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WL Layne 10/28/98	99SN0098
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10/14/98 WL Layne 10/21/98 RB Craner ok for Openmt

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THUNDERPIPE TEST OF
THE HALBERD NOSE CONE
(~~CRD~~) U

Organization 7300 Environmental Test Report

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7331 Test Project Engineer

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THUNDERPIPE TEST OF THE HALBERD NOSE CONE (CRD)

Introduction

The object of this test was to determine the Halberd Nose Cone response to an explosive shock environment, of prime interest was the pressure distribution over the vehicle surface.

This test was requested by H. E. Kinney, 5622, dated April 1, 1966. The vehicle and associated hardware were received April 7, 1966, and the test was completed on April 29, 1966.

Summary

Reviewing the results, it was determined that the vehicle was blown downward at approximately a 40° angle of flight. The vehicle total travel was 16 feet and was protected from damage on impact by a bed of sawdust. The material in the breech end was blown free.

Complete instrumentation coverage was obtained and the results are presented in the form of graphs and annotated oscillograph records in this report.

Procedure and Results

The 6-foot diameter metal shock tube 216 feet long was used for the Halberd Nose Cone test (see Figure 1). The breech of the tube contained 27 lengths of Prima cord which was suspended horizontally in a symetrical pattern in the first 30 feet of the tube. The remainder of the tube was instrumented with pressure gages mounted in it's wall, as shown in Figure 2. Experimental "Nammal" thermocouples were installed in the shock tube. These were located at stations 172a, 172b, 199a and 199b to measure the flow temperature.

The test vehicle was installed at the opposite end from the explosive charge (see Figure 3). The nose of the vehicle was pointed toward the HE at an angle of 20° nose down from true horizontal, as shown in Figure 4. This attitude was established by placing an inclinometer set on minus 29° on top of the 9° shape of the cone. The nose of the cone was even with the end of the shock tube. Alignment of the test vehicle to the axis of the shock tube was aided by a transit sighting through the bore of the tube. This accuracy was within a 16th of an inch. Two 500-pound test nylon cords were used to suspend the vehicle as described.

The instrumentation cabling from the test vehicle was protected by 1" OD thin wall aluminum tubing 20 feet long. Coupling to the vehicle was accomplished by a thick rubber hose. Additional protection against electromagnetic interference was made by the application of a three-mil foil coated zipper tubing grounded to common ground over the remaining exposed cabling to the junction box. Vertical supports were used to align the stinger with the horizontal axis.

Vehicle instrumentation consisted of eight pressure transducers, velocity transducer and 1 thermocouple (shown in Figure 5). The vehicle had a weight of 55.6 pounds, center of gravity of 6.838 inches from the aft lip, and a moment of inertial of .47 slug ft.^{2}.

The HE consisted of 27 lengths of prima cord 30 feet long. The prima cord was of the 2000 grain per foot variety for a total of 240 pounds. The ends of the prima cord at the breech end were brought together and taped to two detonators. Each detonator (SE-1) consisted of one tetryl pellet per detonator. This point was located 15' from the breech on center line of the tube. The energy used to ignite the detonators was obtained from an "Exploding Bridge Wire," mod 2 firing set. It's capacity discharge circuit supplies 2500 volts DC.

The explosive end of the tube was sealed with an 8-inch thick plywood plug. This plug was mounted to a 1-inch thick steel plate. A concrete mass 2 x 6 x 2 feet was placed against this plug. These items are shown in Figure 6.

Calculations of the shock velocity were obtained from the gages mounted in the tube and the results are listed in Table I. Shock velocity, as shown in Figures 2 and 3, across the unit was acquired with piezoelectric shock arrival crystals located 2 feet apart. The third crystal was even with the open end of the tube. This position represented the vehicle nose. Shock Position vs Time, and Shock Velocity vs Position can be seen in Figures 8 through 11.

The following results were recorded on the Nammal thermocouples:

Station	Temp. °F	To Rise Time	Time at Max.
172a	1170	20	52
172b	1010	20	52
199a	1065	22	62
199b	1200	22	62

[redacted]

The Metro information for April 29, 1966 was 72°F temperature, 831.9 mb Atmospheric Pressure and 9% Relative Humidity.

Colored photographs of the shock front as it leaves the shock tube were given to the requester. Scotch lite photographic technique was employed. Coverage of the unit as the suspensions desolved shows the nose drop slightly and continued to drop. The final photo shows the stinger still intact and its nose completely down. A photograph showing the nose cone after the test can be seen in Figure 7.

Results of the instrumentation coverage are presented in the form of anotated oscillograph records shown in Figures 12 through 19. Channel identification is shown in Table II.

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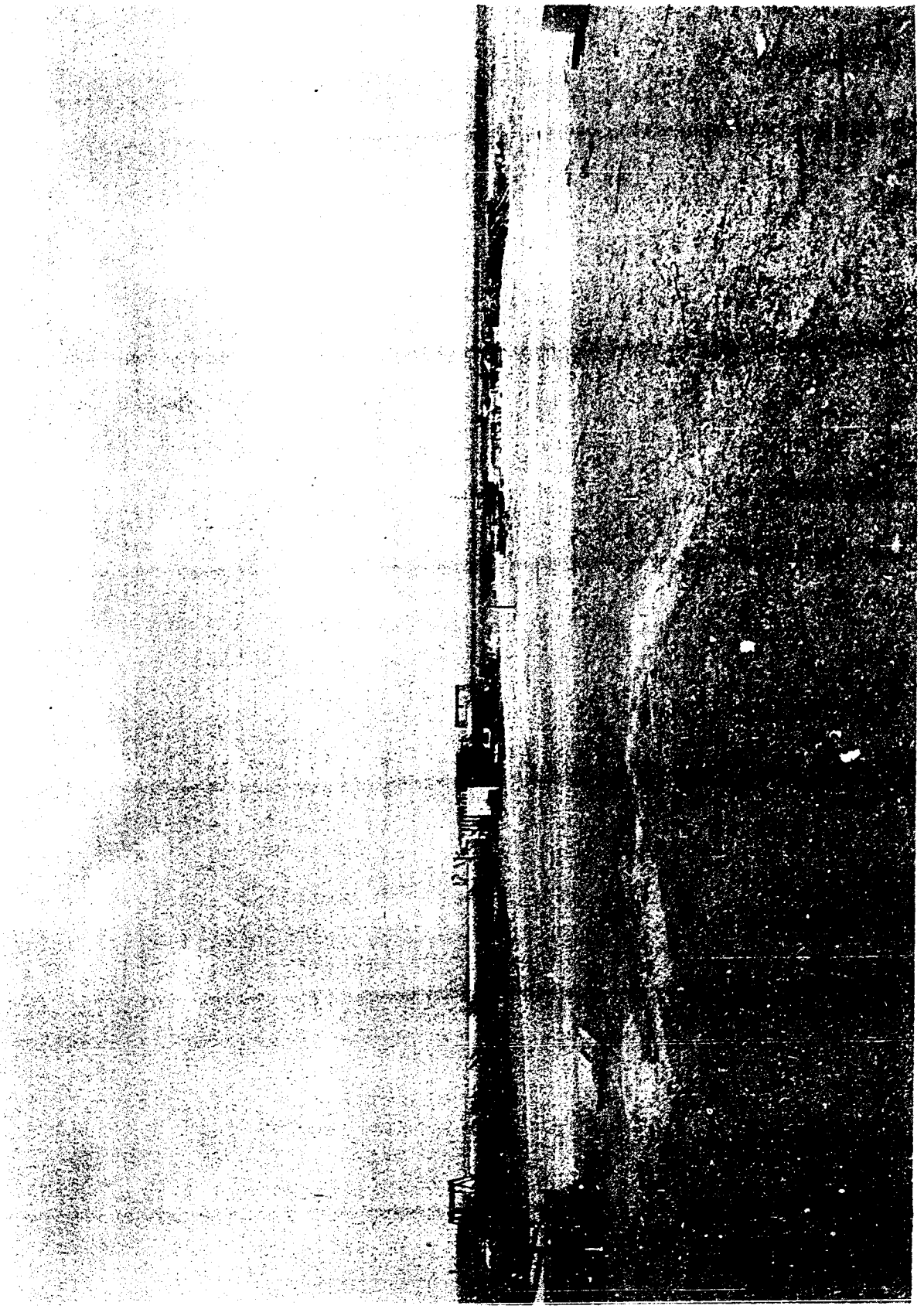

