
-.02
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

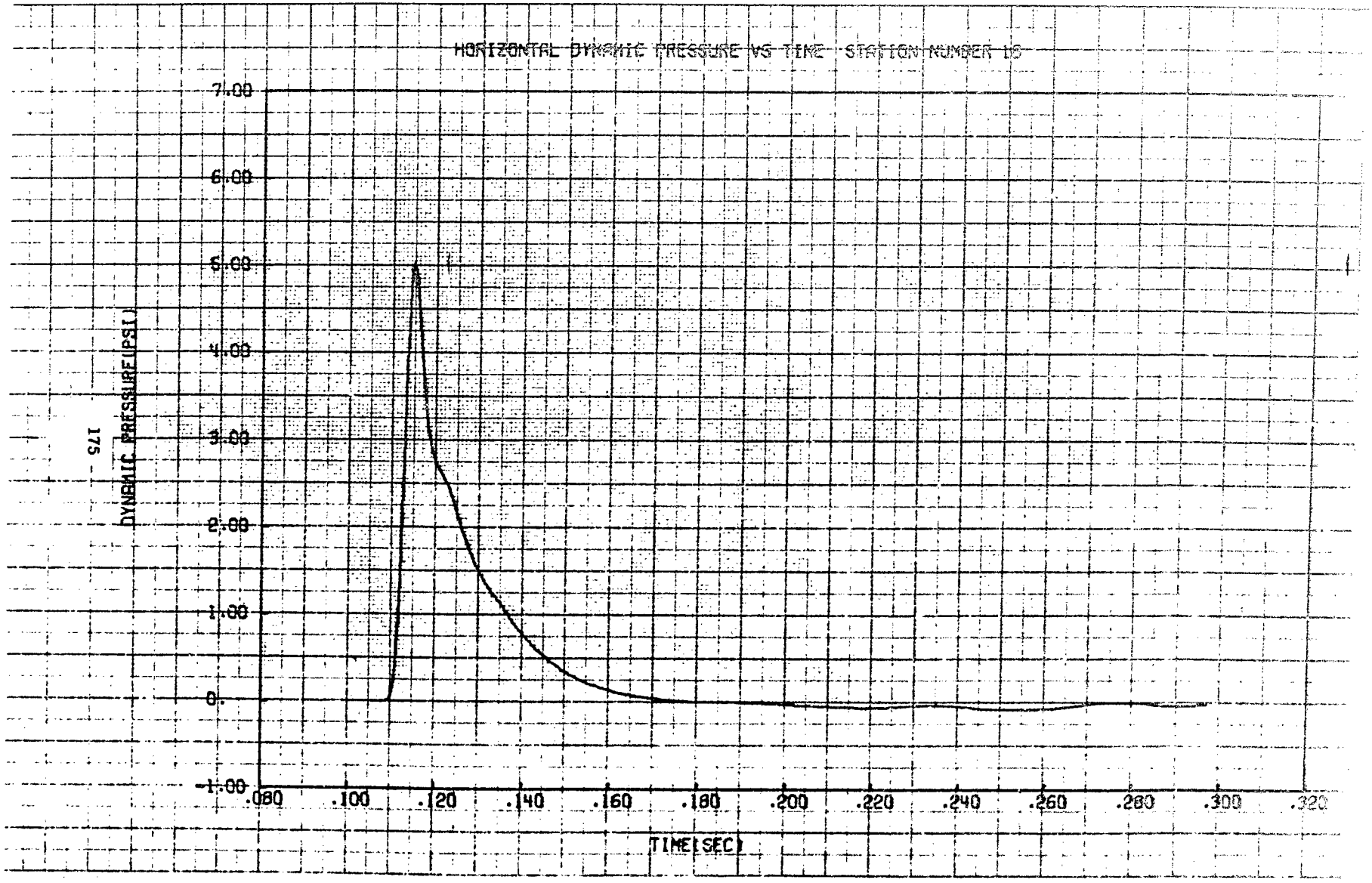

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE(PSI)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

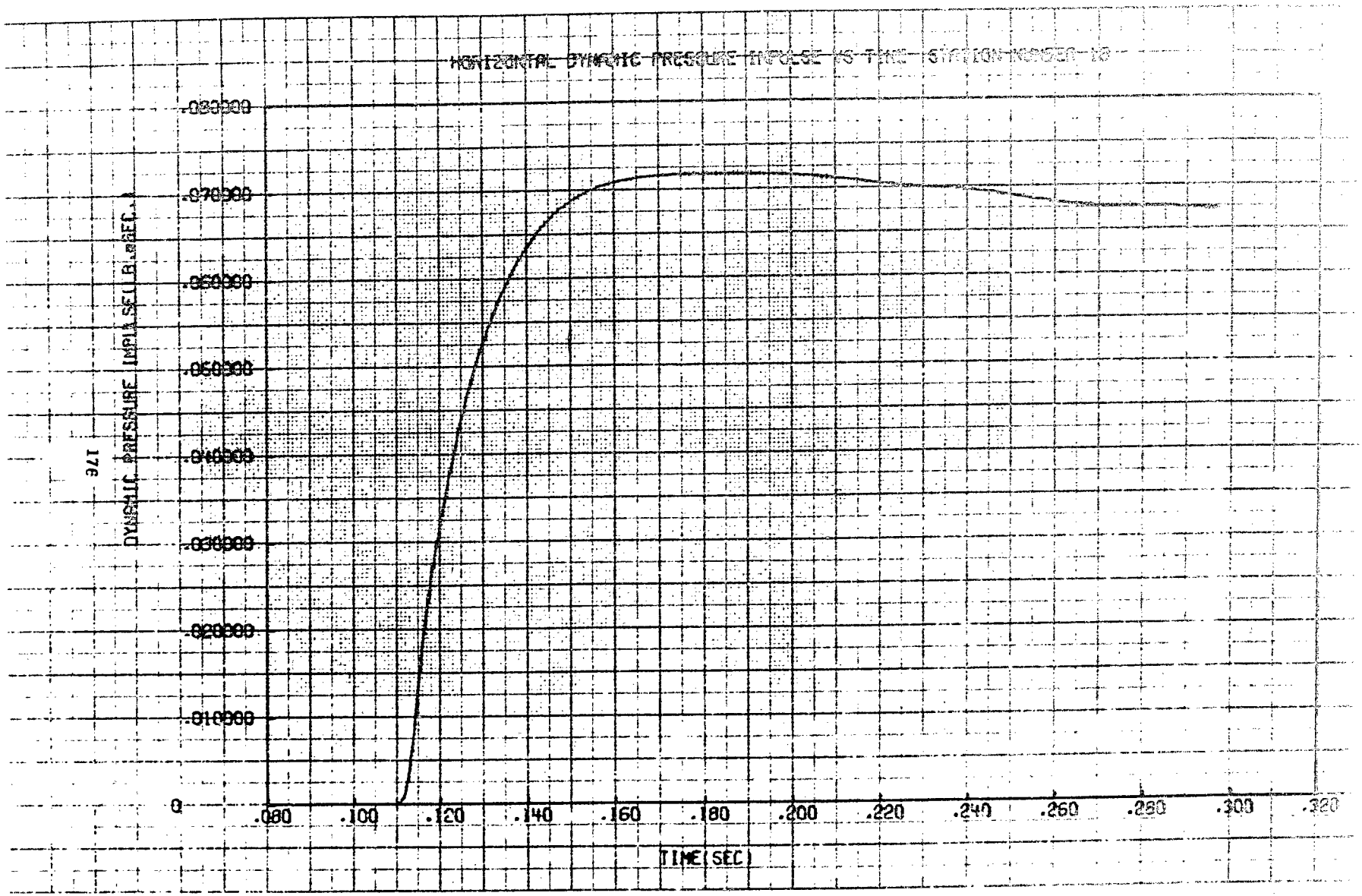

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 17
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.007000
.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

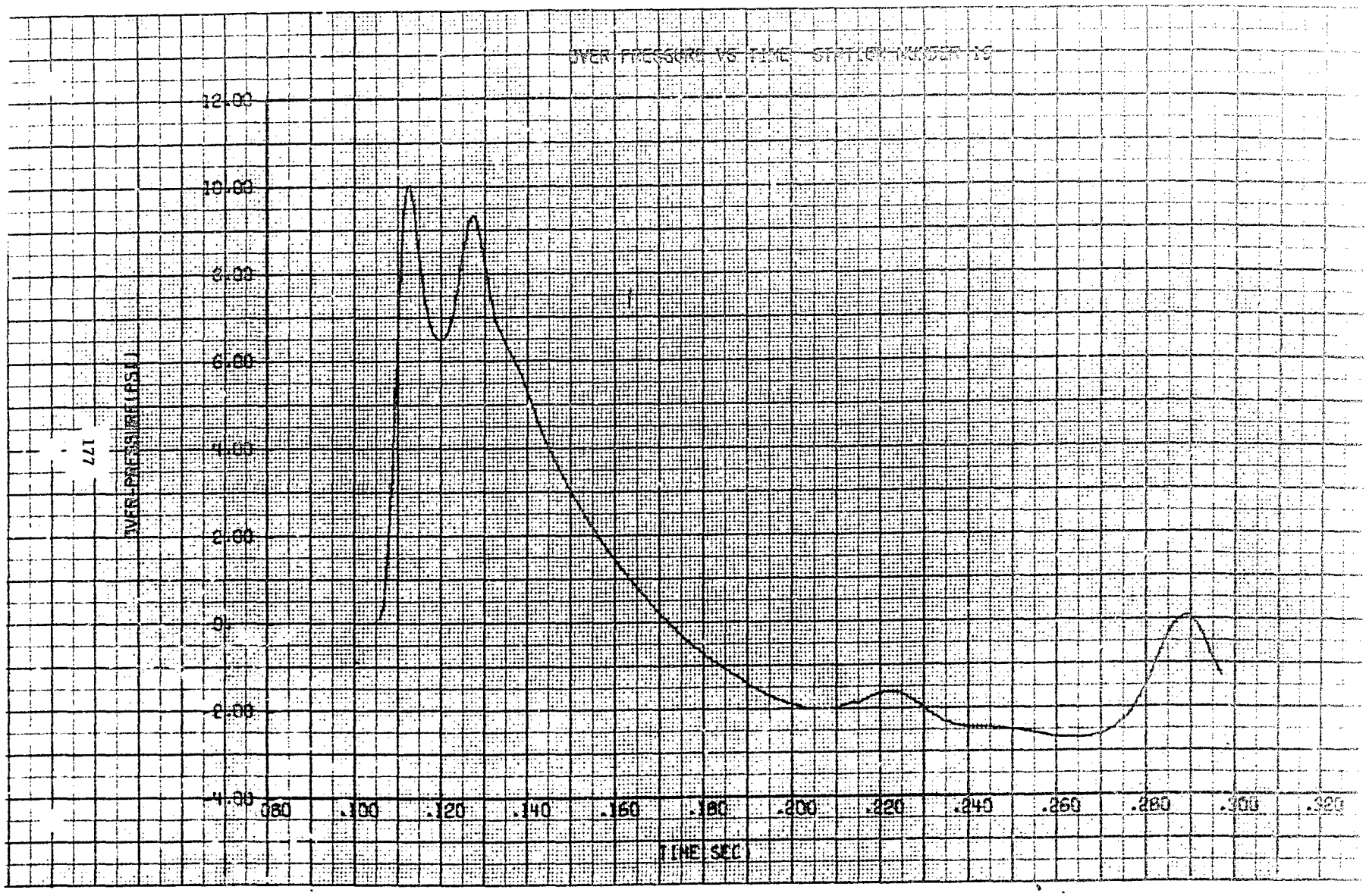

OVER PRESSURE VS TIME STATION NUMBER 10
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER PRESSURE (PSI)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)


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

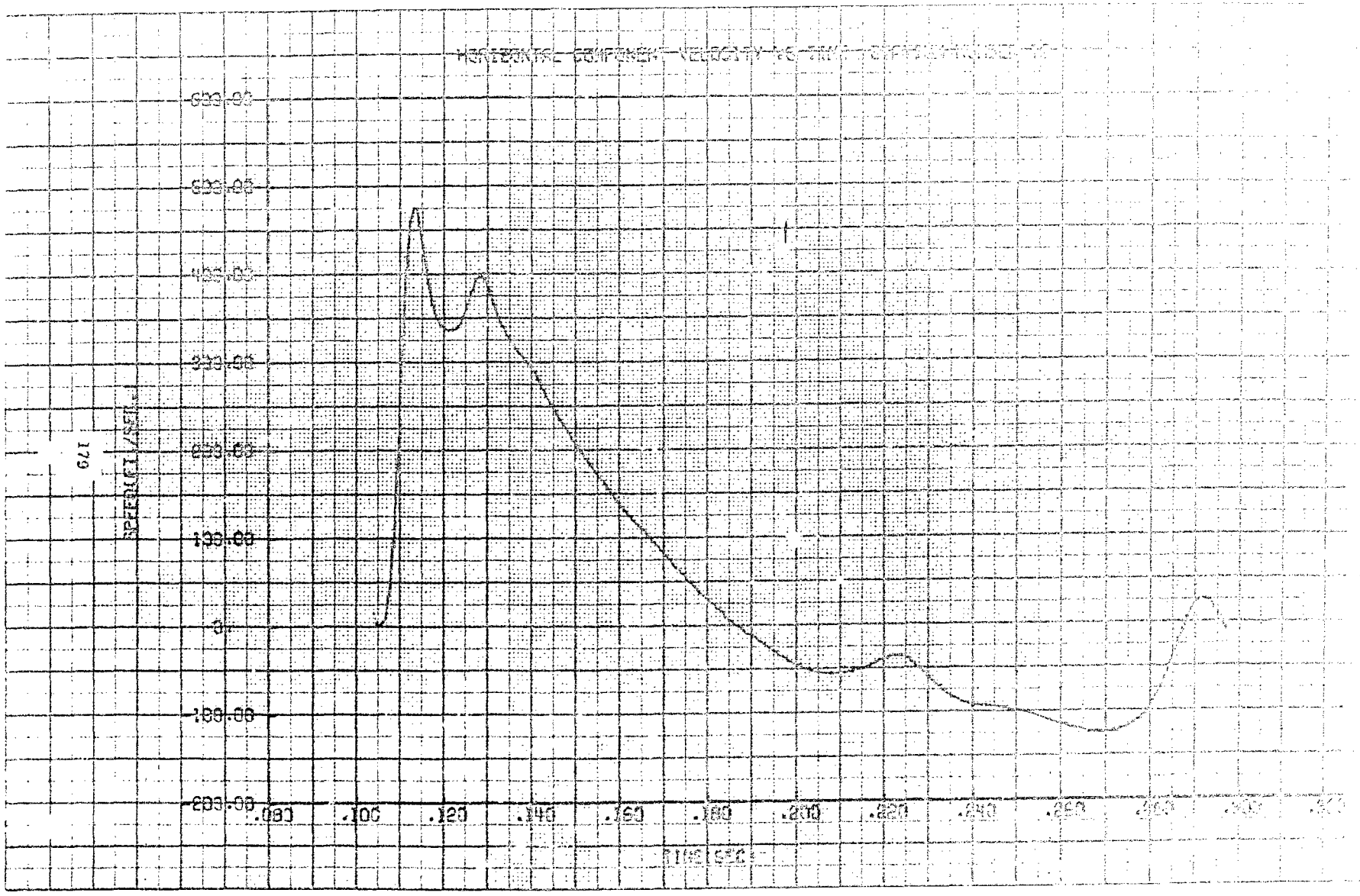

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 13
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
SPEED(FT./SEC.)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)


HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 16
DYNAMIC PRESSURE(PSI)
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)

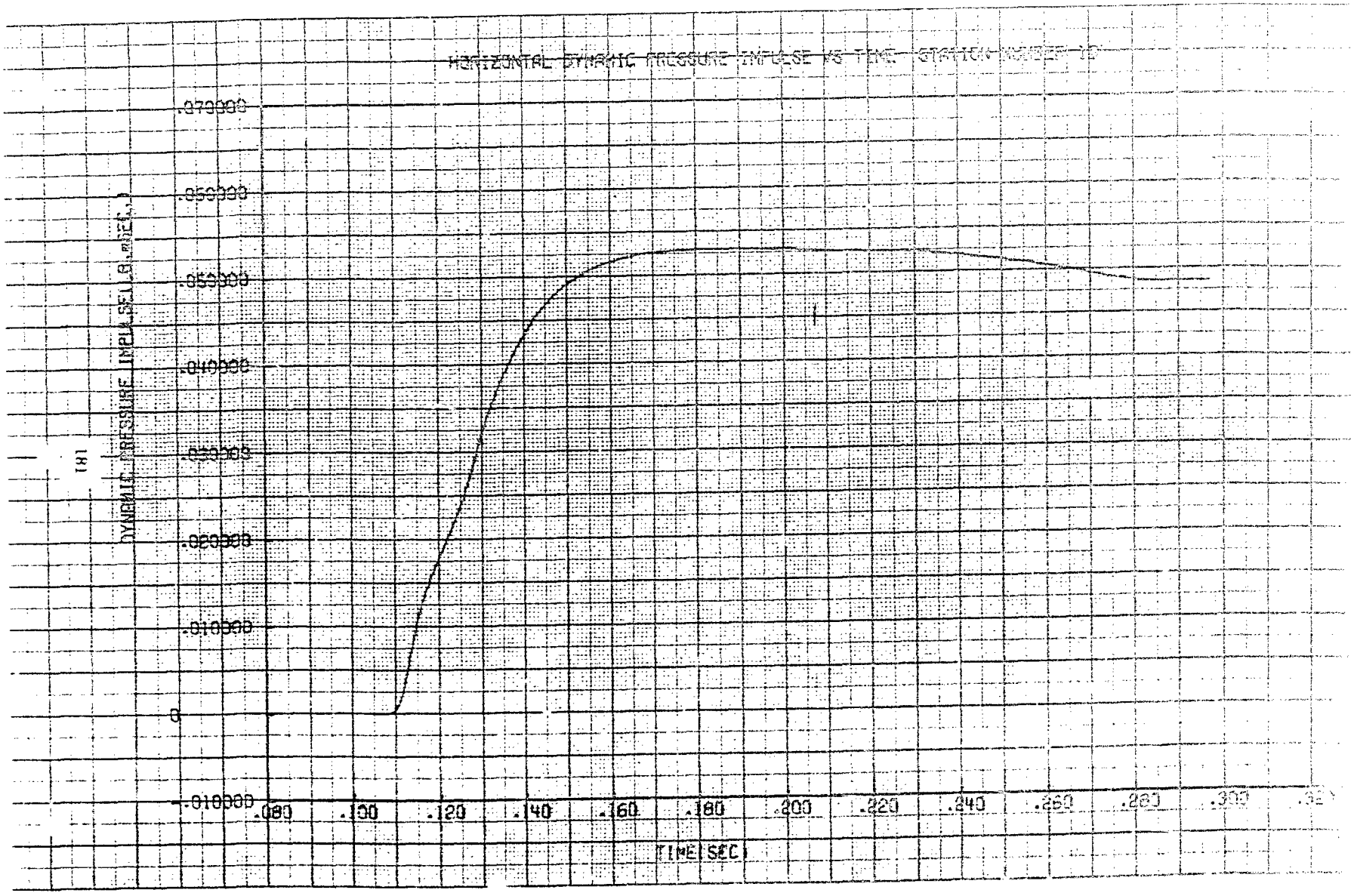

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
.080000
.070000
.060000
.050000
.040000
.030000
.020000
.010000
0
DYNAMIC PRESSURE IMPULSE(LB-SEC)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)


OVER PRESSURE VS TIME STATION NUMBER 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
.320
TIME SEC

.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)
50
55
45
35
25
15
5
-5
-15
-25


HORIZONTAL COMPONENT VELOCITY VS TIME
SPEED(FT/SEC)
TIME(SEC)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320

.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE (LB-MSEC)
.070000
.060000
.050000
.040000
.030000
.020000
.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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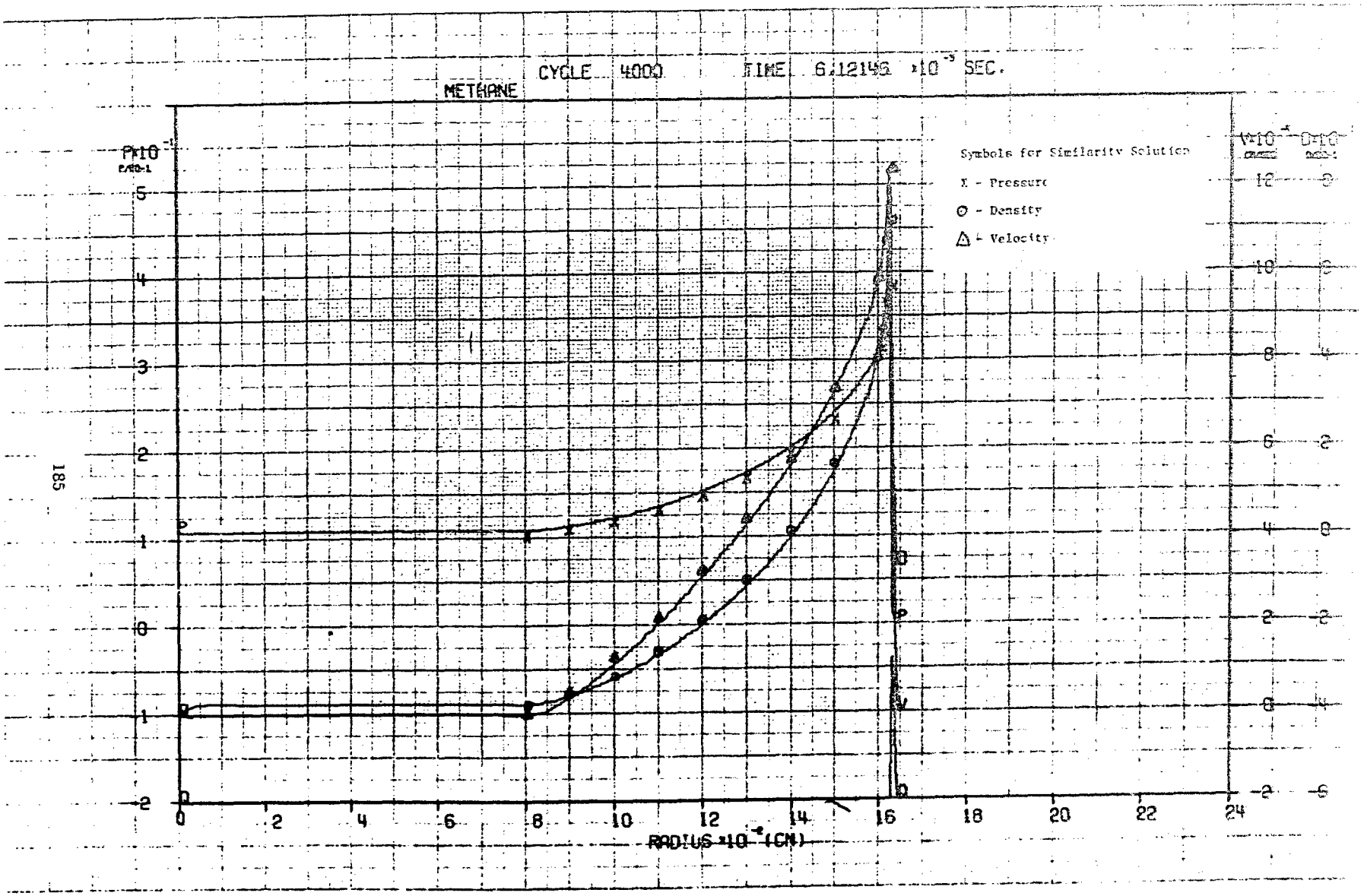
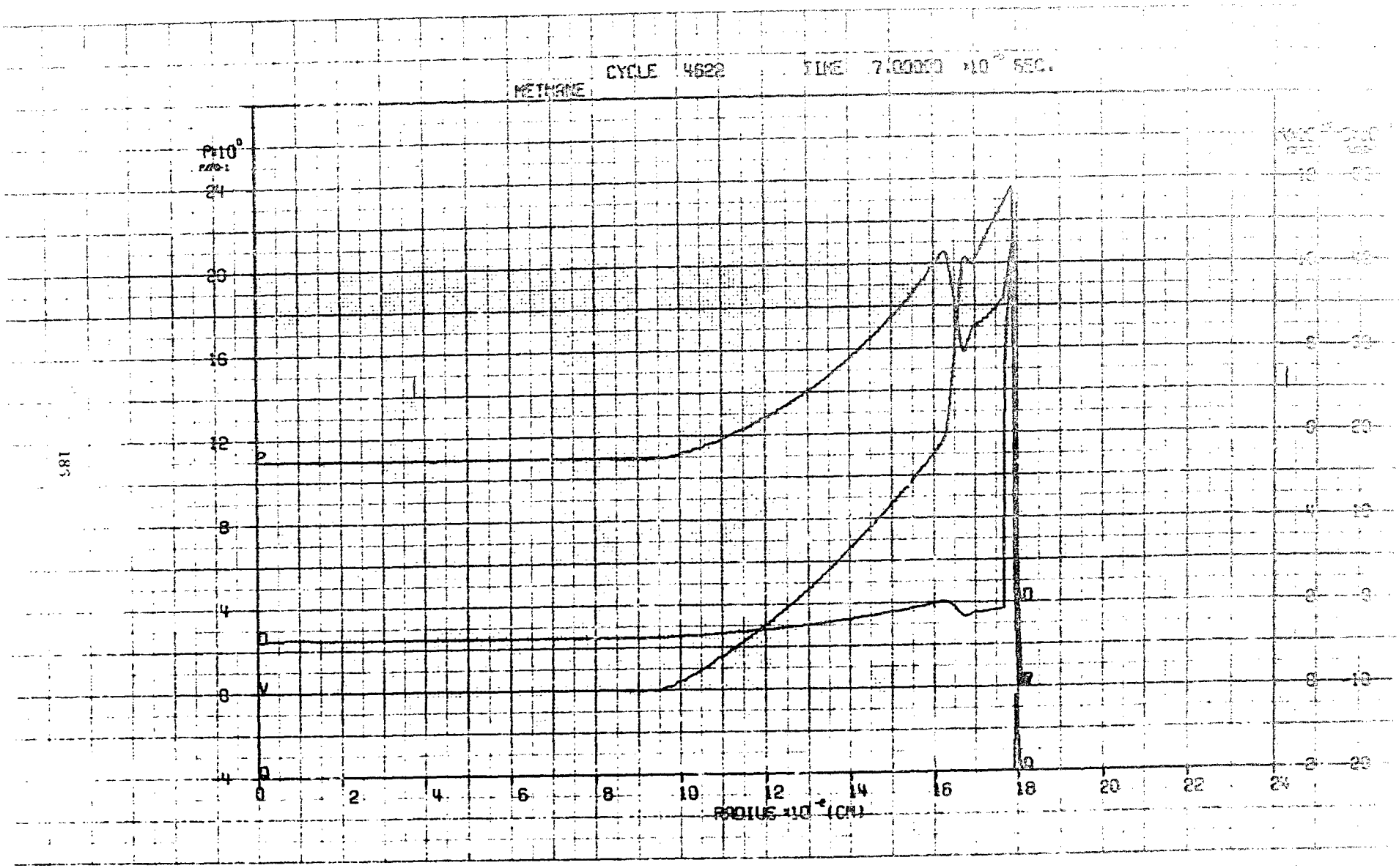
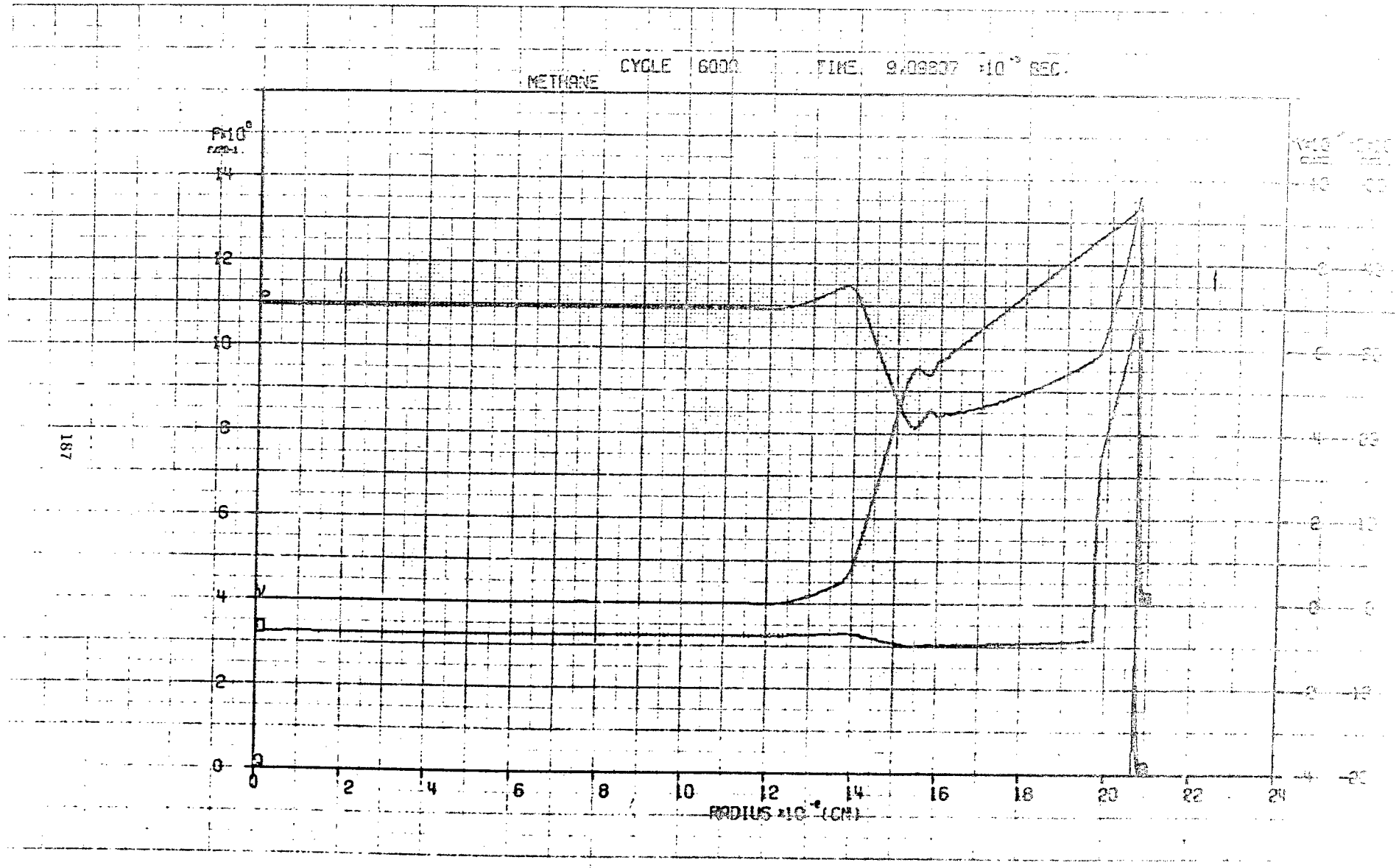
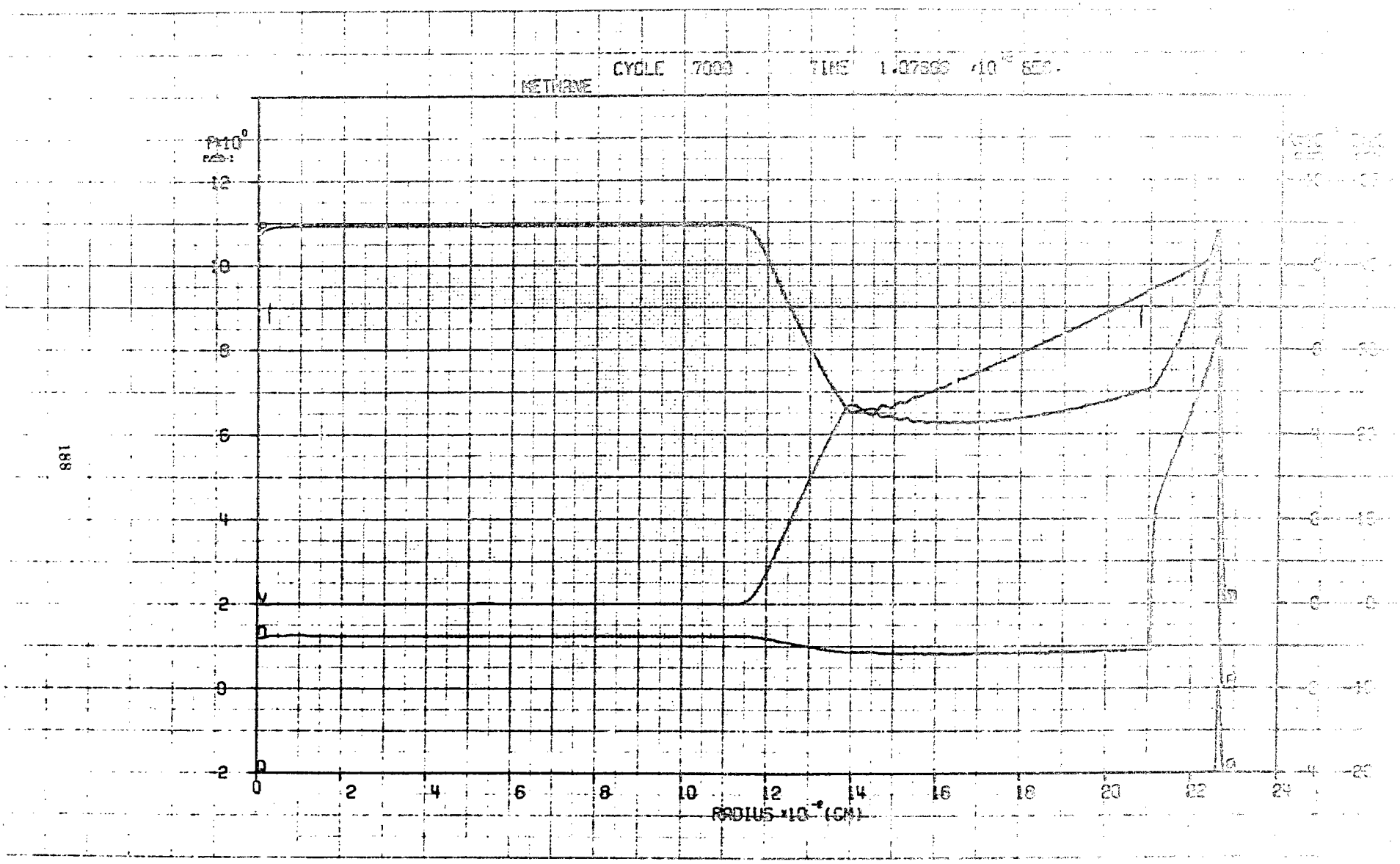
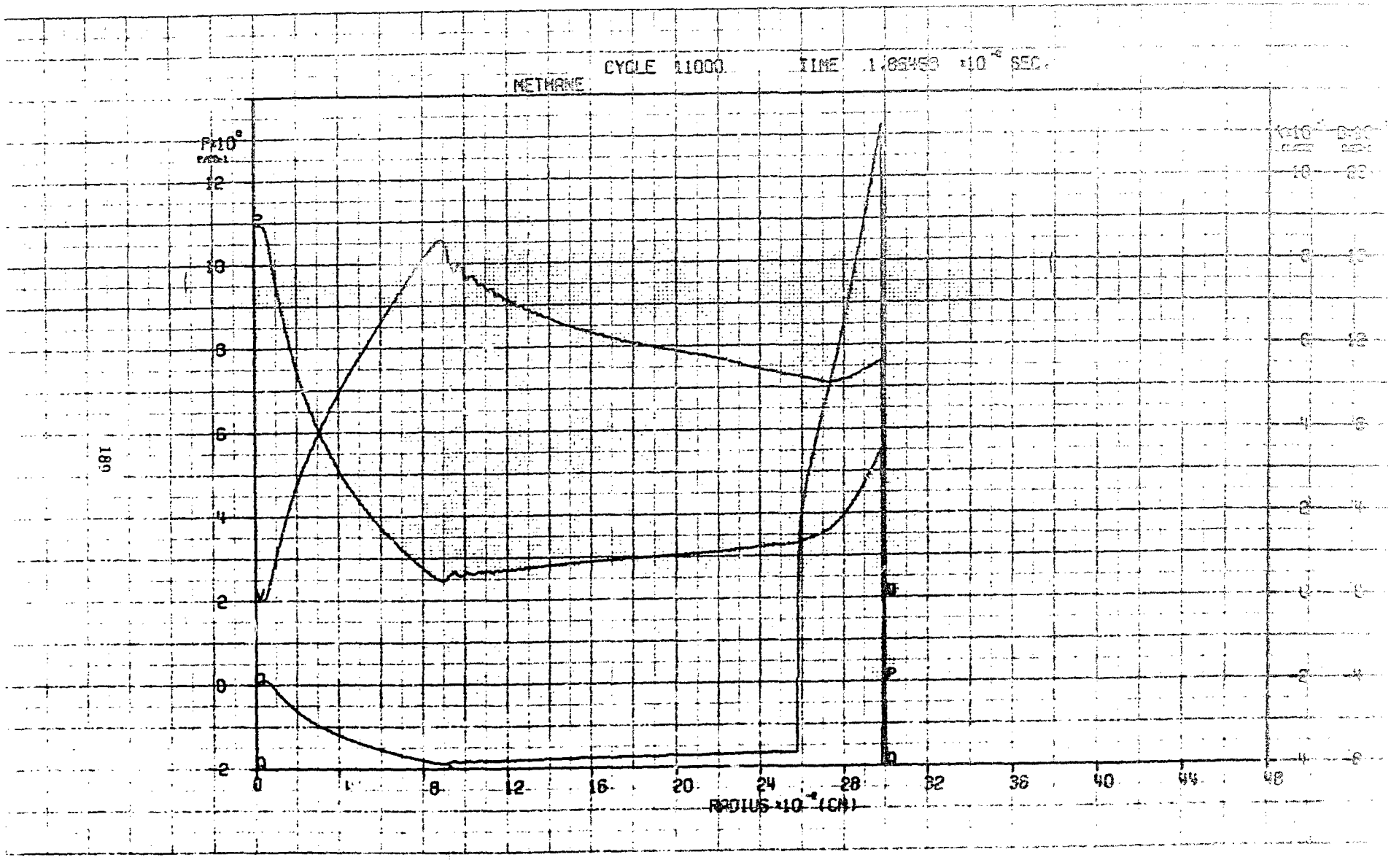
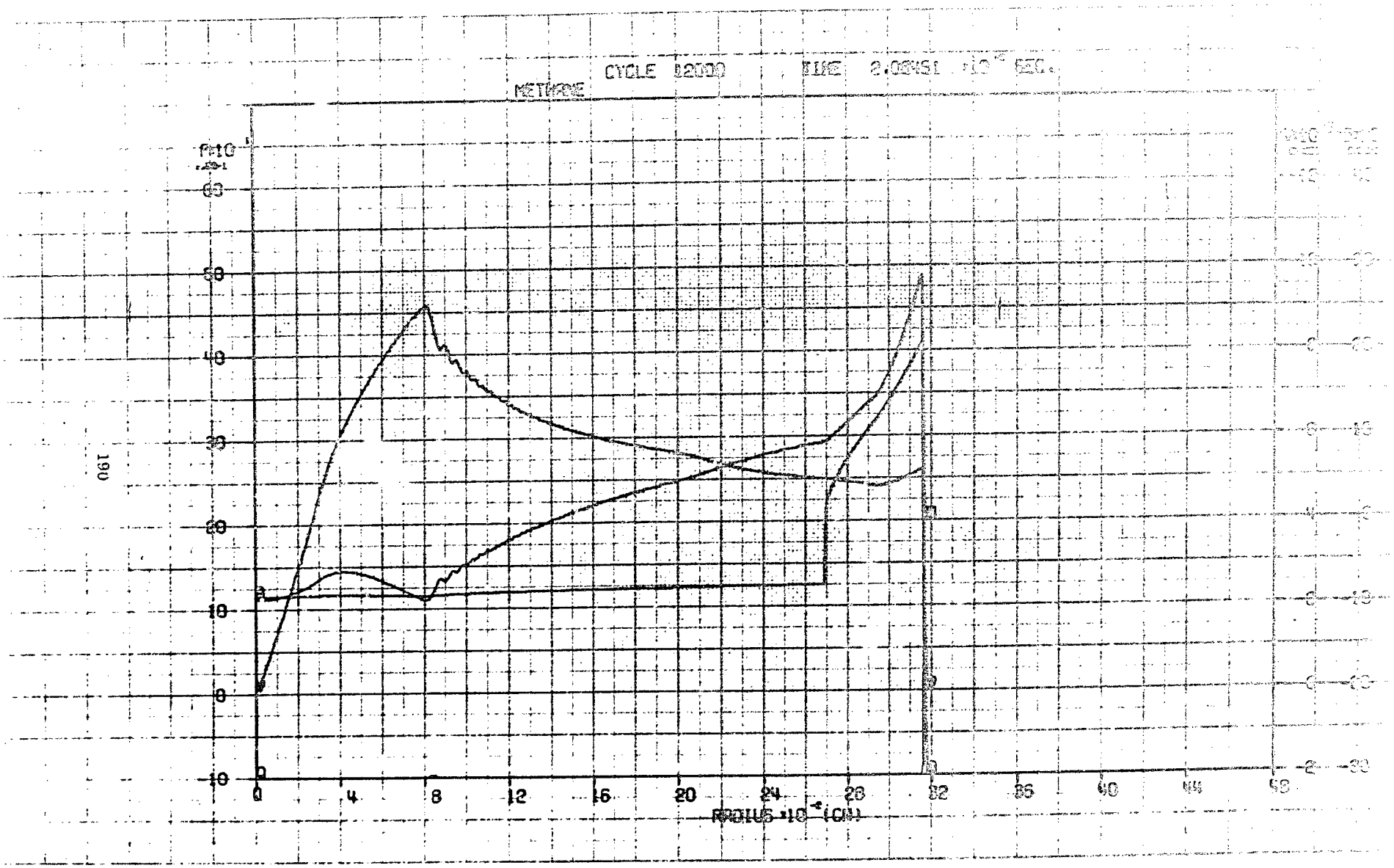

METHANE
CYCLE 4000
TIME 6.12145 ×10⁻⁵ SEC.
Symbols for Similarity Solution
X - Pressure
⊙ - Density
△ - Velocity
RADIUS ×10⁻² (CM)

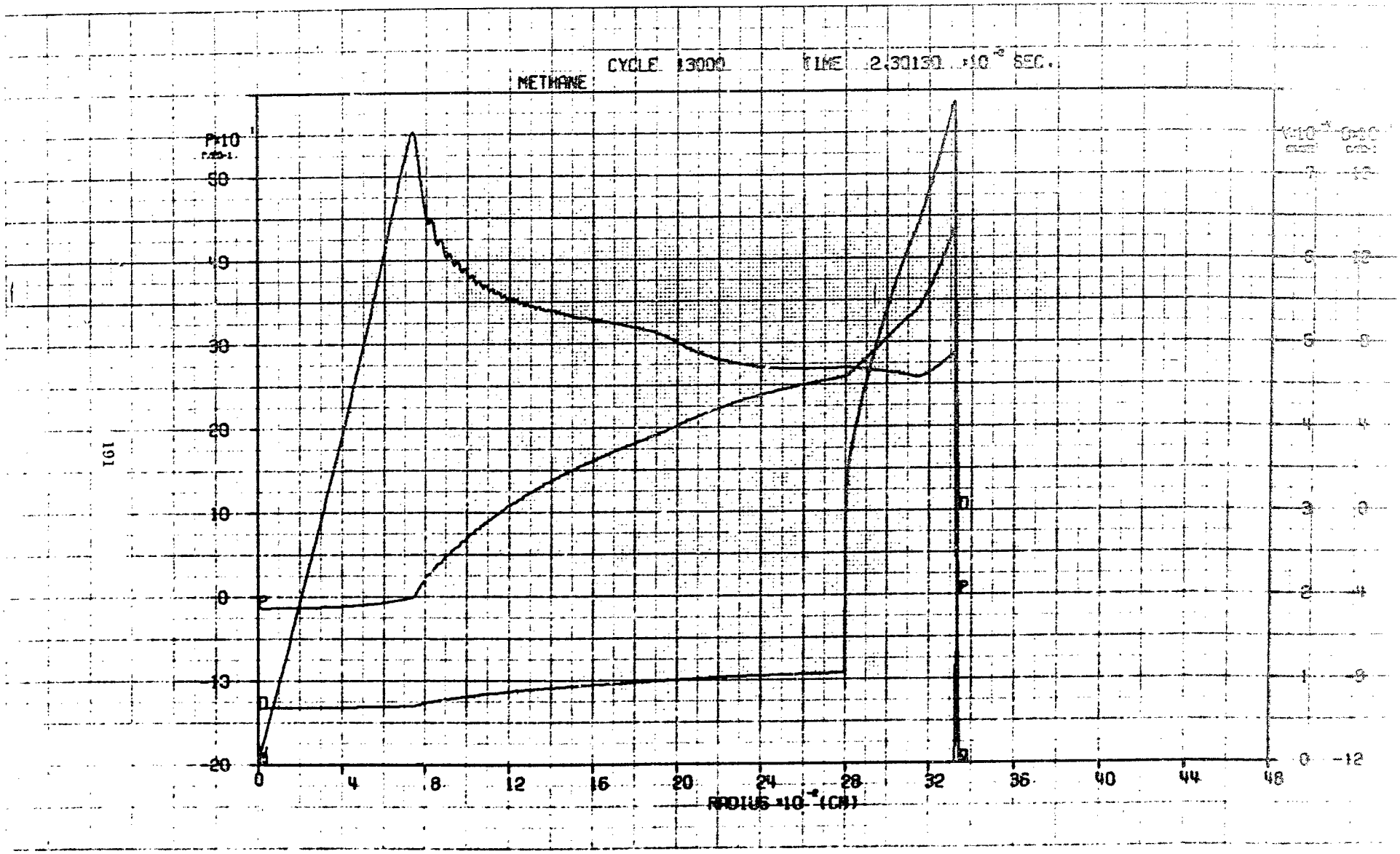

CYCLE 4622
METHANE
P=10^0
24
20
16
12
8
4
0
4
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10^-2 (CM)

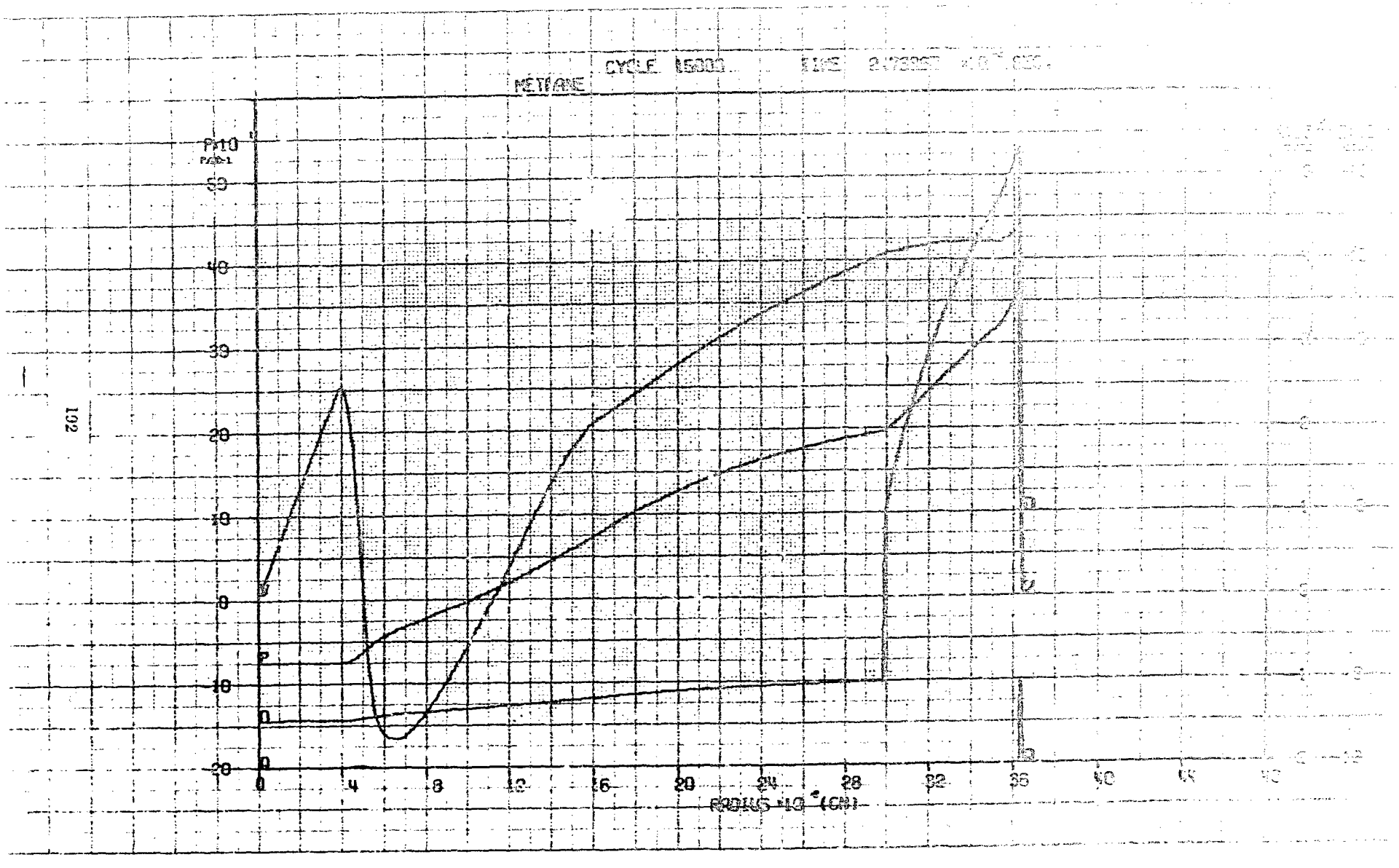

METHANE
CYCLE 6000
TIME 9.09807 ×10⁻⁵ SEC.
P×10⁶
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10⁻⁶ (CM)

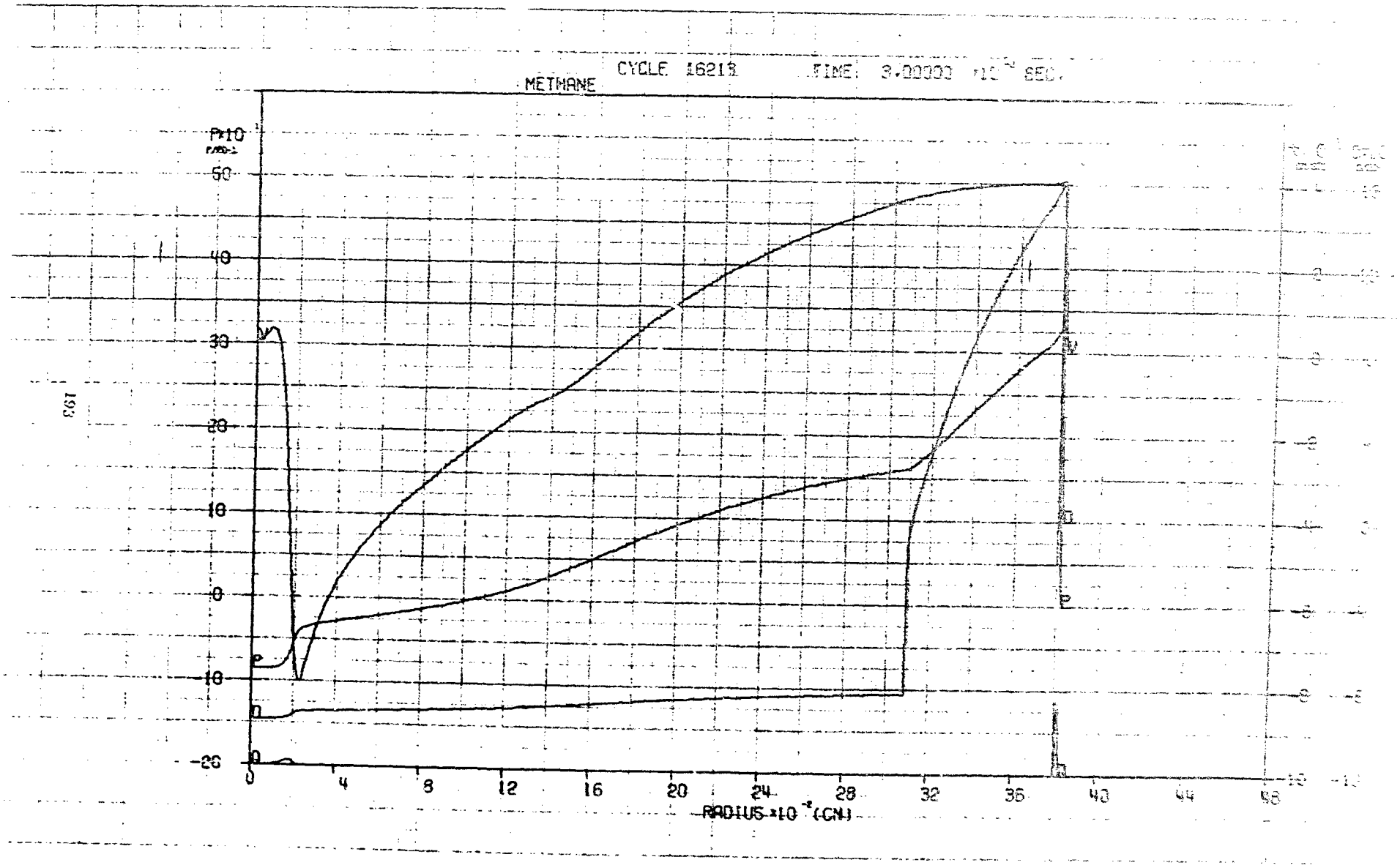

CYCLE 7000
TIME 1.07889 ×10⁻¹² SEC.
NETRONE
P×10⁰
12
10
8
6
4
2
0
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
RADIUS ×10⁻² (CM)

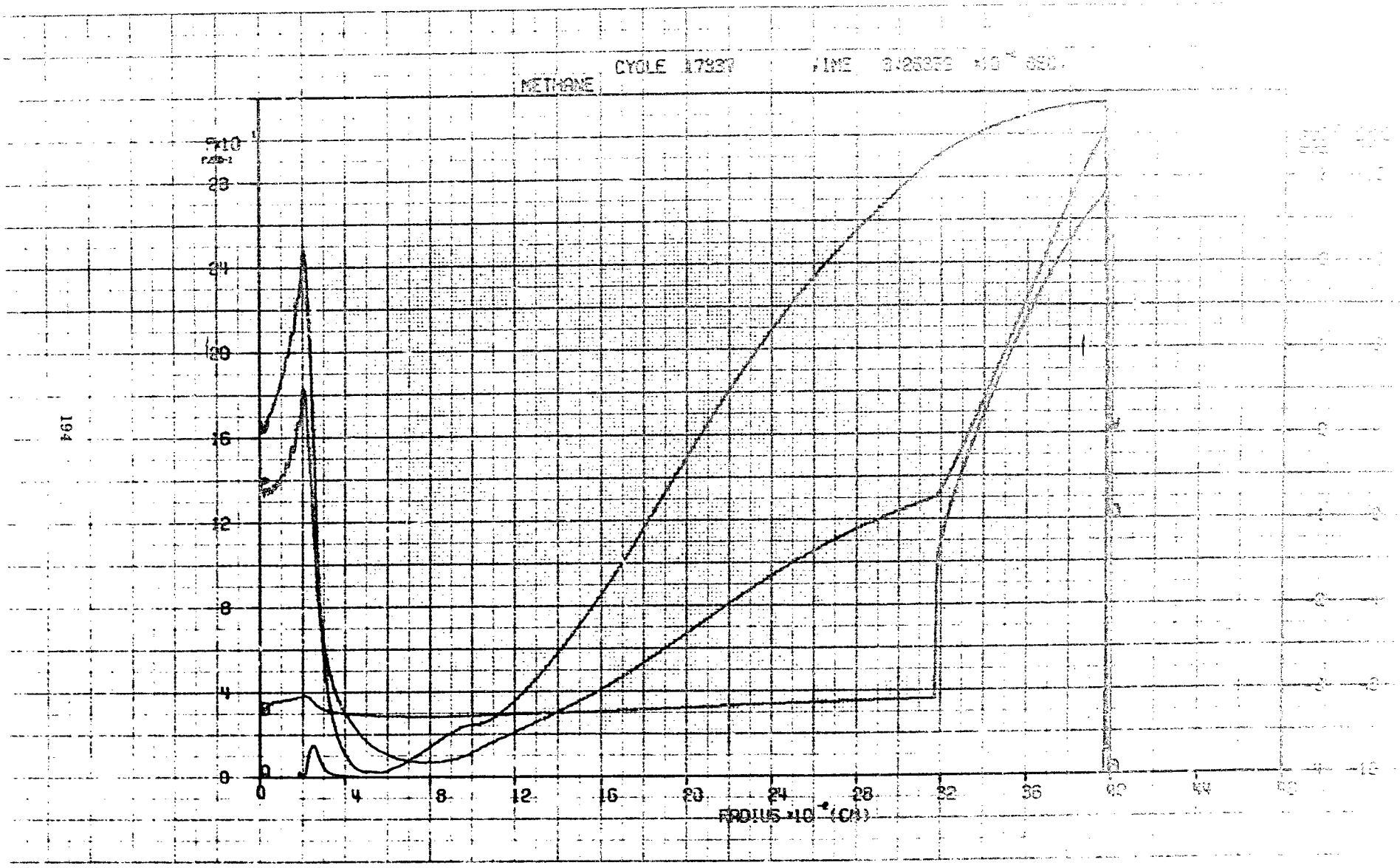

CYCLE 11000
TIME 1.865458 ×10⁻⁶ SEC.
METHANE
P×10⁸
12
10
8
6
4
2
0
-2
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS×10⁻⁴ (CM)

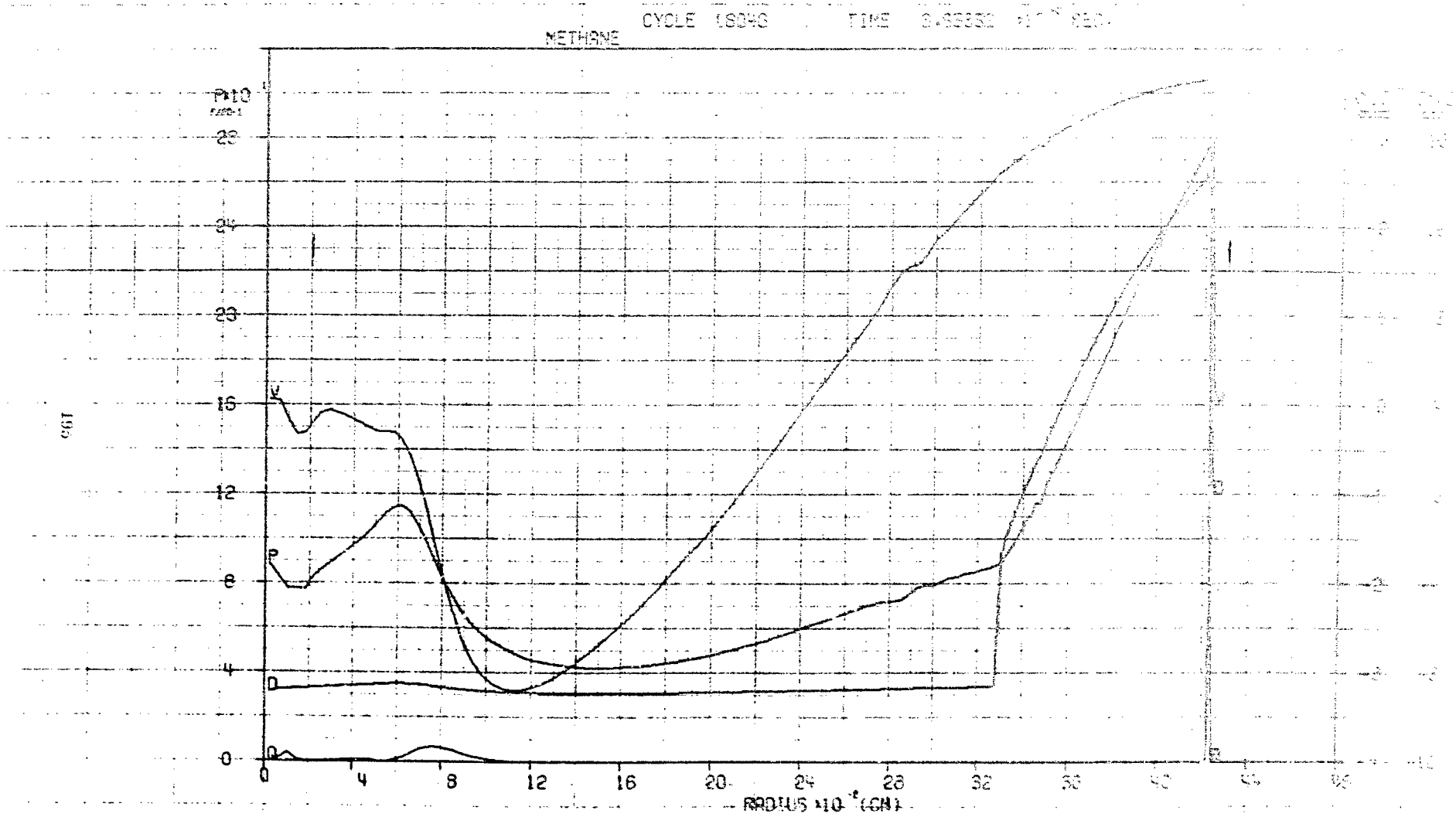

CYCLE 12000
METHANE
RHO
60
50
40
30
20
10
0
-10
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁴ (CM)

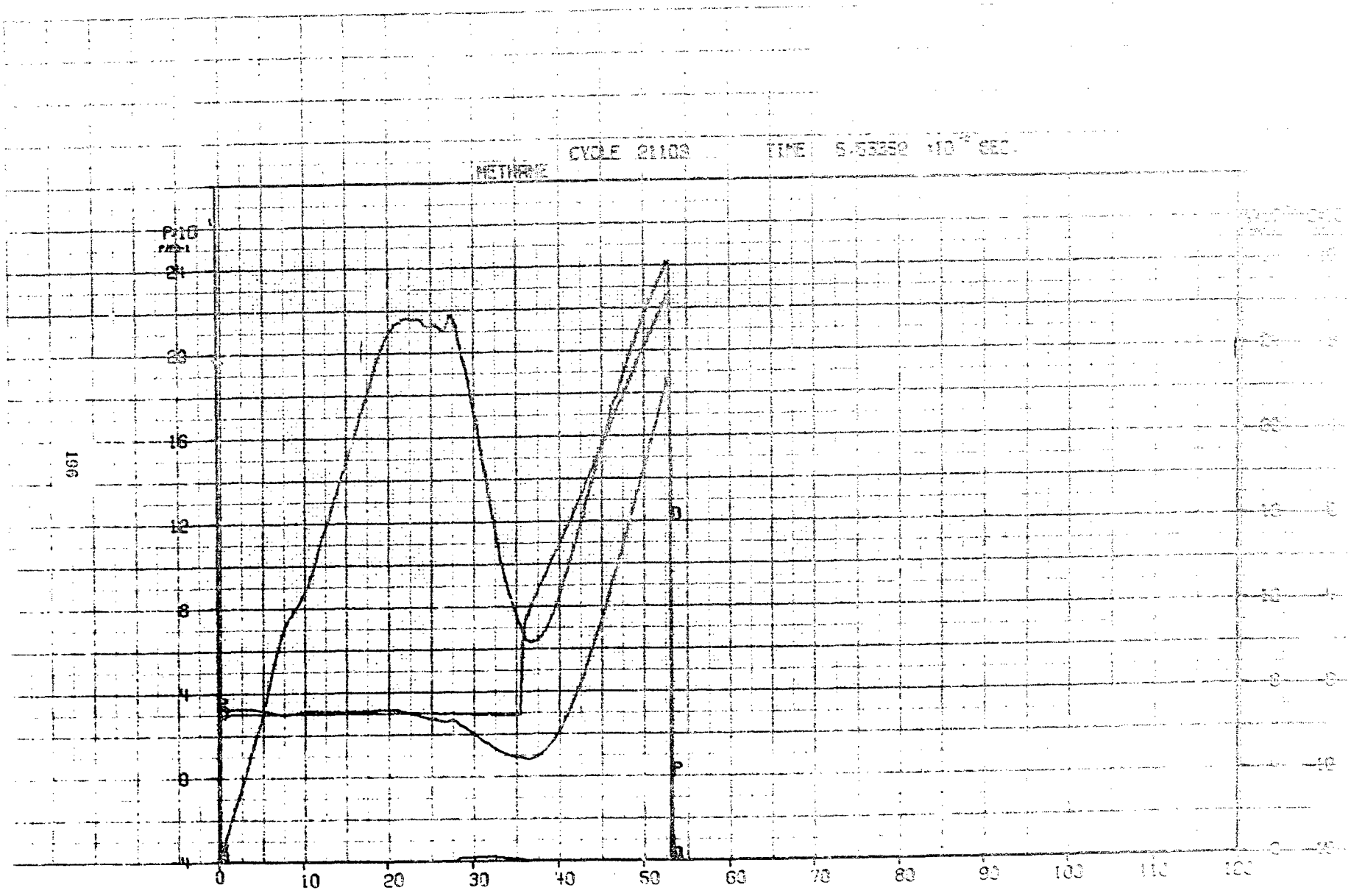

CYCLE 13000
TIME 2.30130 ×10⁻⁸ SEC.
METHANE
P×10¹
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)

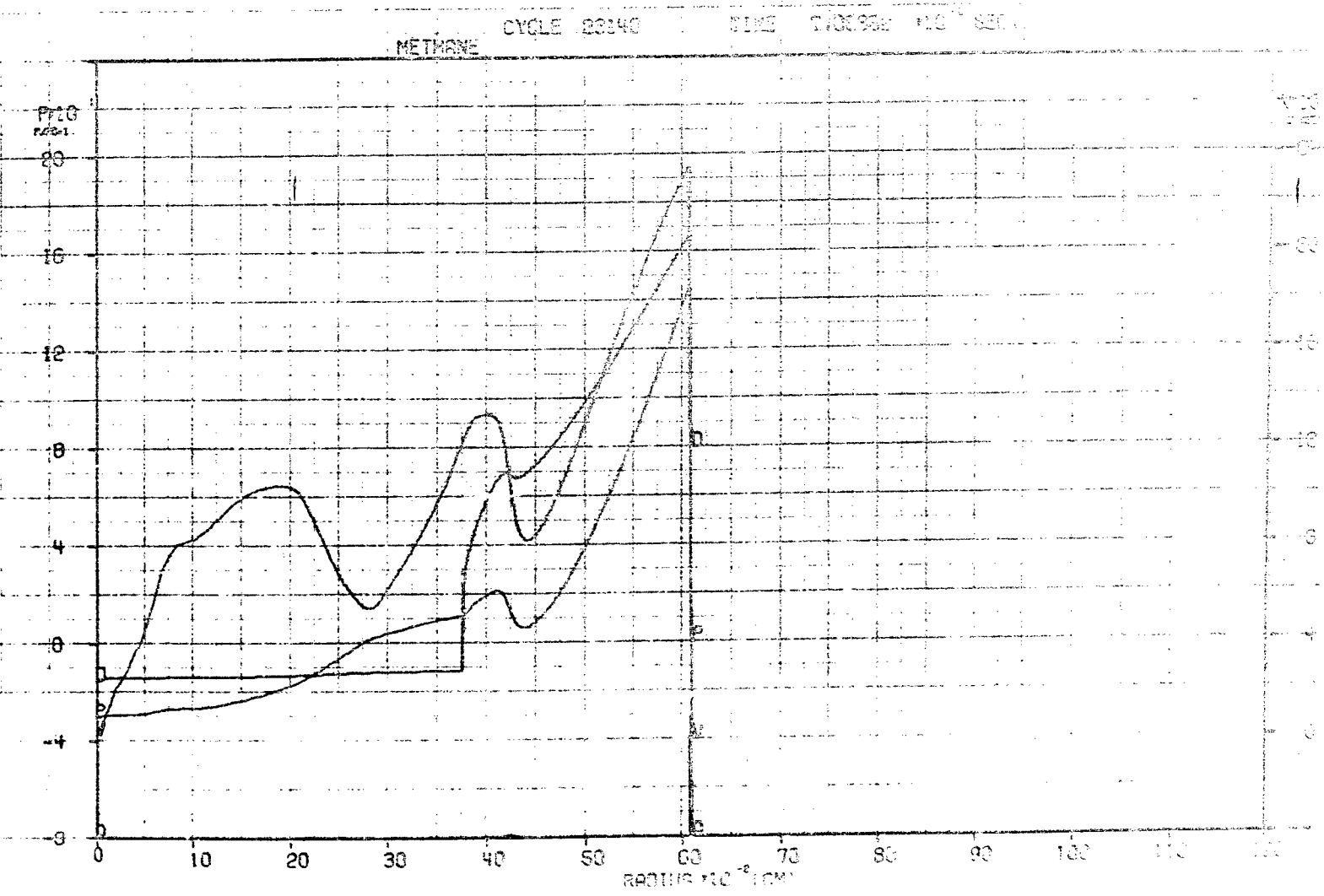

METHANE
CYCLE 15000
P*10
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS *10 (CM)

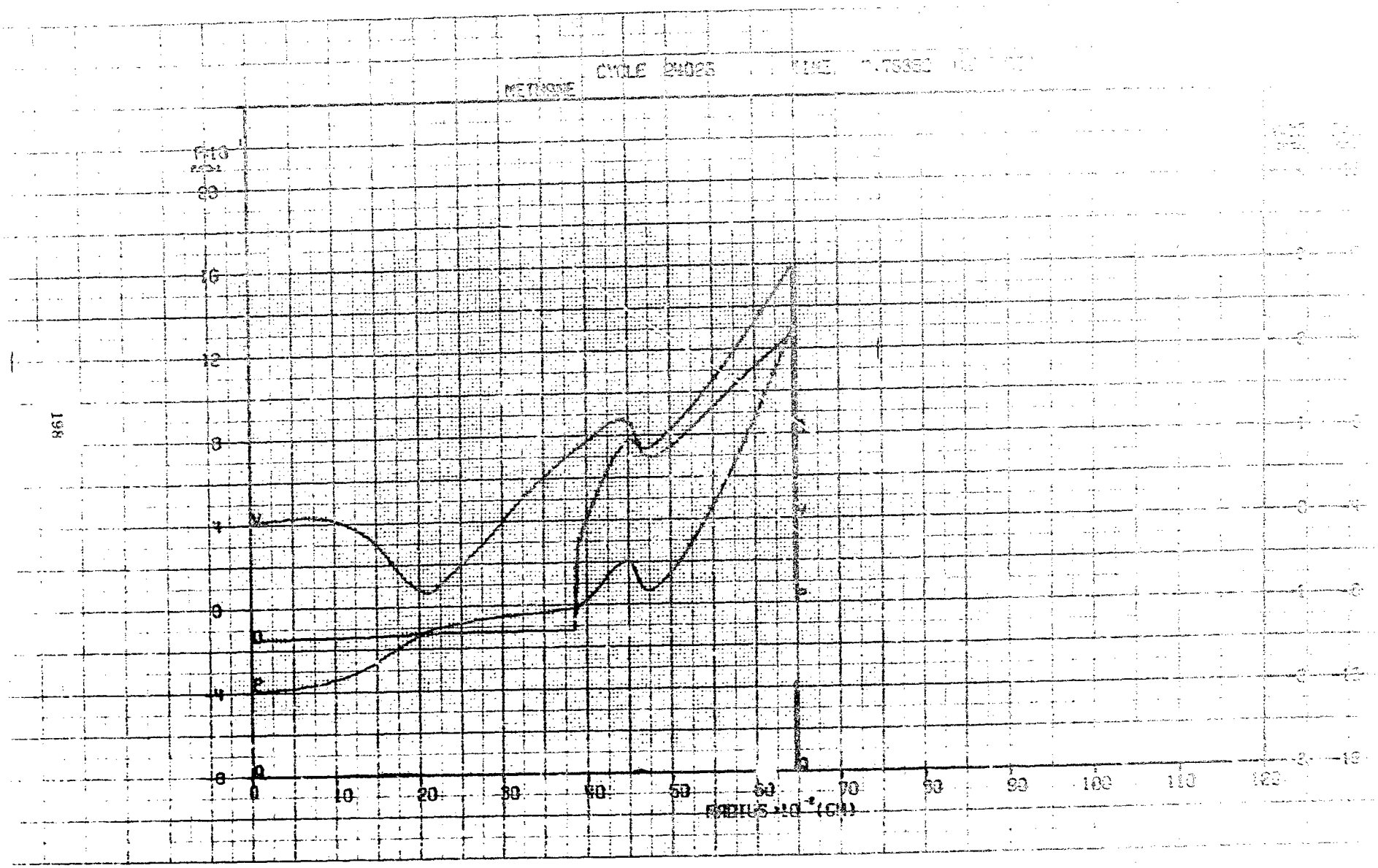

METHANE
CYCLE 16213
TIME: 3.00000 ×10⁻⁹ SEC.
P×10
50
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)

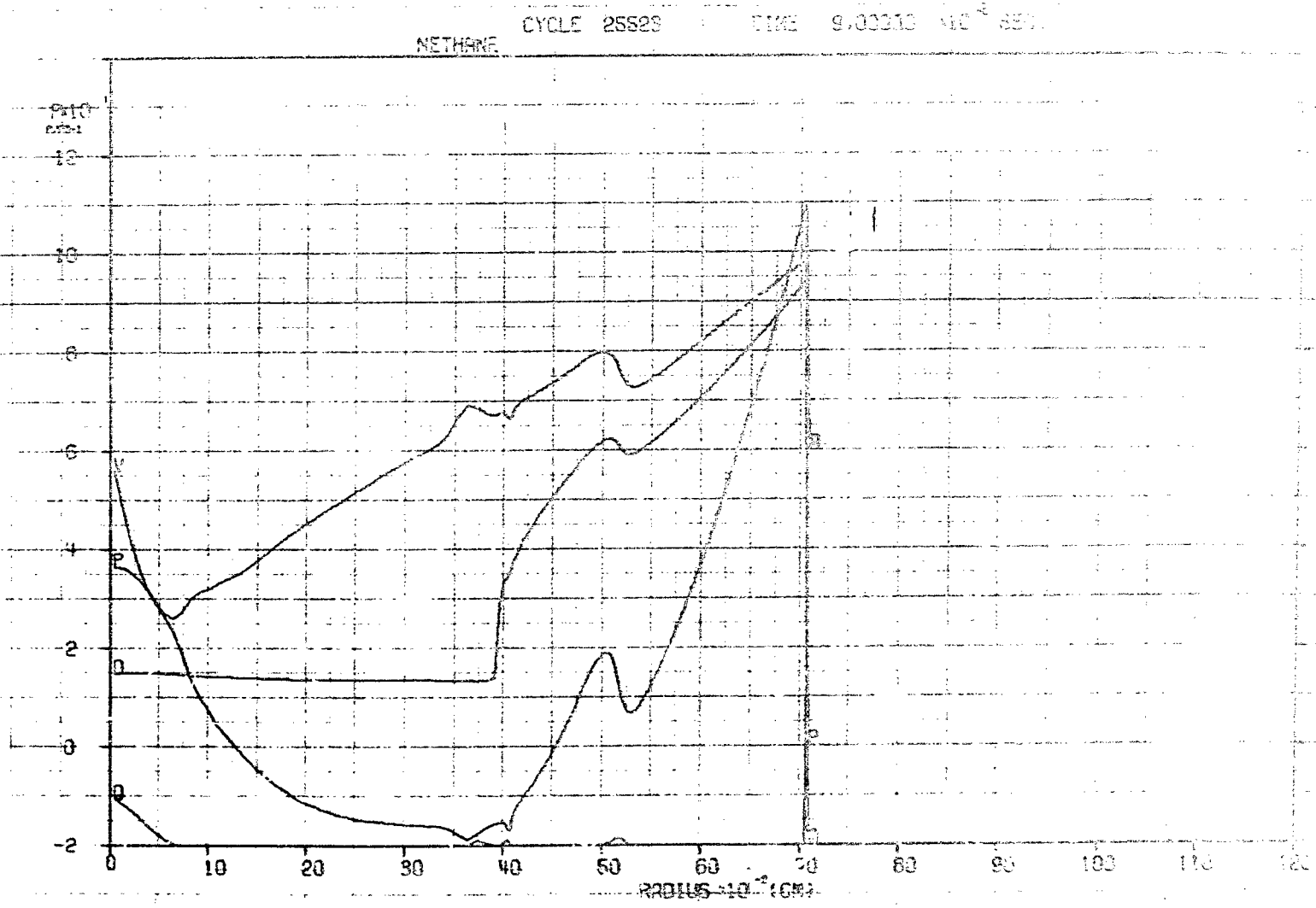

METHANE
CYCLE 17337
TIME
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻² (CM)
0
4
8
12
16
20
24
28

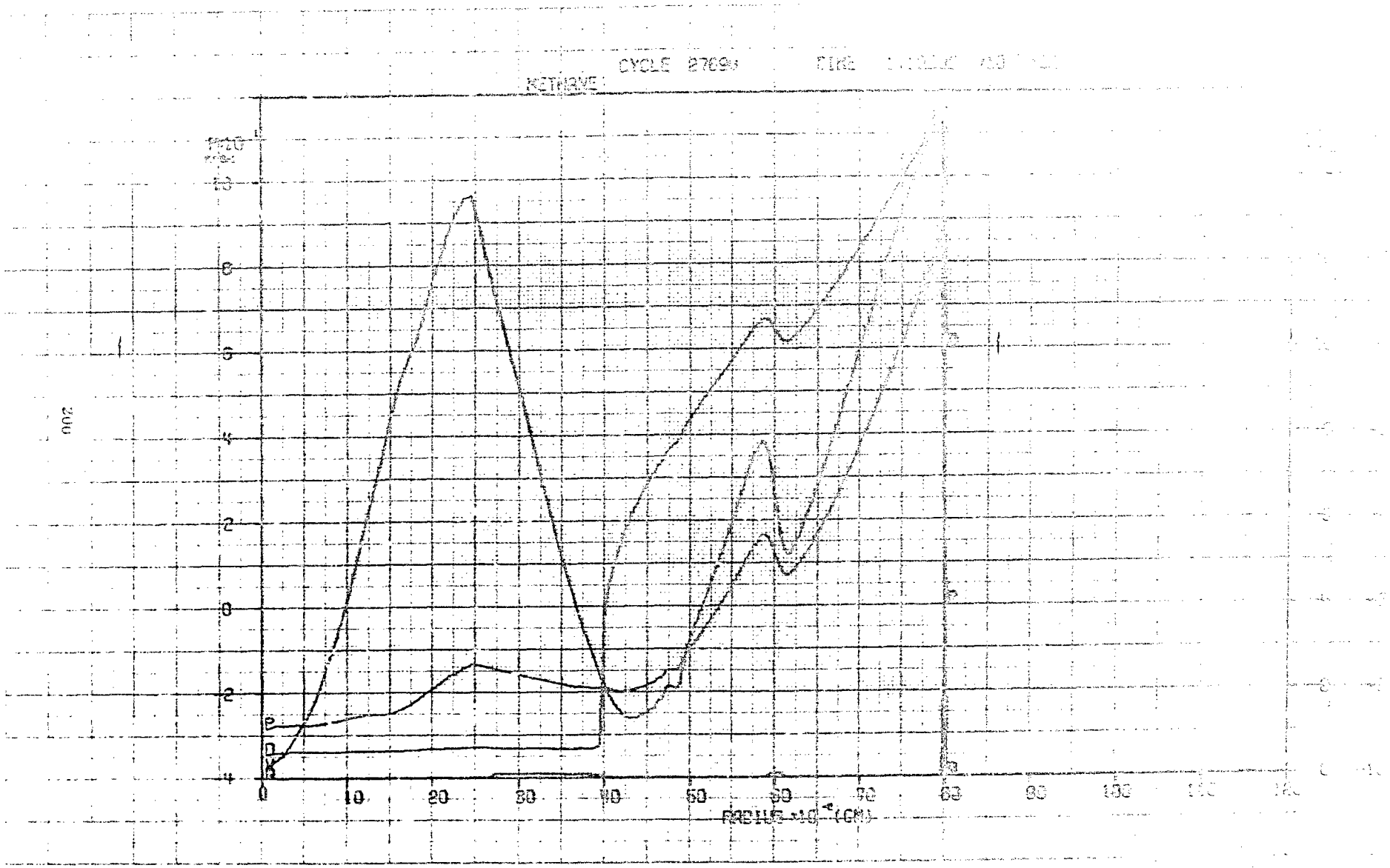

METHANE
CYCLE 18040
TIME
P*10
V
P
D
0
4
8
12
16
20
24
28
32
RADIUS *10 (CM)


CYCLE 21103
METHANE
P*10
0
10
20
30
40
50
60
70
80
90
100
110
120


METHANE
PRLG
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)
0
10
20
30
40
50
60
70
80
90
100
110
120


CYCLE 25523
METHANE
12
10
8
6
4
2
0
-2
0
10
20
30
40
50
60
80
90
100


CYCLE 2769
KETHAVE
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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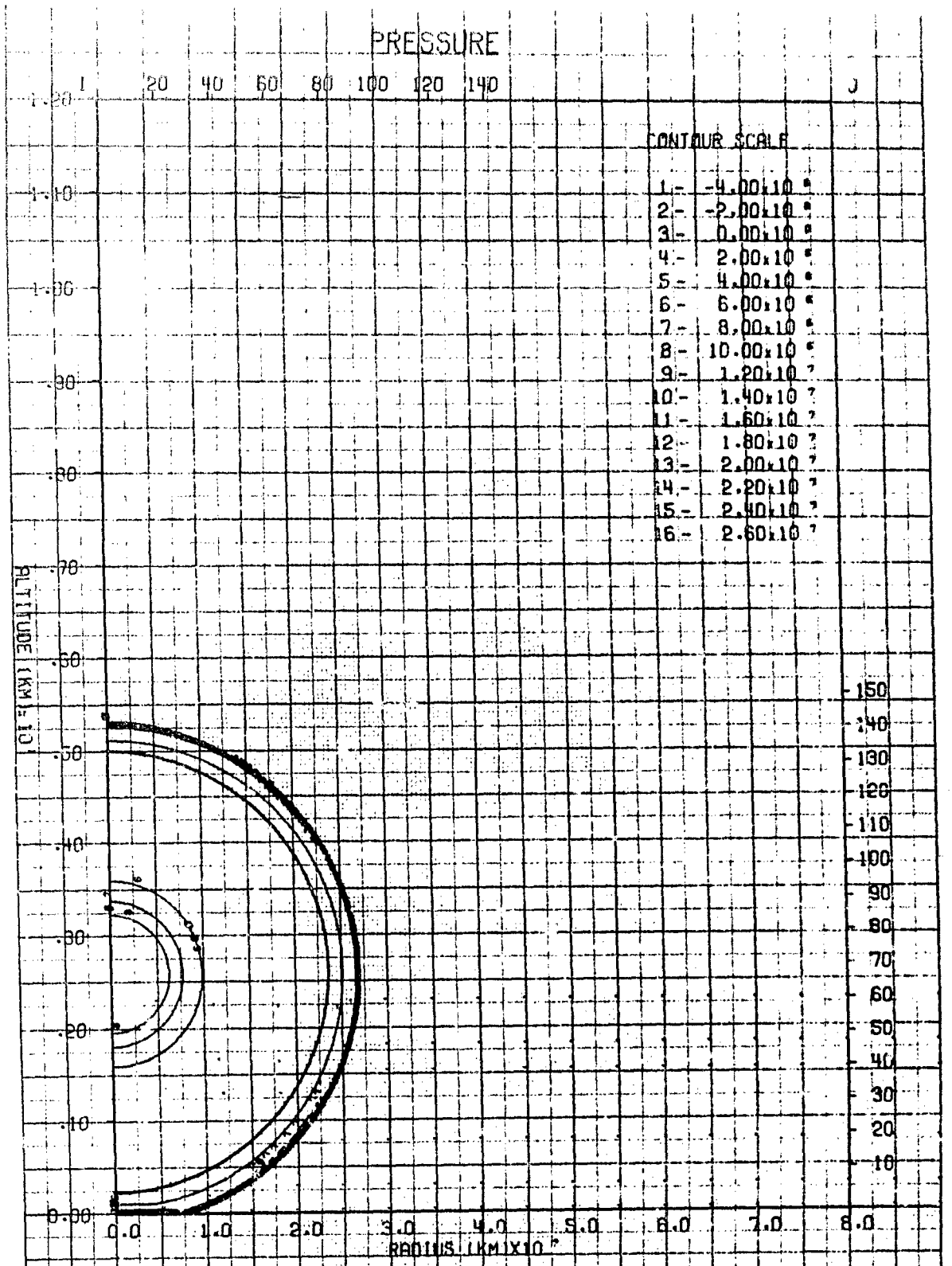
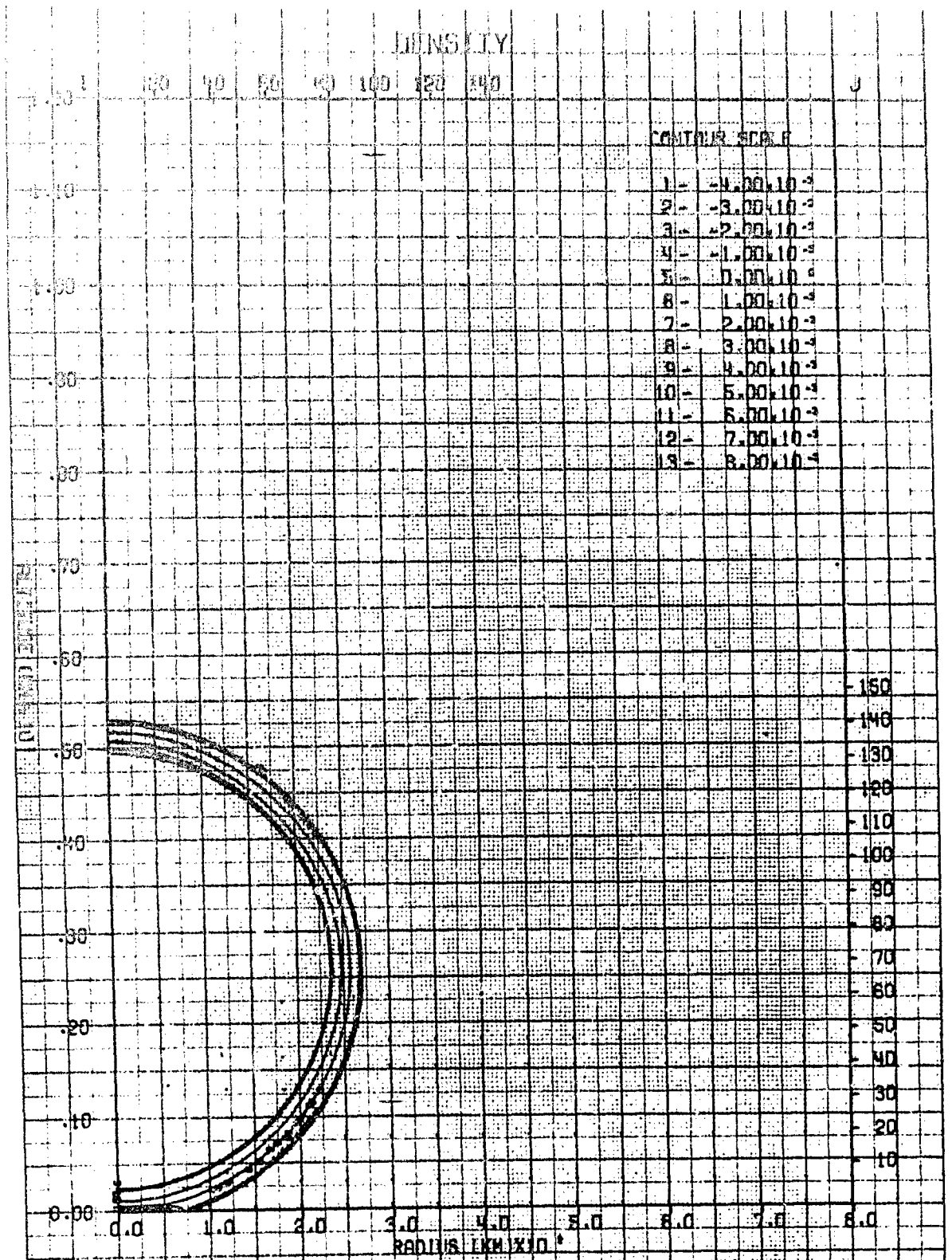
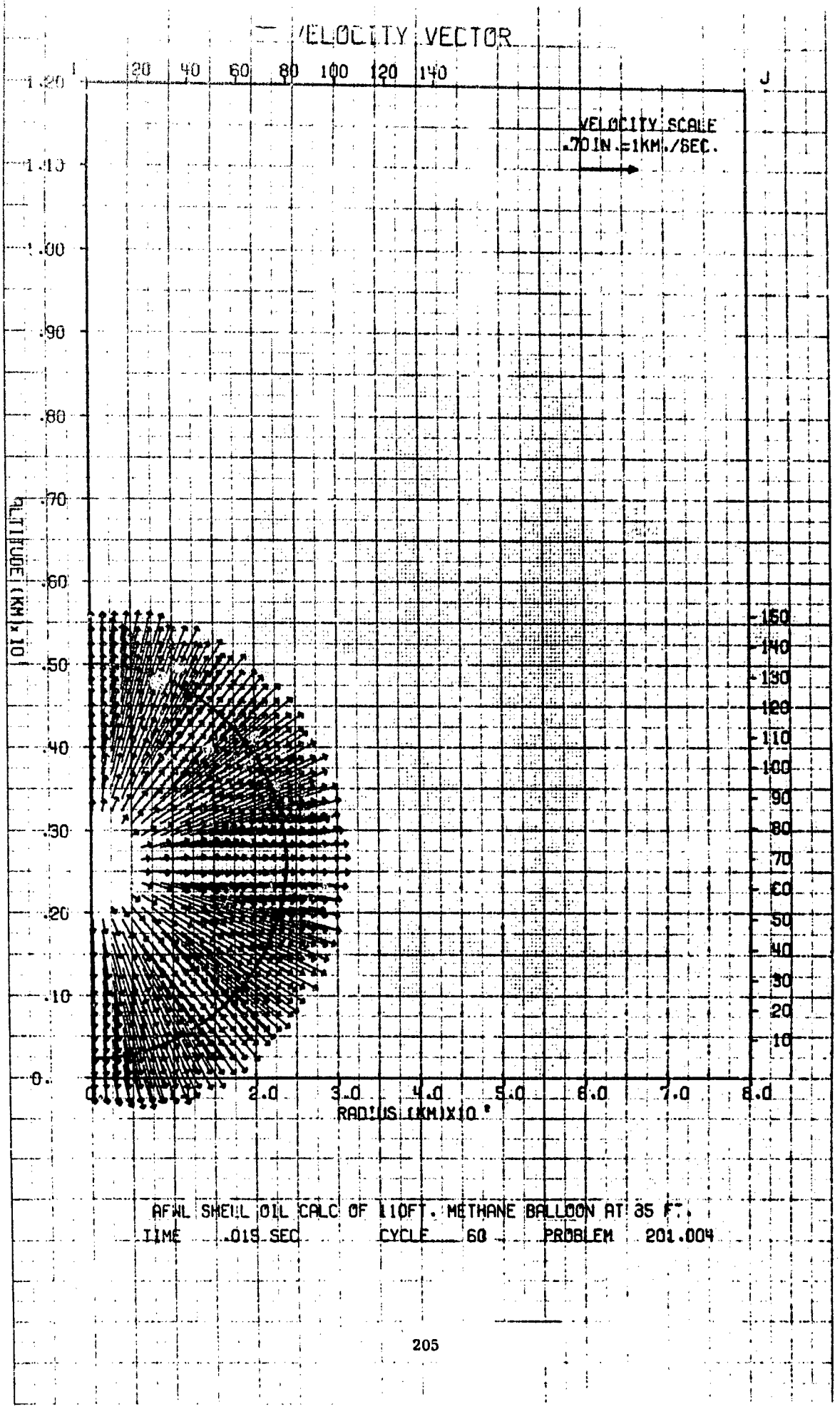
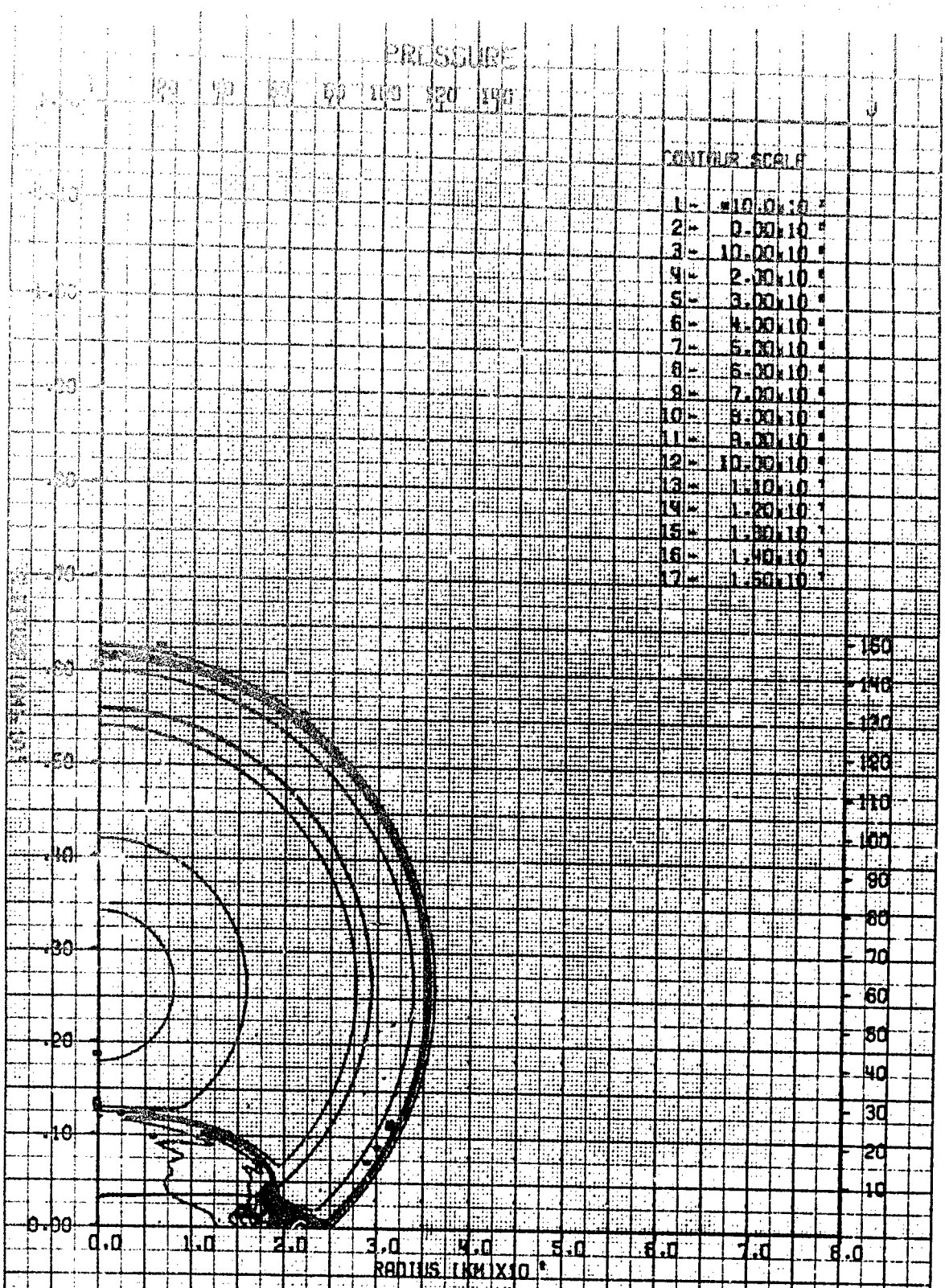

