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**THE DYNAMIC PERFORMANCE OF A
VARIETY OF SEAT CUSHION MATERIALS
UNDER VERTICAL IMPACT LOADS**

D.R. Day

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West
P.O. Box 2000
Downsview, Ontario M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

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ABSTRACT

A series of twenty-nine impacts using the HyGe Crash Simulator at the Impact Studies Facility of the Defence and Civil Institute of Environmental Medicine (DCIEM) was performed in order to determine the effectiveness of a variety of seat cushion materials in preventing spinal injuries during high accelerative loading. These commonly occur during helicopter crashes with relatively large vertical velocity components, hard landings of Schweizer training gliders, and ejections from jet aircraft. Two simple wooden seats were mounted on the impact sled so as to simulate impacts in the vertical (bottom of seat pan to top) direction only, with a velocity change of 21 miles per hour, with a peak deceleration of 17G. The results showed that none of the "energy-absorbing" cushions tested had any significant effect on the probable occurrence of spinal injury. However, 2-inch, and thicker foam-rubber cushions increased the risk of spinal injury significantly, with the probable severity of the injury increasing as the thickness of the foam increased.

1. INTRODUCTION AND OBJECTIVES

It is widely believed that the use of foam, or a similar material between the body and the seat pan of an aircraft can reduce the risk of injury to the occupant's spine by reducing the forces on the spine resulting from high, vertical, upwards acceleration. Such accelerations are found during (a) otherwise survivable helicopter crashes, in which the helicopter was hovering or travelling at low altitude when it suffered a loss of lift due to mechanical problems, and had a relatively large change in vertical velocity during the impact, (b) hard landings of Schweizer training gliders, due to launch errors and/or inexperienced crew, and (c) ejections from jet aircraft.

Deaths and/or serious back injuries regularly occur within DND from these three sources. While the choice of seat cushion material used in a particular aircraft has usually been determined by considerations of comfort only, there has been an increasing awareness that the type of material might effect the forces exerted on the spine by the high acceleration levels. This feeling has been reinforced by the discovery, through unfortunate field experiences, that large thicknesses (up to 8 inches) of foam rubber which were placed under short students training in Schweizer gliders did not alleviate the crash forces, and indeed may have aggravated them. Other students have received serious injuries using thinner cushions. Helicopter pilots also suffer similar injuries, resulting in the occasional fatality in the Canadian Forces (CF); however, material for seat cushions in helicopters has generally been selected for comfort over any other requirement. However, in all of the cases described above, there has been much uncertainty as to which cushion material and thicknesses are beneficial or deficient, and by how much.

DCIEM's Medical Life Support Division (MLSD) had previously requested the Impact Studies Facility (ISF) to conduct a series of simulated impacts using the HyGe crash simulator. Those tests were designed to determine the comparative effectiveness of a variety of different seat cushion materials, including several of the newer "energy-absorbing" materials (Temper-foam® and Ethafoam®), in reducing the probability of spinal injury. The results of that test program, using two different sizes of anthropomorphic dummies and eight different foam materials (in a very limited number of combinations and thicknesses) are presented in Reference 1. While that study provided some insight into the mechanisms at work and their effects, it was very limited in nature and scope, and could not even begin to answer MLSD's subsequent questions. They needed more detailed information, such as (a) what is the effect of increasing the cushion thickness, for a given material?, (b) how well do certain cushions in widespread use in specific DND aircraft perform?, and (c) can extra-thick cushions (e.g., 4 inches - 8 inches) of certain materials act as efficient energy absorbers, providing a truly significant reduction in spinal acceleration, to the same extent as that provided by stroking seats?

Consequently, the ISF proposed a test program using the HyGe crash simulator to determine the comparative performance and effectiveness in reducing the probability of spinal injury of a carefully selected group of either common and/or comfort-oriented seat cushion materials, some of which were of the new "energy-absorbing" type. This program was to be more exhaustive than the previous one; and the five materials selected were all to be used in three different thicknesses, with the two different-sized anthropomorphic dummies. Also, the special, multi-layer cushions used in the DND's Tracker and Labrador aircraft were to be evaluated. This would require approximately 29 sled impact runs, with two dummies mounted on the sled for each impact.

2. TEST METHODOLOGY

2.1 Instrumentation and Test Equipment

The tests were performed on the DCIEM 12-inch HyGe impact accelerator (Bendix Corp.), which simulates impact by rapid acceleration. The crash deceleration pulse which was delivered to the test package was programmed by the adjustment of various gas pressures and volumes within the impact accelerator, and by the selection of a suitably-shaped internal metering pin. During the short period of rapid acceleration, the payload experienced the same dynamic loads that would occur during a sudden decelerative crash. After the initial acceleration, the sled was slowly decelerated to a stop.

The deceleration was simulated using a half-sinusoid acceleration pulse, with a nominal peak acceleration of 17G, as recommended by MLS D for a moderately hard, but survivable landing of a rotary-wing aircraft craft. This was selected from the Crash Survival Design Guide (2) for a cumulative frequency of occurrence level of 76%*, which gives a nominal change in velocity of 21 miles per hour (mph). The actual sled velocities and accelerations were 20.5 ± 0.2 mph and $17 \pm 0.2G$.

NOTE: *In order to quantify the severity of a crash, the Crash Survival Design Guide (2) is normally consulted in order to ascertain the appropriate impact velocity and peak deceleration occurring during an impact. This extensive report gives a statistical analysis of the impact conditions for various types of U.S. Army rotary and light fixed-wing aircraft which crashed between 1960-65 and 1971-76. Data are presented concerning longitudinal, vertical, and lateral decelerations and their corresponding changes in velocity. These are plotted in order to show their various interrelationships; and, particularly, to show the "percent cumulative frequency of occurrence" (CFO) of all potentially survivable accidents, as a function of deceleration and impact velocity. The reference defines the CFO as the fraction, expressed as a percentage, obtained by dividing the cumulative total number of crashes which were judged to be potentially survivable, by the cumulative total number of crashes during the period studied, for a specified impact deceleration level and change in velocity. For example, for an impact of 15G and 24 miles per hour (mph), the reference gives a CFO of 80%, indicating that 80% of all potentially survivable crashes occur at decelerations and velocity levels below 15G and 24 mph.

The plot of an actual acceleration pulse from the tests is shown in Figure 1. For pulse measurement purposes, the basic sled acceleration data were monitored using two Setra[®], Model 14, high-out accelerometers, which were mounted directly on the impact sled.

The tests were conducted using both 95th-percentile male, and 5th-percentile female anthropomorphic dummies, with weights of 215 and 101 pounds, respectively. Both dummies were outfitted with Endevco[®] triaxial accelerometers in their chest and pelvic areas; the latter was used to calculate the Dynamic Response Index (DRI) of each dummy. They were seated on two flat, wooden surfaces simulating a simple seat having a 90° angle between the back and bottom seat surfaces, as shown in Figure 2. The back of the seat was horizontal (parallel to the sled surface) and the acceleration was directed through the seat-bottom in the direction from the bottom to the top of the seat, thereby simulating an aircraft crash or ejection. By means of a strap across their laps the dummies were pre-loaded in a downward direction (i.e., in the direction from head-to-foot) so as to simulate their weights. In that way, the cushions were realistically compressed before the impact. Also, the maximum amount of compression into the cushion by this static load was measured.

Five different cushion materials were used in the tests, as follows: T-50, T-47, and T-41 Temper-Foams[®]; foam-rubber; and Ethafoam[®] 45. Each of these was used in 2-, 4-, and 8-inch thicknesses under both the 95th- and 5th-percentile dummies. In addition, the following combinations of materials were used under each dummy, as requested by MLSL:

- a. 1-inch thick T-41, 1-inch thick T-47;
- b. 1-inch thick T-41, 2-inch thick T-47;
- c. 1-inch thick T-41, 3-inch thick T-47;
- d. 1-inch thick T-41, 1-inch thick T-47, 1-inch thick T-50;
- e. 1-inch thick T-41, 1-inch thick T-47 (cut-out), 1-inch thick T-47, (as used in the Labrador); and
- f. 1/2-inch special soft Temper-Foam[®], 1-inch thick T-41, 2-inch thick T-47, (as used in the Tracker).

Photographic coverage was provided by one LOCAM[®] pin-registered movie camera and one Stalex[®] rotating prism movie camera, both of which were mounted on an outrigger attached to the sled directly to one side of the dummies. These cameras used 10- and 13-mm lenses respectively. Occasionally, two additional movie cameras were used: one LOCAM[®] on the sled on the opposite side of the dummies, and another LOCAM[®] on the laboratory floor, showing the complete sled set-up (utilizing 5.9- and 12-200-mm zoom lenses, respectively). All cameras operated at 500 frames per second, providing slow-motion views of the dummies during the impact. Also, before and after each run, photographs were taken of the sled and seat set-ups.

2.2 Data Recording and Processing

Sled inertial data were obtained from accelerometers on board the sled, using a series of specially-designed, ruggedized, low-noise pre-amplifiers to increase the signal strength. The signals were analog-filtered at 5 kHz on board the sled, and then transmitted along a low noise, flying-lead, umbilical cable to the recording and data reduction area. There, they were stored in the memories of a multi-channel transient recorder (Datalab, Mitcham, UK). The transient recorder equipment digitized the input signal at a sampling rate of 10 kHz, with an accuracy of 10 bits (1 part in 1024). The total recording time of the digitized data was 0.4 seconds. Complete details of the data acquisition system in the Impact Studies Facility are available elsewhere (3). The specifications of the digitizing and recording equipment are more stringent than those established by the Society of Automotive Engineers (SAE), which sets standards for instrumentation for dynamic test purposes (4).

Immediately after the sled was fired, the data were transferred to a computer disk for processing. (The raw data for all runs are being retained on magnetic tape in the DCIEM computer centre on an indefinite basis.) The computer programs first performed digital filtering on the data, according to the SAE specification (4) which details the specific filtering to be carried out on signals emanating from various sources. For this test, only the sled, chest, and pelvic accelerations were recorded. The sled acceleration was filtered at 60 Hz, as specified, while the dummy accelerations were both filtered at 180 Hz. The data were then scaled and the velocity computed by successive integrations of the sled acceleration. Finally, appropriate graphs were produced by a plotter under computer control.

3. THE DYNAMIC RESPONSE INDEX

The accelerations recorded at the chest and pelvis in these tests do not, in themselves, give a measure of the potential for injury to a human subject exposed to the same impact. The body responds in a complex way to vertical impacts; our understanding of this response can be used to interpret the data from the accelerations.

The assessment of tolerance to vertical impacts delivered to the buttocks through a seat pan has been the subject of standards related to ejection seat design. Two such standards, the United States Air Force MIL-S-9479B (5) and the Air Standardization Coordinating Committee Air Standard 61/1 (6), use the Dynamic Response Index (DRI), as proposed by Stech and Payne (7). The DRI is related to the maximum value of the deflection δ which is the solution of the differential equation describing a damped harmonic oscillator $\ddot{y} = \delta + 2cWn\dot{\delta} + Wn^2\delta$ [1]

by the formula:
$$DRI = \frac{Wn^2\delta_{max}}{g_0}$$

where

\ddot{y} is the acceleration of the seat pan,

c is the normalized damping coefficient,

ω_n is the natural angular frequency of oscillation, and

g_0 is the acceleration of gravity.

The DRI has the dimensions of acceleration in units of g_0 , and can be compared with accelerations in G's. The values used in the standards for the DRI are $\omega_n = 52.9$ radians-sec⁻¹, and $c = 0.225$.

The DRI is an application of the mathematically-simplest model of the response of the human body to vertical acceleration. This model assumes that the upper body is a mass supported by a column (the trunk and spine) that has elastic and viscous elements. The deflection of the column corresponds to the hazard of mechanical injury to the spine. Experiments with human subjects exposed to vertical vibration, as well as injury data gathered from aircraft ejections, tend to support the use of the DRI as a predictor of spinal injury resulting from vertical impacts. According to Brinkley and Shaffer (8), a DRI of 20G corresponds to a 50 per cent probability of injury to the spine. Although their data do not include experience with DRI values greater than 20G, the probability of injury increases rapidly with DRI, so that impacts with DRI values above 22G should be considered almost certain to cause severe spinal injury.

However, the use of the DRI in these tests is not entirely appropriate. The anthropometric test devices used here are not intended to simulate human response to vertical impacts, and may create unrealistic accelerations at the pelvis when coupled to a cushion. However the DRI is the only widely-accepted means of assessing the hazard resulting from complex vertical accelerations applied to a seat.

The DRI values were calculated from the pelvic z-accelerations in these tests. Normally, they are calculated from vertical accelerations of the seat pan, but the pelvic acceleration is appropriate for tests of this kind. Because of the rigidity of the spine of the dummy used in these tests, the DRI values may be higher than those that would be derived from impacts involving human subjects. Because of this limitation, it is only appropriate to use the calculated DRI values for comparing the relative severity of the impacts among the different cushions used in these tests.

In order to evaluate the DRI for this series of tests, a computer program which numerically solved the differential equation for a given array of values of y was written for the Impact Studies Facility computer. The solution of the equation was scaled so that the output variable was not δ but

$$x = \frac{\omega_n^2 \delta}{g_0}$$

The maximum value of this expression is the DRI in units of G. This function was stored in a form which could be plotted. By this means, the DRI could then be calculated and plotted for the pelvis accelerations for each of the cushions and simulated impacts.

The program was tested by first using it to generate the response to an acceleration function which changed from 0G to 20G suddenly at time-zero and remained constant thereafter. The solution of the differential equation [1] for x in this case can be written explicitly as a function of time:

$$x = 20 + Ae^{-cwt} \cos(Wn(1-C^2)^{\frac{1}{2}}t + \phi);$$

where

$$\phi = -\tan^{-1} \frac{C}{(1-C^2)^{\frac{1}{2}}},$$

and

$$A = \frac{20}{\cos \phi}$$

This function was evaluated using the standard mathematical functions in the computer program library. The difference between the result of the numerical integration and the analytic solution was always less than or equal to 0.3 per cent of the analytic solution over the 400-millisecond range of integration. This small error is a fair indication of the accuracy of the numerical integration.

4. RESULTS AND CONCLUSIONS

The set-up conditions and results are summarized in Tables 1 and 2 for the 95th- and 5th-percentile dummies, respectively. In general, for most of the tests, and comparing all cushion materials together, the peak chest and pelvic accelerations were within $\pm 7\%$ and $\pm 10\%$ of a mean, respectively, for each of the two body locations, respectively. Similarly, the large majority of the DRI values which were calculated from the pelvic accelerations, were within $\pm 5\%$ of a mean value. With both dummies the only exceptions occurred for the tests without cushions, and the tests with the foam-rubber cushions, in which significantly higher acceleration values were recorded: the DRI values likewise increased, but only with the foam-rubber cushions.

Eleven of the tests were repeated in order to confirm data and/or to provide an estimate of reliability: these are identified in the 3rd column of the Tables. For these repeated impacts, the peak chest and pelvic acceleration values were usually within $\pm 4\%$ of their respective means, while the DRI values were within $\pm 2\%$. Also, since the peak chest and pelvic accelerations usually differed by less than 10%, for analysis purposes it is convenient and appropriate to compare the average of these two accelerations, and the averages of repeated tests, as shown in the last column of the Tables.

An examination of the chest and pelvis accelerations indicates that their peaks appear often as a series of spikes, and are of very short duration compared to the DRI waveform peaks. This is particularly true for tests in which there is no cushion to absorb energy, or in which the cushion essentially suspends the dummy above the seat, as with the foam-rubber material, and does not hinder his movement or absorb any energy. For all cushions, the randomness and short duration of the spikes combine to cause a much larger variation in the acceleration values than is exhibited by the peak DRI values. Partly for these reasons, and for others outlined in section 3, it is recommended that more importance be placed on the averaged acceleration values than the individual chest and pelvic accelerations, and, furthermore, that, when analyzing the results and forming conclusions, the DRI values be given a higher priority.

Concerning the relative effectiveness of the different cushion materials, the following conclusions are evident from the data:

- a. with the foam-rubber cushions, the DRI increased (over the values obtained without cushions) by about 10%, 25%, and 35% for the two-, four-, and eight-inch thick cushions, respectively;
- b. for all thicknesses of the remaining materials (which are of the "energy-absorbing" type) the DRI was increased over tests without cushions by insignificant amounts ranging from 1% to 8%. On the other hand, these cushions reduced the peak accelerations by between 7% and 50%. This suggests that they may attenuate brief, high frequency forces delivered to the hips, which might reduce local injury, but that they may amplify to some extent the more slowly-changing forces which can cause more serious injury to the spine;
- c. unlike the results given in Reference 1, with the foam-rubber cushions, the 5th-percentile dummy exhibited slightly lower DRI values than were obtained with the 95th-percentile dummy. Normally, it would be expected that the heavier dummy would initially sink further into the cushion than the lighter one, thereby reducing the amount of remaining "free-fall" for the dummy during the impact. This, in turn, would reduce the severity of the second or "bottoming" impact of the heavier dummy with the seat pan. The most likely explanation for this discrepancy may be found by noting that the static deflections for the foam-rubber cushions were higher for the 5th-percentile dummy than for the 95th-percentile, which is opposite to what one would normally expect. This would produce lower DRI values for the 5th-percentile, as observed, and implies that, in these cases, there may have been some error in the preloading procedure.

It can be concluded that the use of any of the energy absorbing cushions results in a small but insignificant increase in the risk of spinal injury. There did not appear to be any meaningful difference between these cushion types, and therefore there is no overall difference in their value when they are considered as impact-protection devices only. However, foam-rubber cushions, particularly those 4-inches and thicker, increase the risk of spinal injury appreciably, with the severity of the injury increasing as the thickness of the foam increases.

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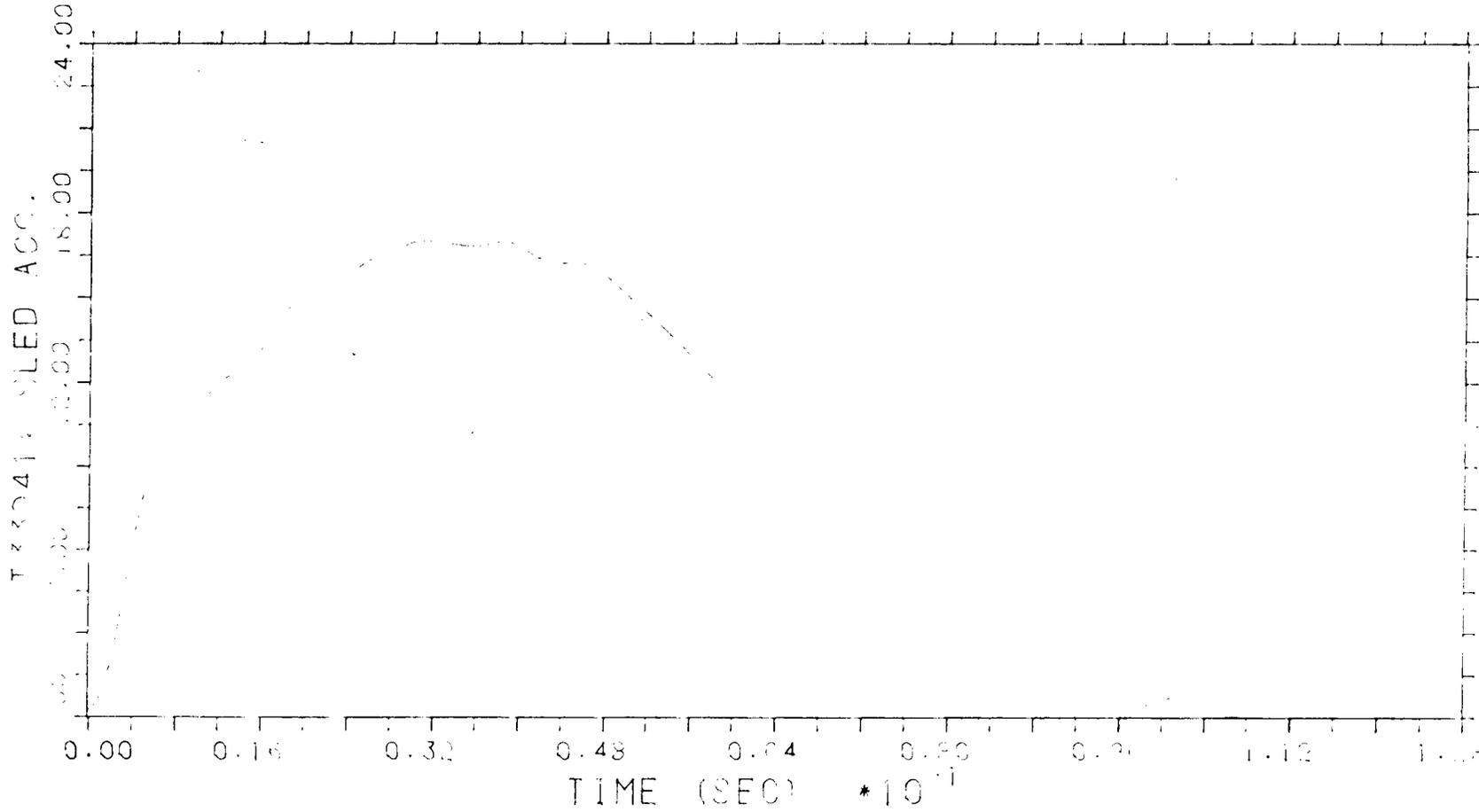


FIGURE 1: ACCELERATION PULSE USED FOR ALL TESTS



FIGURE 2: SLED SEAT SET-UP WITH 95th- and 5th PERCENTILE DUMMIES

TABLE 1: TEST CONDITIONS AND RESULTS FOR THE 95th-PERCENTILE DUMMY

Run Number		Cushion Thickness and Material	Static Deflection (inches)	Peak D.R.I. (G)	Peak Acceleration (G)					
MLSD	HyGe				Chest	Pelvis	Average			
0	925	None	0	27.9	27.6	31	29	34	30.5	
0	926	None Repeat	0	27.4		27	30	32		
1	944	2" T-50	1/4	28.8	30.5	31		25	28	
6	927	4" T-50	1/4	28.8		27		24		
6	954	4" T-50 Repeat	1/4	28.8		37	31	25		25
6	928	4" T-50	3/8	33.8		29		26		
11	940	8" T-50	1/4	29.3		30		27	28.5	
2	943	2" T-47	1/8	28.6		27		24	25.5	
7	929	4" T-47	1/4	29.4		28		26		
7	932	4" T-47 Repeat	1/4	29.4	29.3	29	29	25	25	
7	934	4" T-47	1/4	29.0		31		24		
12	939	8" T-47	-----	28.6		31		25	28	
3	945	2" T-41	1/2	28.6		29		25	27	
8	930	4" T-41	5/8	29.3		30		24	27	
13	938	8" T-41	1 1/8	26.6	26.9	23	24	20	20	
13	942	8" T-41 Repeat	1 1/2	27.2		25		21		
4	946	2" Foam-Rubber	3/4	31.3		46		46	46	
9	931	4" Foam-Rubber	7/8	35.5	35.7	70	69	82		83
9	933	4" Foam-Rubber Repeat	1 3/4	35.9		68		83		
14	937	8" Foam-Rubber	1 1/4	37.6		84		94		
5	947	2" Ethafoam 45	1/4	28.6		25		24	24.5	
10	936	4" Ethafoam 45	1/4	28.6		25		22	23.5	
15	941	8" Ethafoam 45	0	28.0		25		22	23.5	
16	948	1" T-41, 1" T-47	3/8	29.0		29		24	26.5	
17	949	1" T-41, 2" T-47	-----	28.8		29		25	27	
18	950	1" T-41, 3" T-47	1/2	28.6		28		25	26.5	
19	951	1" T-41, 1" T-47, 1" T-50	1/2	28.7		27		24	25.5	
20	953	Labrador (1" T-41, 1" T-47 cut-out, 1" T-47)	1/4	29.0		26		24	25	
21	952	Tracker (1/2" pink, 1" T-41, 2" T-47)	1/2	29.4		30		26	28	

TABLE 2: TEST CONDITIONS AND RESULTS FOR THE 5th-PERCENTILE DUMMY

Run Number		Cushion Thickness and Material	Static Deflection (inches)	Peak D.R.I. (G)	Peak Acceleration (G)				
MLSD	HyGe				Chest	Pelvis	Average		
0	925	None	0	26.4	26.9	44	48	58	56
0	926	None Repeat	0	27.3		52	64	64	
1	944	2" T-50	1/4	27.1	27.7	27	27	27	27
6	927	4" T-50	1/4	28.4		34	30	32	
6	928	4" T-50 Repeat	1/8	27.1		26	26	26	
11	939	8" T-50	1/4	27.4	26	26	26	26	
2	943	2" T-47	3/8	27.0	27.3	27	26	26	26.5
7	930	4" T-47	-----	27.2		27	28	27	
7	935	4" T-47 Repeat	1/2	27.5		28	28	28	
12	941	8" T-47	3/8	27.7	27	26	26	26.5	
3	945	2" T-41	5/8	27.9	27.8	25	22	22	24
8	929	4" T-41	1	27.7		26	24	24	
8	932	4" T-41 Repeat	1 5/8	27.8		26	26	22	
8	934	4" T-41	1 1/2	28.0		27	23	23	
13	937	8" T-41	2 5/8	29.5		25	25	24	
13	942	8" T-41 Repeat	2	28.5	24	22	23	24	
4	946	2" Foam-Rubber	1	29.4	32.5	55	65	60	88
9	931	4" Foam-Rubber	1 3/8	33.5		84	83	98	
9	933	4" Foam-Rubber Repeat	1 5/8	31.5		81	88	93	
14	938	8" Foam-Rubber	1 5/8	35.8		79	82	80	
5	947	2" Ethafoam 45	1/8	28.2	25	23	24	24	
10	936	4" Ethafoam 45	1/4	29.1	26	25	26	26	
15	940	8" Ethafoam 45	1/4	29.2	26	23	24.5	24.5	
16	948	1" T-41, 1" T-47	1/2	27.5	26	22	24	24	
17	949	1" T-41, 2" T-47	-----	27.1	25	22	23.5	23.5	
18	950	1" T-41, 3" T-47	1/2	27.2	24	22	23	23	
19	951	1" T-41, 1" T-47, 1" T-50	1/2	27.5	24	23	24	24	
20	952	Labrador (1" T-41, 1" T-47 cut-out, 1" T-47)	1/2	27.4	25	24	25	25	
21	953	Tracker (1/2" pink, 1" T-41, 2" T-47)	7/8	27.8	27	26	26.5	26.5	

APPENDIX A

CHEST AND PELVIC INERTIAL DATA

AND PELVIC DRI VALUES

The inertial data are grouped in chronological order by HyGe run number. Plots are presented for each run in the following order:

Page Two: 95th-Percentile - Chest acceleration in the x-direction
Chest acceleration in the y-direction
Chest acceleration in the z-direction
Resultant chest acceleration

Page Three: 95th-Percentile - Pelvic acceleration in the x-direction
Pelvic acceleration in the y-direction
Pelvic acceleration in the z-direction
Resultant pelvic acceleration

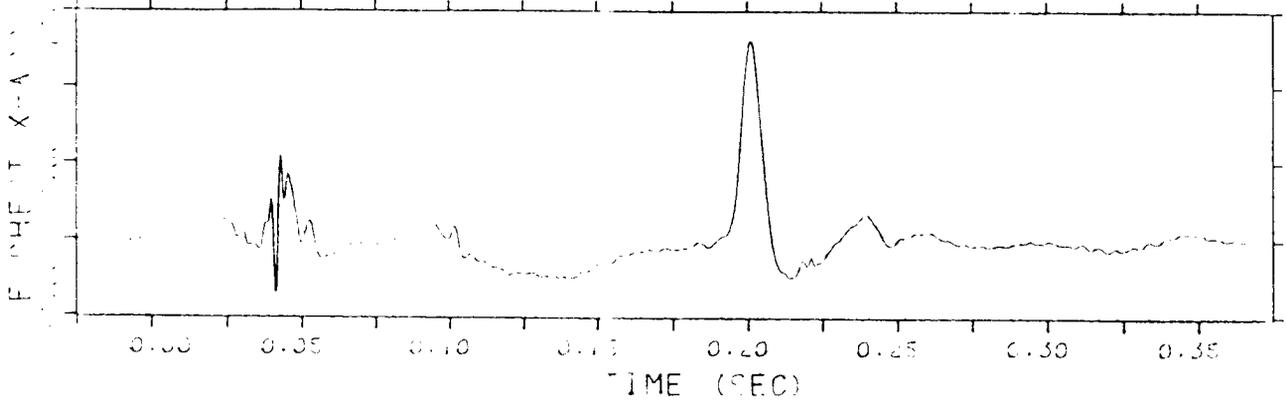
Page Four: 5th-Percentile - Plot type and order as per page two

Page Five: 5th-Percentile - Plot type and order as per page three

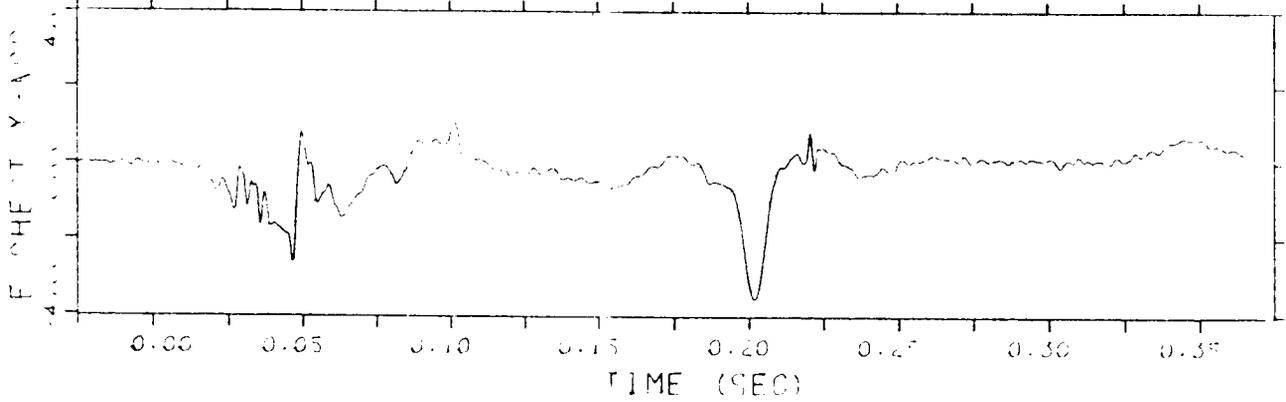
The identifying run number appears as the last 3 digits in the upper left corner of each page. Also, the "E" (east) and "W" (west) suffixes at the top center, of each page designate that the data is for 95th- and 5th-percentile dummies, respectively.

The plots of DRI value for each run are grouped together by run number after the inertial plots. The run number for each pair of plots appears above and near the left side of each (East) 95th-Percentile plot.

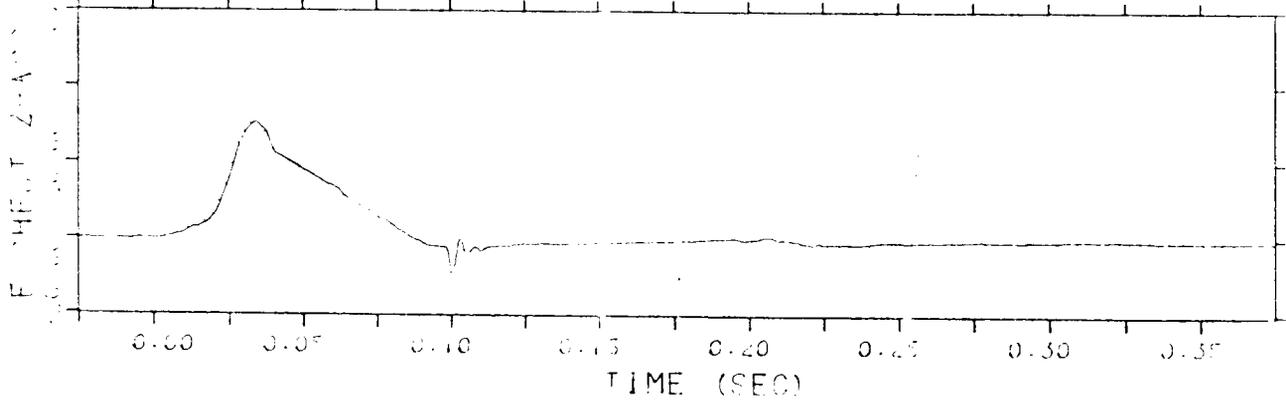
MAX=13.1



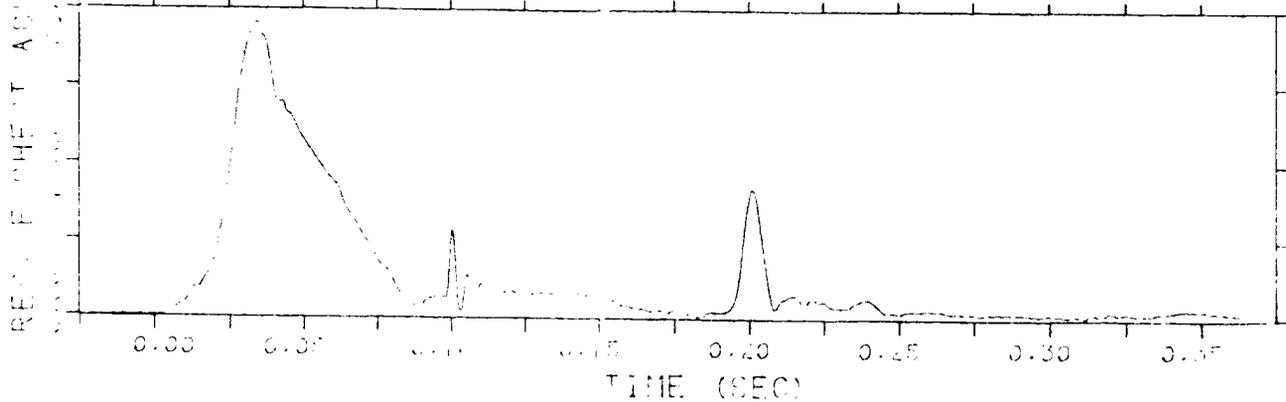
MIN=-3.58



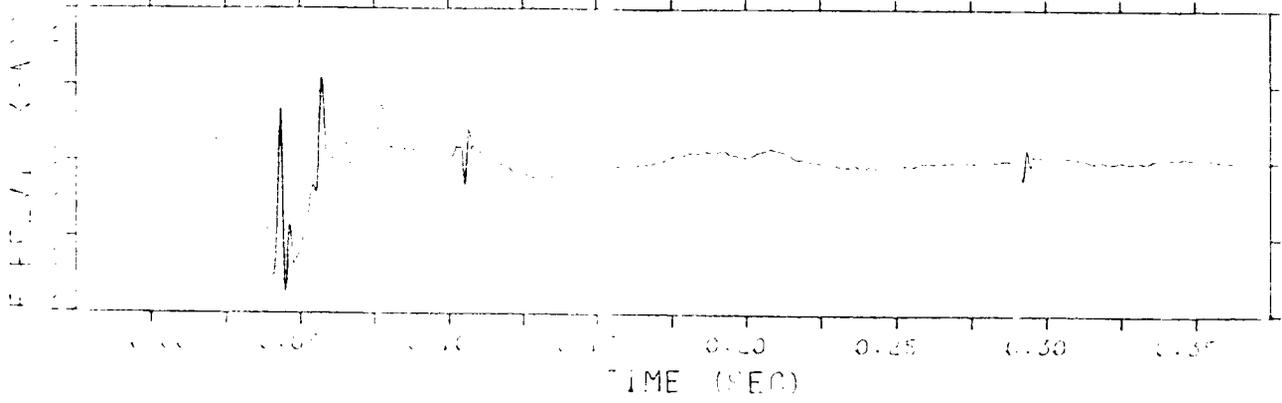
MAX=30.7



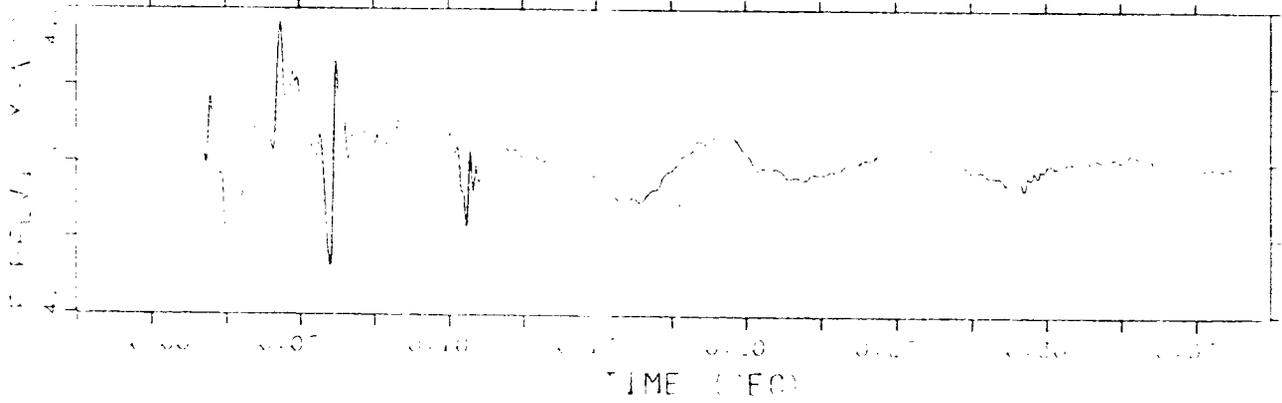
MAX=30.7



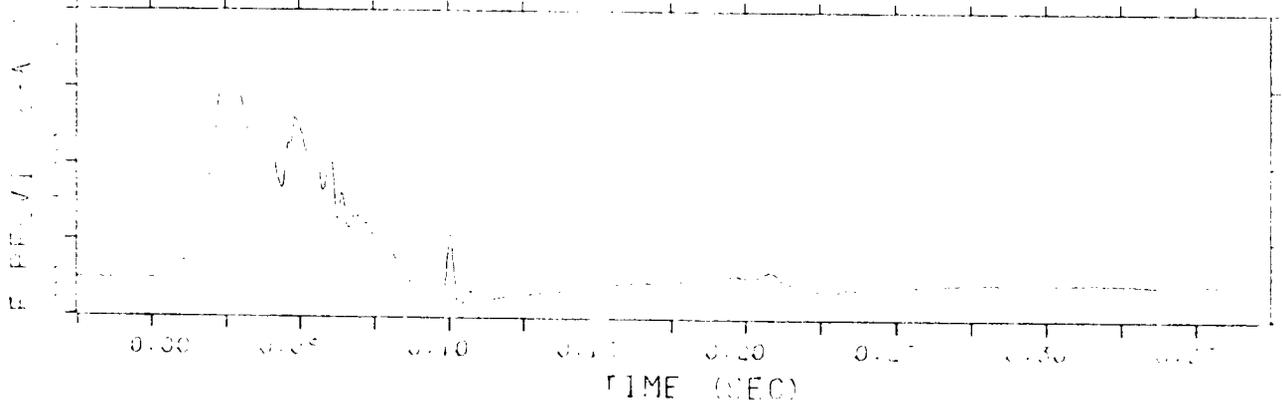
MIN=-0.75



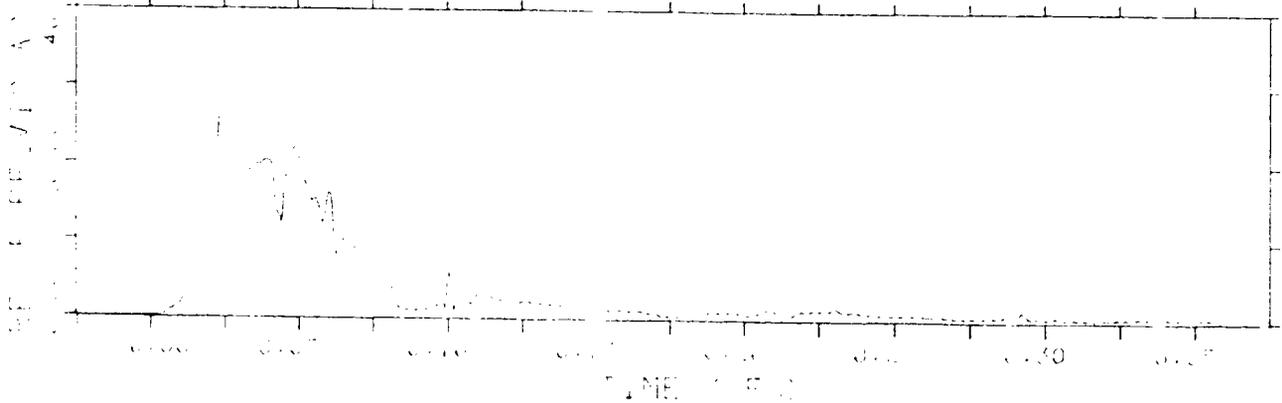
MAX=3.75



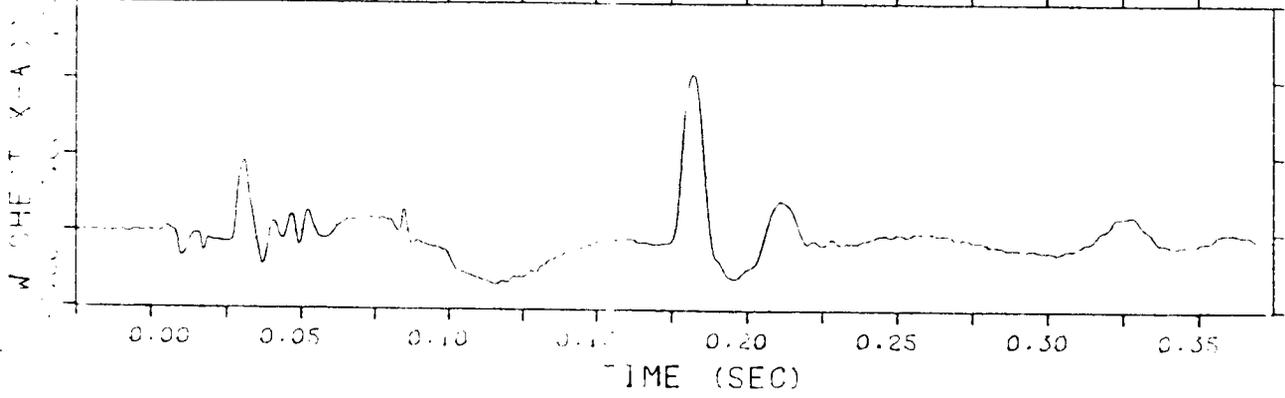
MAX=3.4



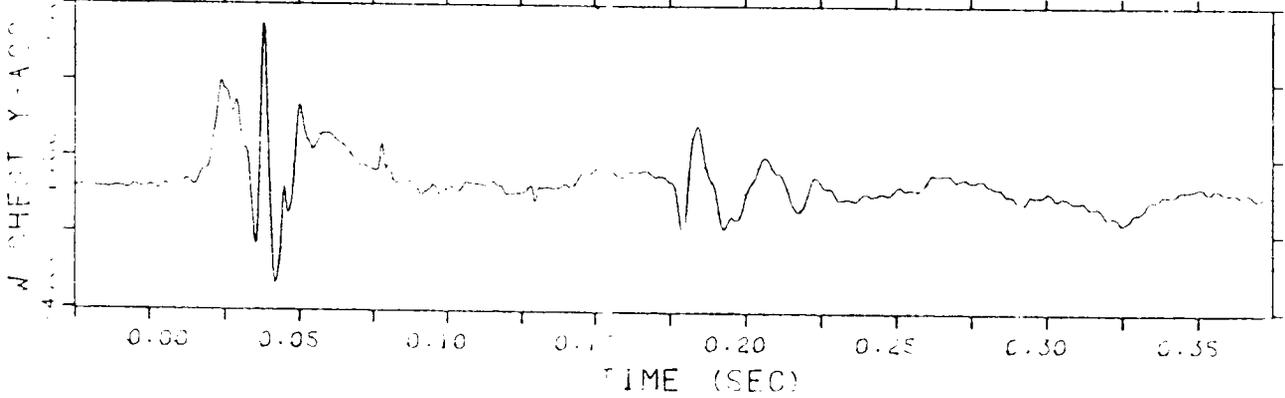
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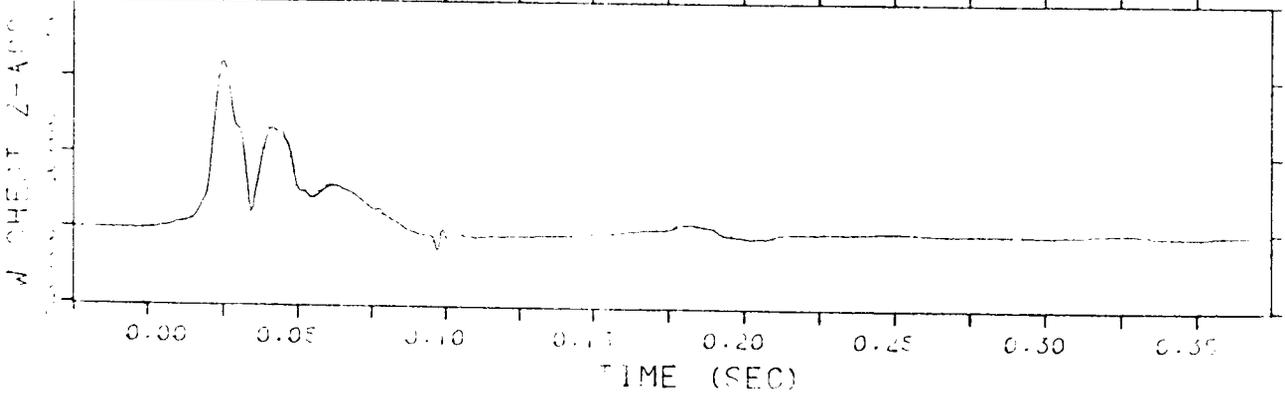
MAX=10.4



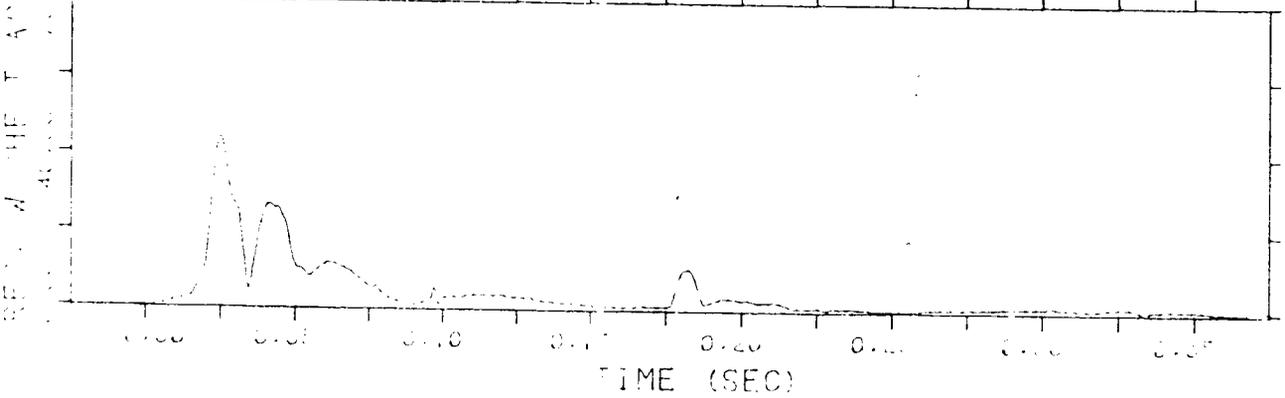
MAX=5.30



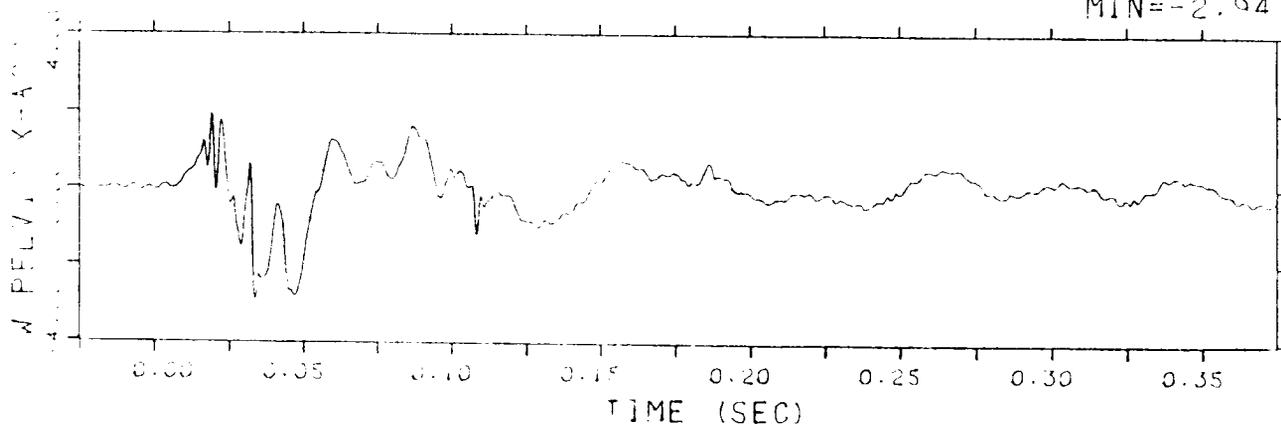
MAX=44.2



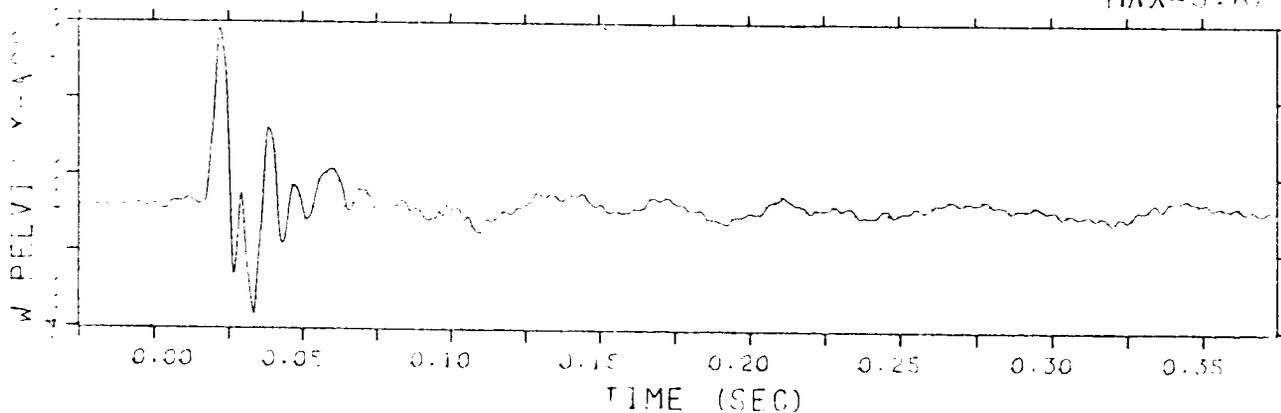
MAX=44.3



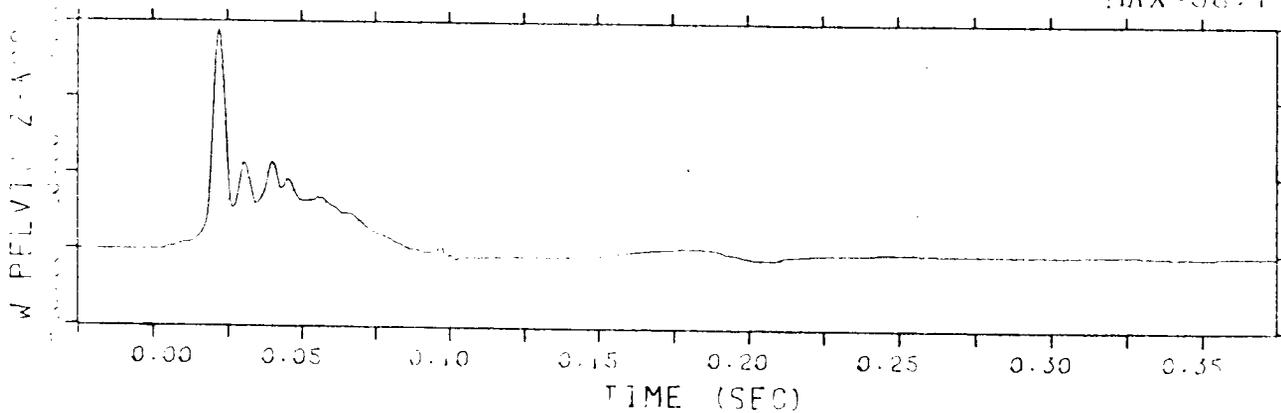
MIN=-2.94



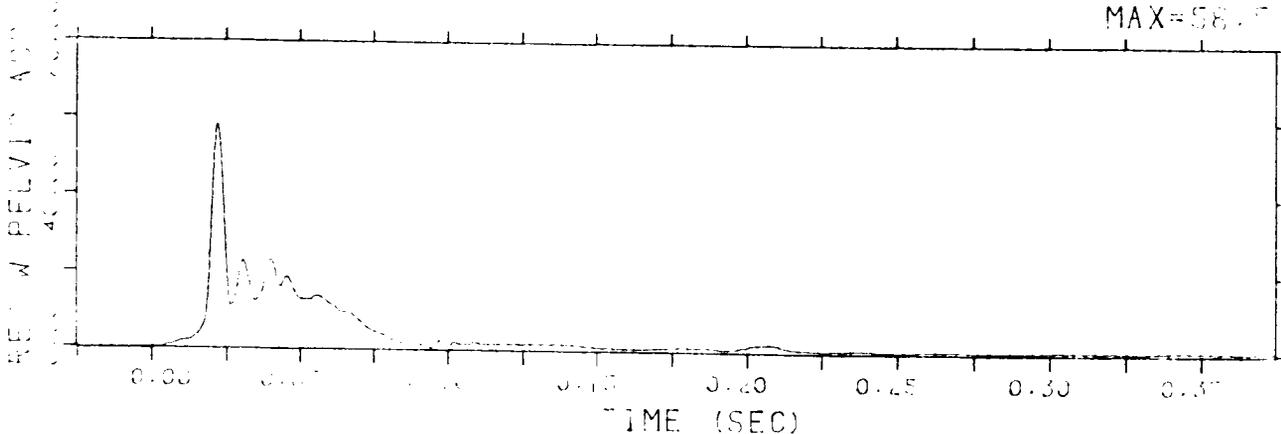
MAX=5.87



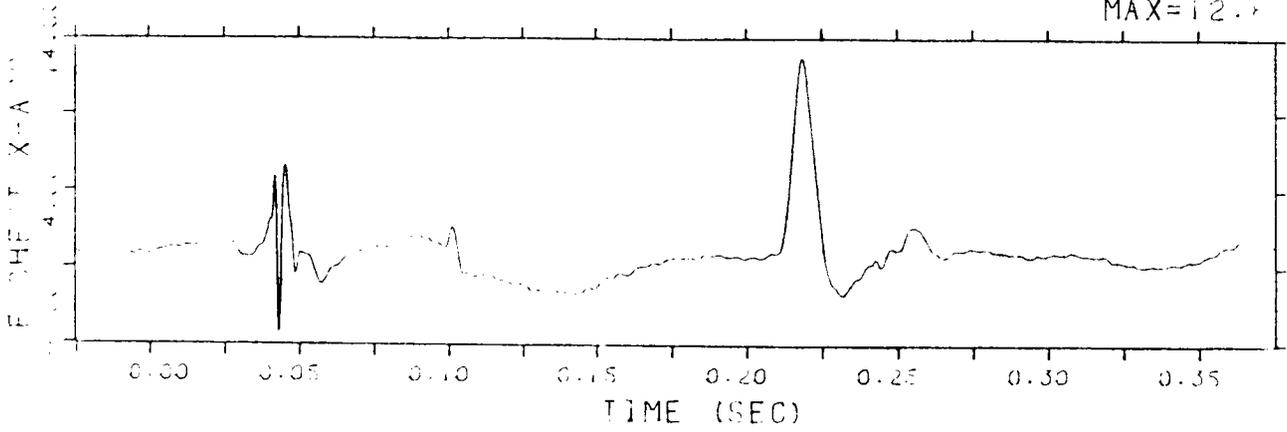
MAX=58.1



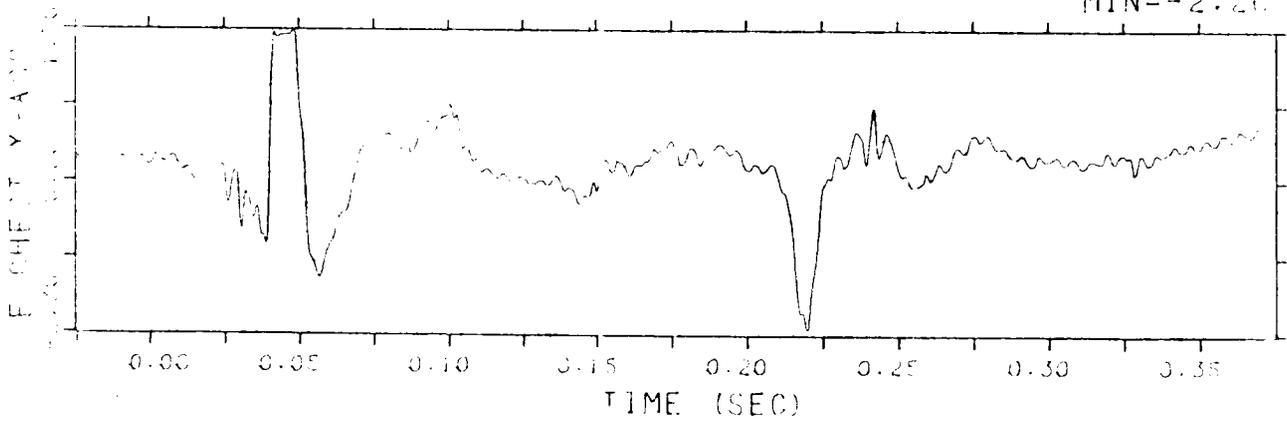
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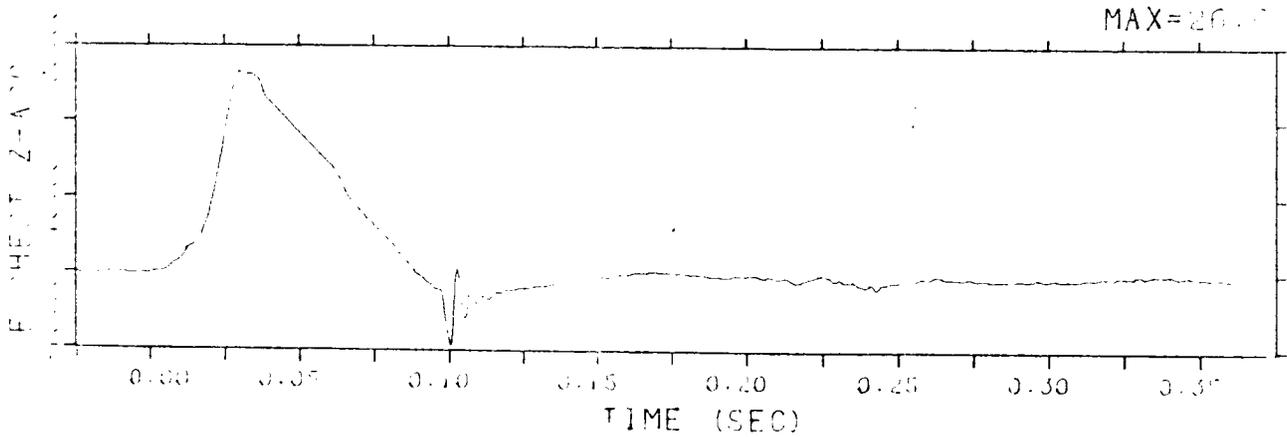
MAX=12.7



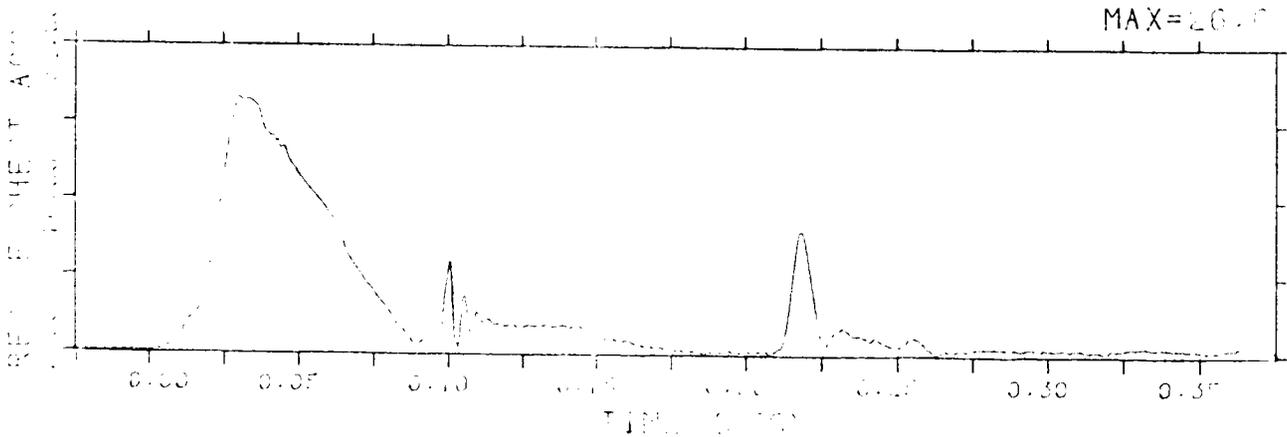
MIN=-2.20



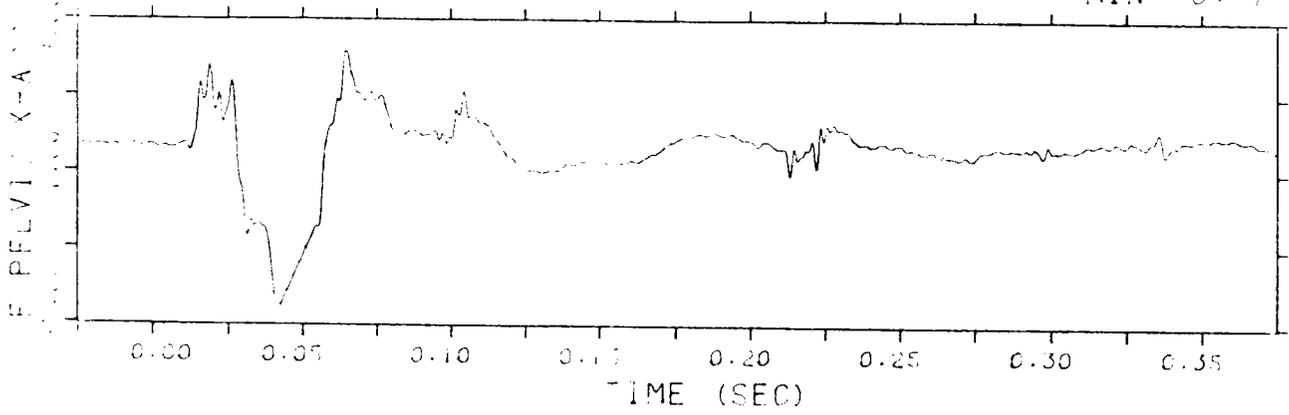
MAX=26.7



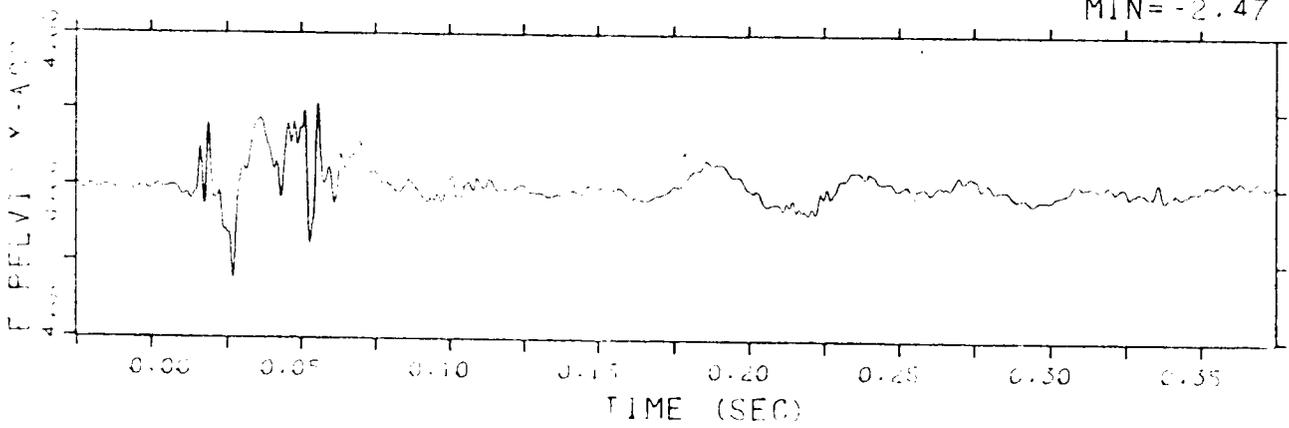
MAX=26.7



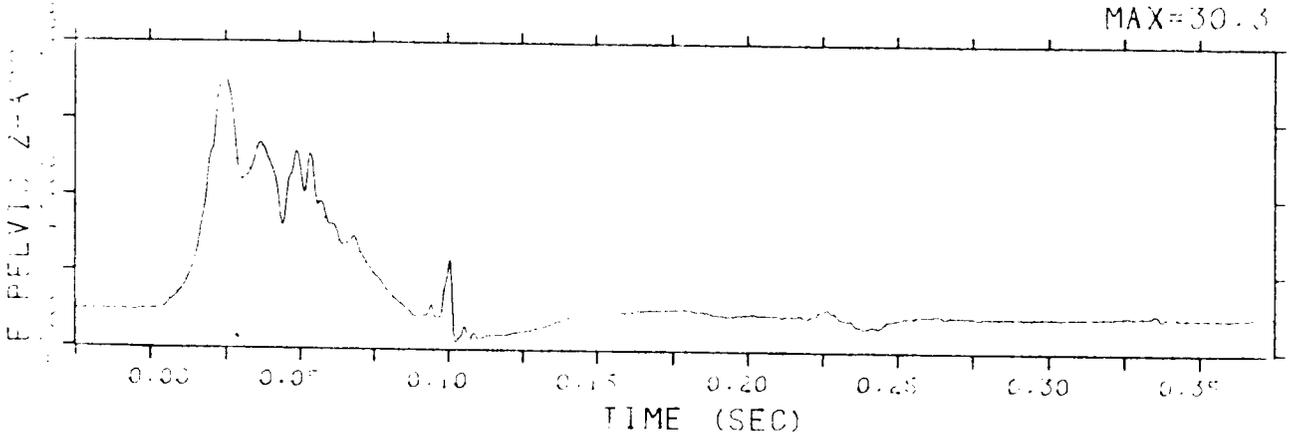
MIN=-6.47



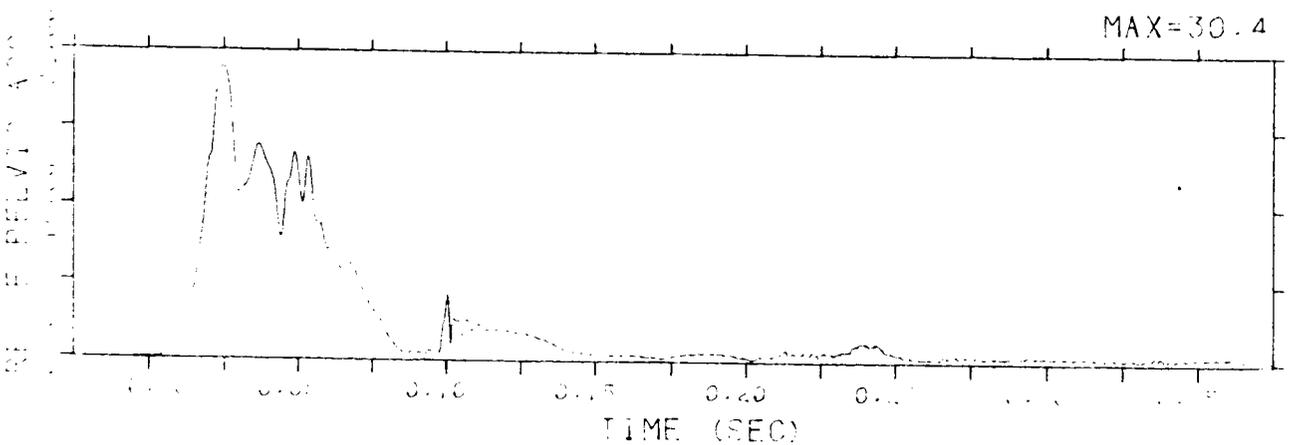
MIN=-2.47



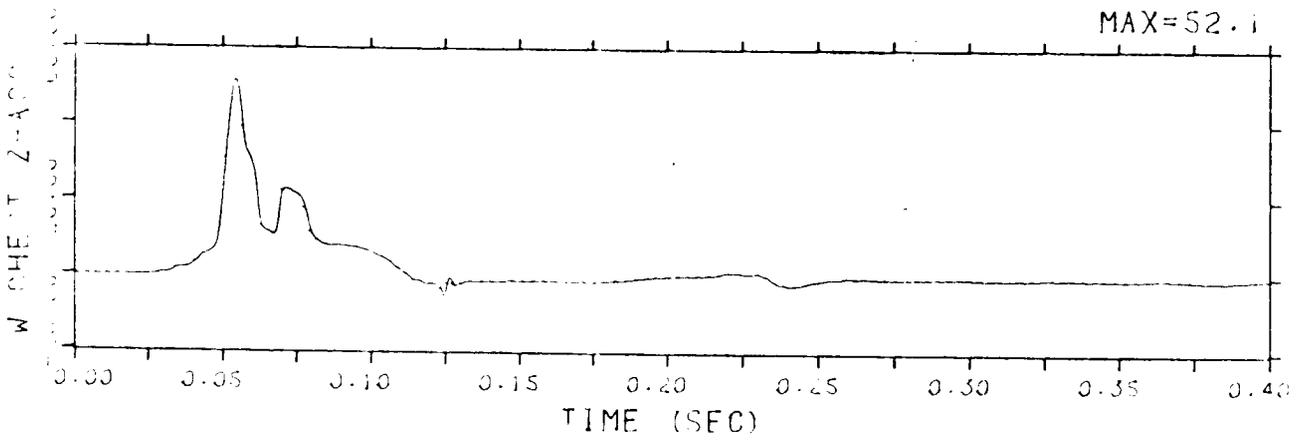
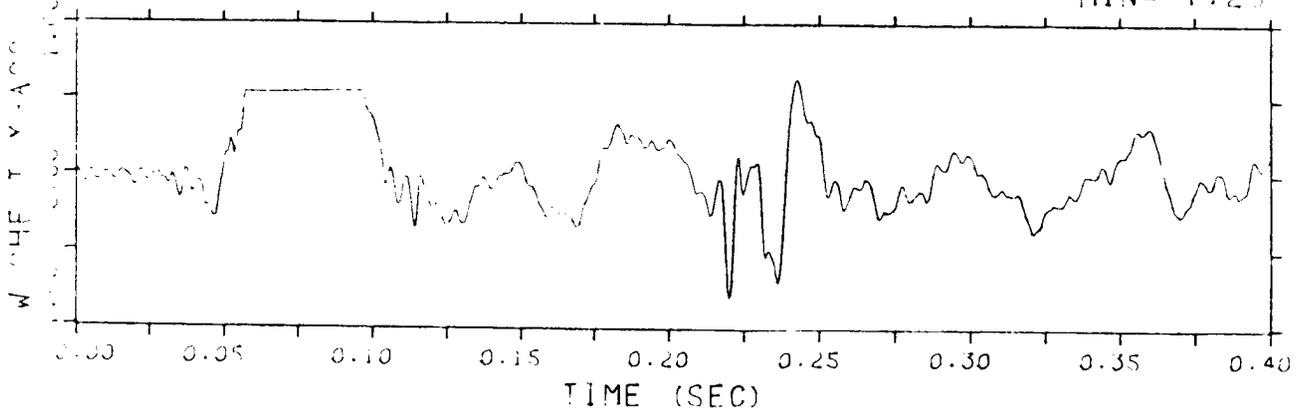
MAX=30.3



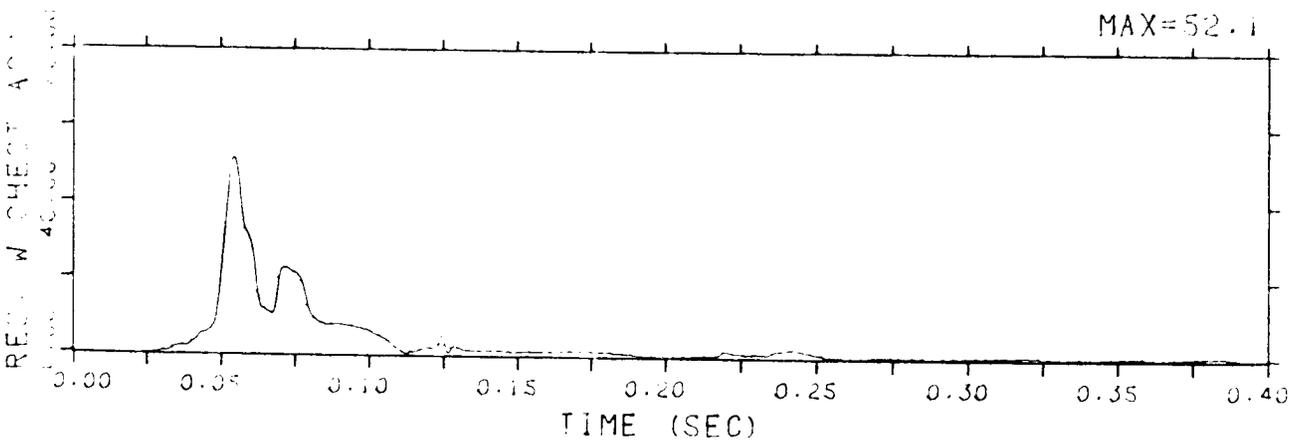
MAX=30.4



MIN=-1.29

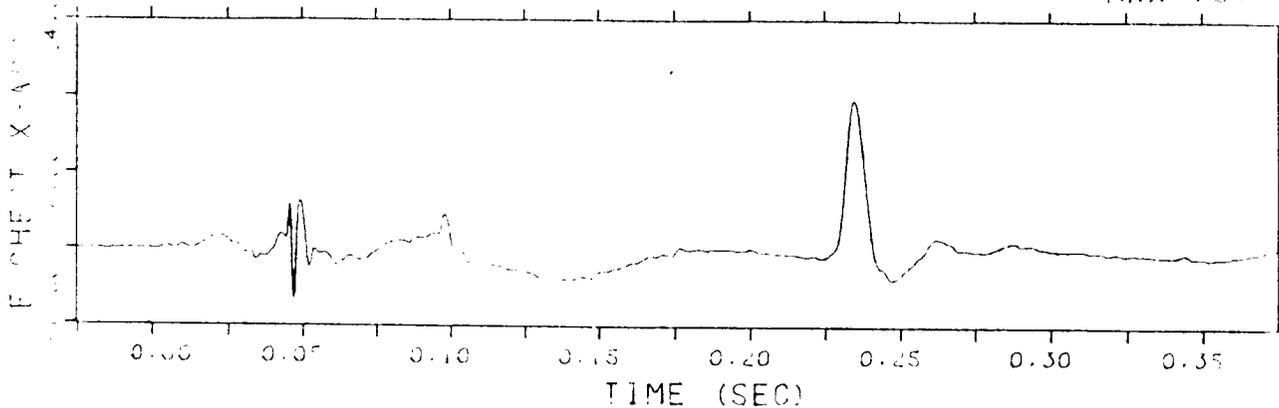


MAX=52.1

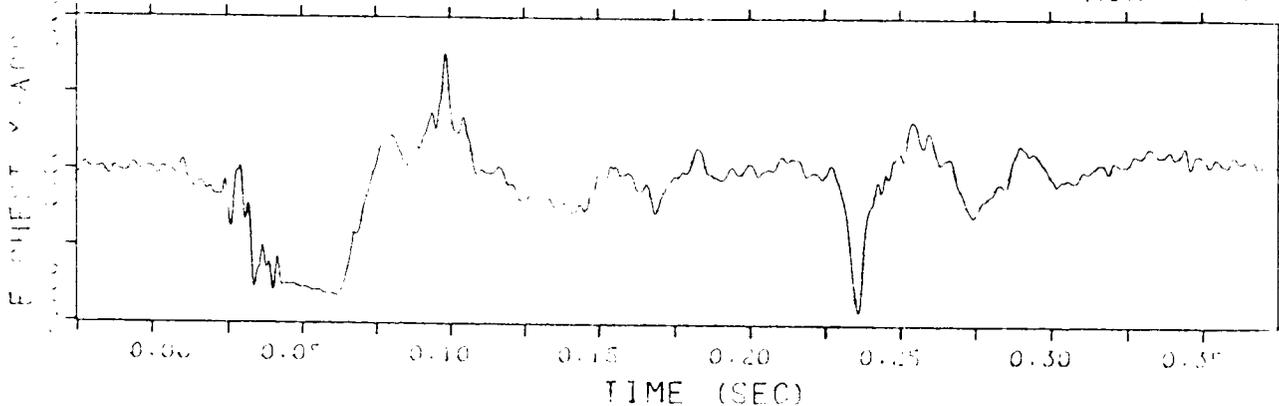


MAX=52.1

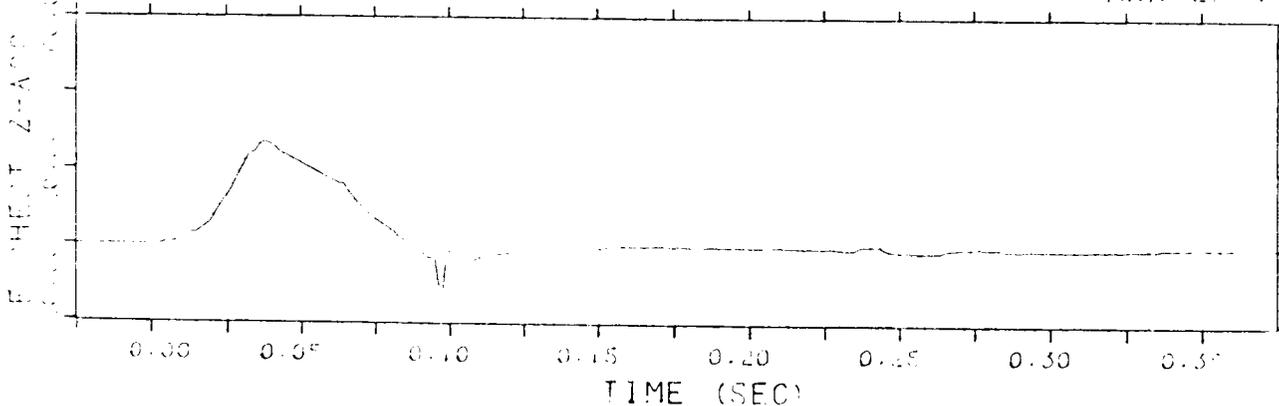
MAX=15.1



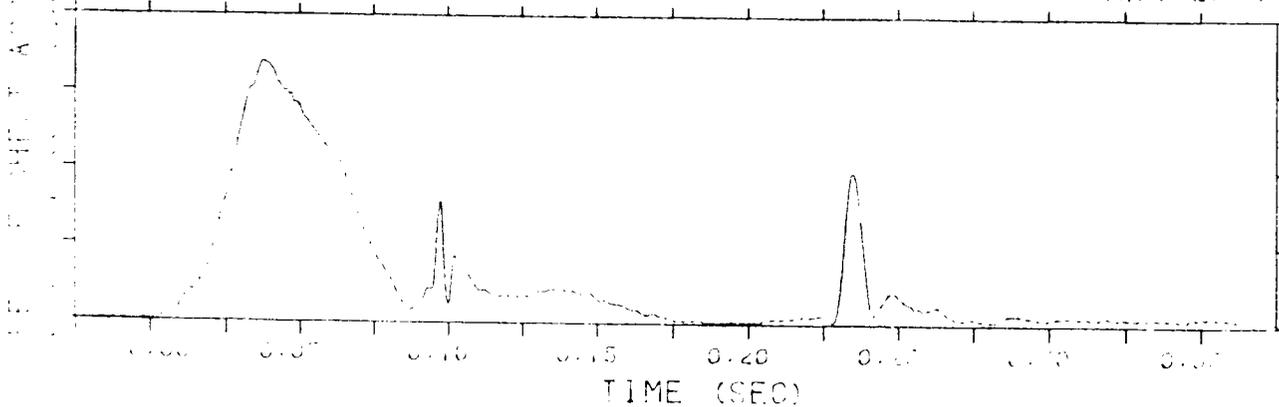
MIN=-1.85



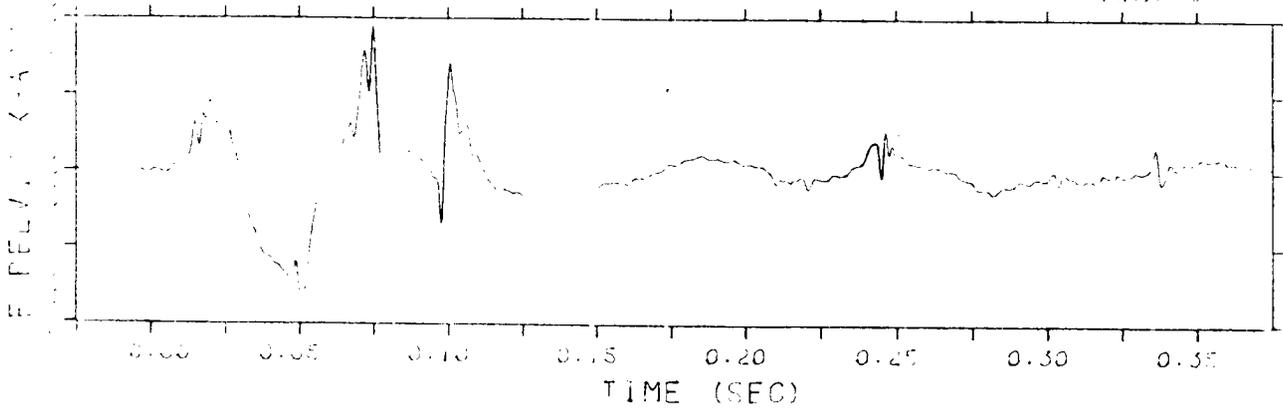
MAX=27.1



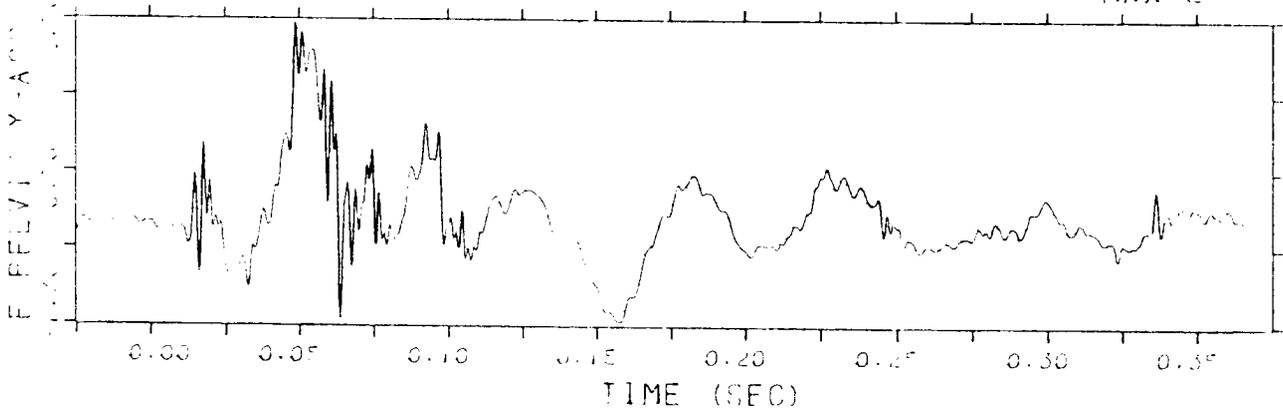
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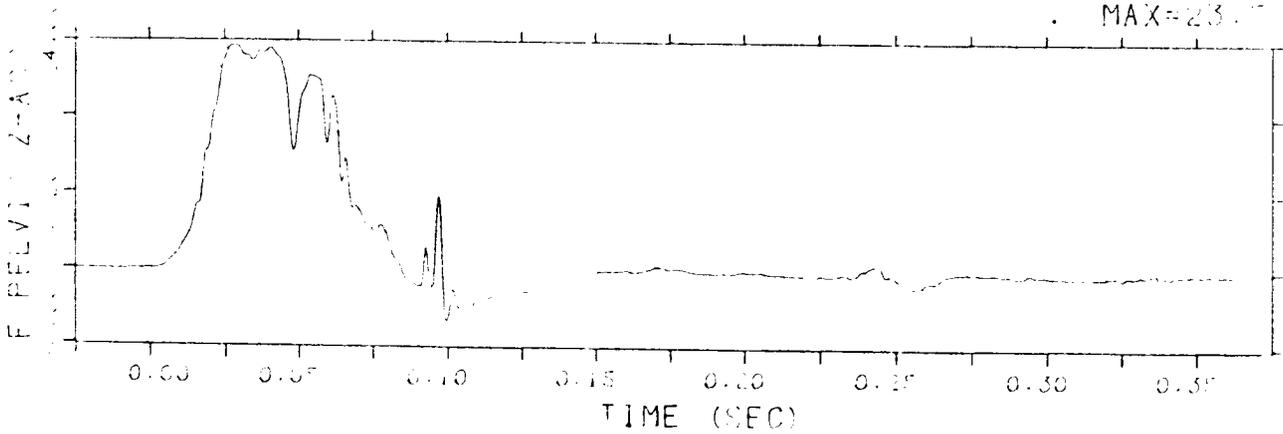
MAX=5.74



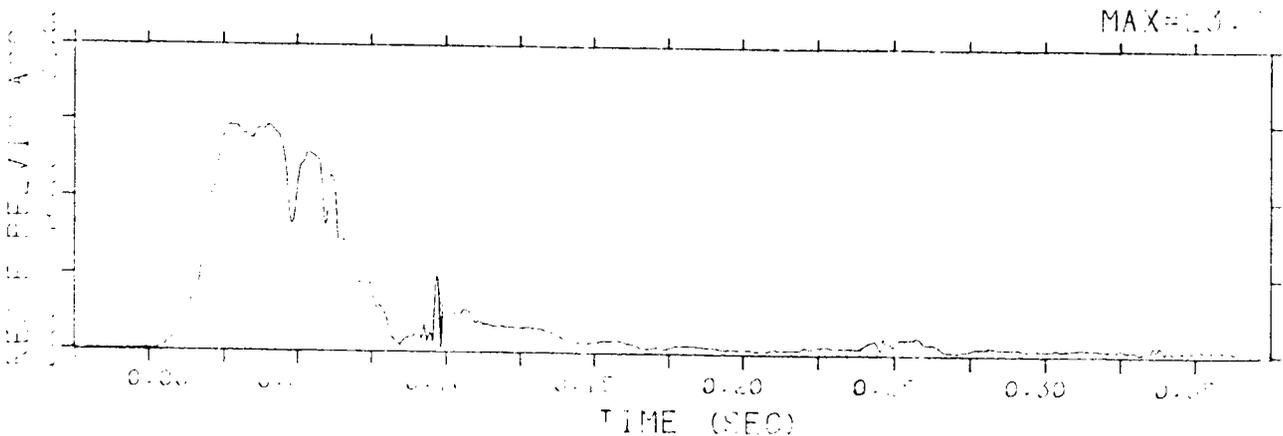
MAX=21.07



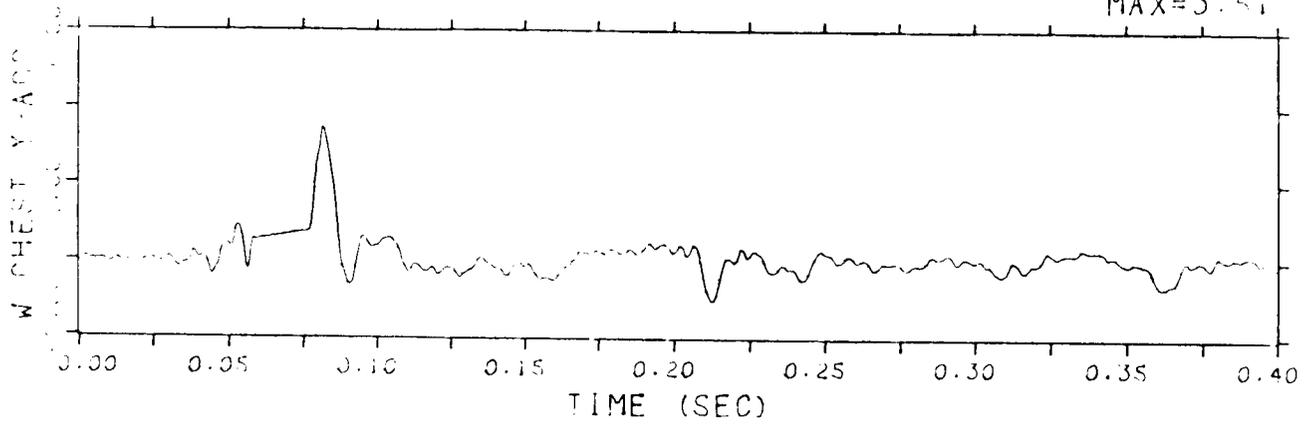
MAX=23.17



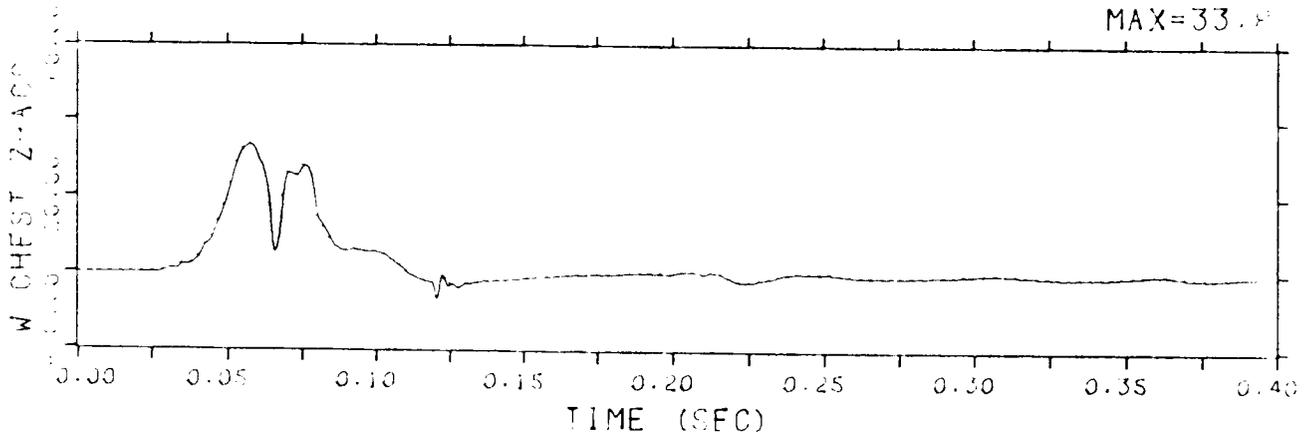
MAX=13.17



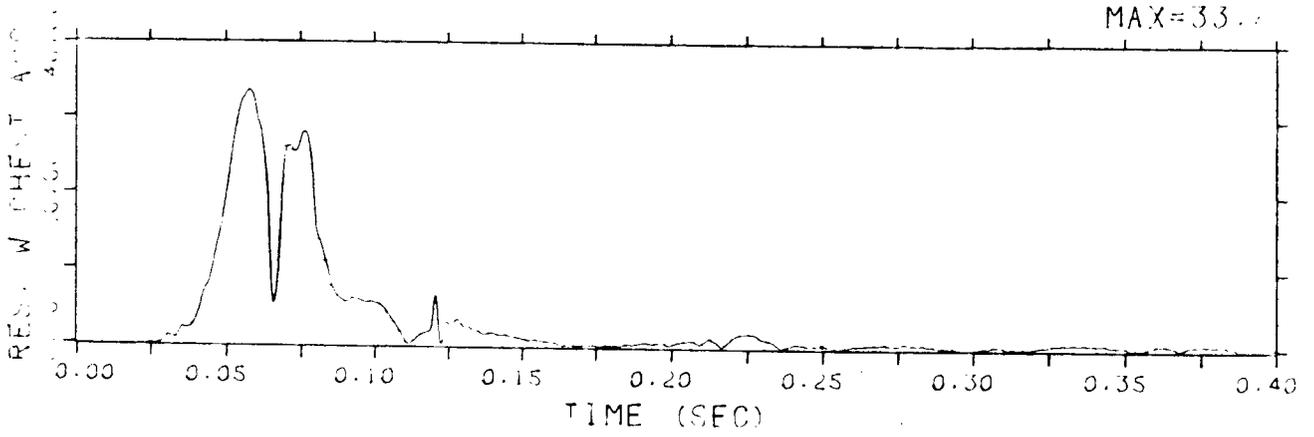
MAX=3.51



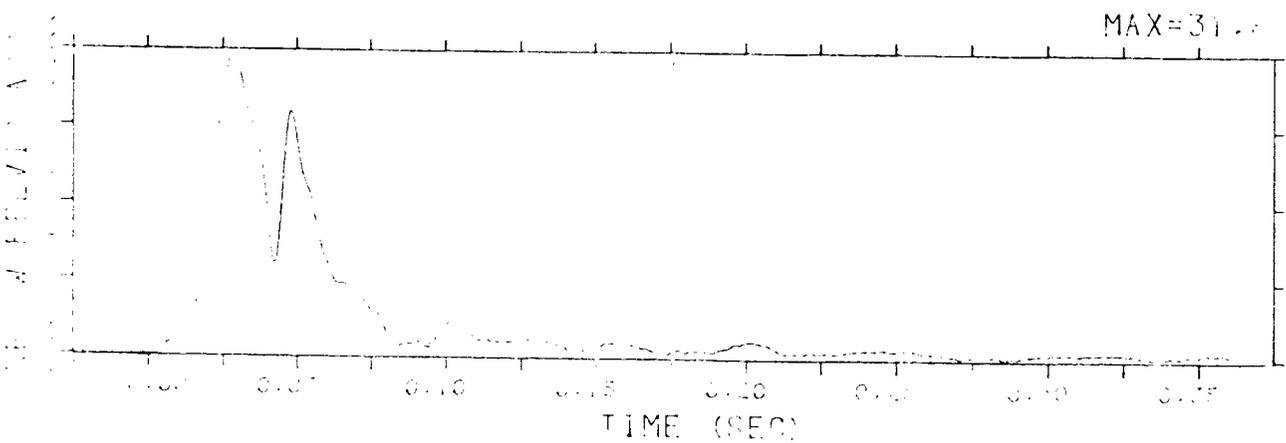
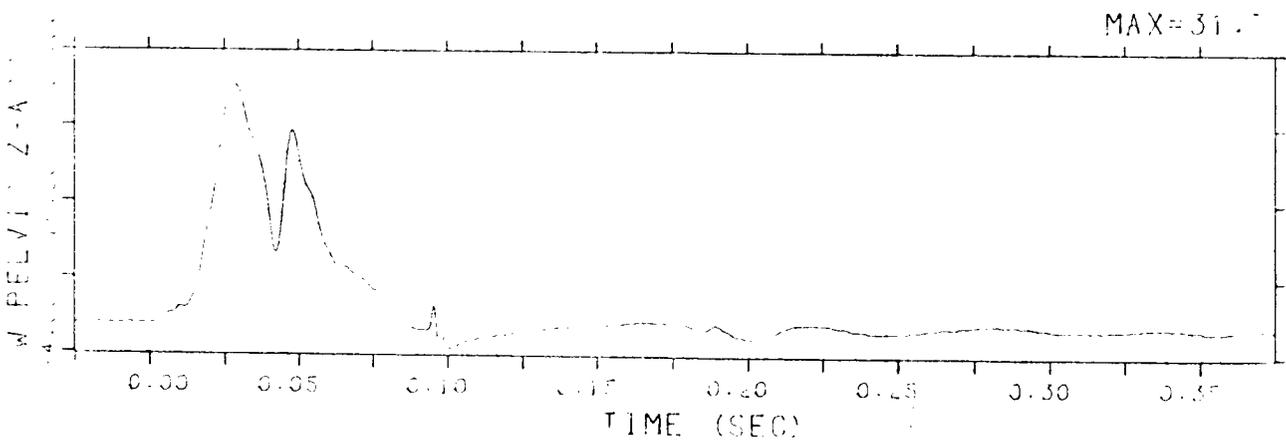
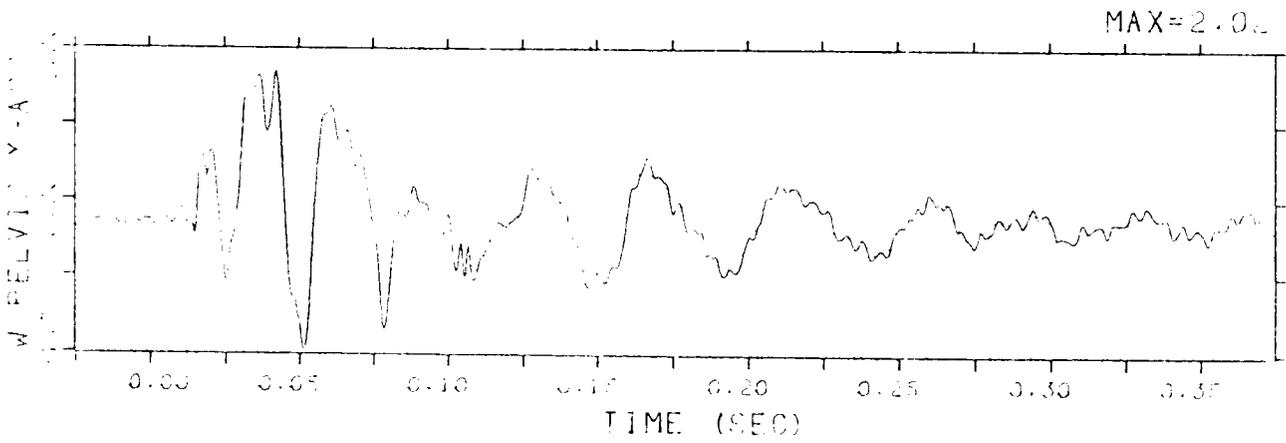
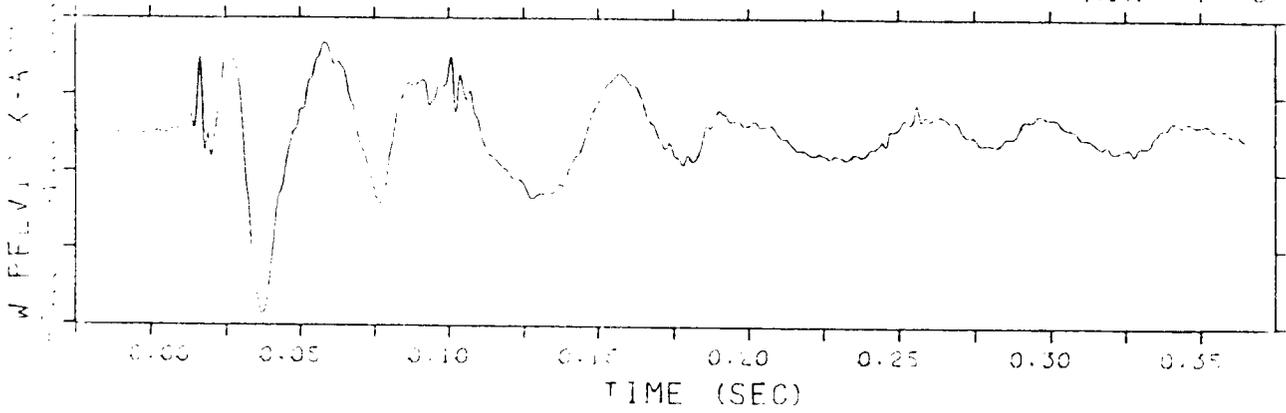
MAX=33.8



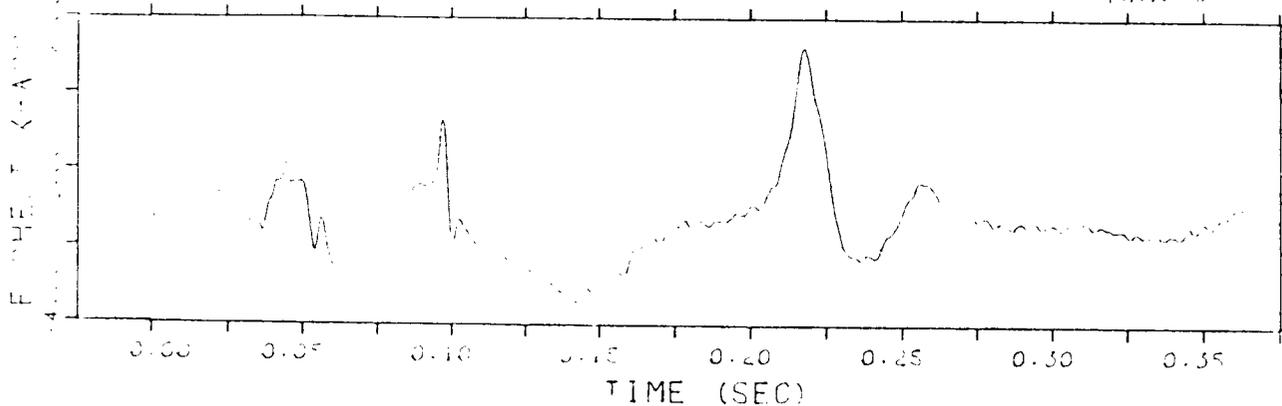
MAX=33.7



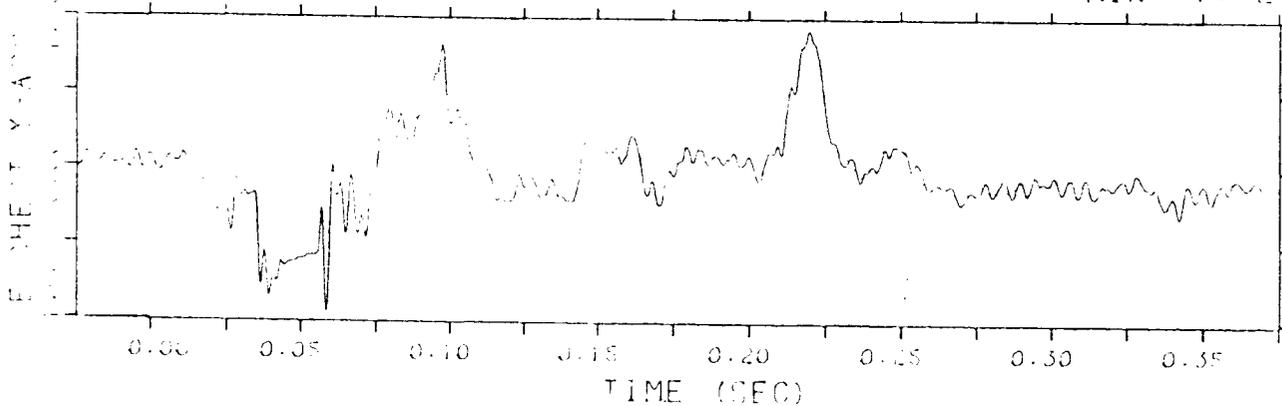
MIN=-4.73



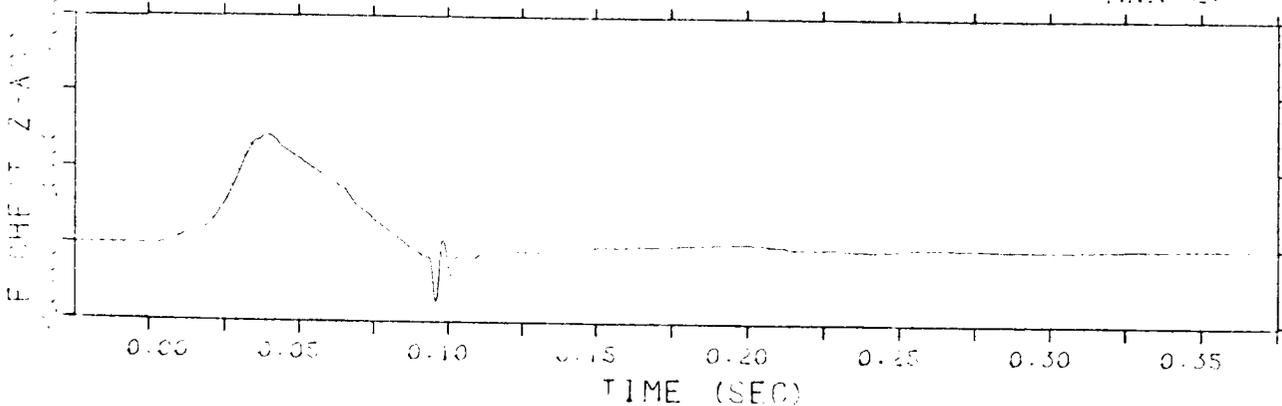
MAX=0.87



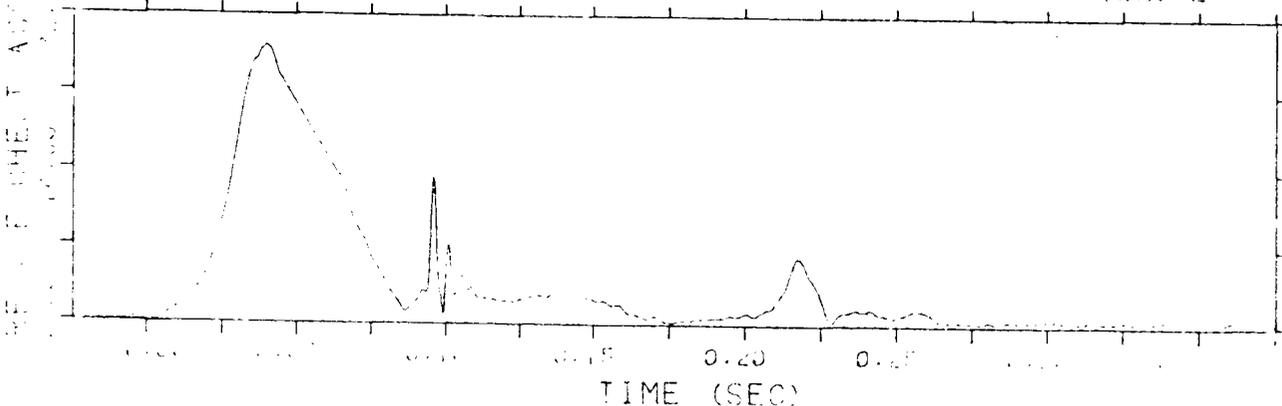
MIN=-1.72



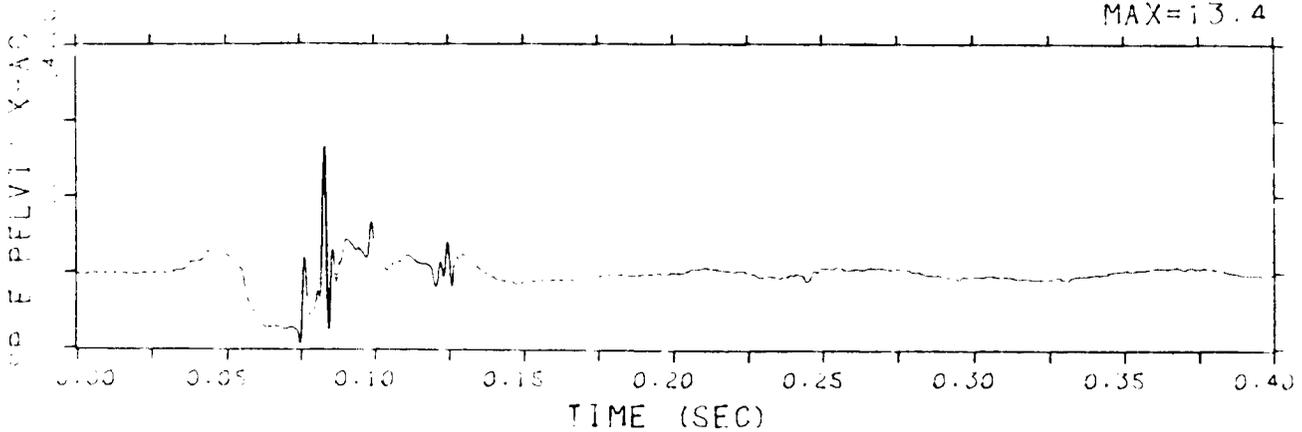
MAX=20.77



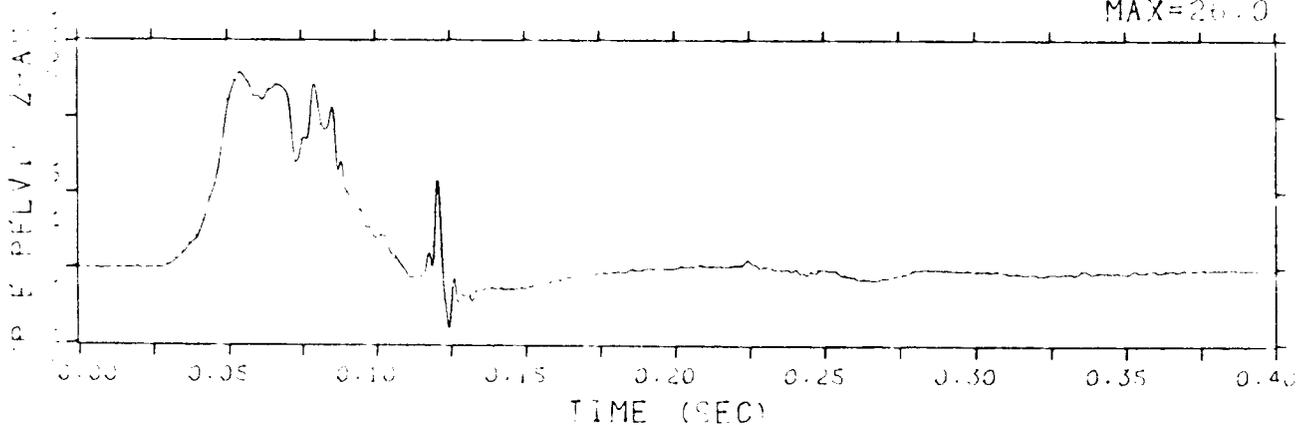
MAX=27.77



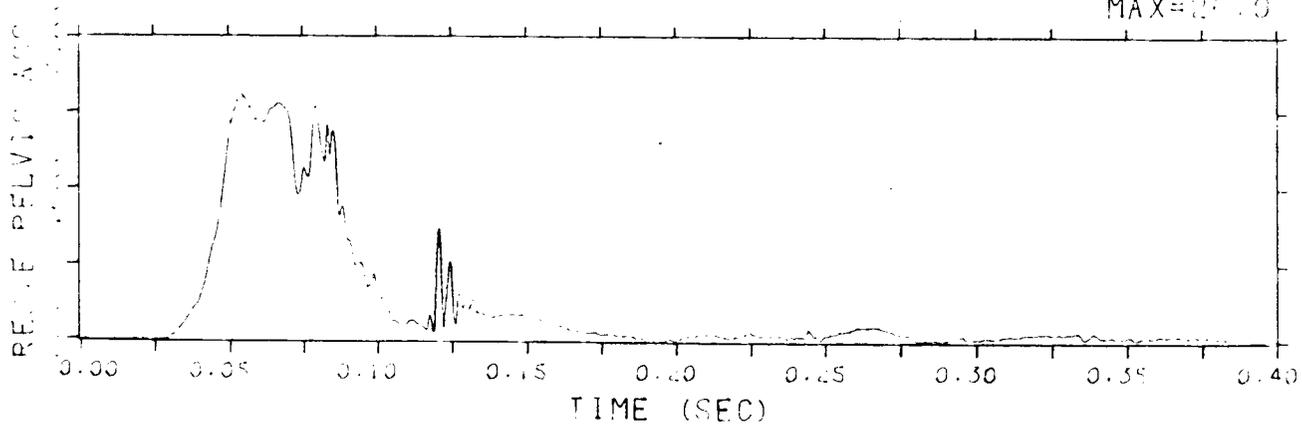
MAX=13.4



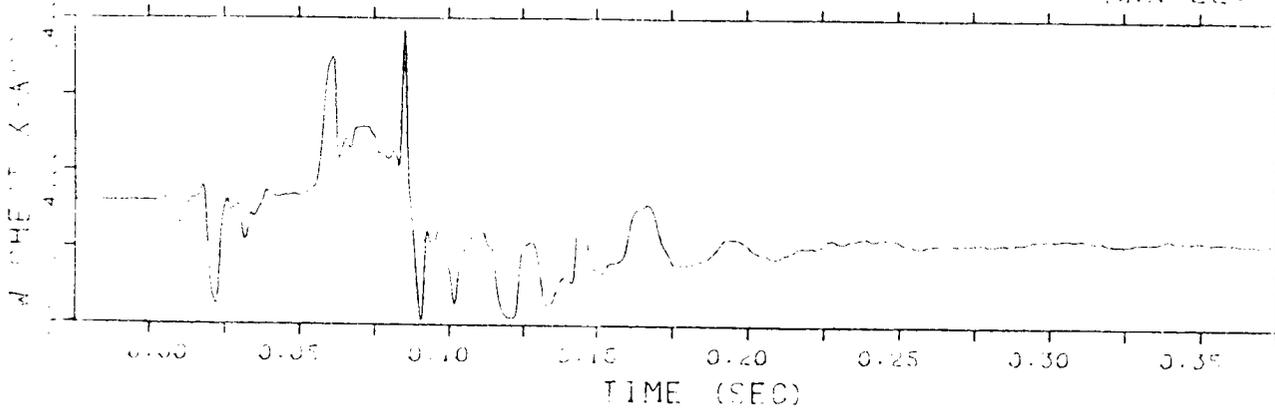
MAX=26.0



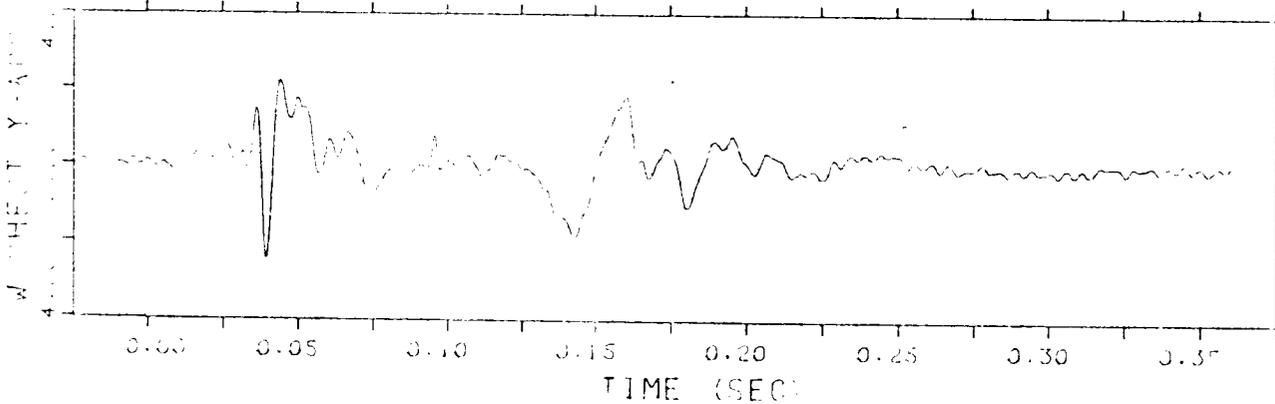
MAX=26.0



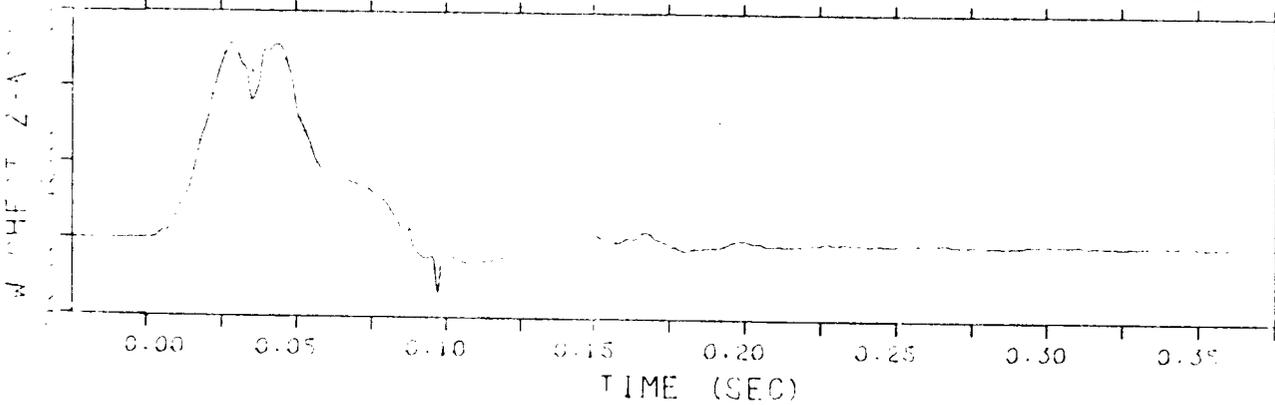
MAX=22.7



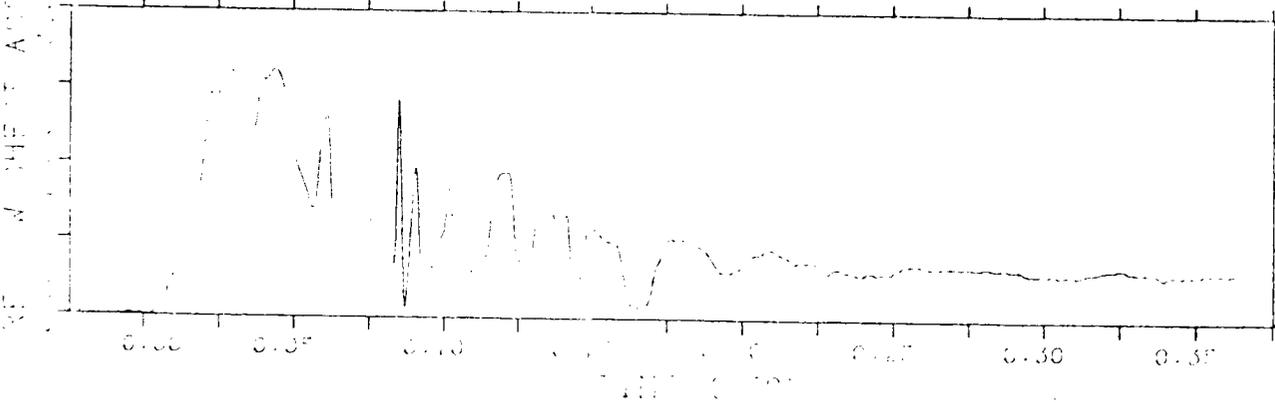
MIN=-2.46



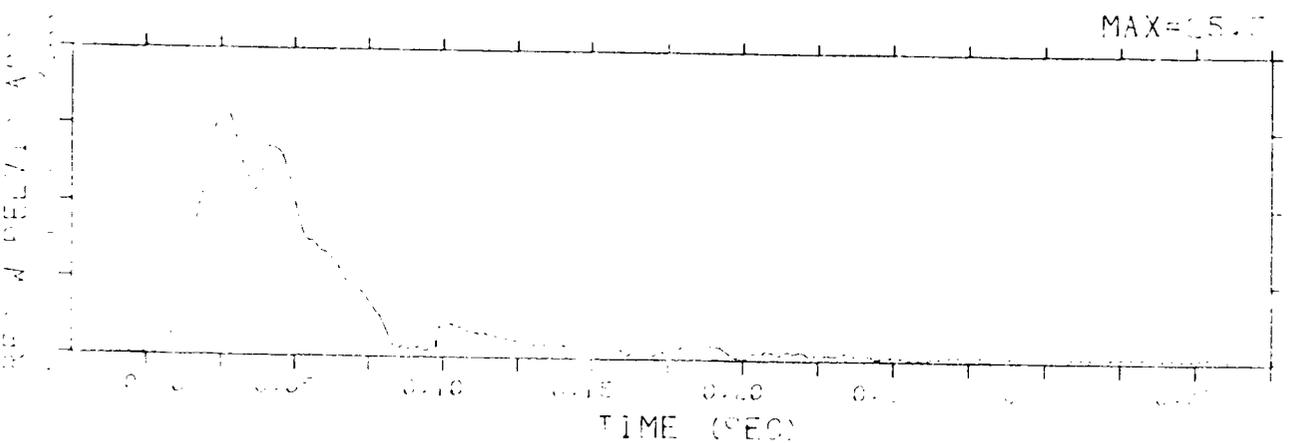
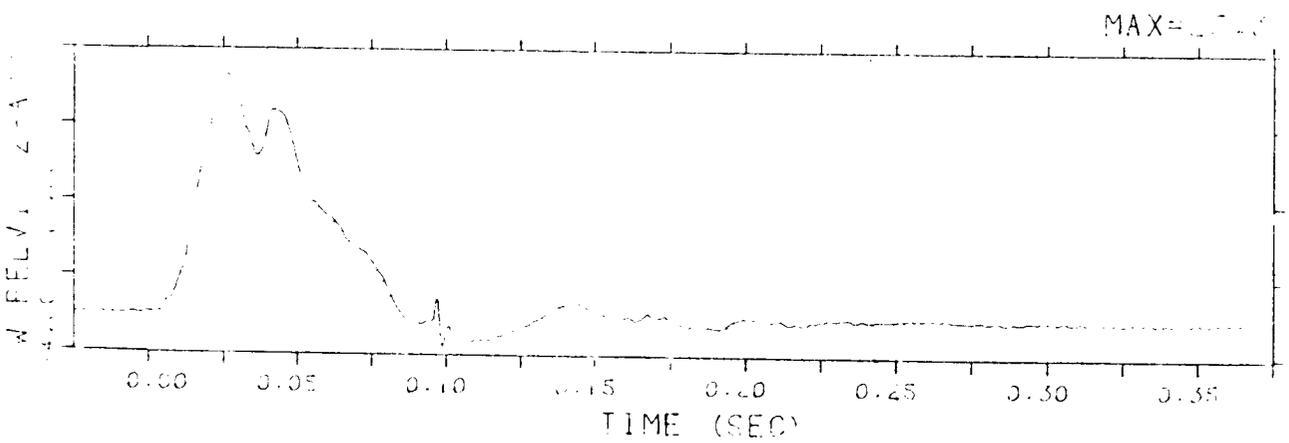
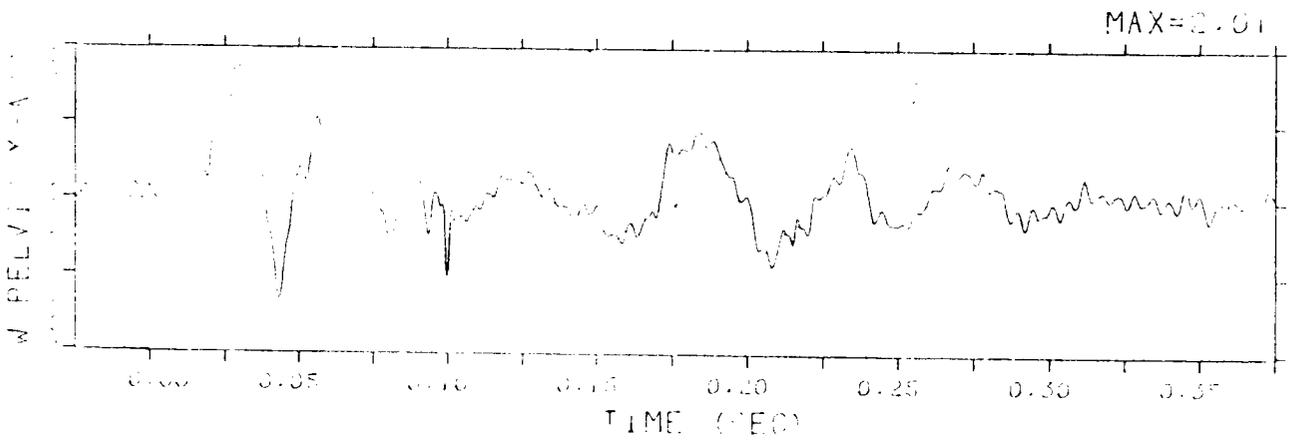
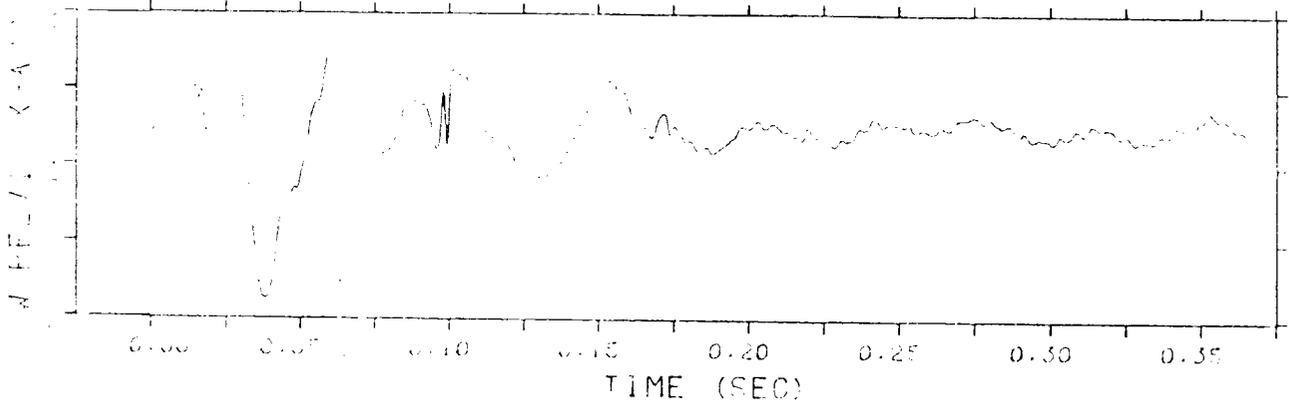
MAX=25.7