FIG. [illegible] 1x Foot Shock Tube.

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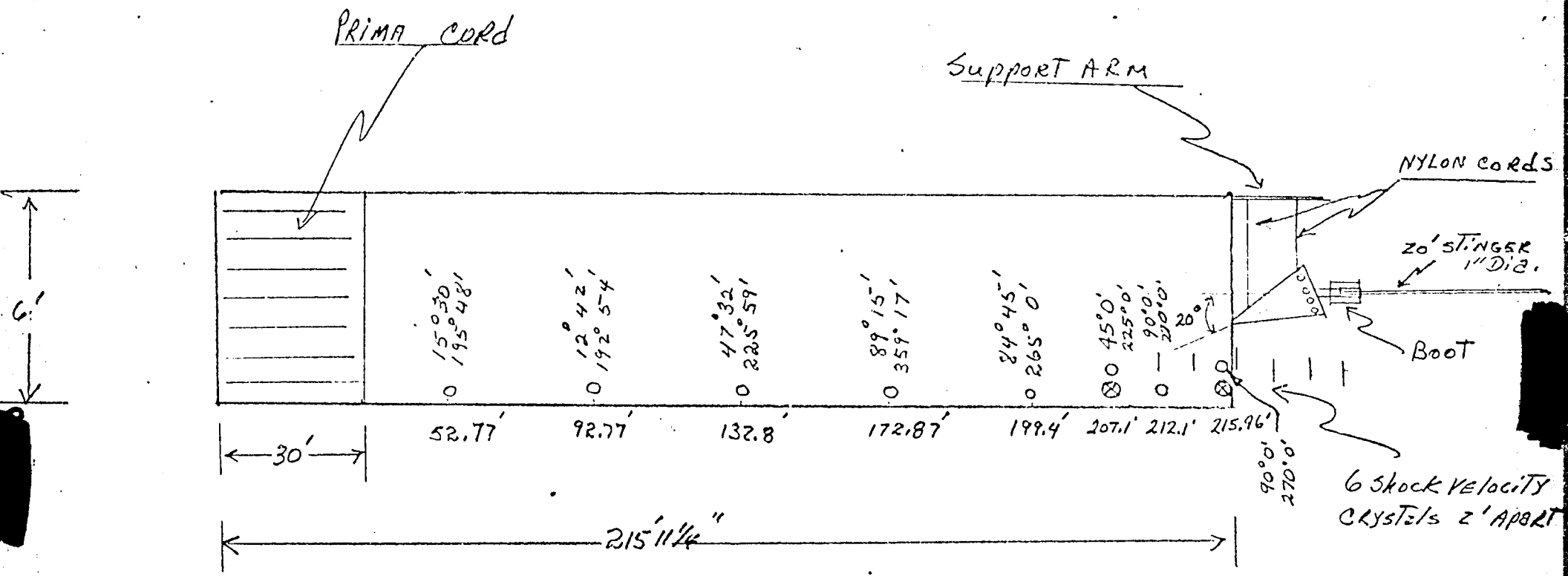

6' Dia 215'11¼" Shock Tube —
—CTF—

Stagnation Probes located:
2 at 207'1" → 0° + 180°
2 at 215'11¼" → 90° + 270°

o Side on pressure gages

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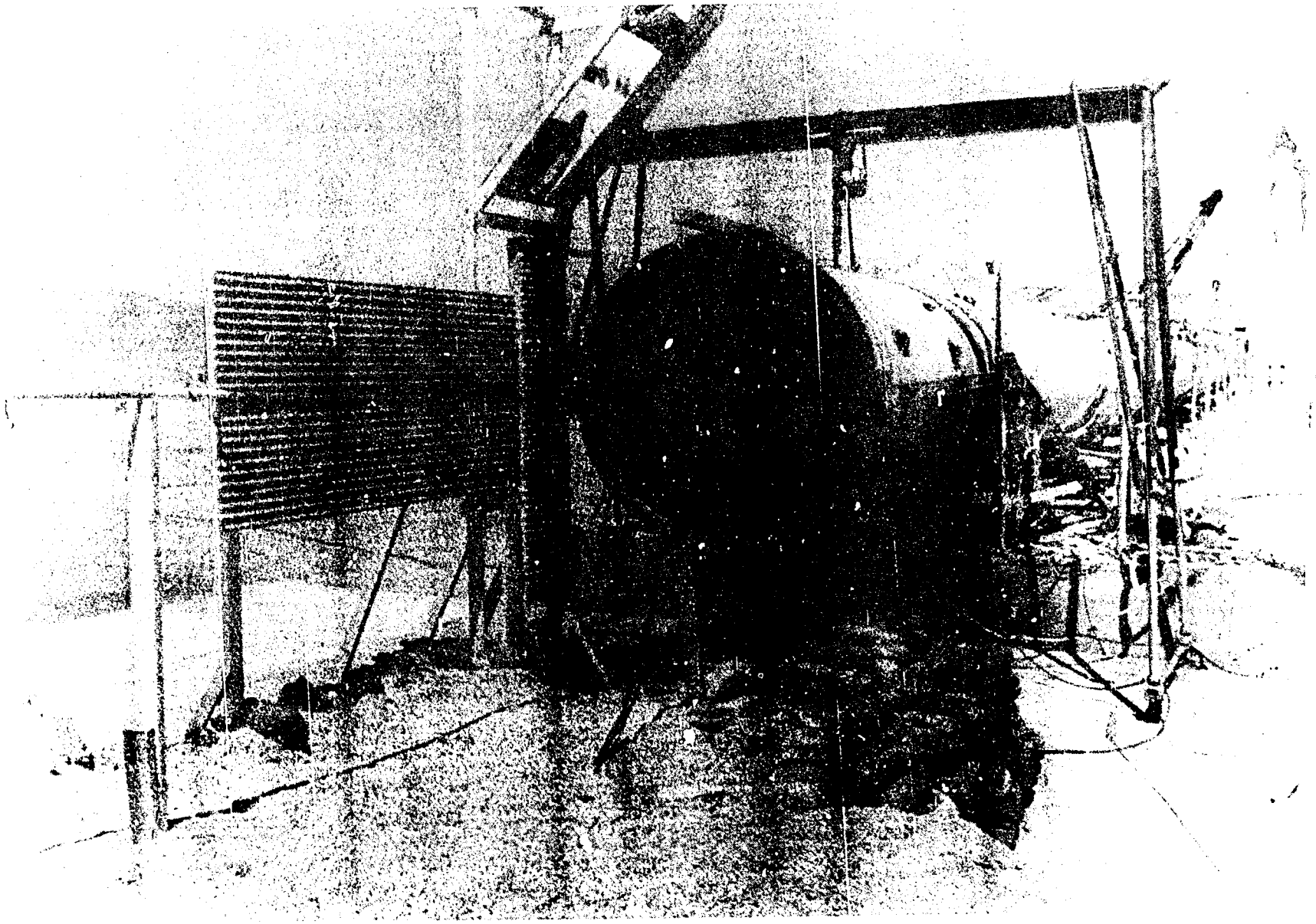