PRESSURE
CONTOUR SCALE
1.- -4.00x10 8
2.- -2.00x10 8
3.- 0.00x10 8
4.- 2.00x10 8
5.- 4.00x10 8
6.- 6.00x10 8
7.- 8.00x10 8
8.- 10.00x10 8
9.- 1.20x10 9
10.- 1.40x10 9
11.- 1.60x10 9
12.- 1.80x10 9
13.- 2.00x10 9
14.- 2.20x10 9
15.- 2.40x10 9
16.- 2.60x10 9
ALTITUDE (KM)=10
RADIUS (KM)X10 3
AFWL SHELL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

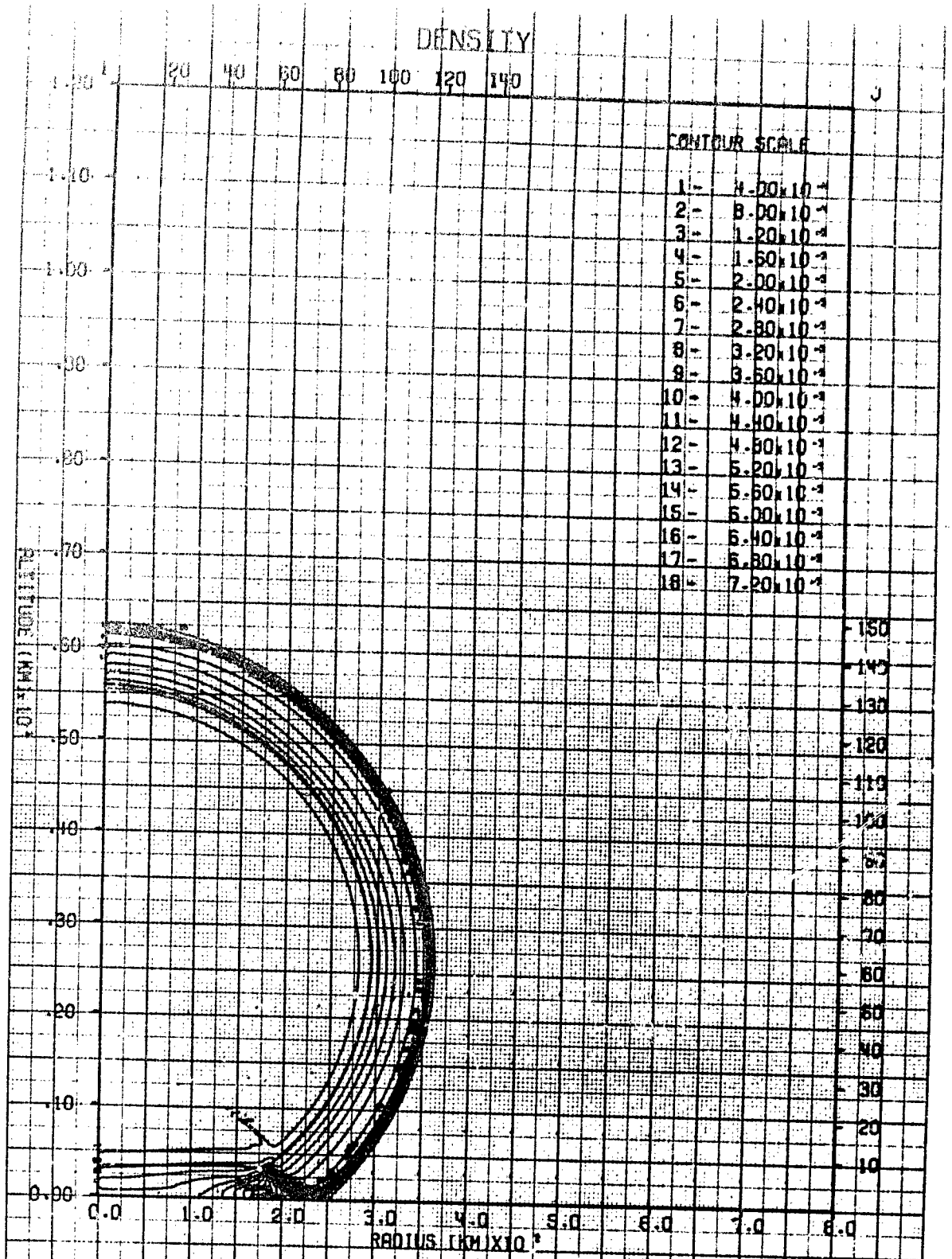


AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .015 SEC CYCLE 80. PROBLEM POL.004

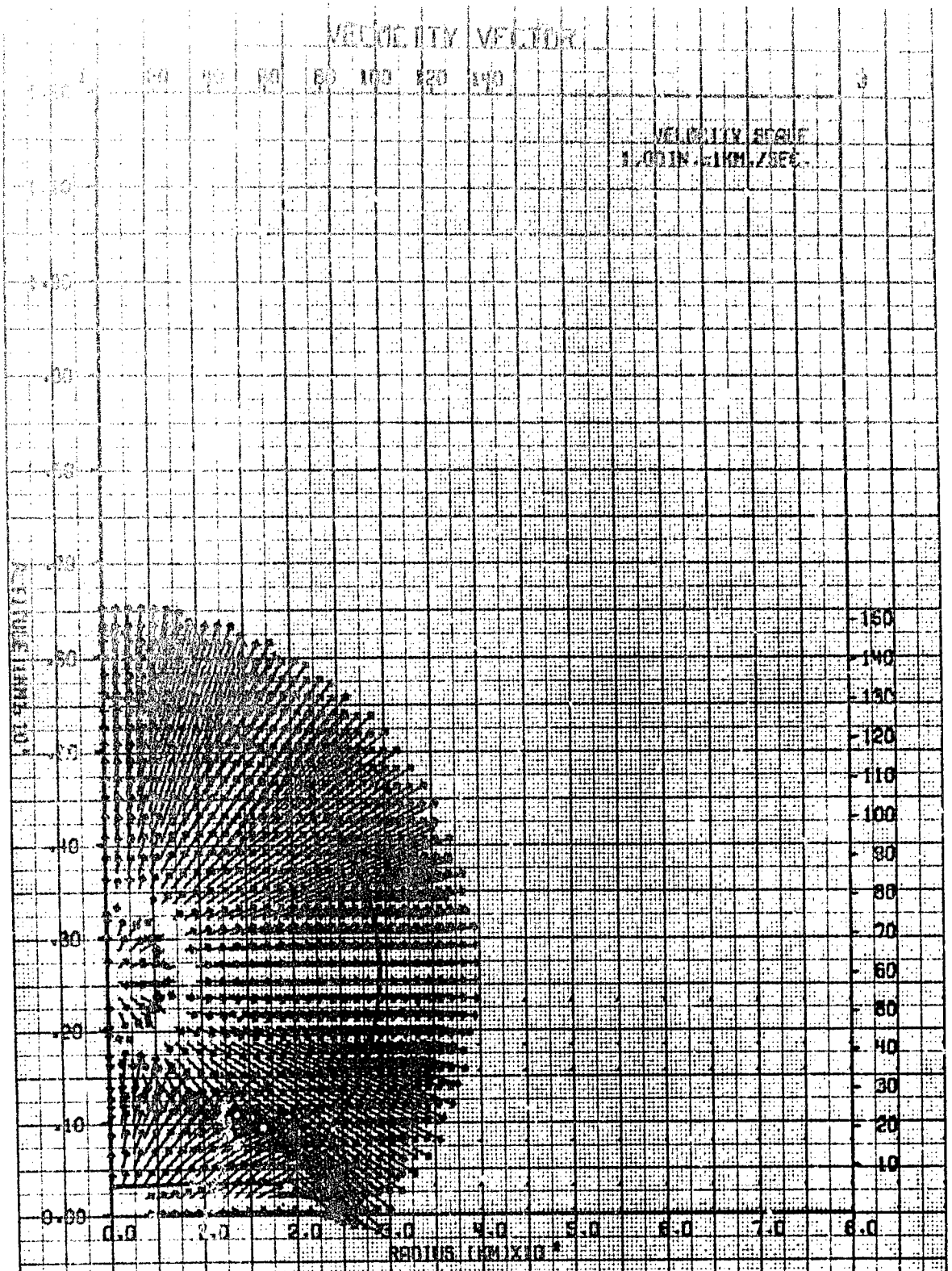

VELOCITY VECTOR
VELOCITY SCALE
.70 IN. = 1KM./SEC.
ALTITUDE (KM) x 10
RADIUS (KM) X10
AFWL SHELL OIL CALC OF 110FT. METHANE BALLOON AT 35 FT.
TIME .015 SEC CYCLE 60 PROBLEM 201.004



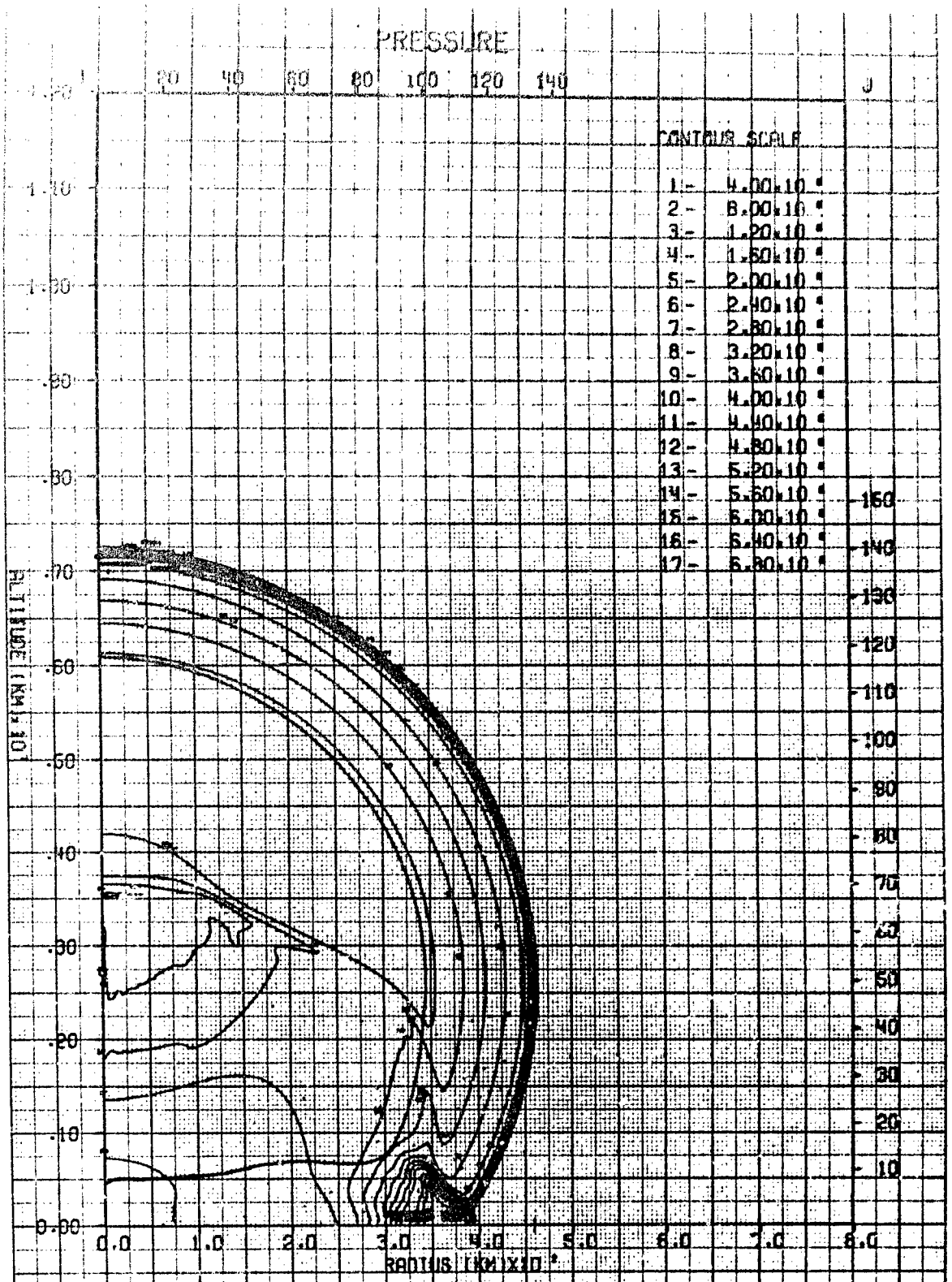
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .026 SEC CYCLE 151 PROBLEM 201.004 9



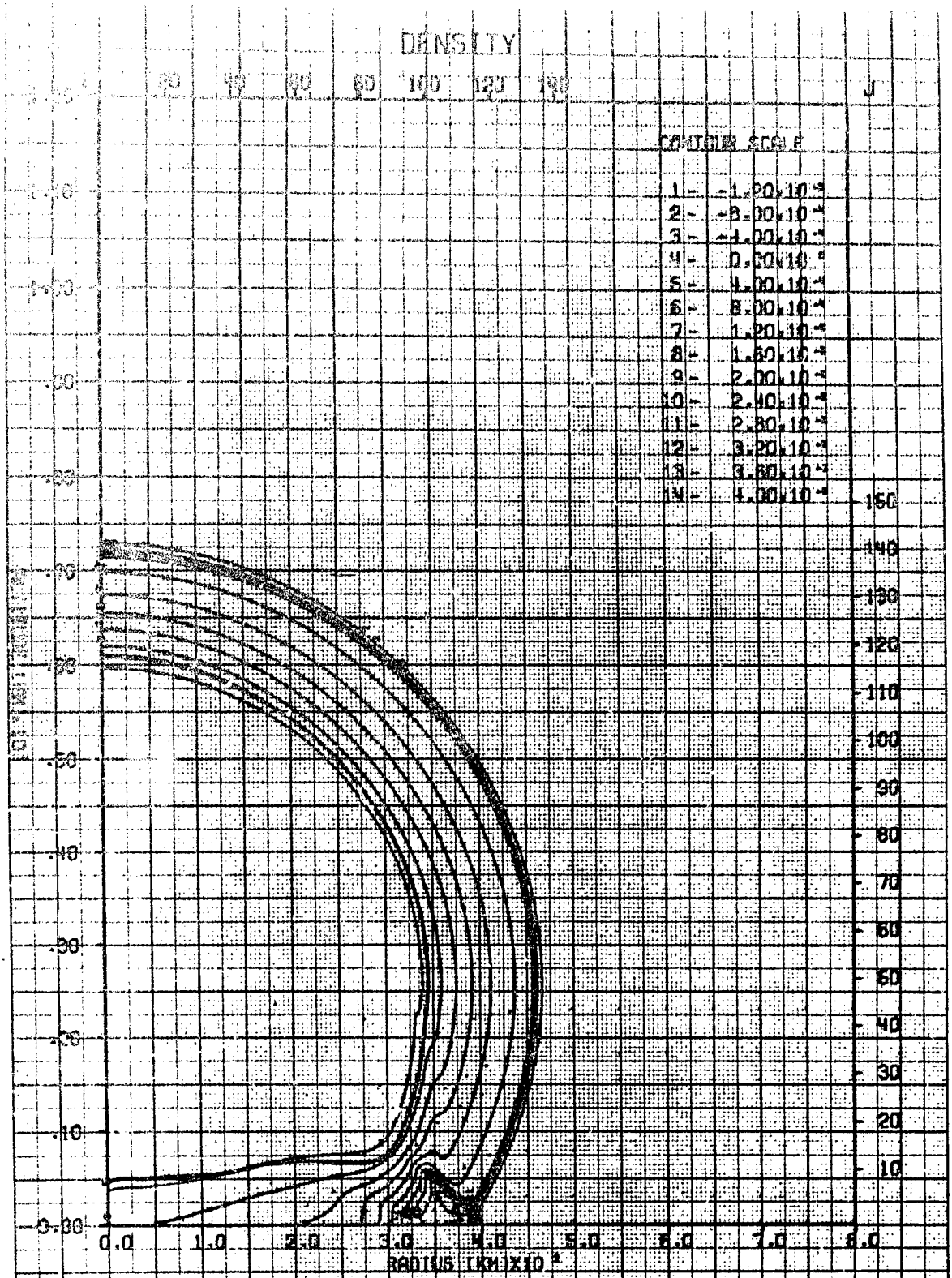
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .026 SEC CYCLE 151. PROBLEM 201.004 /0



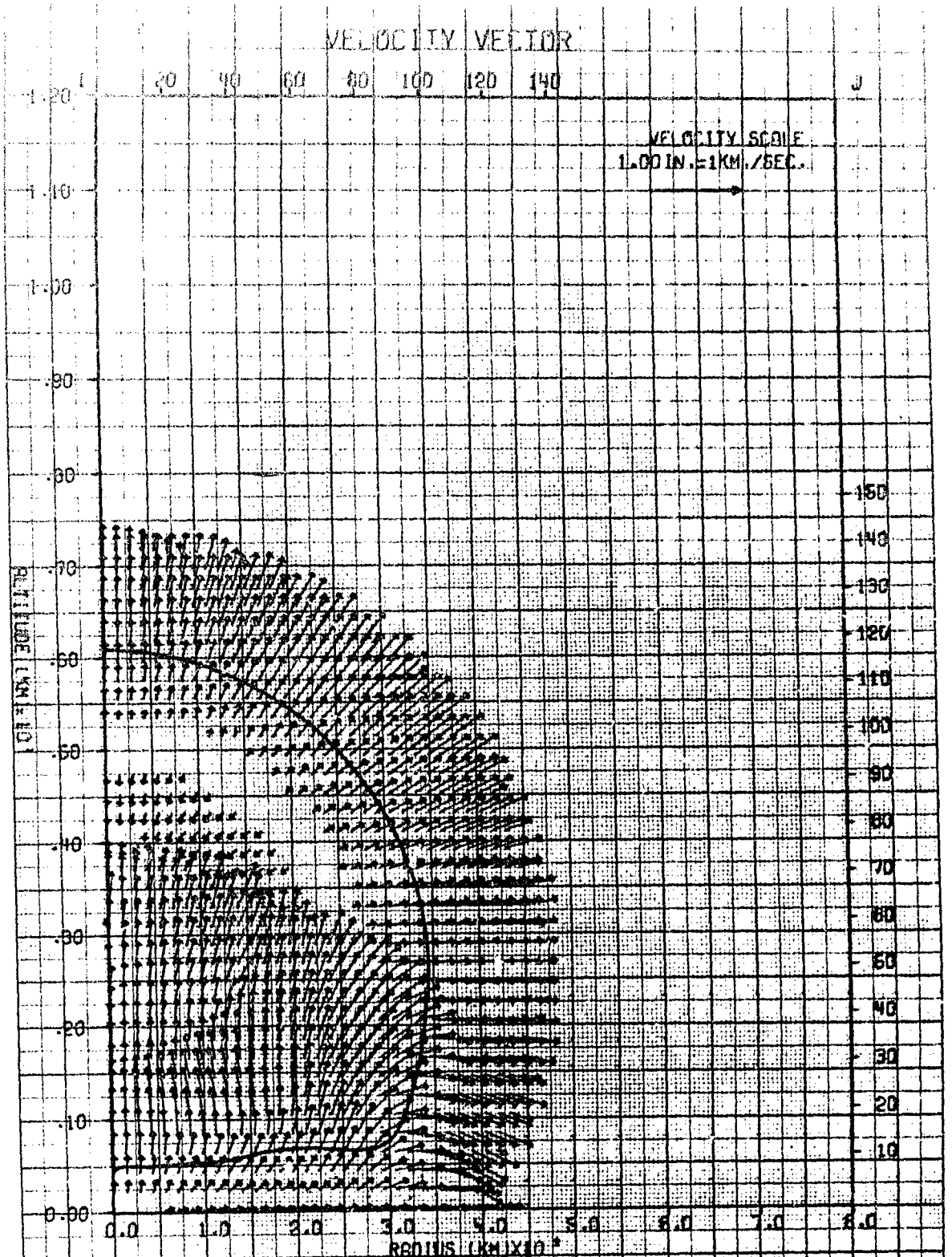
RFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .028 SEC CYCLE 151. PROB.FM 201.00%



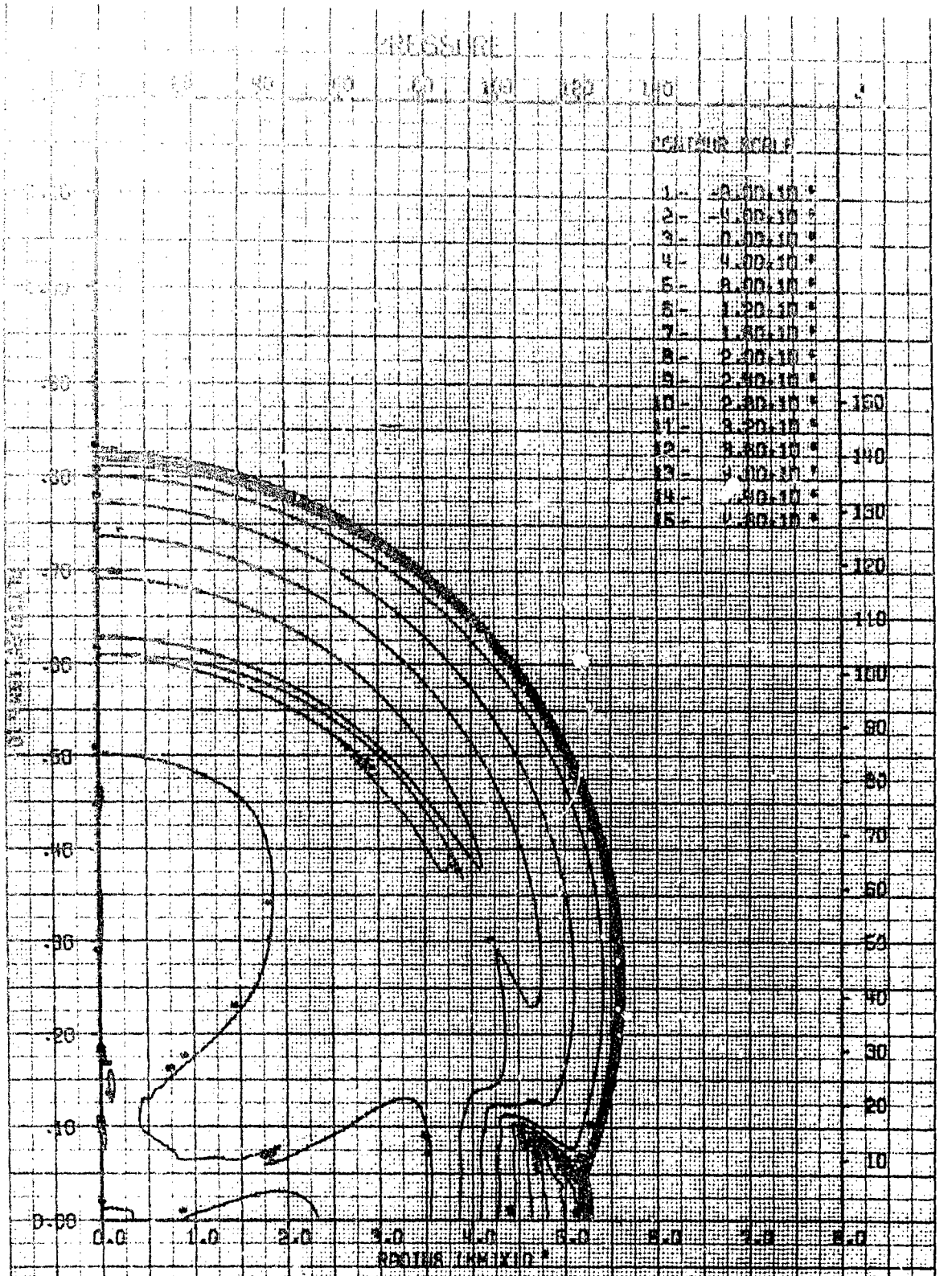
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 286 PROBLEM 201.009



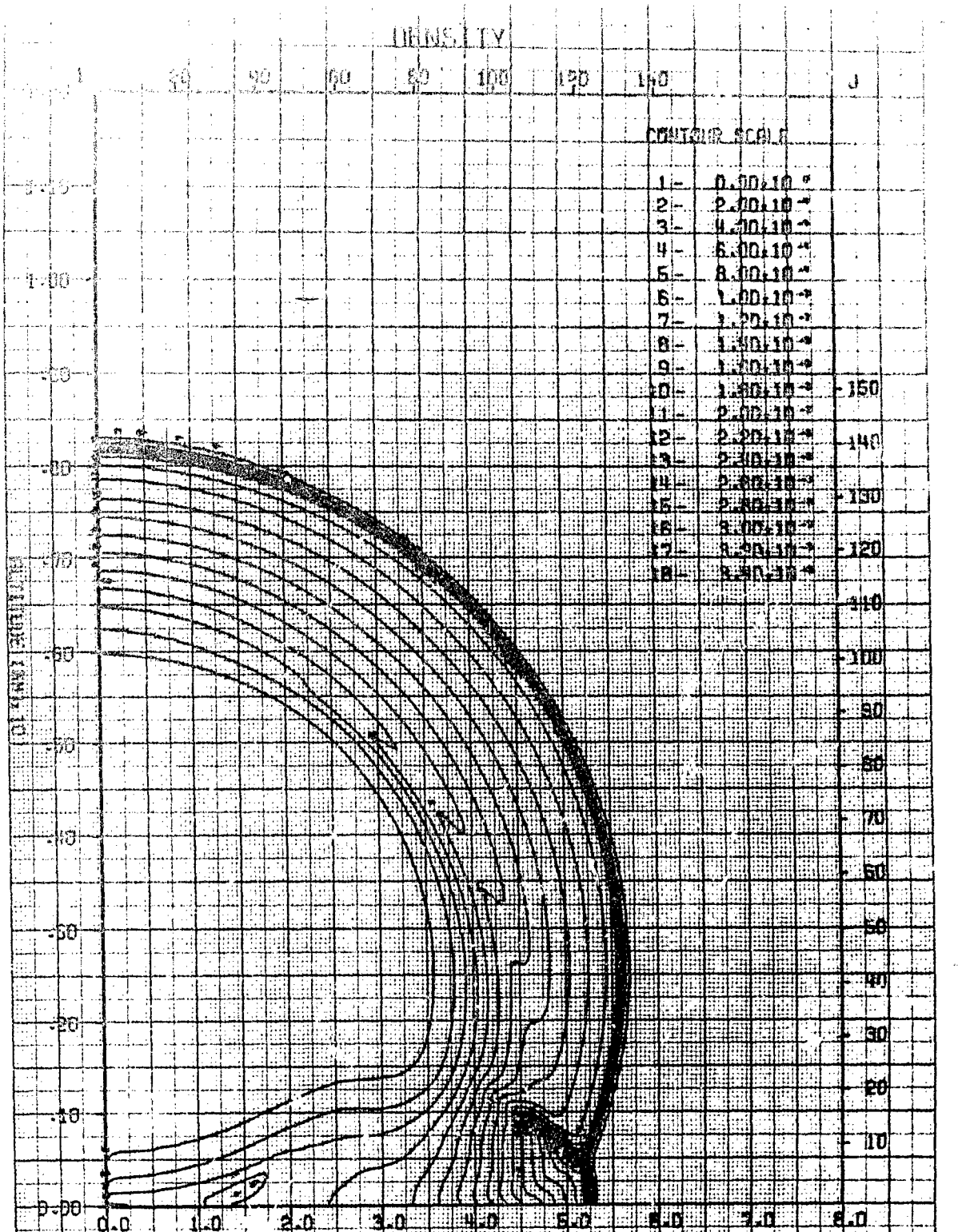
RFW. SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 266. PROBLEM 201.004 13



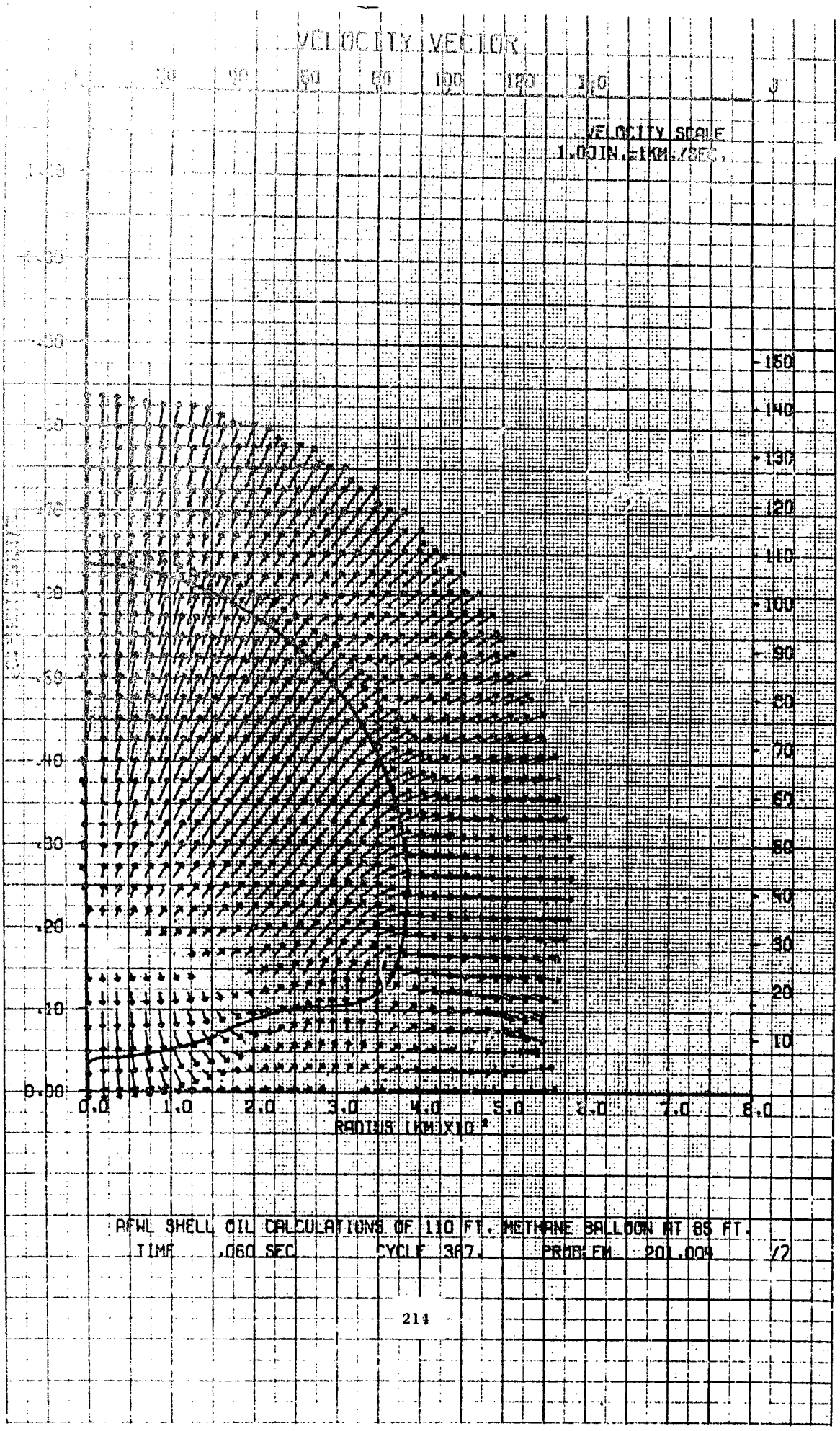
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .042 SEC CYCLE 286. PROBLEM 201.004

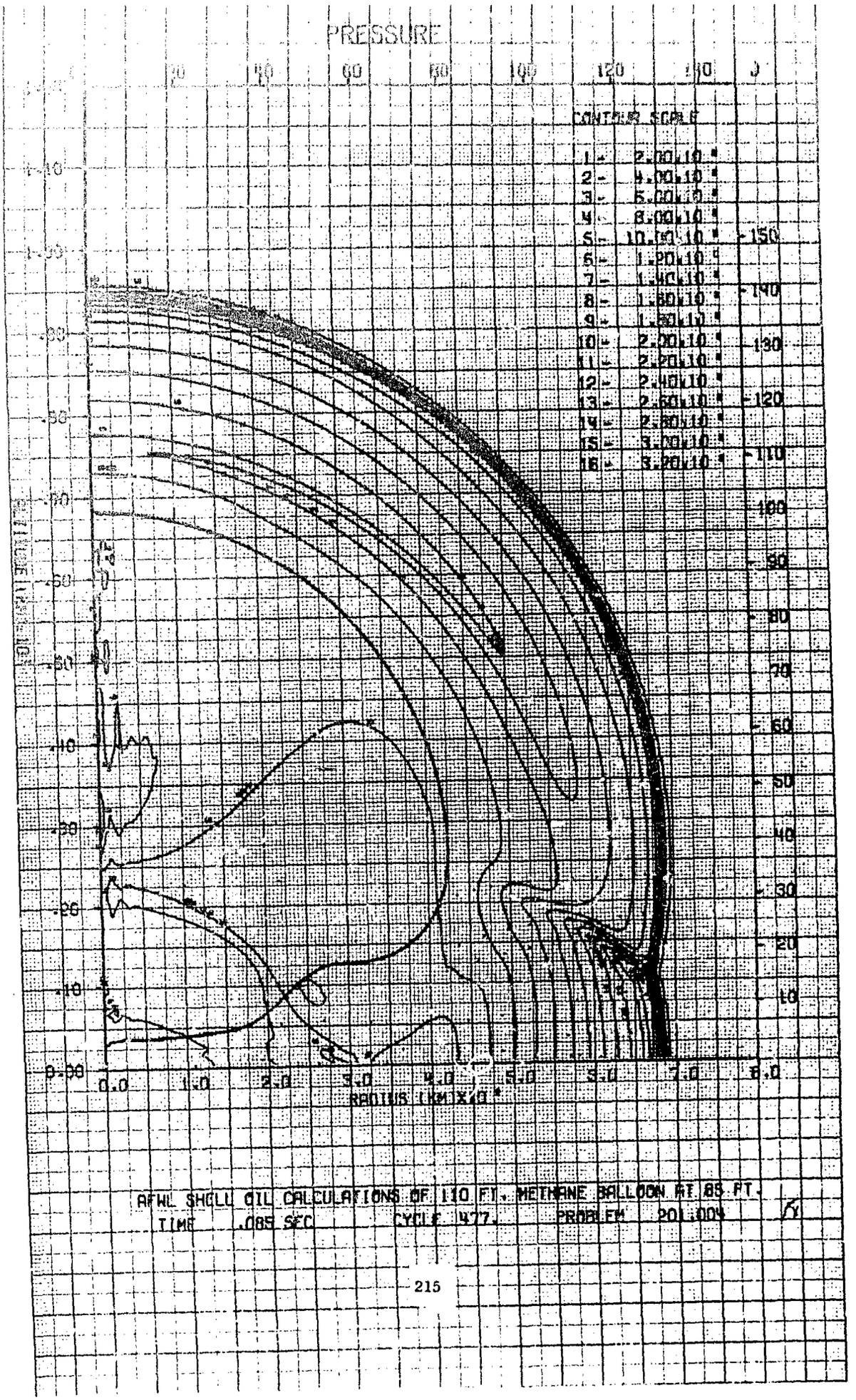


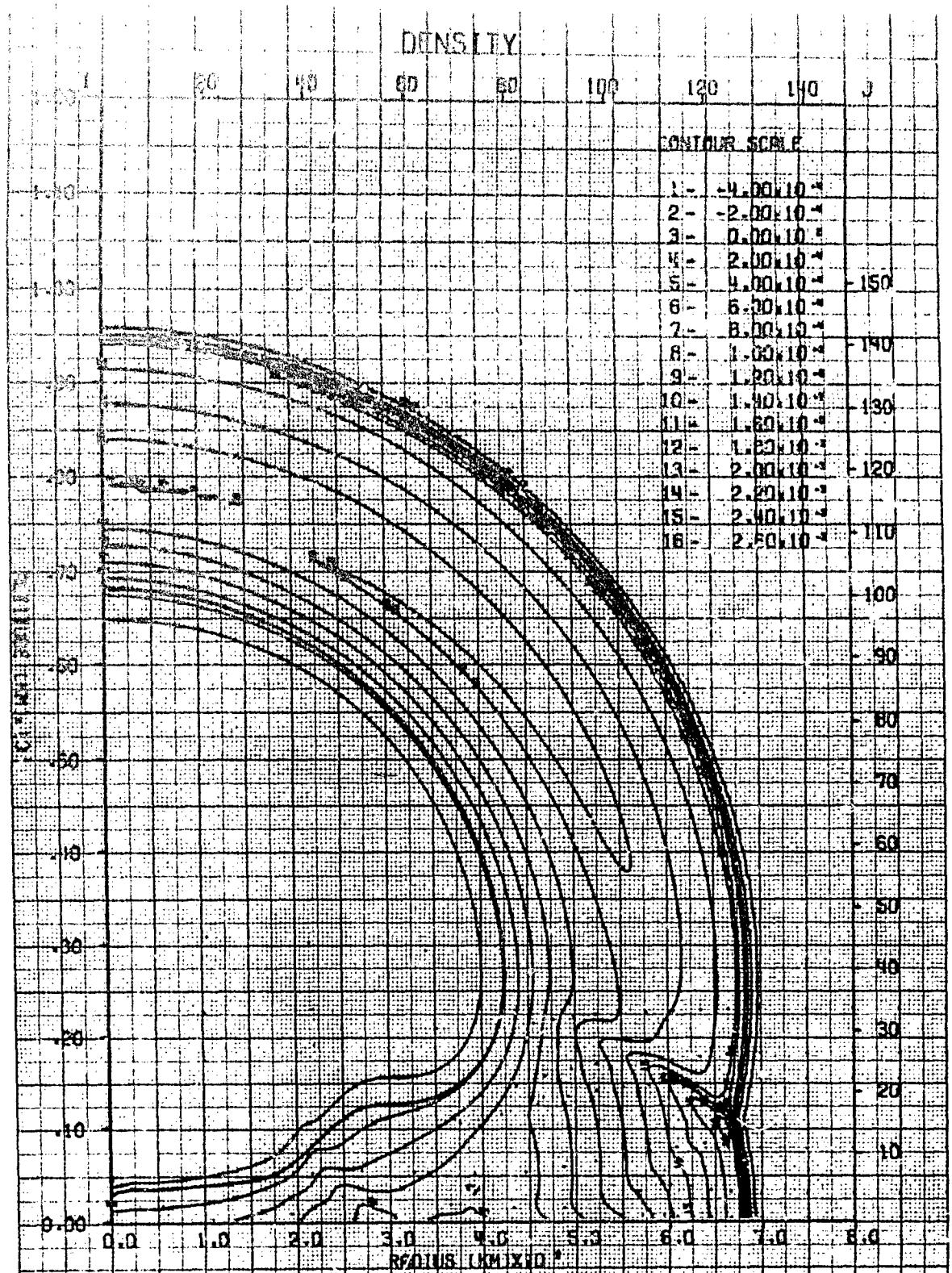
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 86 FT.
TIME .060 SEC CYCLE 387. PROBLEM 201.004



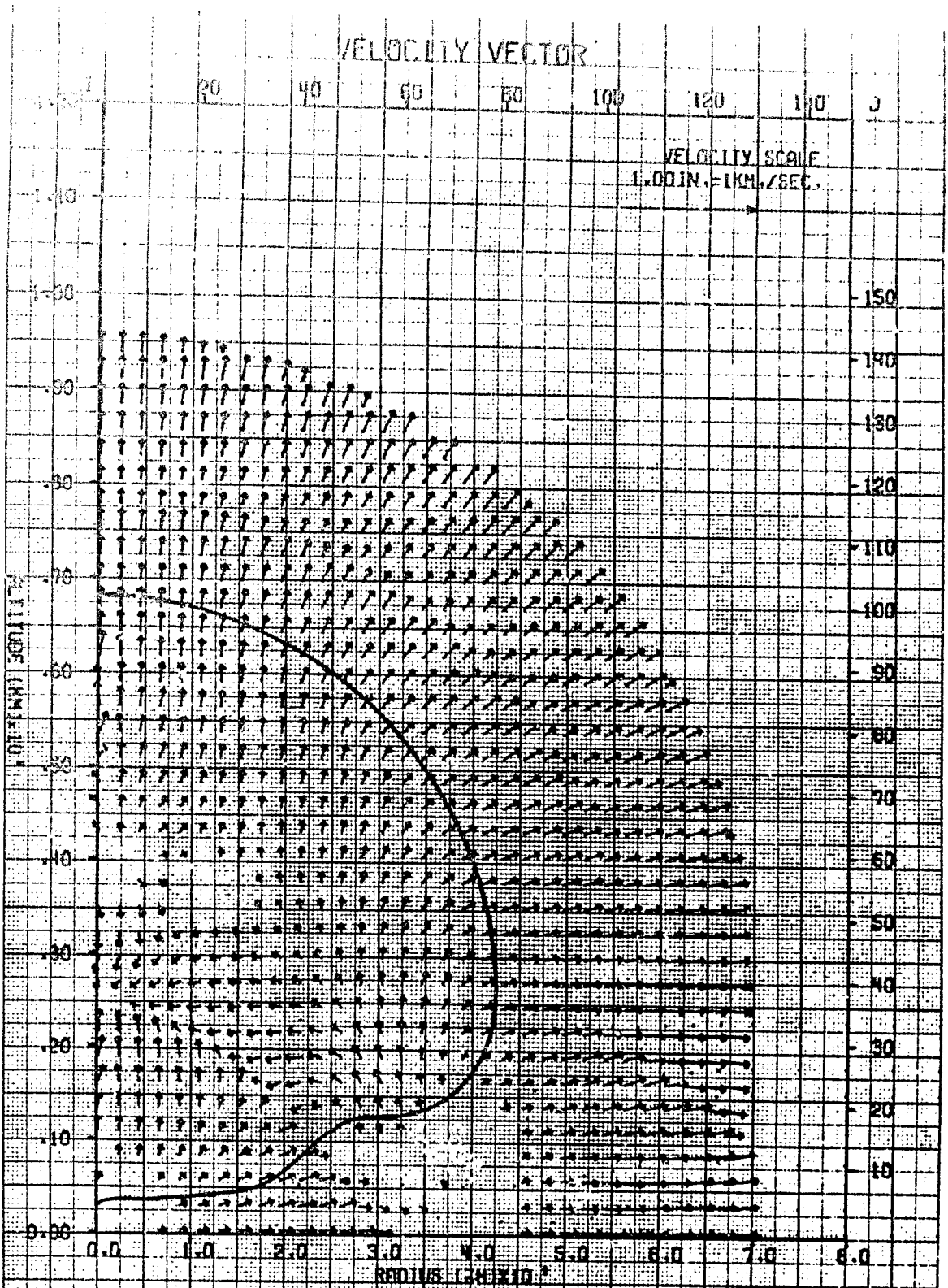
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .060 SEC CYCLE 367. PROBLEM 201.004 16


VELOCITY VECTOR
VELOCITY SCALE
1.00IN.=1KM/SEC.
RADIUS (KM)X10 4
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .060 SEC CYCLE 387. PROBLEM 201.004 /2

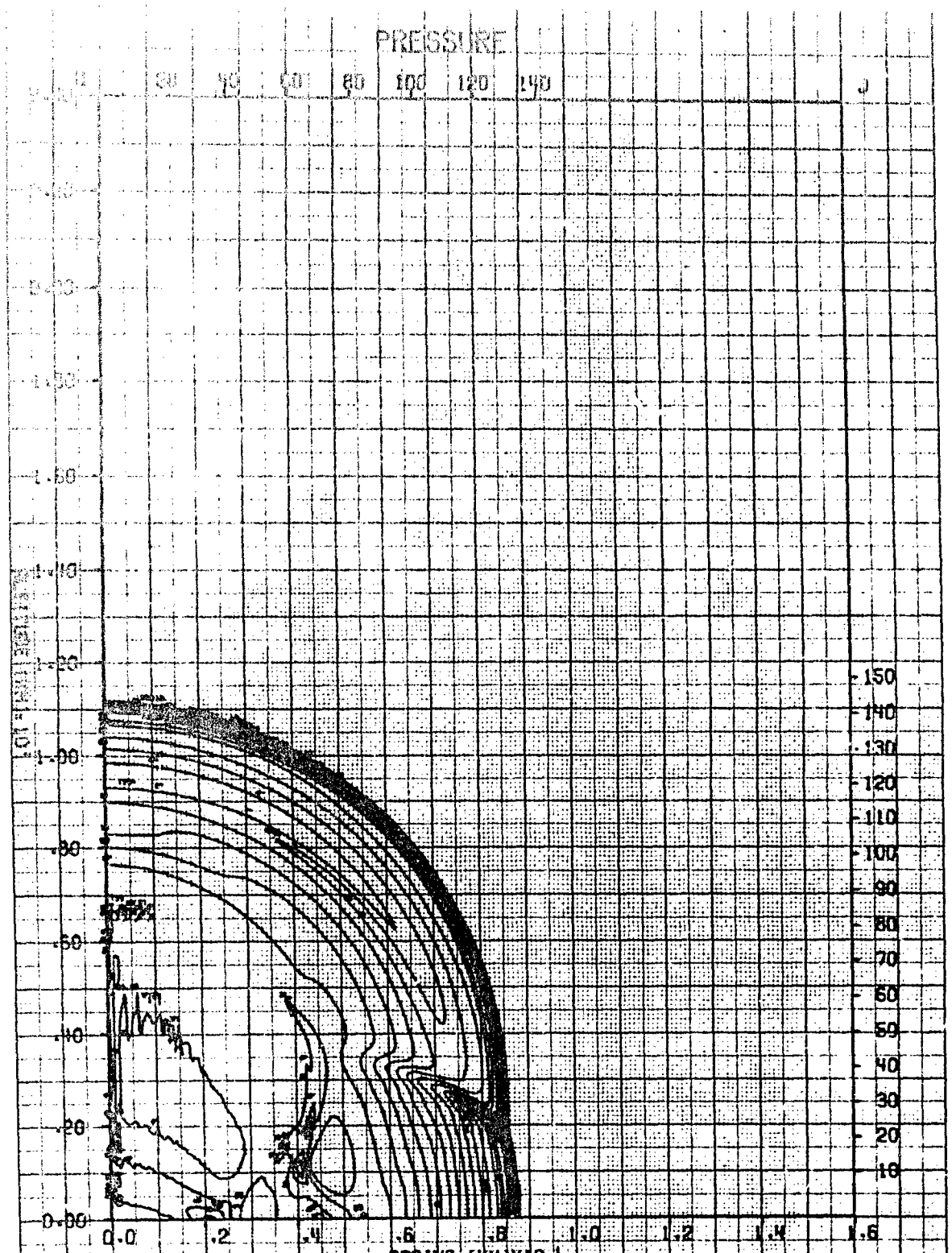

PRESSURE
CONTOUR SCALE
1 - 2.00x10
2 - 4.00x10
3 - 6.00x10
4 - 8.00x10
5 - 10.00x10
6 - 1.20x10
7 - 1.40x10
8 - 1.60x10
9 - 1.80x10
10 - 2.00x10
11 - 2.20x10
12 - 2.40x10
13 - 2.60x10
14 - 2.80x10
15 - 3.00x10
16 - 3.20x10
RADIUS (KM)x10
AFWL SHOCK OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC CYCLE 477. PROBLEM P01.004



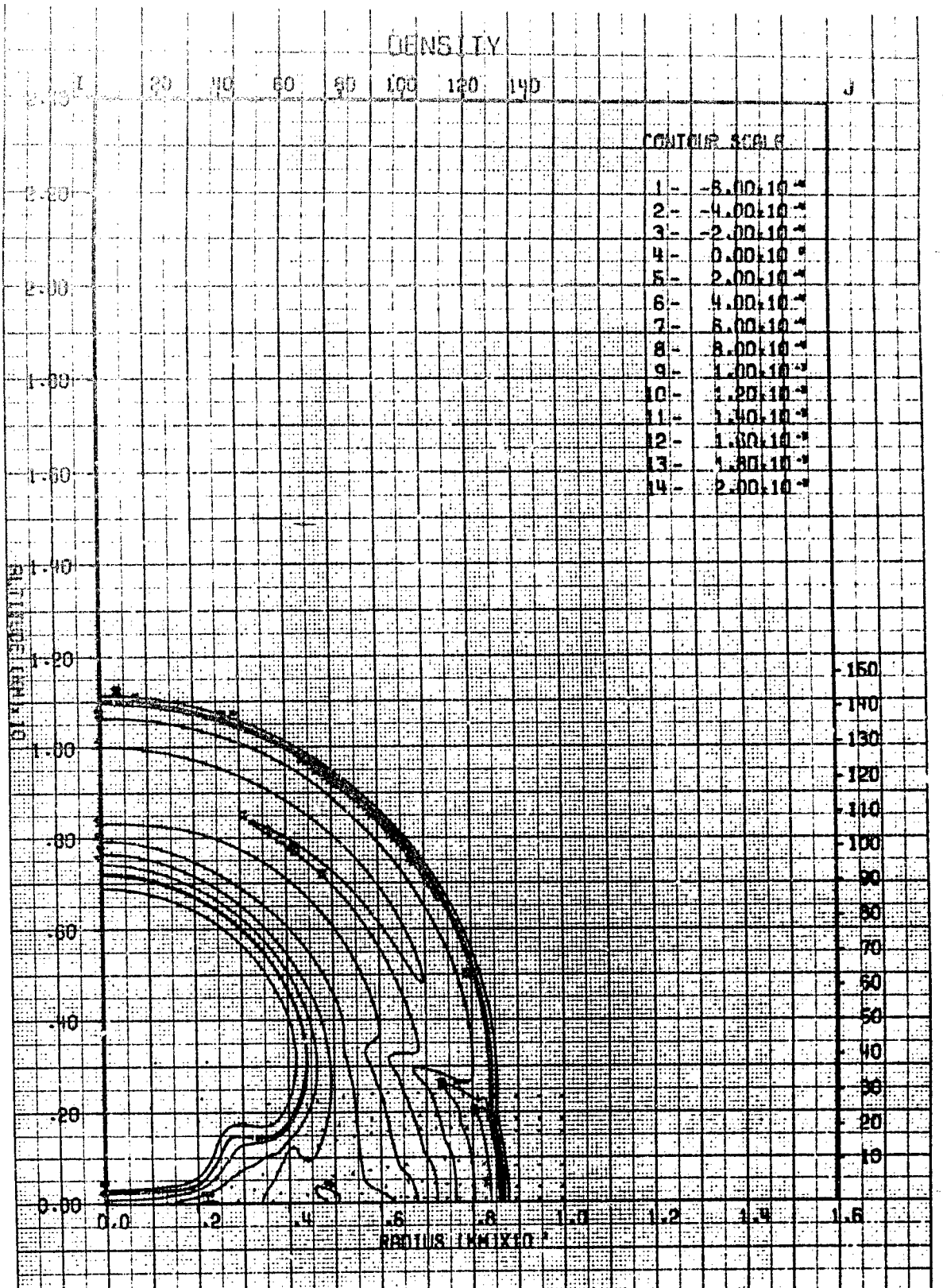
RFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC CYCLE 477. PROBLEM 201.004 19



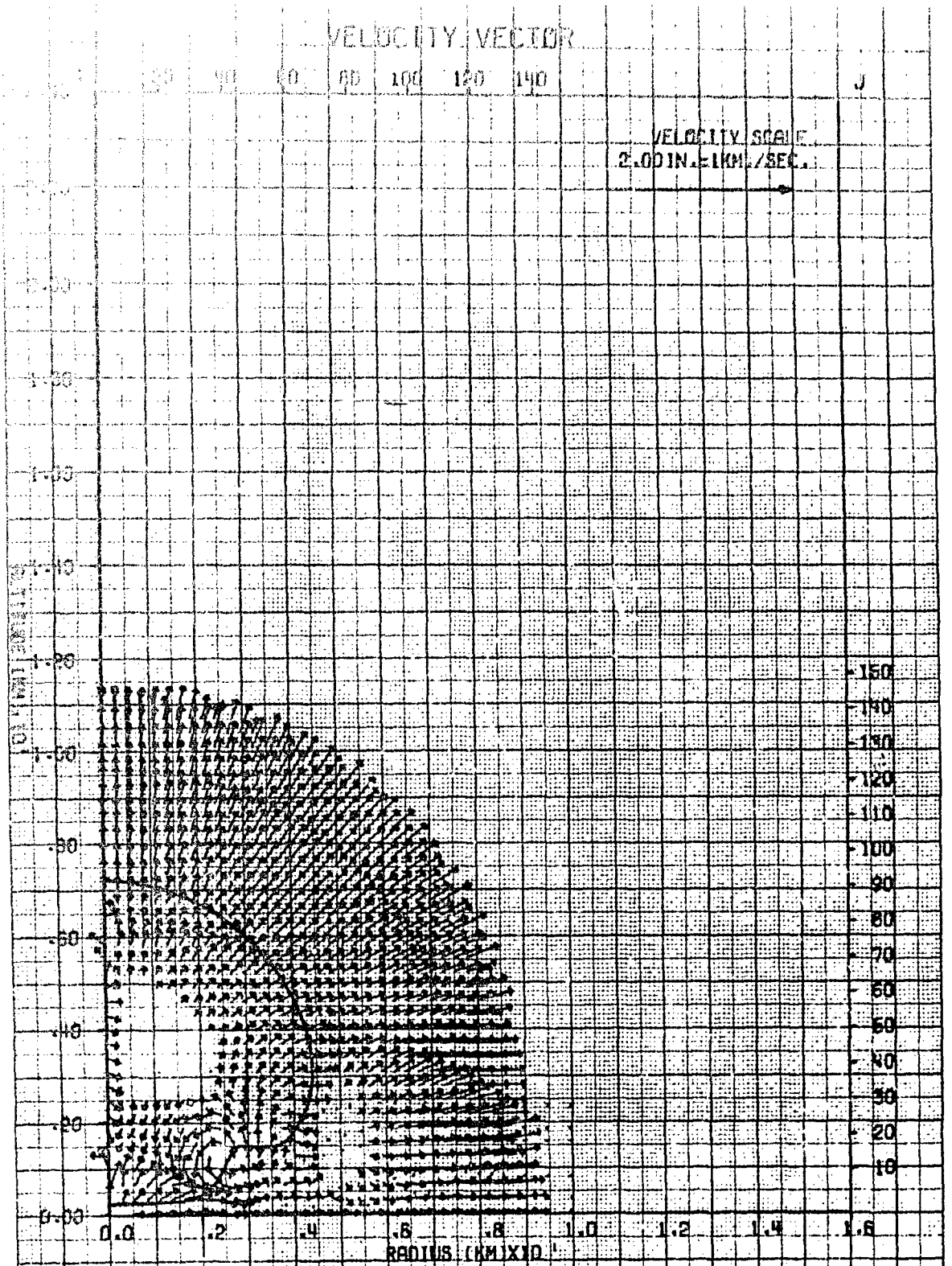
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .085 SEC CYCLE 477. PROBLEM 201.004 20



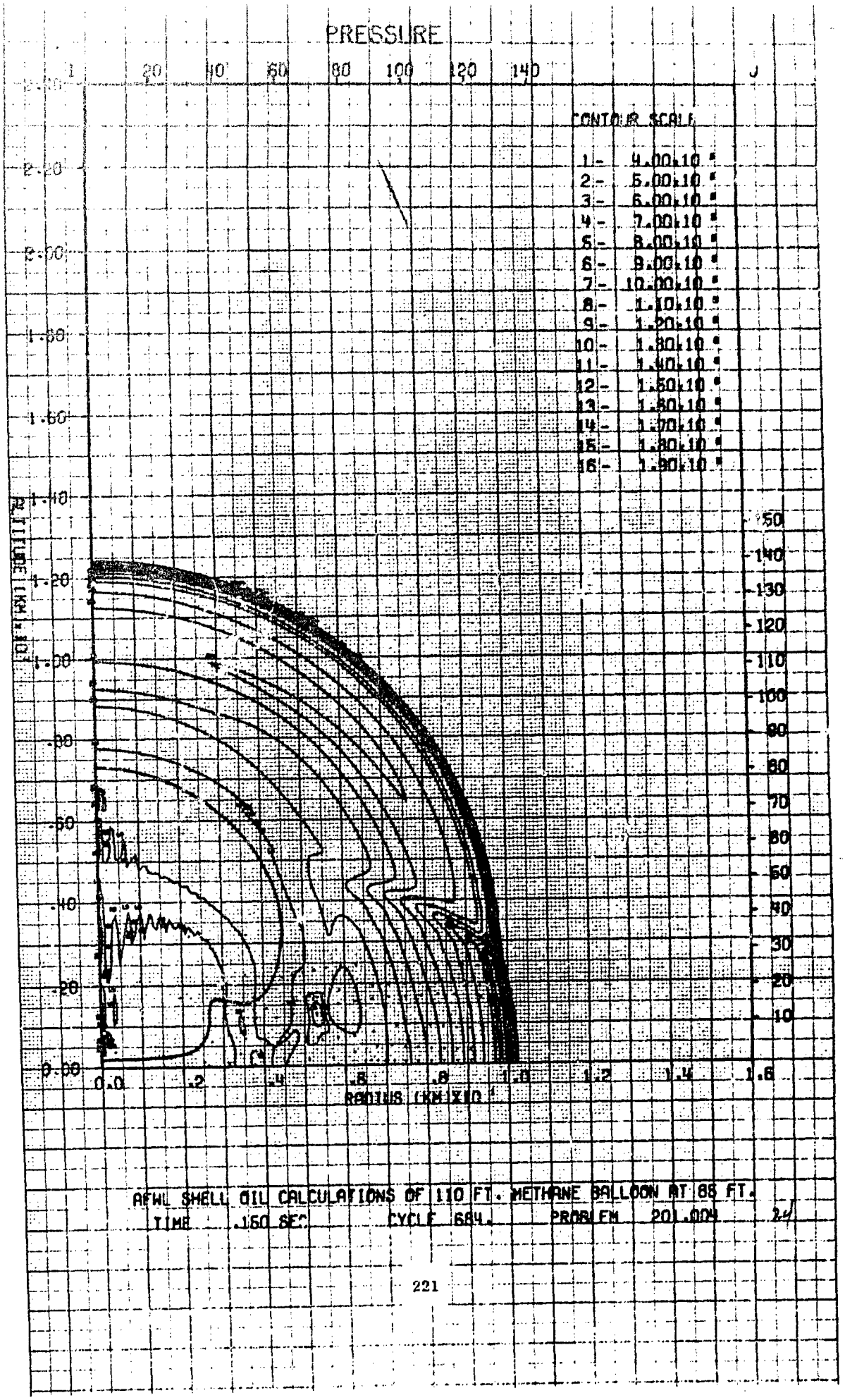
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004 2/

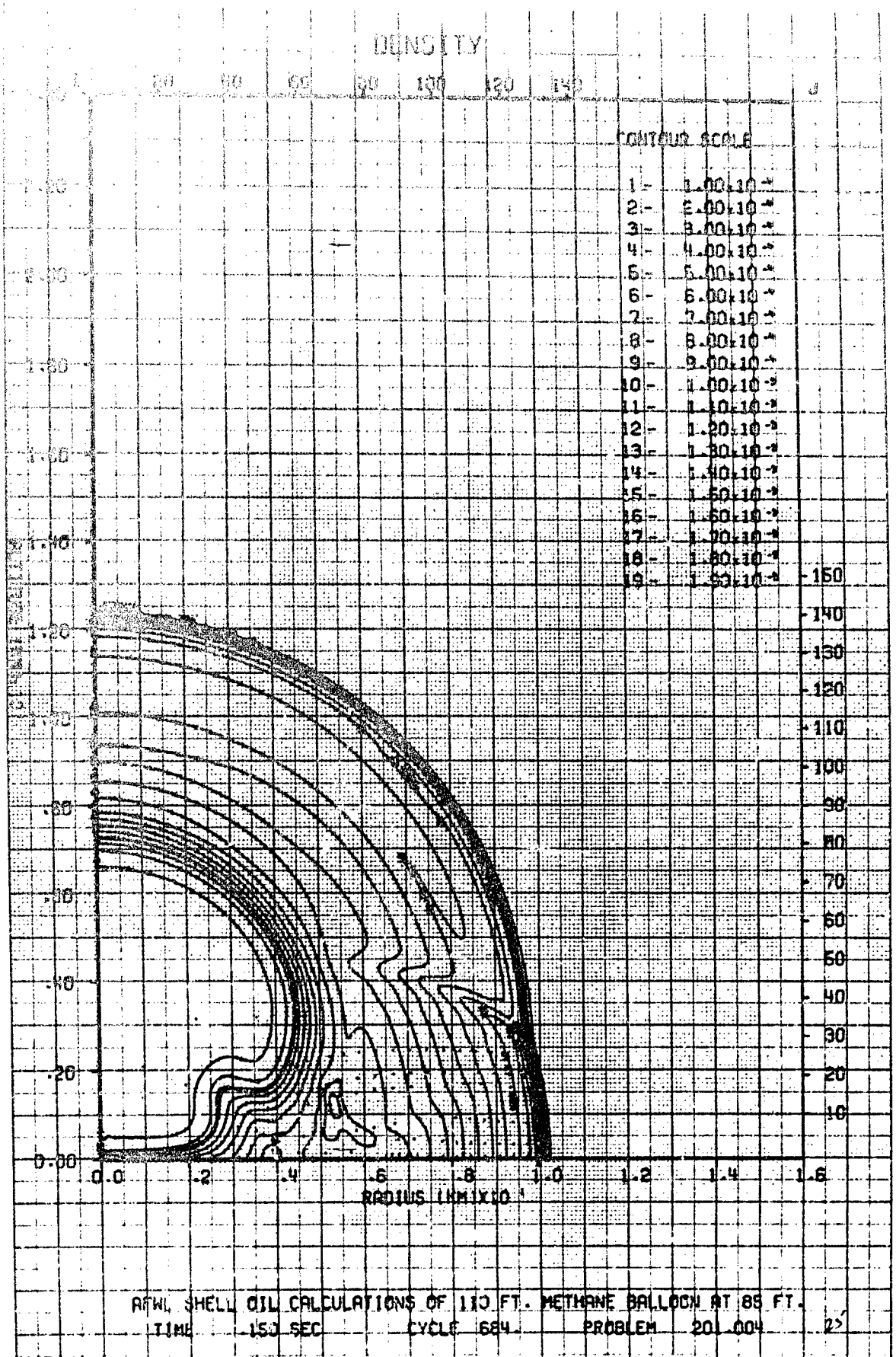


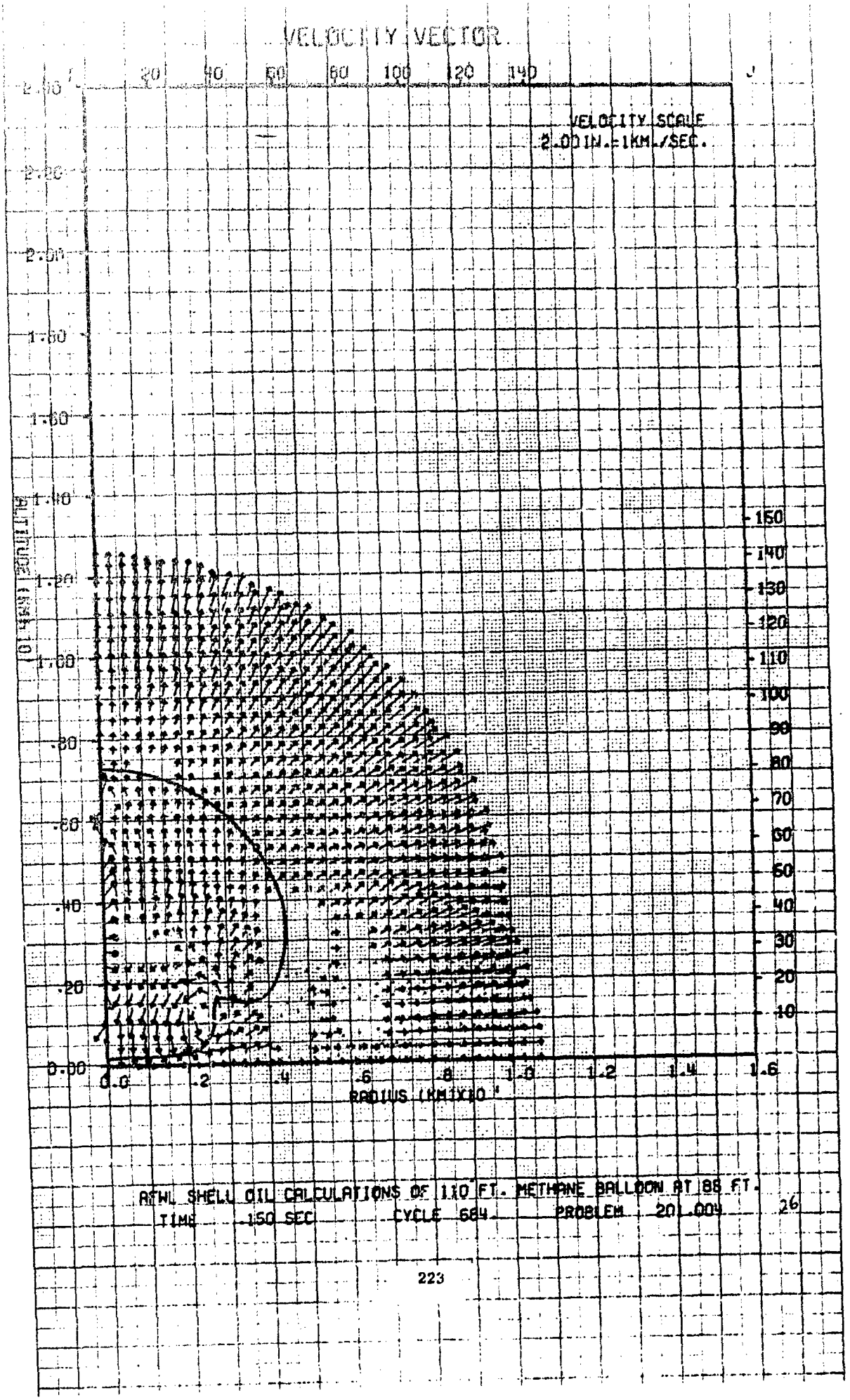
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004

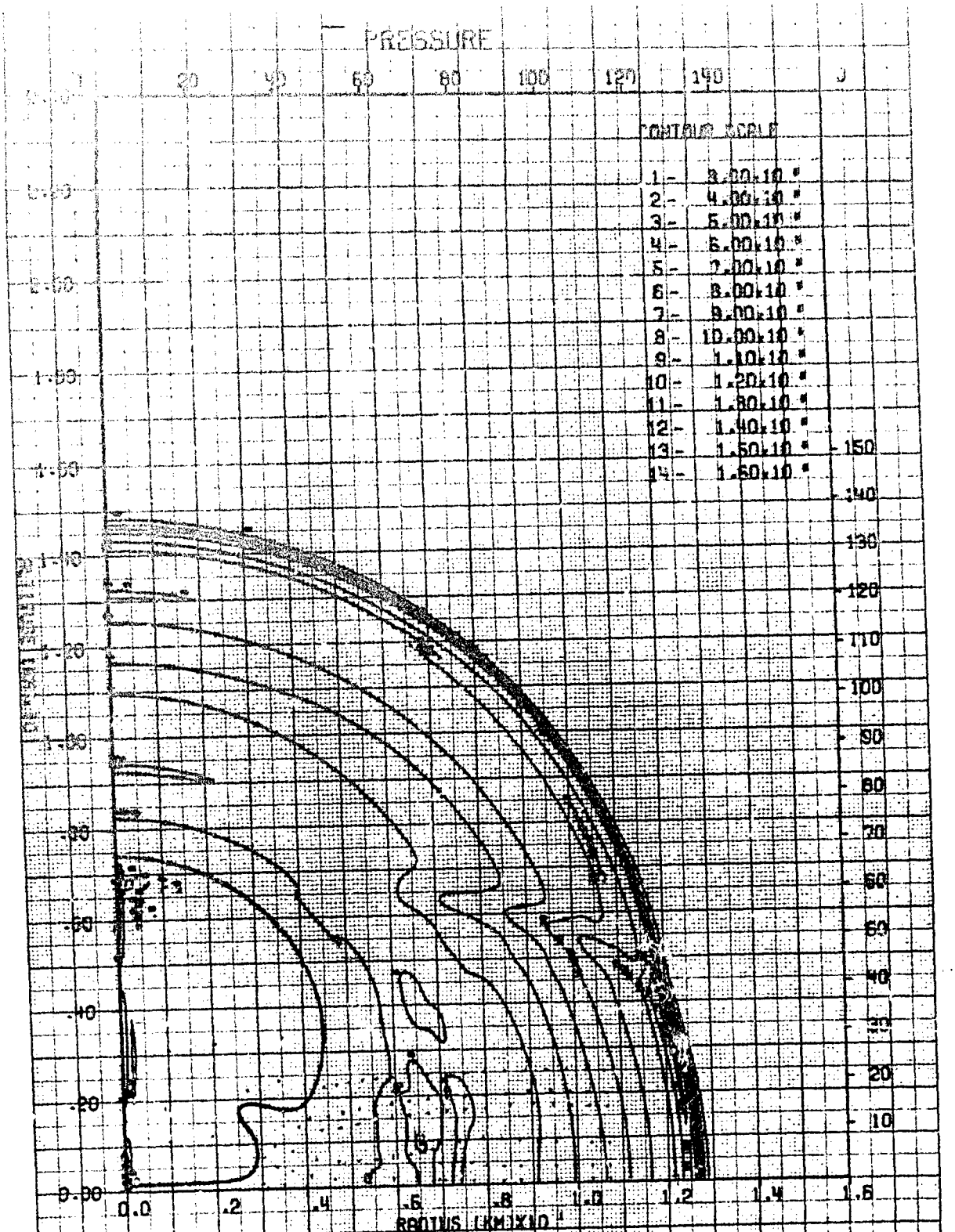


AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 88 FT.
TIME .120 SEC CYCLE 599. PROBLEM 201.004

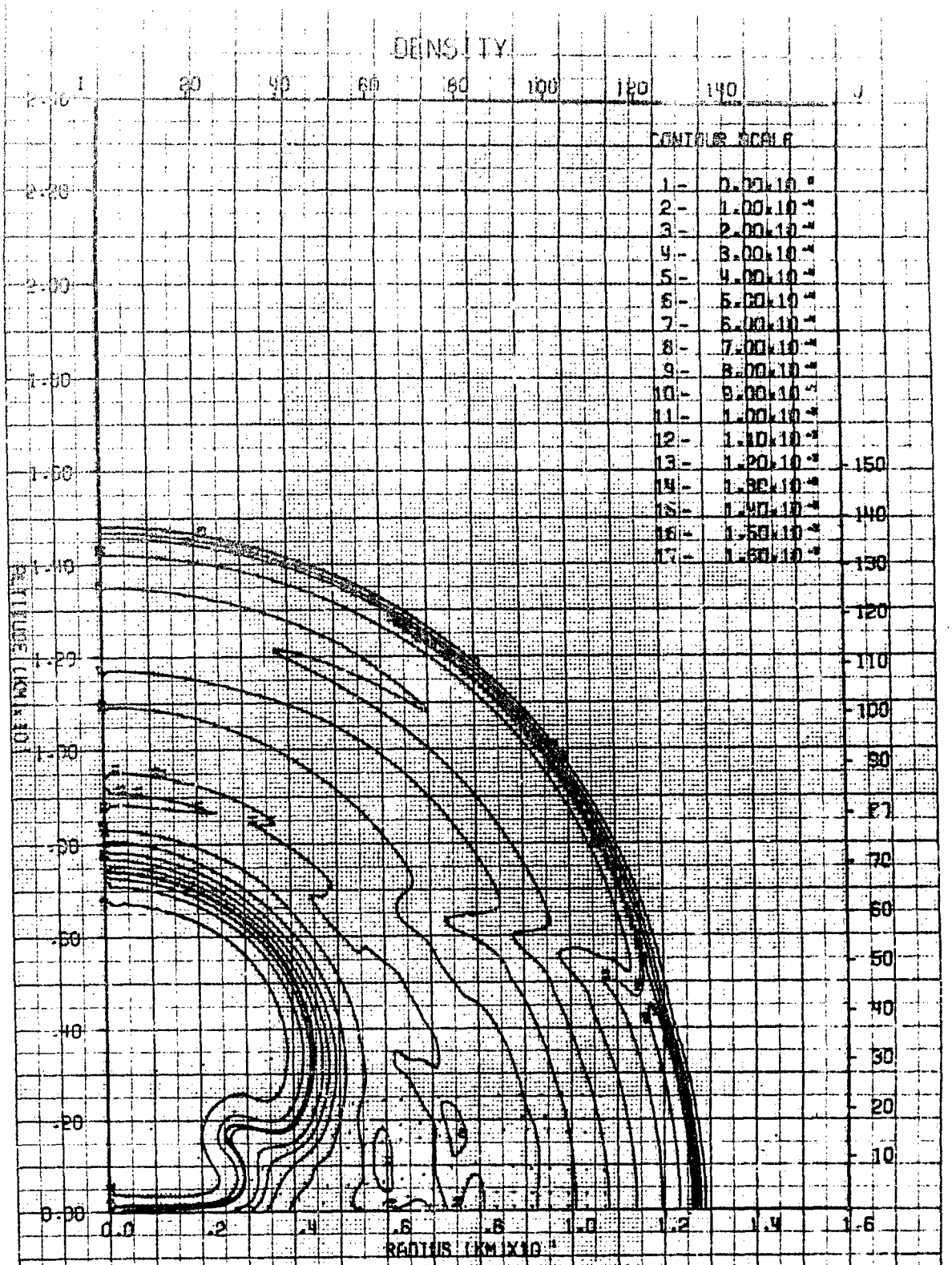

PRESSURE
CONTOUR SCALE
1- 4.00,10
2- 5.00,10
3- 6.00,10
4- 7.00,10
5- 8.00,10
6- 9.00,10
7- 10.00,10
8- 1.10,10
9- 1.20,10
10- 1.30,10
11- 1.40,10
12- 1.50,10
13- 1.60,10
14- 1.70,10
15- 1.80,10
16- 1.90,10
ALTITUDE (KM*10)
RADIUS (KM*10)
AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .150 SEC CYCLE 684. PROBLEM 201.004


DENSITY
CONTOUR SCALE
1 - 1.00,10 -1
2 - 2.00,10 -1
3 - 3.00,10 -1
4 - 4.00,10 -1
5 - 5.00,10 -1
6 - 6.00,10 -1
7 - 7.00,10 -1
8 - 8.00,10 -1
9 - 9.00,10 -1
10 - 1.00,10 -2
11 - 1.10,10 -2
12 - 1.20,10 -2
13 - 1.30,10 -2
14 - 1.40,10 -2
15 - 1.50,10 -2
16 - 1.60,10 -2
17 - 1.70,10 -2
18 - 1.80,10 -2
19 - 1.90,10 -2
RADIUS (KMIXCO)
RFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME 150 SEC CYCLE 684 PROBLEM 201.004

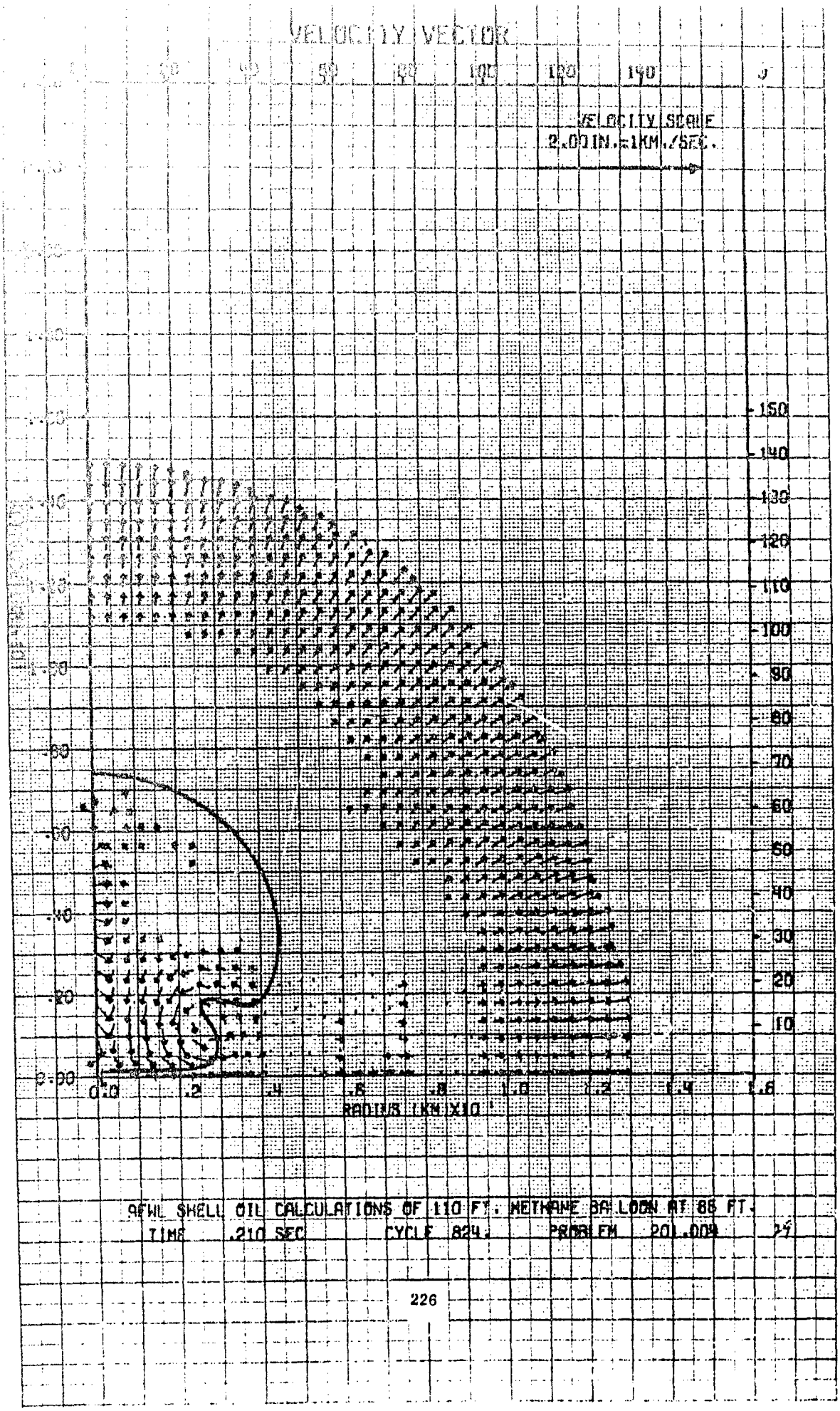

VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
ALTITUDE (KM*10)
RADIUS (KM*10)
RAWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 86 FT.
TIME 150 SEC CYCLE 684 PROBLEM 201.004
26



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



AFWL SHELL OIL CALCULATIONS OF 110 FT. METHANE BALLOON AT 85 FT.
TIME .210 SEC CYCLE 824 PROBLEM 201.00


VELOCITY VECTOR
VELOCITY SCALE
2.00 IN.=1KM./SEC.
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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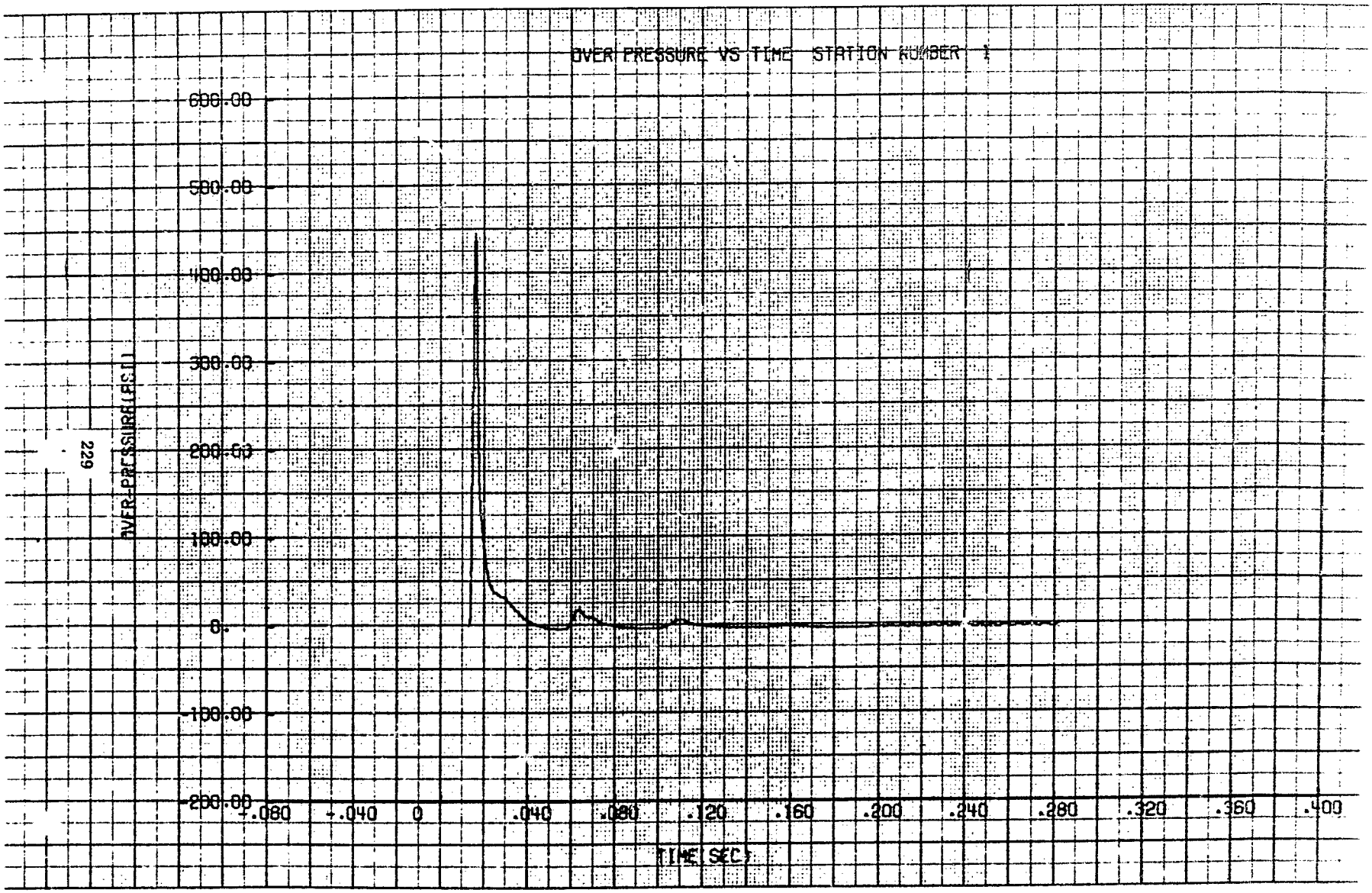
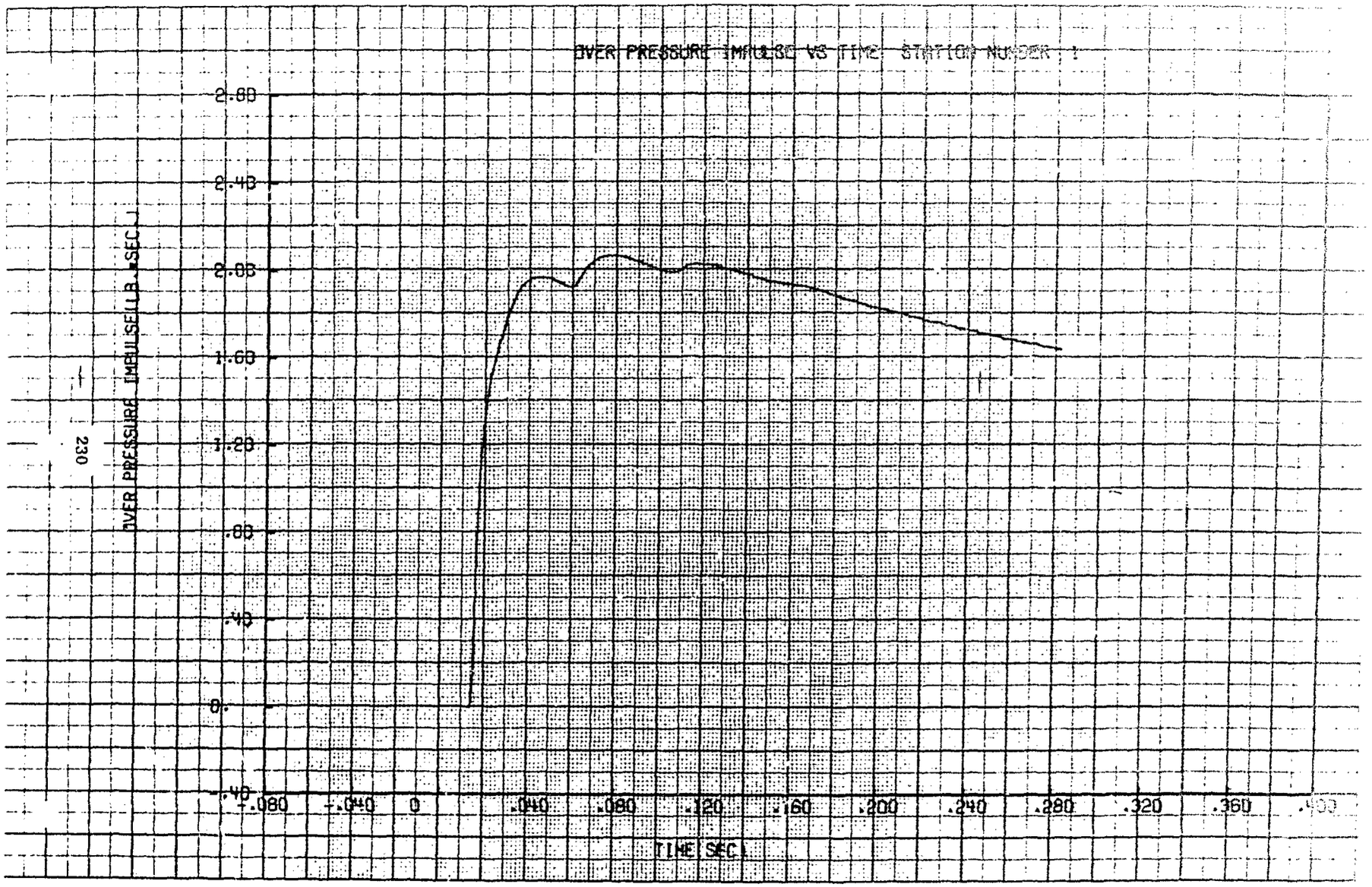
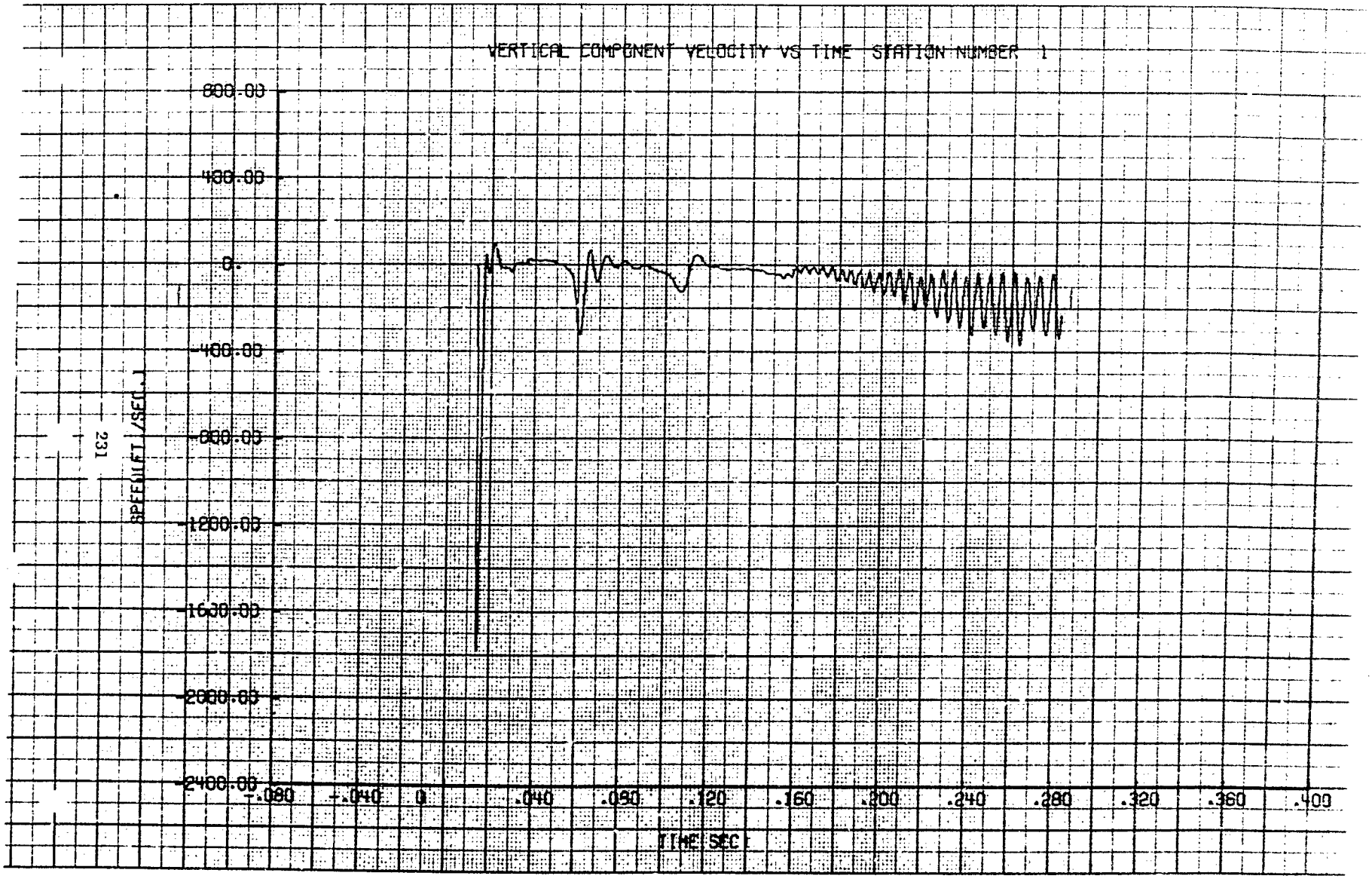
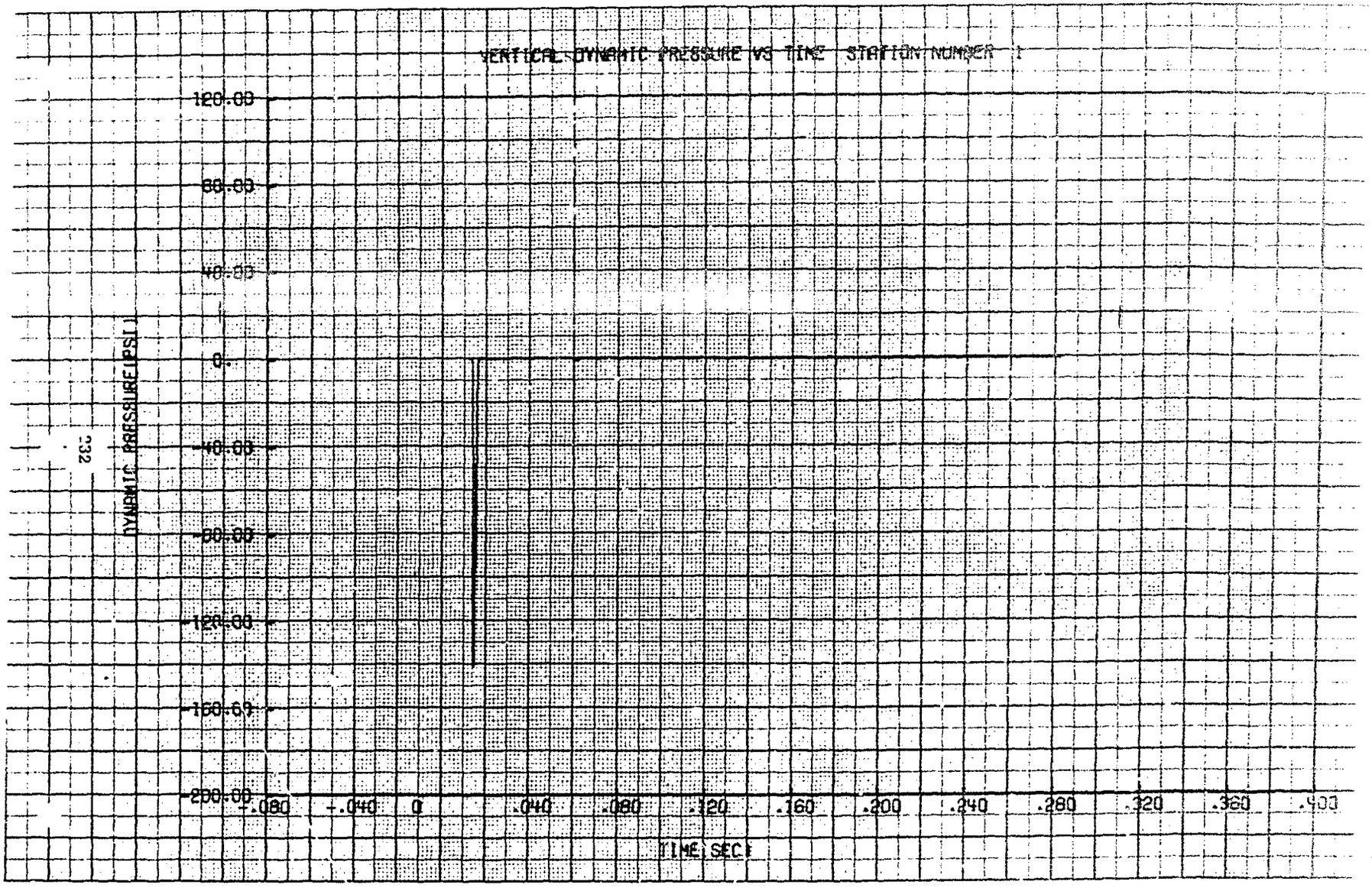
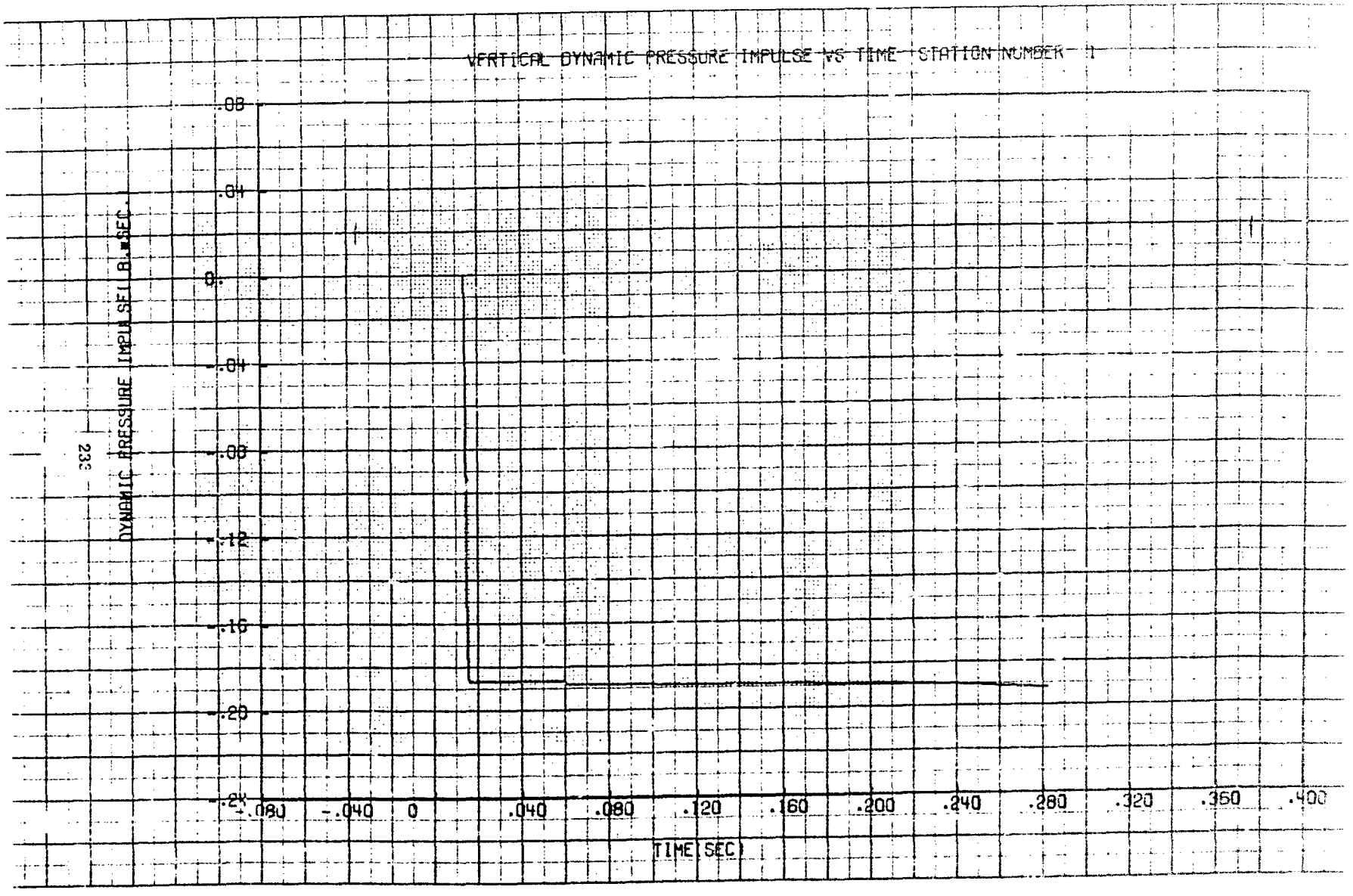

OVER PRESSURE VS TIME STATION NUMBER 1
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
OVER-PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

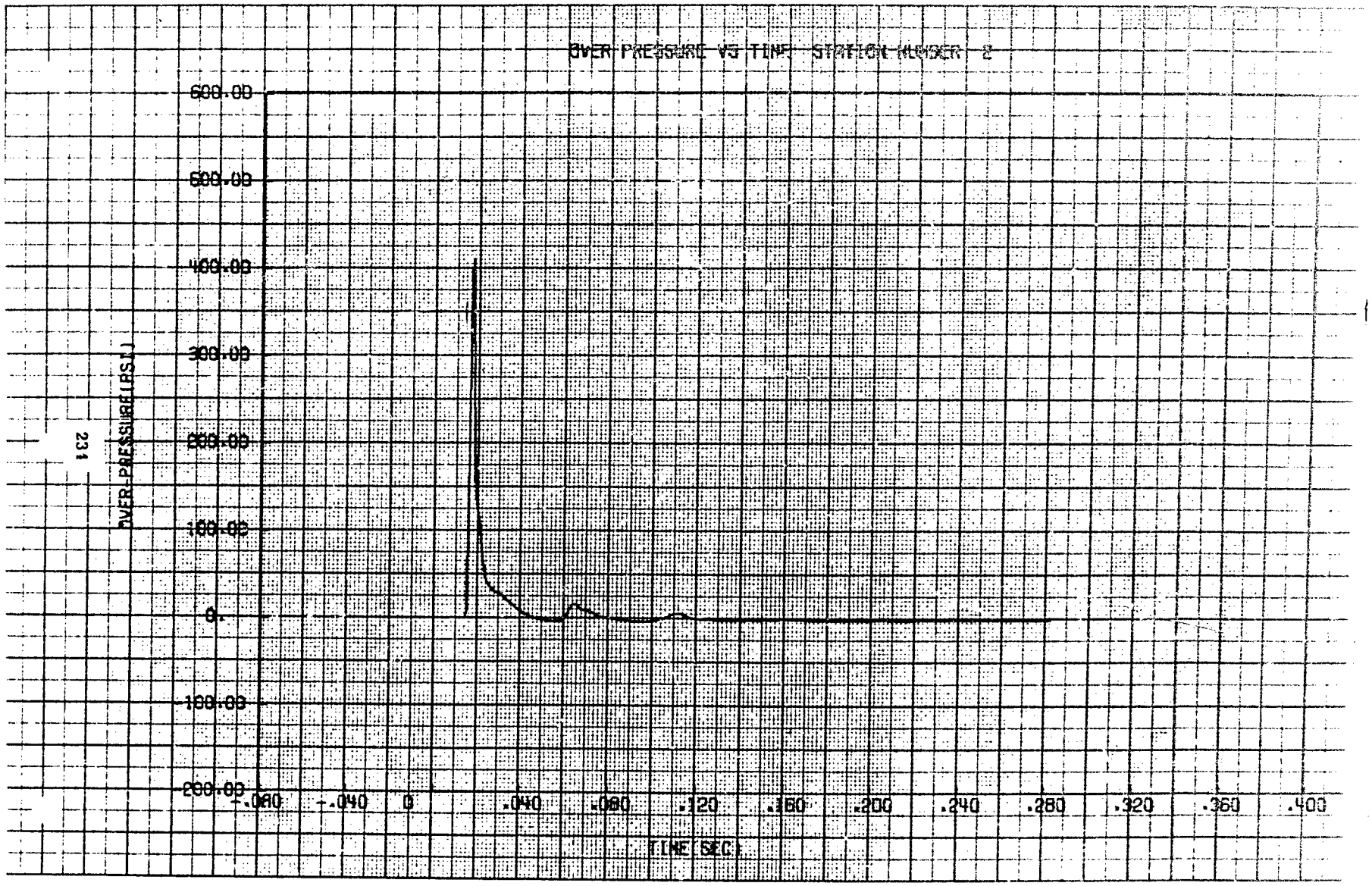

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 1
OVER PRESSURE IMPULSE(LB.*SEC.)
2.80
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC.)