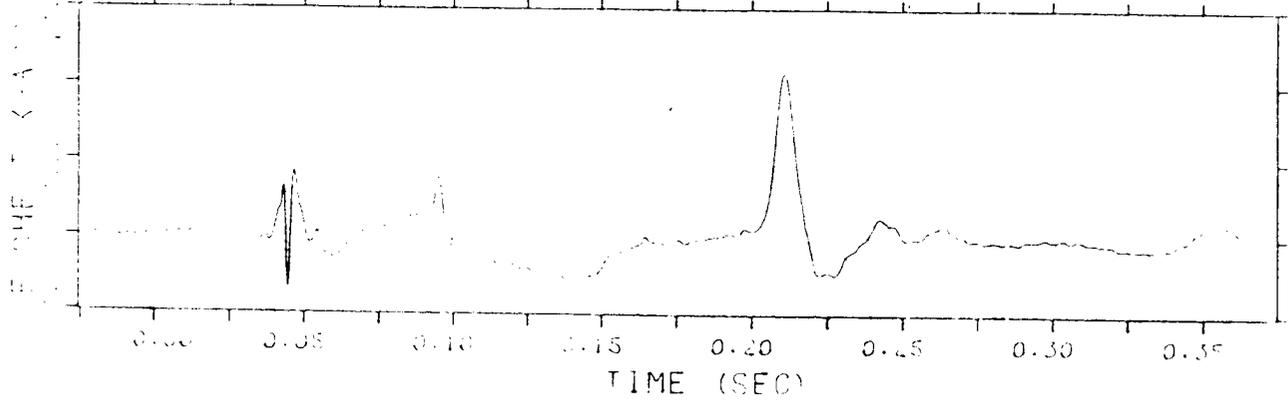
MAX=25.9



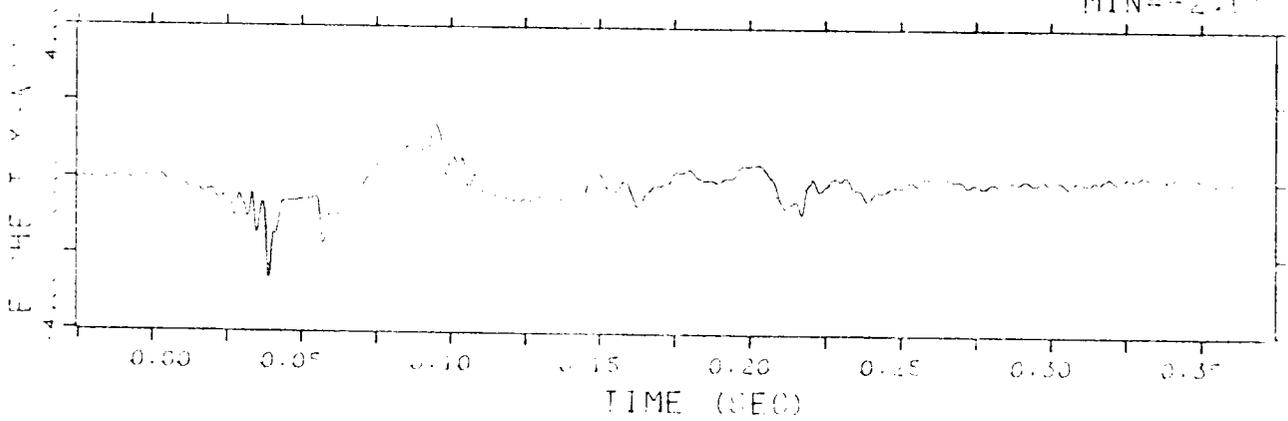
MIN=-4.70



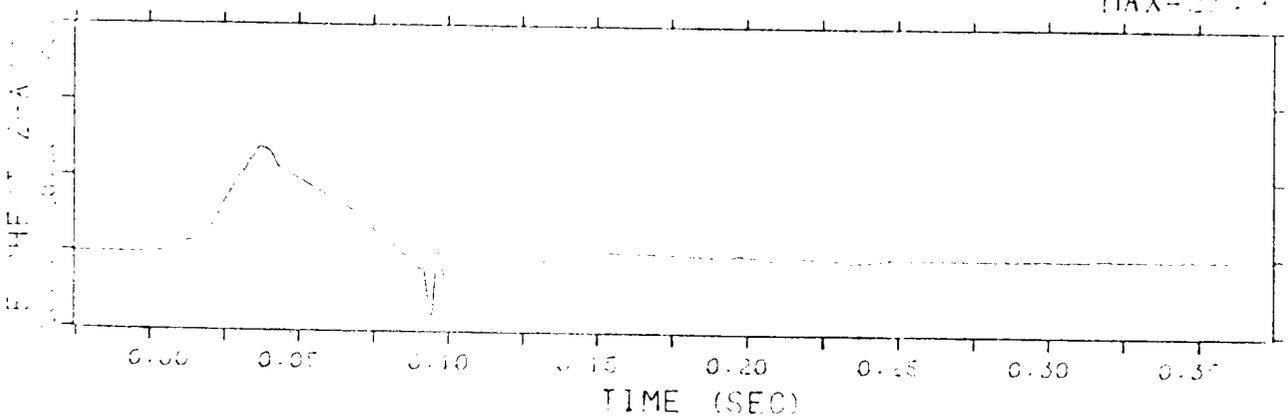
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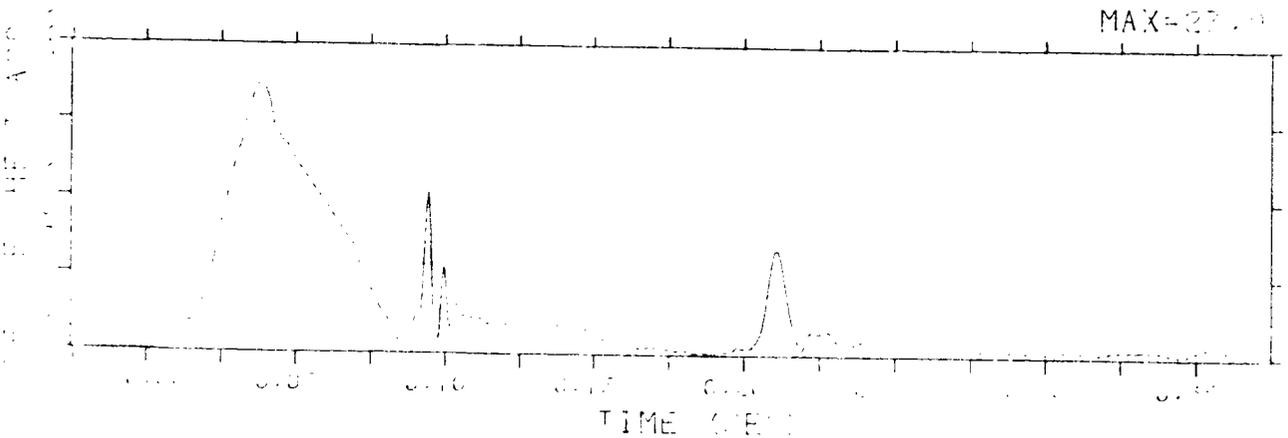
MIN=-2.00



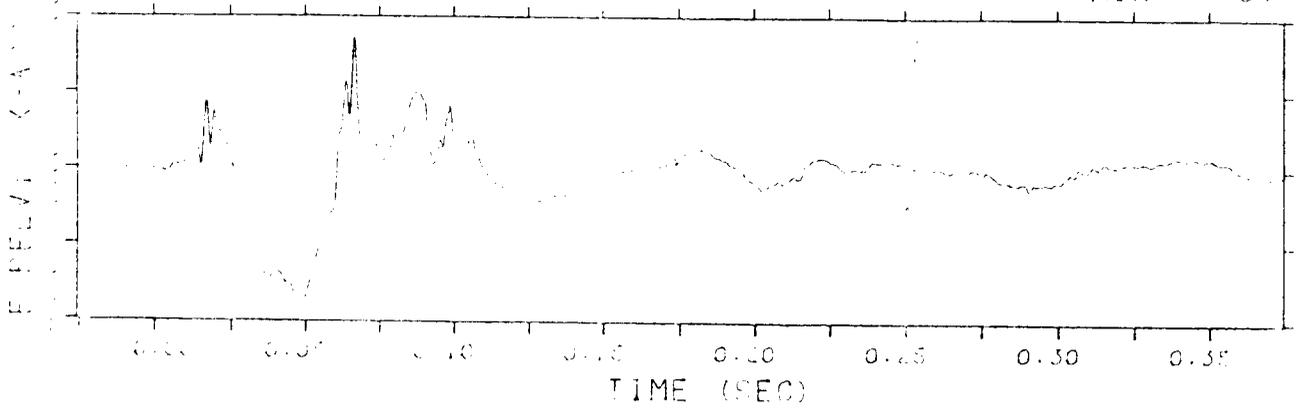
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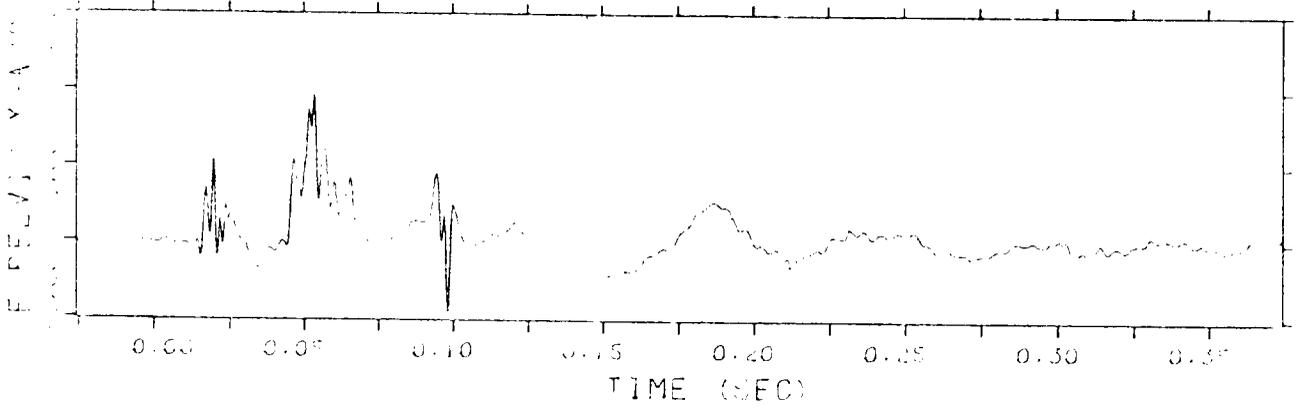
MAX=23.0



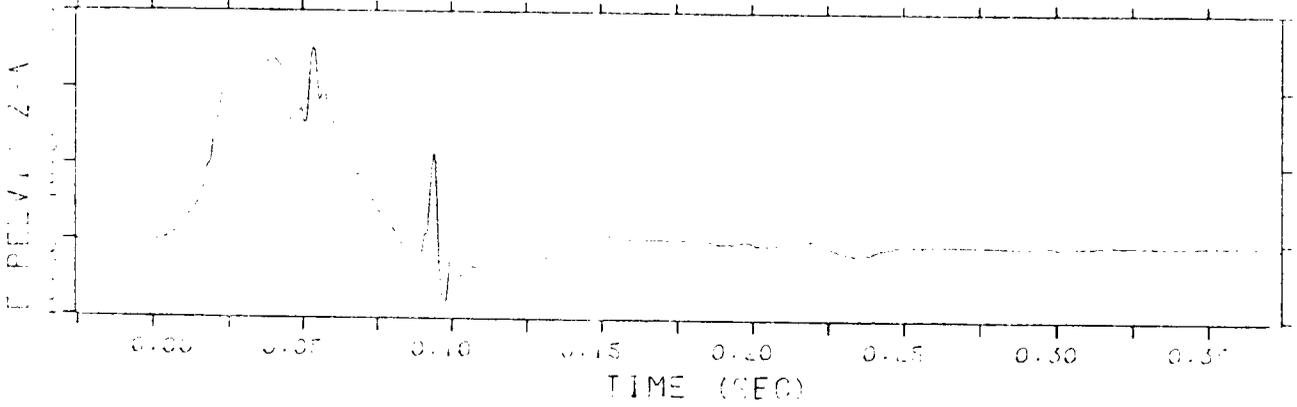
MIN=-6.01



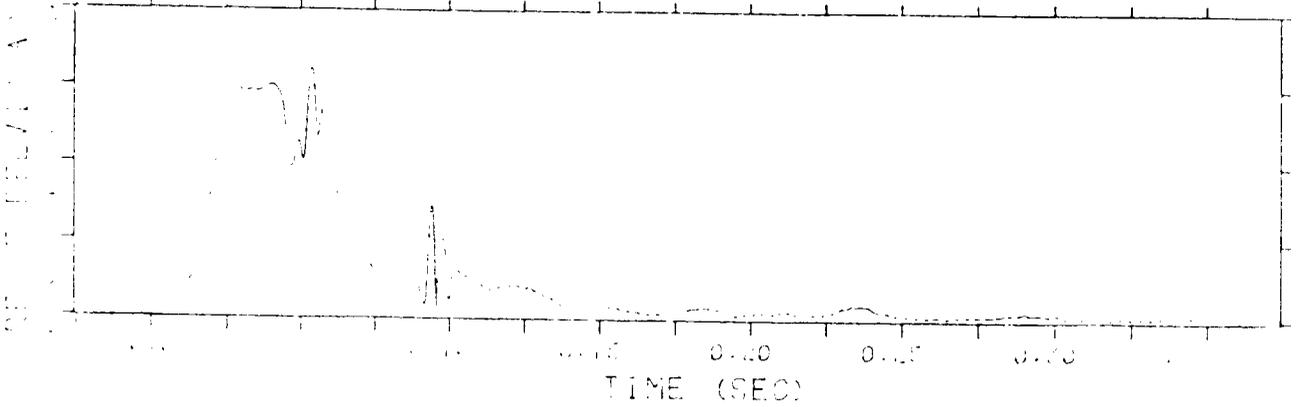
MAX=3.91



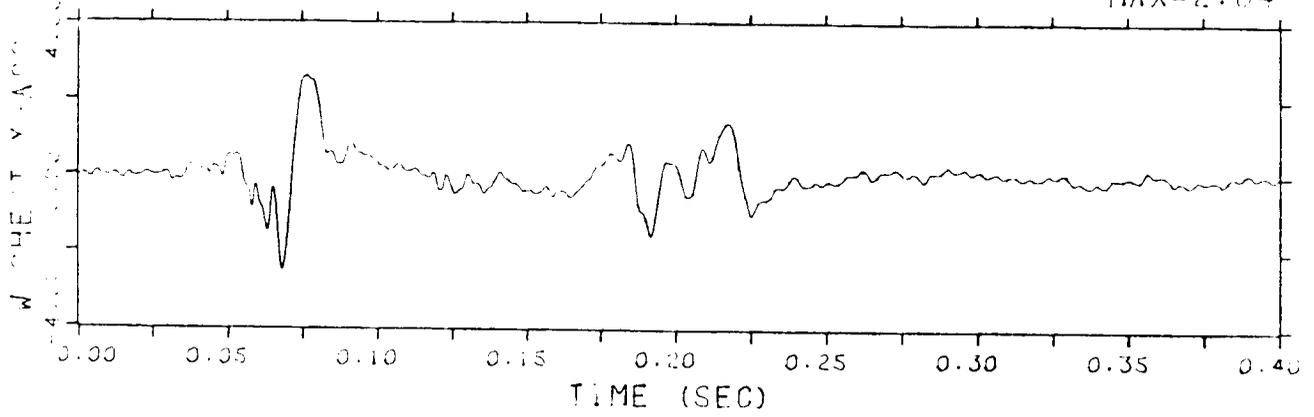
MAX=27.7



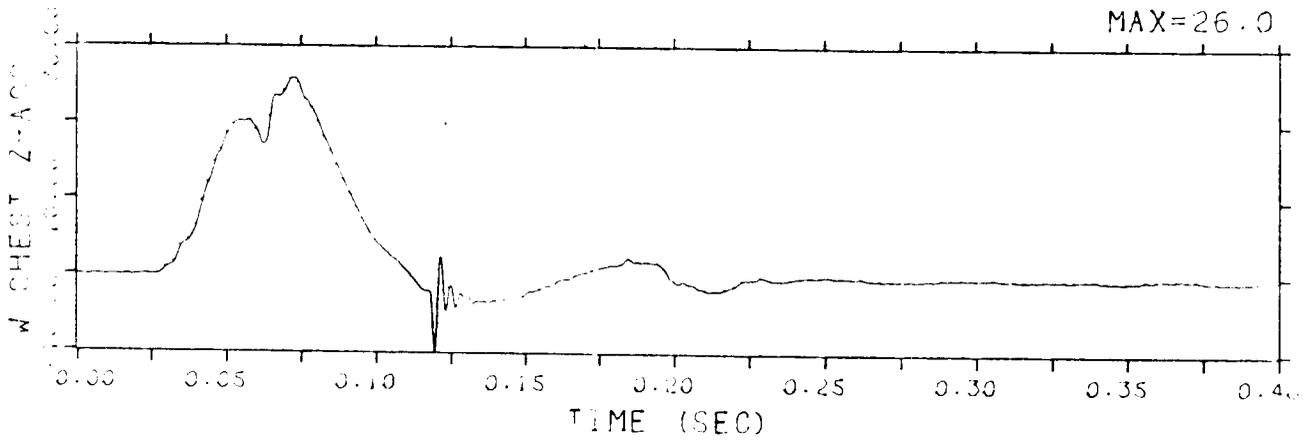
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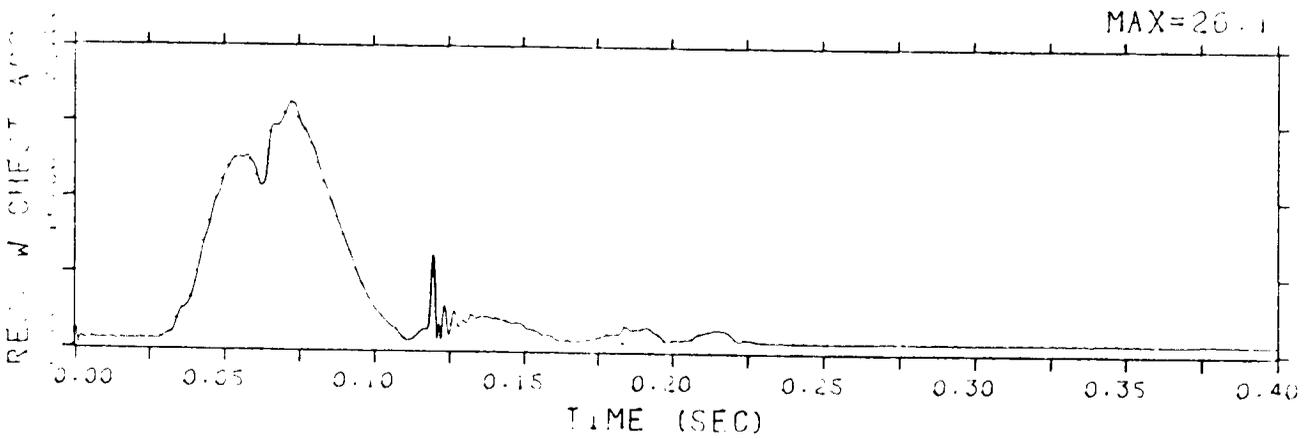
MAX=2.64



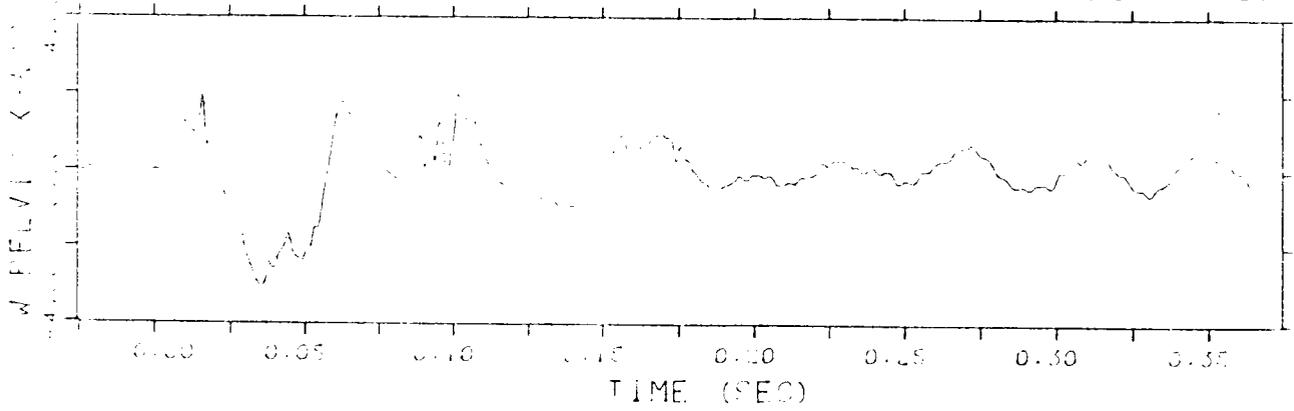
MAX=26.0



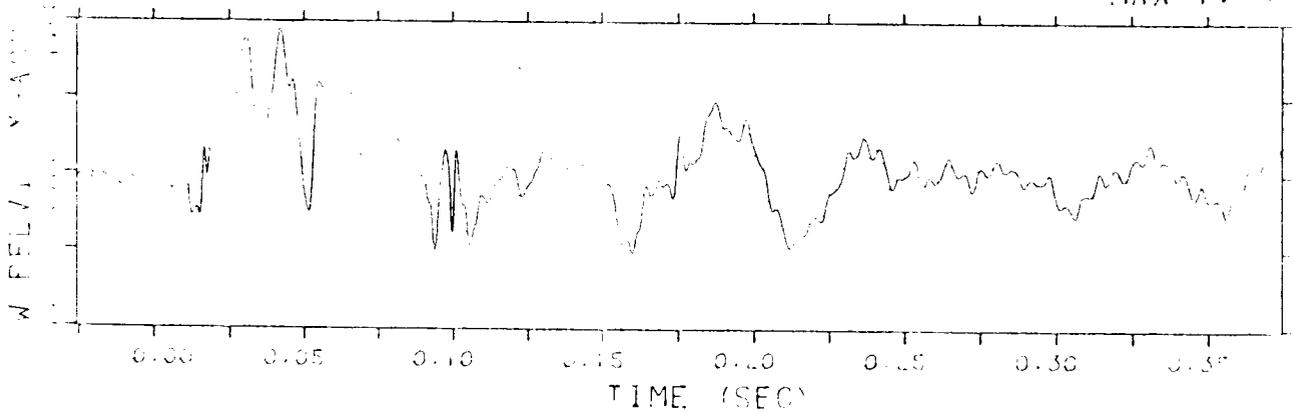
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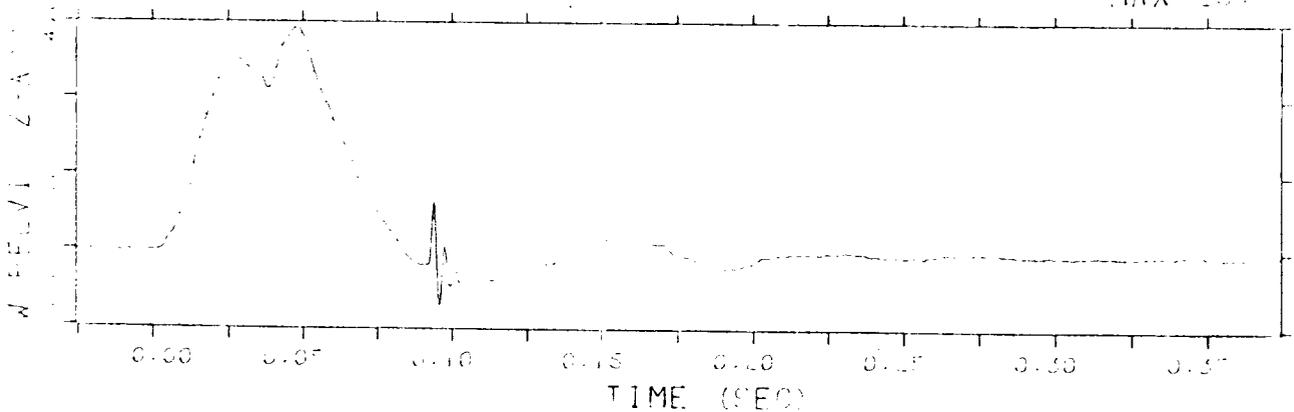
MIN=-3.07



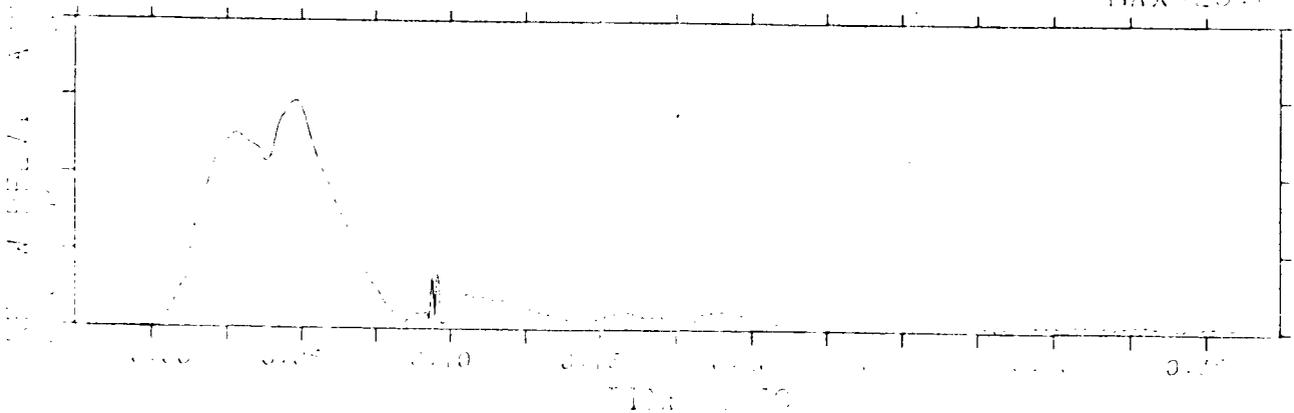
MAX=1.74



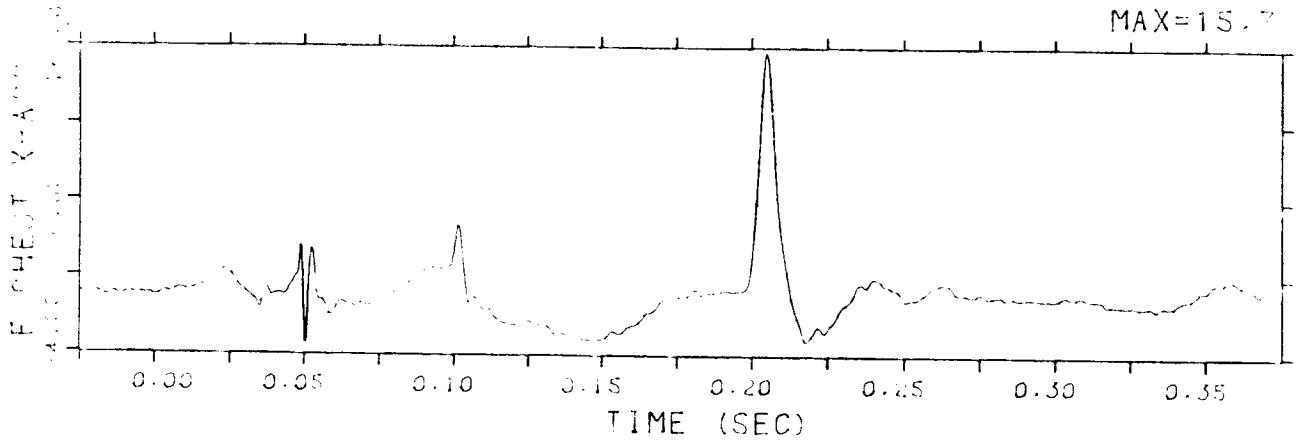
MAX=23.7



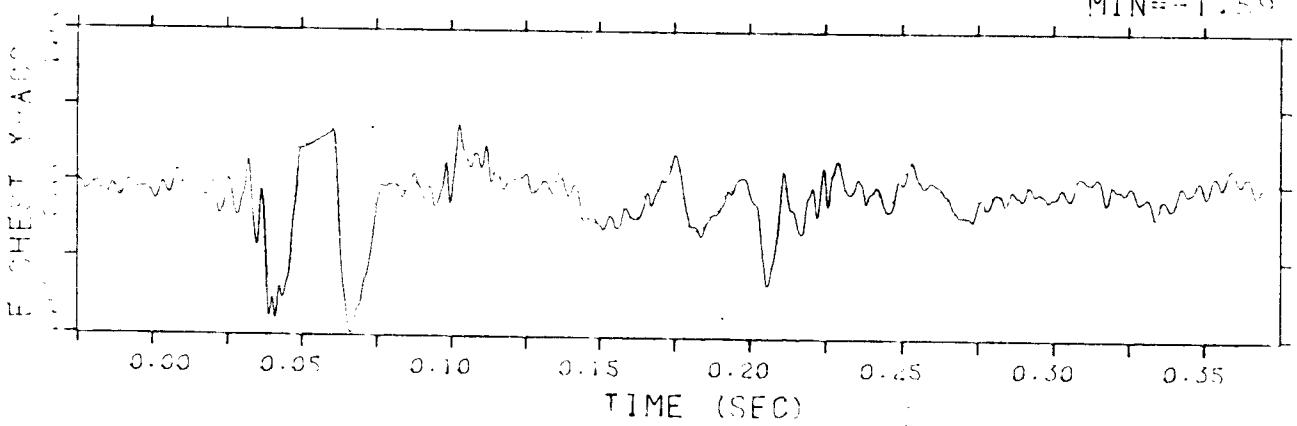
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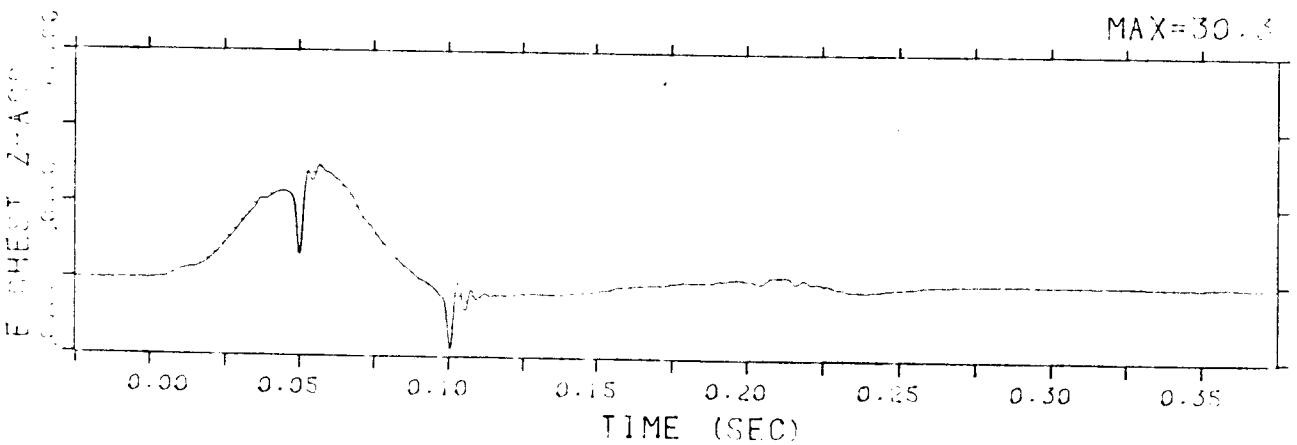
MAX=15.7



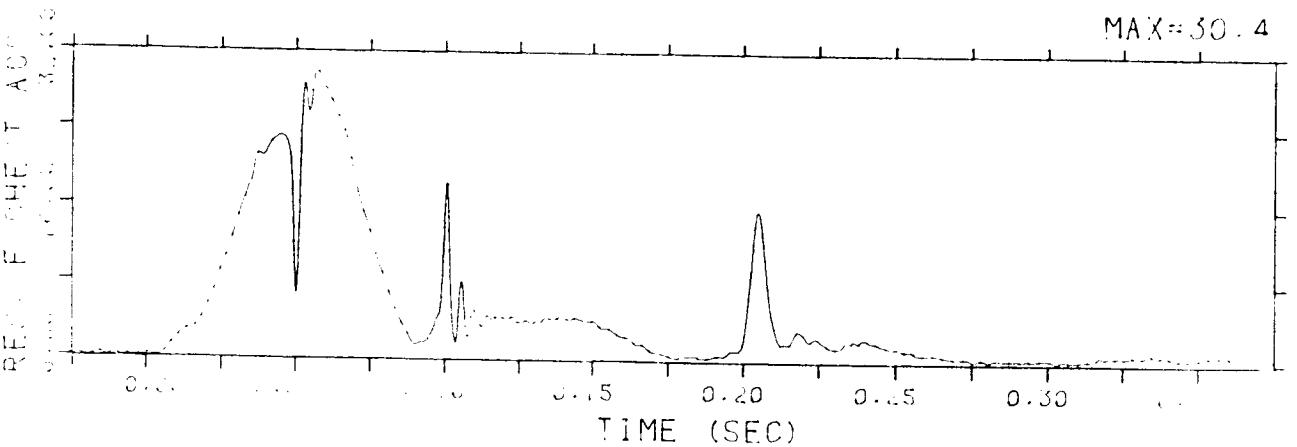
MIN=-1.59



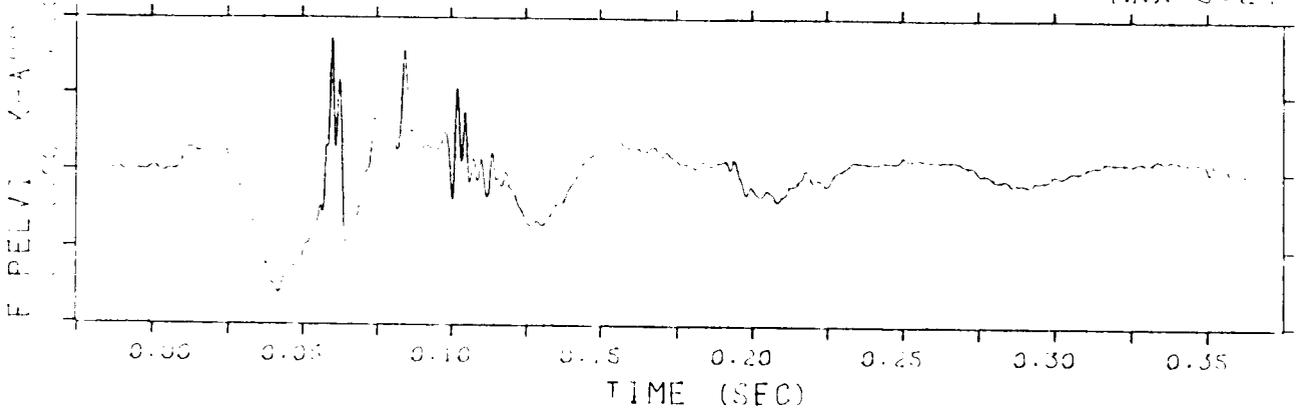
MAX=30.5



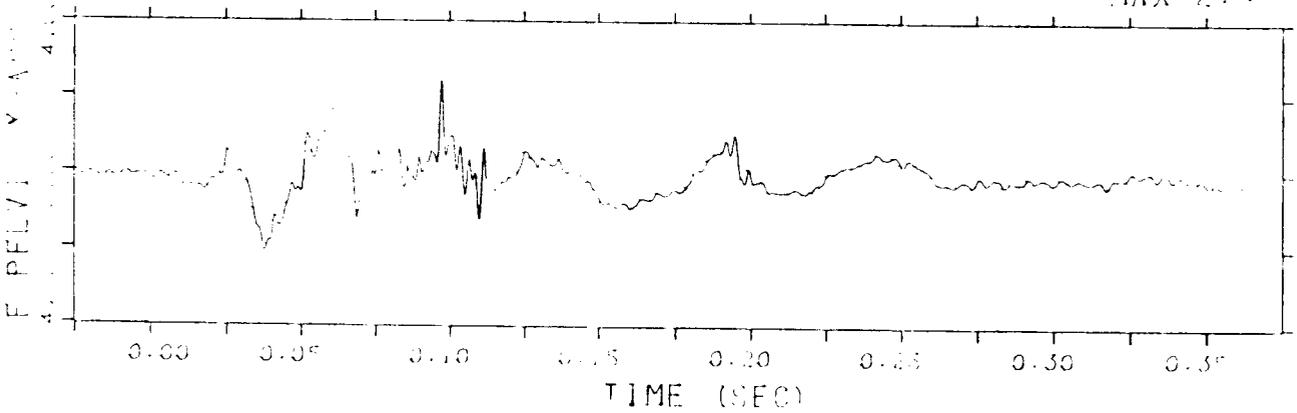
MAX=30.4



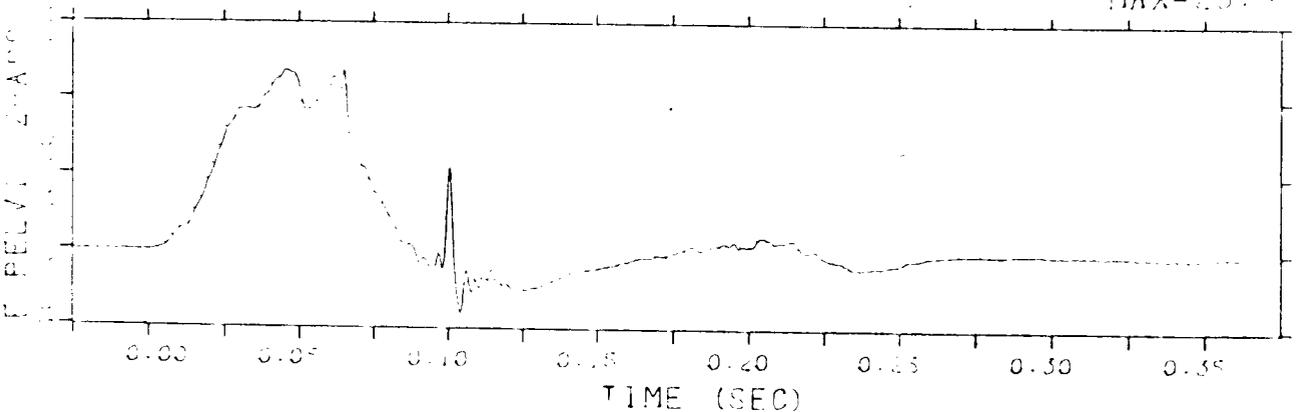
MAX=5.24



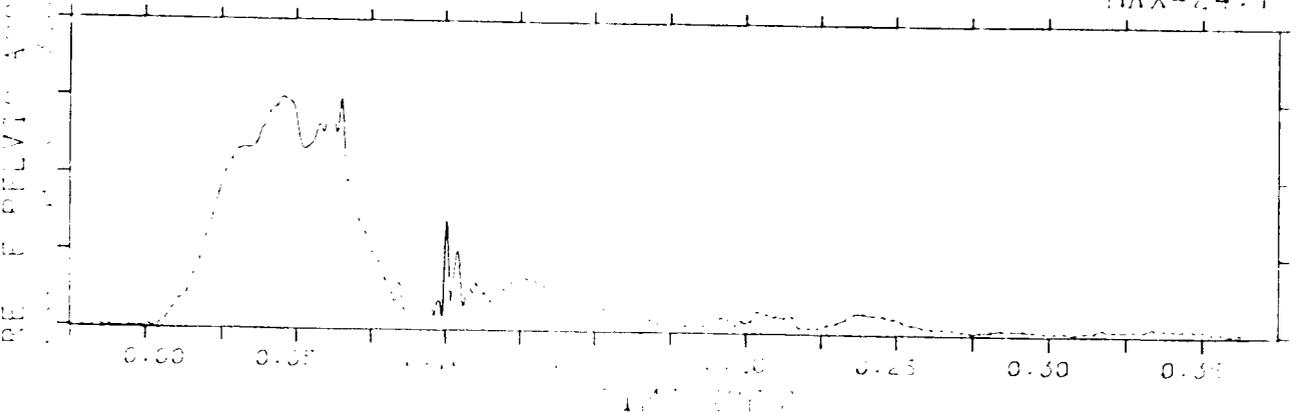
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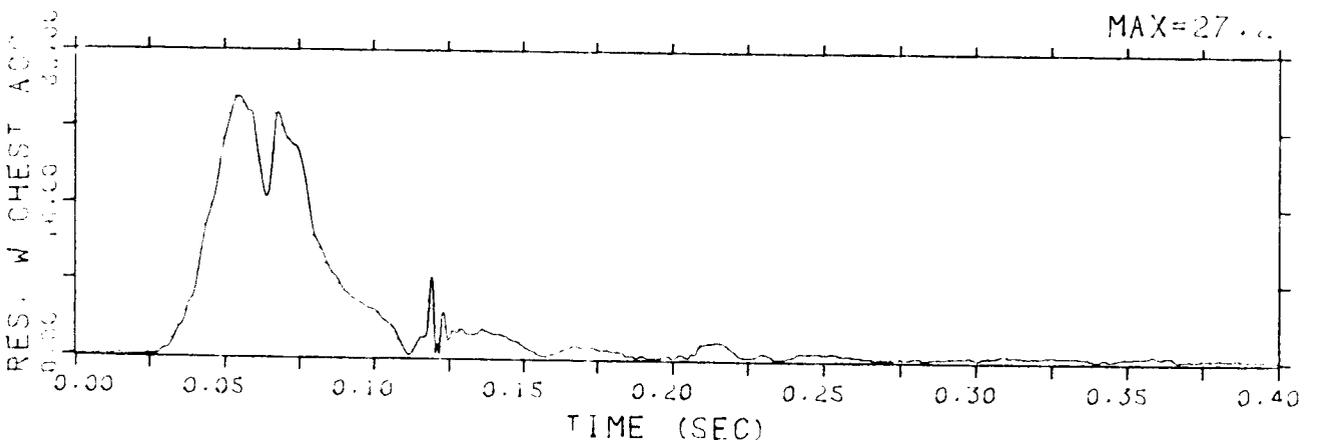
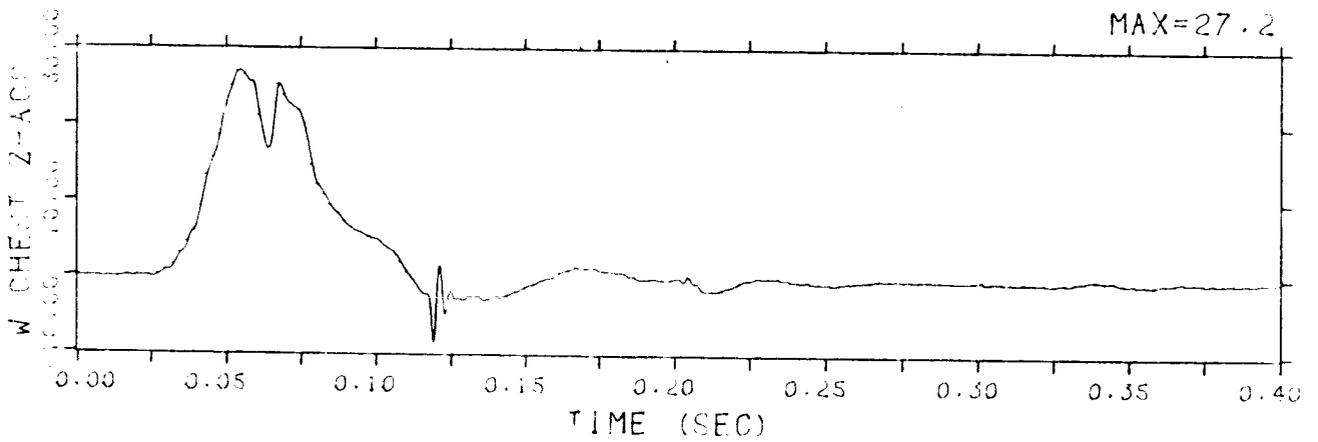
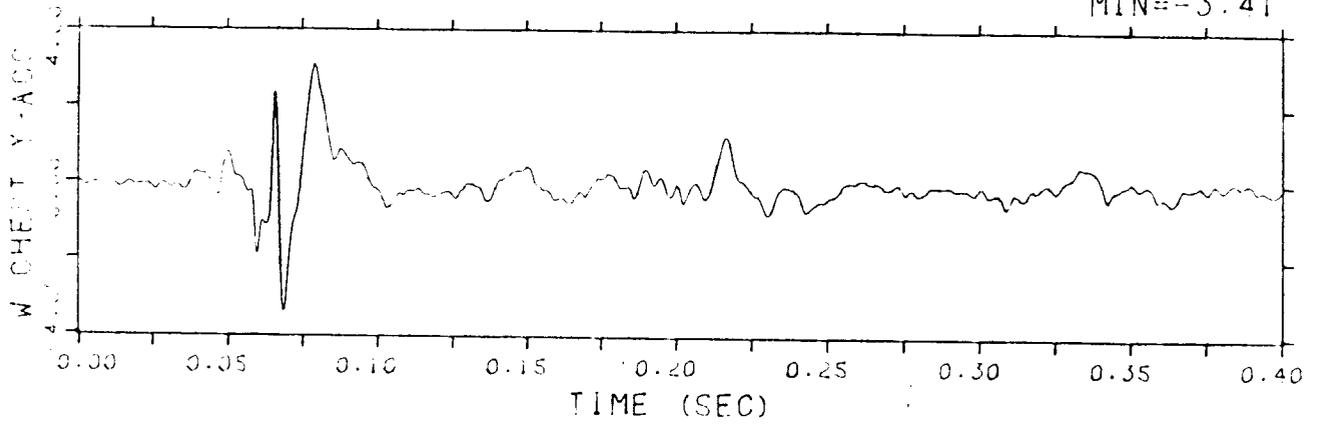
MAX=23.79



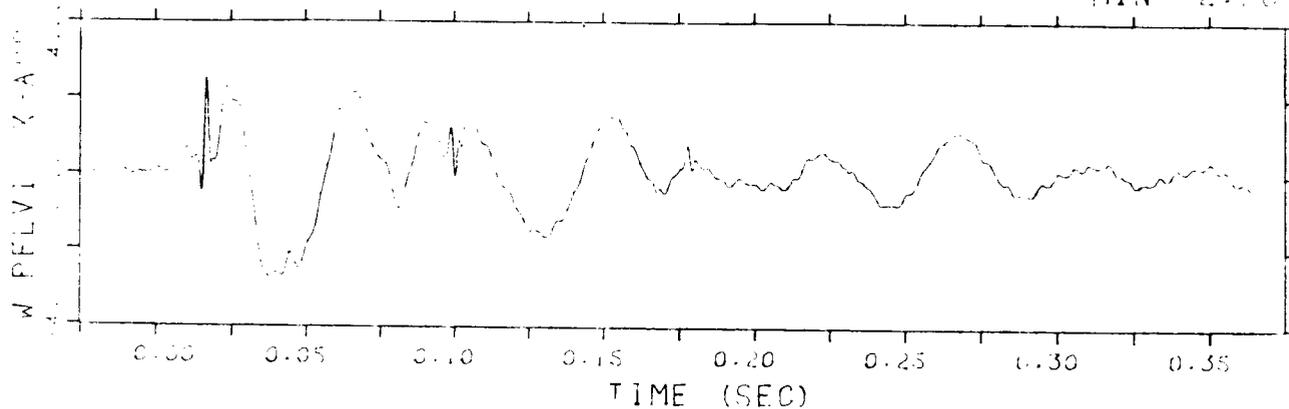
MAX=24.1



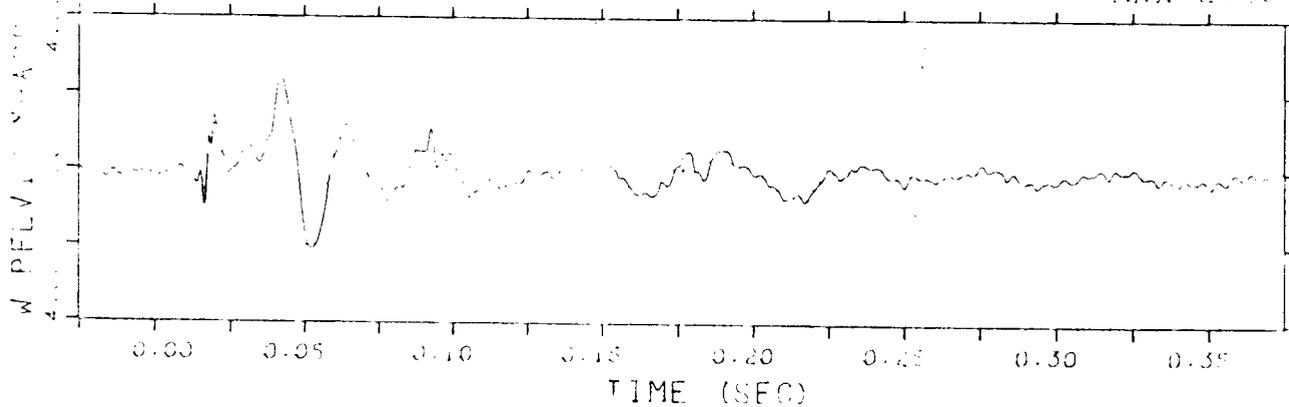
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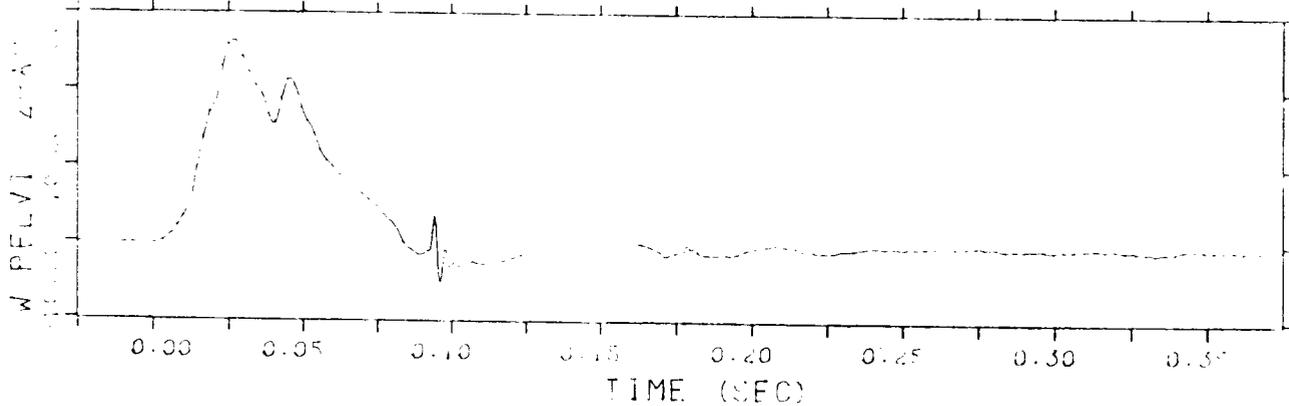
MIN=-2.76



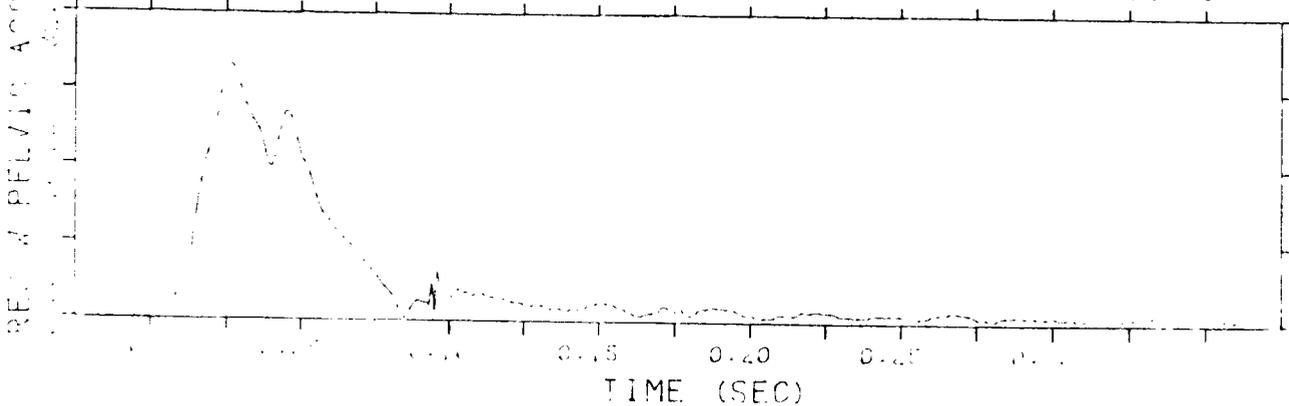
MAX=2.49



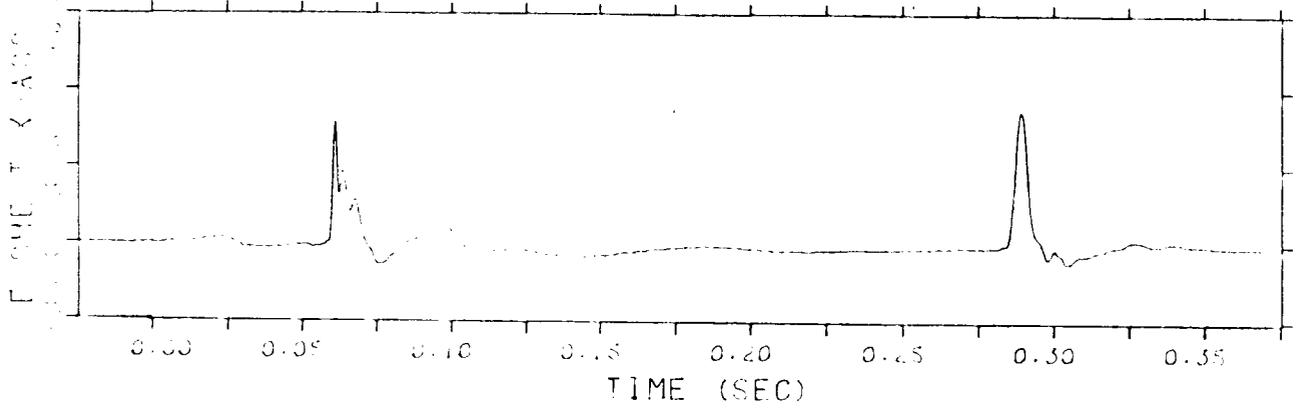
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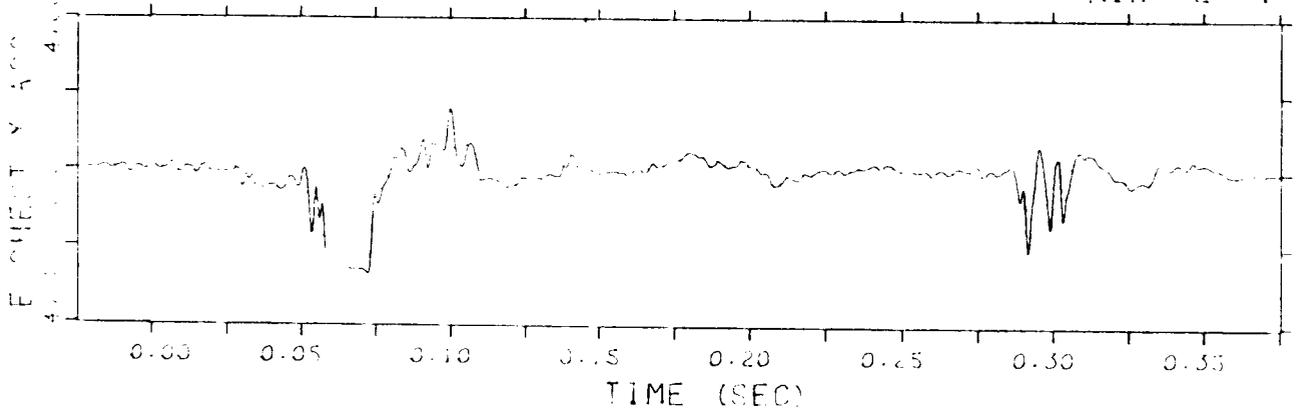
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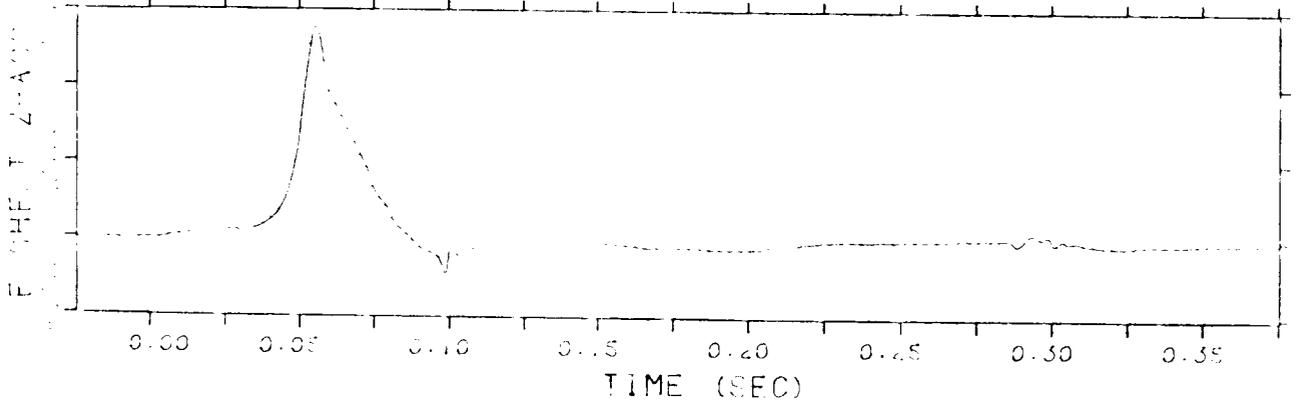
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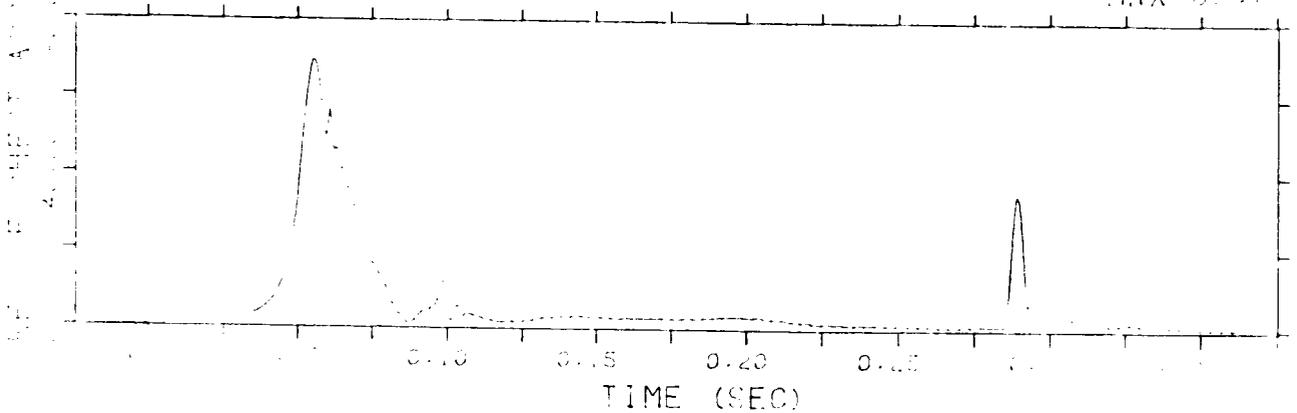
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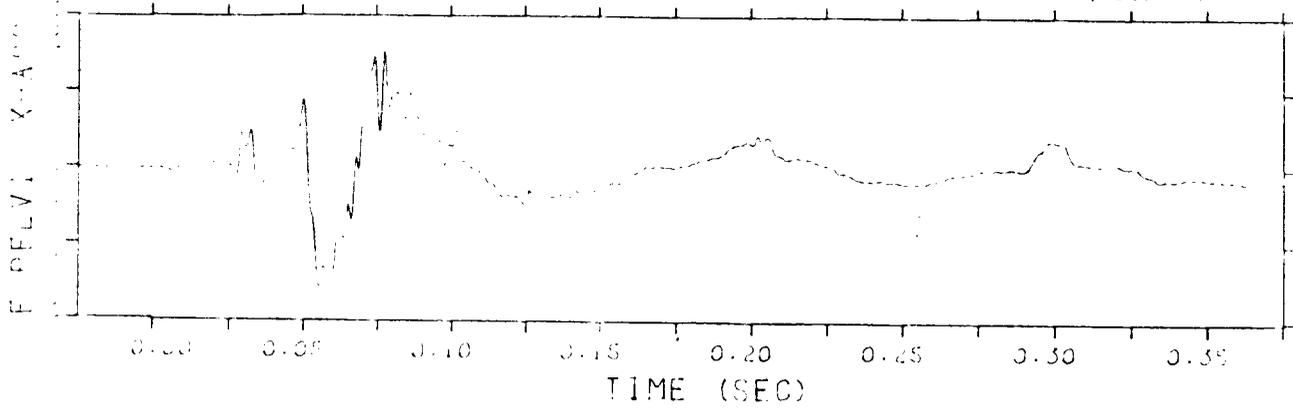
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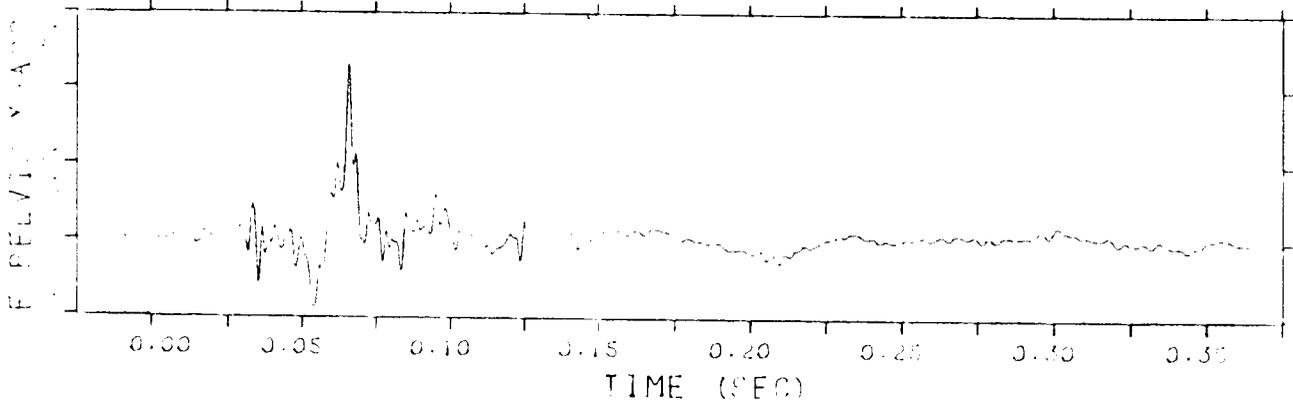
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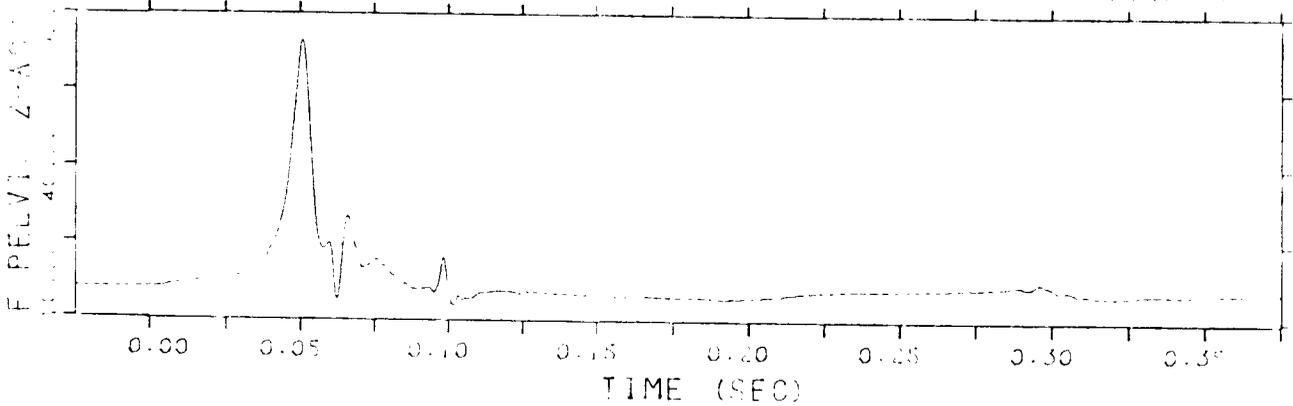
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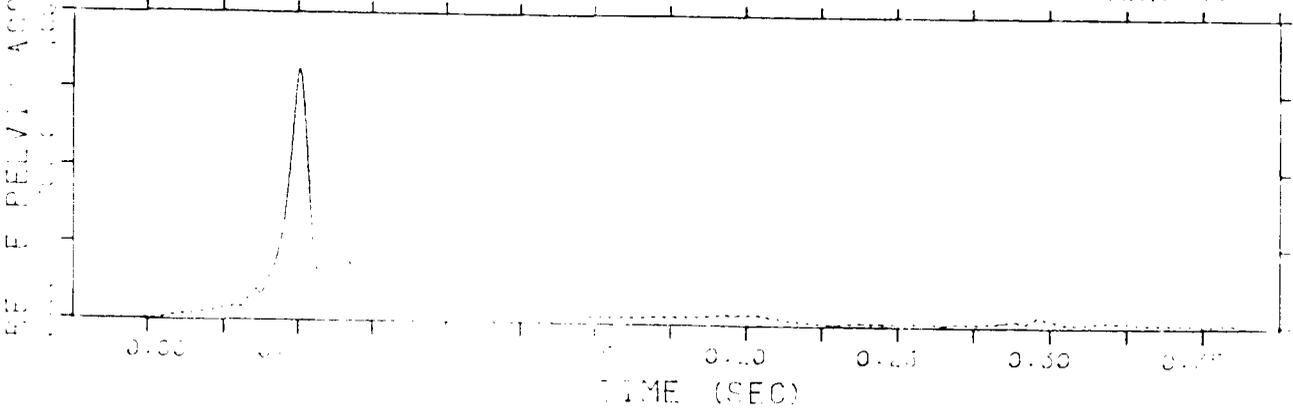
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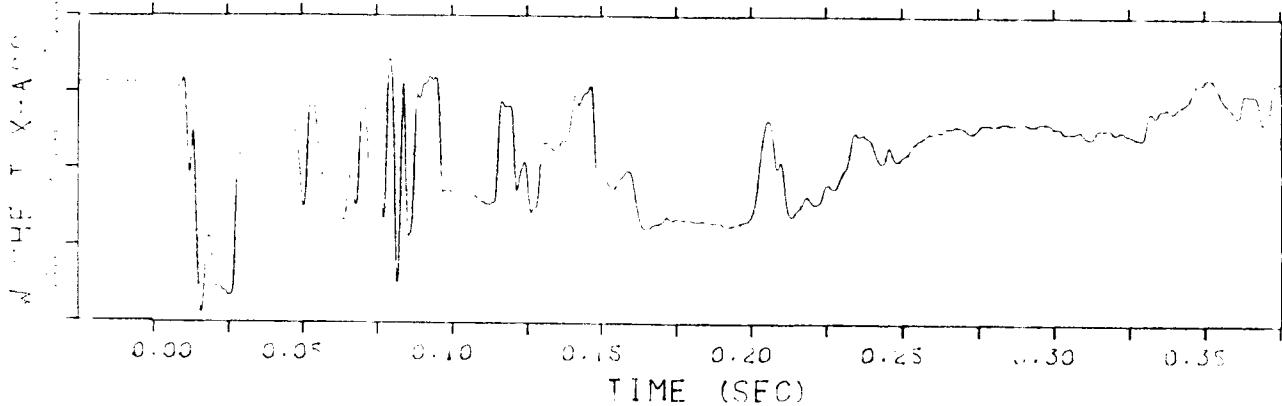
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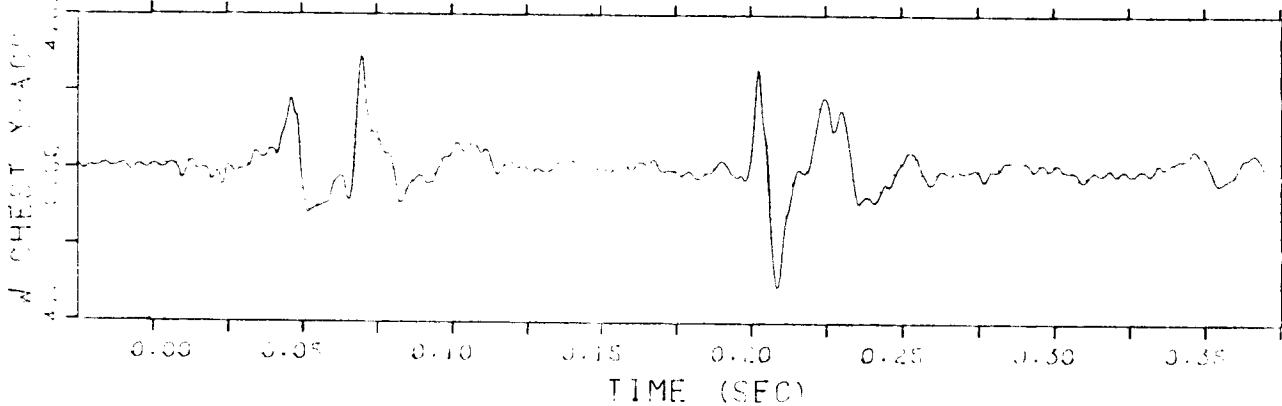
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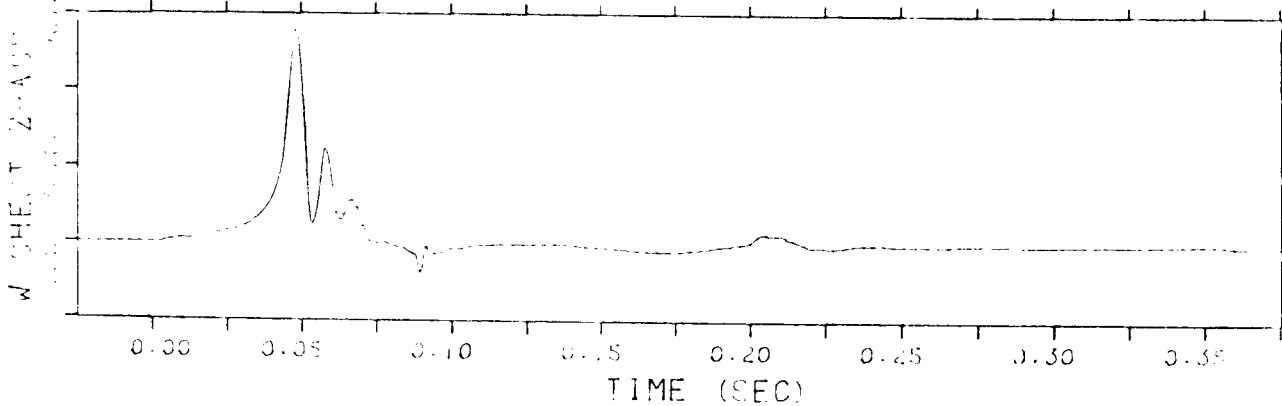
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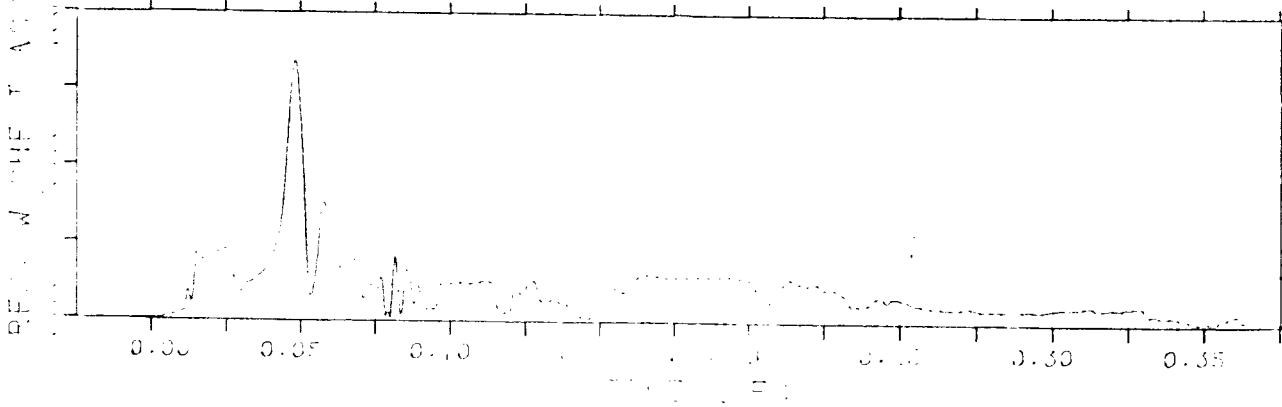
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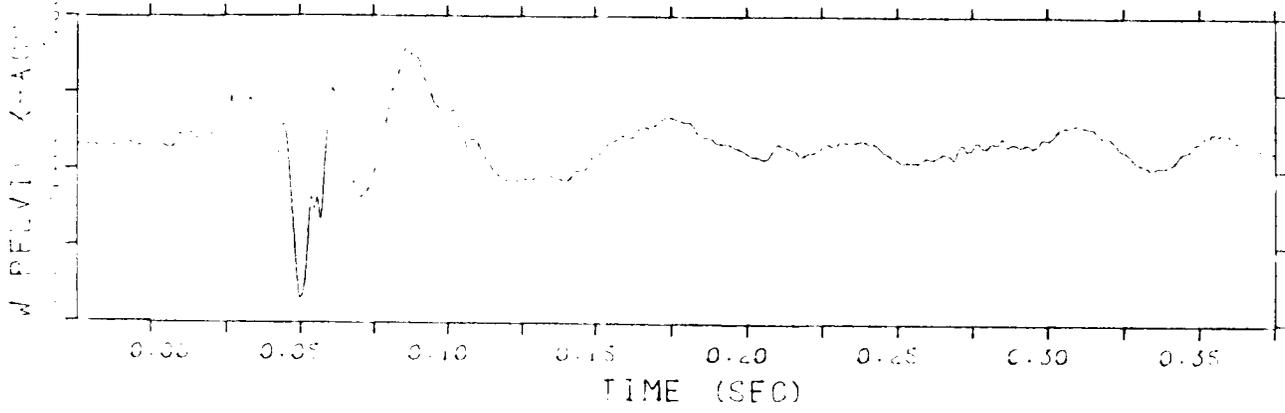
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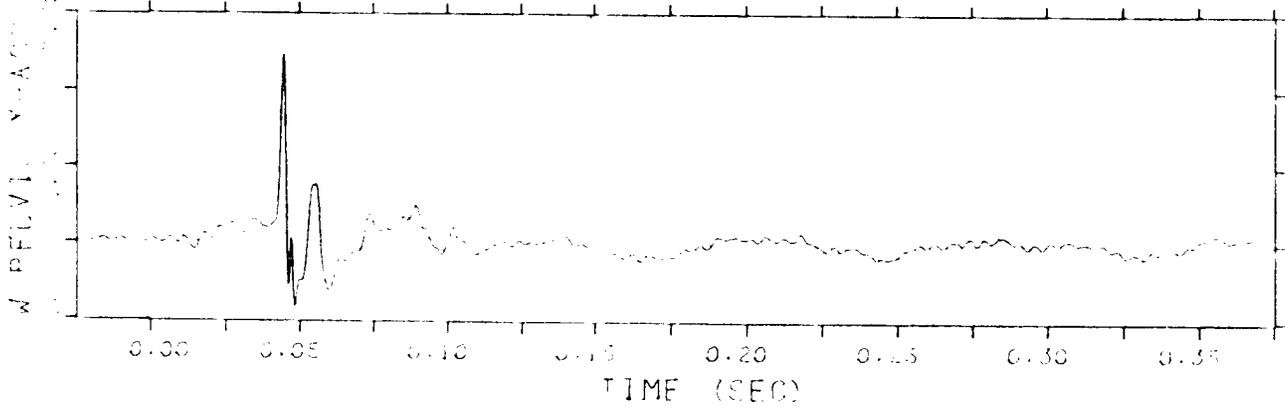
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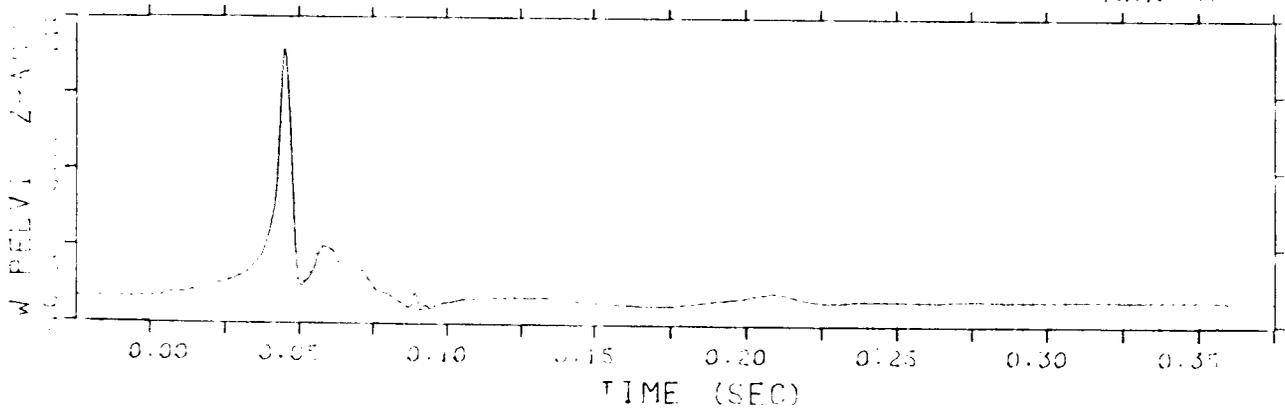
MIN=-6.11



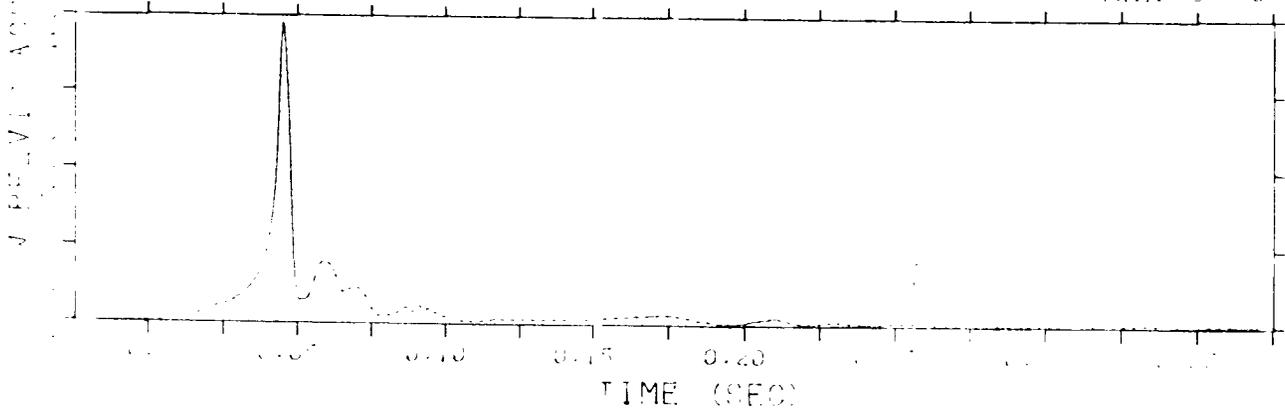
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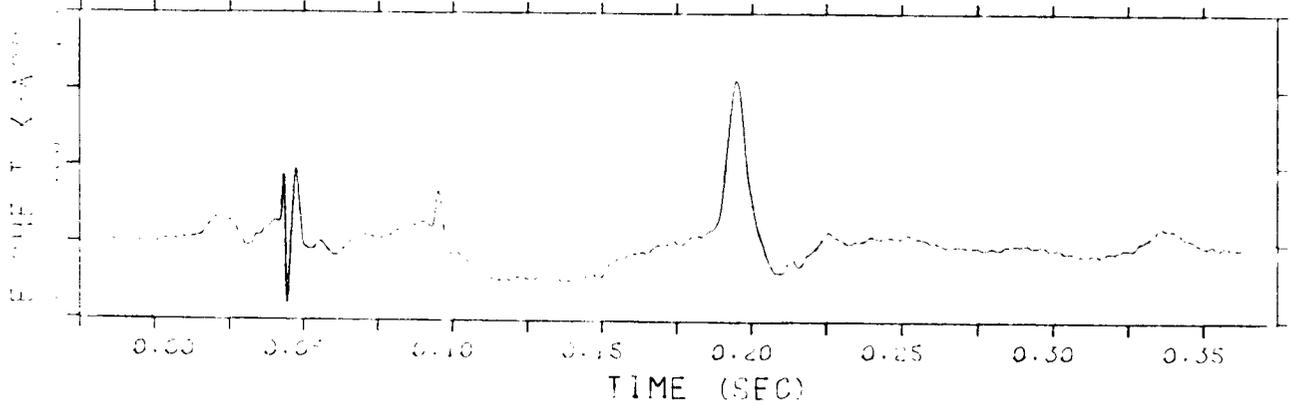
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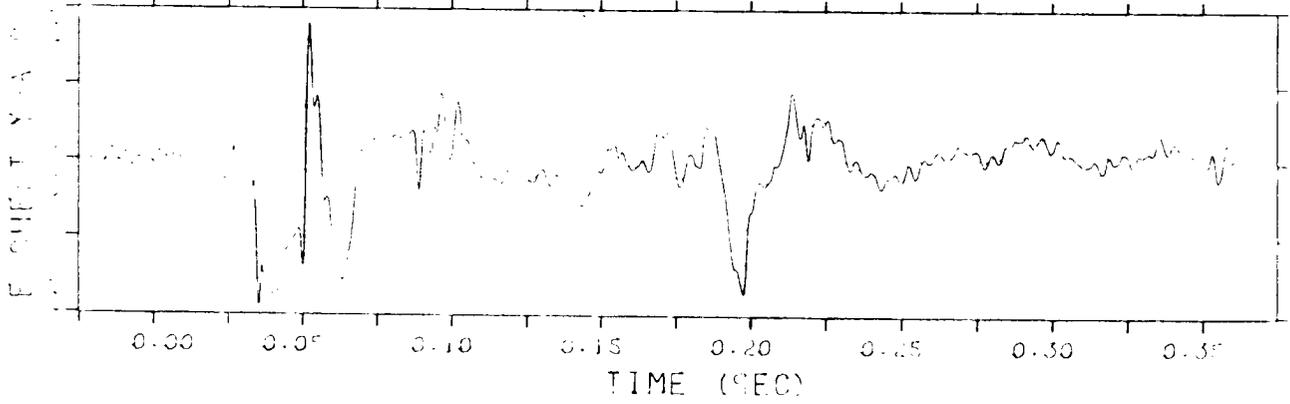
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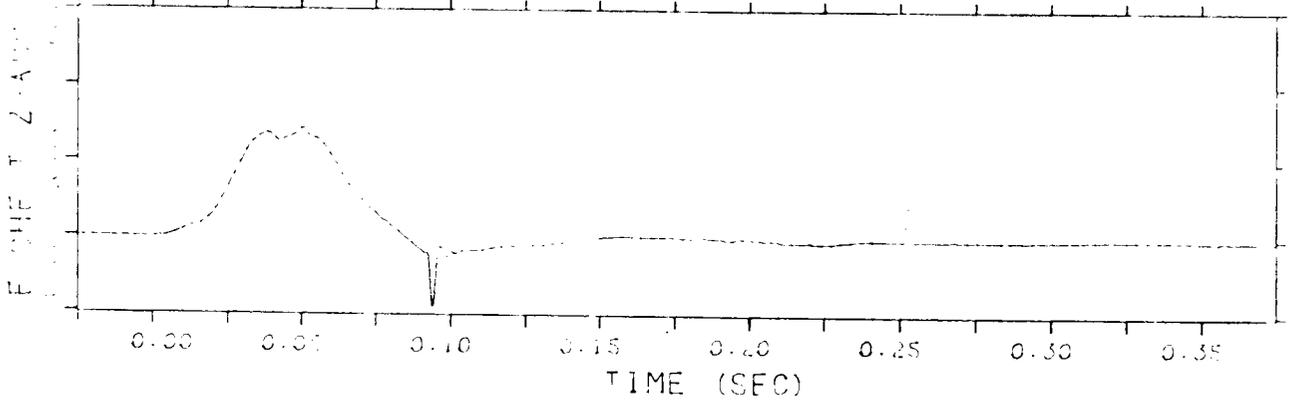
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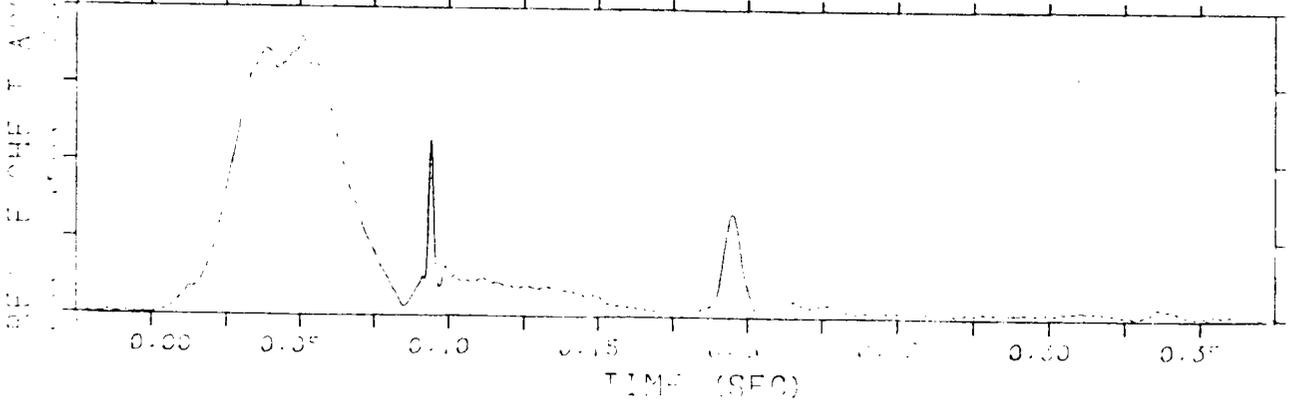
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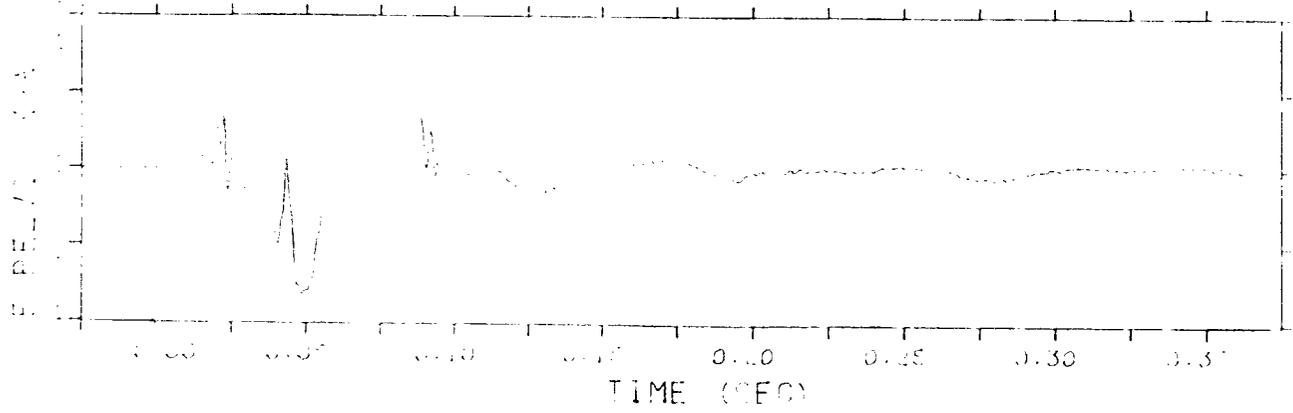


MAX=20.1

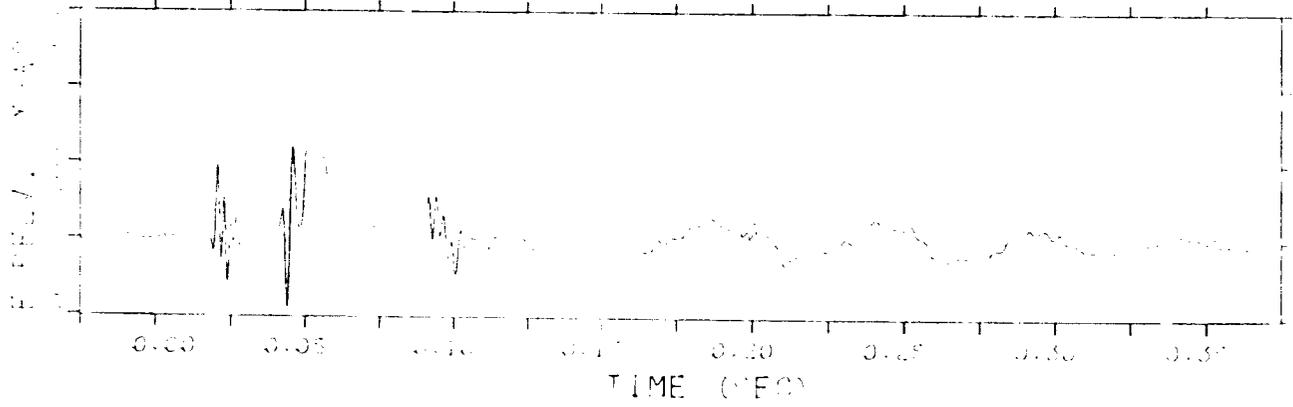


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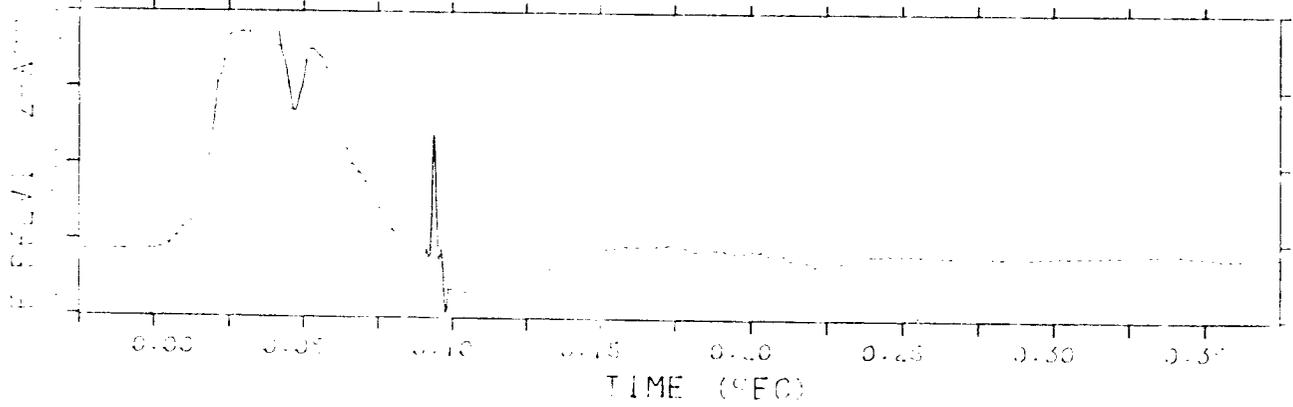




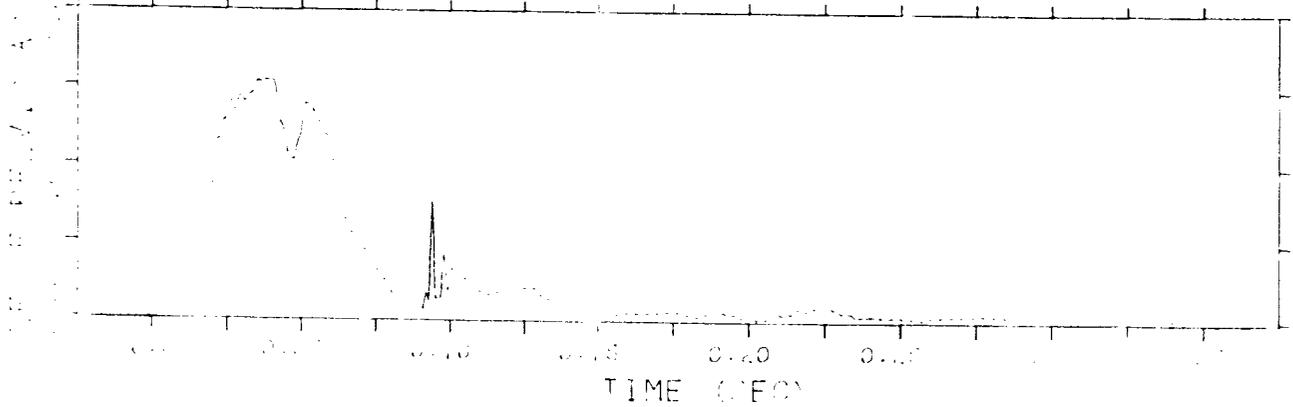
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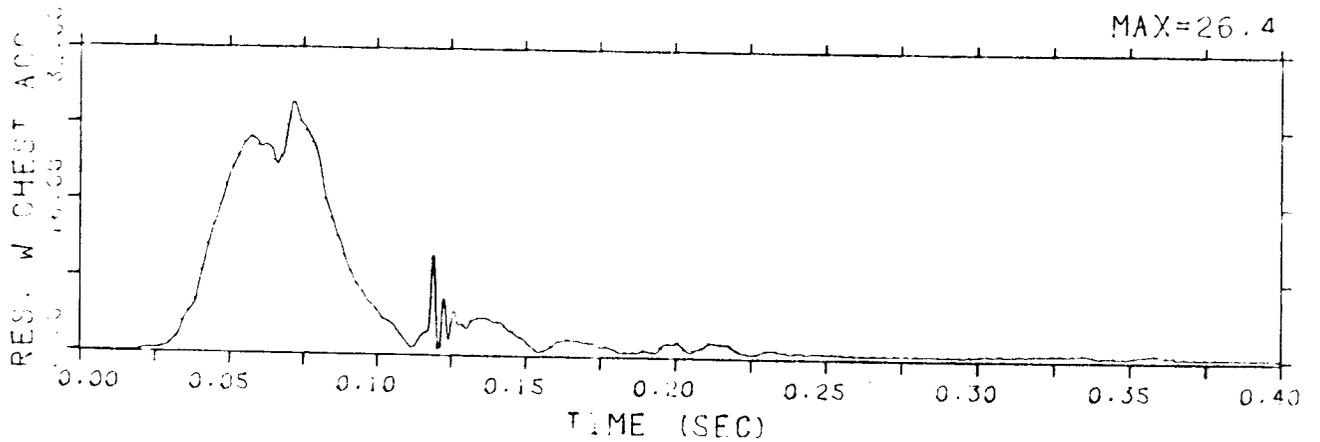
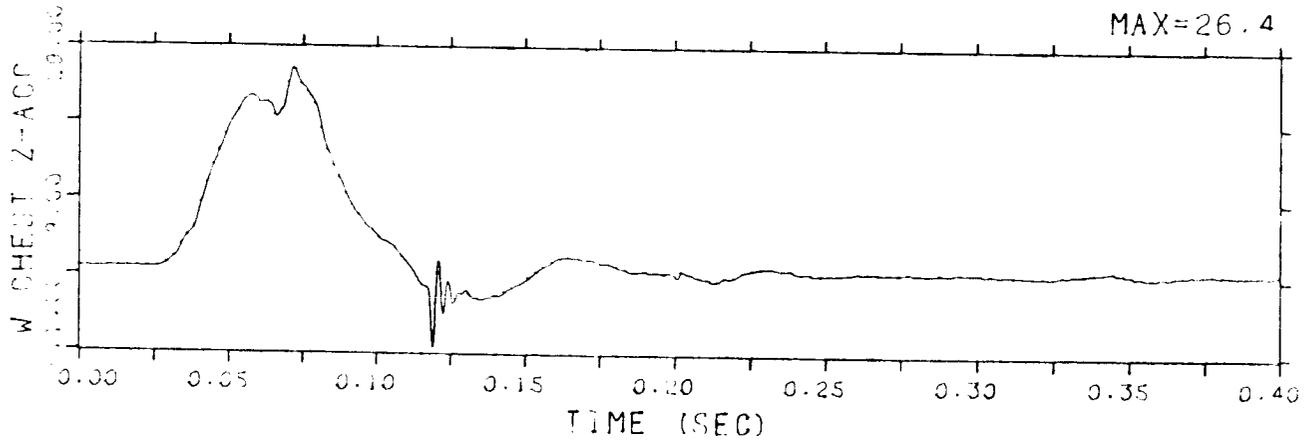
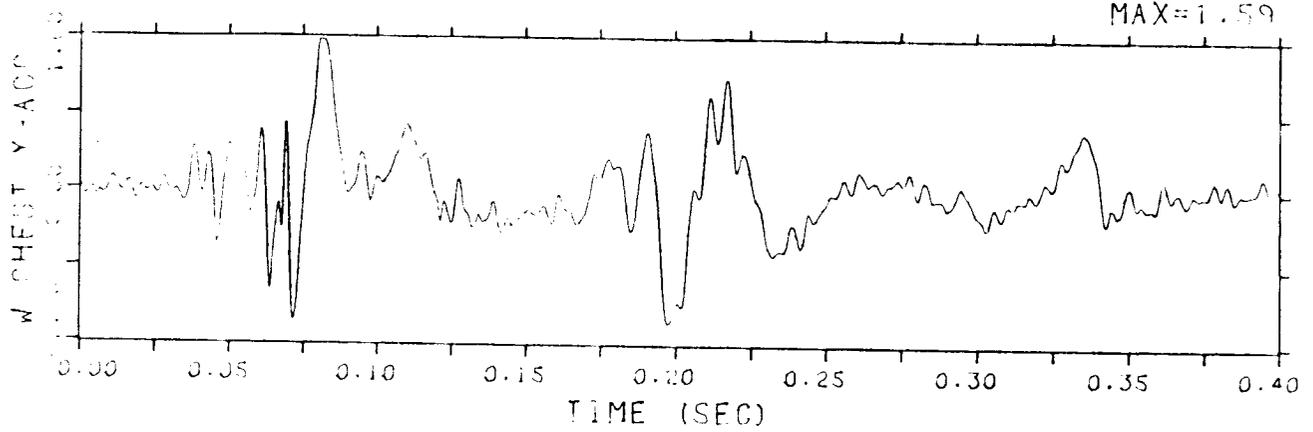


MAX=14.0

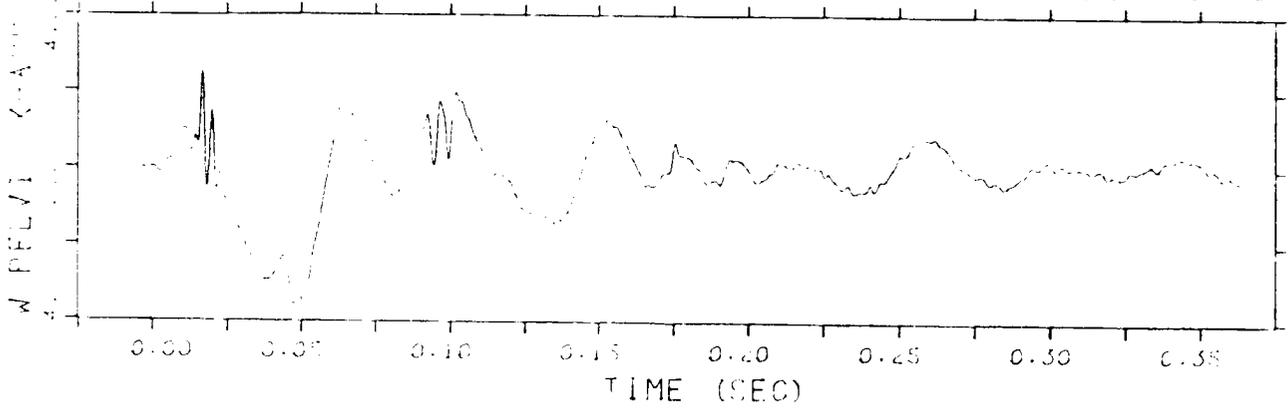


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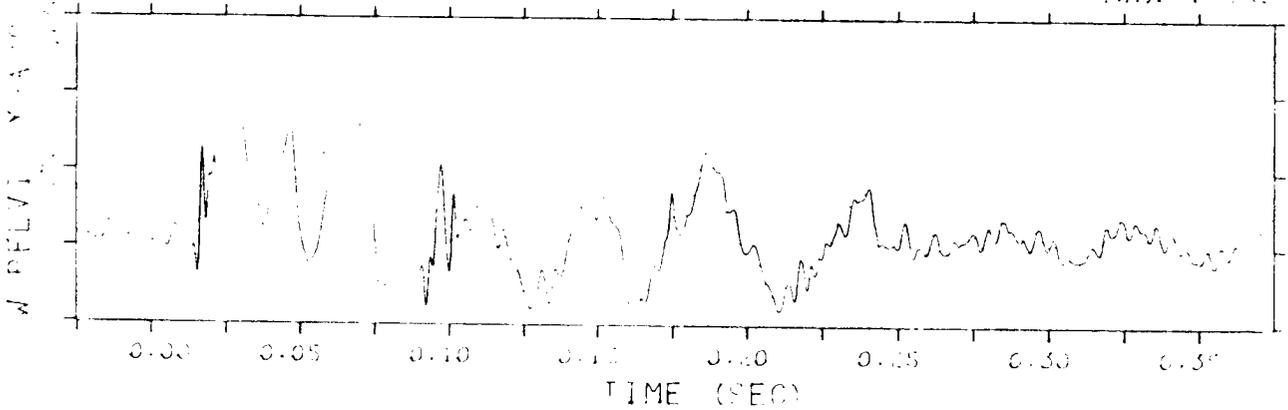