FIGURE 1 Test Stop

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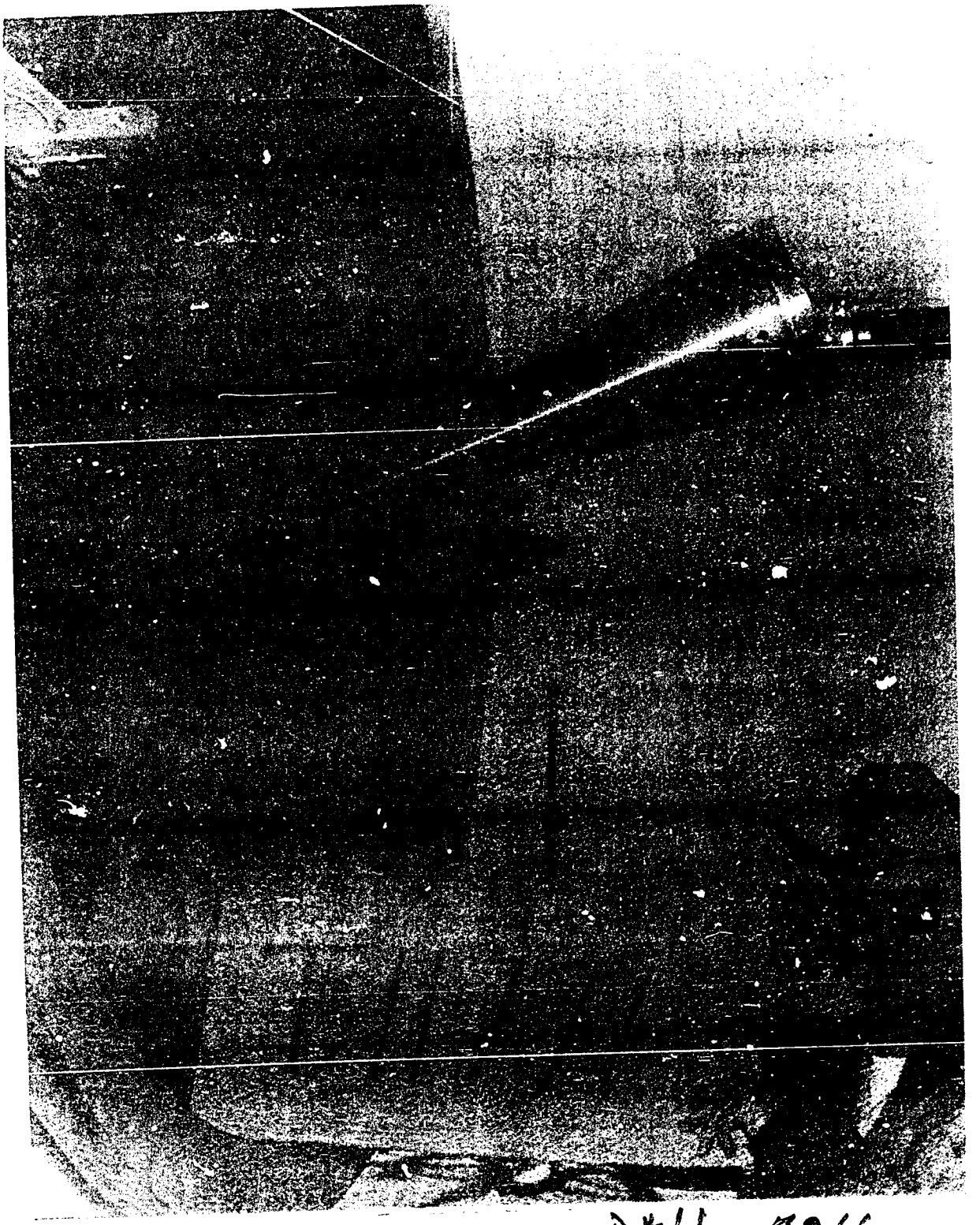