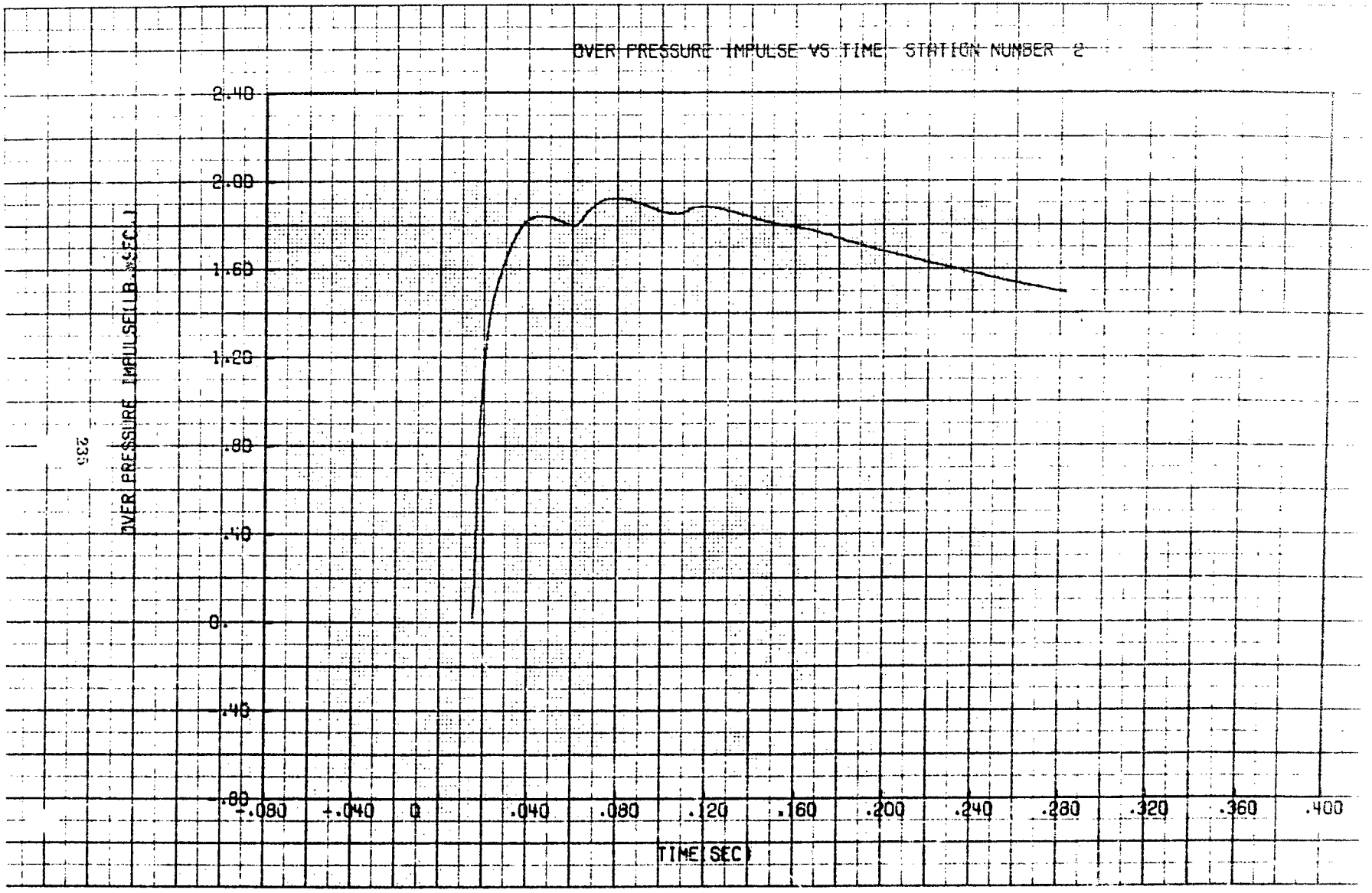


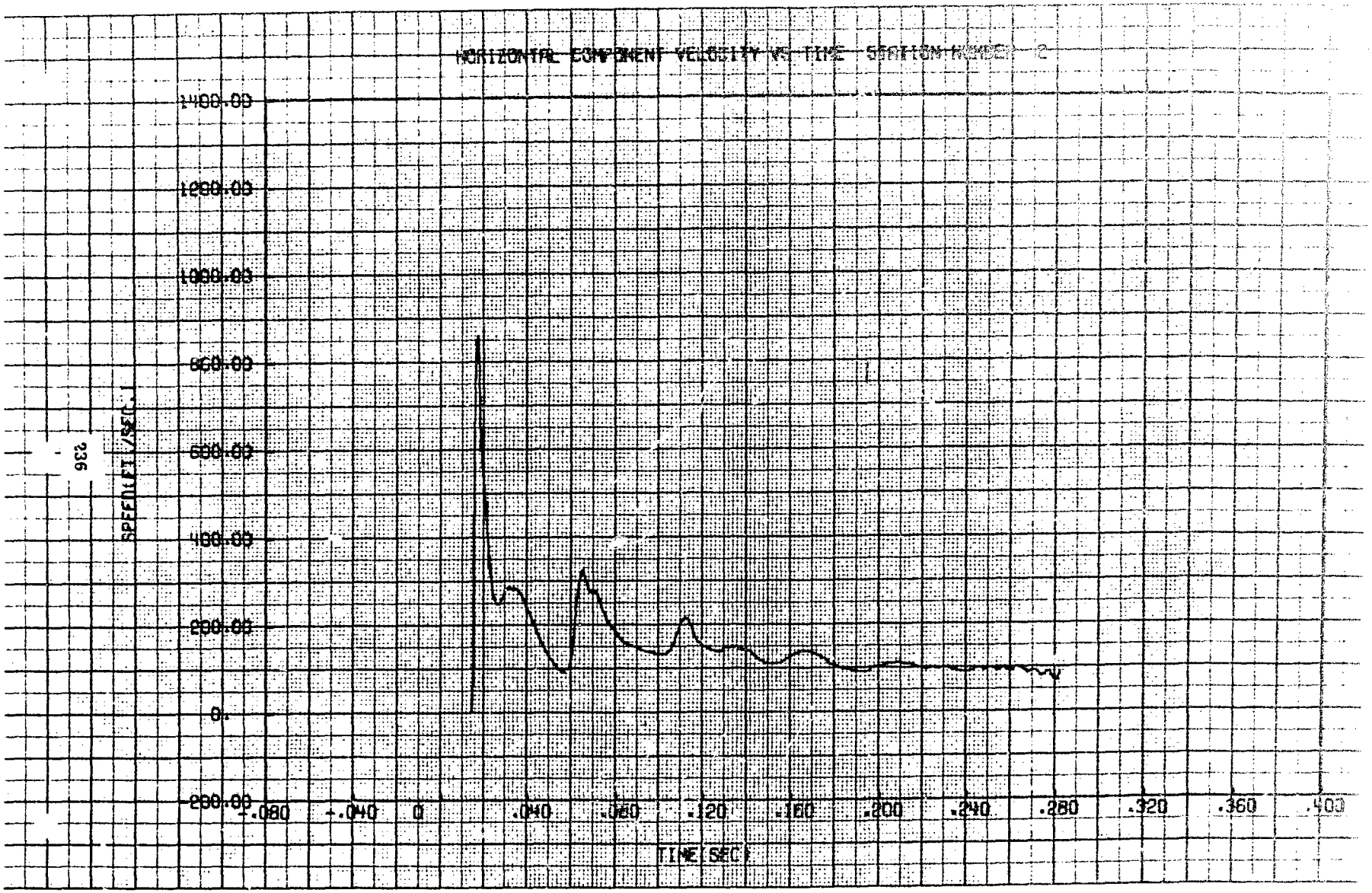
CALIFORNIA COMPUTER PRODUCTS, INC. ANAHEIM, CALIFORNIA

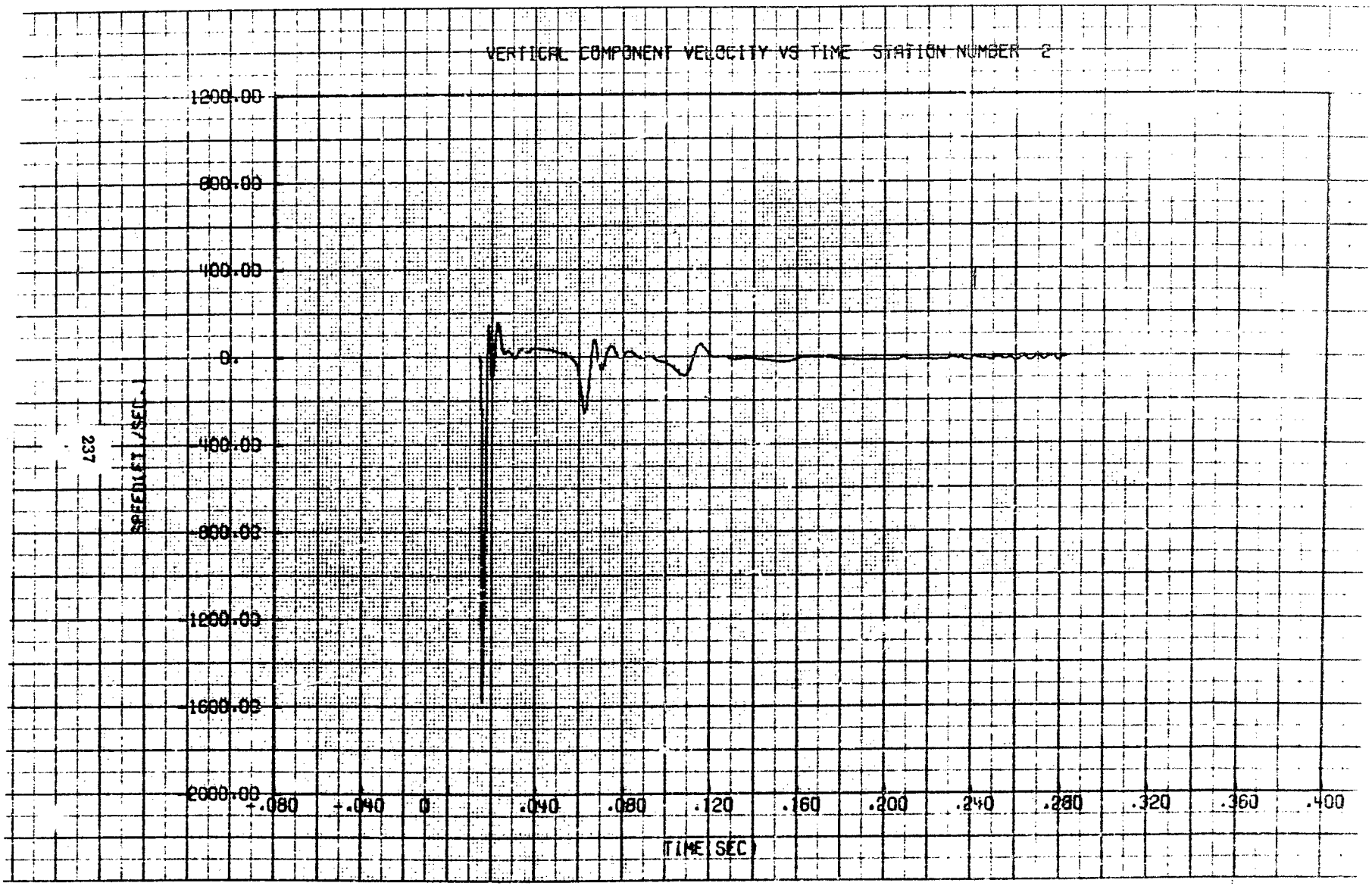

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 1
120.00
80.00
40.00
0.
-40.00
-80.00
-120.00
-160.00
-200.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

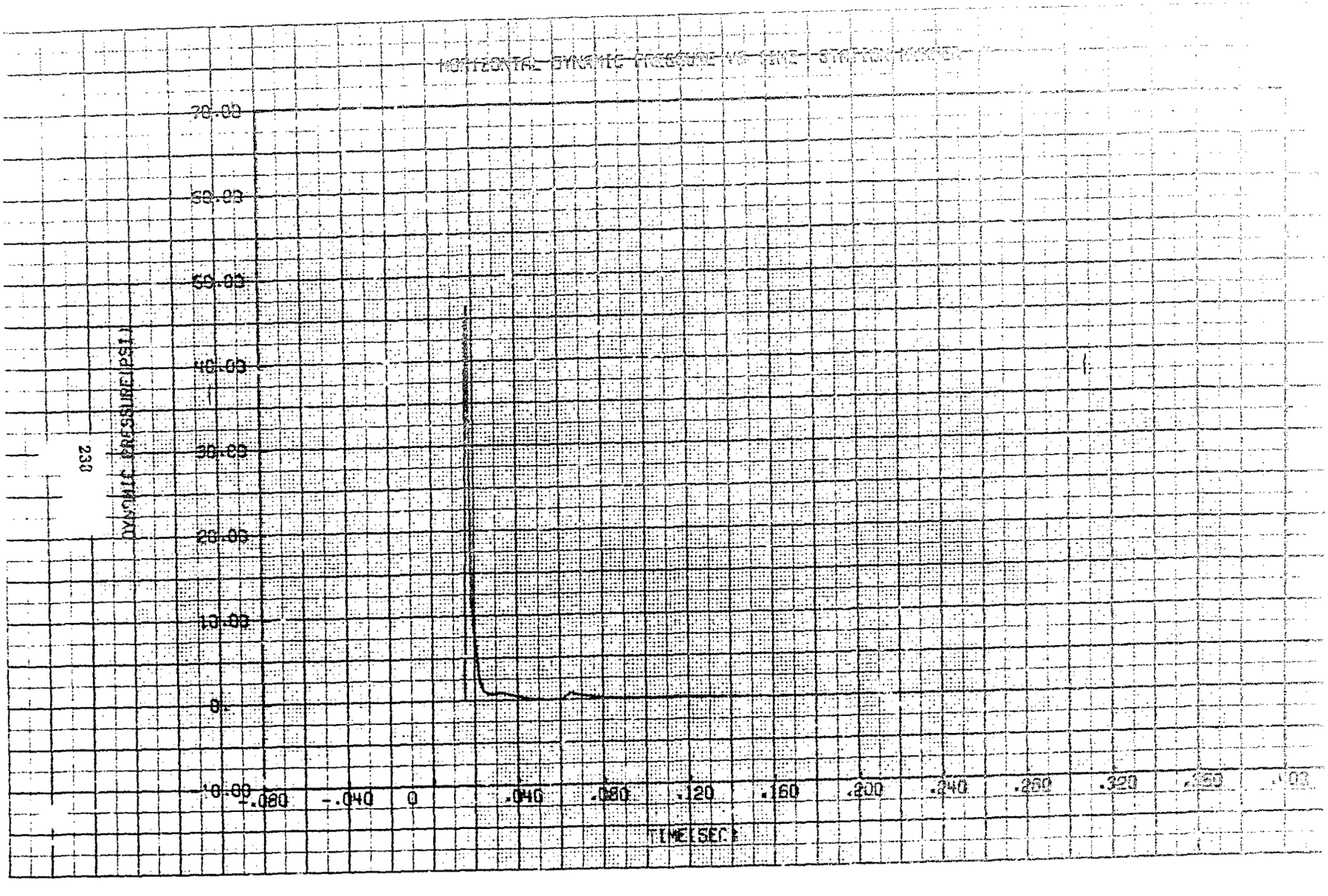

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.08
.04
0.
-.04
-.08
-.12
-.16
-.20
-.24
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

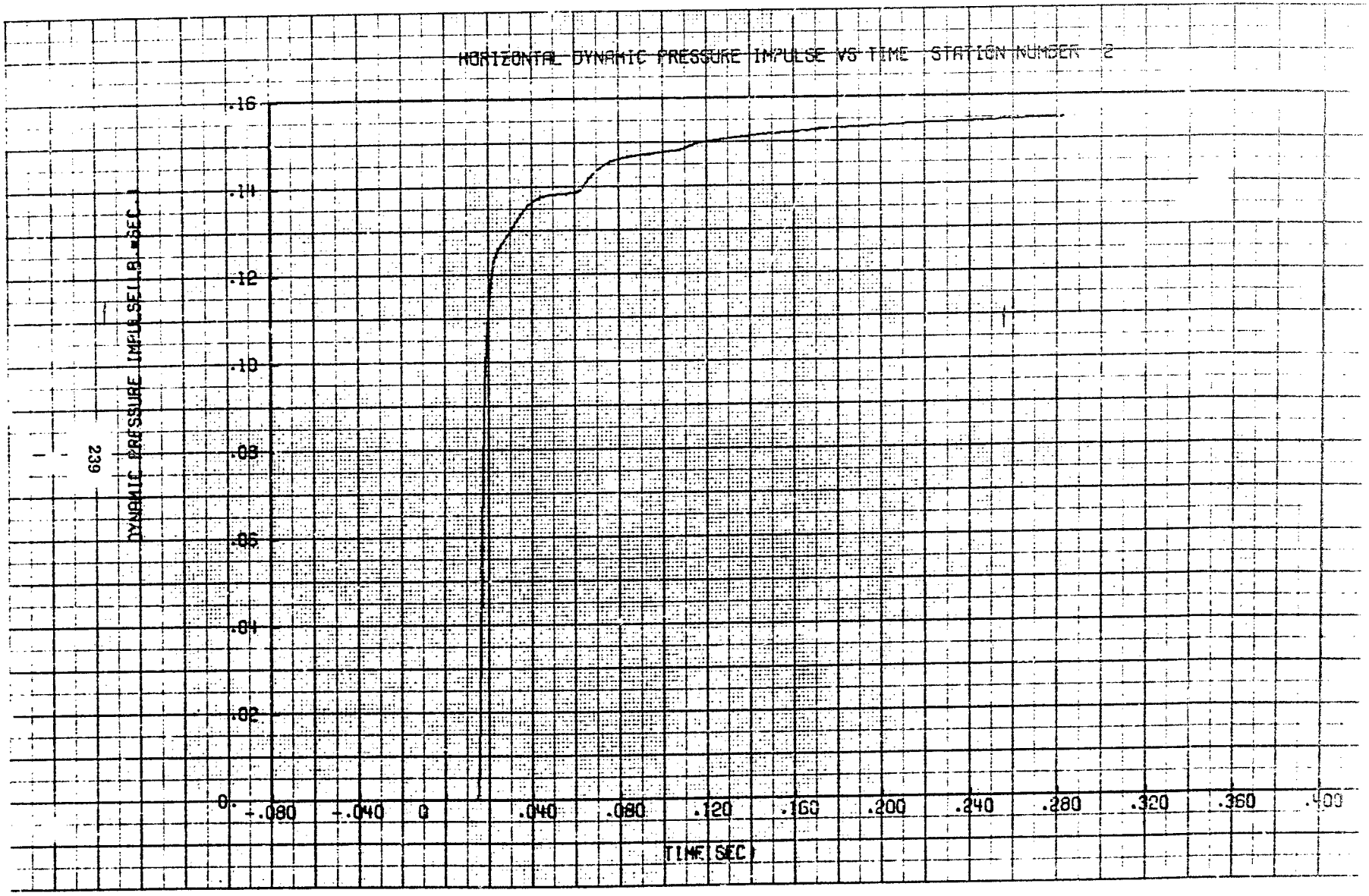

OVER PRESSURE VS TIME STATION NUMBER 2
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
OVER PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

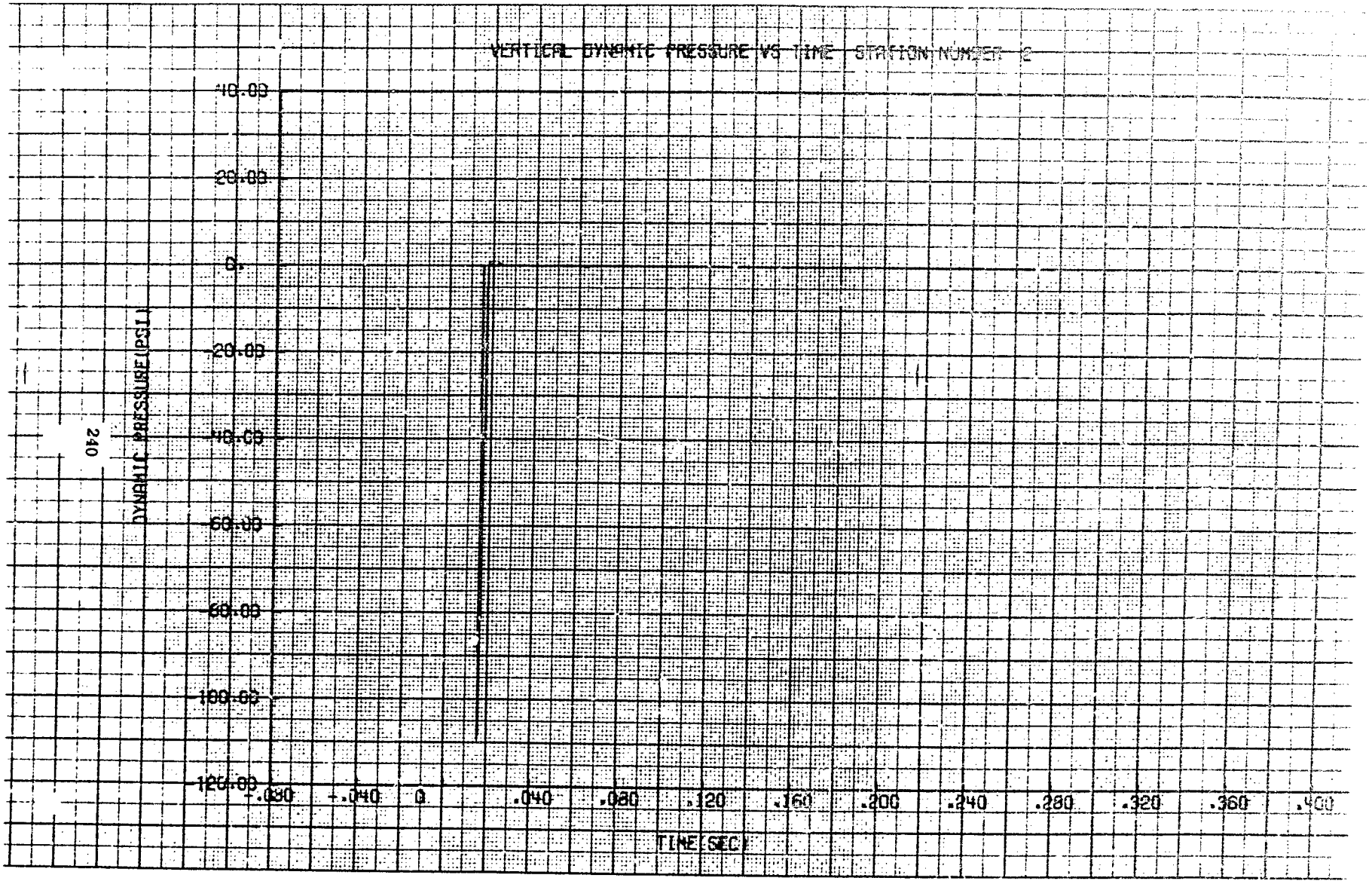

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 2
OVER PRESSURE IMPULSE(LB.*SEC.)
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.80
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

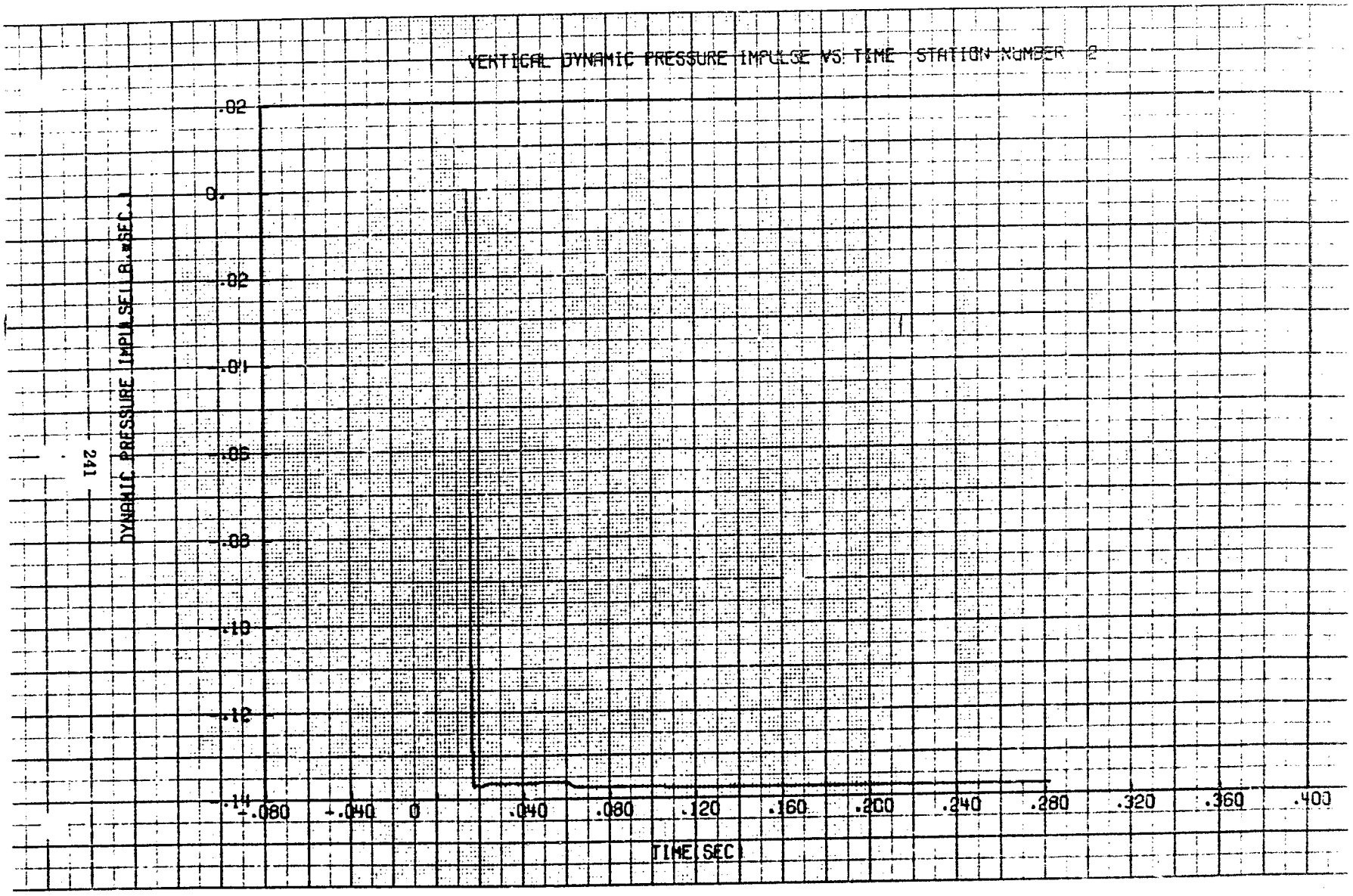

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

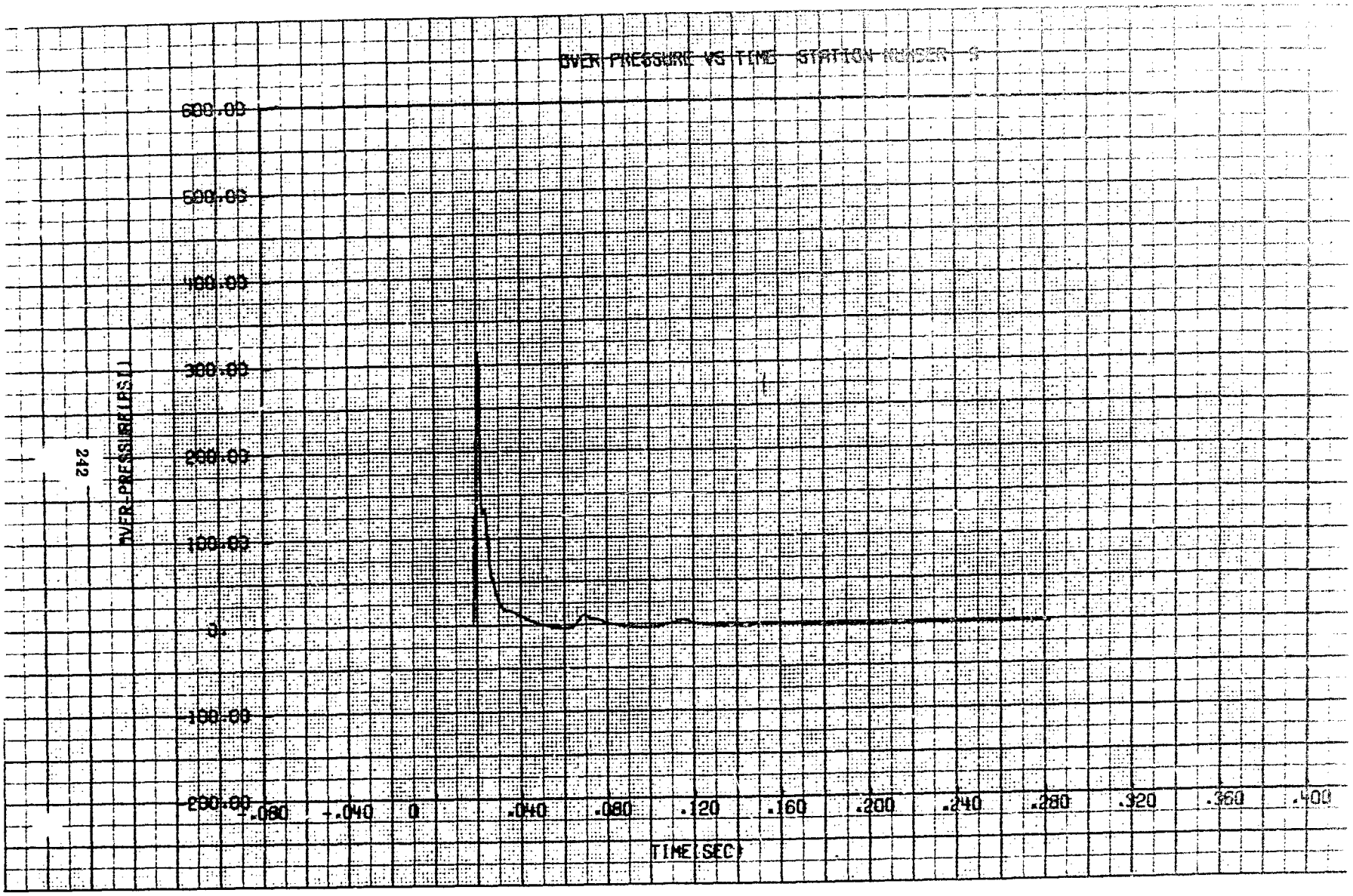

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 2
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
-2000.00
VELOCITY (MICRONS/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

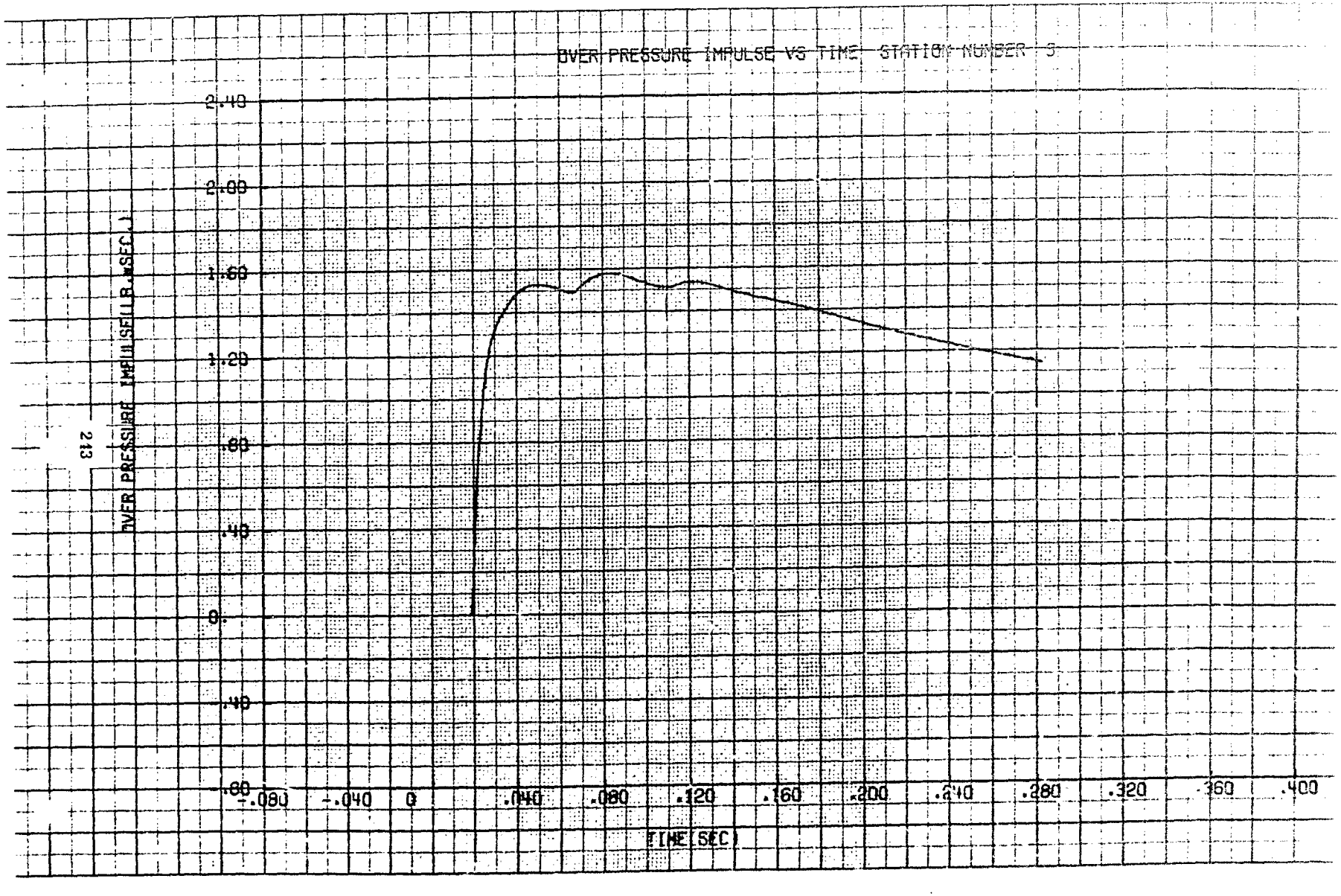

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

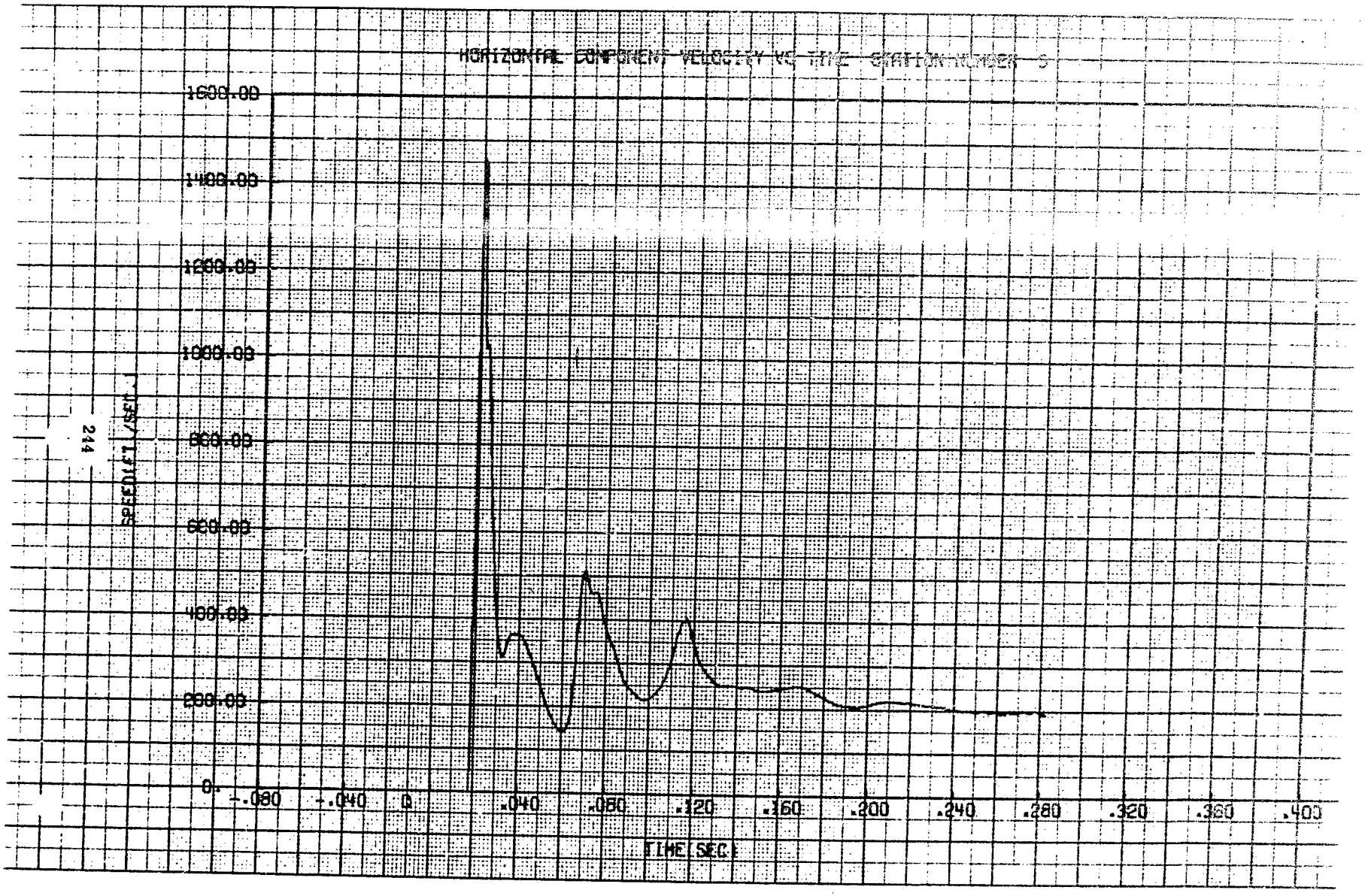

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
.16
.14
.12
.10
.08
.06
.04
.02
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN²)

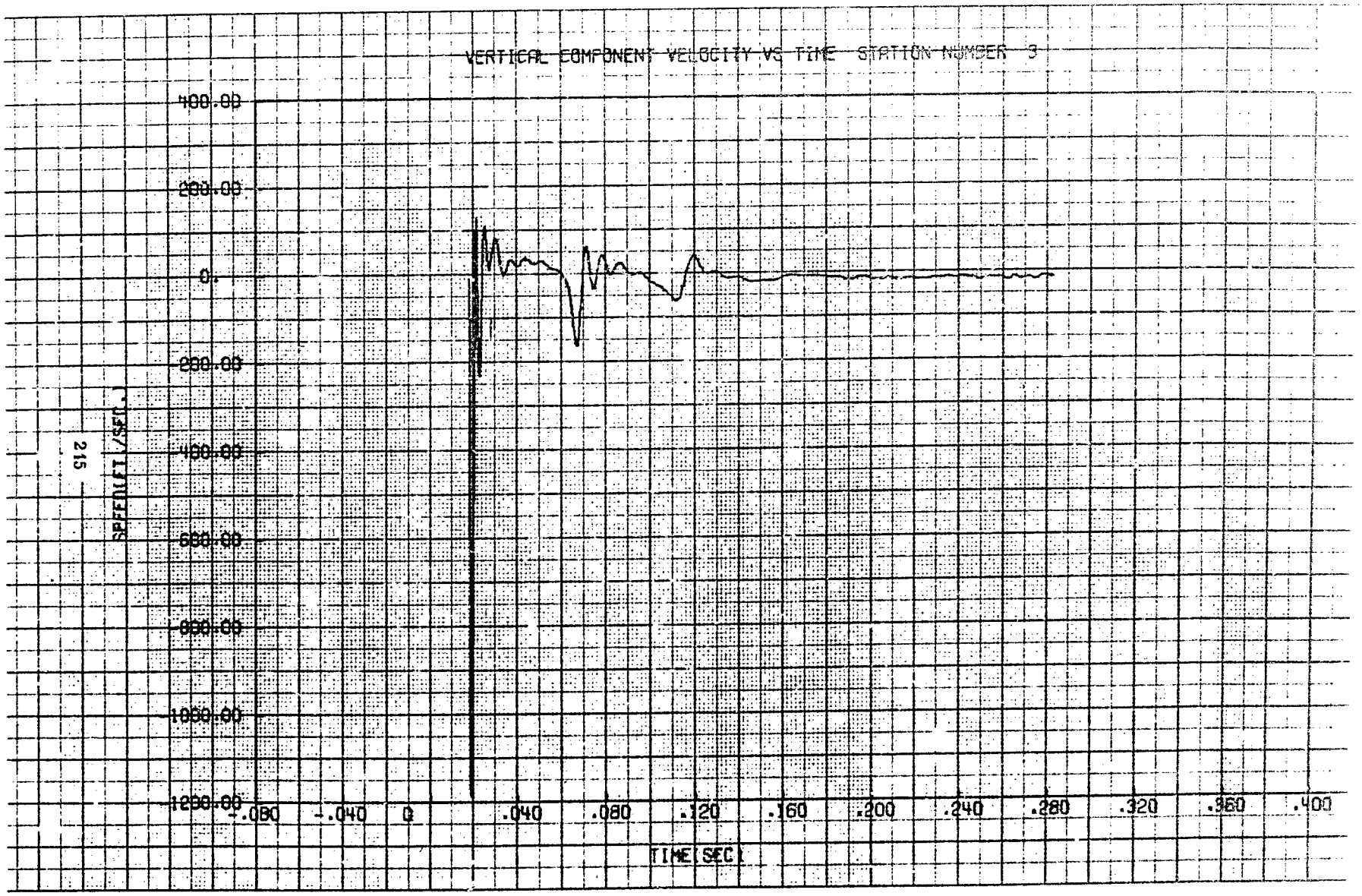

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 2
40.00
20.00
0.
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

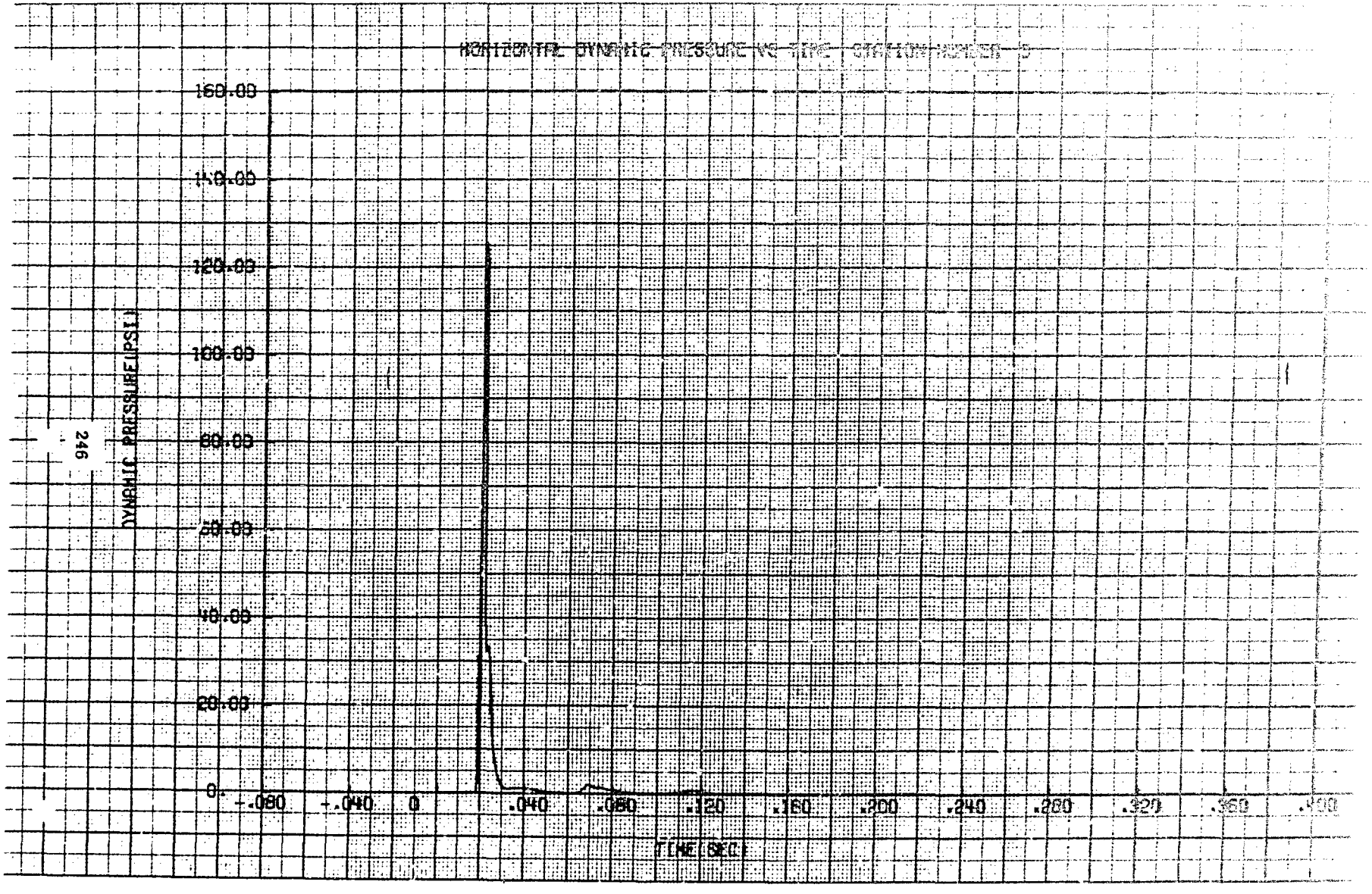

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 2
.02
0.
-.02
-.01
-.05
-.08
-.10
-.12
-.14
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)

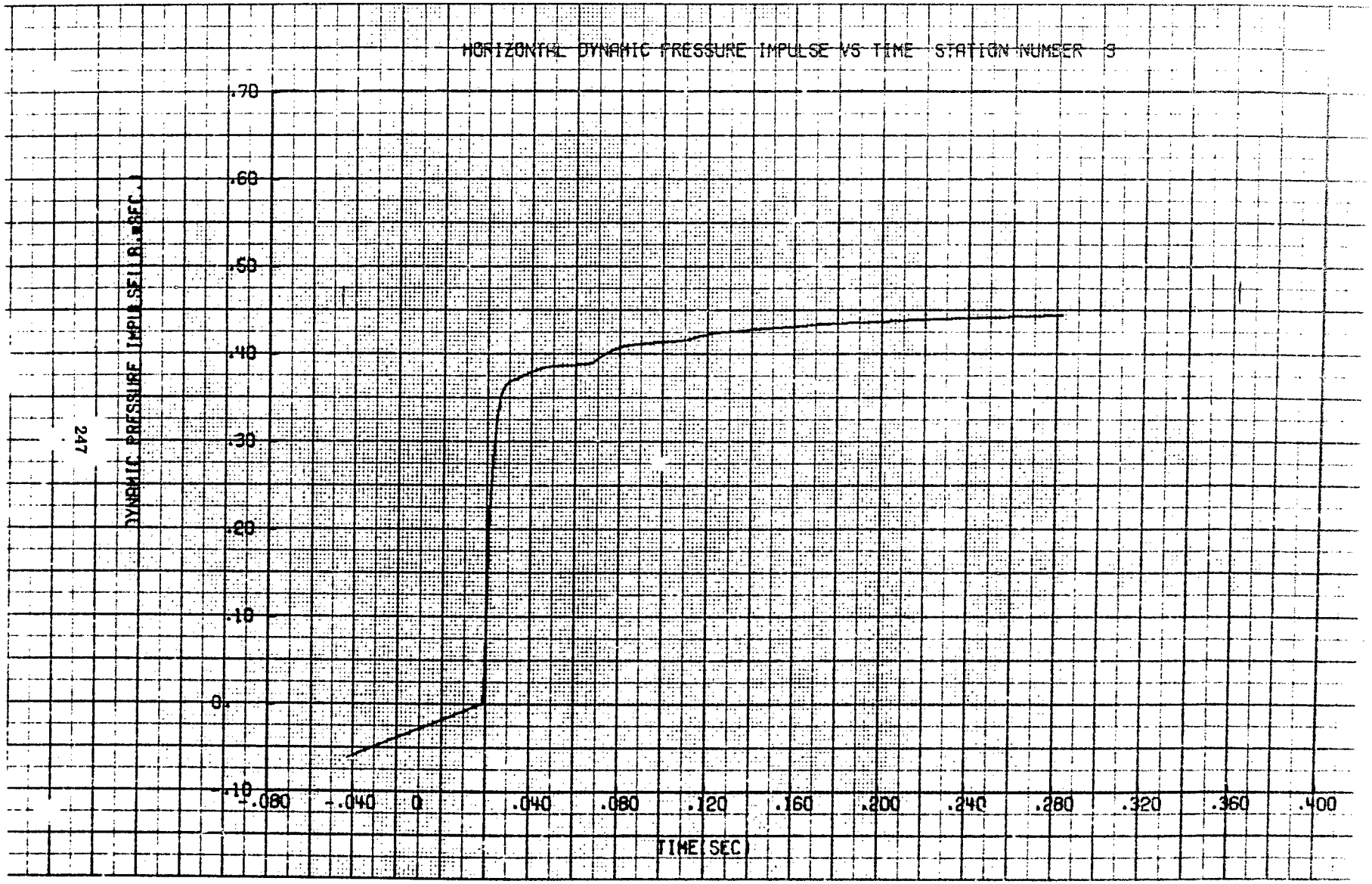

OVER PRESSURE VS TIME STATION NUMBER 9
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
OVER-PRESSURE(LBS/)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

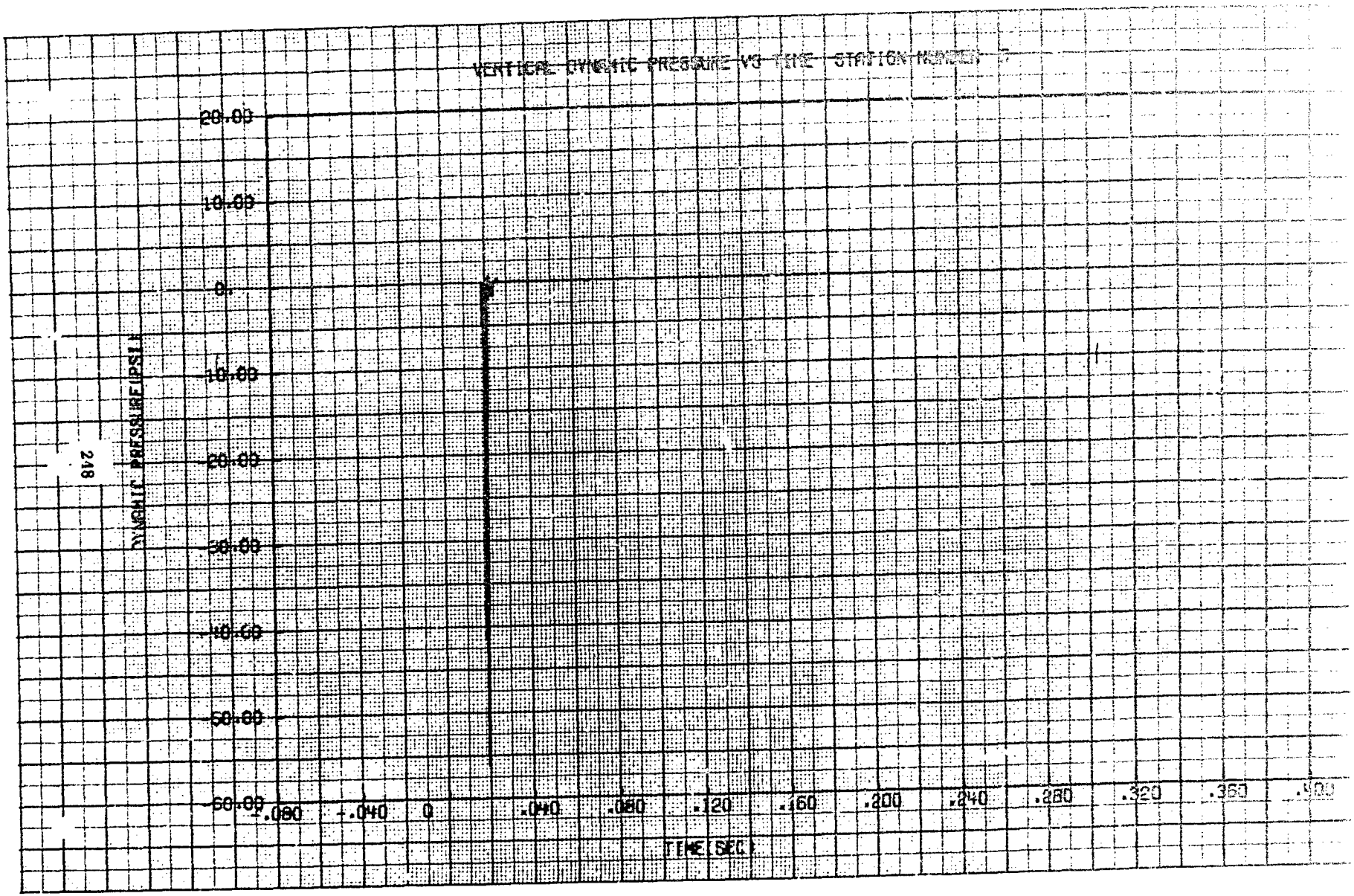

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 3
OVER PRESSURE IMPULSE(LB.*SEC.)
2.40
2.00
1.60
1.20
.80
.40
0.
-.40
-.80
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

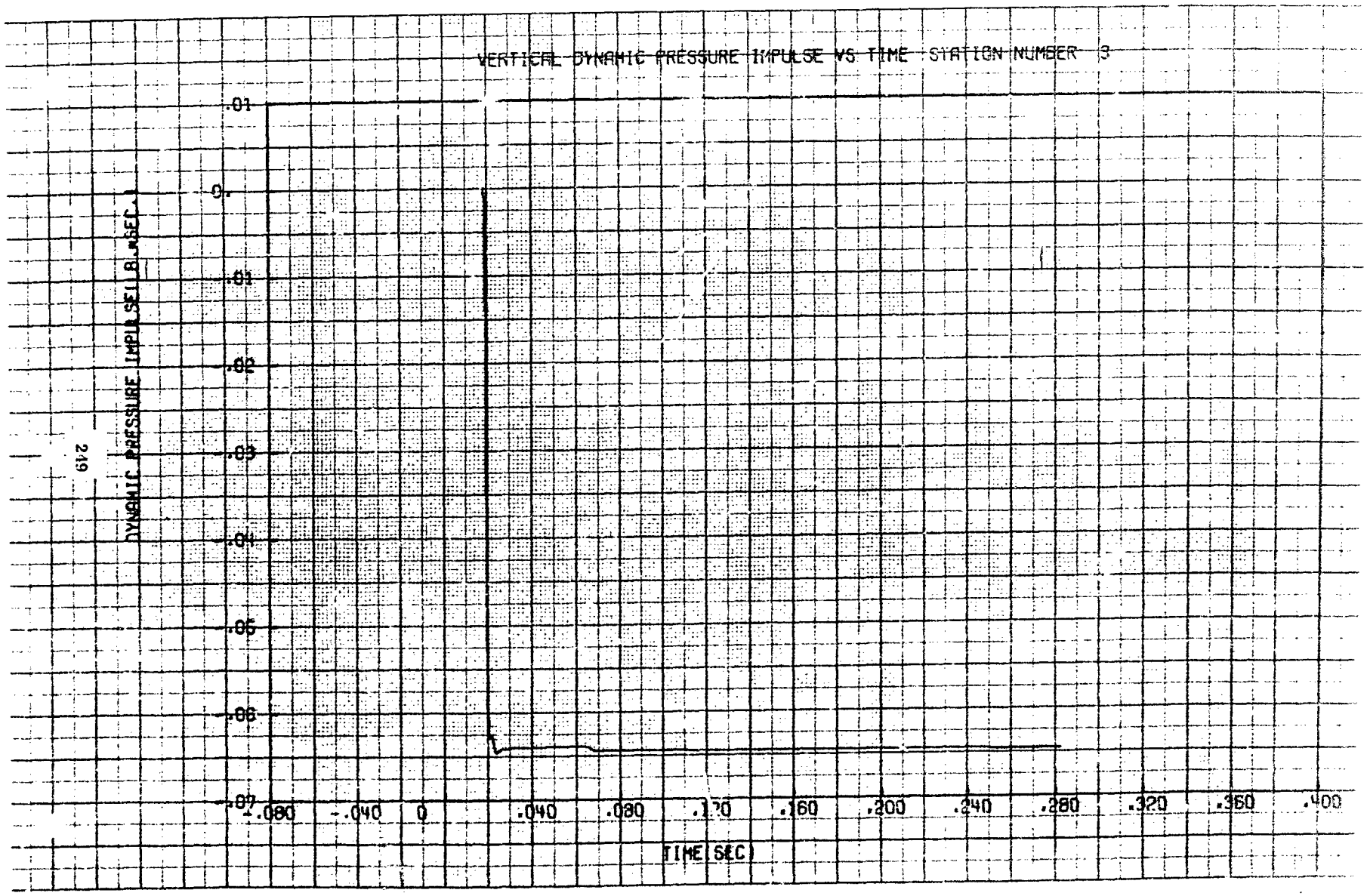

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

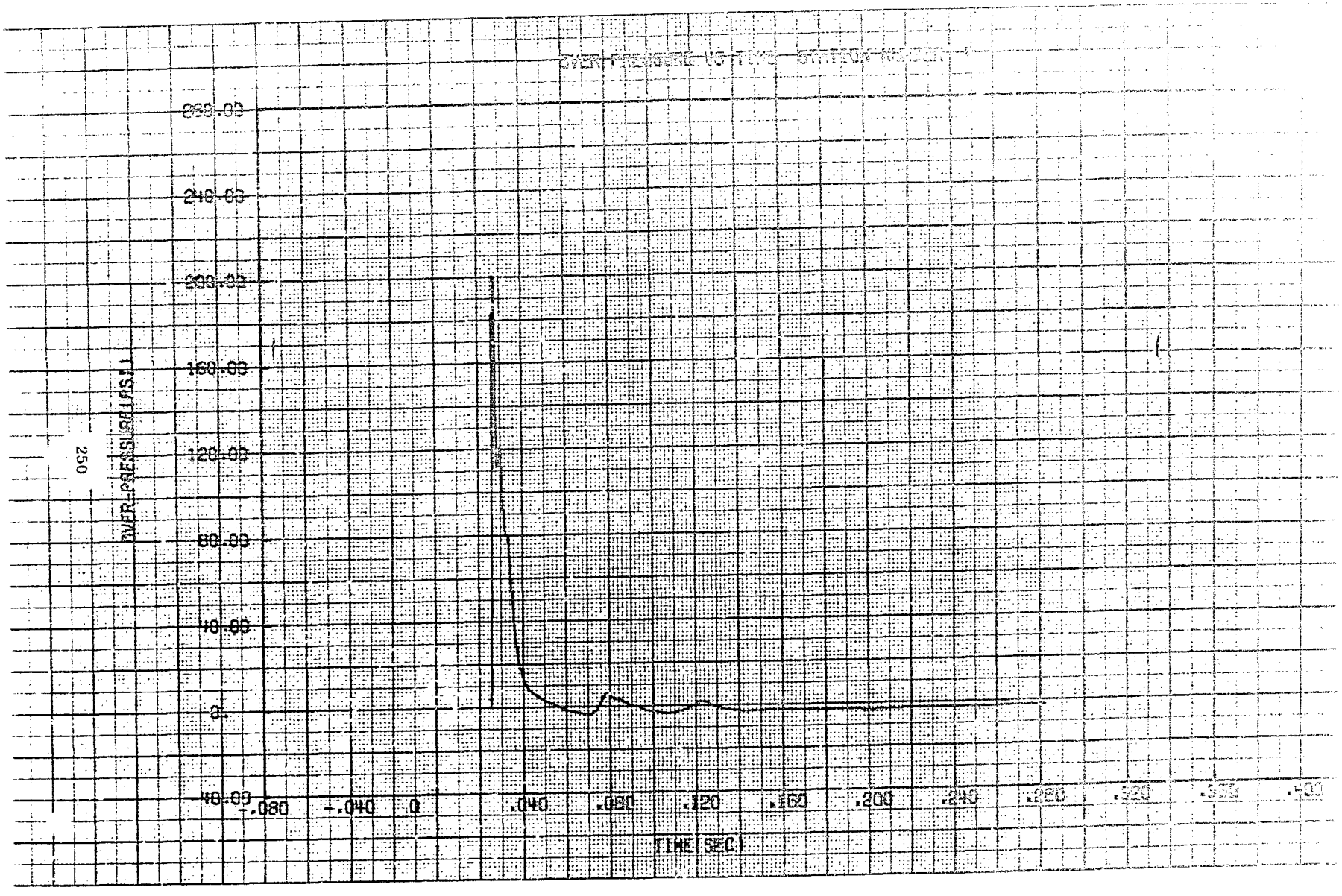

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 3
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
-1200.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

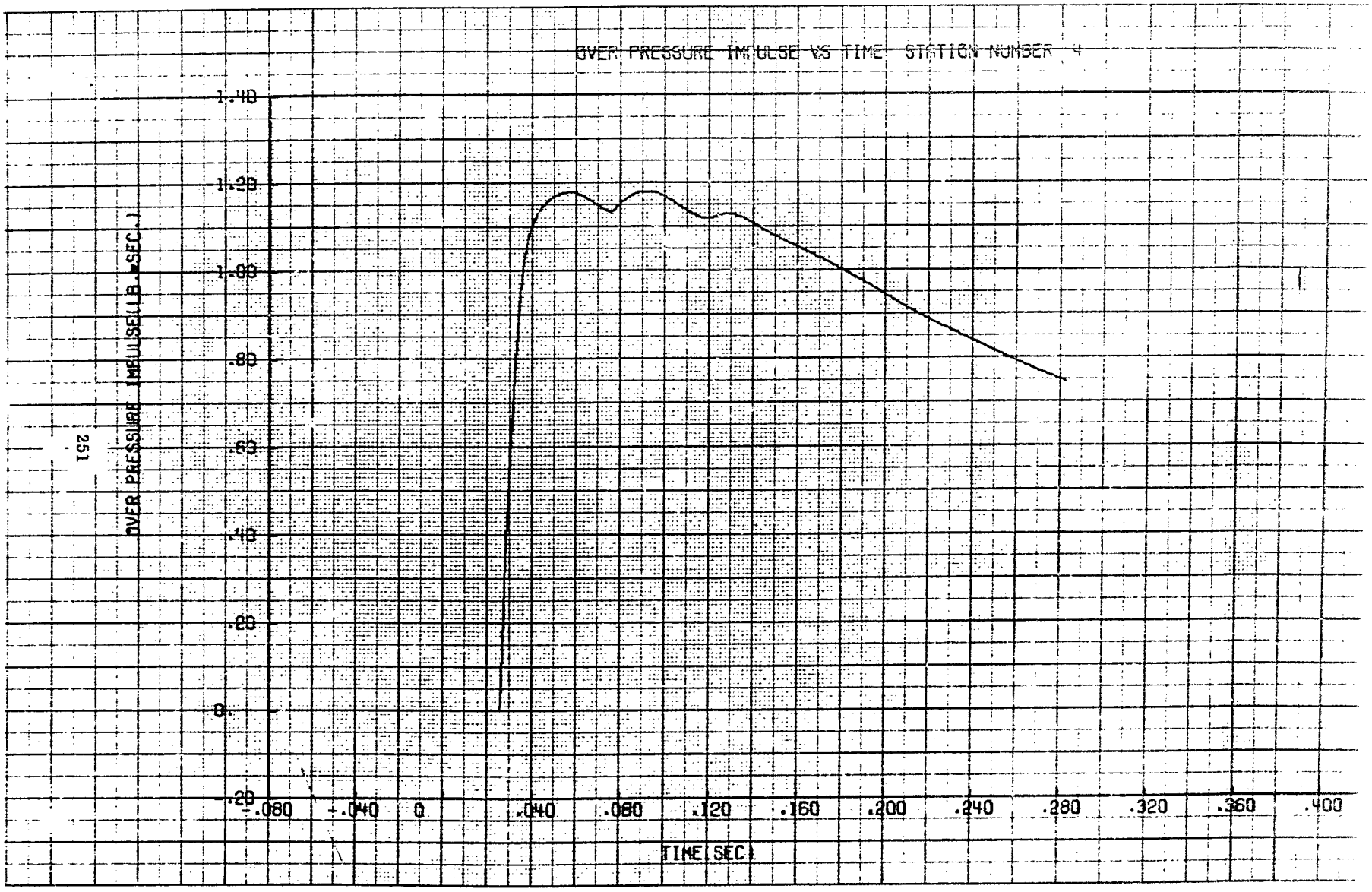

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
DYNAMIC PRESSURE PSI

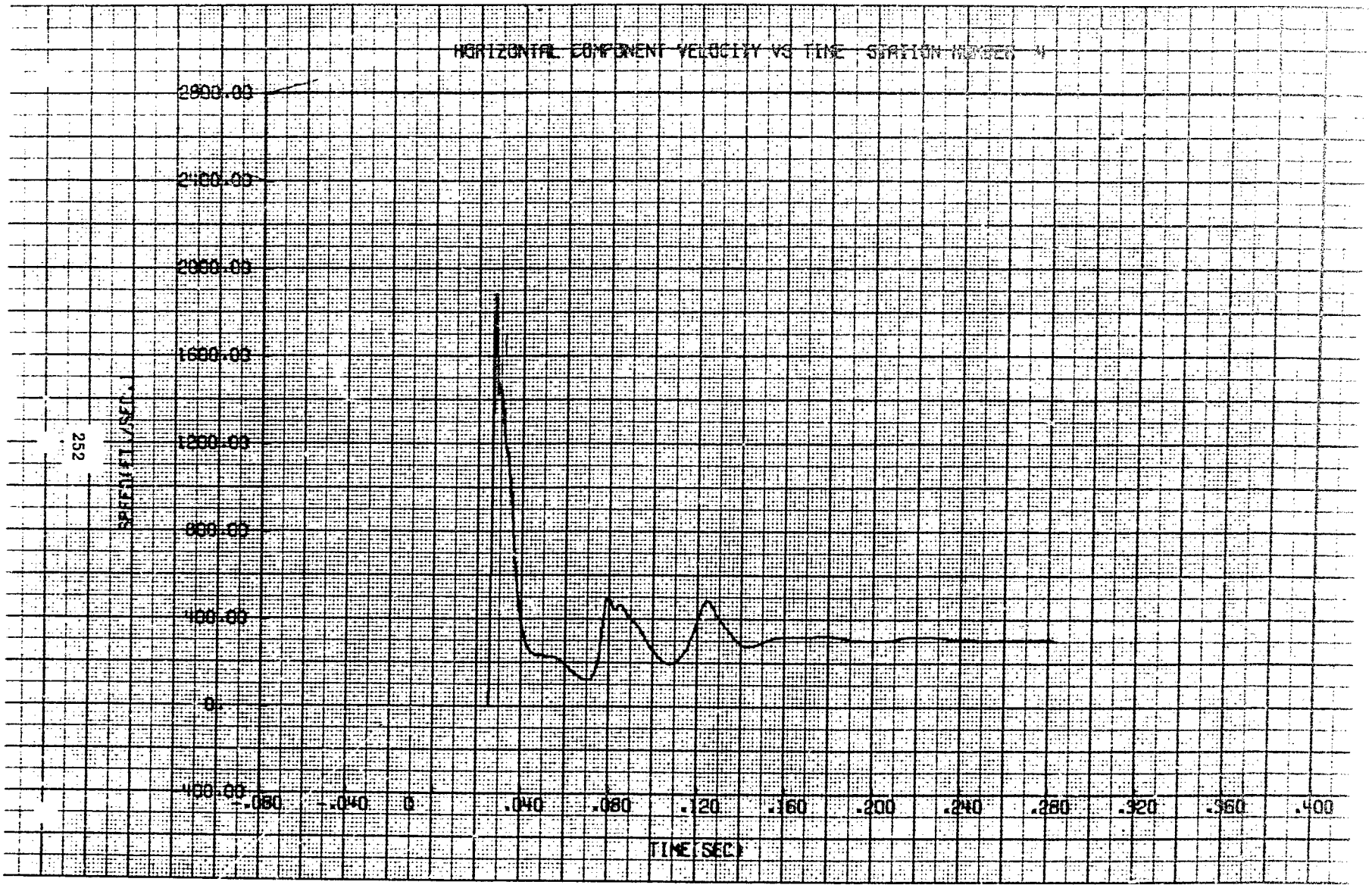

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

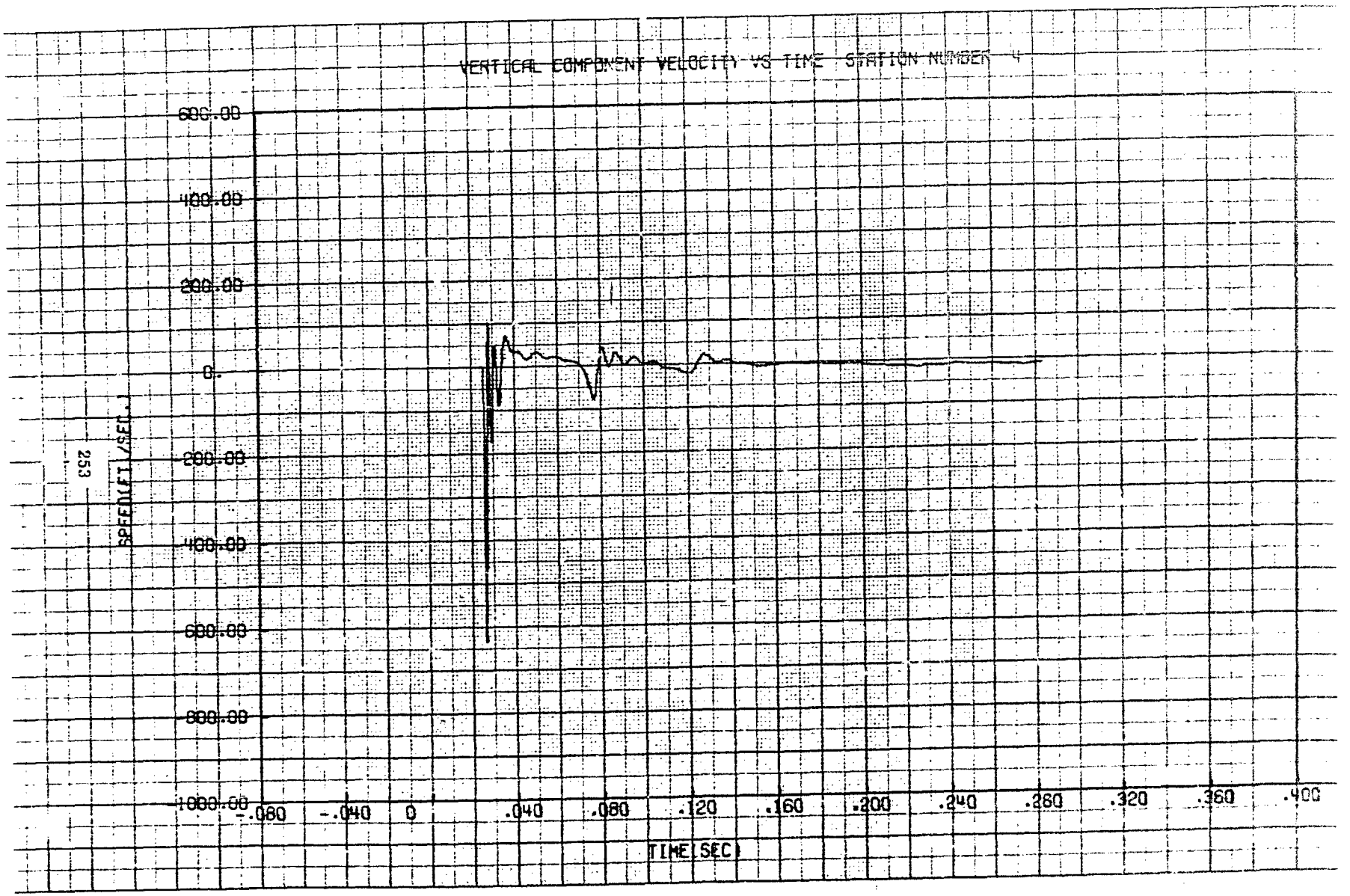

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
DYNAMIC PRESSURE(PSI)

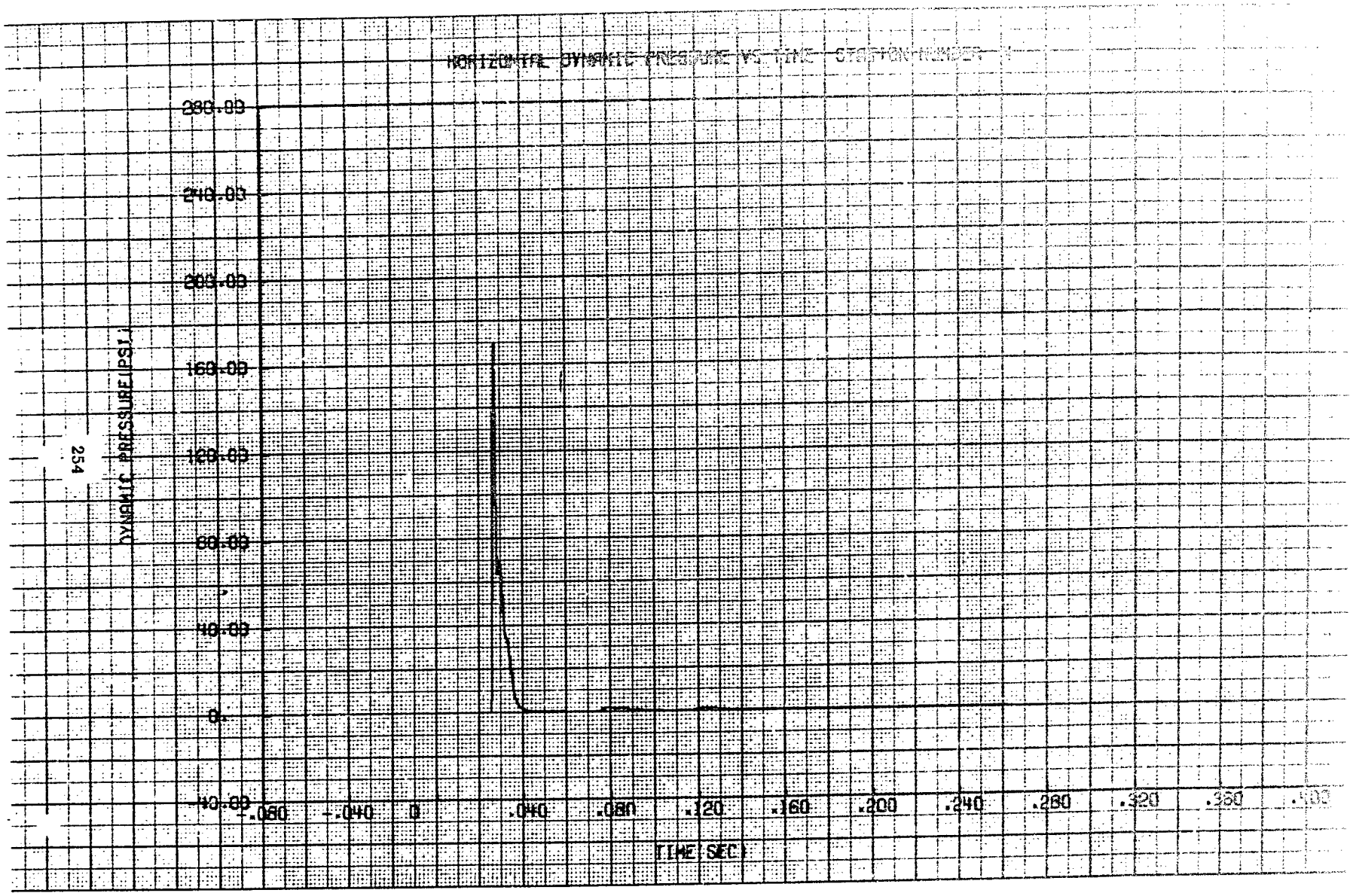

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.01
0.
-.01
-.02
-.03
-.04
-.05
-.06
-.07
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

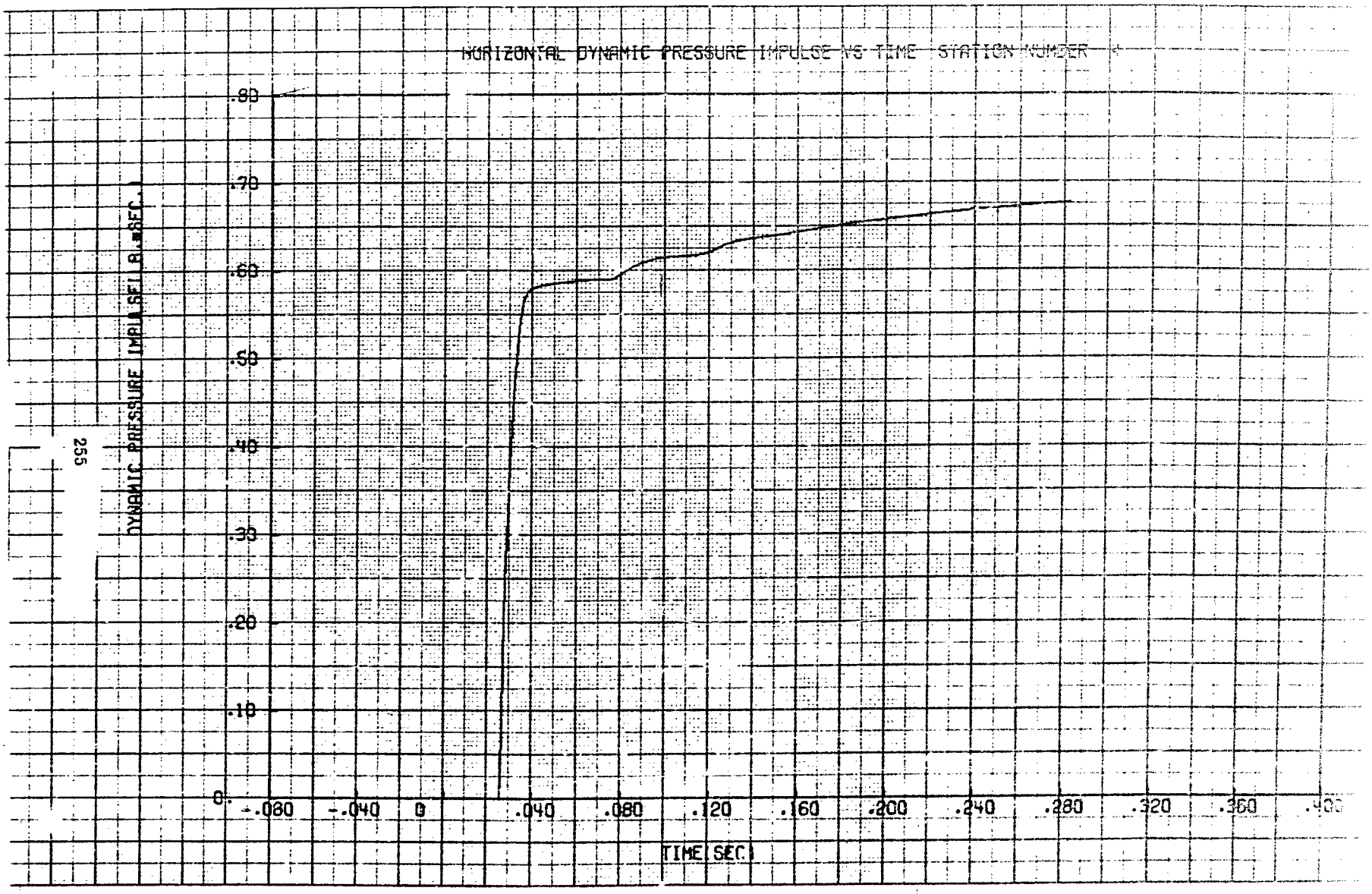

OVER PRESSURE (STATIC) SANTA MONICA
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
OVER PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

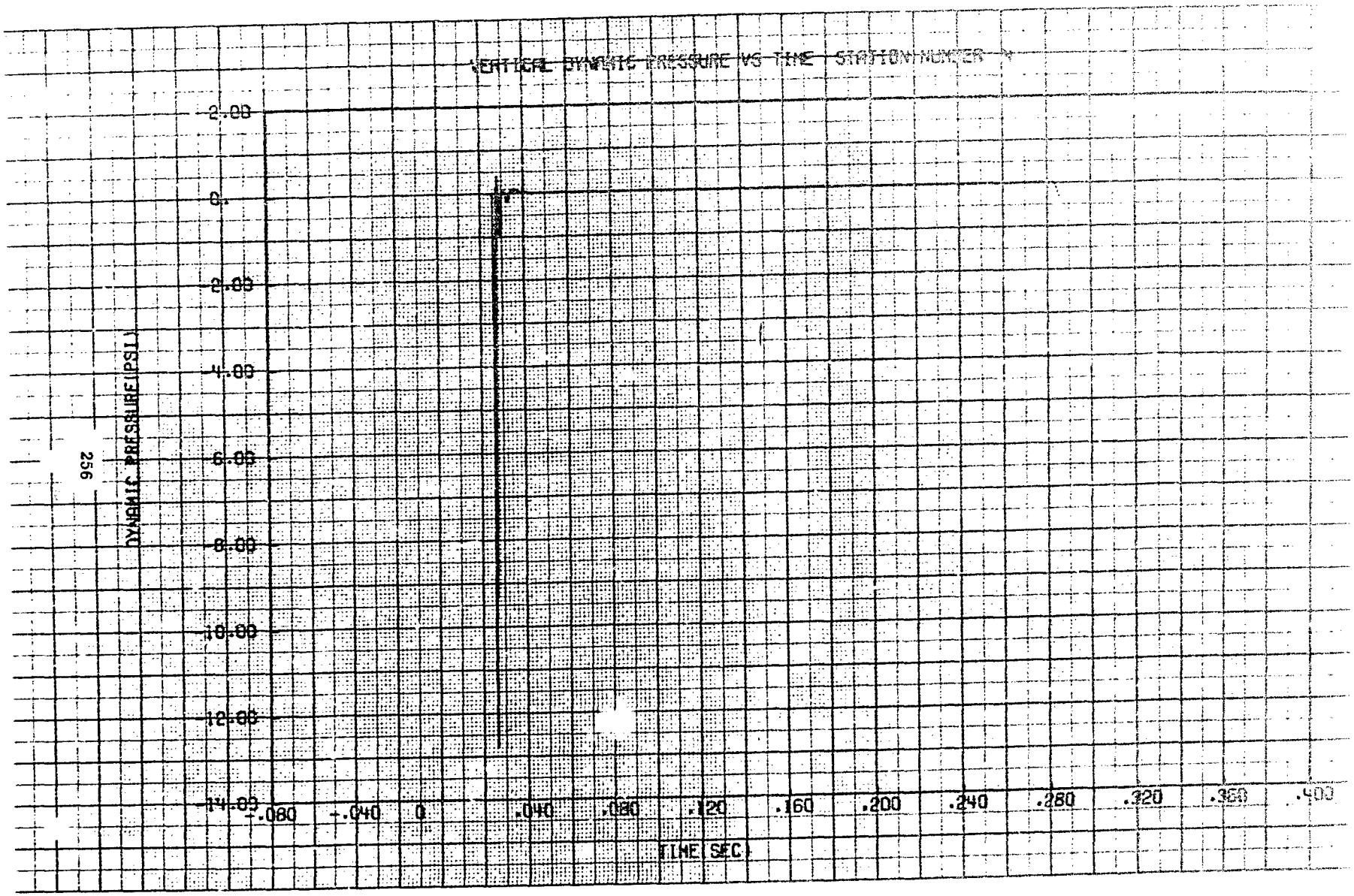

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 4
OVER PRESSURE IMPULSE(LB.*SEC.)
1.40
1.20
1.00
.80
.60
.40
.20
0.
-.20
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

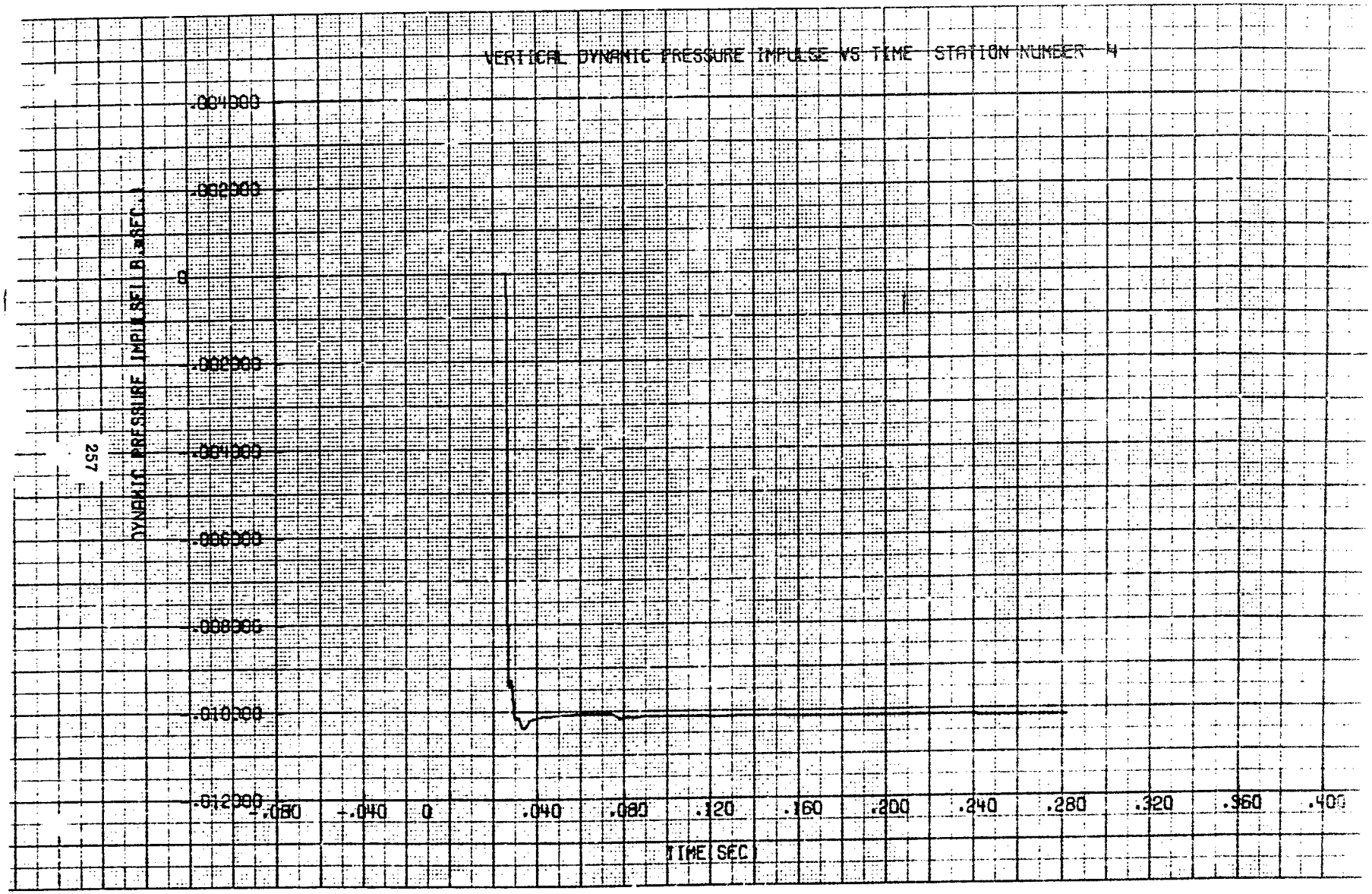

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 4
2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
SPECIFIC VELOCITY
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

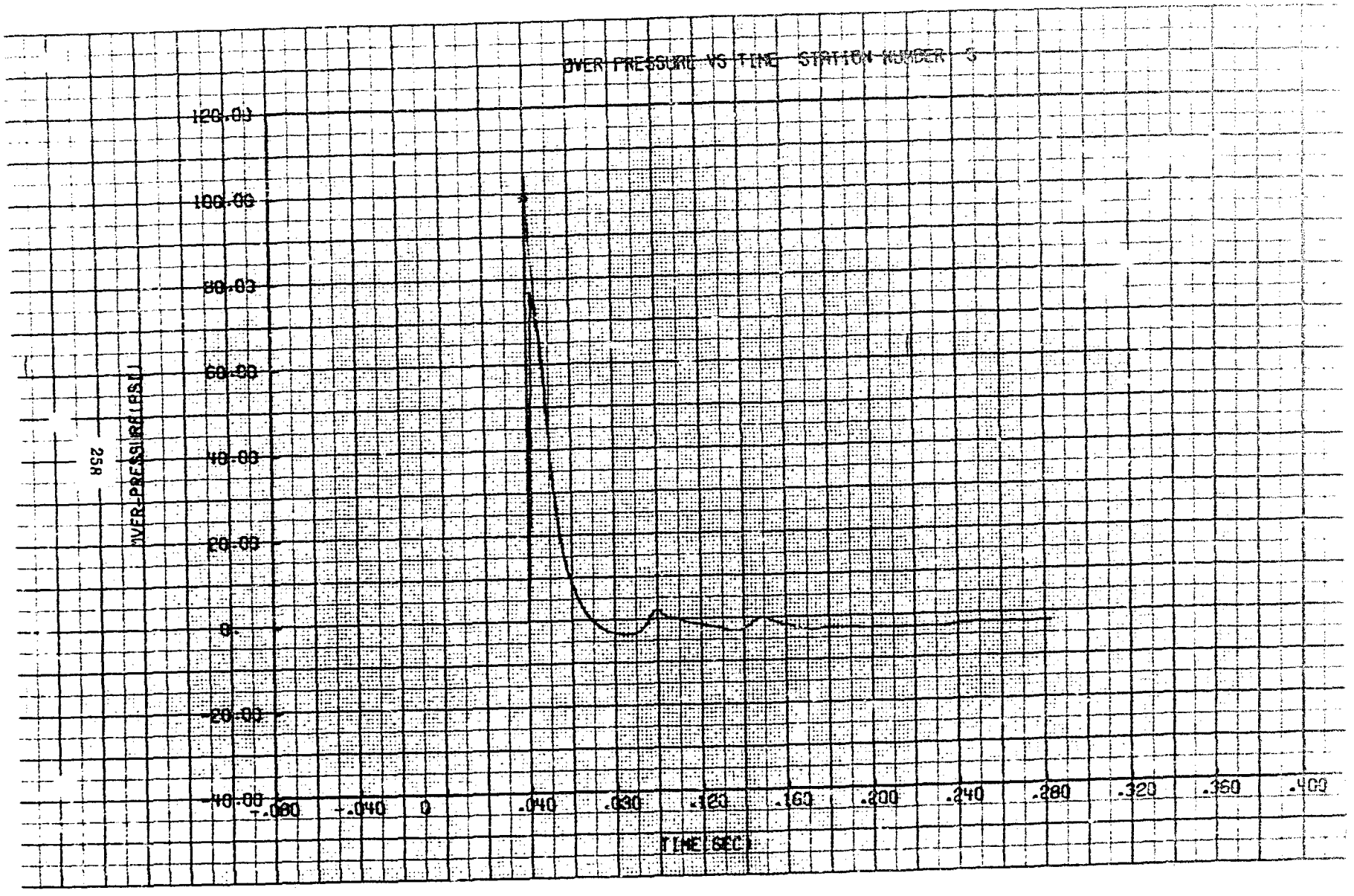

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 4
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

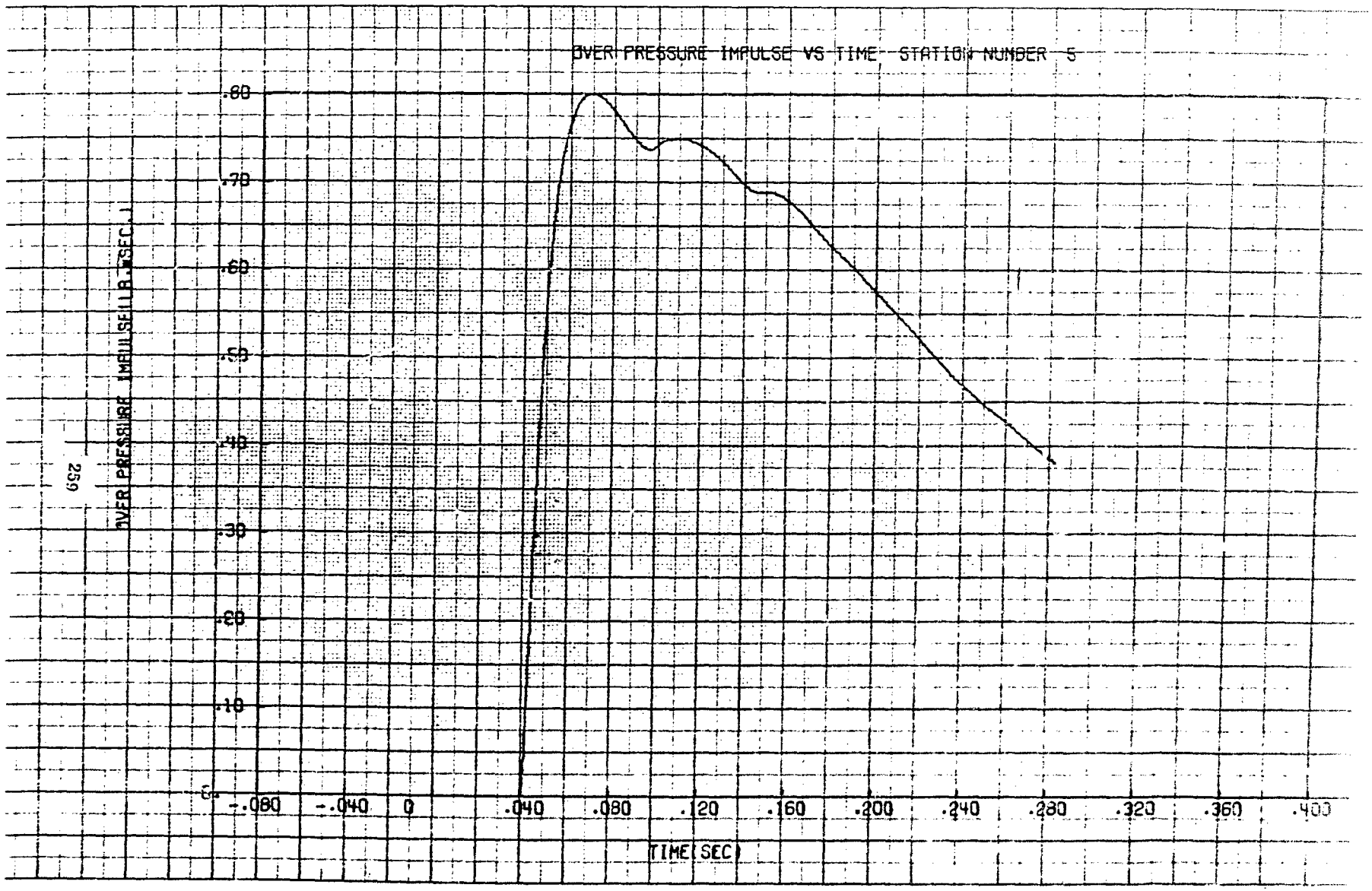

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER
280.00
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC
DYNAMIC PRESSURE (PSI)

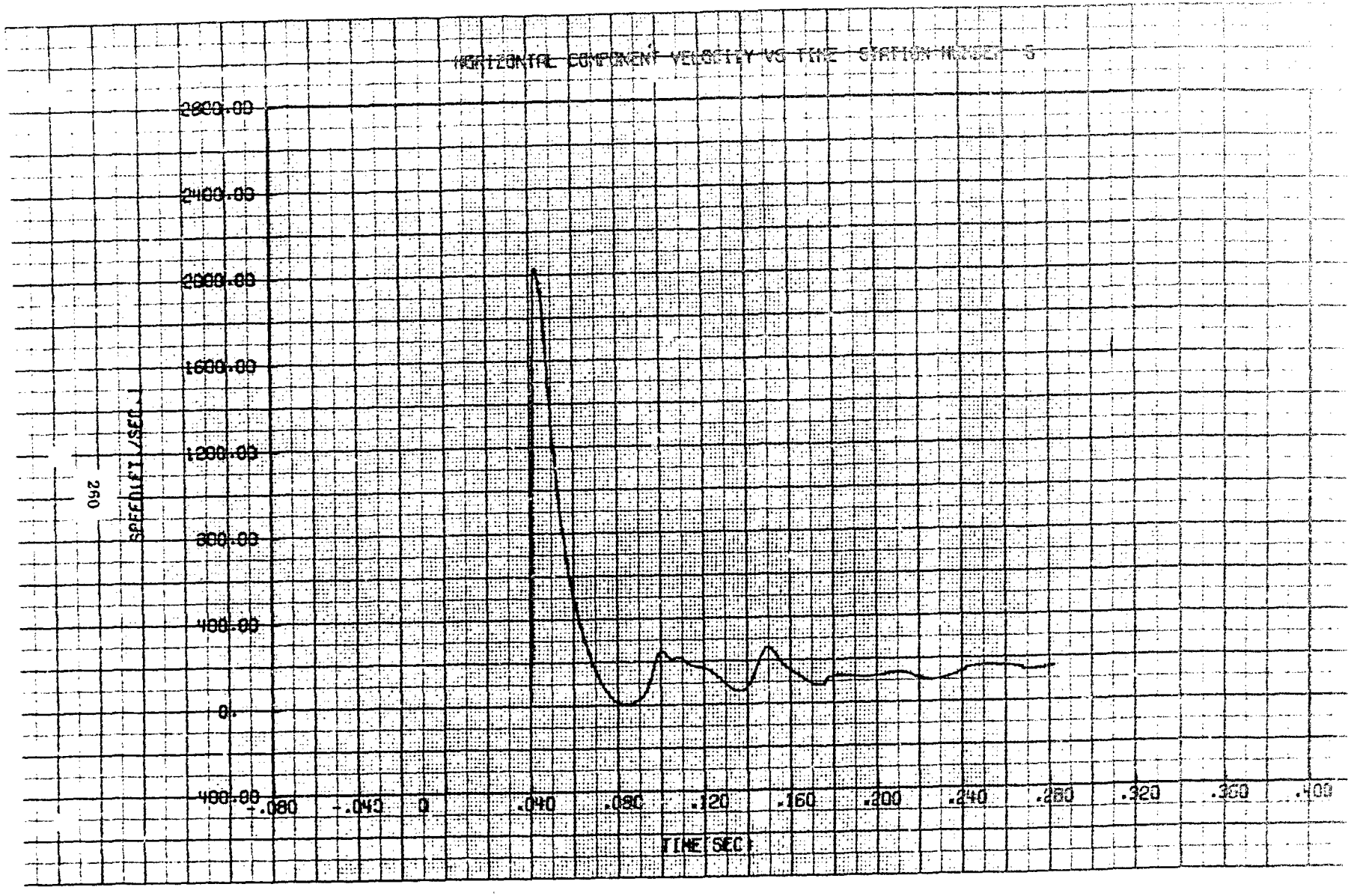

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.80
.70
.60
.50
.40
.30
.20
.10
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC.)