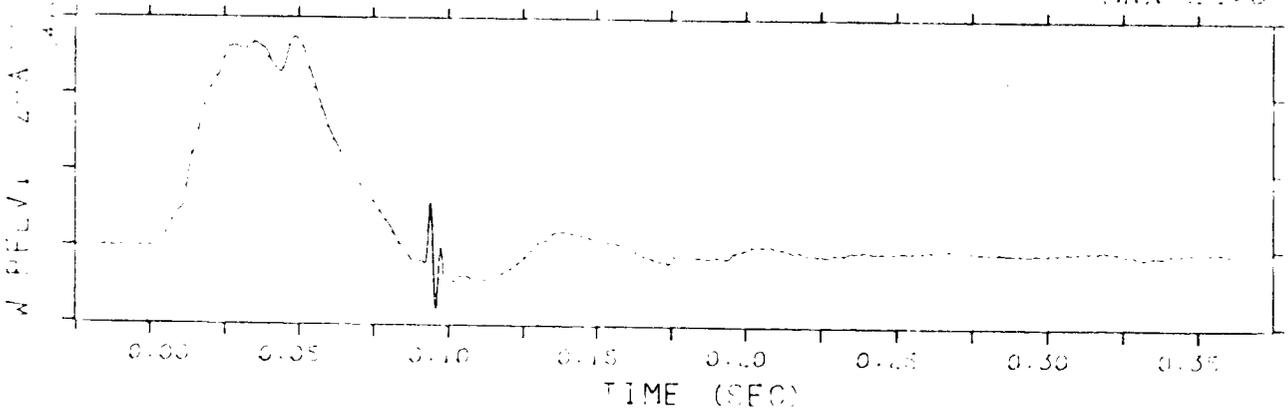
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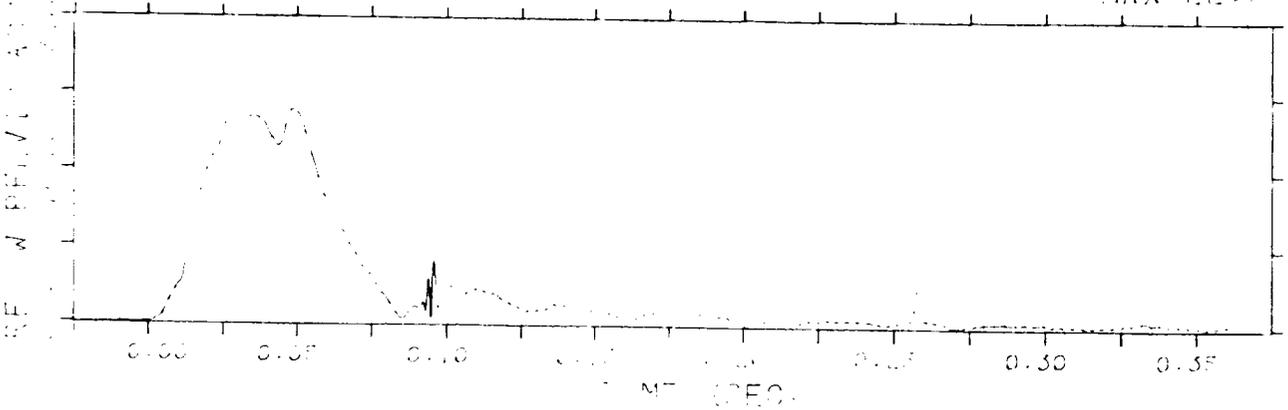
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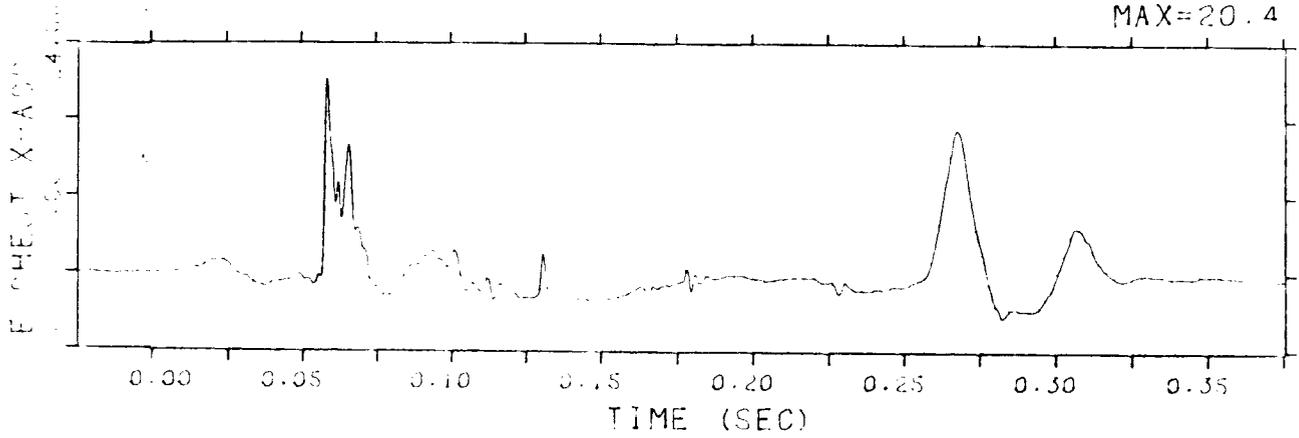
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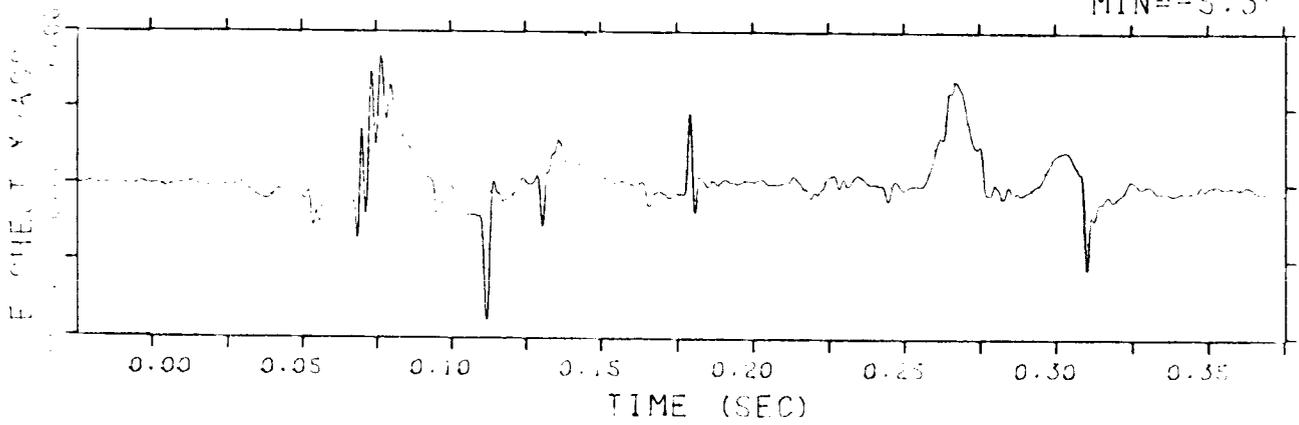
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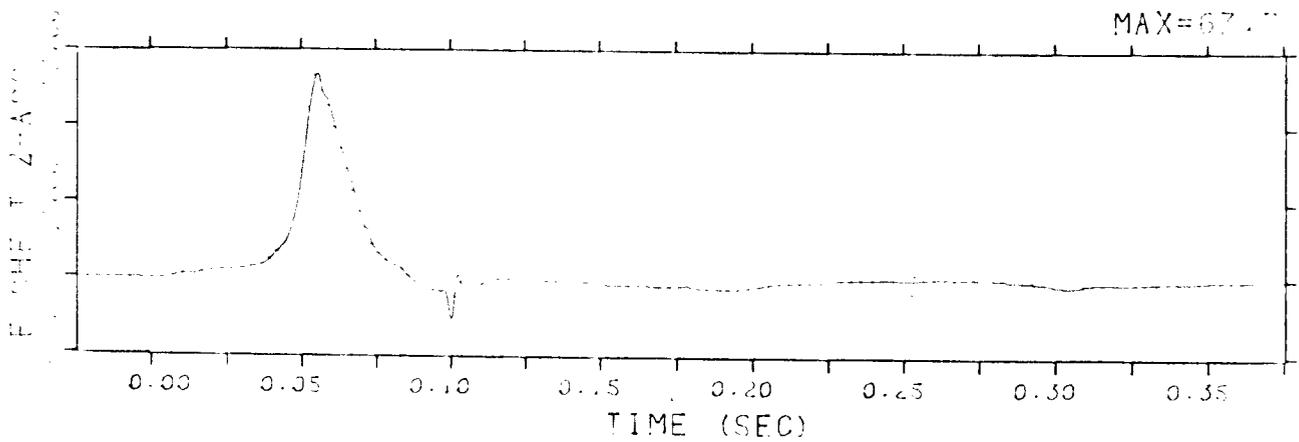
MAX=20.4



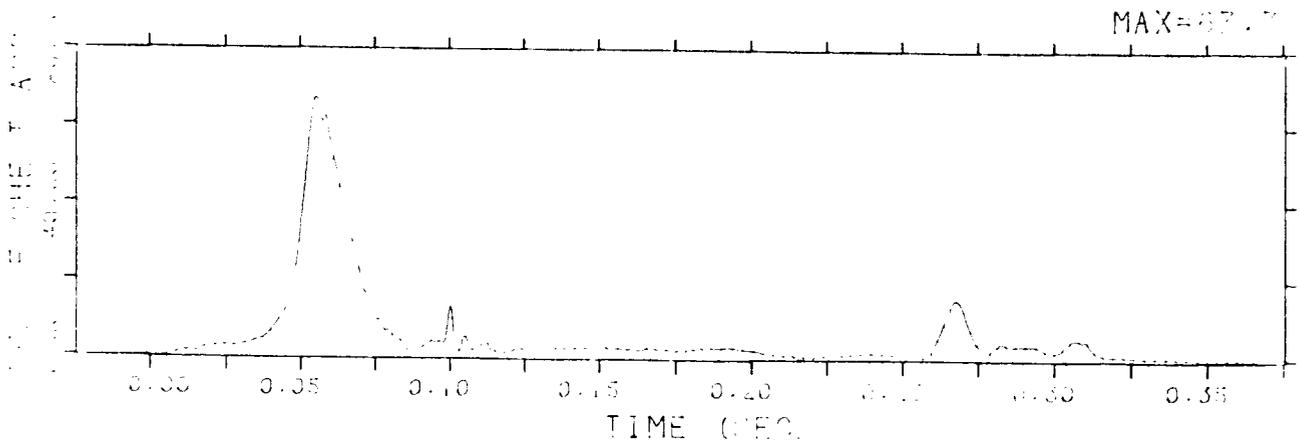
MIN=-5.3



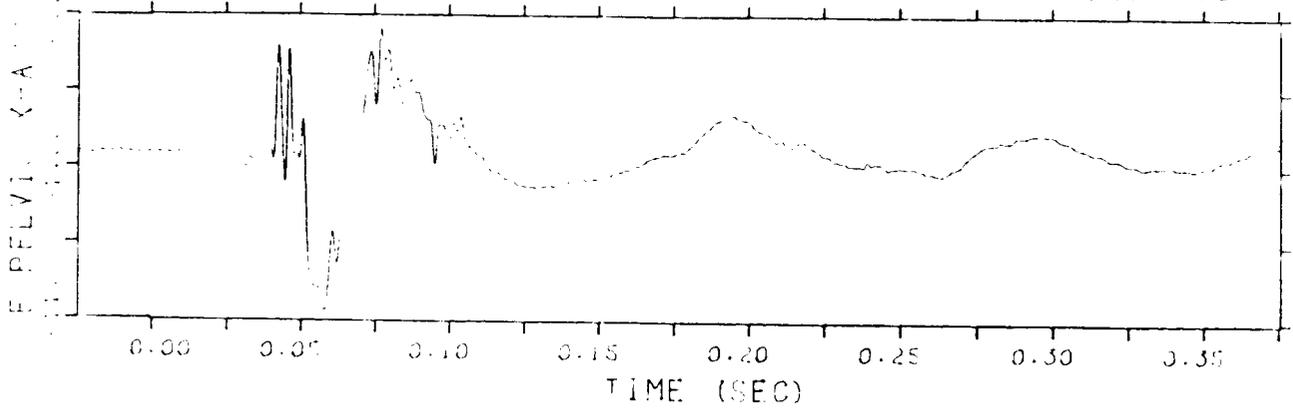
MAX=67.7



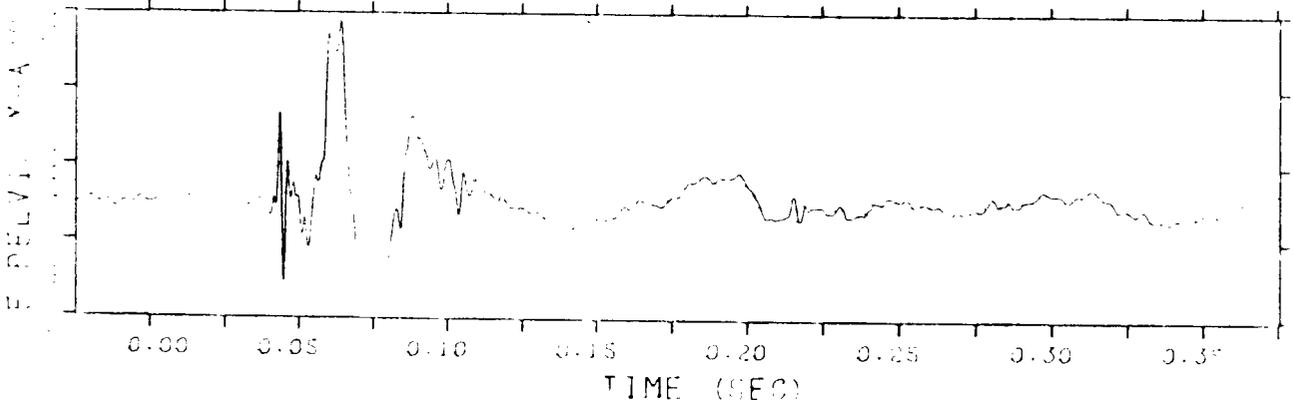
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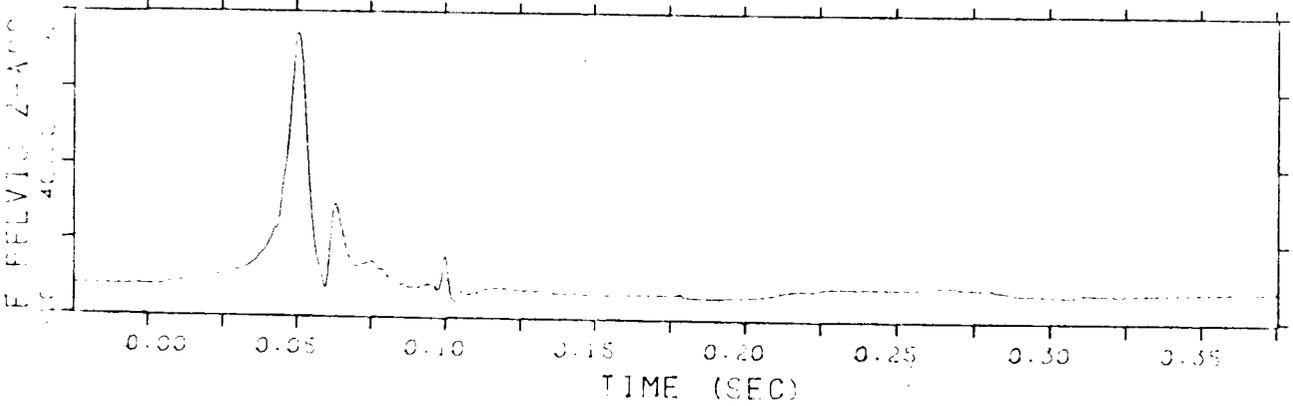
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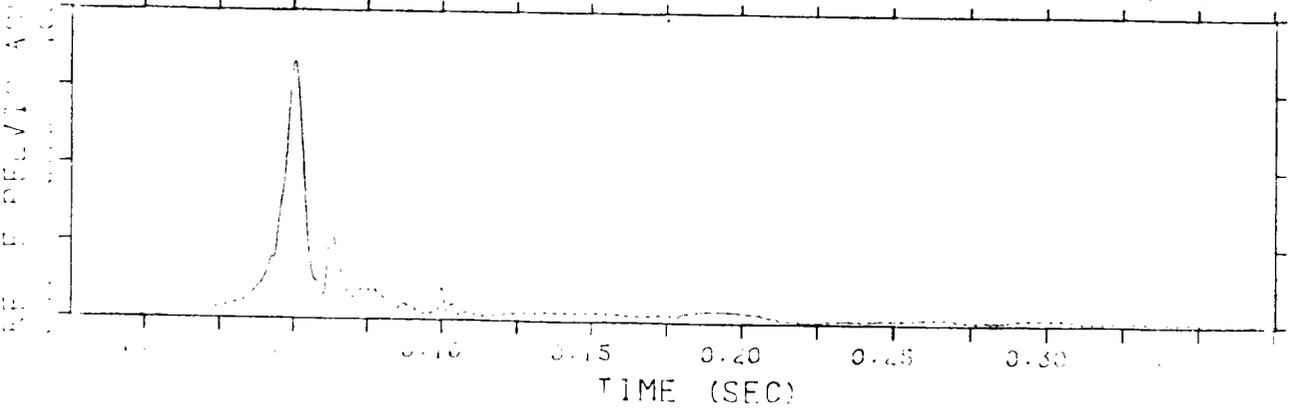
MAX=4.83



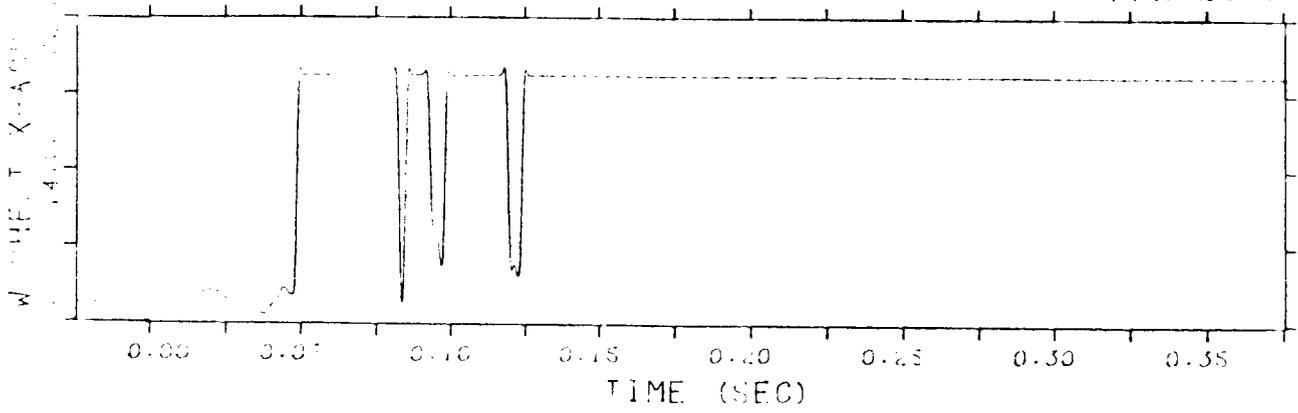
MAX=2.54



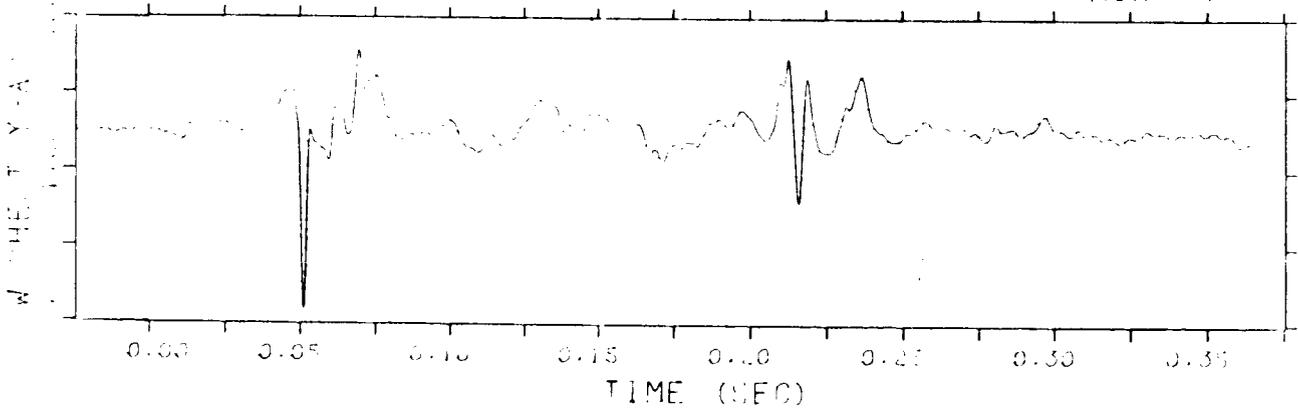
MAX=8.57



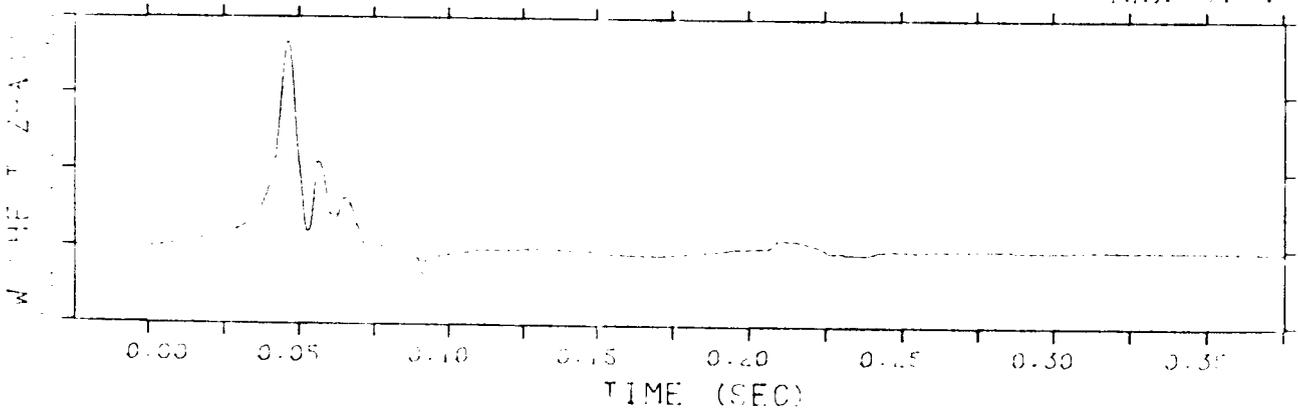
MAX=25.1



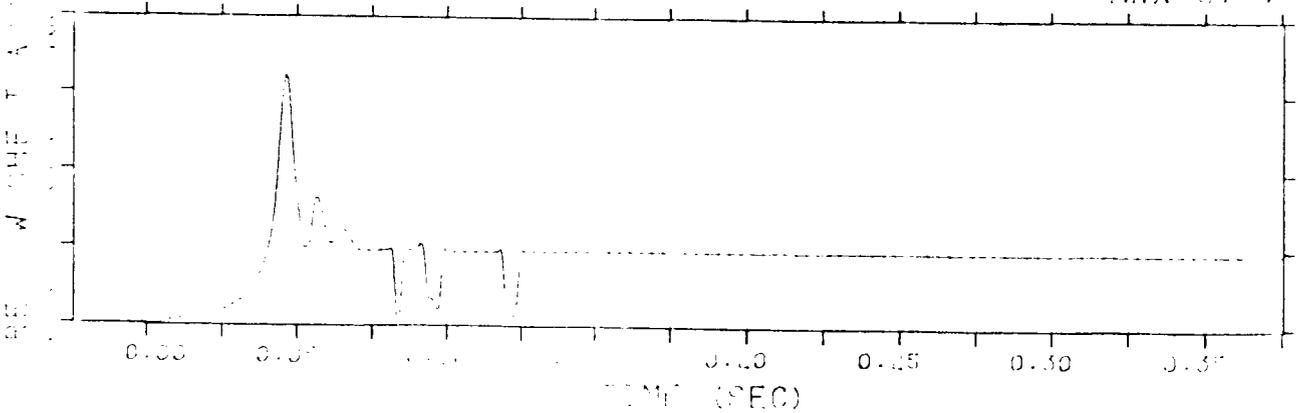
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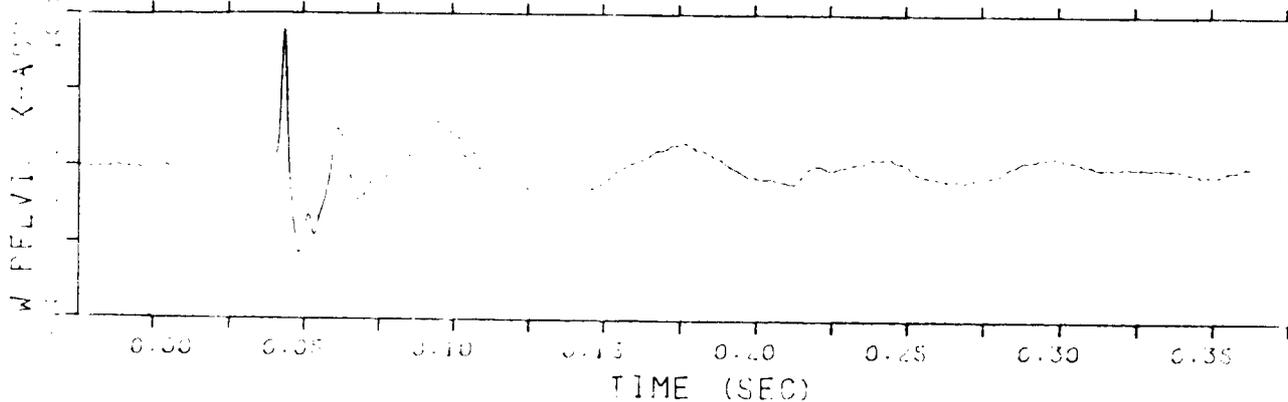
MAX=6.11



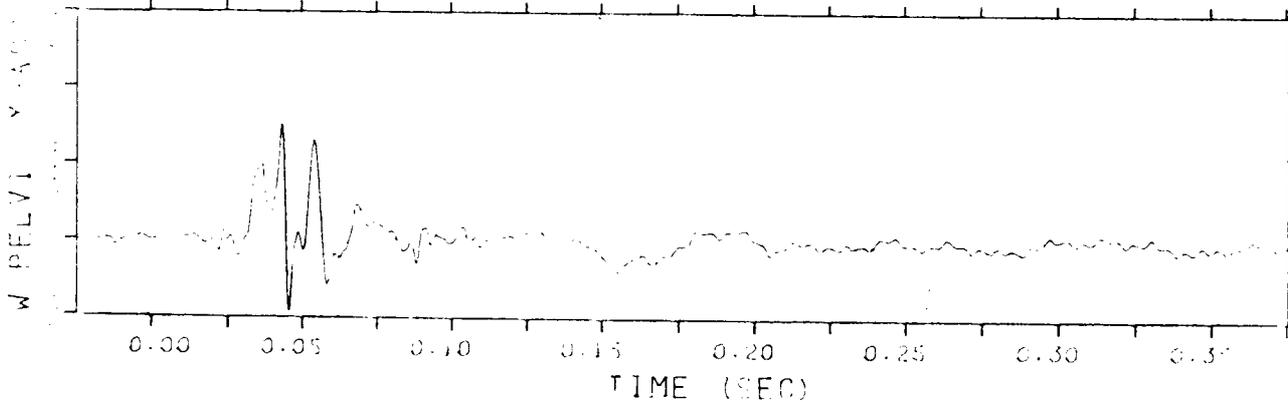
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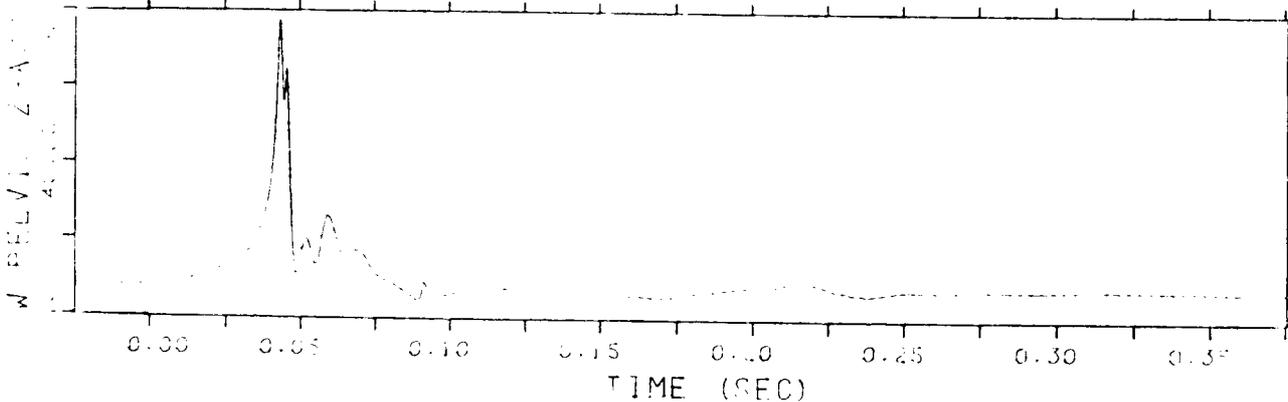
MAX=8.07



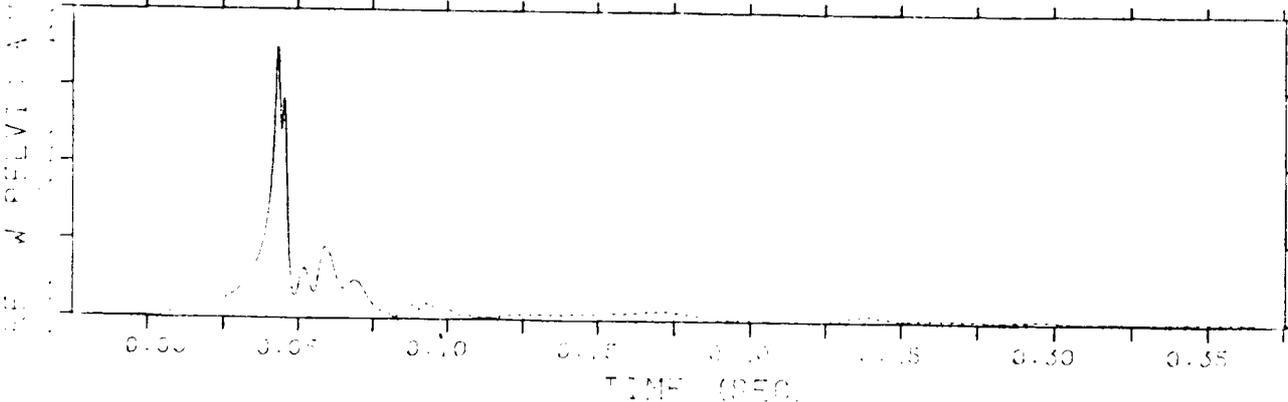
MAX=3.07



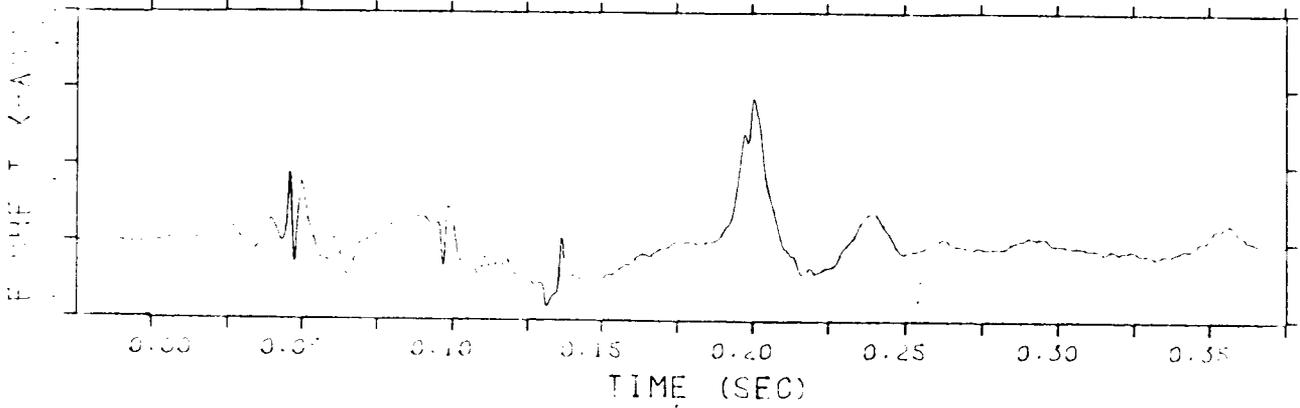
MAX=87.77



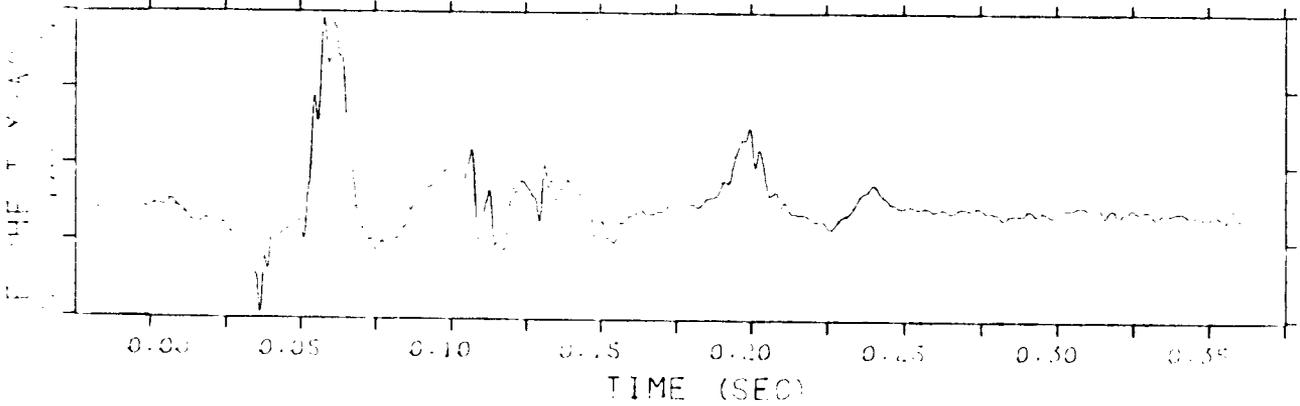
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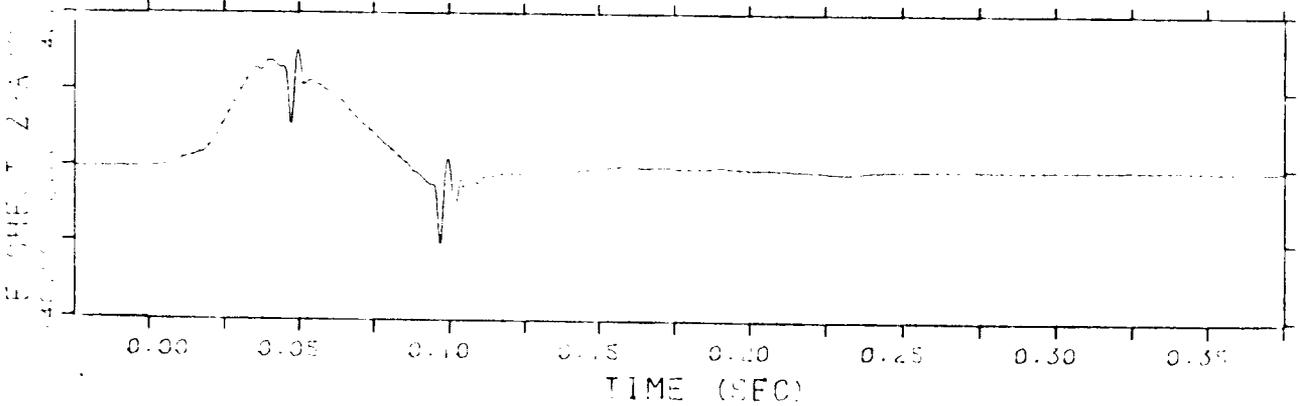
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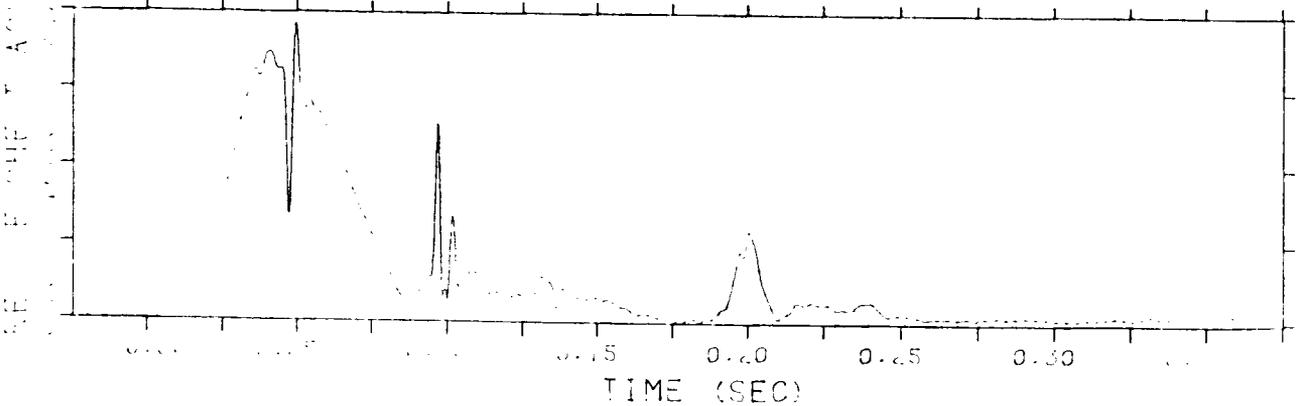
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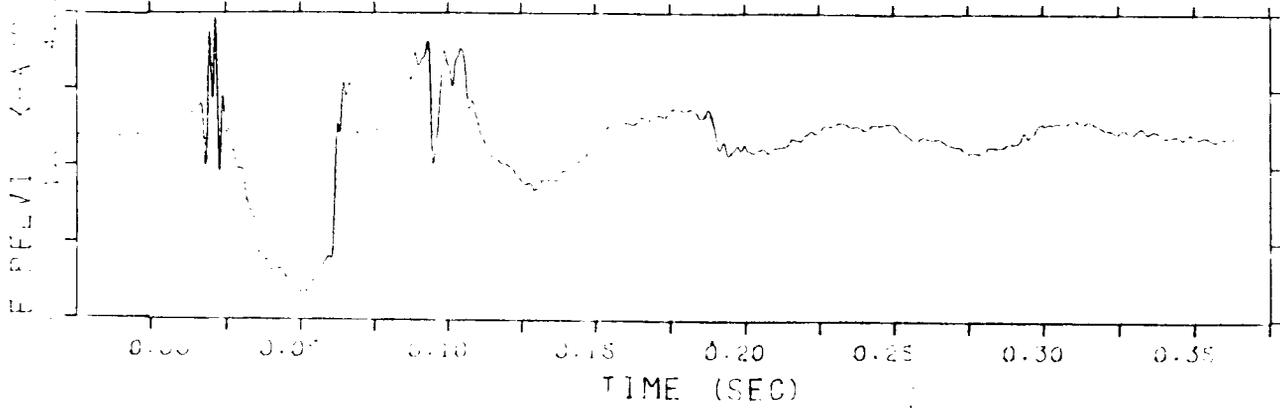
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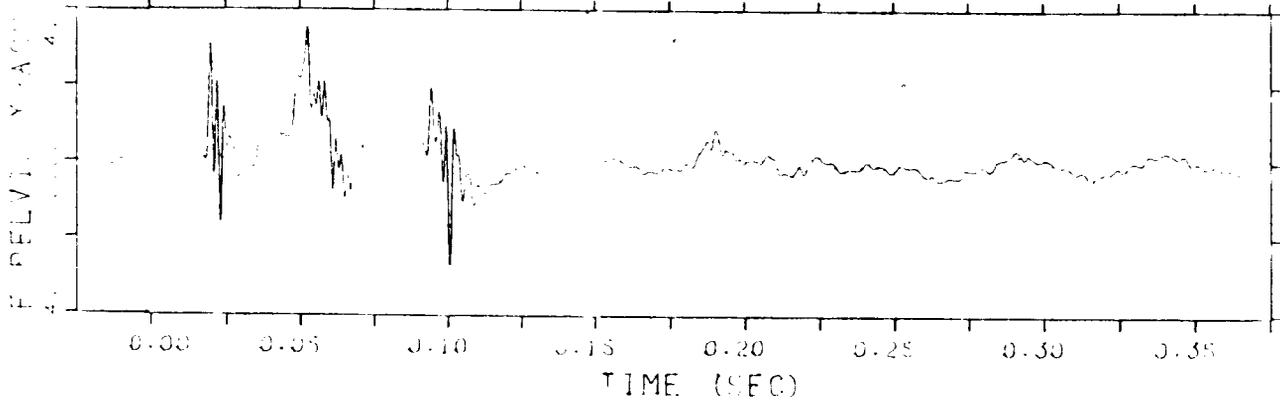
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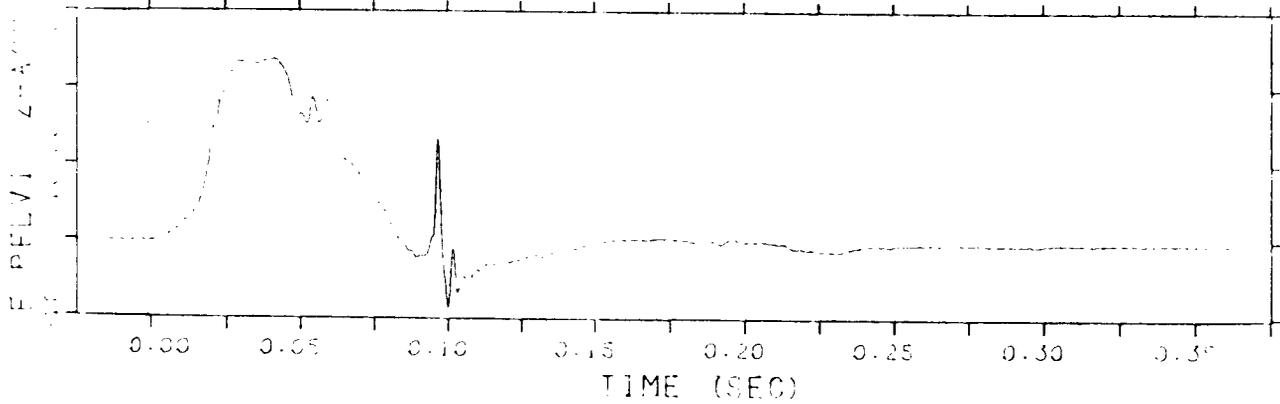
MIN=-5.54



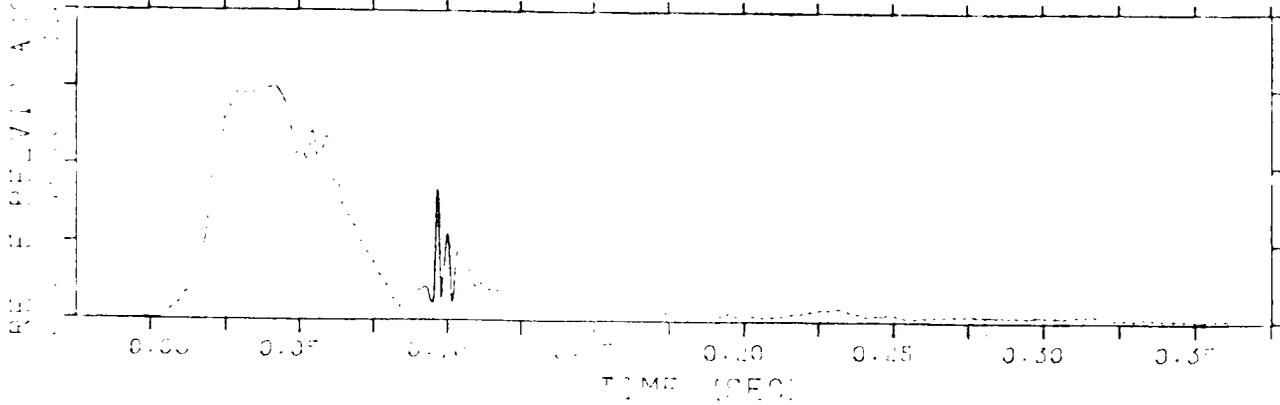
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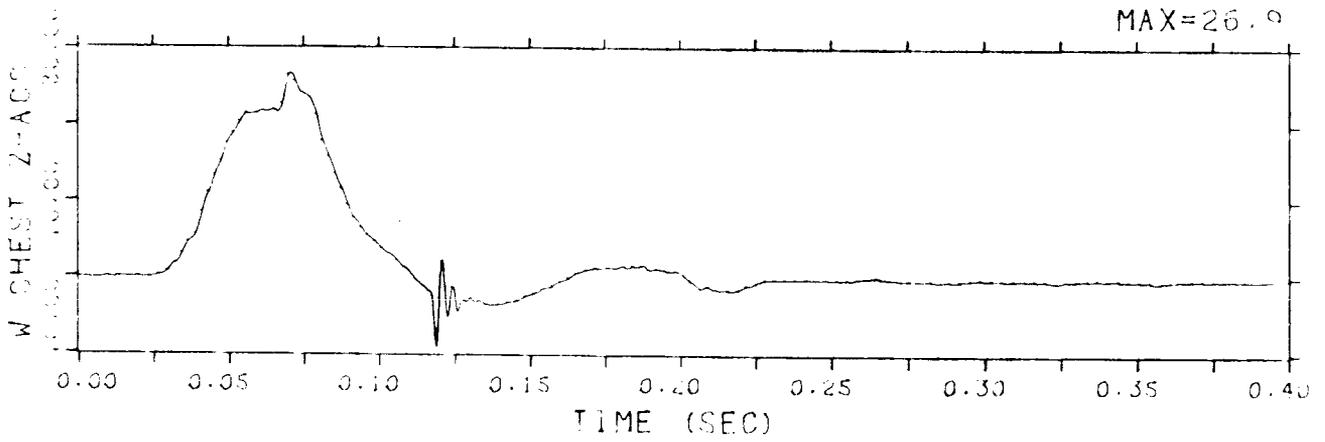
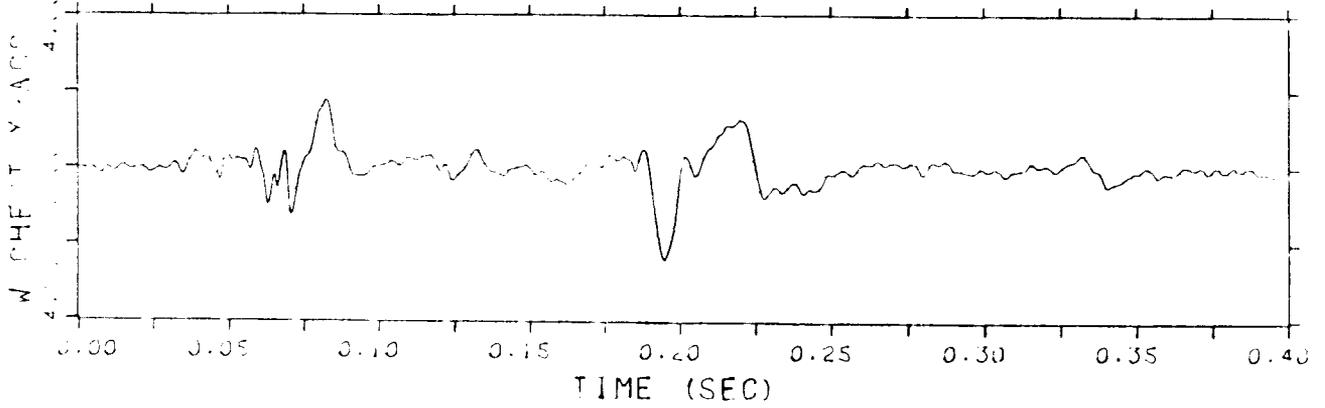
MAX=25.1



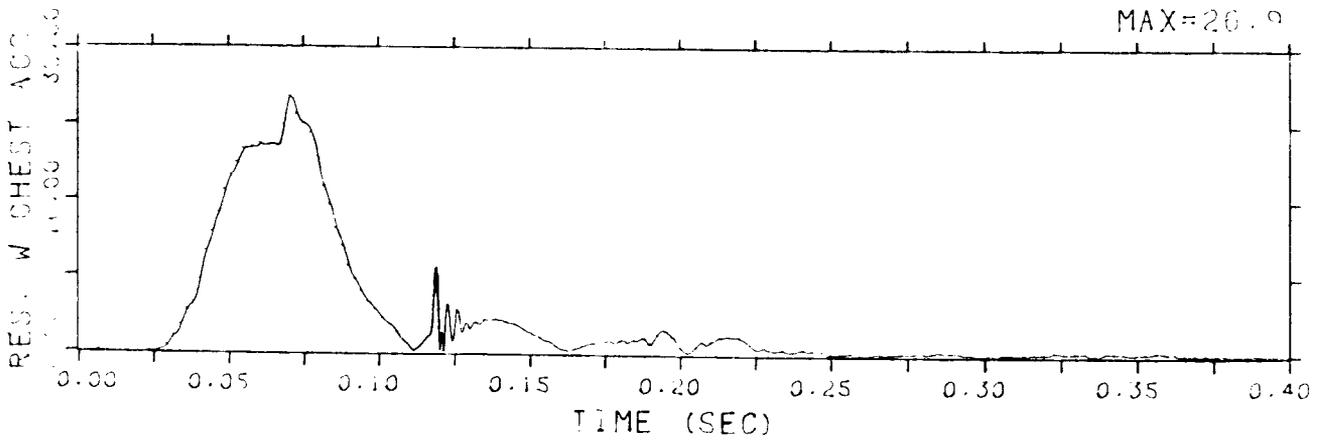
MAX=24.1



MIN=-2.39

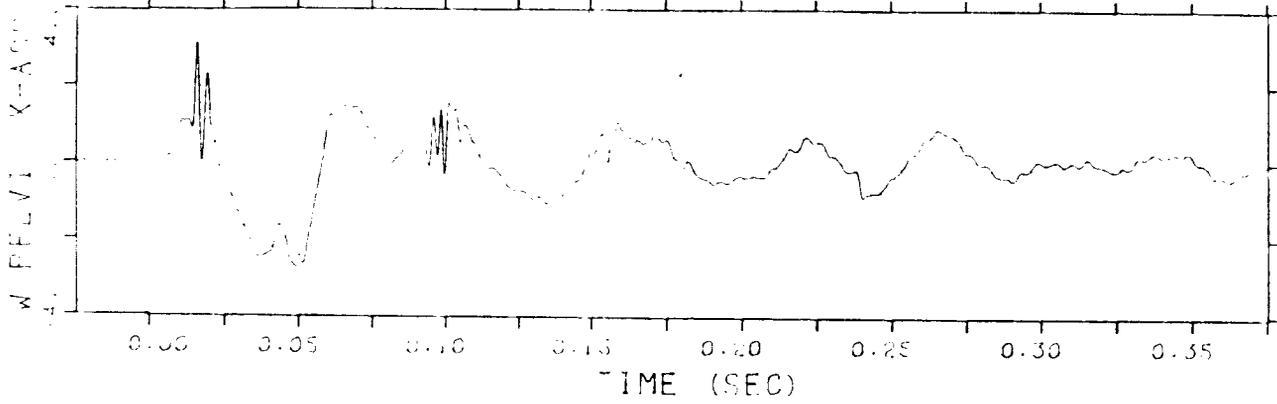


MAX=26.9

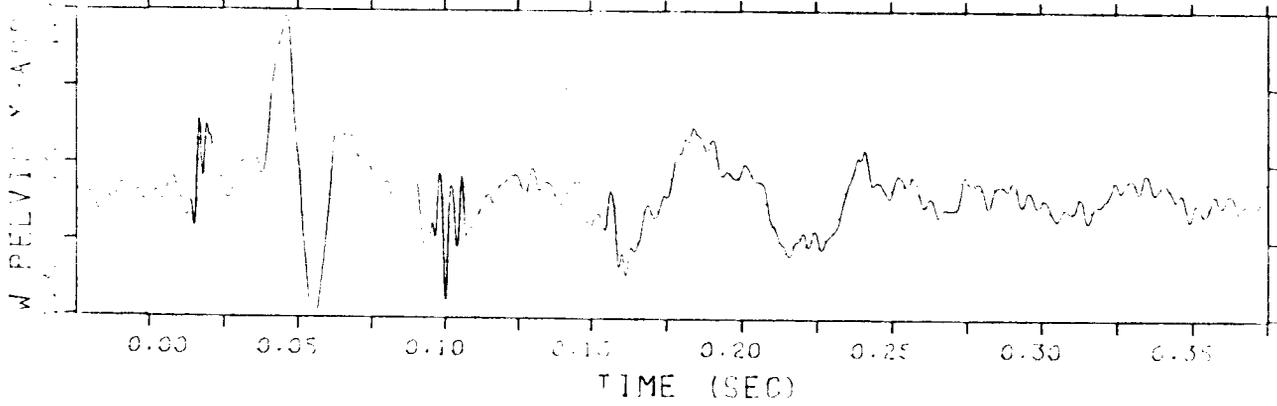


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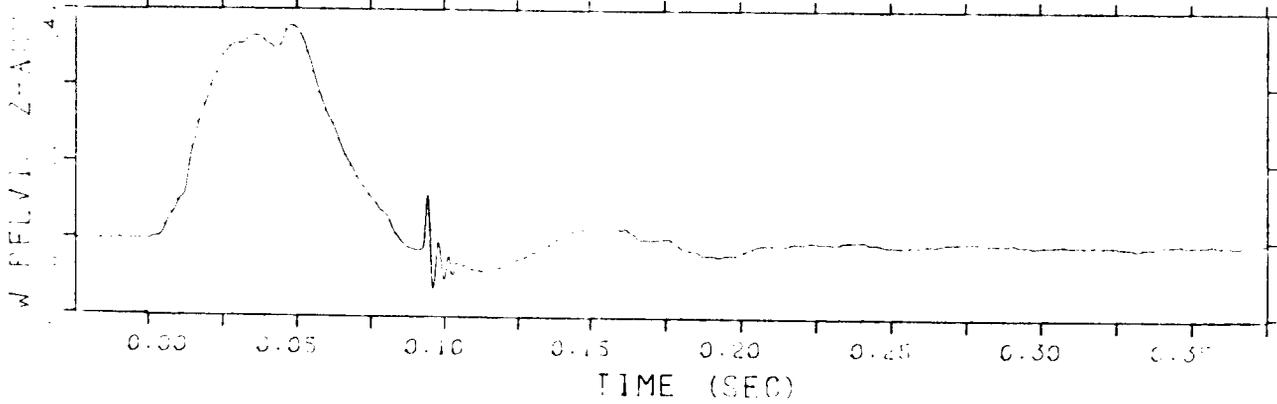
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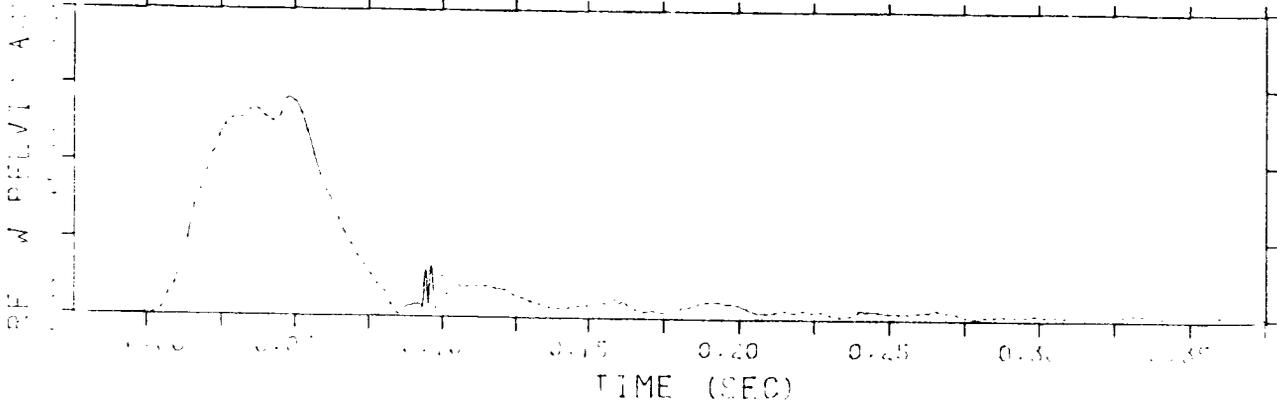
MAX=1.80



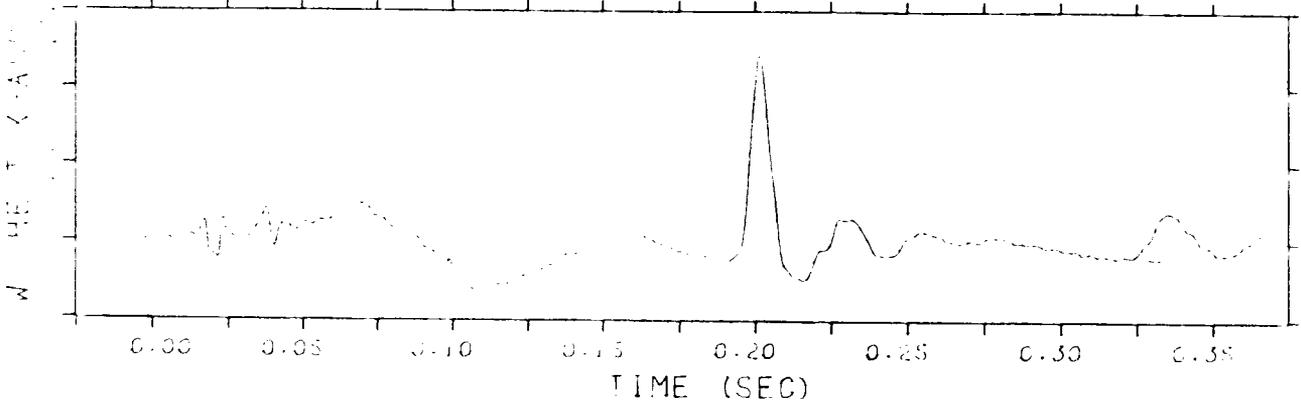
MAX=22.7



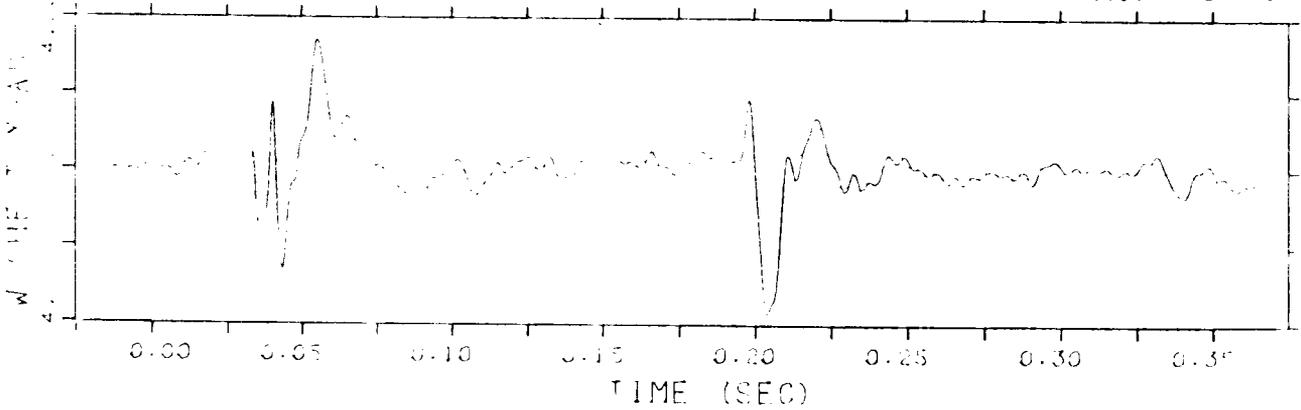
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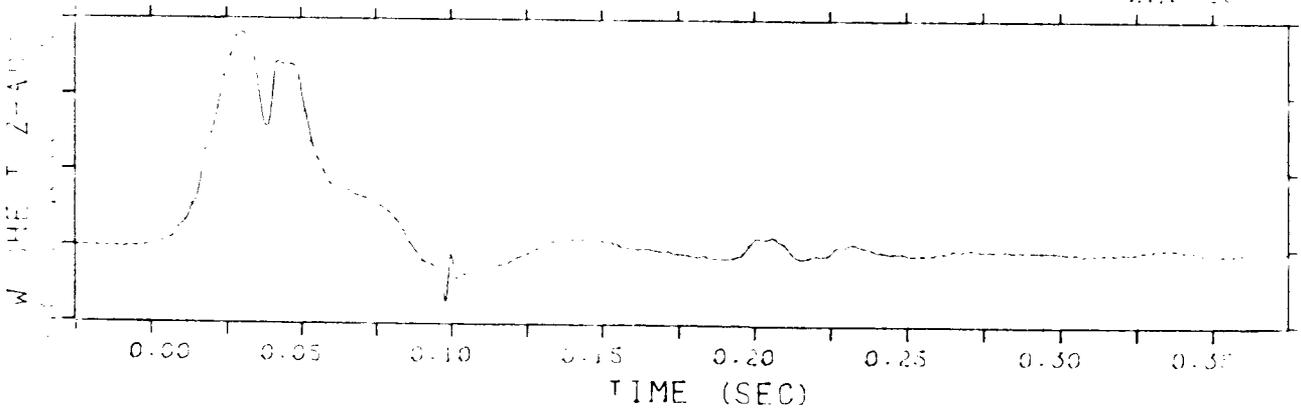
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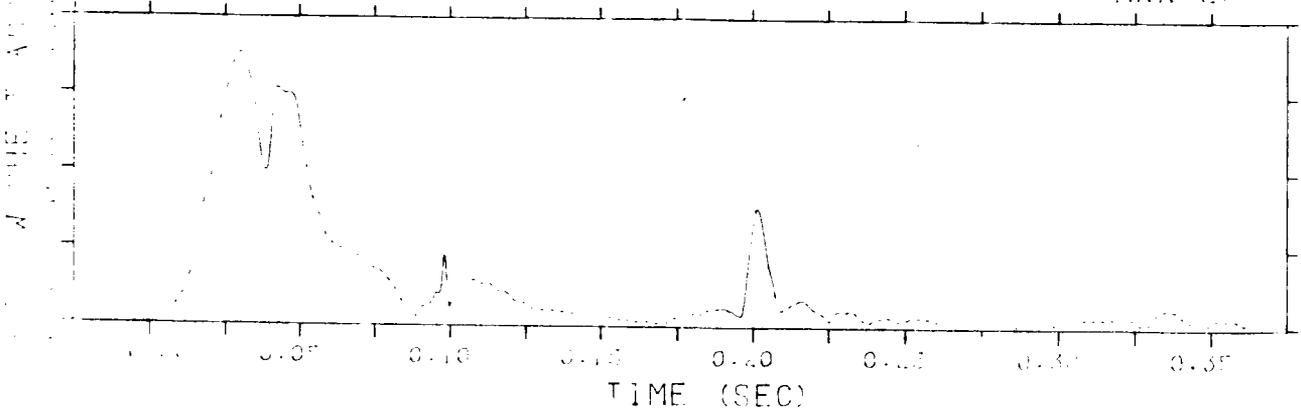
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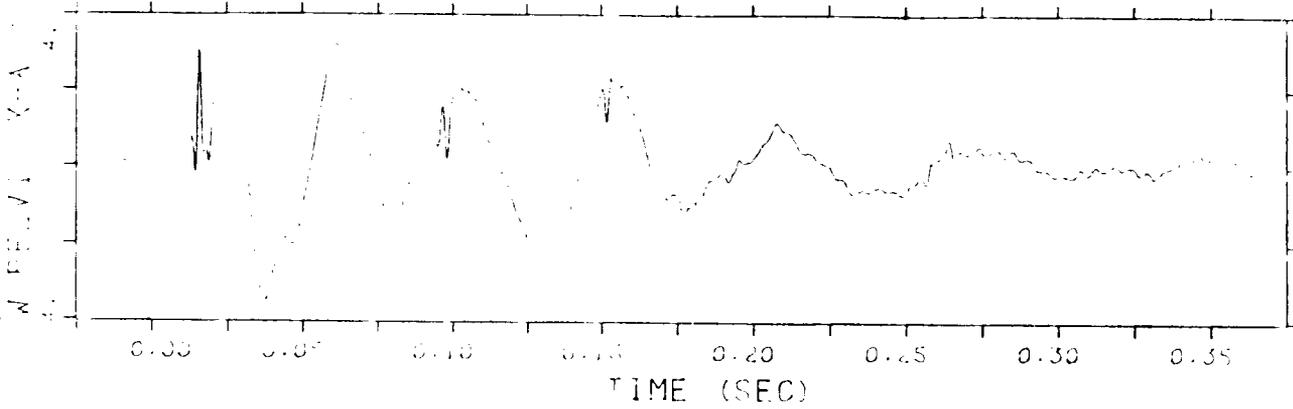
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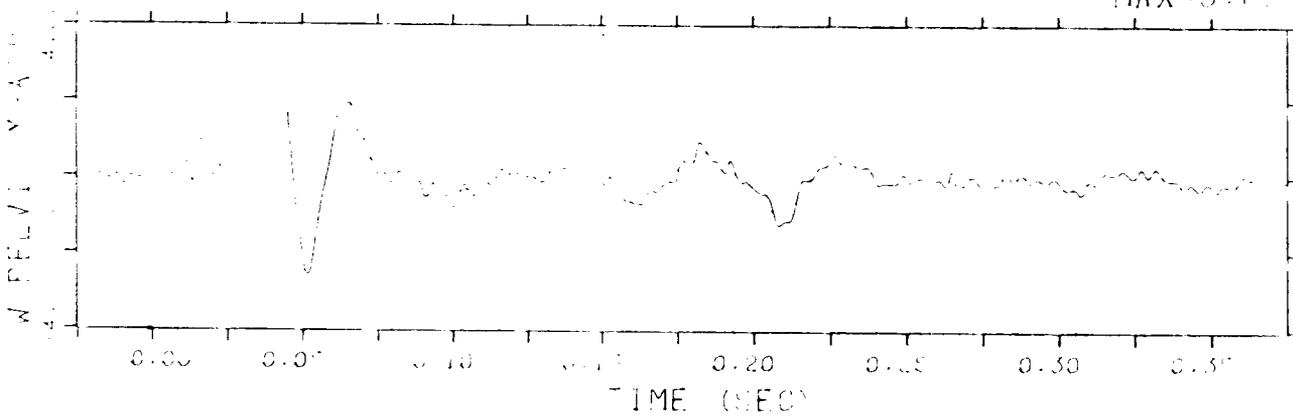
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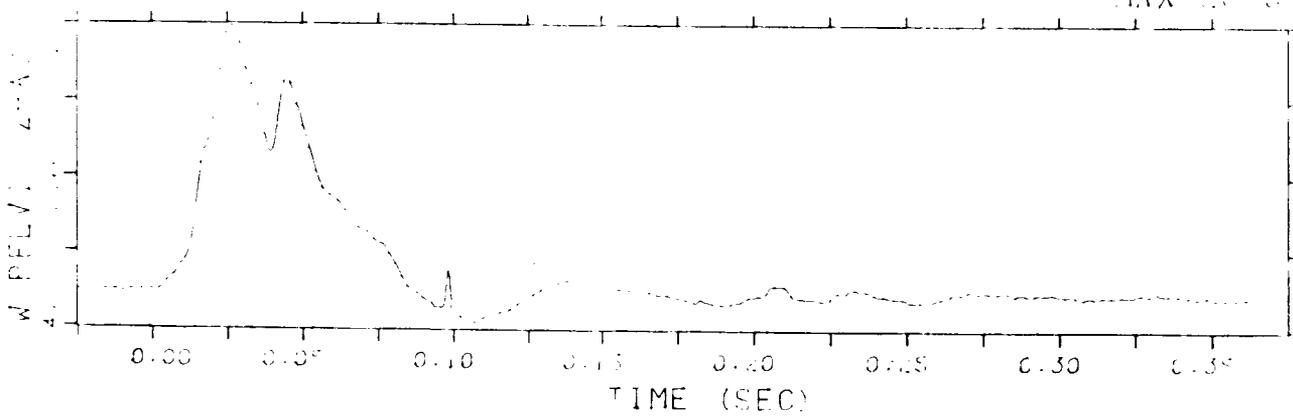
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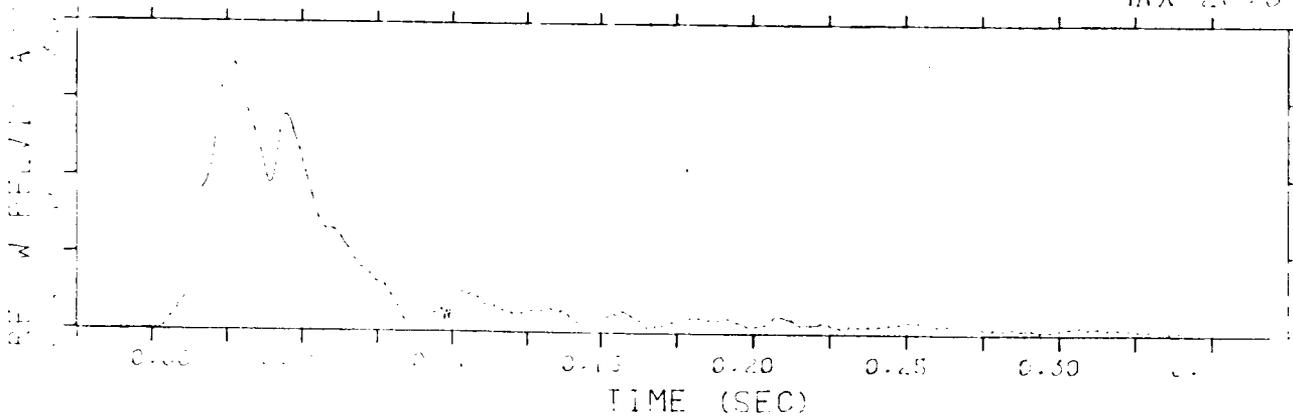
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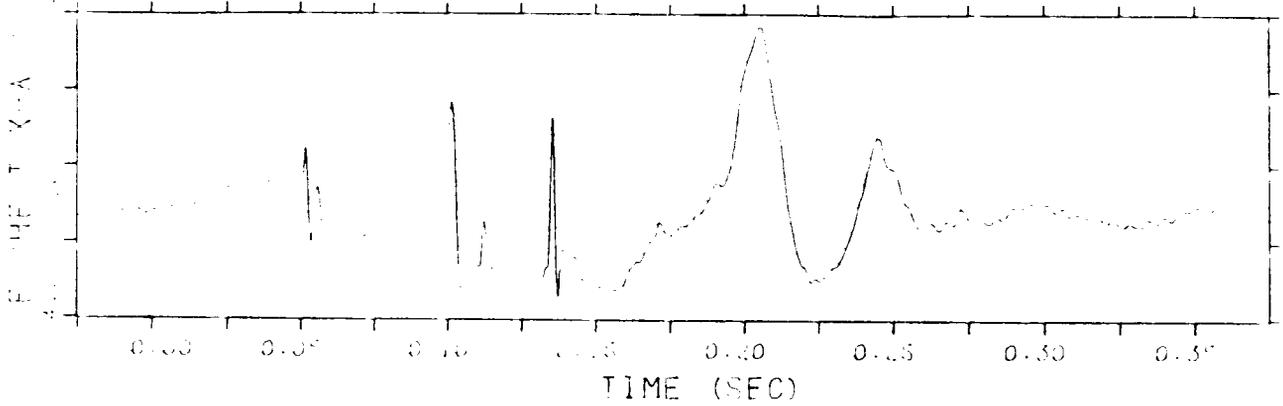
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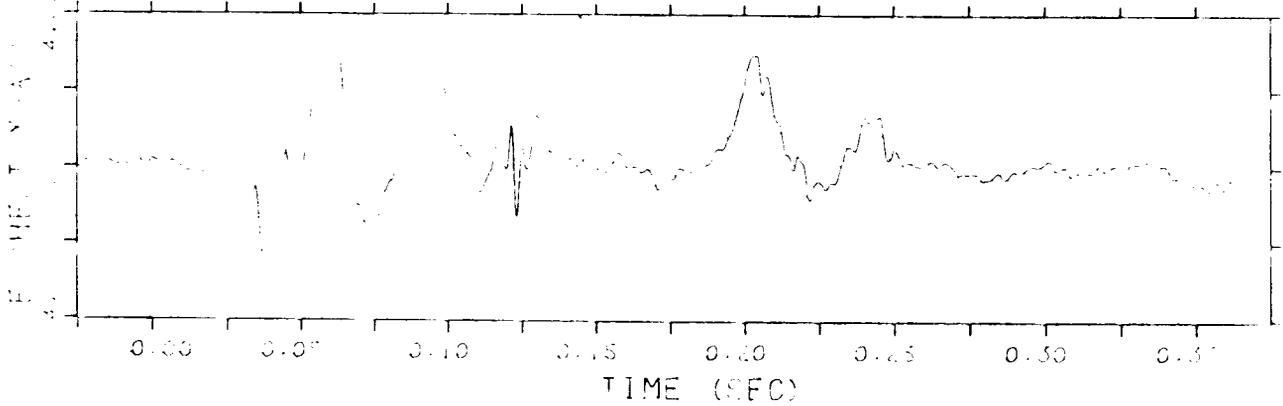
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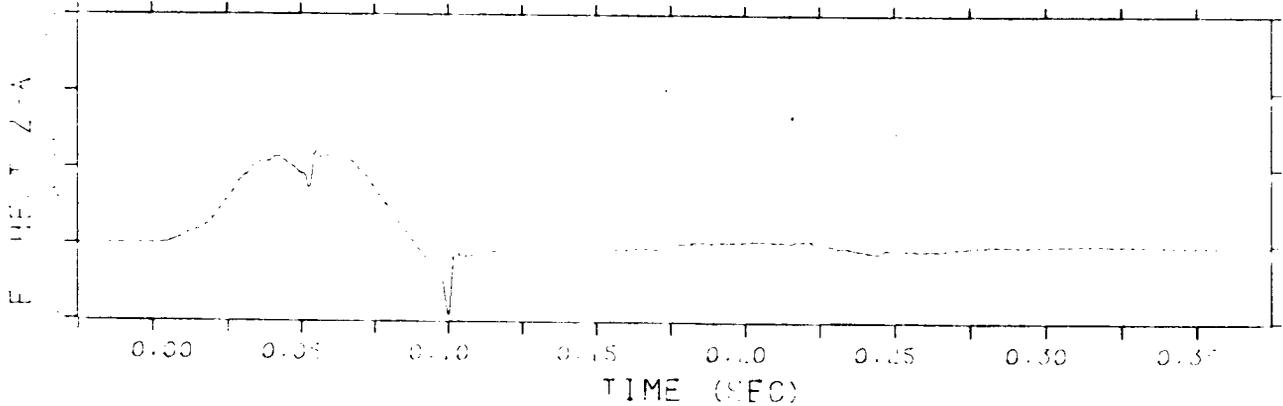
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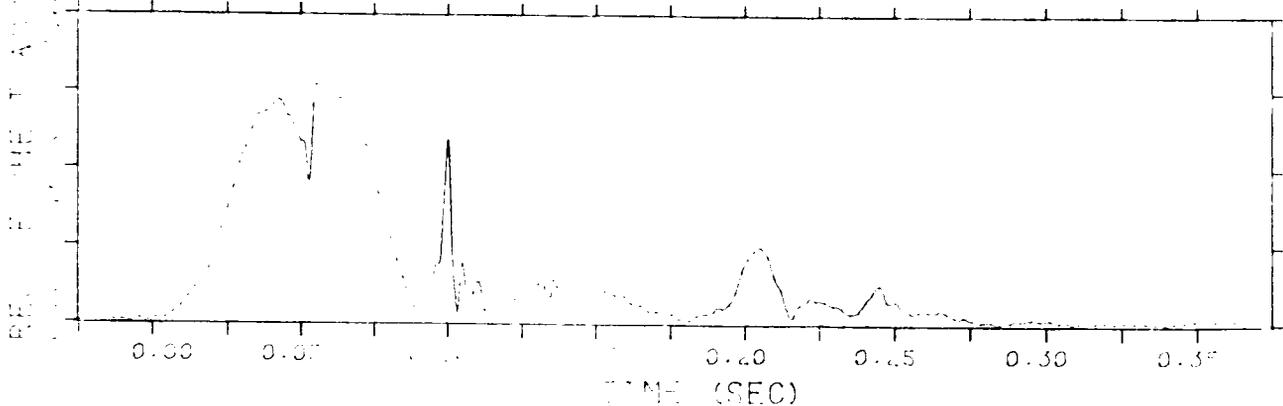
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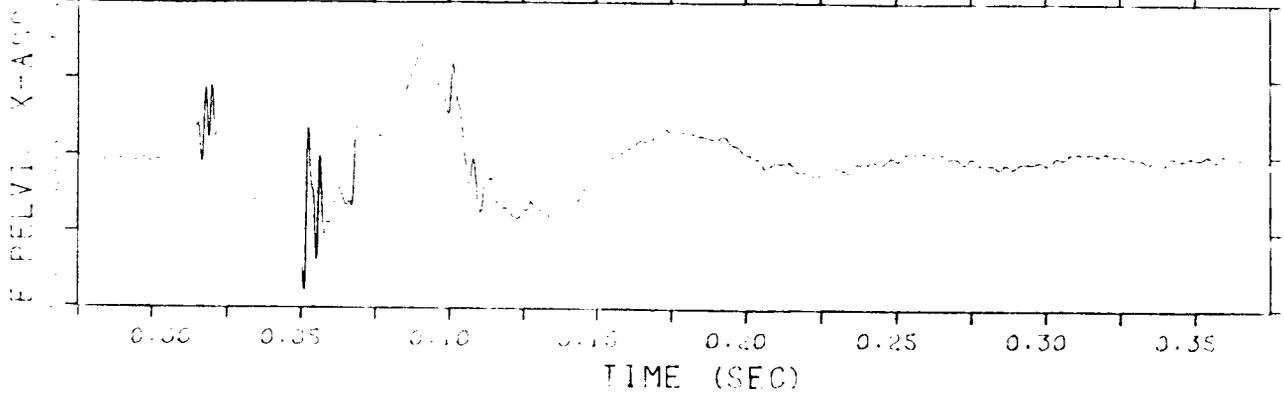
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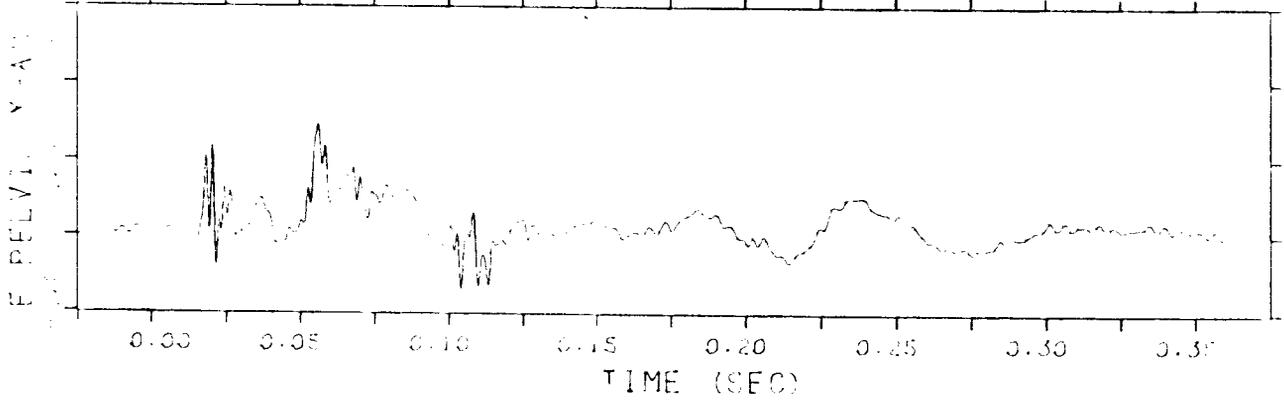
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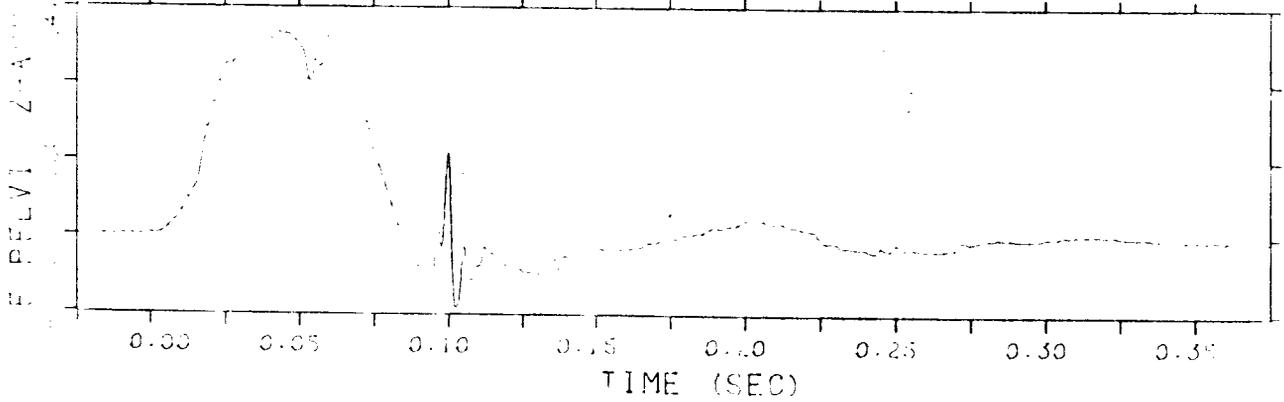
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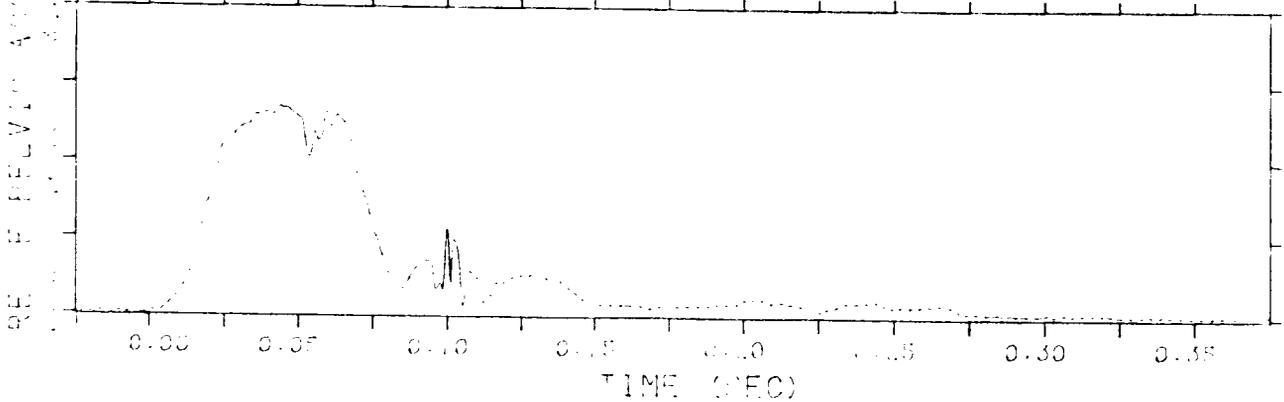
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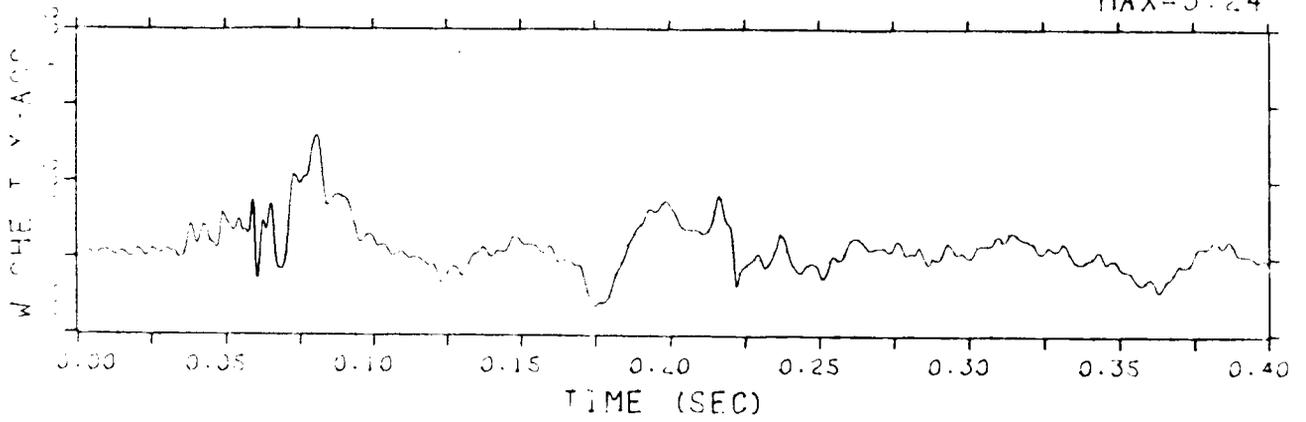
MAX=11.77



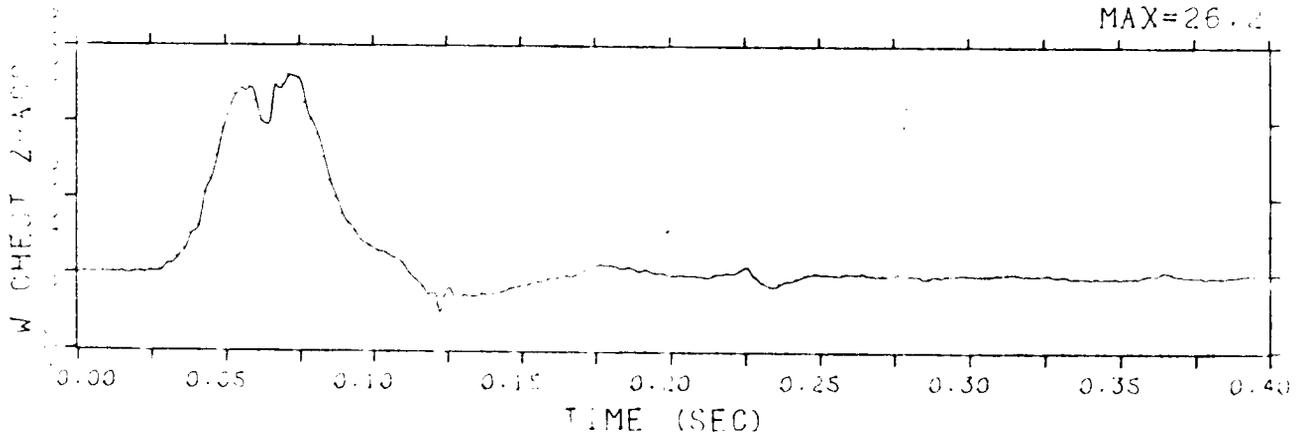
MAX=21.77



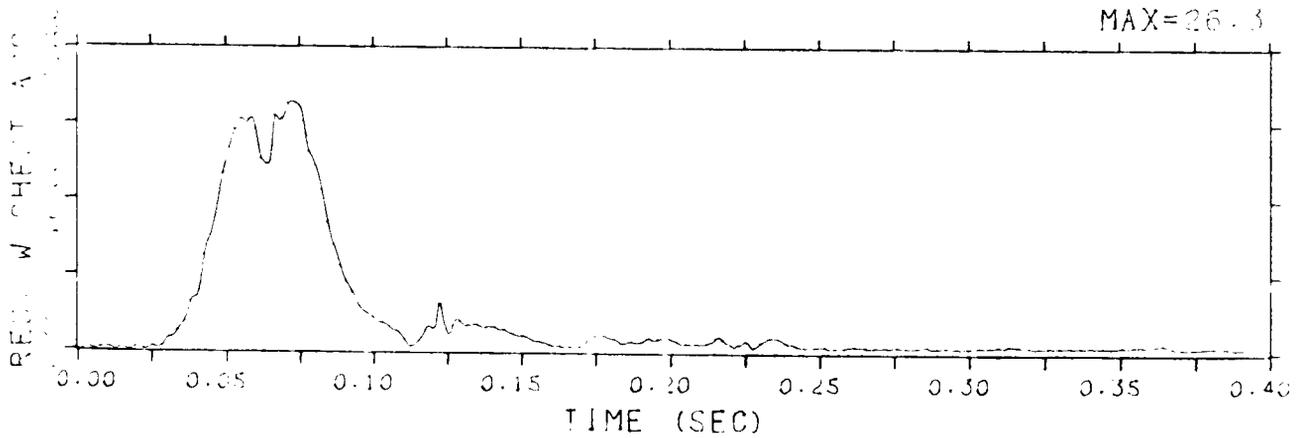
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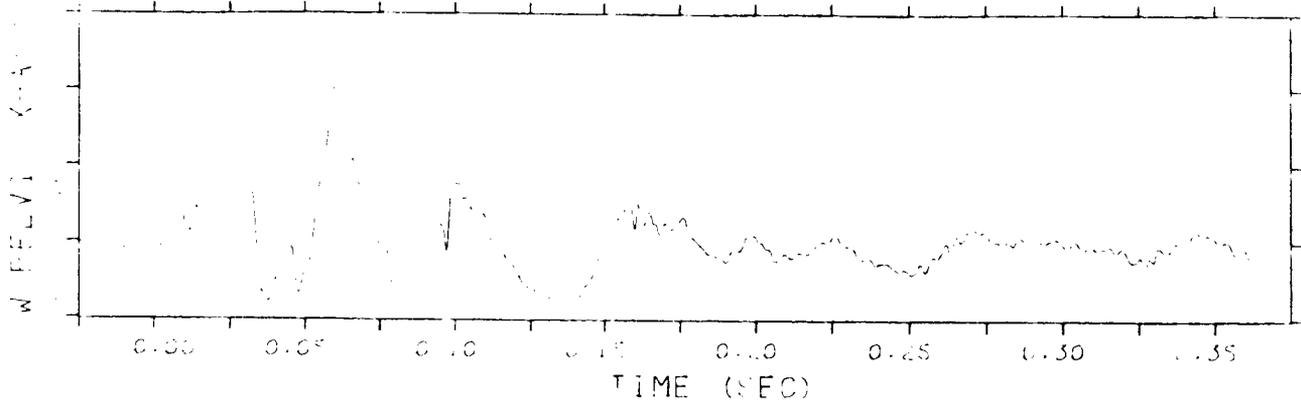
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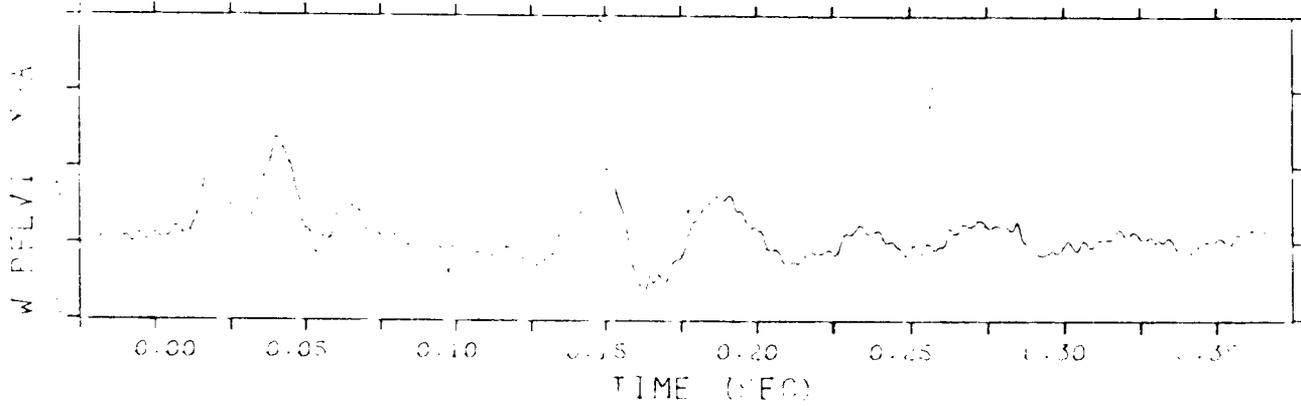
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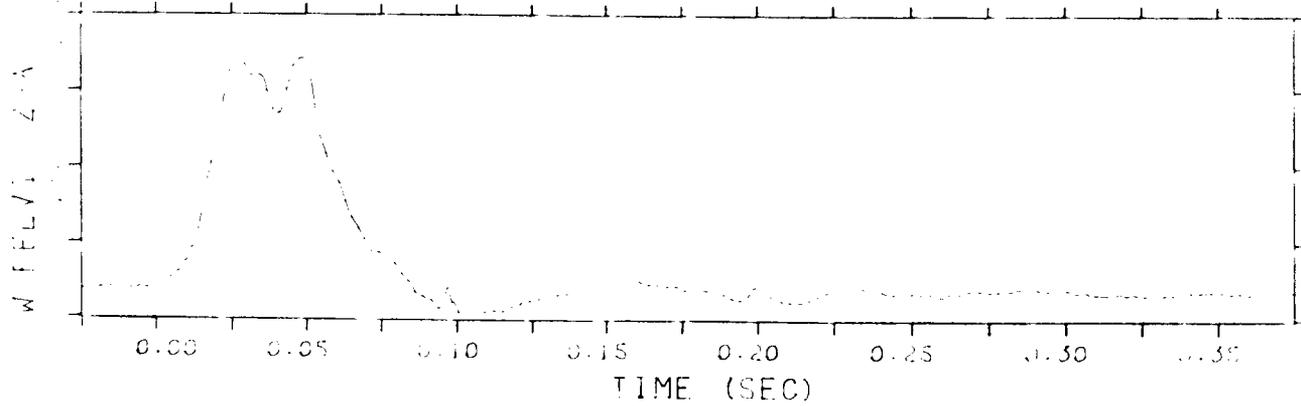
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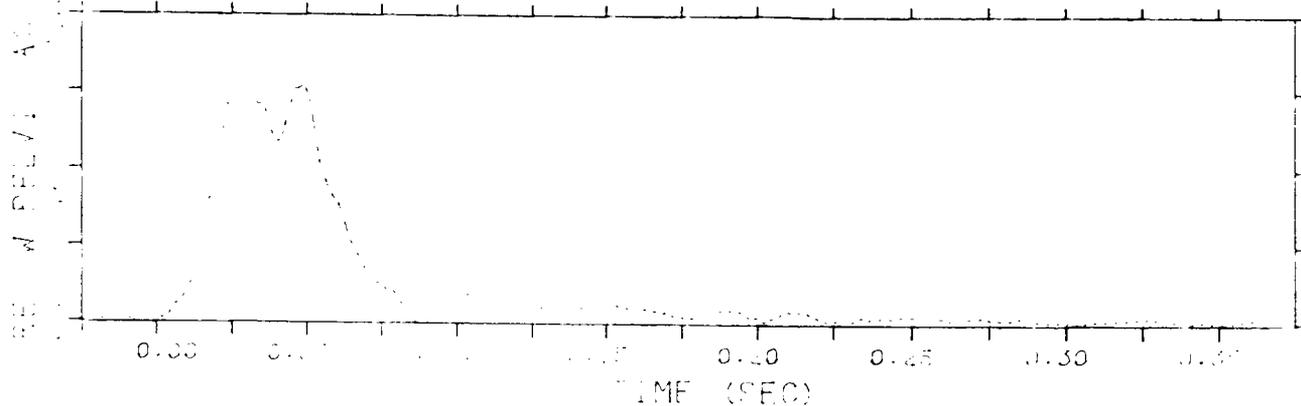
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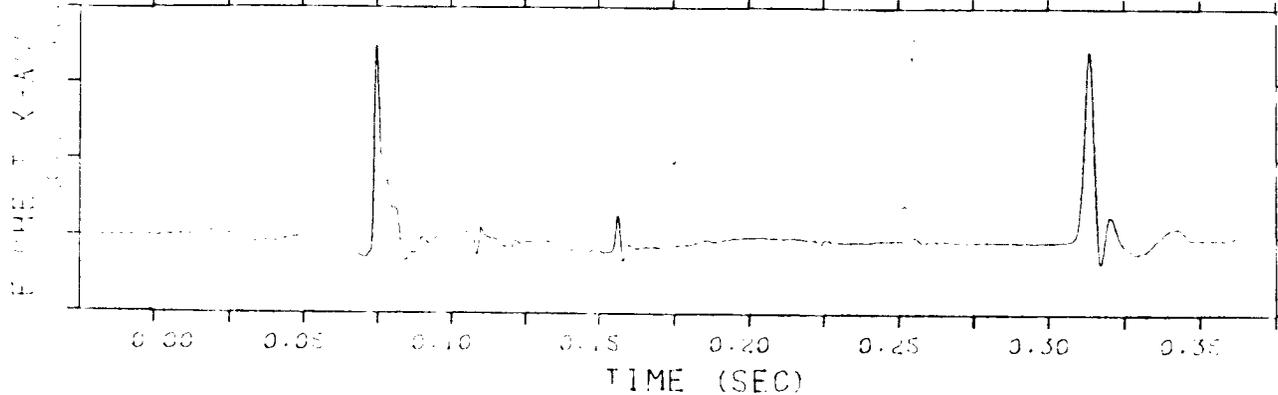
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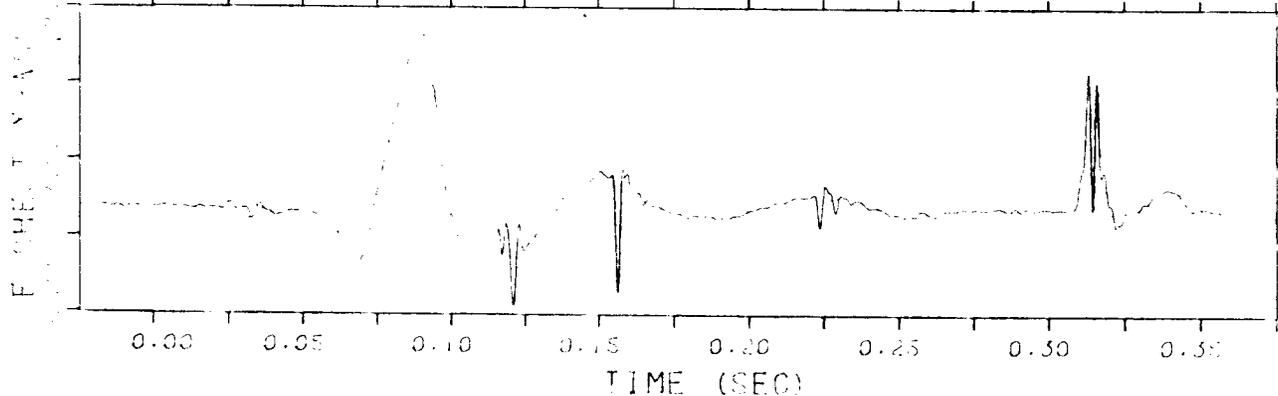
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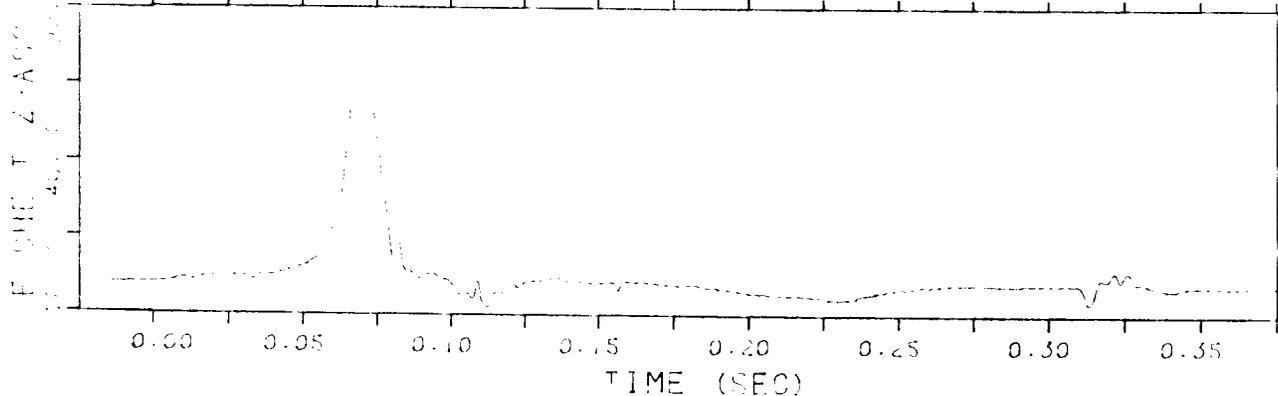
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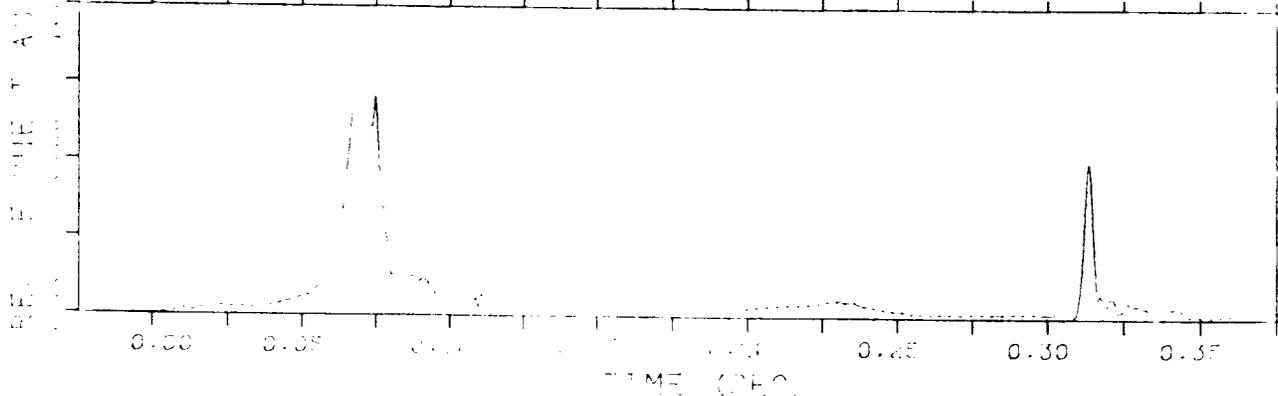
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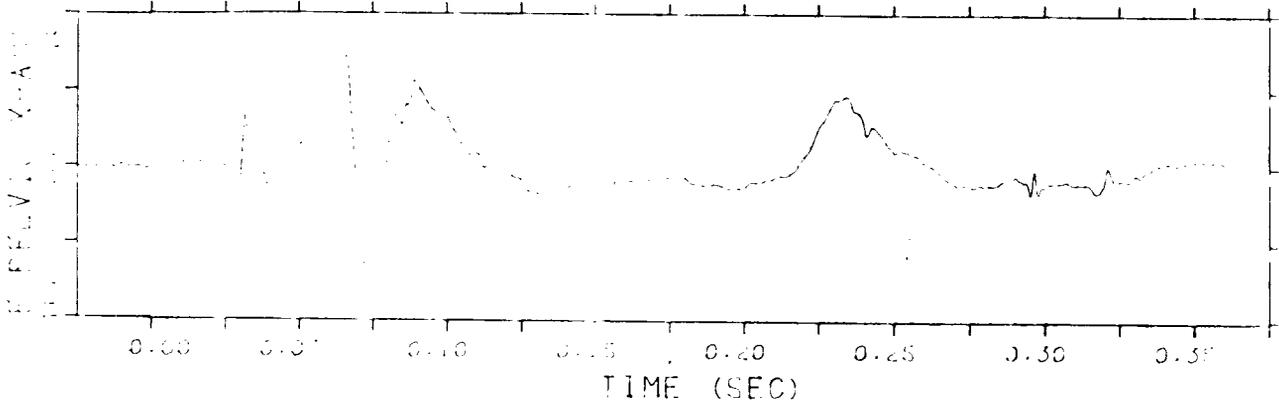
MAX=8.4



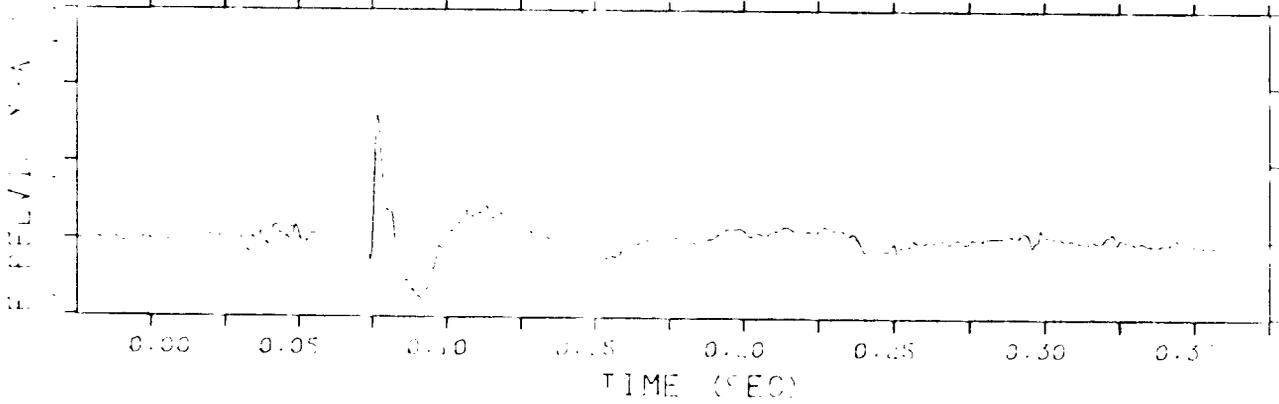
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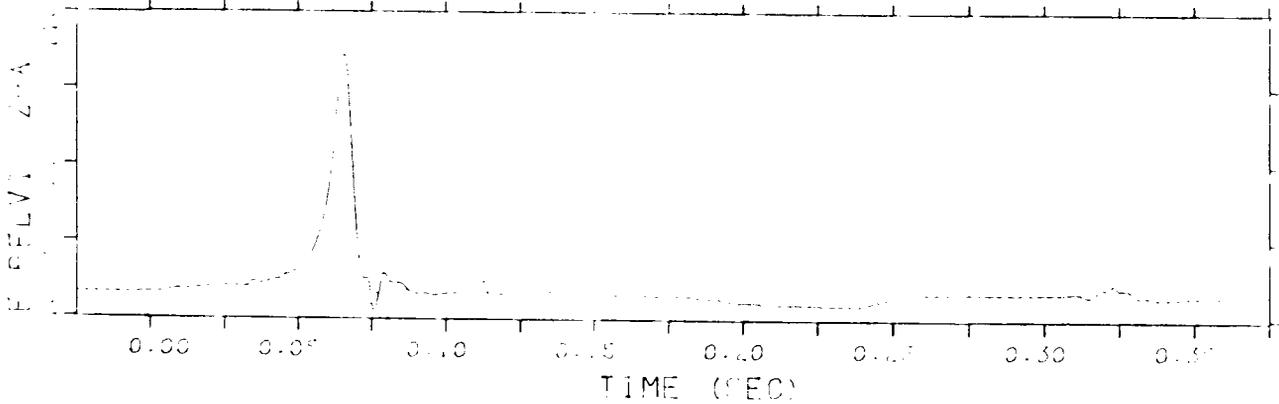
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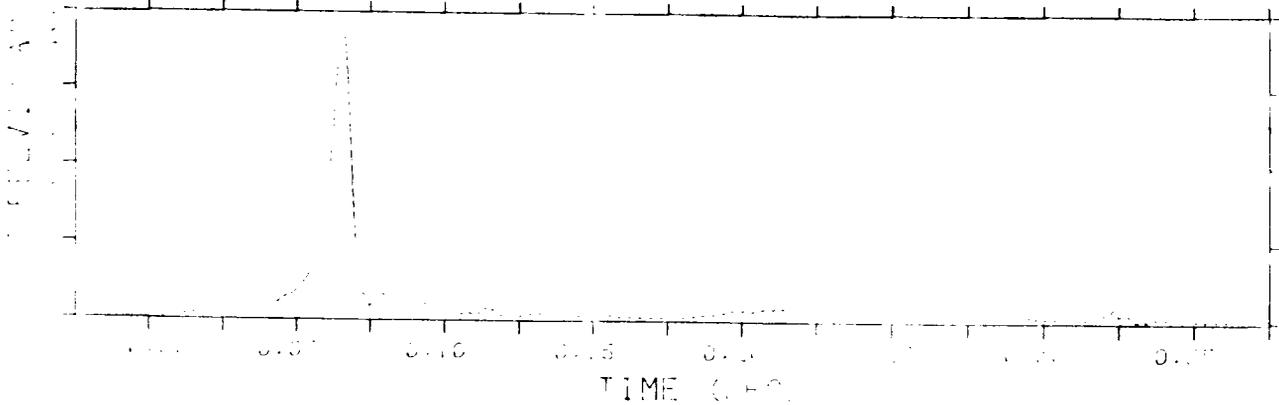
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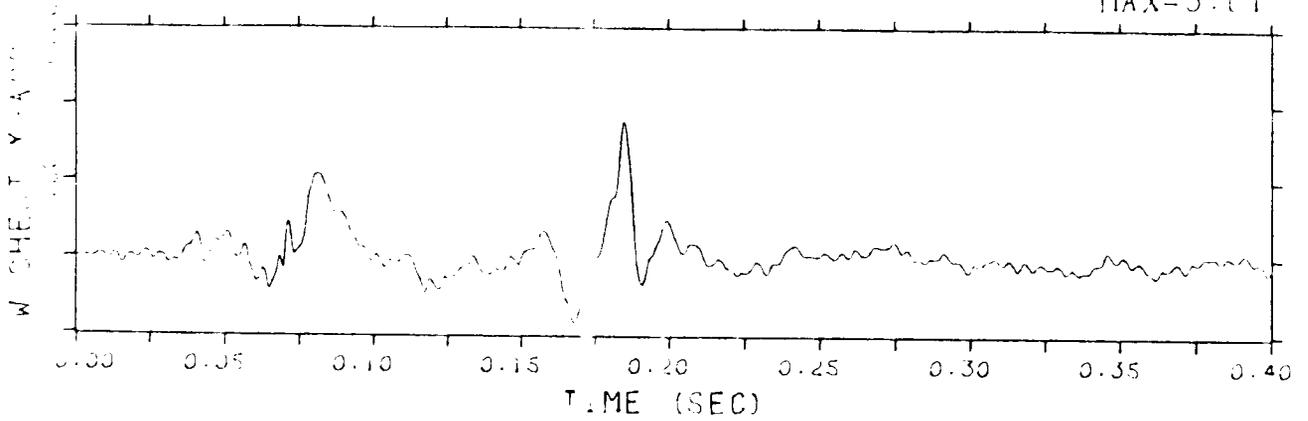
MAX=9.34



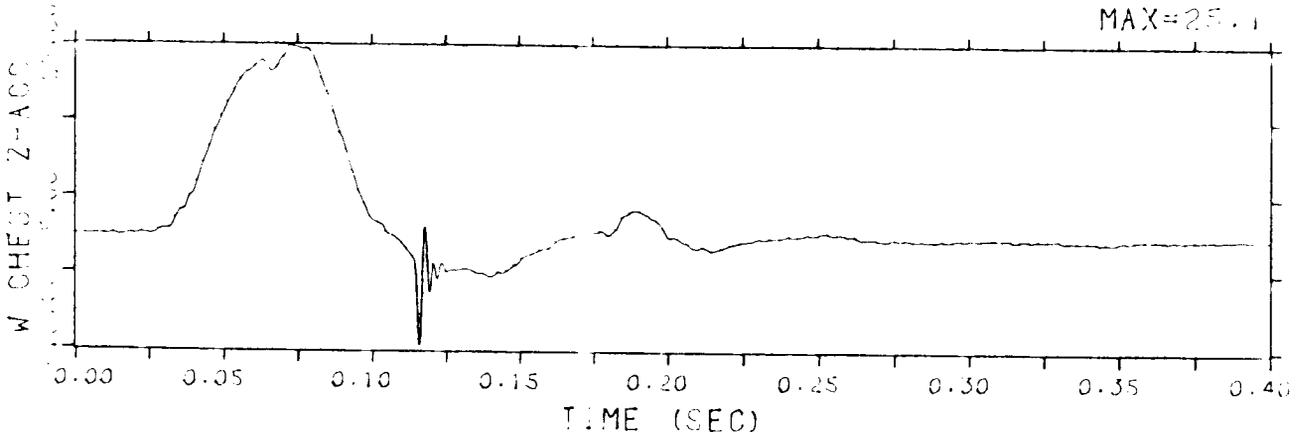
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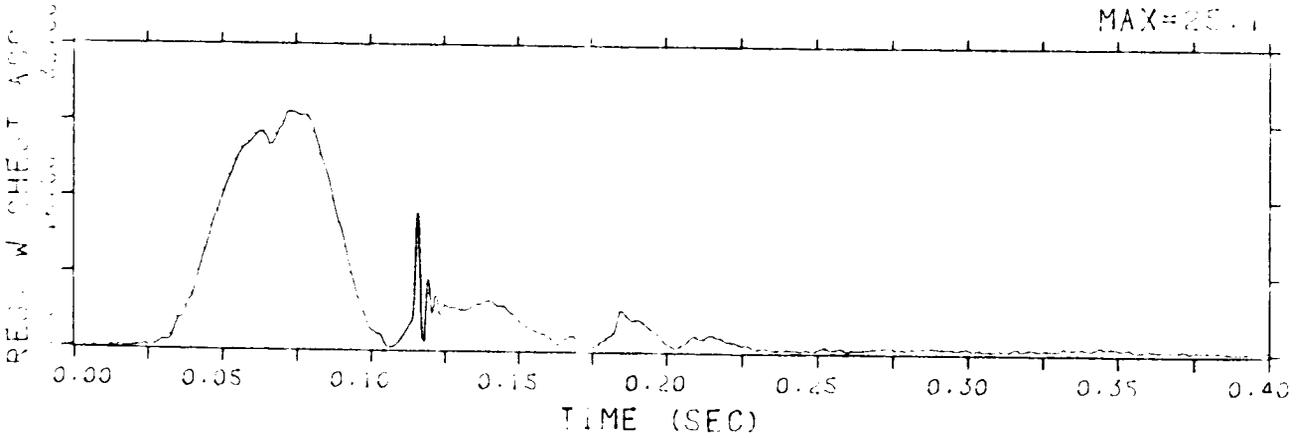
MAX=3.01