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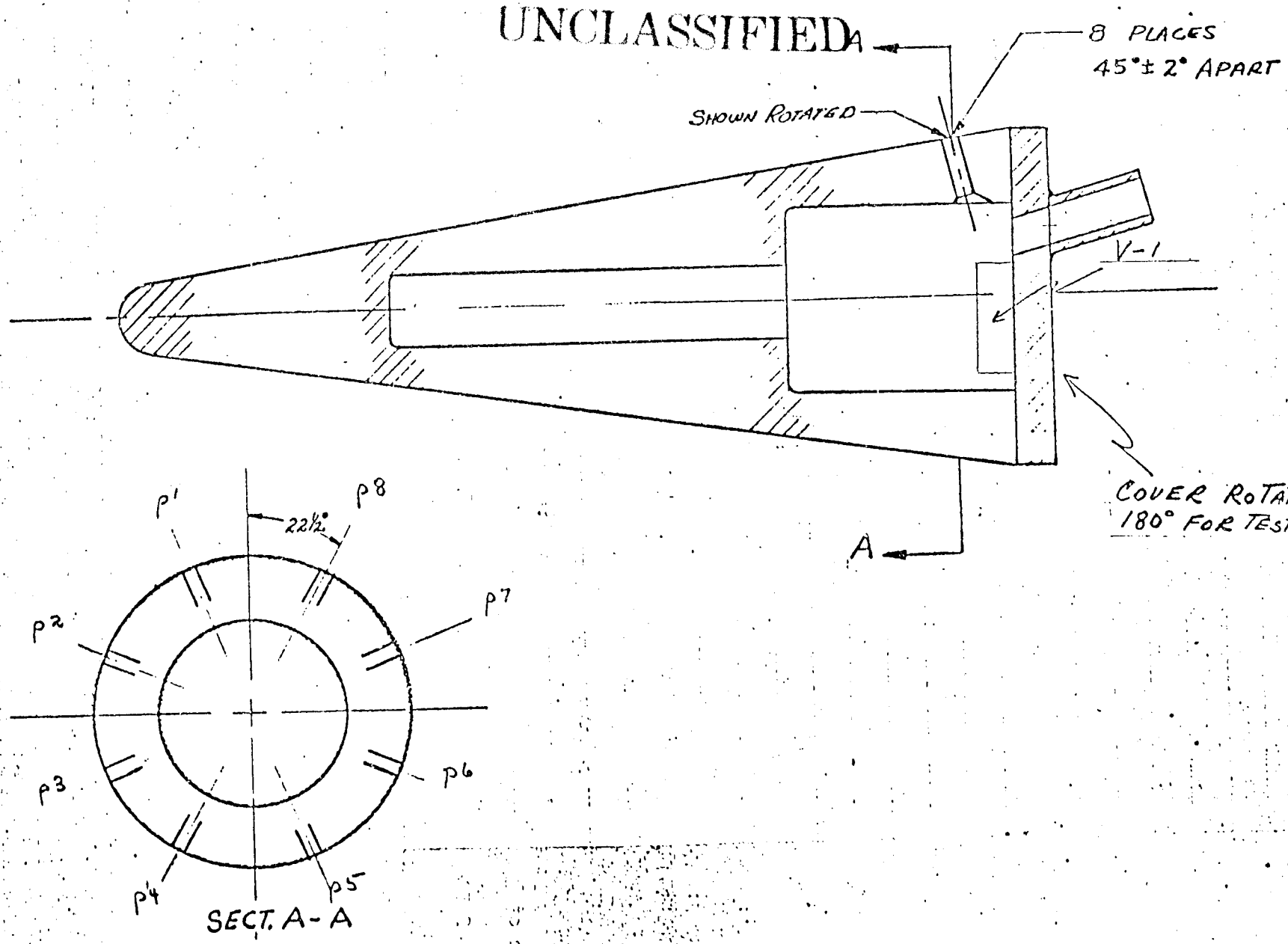

FIGURE 5 -- Transducer Locations in Nose Cone.

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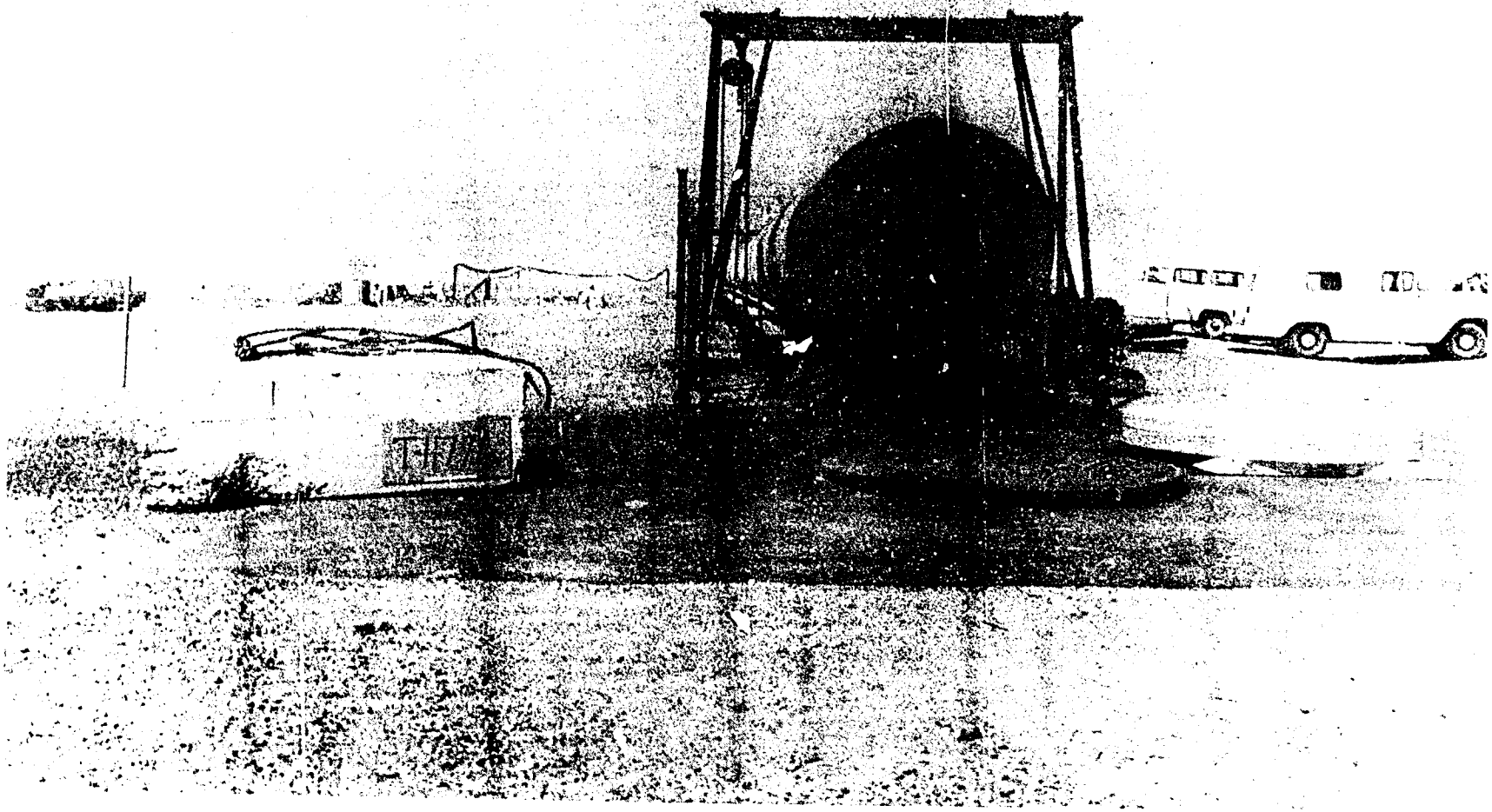

Breech End of Pipe Showing Plywood Plug, Steel Plate and Concrete Mass.