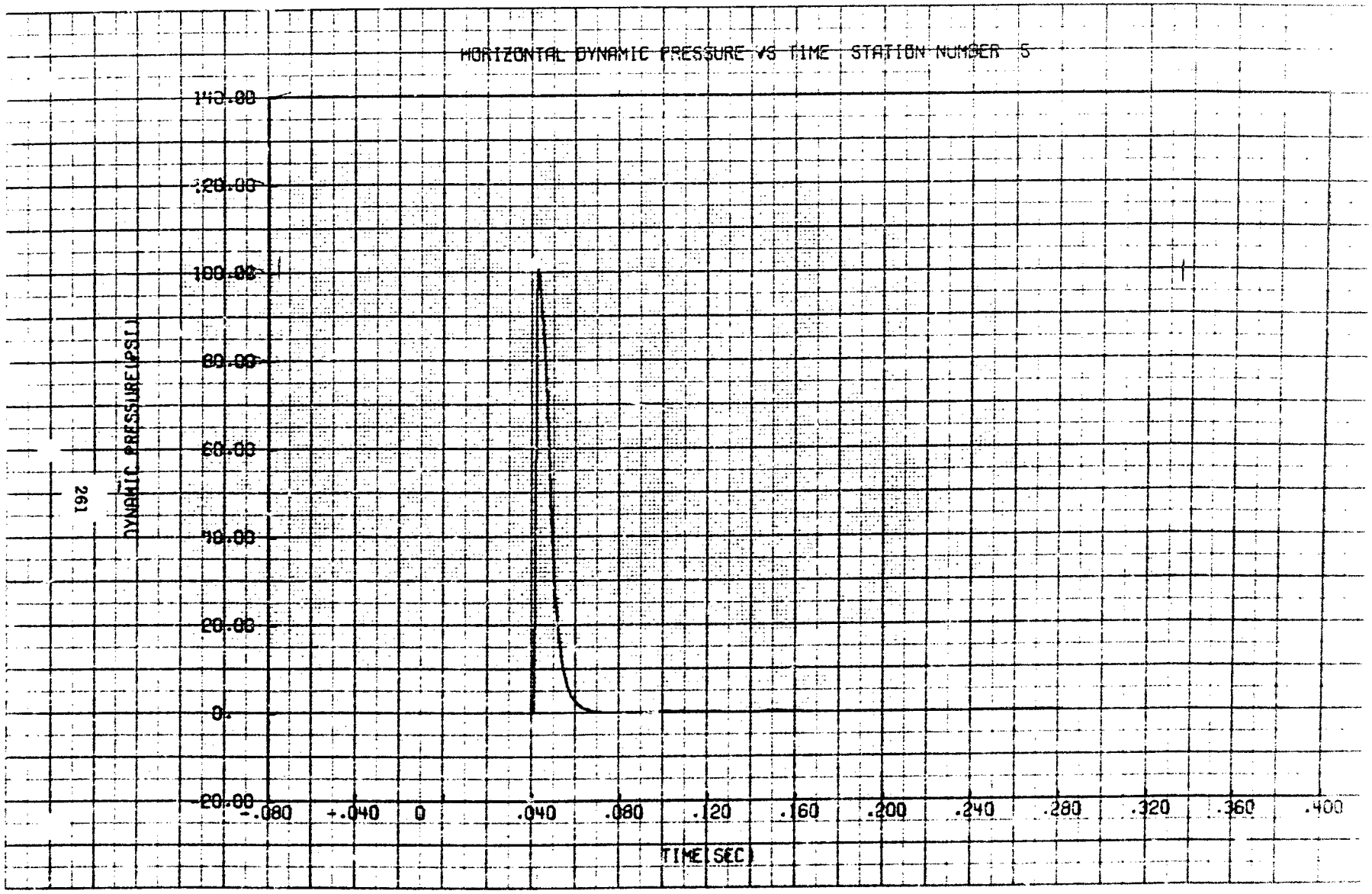

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER
2.00
0.
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
DYNAMIC PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

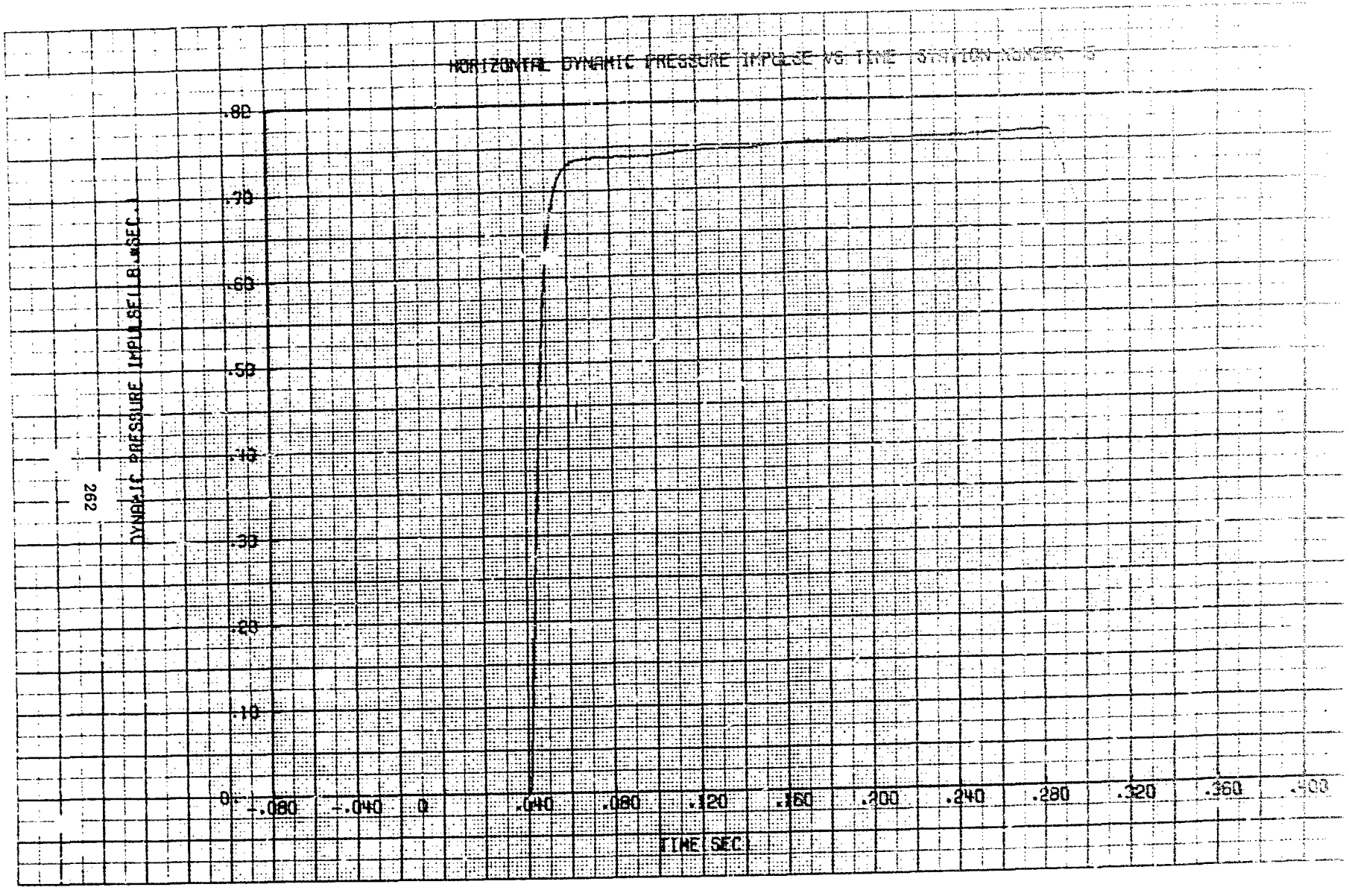

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 4
.004000
.002000
0
-.002000
-.004000
-.006000
-.008000
-.010000
-.012000
DYNAMIC PRESSURE IMPULSE(LB.SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

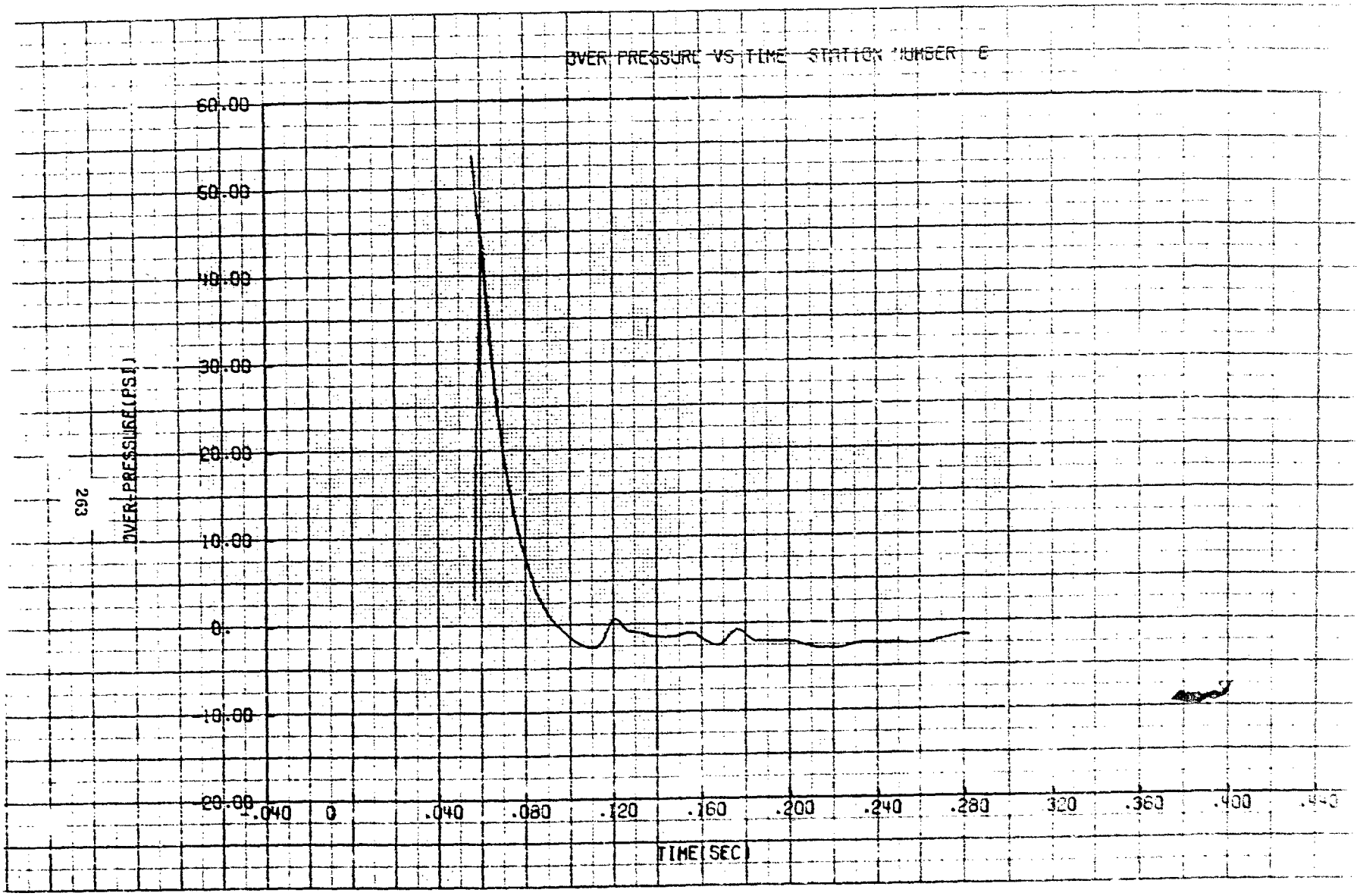

OVER PRESSURE VS TIME STATION NUMBER 5
OVER PRESSURE (PSI)
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

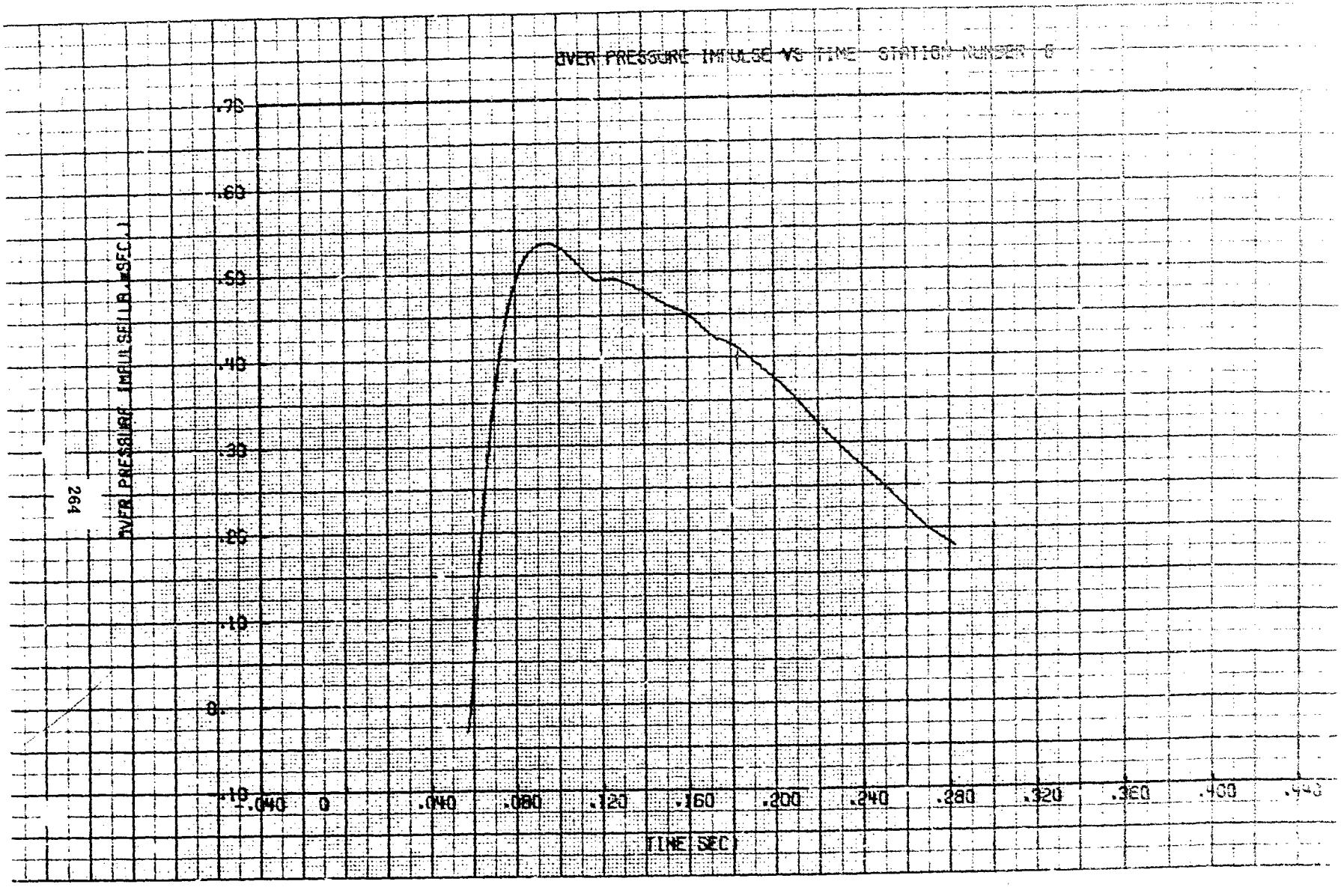

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 5
OVER PRESSURE IMPULSE(LB.*SEC.)
.80
.70
.60
.50
.40
.30
.20
.10
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

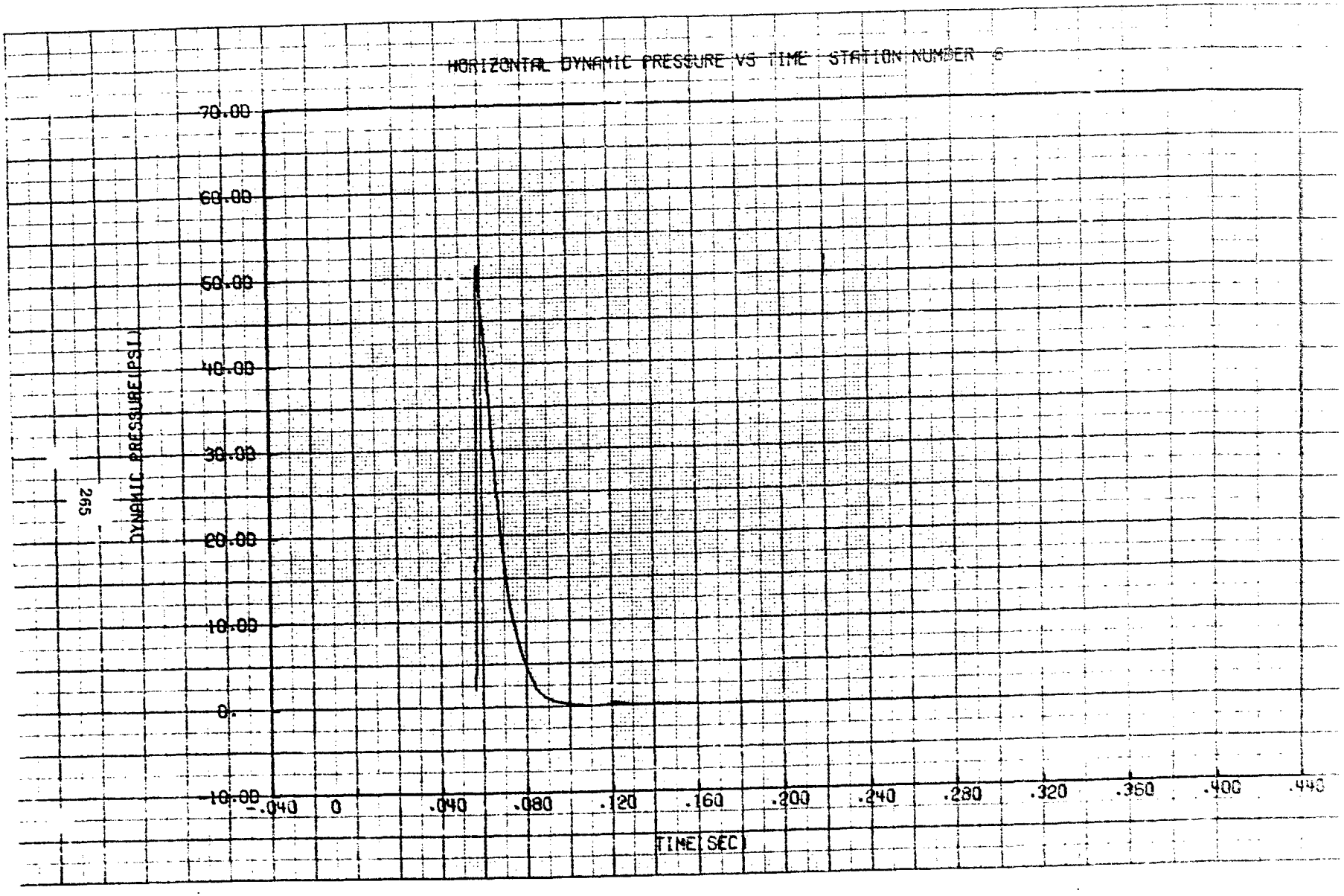

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

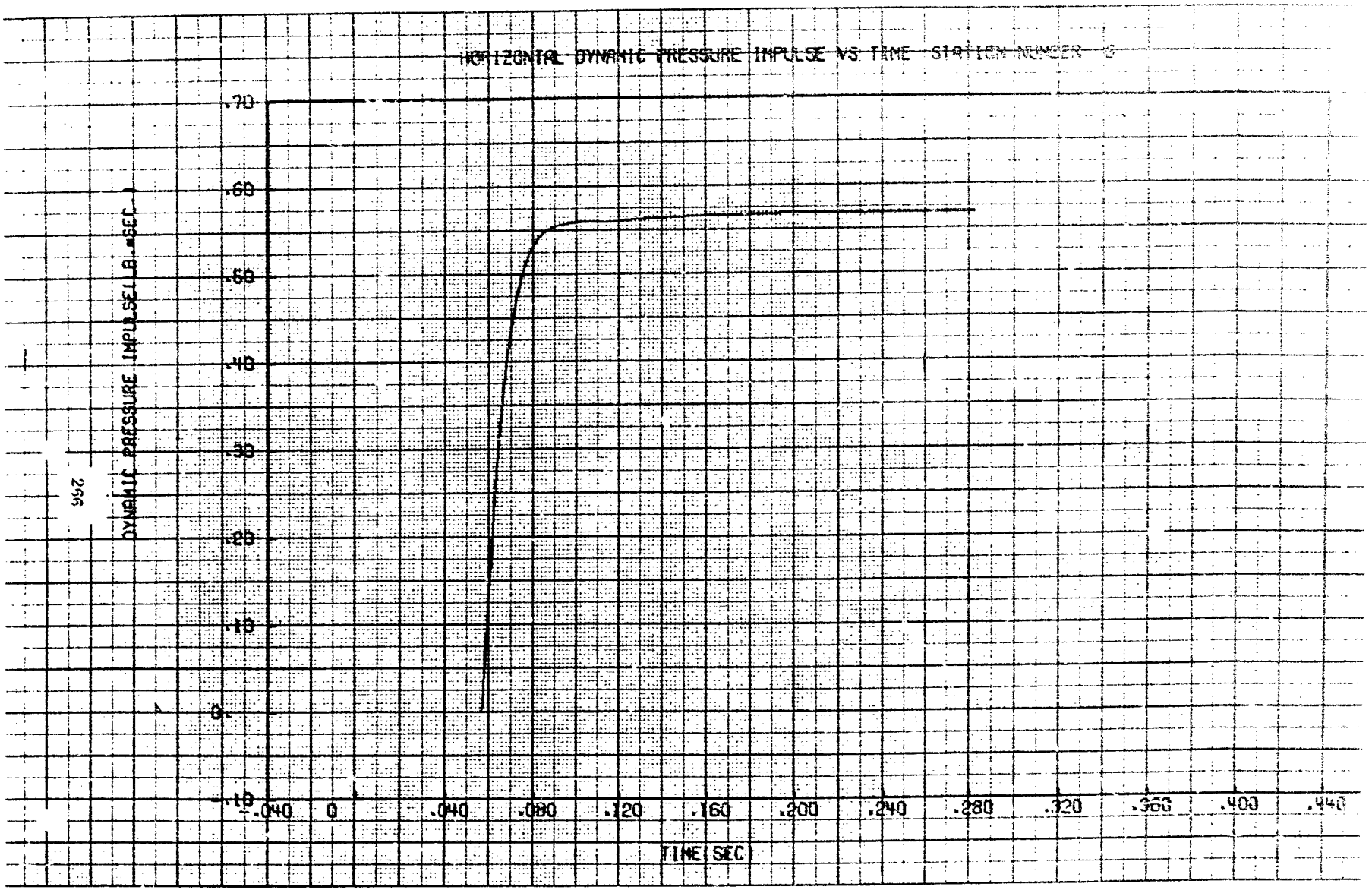

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE(PSI)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

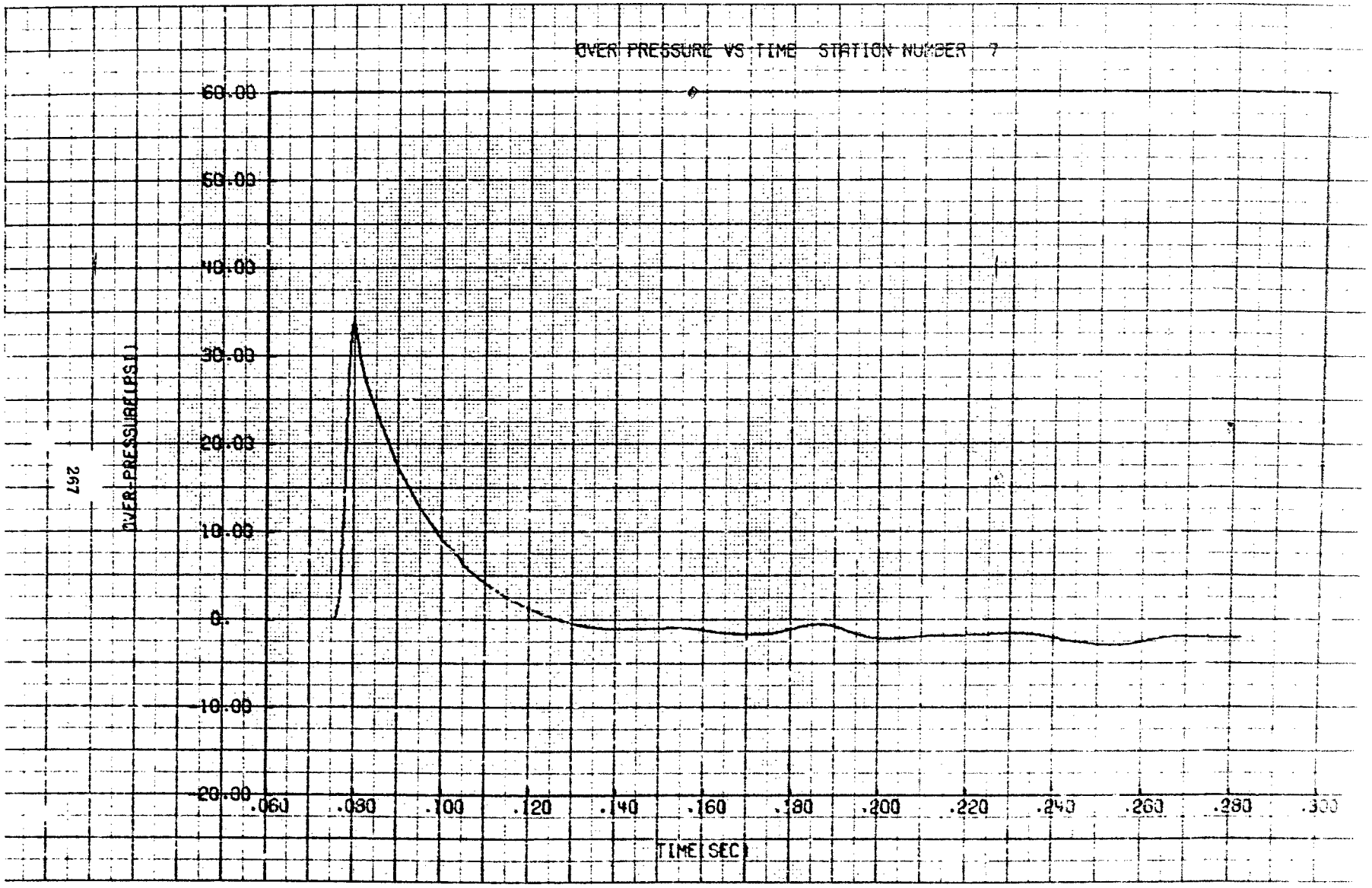

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 5
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.80
.70
.60
.50
.40
.30
.20
.10
0
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

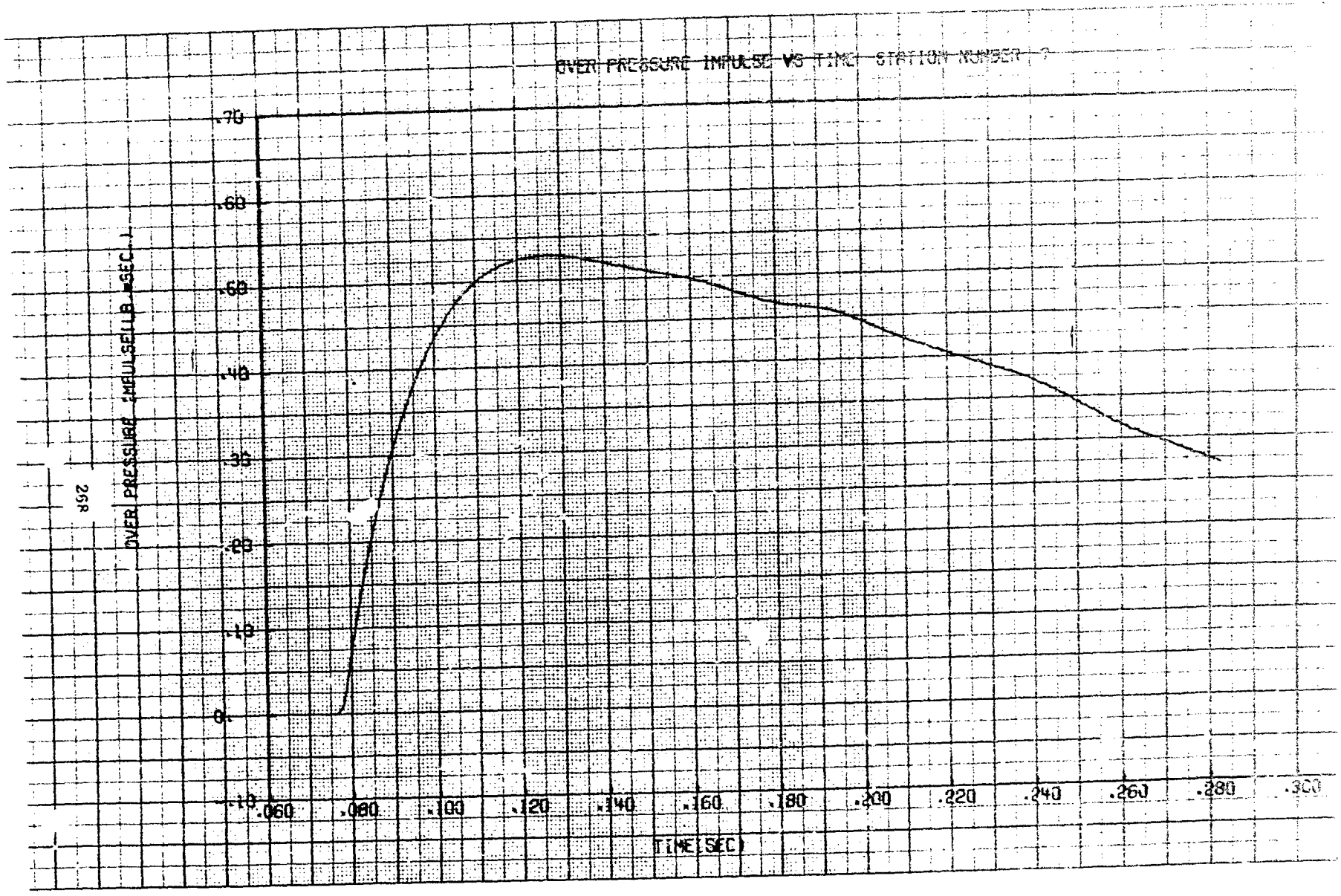

OVER PRESSURE VS TIME STATION NUMBER E
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER PRESSURE (PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

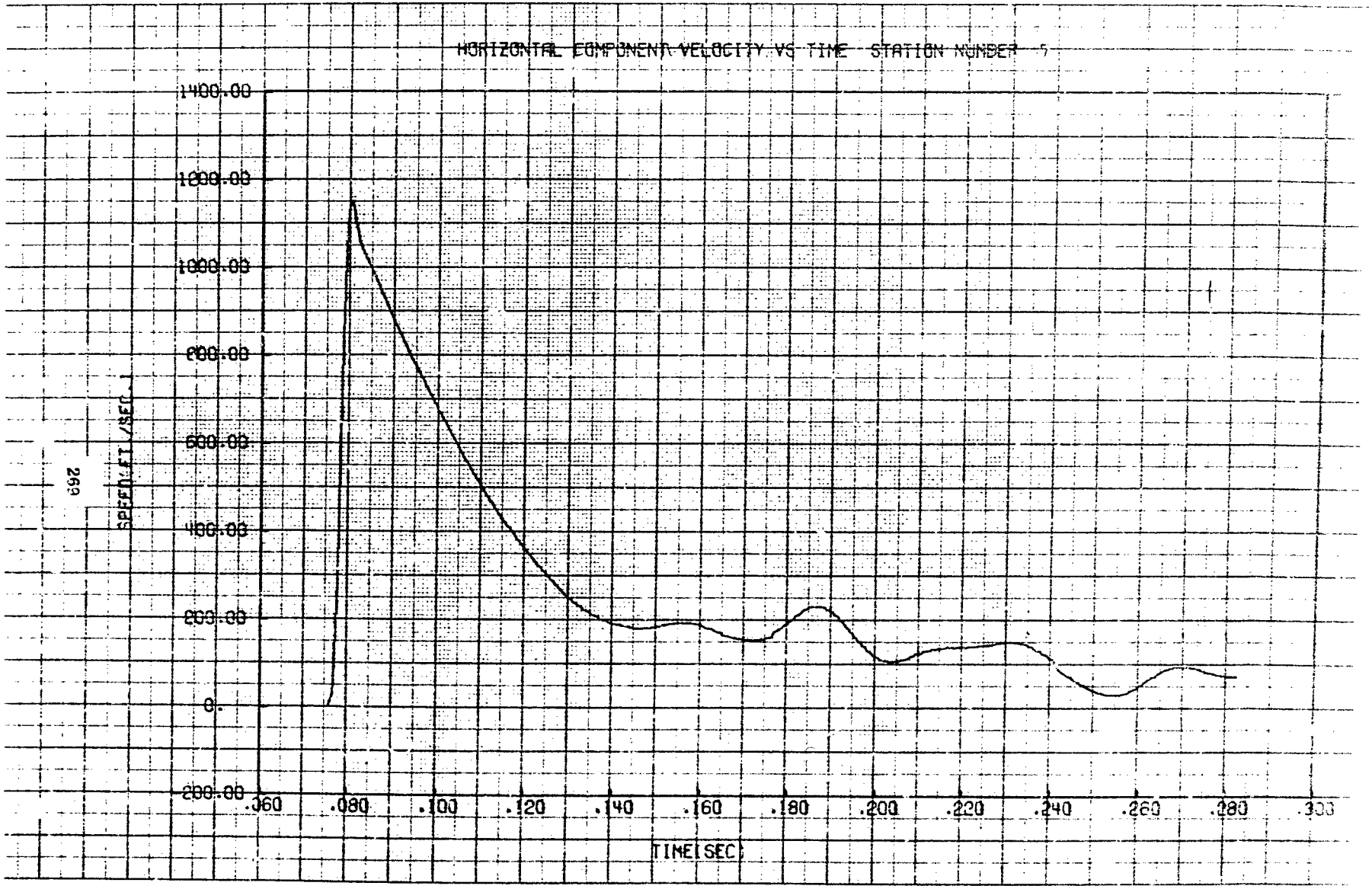

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 6
OVER PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC)

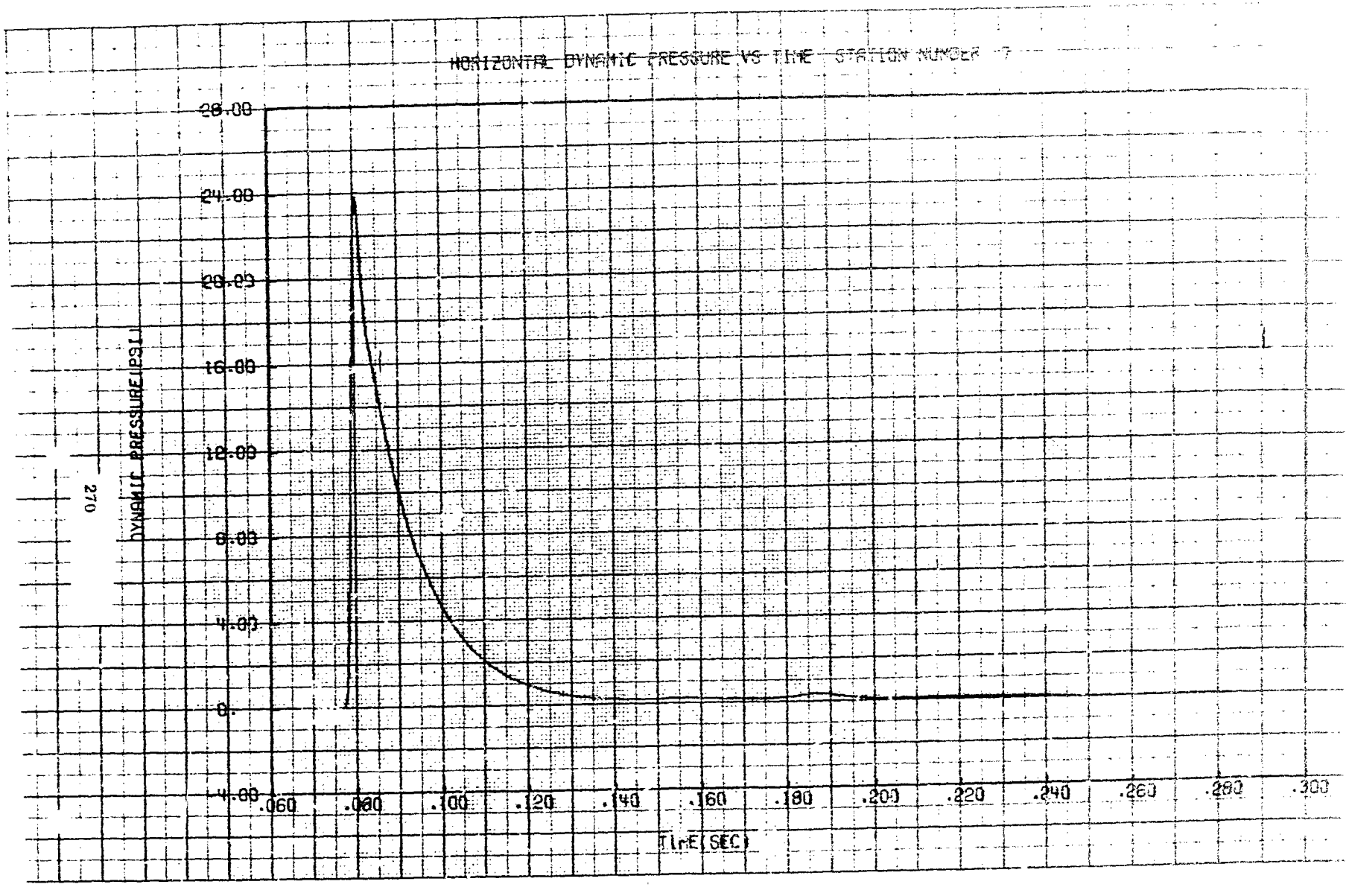

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 6
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

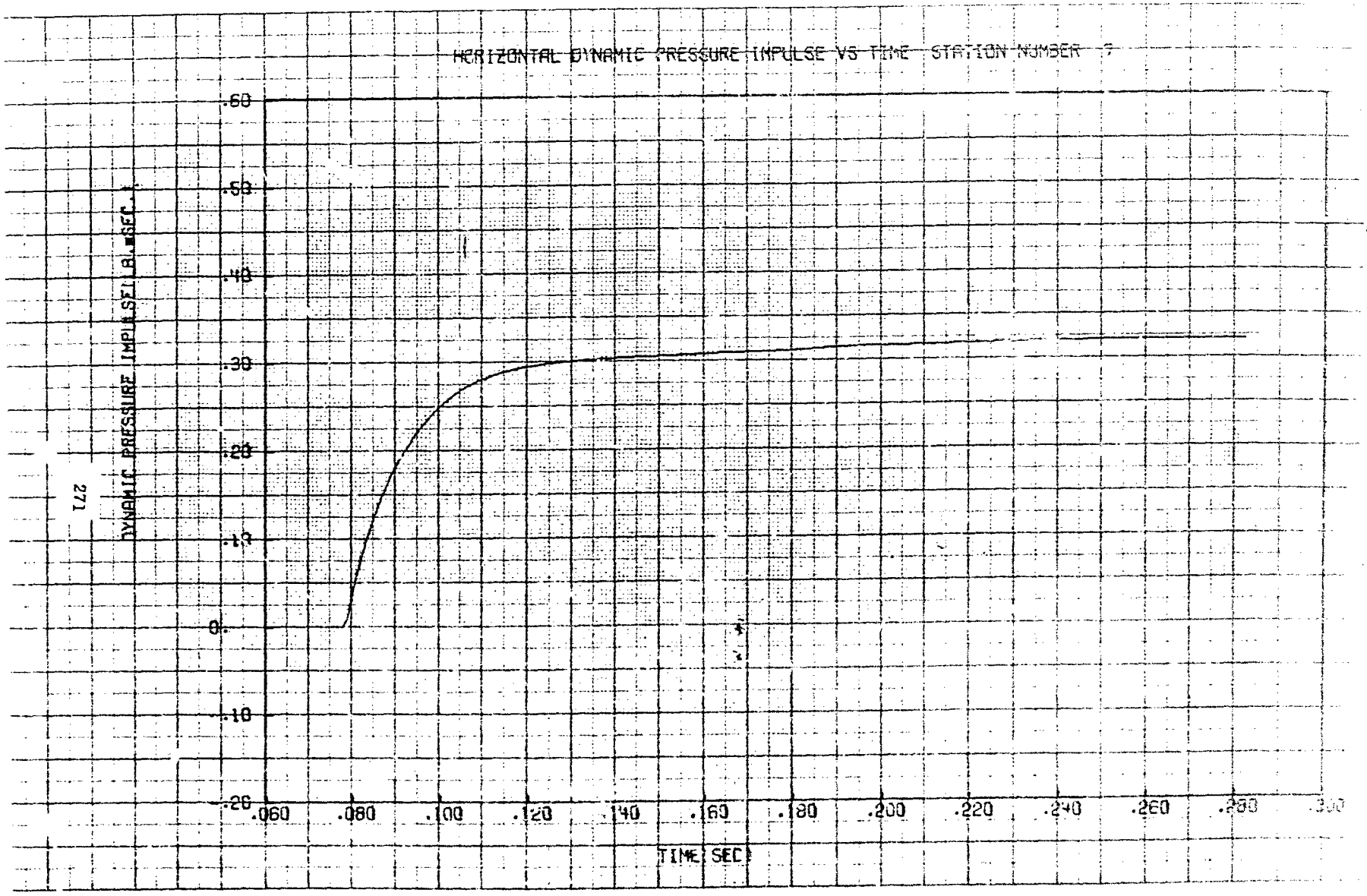

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

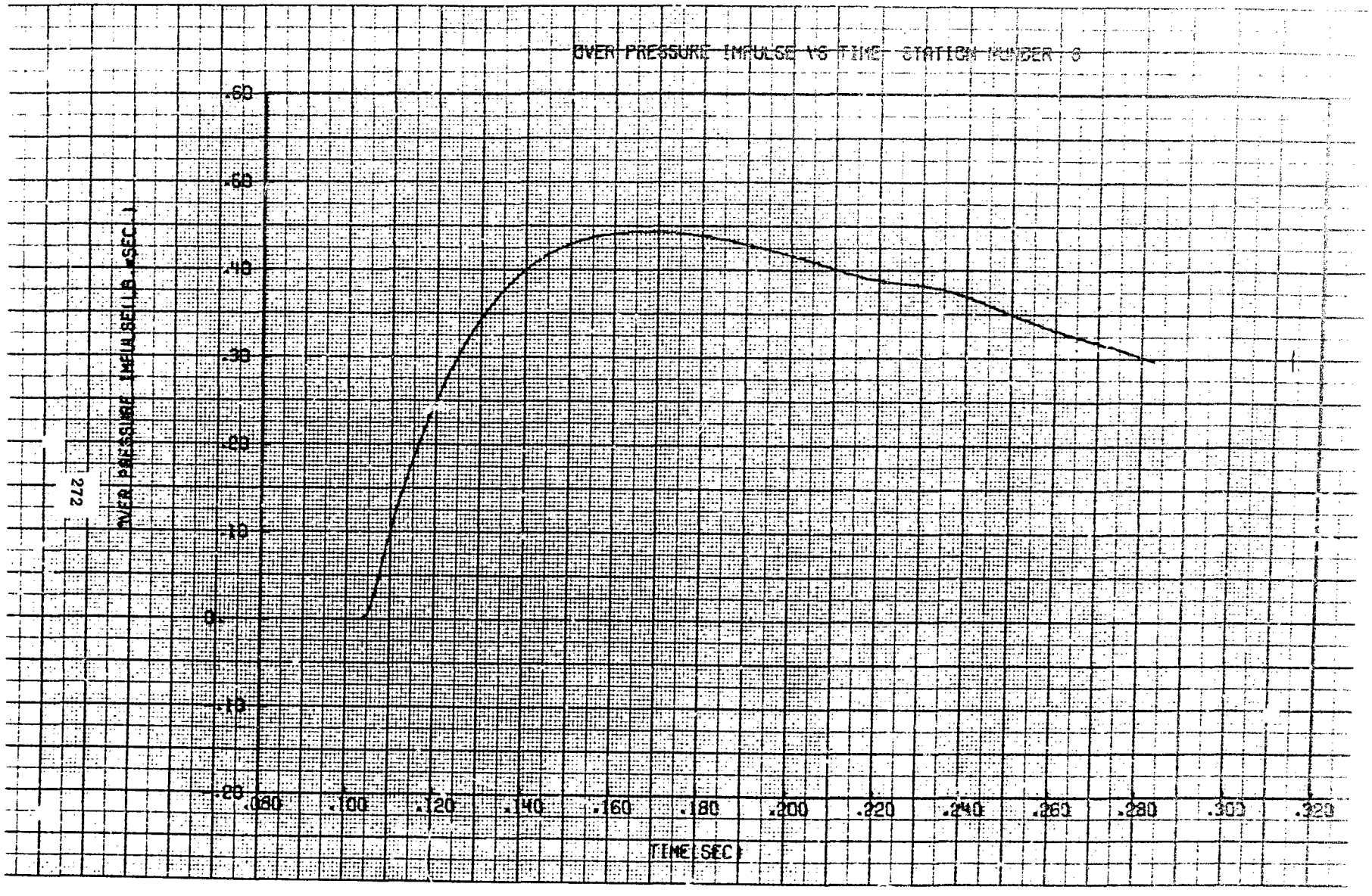

OVER PRESSURE VS TIME STATION NUMBER 7
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

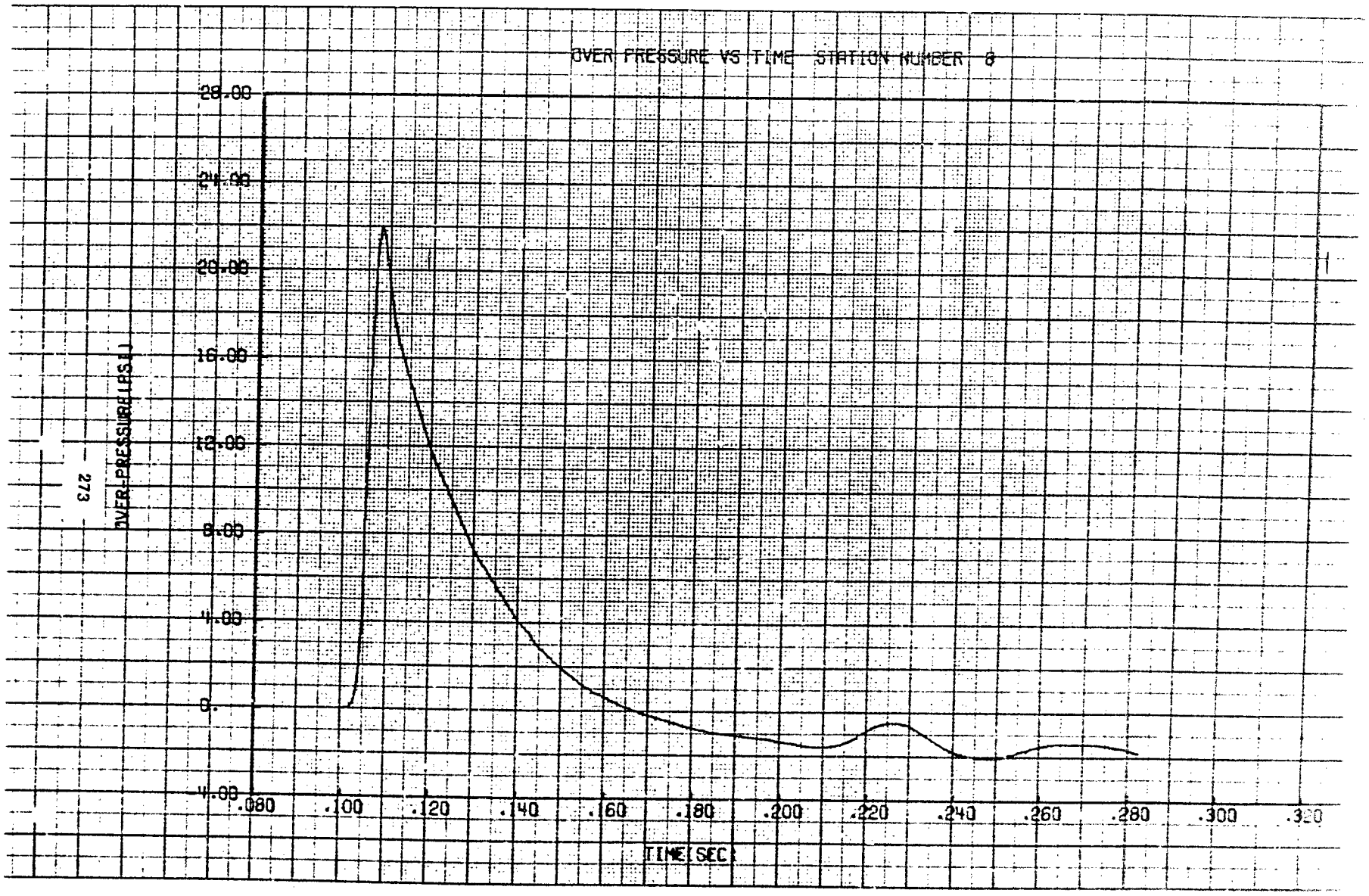

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 7
OVER PRESSURE IMPULSE(LB *SEC)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

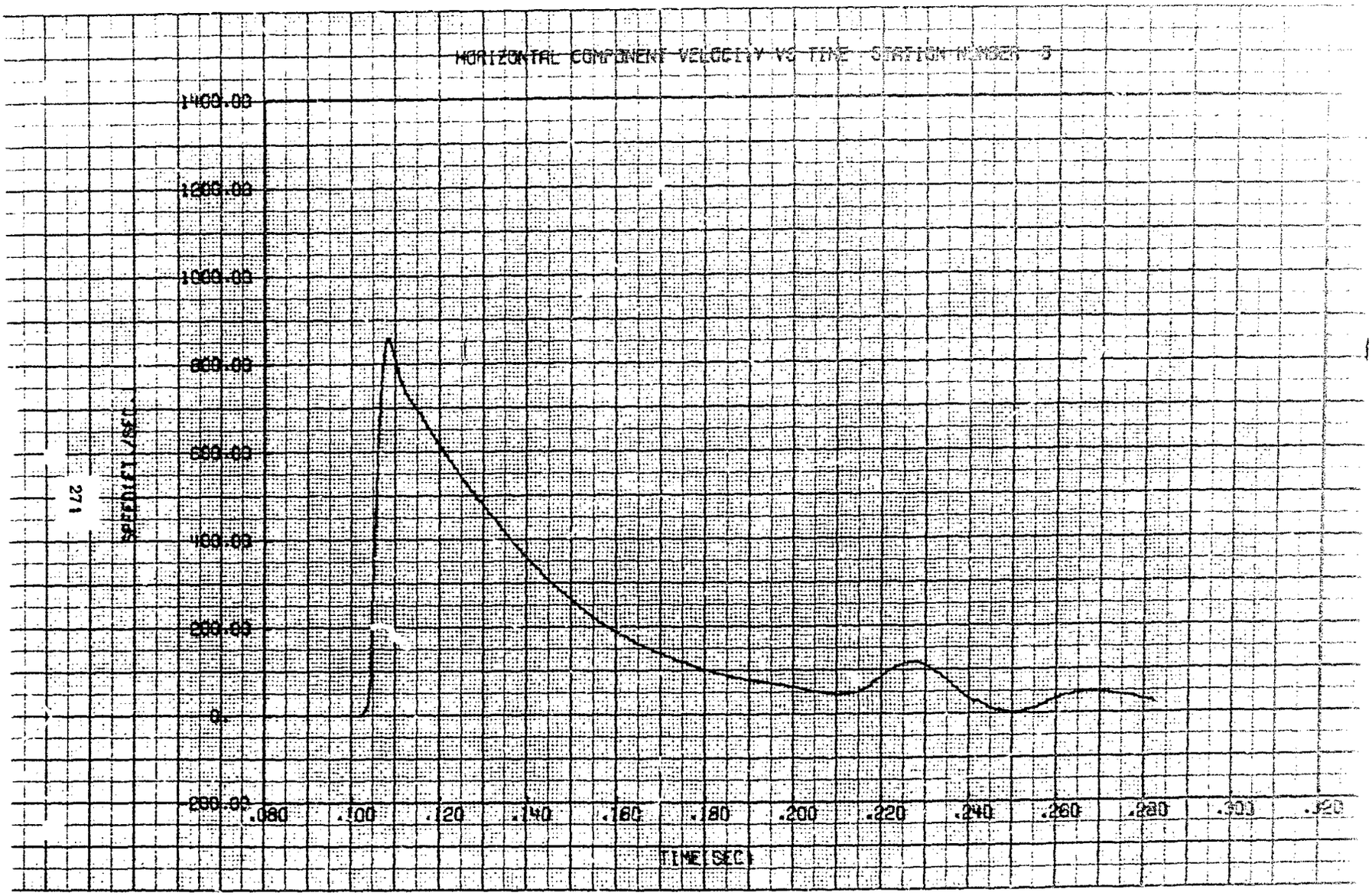

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

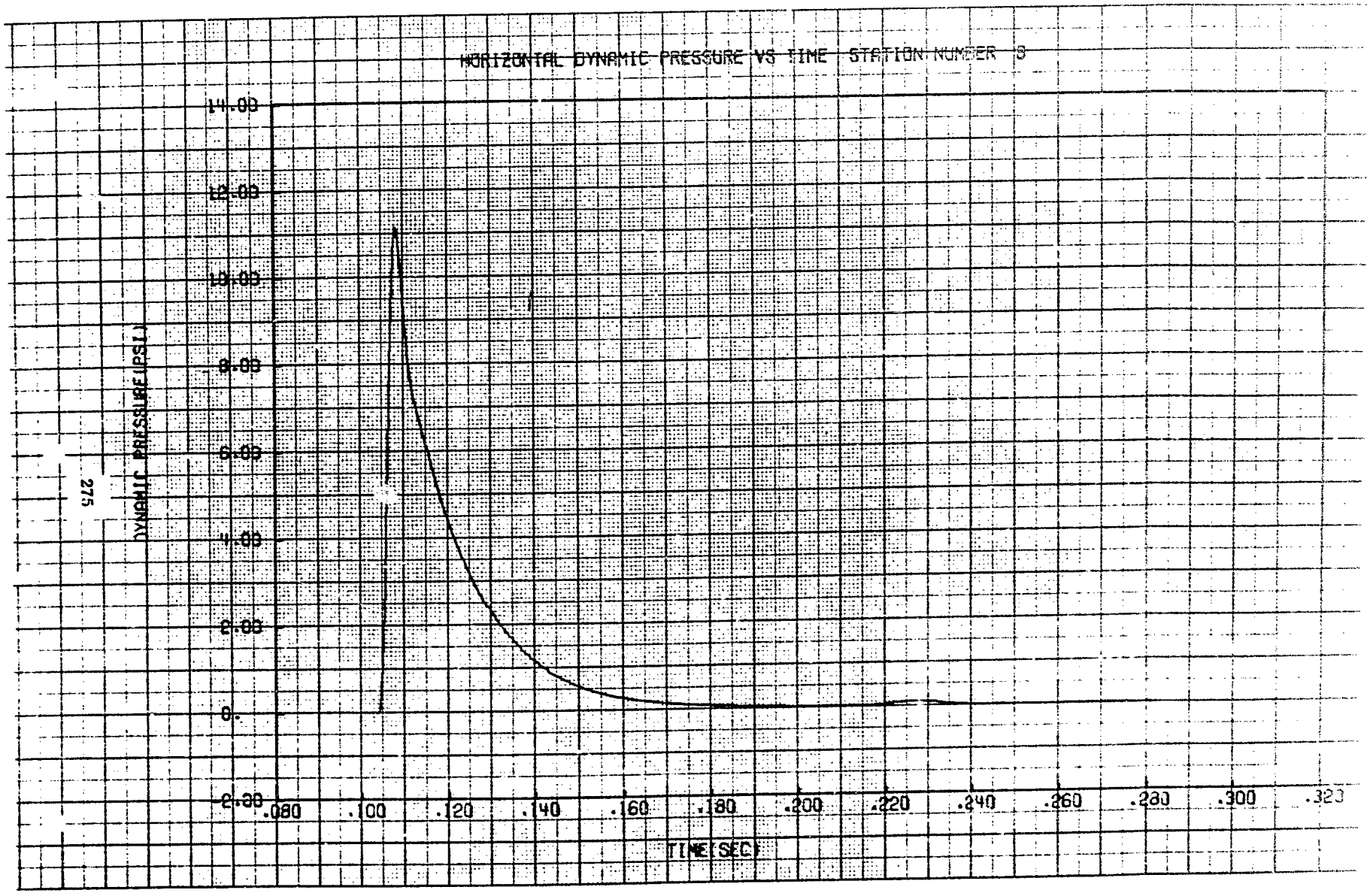

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE(PSI)
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

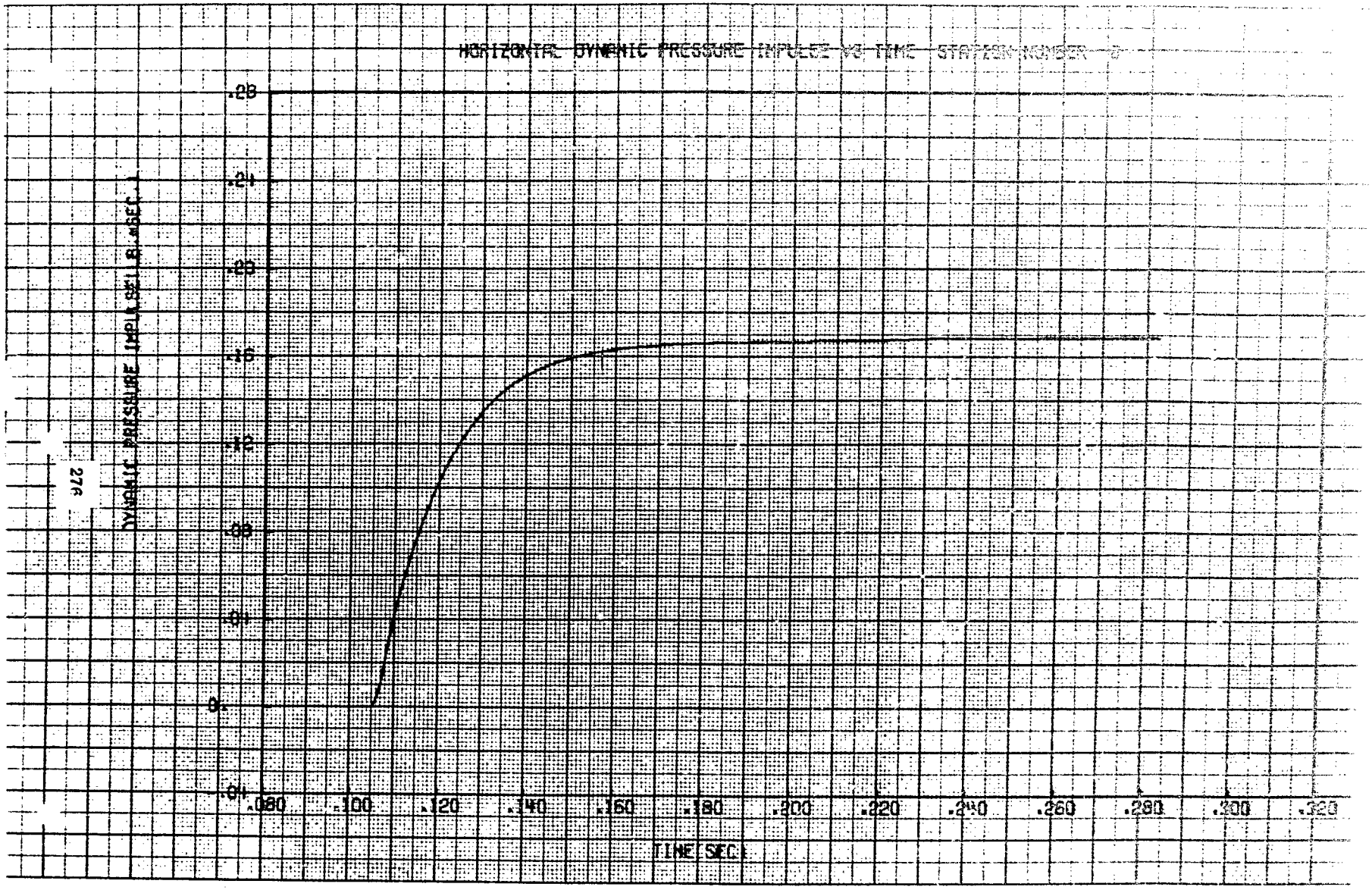

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 7
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

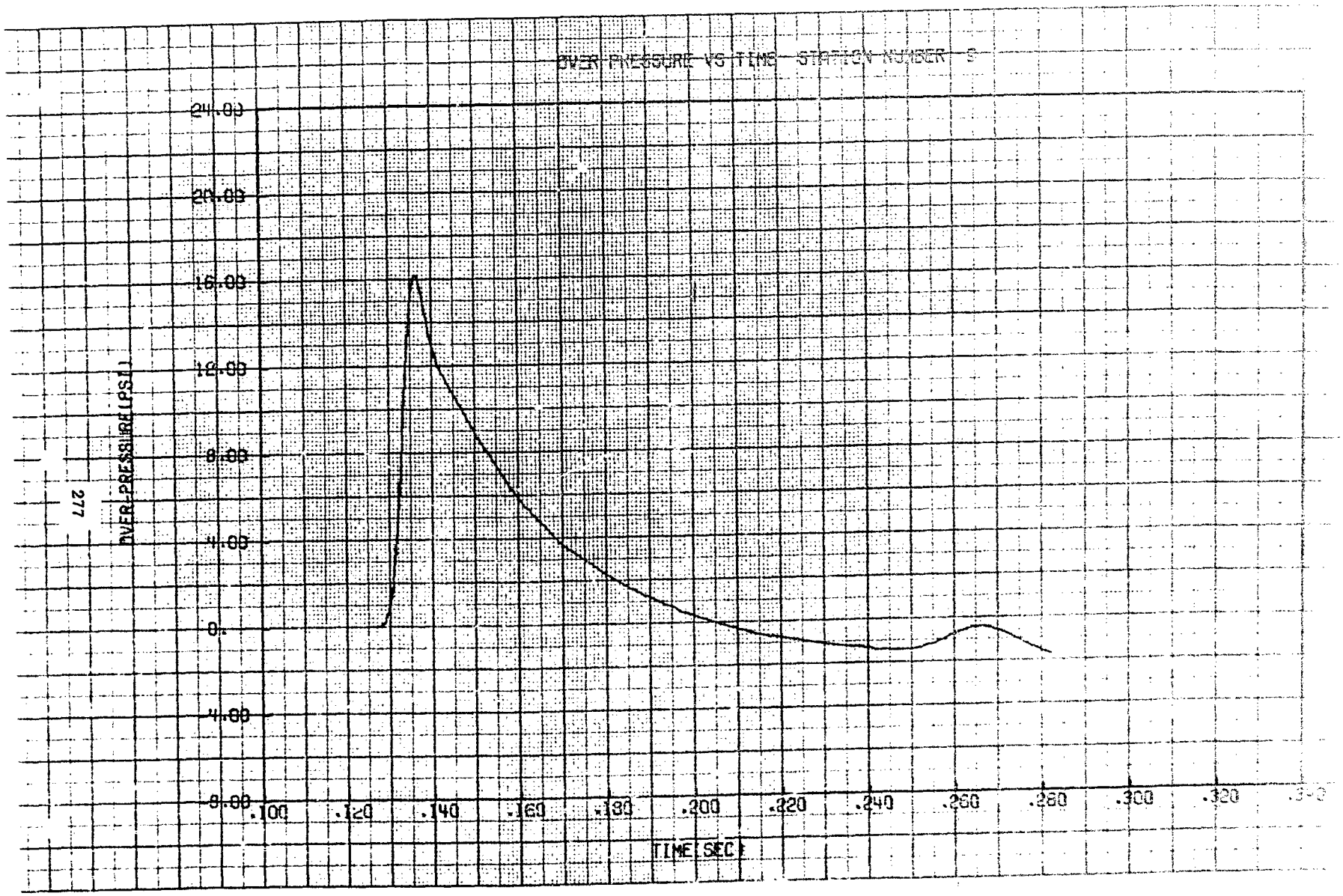

OVER PRESSURE IMPULSE VS TIME- STATION NUMBER 6
OVER PRESSURE IMPULSE(LB.-SEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

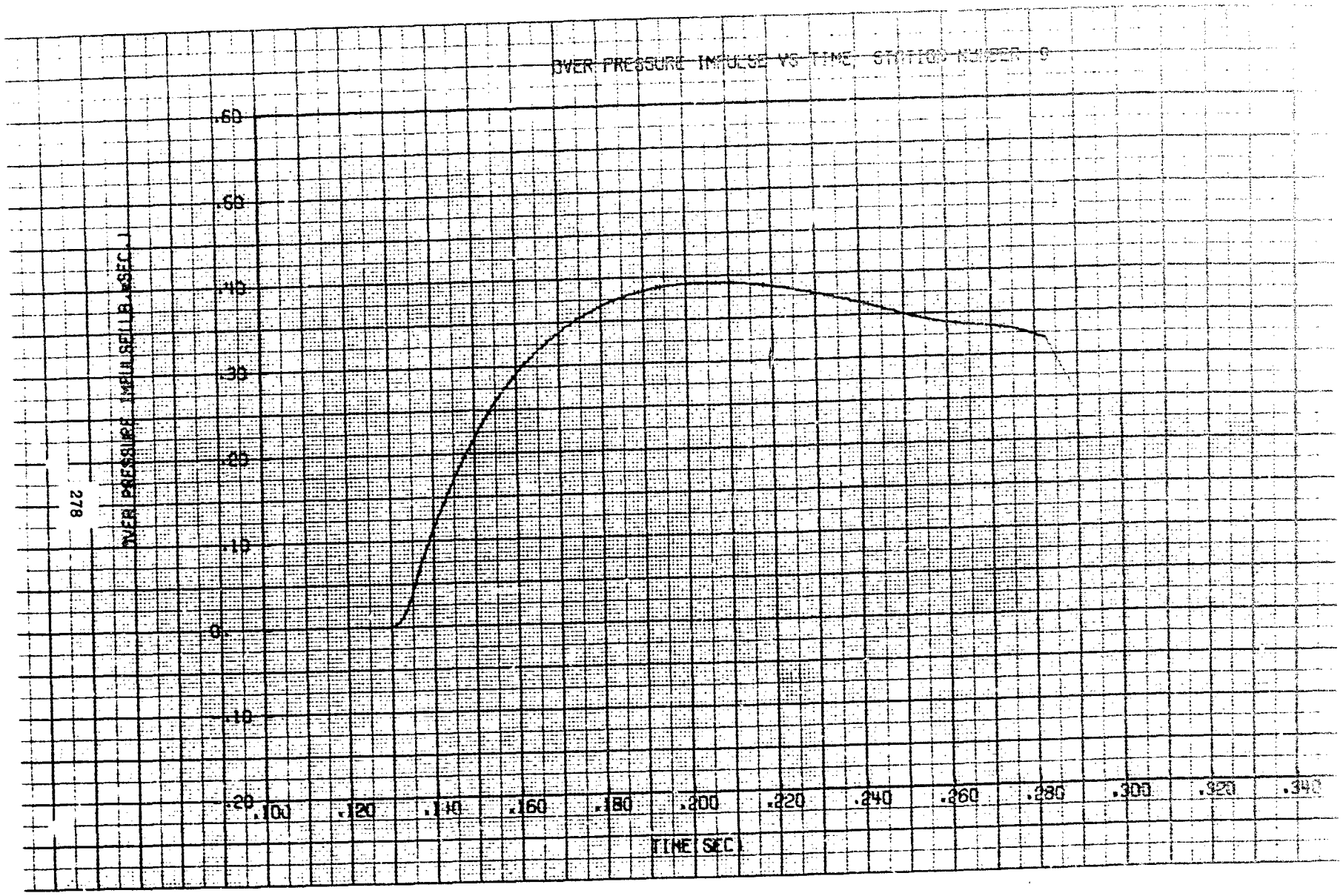

OVER PRESSURE VS TIME STATION NUMBER 8
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
OVER-PRESSURE(PSI)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

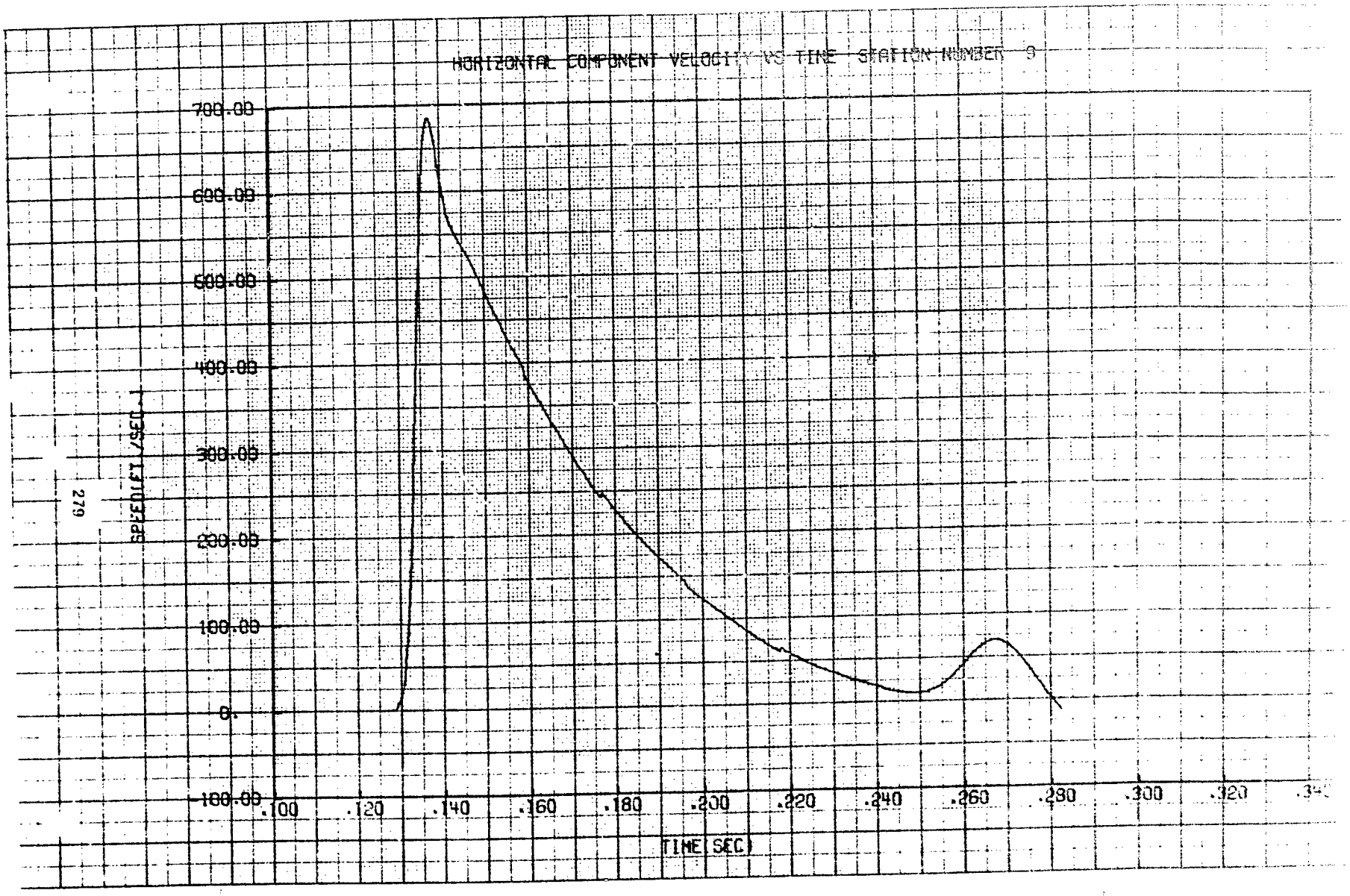

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 5
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)
VELOCITY(FT/SEC)

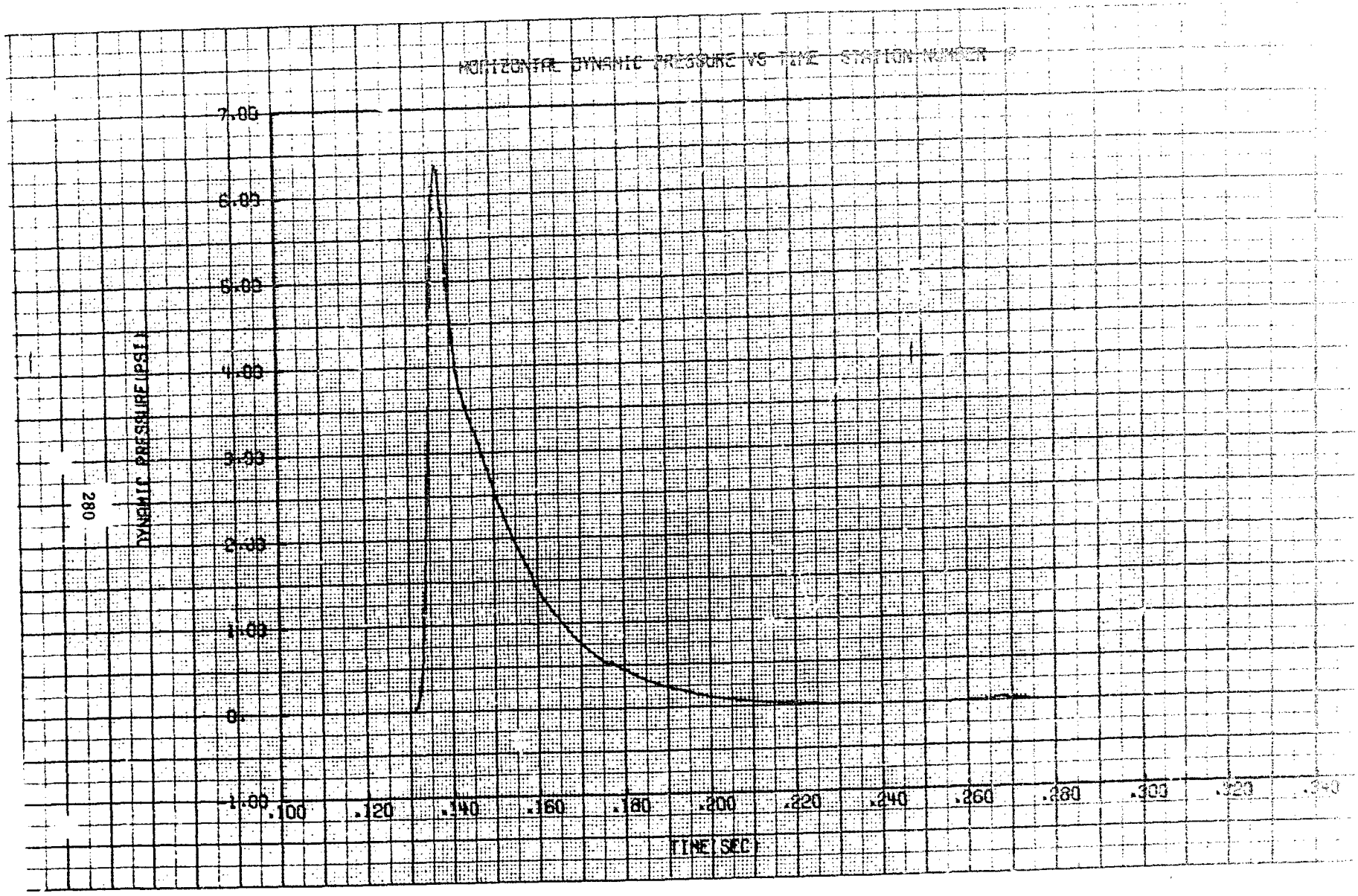

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 3
DYNAMIC PRESSURE(PSI)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

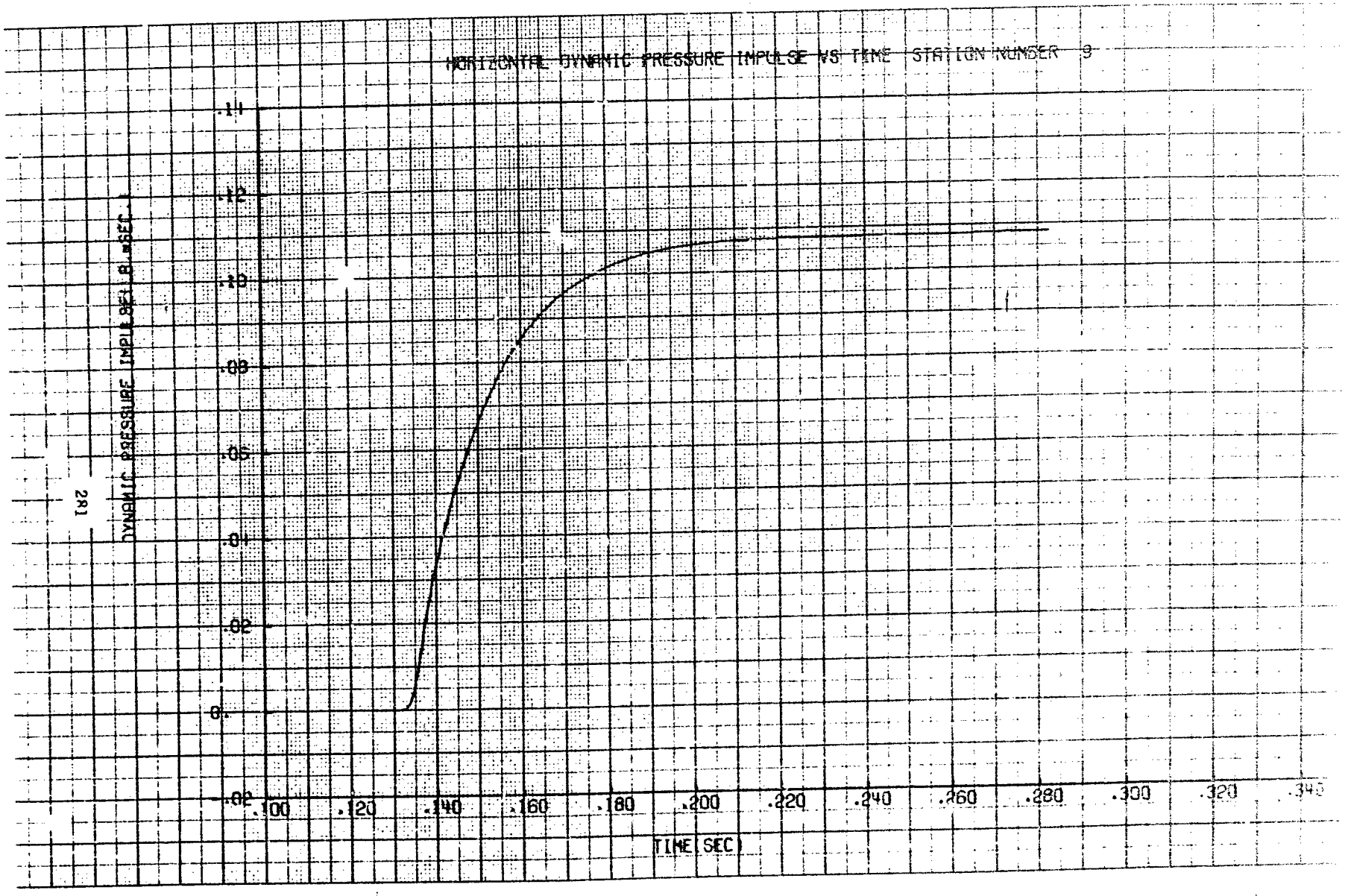

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 0
DYNAMIC PRESSURE IMPULSE(LB-MSEC)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

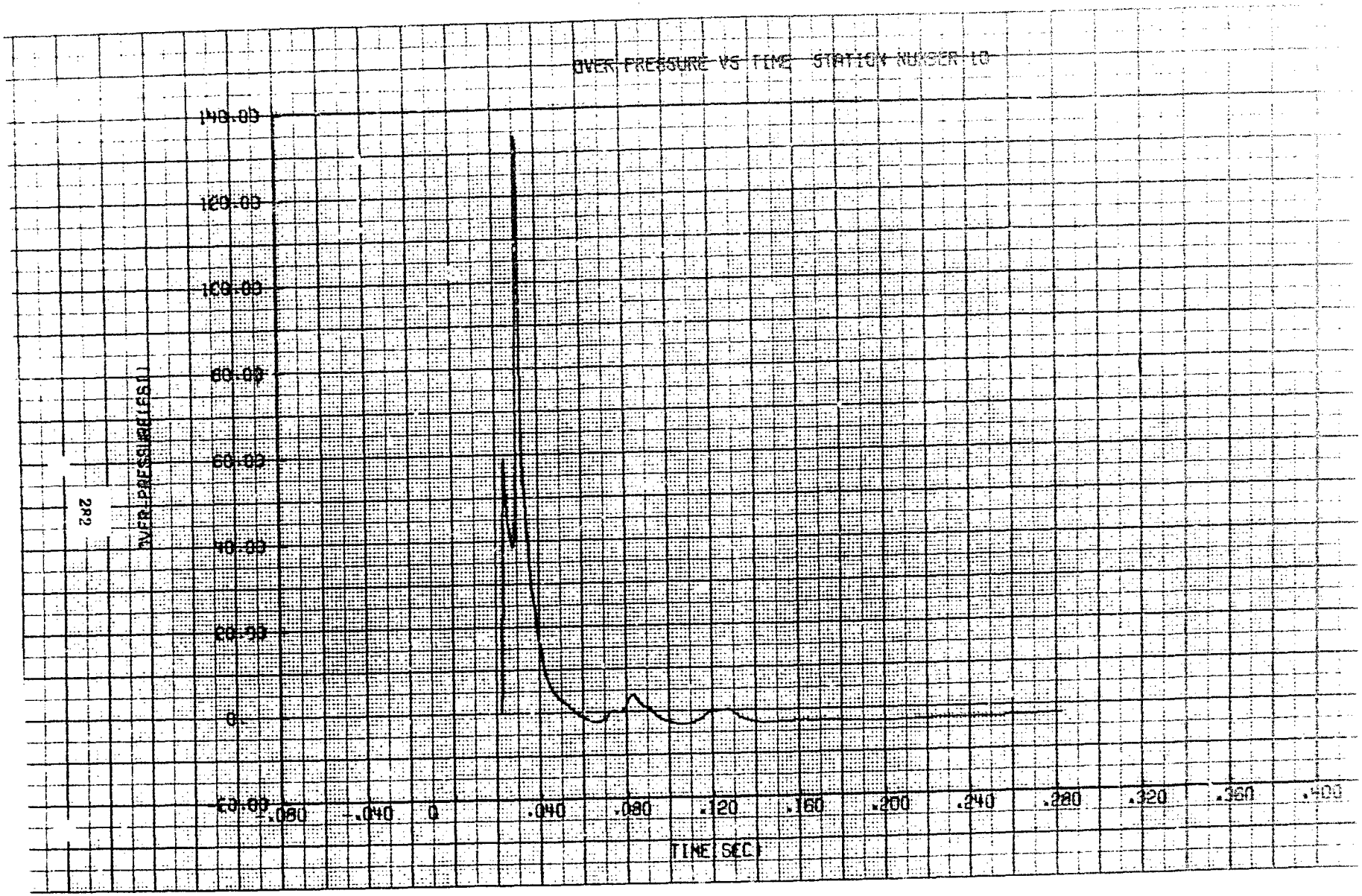

OVER PRESSURE VS TIME STATION NUMBER 5
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVERPRESSURE (PSI)
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)

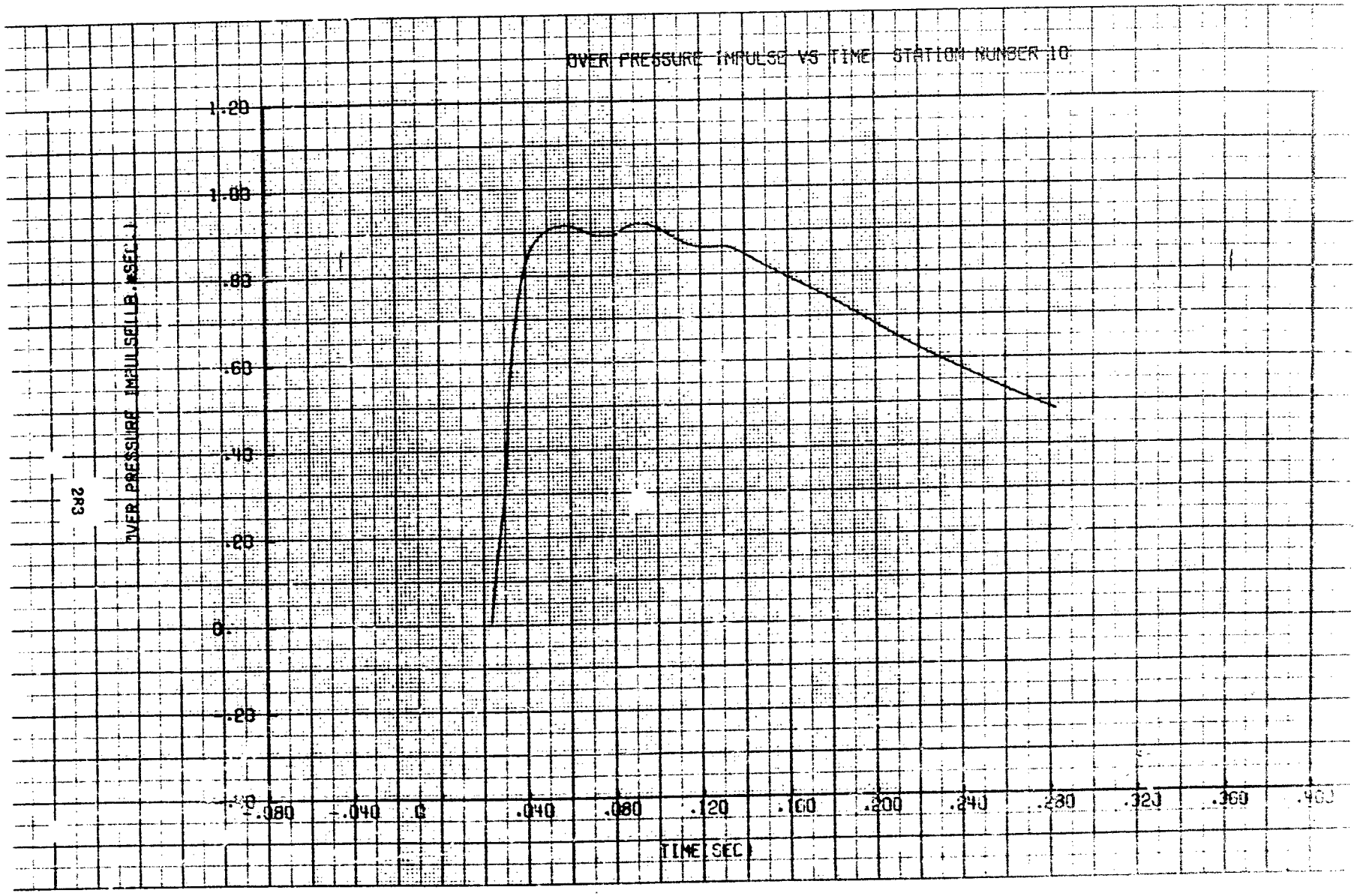

OVER PRESSURE IMPULSE VS TIME, STATION NUMBER 9
.60
.50
.40
.30
.20
.10
0
-.10
-.20
OVER PRESSURE IMPULSE(LB.*SEC.)
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME SEC.