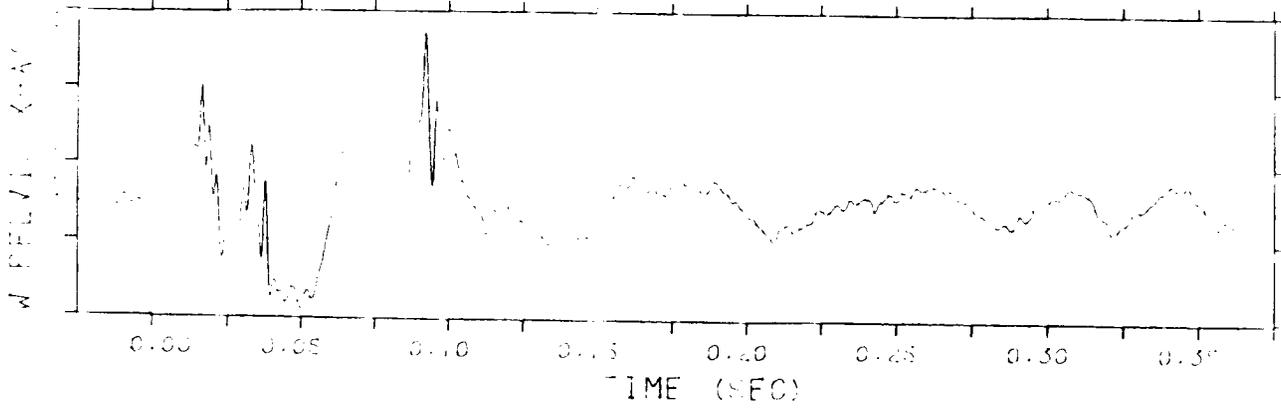
MAX=25.1



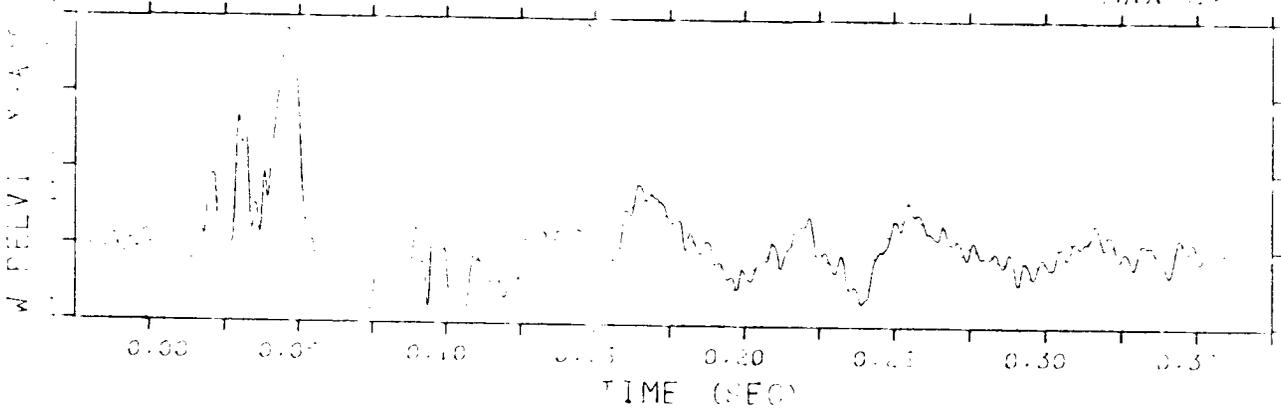
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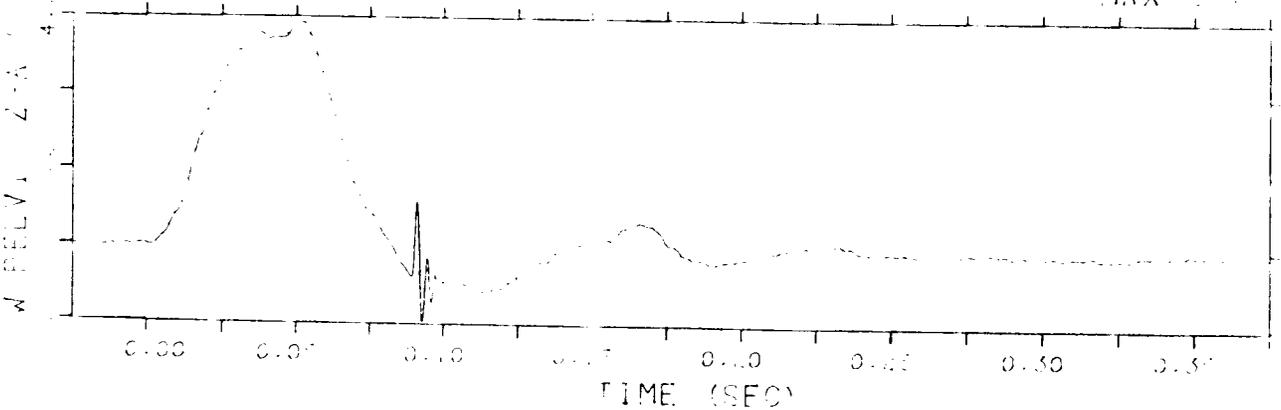
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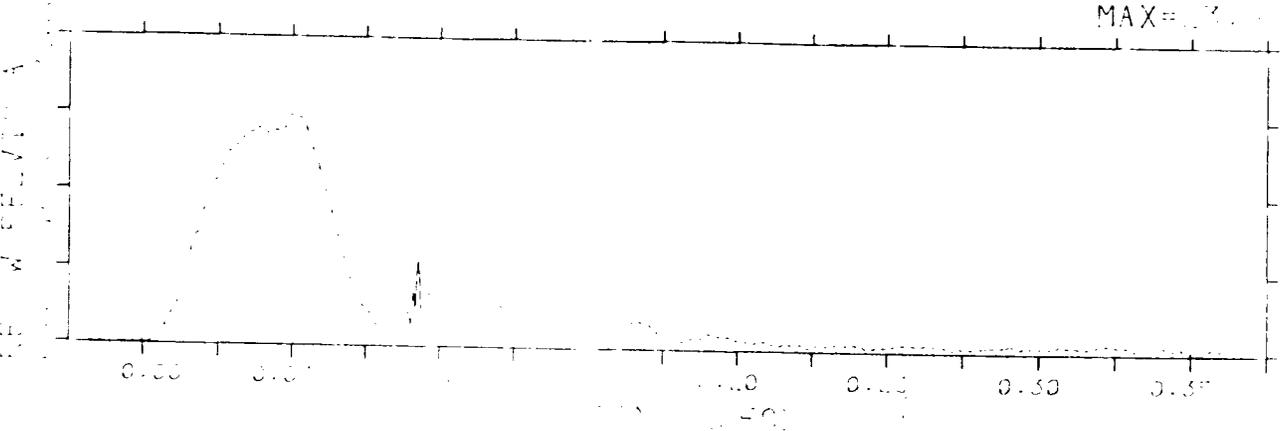
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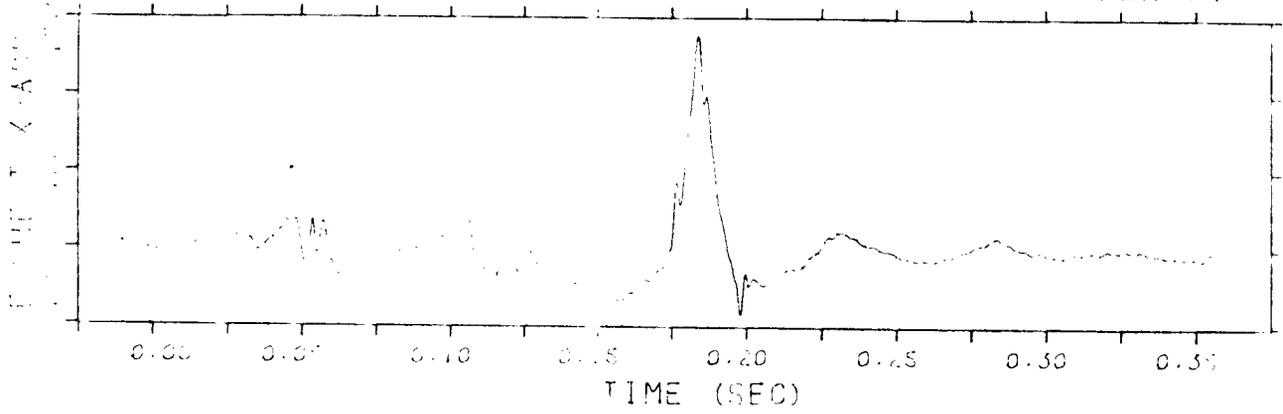
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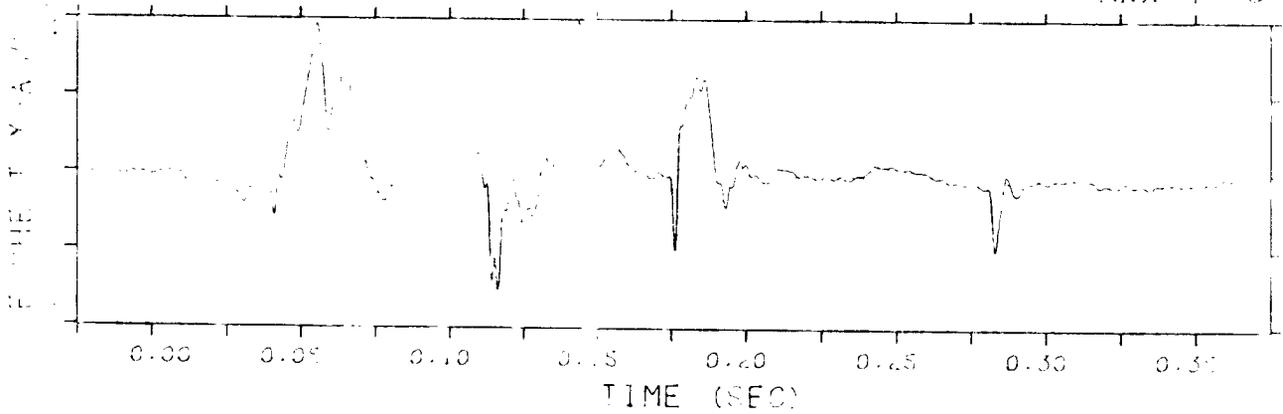
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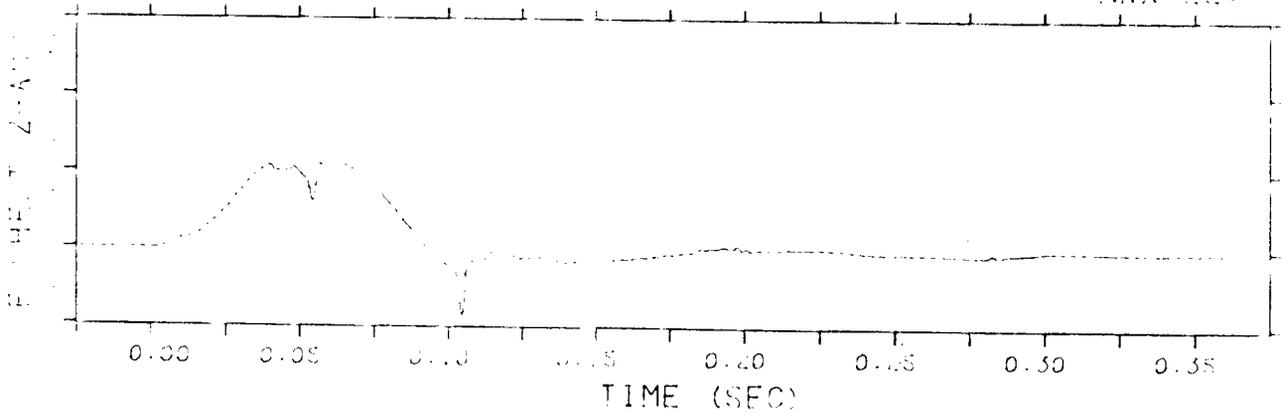
MAX=14.6



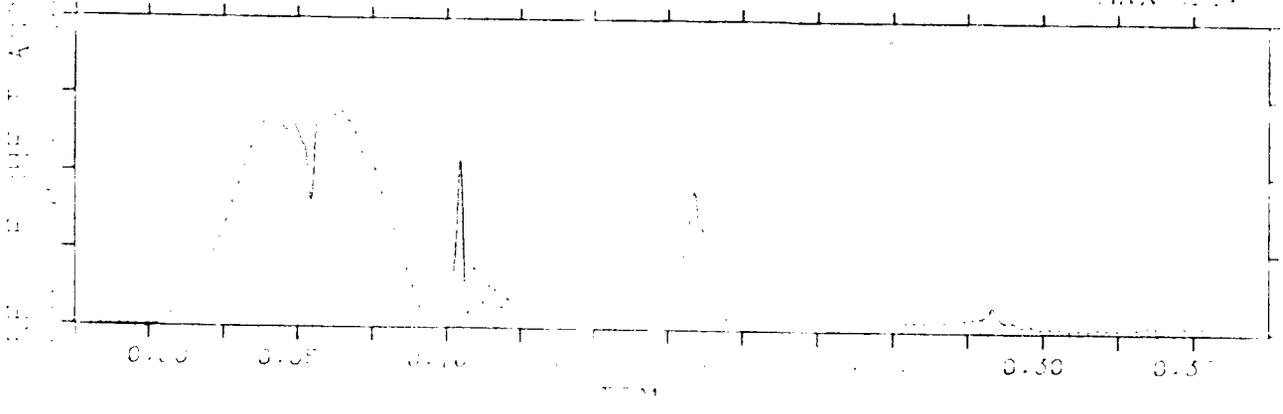
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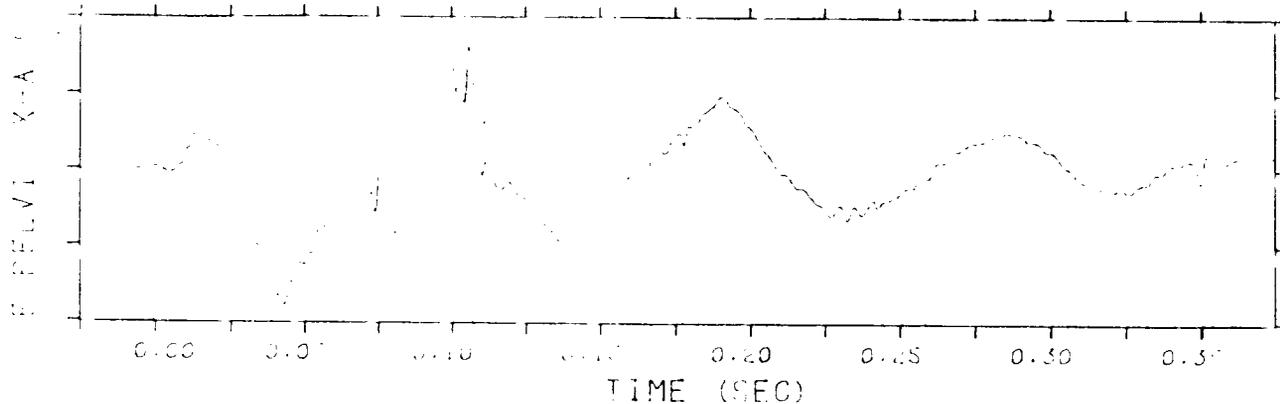
MAX=1.10



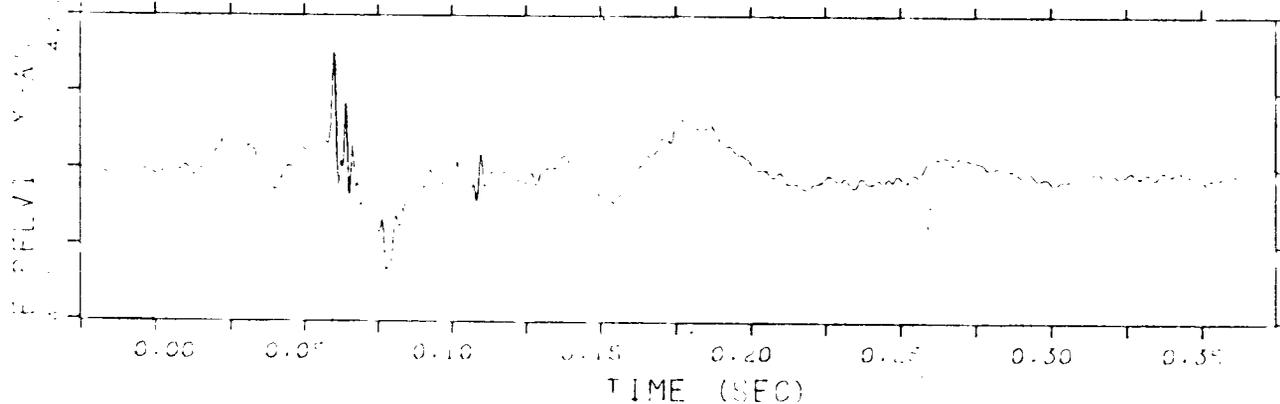
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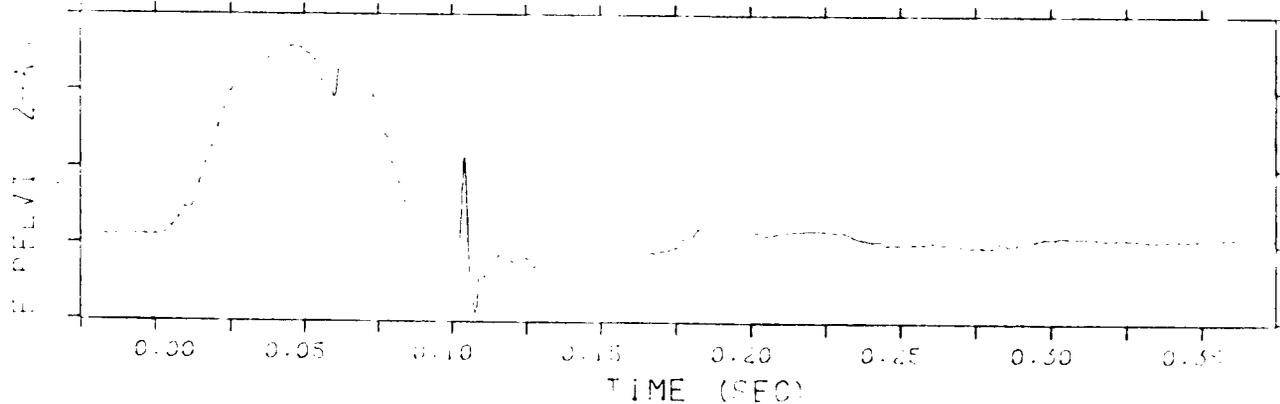
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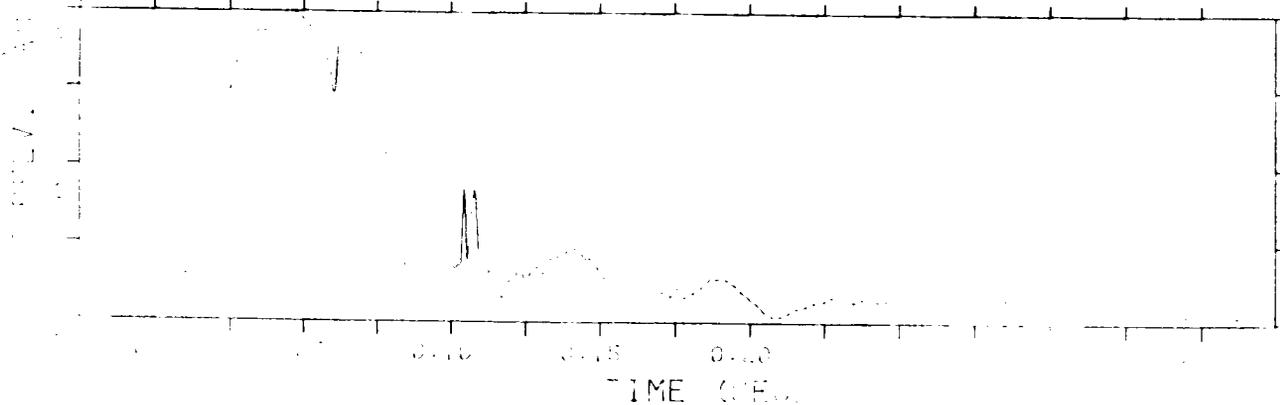
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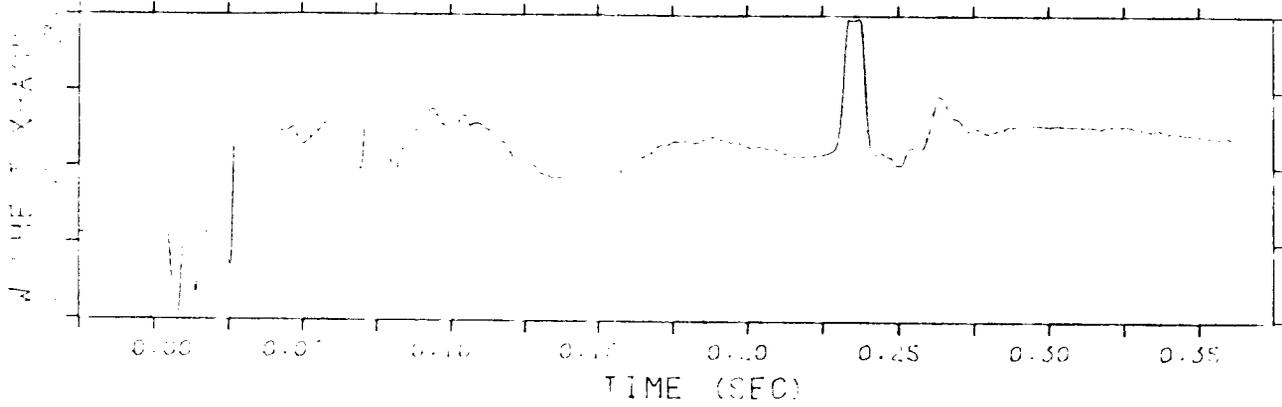
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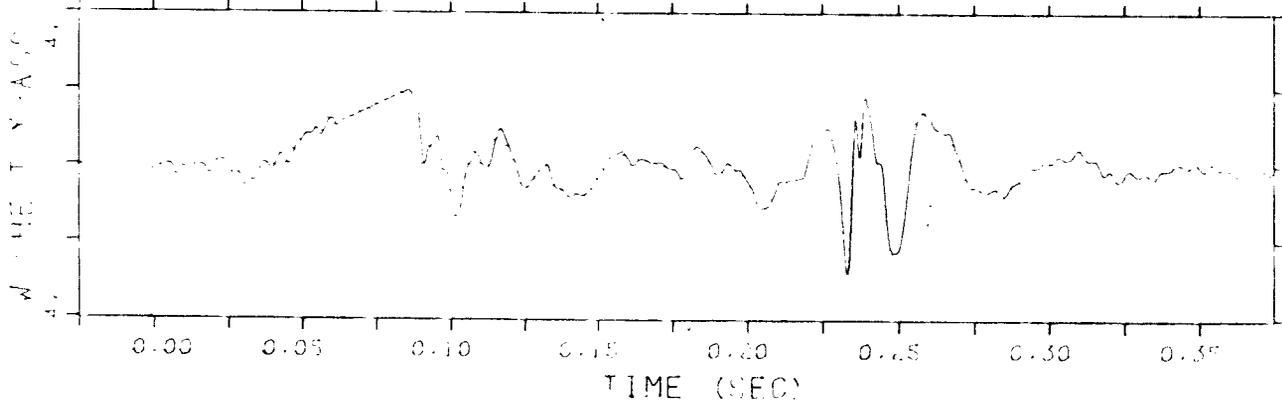
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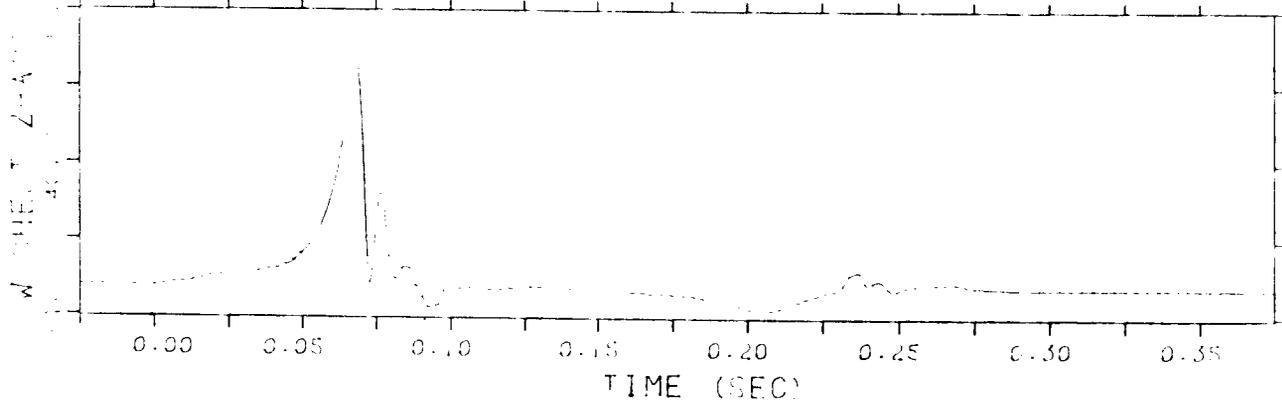
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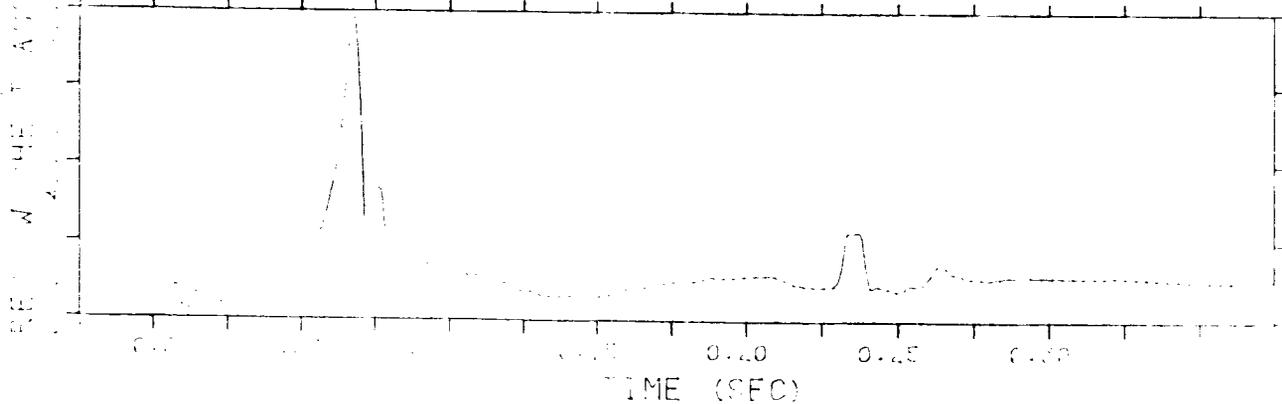
MIN=-2.8



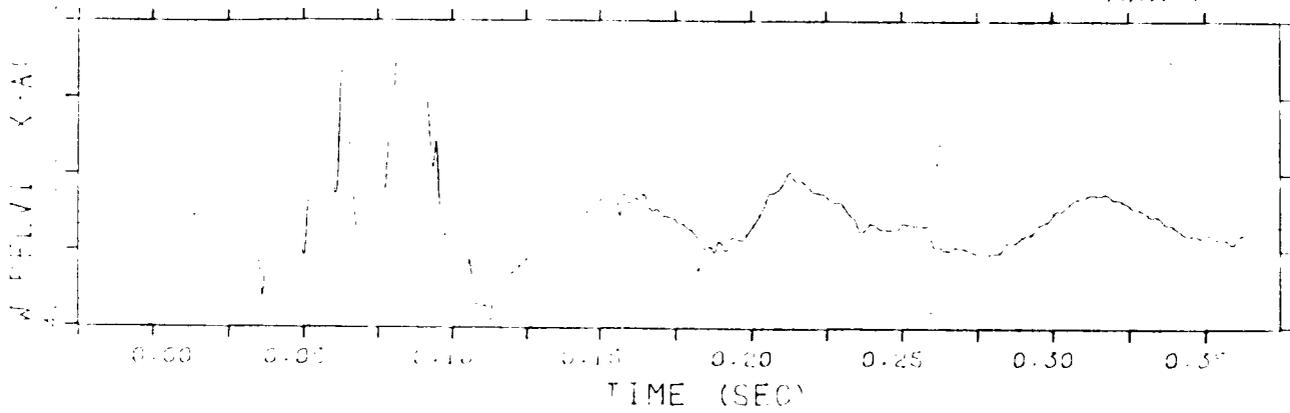
MAX=76.1



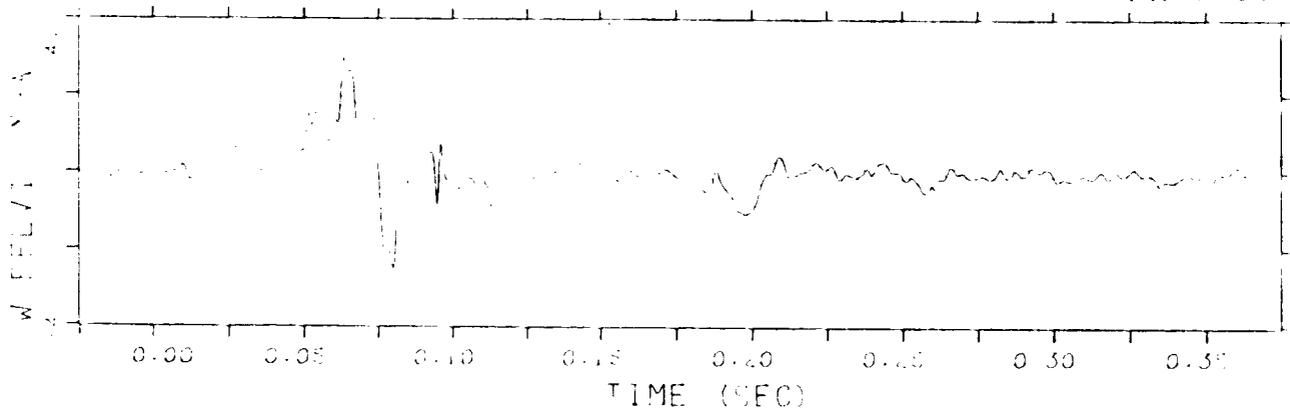
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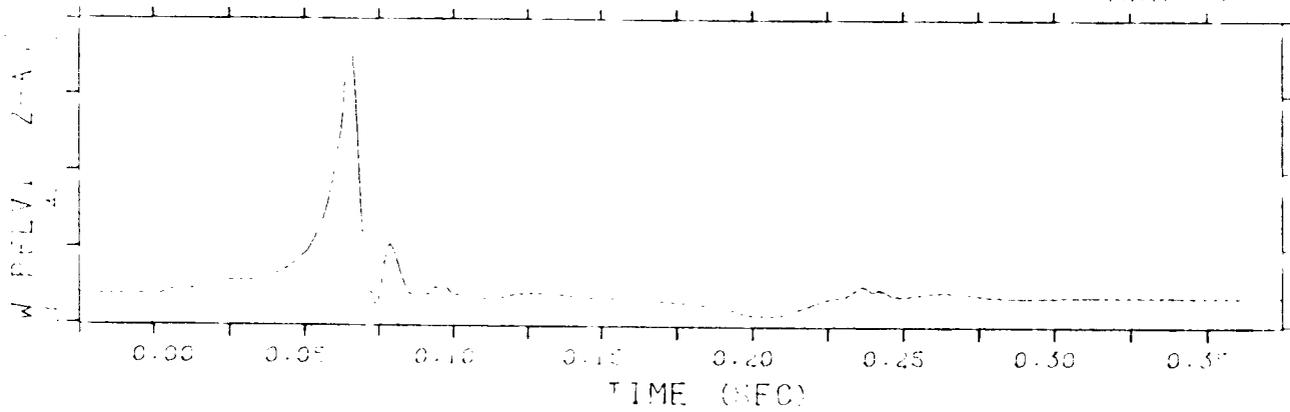
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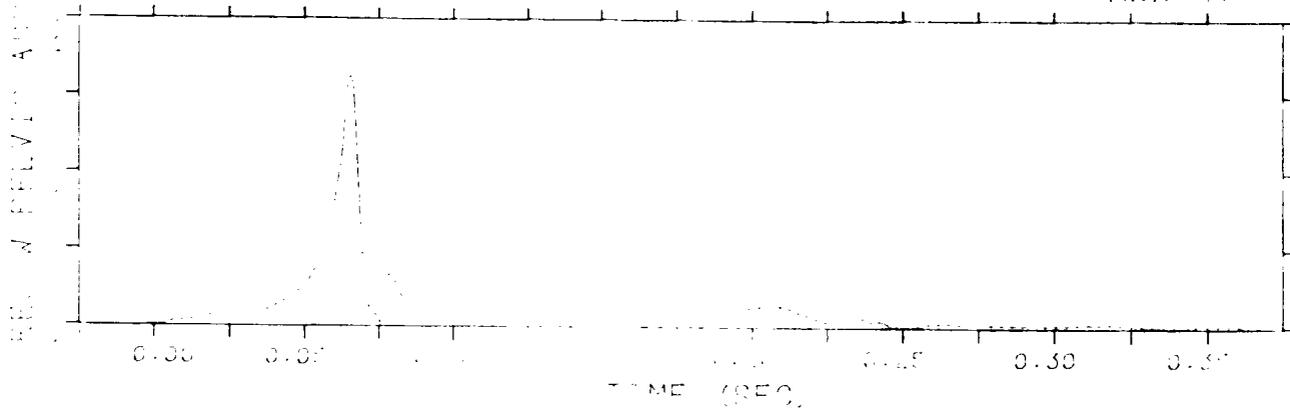
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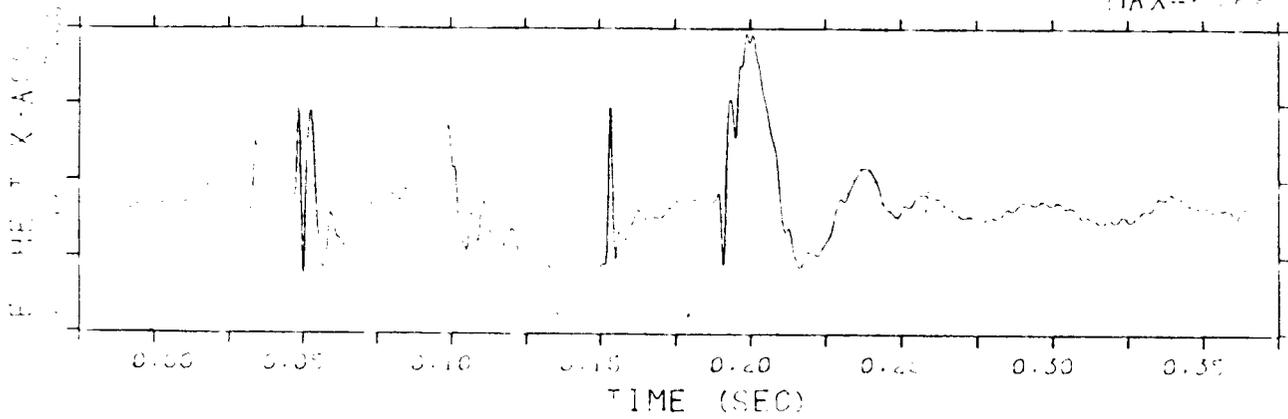
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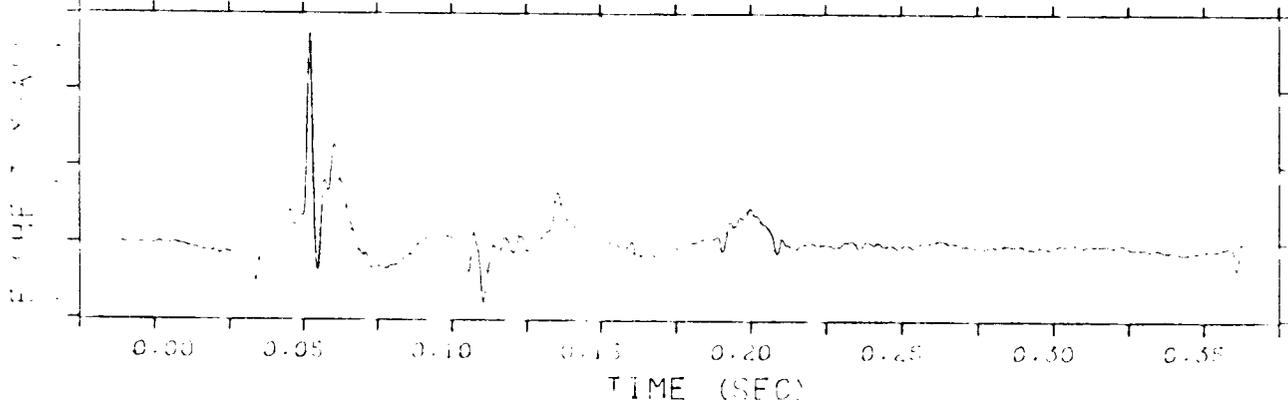
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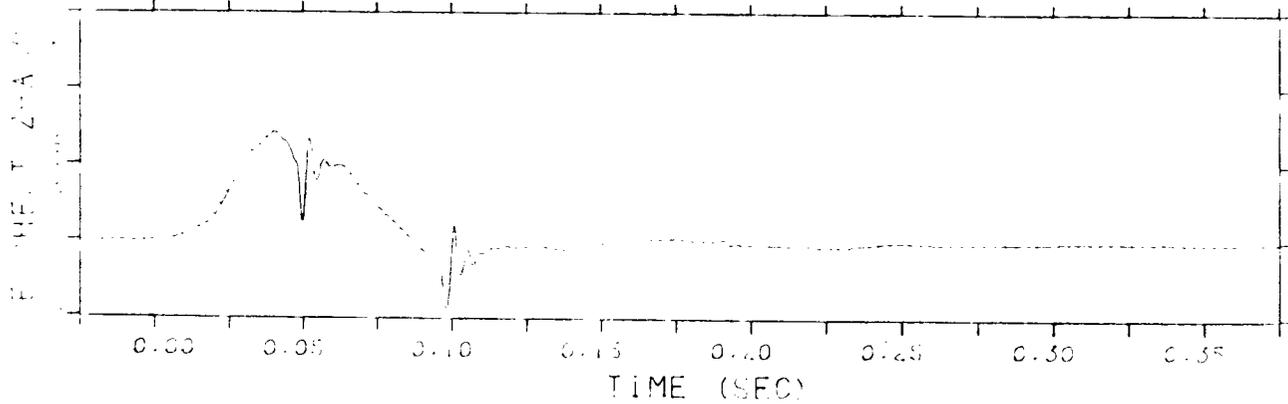
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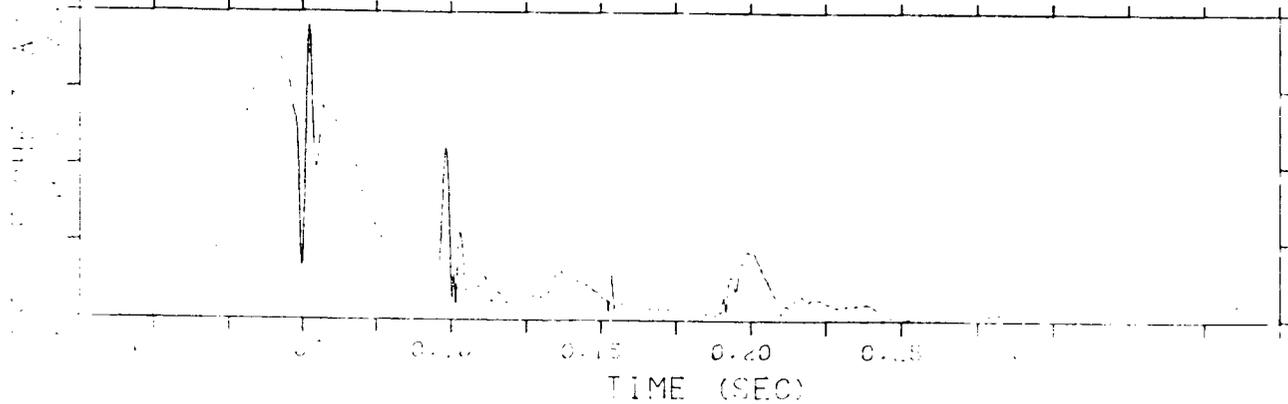
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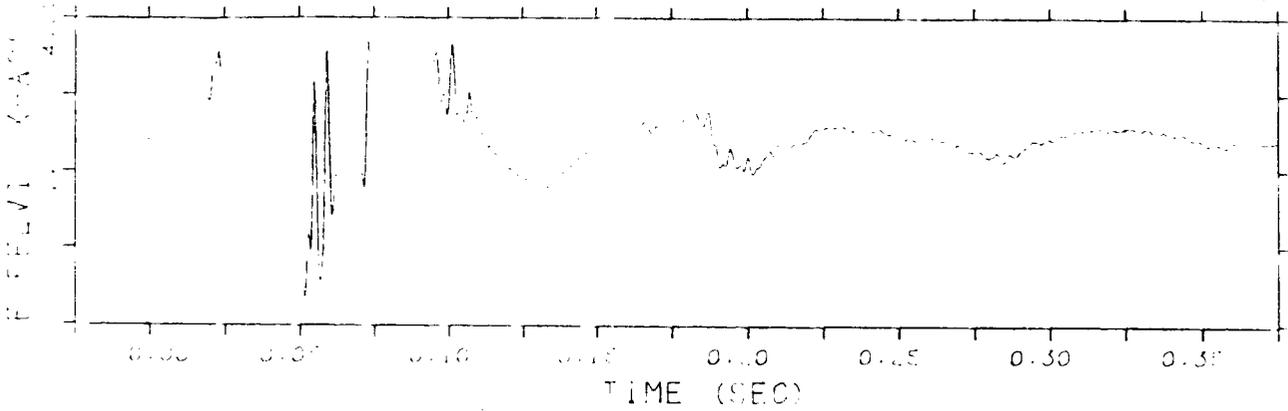
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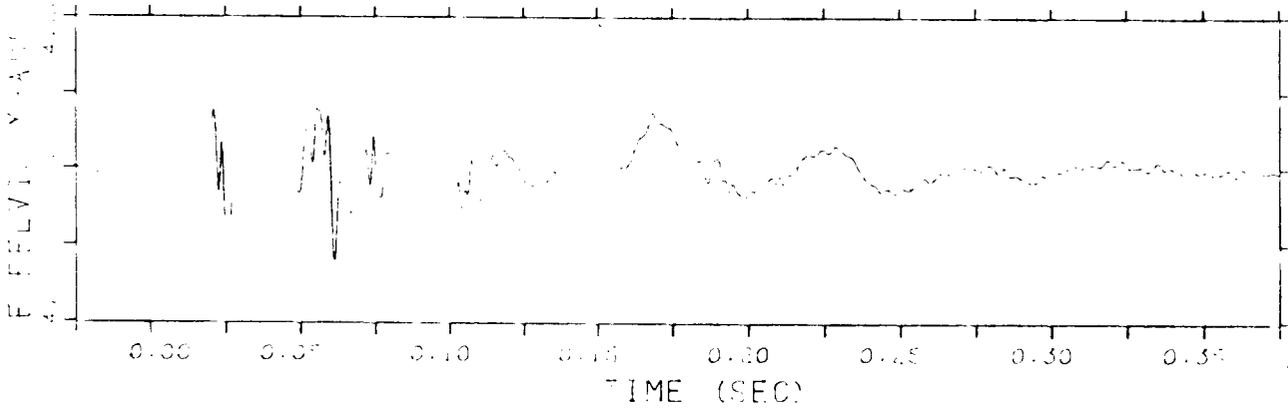
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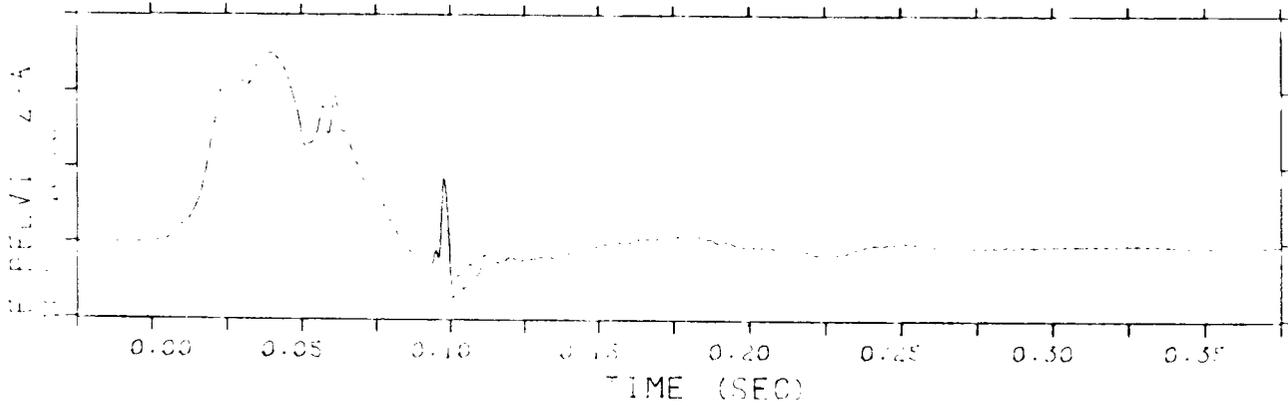
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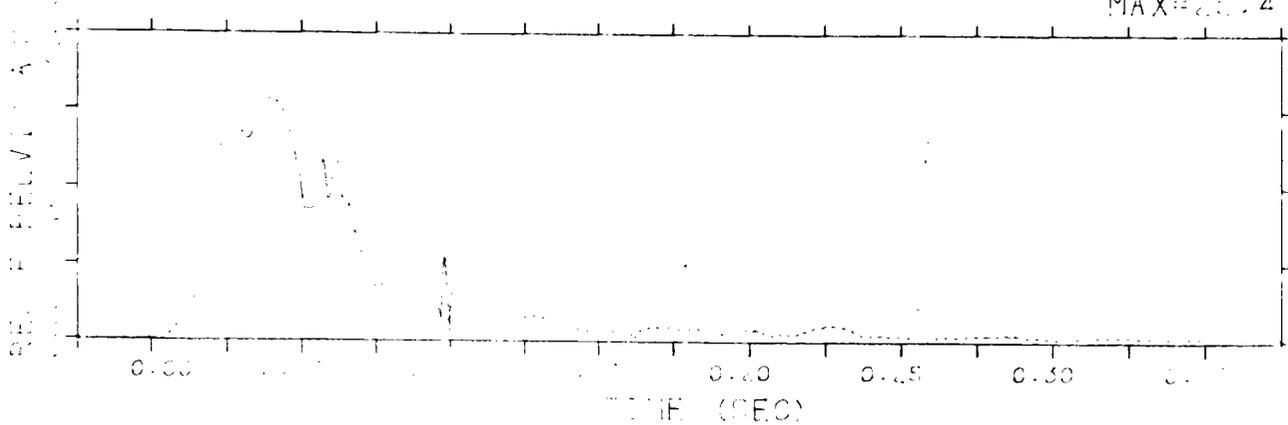
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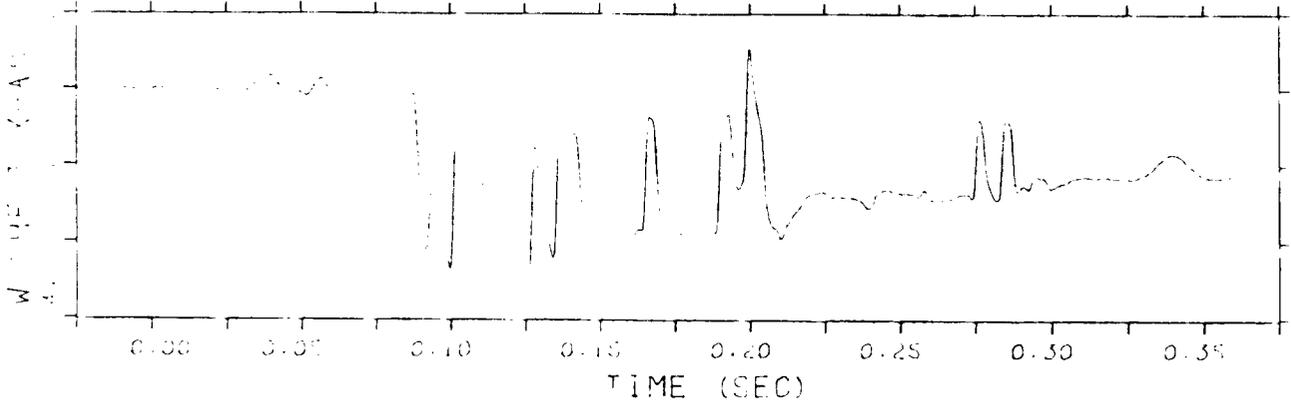
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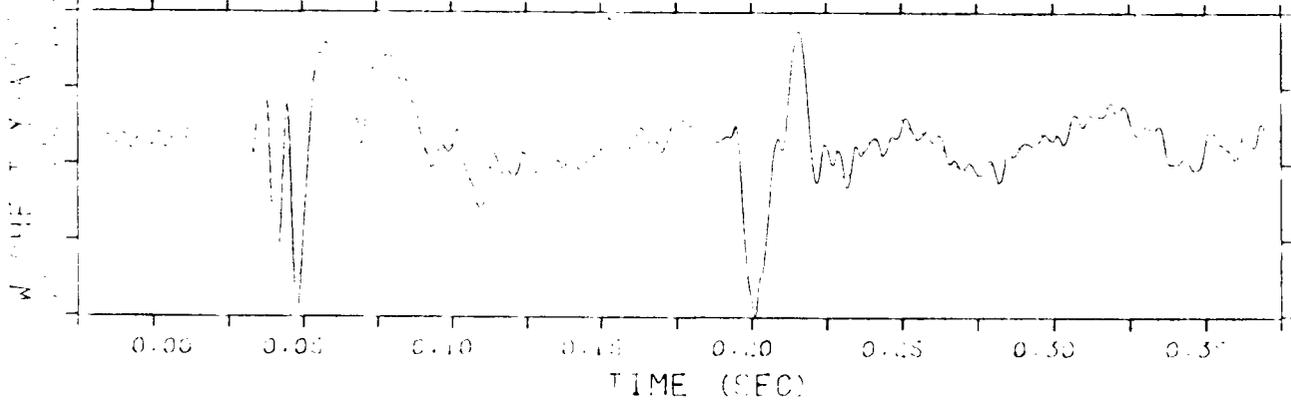
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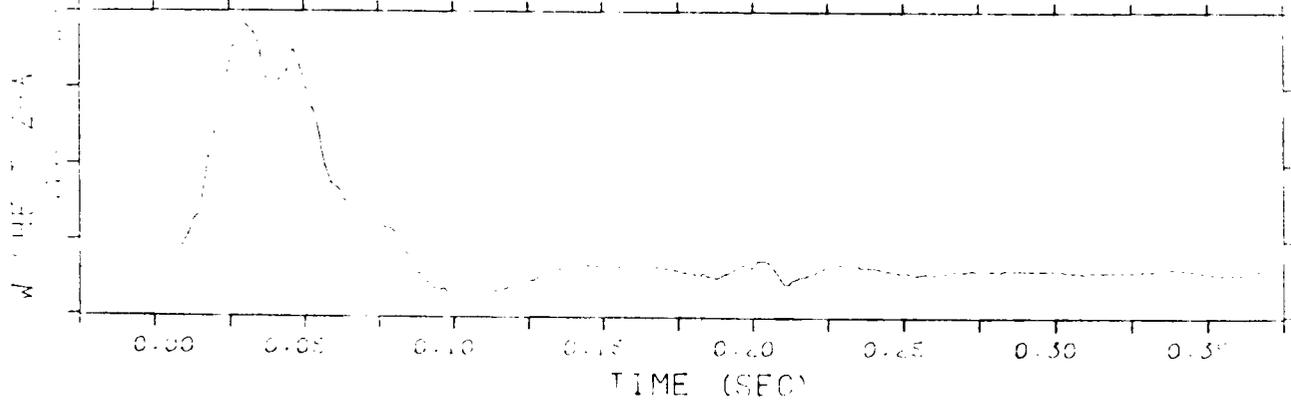
MIN=-19.0



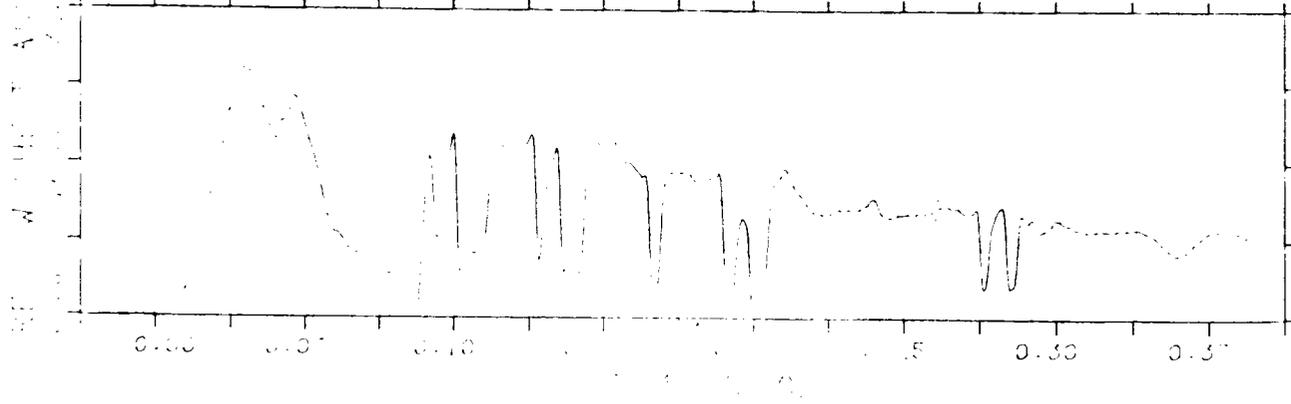
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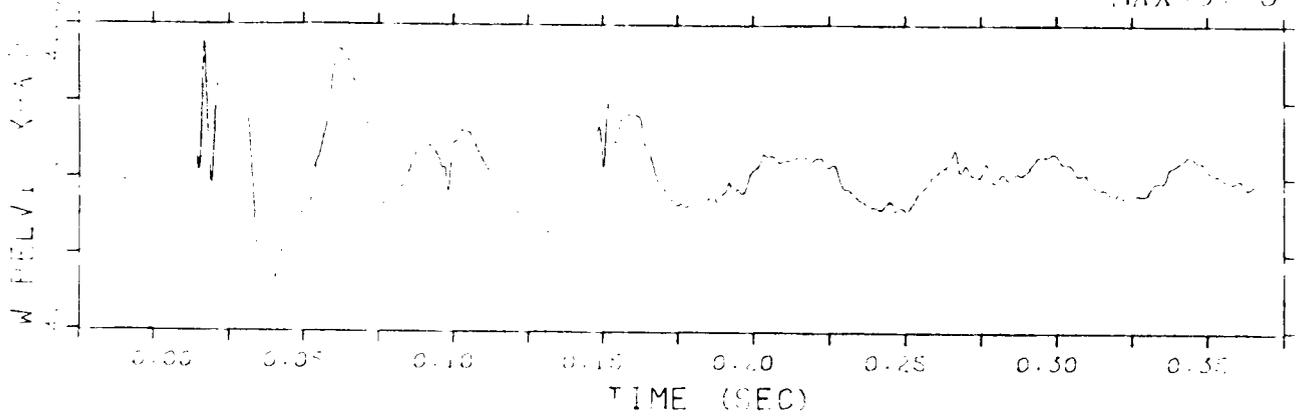
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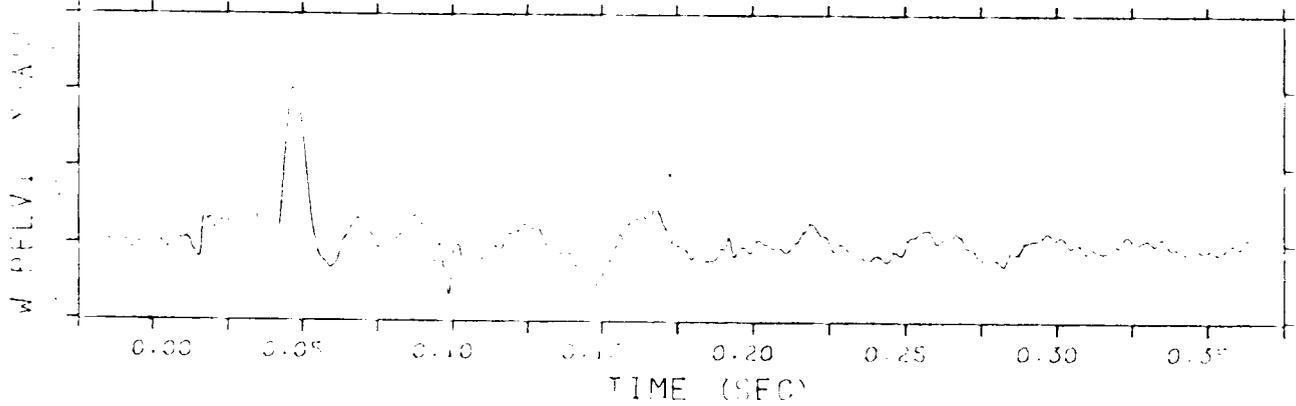
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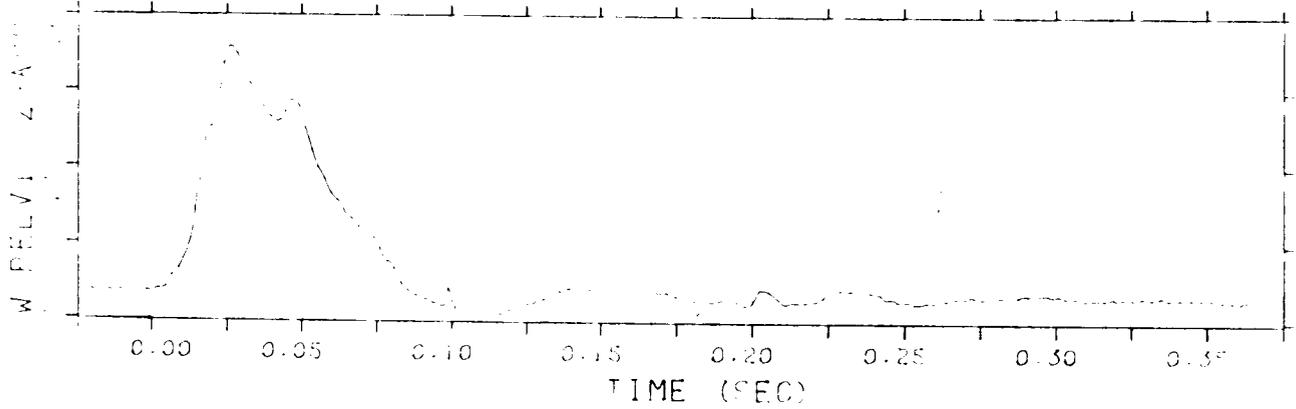
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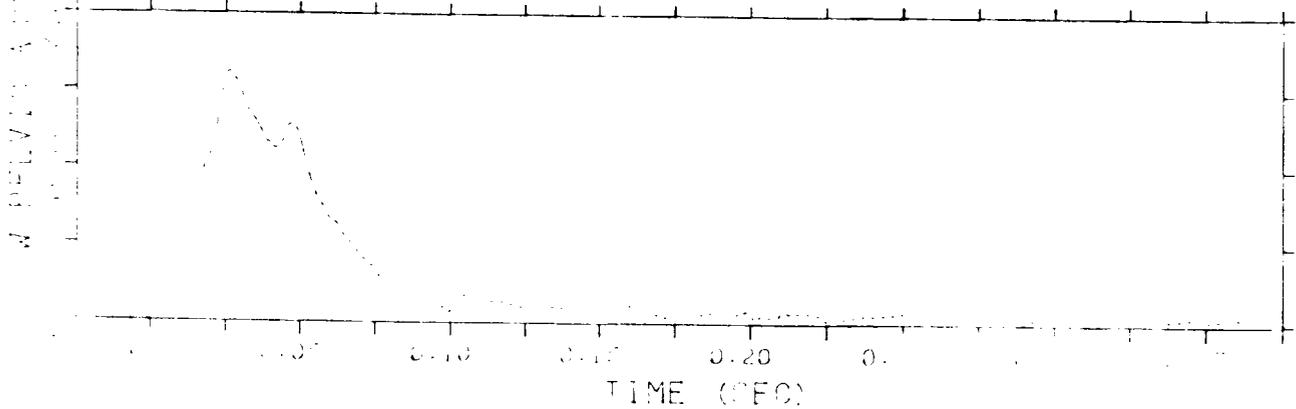
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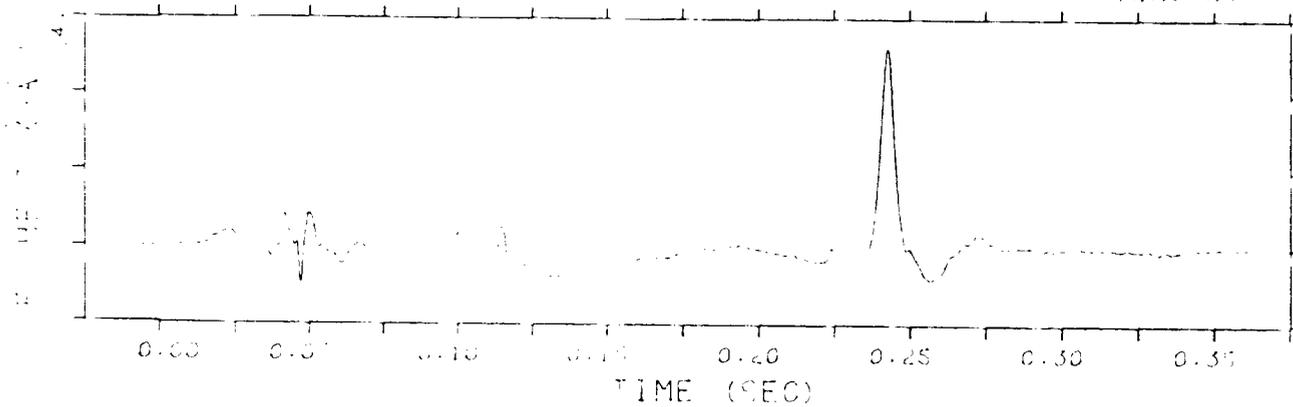
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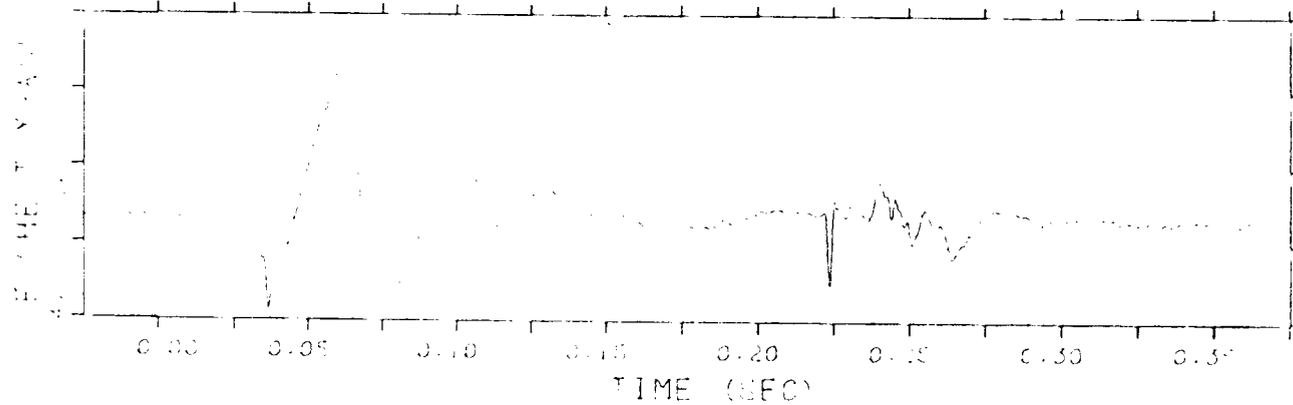
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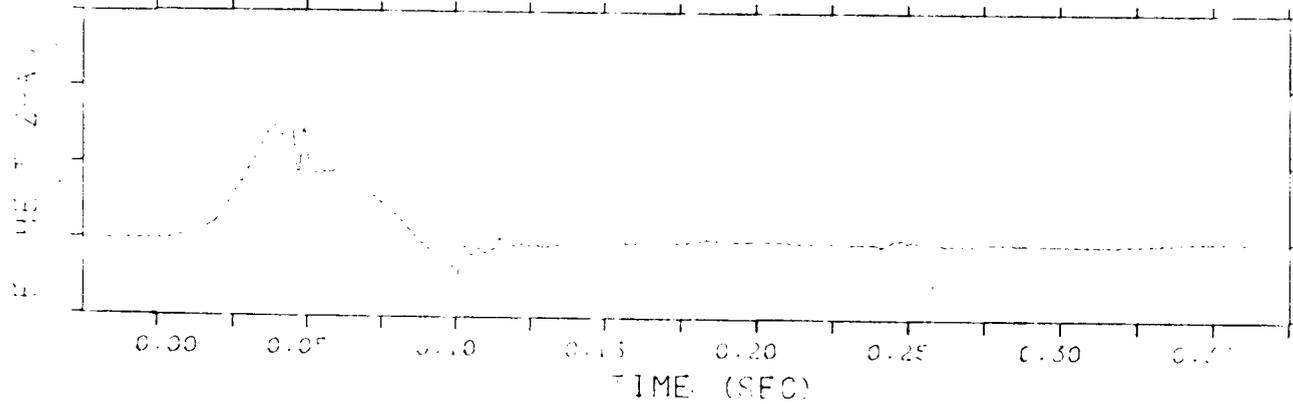
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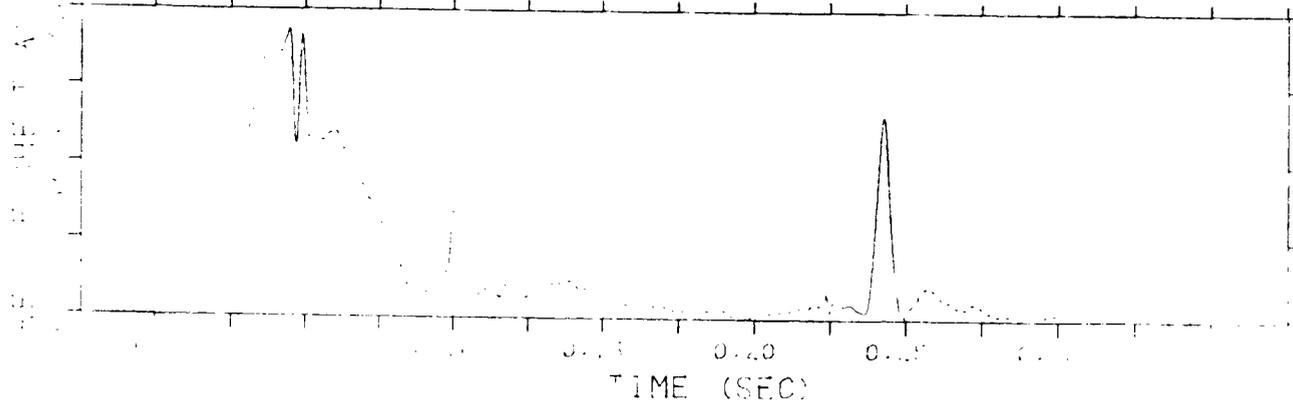
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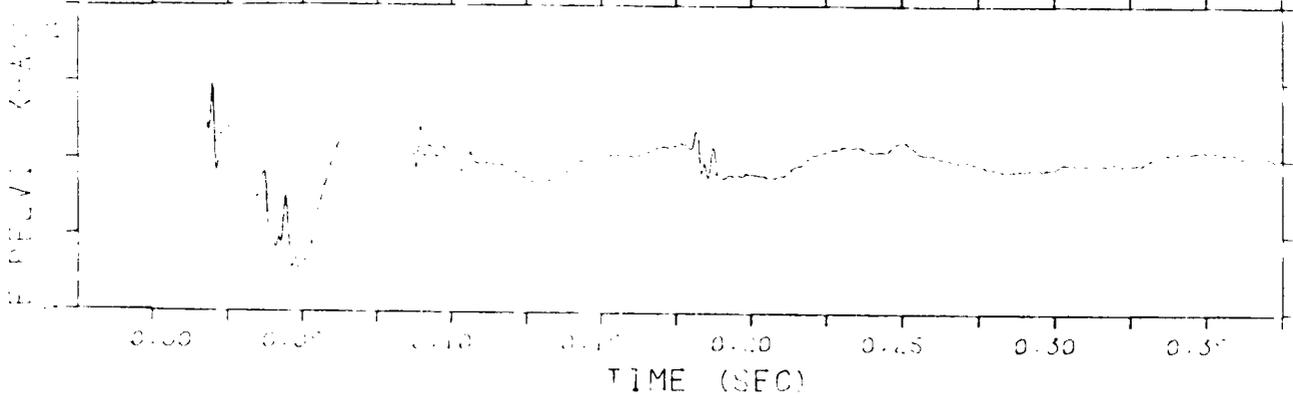
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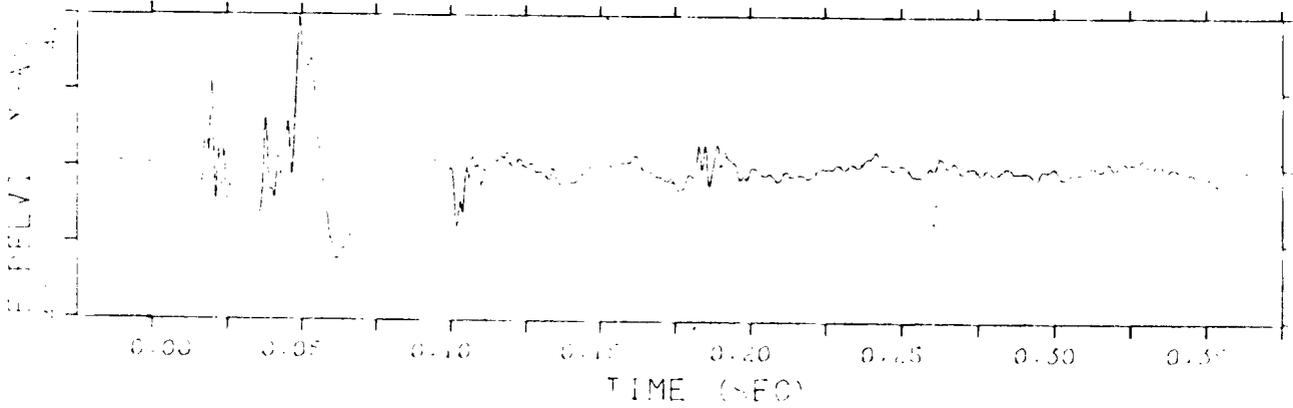
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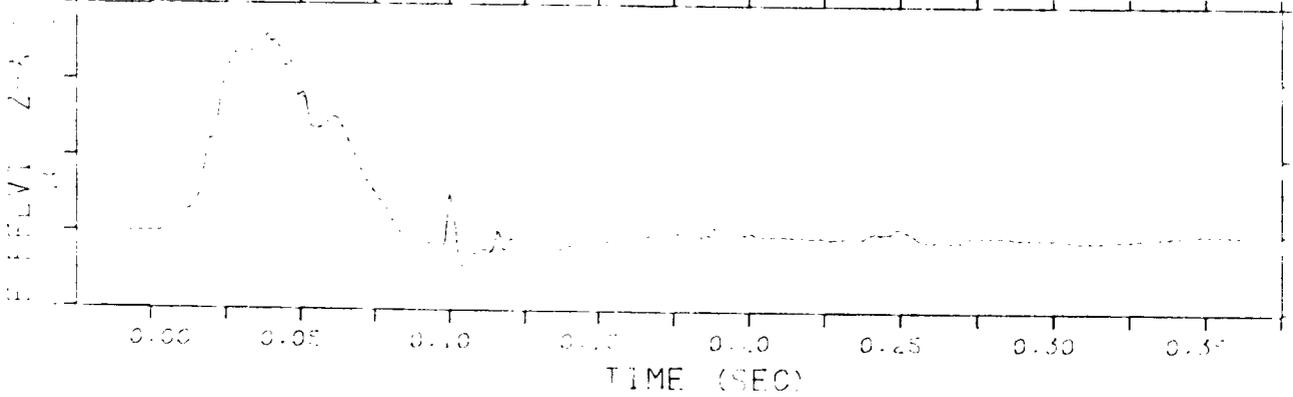
MIN=-7.34



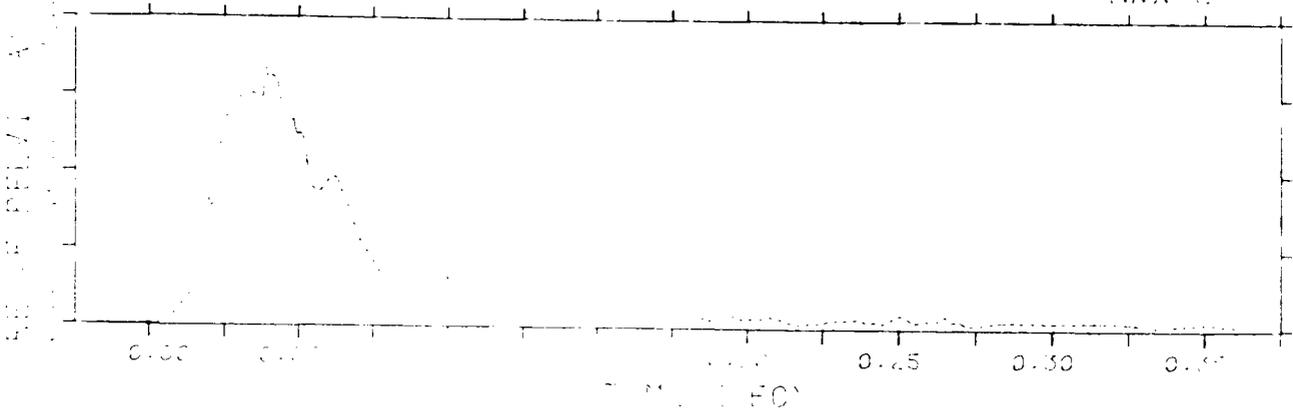
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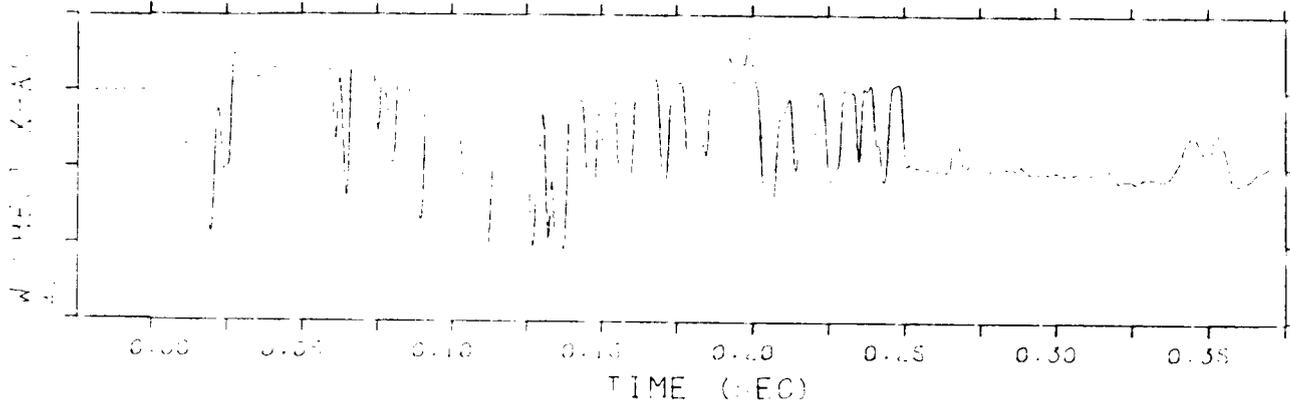
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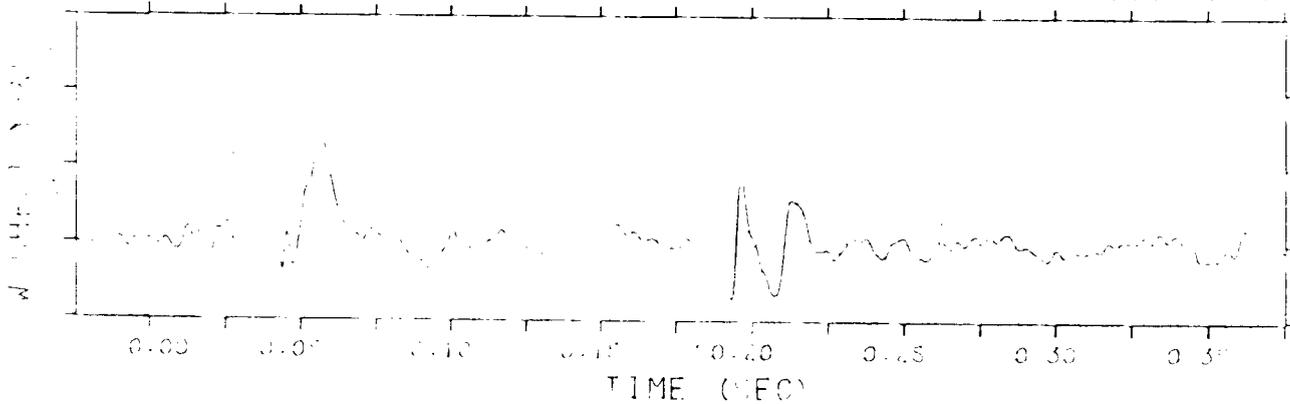
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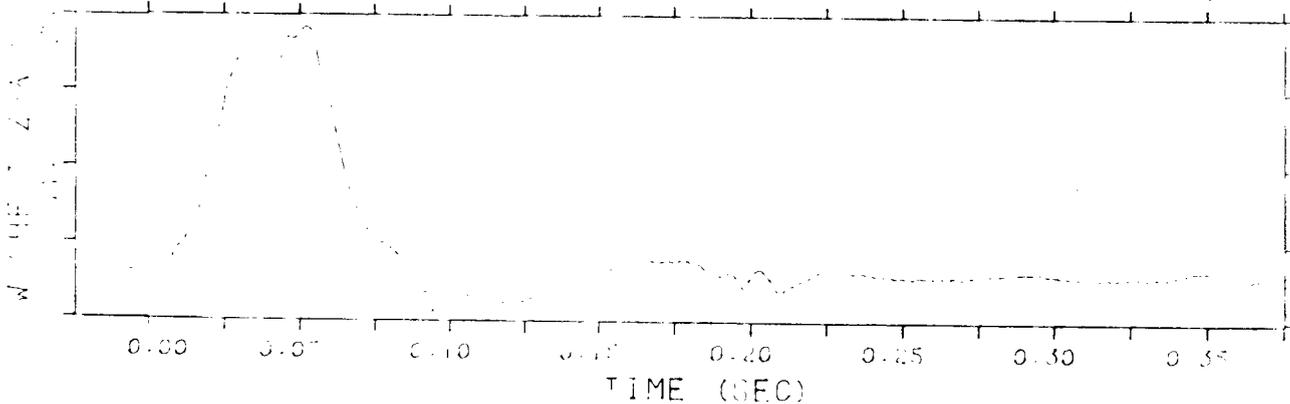
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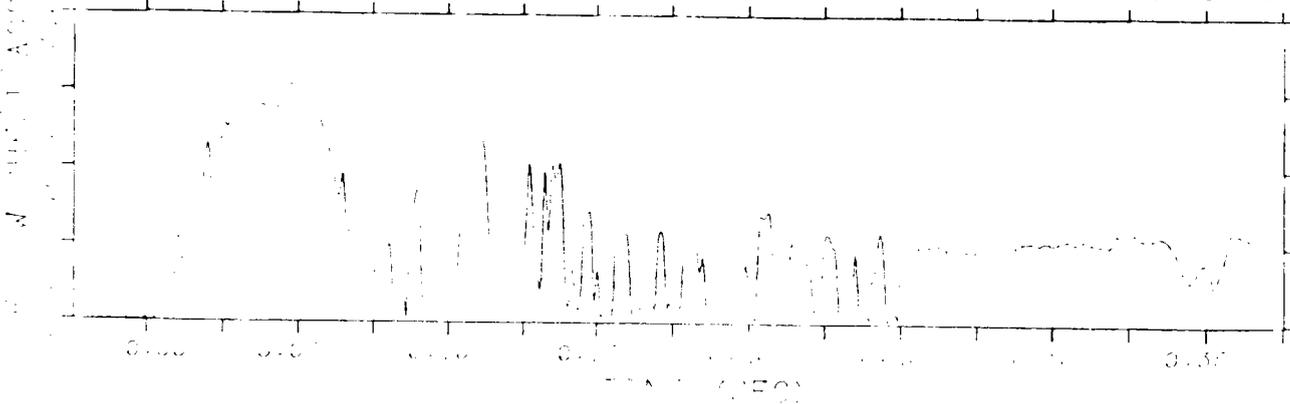
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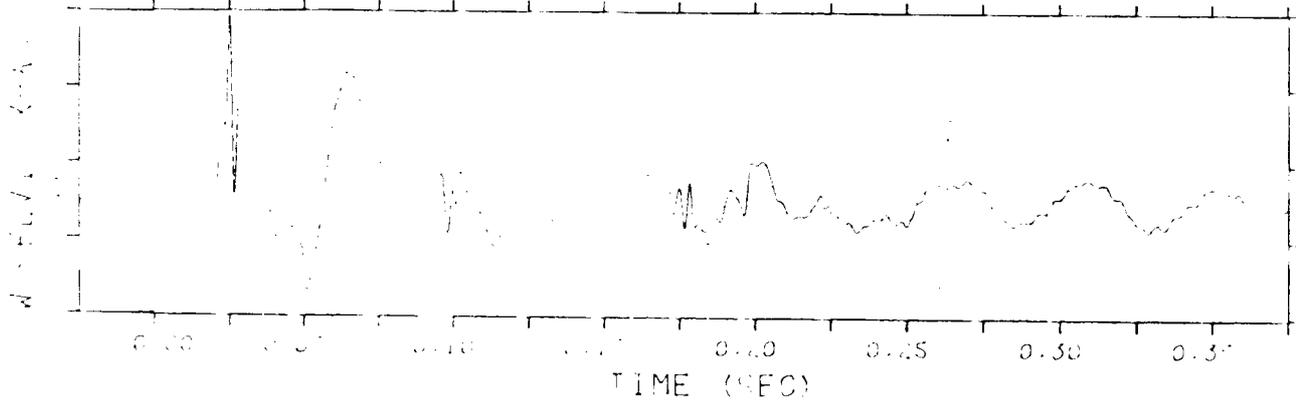
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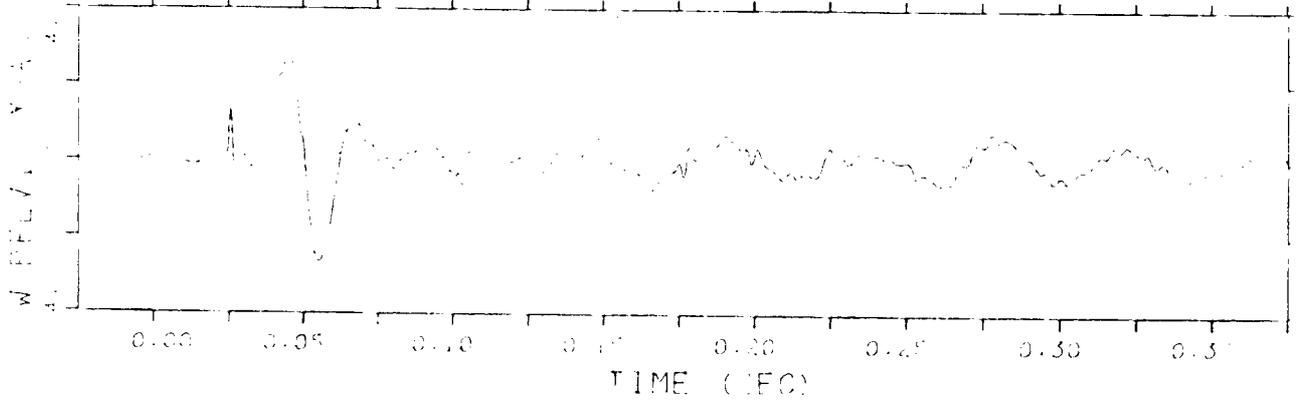
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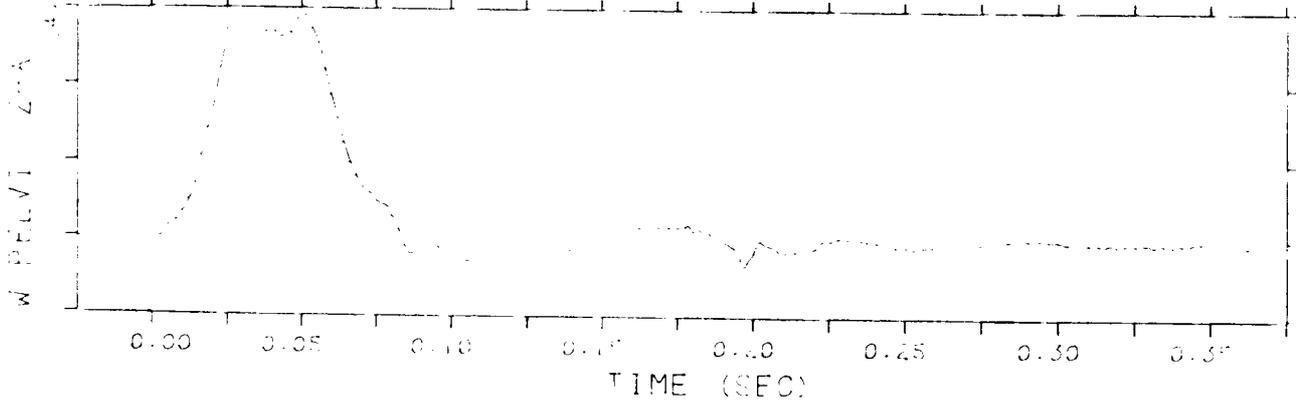
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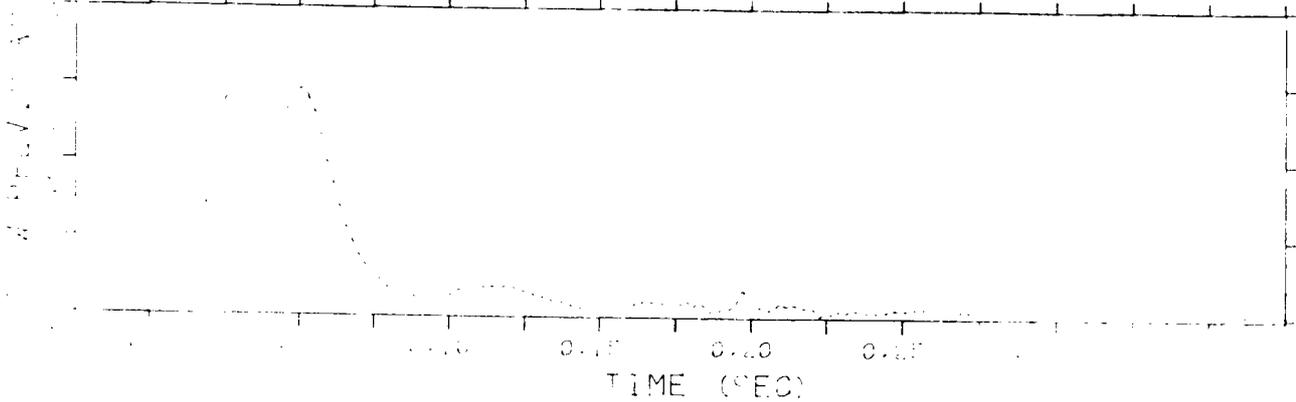
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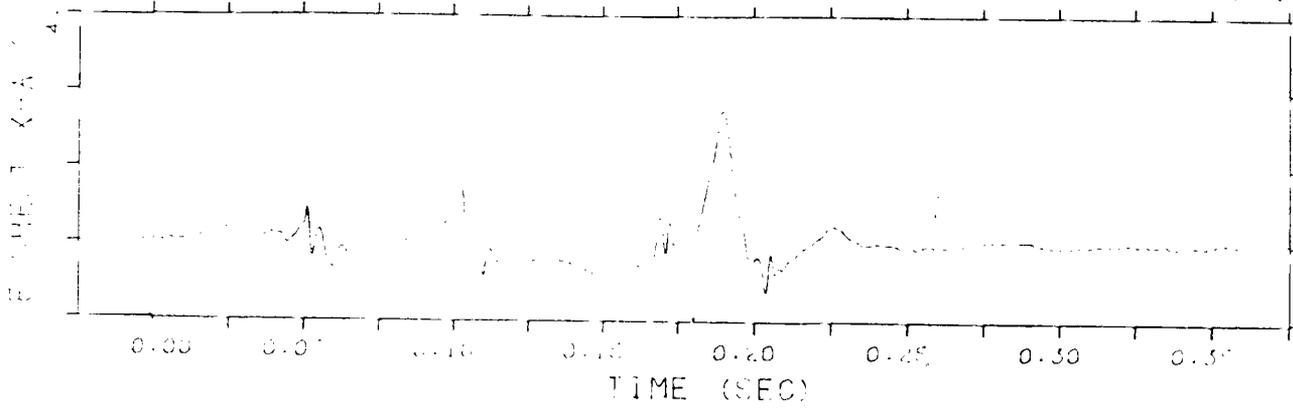
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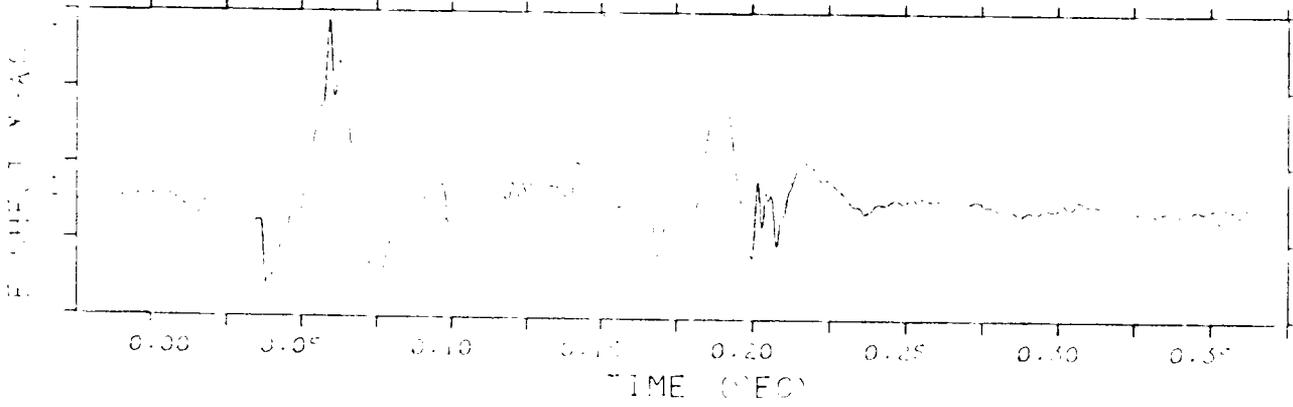
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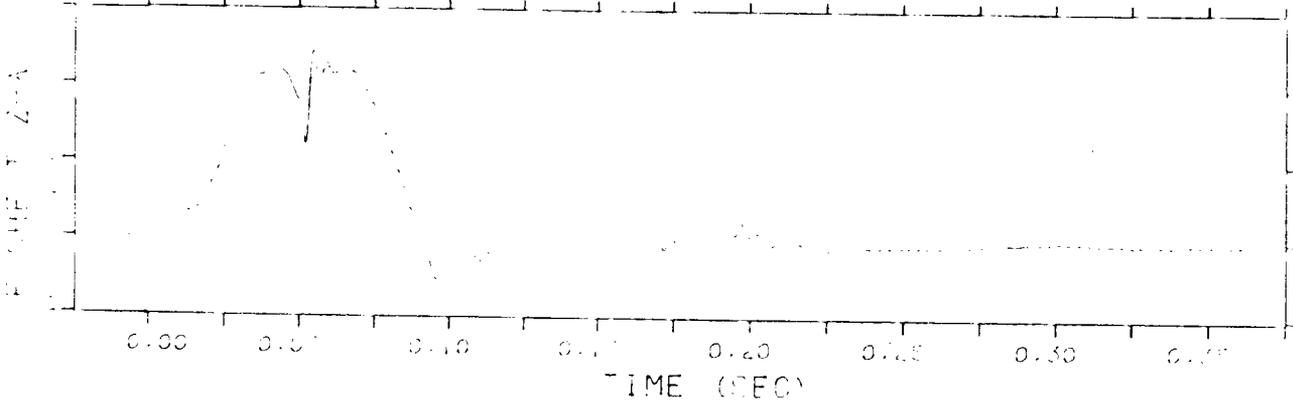
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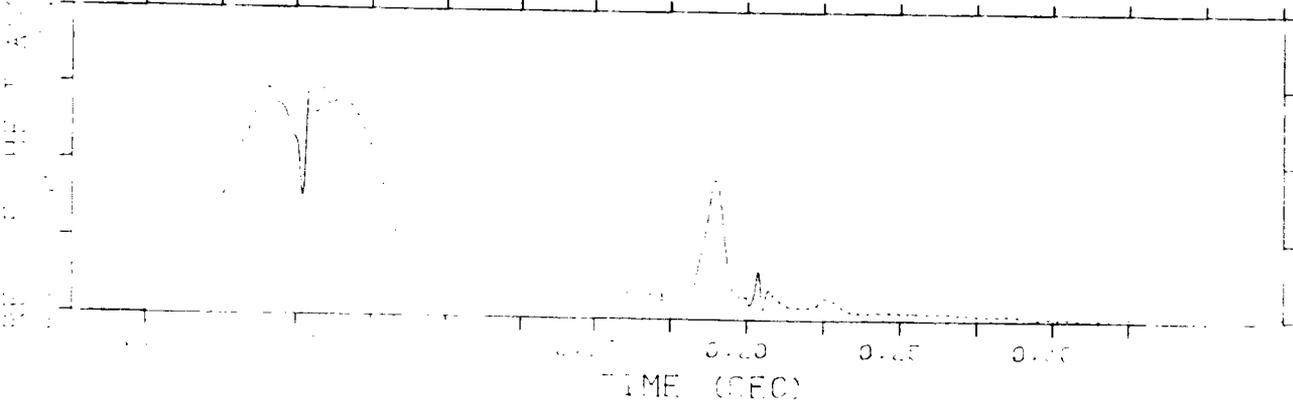
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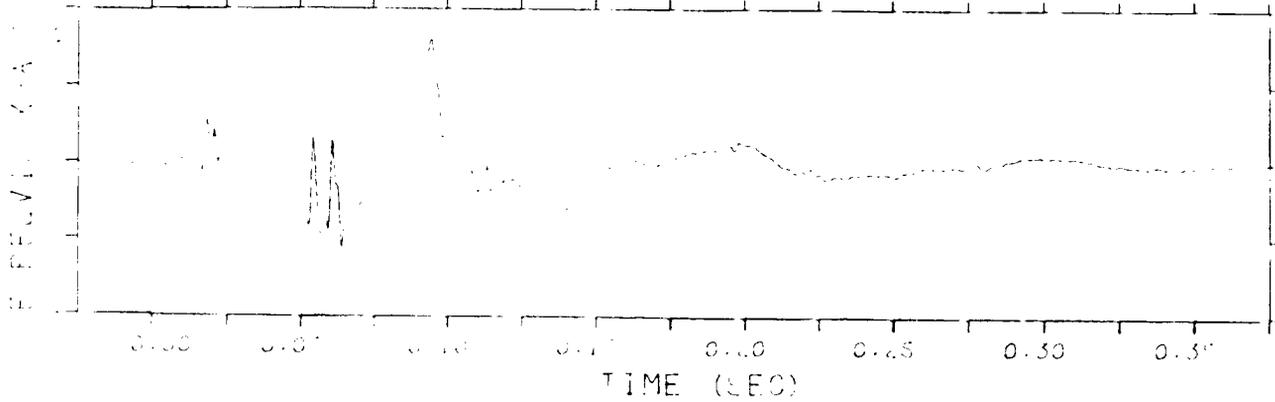
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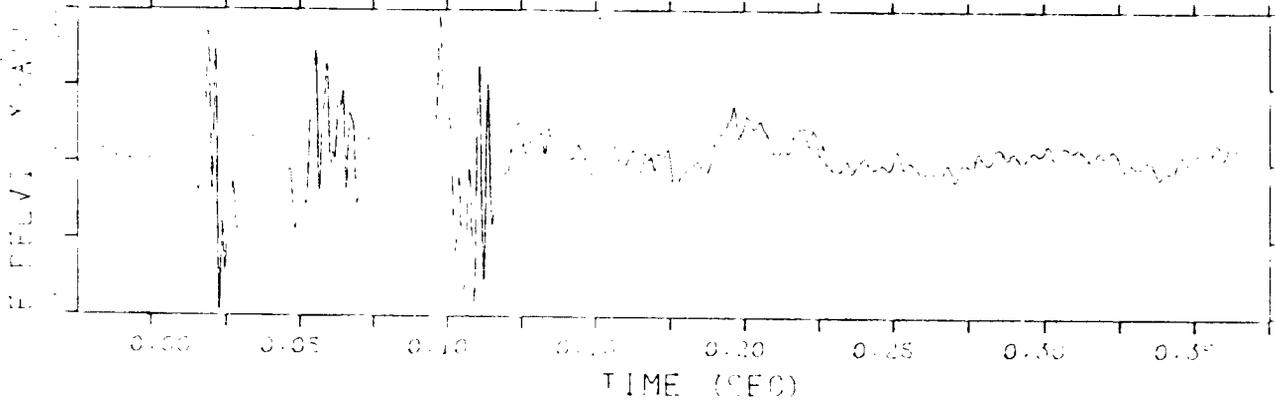
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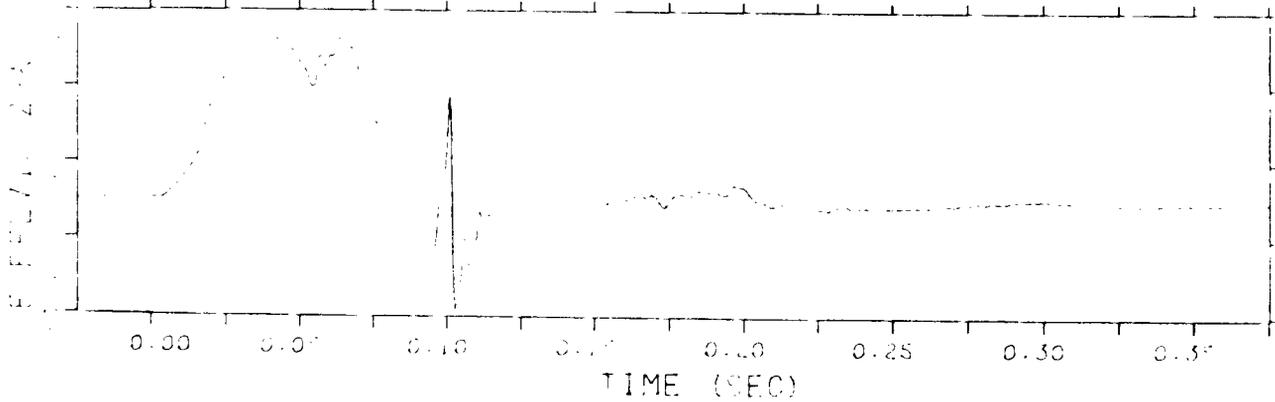
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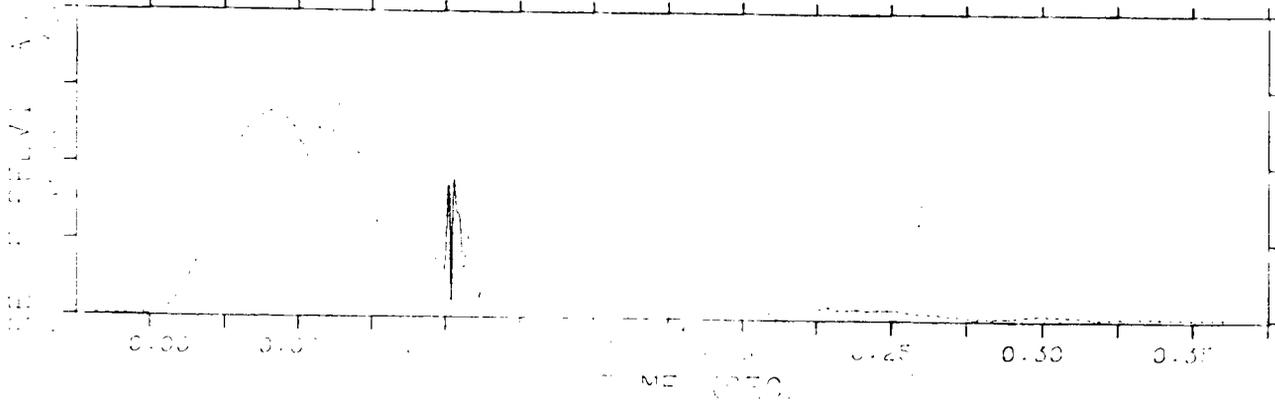
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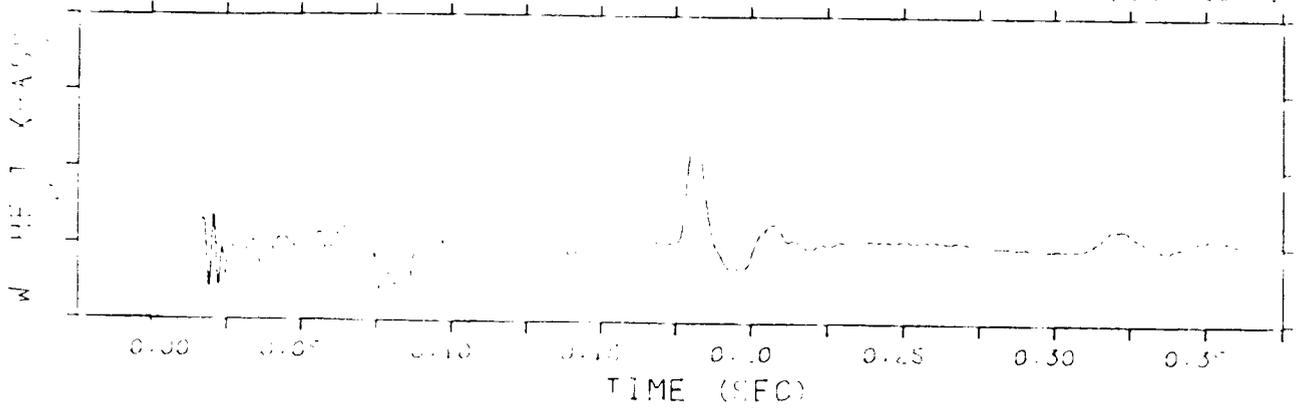
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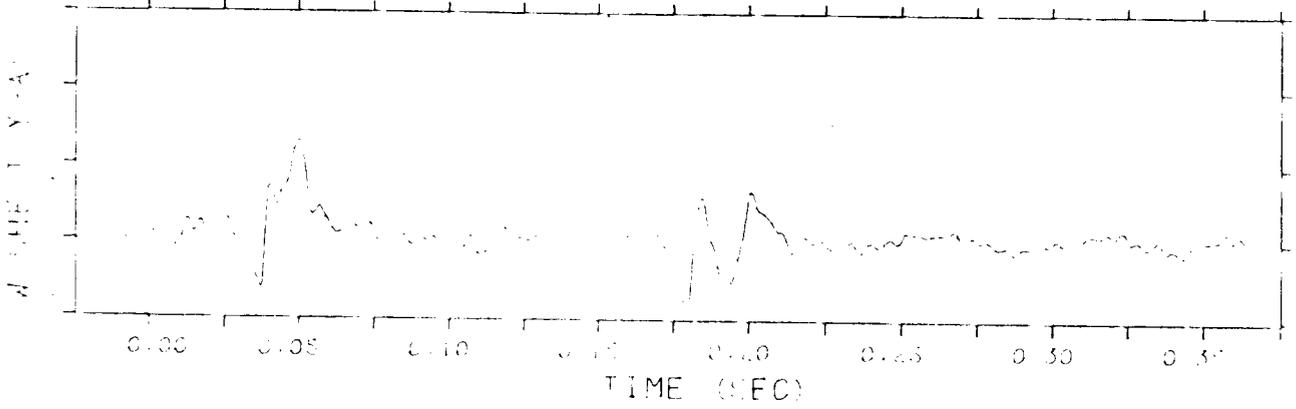
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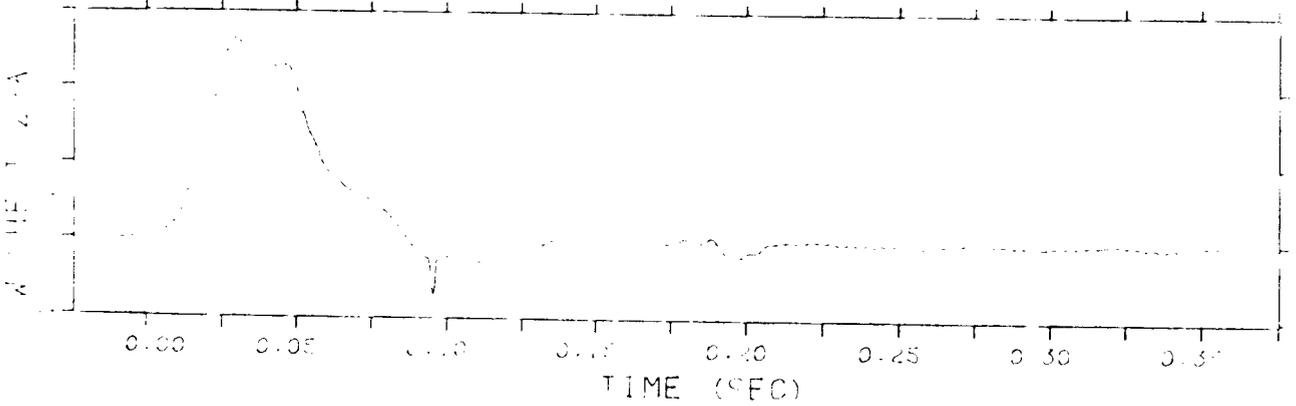
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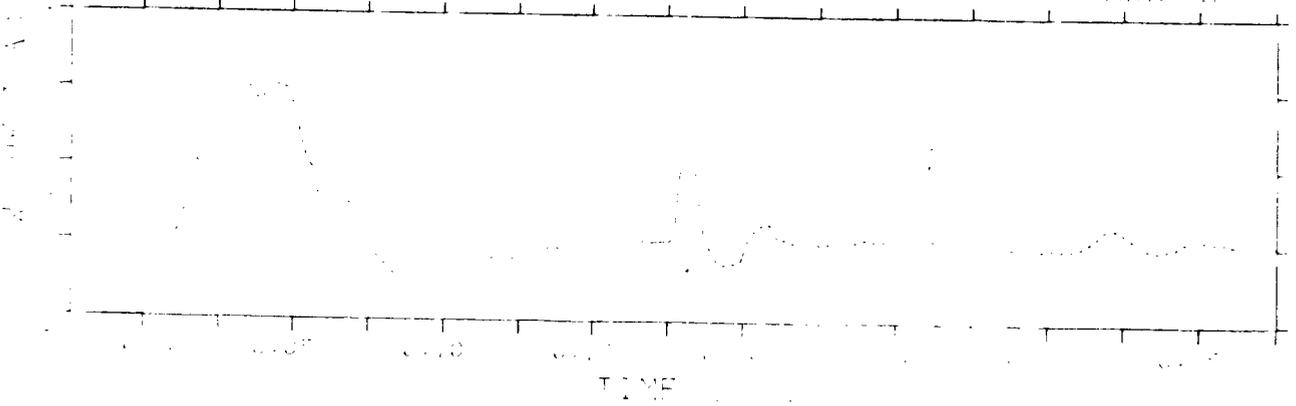
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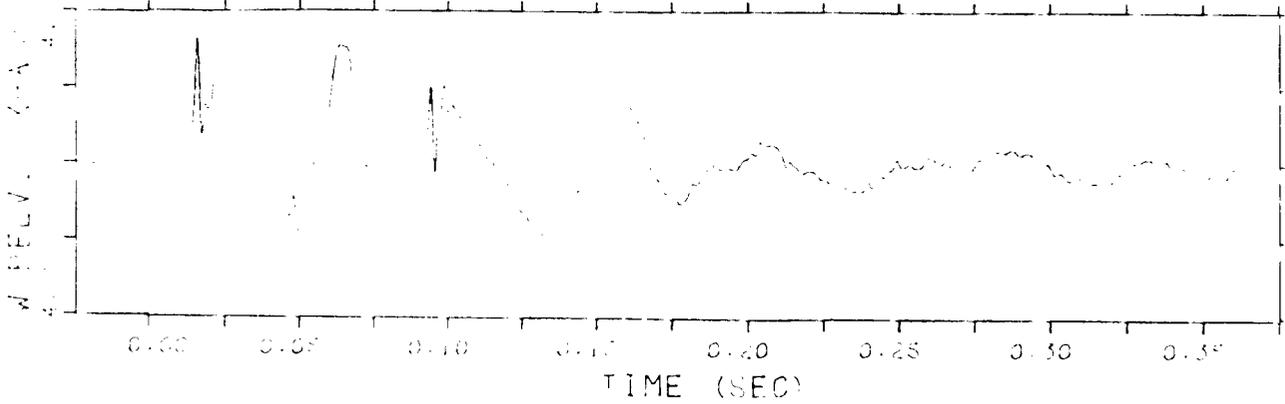
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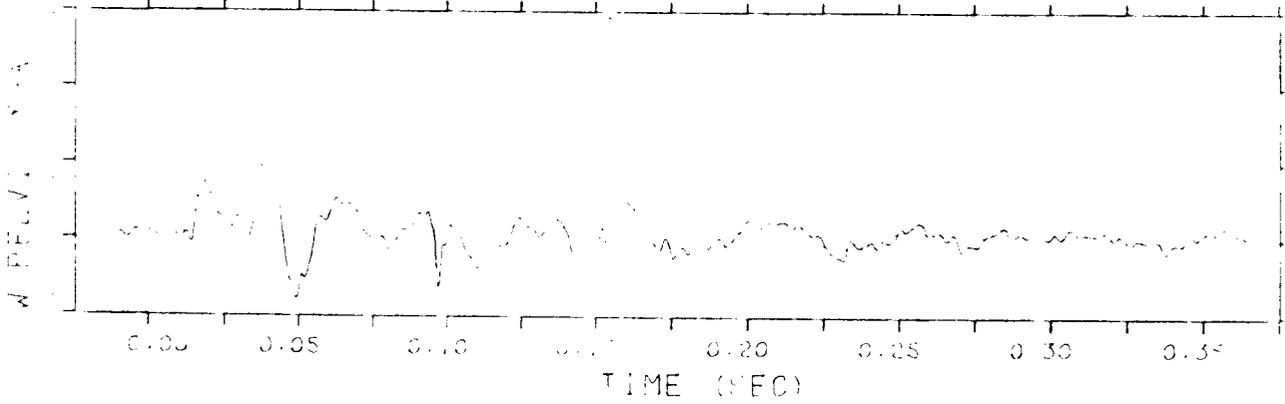
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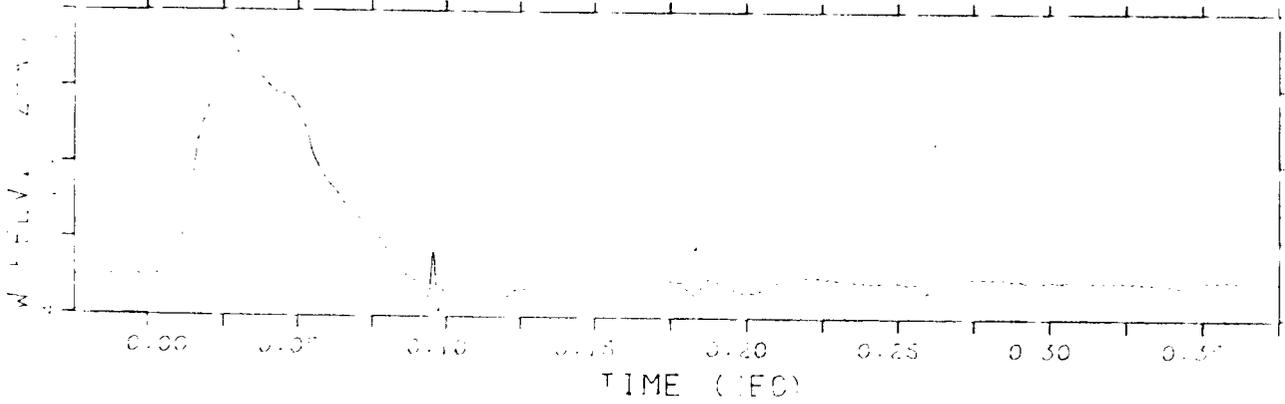
MAX=3.40