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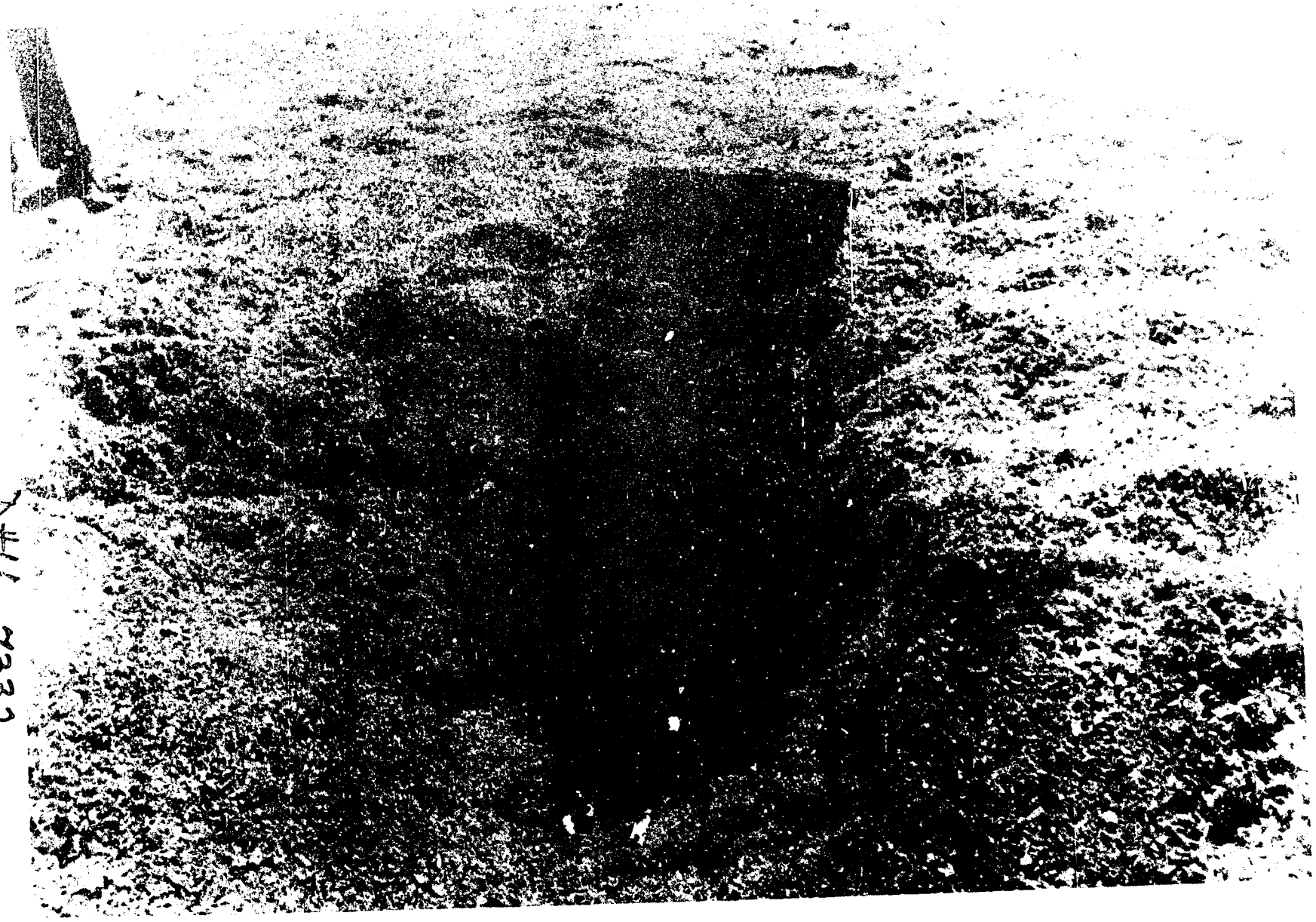

FIGURE 7 -- Nose Cone Position After Test

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K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

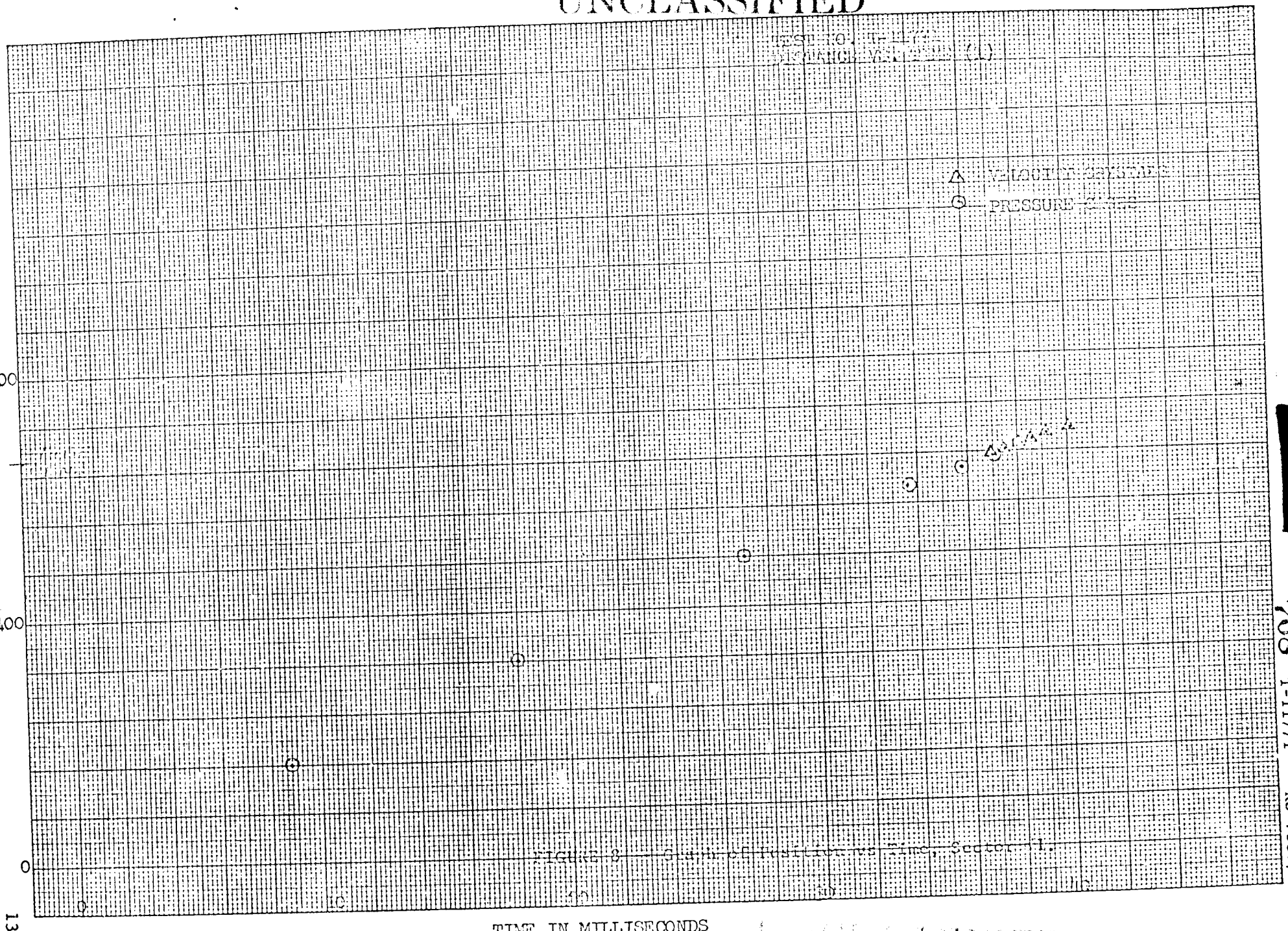

FIGURE 8 — Graph of Position vs Time, Sector 1.