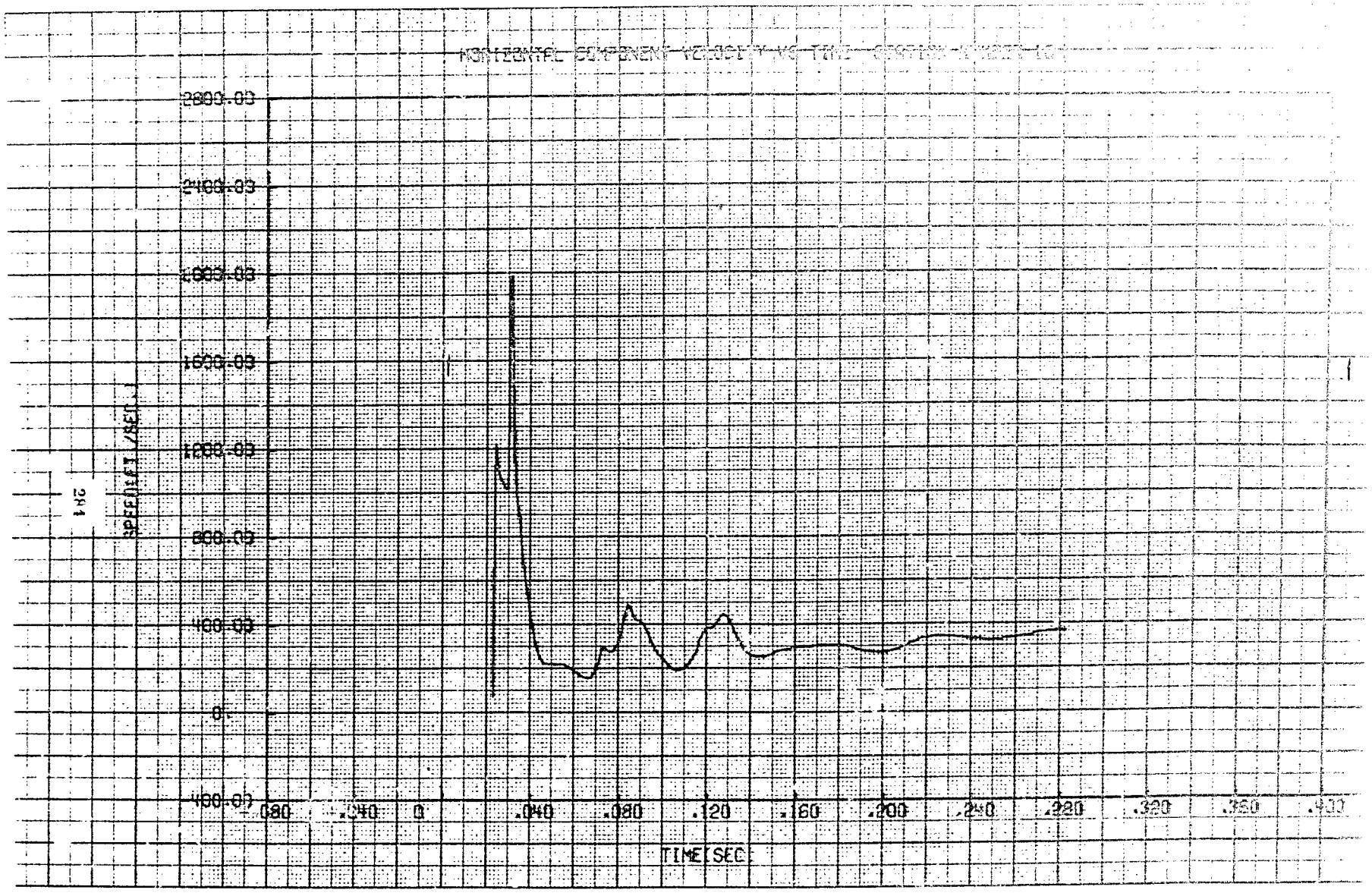

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 9
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)
SPECIFIC FT/SEC

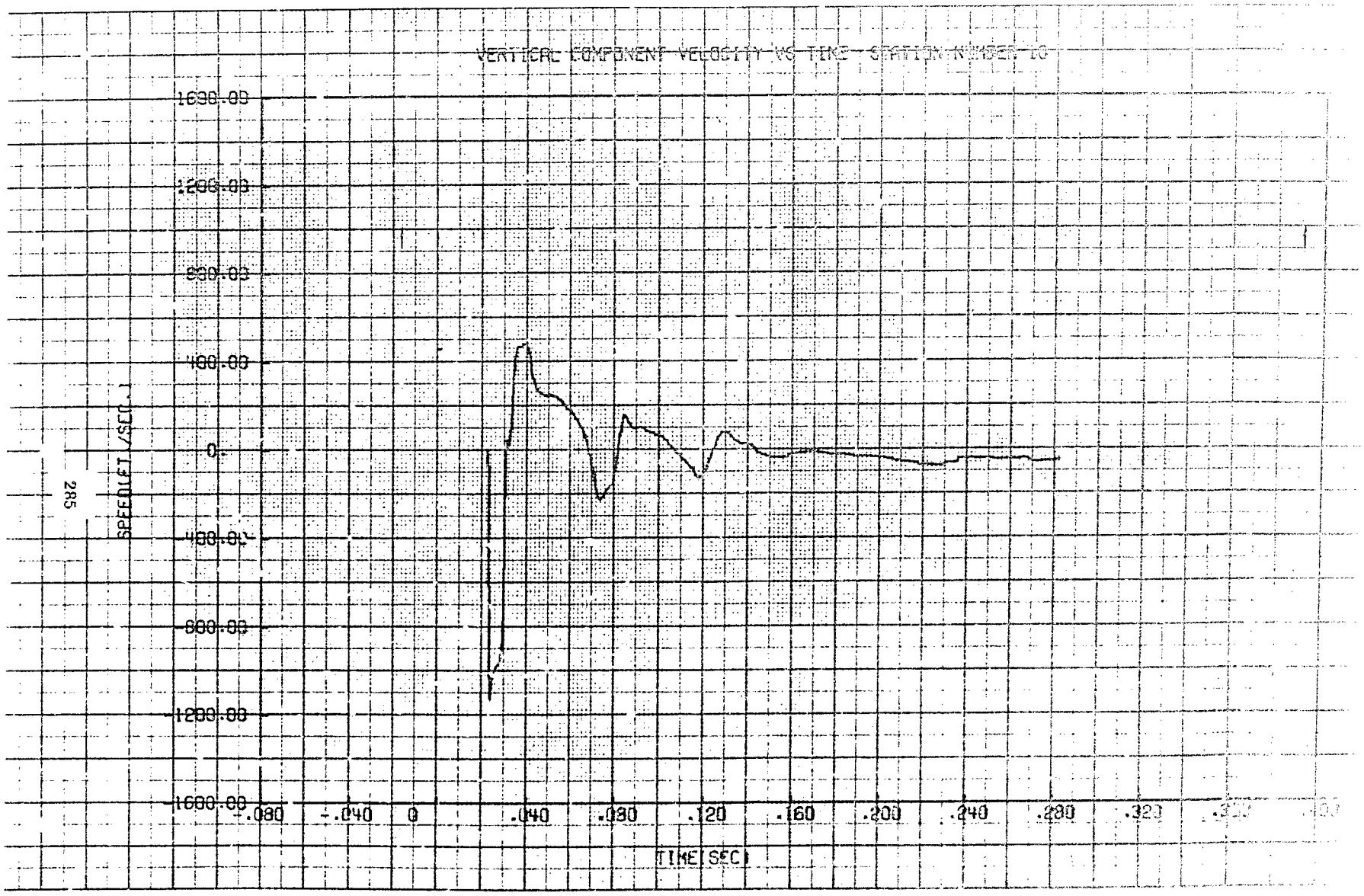

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER
DYNAMIC PRESSURE (PSI)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.
-1.00
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME (SEC)

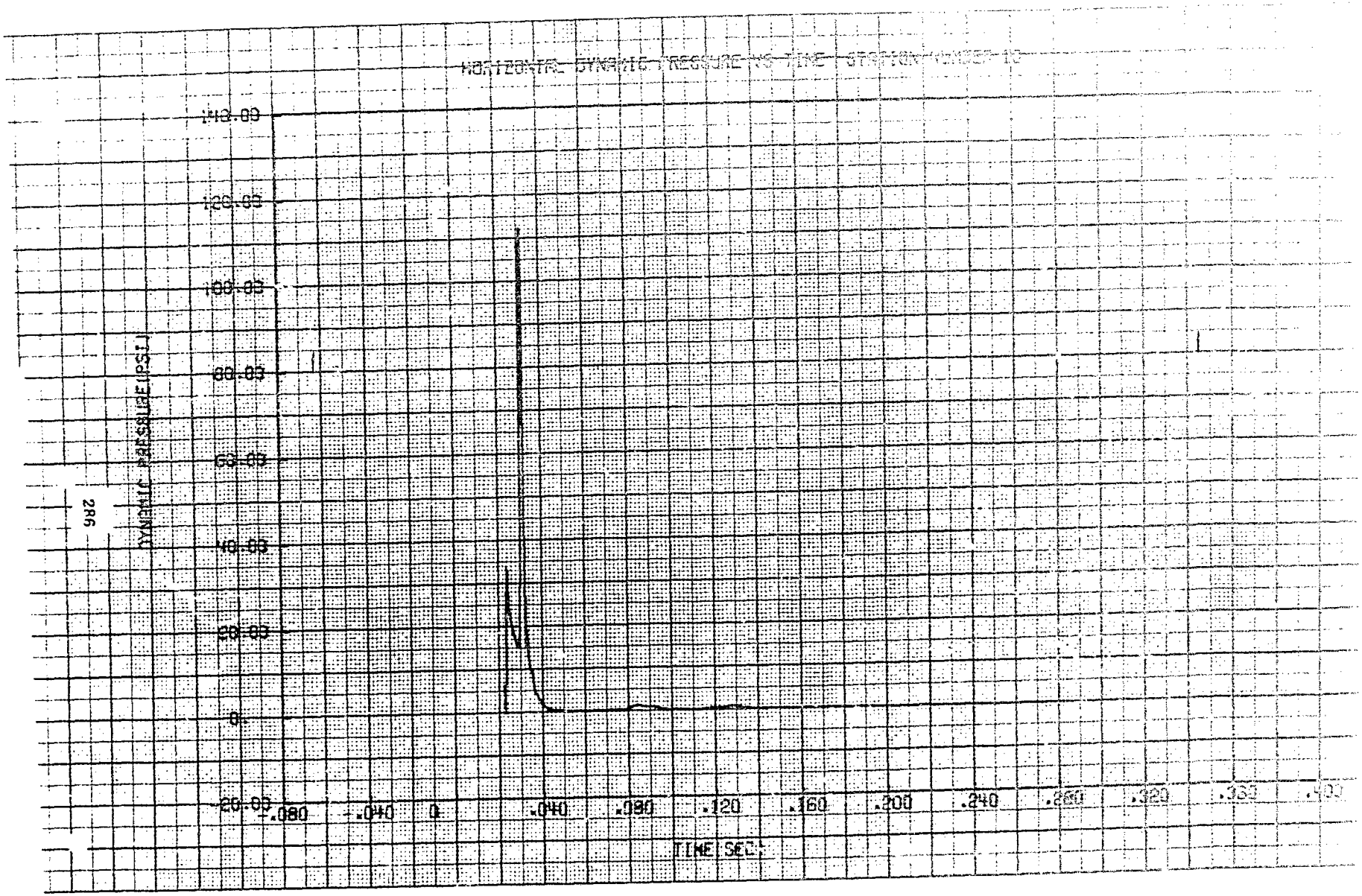

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 9
DYNAMIC PRESSURE IMPULSE(LB-MSEC)
.14
.12
.10
.08
.06
.04
.02
0.
-.02
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
.340
TIME(SEC)

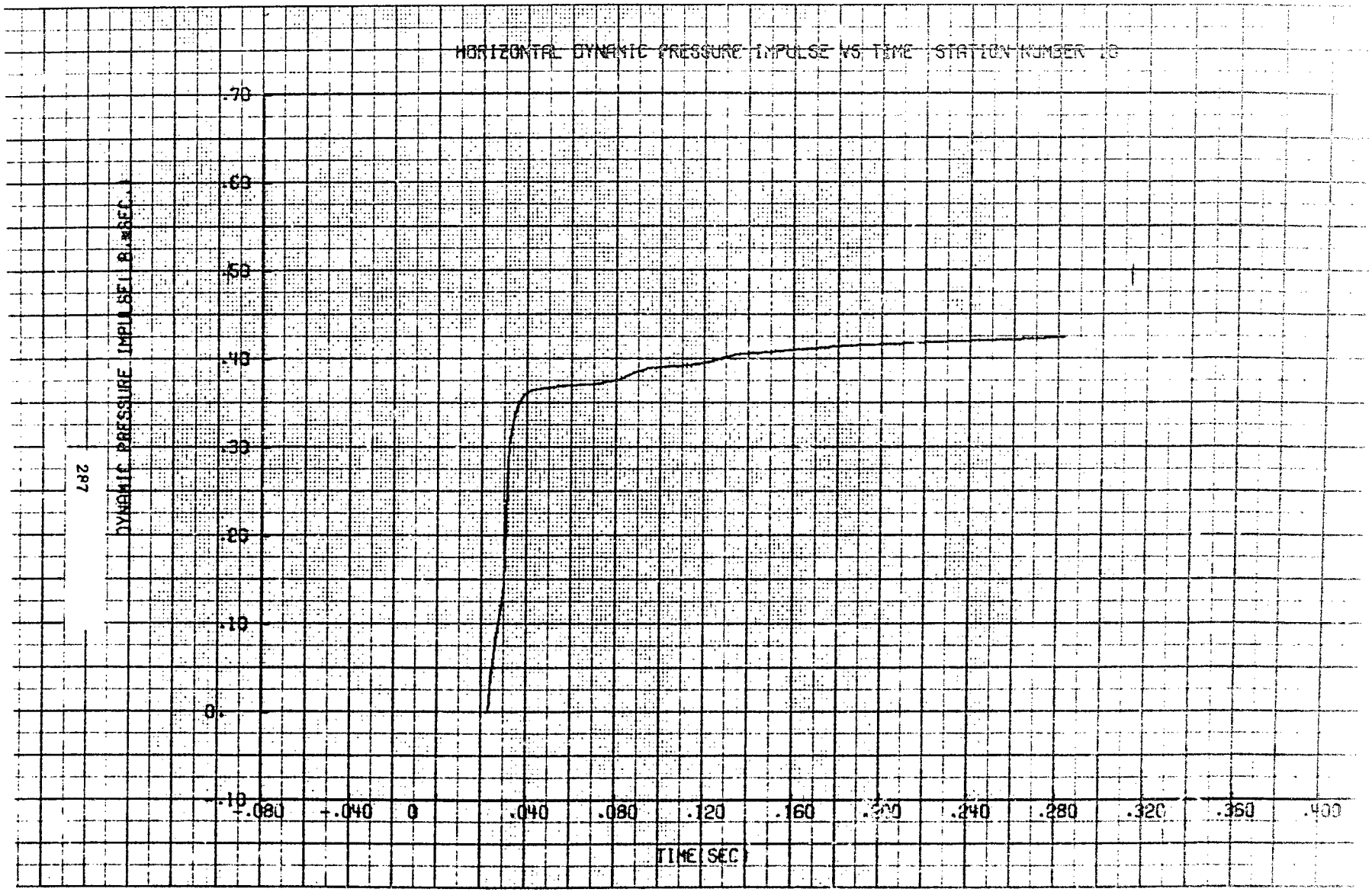

OVER PRESSURE VS TIME STATION NUMBER 10
OVER PRESSURE (PSI)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

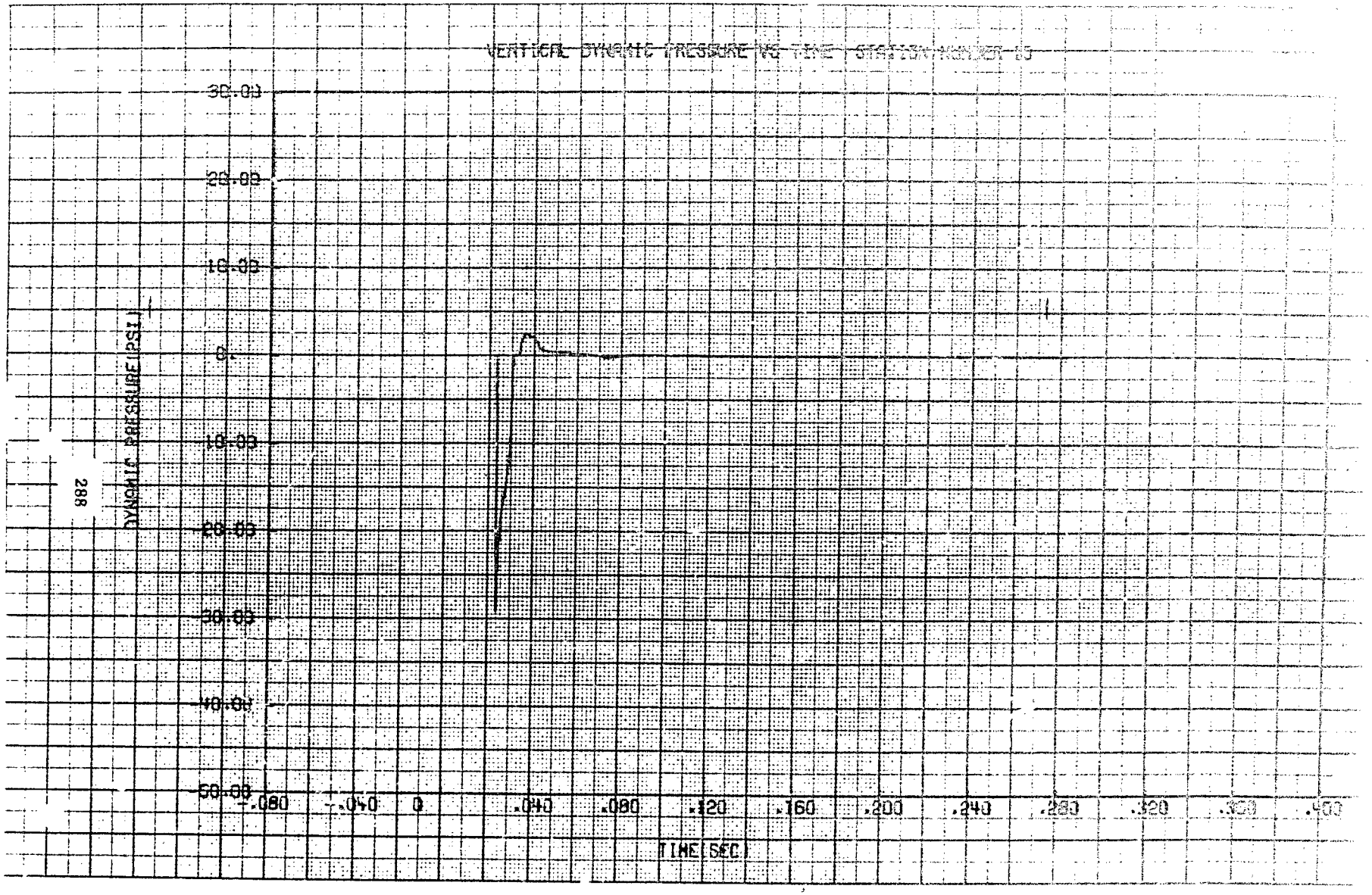

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 10
OVER PRESSURE IMPULSE(LB.*SEC.)
1.20
1.00
.80
.60
.40
.20
0.
-.20
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

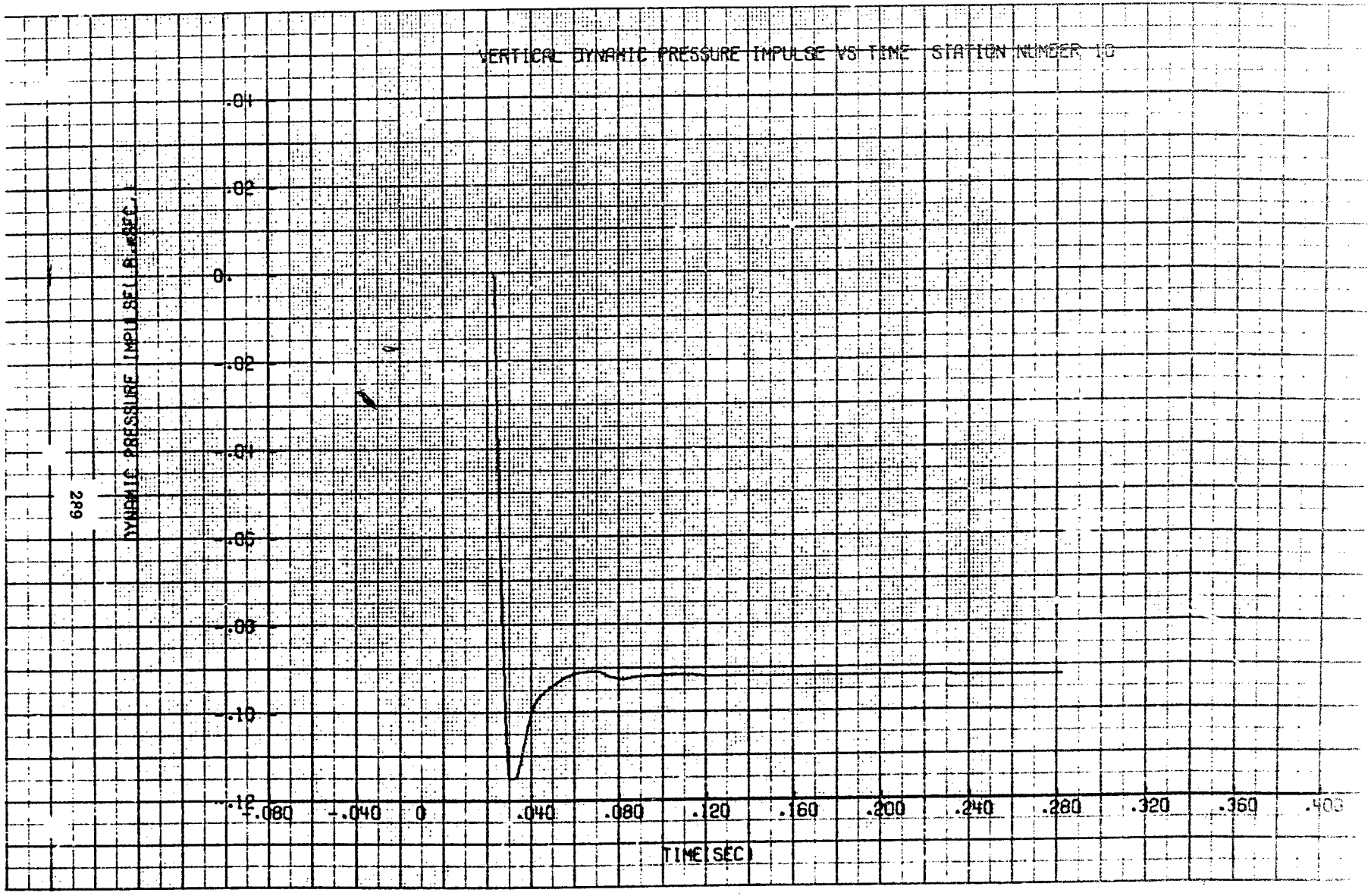

2800.00
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
SPEED(FT/SEC)
.080
.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

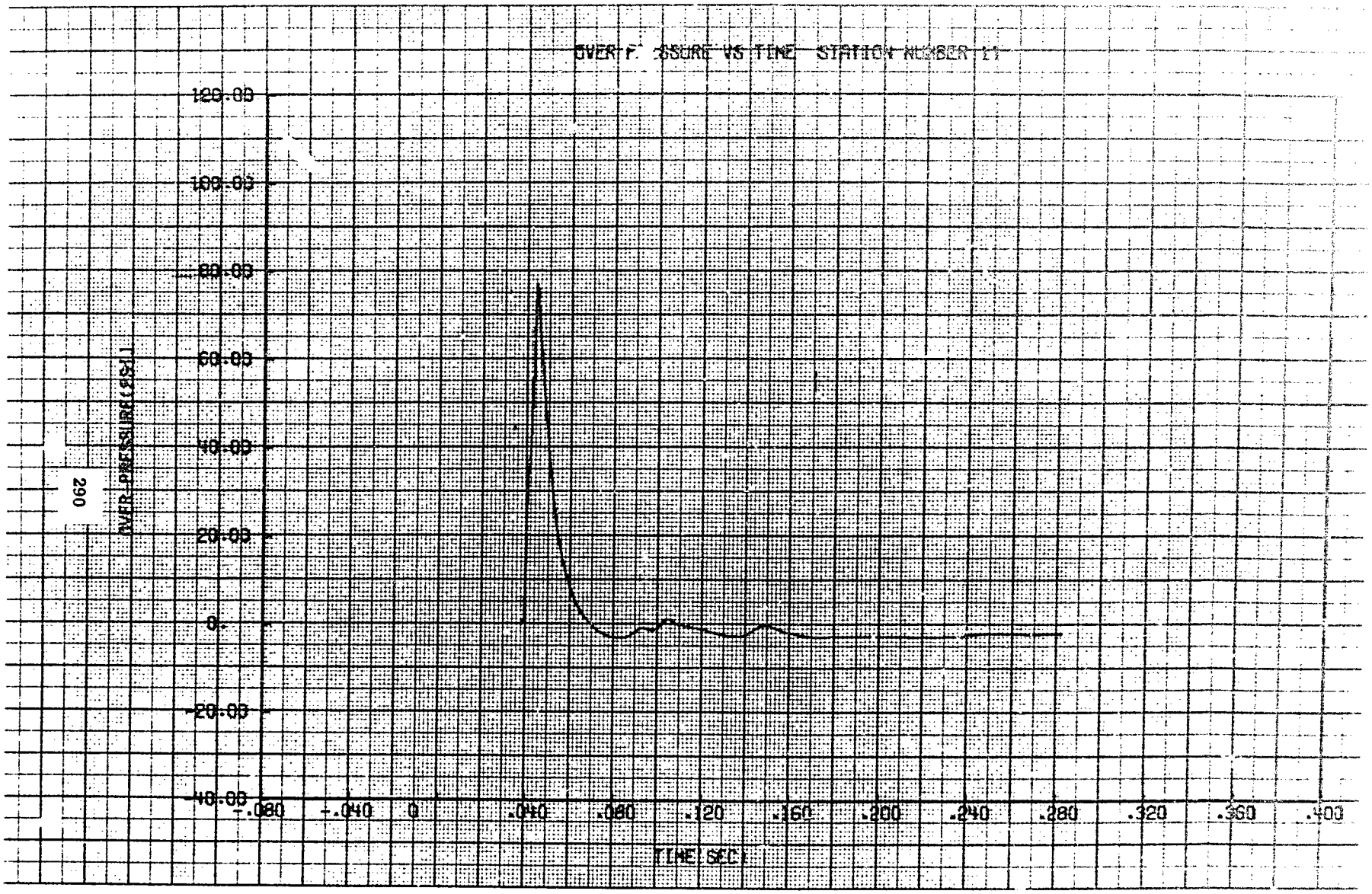

VERTICAL COMPONENT VELOCITY VS TIME - STATION NUMBER 10
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-1200.00
-1600.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
TIME(SEC)

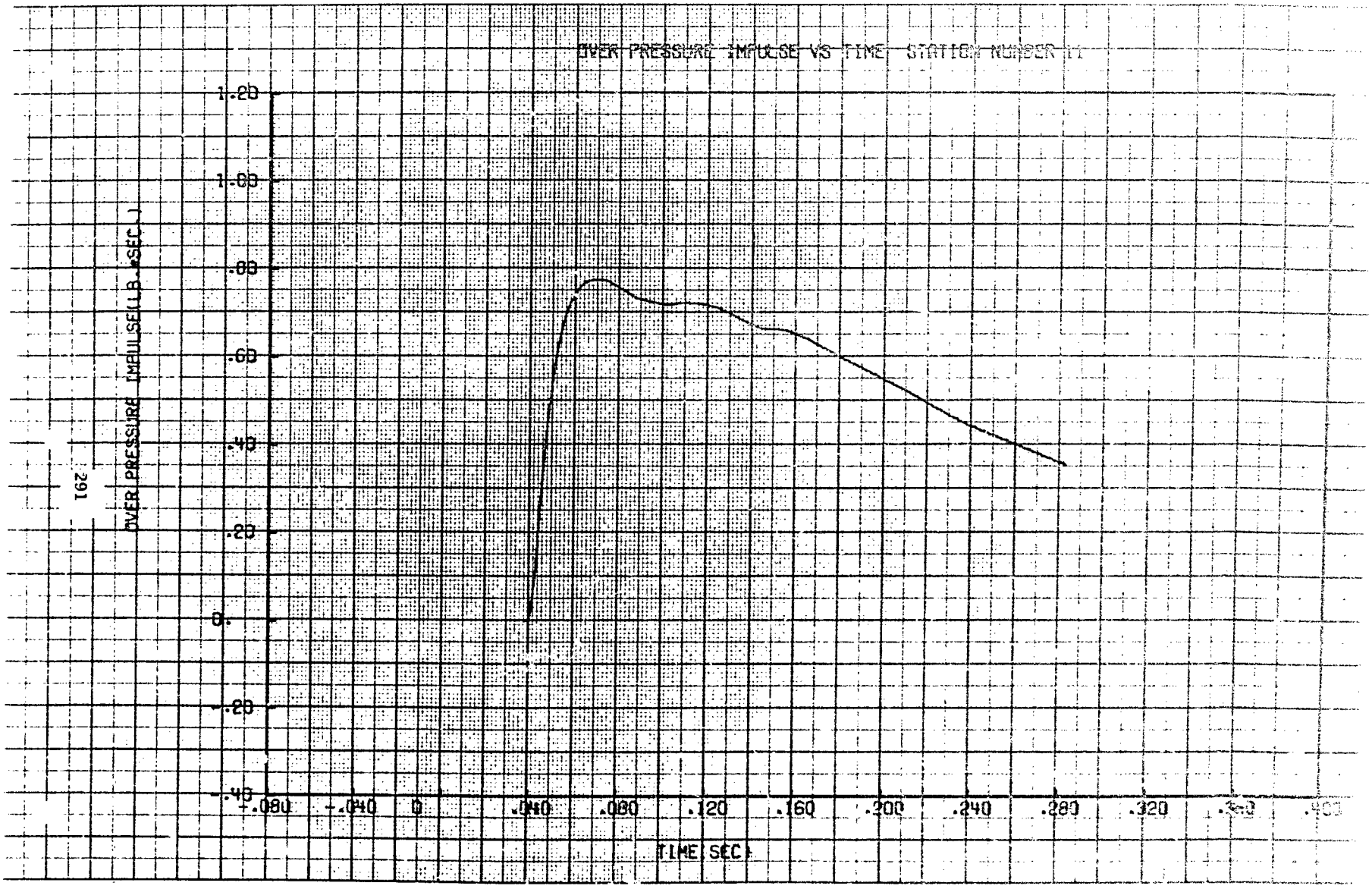

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 10
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC.

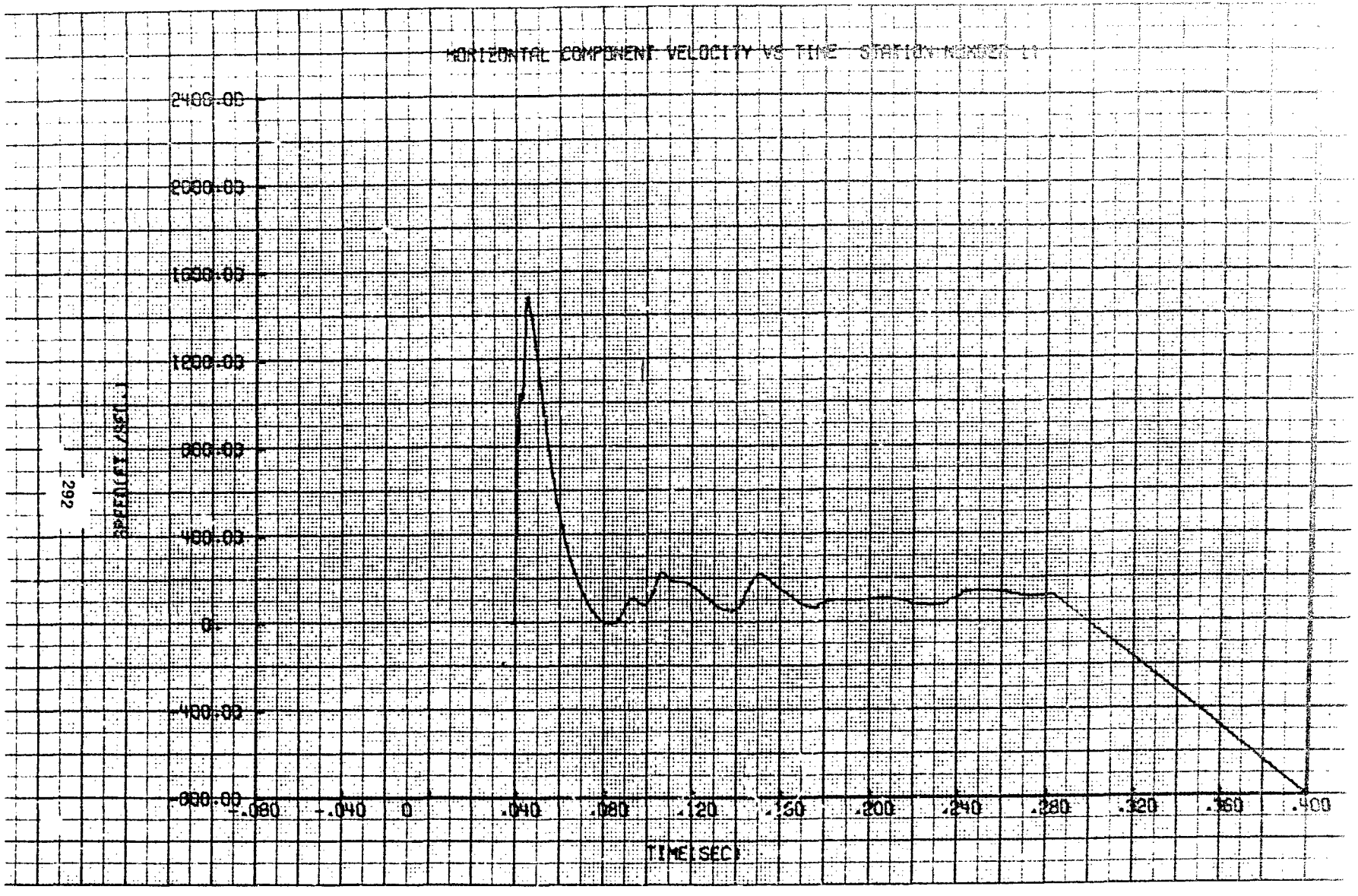

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE(B.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

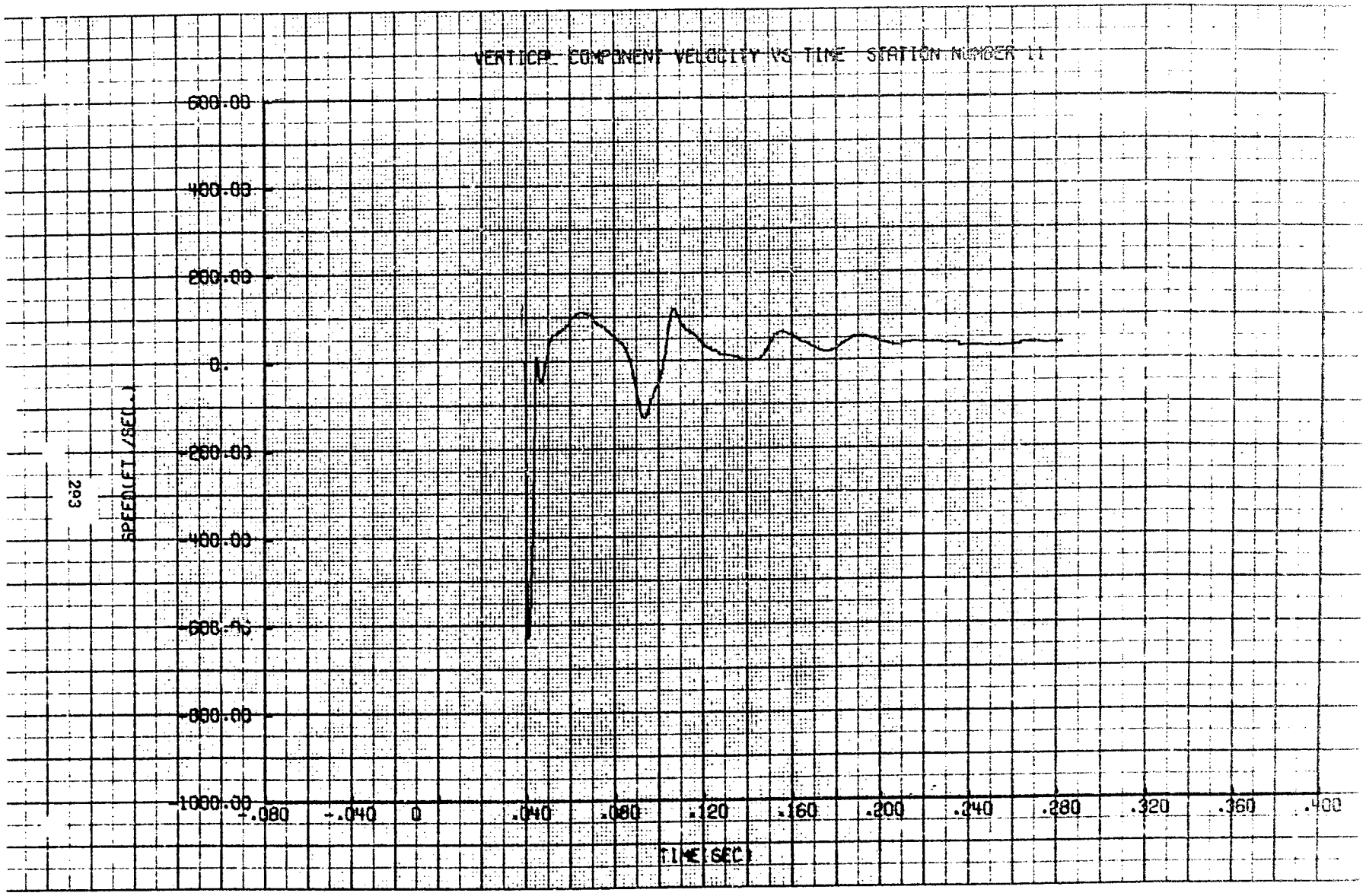

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER 15
30.00
20.00
10.00
0.
-10.00
-20.00
-30.00
-40.00
-50.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

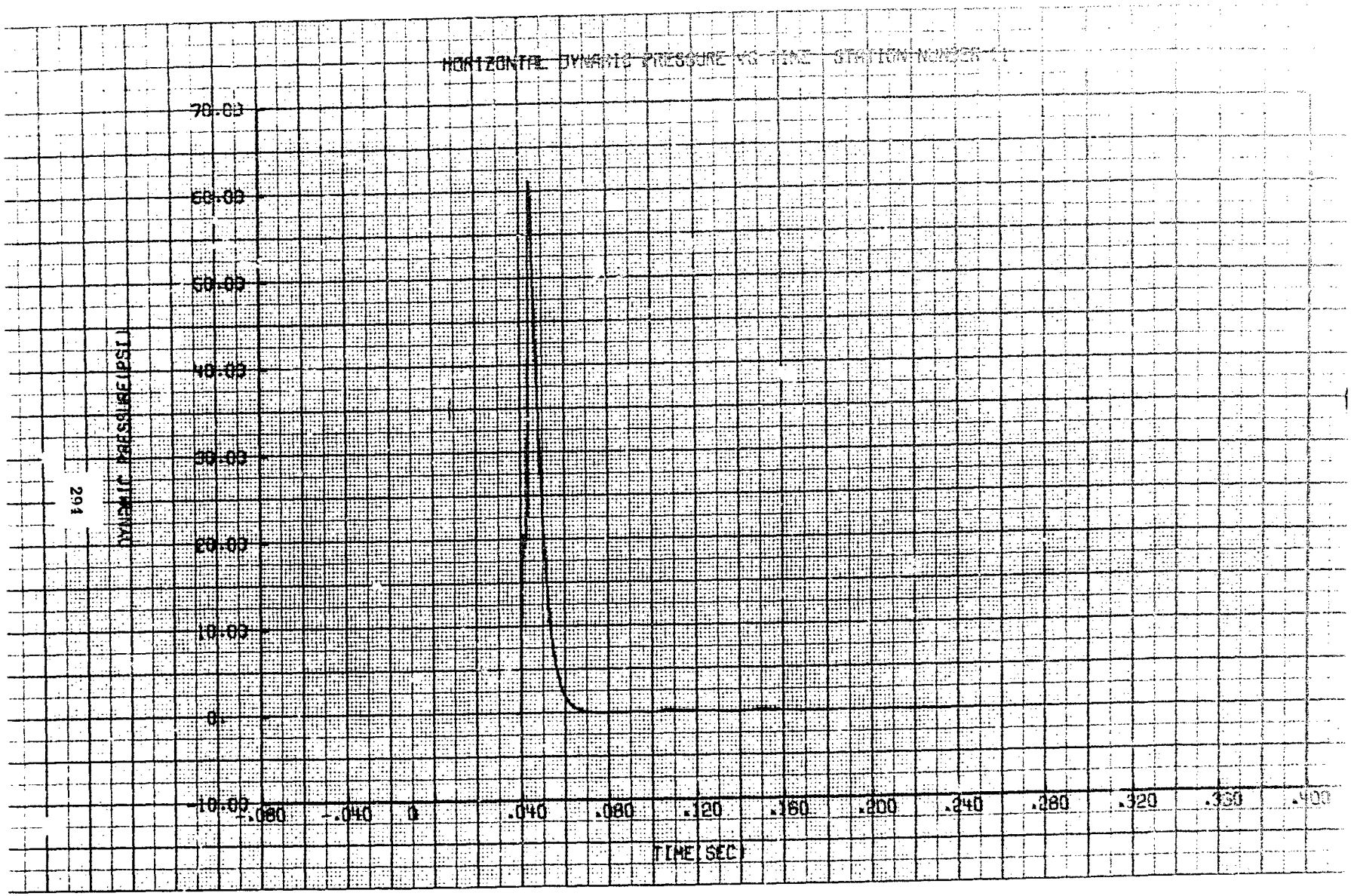

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
DYNAMIC PRESSURE IMPULSE(LB/FT2-SEC)
.04
.02
0.
-.02
-.04
-.06
-.08
-.10
-.12
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

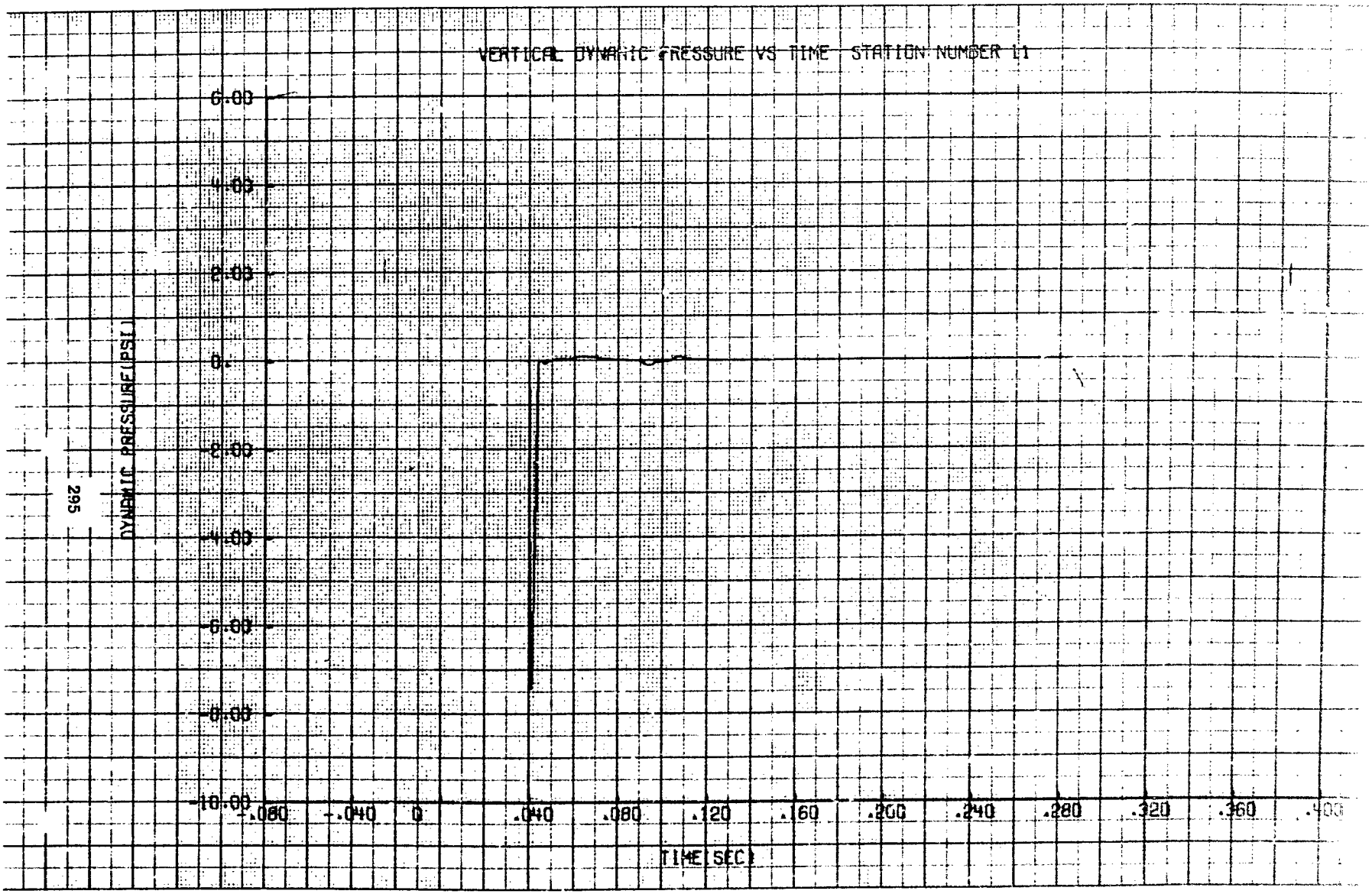

OVERPRESSURE VS TIME STATION NUMBER 11
OVER PRESSURE (PSI)
120.00
100.00
80.00
60.00
40.00
20.00
0.
-20.00
-40.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME SEC

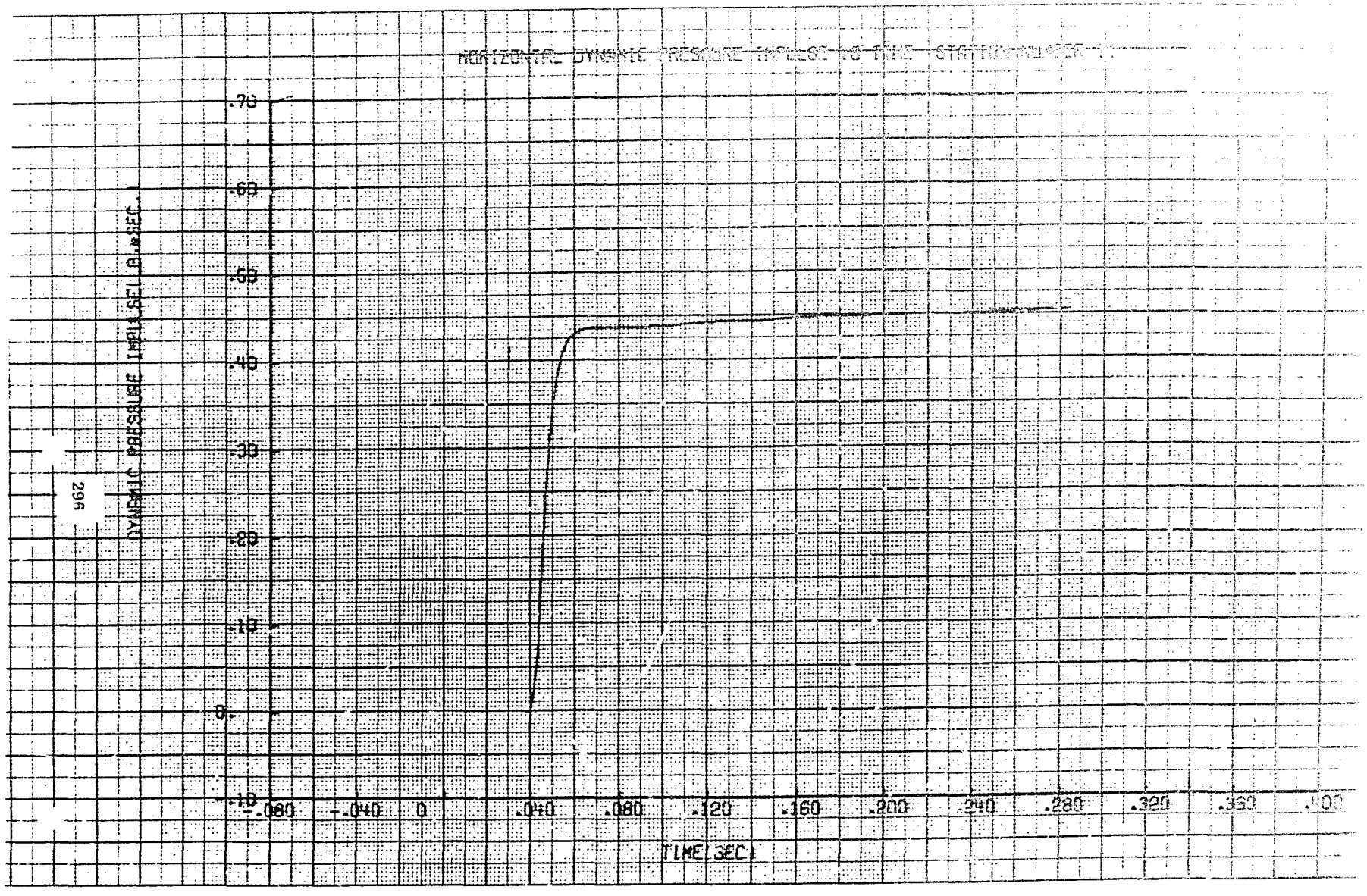

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 11
OVER PRESSURE IMPULSE(LB.*SEC.)
1.20
1.00
.80
.60
.40
.20
0.
-.20
-.40
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
TIME(SEC)

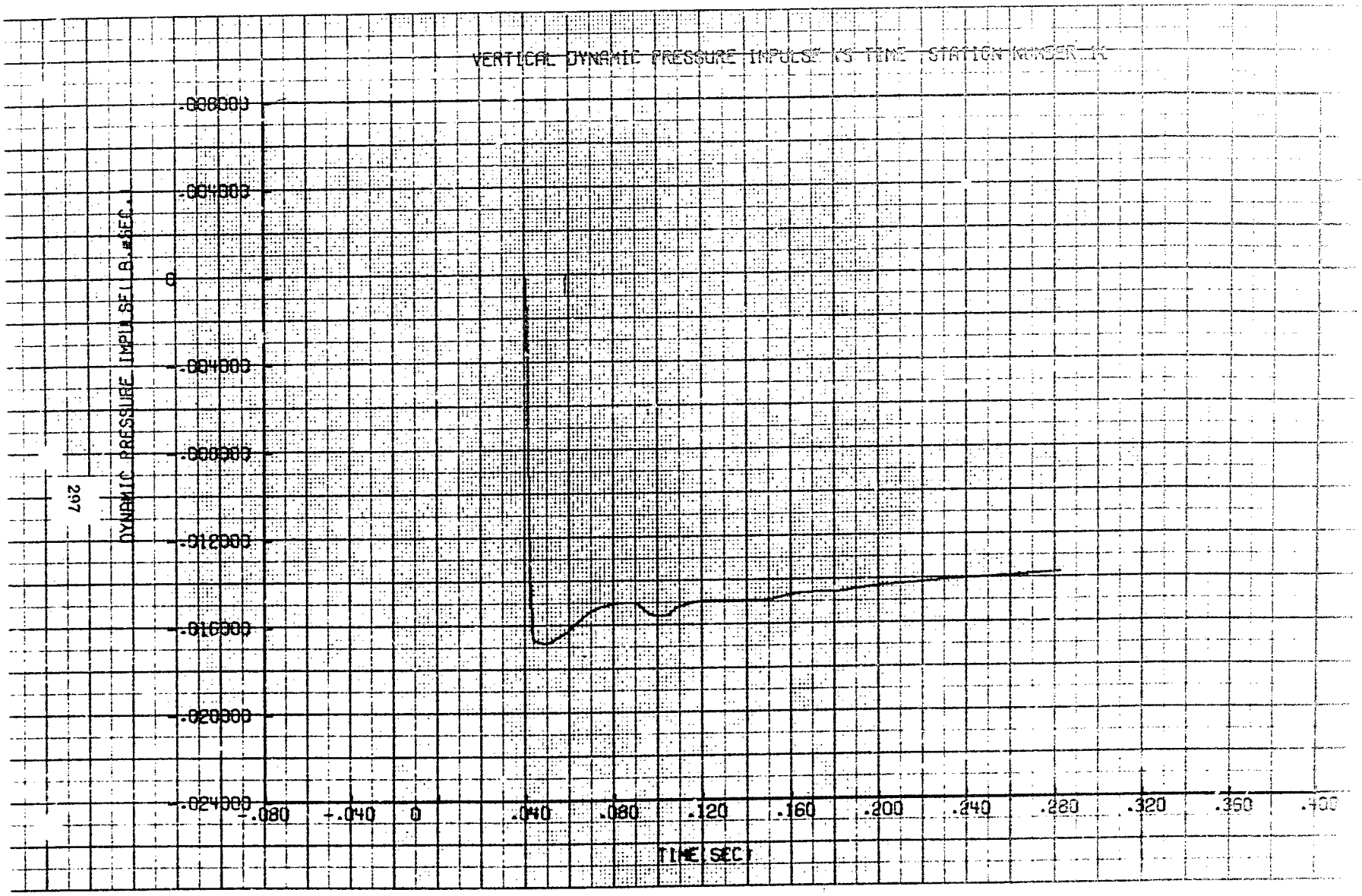

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

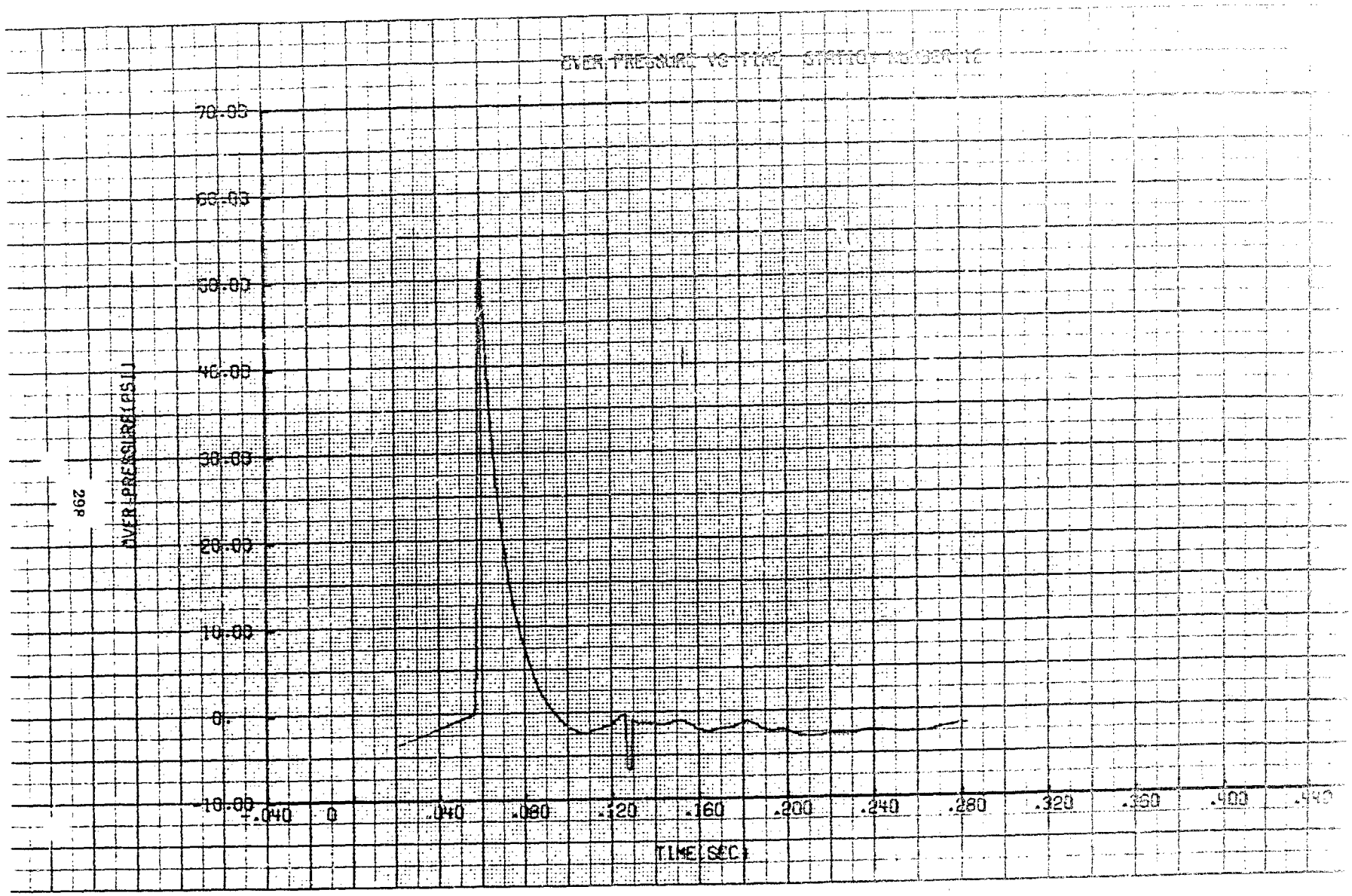

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 11
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-1000.00
SPEED(FT/SEC.)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

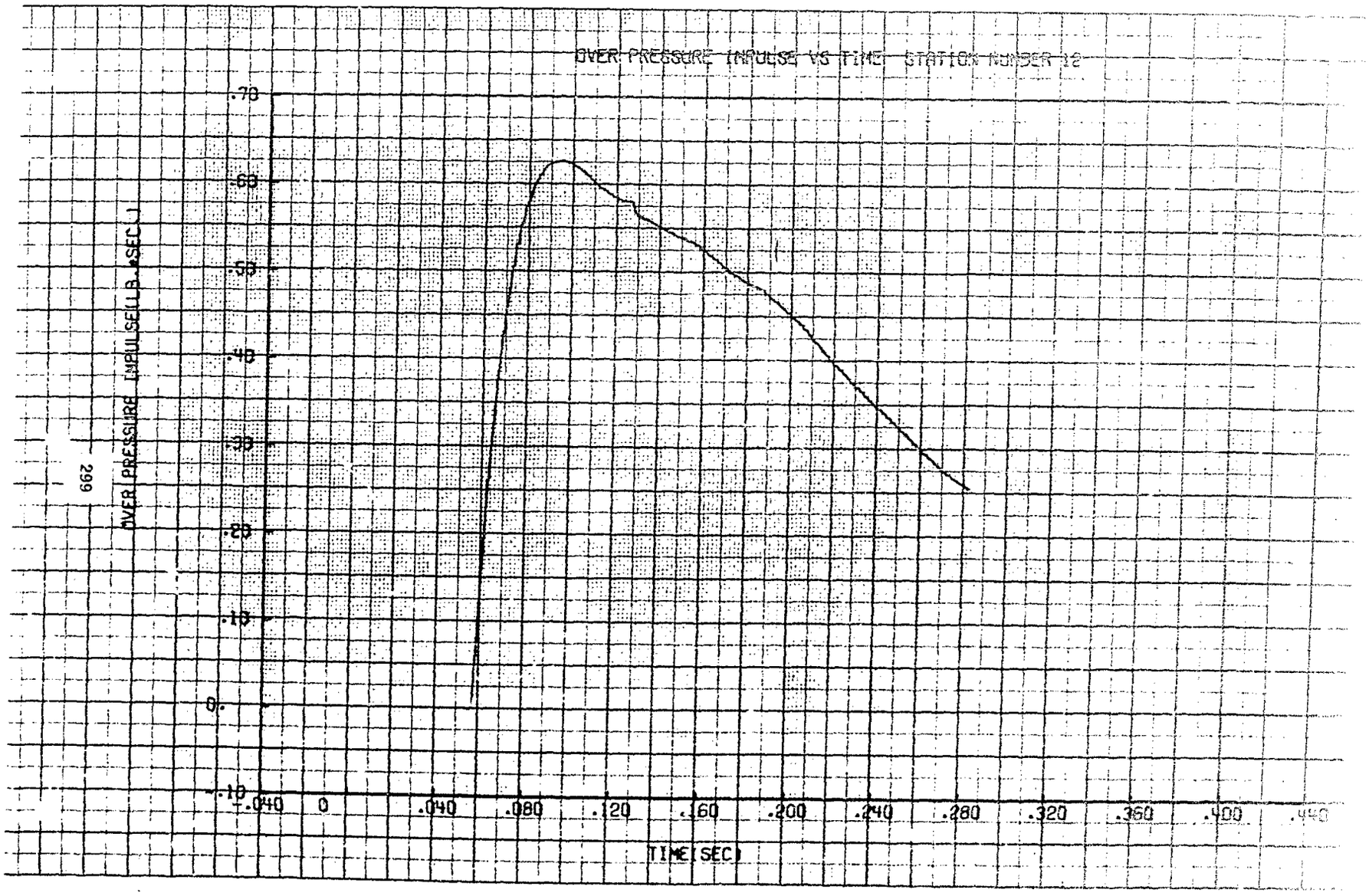

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 11
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
DYNAMIC PRESSURE (PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

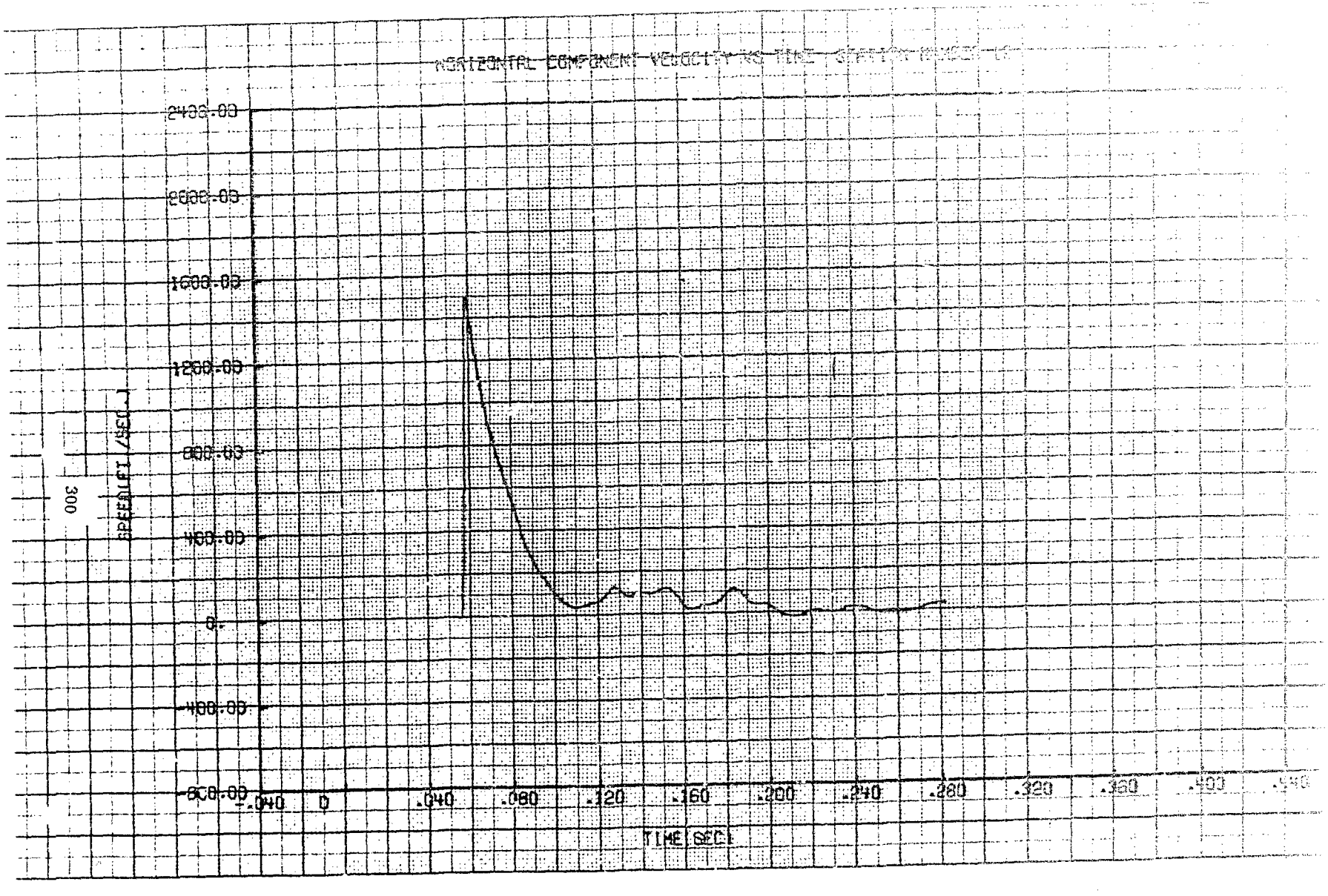

VERTICAL DYNAMIC PRESSURE VS TIME STATION NUMBER L1
DYNAMIC PRESSURE(PSI)
6.00
4.00
2.00
0.
-2.00
-4.00
-6.00
-8.00
-10.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

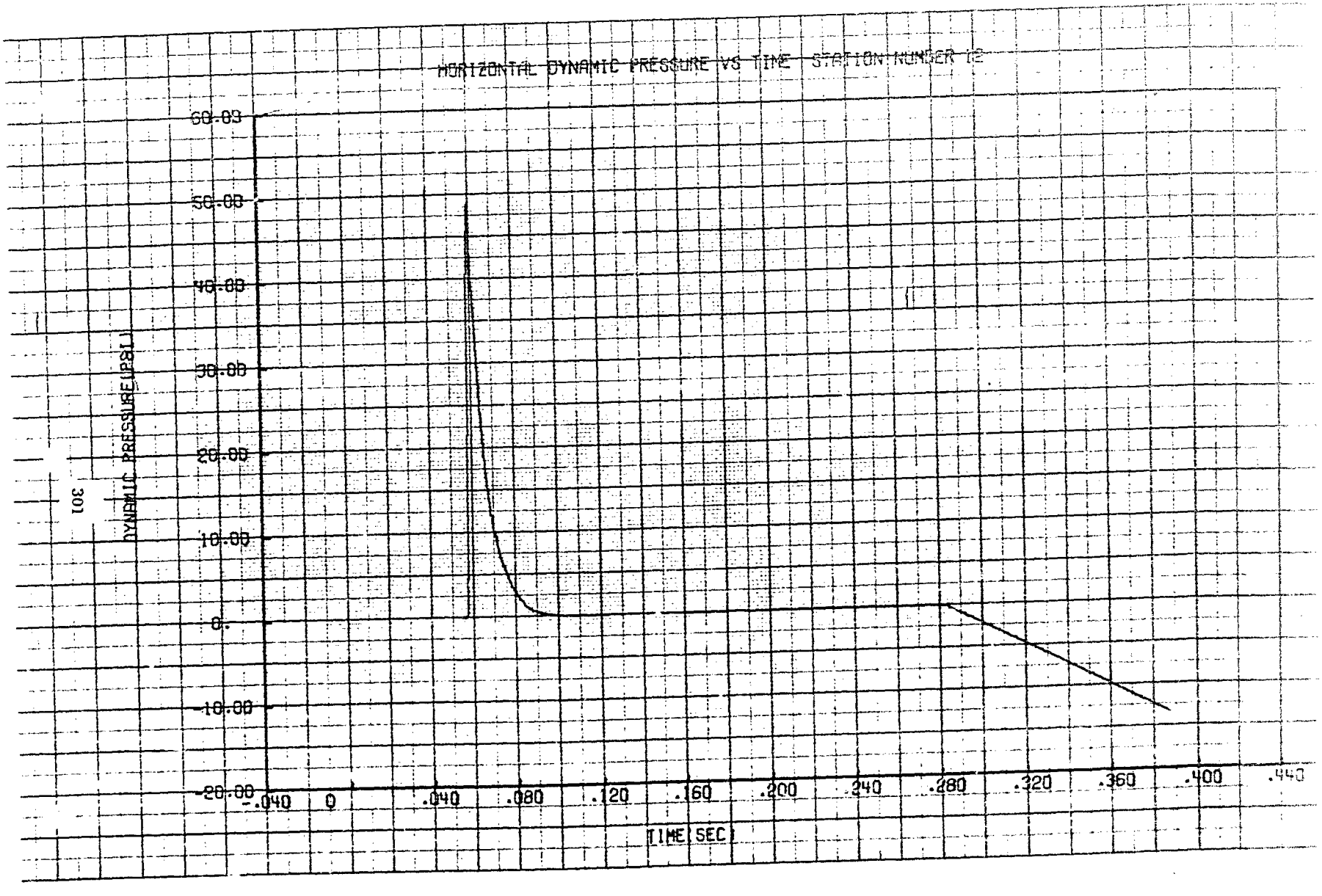

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER
DYNAMIC PRESSURE IMPULSE (LB/IN.SEC)
.70
.60
.50
.40
.30
.20
.10
0
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

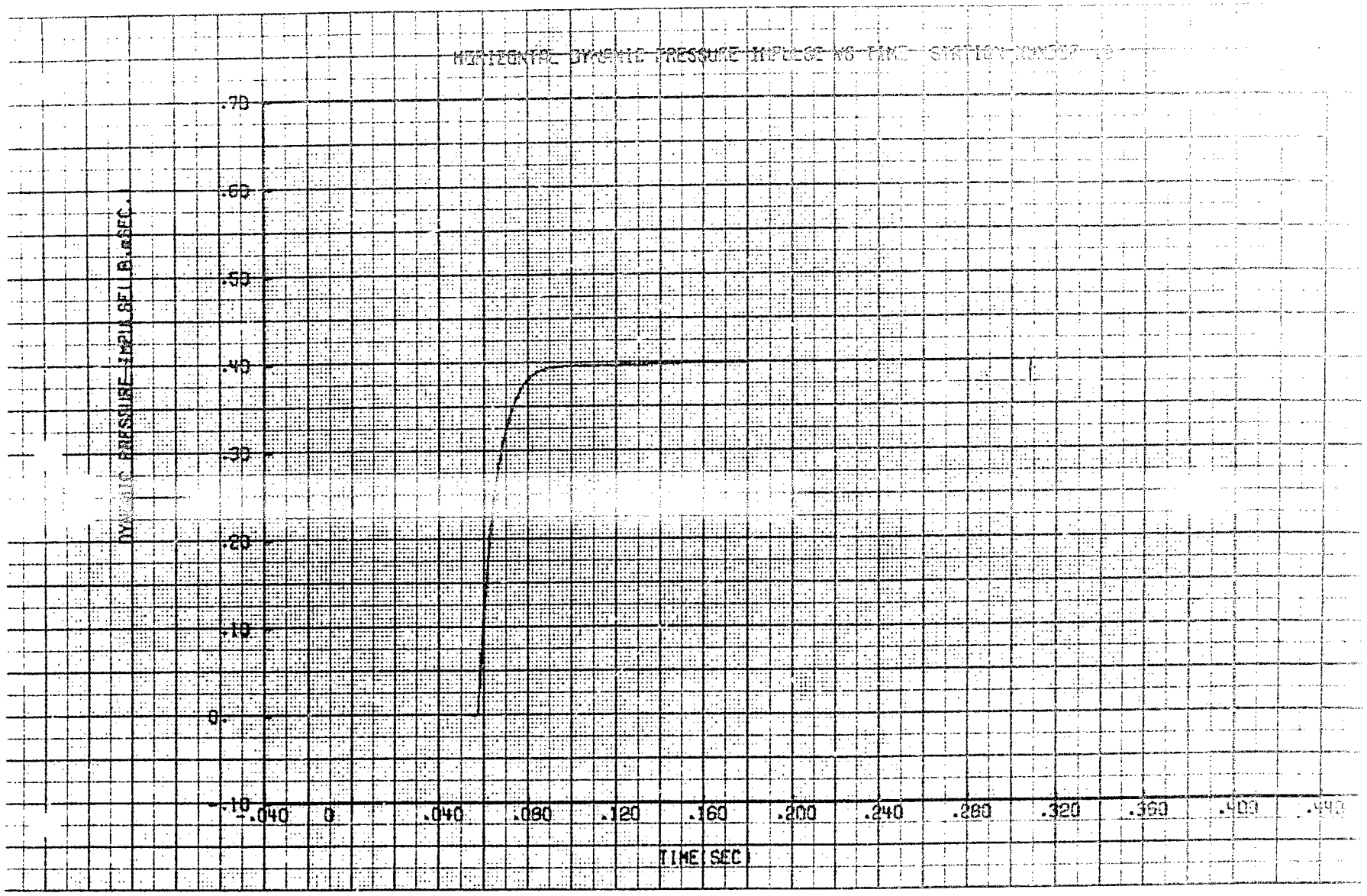

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 1K
DYNAMIC PRESSURE IMPULSE (LB-SEC)
.008000
.004000
0
-.004000
-.008000
-.012000
-.016000
-.020000
-.024000
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME (SEC)

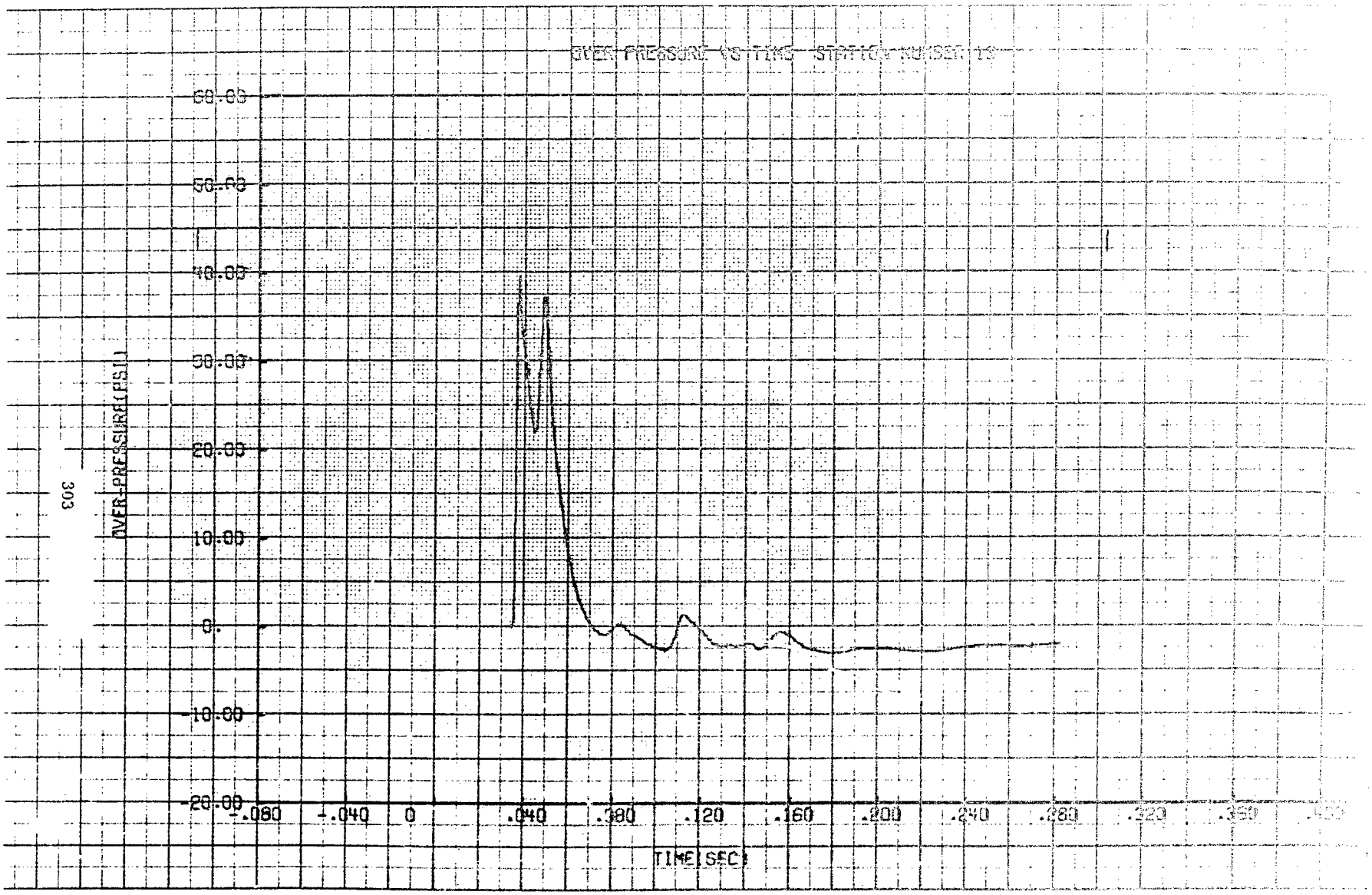

OVER PRESSURE VS TIME STATION NUMBER 12
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
OVER PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

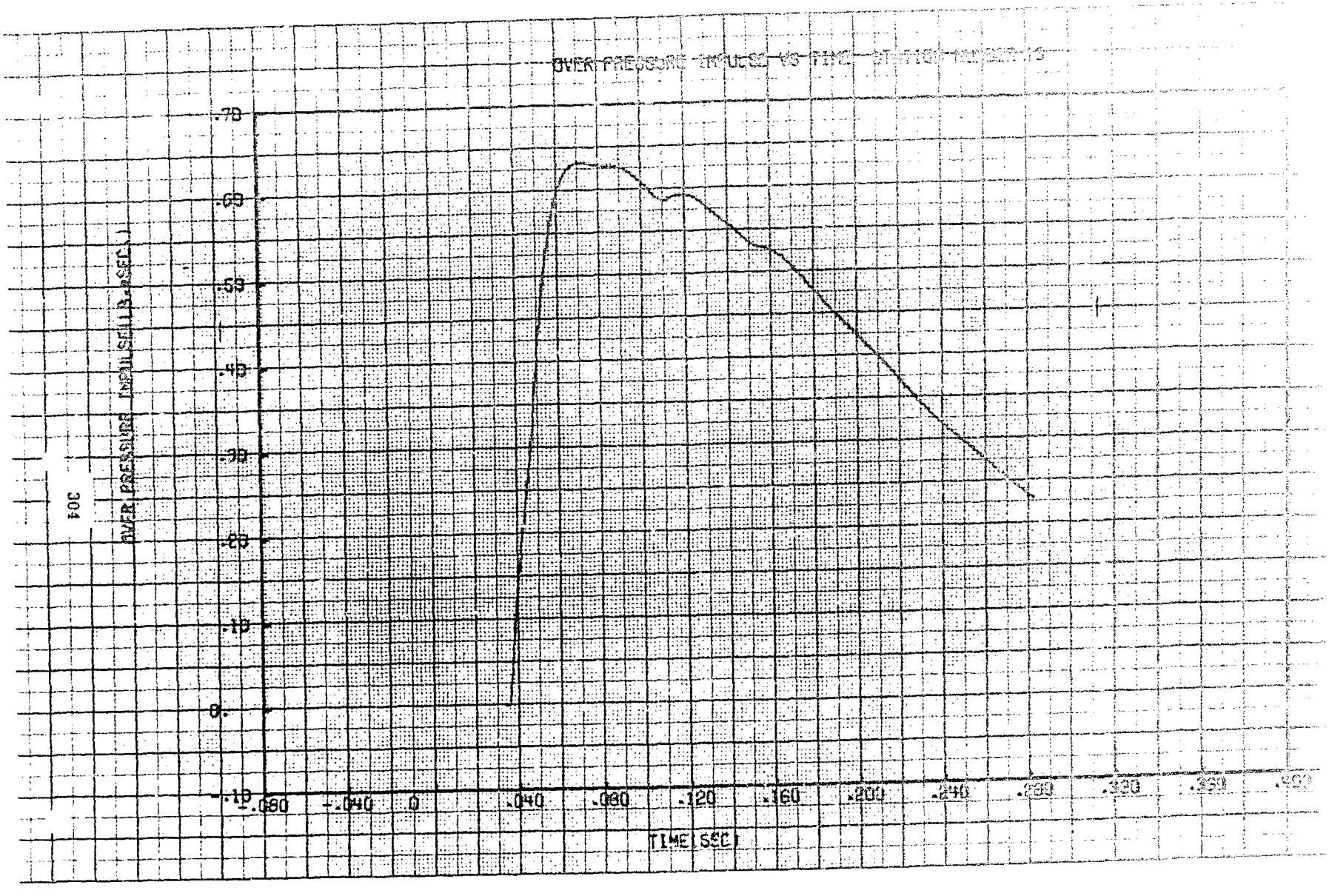

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 12
OVER PRESSURE IMPULSE(LB-SEC)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

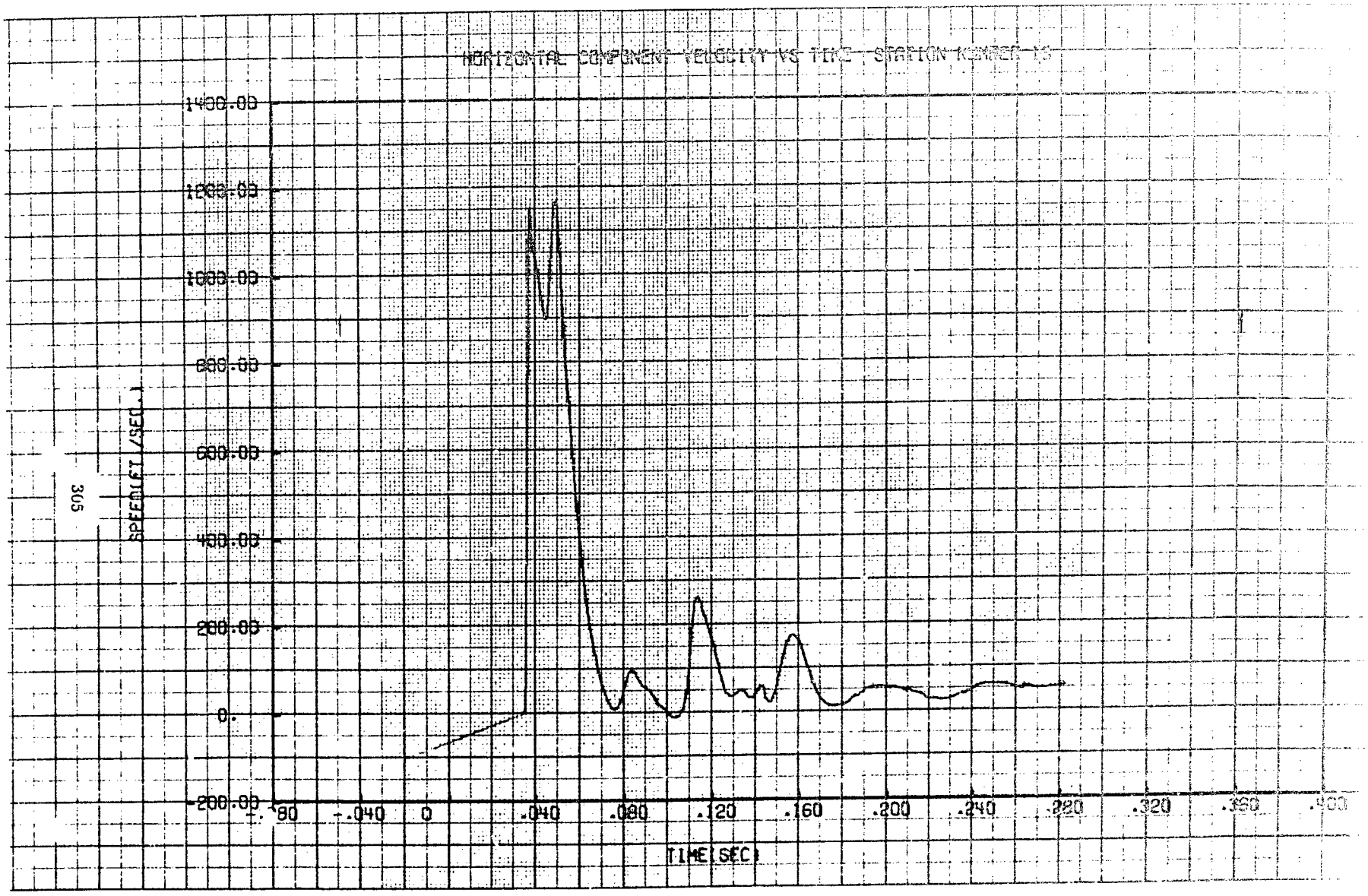

HORIZONTAL COMPONENT VELOCITY VS TIME
2400.00
2000.00
1600.00
1200.00
800.00
400.00
0.
-400.00
-800.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME SEC
SPEED(FT/SEC)

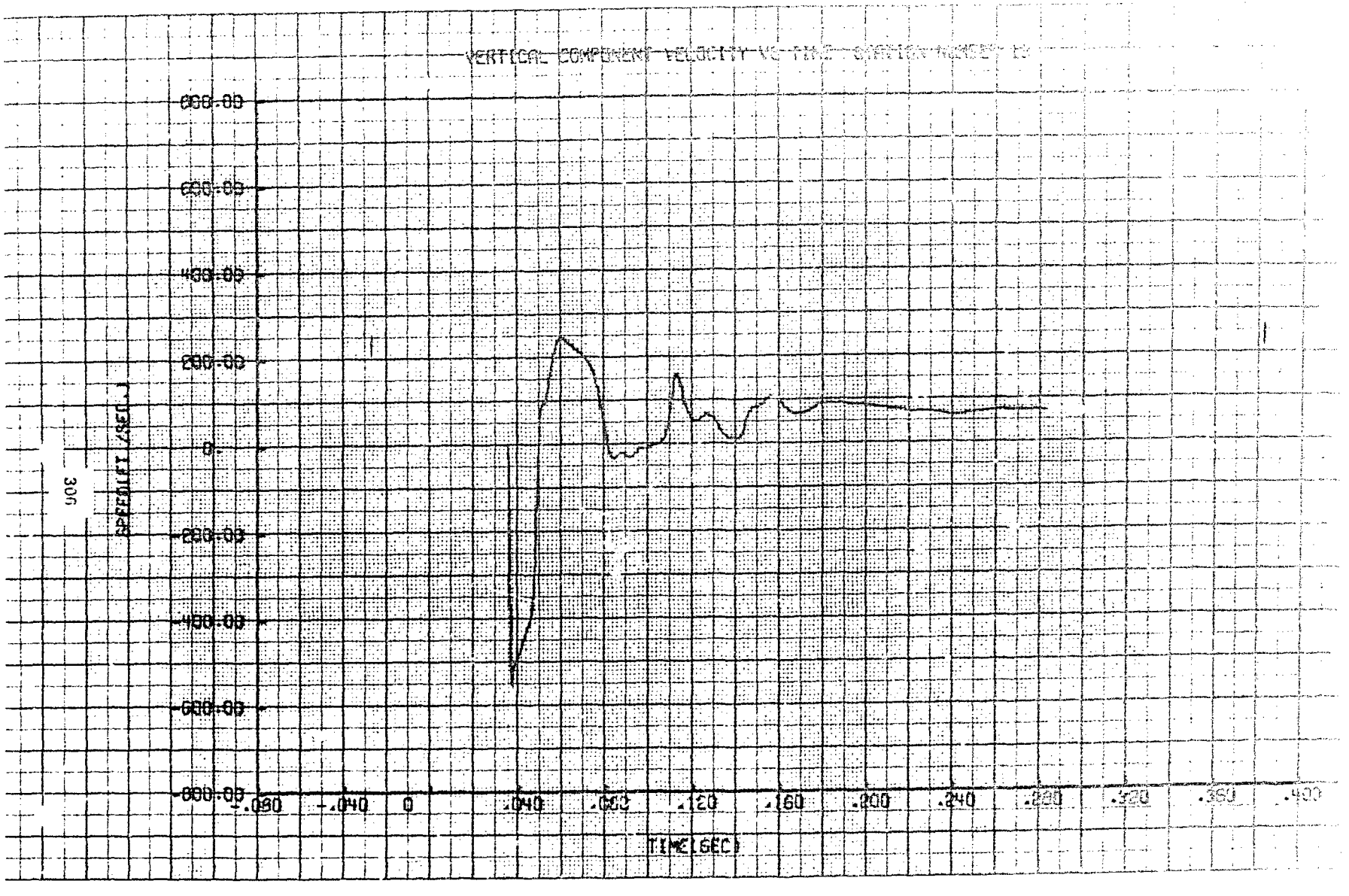

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 12
DYNAMIC PRESSURE(PSI)
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