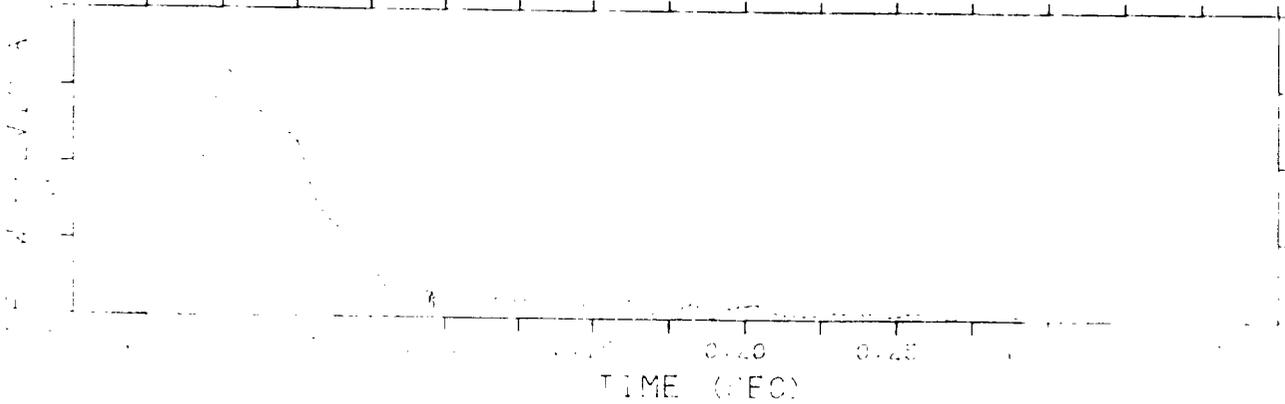
MAX=0.90



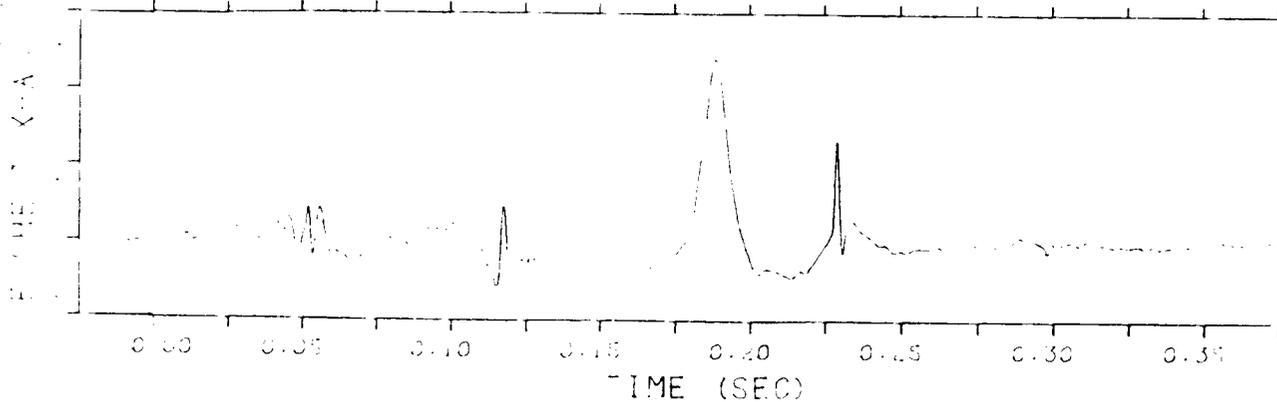
MAX=1.00



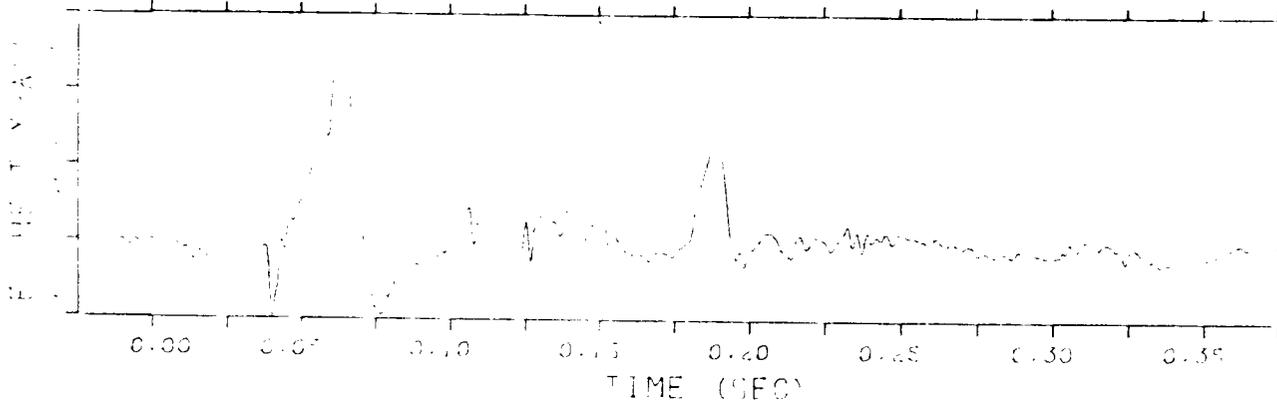
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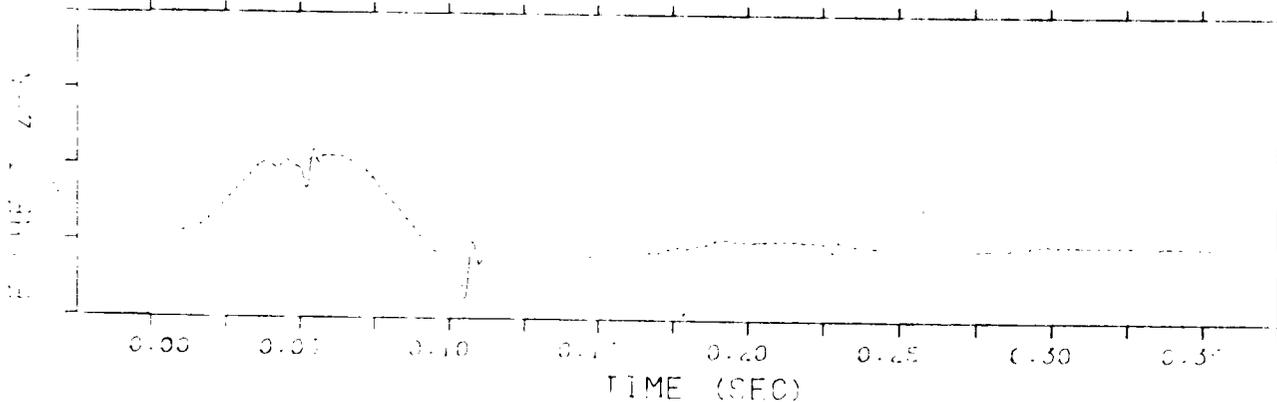
MAX=10.1



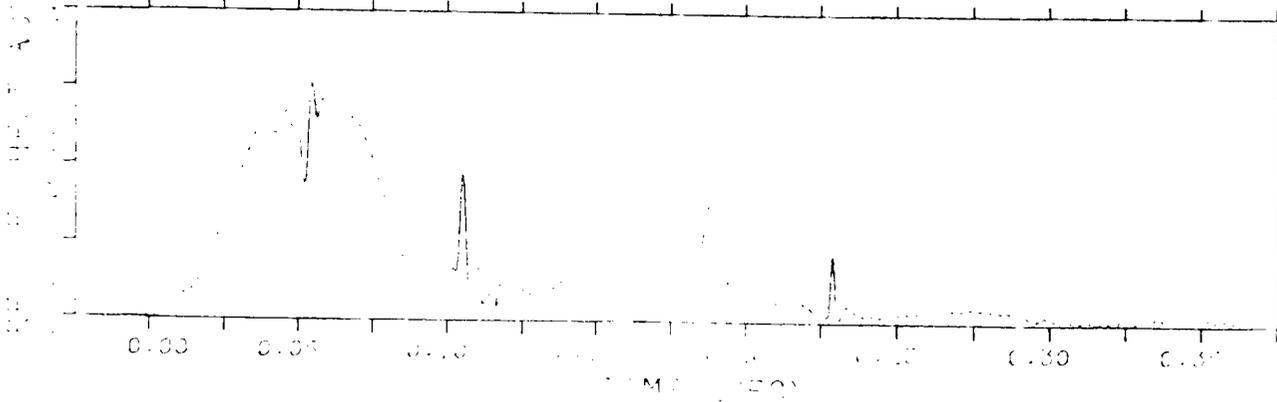
MAX=5.04



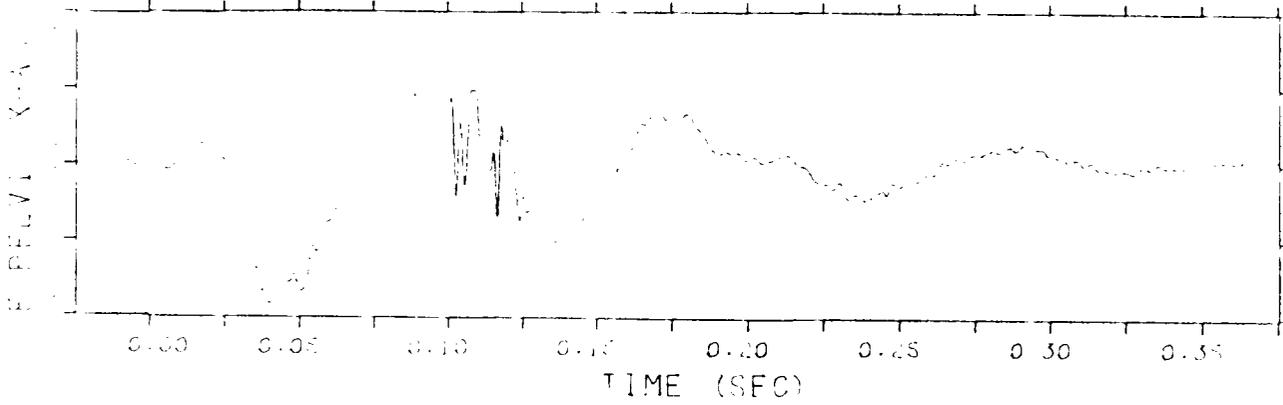
MAX=4.4



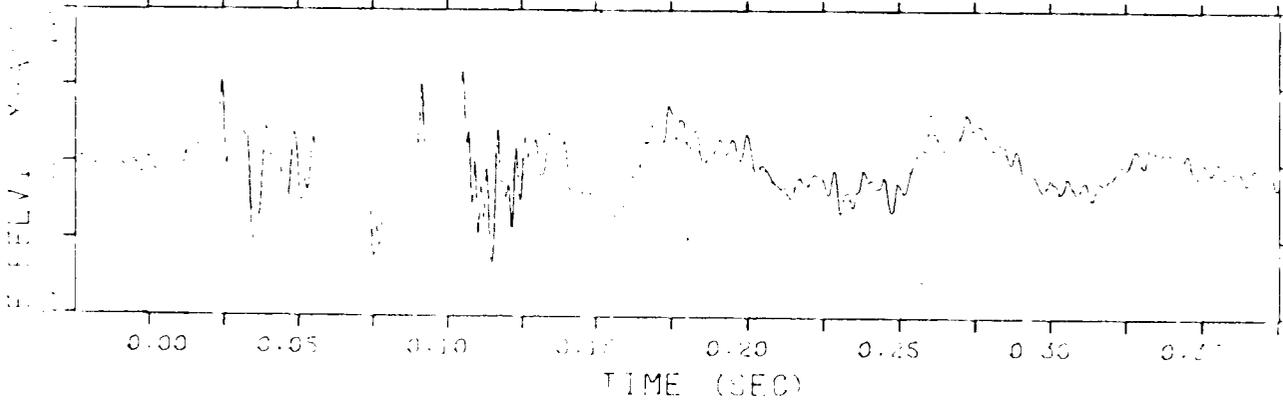
MAX=6.4



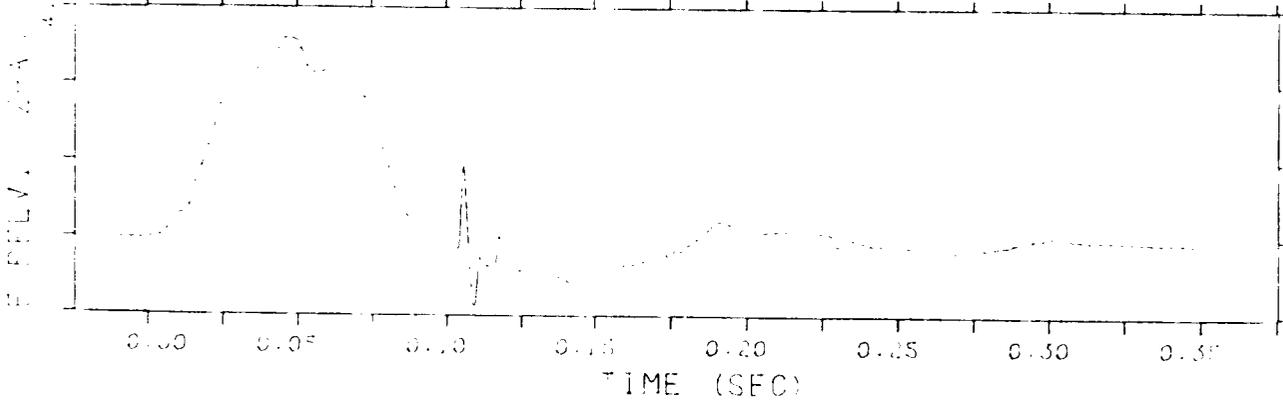
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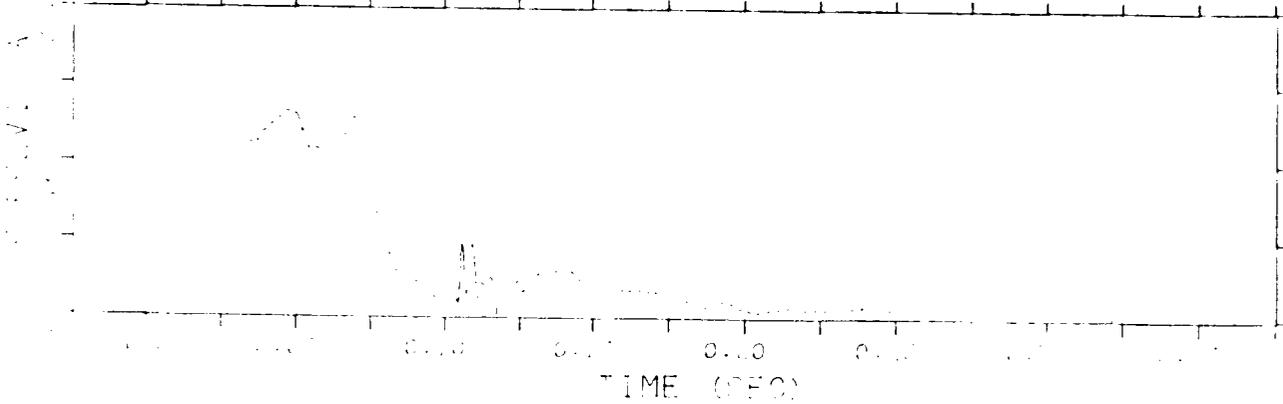
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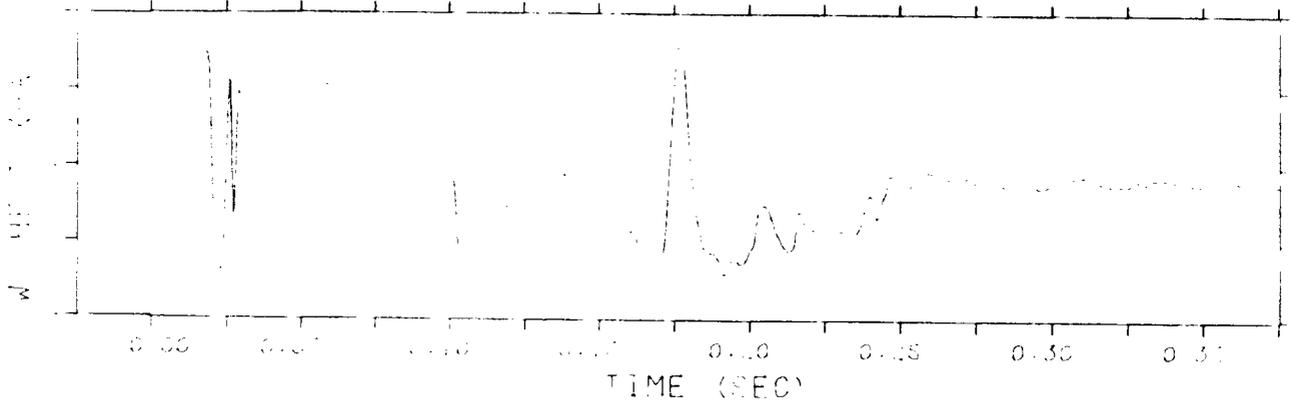
MAX=01.16



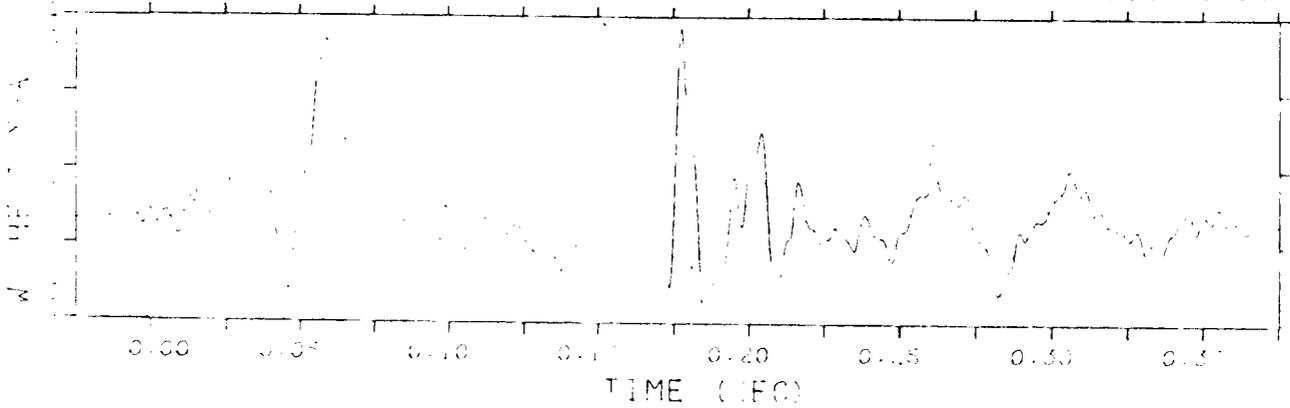
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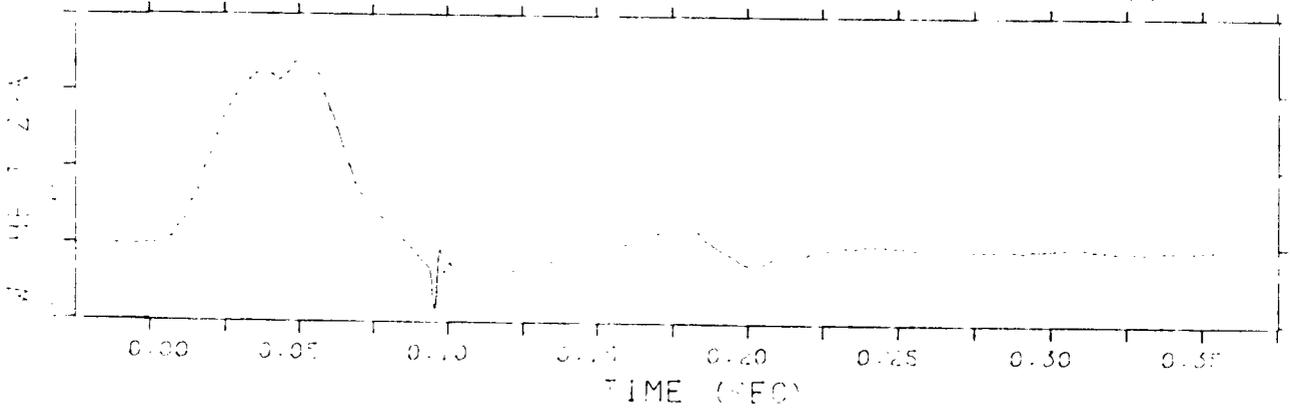
MIN=-11.1



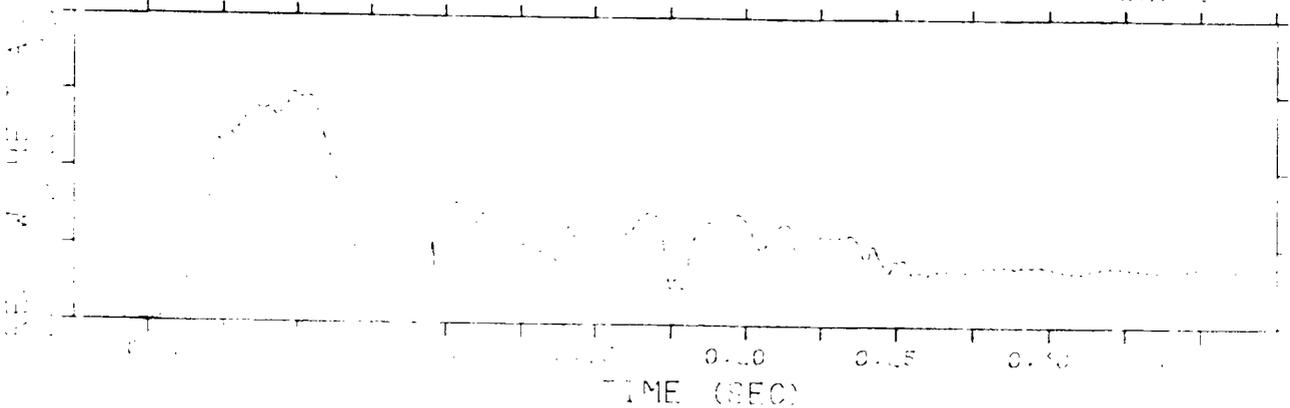
MAX=2.01



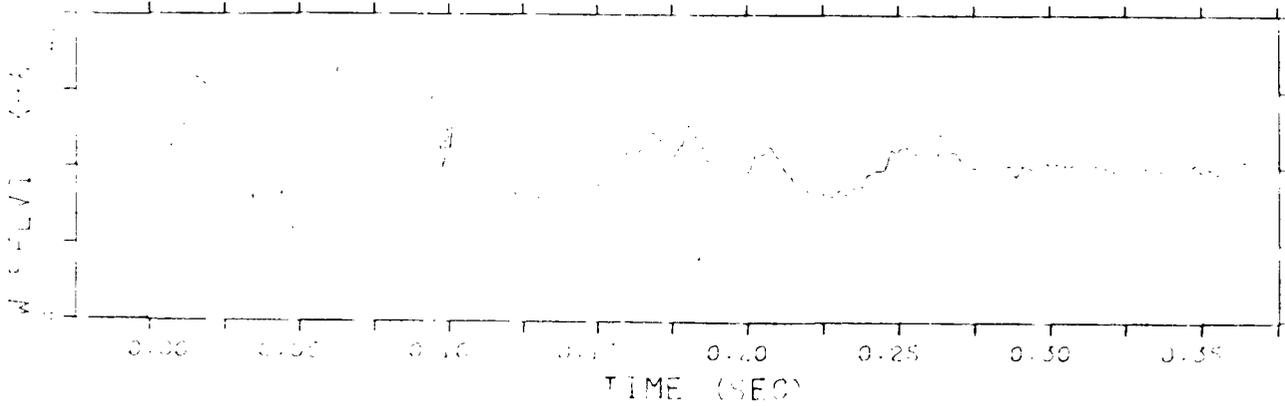
MAX=3.00



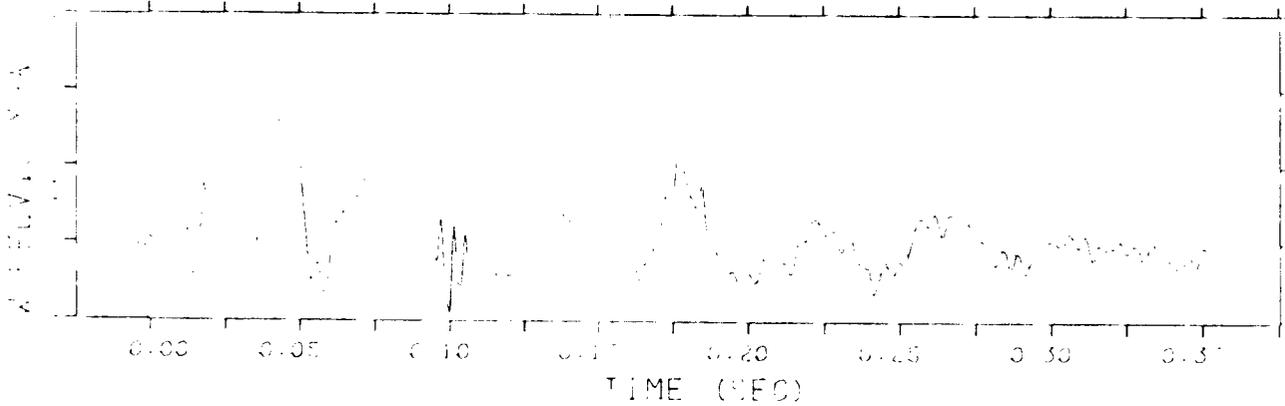
MAX=2.00



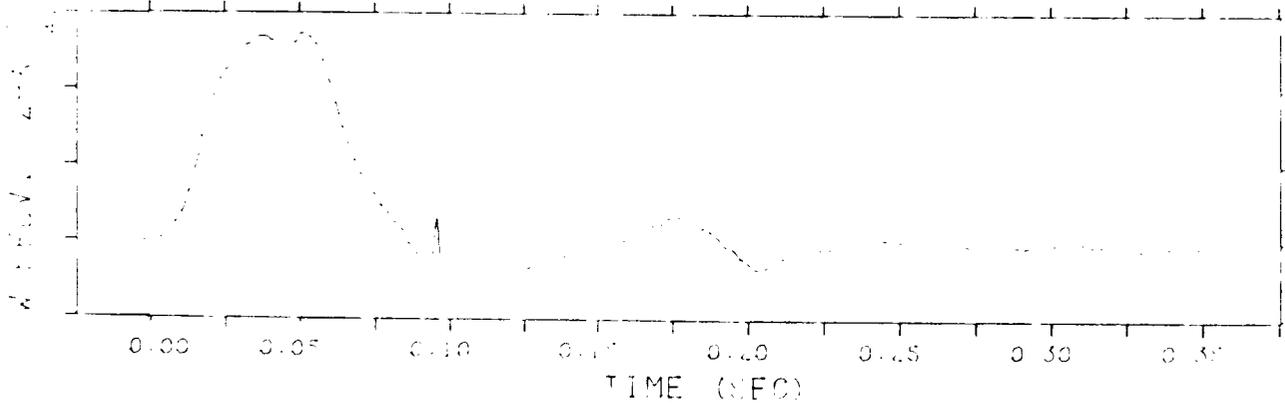
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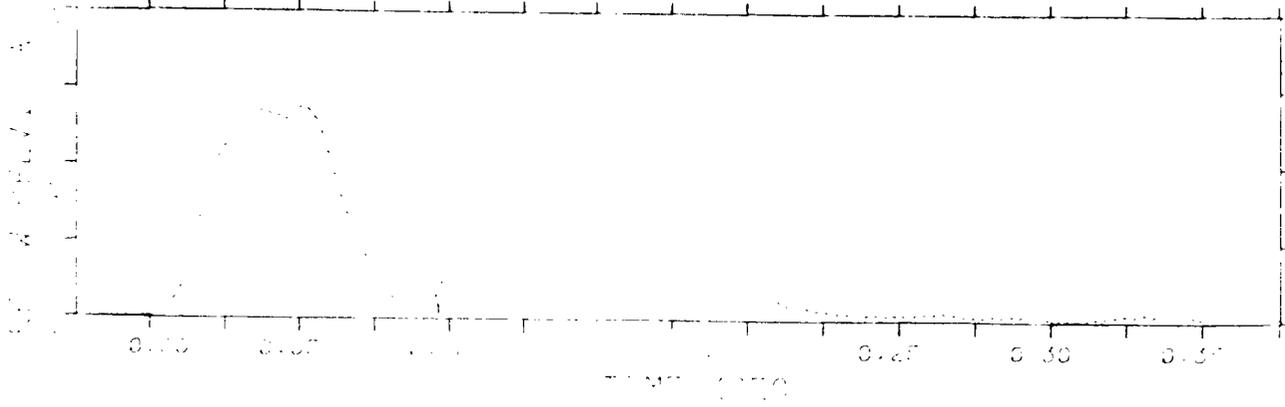
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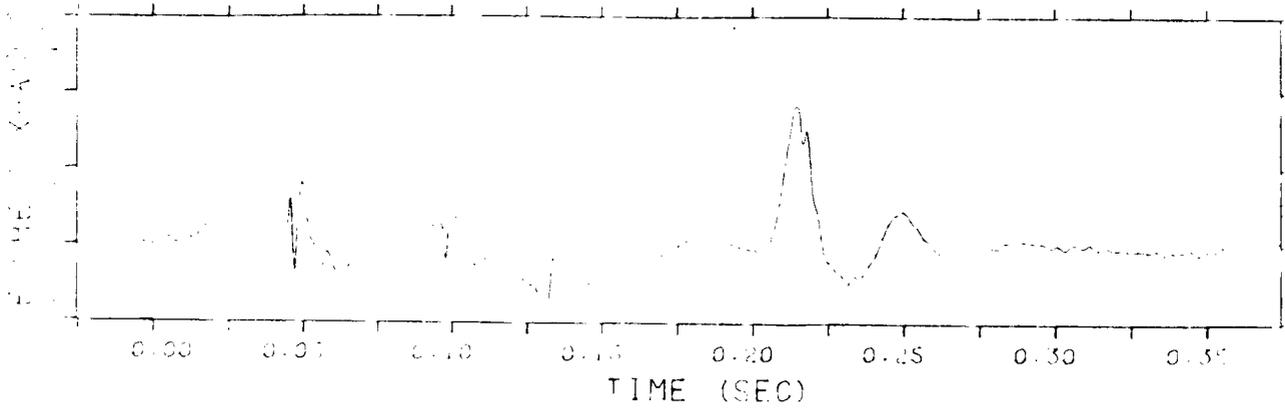
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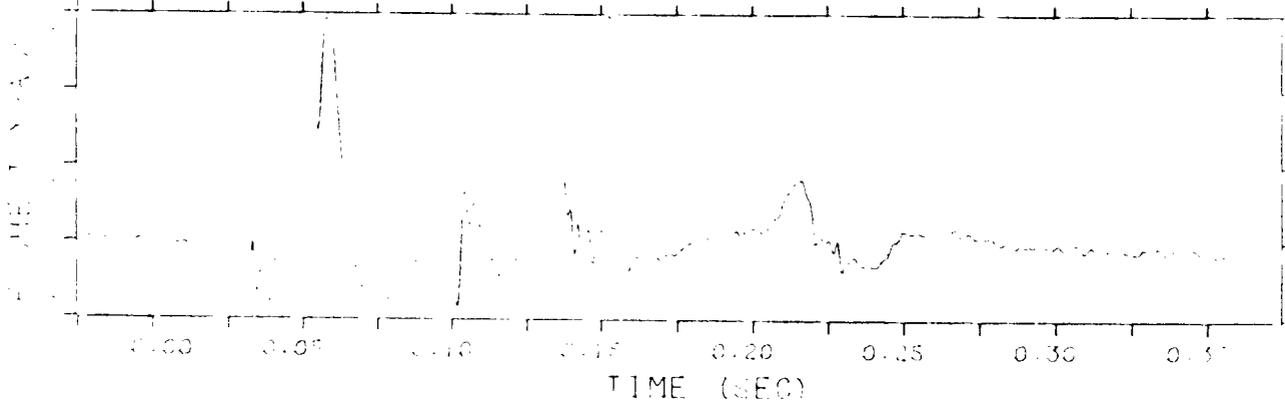
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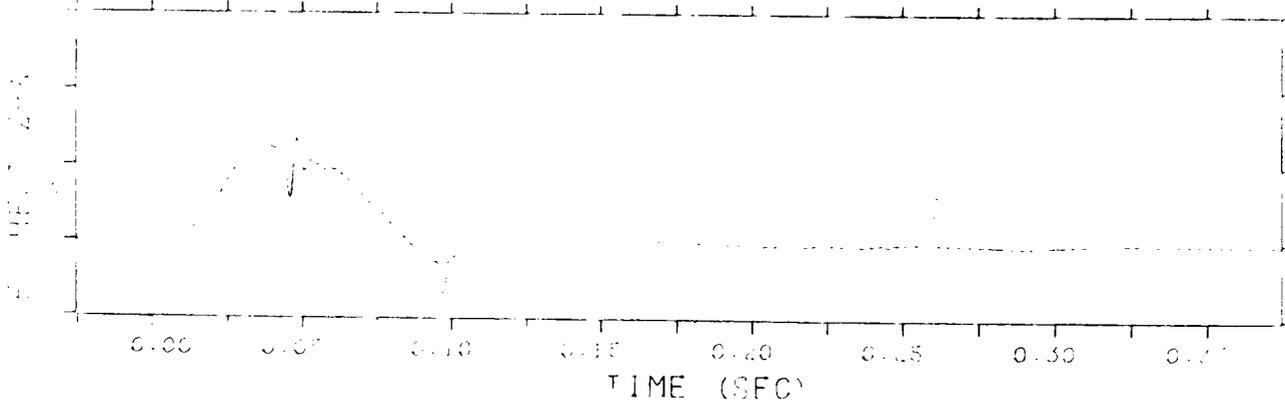
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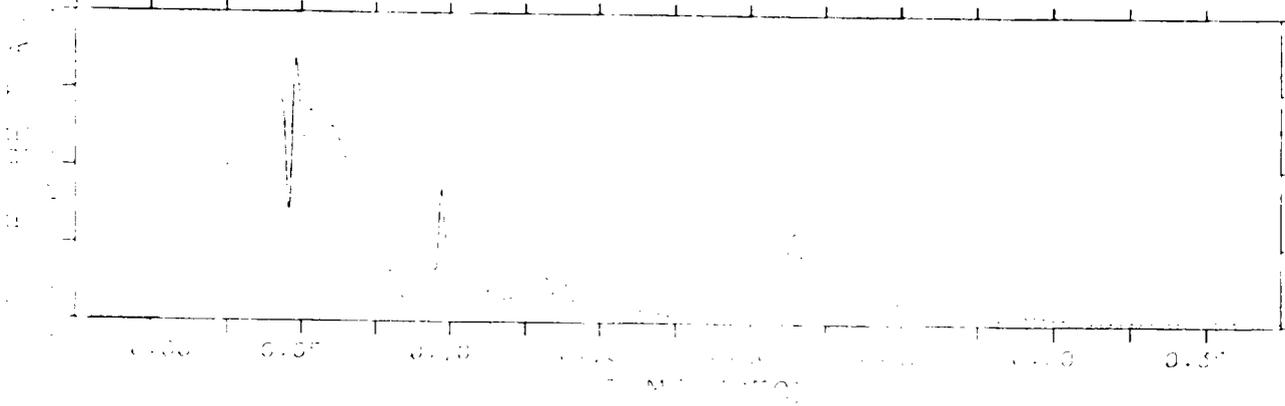
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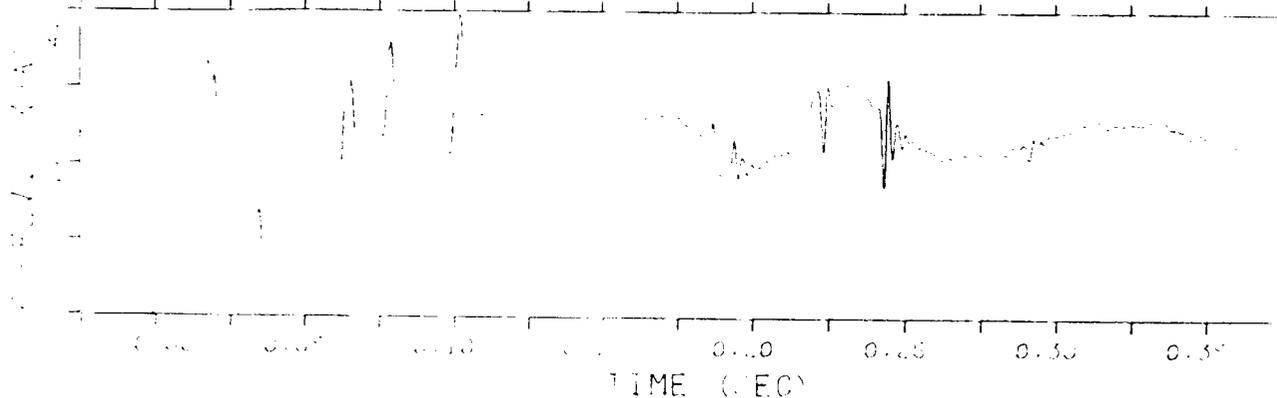
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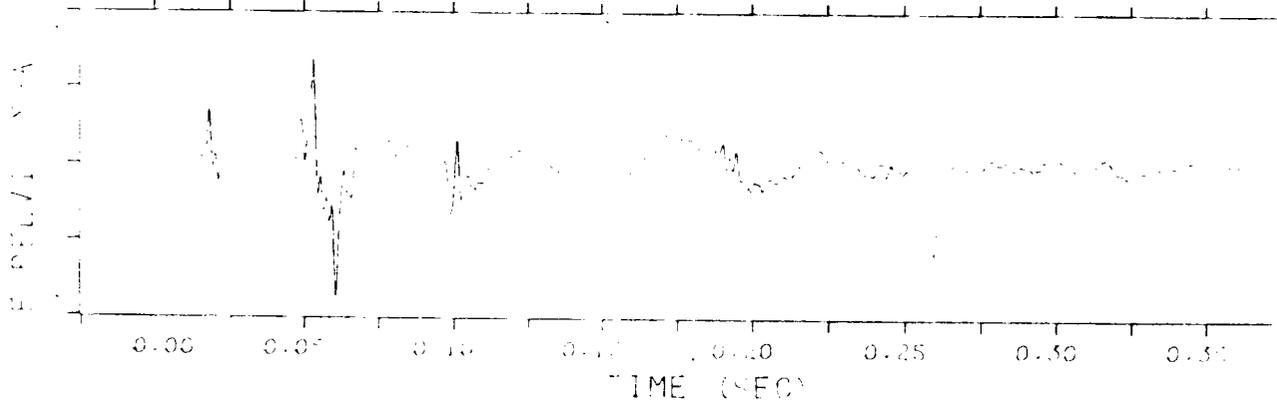
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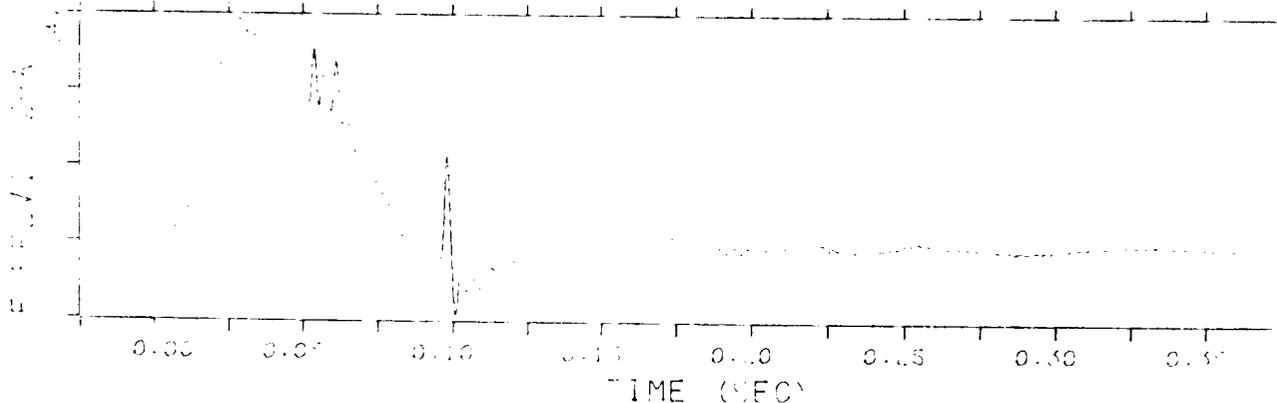
MIN=-5.00



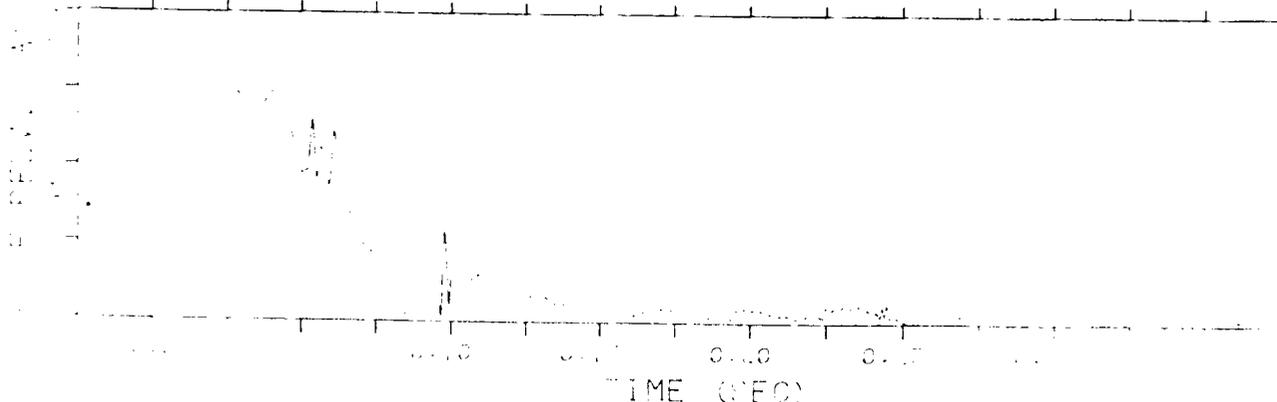
MIN=-4.33

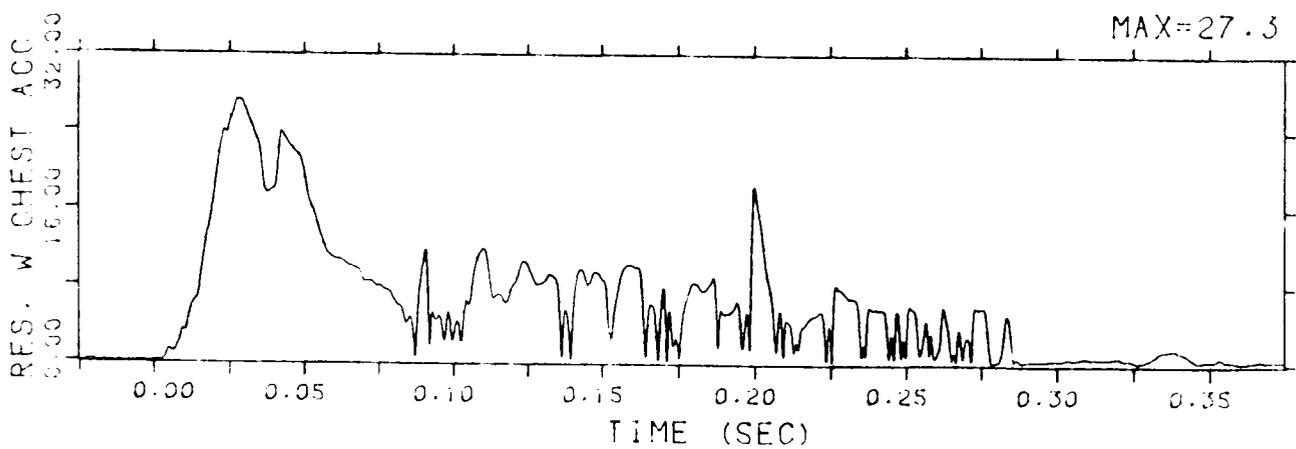
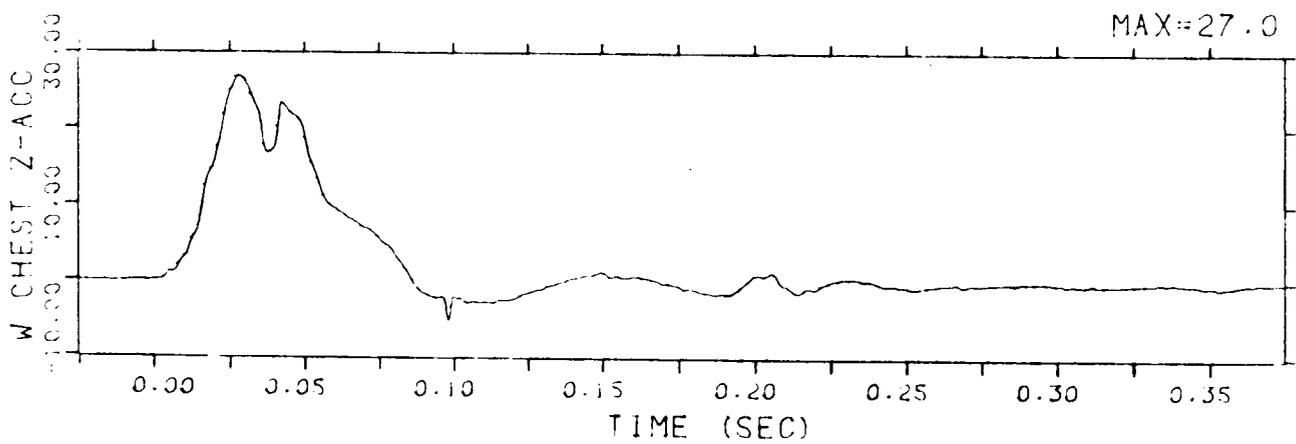
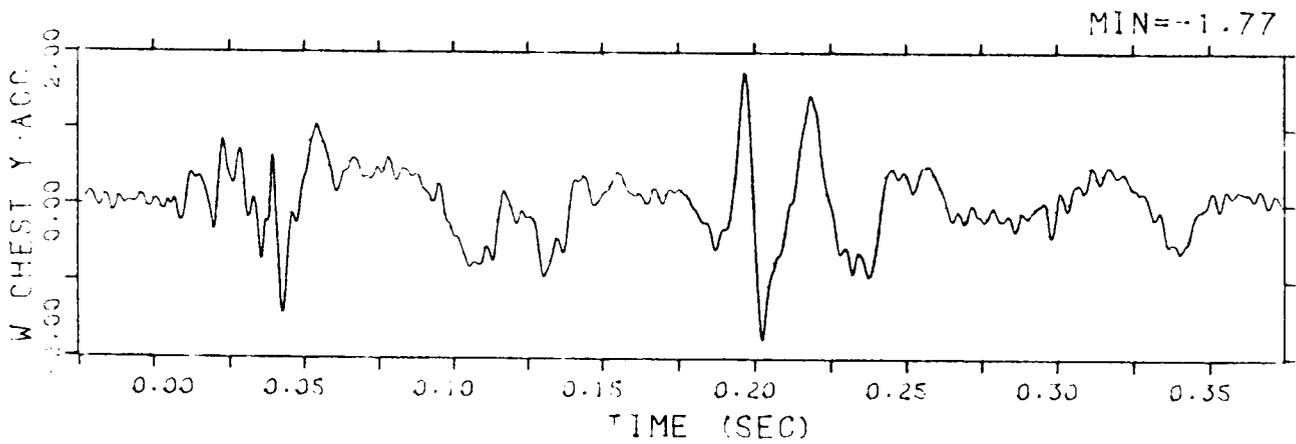
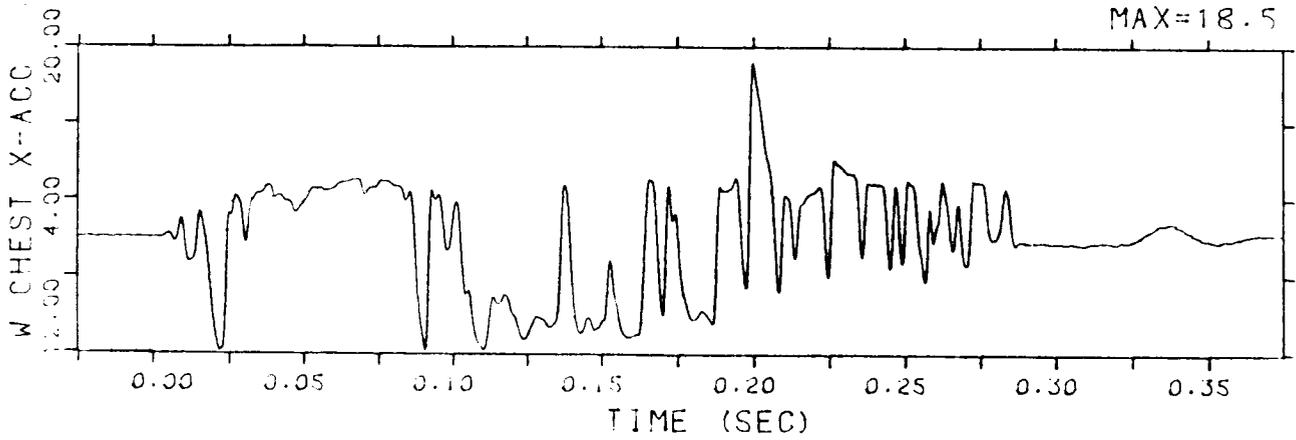


MAX=13.33

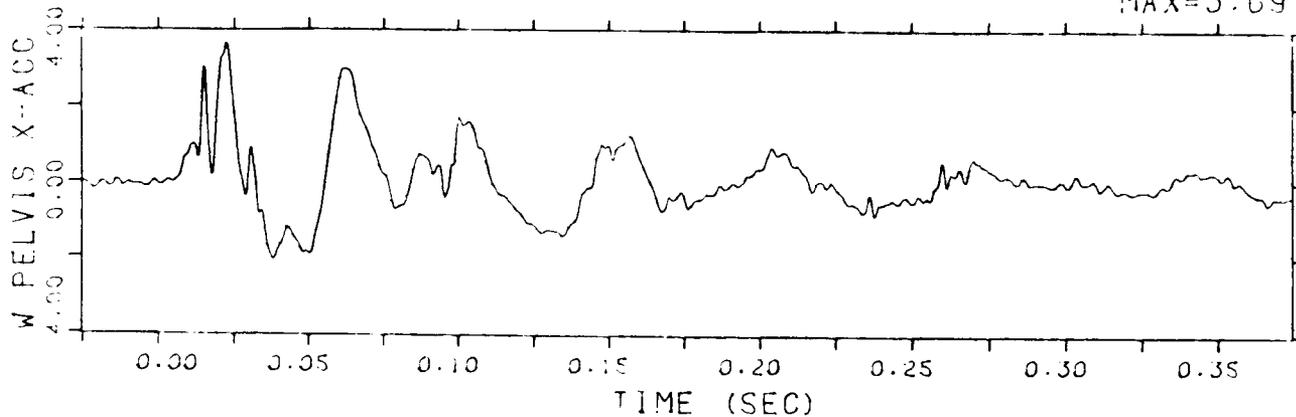


MAX=13.33

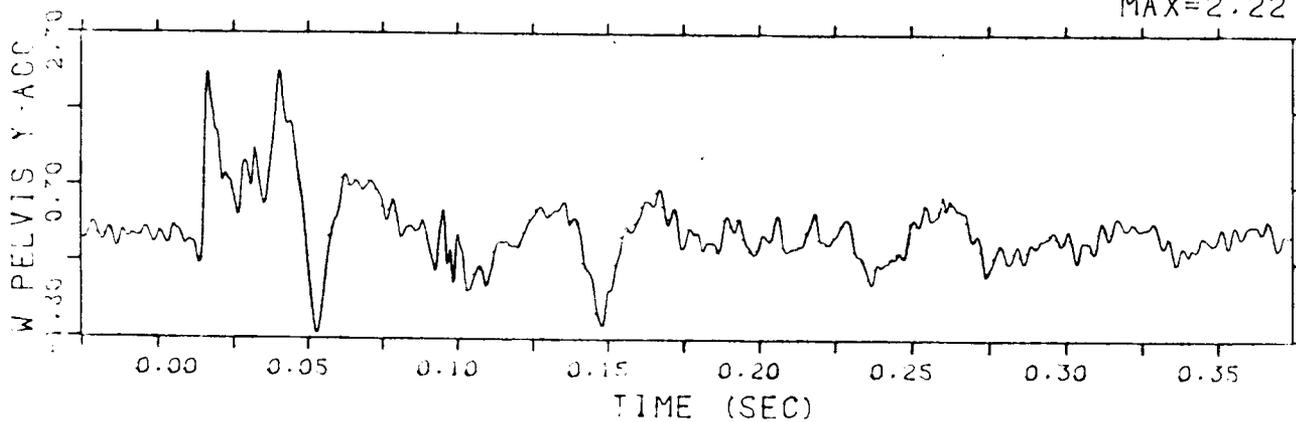




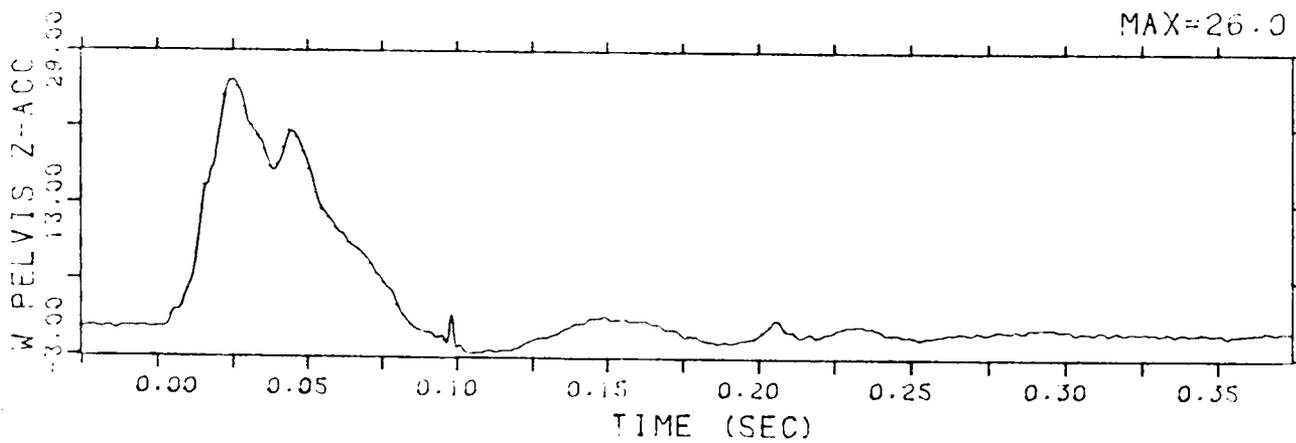
MAX=3.09



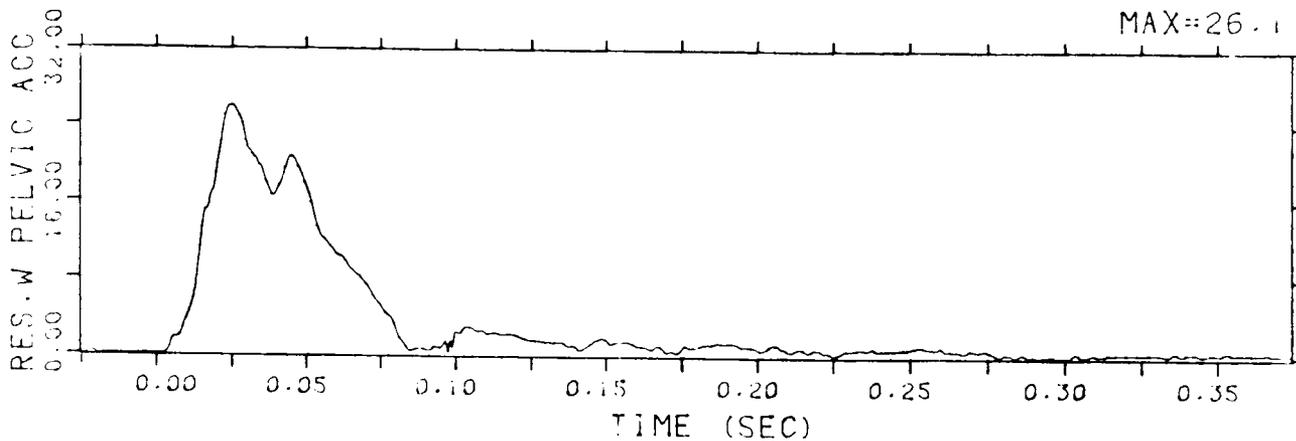
MAX=2.22



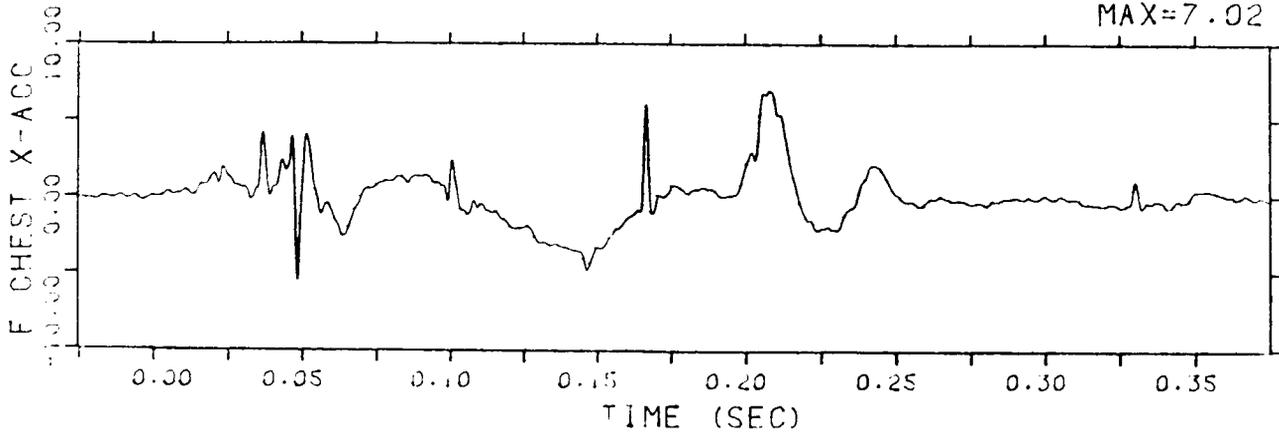
MAX=26.0



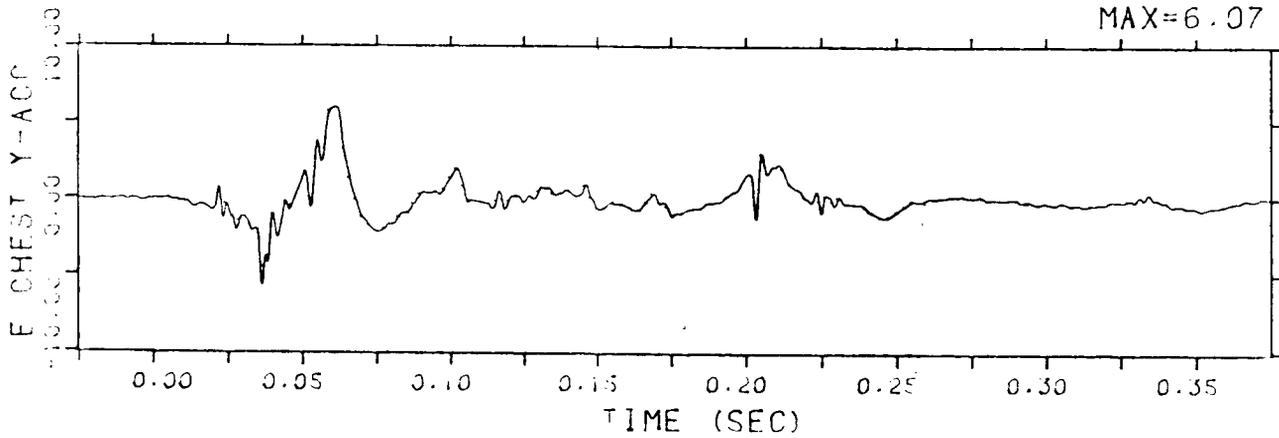
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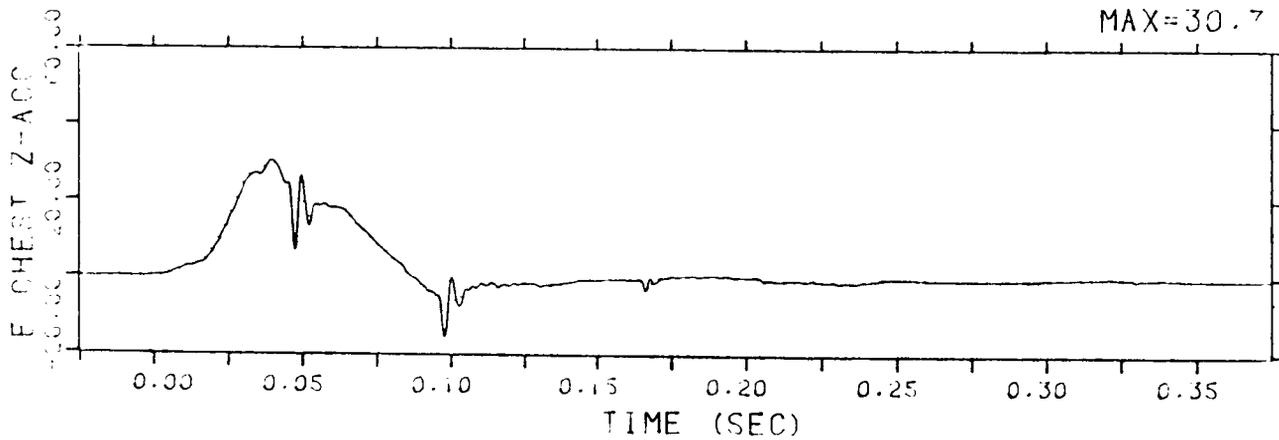
MAX=7.02



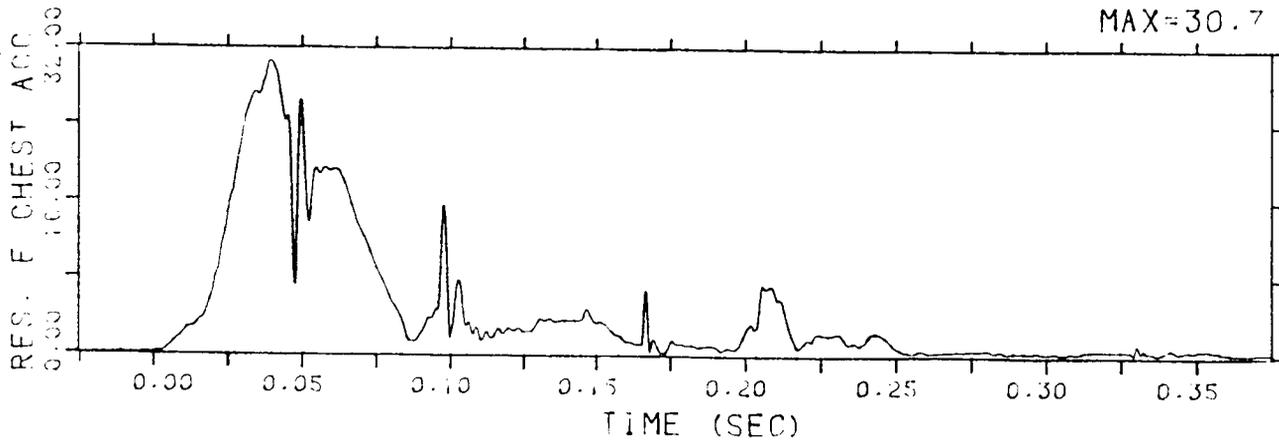
MAX=6.07



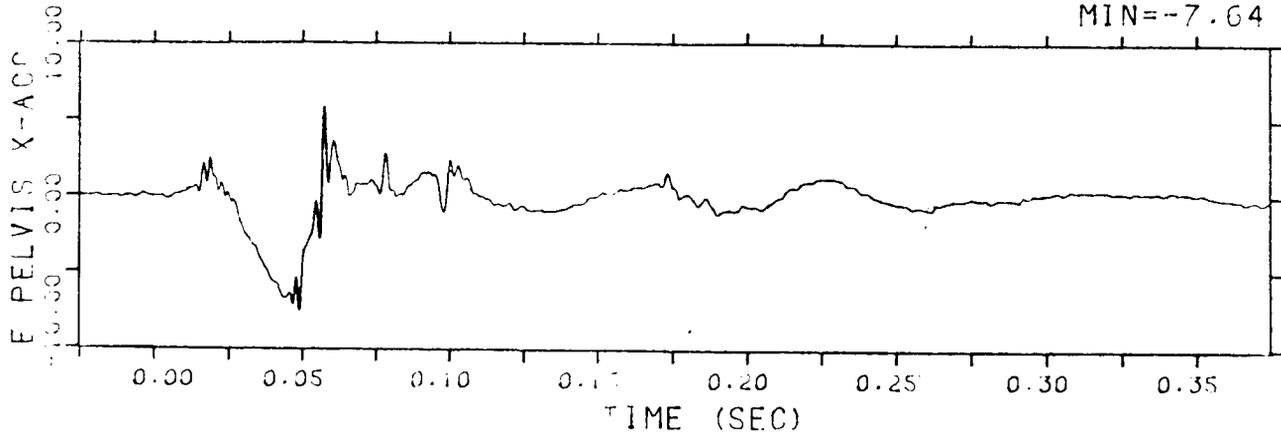
MAX=30.7



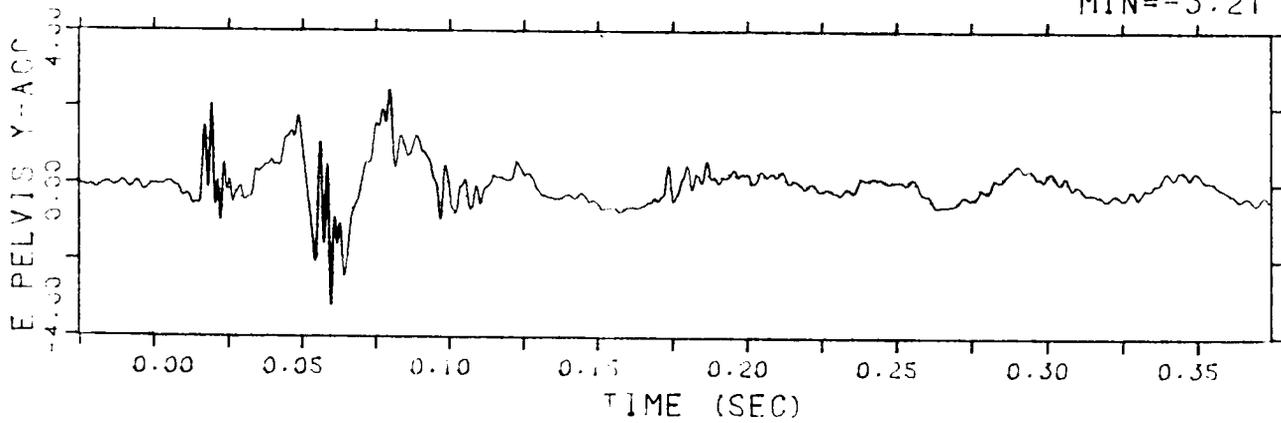
MAX=30.7



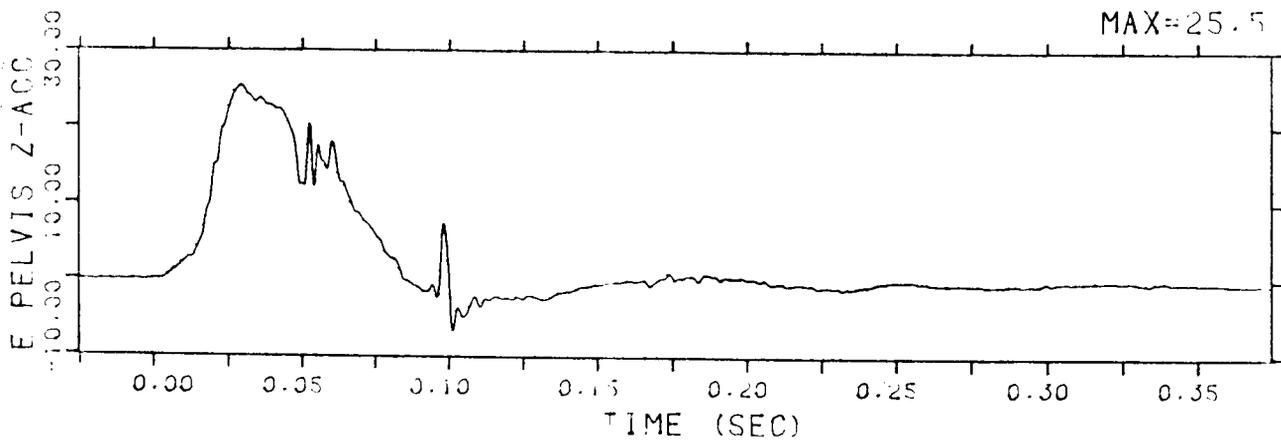
MIN=-7.64



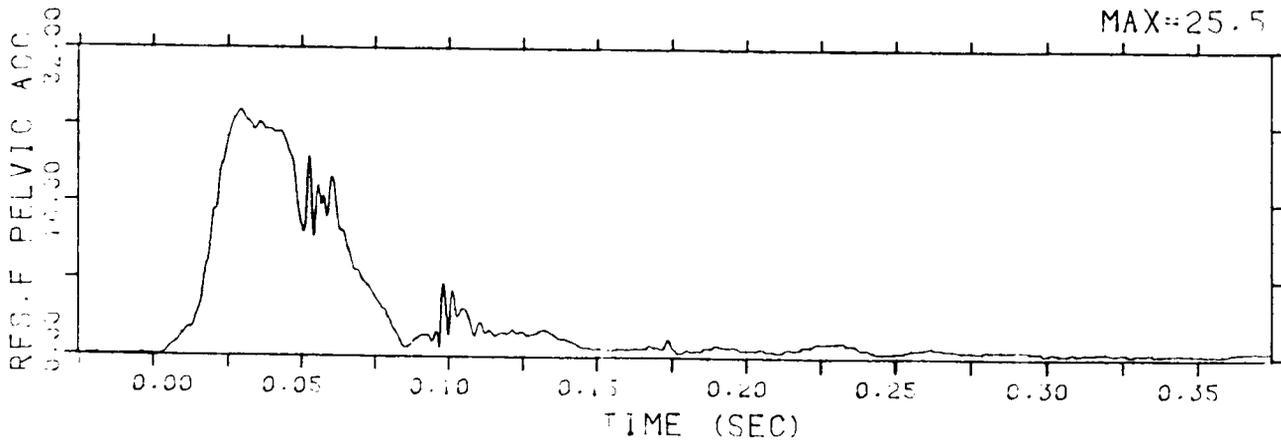
MIN=-3.21



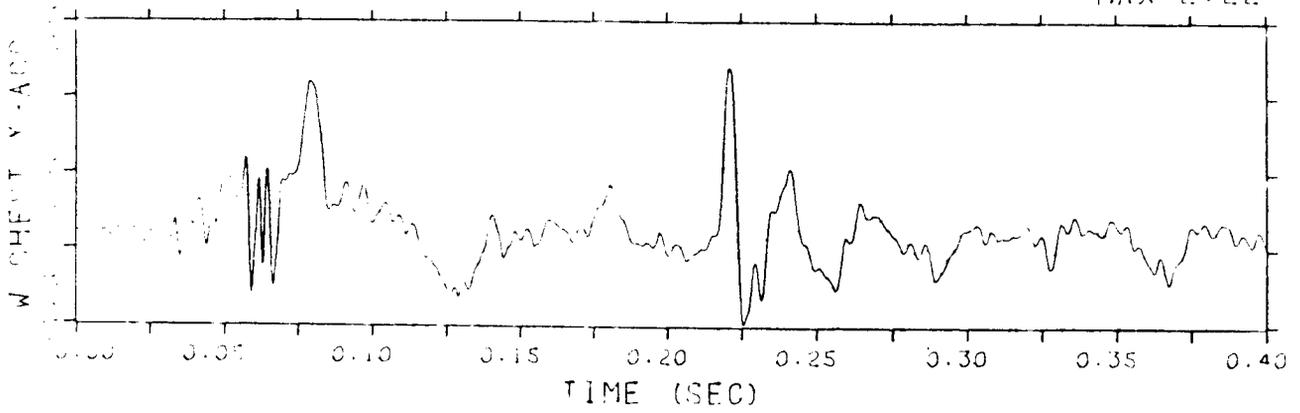
MAX=25.5



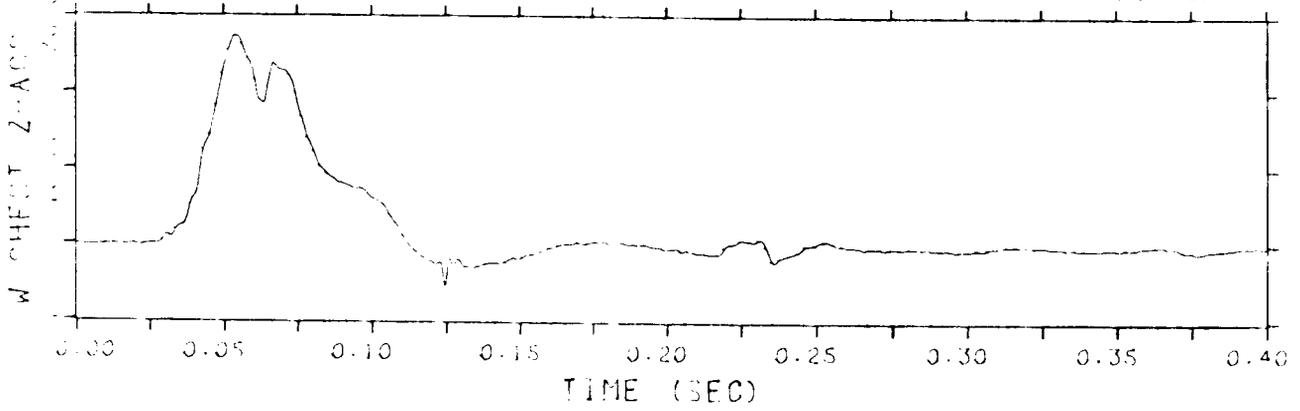
MAX=25.5



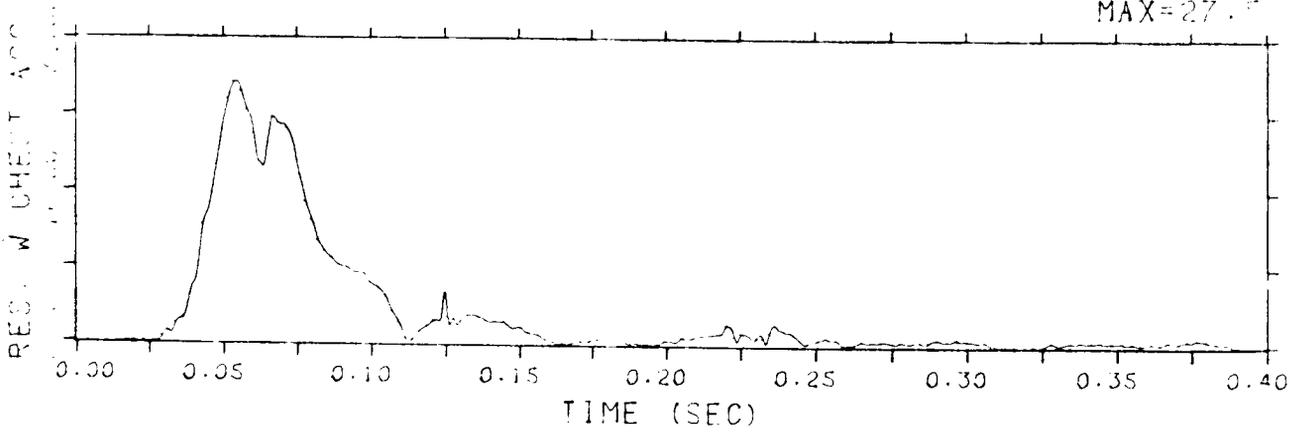
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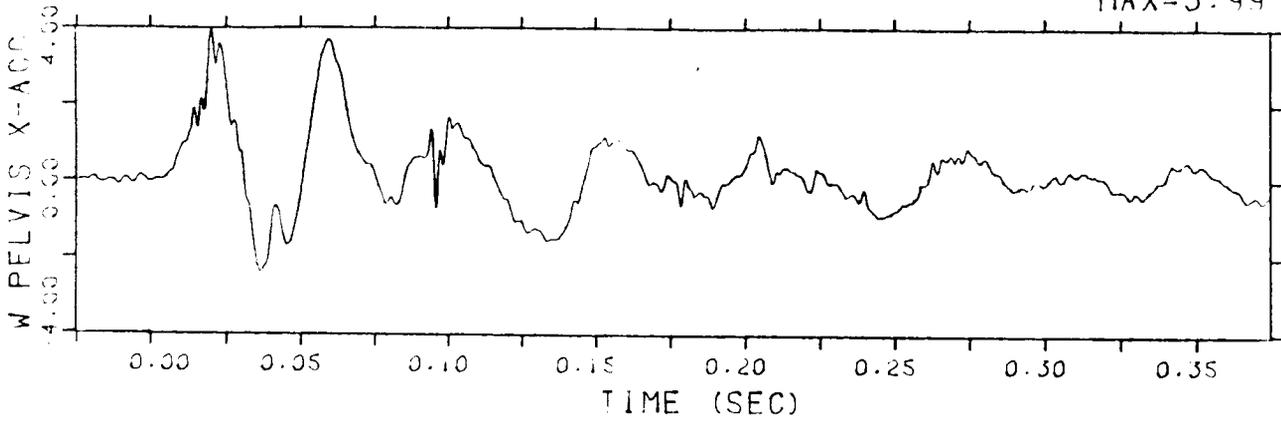
MAX=27.5



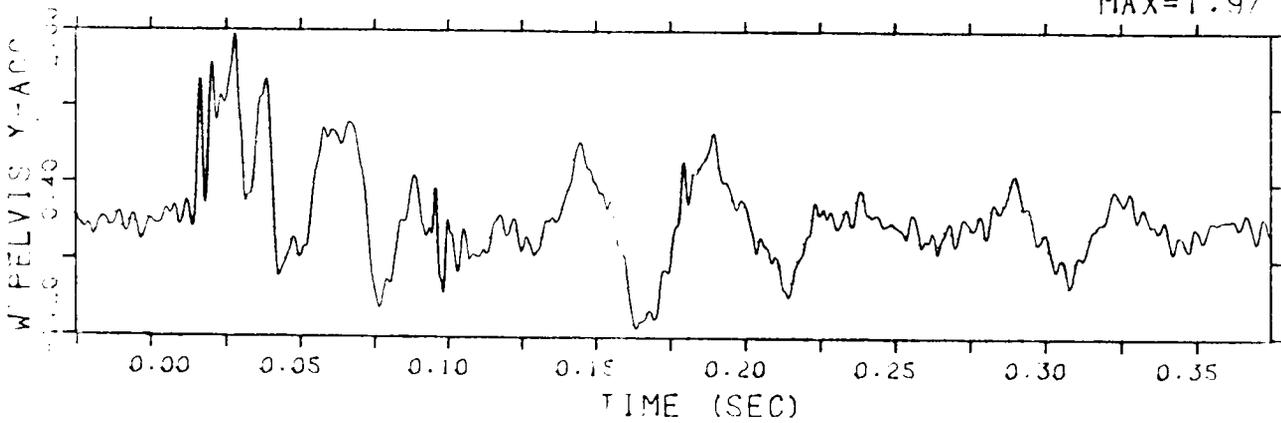
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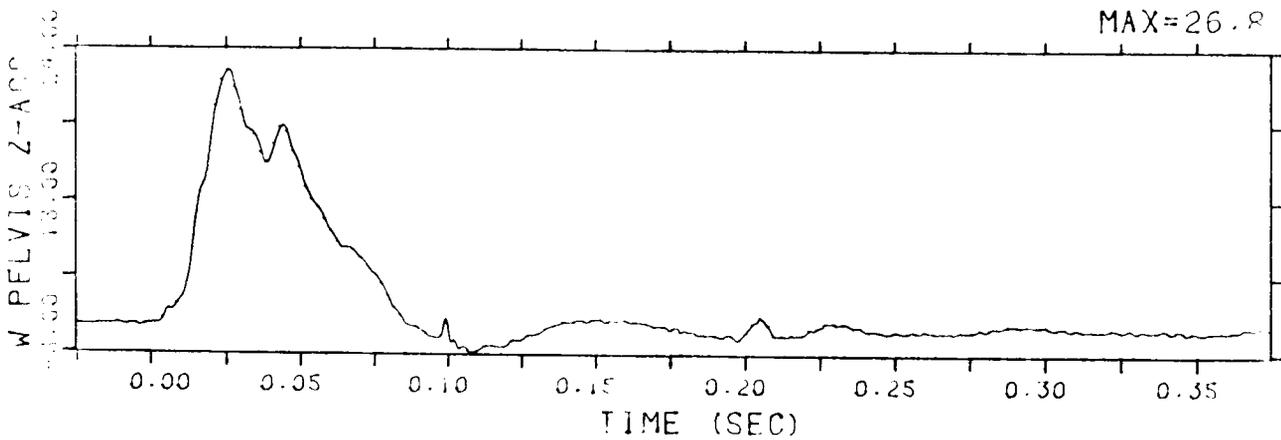
MAX=3.99



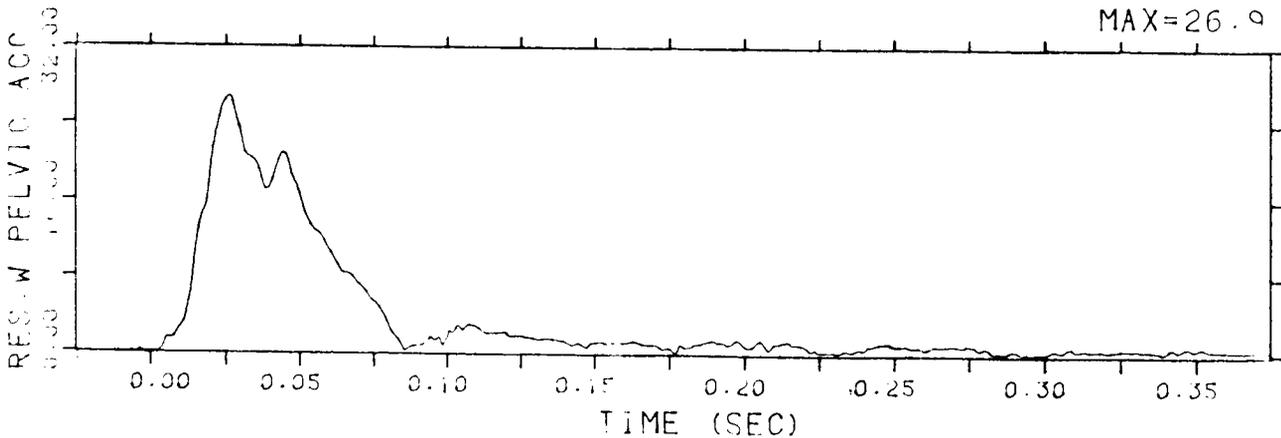
MAX=1.97



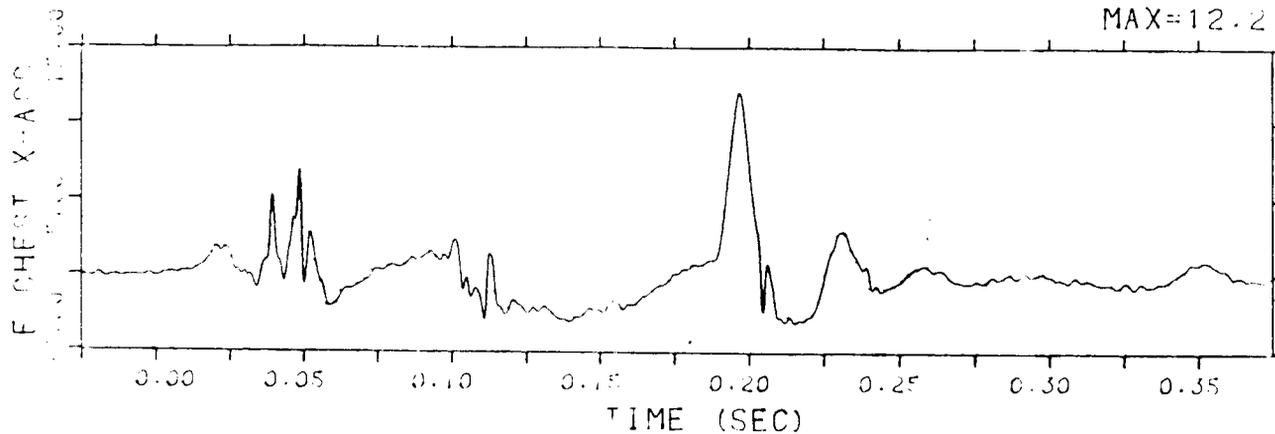
MAX=26.8



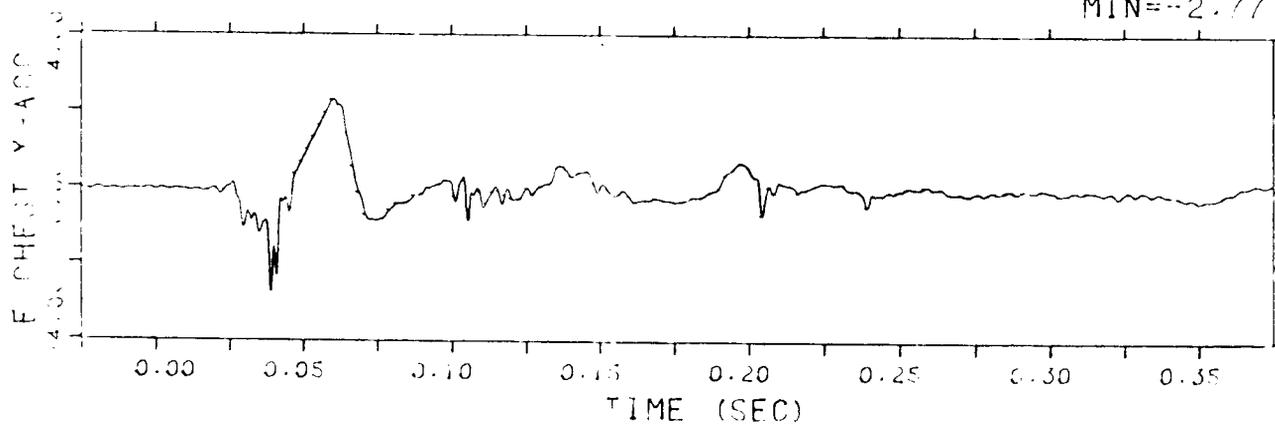
MAX=26.9



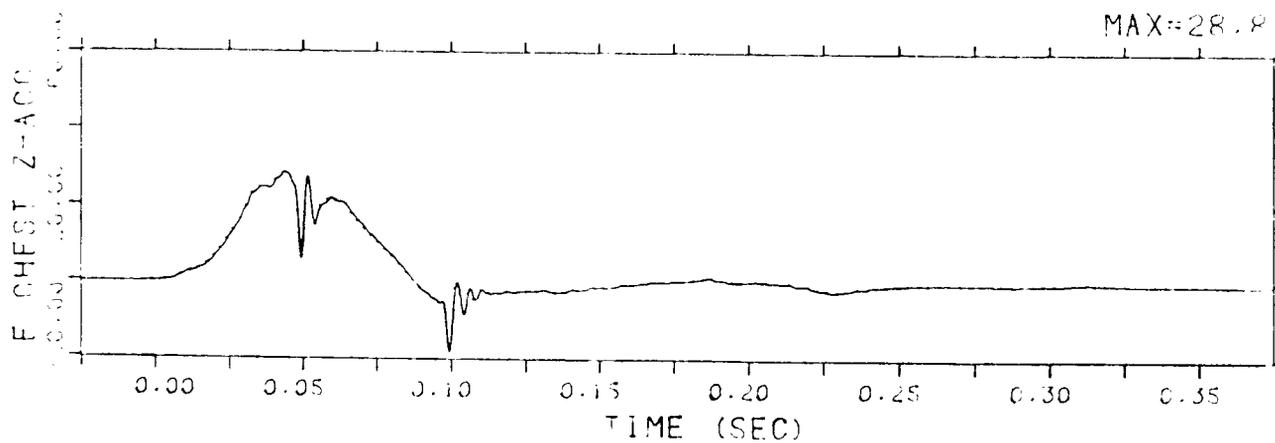
MAX=12.2



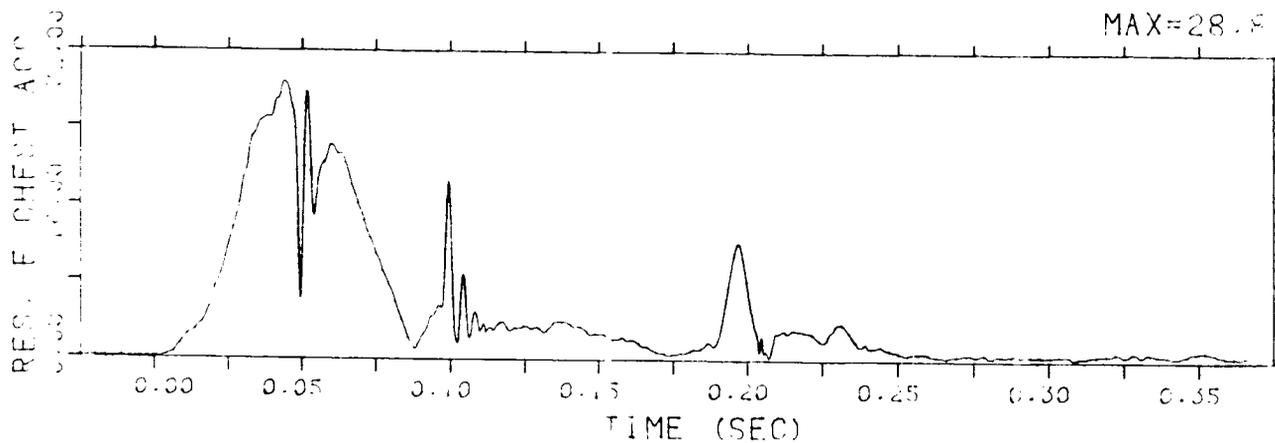
MIN=-2.77



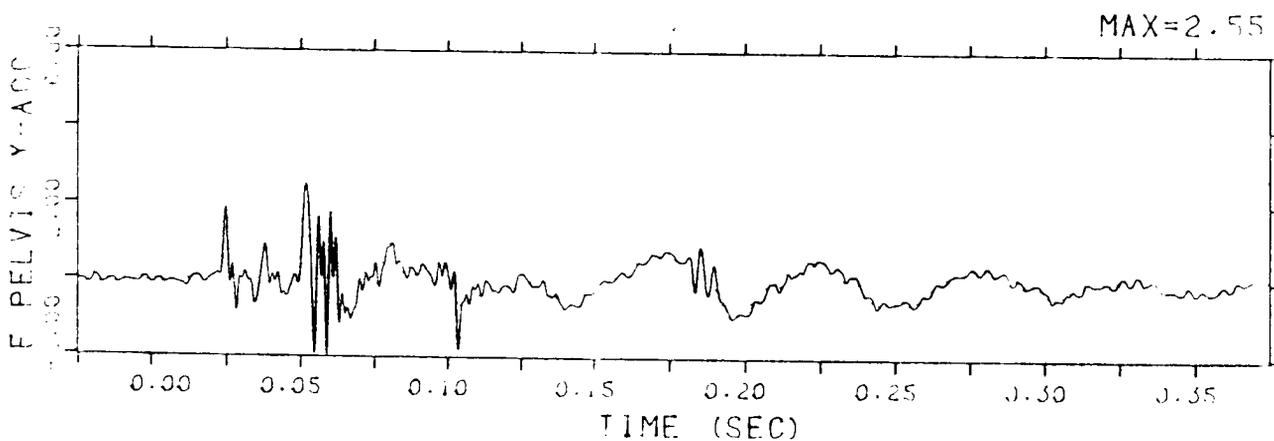
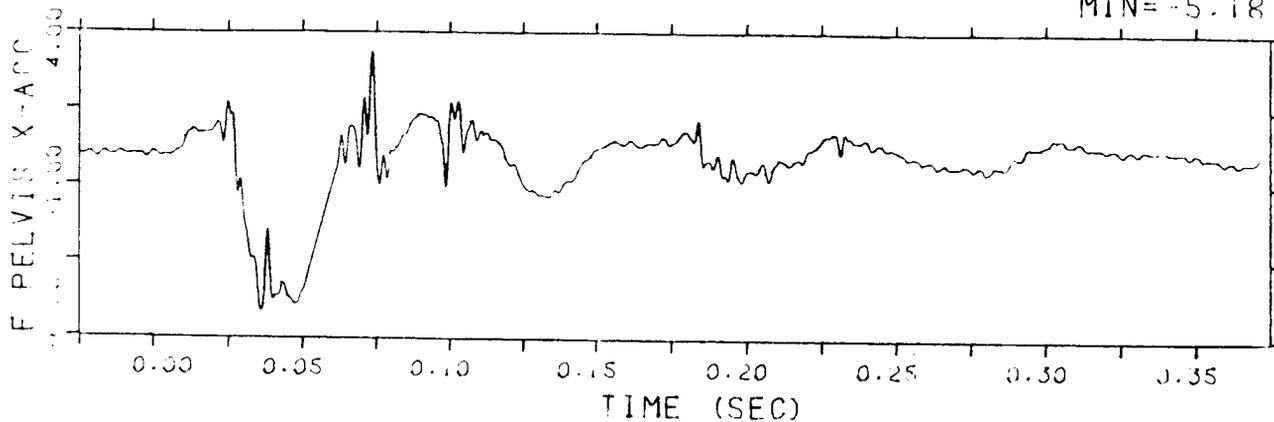
MAX=28.8



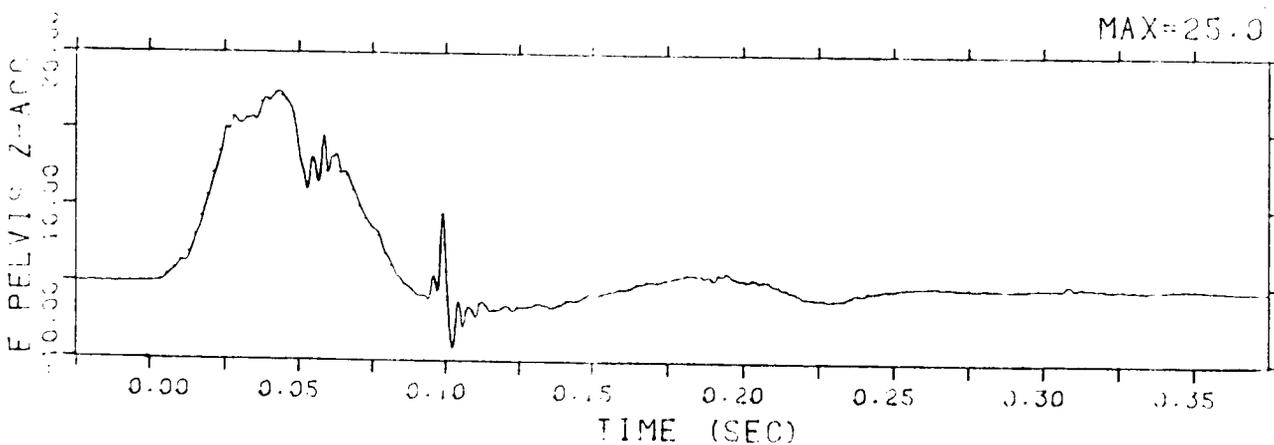
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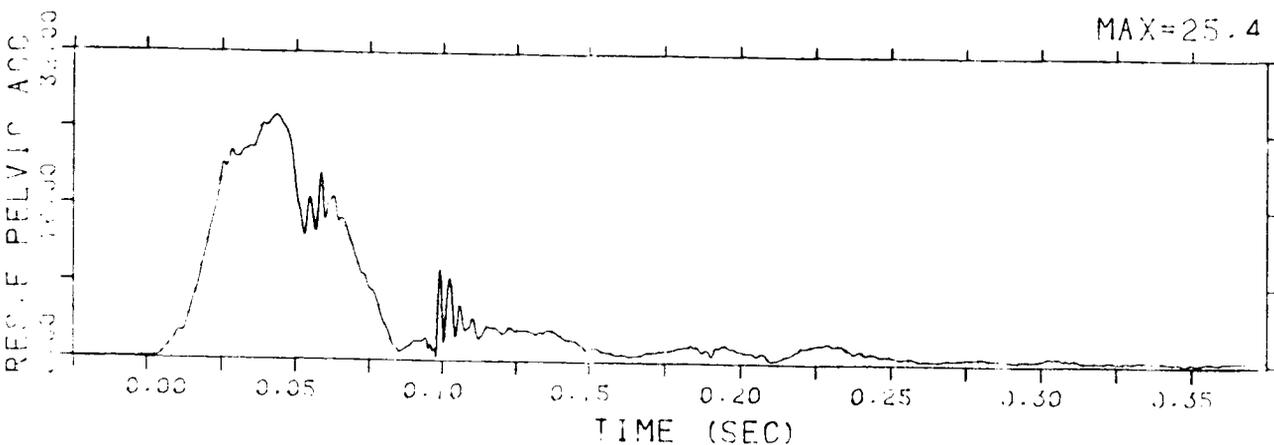
MIN=-5.18



MAX=2.55

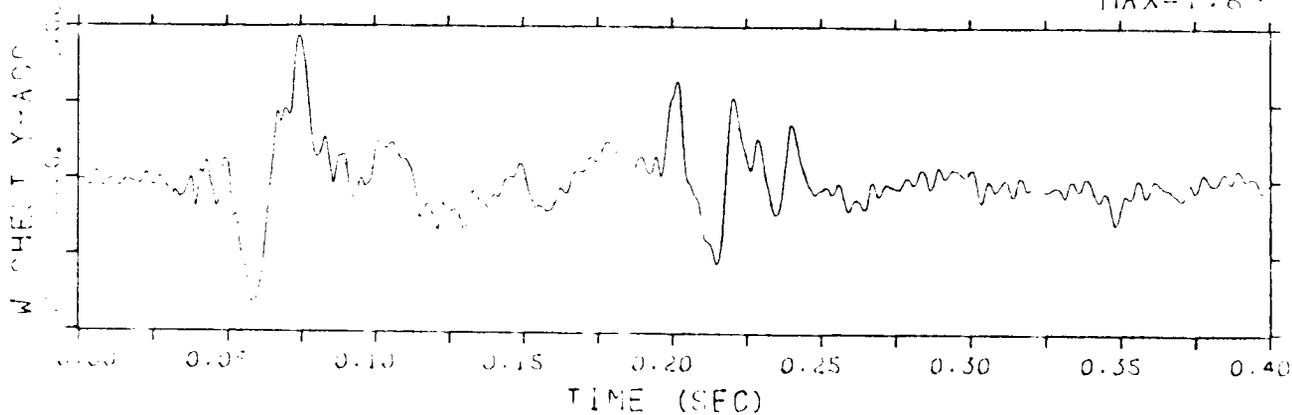


MAX=25.0

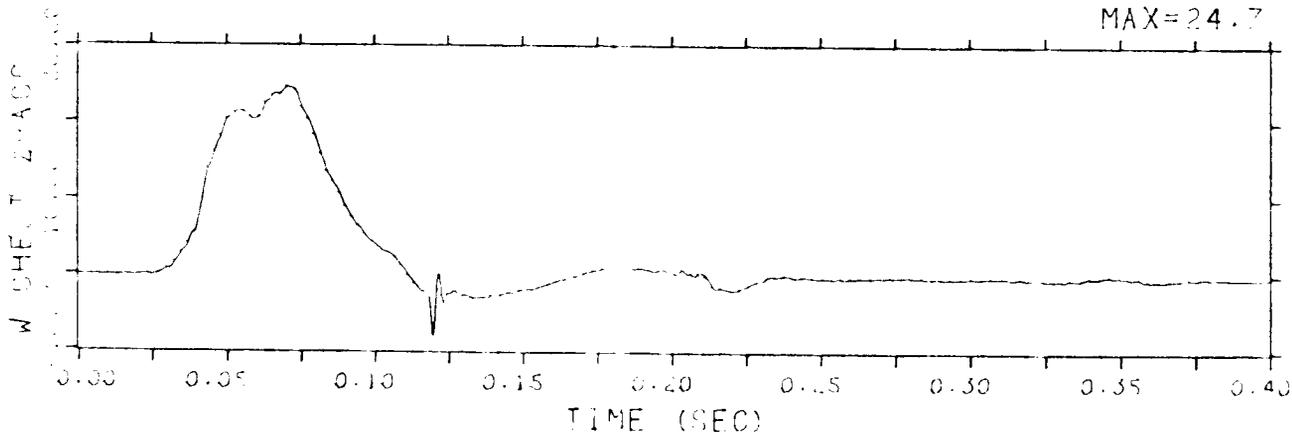


MAX=25.4

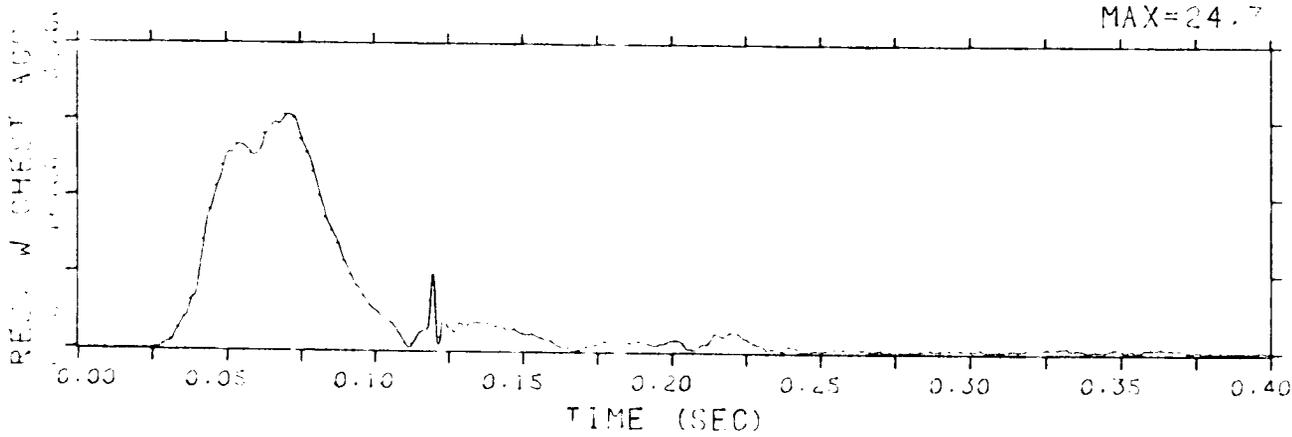
MAX=1.89



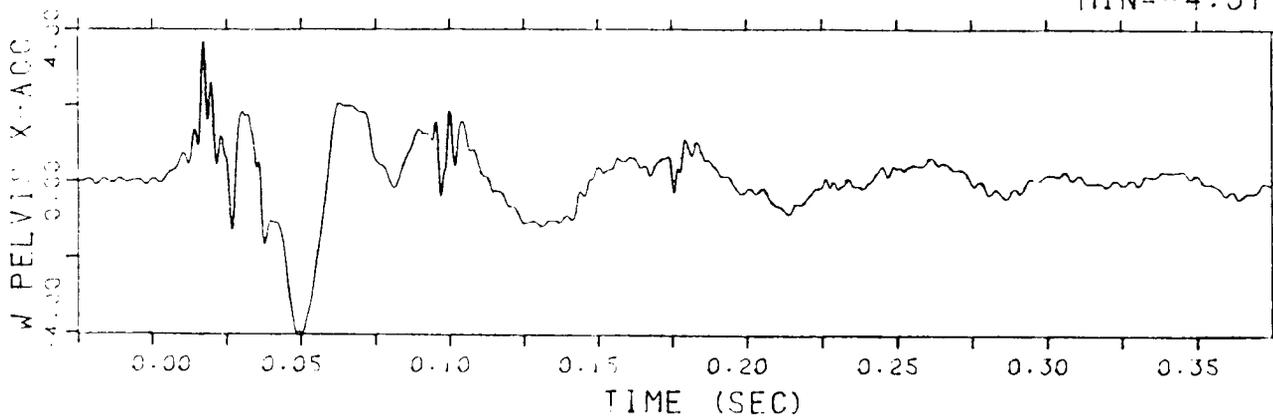
MAX=24.7



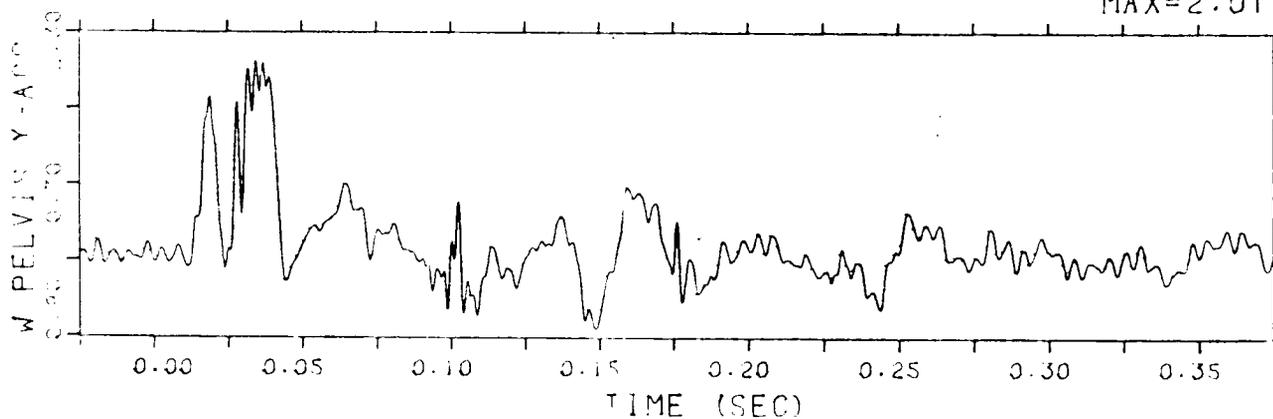
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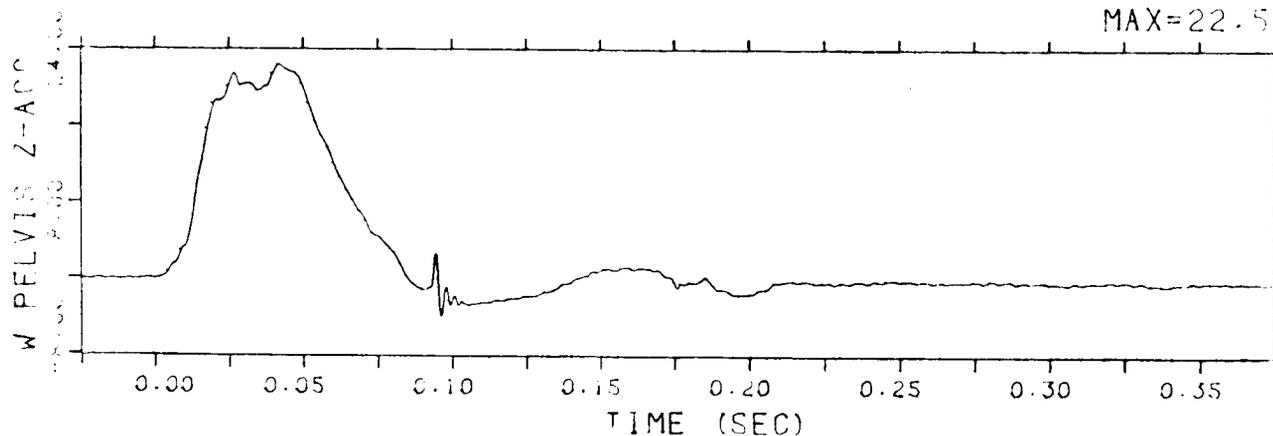
MIN=-4.01