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

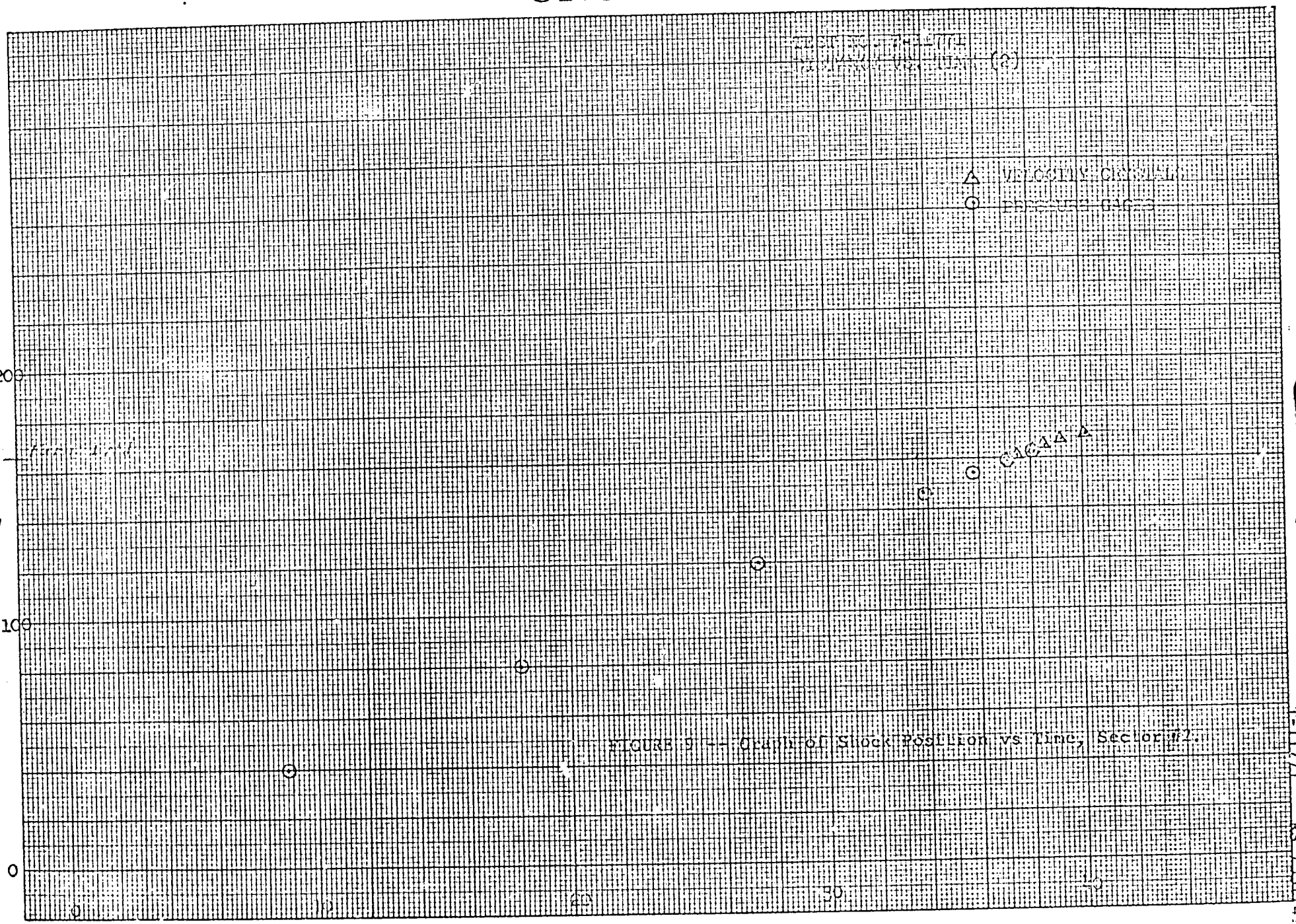

FIGURE 9 -- Graph of Shock Position vs Time, Section #2.

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K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

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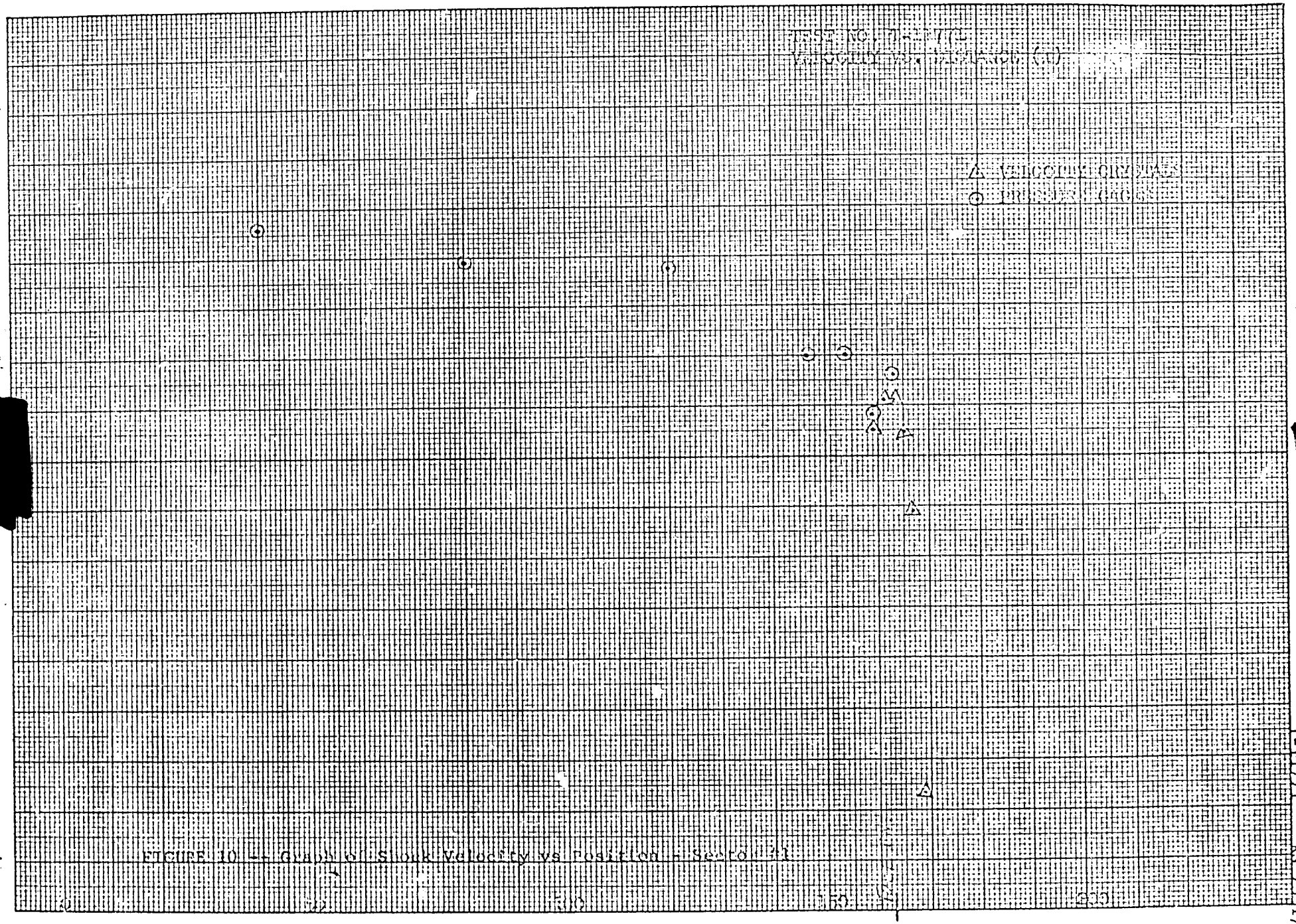