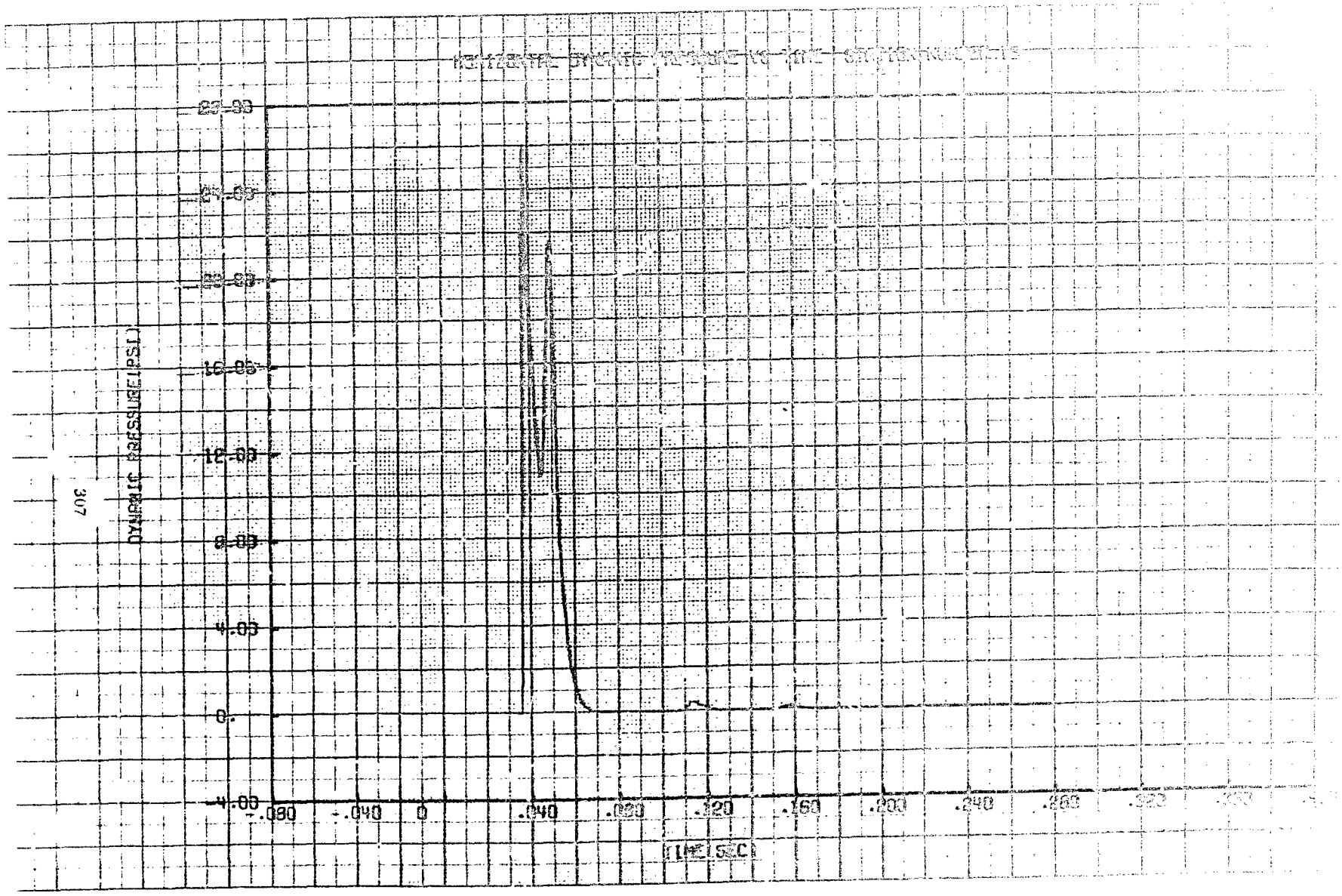

.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)


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)

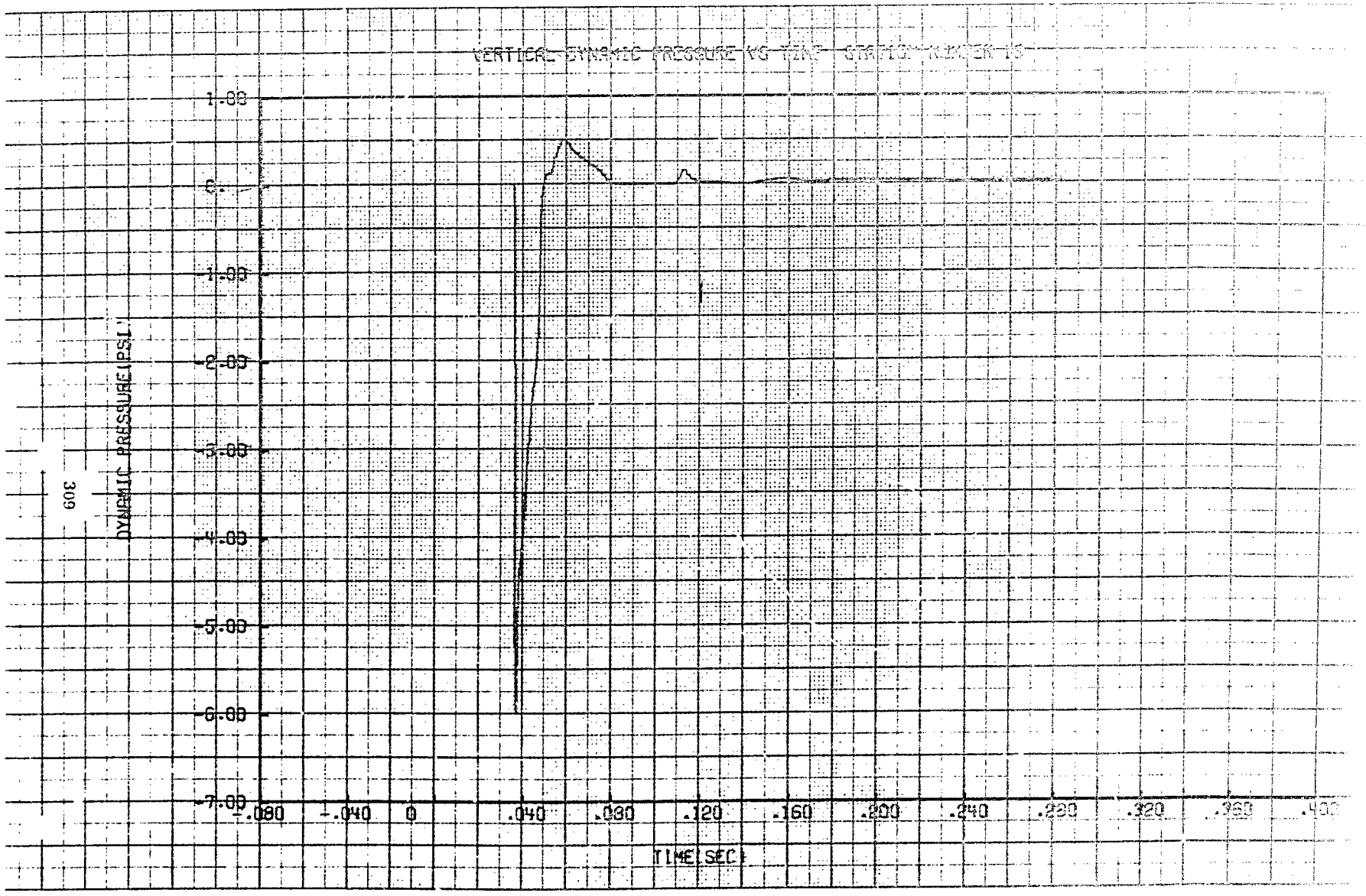

OVER PRESSURE (MPSI)(LB/SQ.IN.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

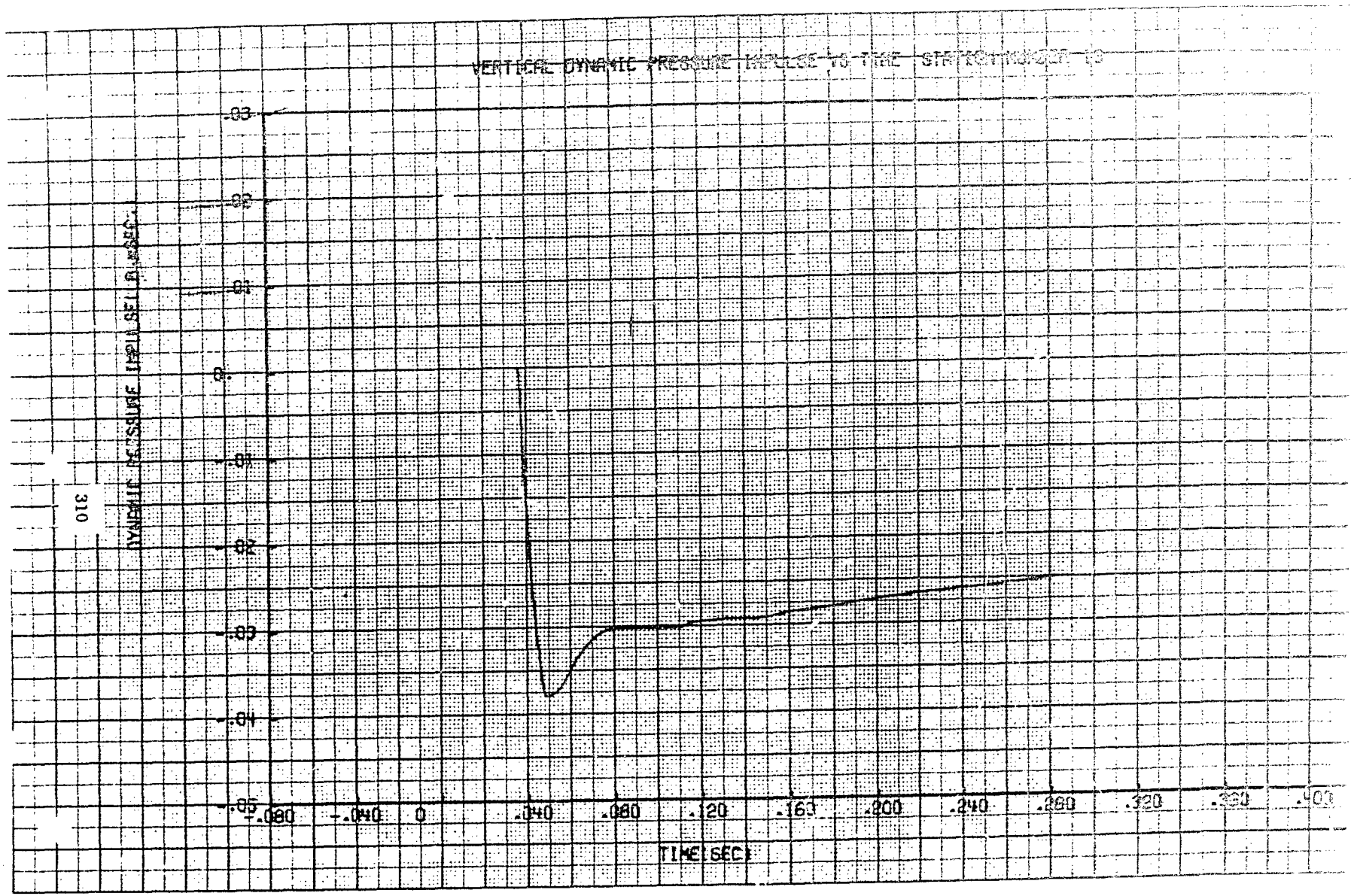

HORIZONTAL COMPONENT VELOCITY VS TIME : STATION NUMBER 15
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

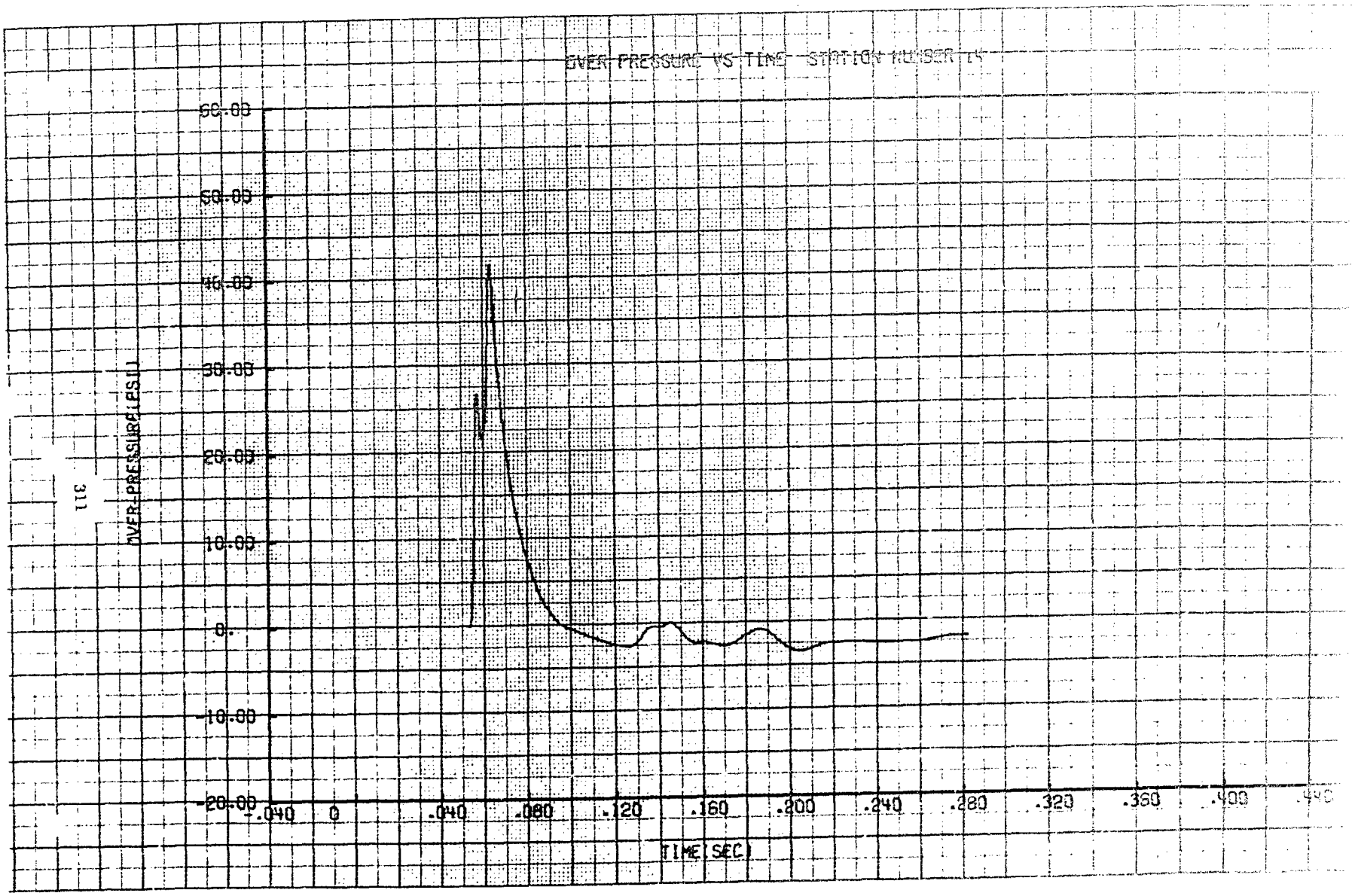

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
-600.00
-800.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
REFERENCE

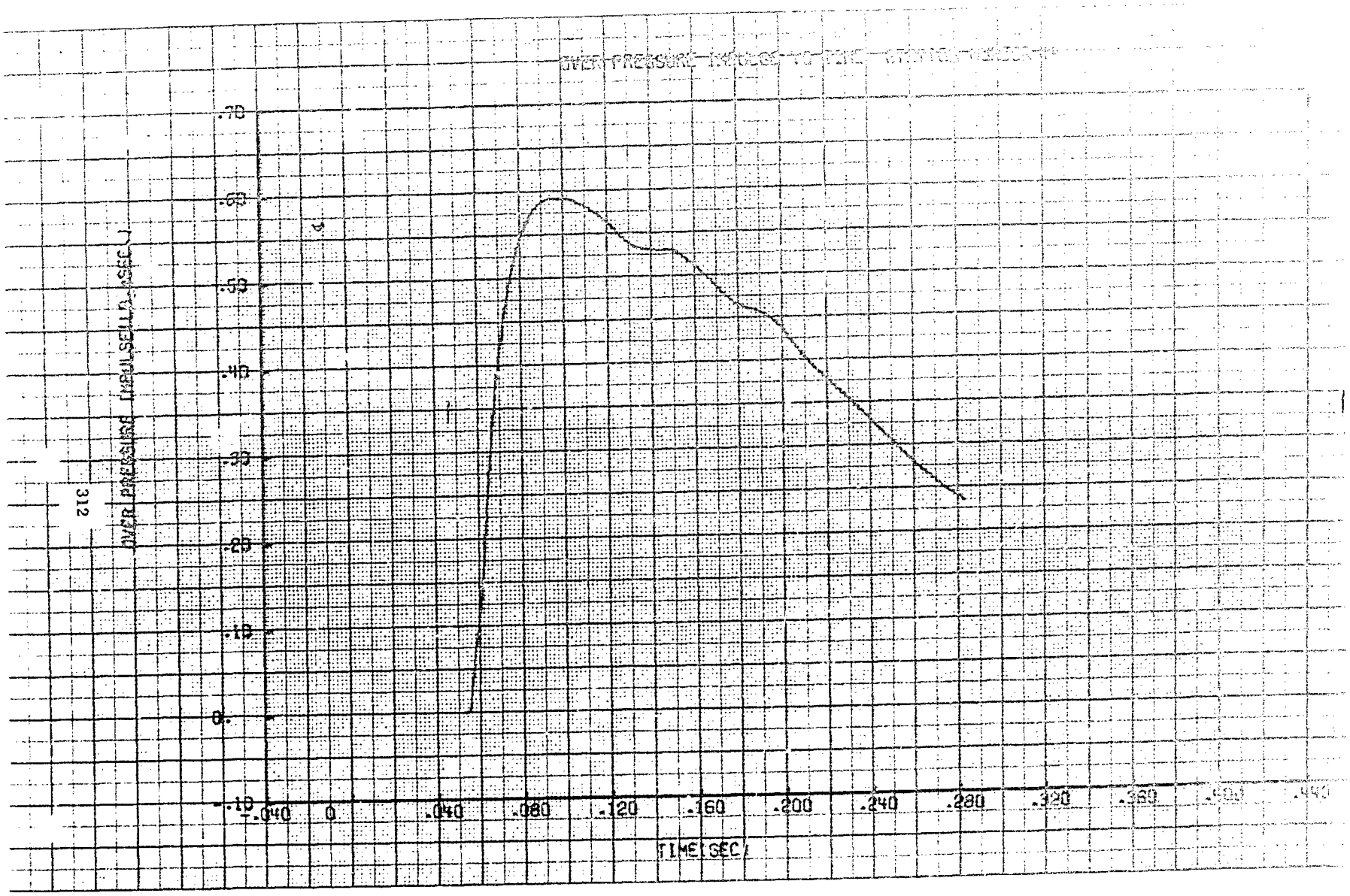

DYNAMIC PRESSURE(PSI)
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
TIME(SEC)

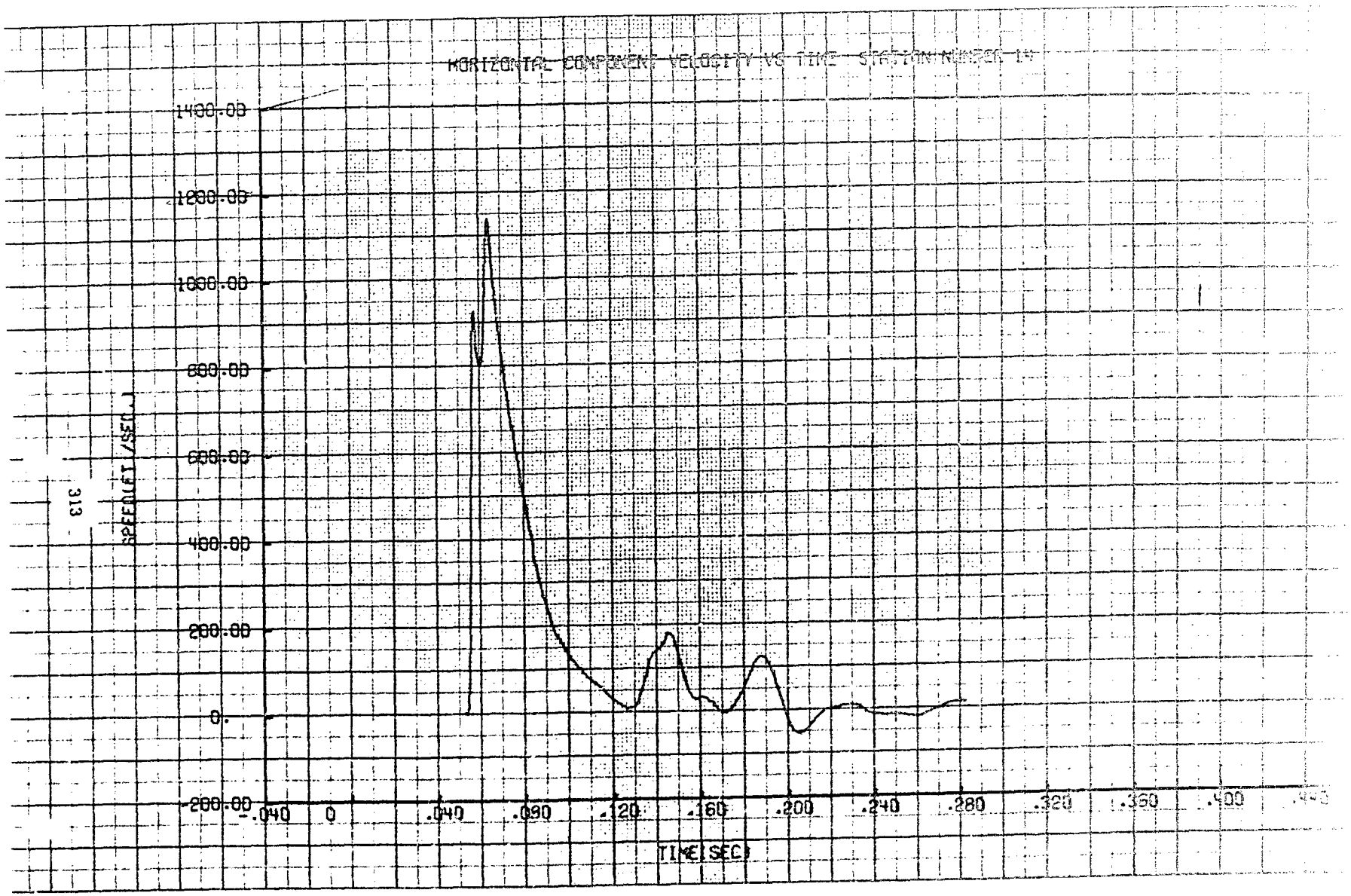
HOLLIDAY DYNAMIC PRESSURE IMPULSE - 1.0 TON - SAMPLE 3
DYNAMIC PRESSURE IMPULSE PSI-MSEC
TIME SEC
0.
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
.480
.520
.560
.600
.640
.680
.720
.760
.800
.840
.880
.920
.960
1.000
1.040
1.080
1.120
1.160
1.200
1.240
1.280
1.320
1.360
1.400
1.440
1.480
1.520
1.560
1.600
1.640
1.680
1.720
1.760
1.800
1.840
1.880
1.920
1.960
2.000
2.040
2.080
2.120
2.160
2.200

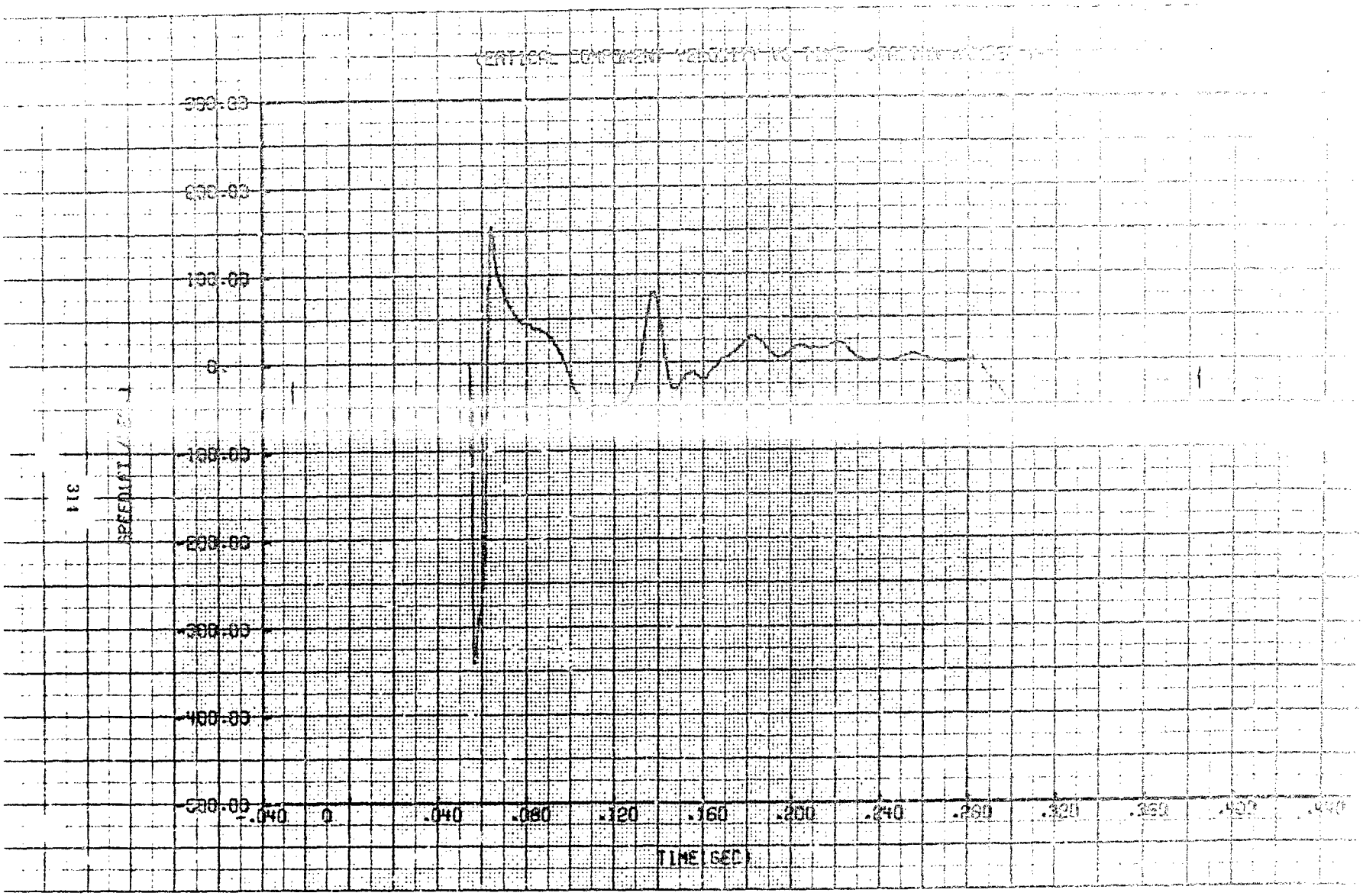

VERTICAL DYNAMIC PRESSURE VS TIME GRAPH NUMBER 16
1.00
0.
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
DYNAMIC PRESSURE(PSI)
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

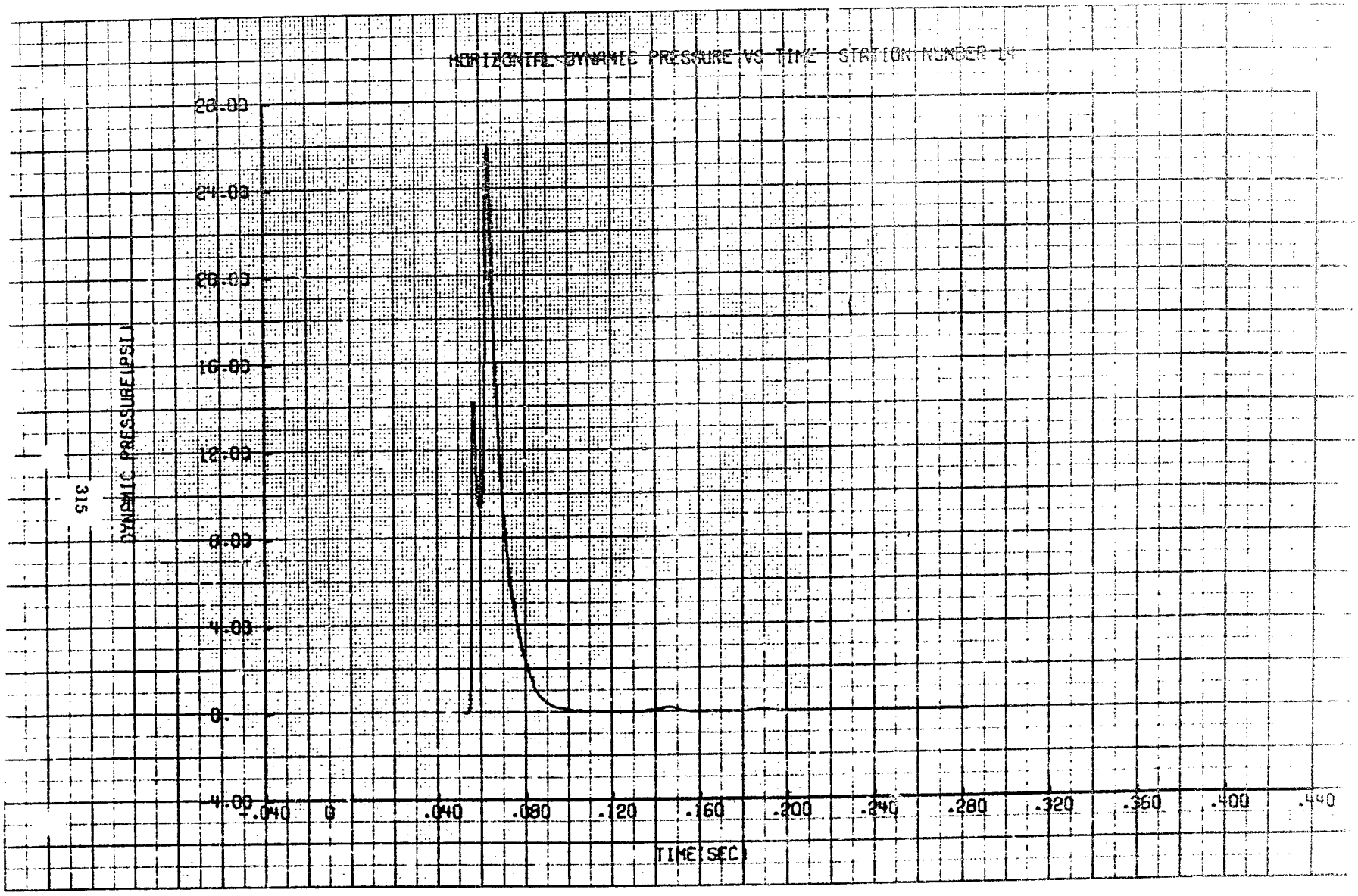

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 10
.03
.02
.01
0.
-.01
-.02
-.03
-.04
-.05
-.080
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN.**2)

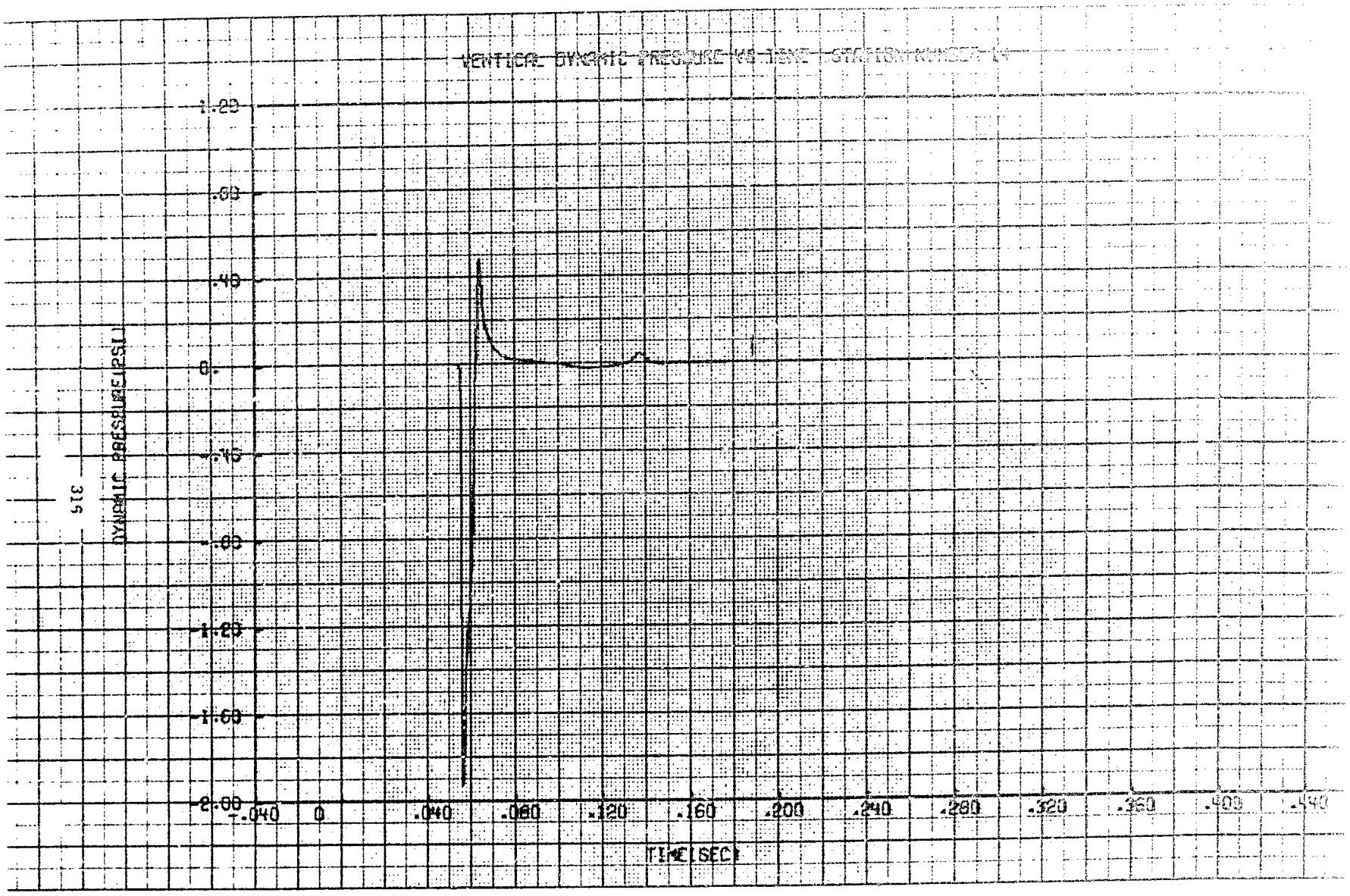

OVER PRESSURE VS TIME STATION NUMBER 14
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER-PRESSURE(PSI)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)


.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 (MPULSE)(LB-MSEC)

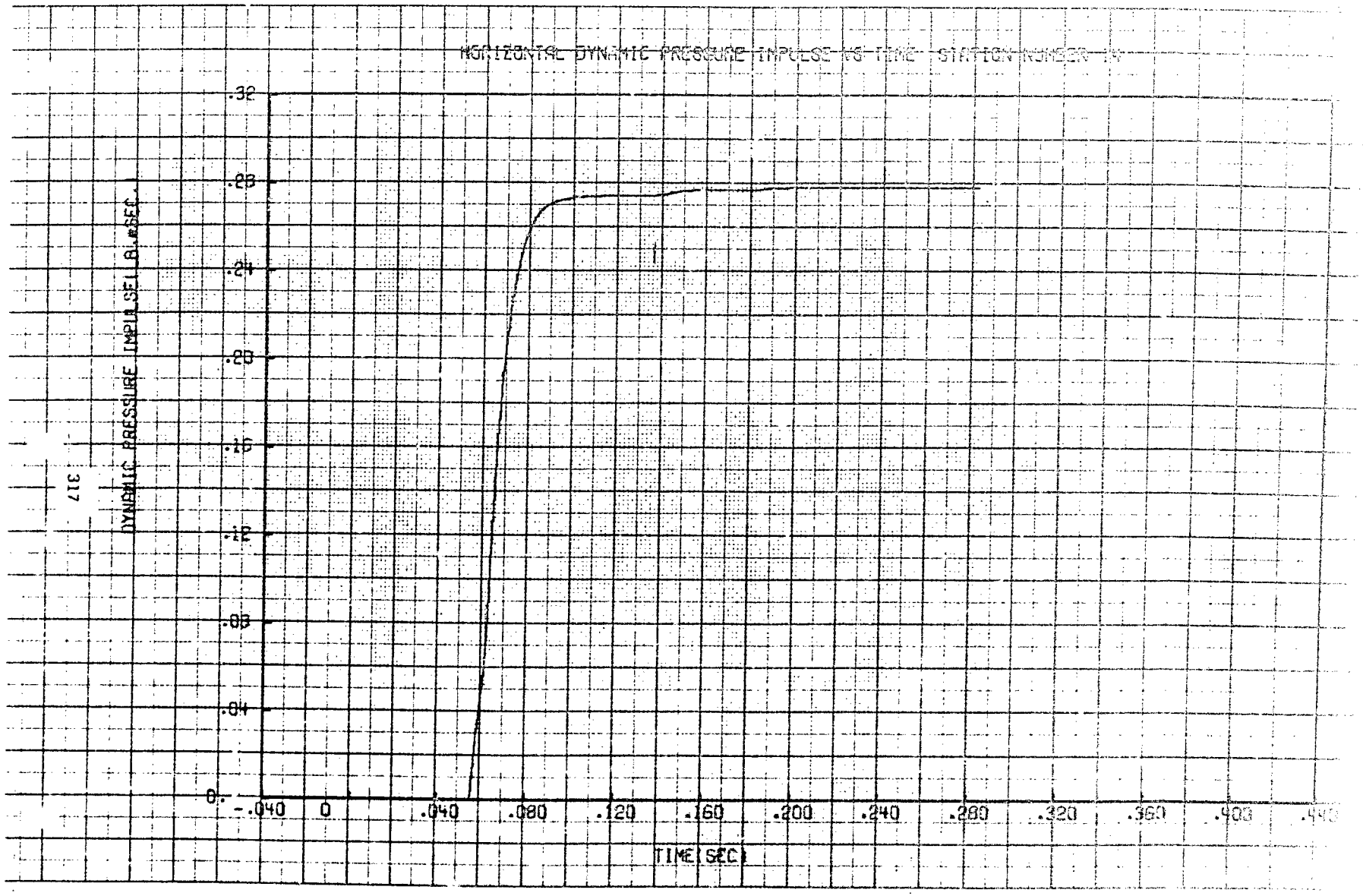

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 14
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

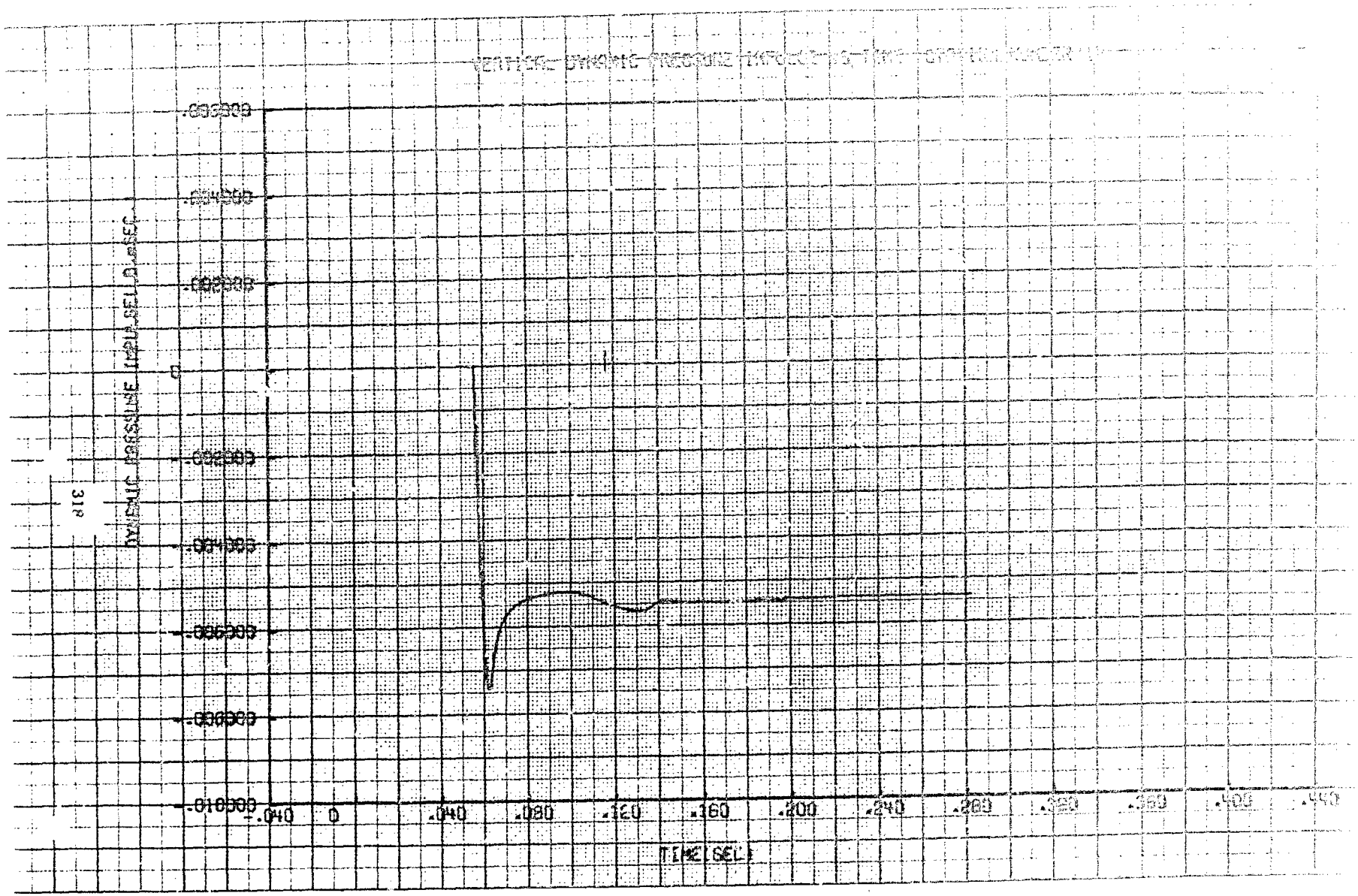

300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
-400.00
-500.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

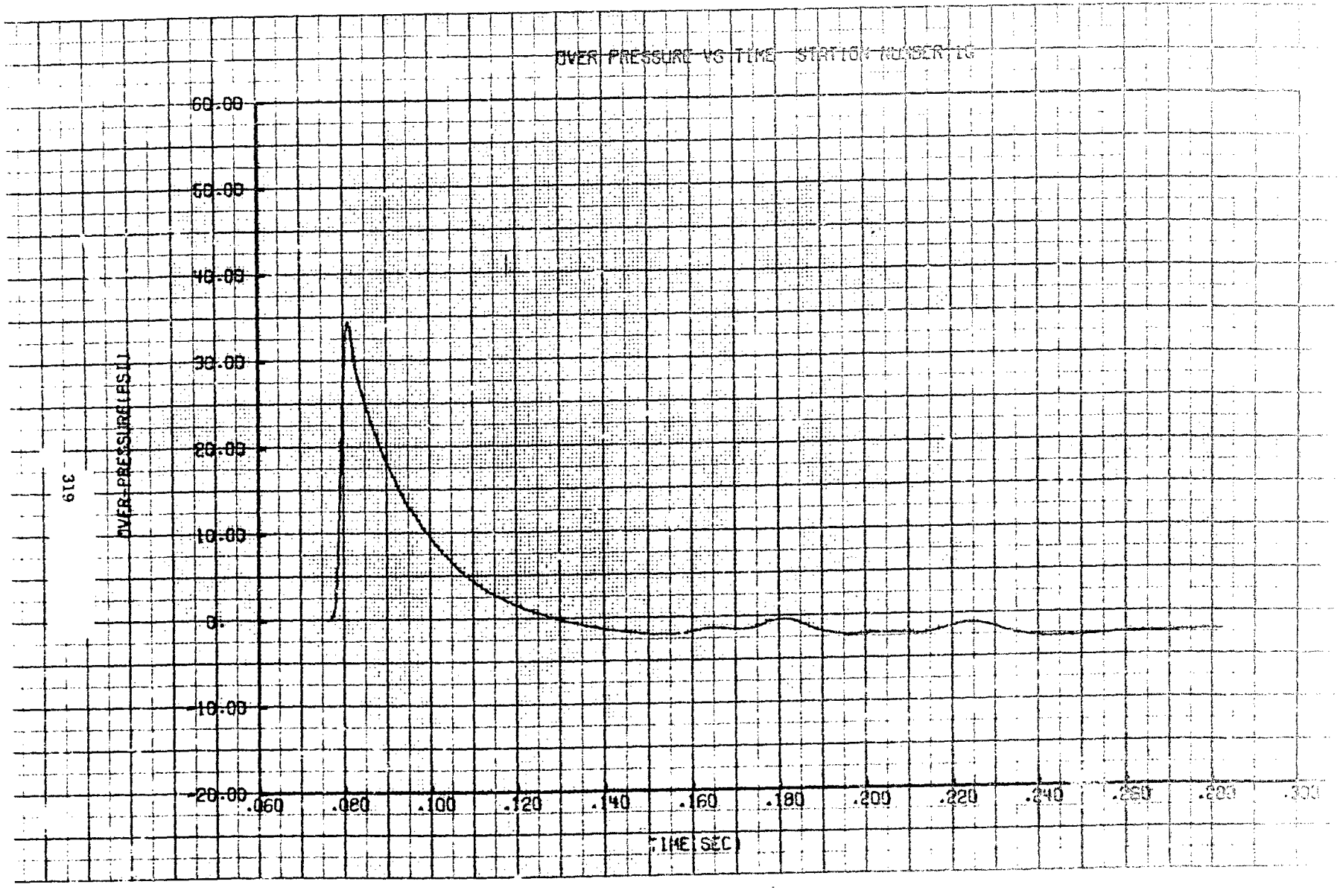

HORIZONTAL DYNAMIC PRESSURE VS TIME STATION NUMBER 14
DYNAMIC PRESSURE(PSI)
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

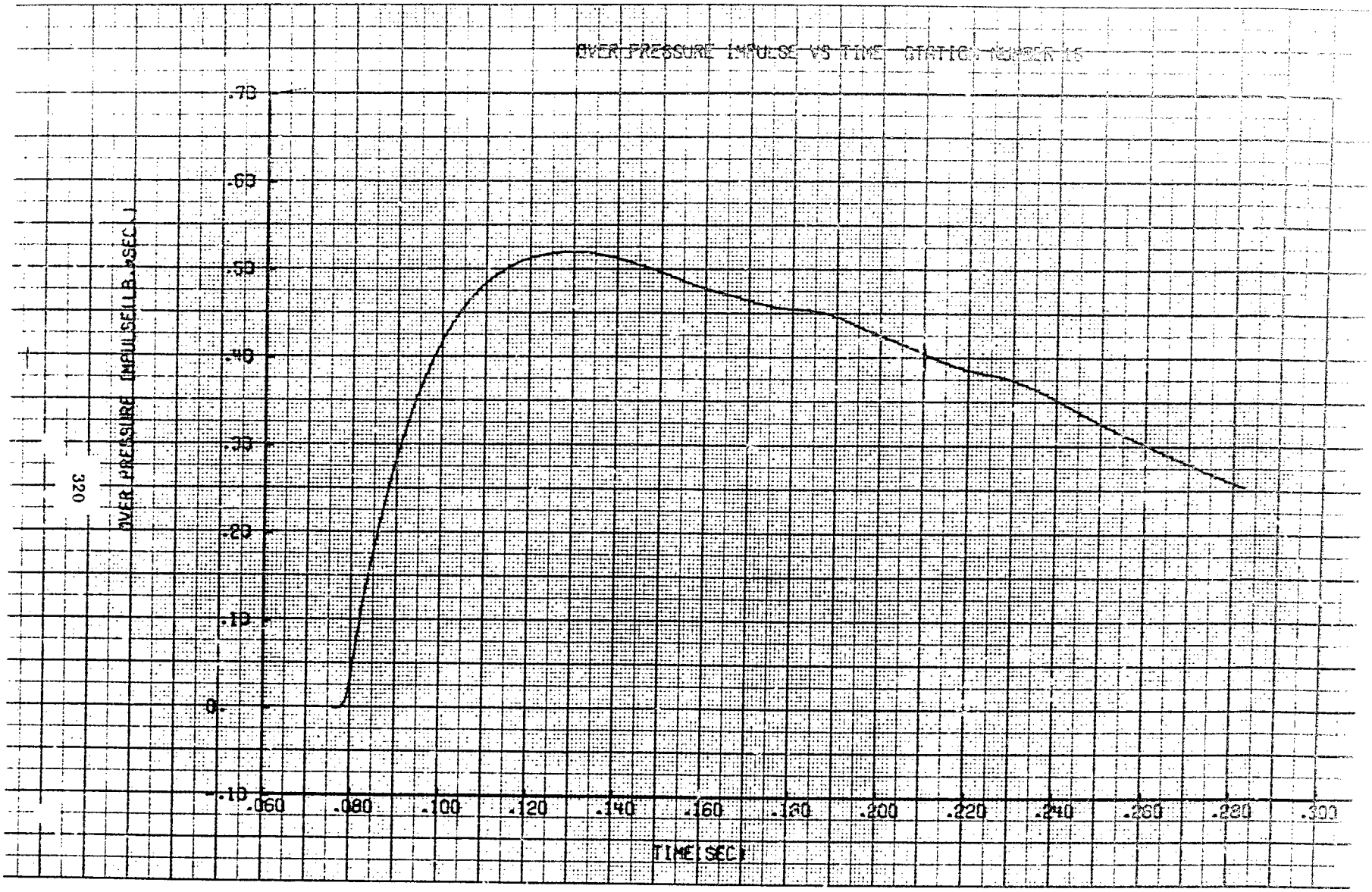


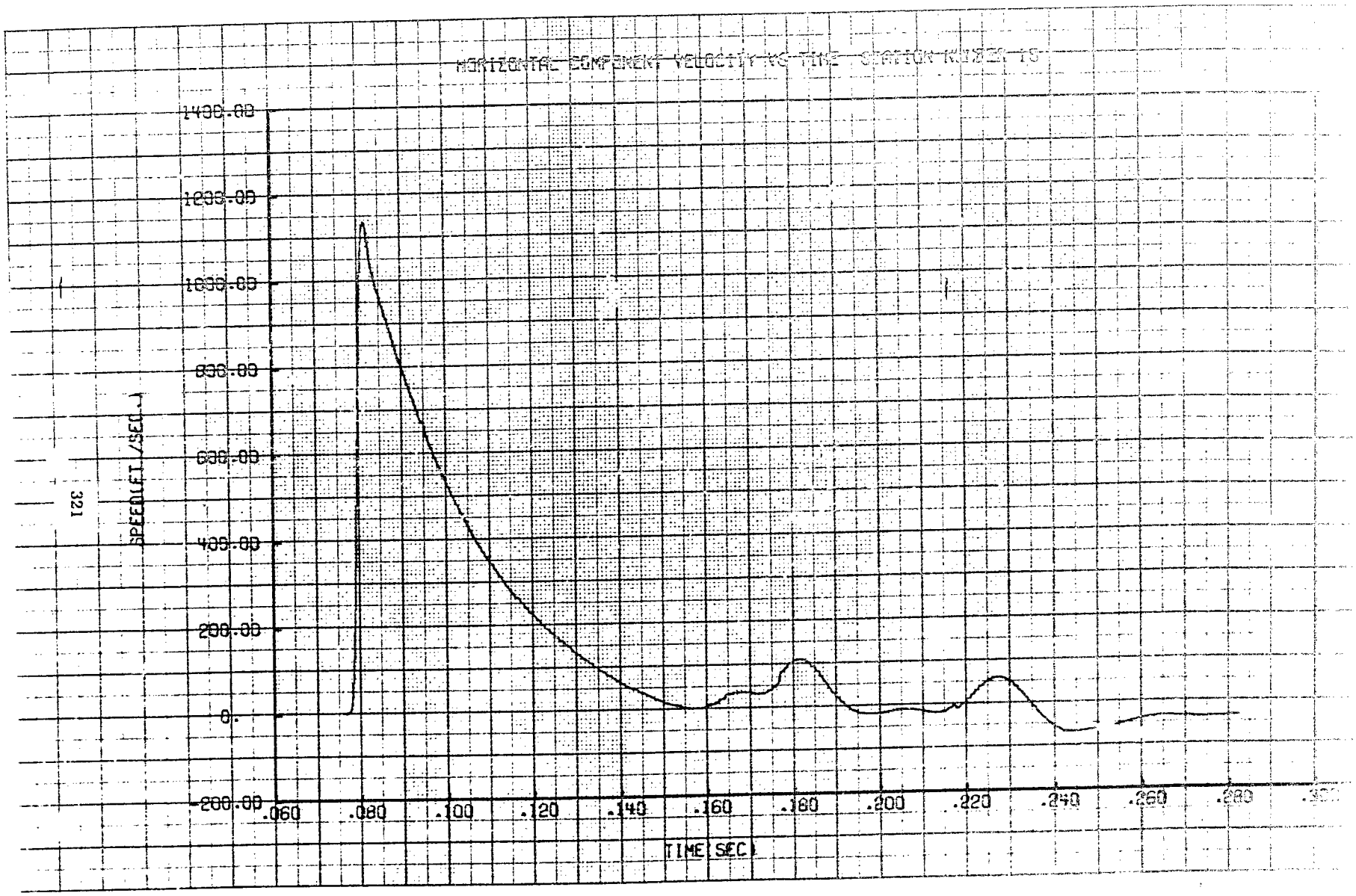
DYNAMIC PRESSURE (PSI)

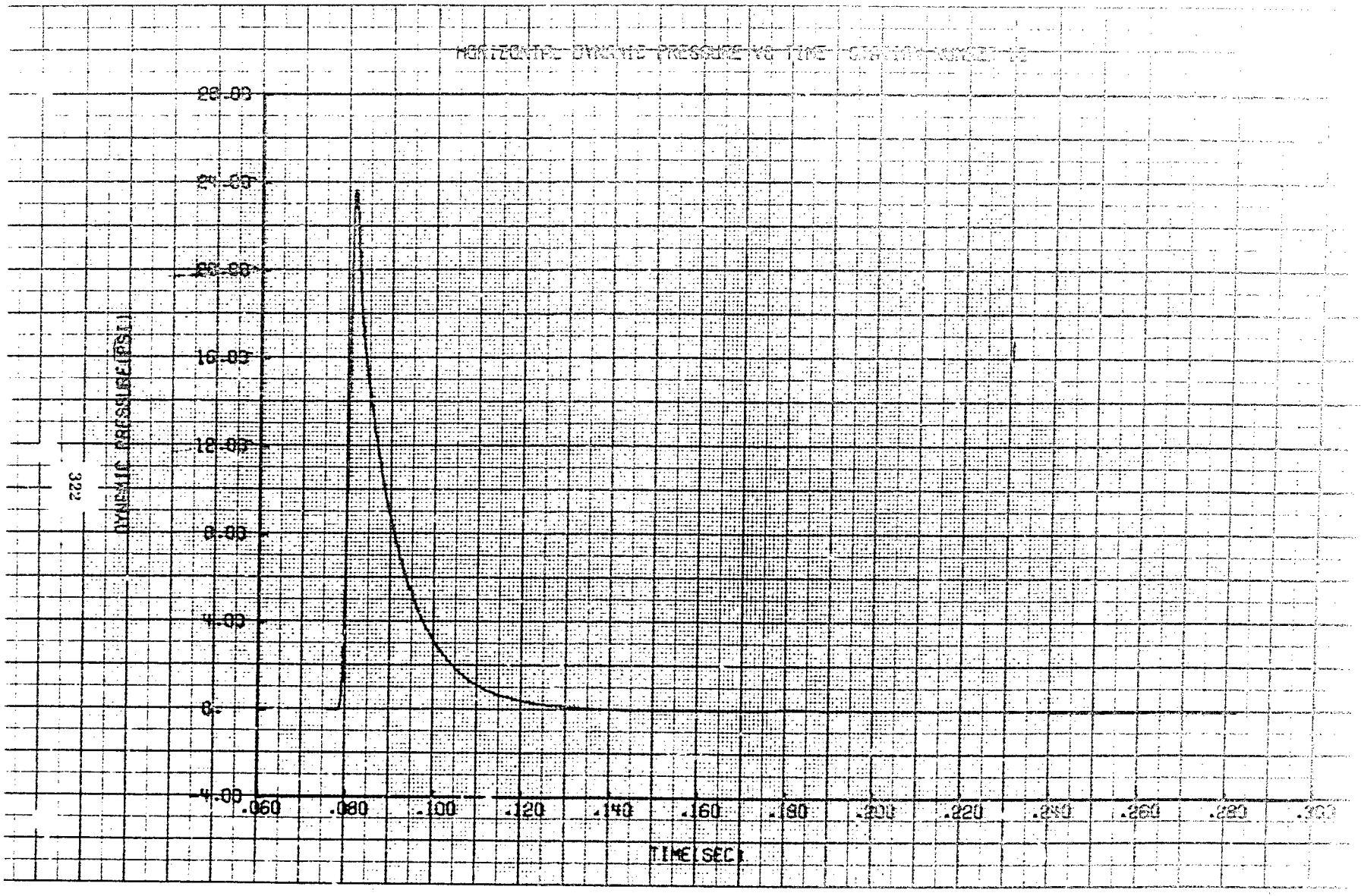

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 14
DYNAMIC PRESSURE IMPULSE(LB-SEC)
.32
.28
.24
.20
.16
.12
.08
.04
0.
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

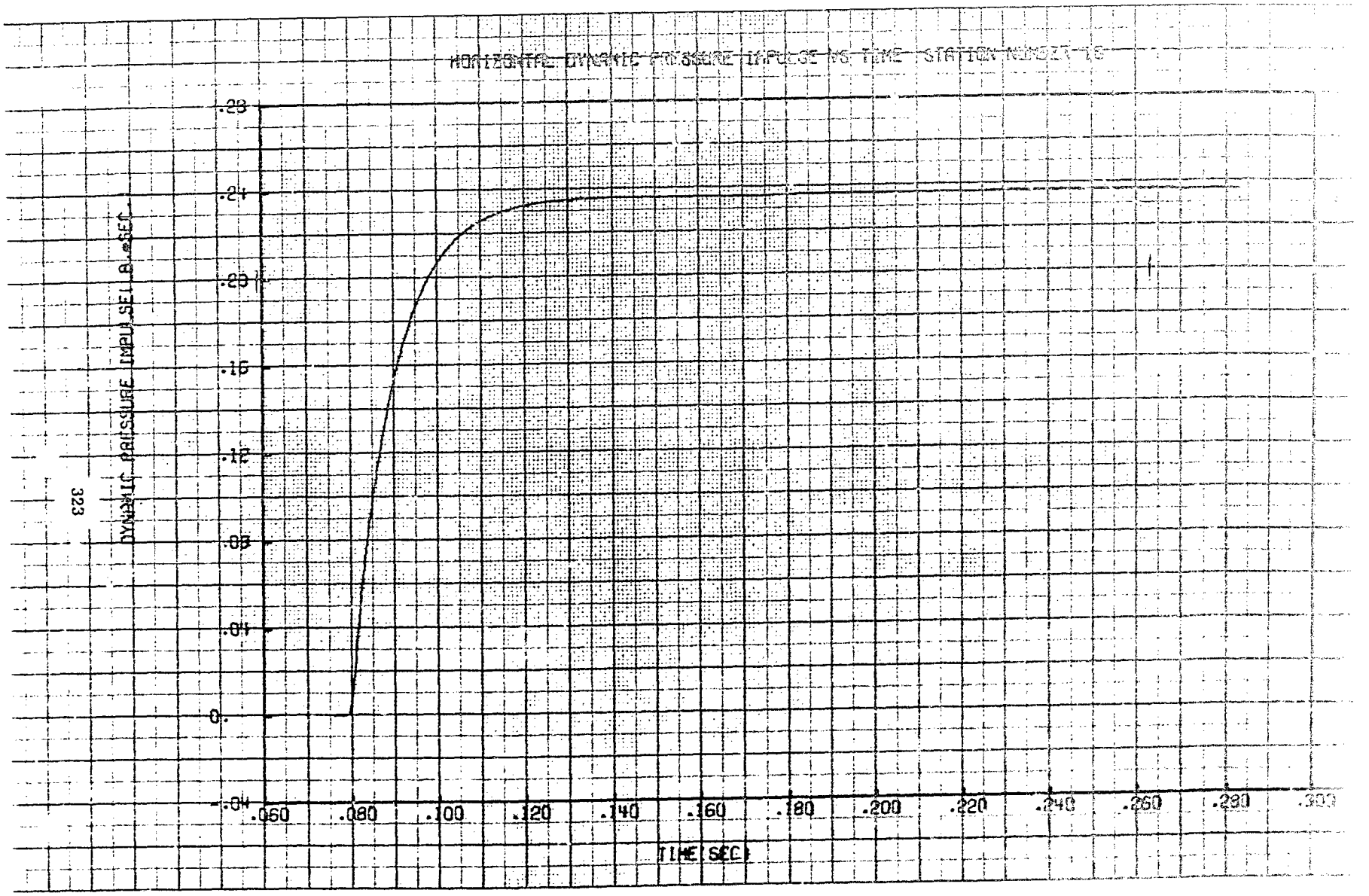

VERTICAL DYNAMIC PRESSURE IMPULSE VS TIME (PRESSURE TRANSDUCER)
DYNAMIC PRESSURE IMPULSE (LB-SEC/IN.-SEC)
.000000
.004000
.002000
0
-.002000
-.004000
-.006000
-.008000
-.010000
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)

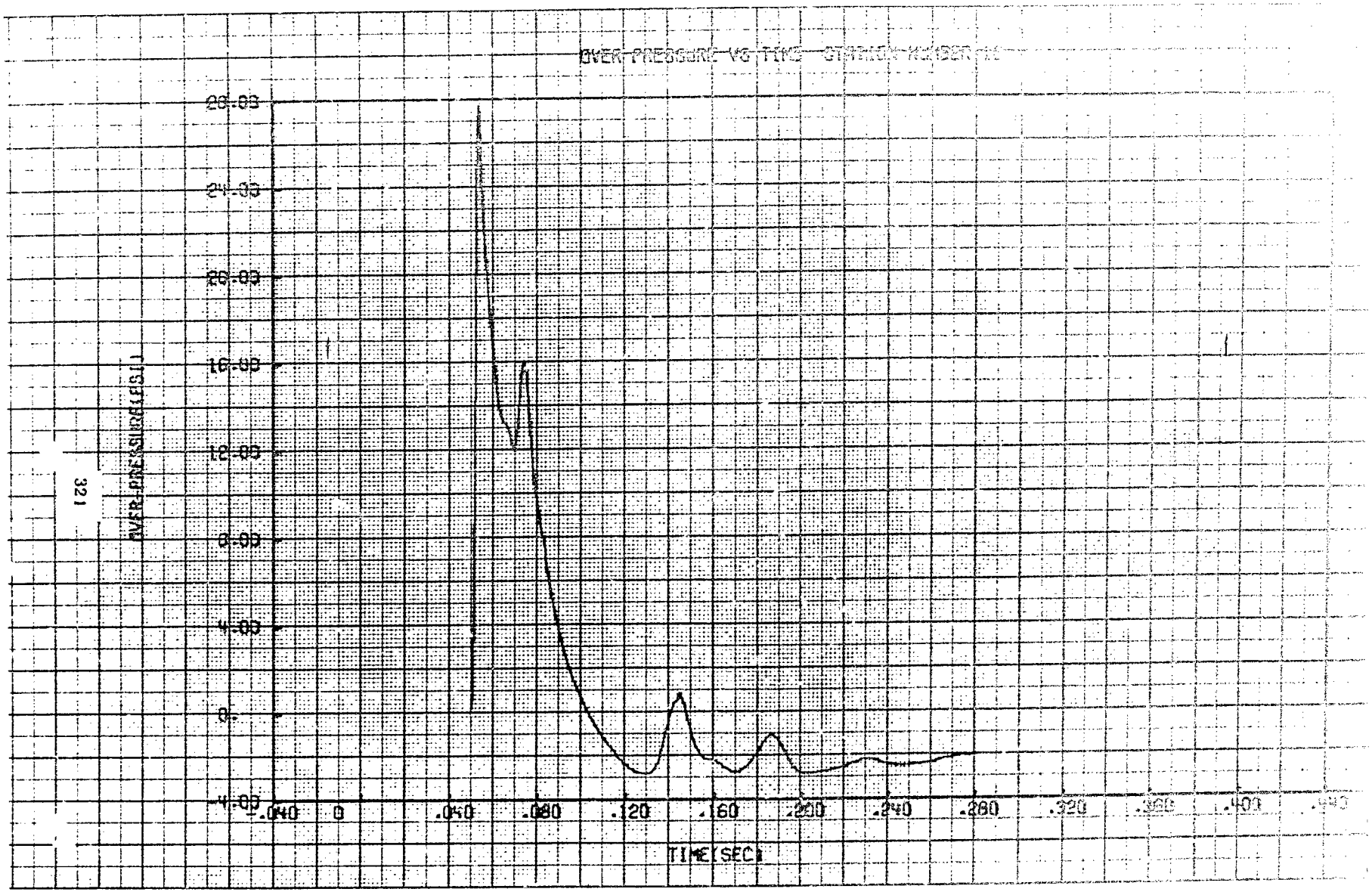

OVER PRESSURE VS TIME STATION NUMBER 16
60.00
50.00
40.00
30.00
20.00
10.00
0.
-10.00
-20.00
OVER PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

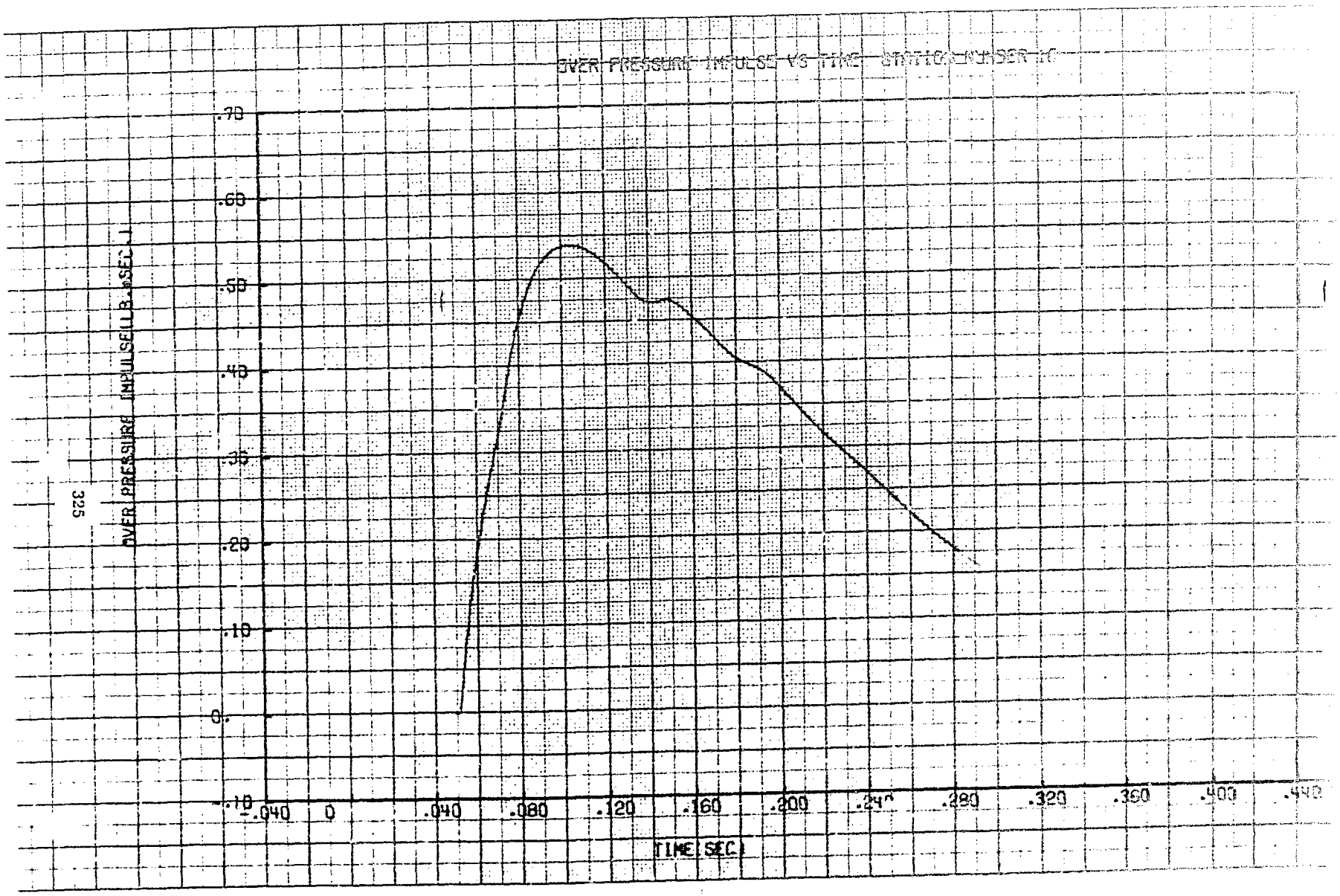

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 16
OVER PRESSURE (IMPULSE(LB.*SEC))
.70
.60
.50
.40
.30
.20
.10
0
-.10
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

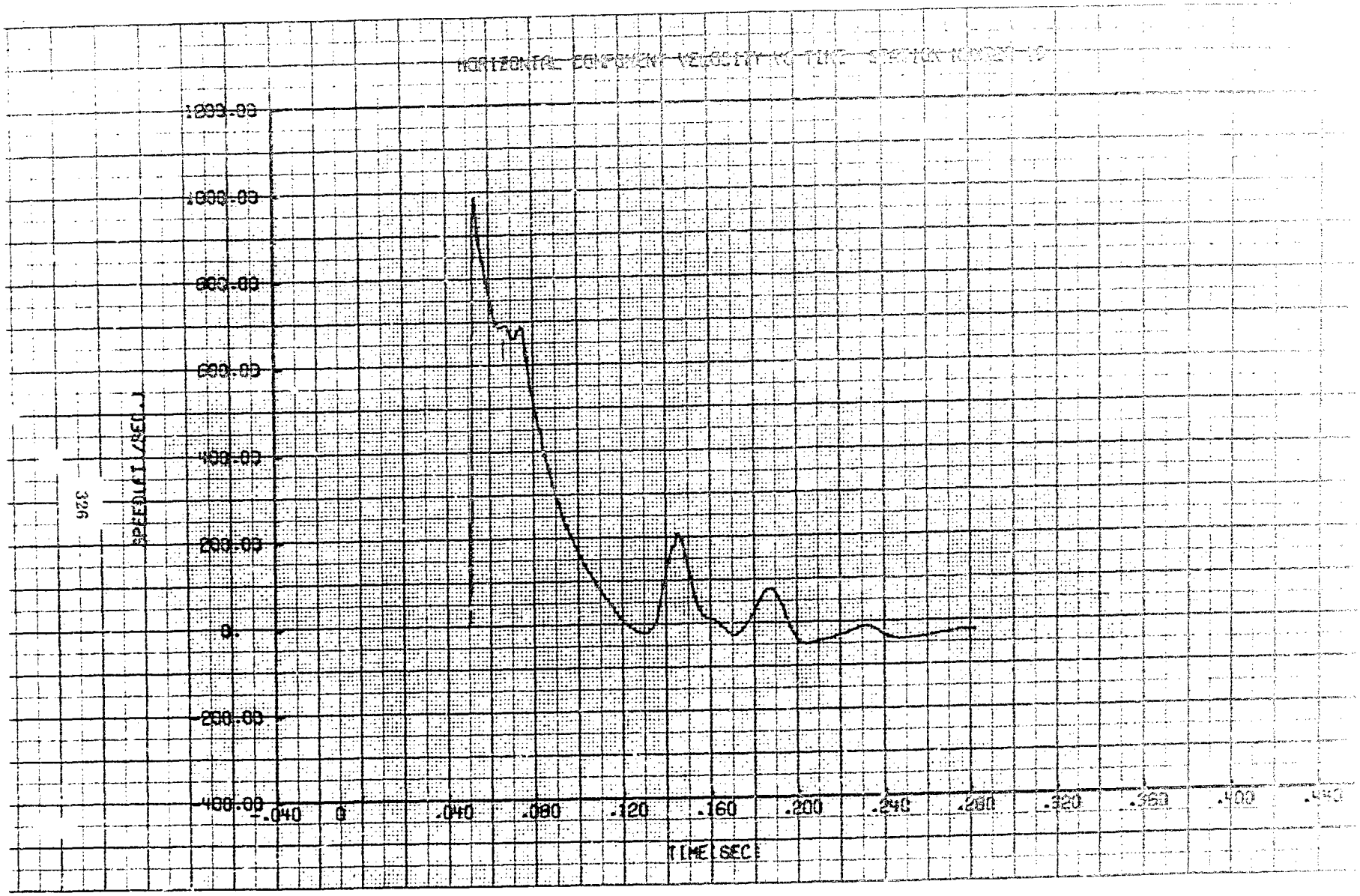

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 15
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
SPEED(FT/SEC.)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME SEC)

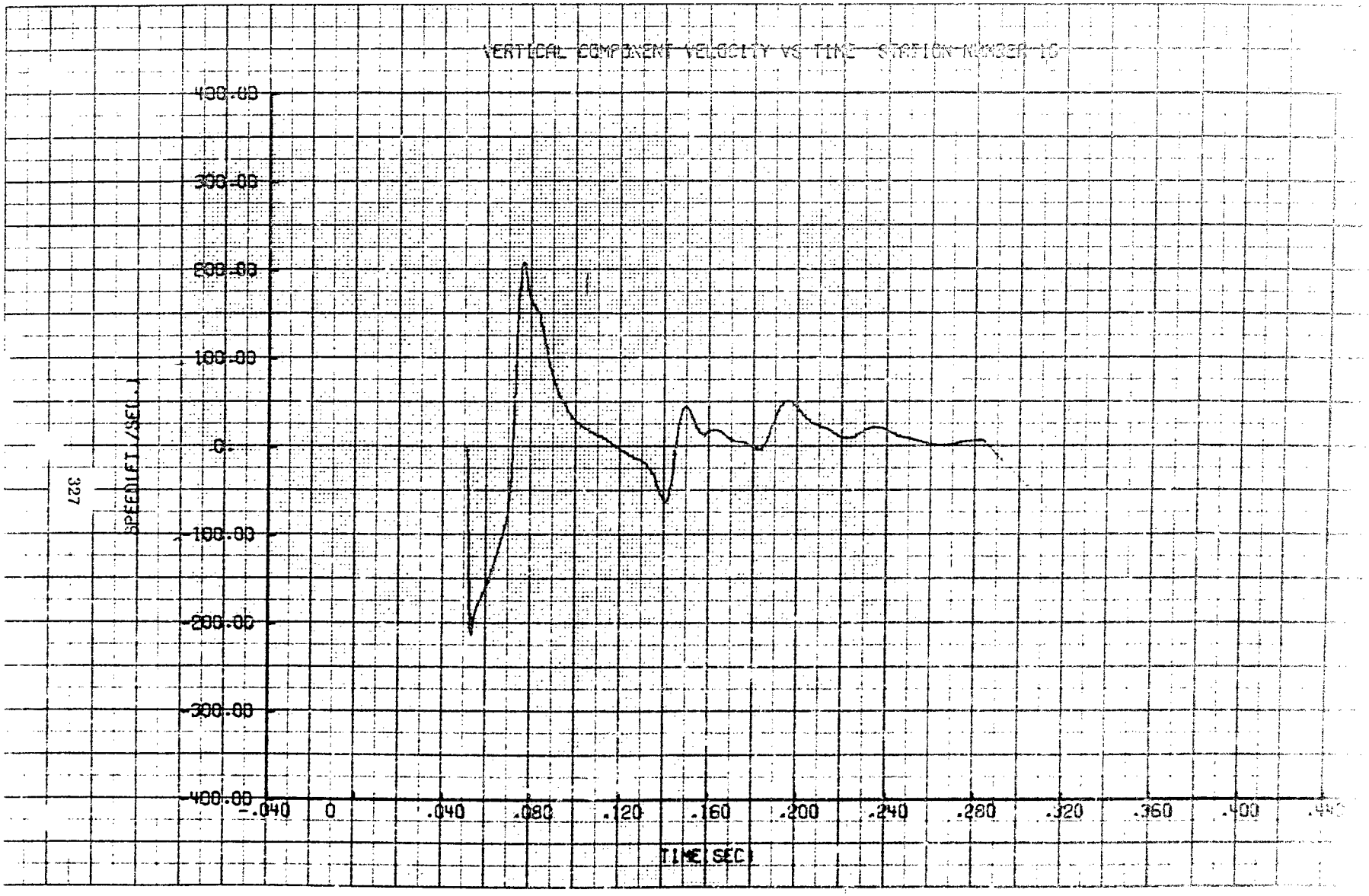

HORIZONTAL DYNAMIC PRESSURE VS TIME
DYNAMIC PRESSURE(PSI)
TIME(SEC)
16.00
12.00
8.00
4.00
0.
-4.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300

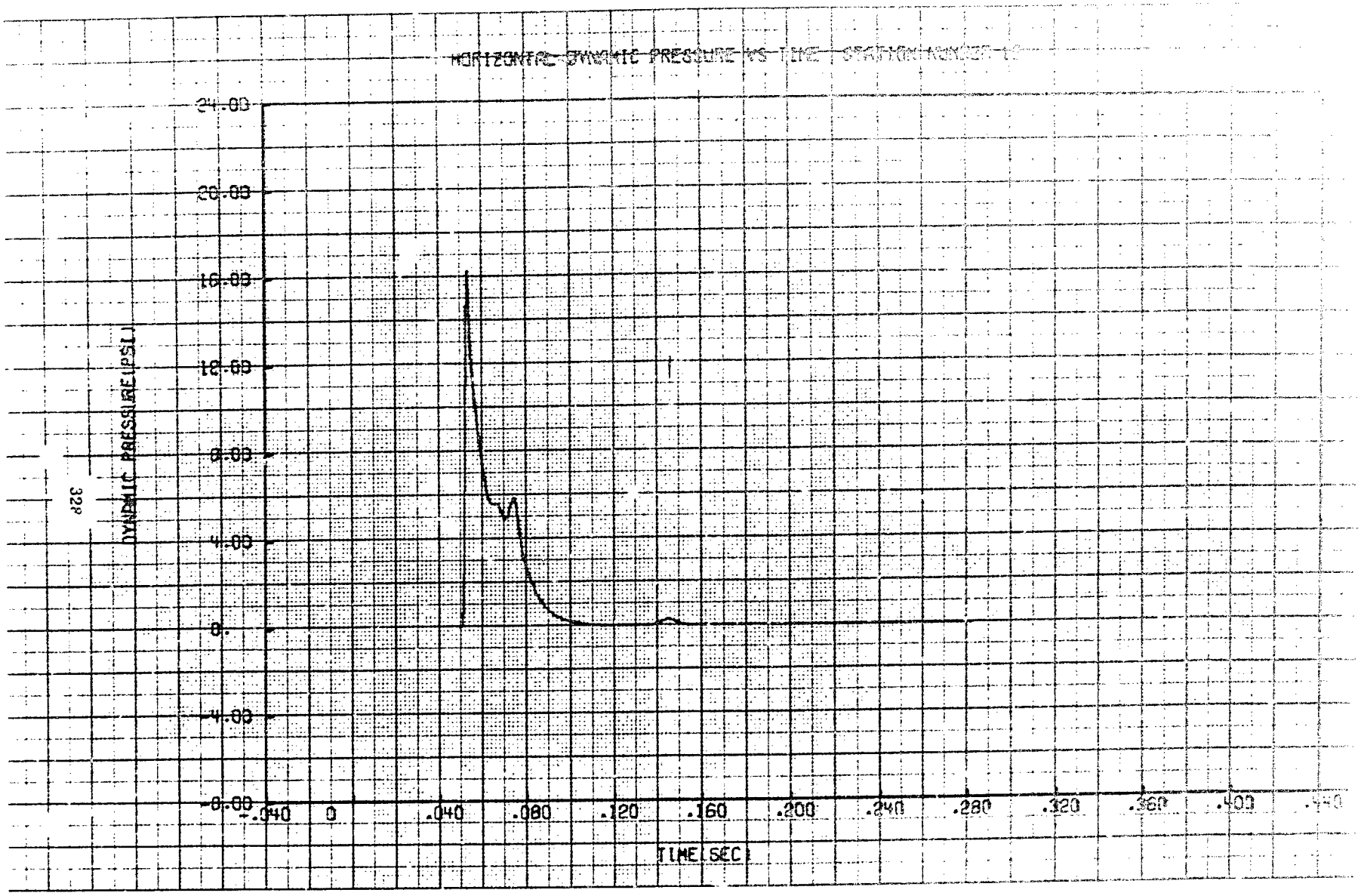

HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME STATION NUMBER 16
DYNAMIC PRESSURE IMPULSE (LB-SEC)
.28
.24
.20
.16
.12
.08
.04
0.
-.04
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME (SEC)

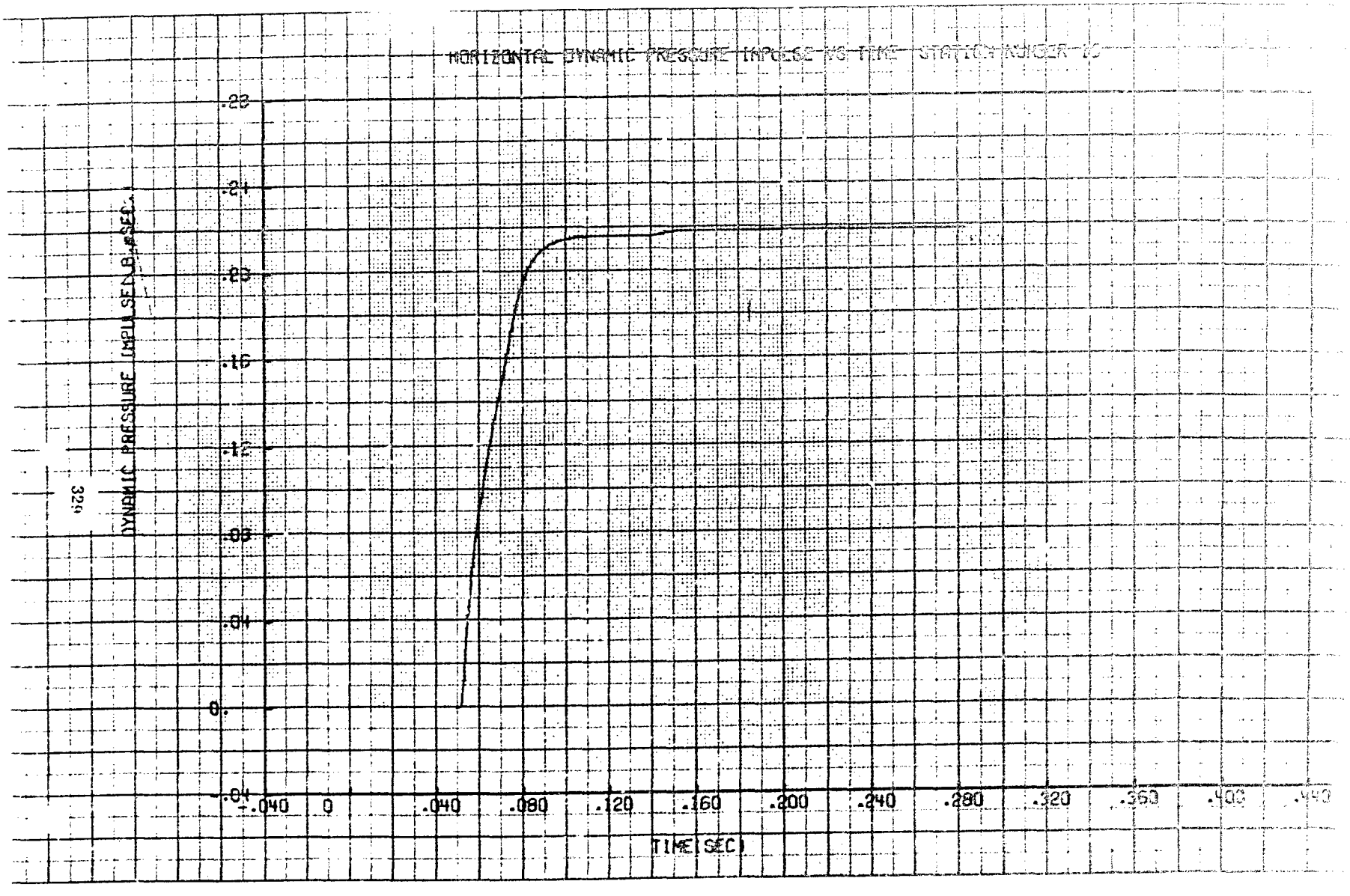

OVER-PRESSURE VS TIME
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
OVER-PRESSURE(LBS/I.)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

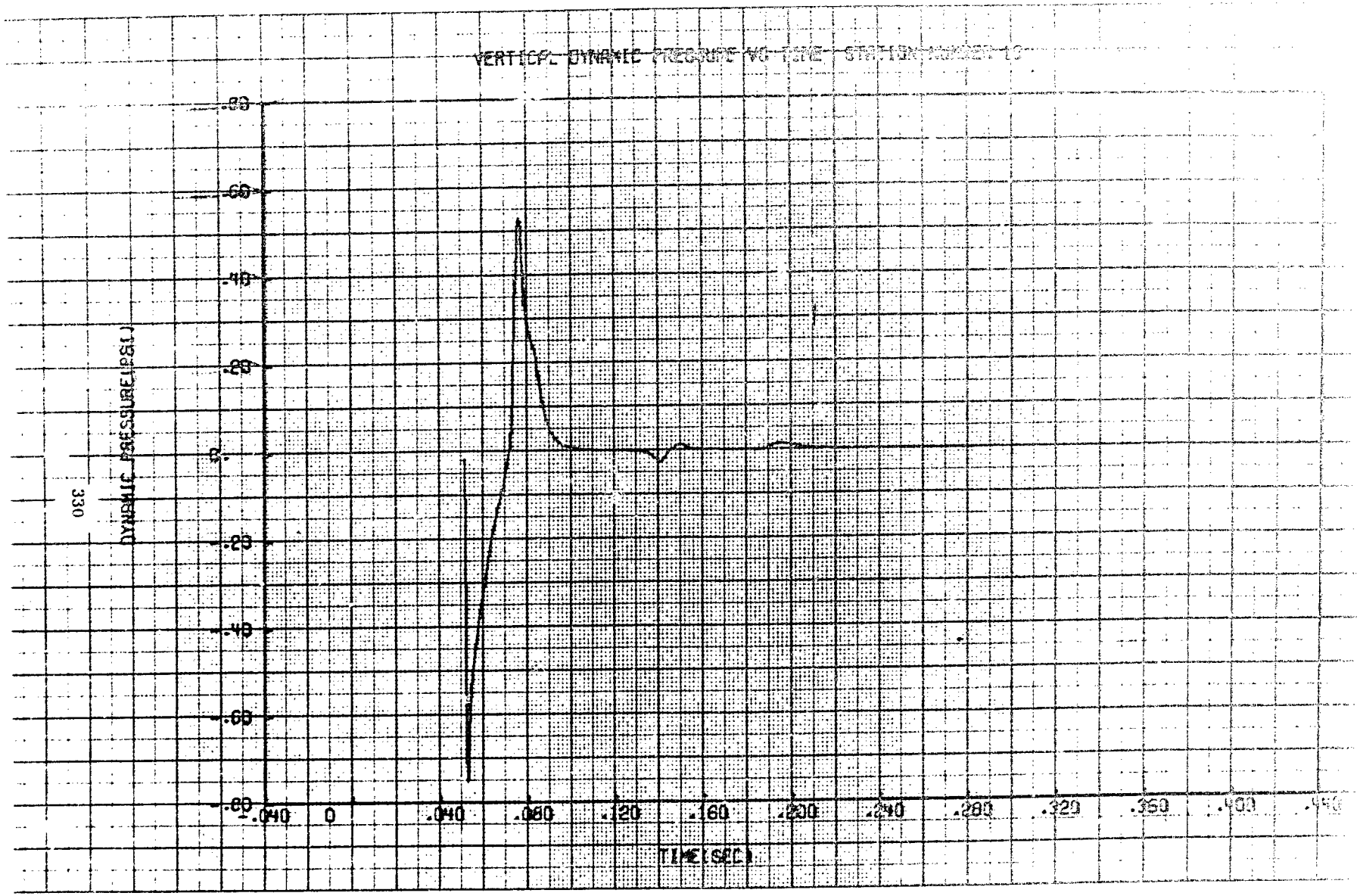

OVER PRESSURE IMPULSE VS TIME STATION NUMBER 10
OVER PRESSURE IMPULSE(LB.*SEC.)
.70
.60
.50
.40
.30
.20
.10
0.
-.10
-.040
0
.040
.080
.120
.160
.200
.280
.320
.360
.400
TIME(SEC.)