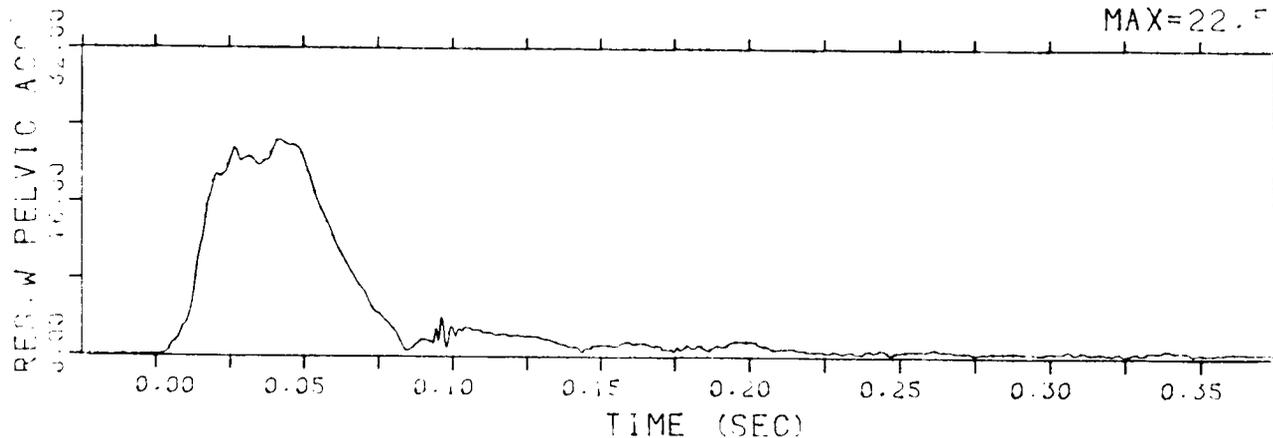
MAX=2.01



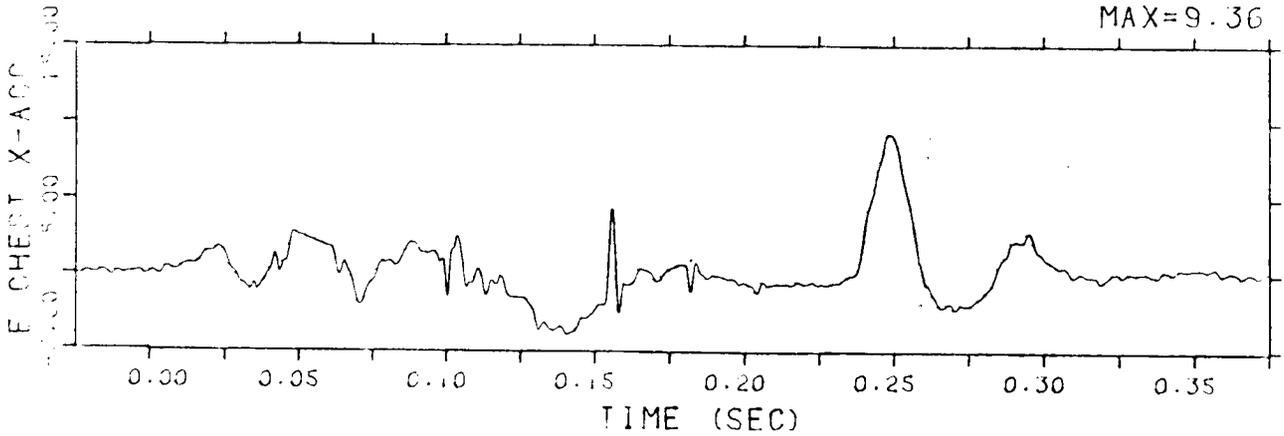
MAX=22.5



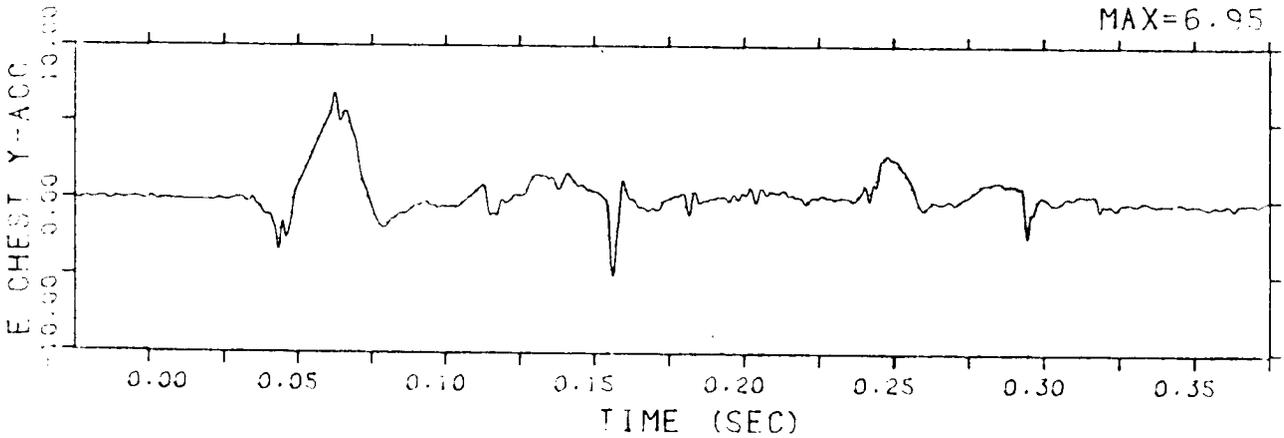
MAX=22.5



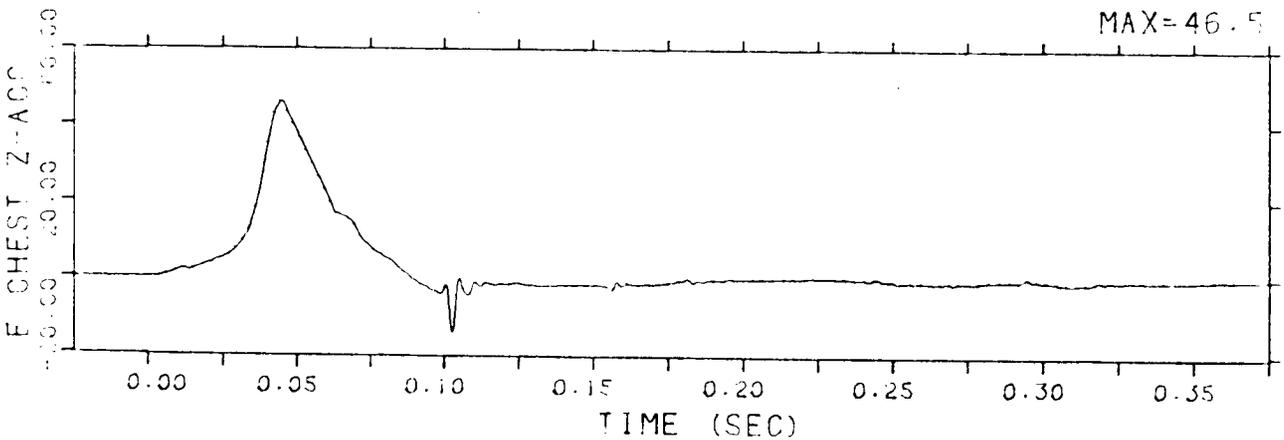
MAX=9.36



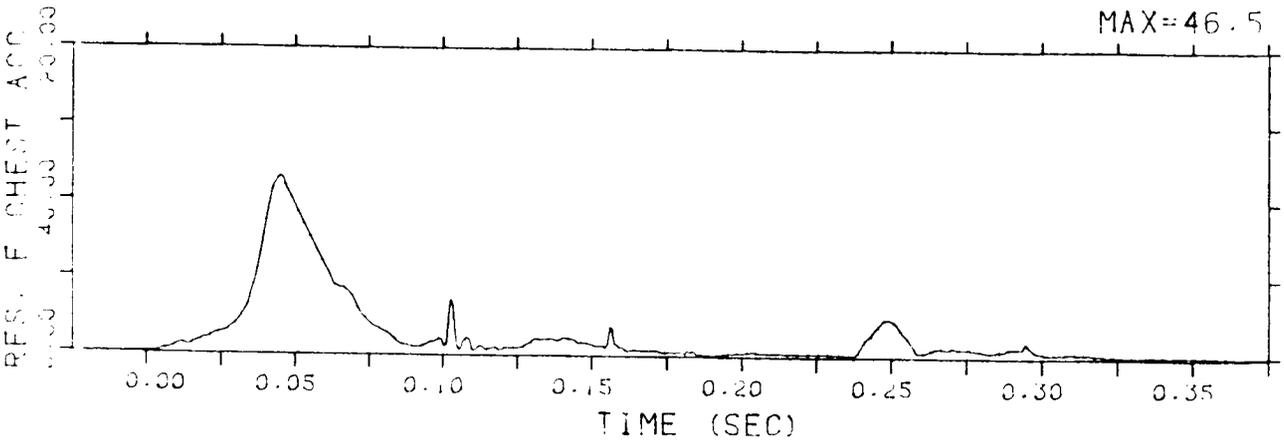
MAX=6.95



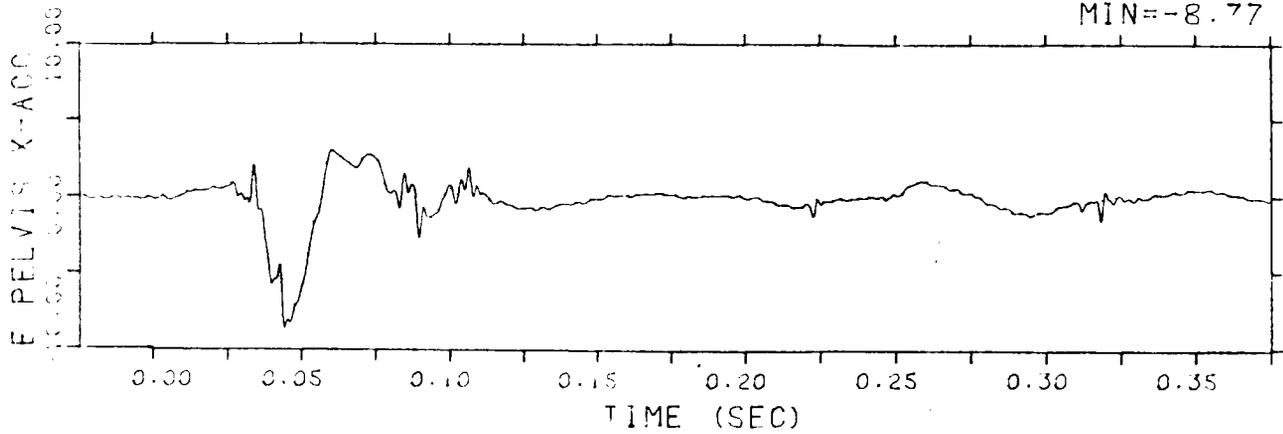
MAX=46.5



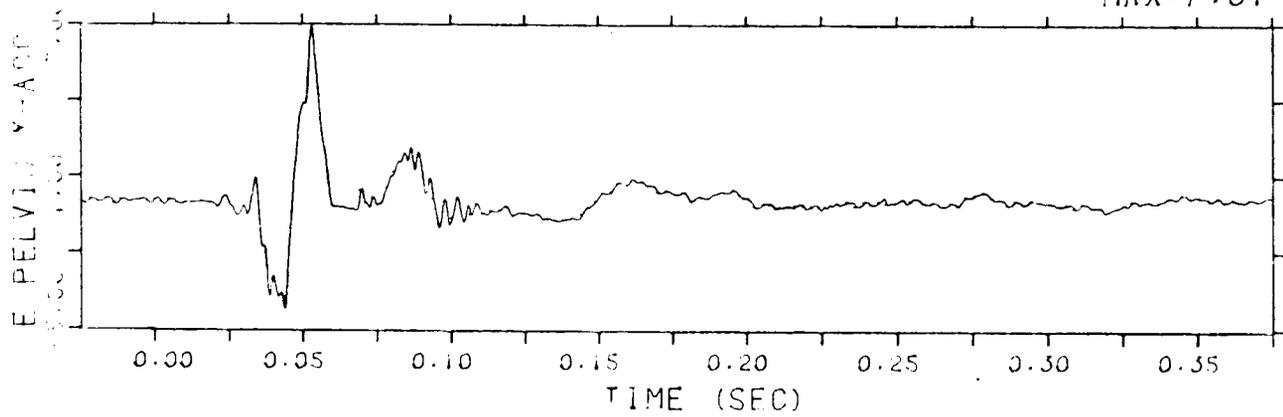
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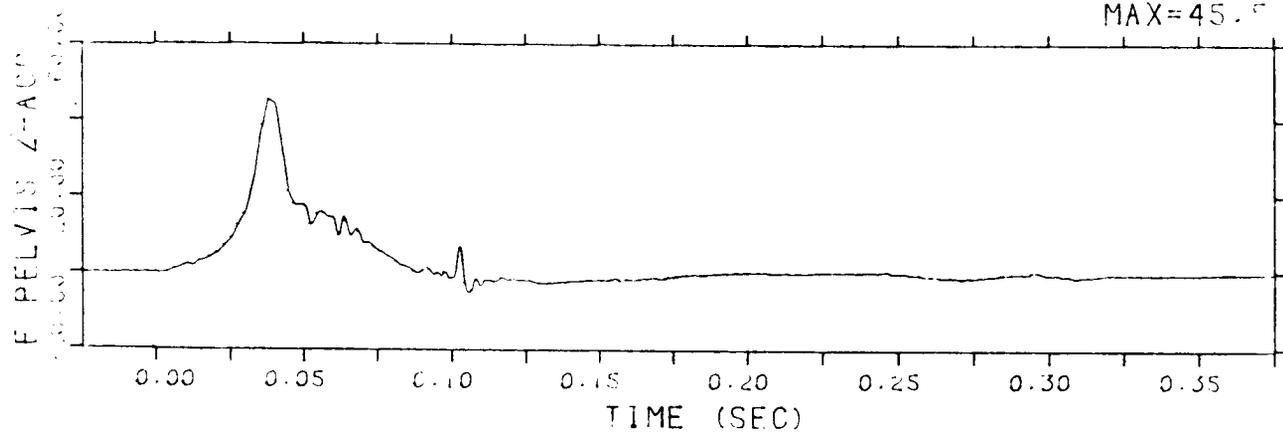
MIN=-8.77



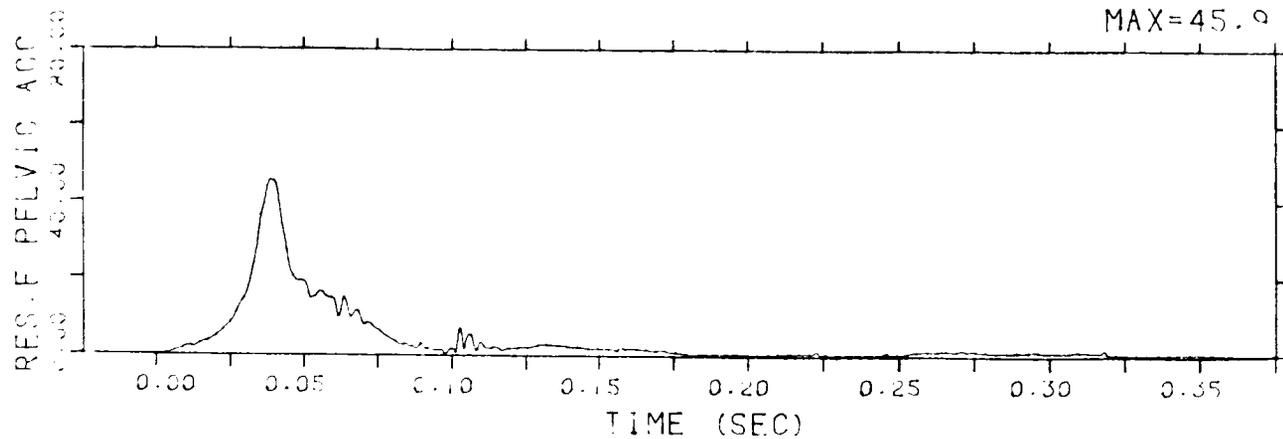
MAX=7.01



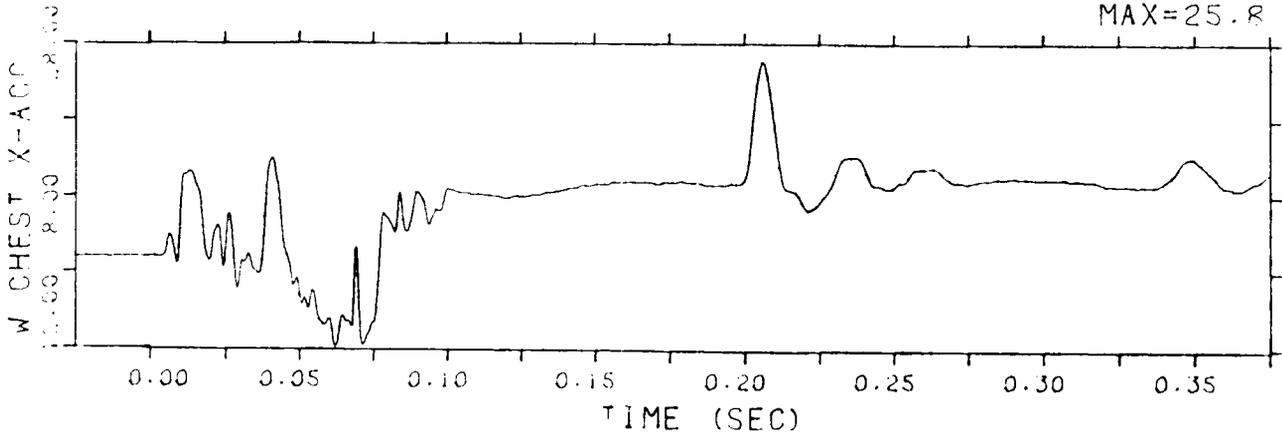
MAX=45.7



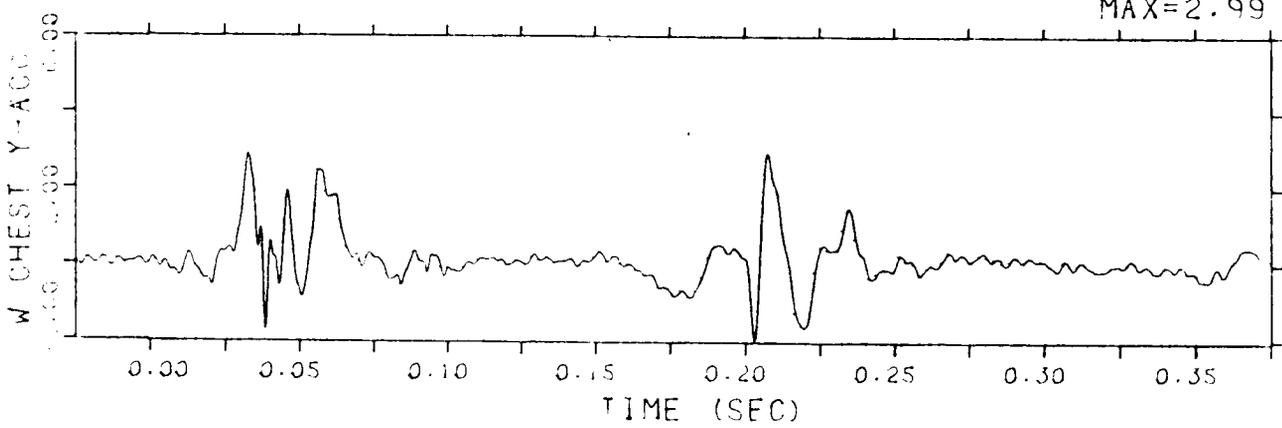
MAX=45.9



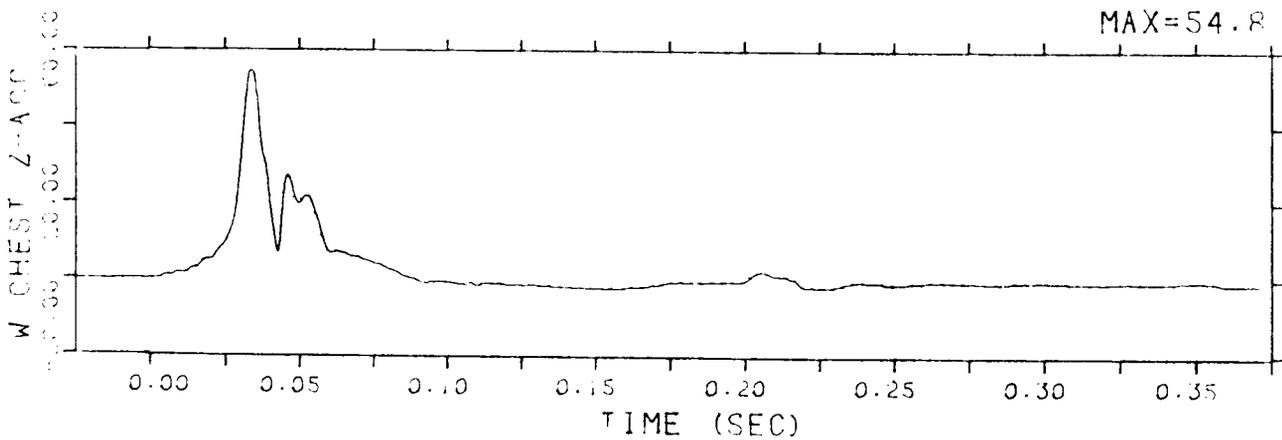
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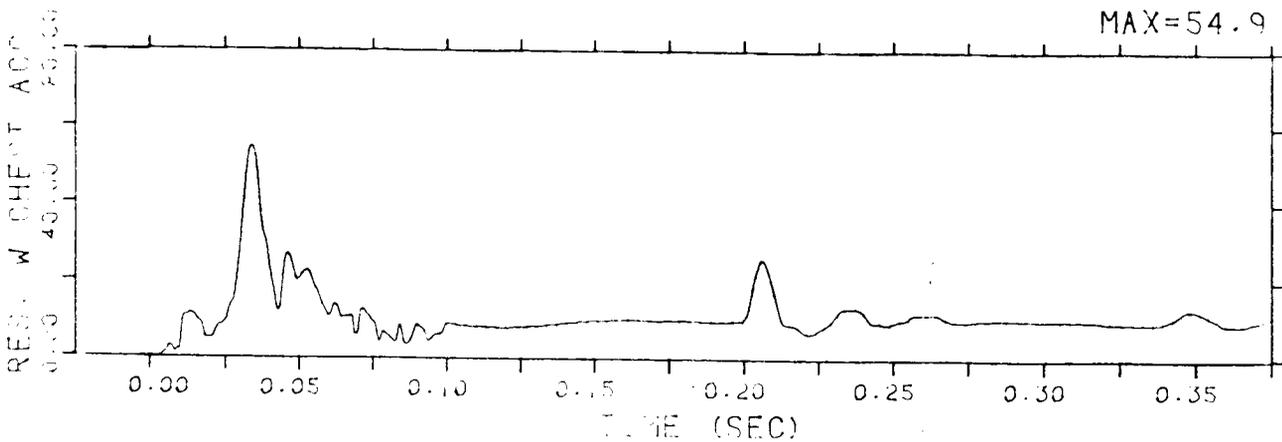
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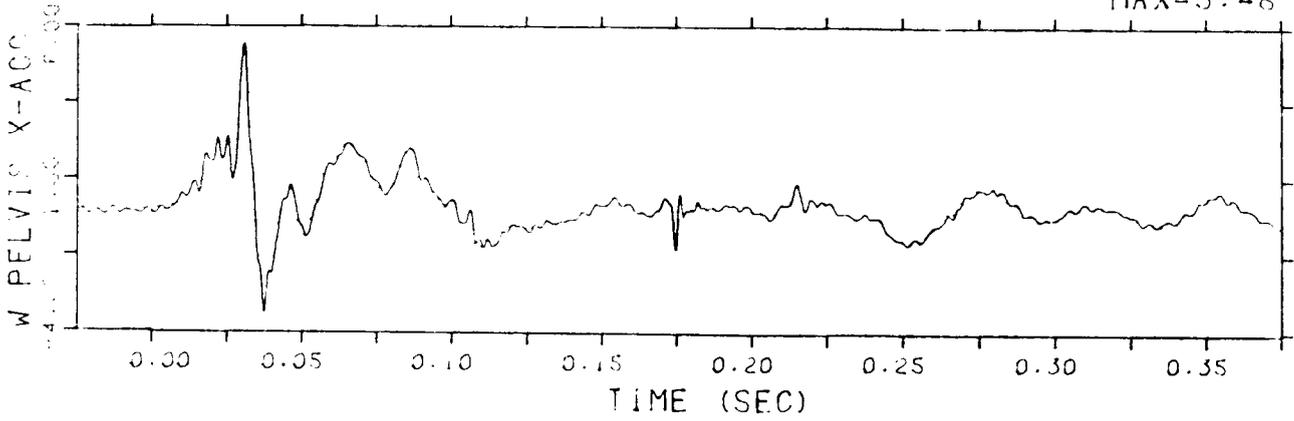
MAX=54.8



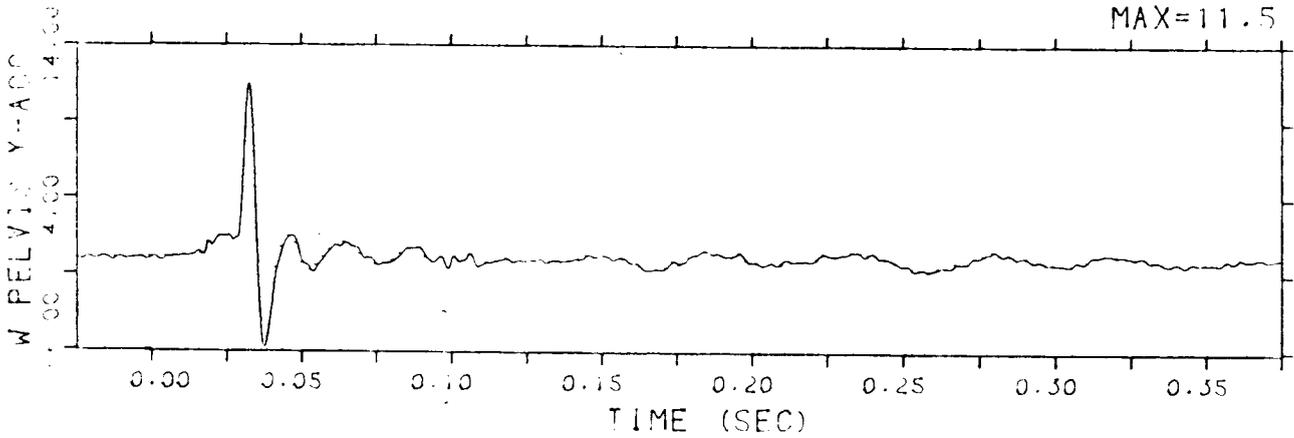
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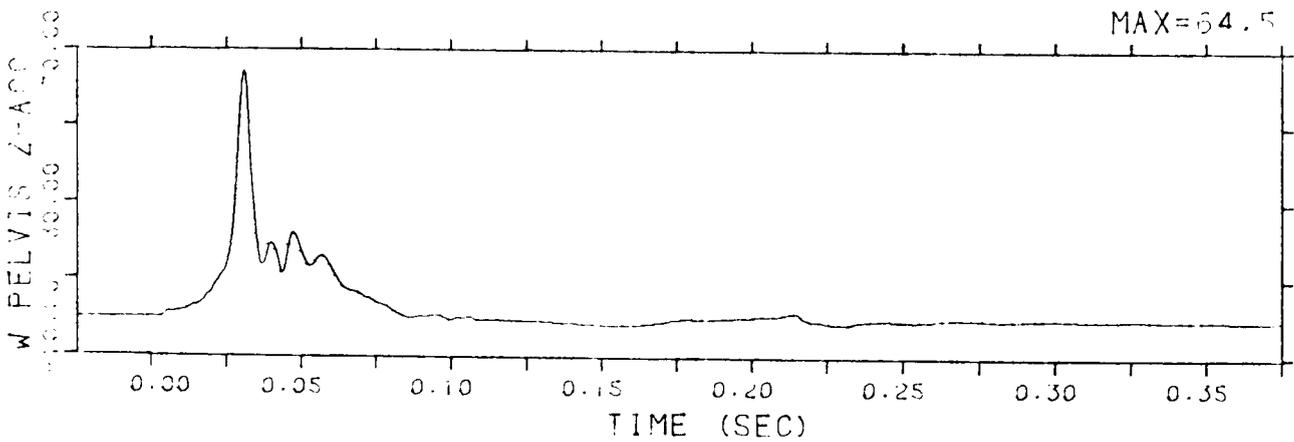
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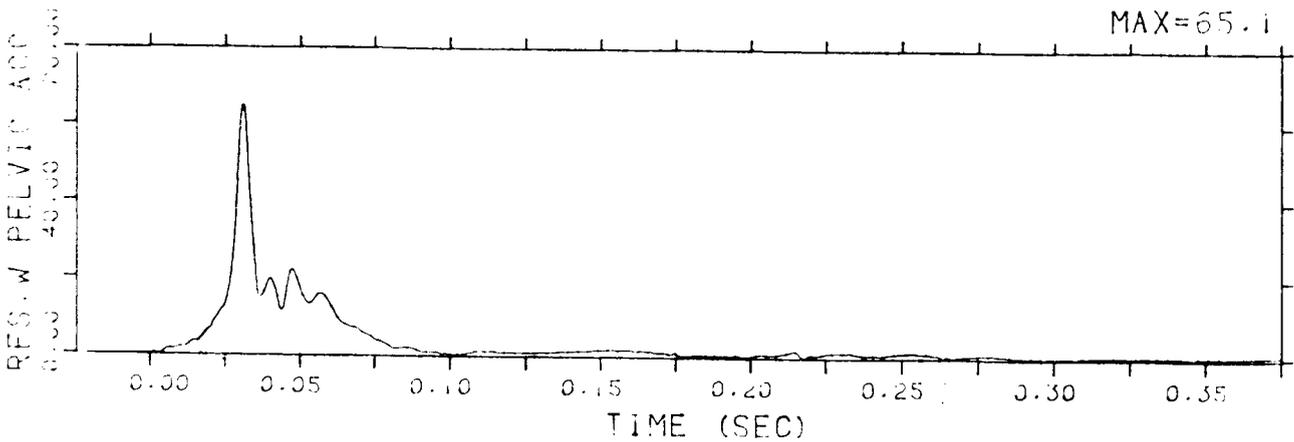
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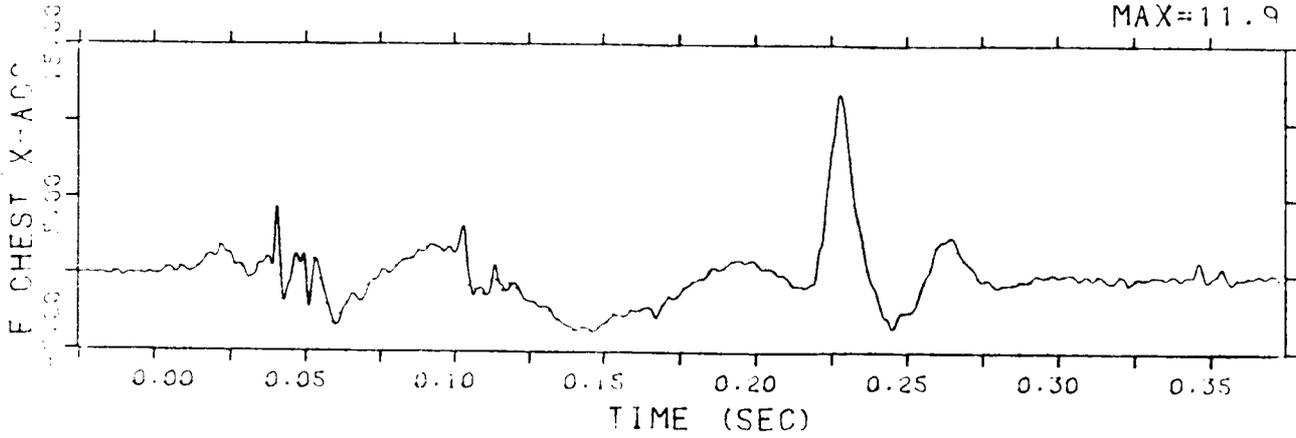
MAX=64.5



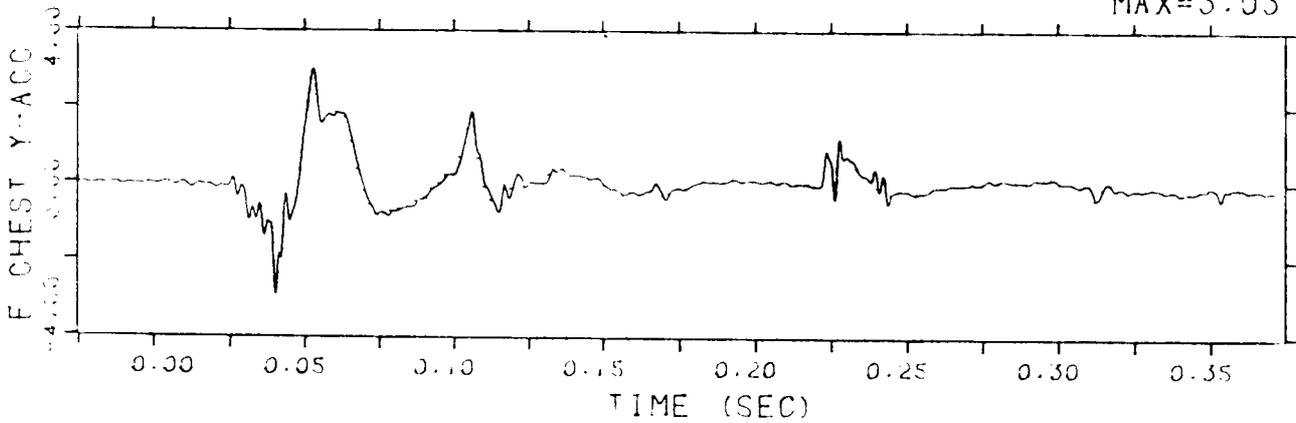
MAX=65.1



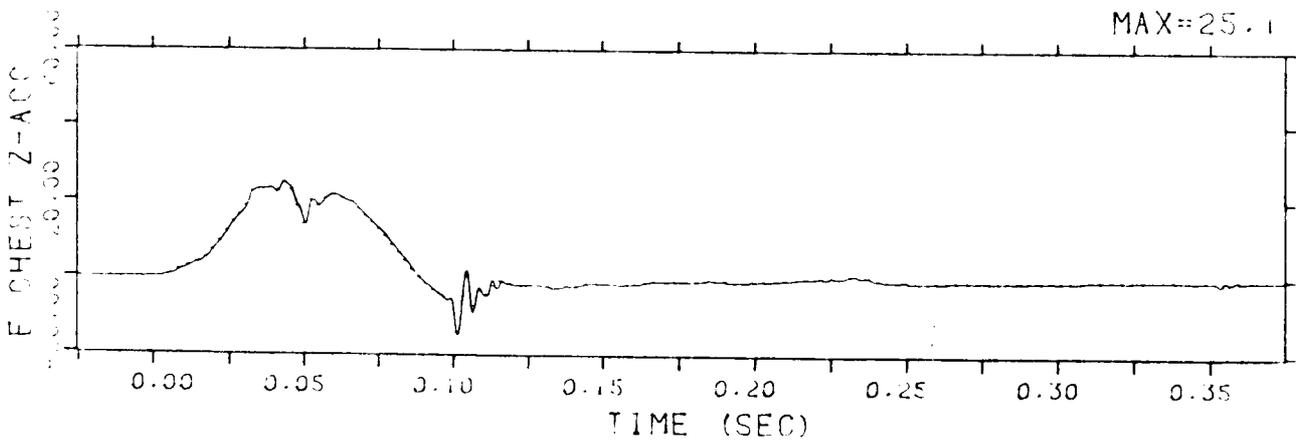
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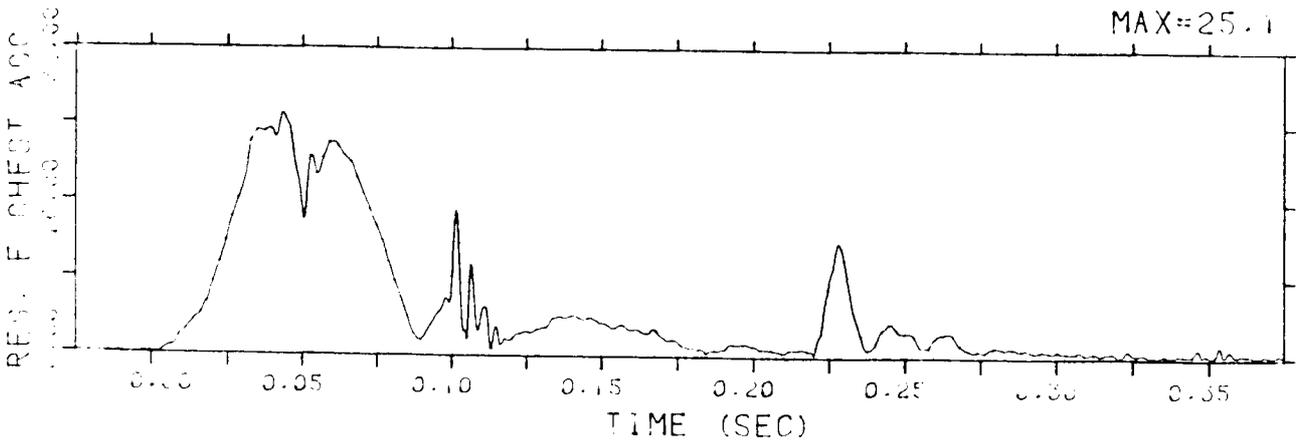
MAX=3.03



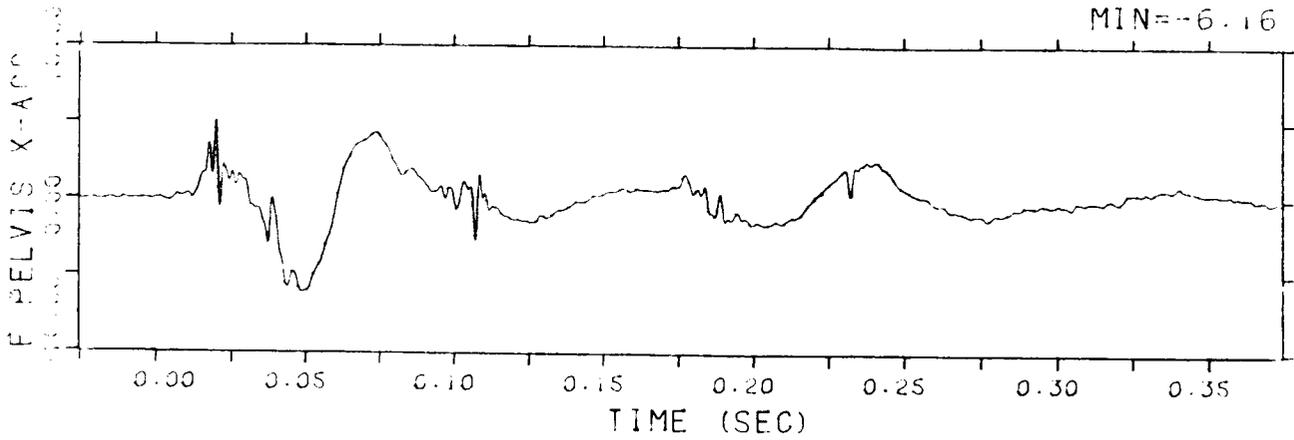
MAX=25.1



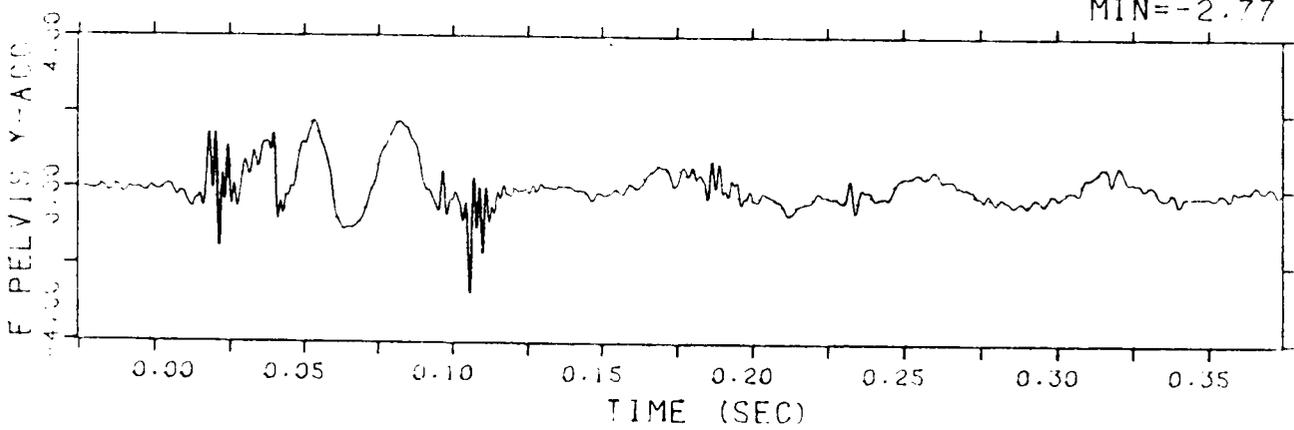
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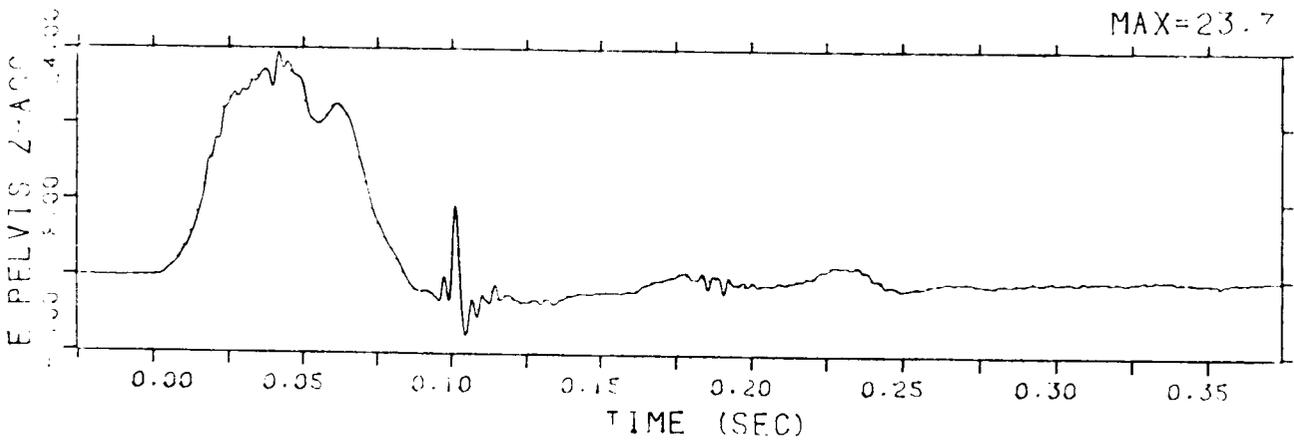
MIN=-6.16



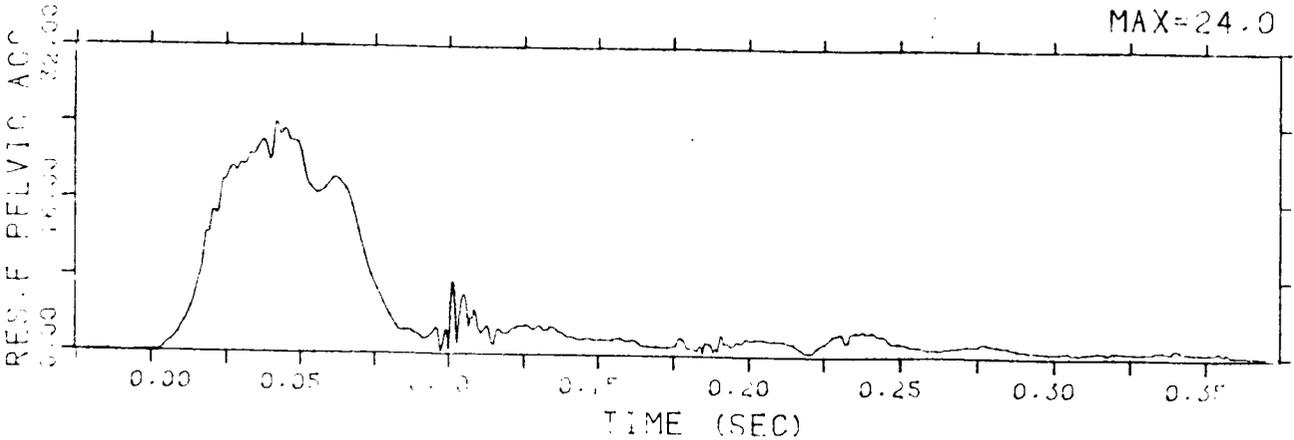
MIN=-2.77



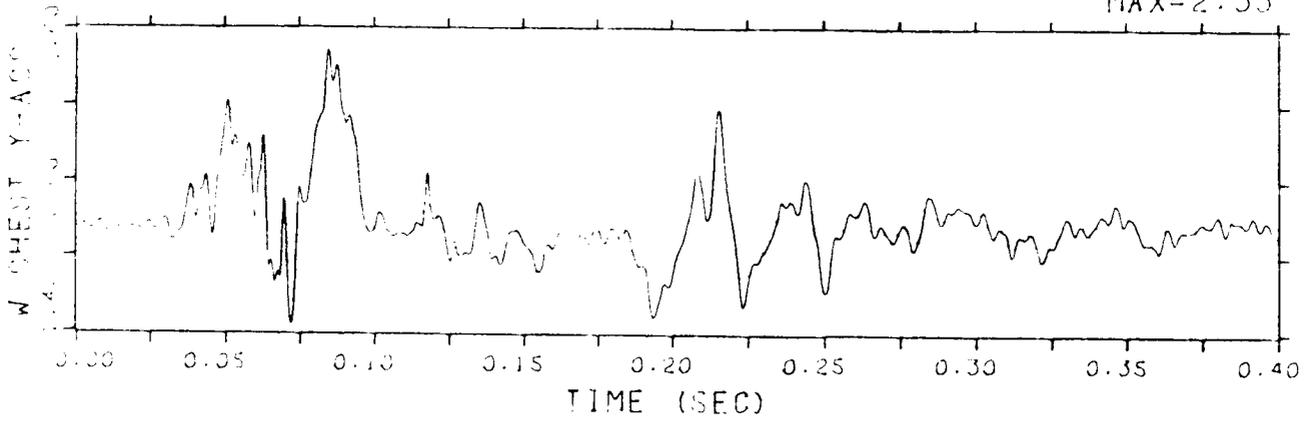
MAX=23.7



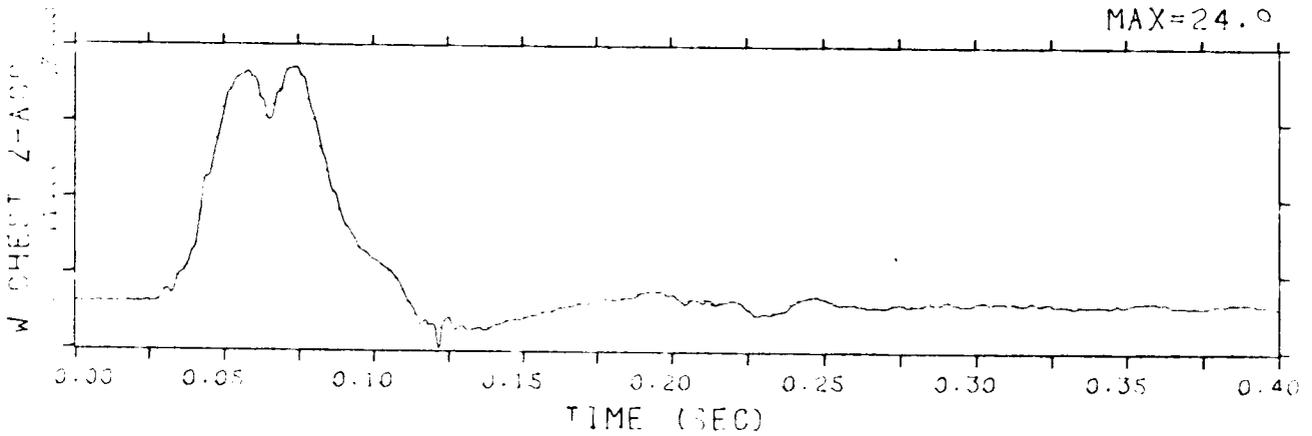
MAX=24.0



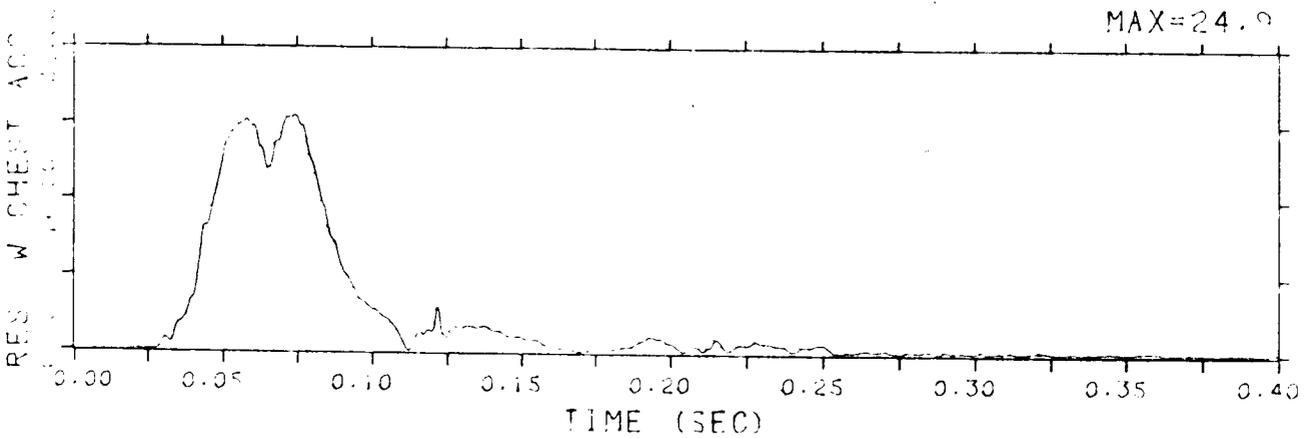
MAX=2.33



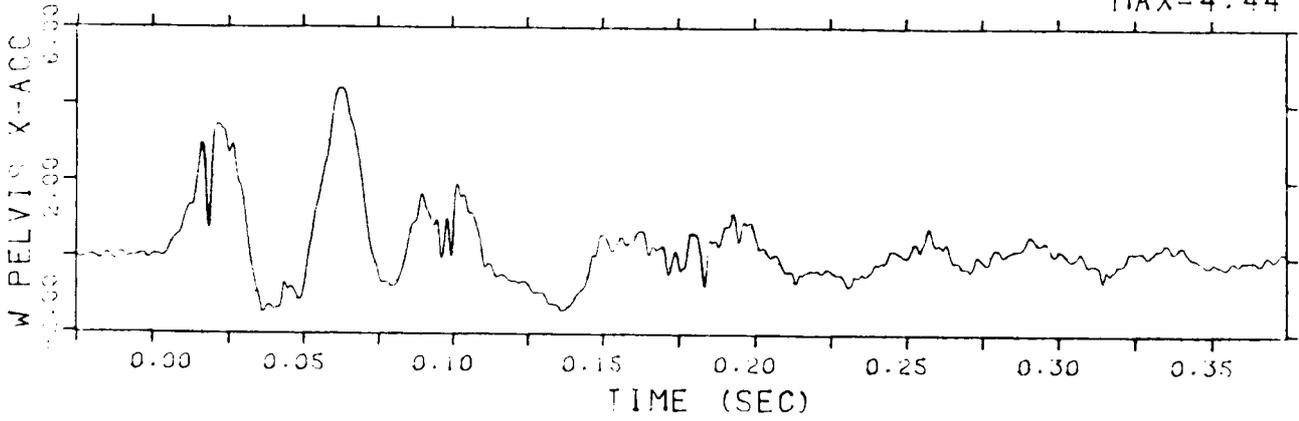
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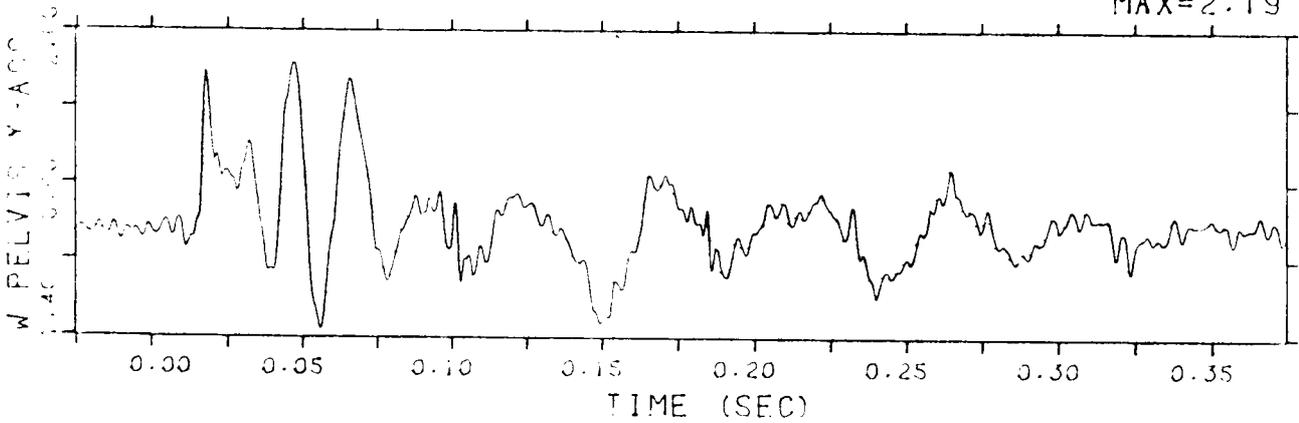
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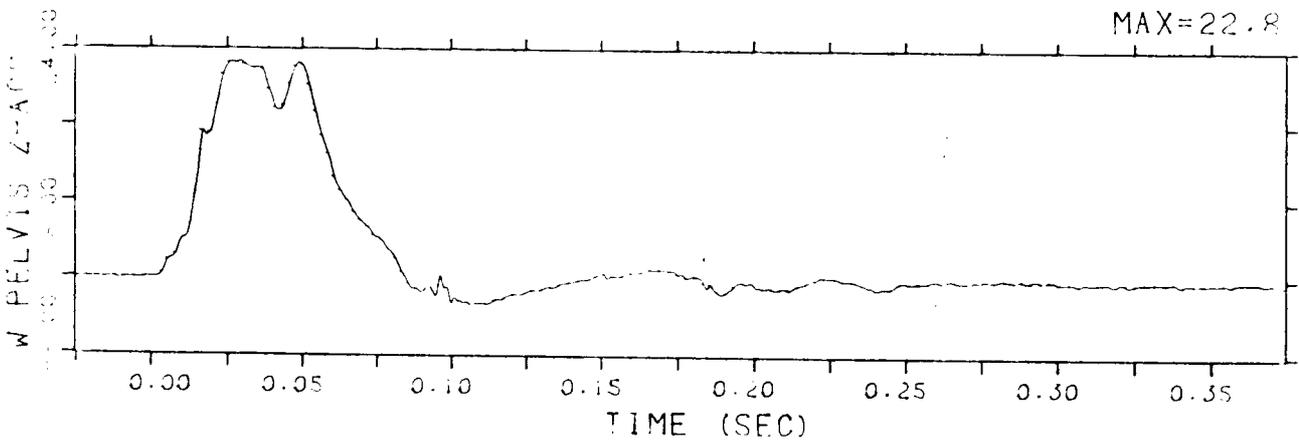
MAX=4.44



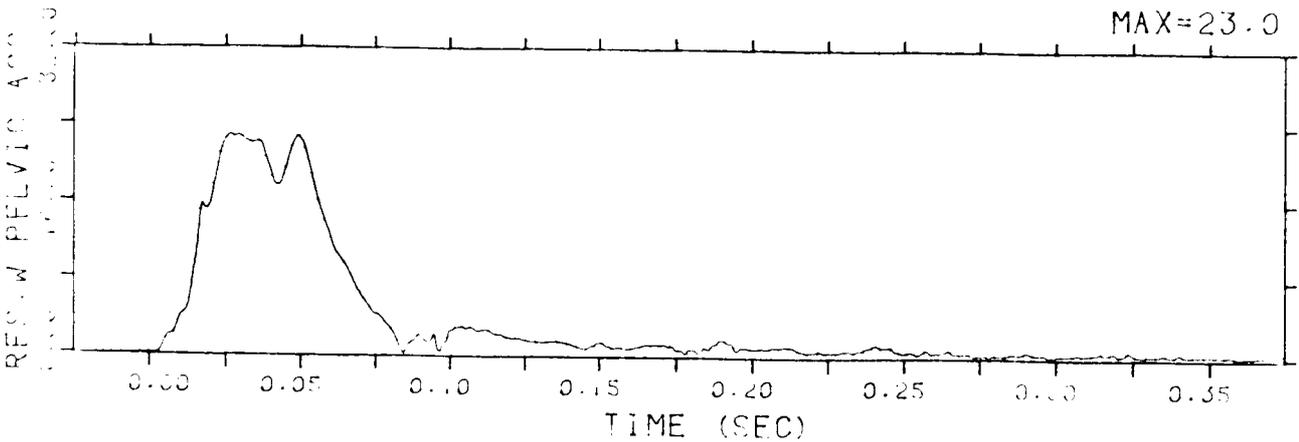
MAX=2.19



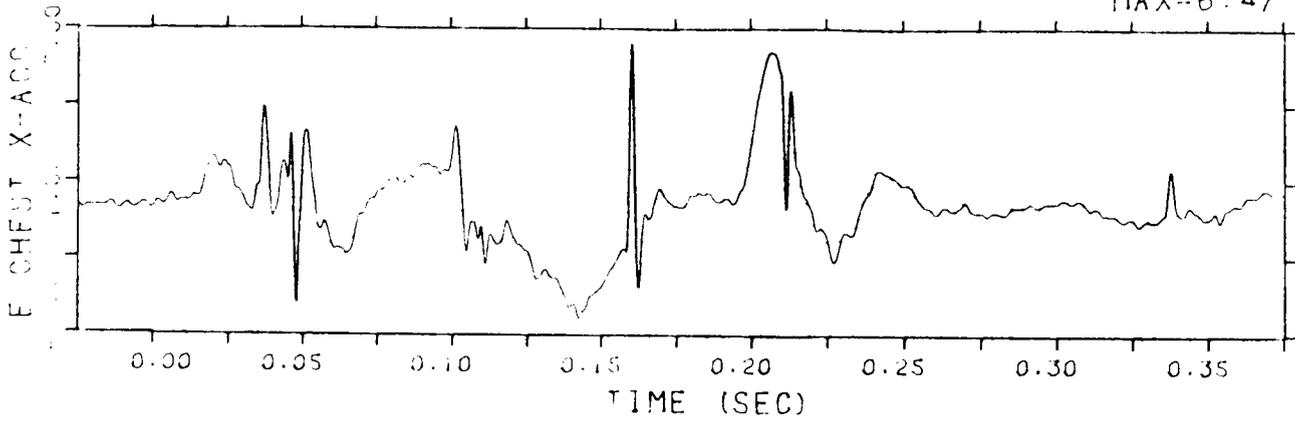
MAX=22.8



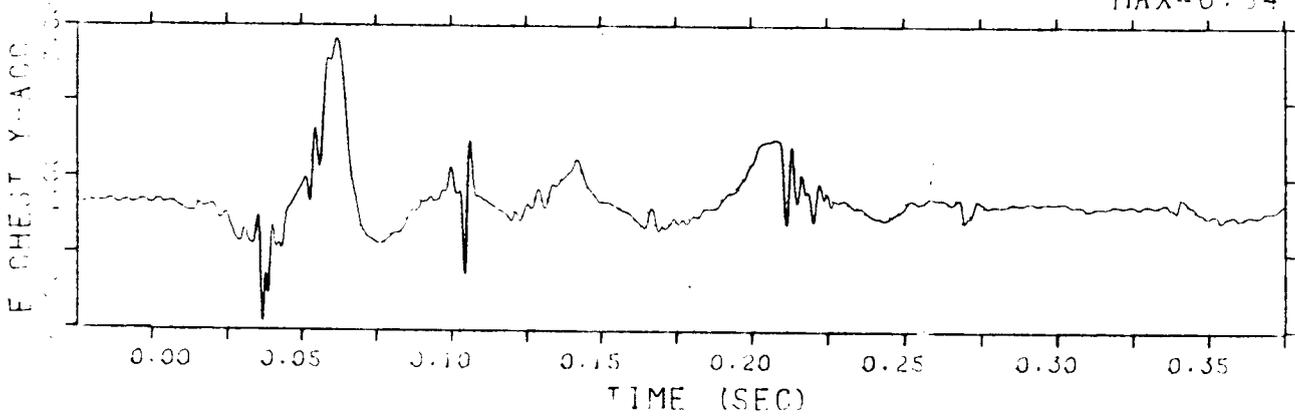
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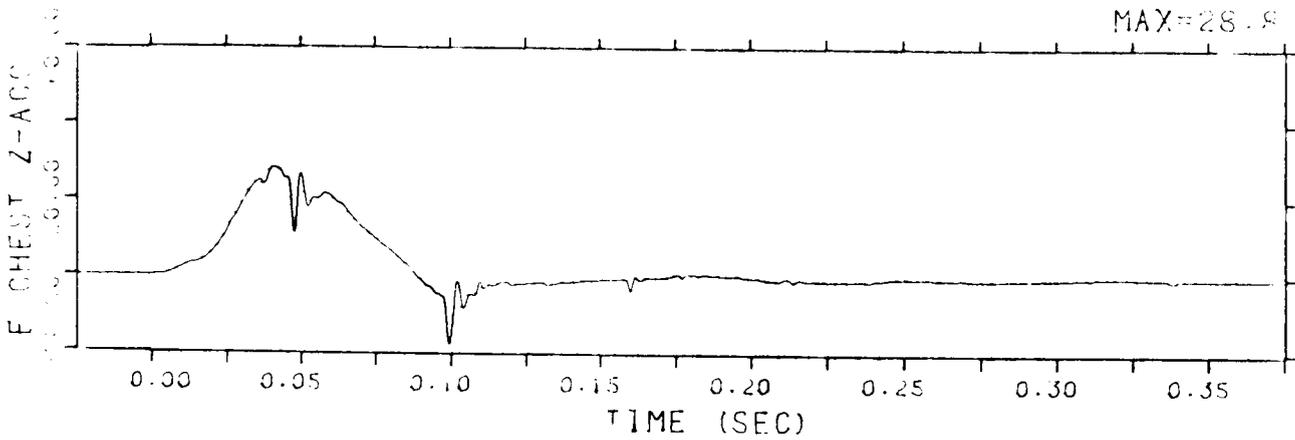
MAX=6.47



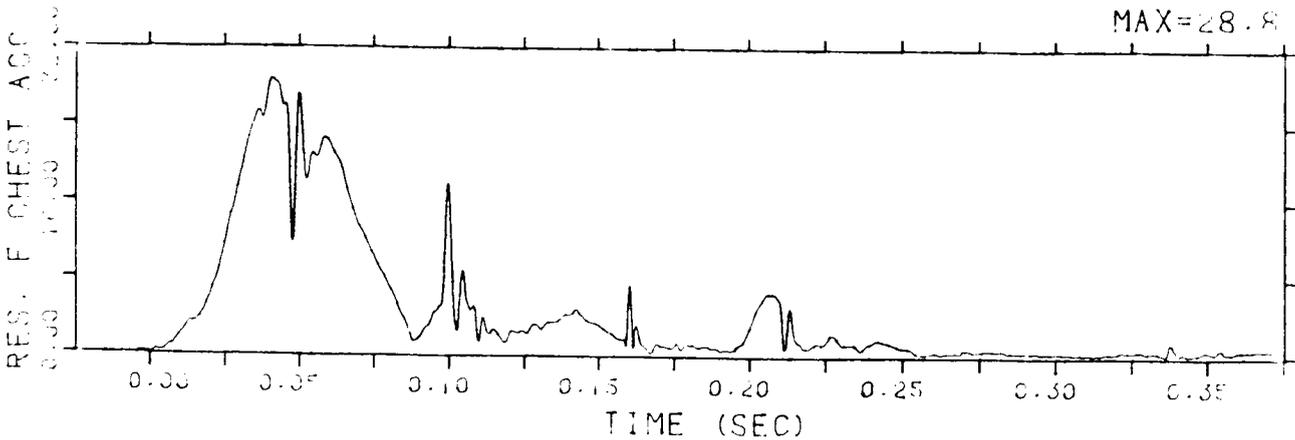
MAX=6.54



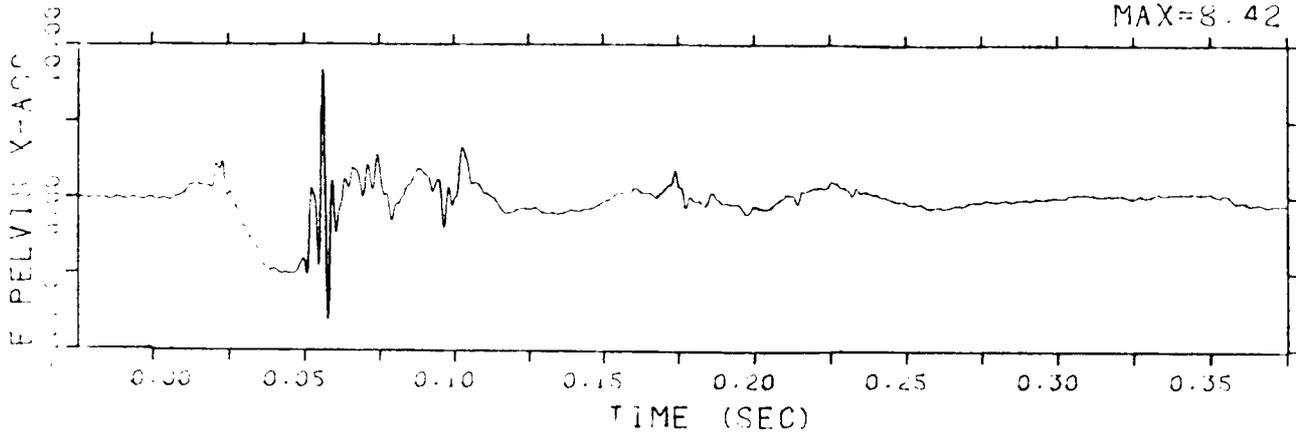
MAX=28.8



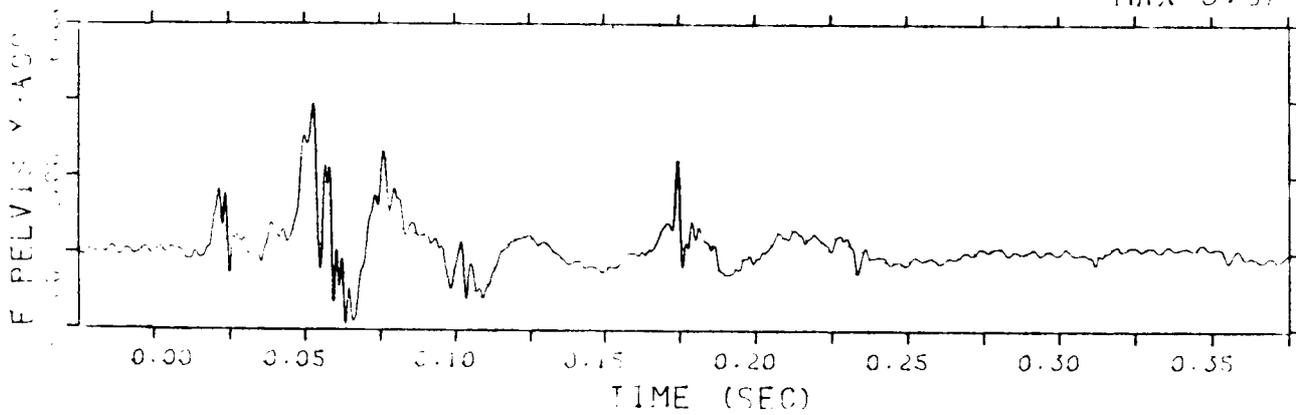
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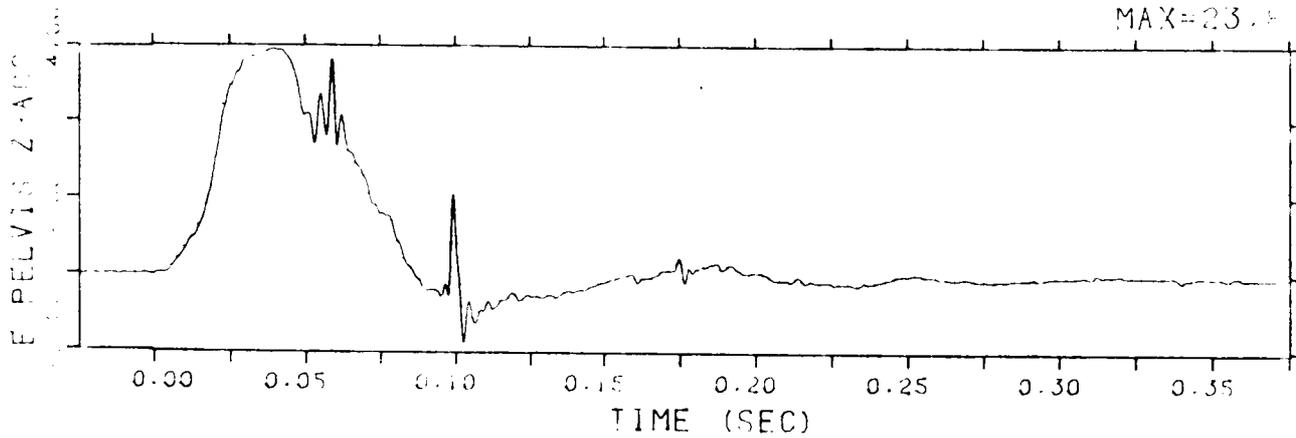
MAX=8.42



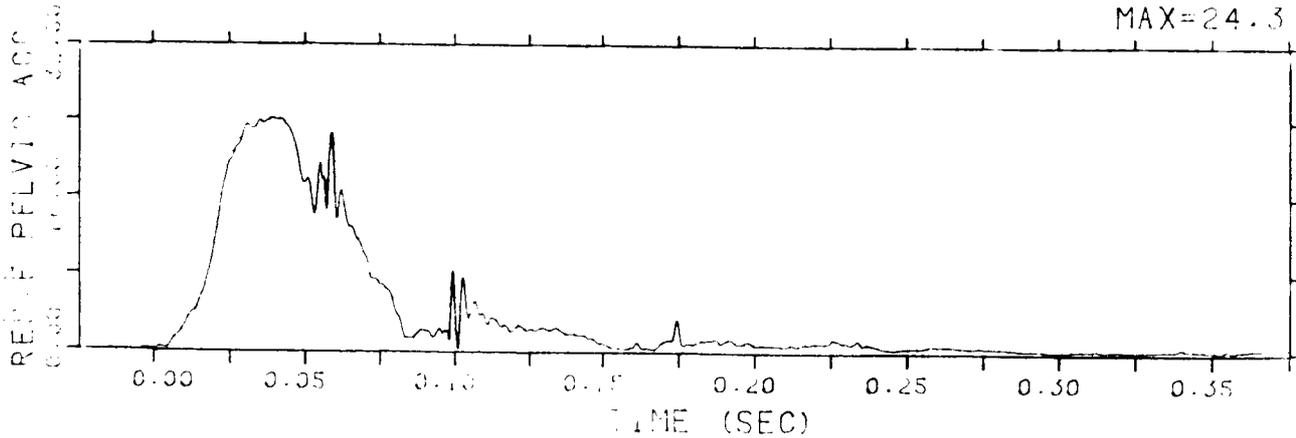
MAX=3.97



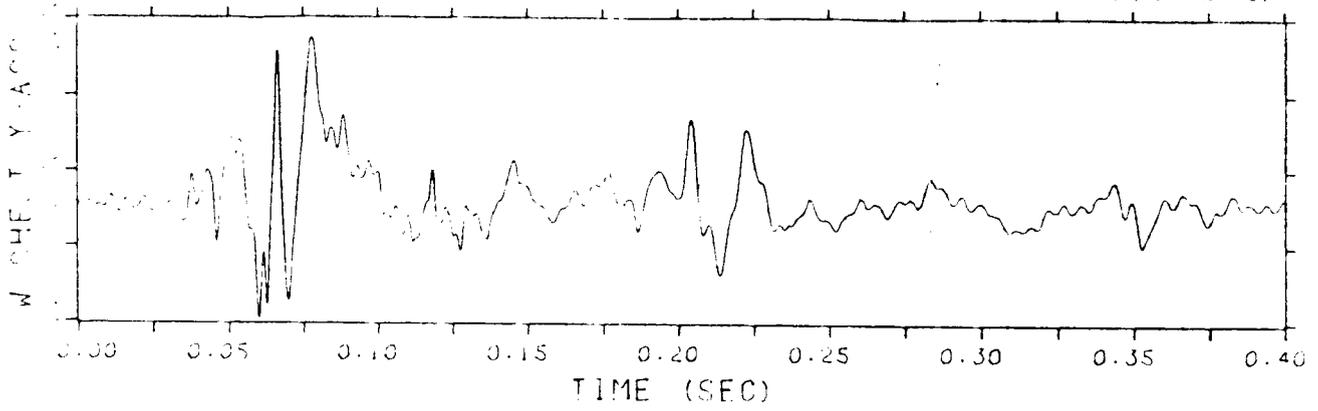
MAX=23.4



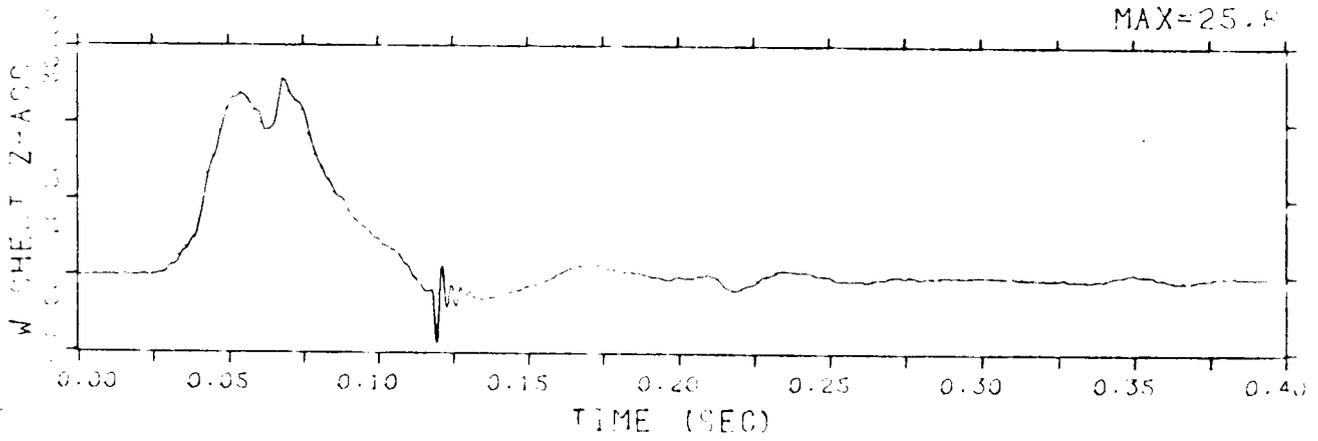
MAX=24.3



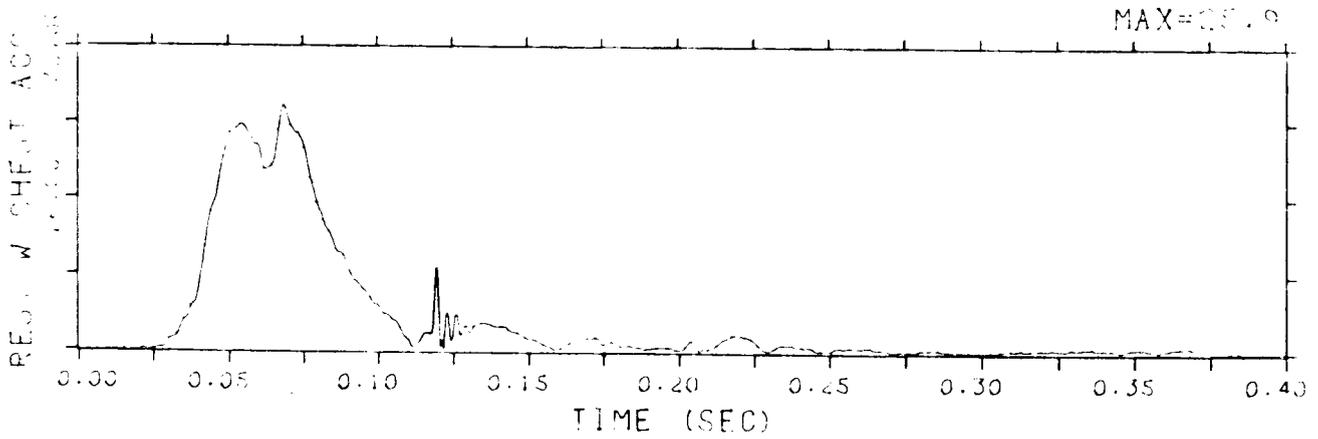
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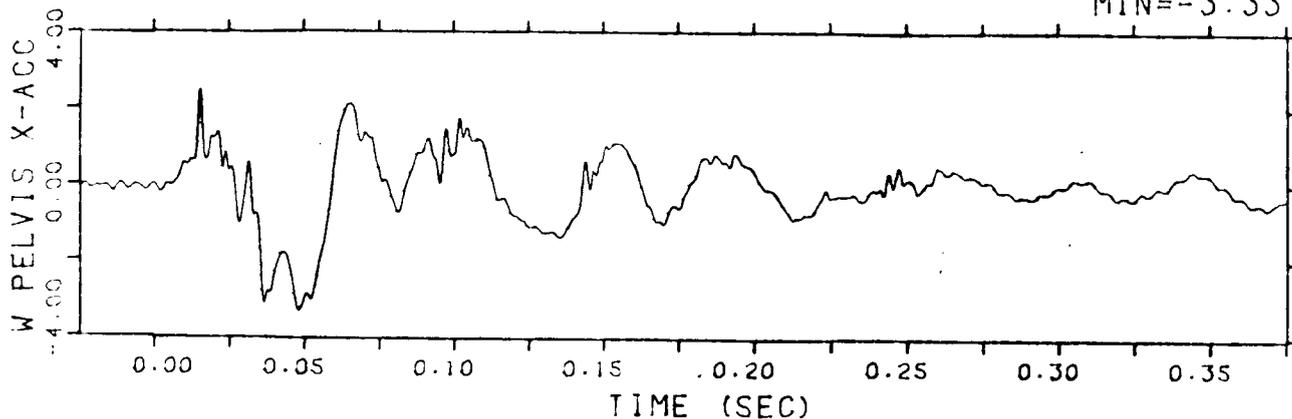
MAX=25.8



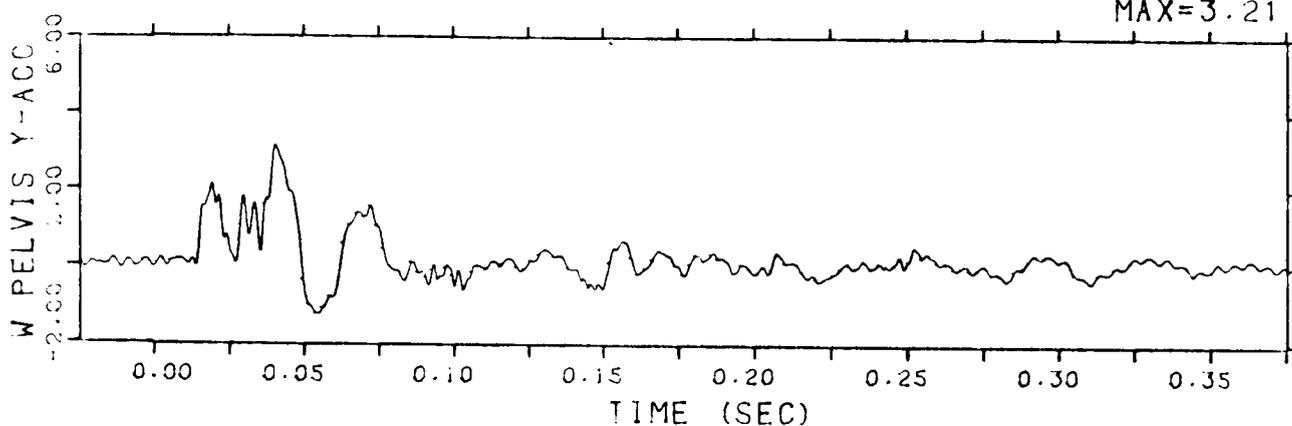
MAX=25.9



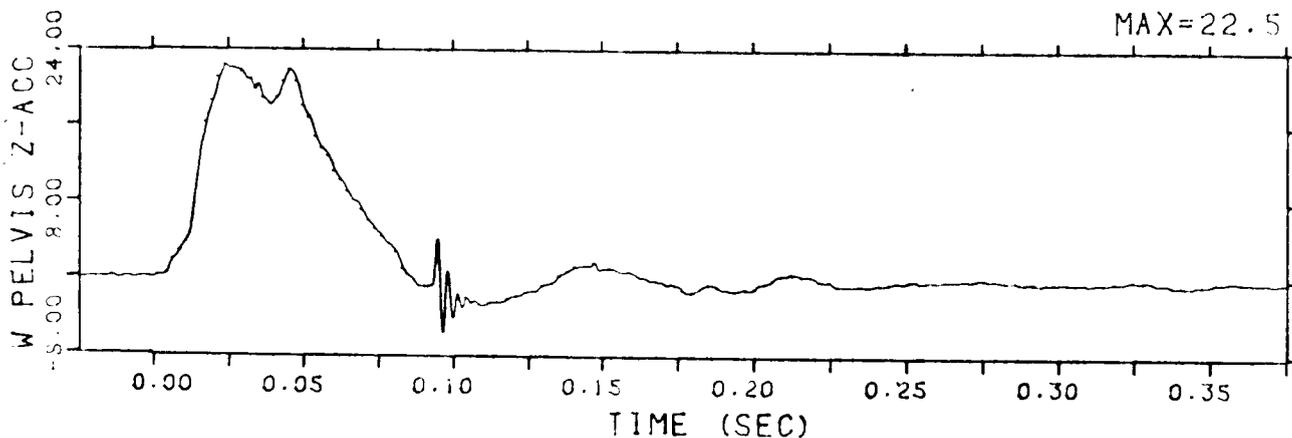
MIN=-3.33



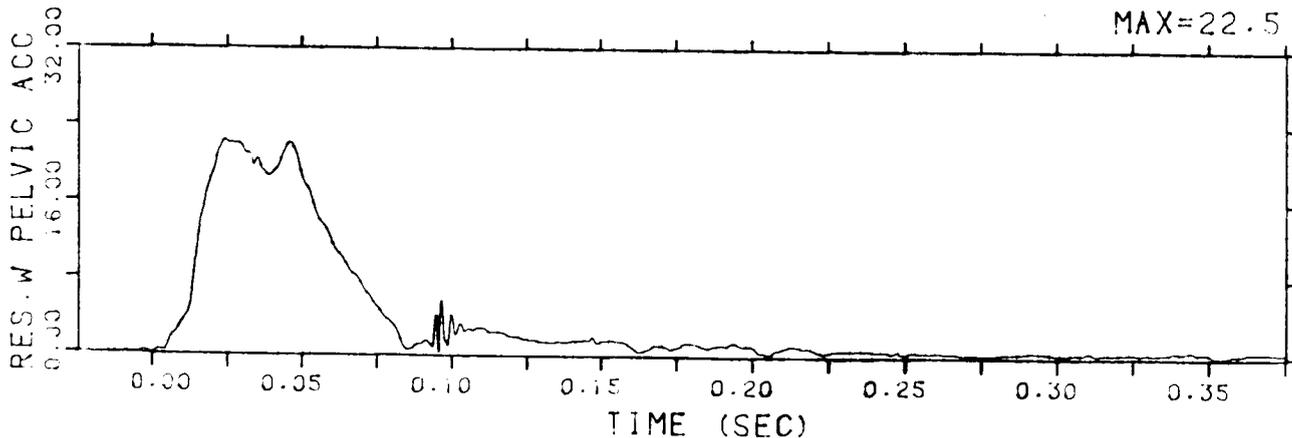
MAX=3.21

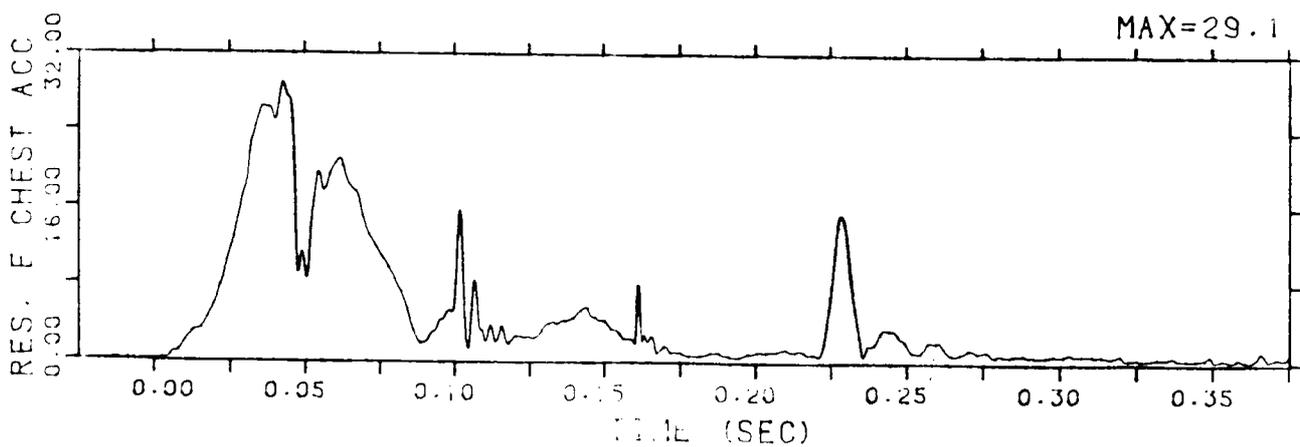
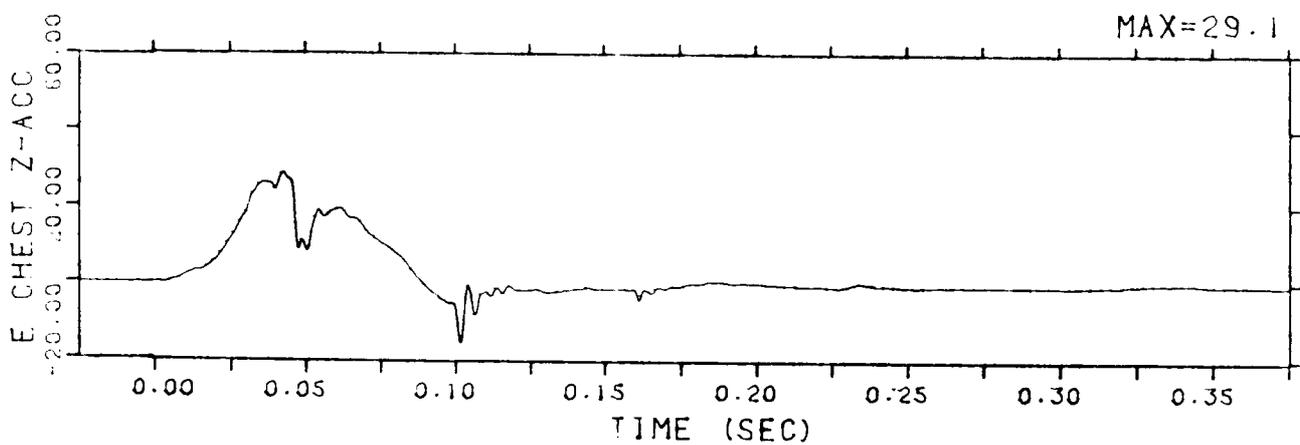
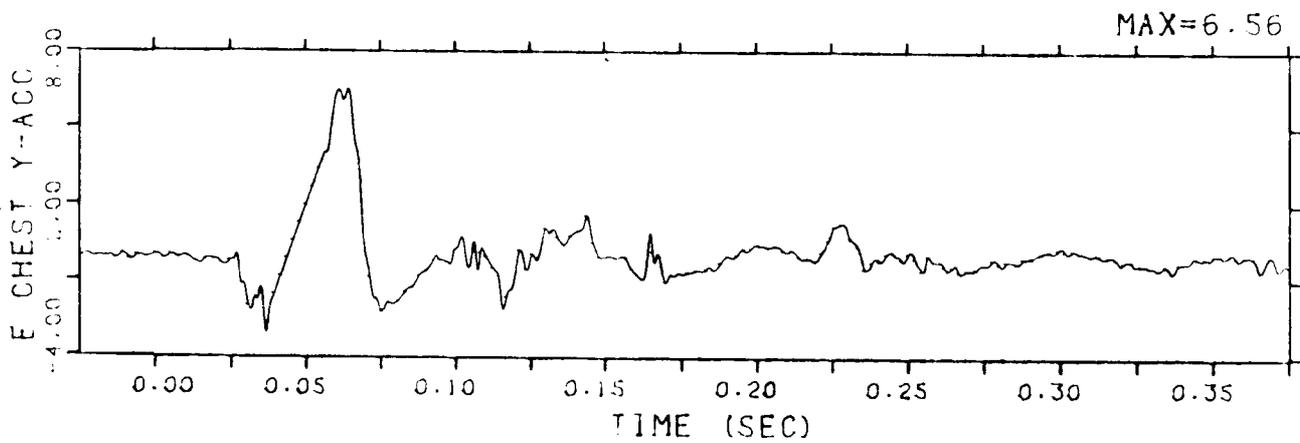
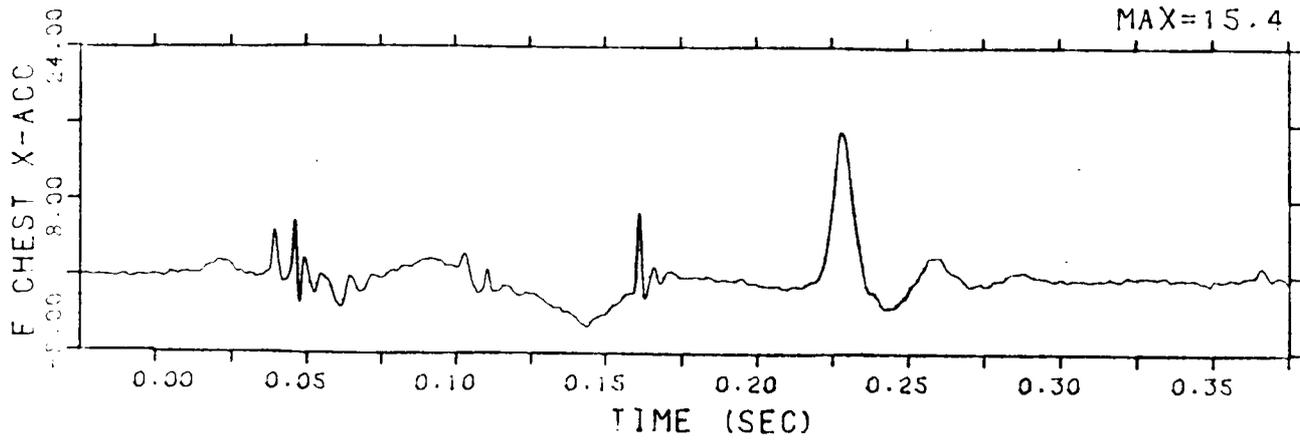


MAX=22.5

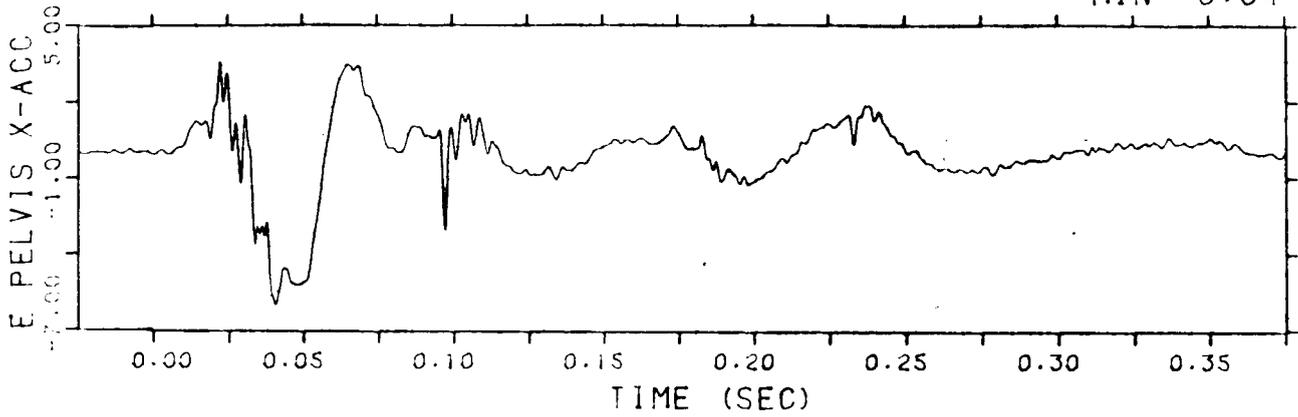


MAX=22.5

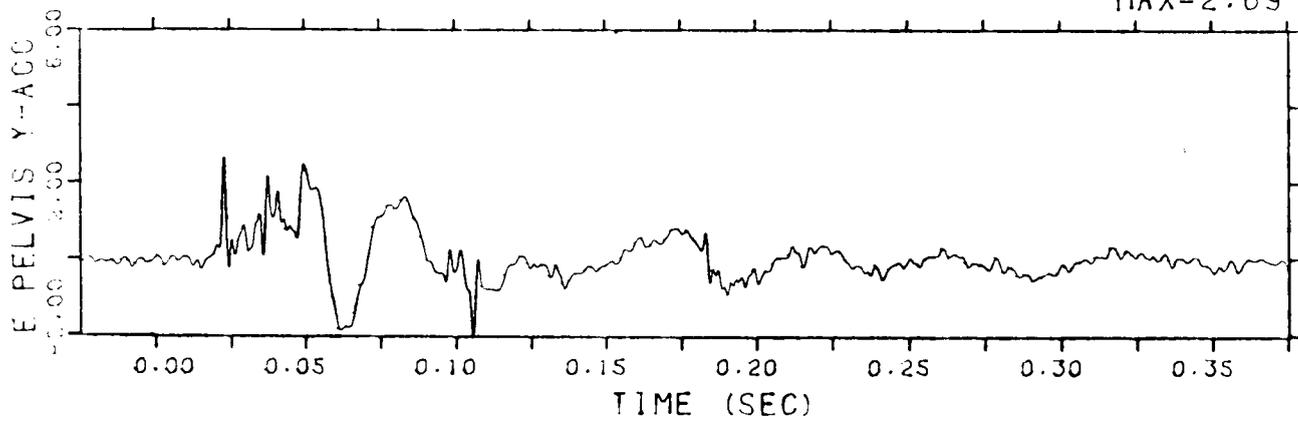




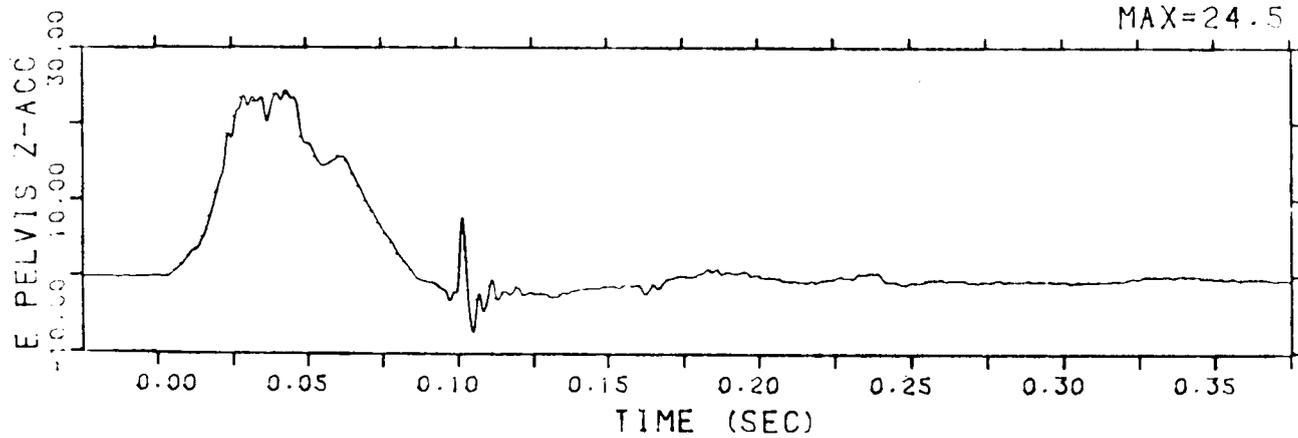
MIN=-6.04



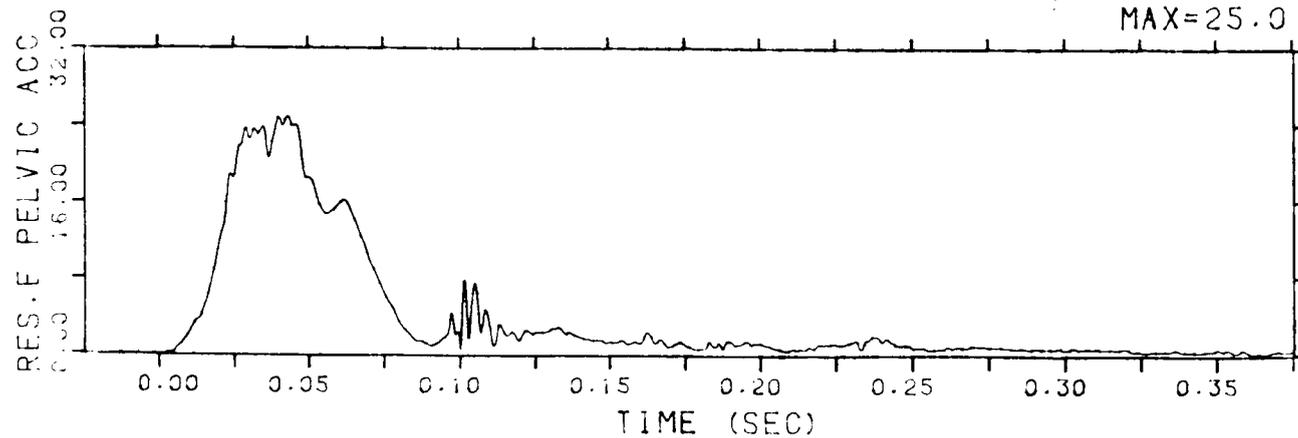
MAX=2.69



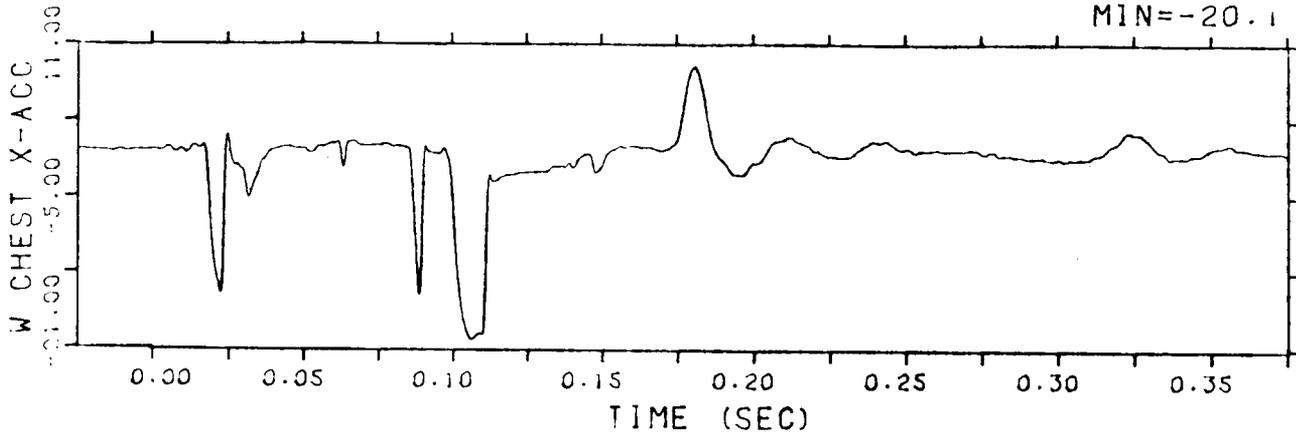
MAX=24.5



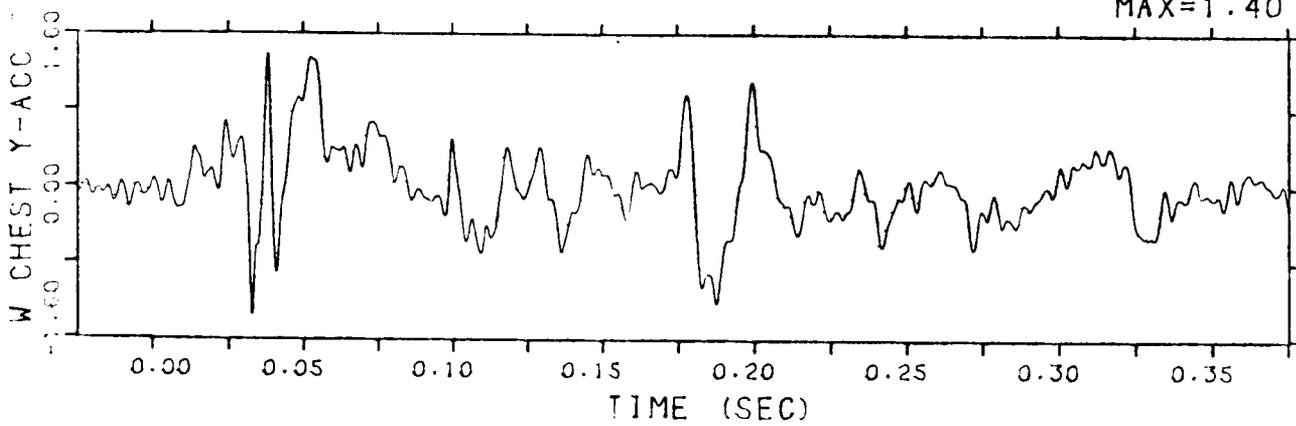
MAX=25.0



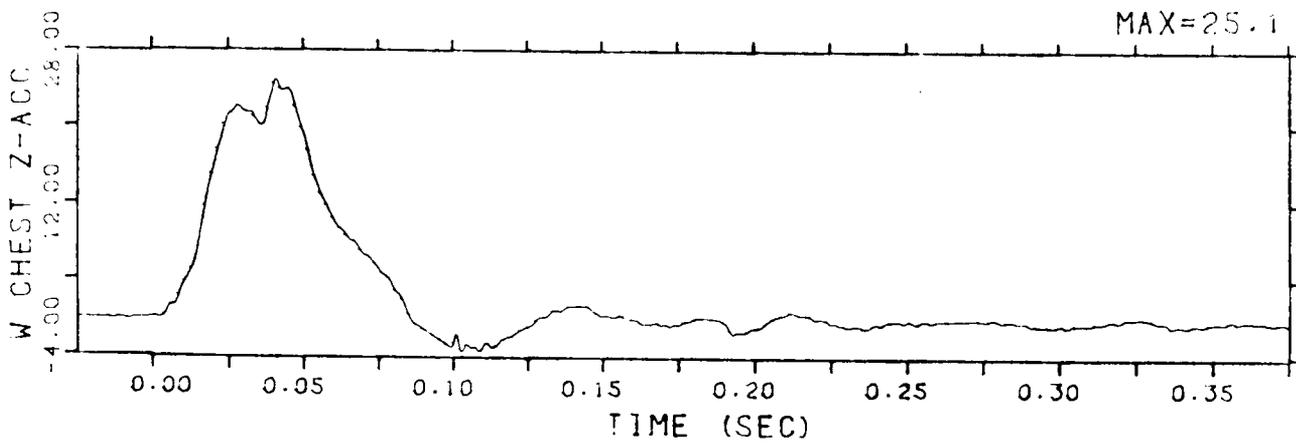
MIN=-20.1



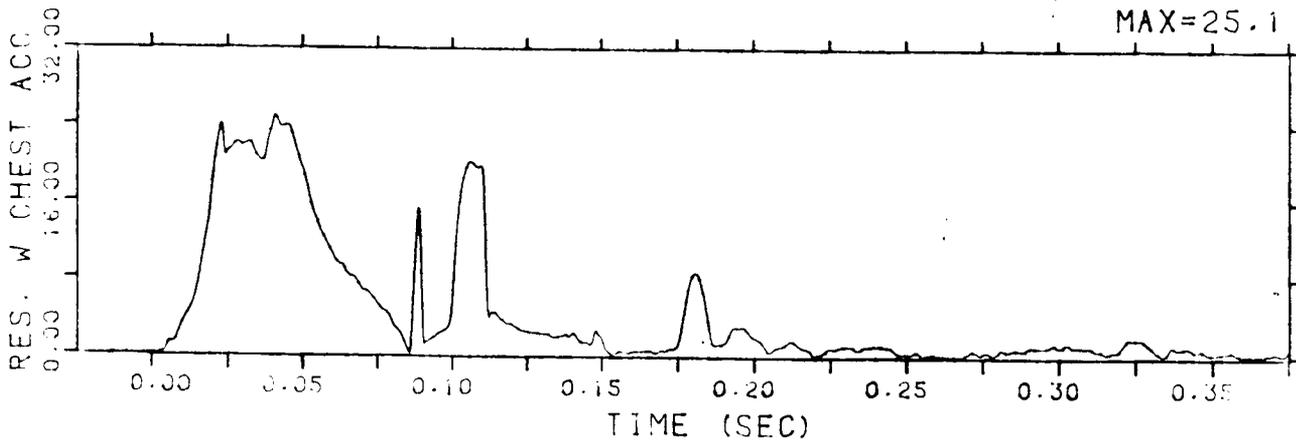
MAX=1.40



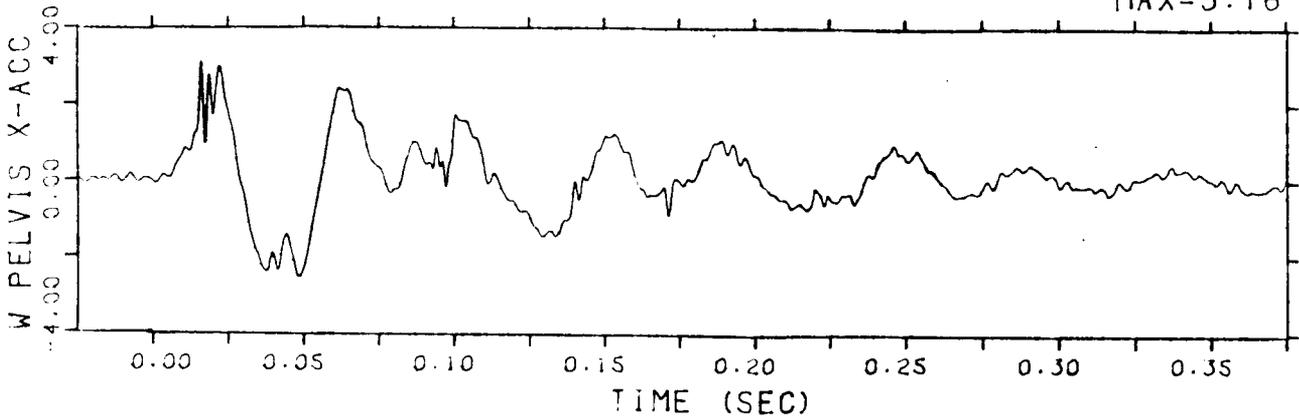
MAX=25.1



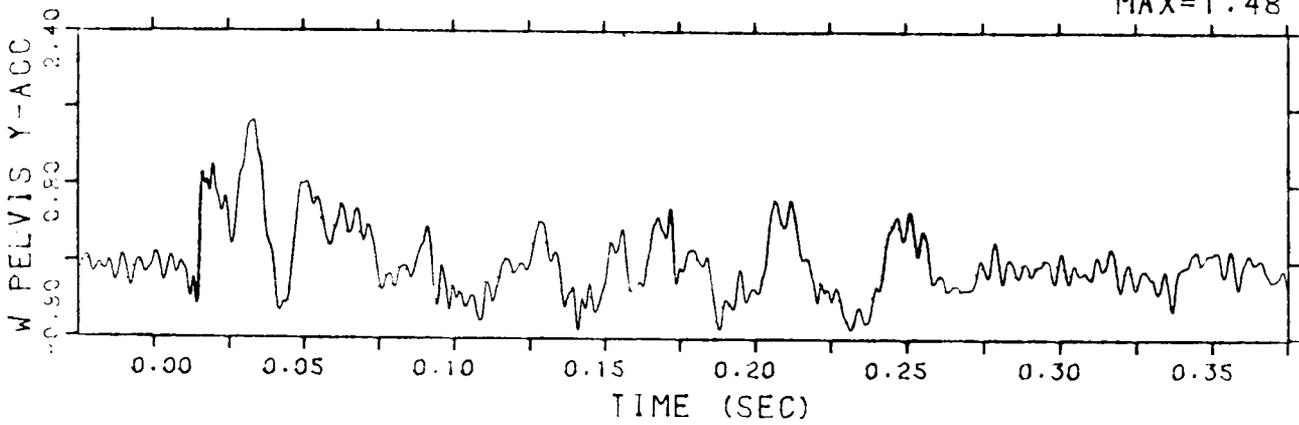
MAX=25.1



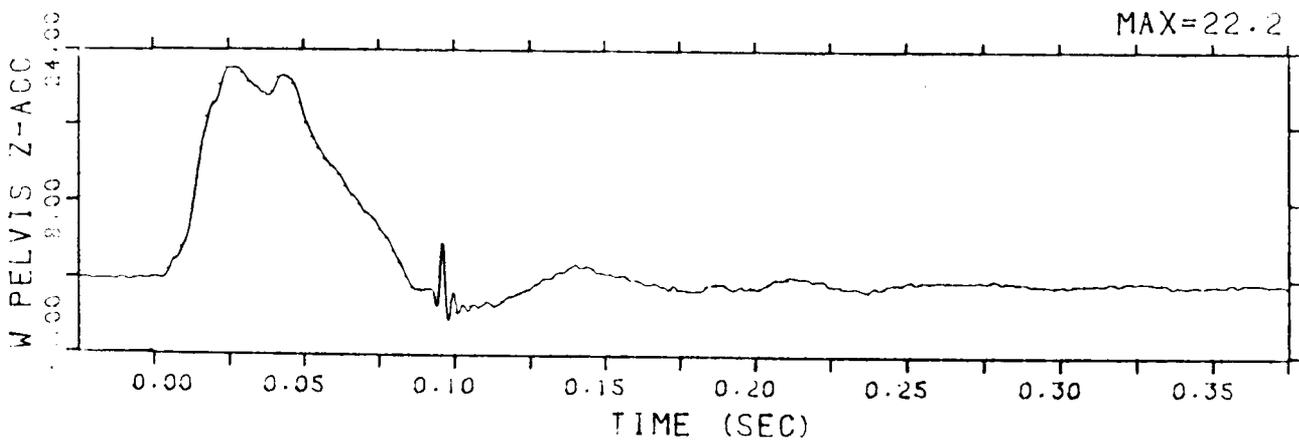
MAX=3.16



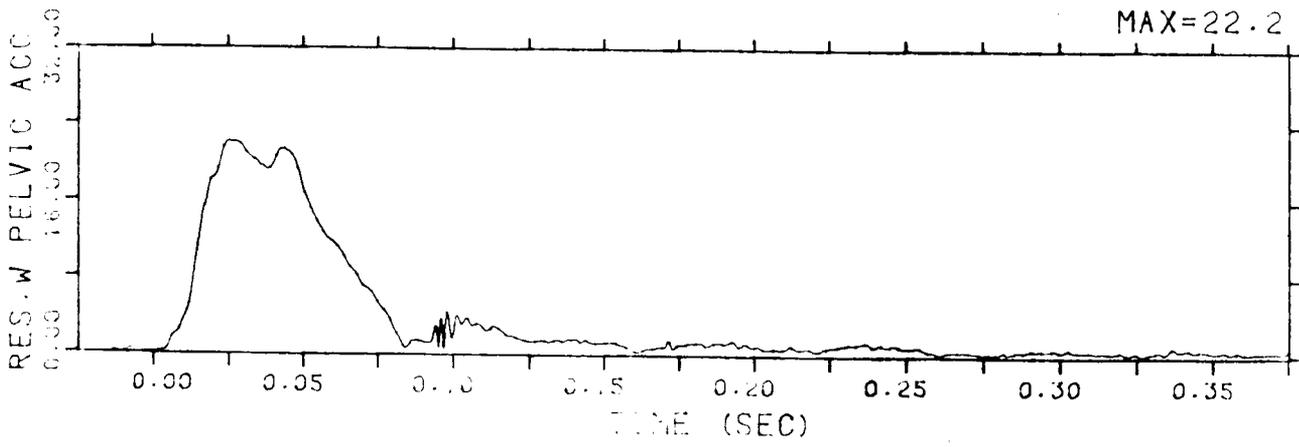
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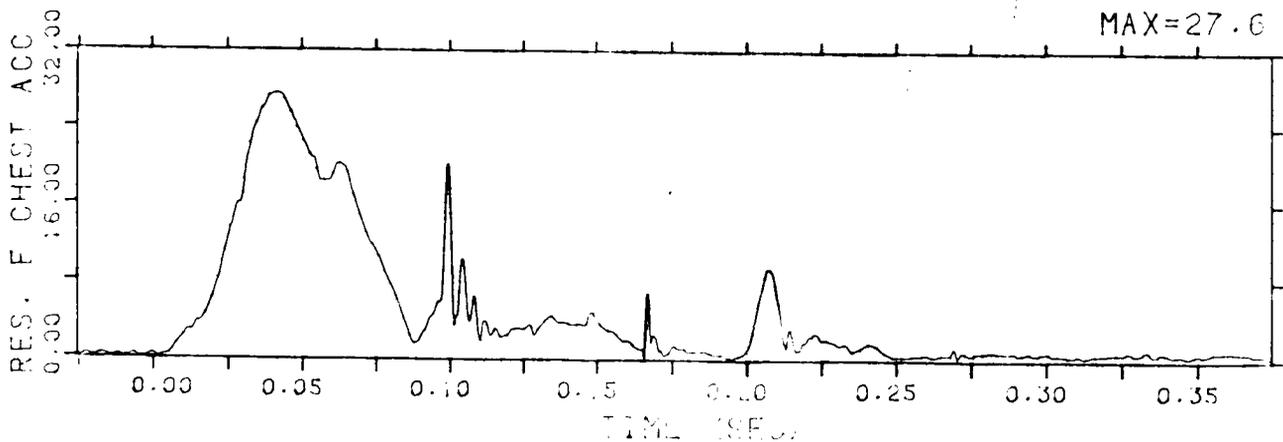
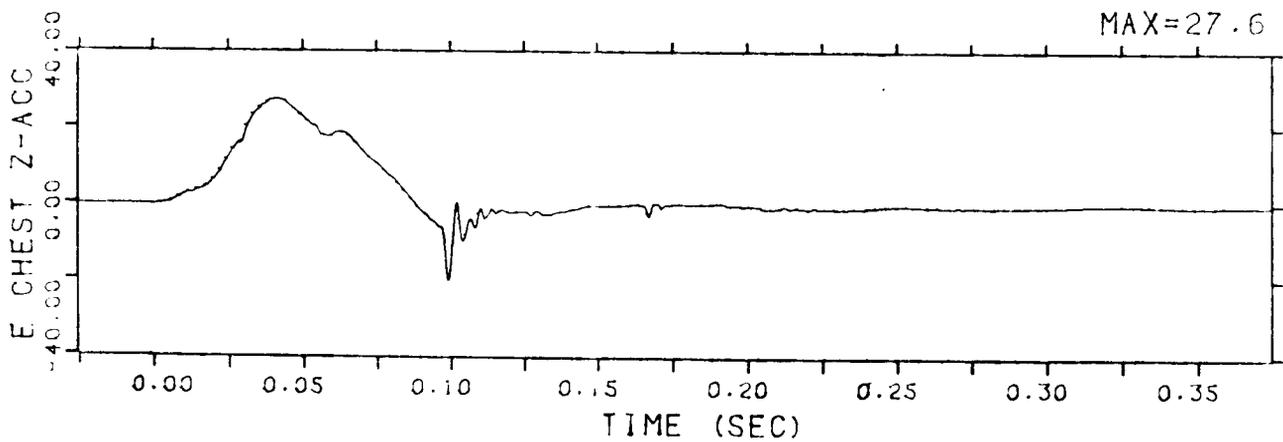
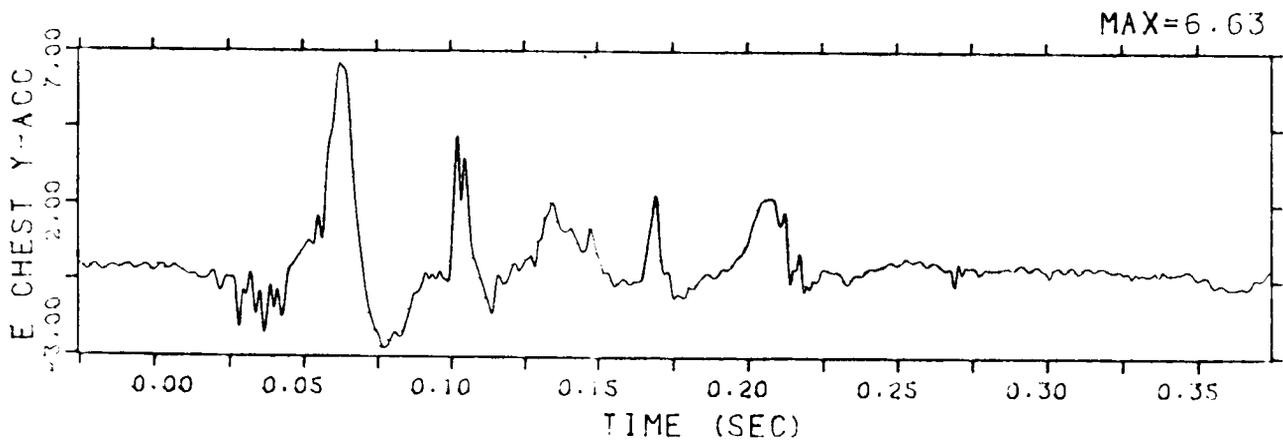
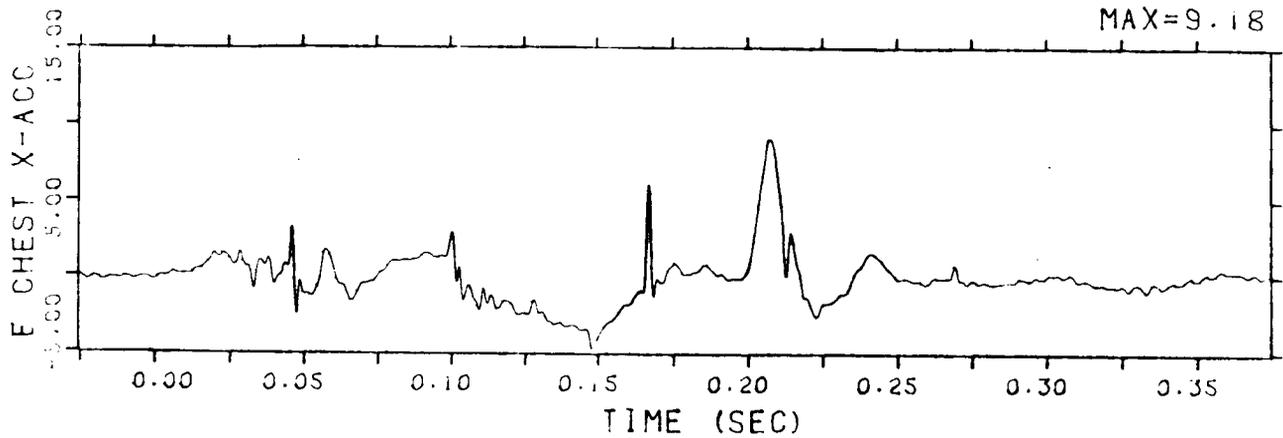