FIGURE 10 -- Graph of Shock Velocity vs Position - Section #1

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K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

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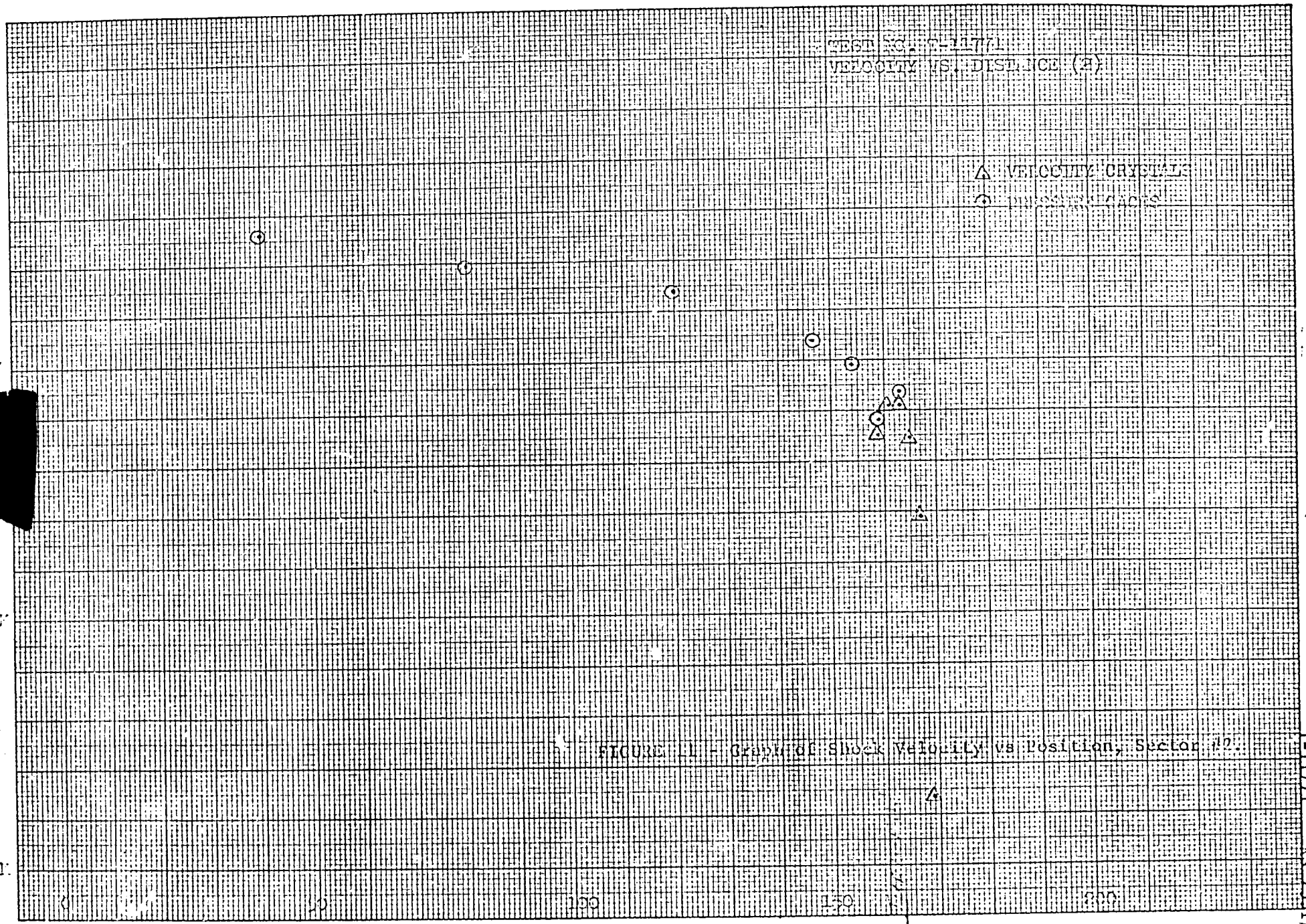

FIGURE 11 - Graph of Shock Velocity vs Position, Section #2.