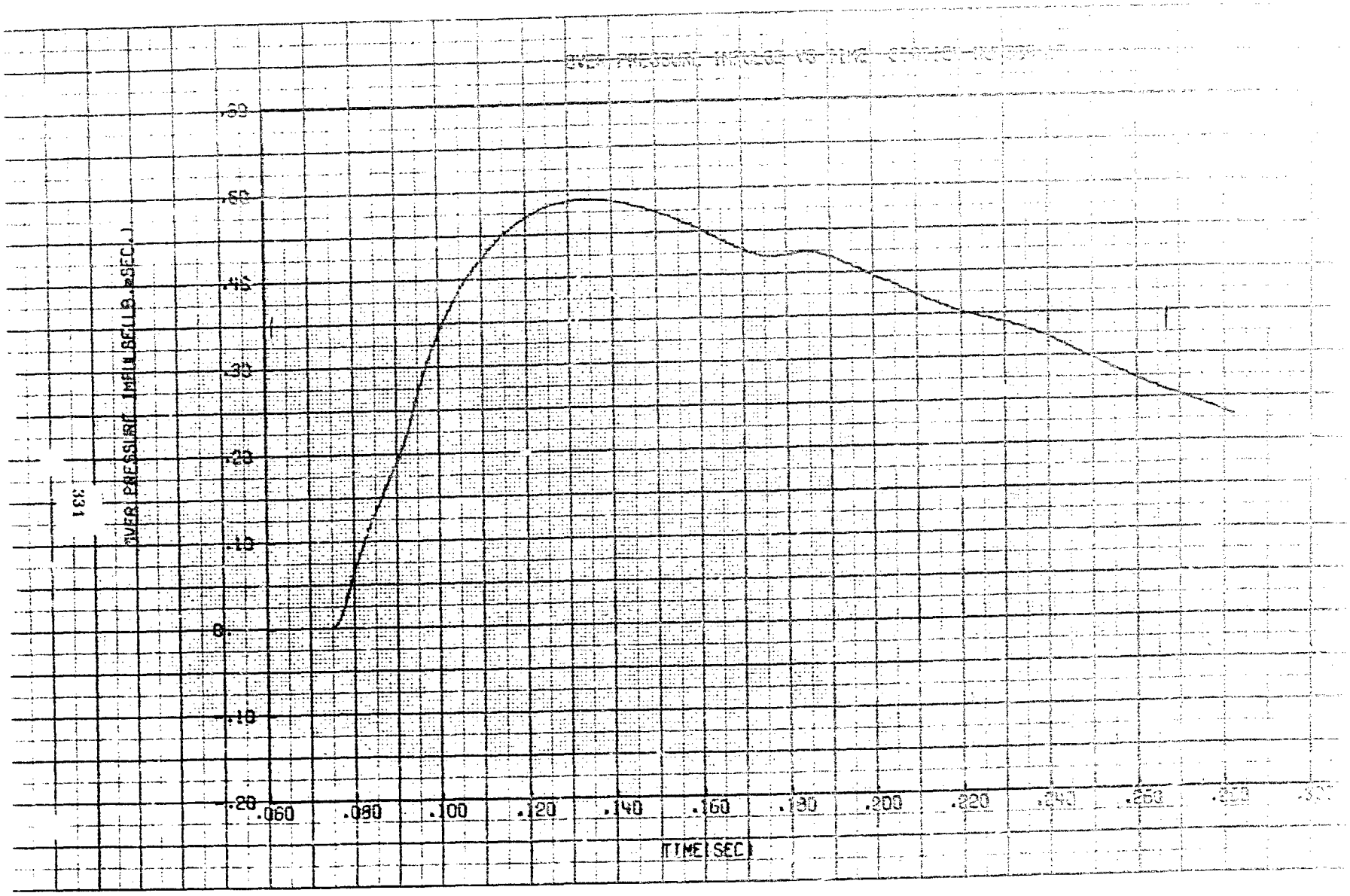

HORIZONTAL COMPONENT VELOCITY VS TIME SPECIMEN NUMBER 10
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

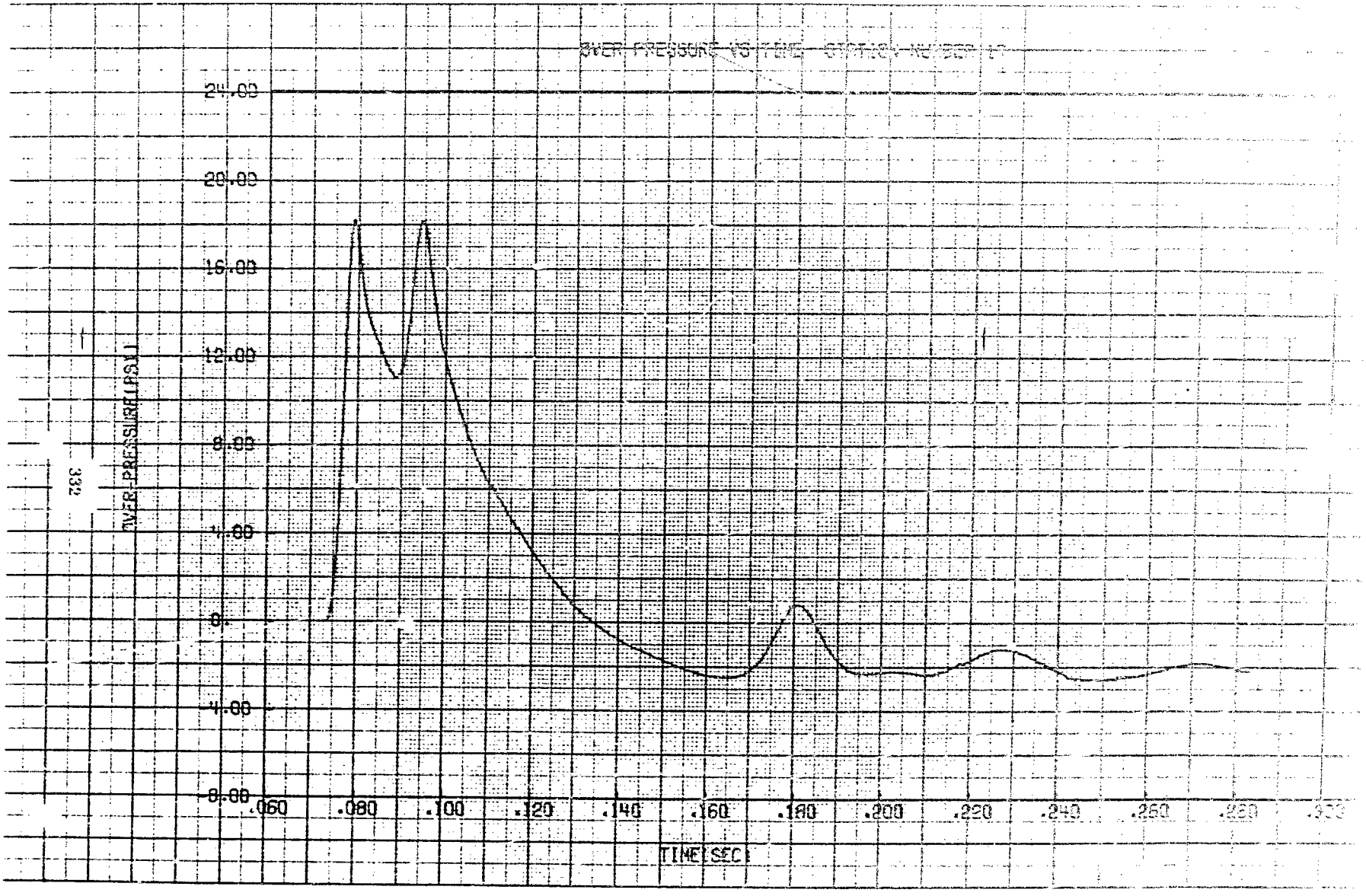

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
-400.00
SPEED(FT/SEC)
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
TIME(SEC)

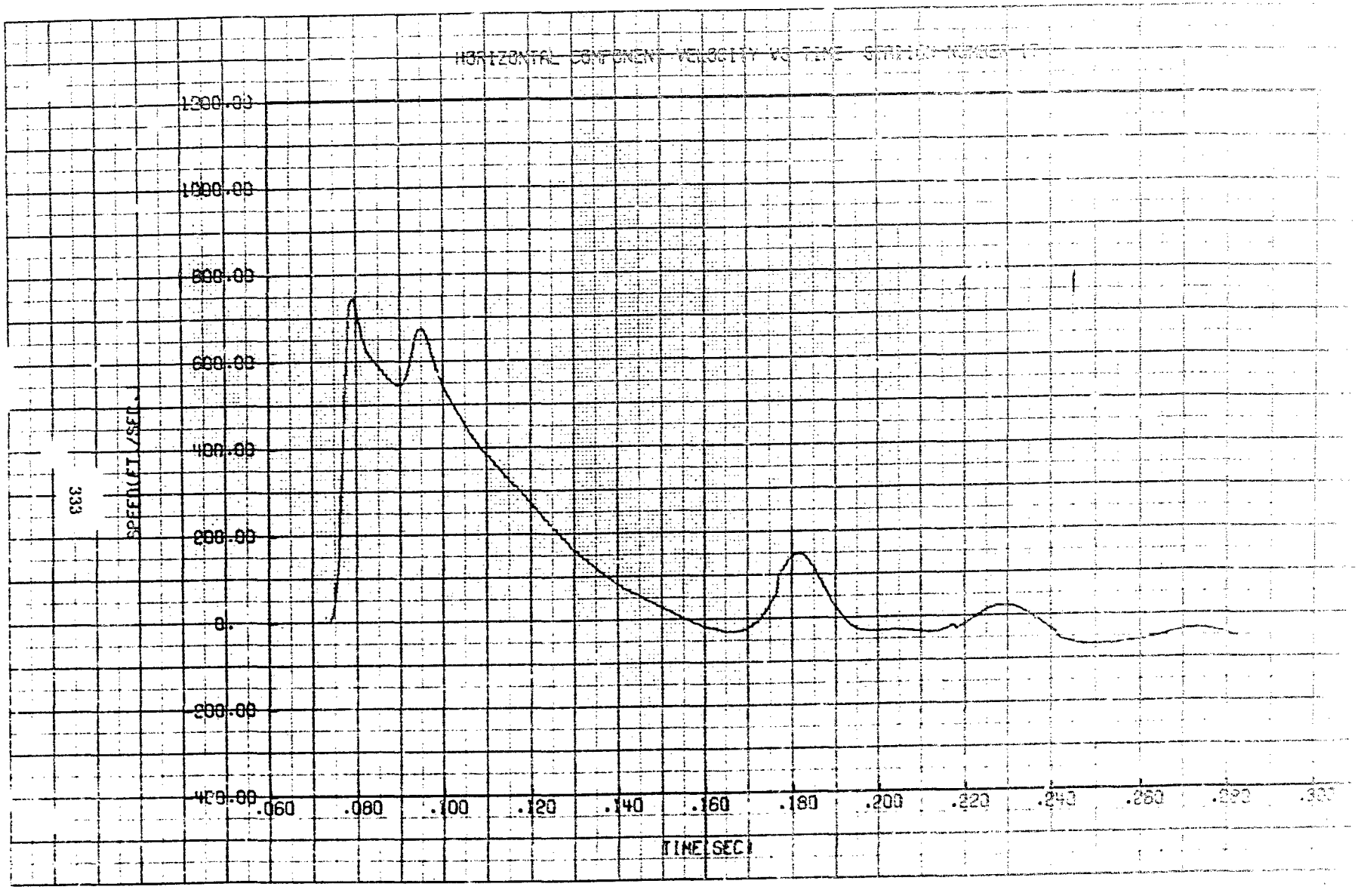

HORIZONTAL DYNAMIC PRESSURE VS TIME (STATION NUMBER 1)
DYNAMIC PRESSURE (PSI)
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME (SEC)


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 STATION NUMBER 10
DYNAMIC PRESSURE(PSI)
.80
.60
.40
.20
0
-.20
-.40
-.60
-.80
-.040
0
.040
.080
.120
.160
.200
.240
.280
.320
.360
.400
.440
TIME(SEC)

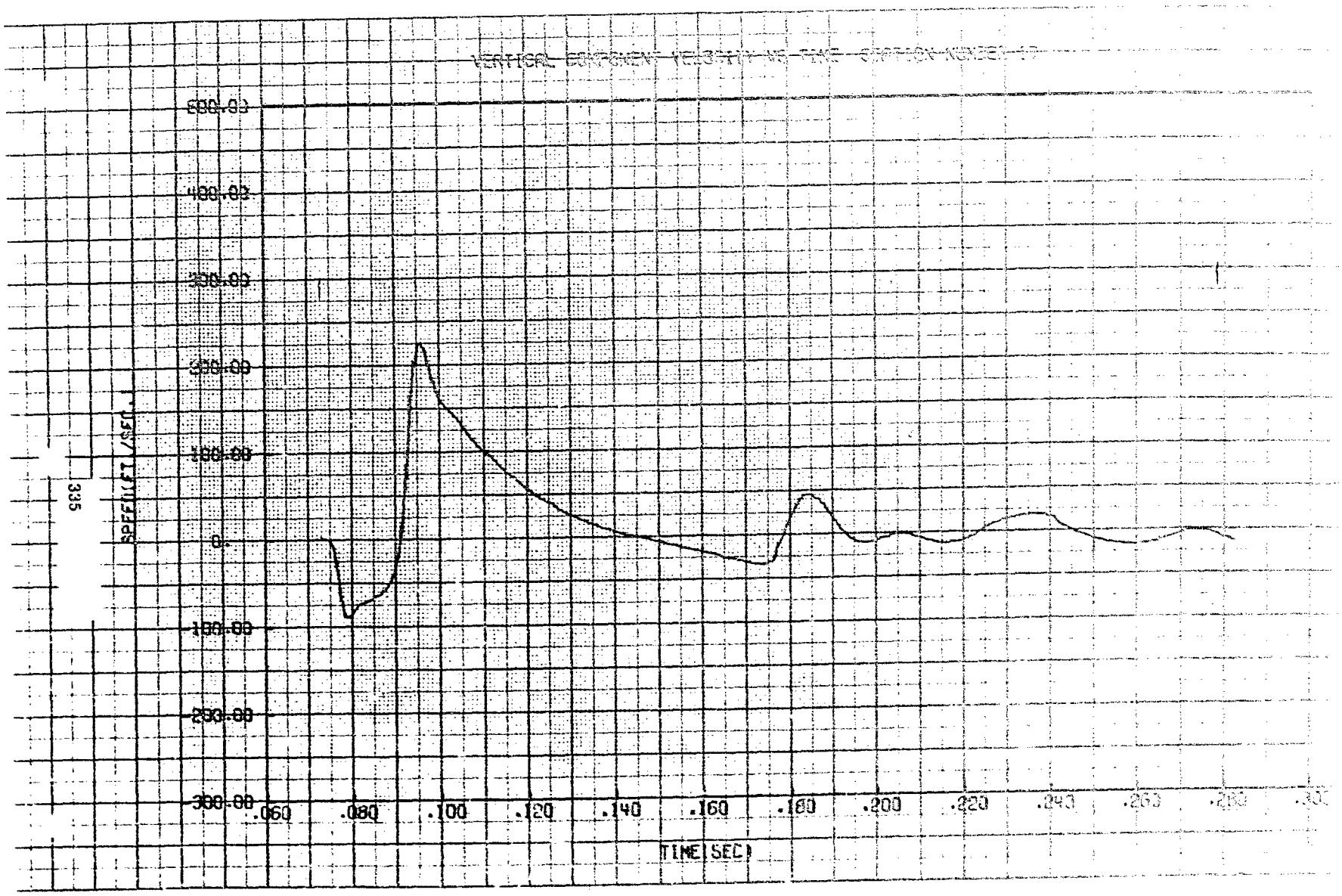

OVER PRESSURE (MBLN BELLB.*SEC.)
.30
.25
.20
.15
.10
.05
.00
-.05
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME (SEC)

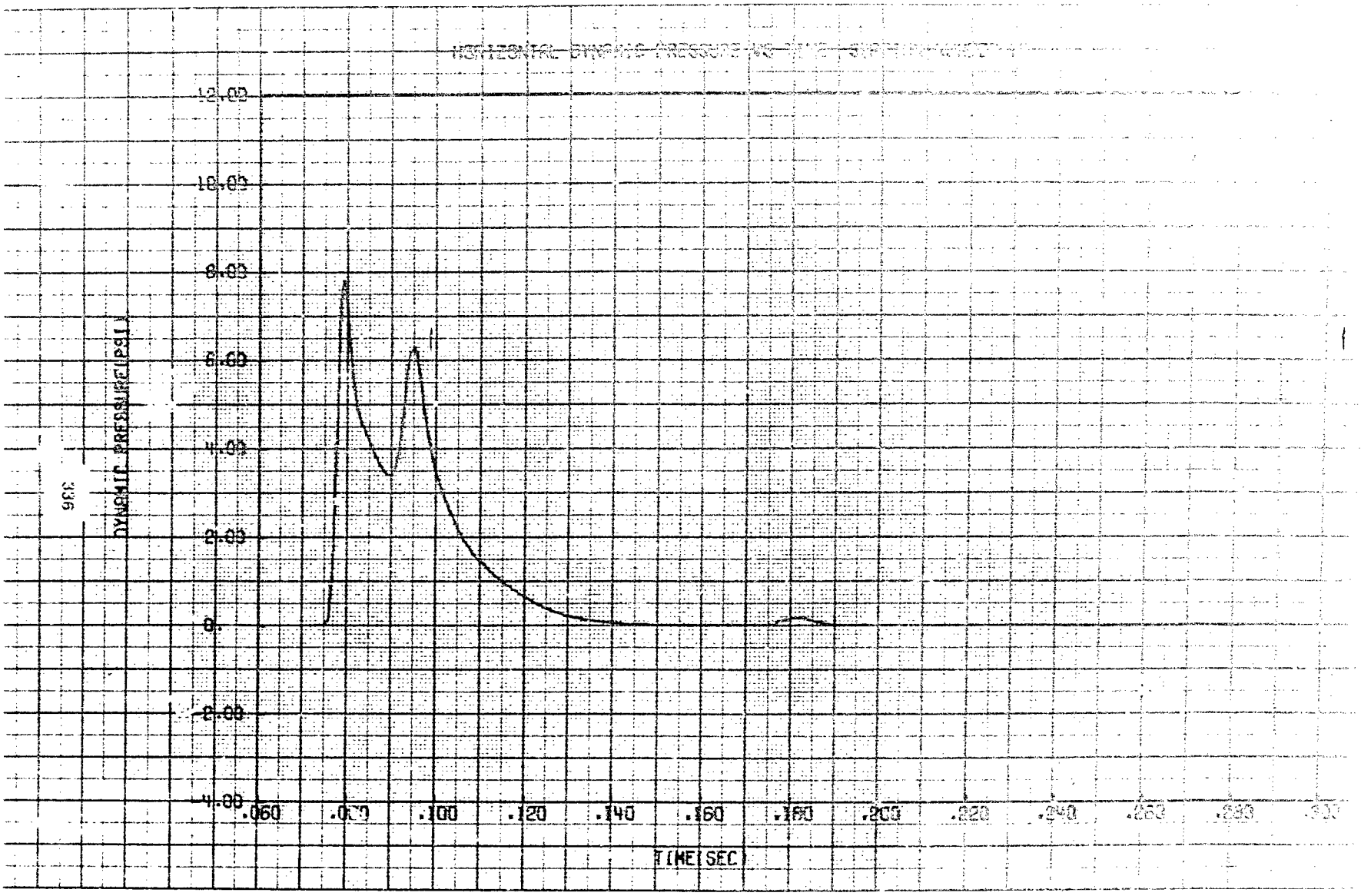

OVER PRESSURE VS TIME STATION NO 2 SEP 17
24.00
20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
OVER-PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

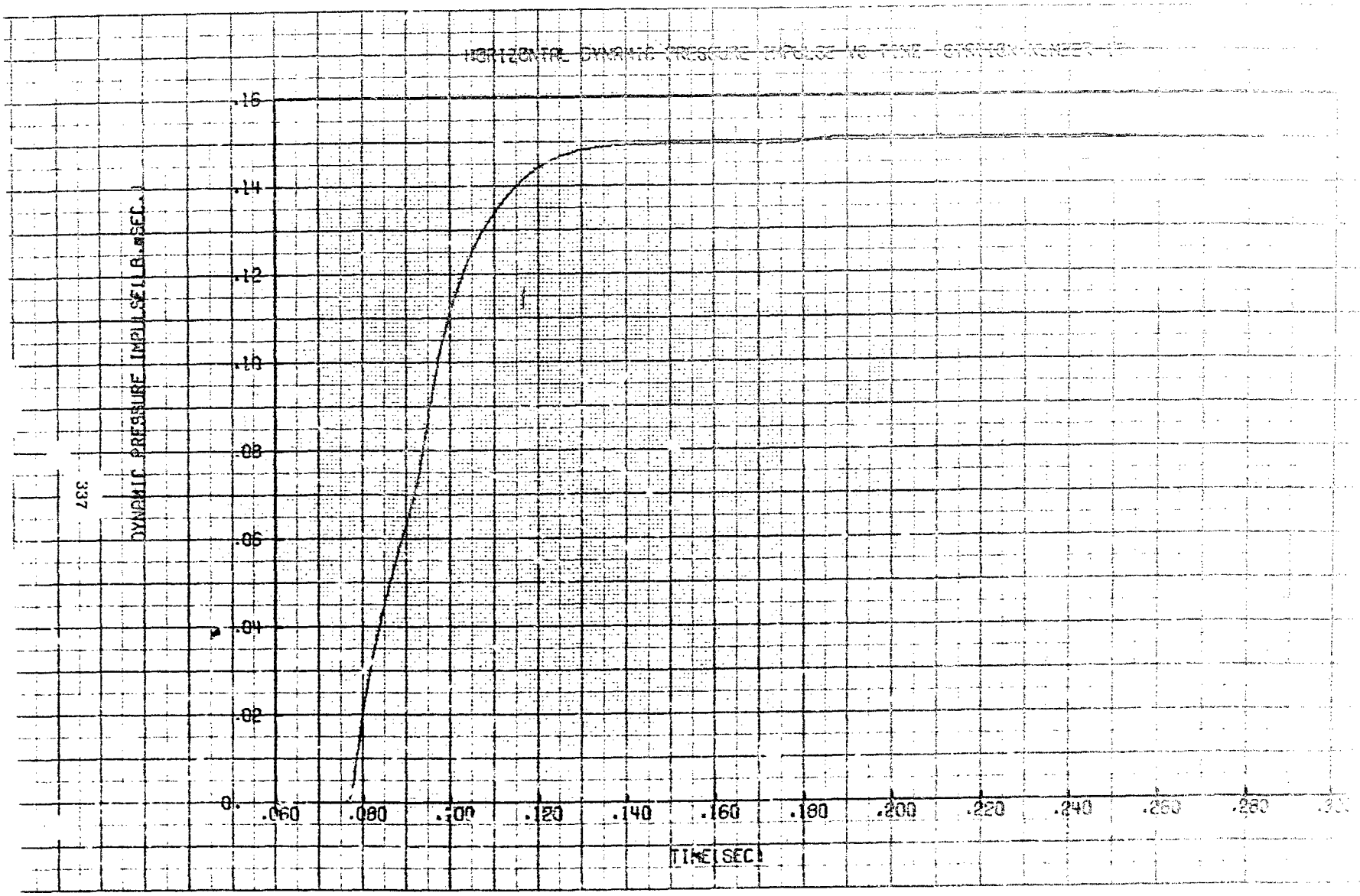

HORIZONTAL COMPONENT VELOCITY VS TIME STATION NUMBER 17
1200.00
1000.00
800.00
600.00
400.00
200.00
0.
-200.00
-400.00
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
FT/SEC

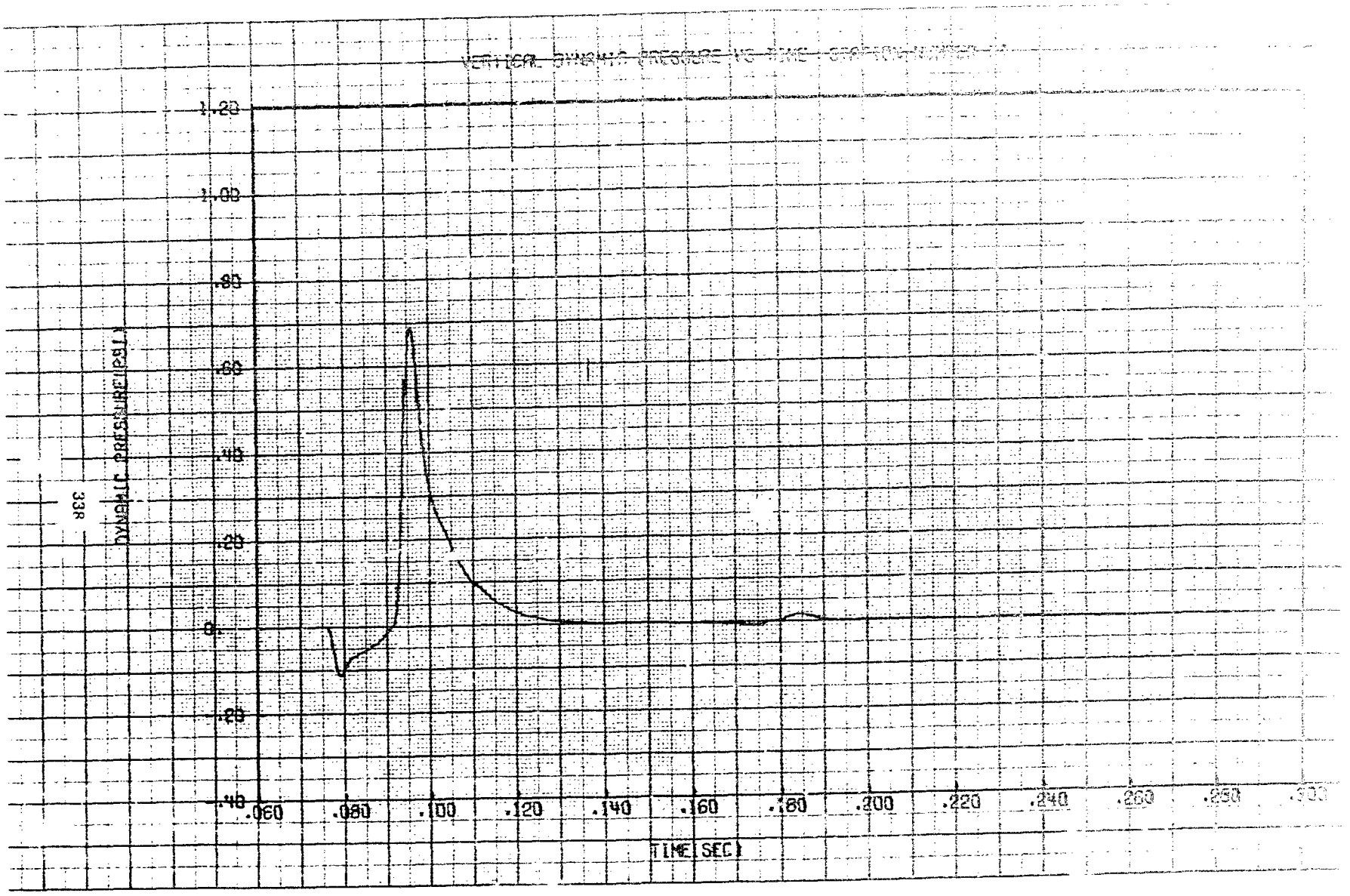
TIME SEC
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.20
.10
0
.10
.20
.30
.40
.50
.60

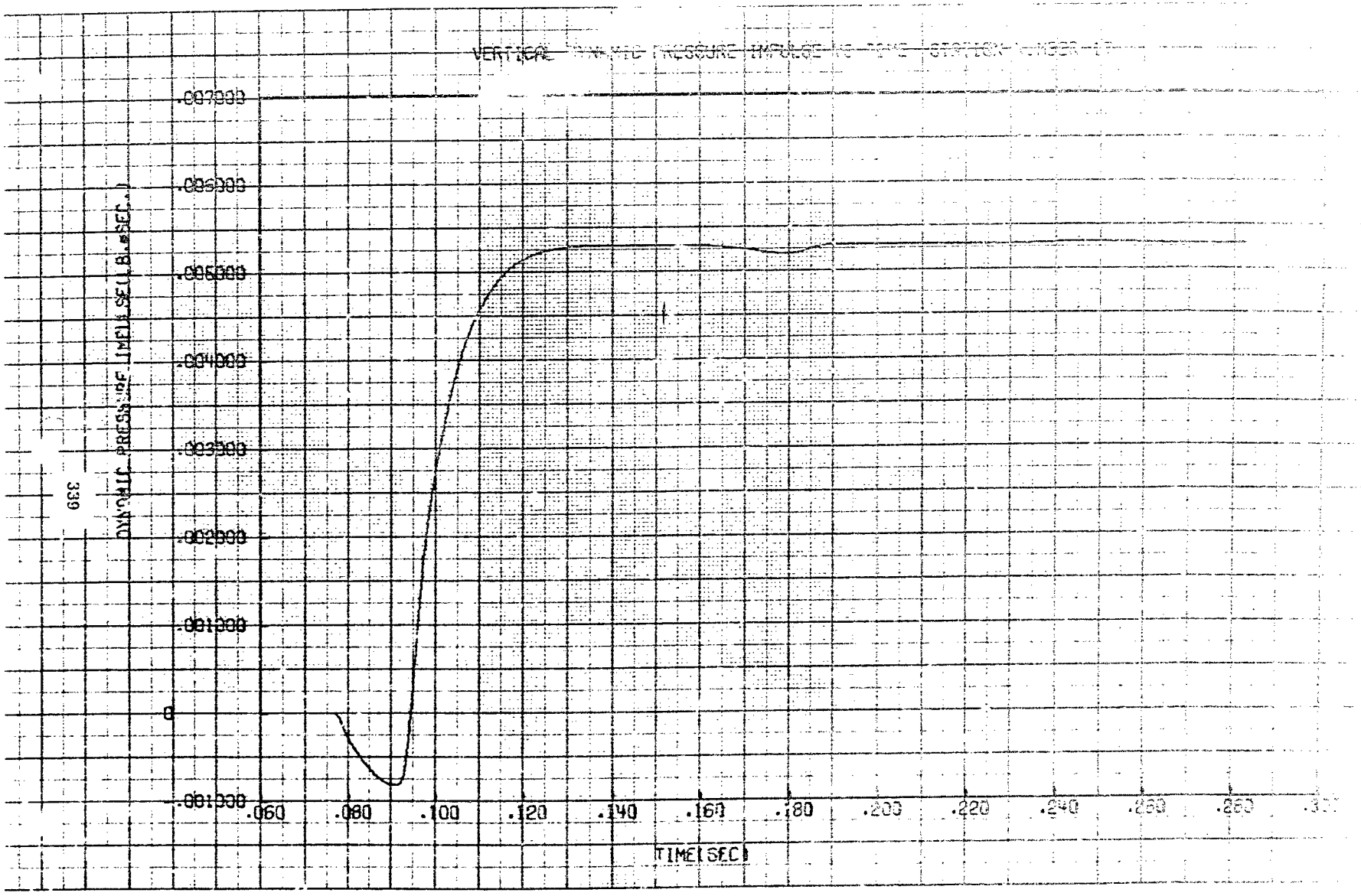
33A

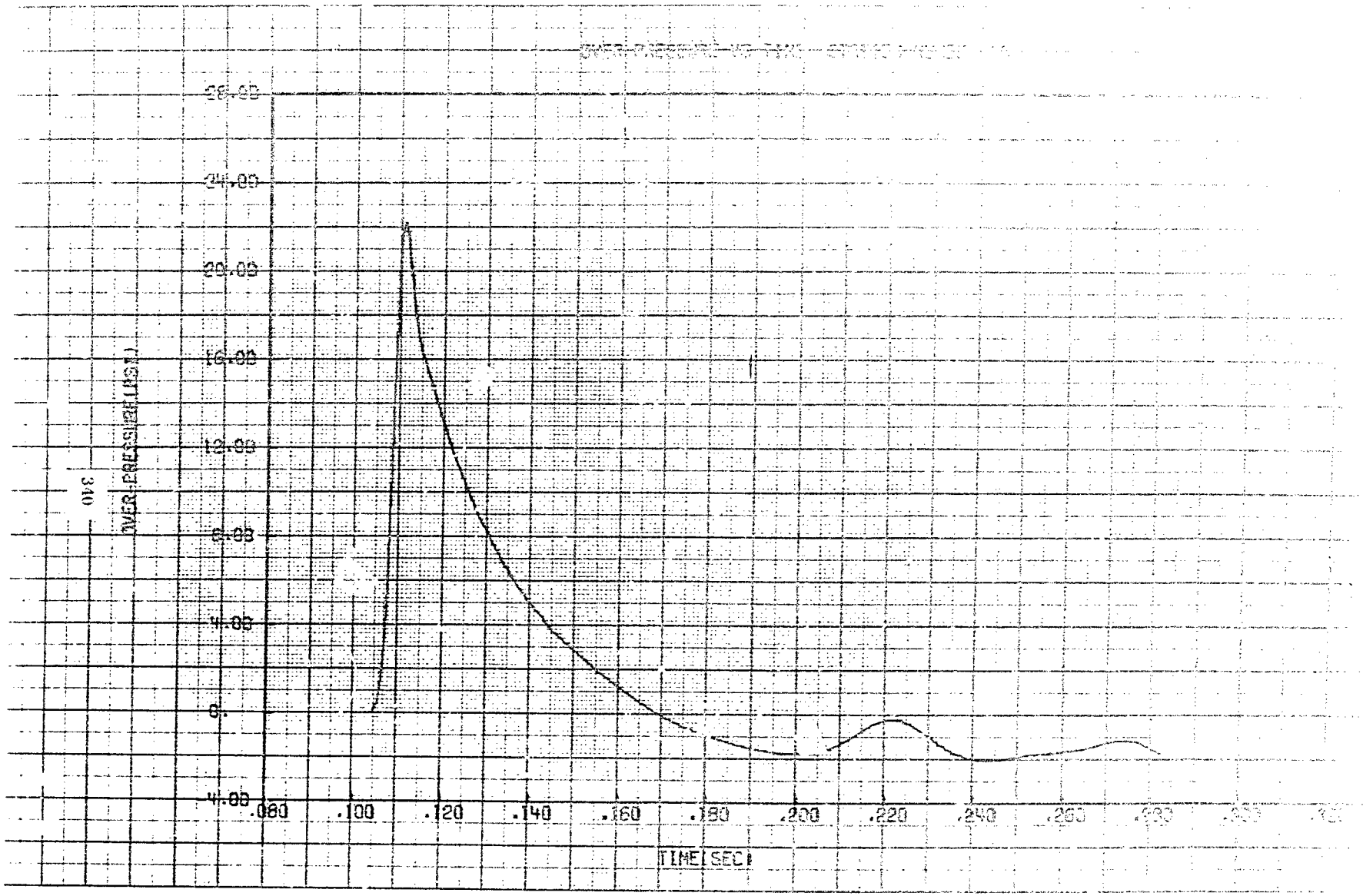

VERTICAL EQUIVALENT VELOCITY VS TIME
500.00
400.00
300.00
200.00
100.00
0.
-100.00
-200.00
-300.00
SPEED(FT/SEC)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)

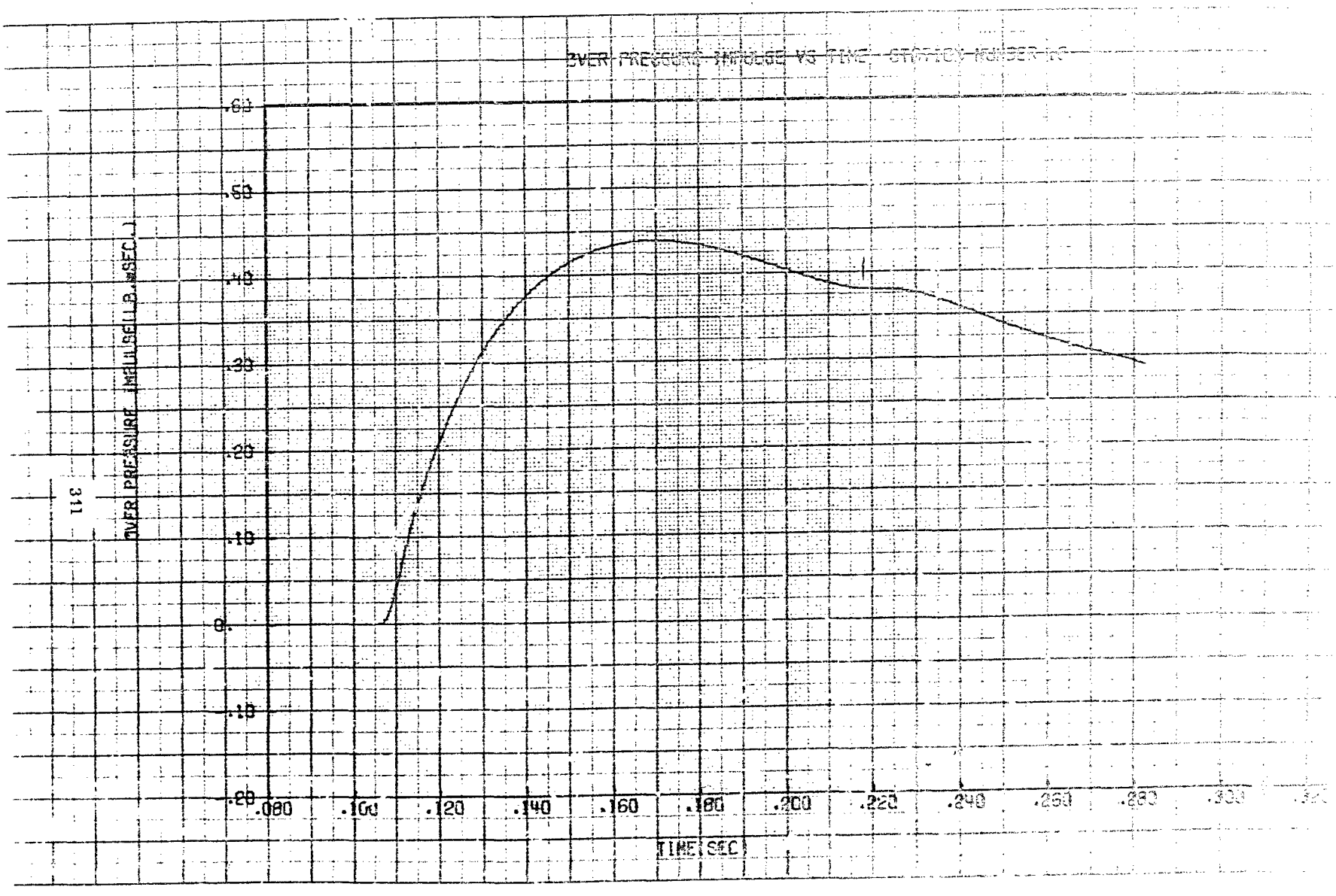

HORIZONTAL DYNAMIC PRESSURE VS TIME
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
-4.00
DYNAMIC PRESSURE(PSI)
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME - STATION NUMBER 1
DYNAMIC PRESSURE IMPULSE(LB.*SEC.)
.16
.14
.12
.10
.08
.06
.04
.02
0.
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)


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


VERTICAL
.007000
.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
.060
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
TIME(SEC)


28.0B
24.0B
20.0B
16.0B
12.0B
8.0B
4.0B
0.
-4.0B
OVER PRESSURE (LBS/I)
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME(SEC)


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

TIME (SEC)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
0.
200.03
400.03
600.03
800.03
1000.03
1200.03
1400.03
1600.03
1800.03
2000.03
2200.03
2400.03
2600.03
2800.03
3000.03
3200.03
3400.03
3600.03
3800.03
4000.03
4200.03
4400.03
4600.03
4800.03
5000.03
5200.03
5400.03
5600.03
5800.03
6000.03
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7600.03
7800.03
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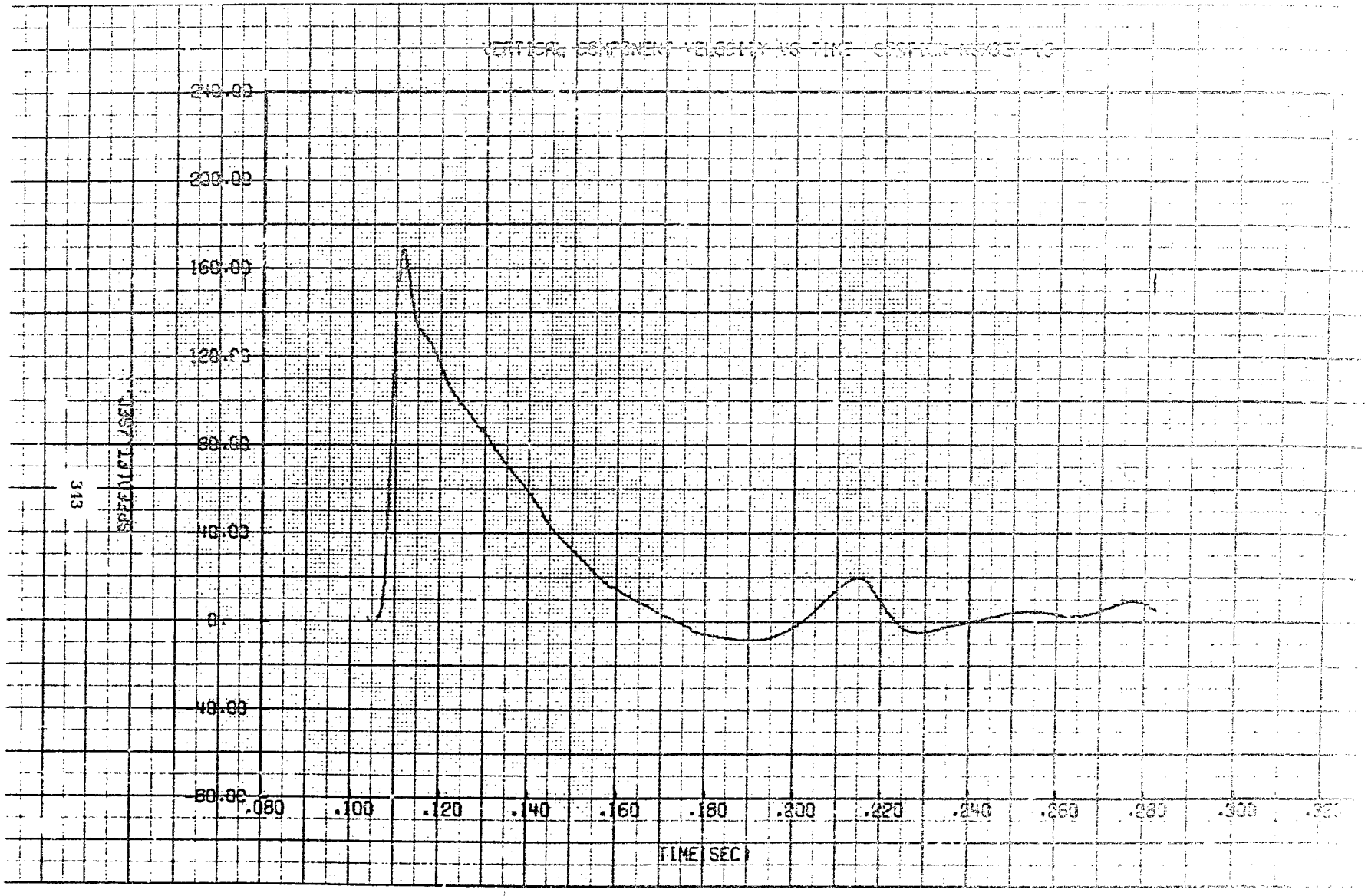
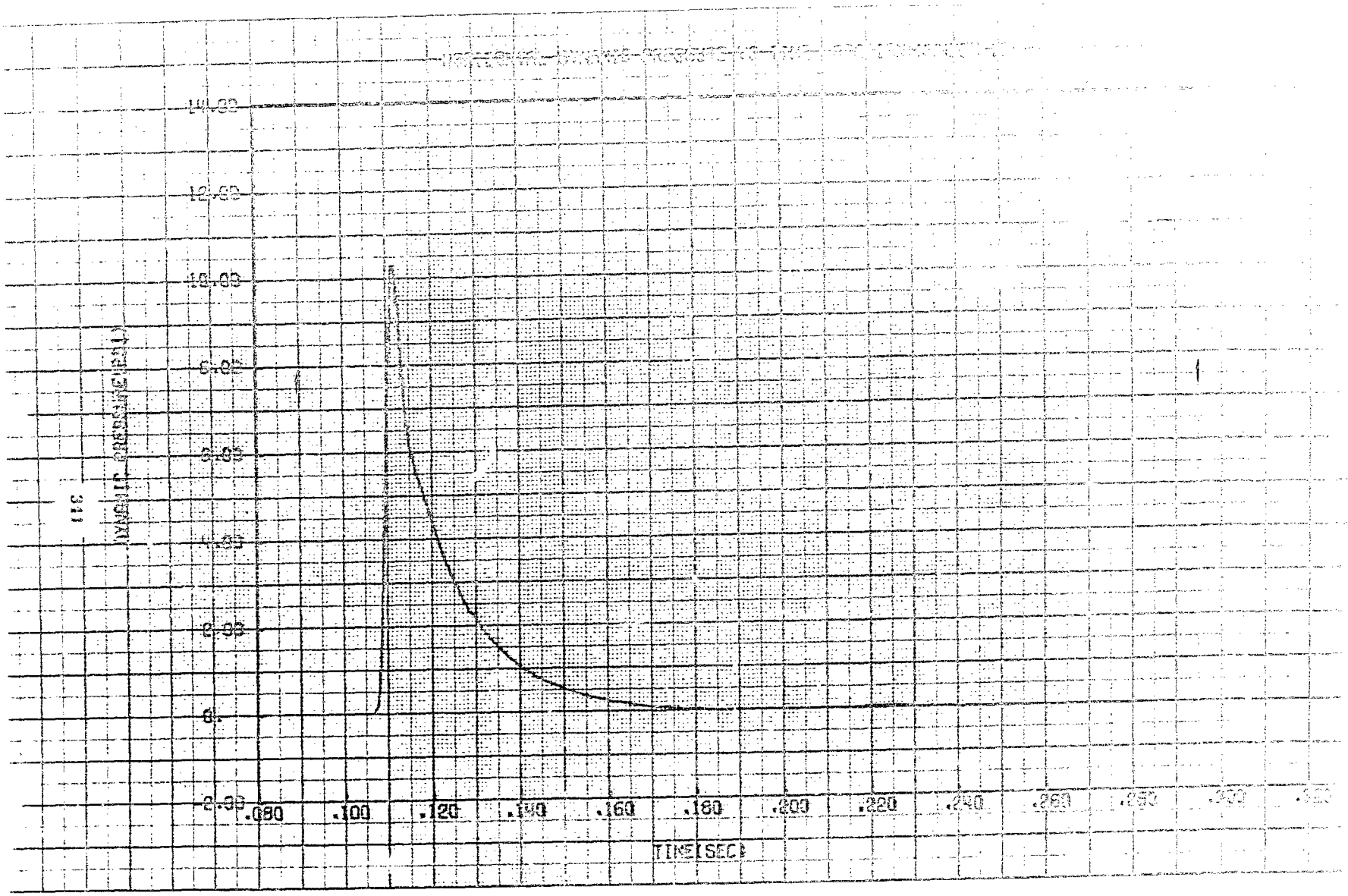
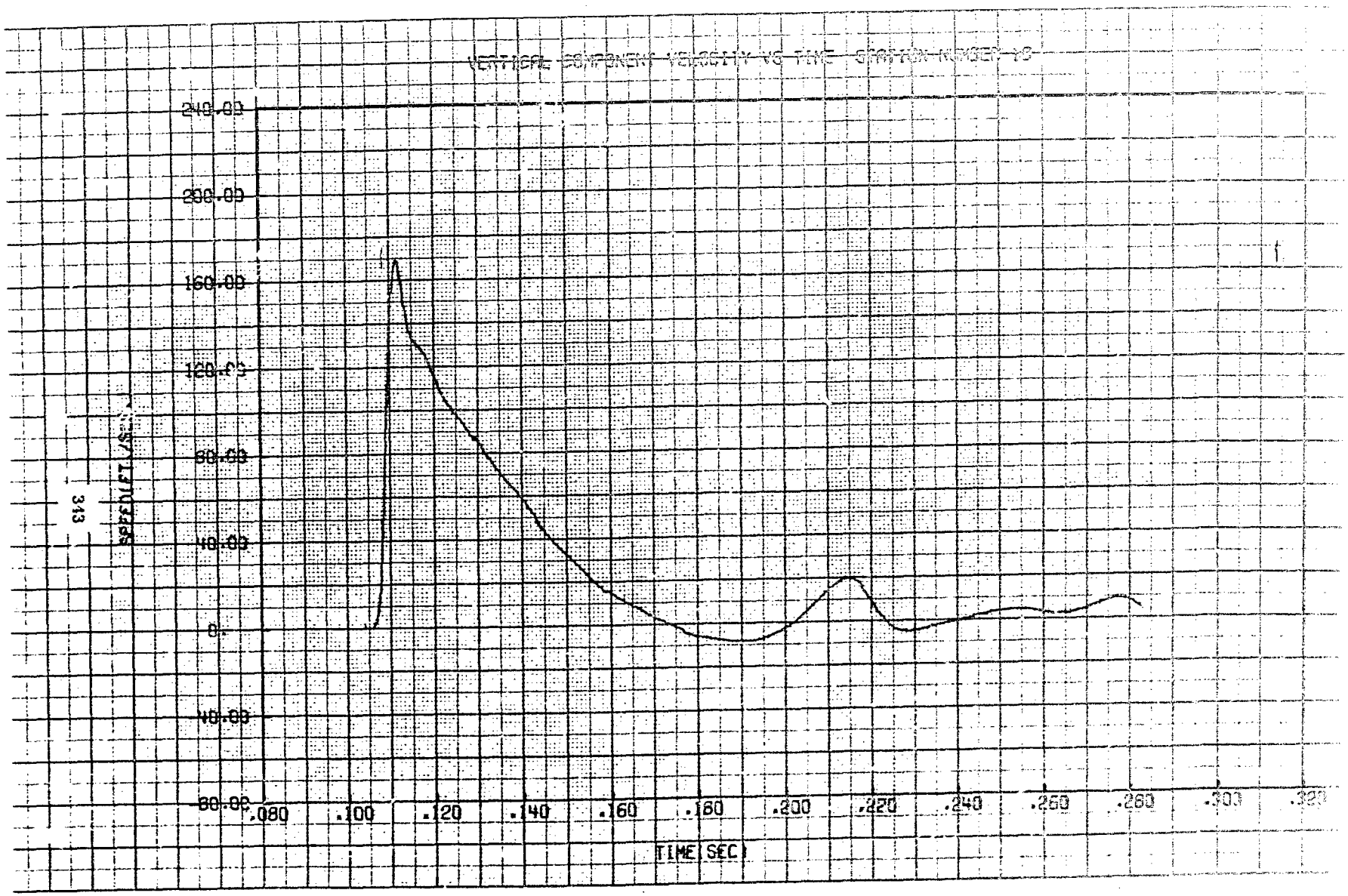
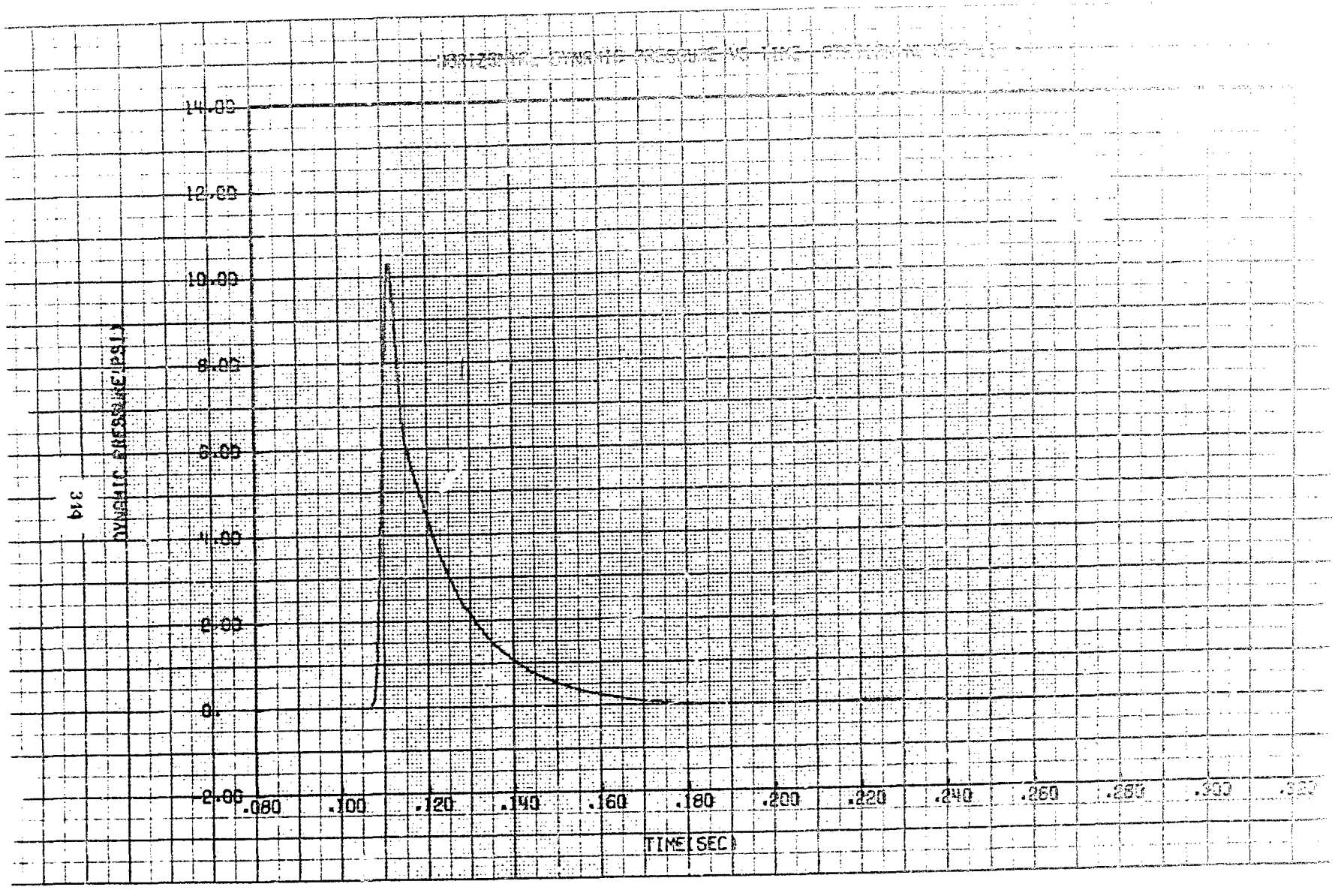
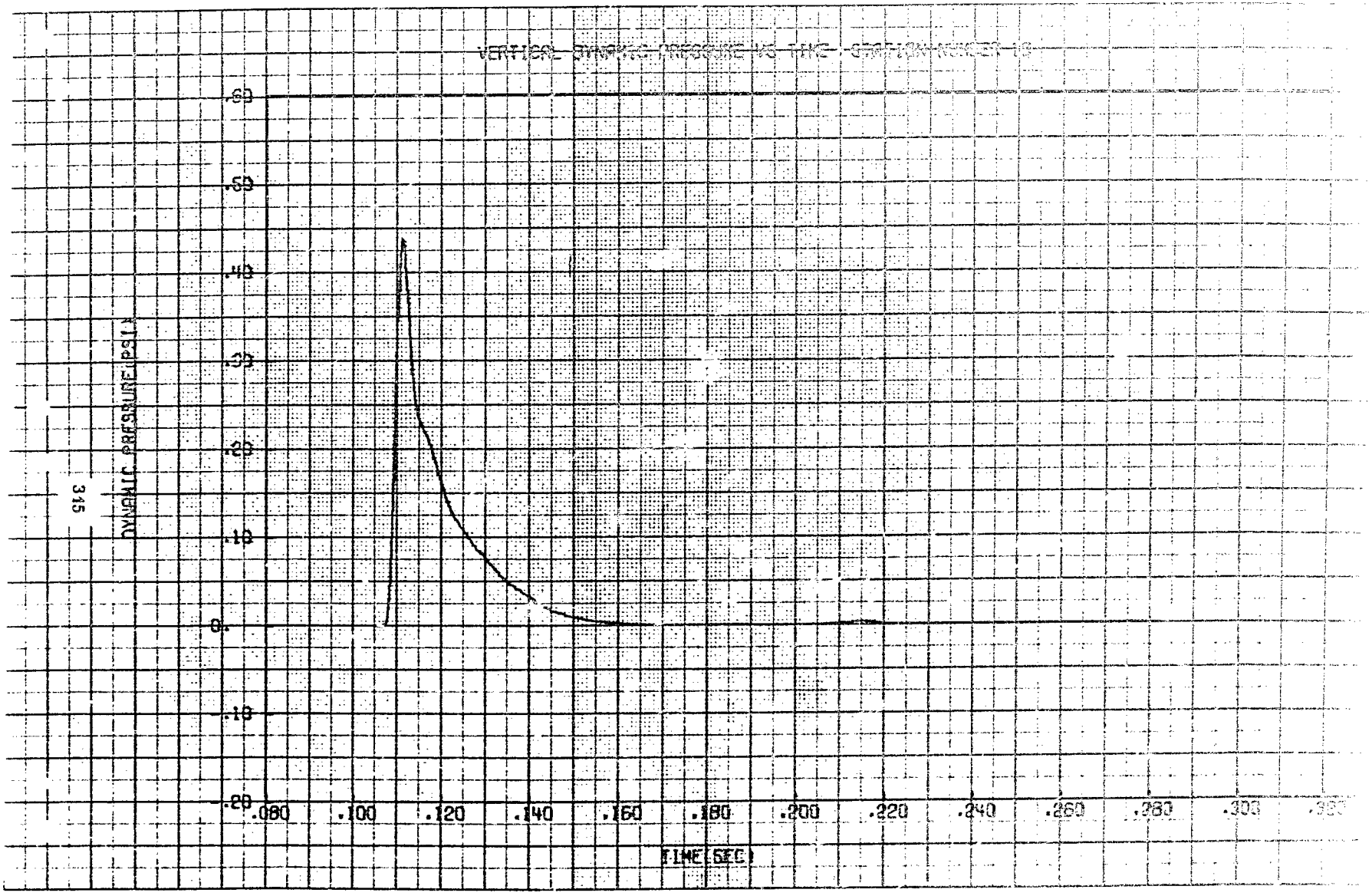
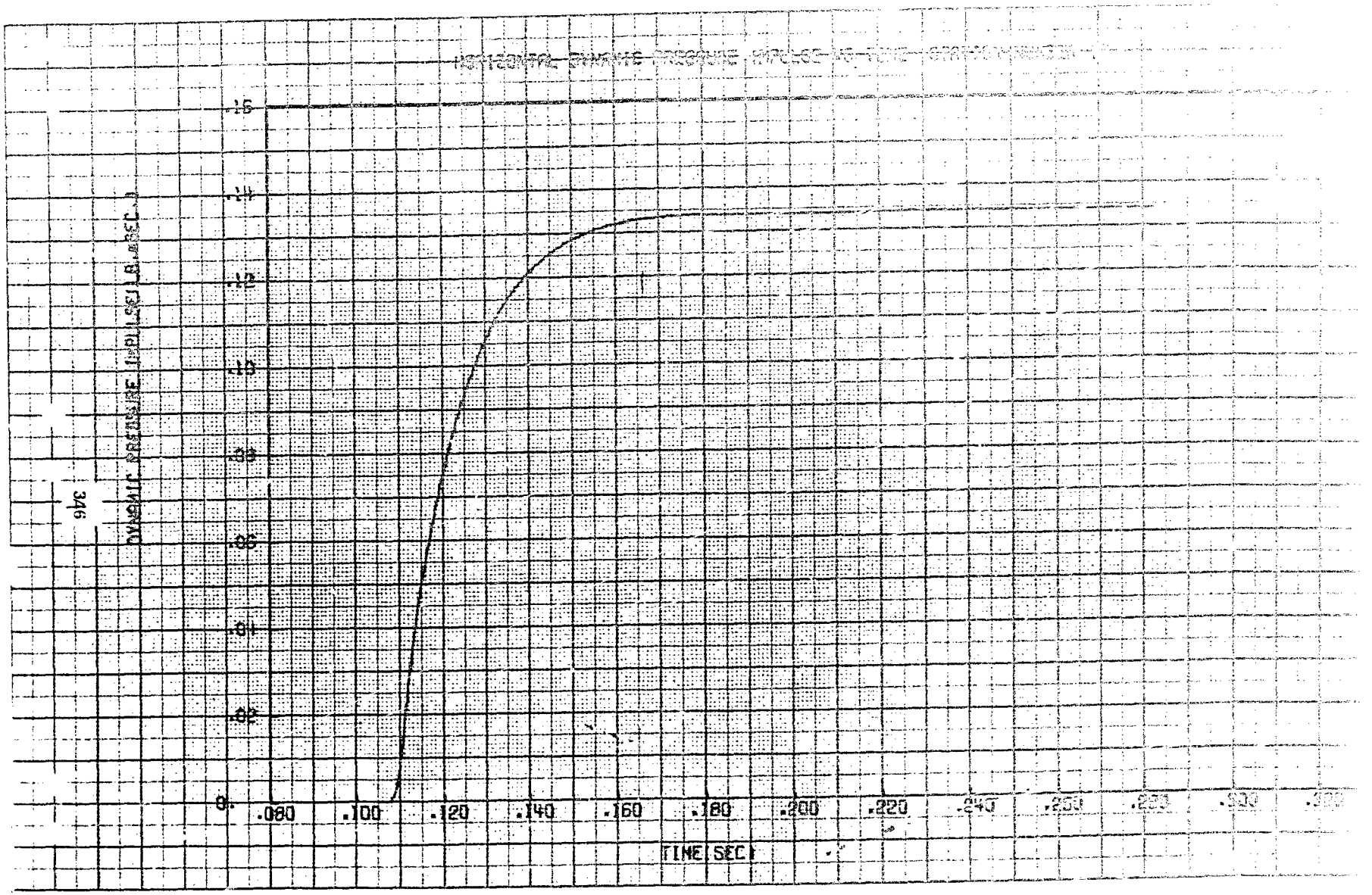

VERTICAL COMPONENT VELOCITY VS TIME (FROM MOVED TO
240.00
200.00
160.00
120.00
80.00
40.00
0.
40.00
80.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

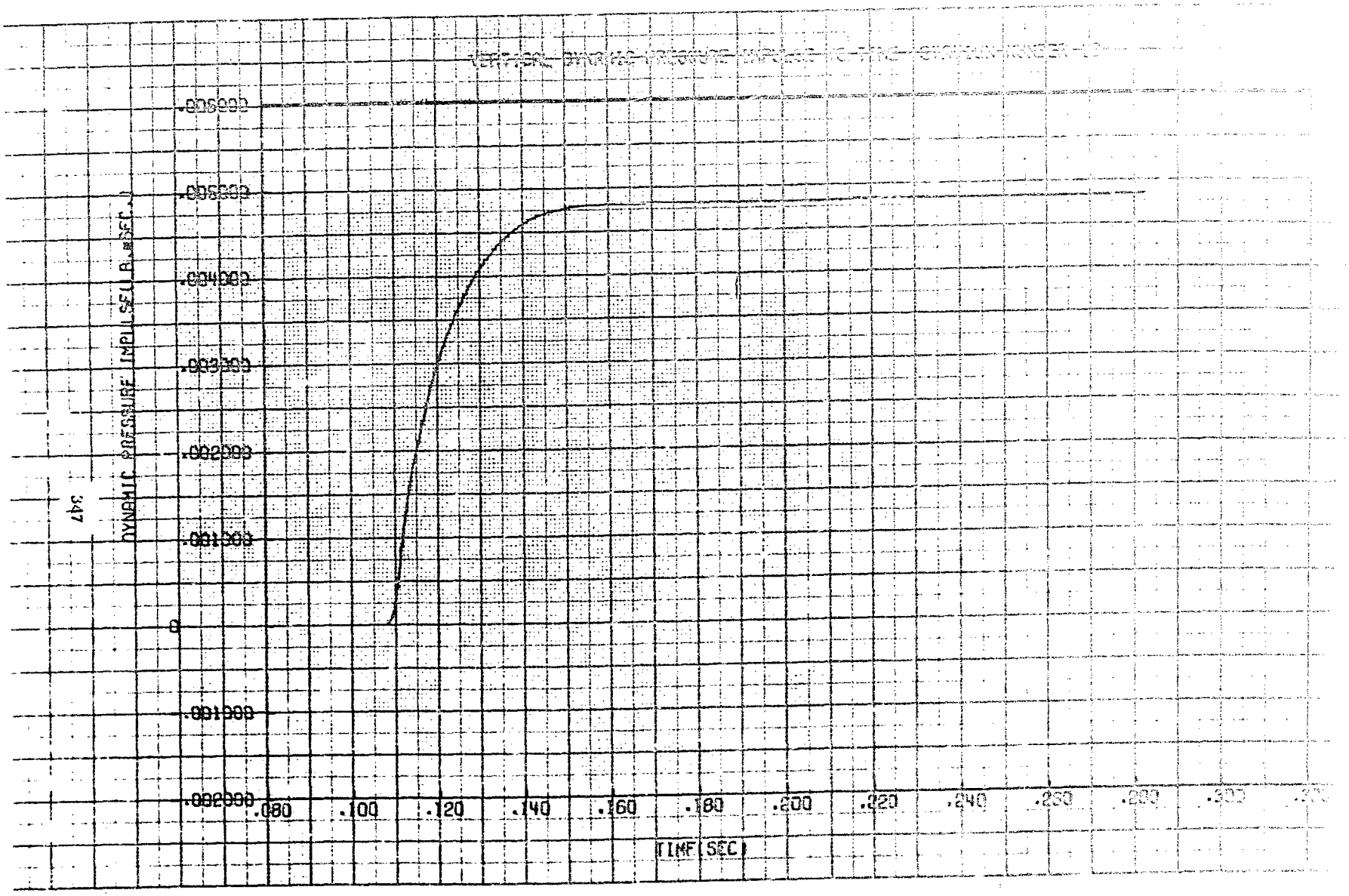

14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME(SEC)

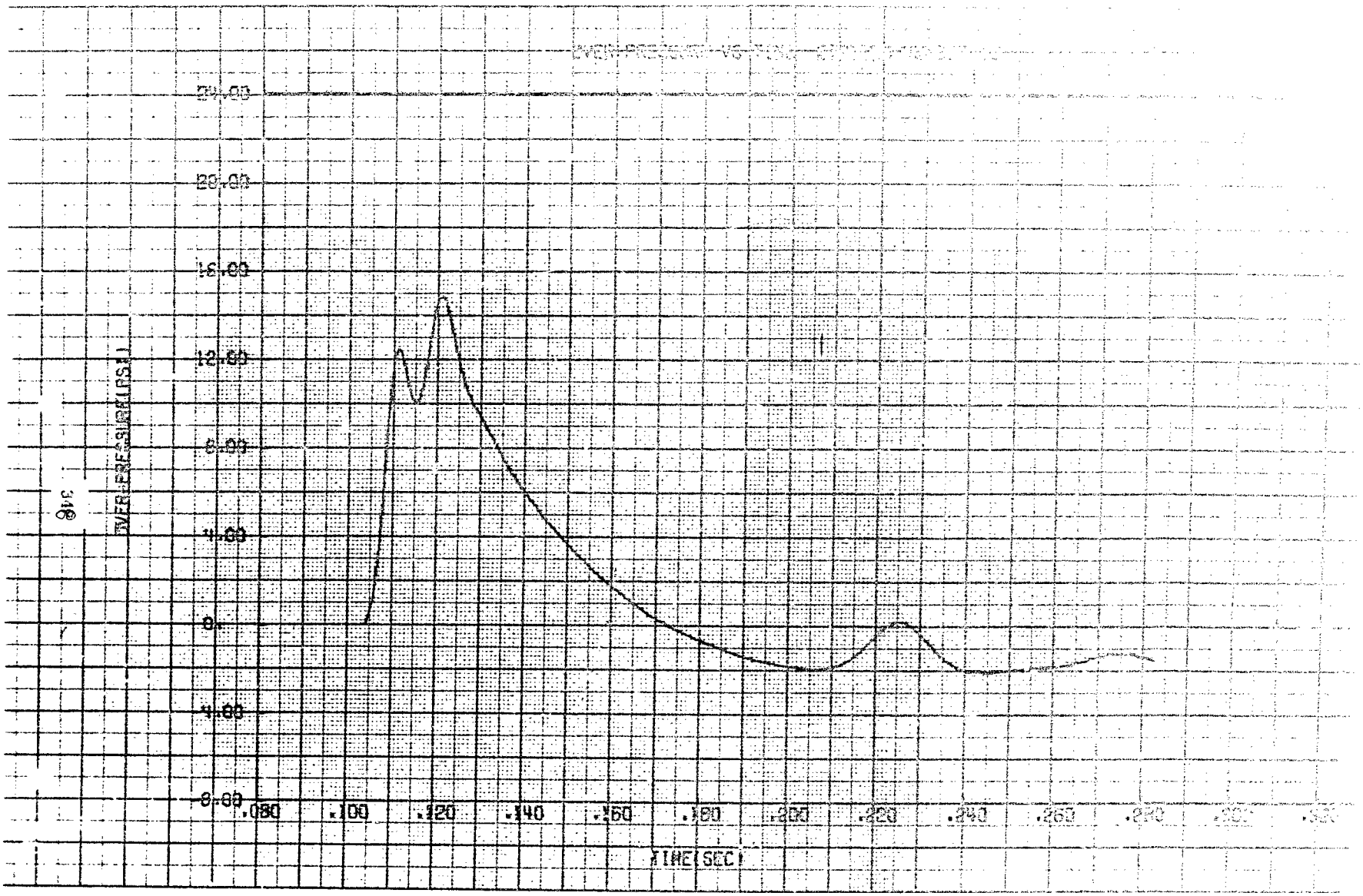

VERTICAL COMPONENT VELOCITY VS TIME STATION NUMBER 10
240.00
200.00
160.00
120.00
80.00
40.00
0.
-40.00
-80.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME (SEC)
VELOCITY (CM/SEC)

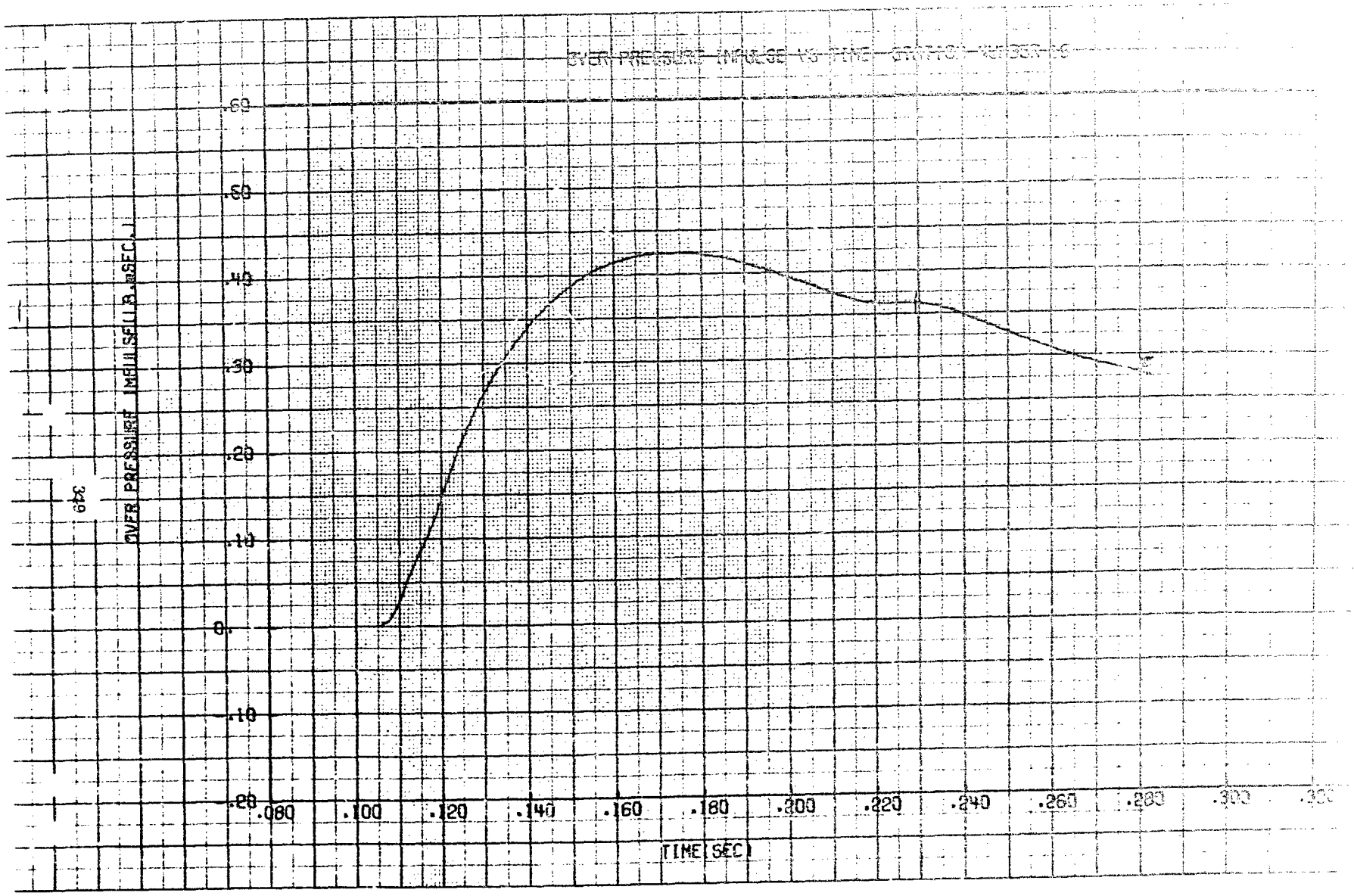

14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.
-2.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)
DYNAMIC PRESSURE(PSI)

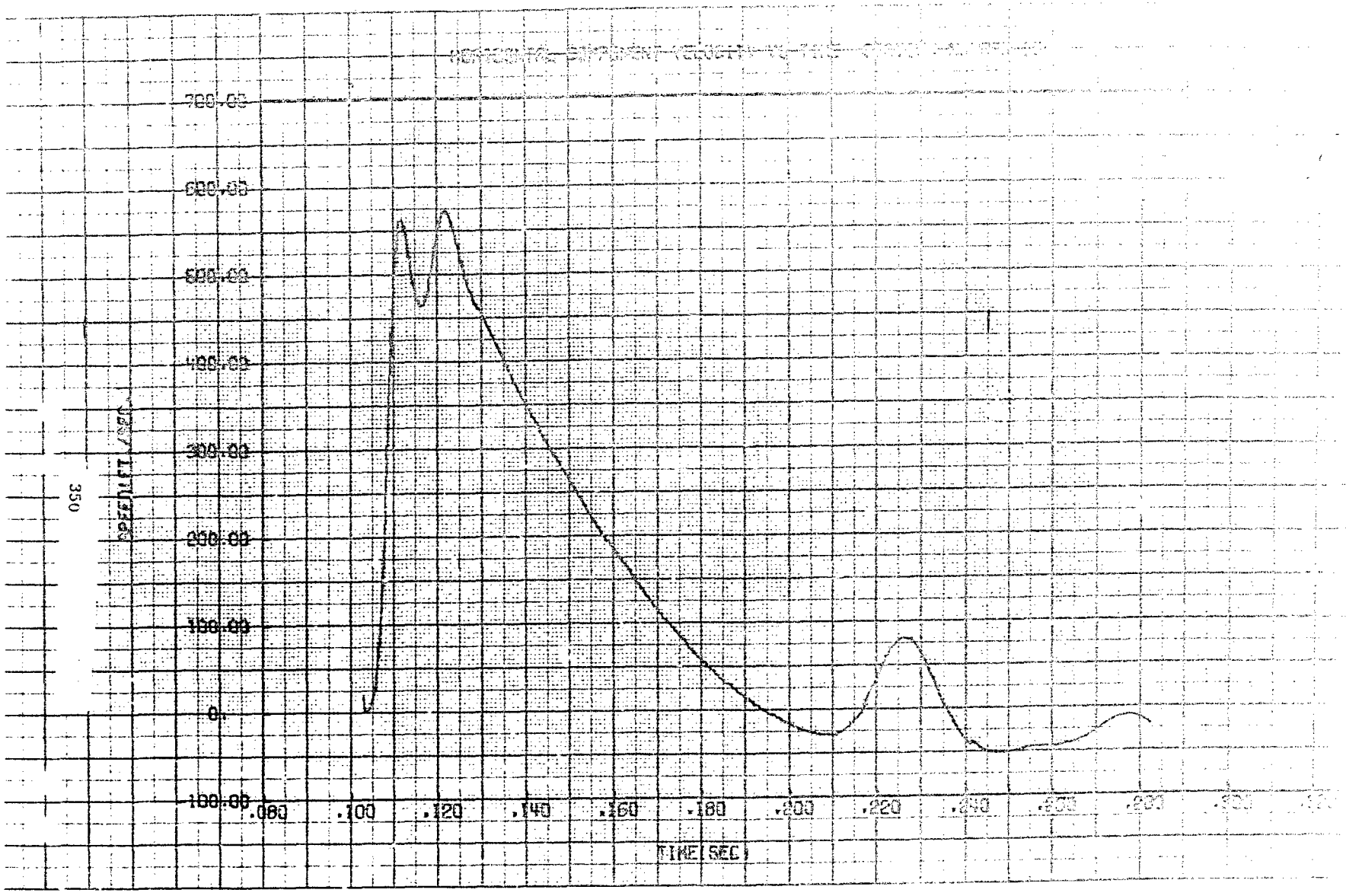

VERTICAL DYNAMIC PRESSURE VS TIME - STATION NUMBER 10
DYNAMIC PRESSURE(PSI)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

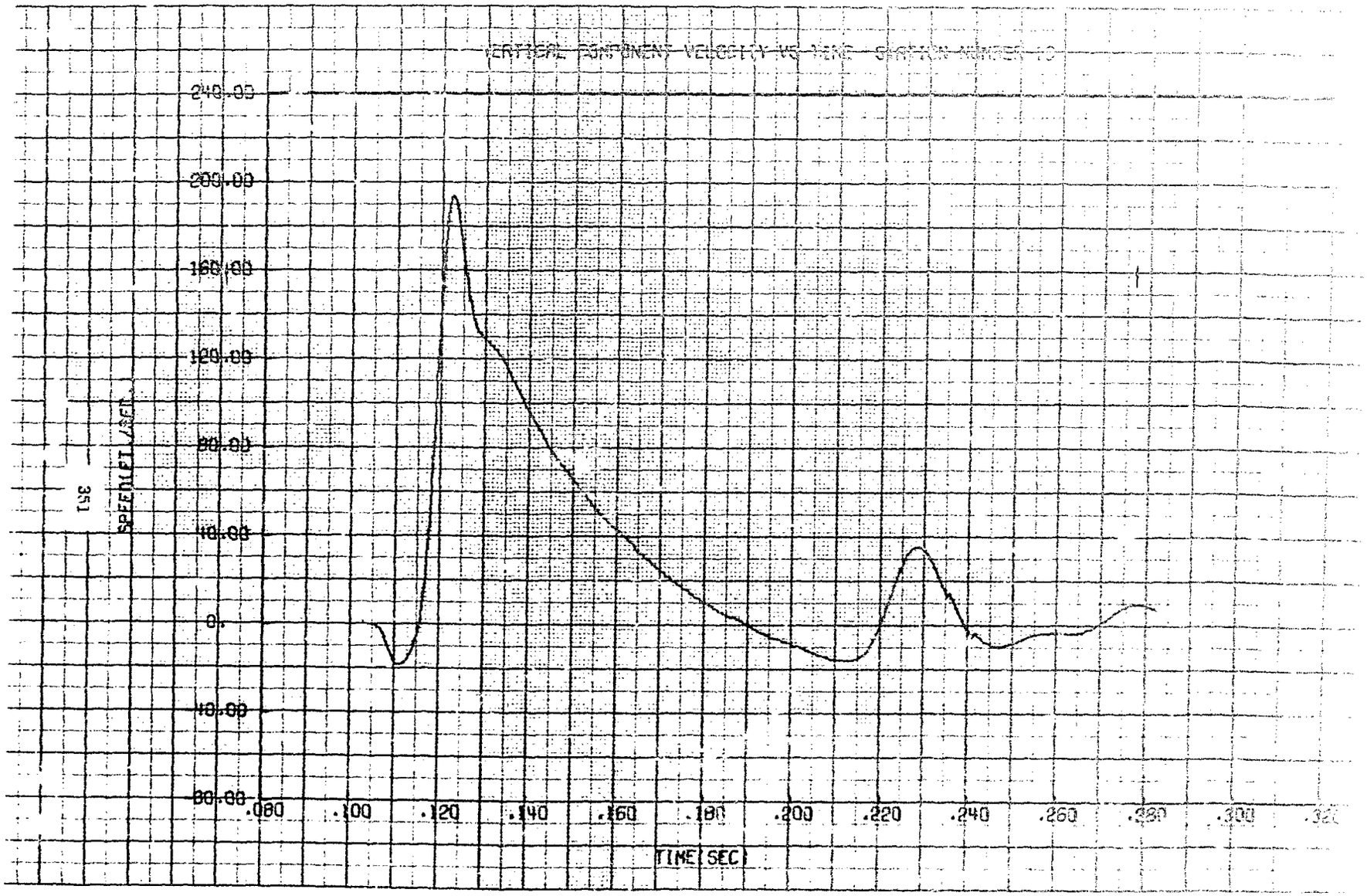

DYNAMIC PRESSURE (PSI)
.16
.14
.12
.10
.08
.06
.04
.02
0
.080
.100
.120
.140
.160
.180
.200
.220
TIME (SEC)

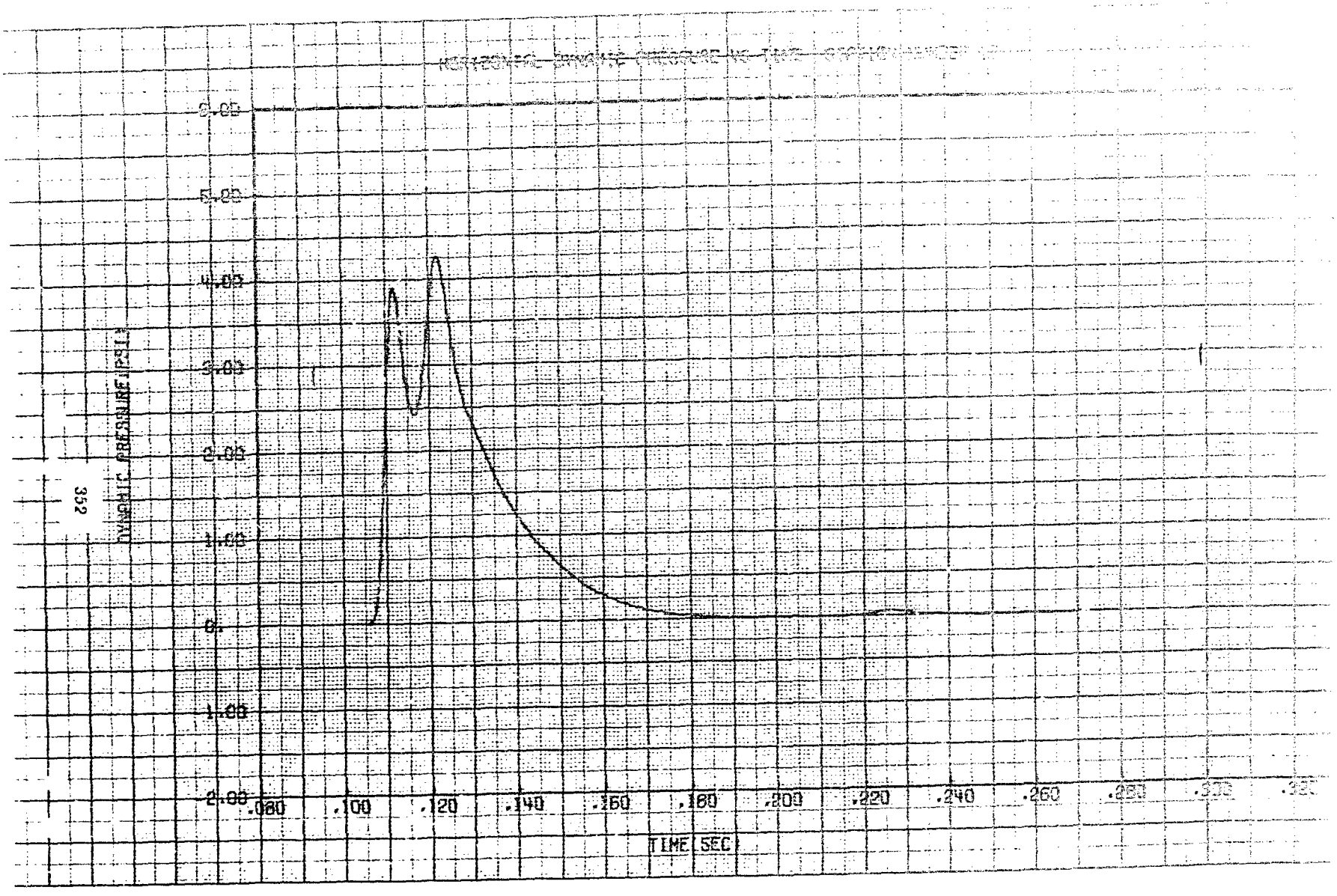

.006000
.005000
.004000
.003000
.002000
.001000
0
-.001000
-.002000
DYNAMIC PRESSURE IMPULSE(LB/SEC)
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)

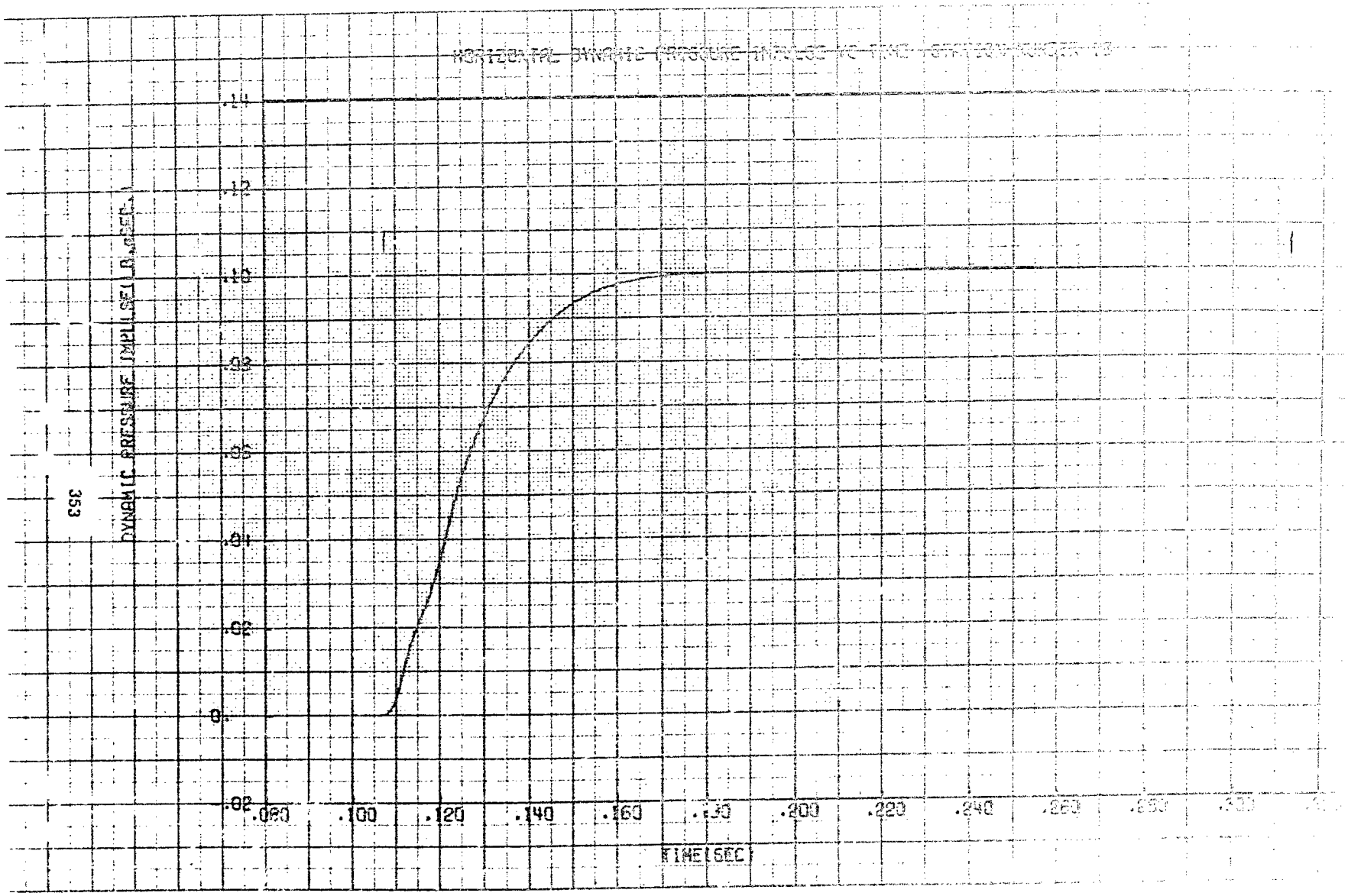

20.00
16.00
12.00
8.00
4.00
0.
-4.00
-8.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
OVER PRESSURE (PSI)
TIME (SEC)

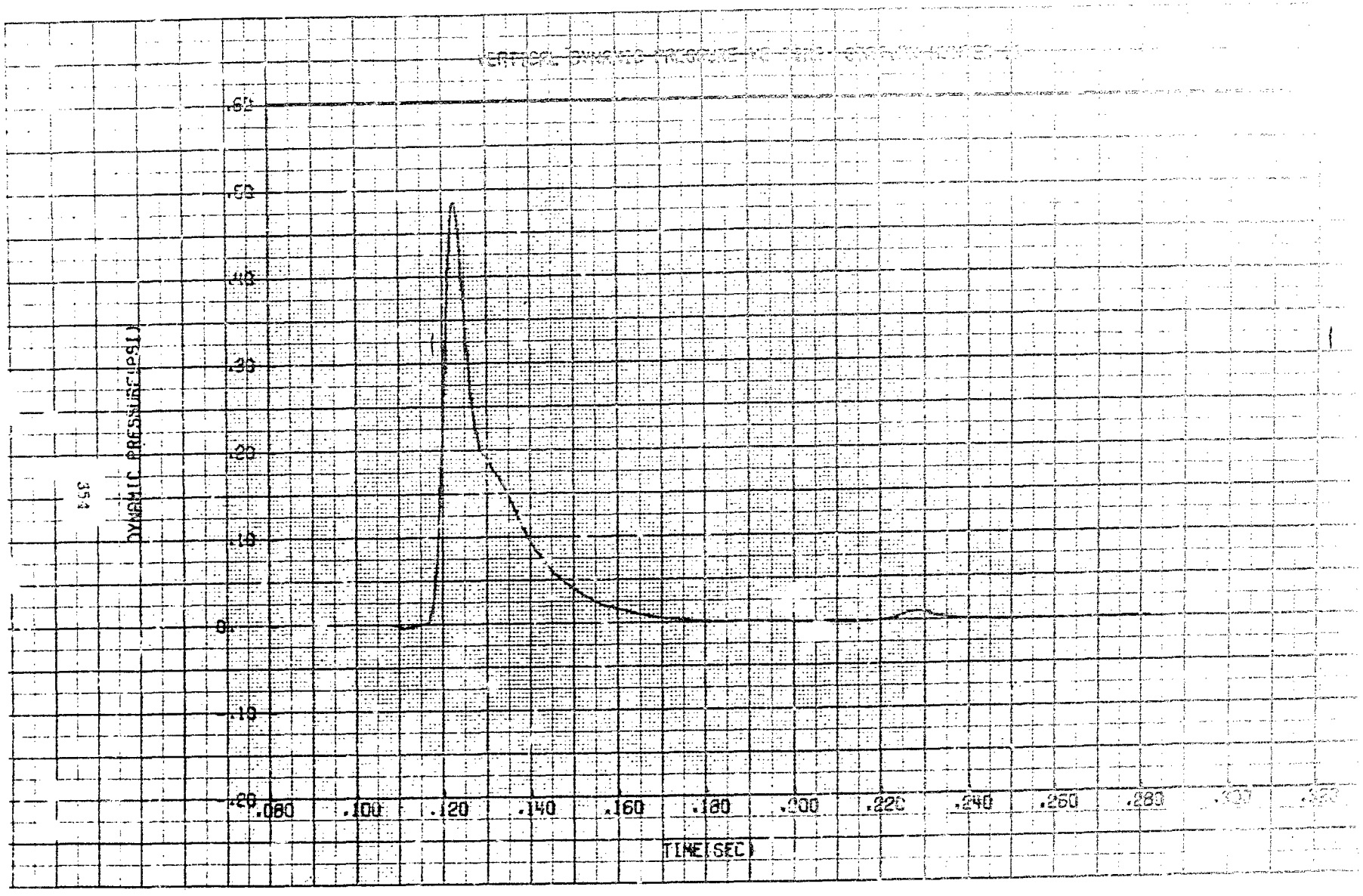

OVER PRESSURE IMPULSE VS TIME
OVER PRESSURE IMPULSE(LB.-MSEC.)
.60
.50
.40
.30
.20
.10
0.
-.10
-.20
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
.320
TIME(SEC)

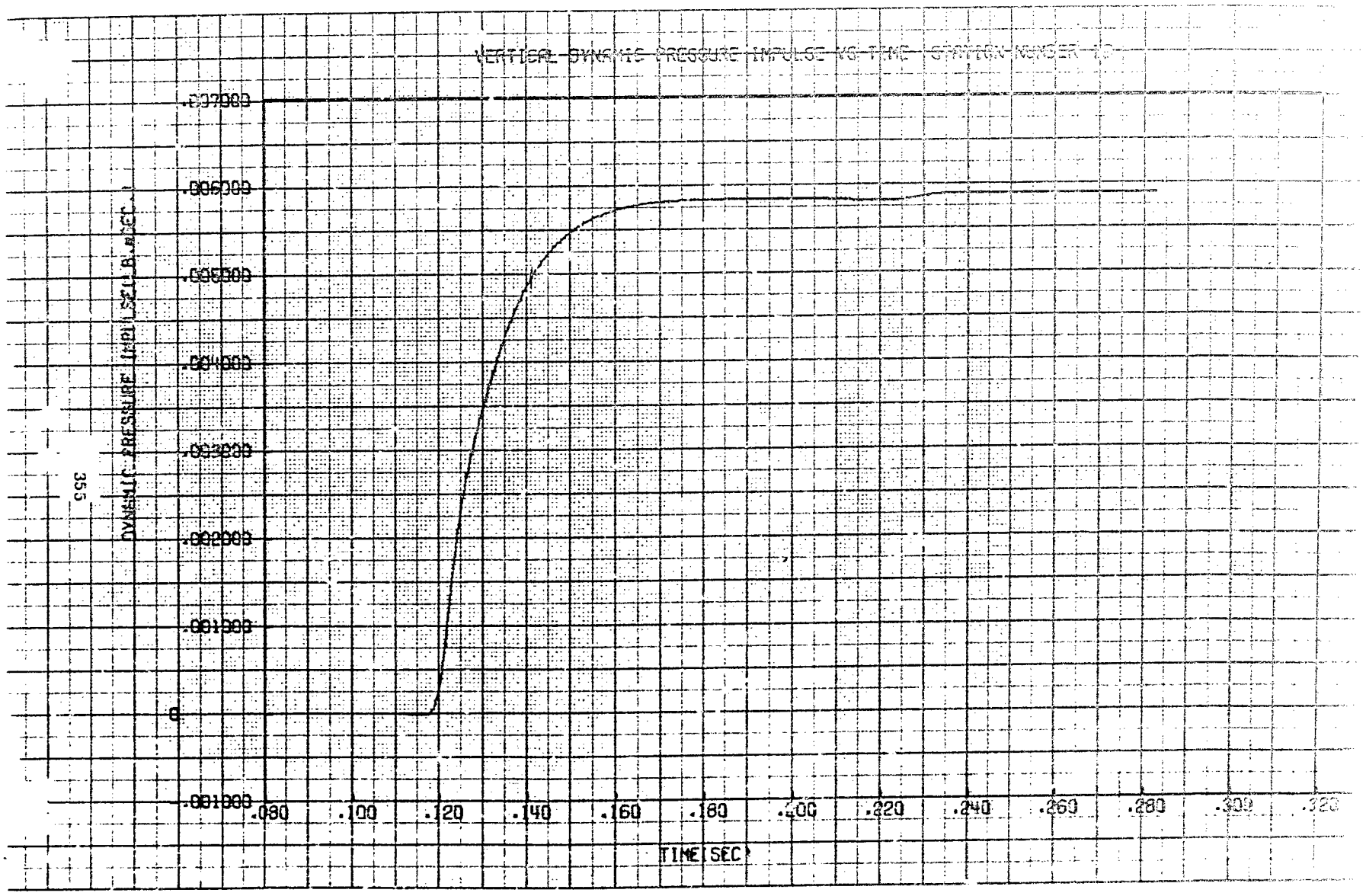

700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.
-100.00
.080
.100
.120
.140
.160
.180
.200
.220
.240
TIME(SEC)
SPEED(FT/SEC)


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)
SPEED(FT/SEC)
351


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


HORIZONTAL DYNAMIC PRESSURE IMPULSE VS TIME (STATION NUMBER 13)
DYNAMIC PRESSURE (MILLISEC.)
.14
.12
.10
.08
.06
.04
.02
0.
-.02
.080
.100
.120
.140
.160
.180
.200
.220
.240
.260
.280
.300
TIME(SEC)


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


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

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Kirtland Air Force Base, New Mexico

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2b. GROUP

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5. AUTHOR(S) (Last name, first name, initial)
Whitaker, William A., Capt, USAF; Nawrocki, Edmund A., Capt, USAF; Needham, Charles E.; Troutman, William W.

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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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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

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Security Classification

Unclassified
Security Classification

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

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SUPPLEMENTARY

INFORMATION

AD-803 657

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.

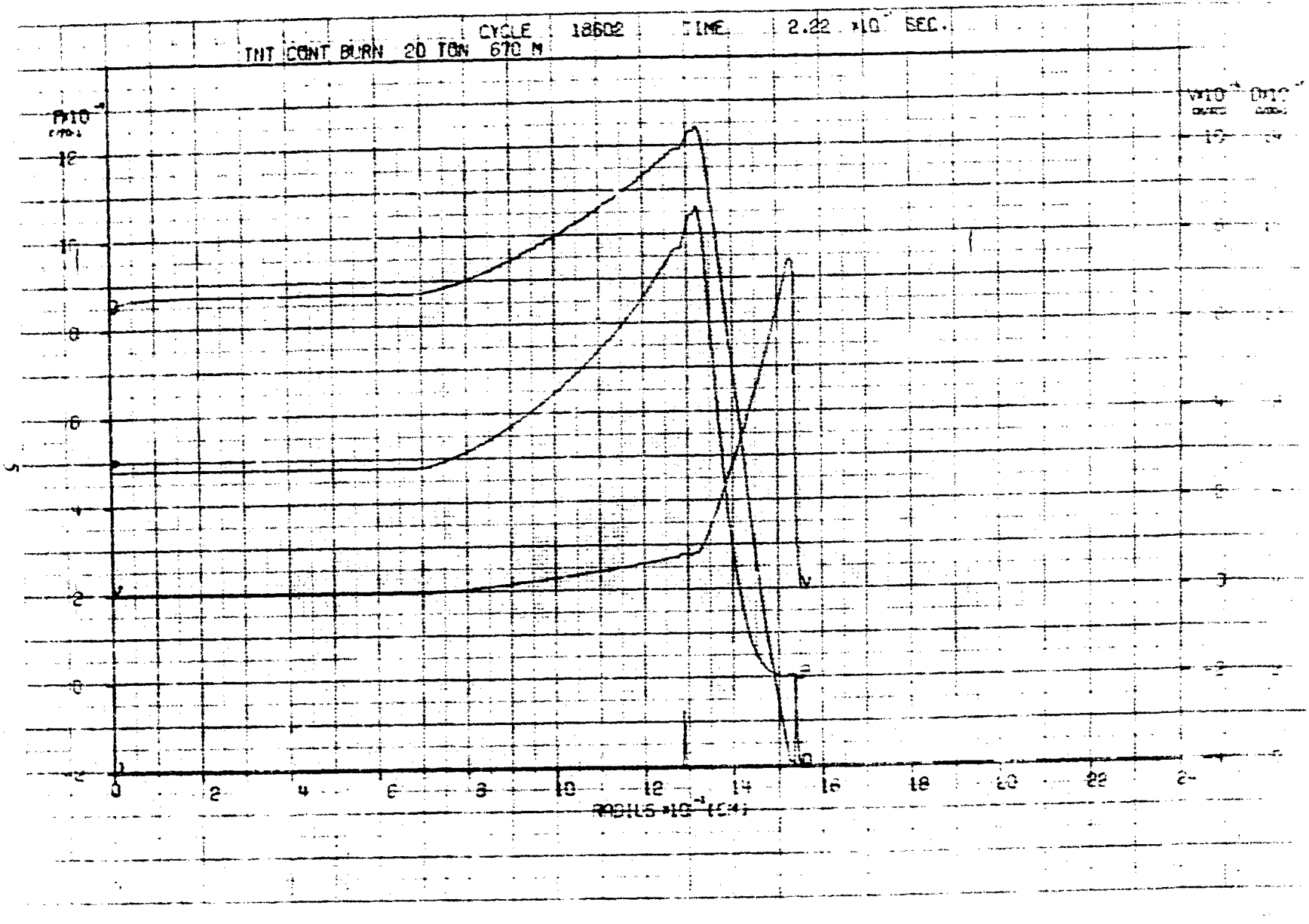
2. The units for the values appearing in the contour scales in Sections II and III are: grams/cm^3 for the density contours and dynes/cm^2 for the pressure contours.