MAX=22.2

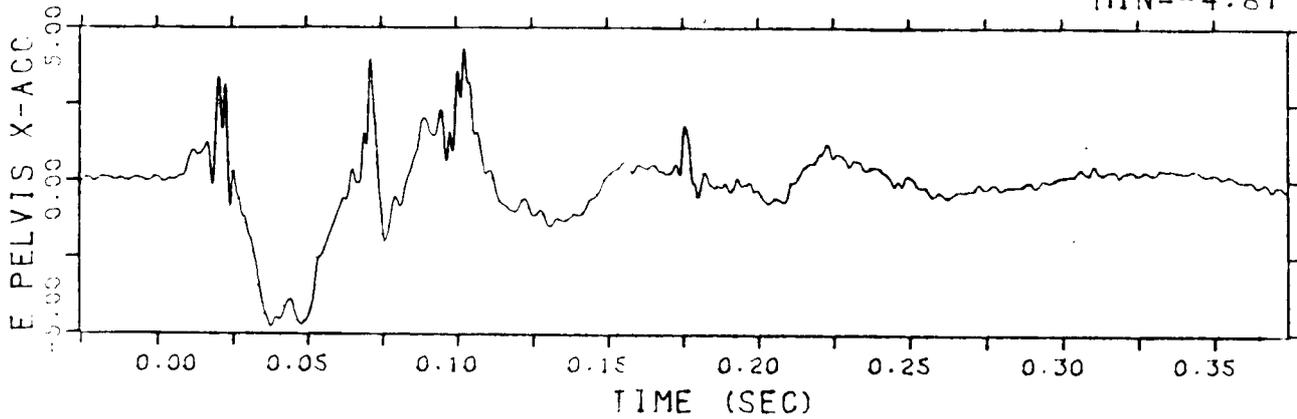


MAX=22.2

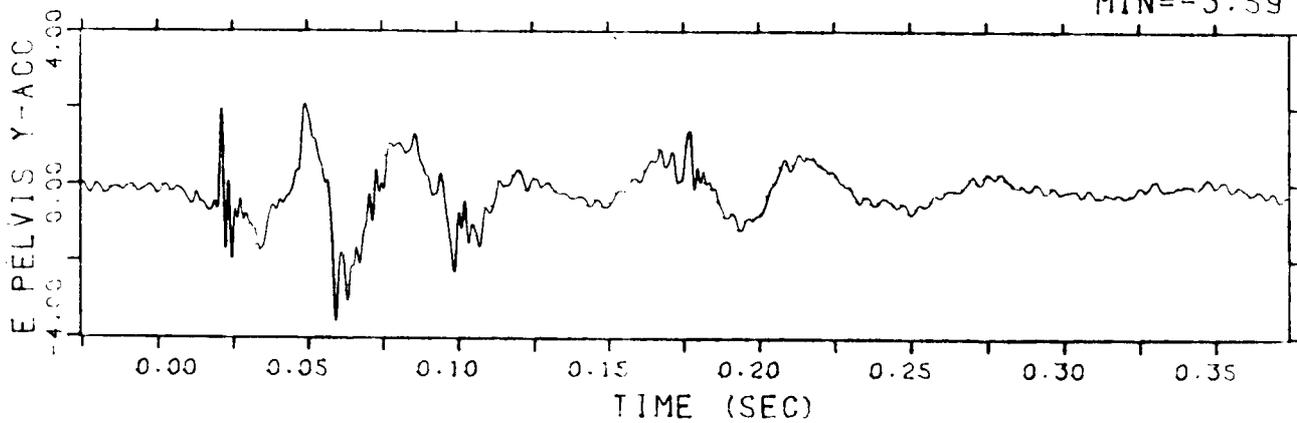




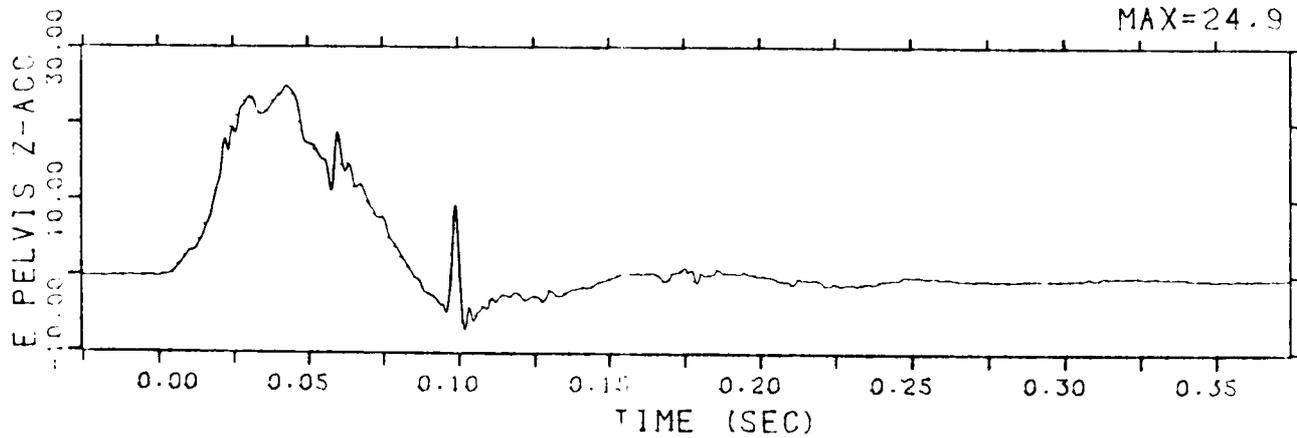
MIN=-4.81



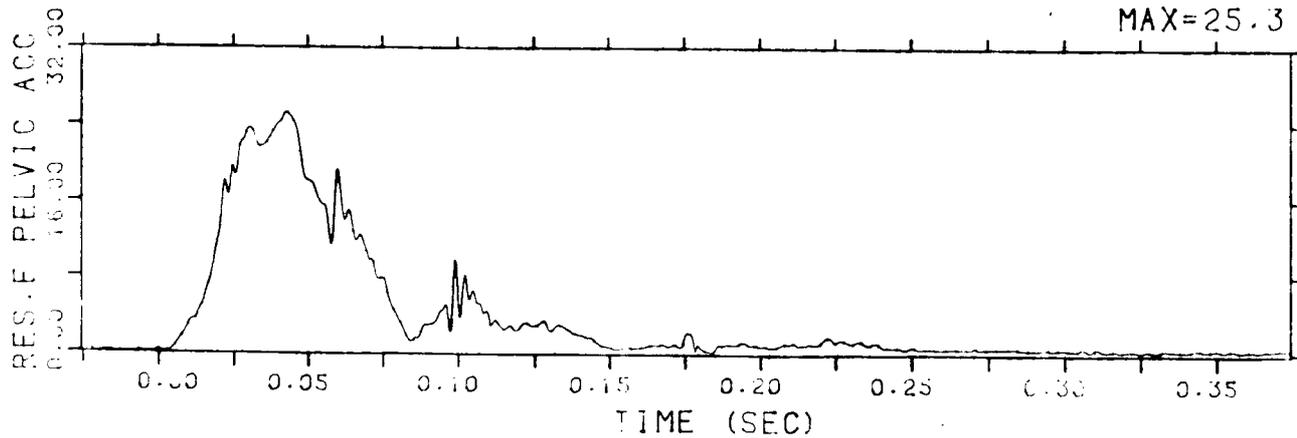
MIN=-3.59



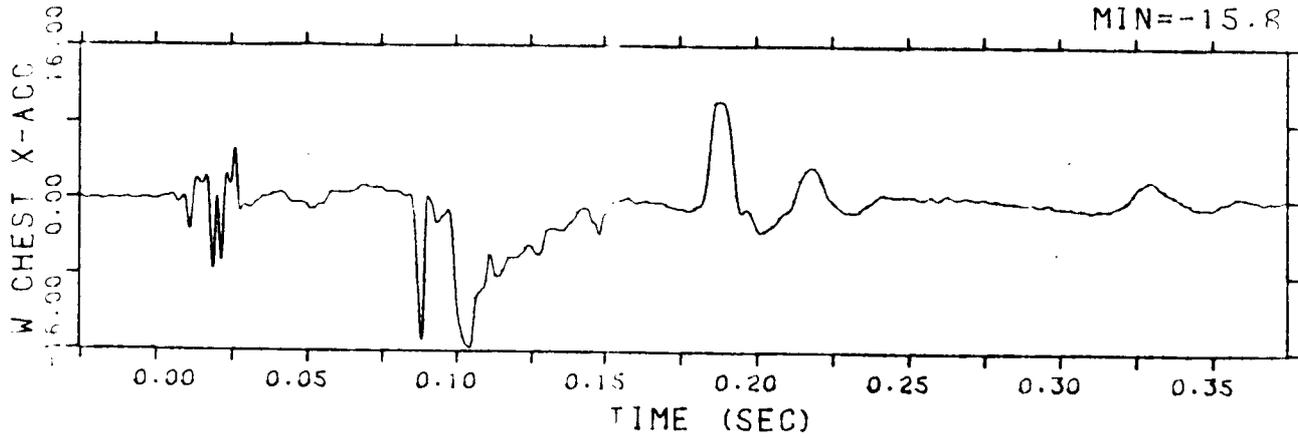
MAX=24.9



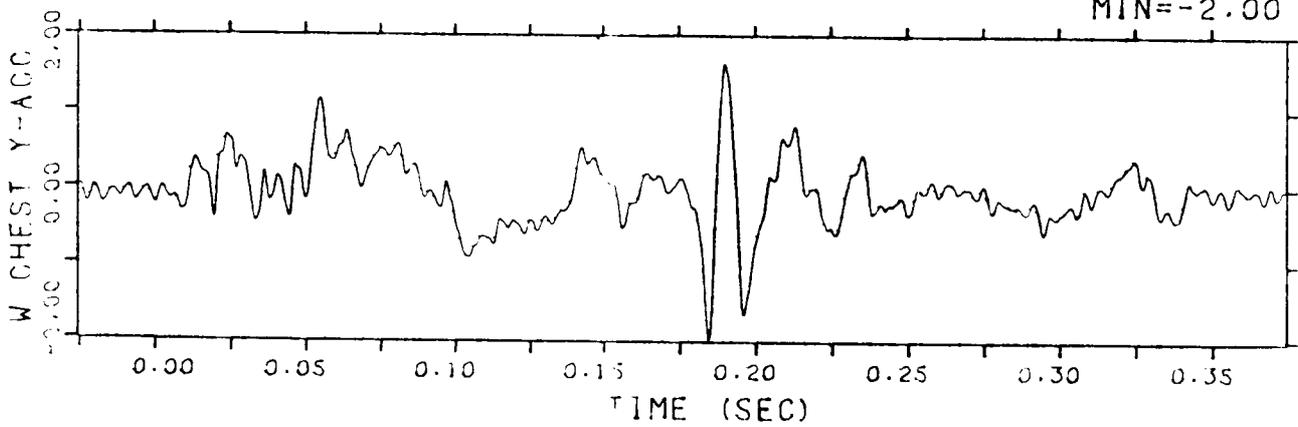
MAX=25.3



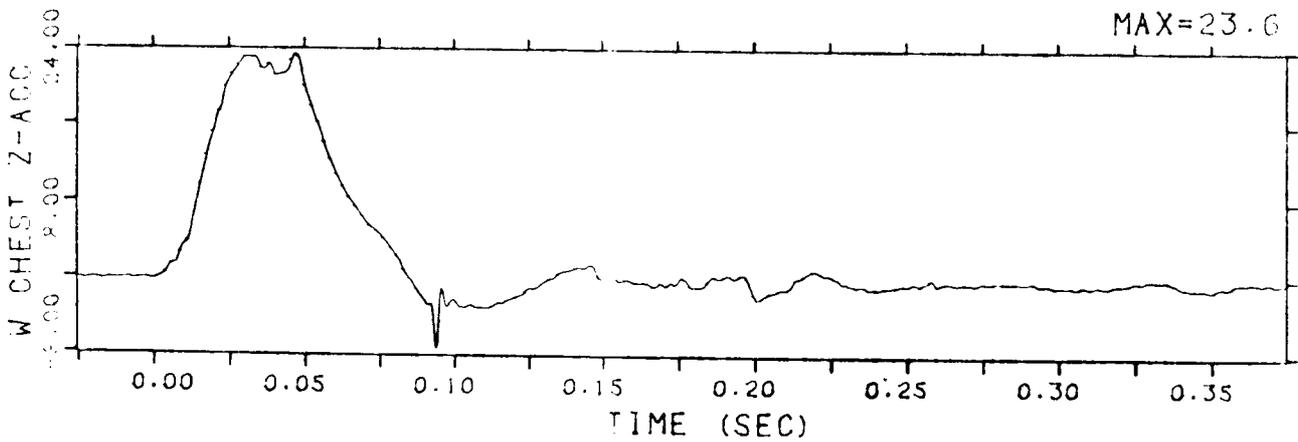
MIN=-15.8



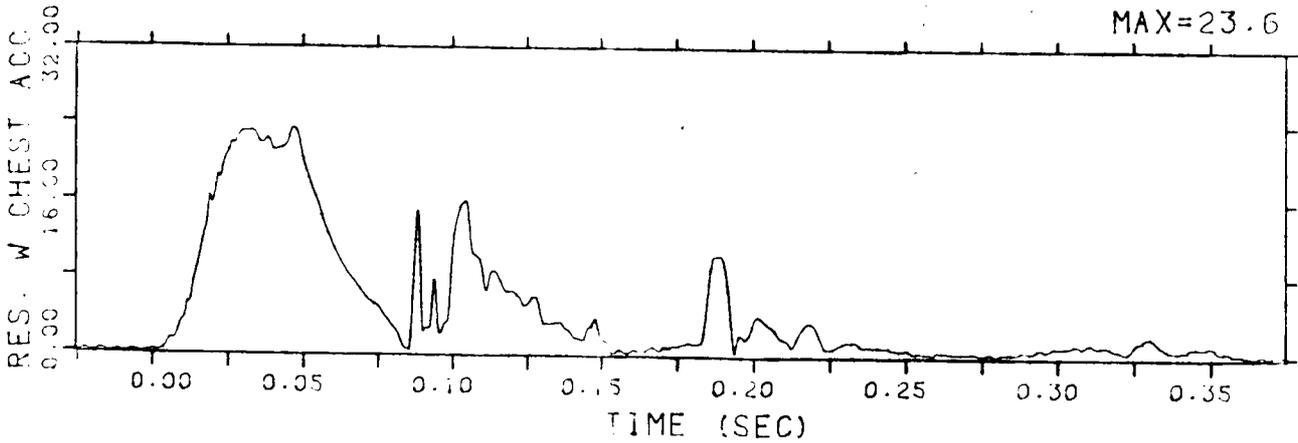
MIN=-2.00



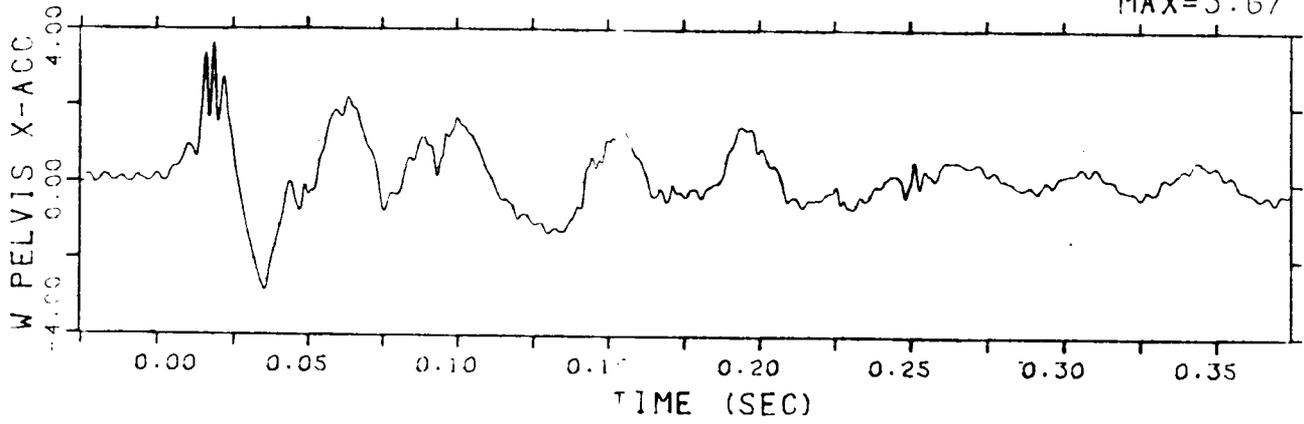
MAX=23.6



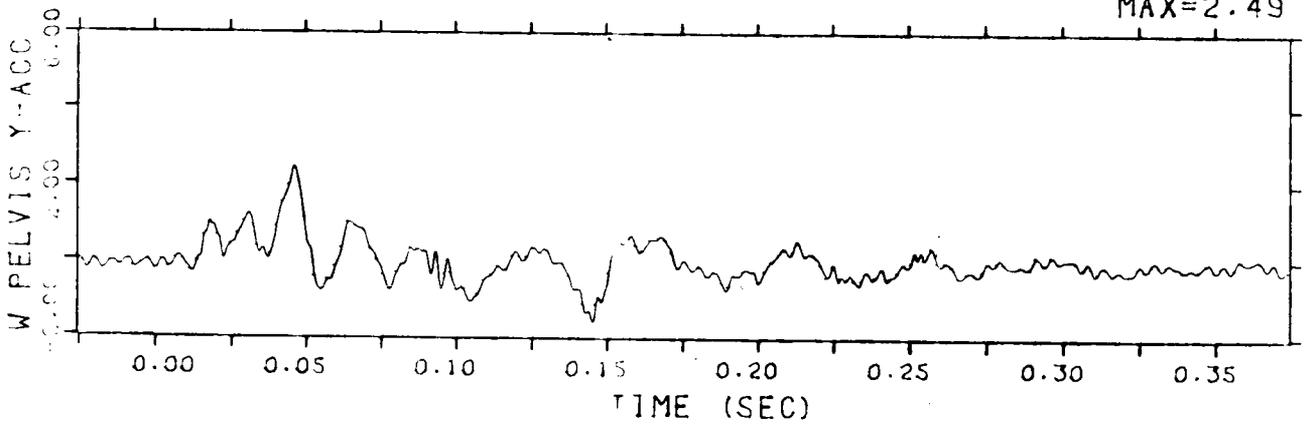
MAX=23.6



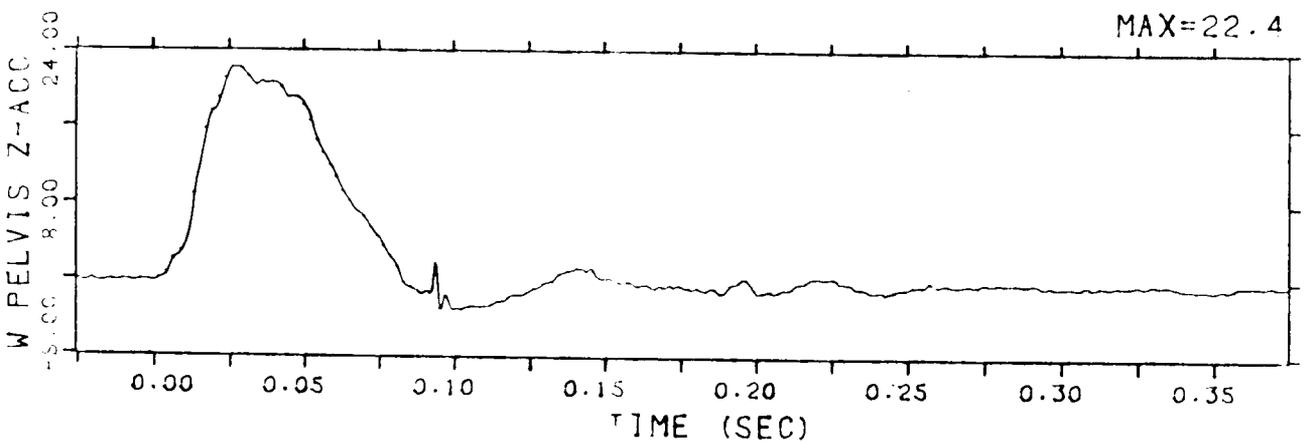
MAX=3.67



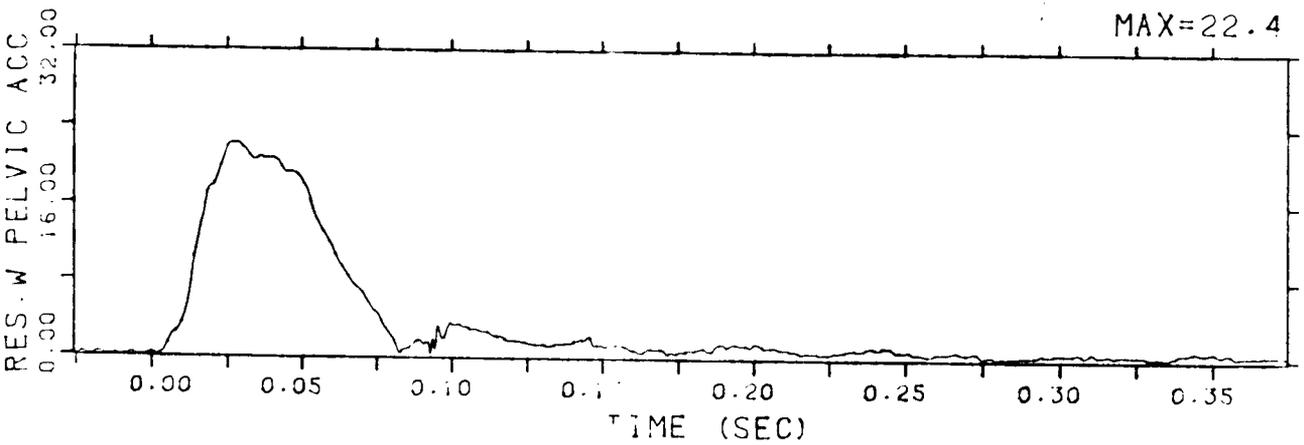
MAX=2.49

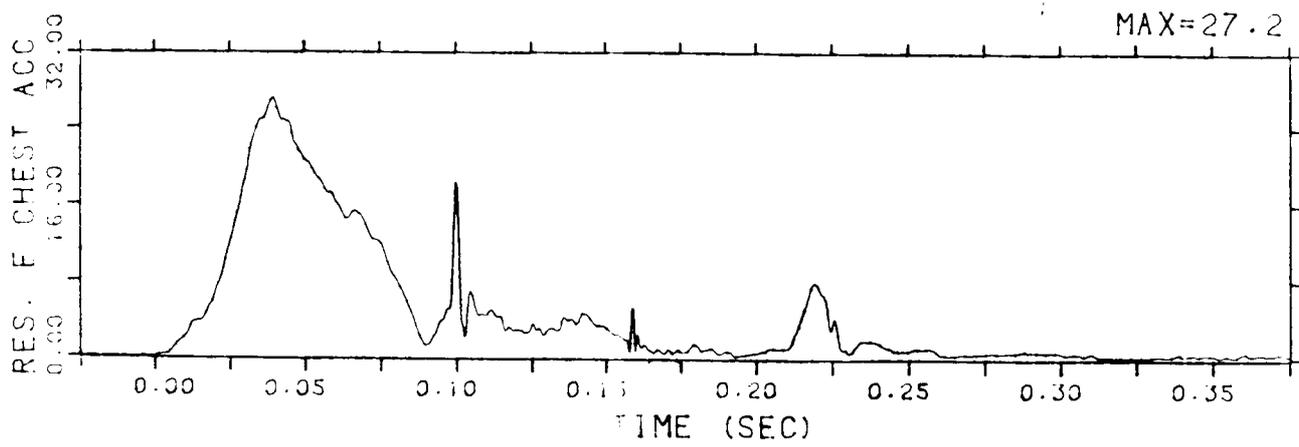
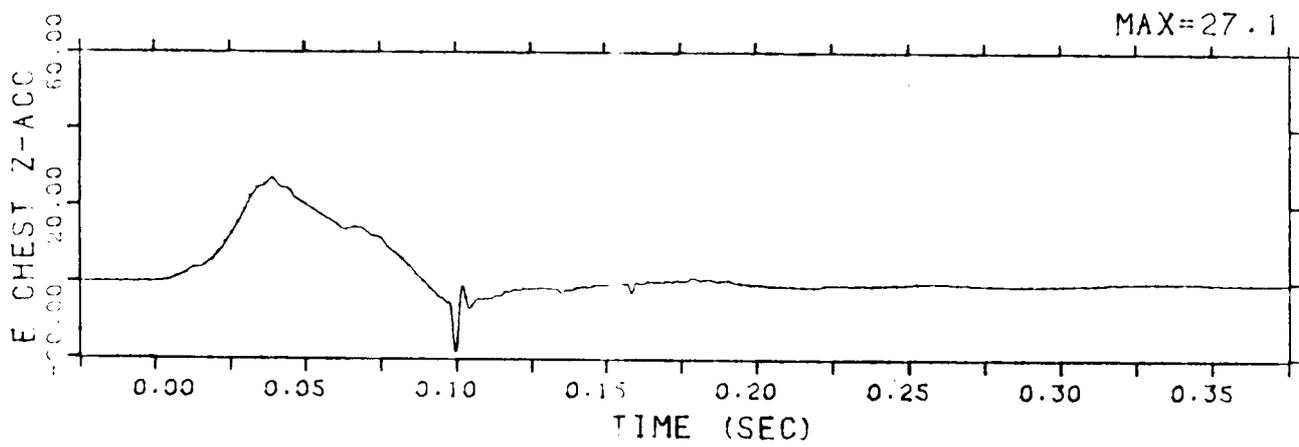
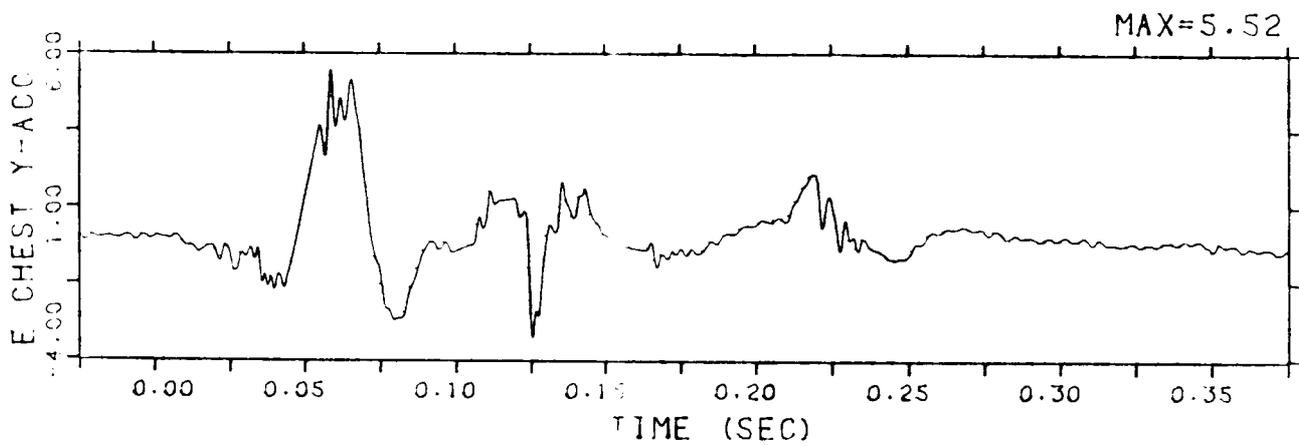
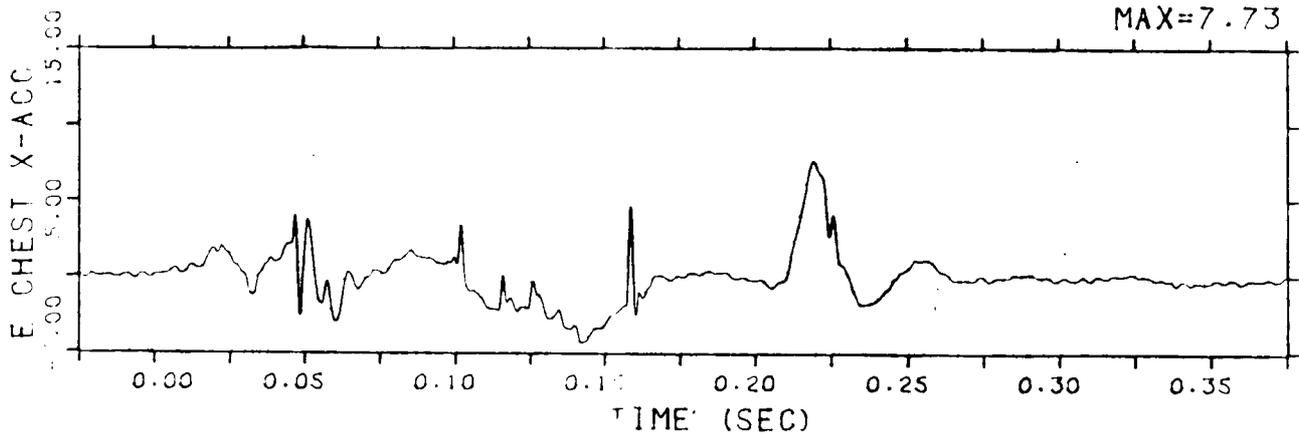


MAX=22.4

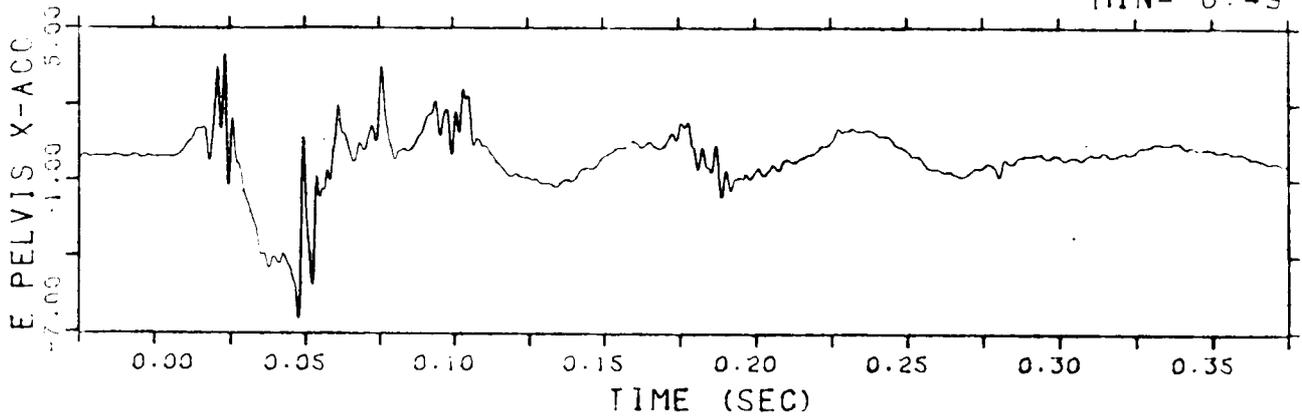


MAX=22.4

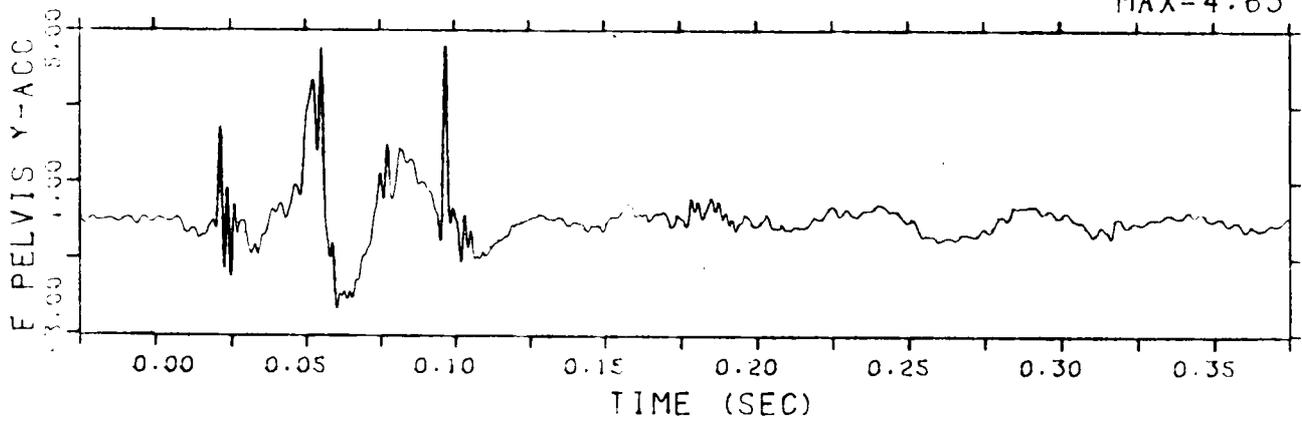




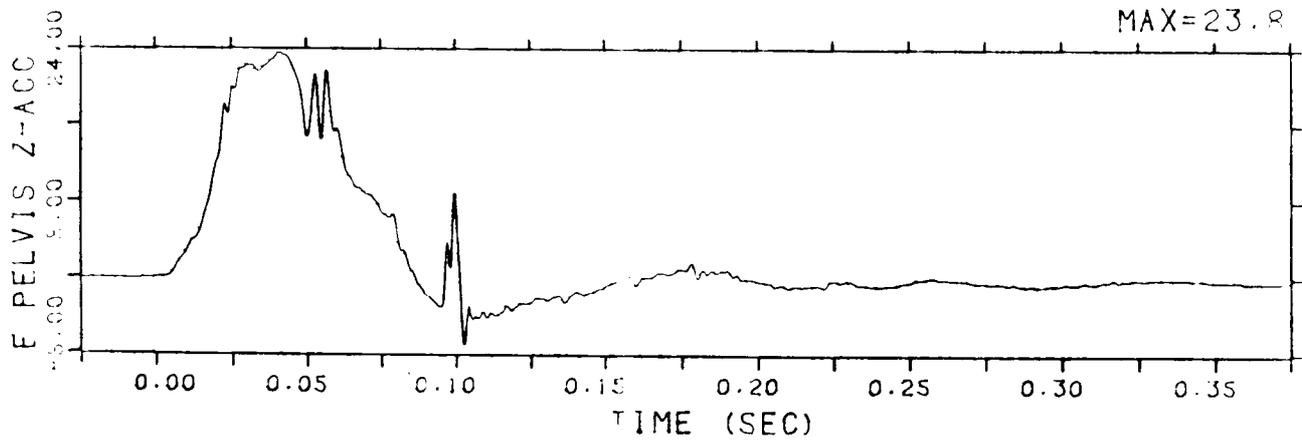
MIN=-6.49



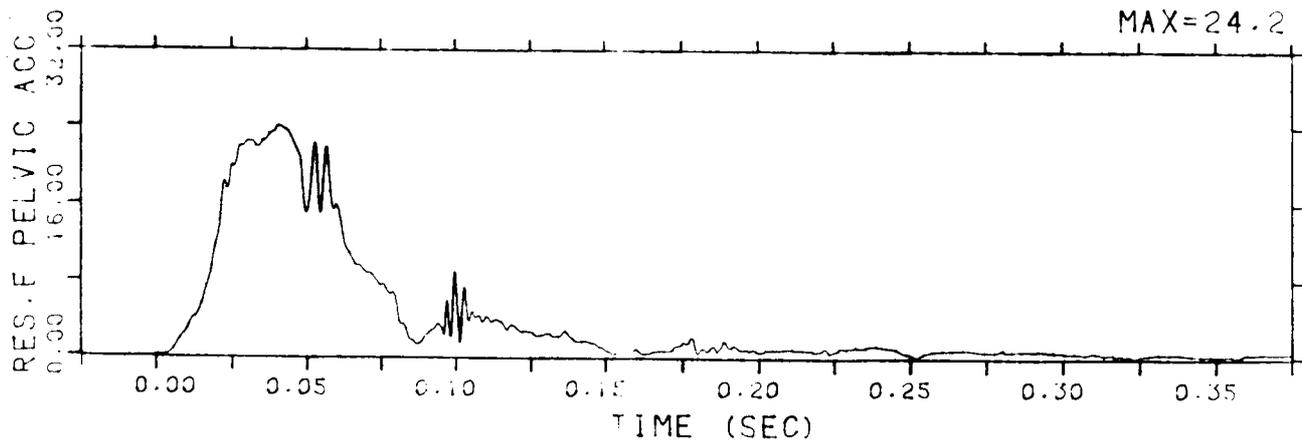
MAX=4.63



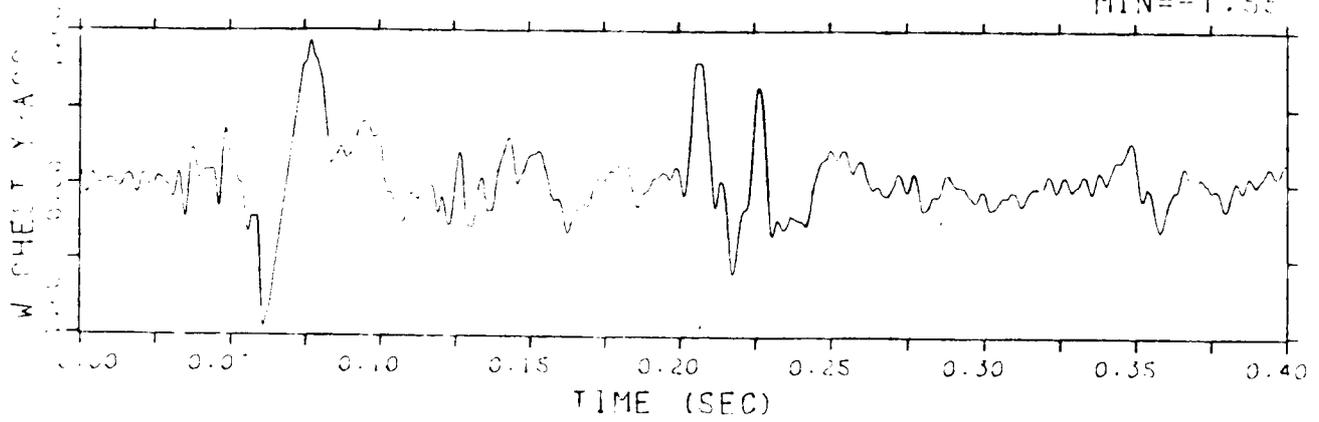
MAX=23.8



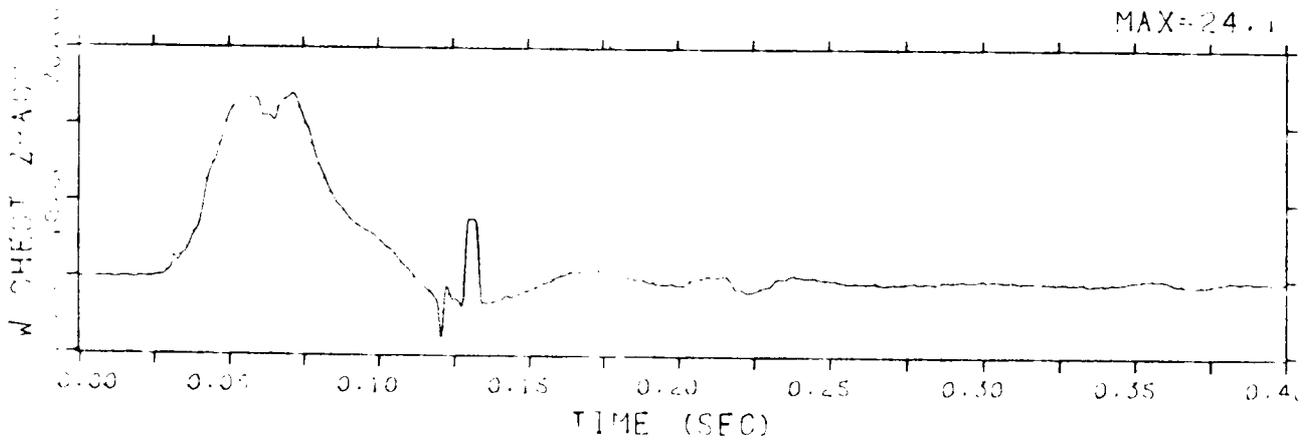
MAX=24.2



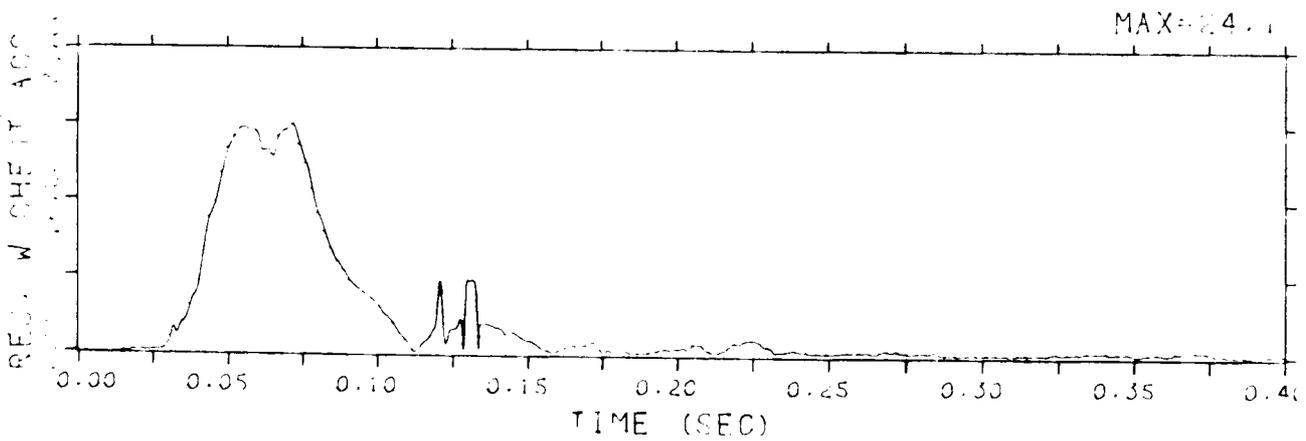
MIN=-1.55



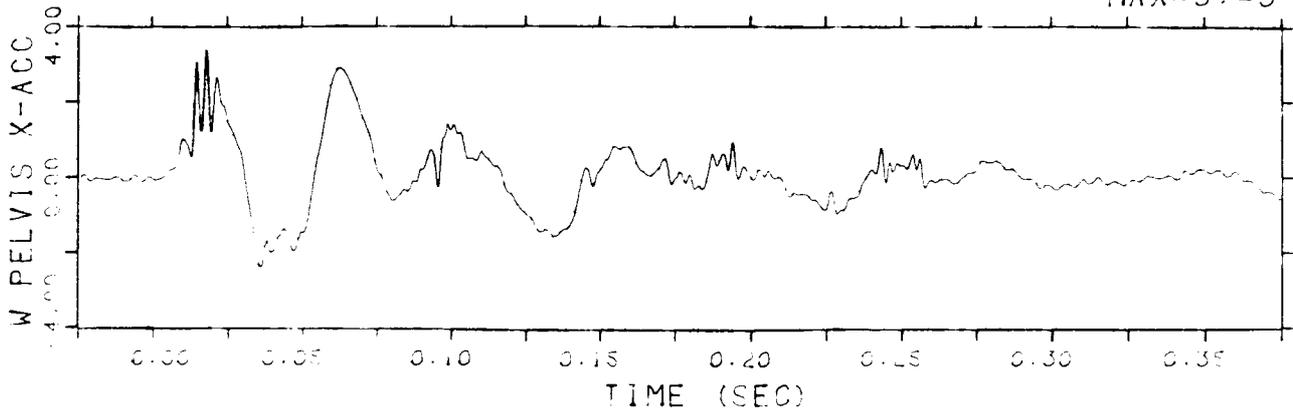
MAX=24.1



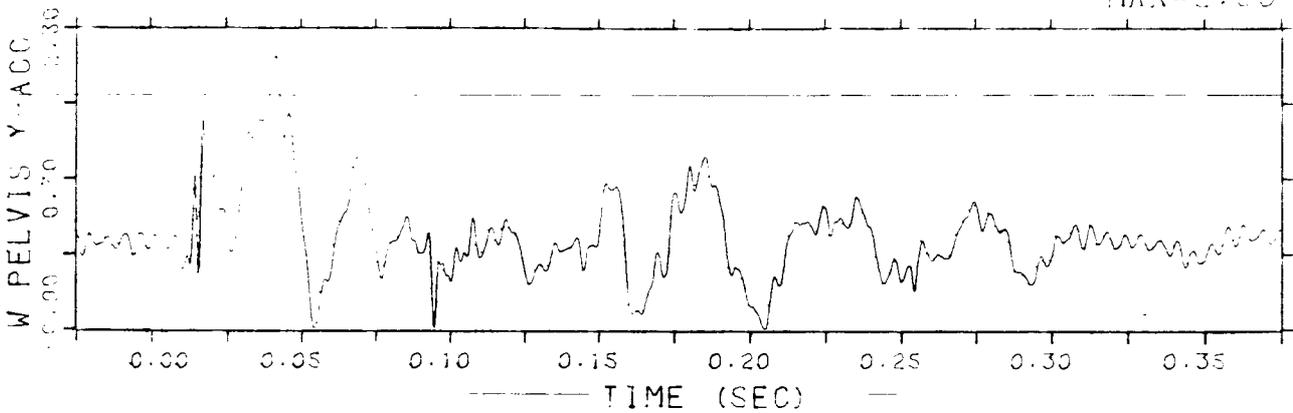
MAX=24.1



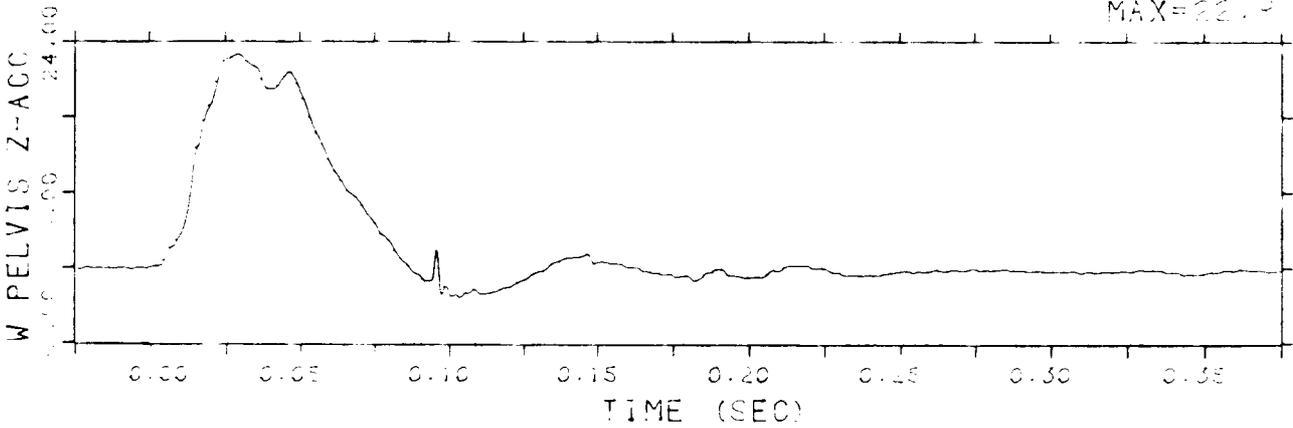
MAX=3.43



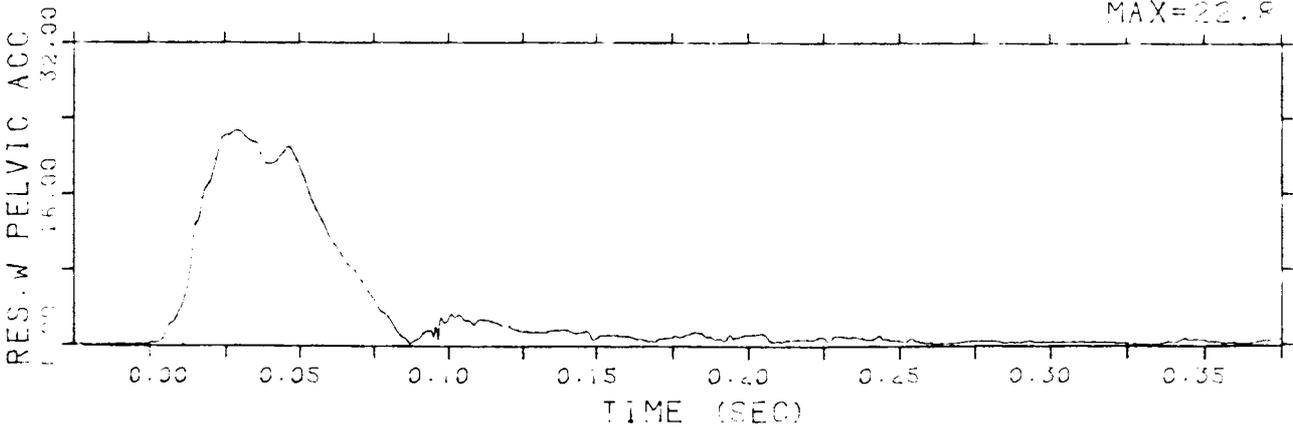
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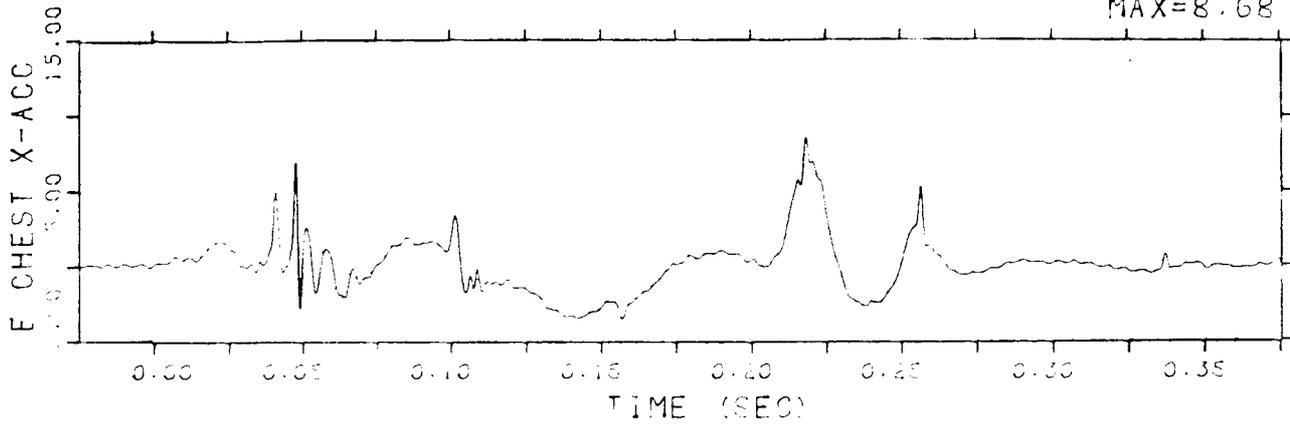
MAX=22.9



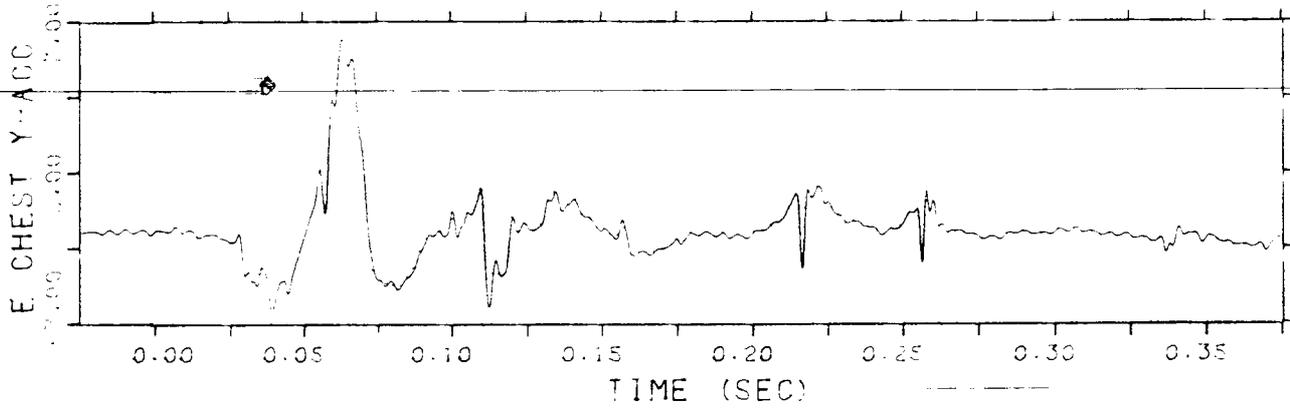
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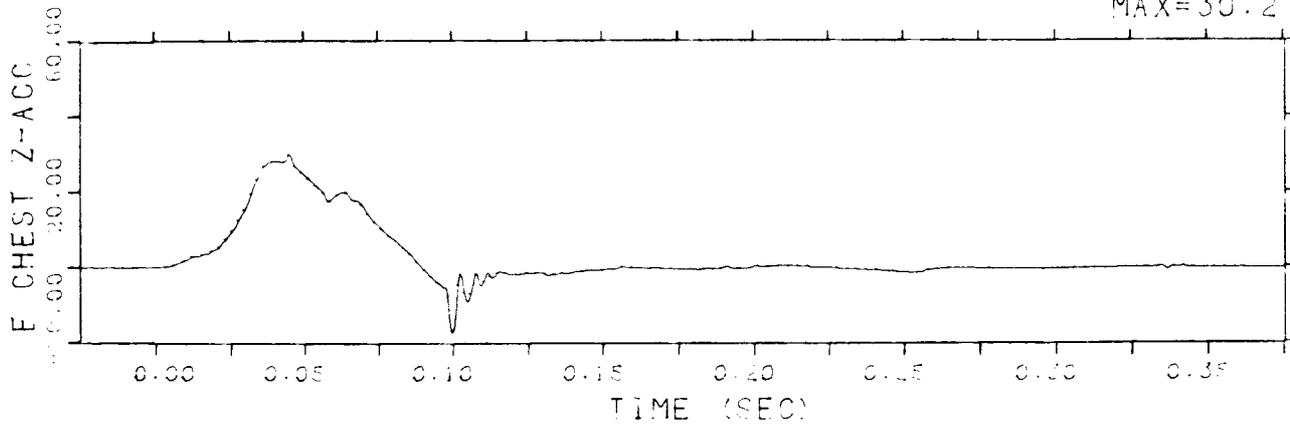
MAX=8.68



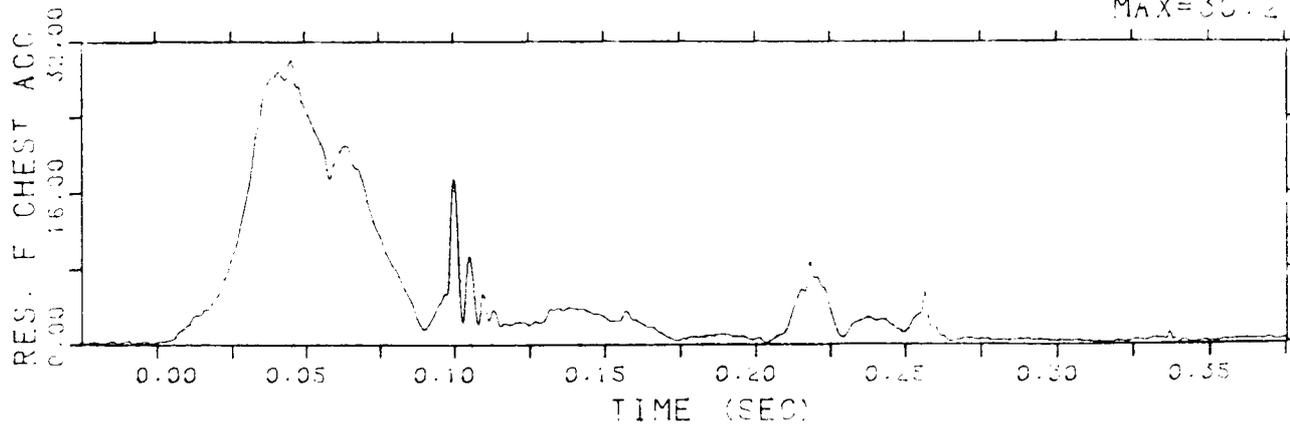
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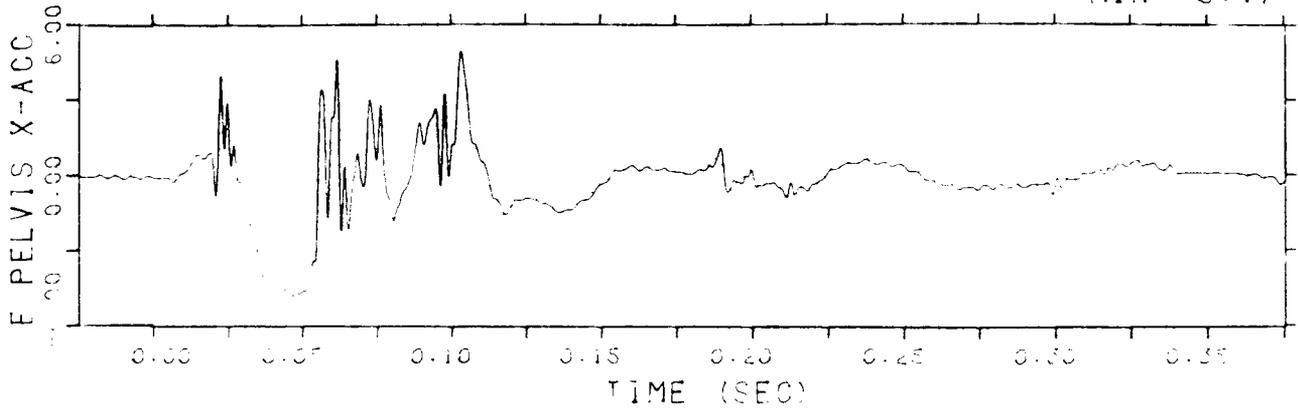
MAX=30.2



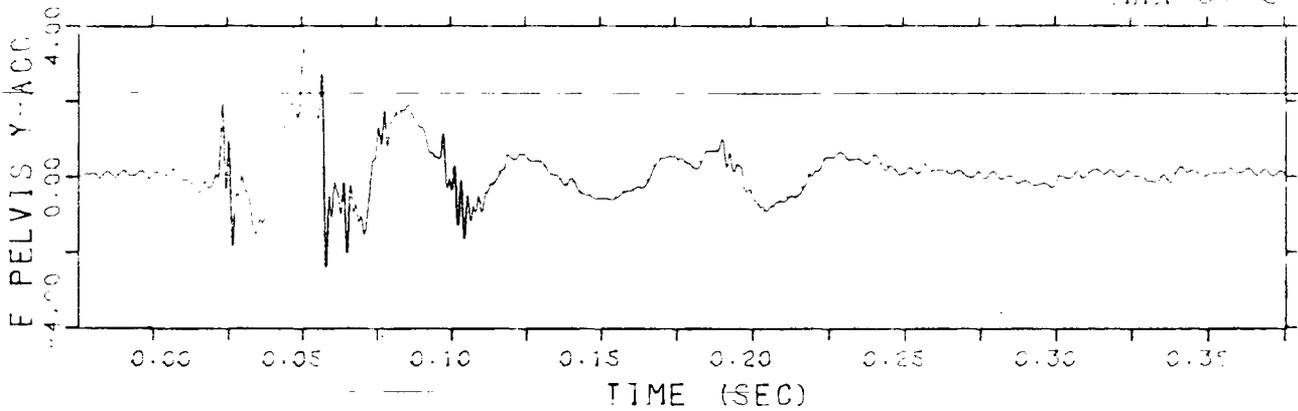
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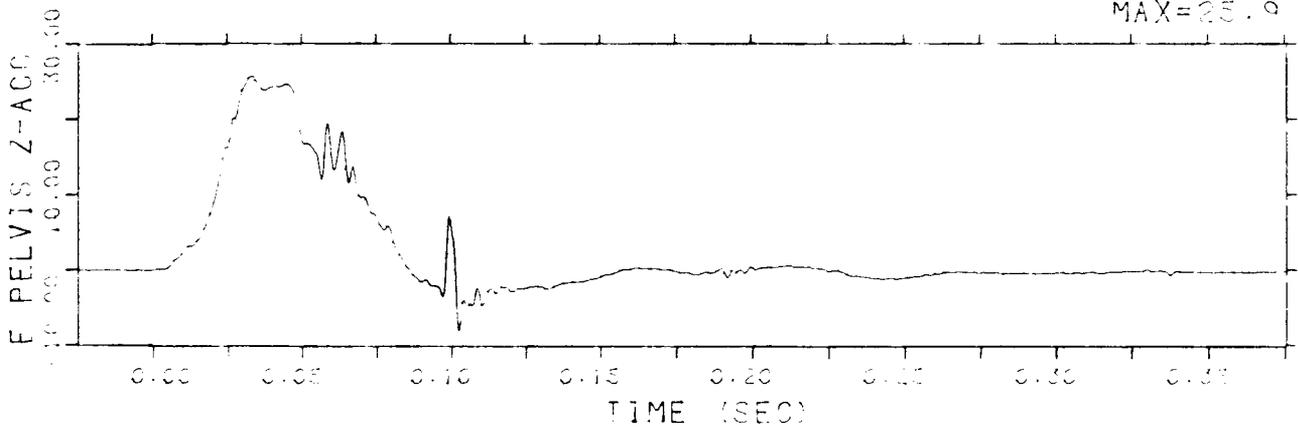
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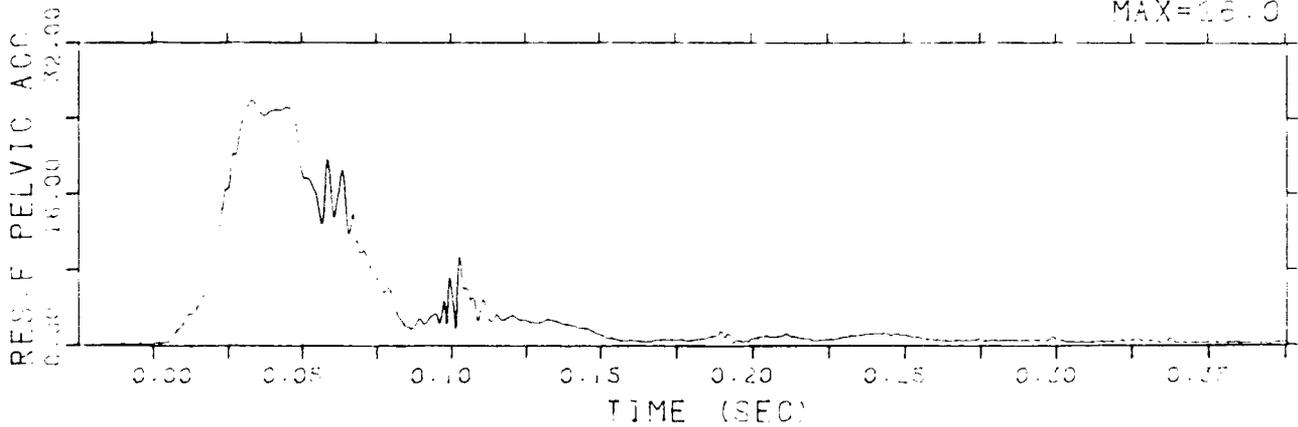
MAX=3.45



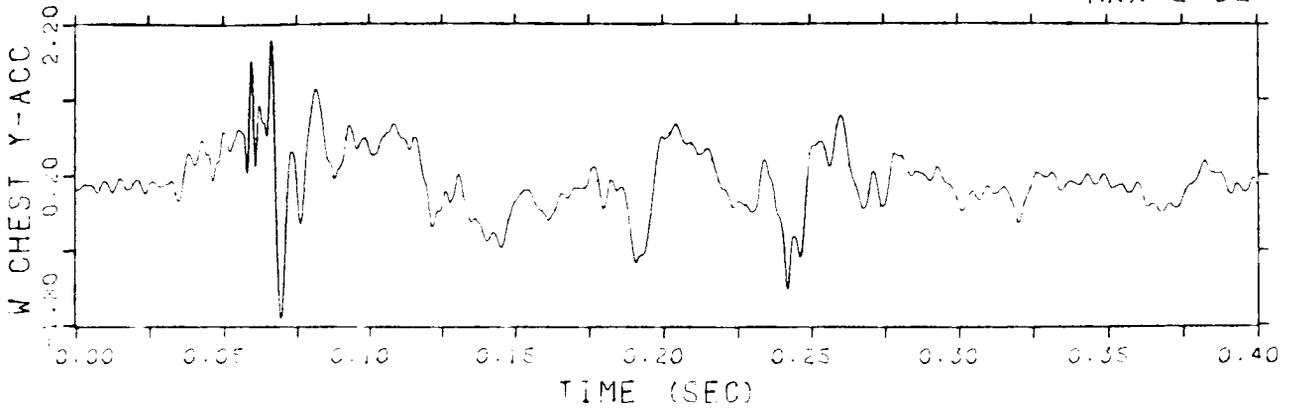
MAX=25.0



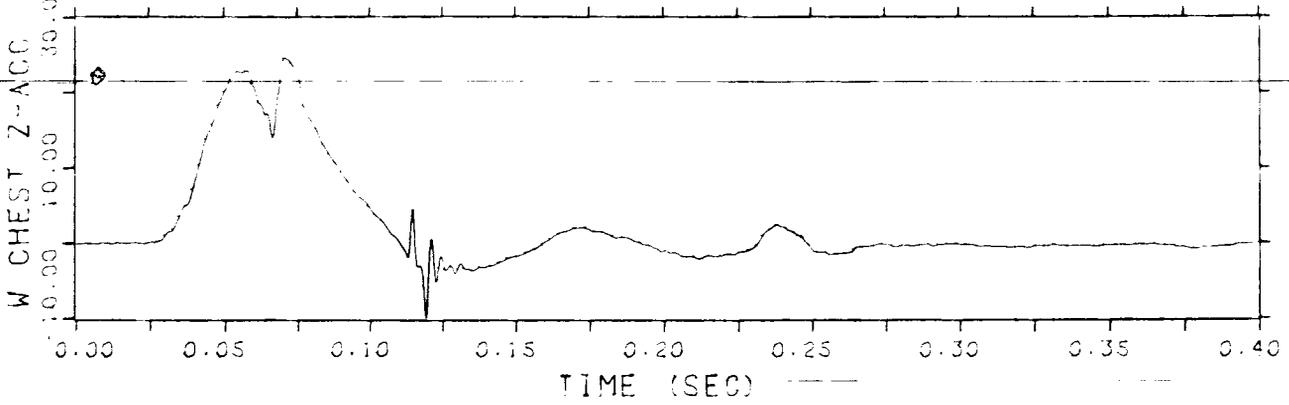
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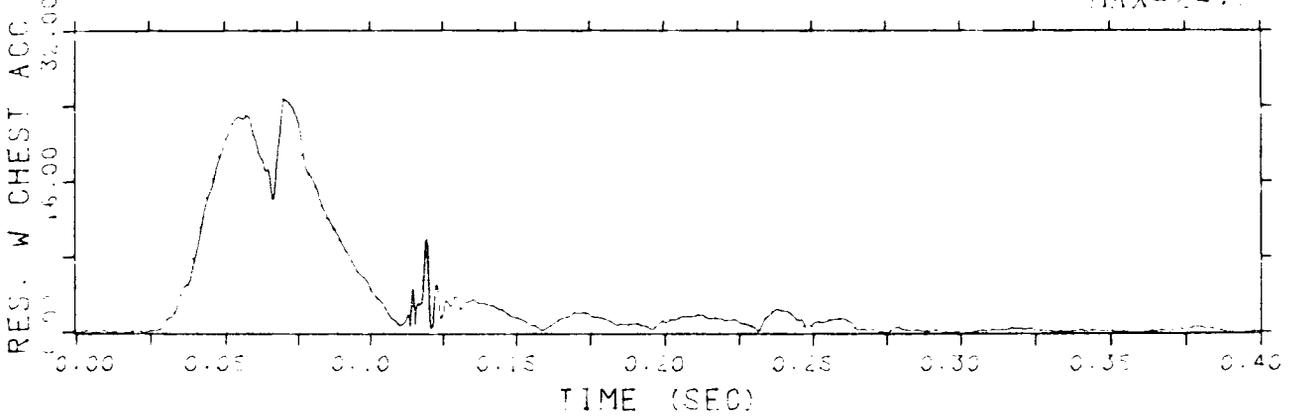
MAX=2.02



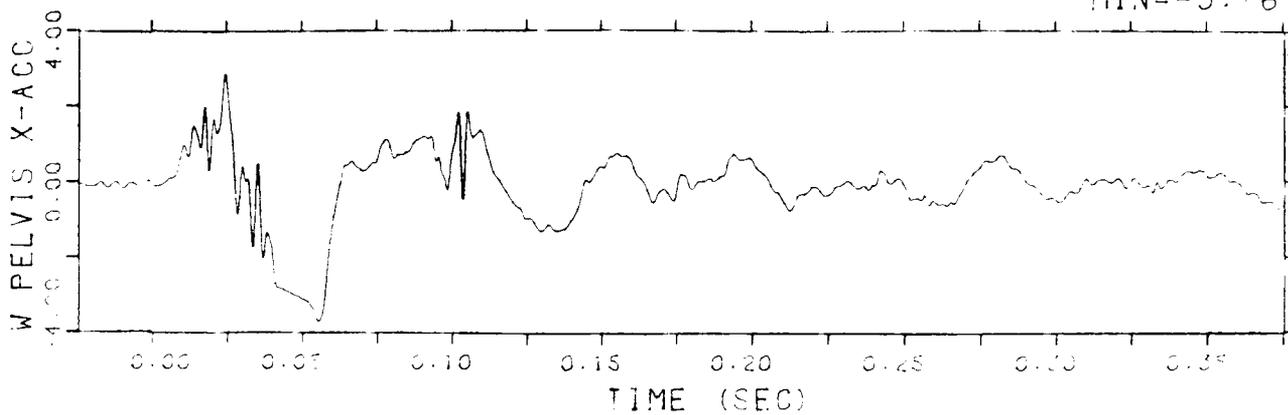
MAX=24.8



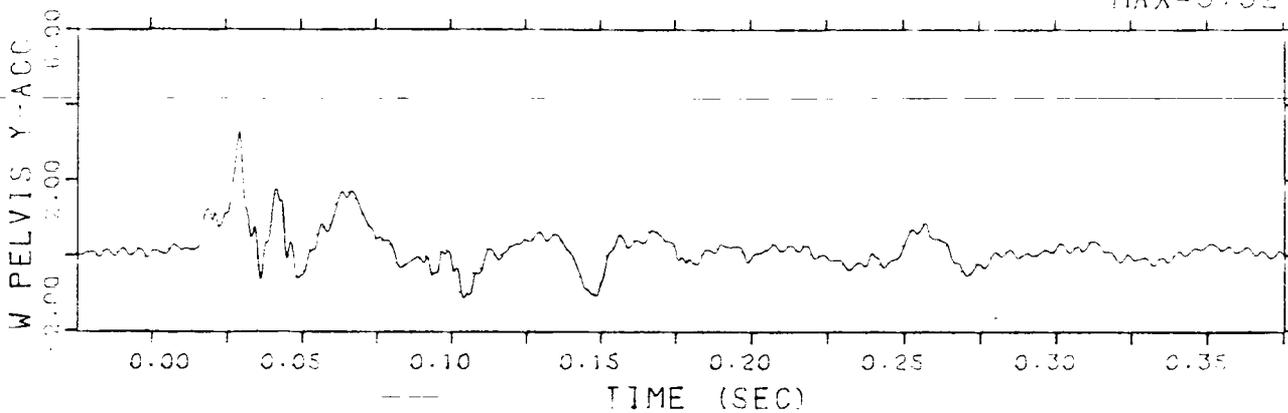
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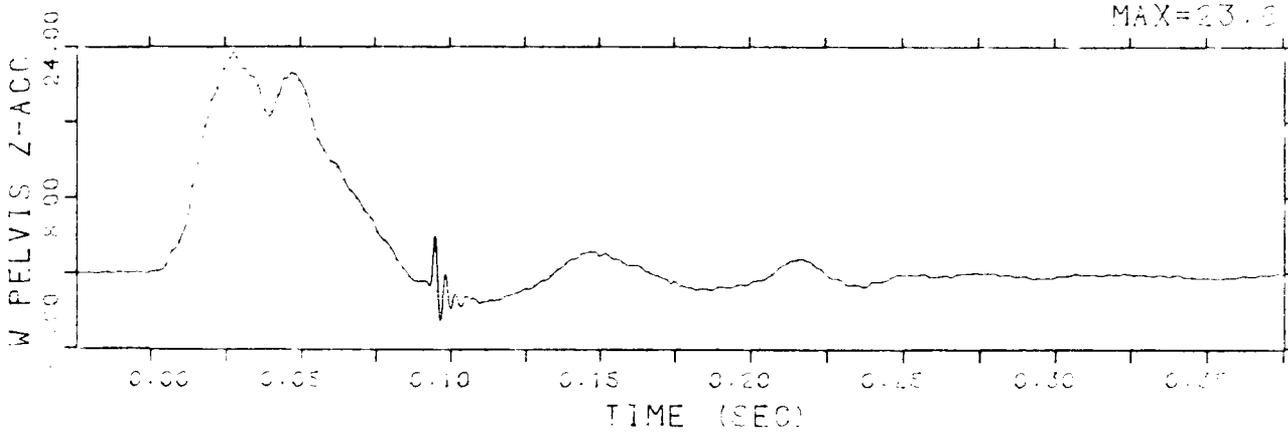
MIN=-3.76



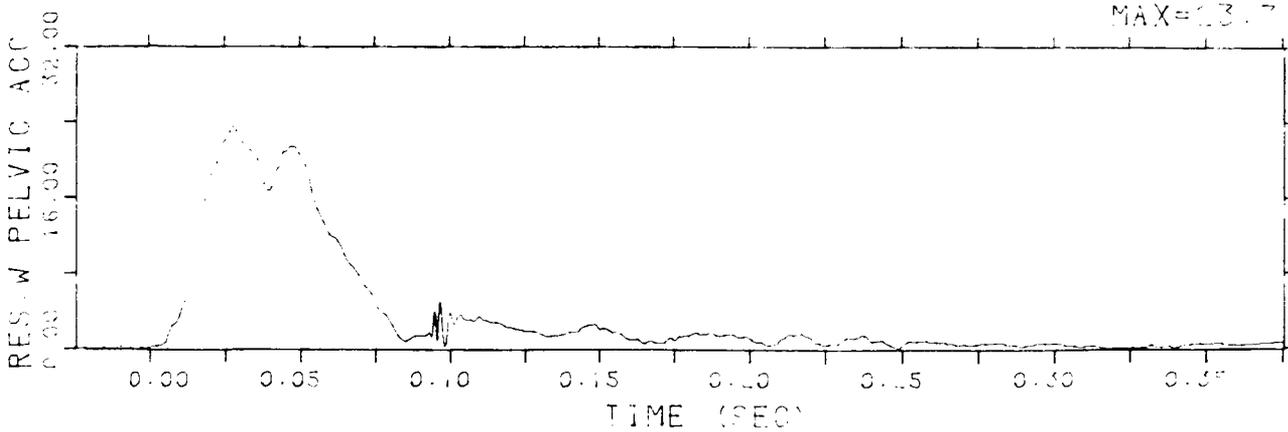
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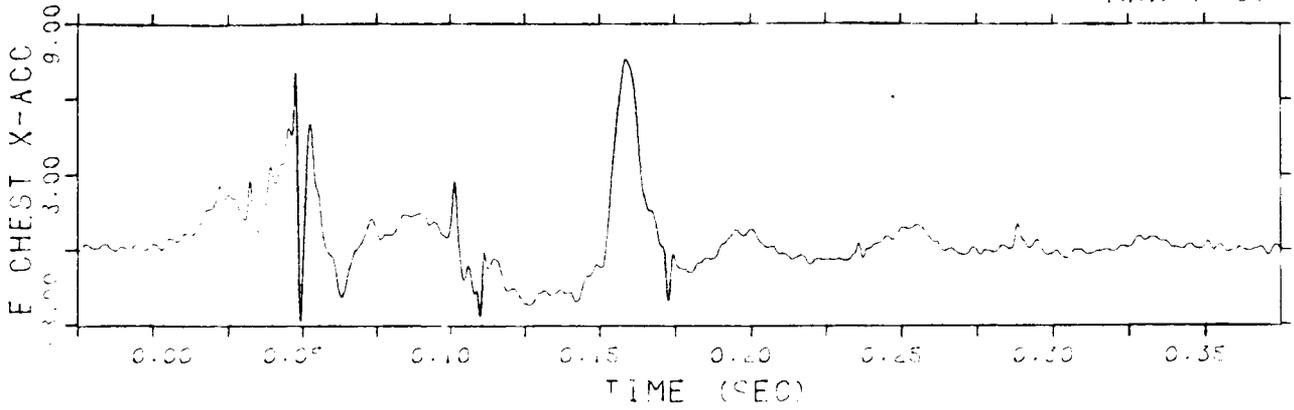
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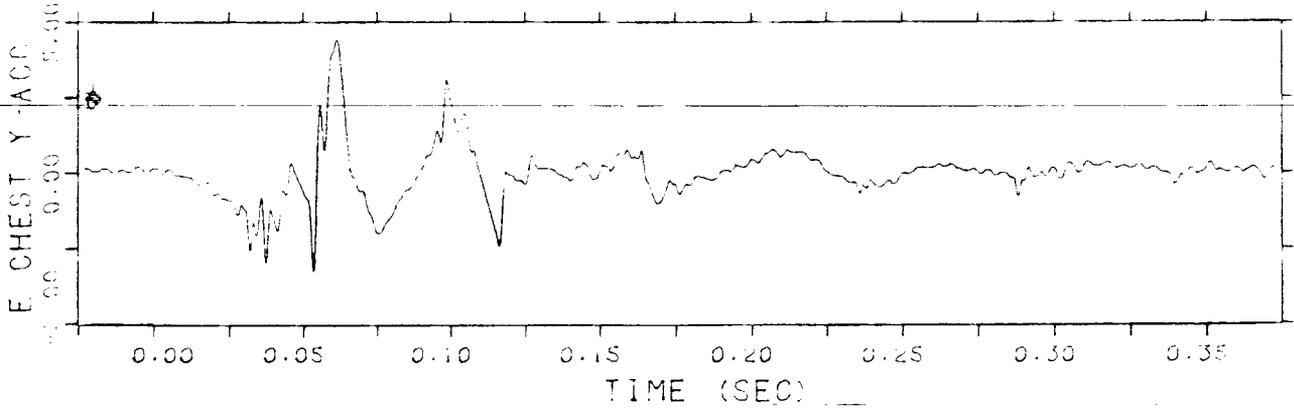
MAX=13.7



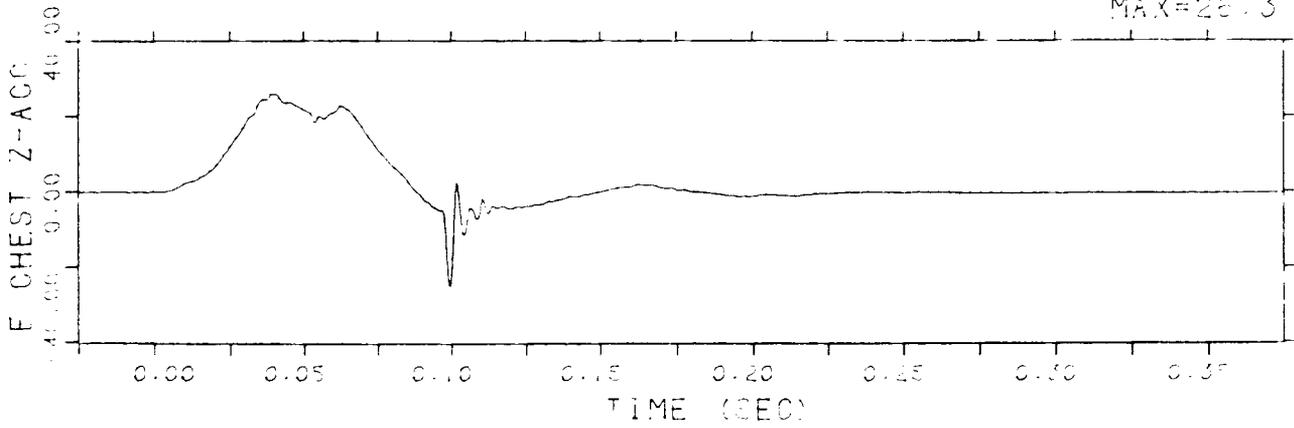
MAX=7.67



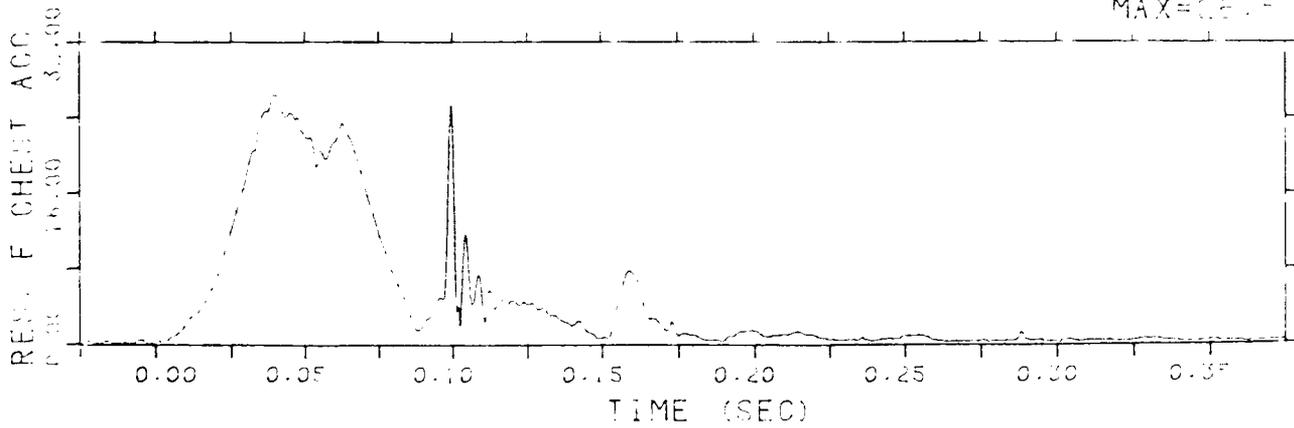
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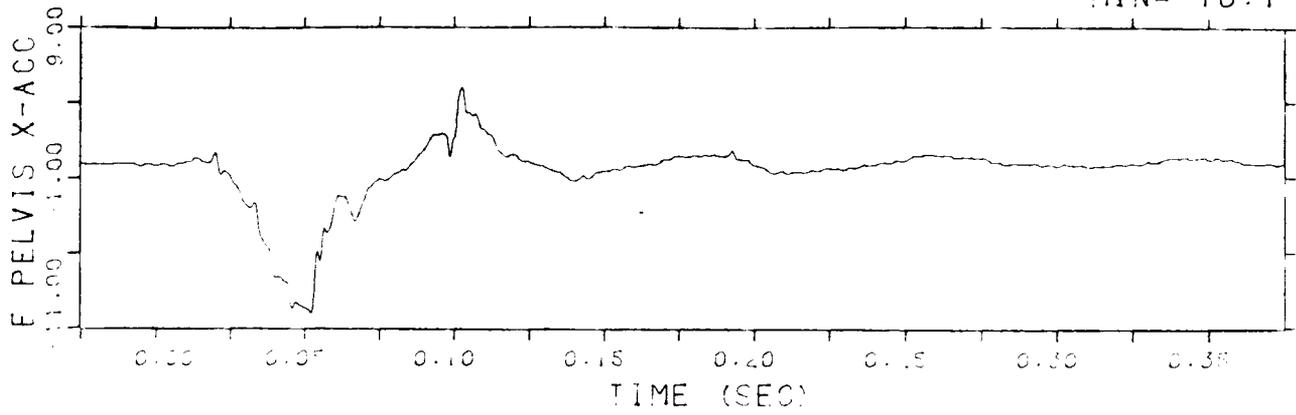
MAX=28.3



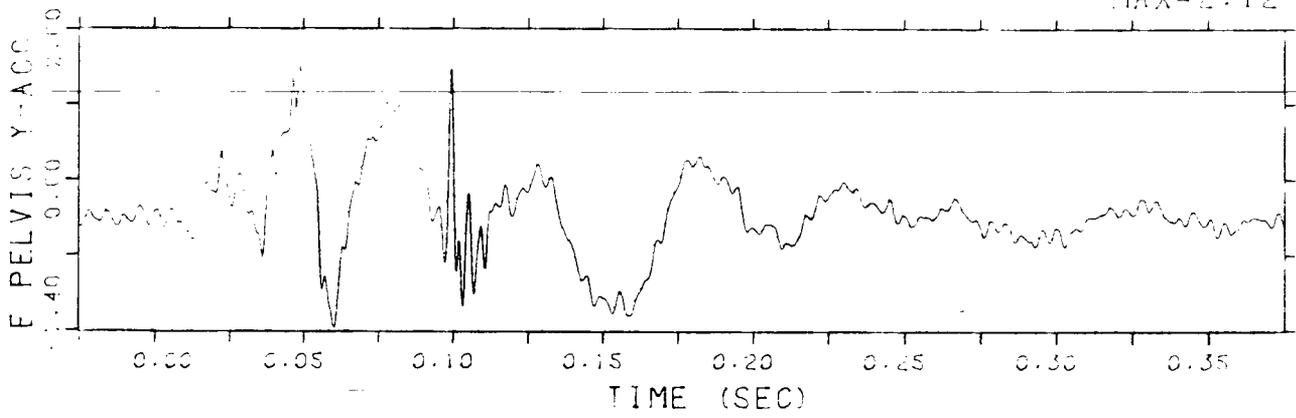
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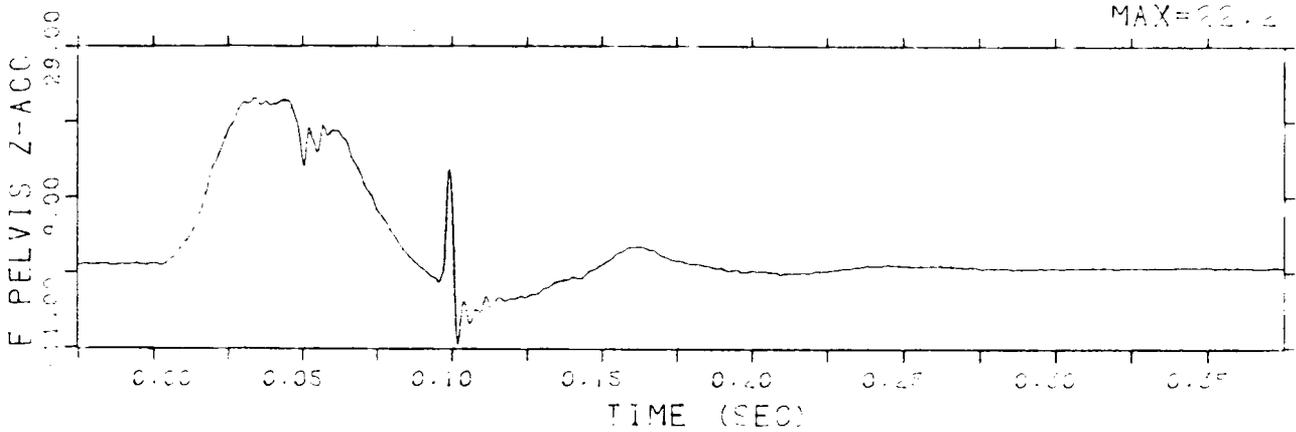
MIN=-10.1



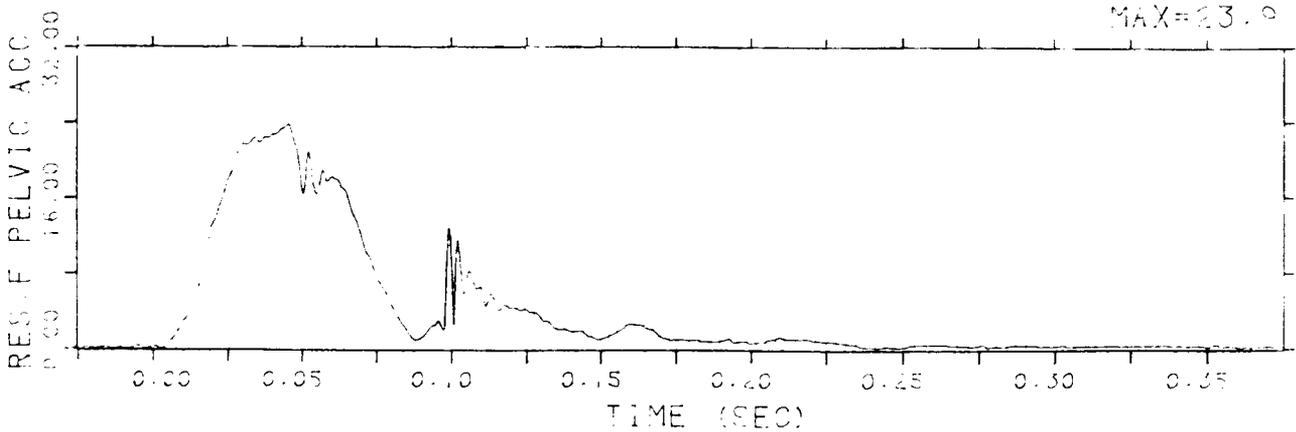
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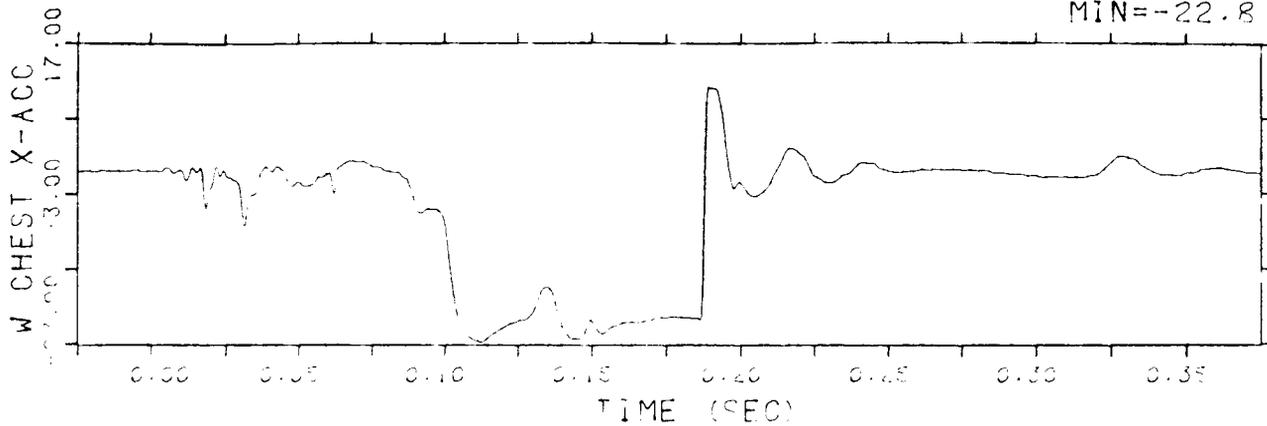
MAX=22.2



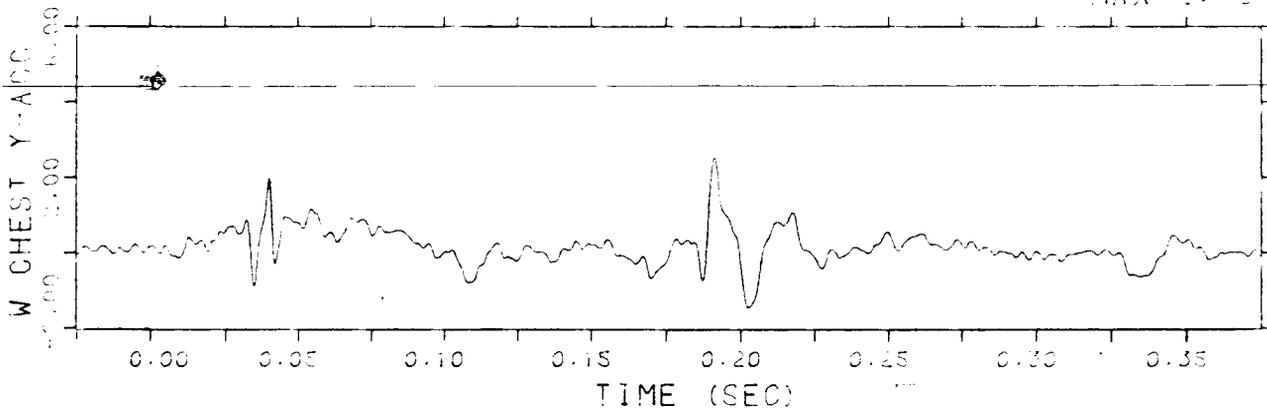
MAX=23.9



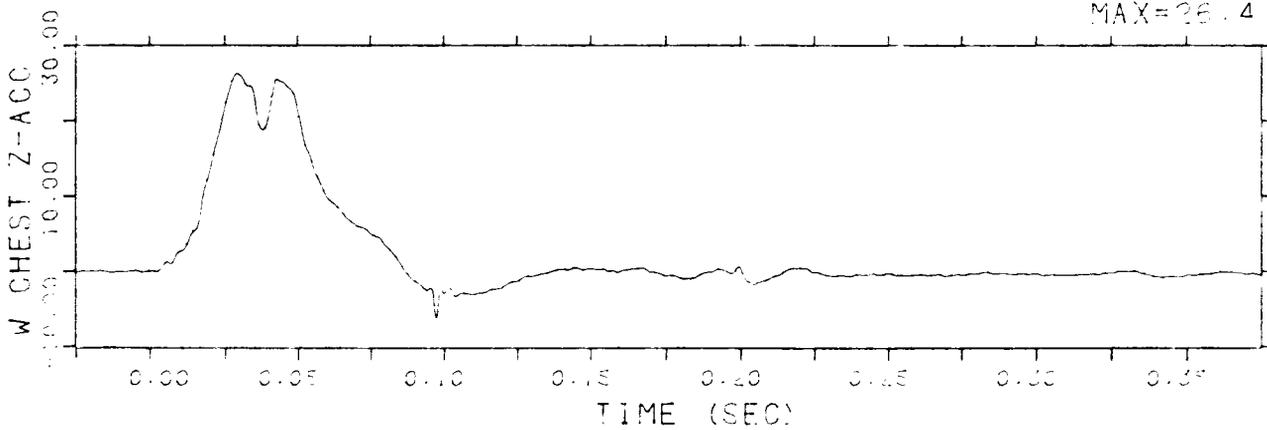
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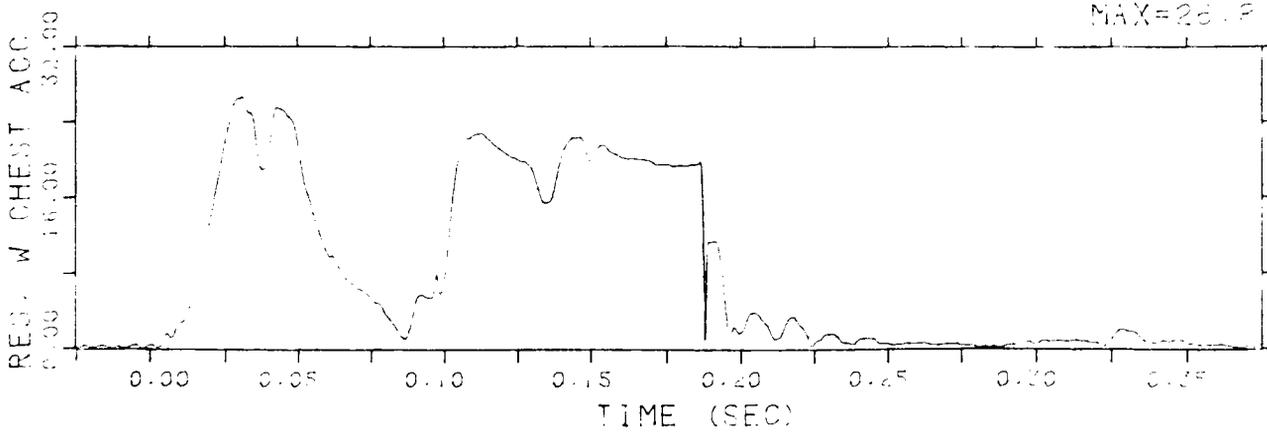
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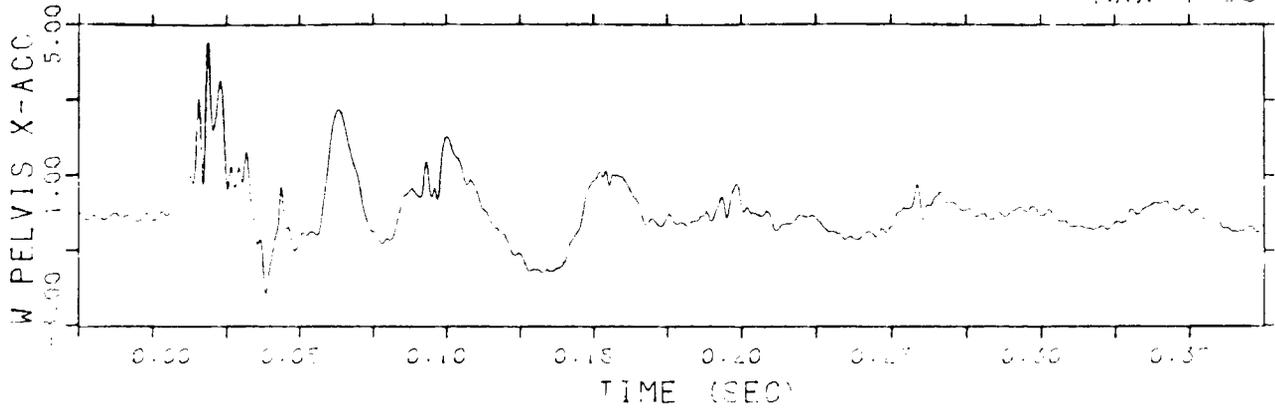
MAX=26.4



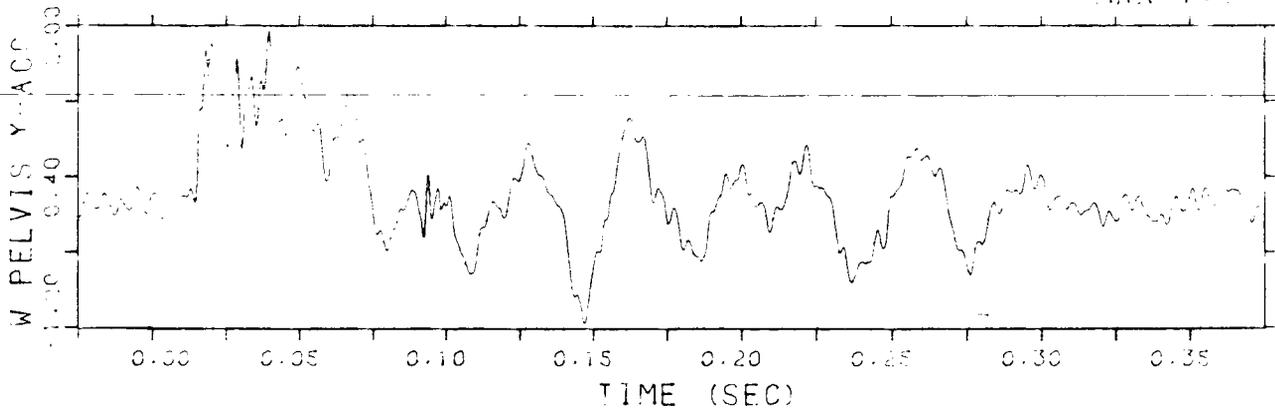
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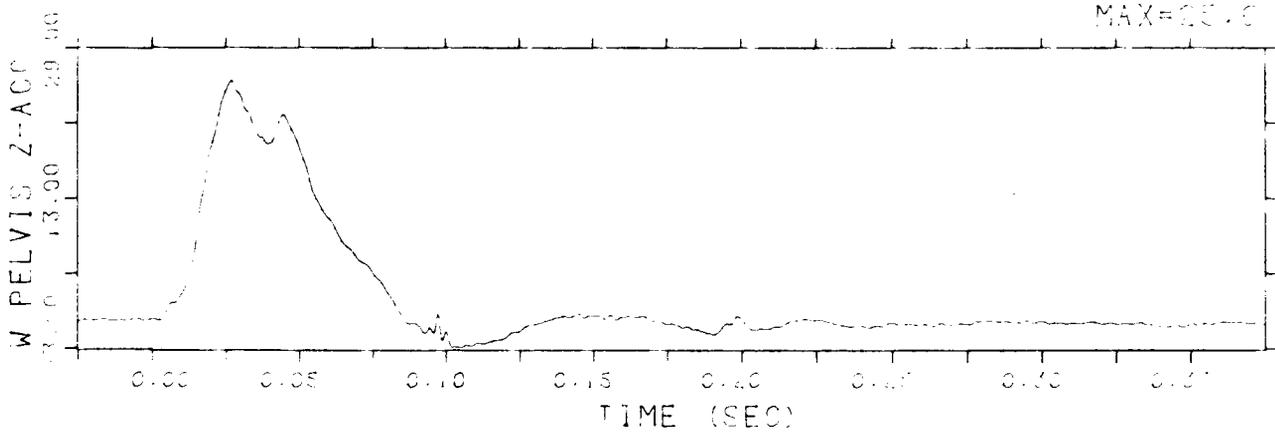
MAX=4.59



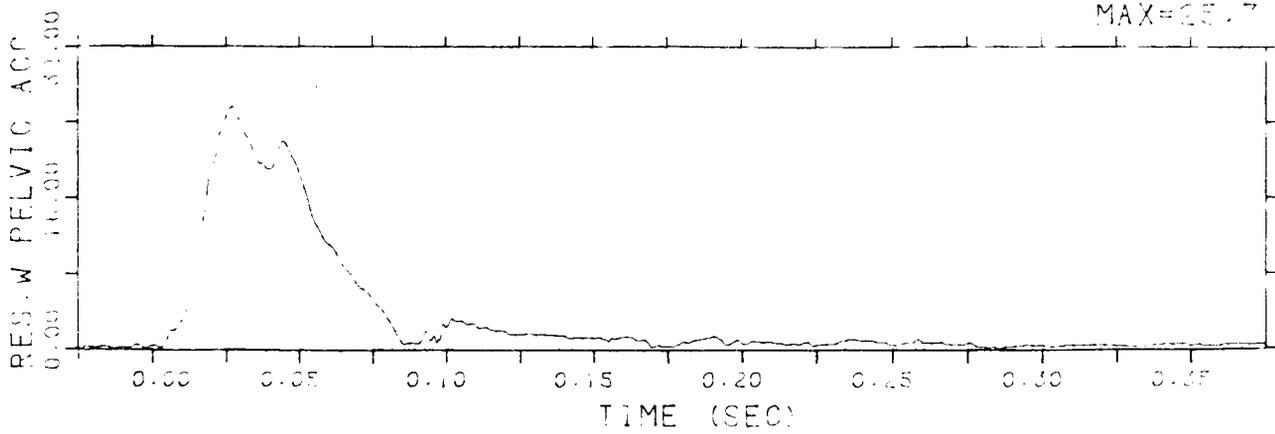
MAX=1.00



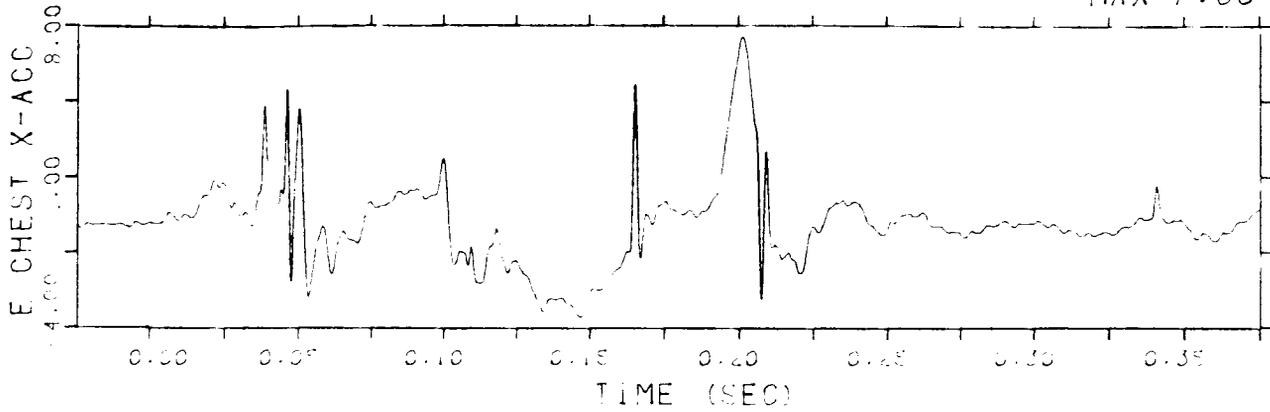
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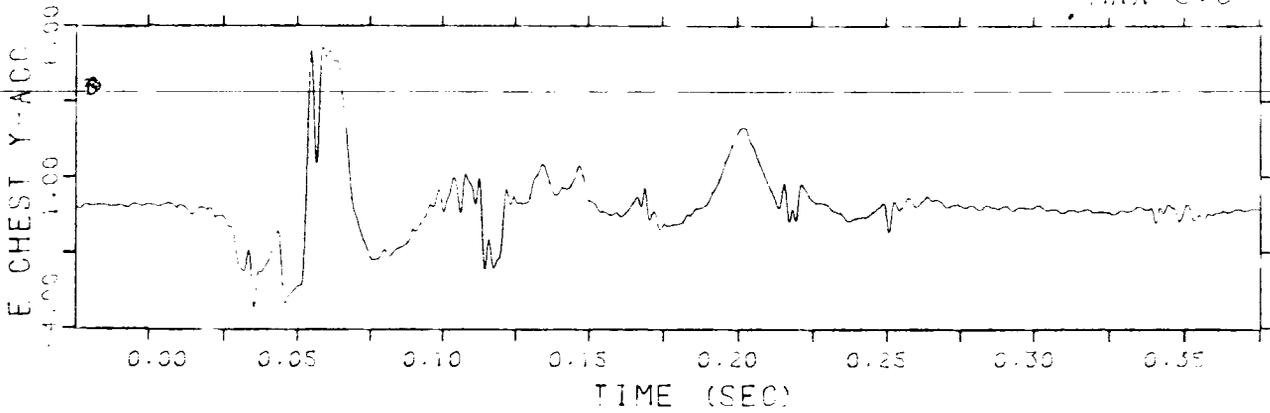
MAX=25.7



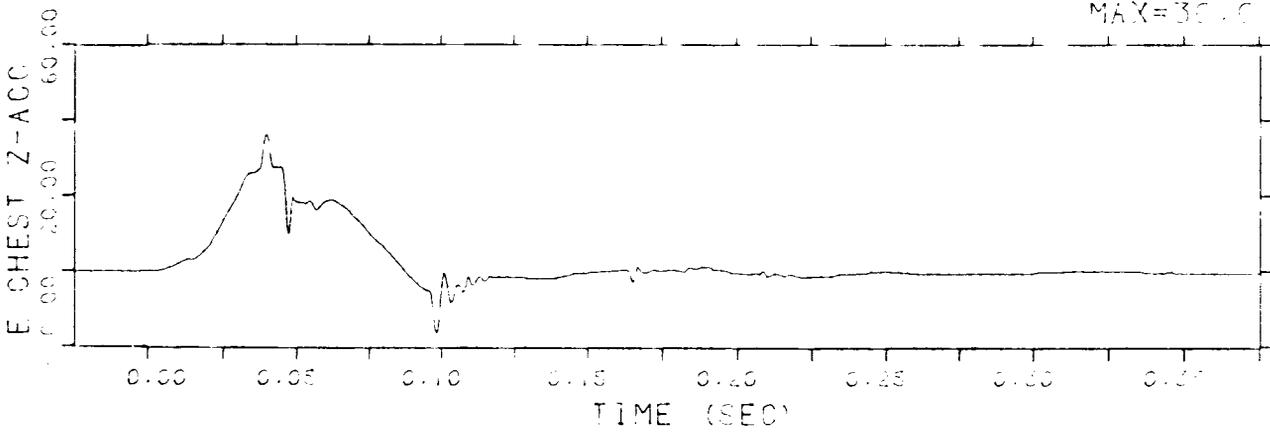
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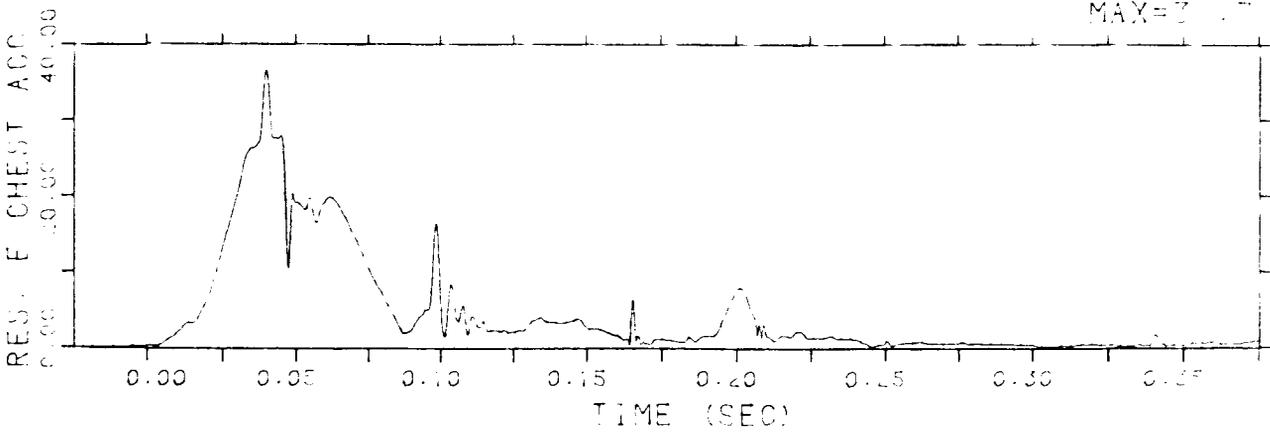
MAX=5.35



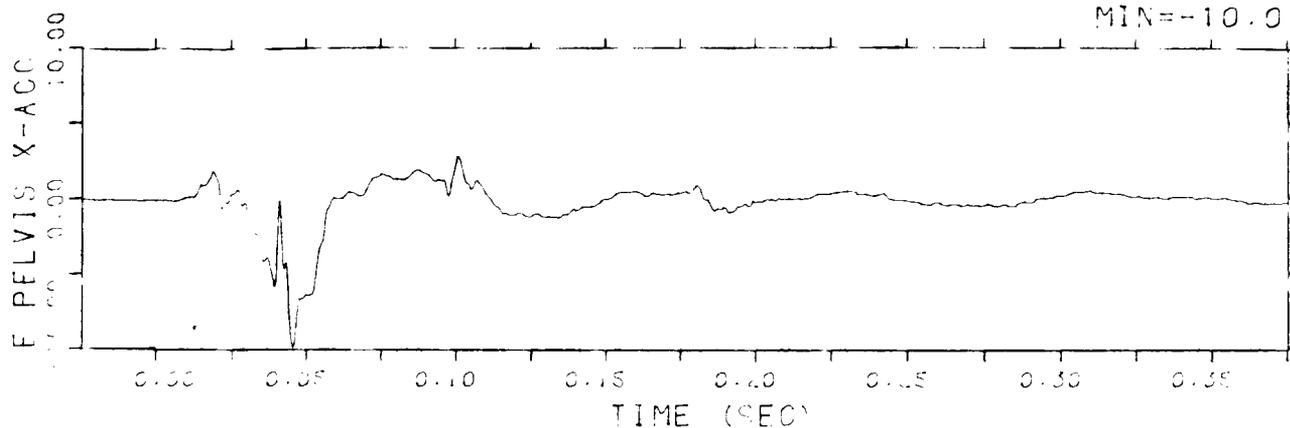
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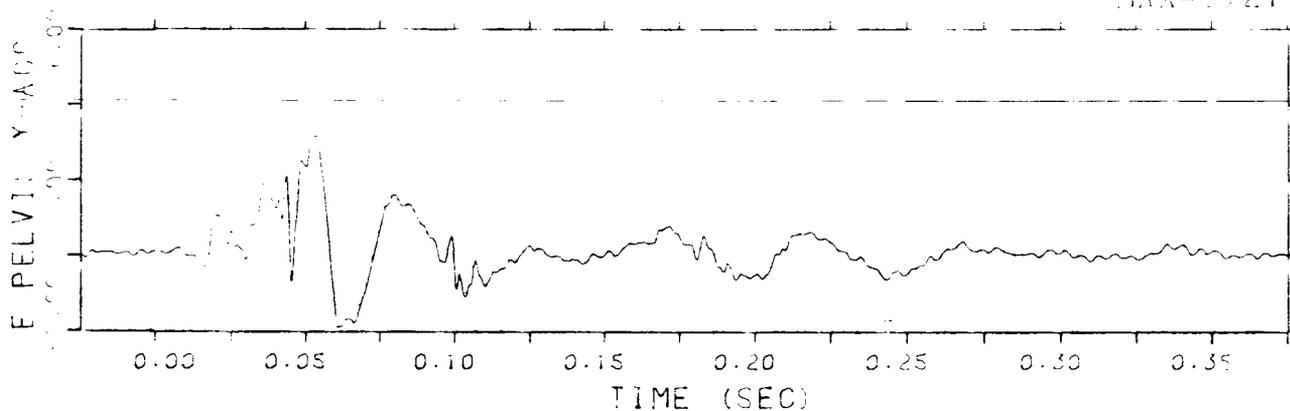
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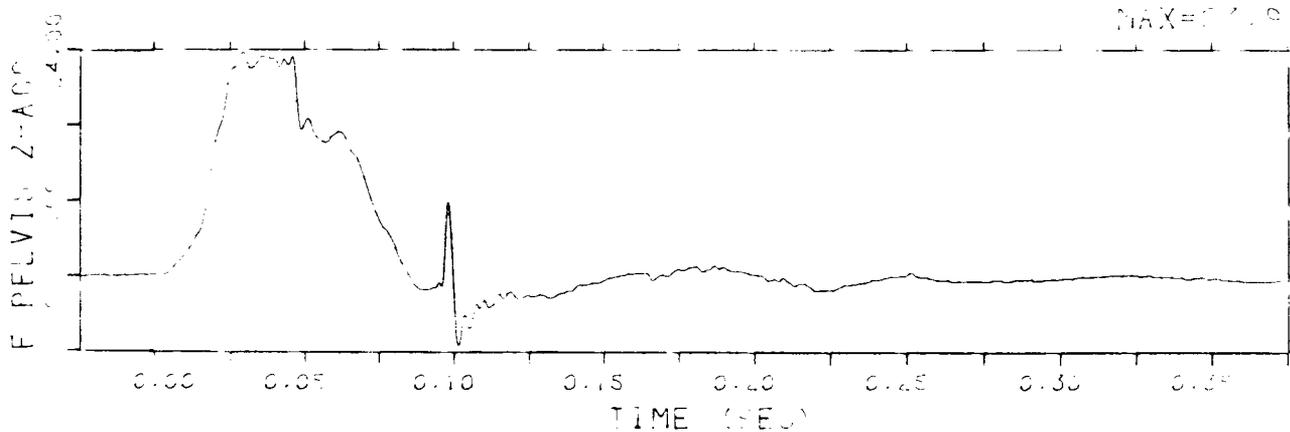
MIN=-10.0



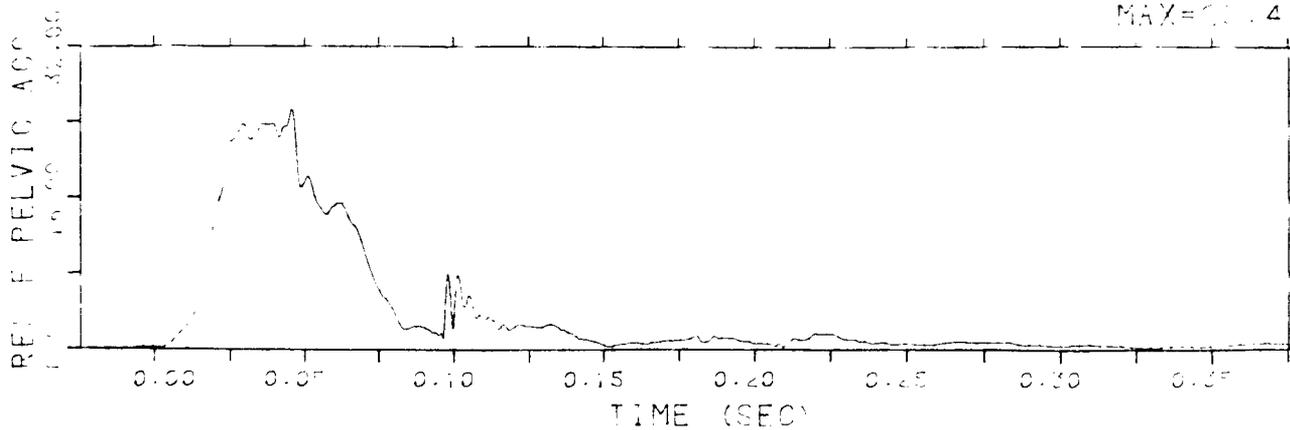
MAX=3.21



MAX=6.10

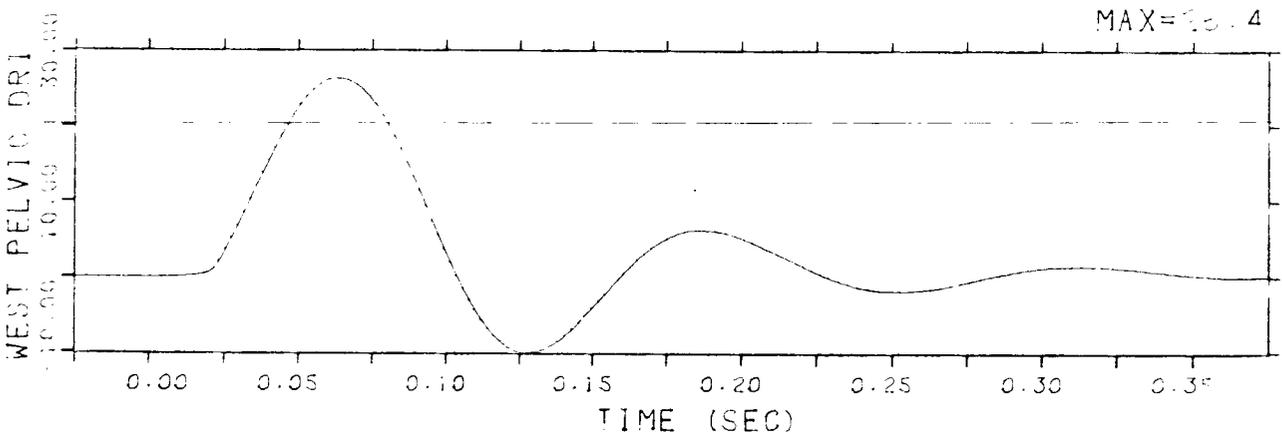
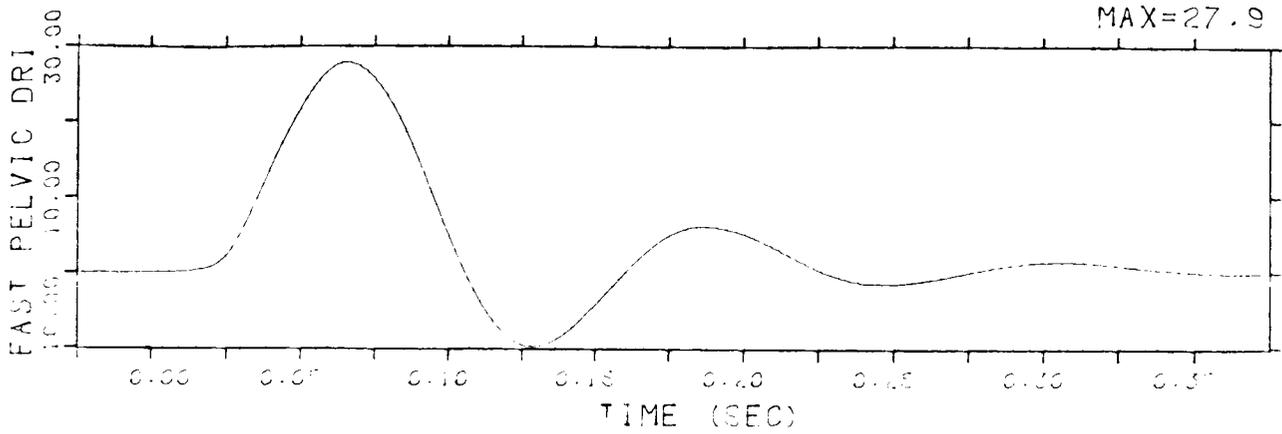


MAX=3.14



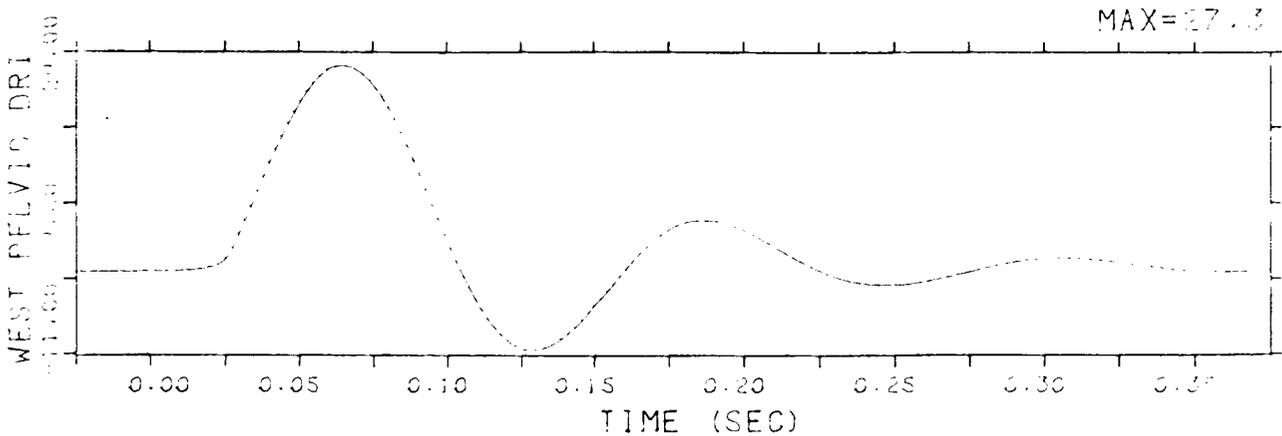
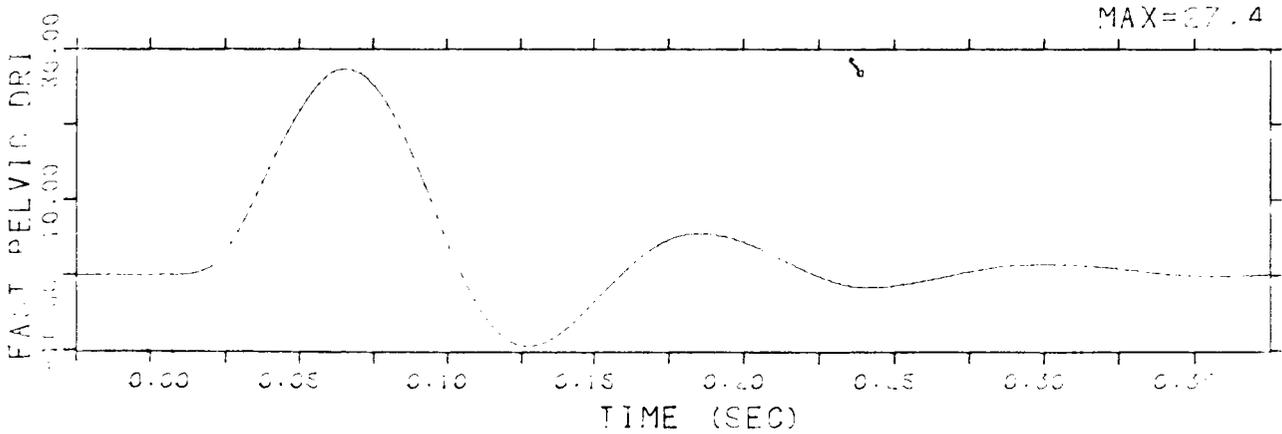
T33925

PELV DRI VALUES



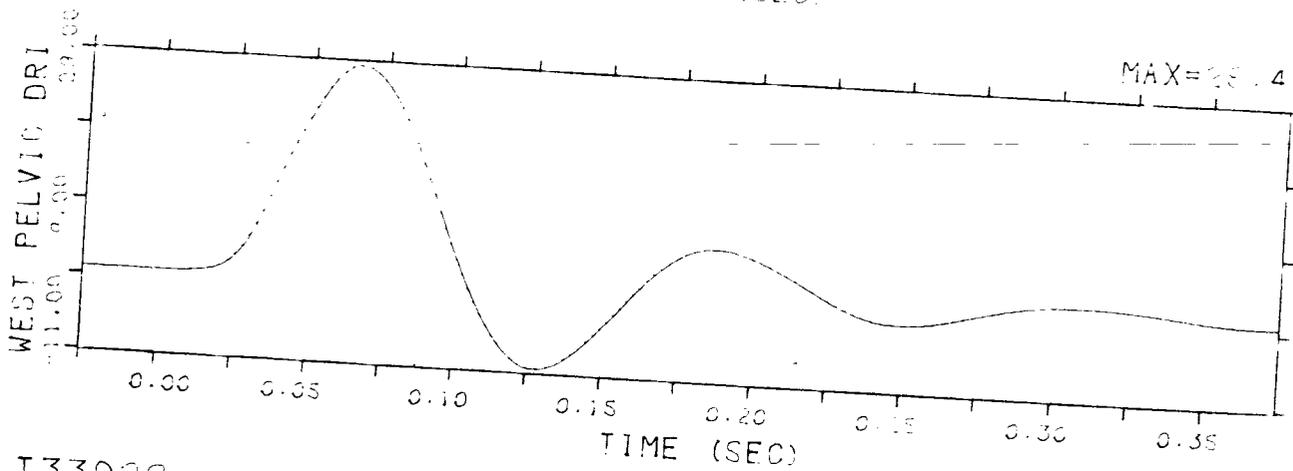
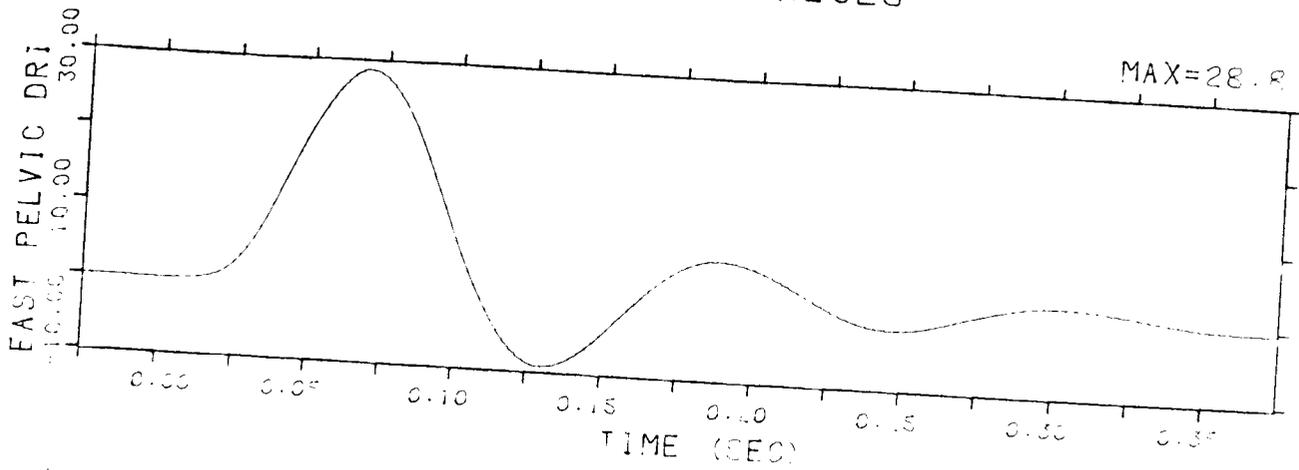
T33926

PELV DRI VALUES



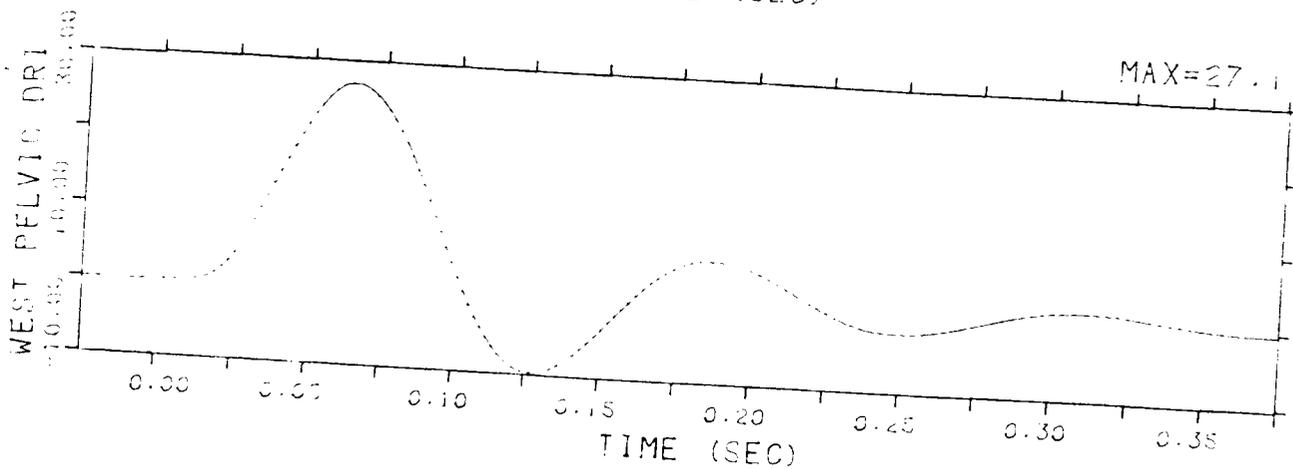
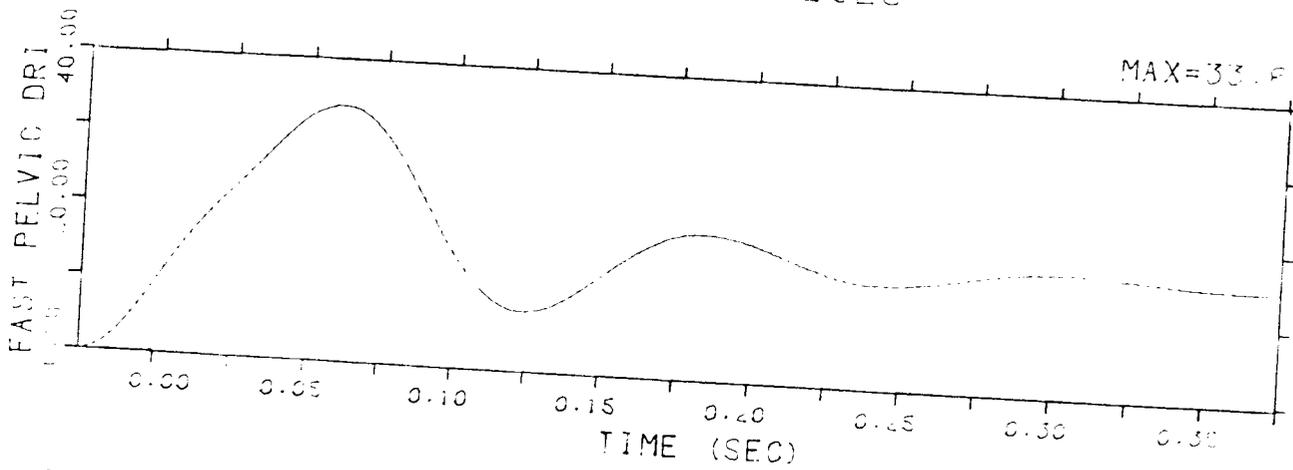
33927

PELV DRI VALUES



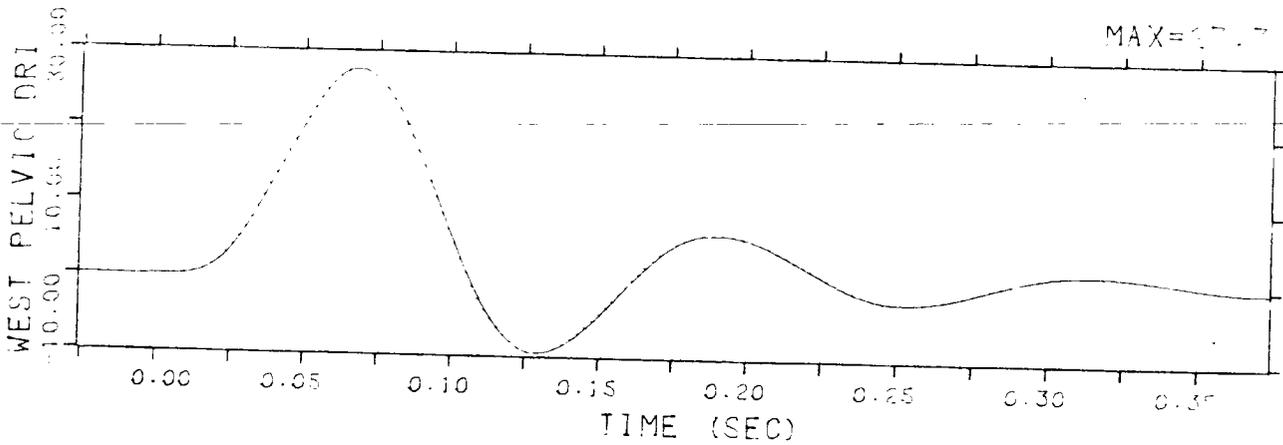
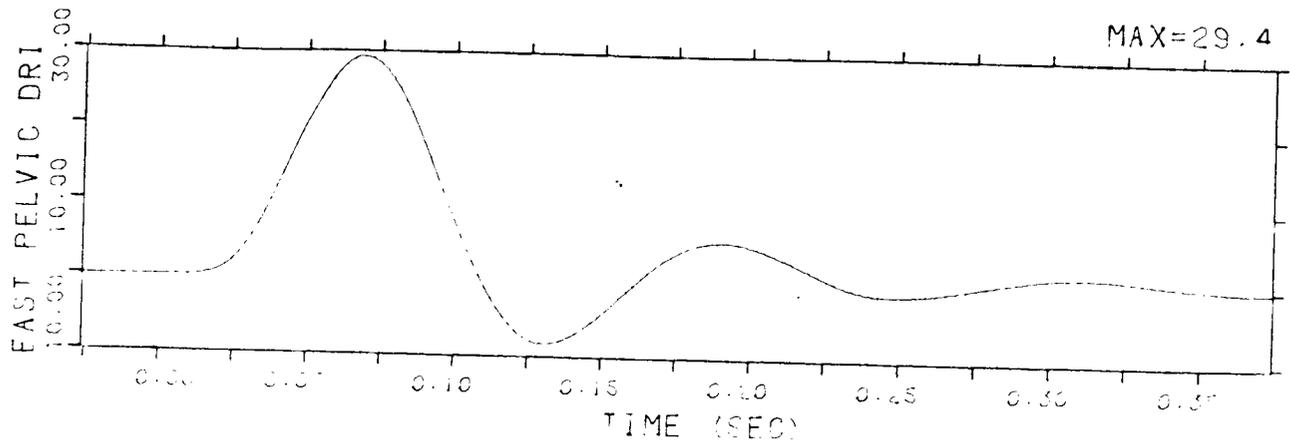
T33928

PELV DRI VALUES



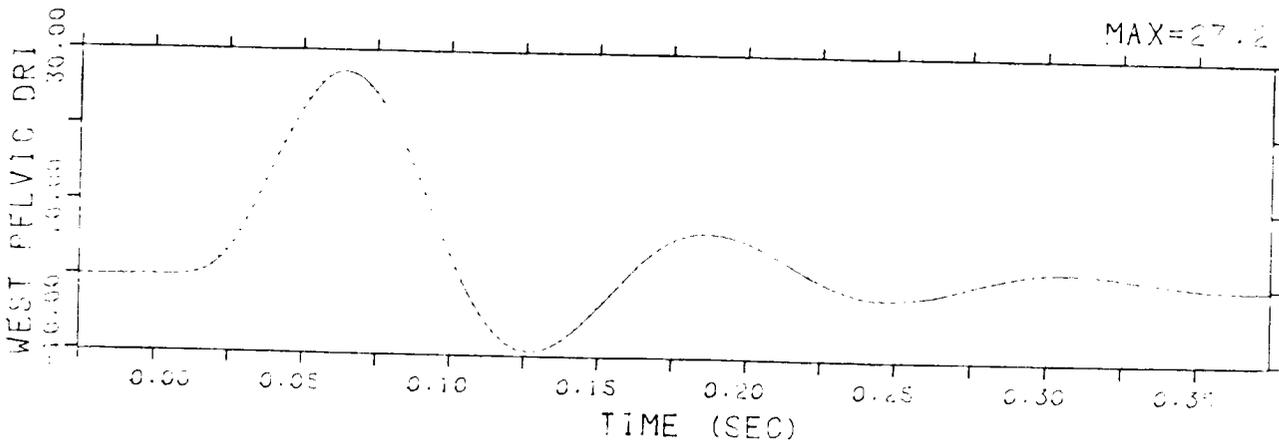
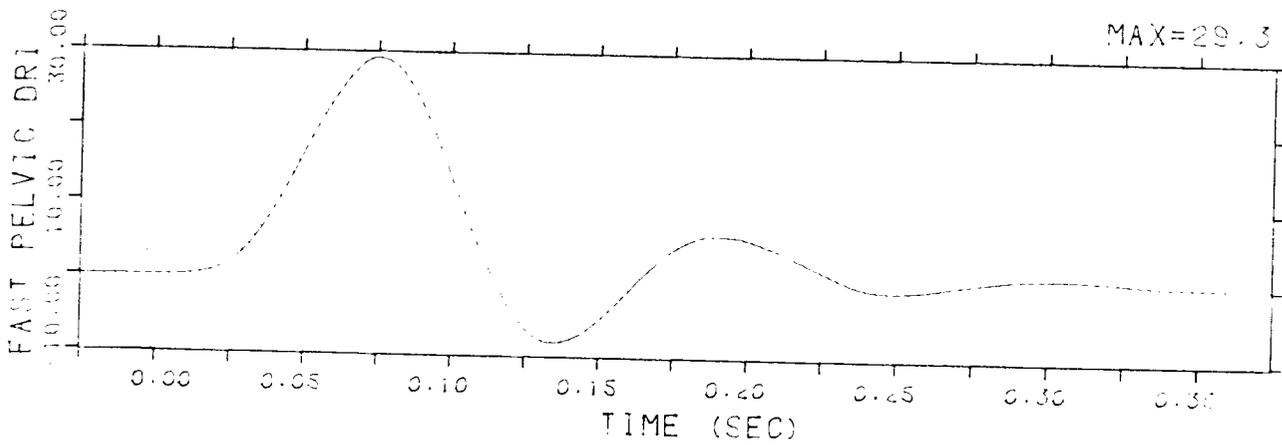
T33929

PELV DRI VALUES



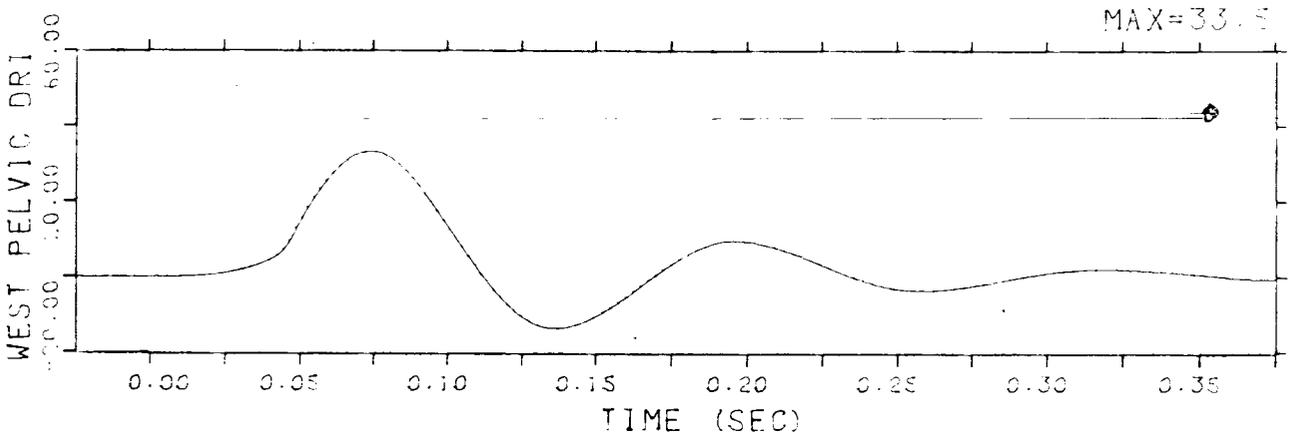
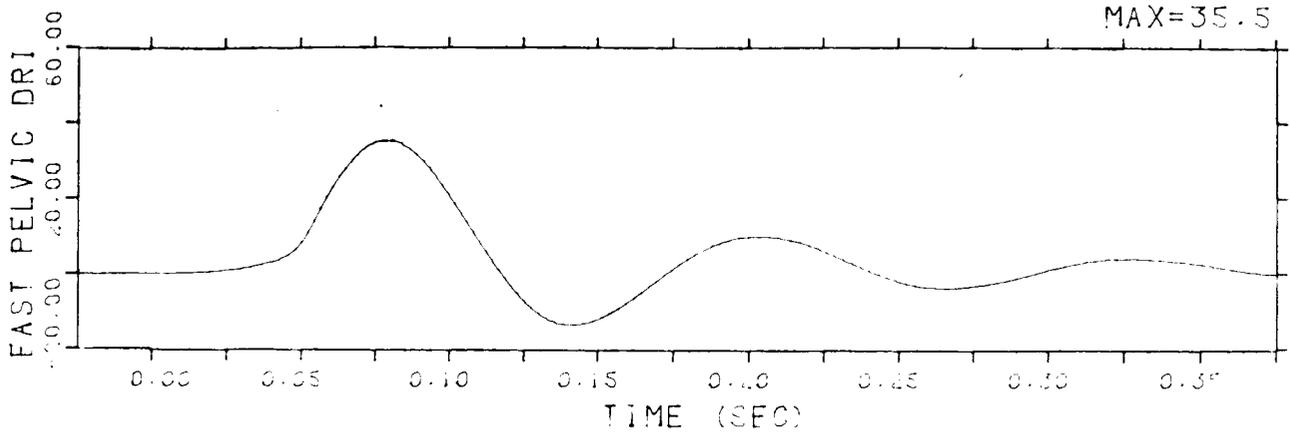
T33930

PELV DRI VALUES



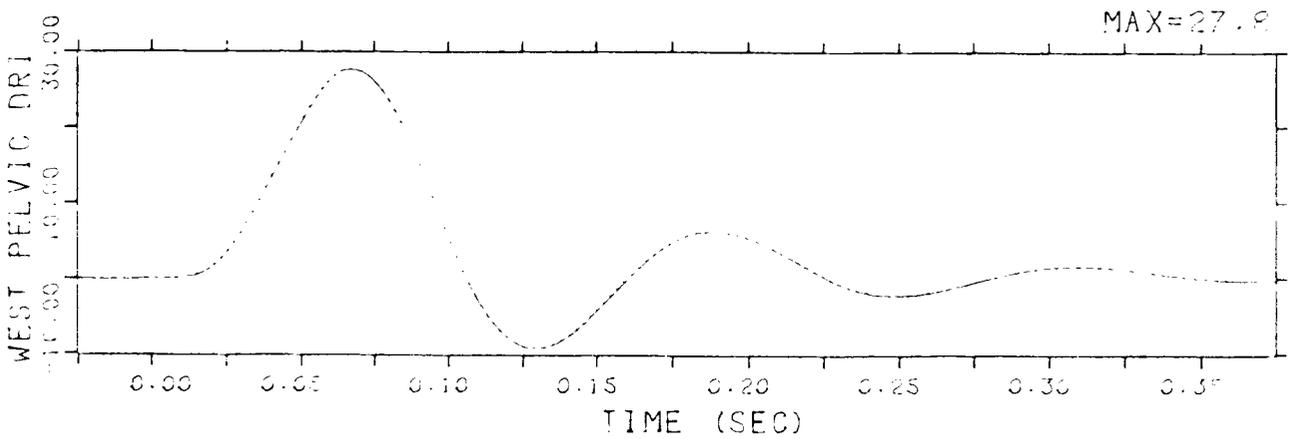
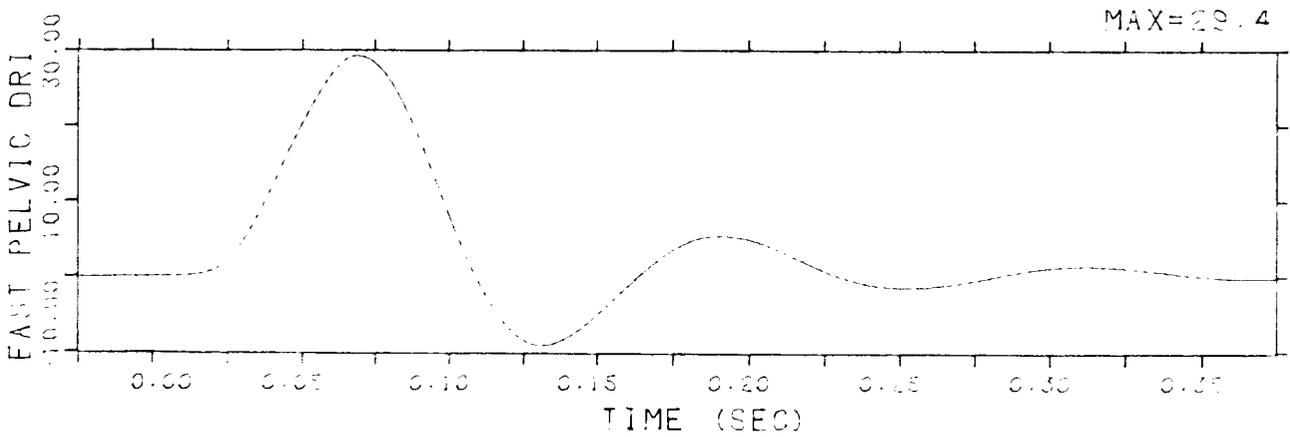
TF3931

PELV DRI VALUES



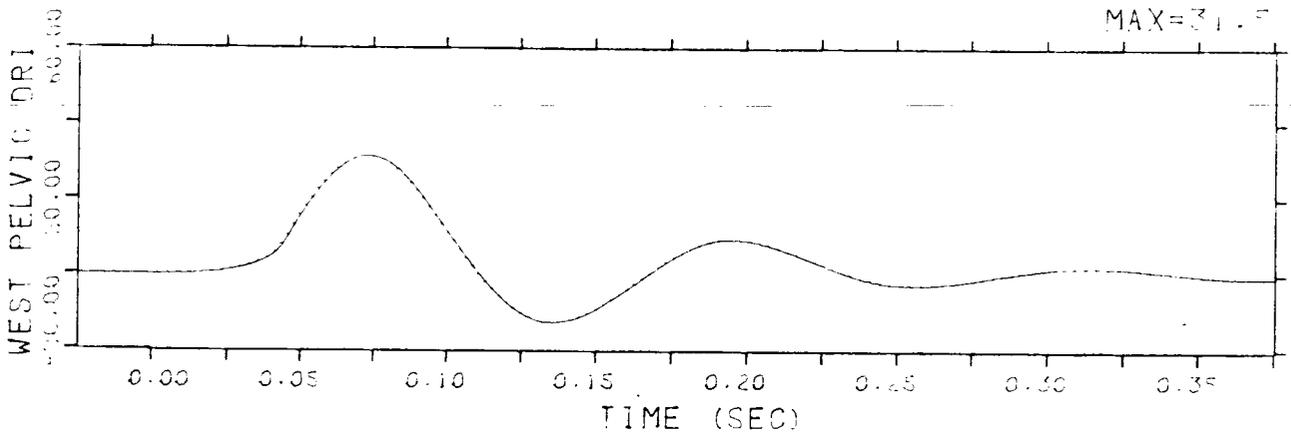
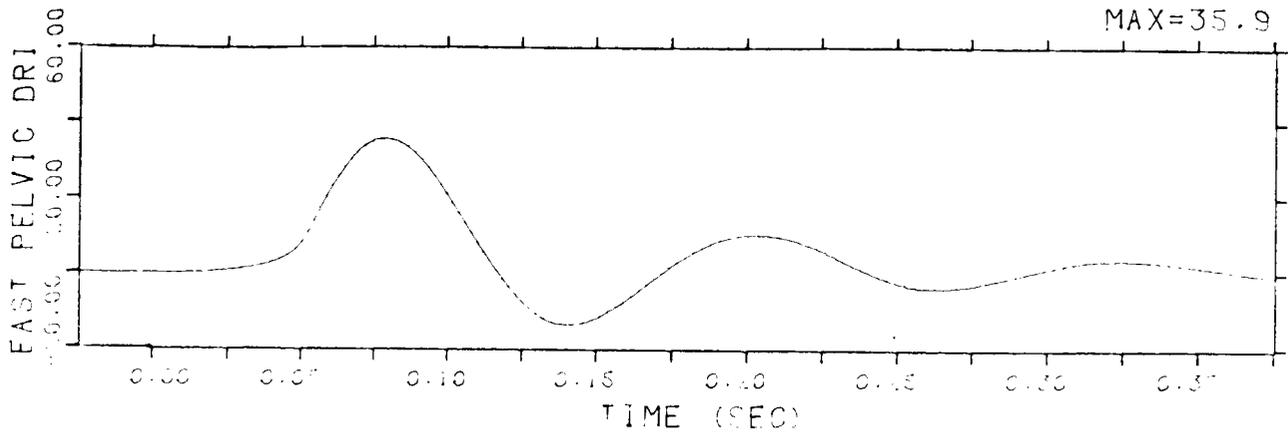
T 33932

PELV DRI VALUES



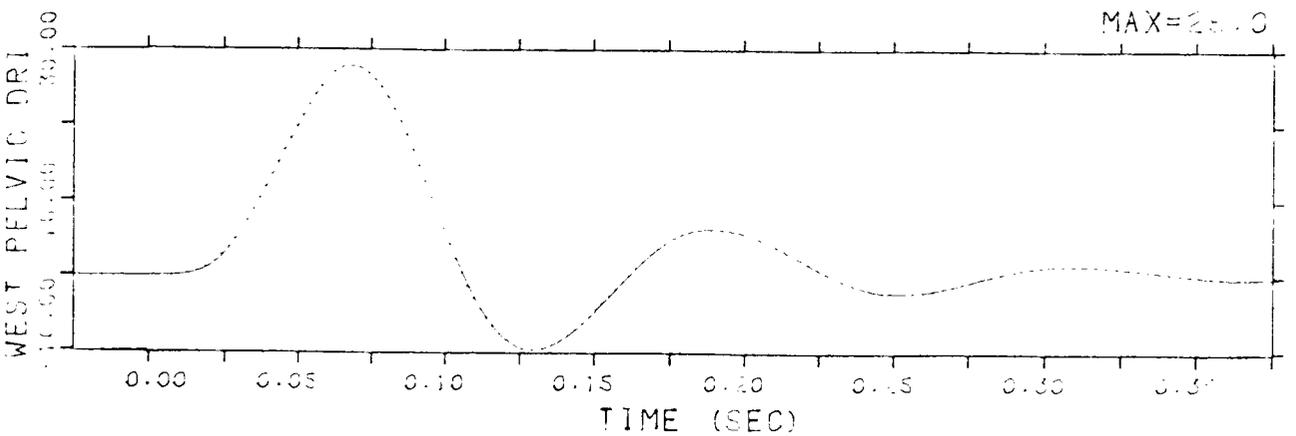
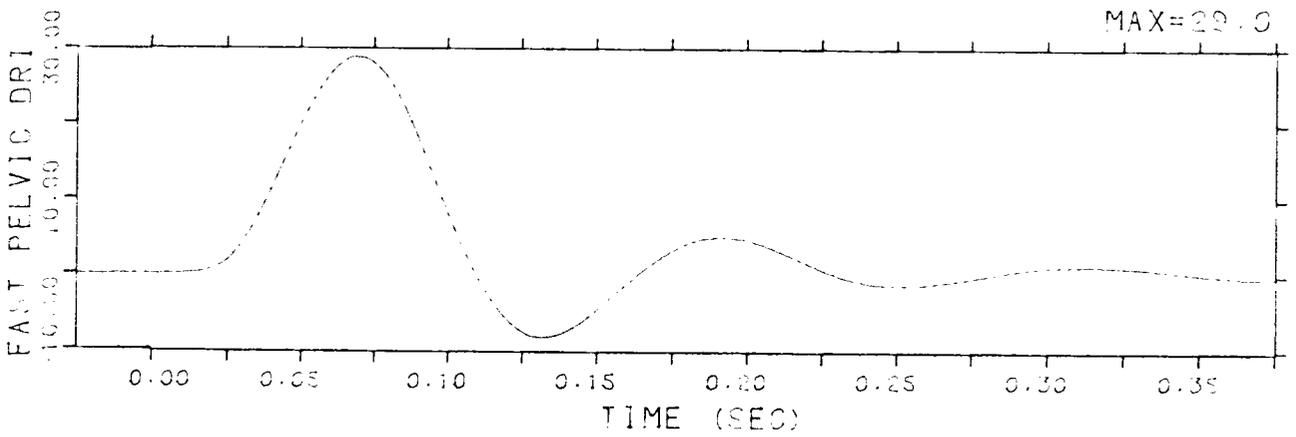
T33933

PELV DRI VALUES



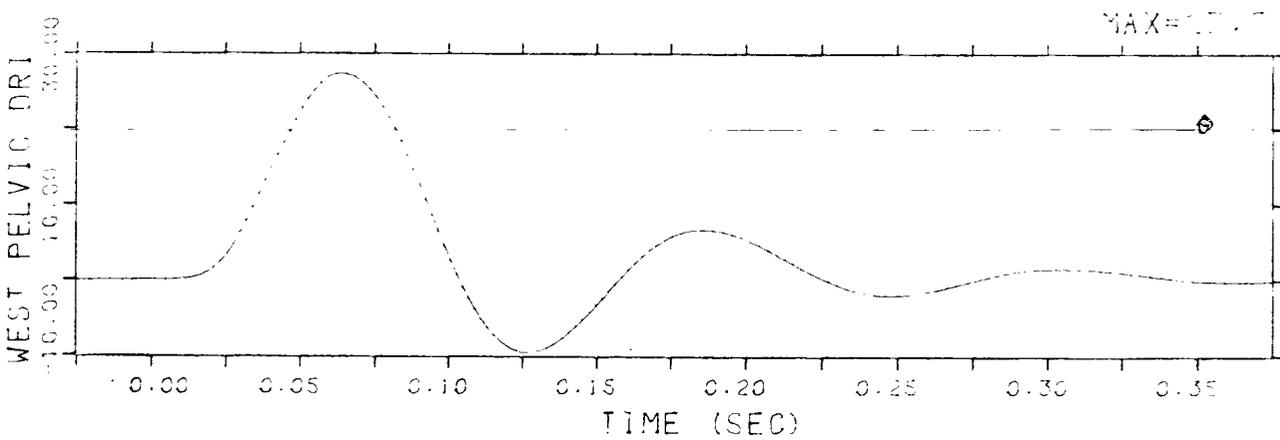
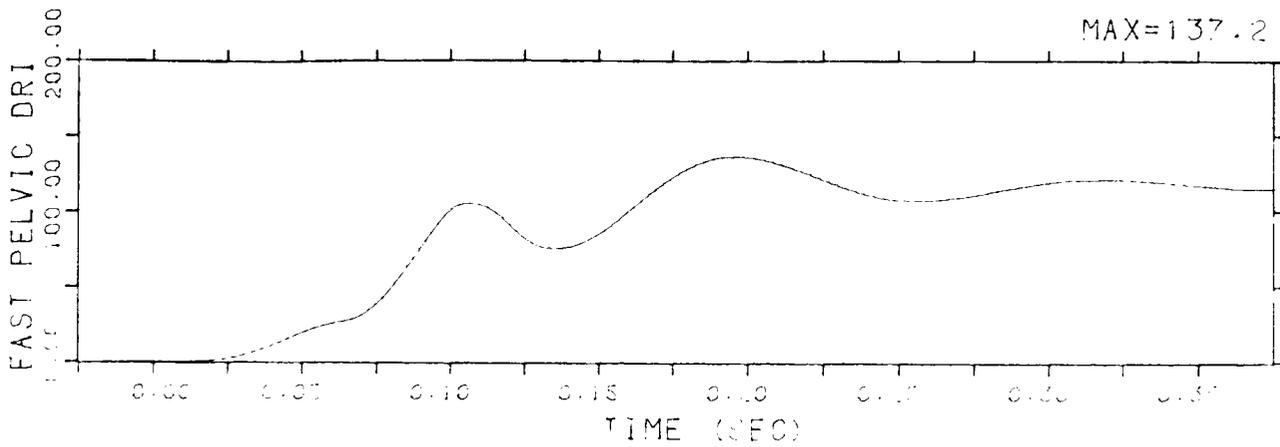
T33934

PELV DRI VALUES



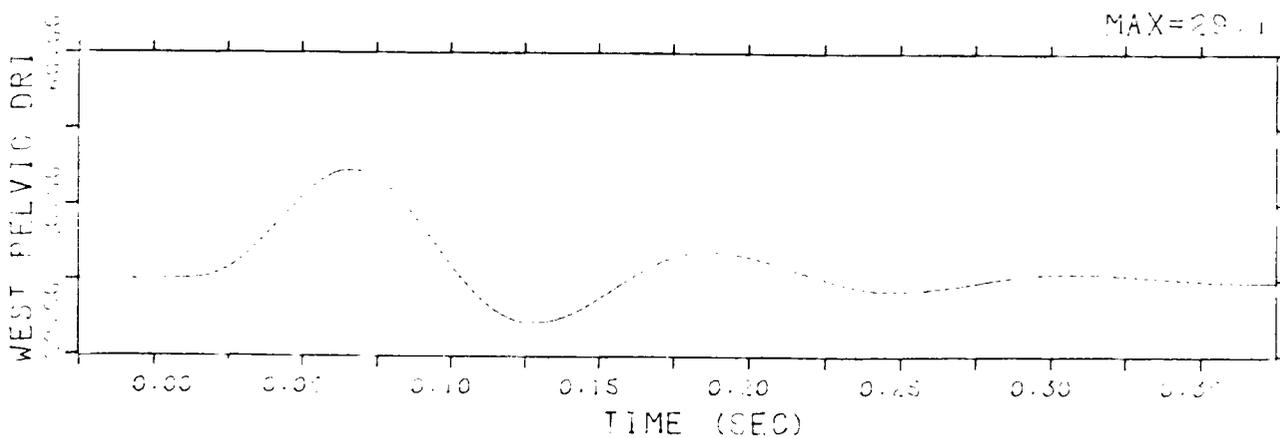
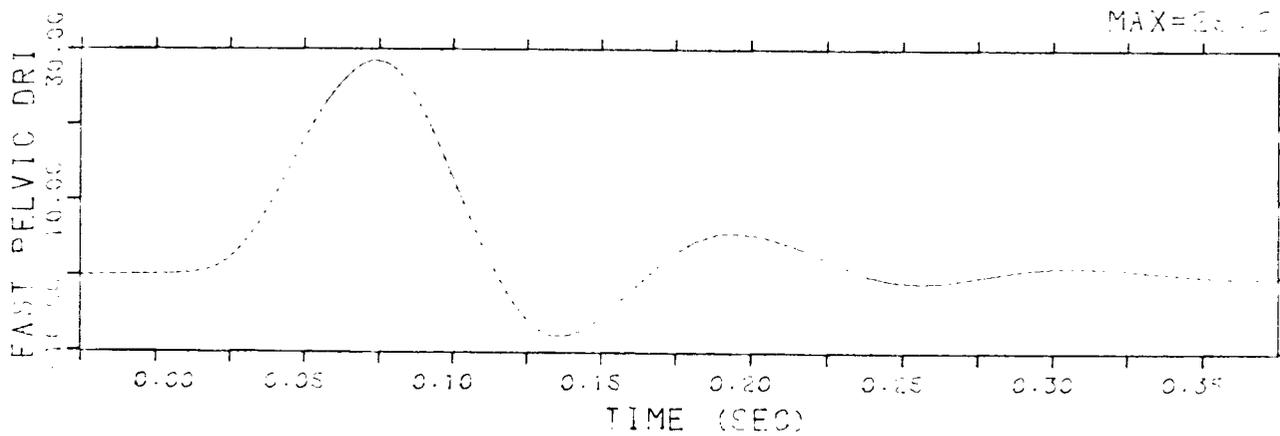
T33935

PELV DRI VALUES



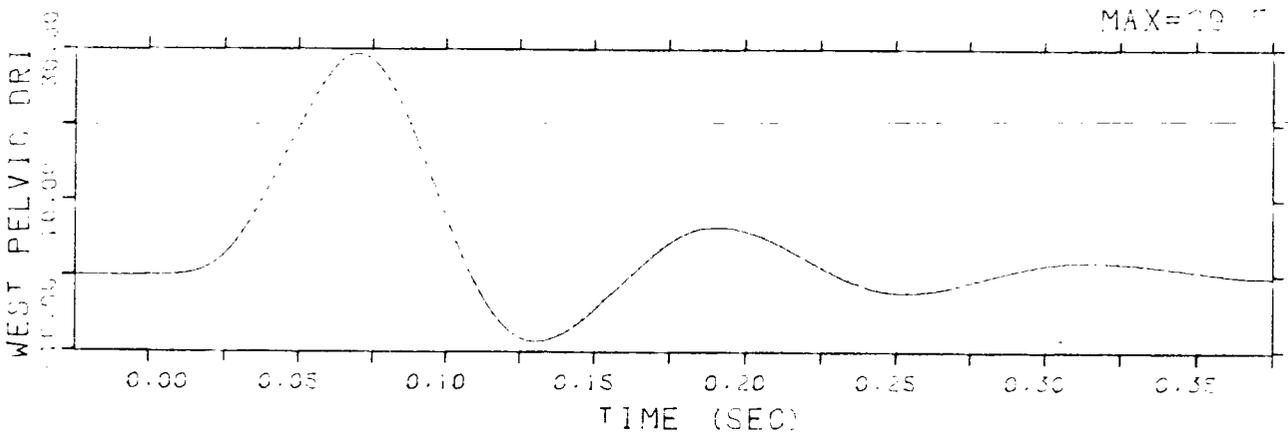
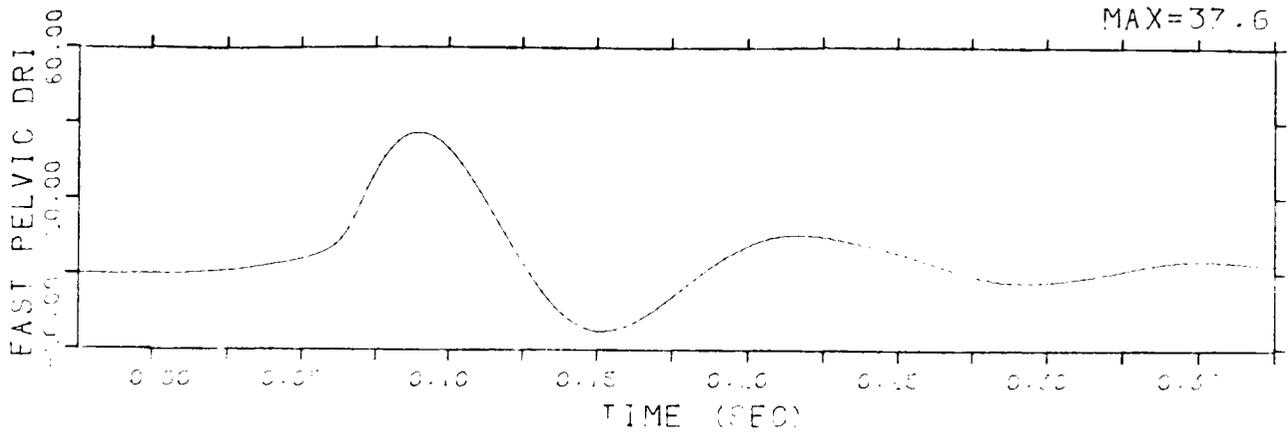
T33936

PELV DRI VALUES



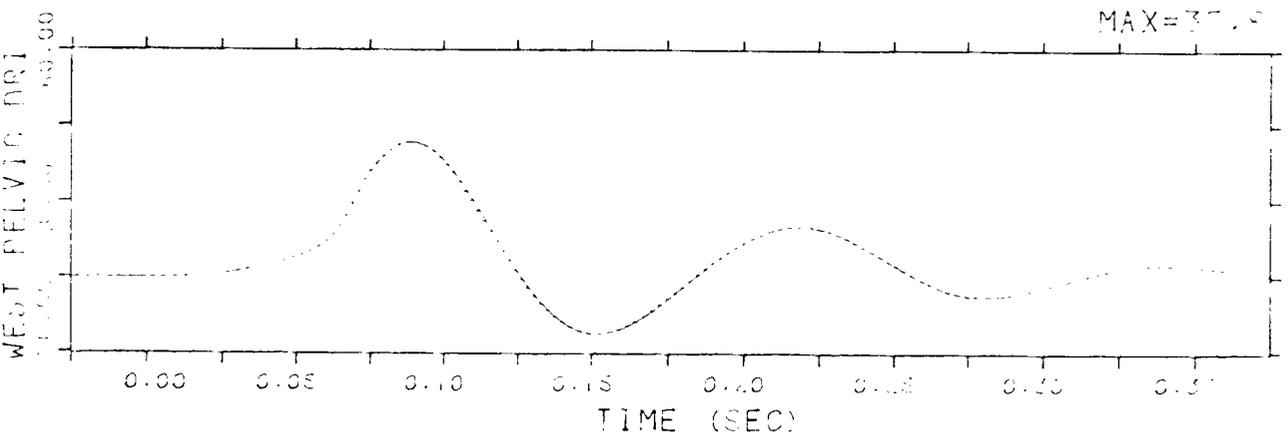
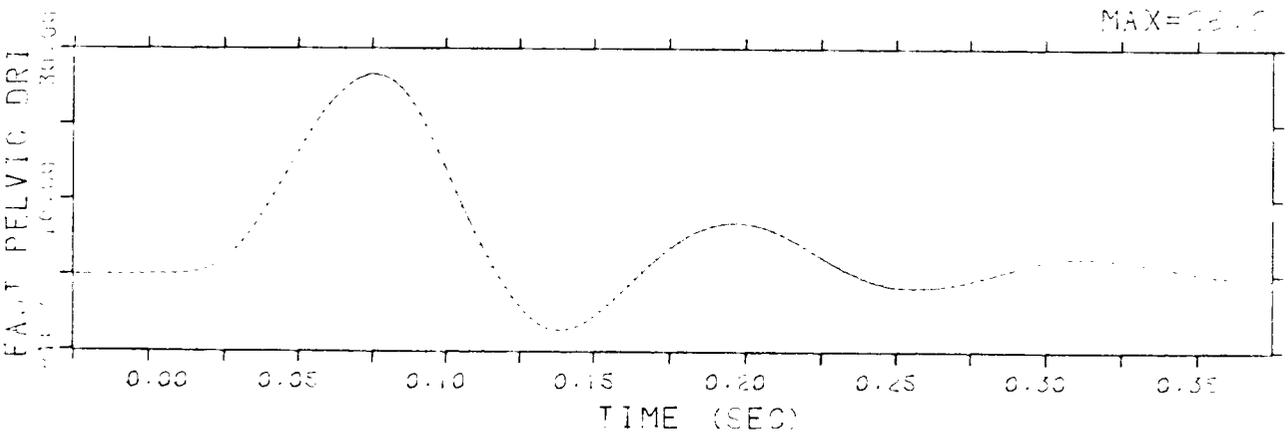
T33937

PELV DRI VALUES



T33939

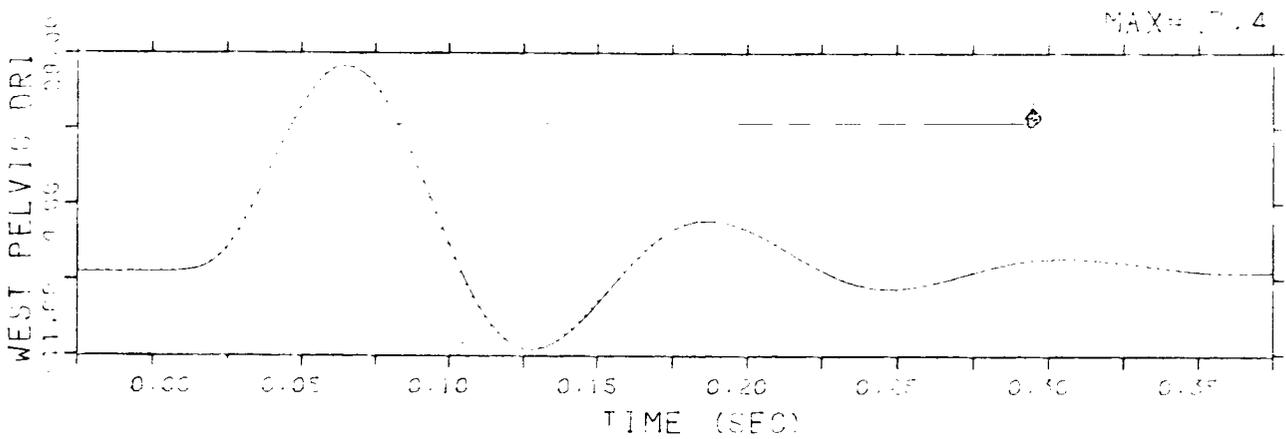
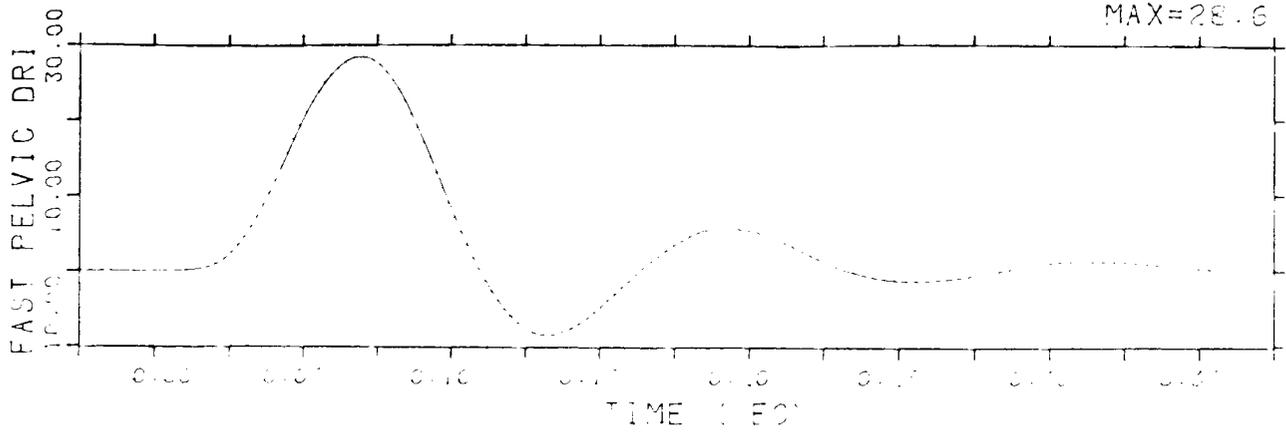
PELV DRI VALUES



T33939

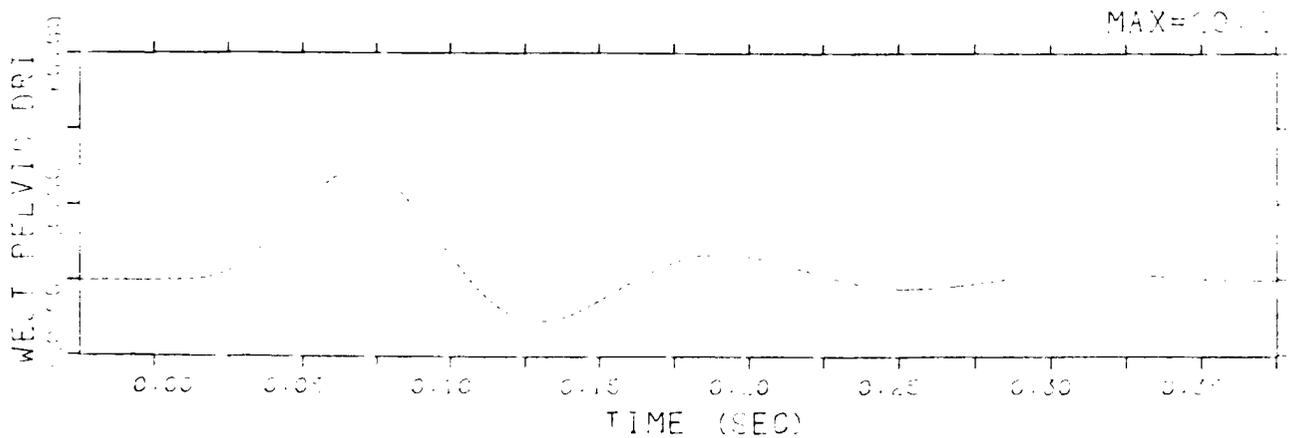
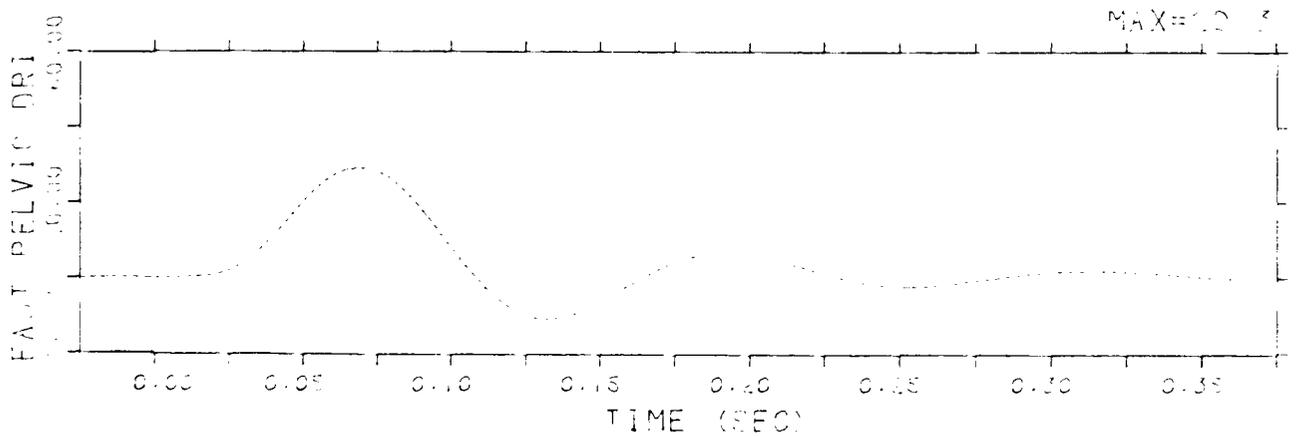
PELV DRI VALUES

246

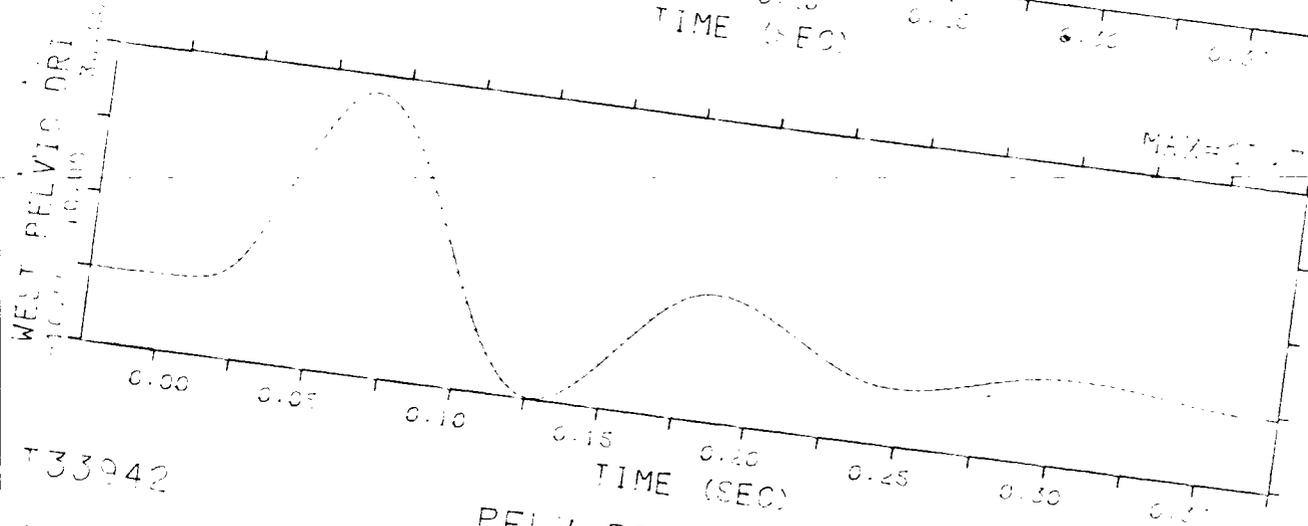
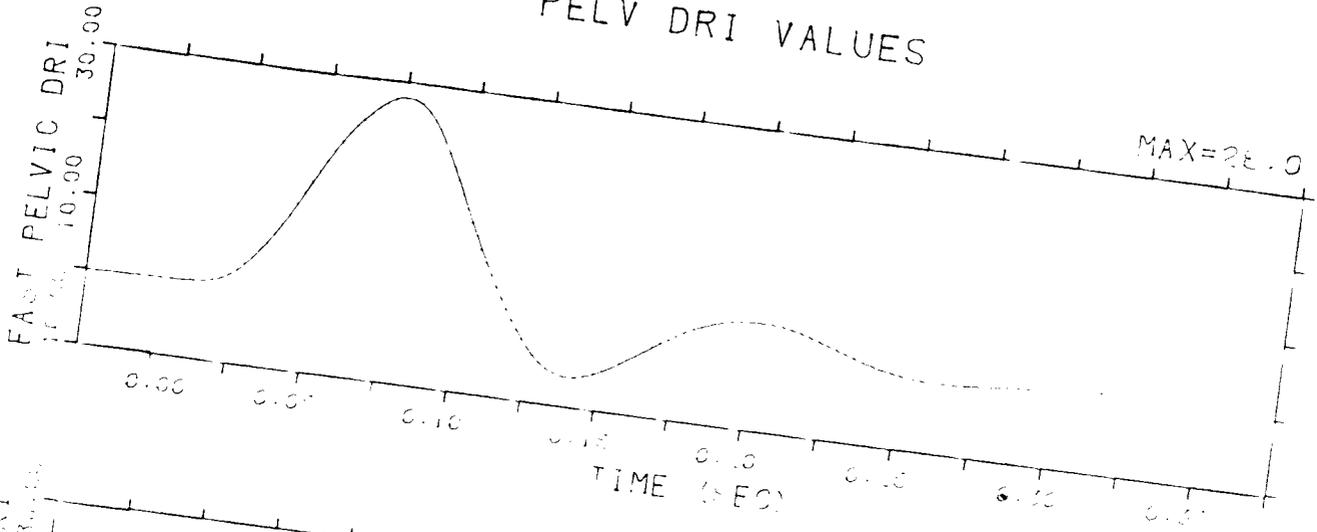


T33940

PELV DRI VALUES

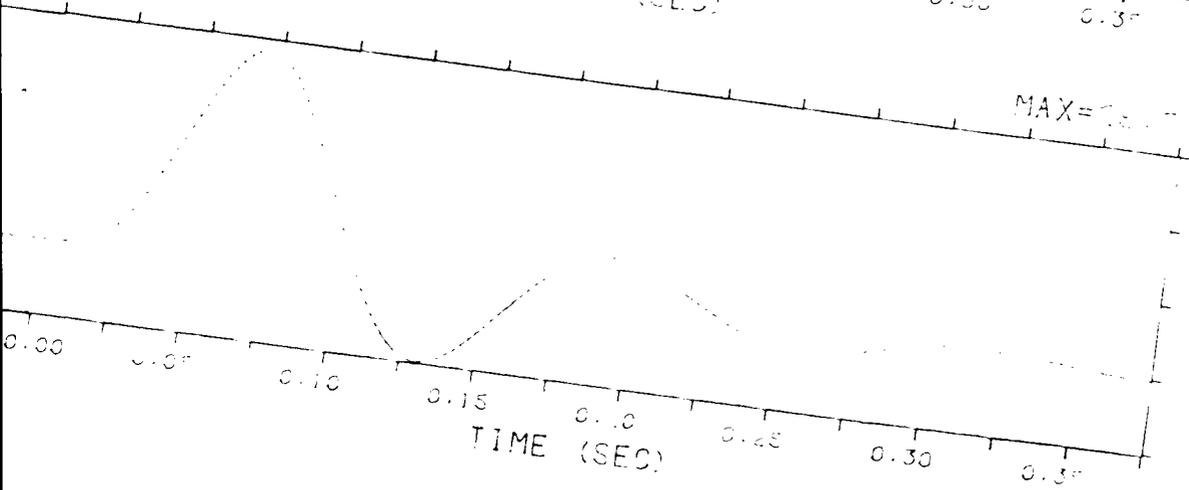
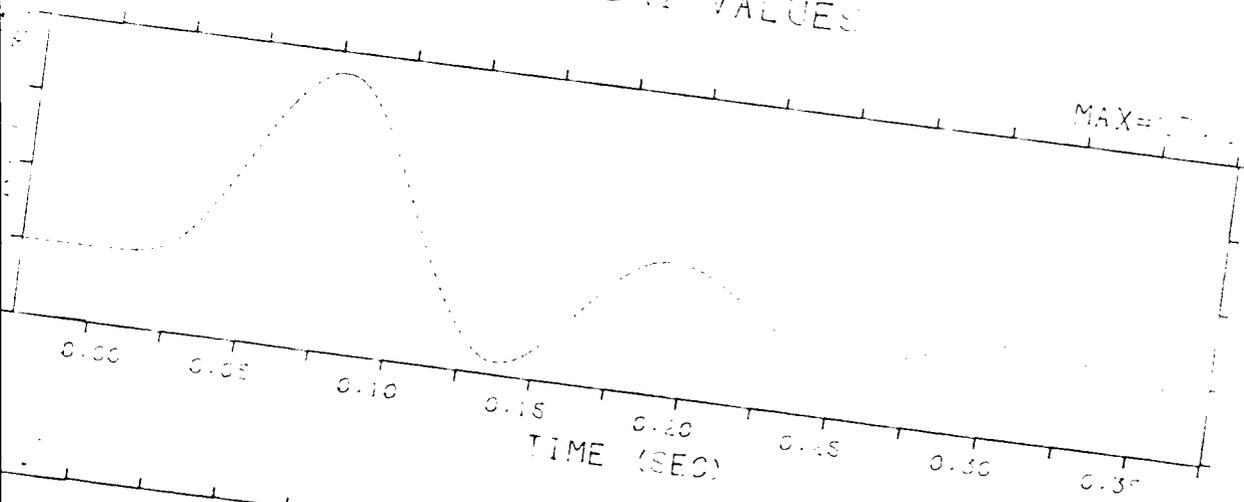


PELV DRI VALUES



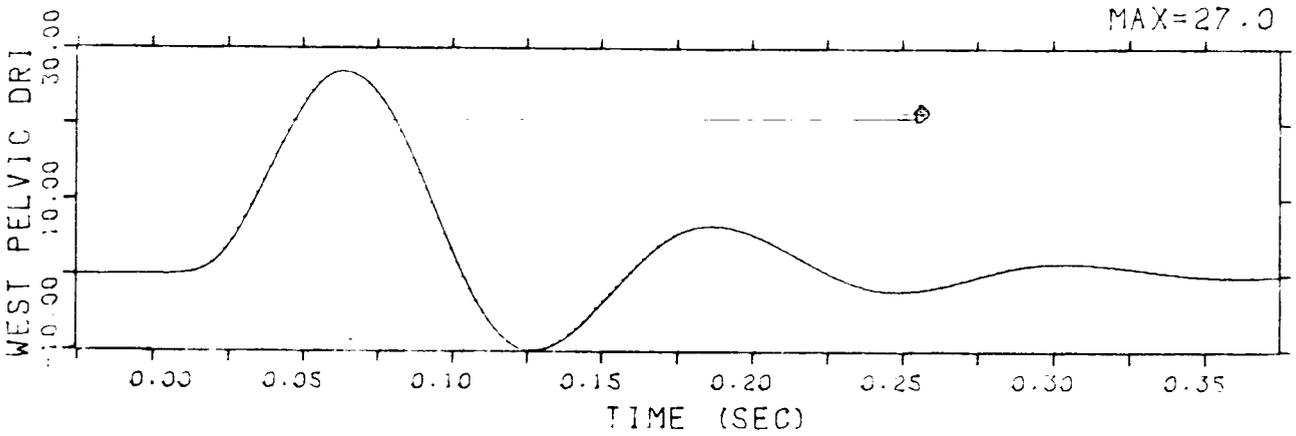
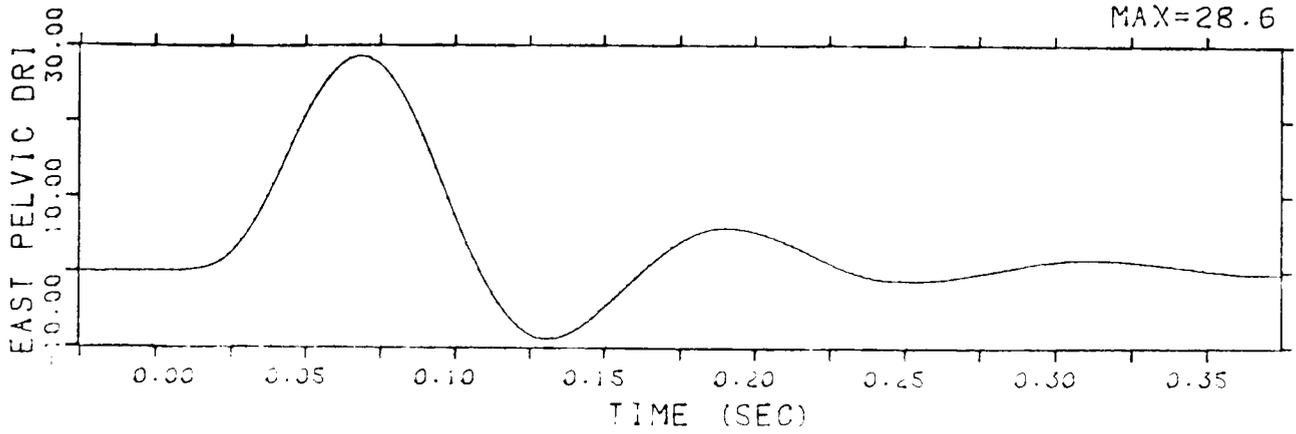
T33942

PELV DRI VALUES



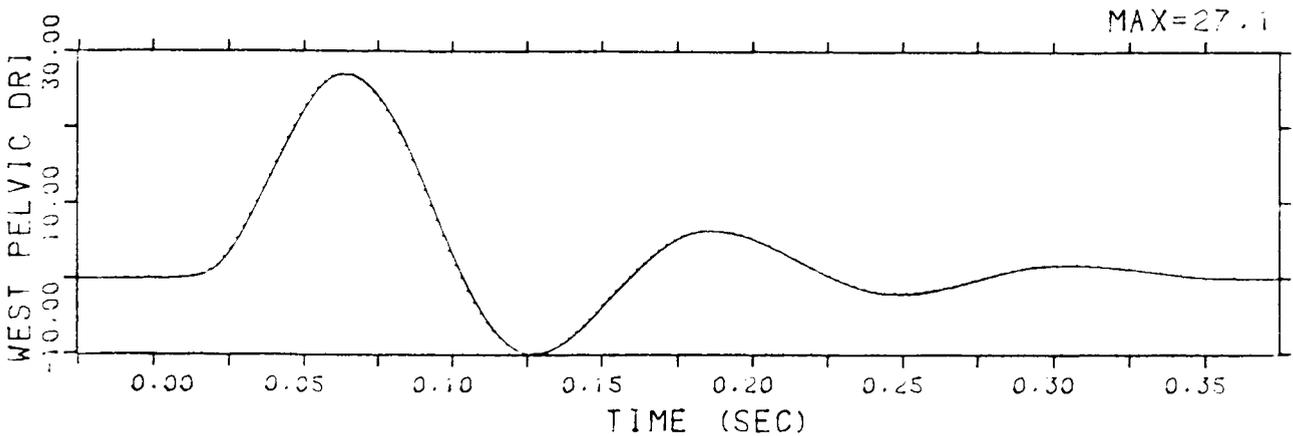
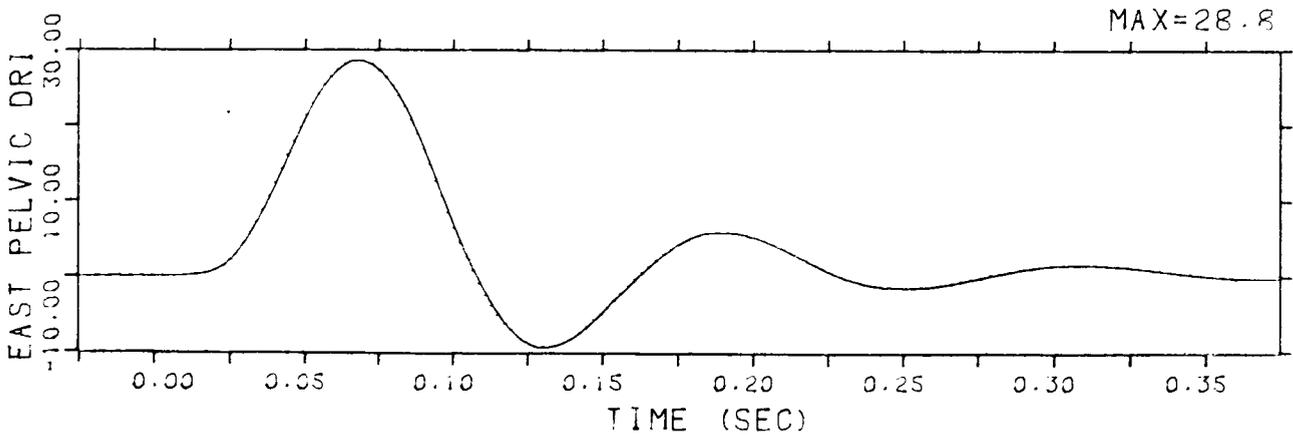
T33943

PELV DRI VALUES



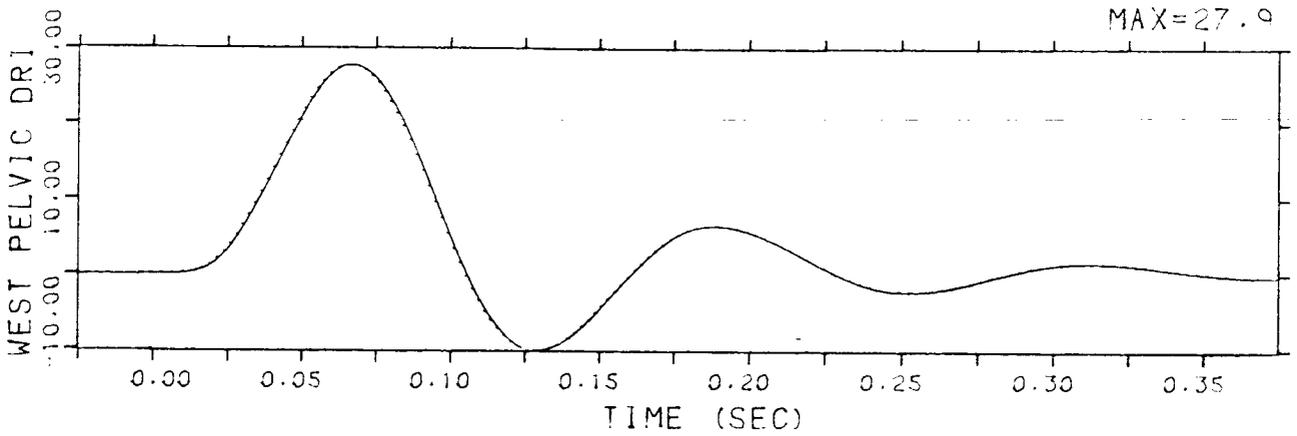
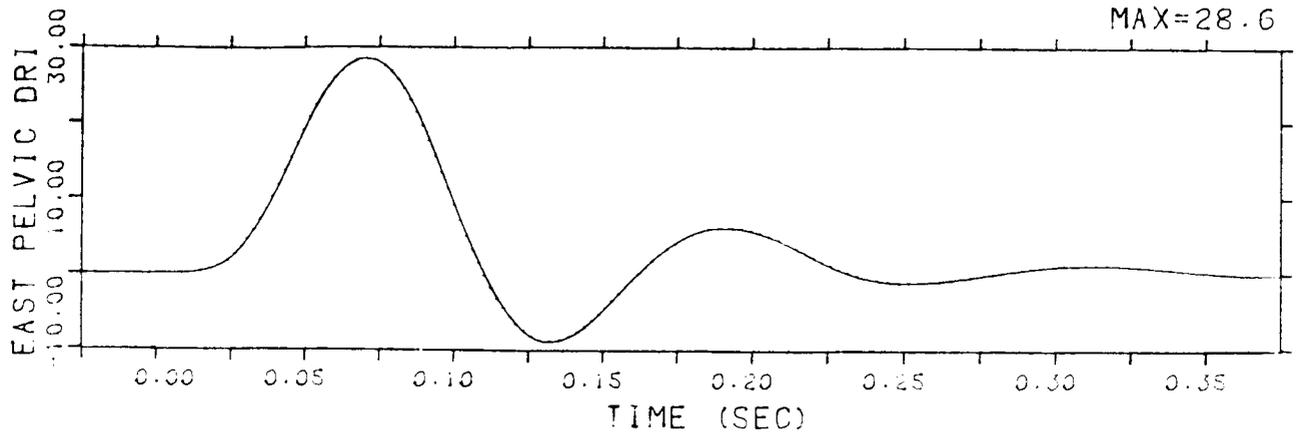
T33944

PELV DRI VALUES



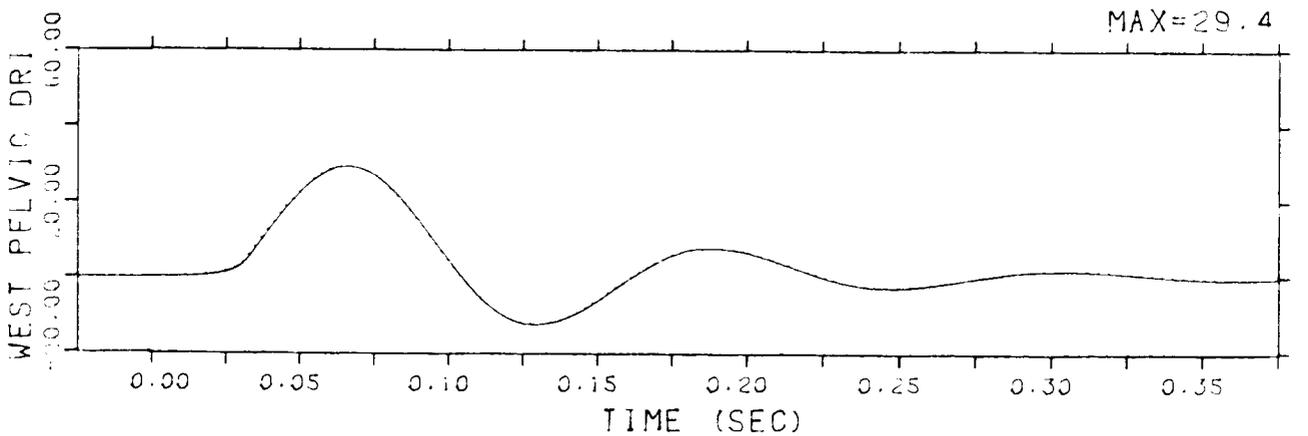
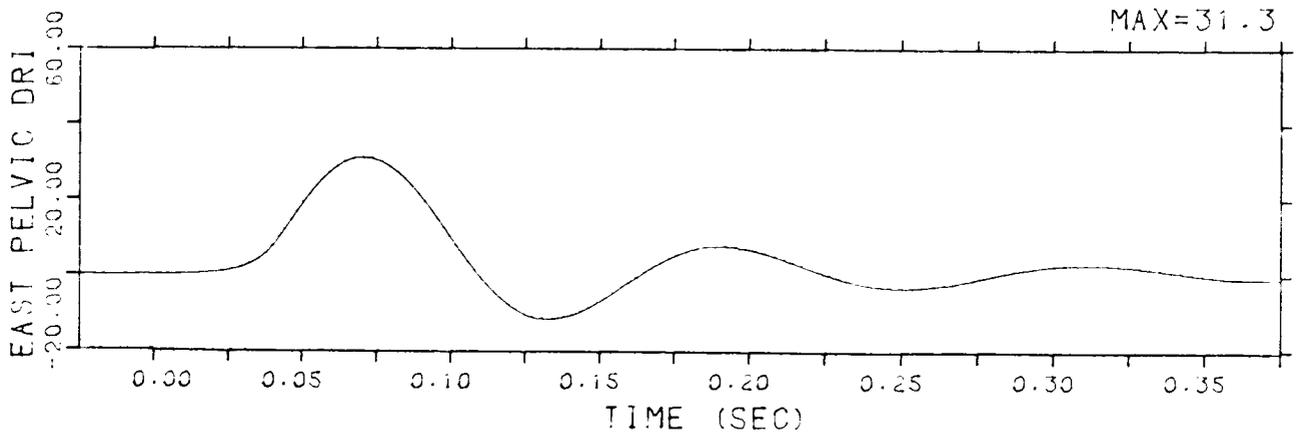
T33945

PELV DRI VALUES



T33946

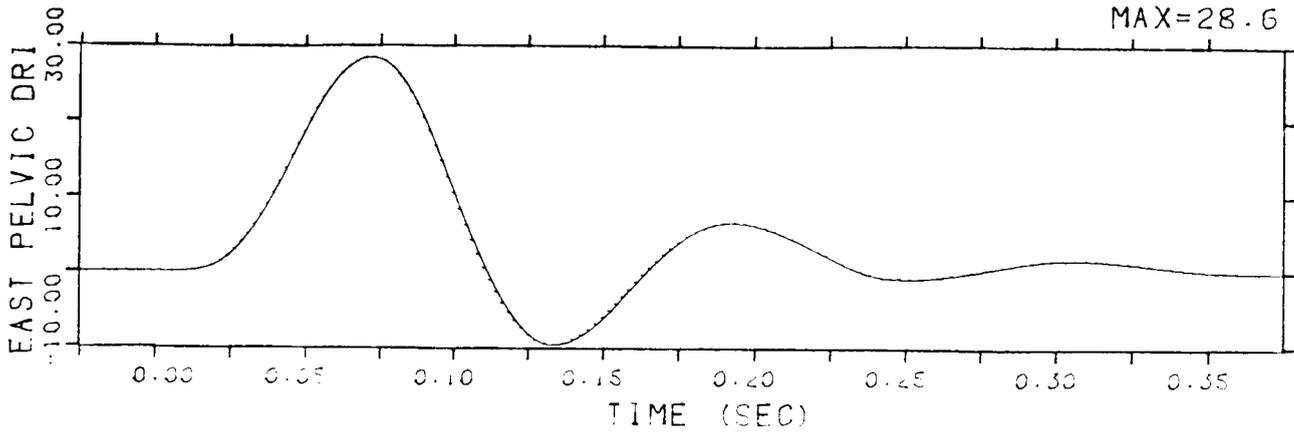
PELV DRI VALUES



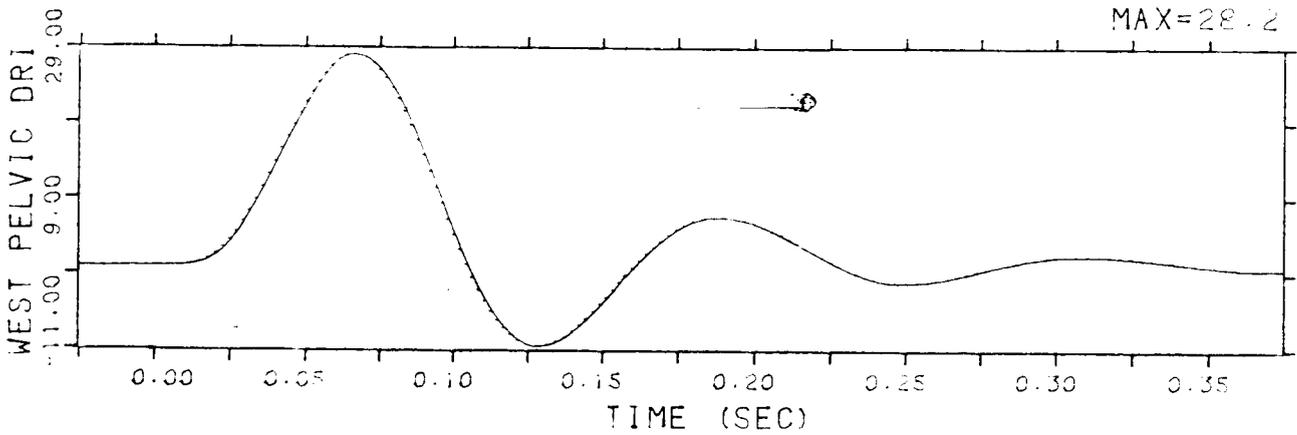
T33947

PELV DRI VALUES

MAX=28.6



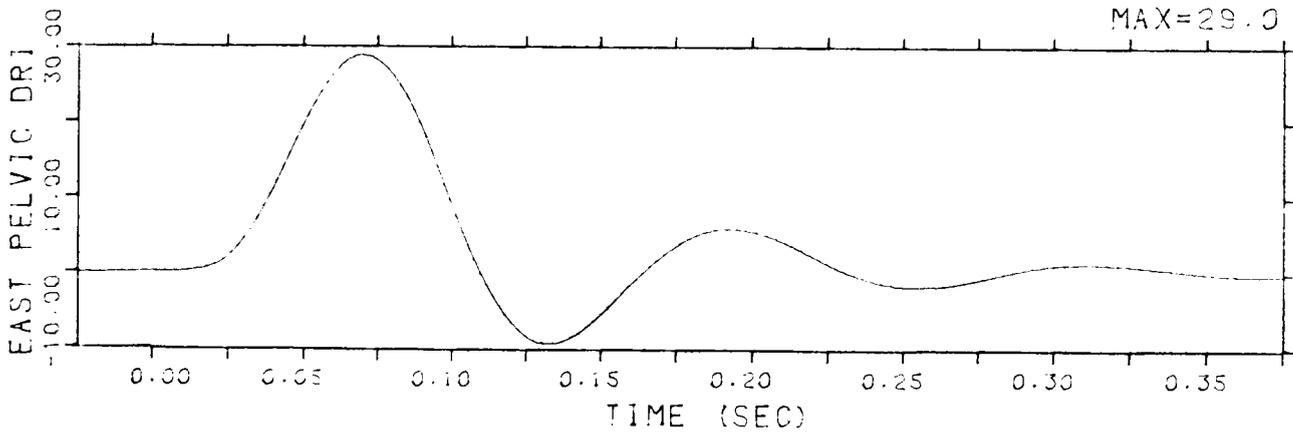
MAX=28.2



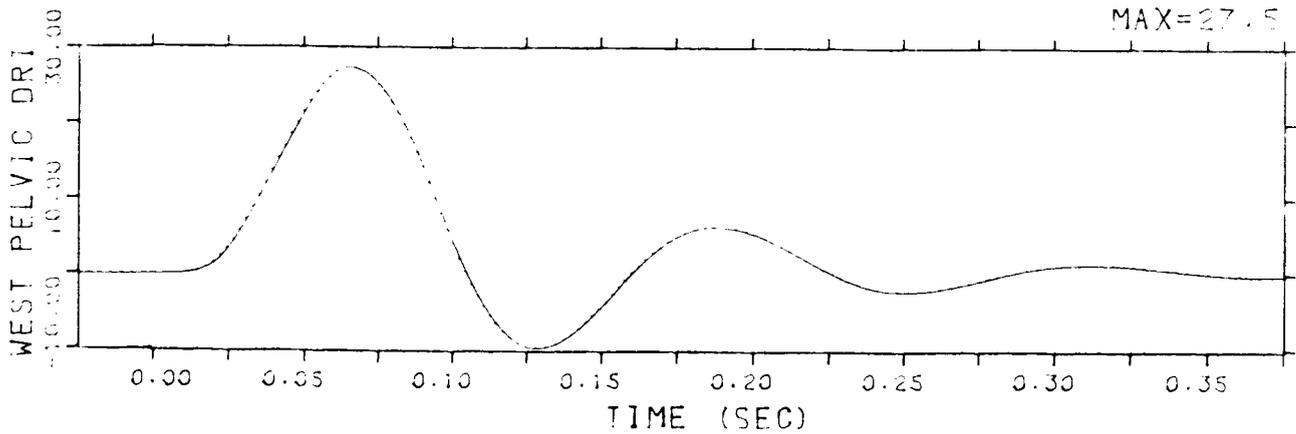
T33948

PELV DRI VALUES

MAX=29.0



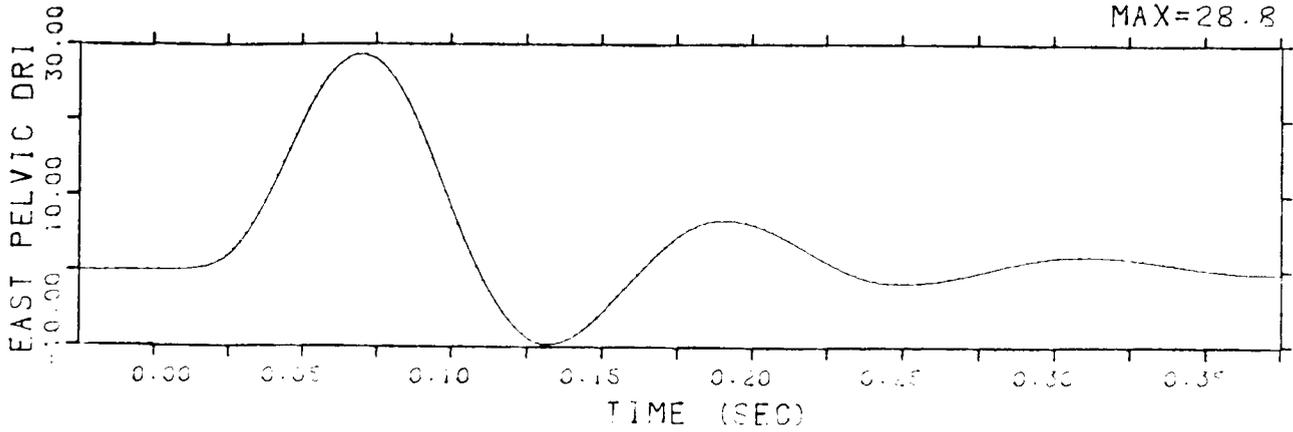
MAX=27.5



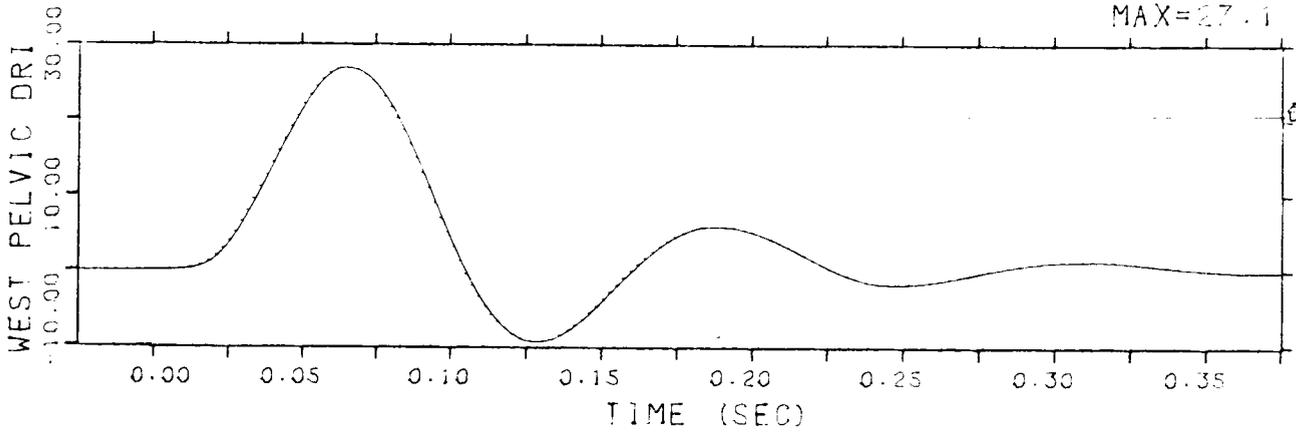
T33949

PELV DRI VALUES

MAX=28.8



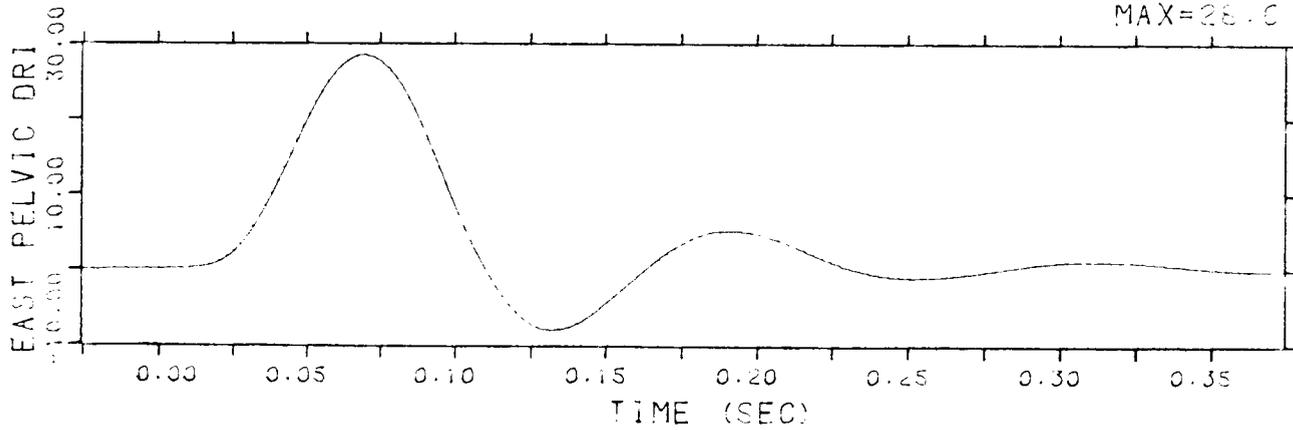
MAX=27.1



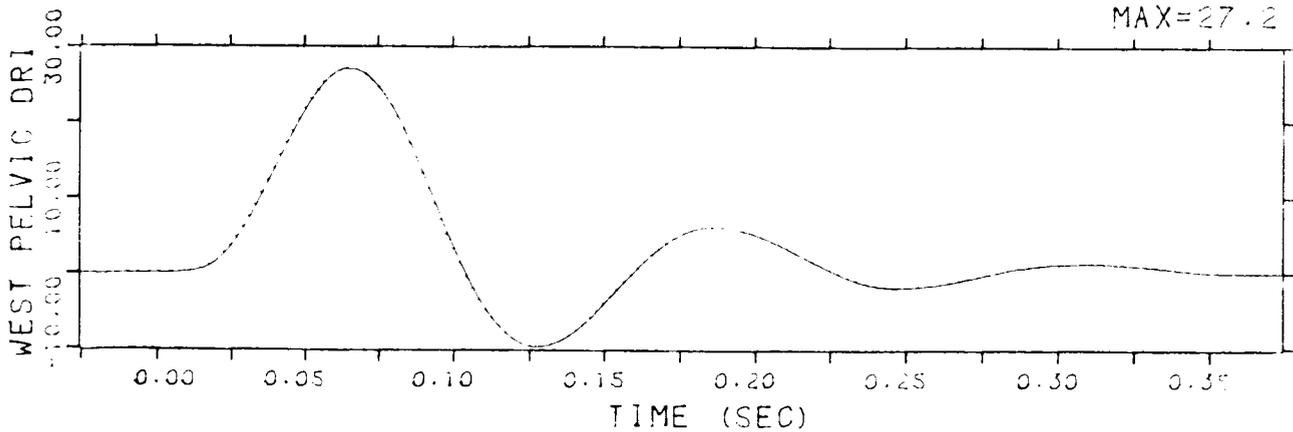
T33950

PELV DRI VALUES

MAX=28.0



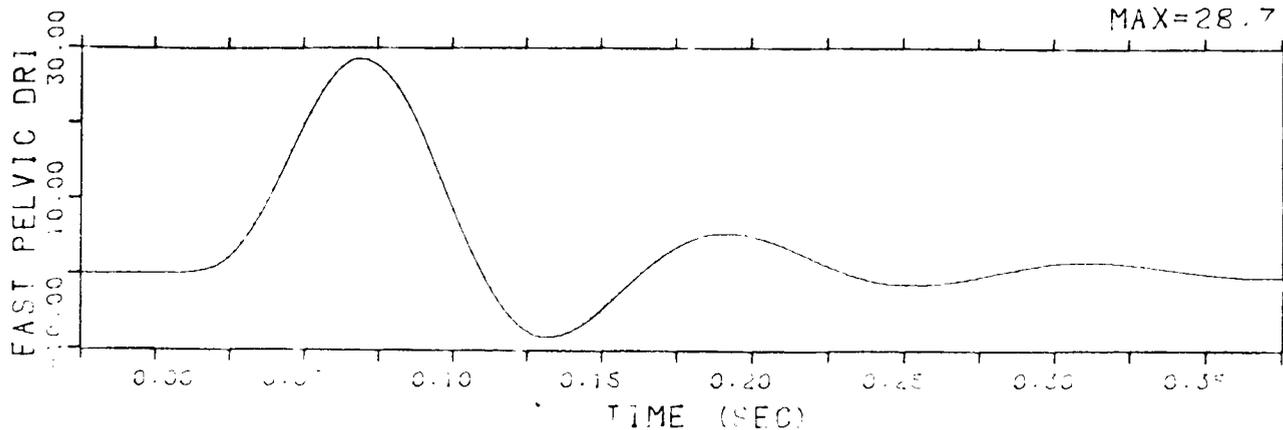
MAX=27.2



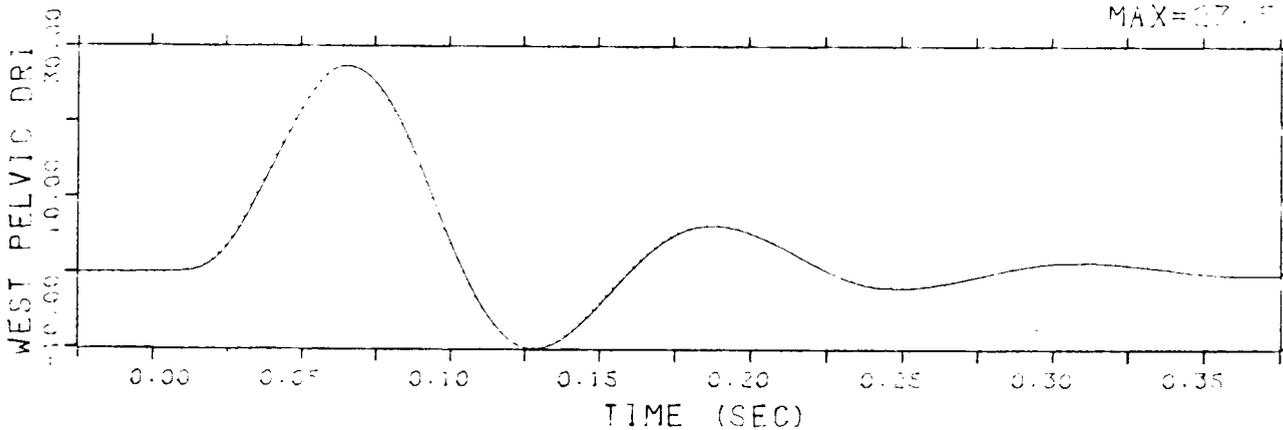
T33951

PELV DRI VALUES

MAX=28.7



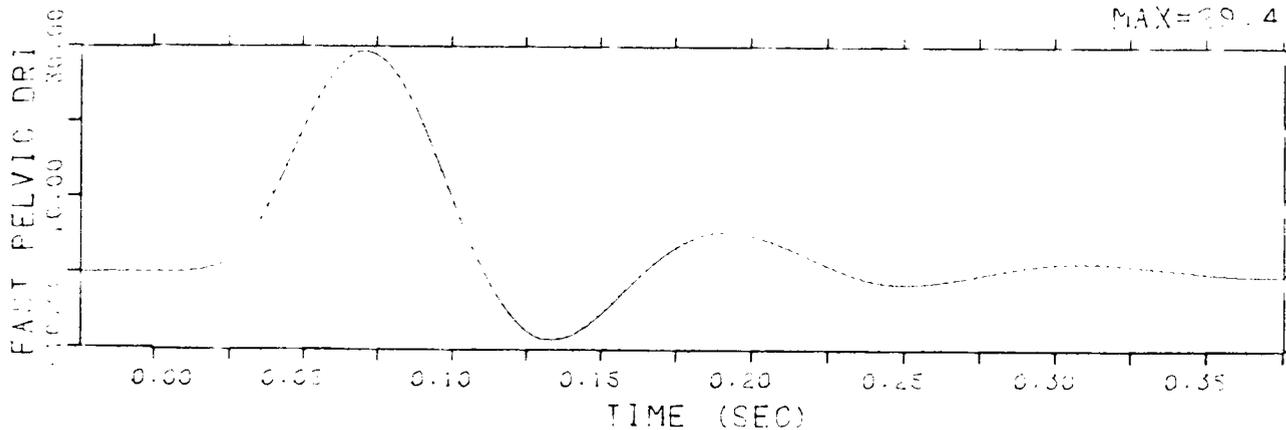
MAX=27.7



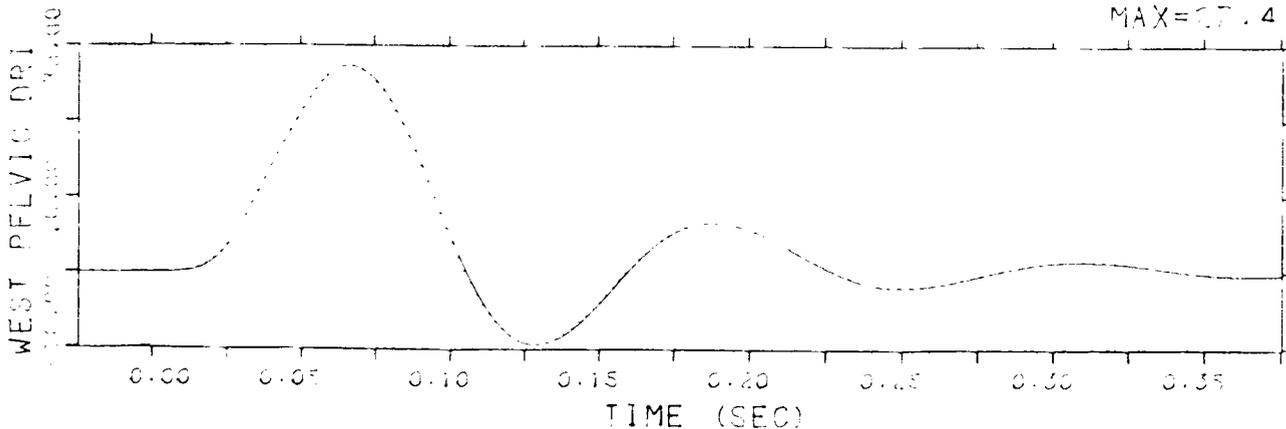
T33952

PELV DRI VALUES

MAX=29.4



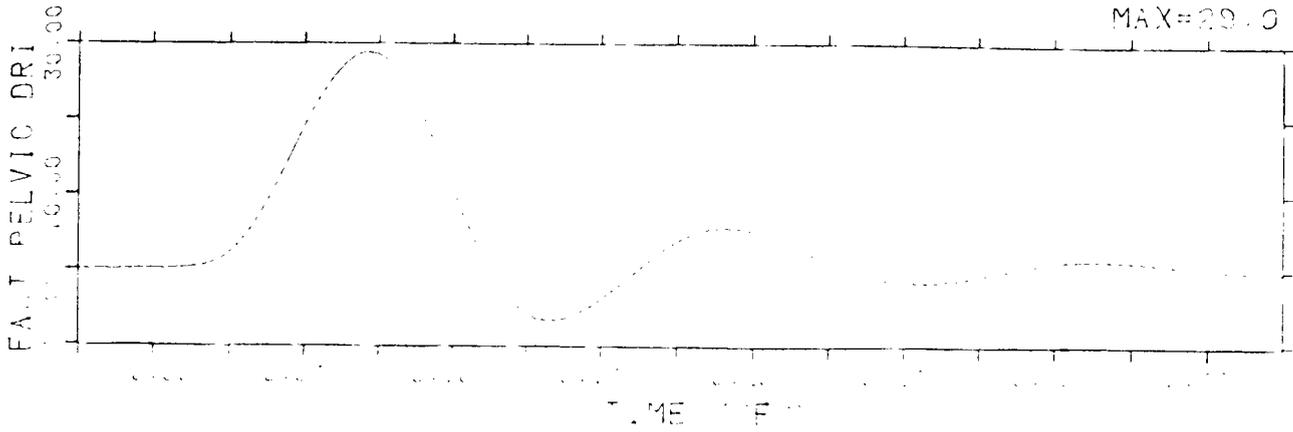
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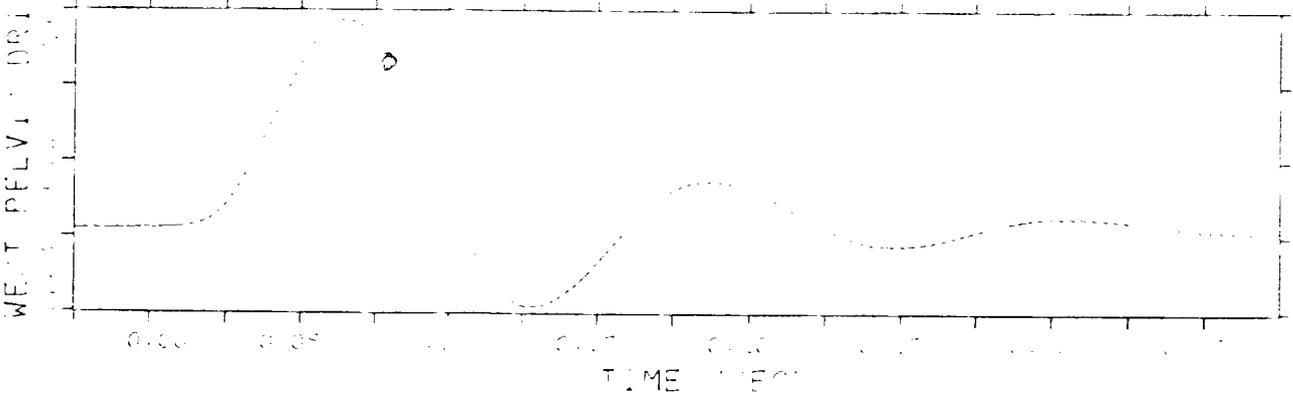
T33953

PELV DRI VALUES

MAX=29.0



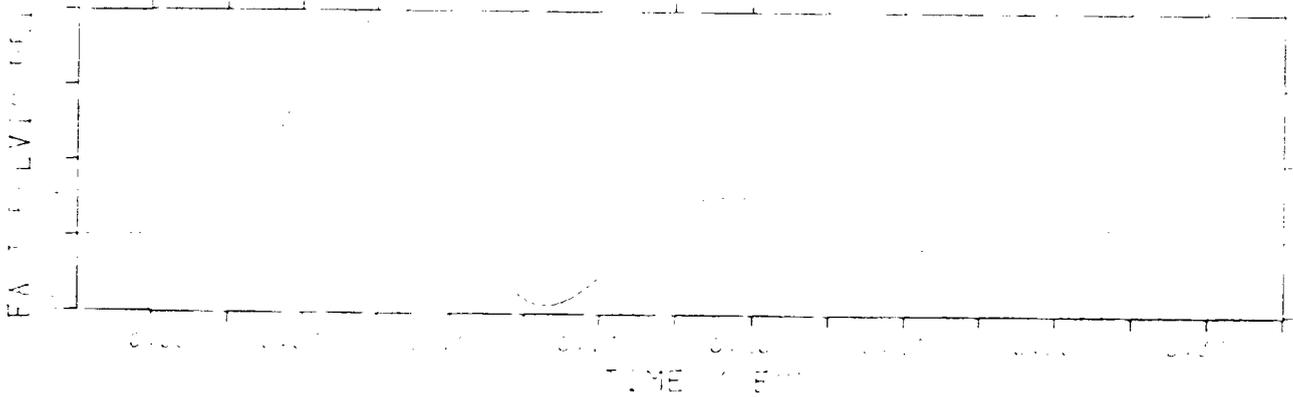
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T33974

PELV DRI VALUE

MAX=10.0



MAX=10.0