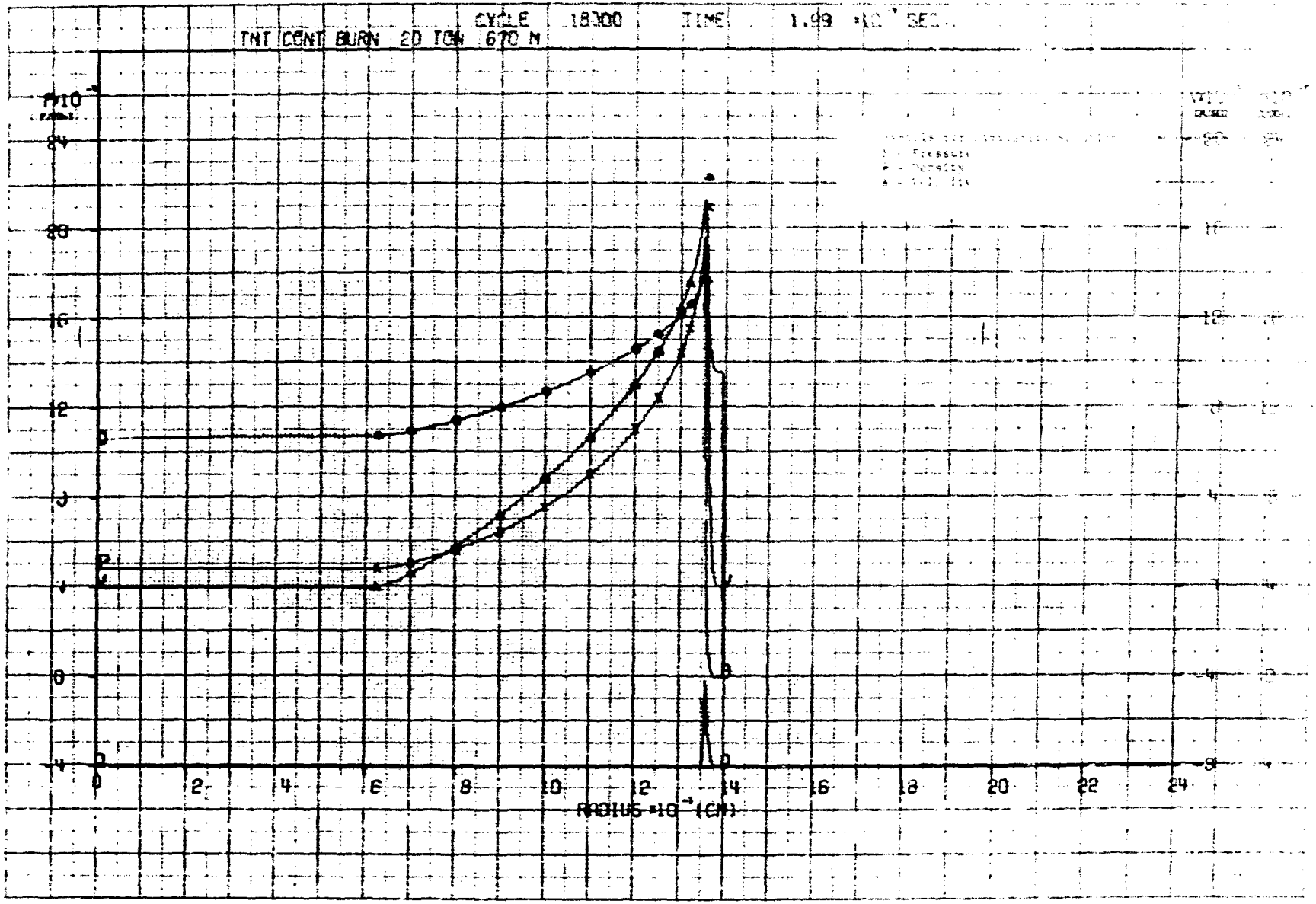
AUTHORITY:

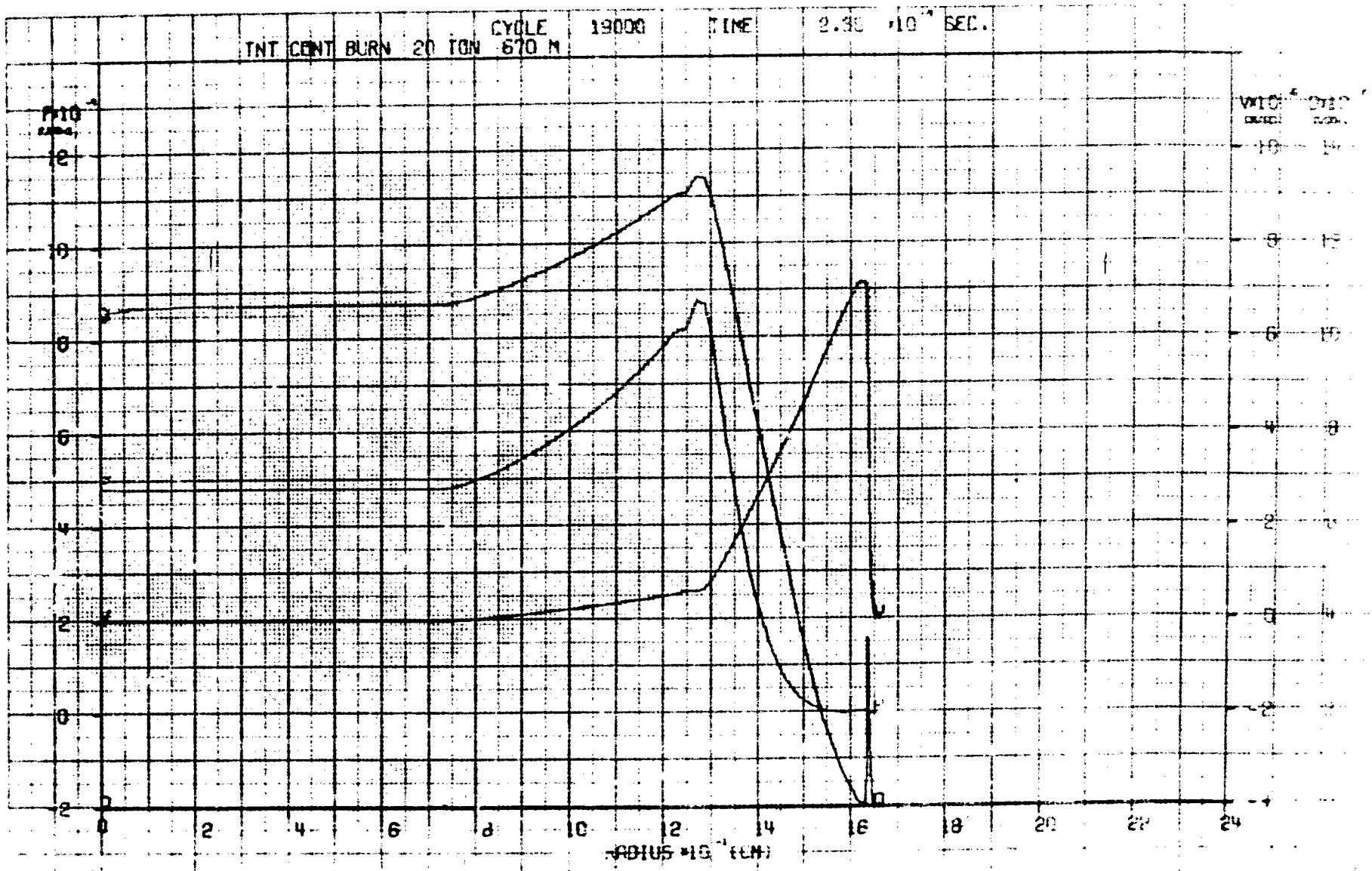
EDWARD A. NAWROCKI
Captain, USAF
4 April 1967

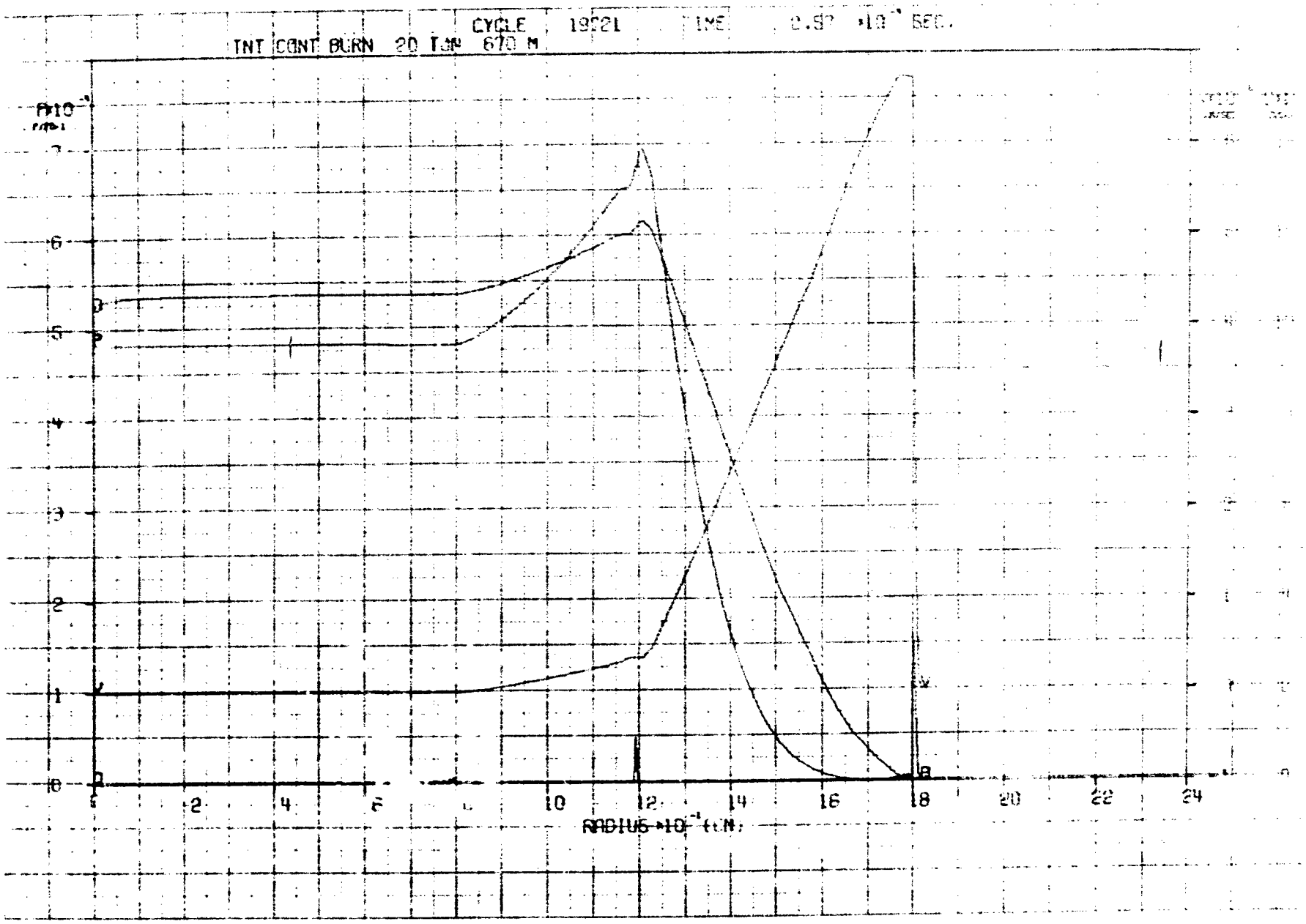
C. W. HAIG
Chief, Reports and Data Branch
Technical Information Division

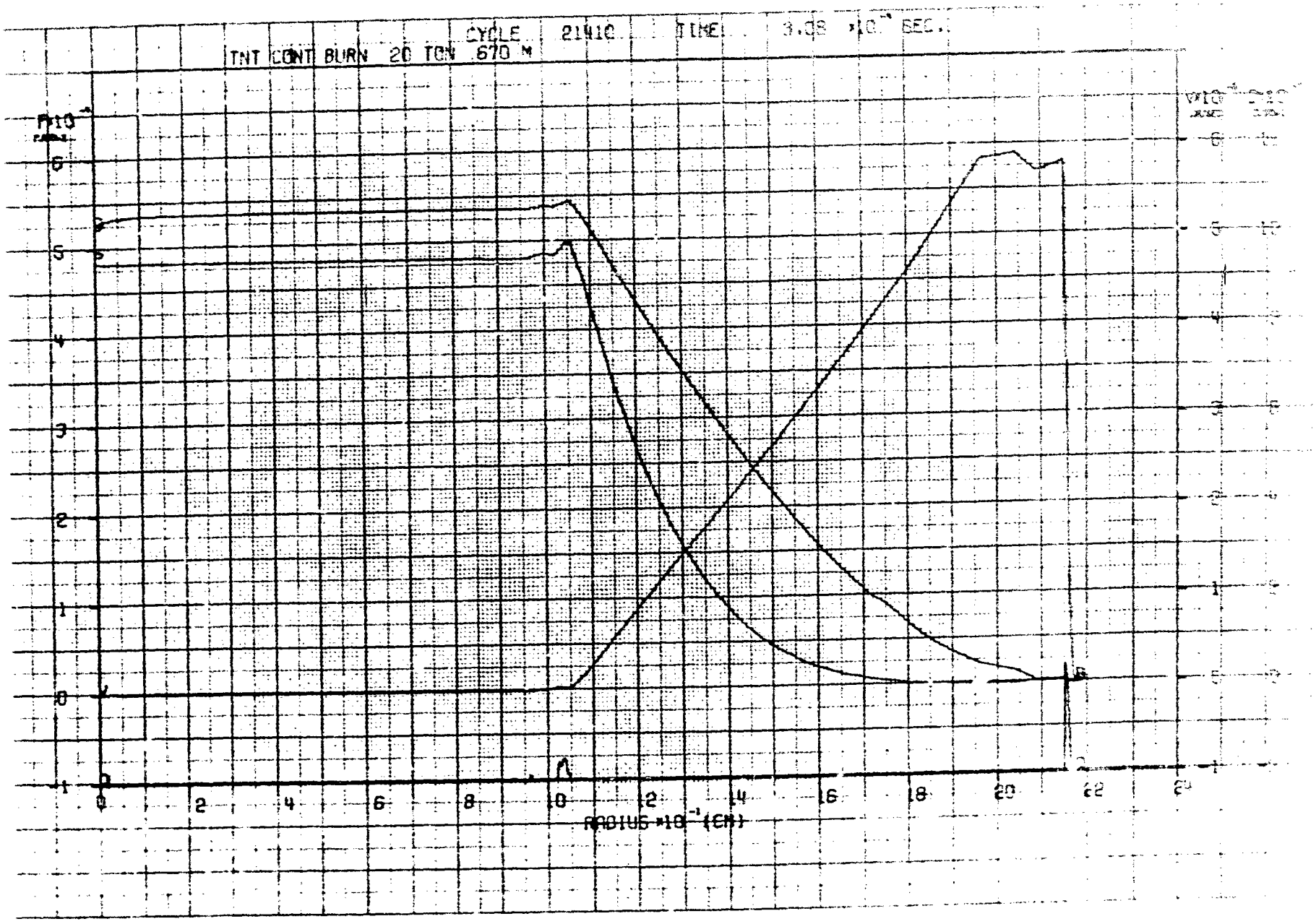
Atch
a/s

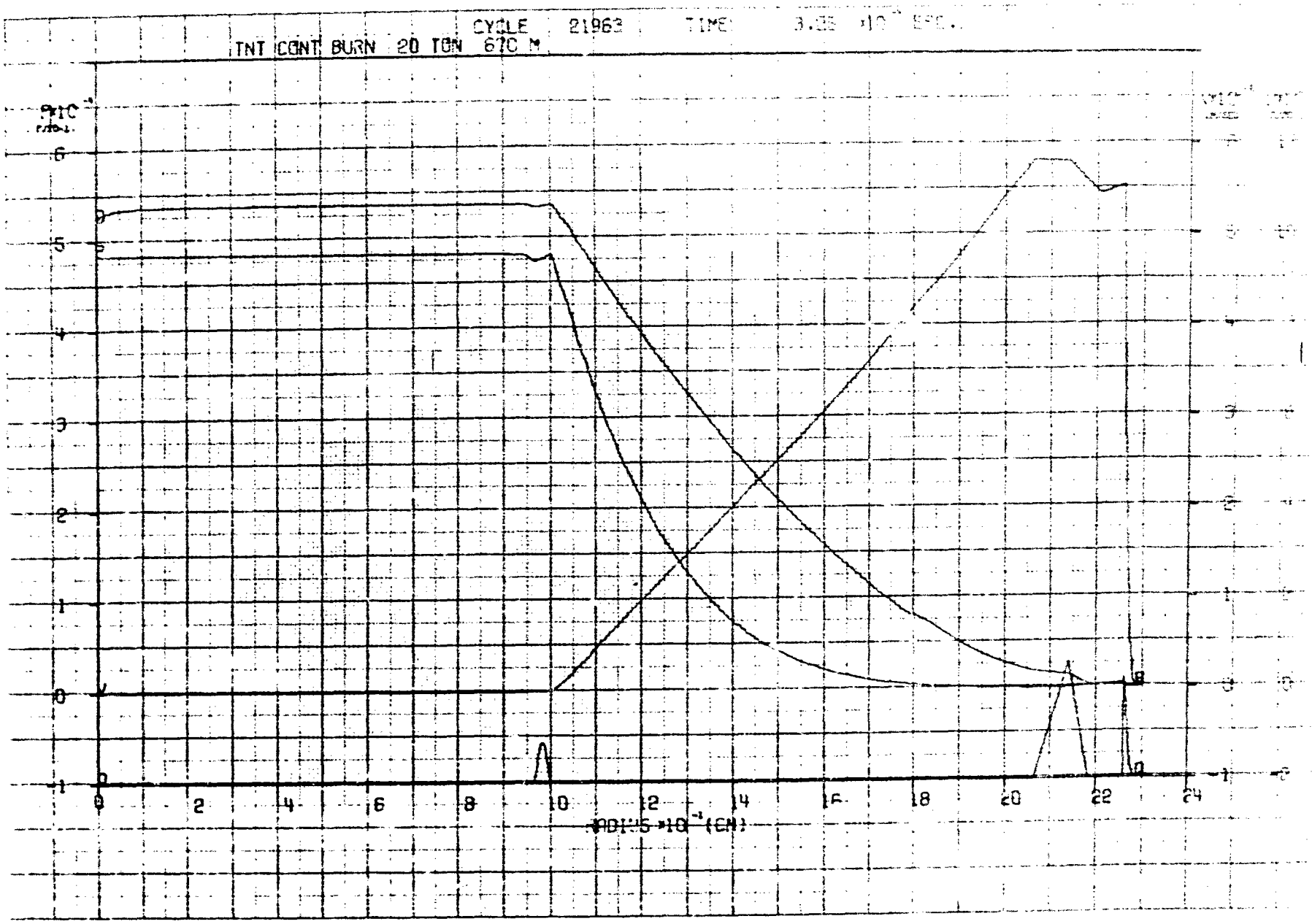

TNT CONT BURN 20 TON 670 M
CYCLE 18602
TIME 2.22 ×10 SEC.
0
2
4
6
8
10
12
14
16
18
20
22

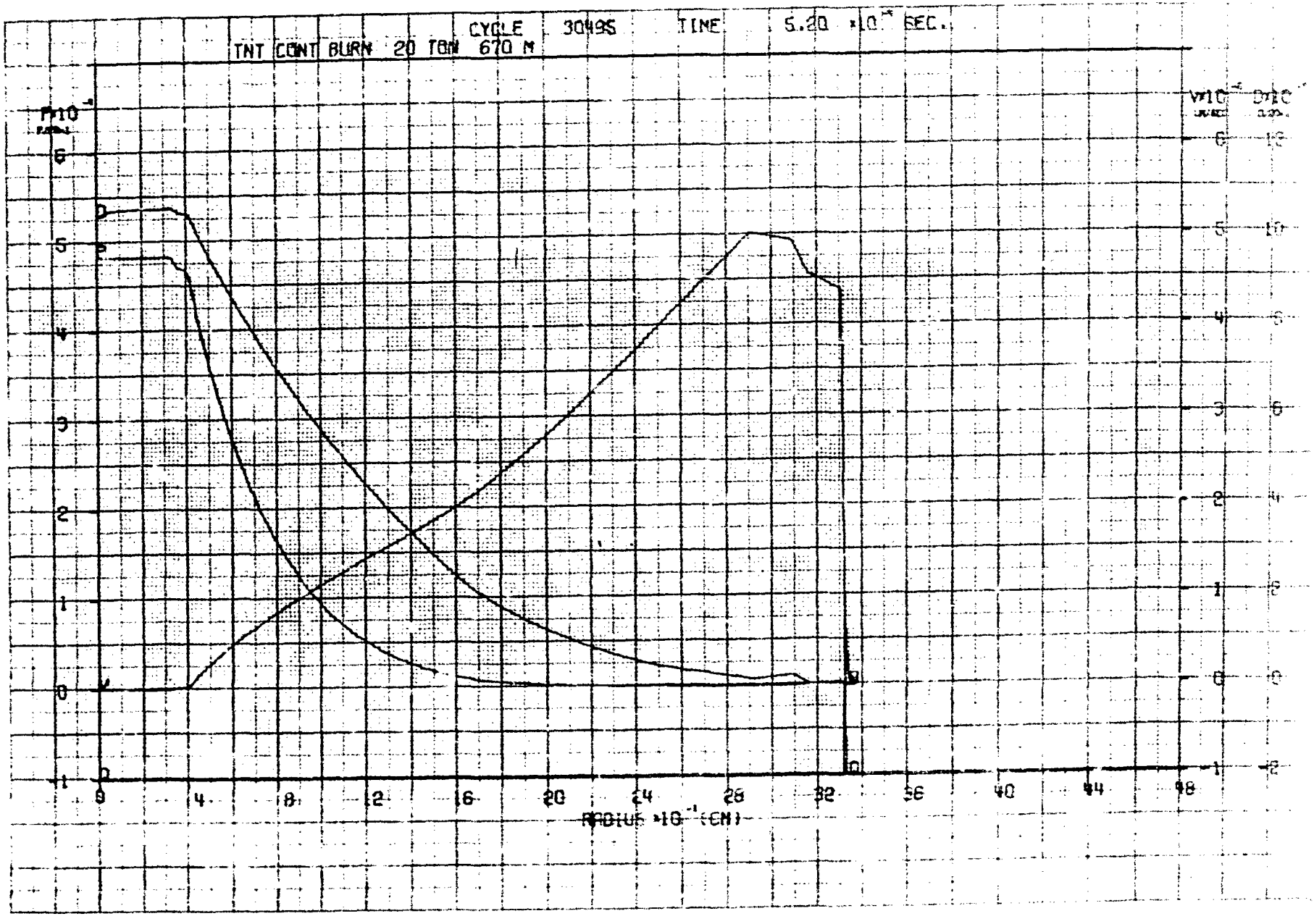

TNT CONT BURN 2D IGN 670 M
CYCLE 18300
TIME 1.49 ×10⁻⁷ SEC
P×10⁻⁹
RADIUS ×10⁻³ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24
28
20
16
12
8
4
0
4

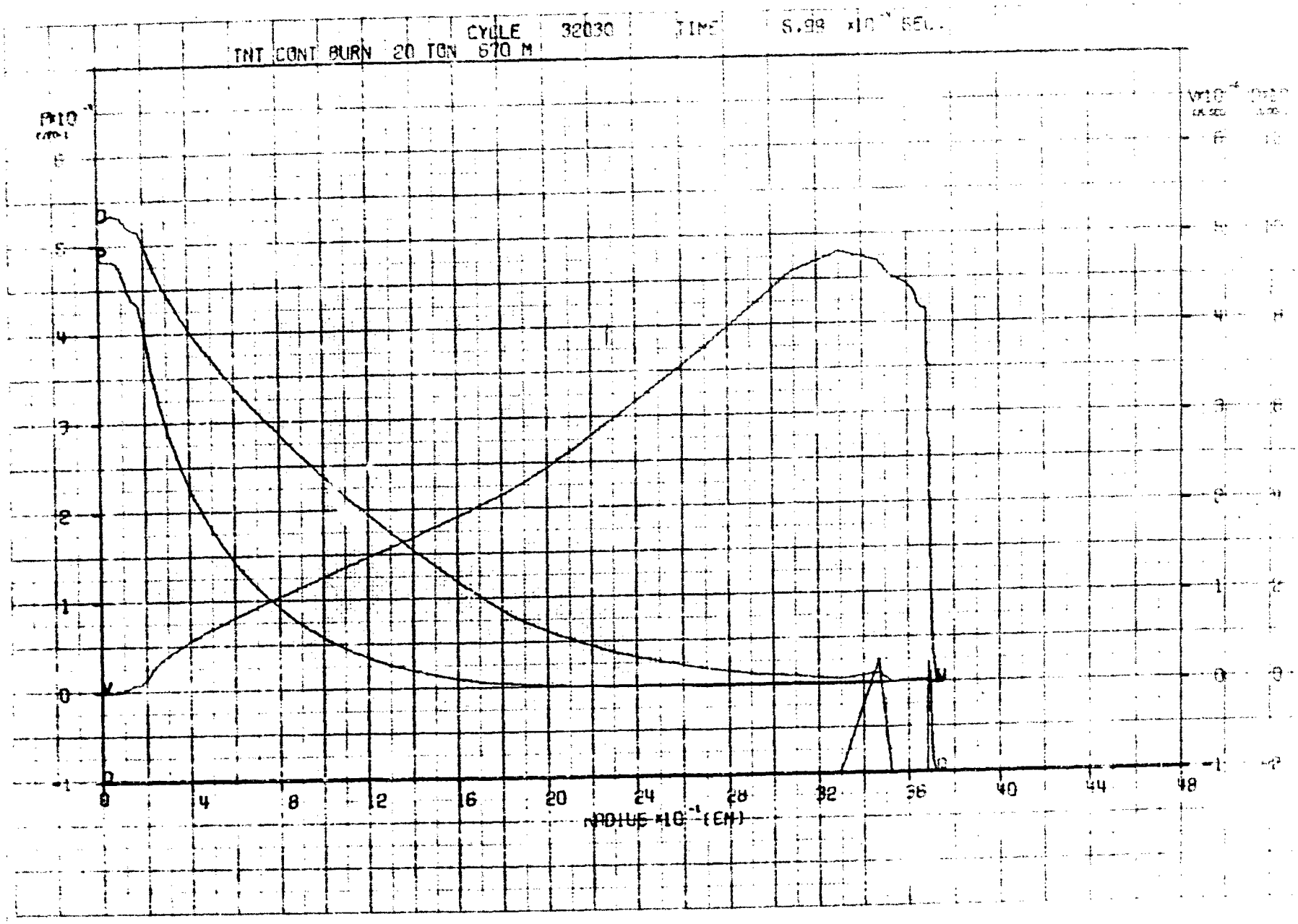

TNT CENT BURN 20 TON 670 M
CYCLE 19000
TIME 2.30 ×10⁻⁴ SEC.
P×10⁻⁴
V×10⁻⁴
D×10⁻⁴
RADIUS ×10⁻¹ (CM)

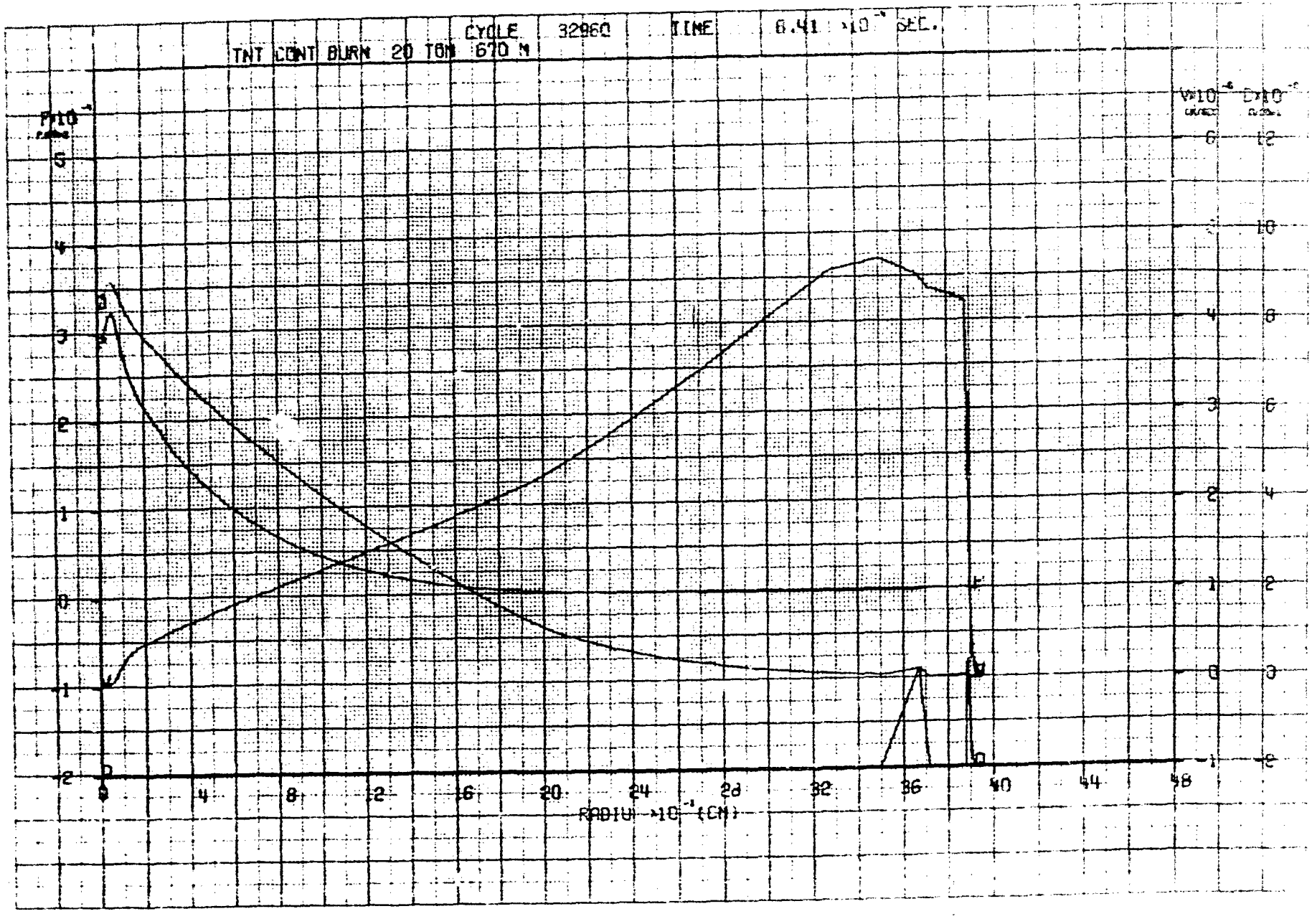

INT CONT BURN 20 JAN 670 M
CYCLE 19221
TIME
SEC.
RADIUS ×10⁻¹ (CM)
0
2
4
6
8
10
12
14
16
18
20
22
24
1
2
3
4
5
6
7

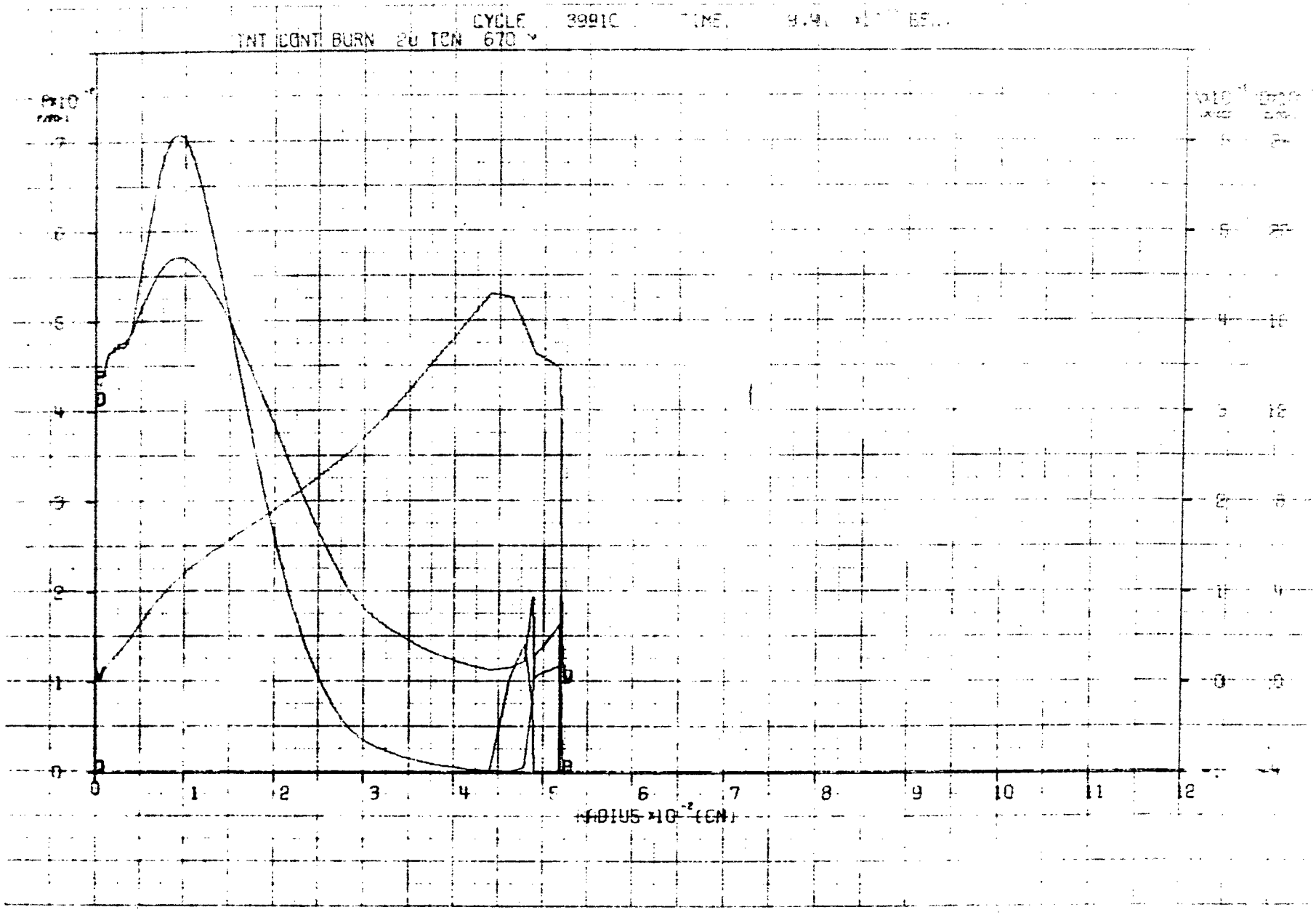

TNT CONT BURN 20 TON 670 M
CYCLE 21410
TIME
RADIUS ×10⁻¹ (CM)

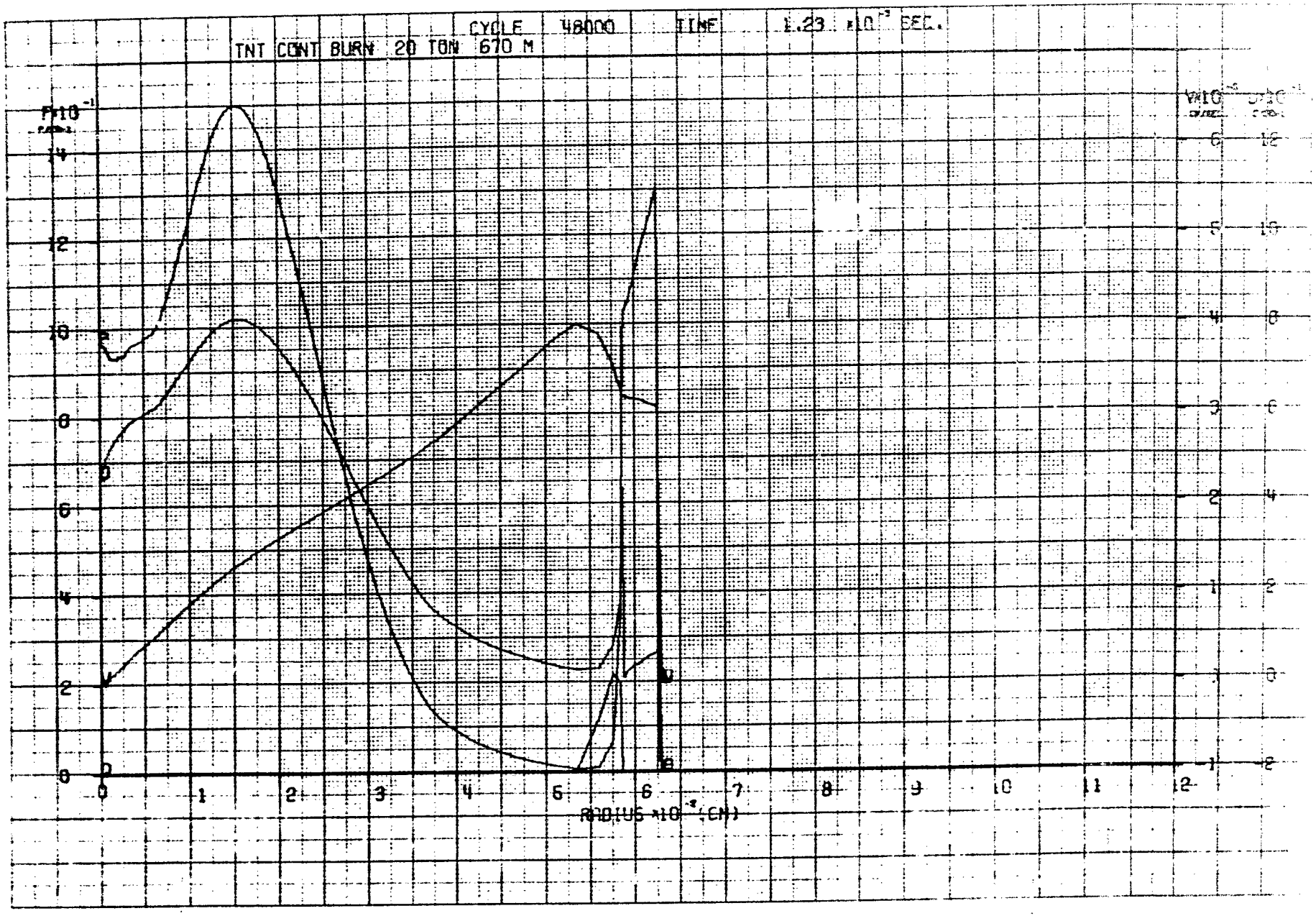

TNT CONT BURN 20 TON 670 M
CYCLE 21963
TIME
RADIUS ×10⁻¹ (CM)

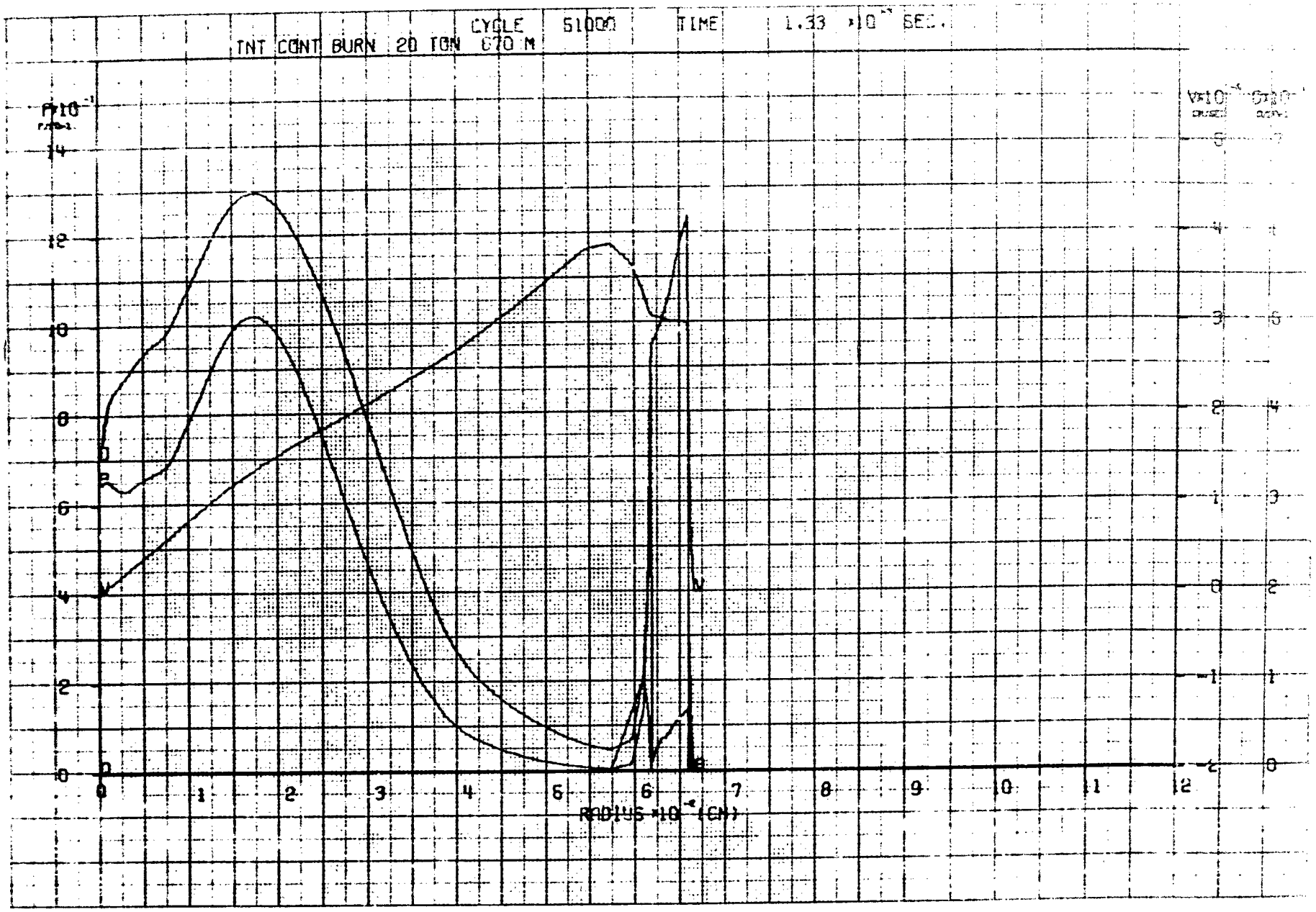

TNT CONT BURN 20 TON 670 M
CYCLE 30495 TIME 5.20 ×10⁻⁴ SEC.
P×10⁻¹
V×10⁻⁴
D×10⁻¹
RADIUS ×10⁻¹ (CM)

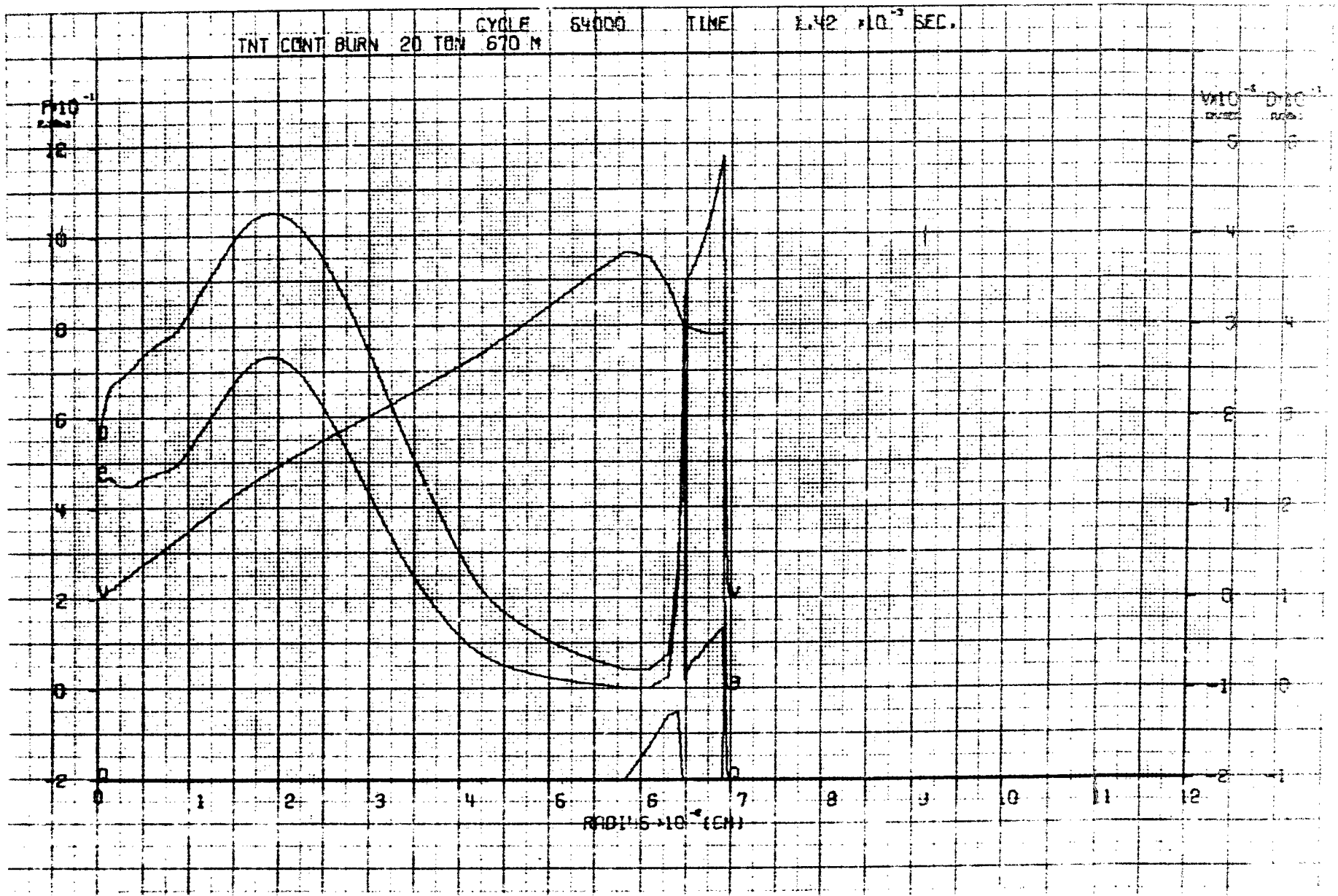

CYCLE 32030
TNT CONT BURN 20 TON 670 M
RADIUS ×10⁻¹ (CM)
0
4
8
12
16
20
24
28
32
36
40
44
48

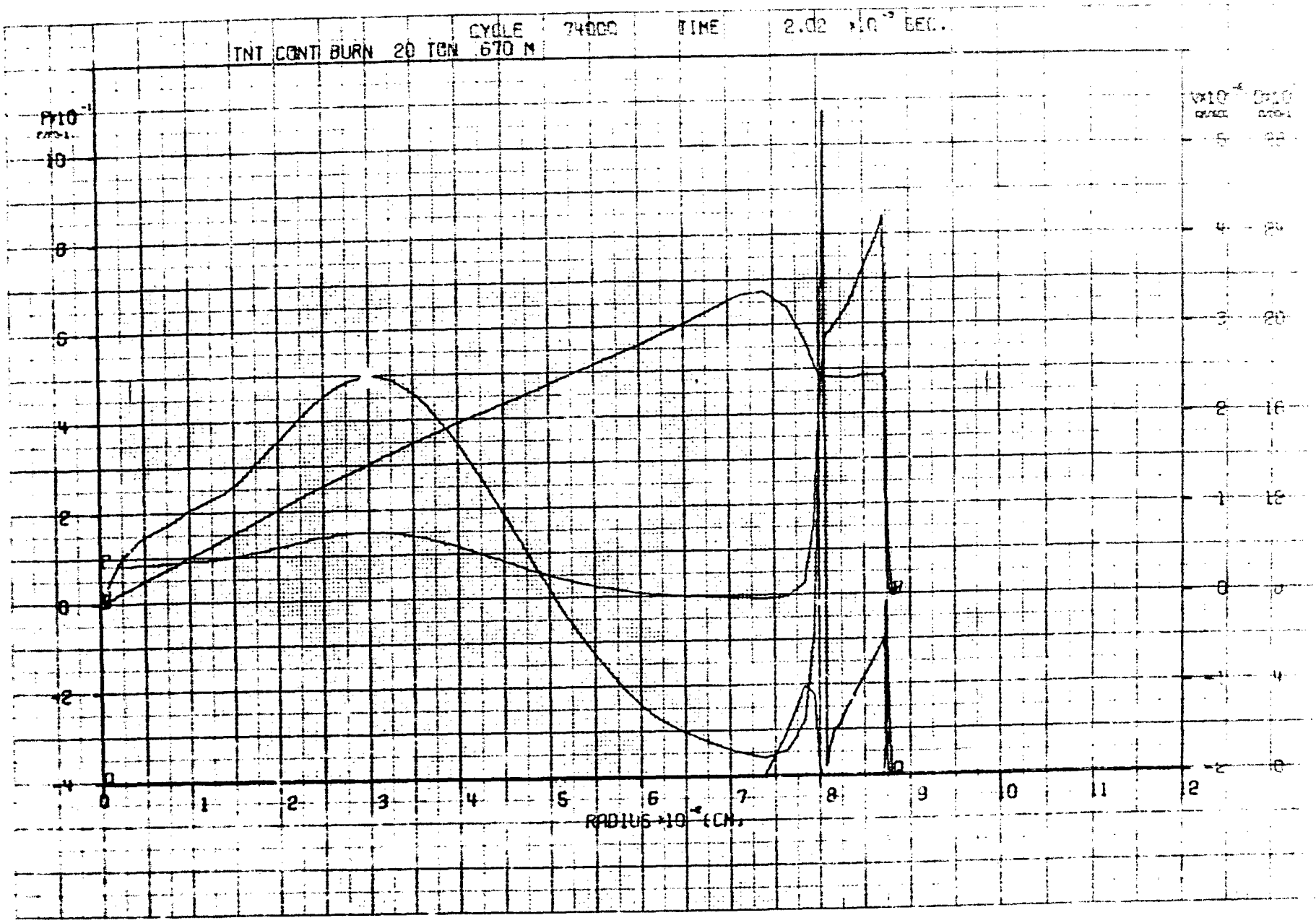

CYCLE 32960 TIME 8.41 ×10⁻⁷ SEC.
TNT CONT BURN 20 TON 670 M
P×10⁻¹
V×10⁻⁶
D×10⁻⁶
RADIUS ×10⁻¹ (CM)

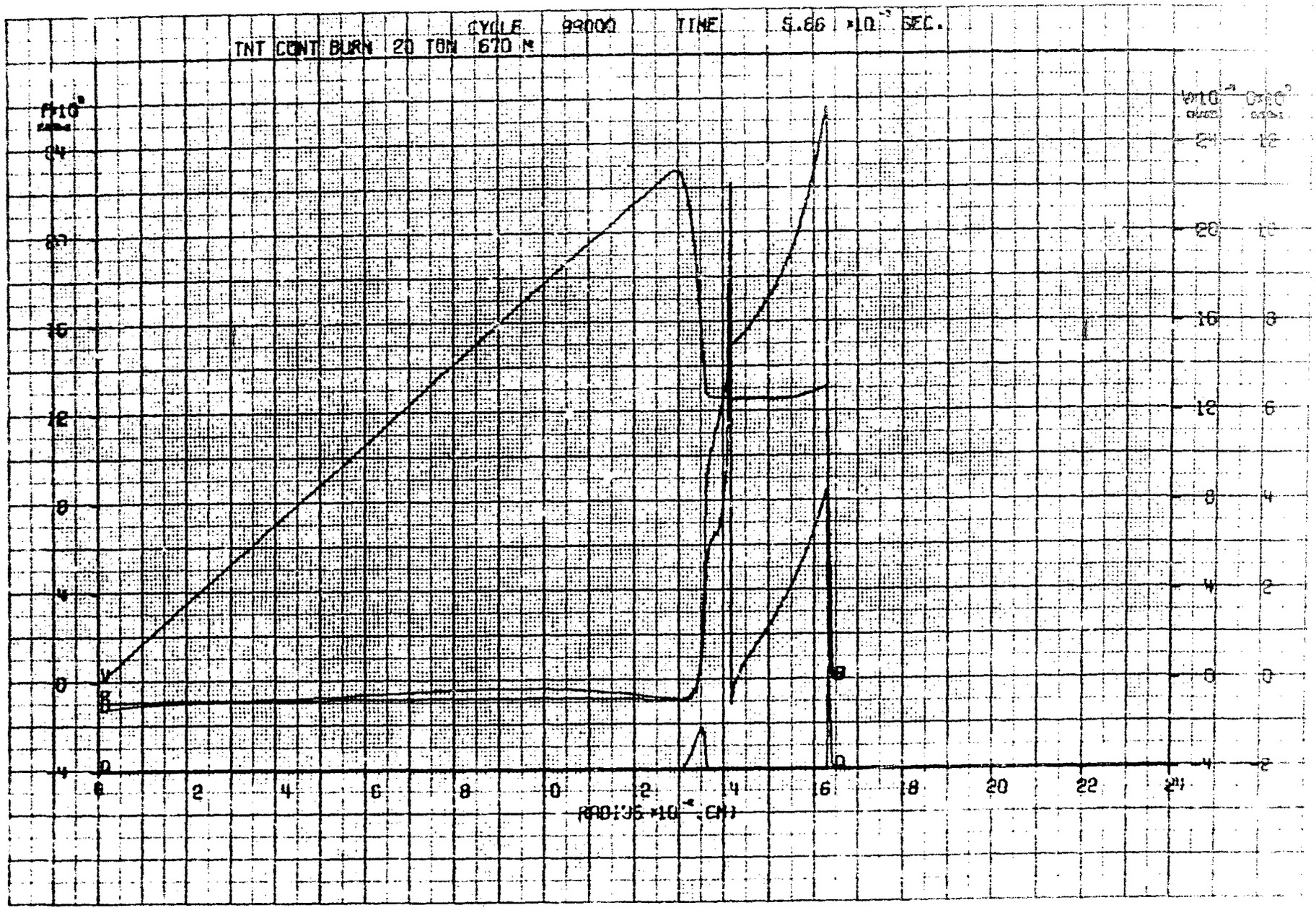

CYCLE 3991C
INT CONT BURN 20 TON 670
0
1
2
3
4
5
6
7
8
9
10
11
12
RADIUS ×10⁻² (CM)

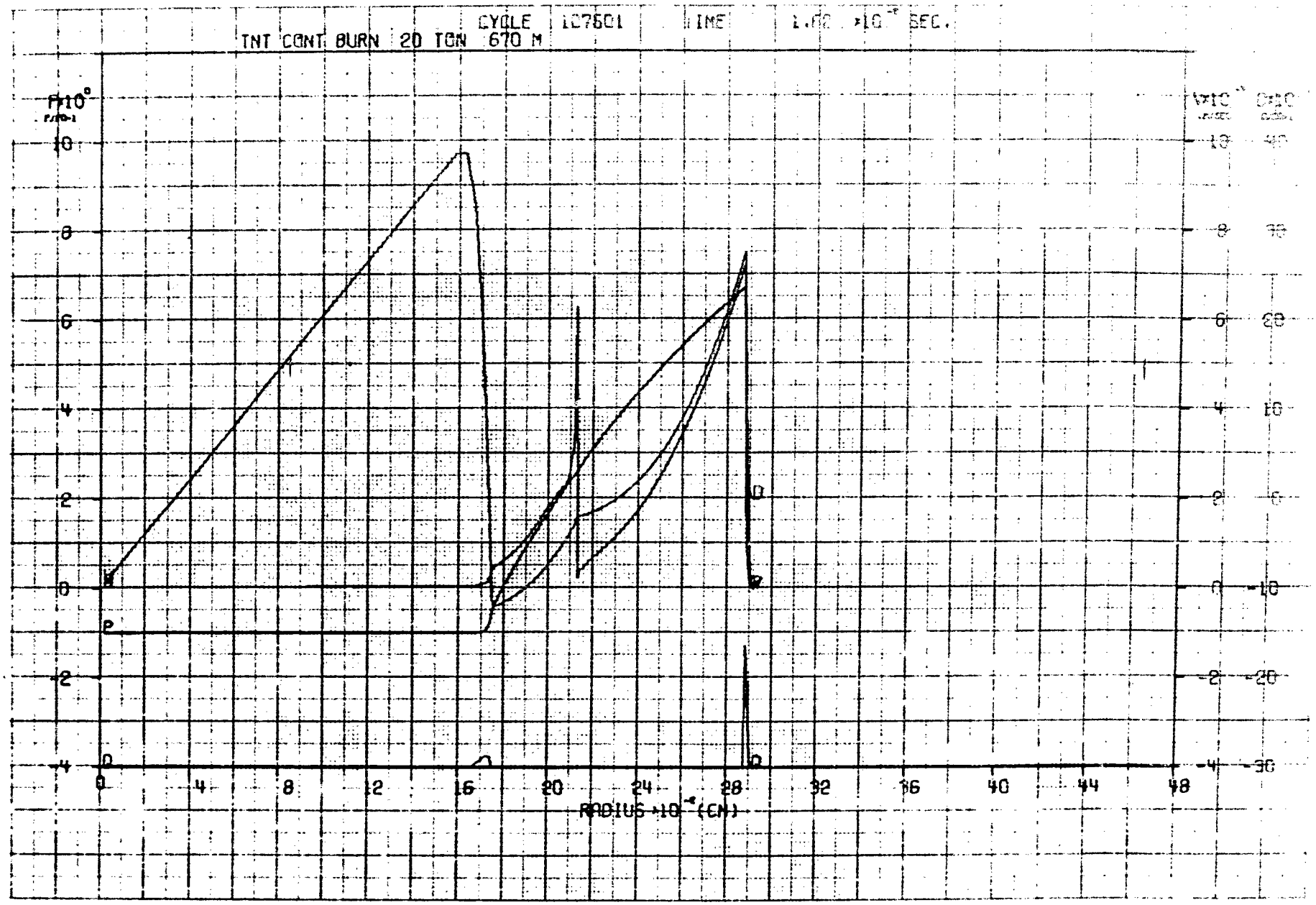

CYCLE 48000 TIME 1.23 ×10⁻³ SEC.
TNT CONT BURN 20 TON 670 M
P×10⁻¹
V×10⁻⁵
RADIUS ×10⁻² (CM)

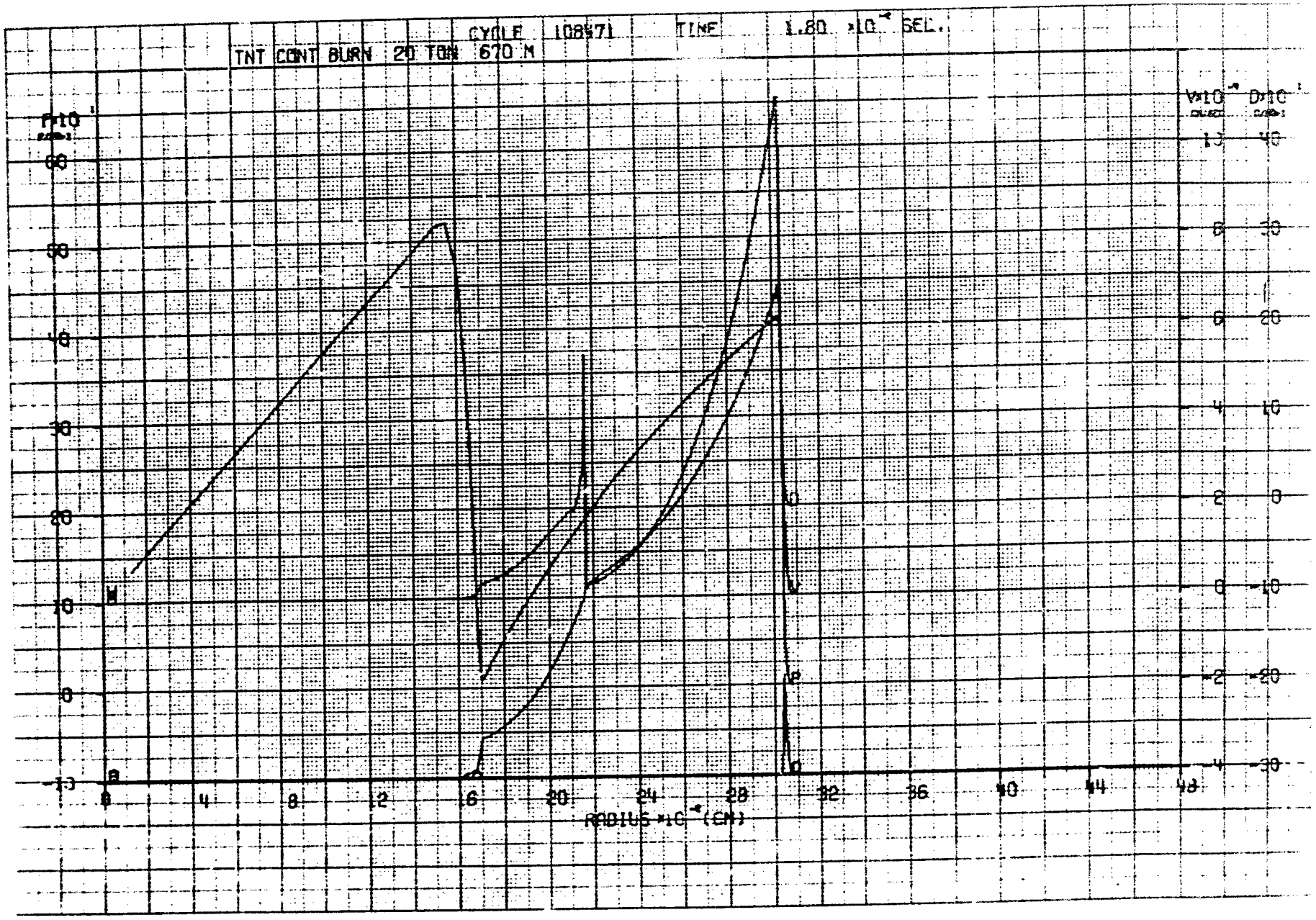

TNT CONT BURN 20 TON 670 M
CYCLE 51000
TIME 1.33 ×10⁻⁴ SEC.
RADIUS ×10⁻⁴ (CM)

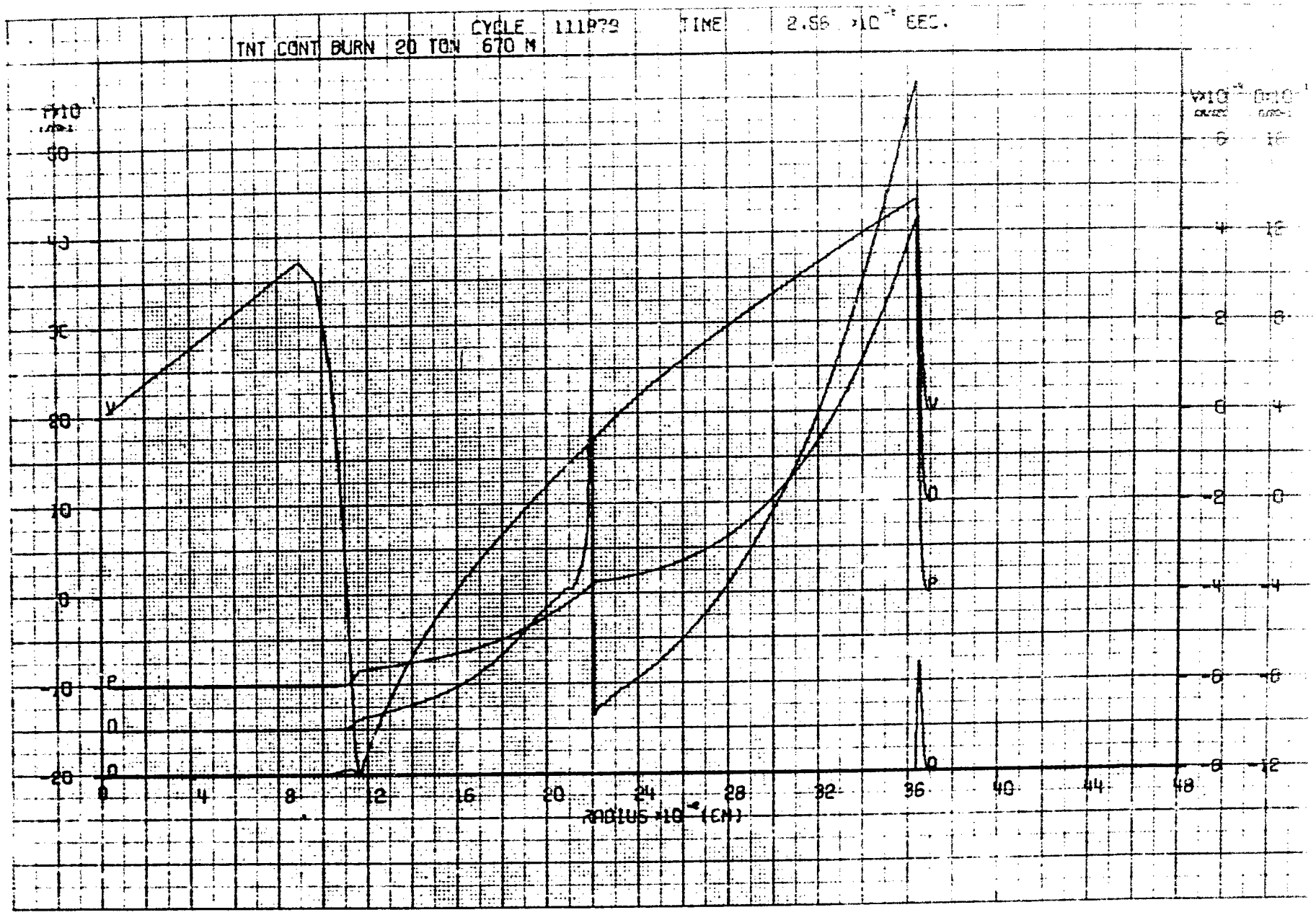

CYCLE 54000 TIME 1.42 ×10⁻³ SEC.
TNT CONT BURN 20 TON 670 M
P×10⁻¹
V×10⁻⁶ D×10⁻¹
RADIUS ×10⁻⁴ (CM)

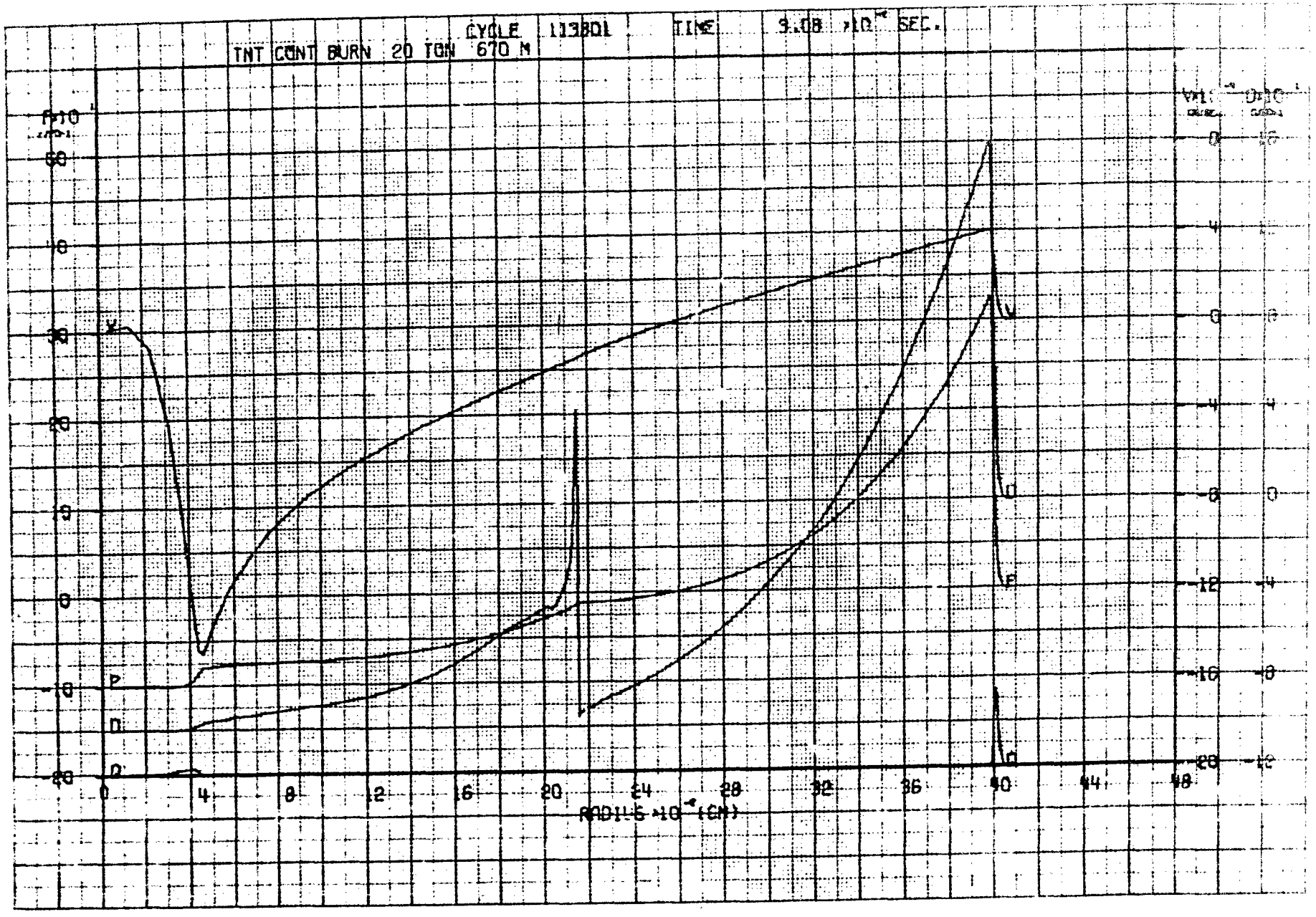

TNT CONT BURN 20 TON 670 M
CYCLE 24000
TIME 2.02 ×10⁻⁷ SEC.
P×10⁻¹
RADIUS ×10⁻⁴ (CM)
0
1
2
3
4
5
6
7
8
9
10
11
12
10
8
6
4
2
0
-2
-4

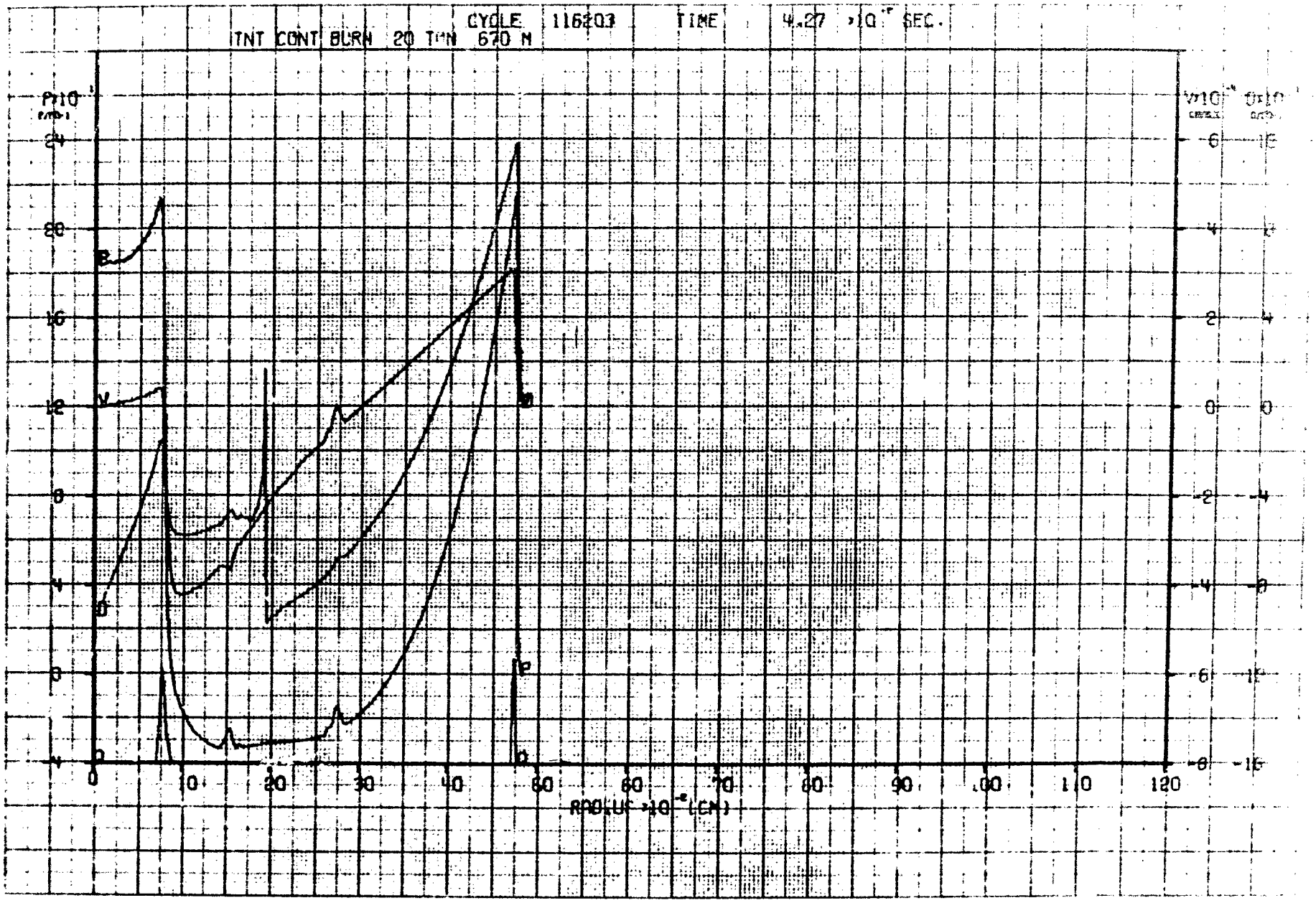

TNT CONT BURN 20 TON 670 M
CYCLE 99000 TIME 5.86 ×10⁻² SEC.
RADIUS ×10⁻² (CM)

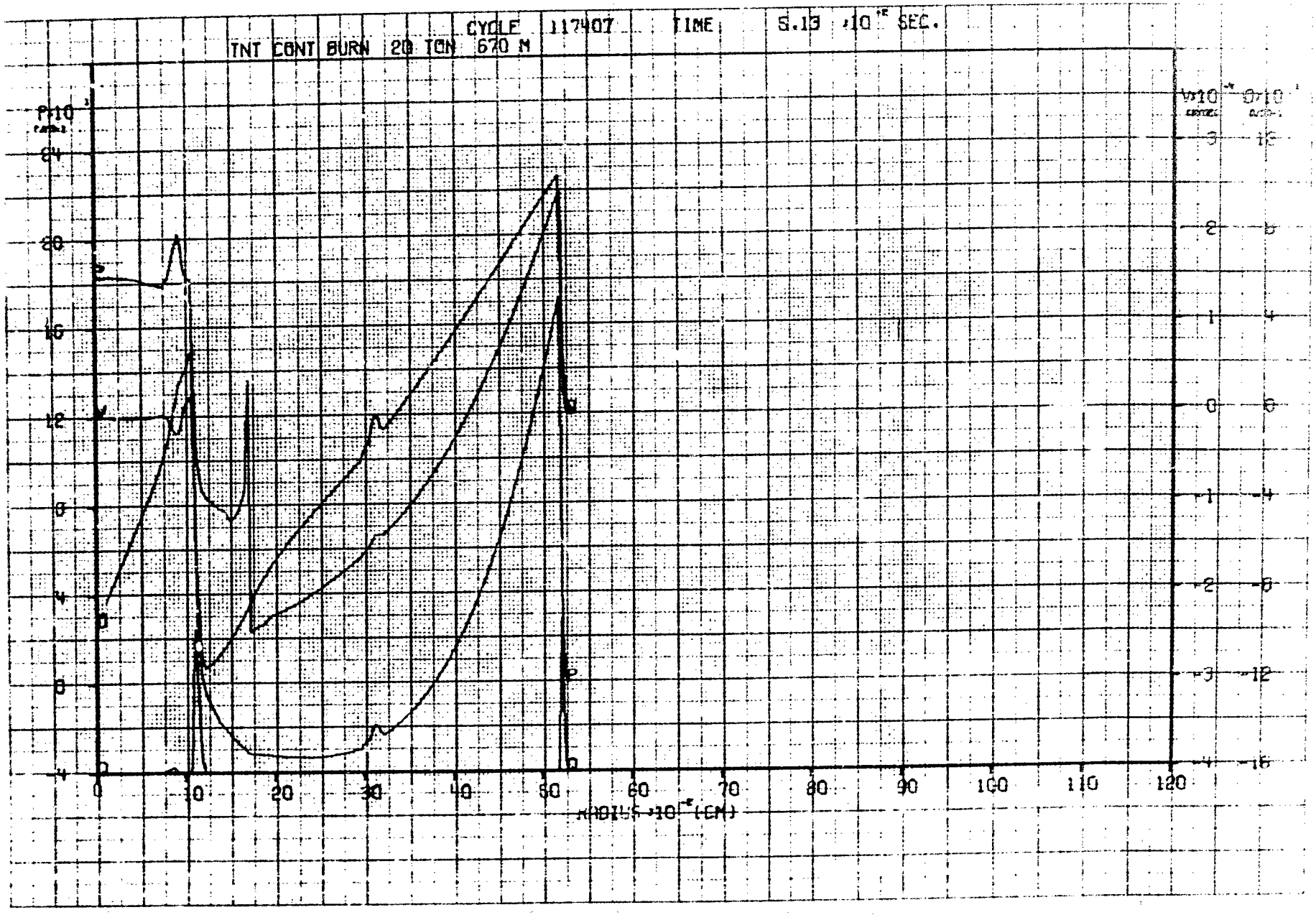

TNT CONT BURN 20 TON 670 M
CYCLE 107601
TIME
SEC.
RADIUS ×10⁻⁶ (CM)
10
8
6
4
2
0
-2
-4
0
4
8
12
16
20
24
28
32
36
40
44
48

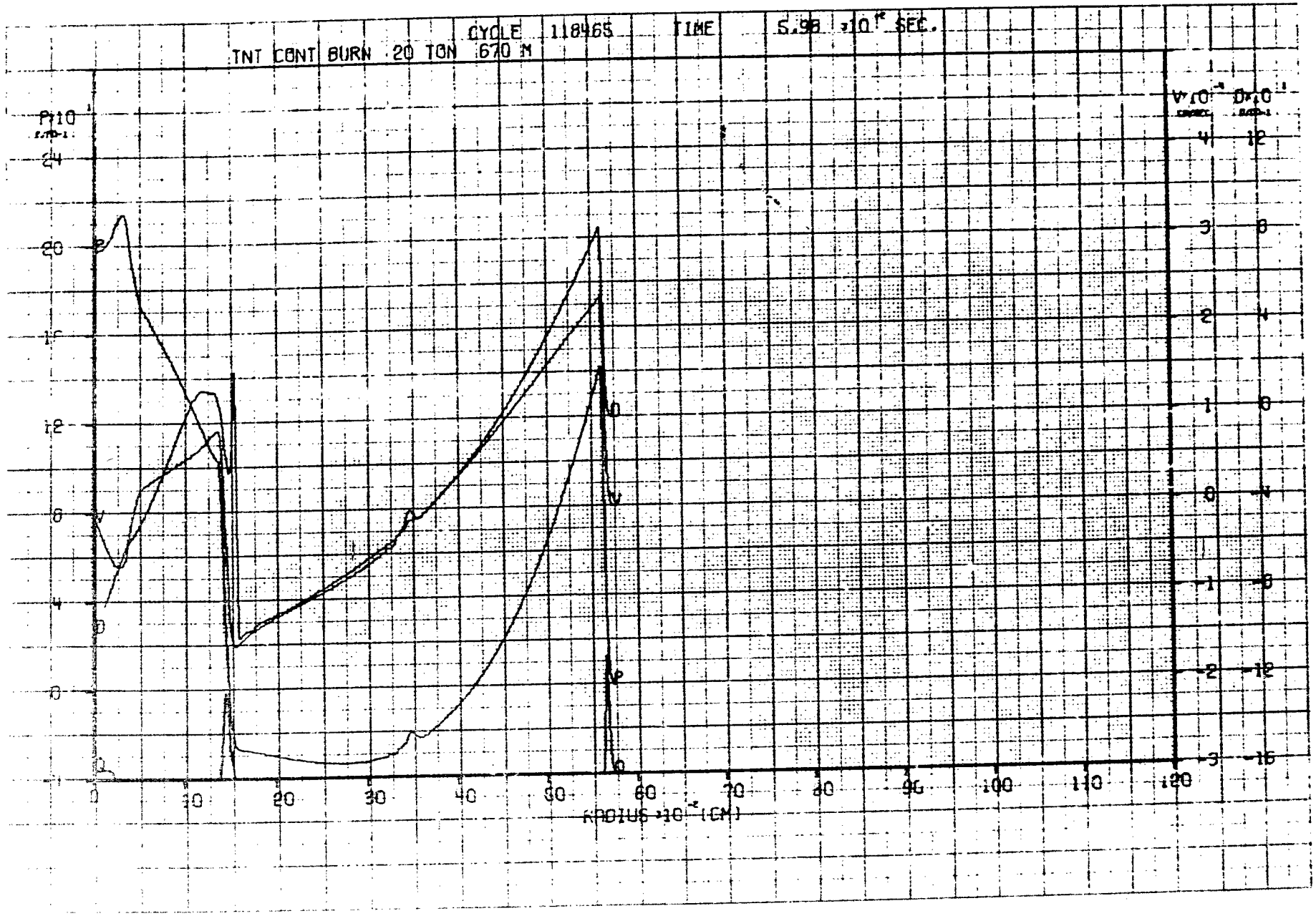

CYCLE 108571 TIME 1.80 ×10⁻⁴ SEC.
TNT CONT BURN 20 TON 670 M
P×10¹
V×10⁻⁹ D×10¹
RADIUS ×10⁻⁴ (CM)

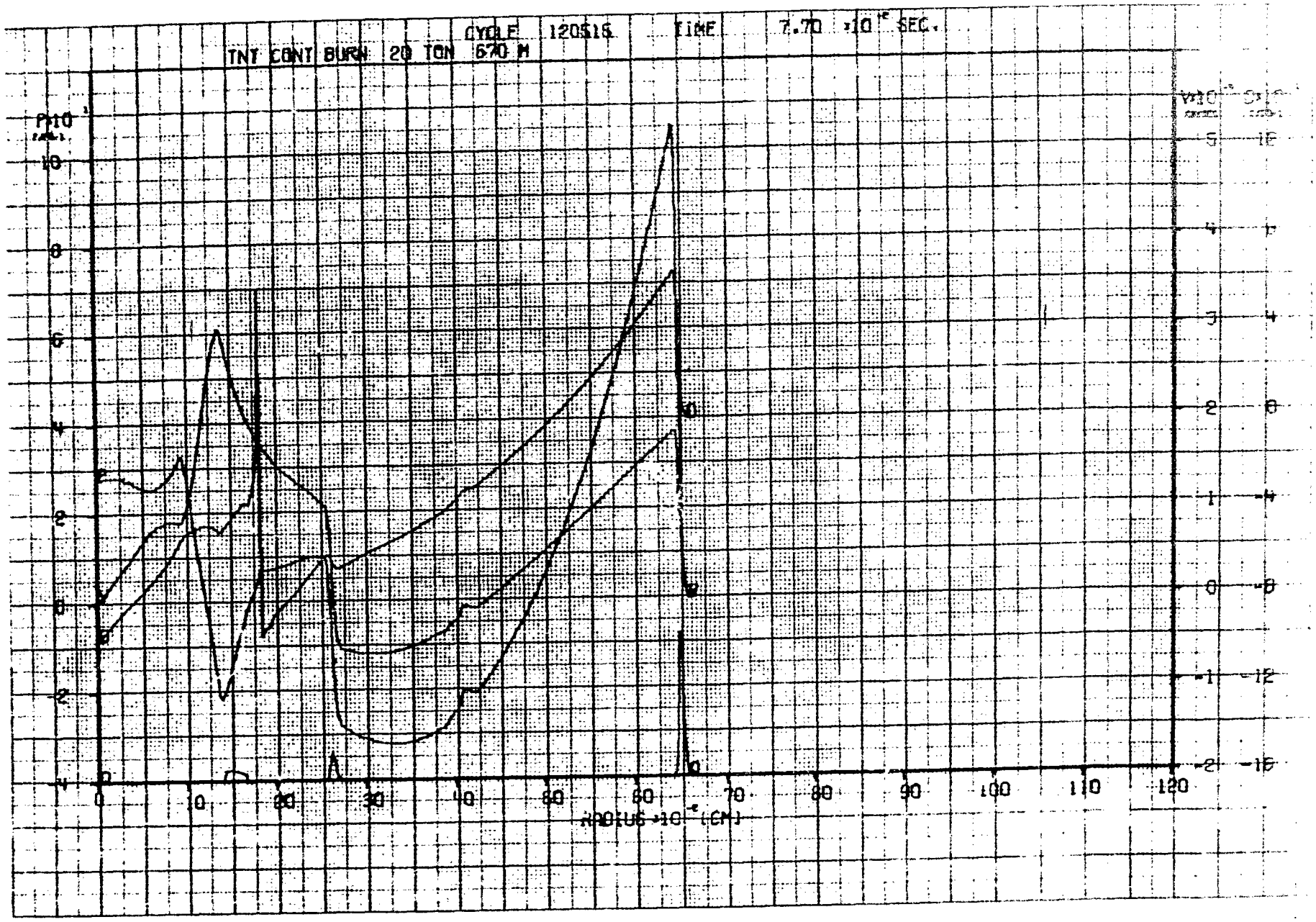

CYCLE 111P72 TIME 2.56 ×10⁻⁴ SEC.
TNT CONT BURN 20 TON 670 M
RADIUS ×10⁻⁴ (CM)

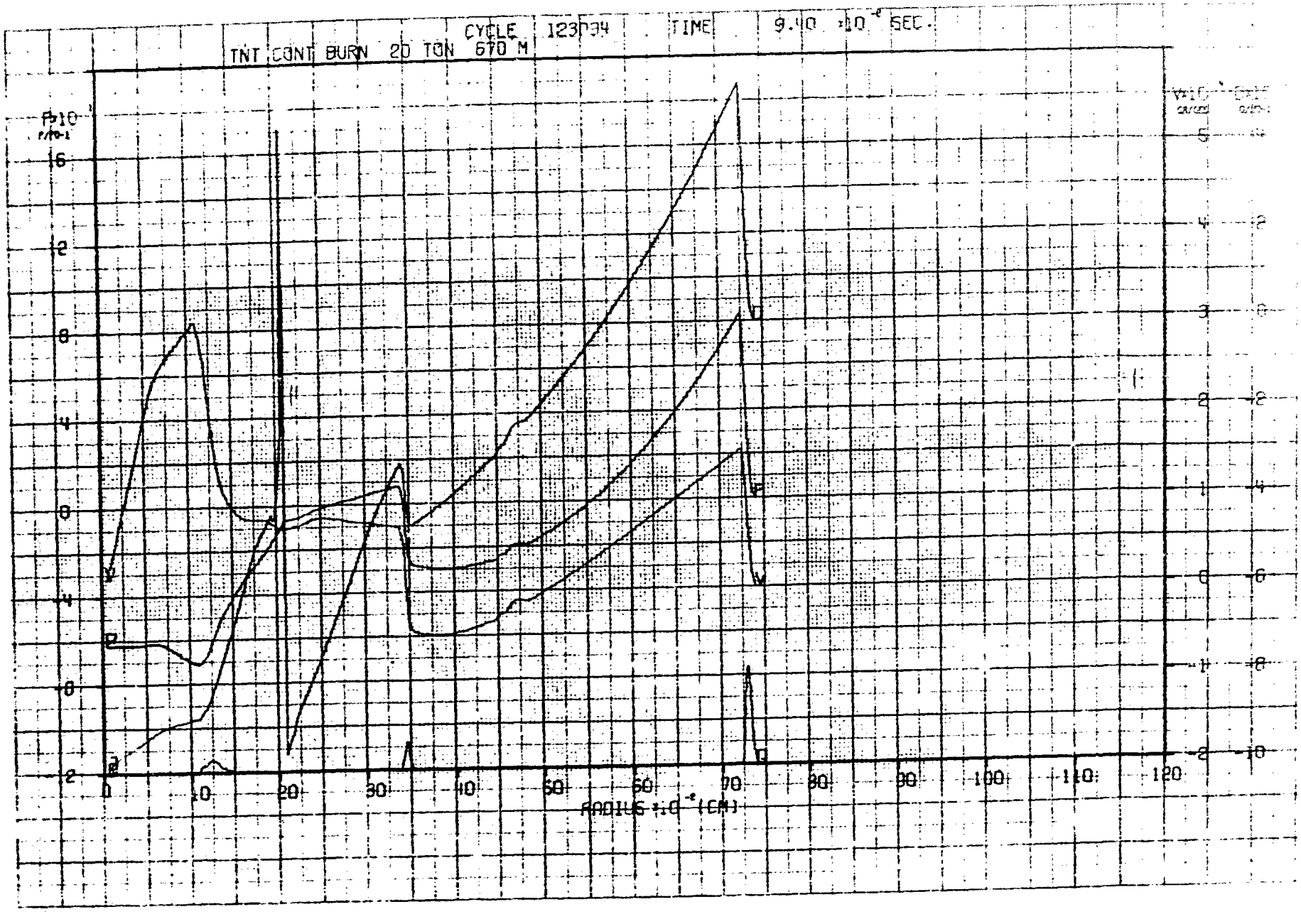

TNT CONT BURN 20 TON 670 M
CYCLE 113801
TIME 9.08 ×10⁻⁴ SEC.
P×10⁻¹
60
40
20
0
-20
-40
0
4
8
12
16
20
24
28
32
36
40
44
48
RADIUS ×10⁻⁴ (CM)
-8
-4
0
4
8
-12
-4
0
4
8
-16
-8
0
8
-20
-12
-4
4
12

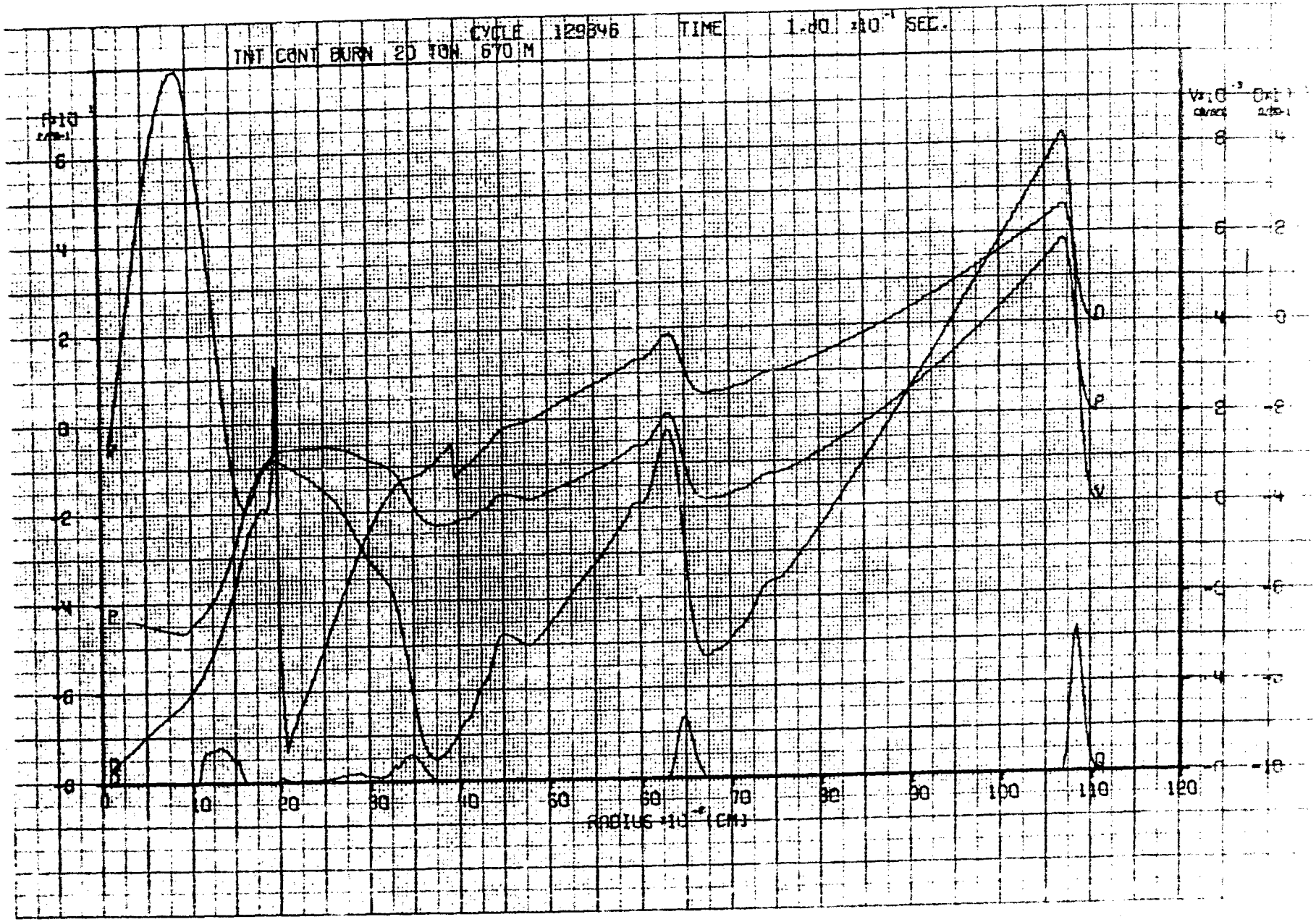

TNT CONT BURN 20 TON 670 M
CYCLE 116203
TIME 4.27 ×10 SEC.
P×10
V×10
U×10
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10 (CM)


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


TNT CONT BURN 20 TON 670 M
CYCLE 118465
TIME 5.98 ×10⁻² SEC.
P×10¹
V×10⁻⁴
D×10¹
RADIUS ×10⁻² (CM)


TNT CONT BURN 20 TON 670 M
CYCLE 120516 TIME 7.70 ×10 SEC.
P×10
10
8
6
4
2
0
-2
-4
0
10
20
30
40
50
60
70
80
90
100
110
120
RADIUS ×10 (CM)


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


TNT CONT BURN 20 TON 670 M
CYCLE 129846
TIME 1.00 ×10⁻¹ SEC.
RADIUS ×10⁻⁶ (CM)
P
R
V
Q