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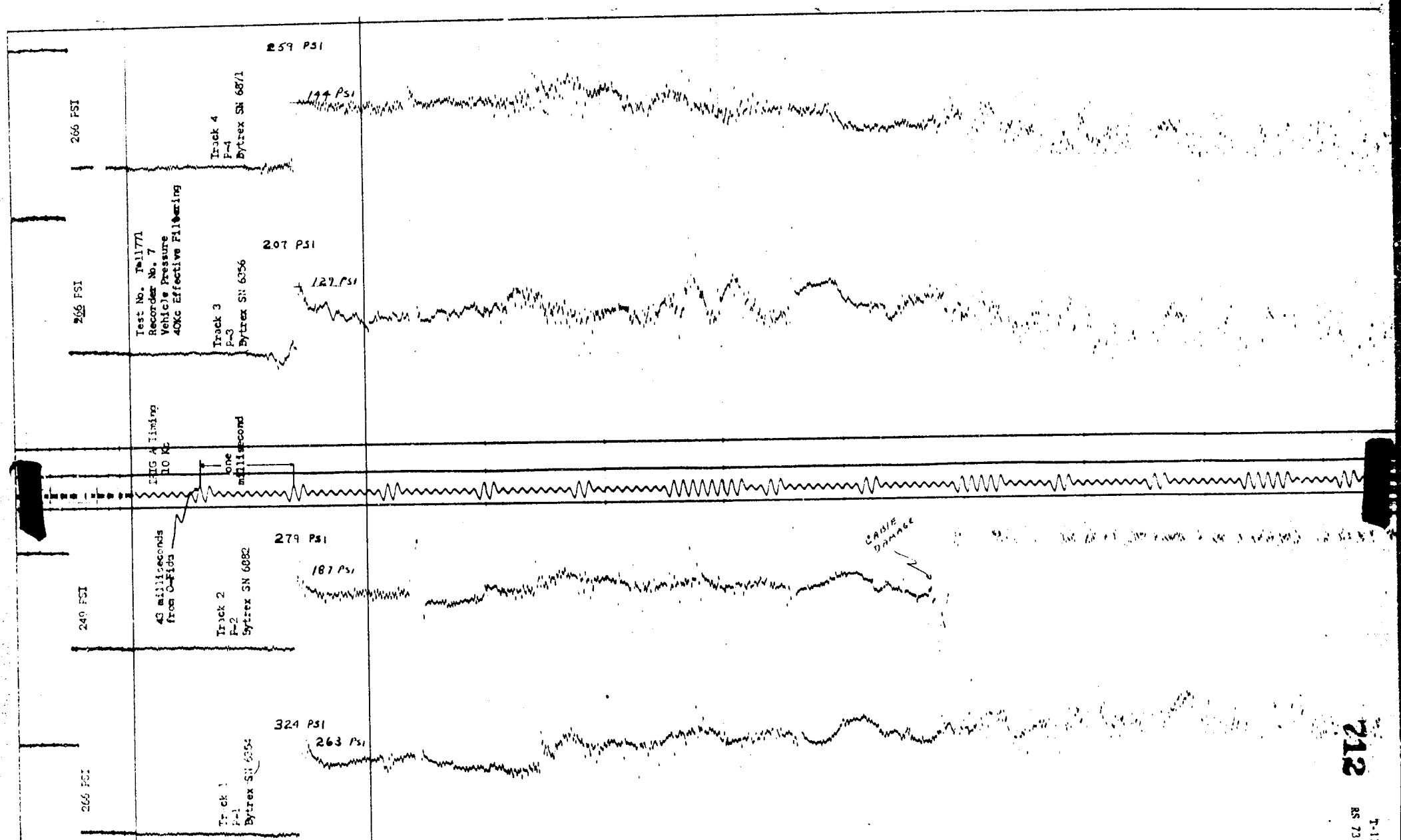

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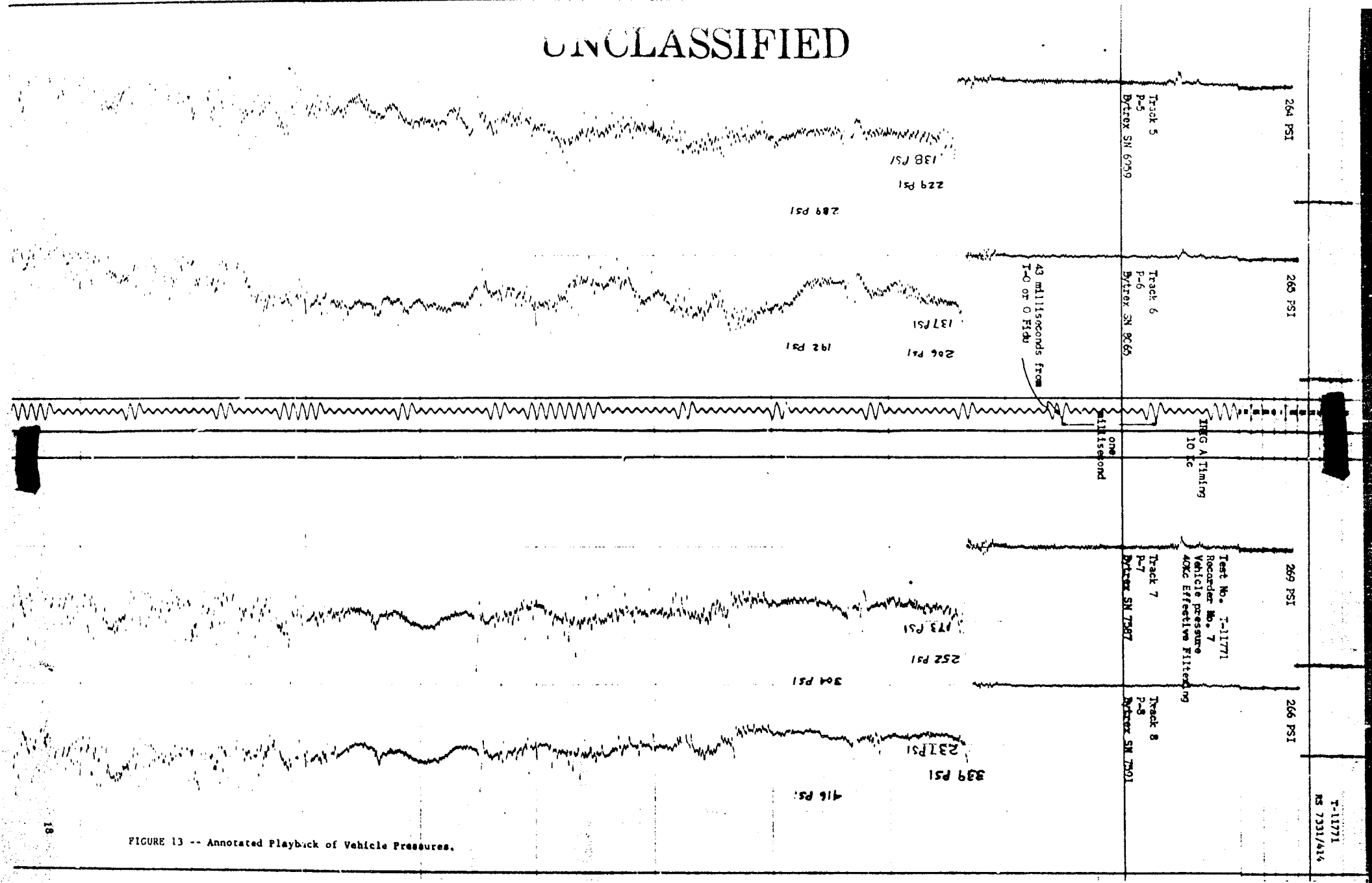

FIGURE 13 -- Annotated Playback of Vehicle Pressures.

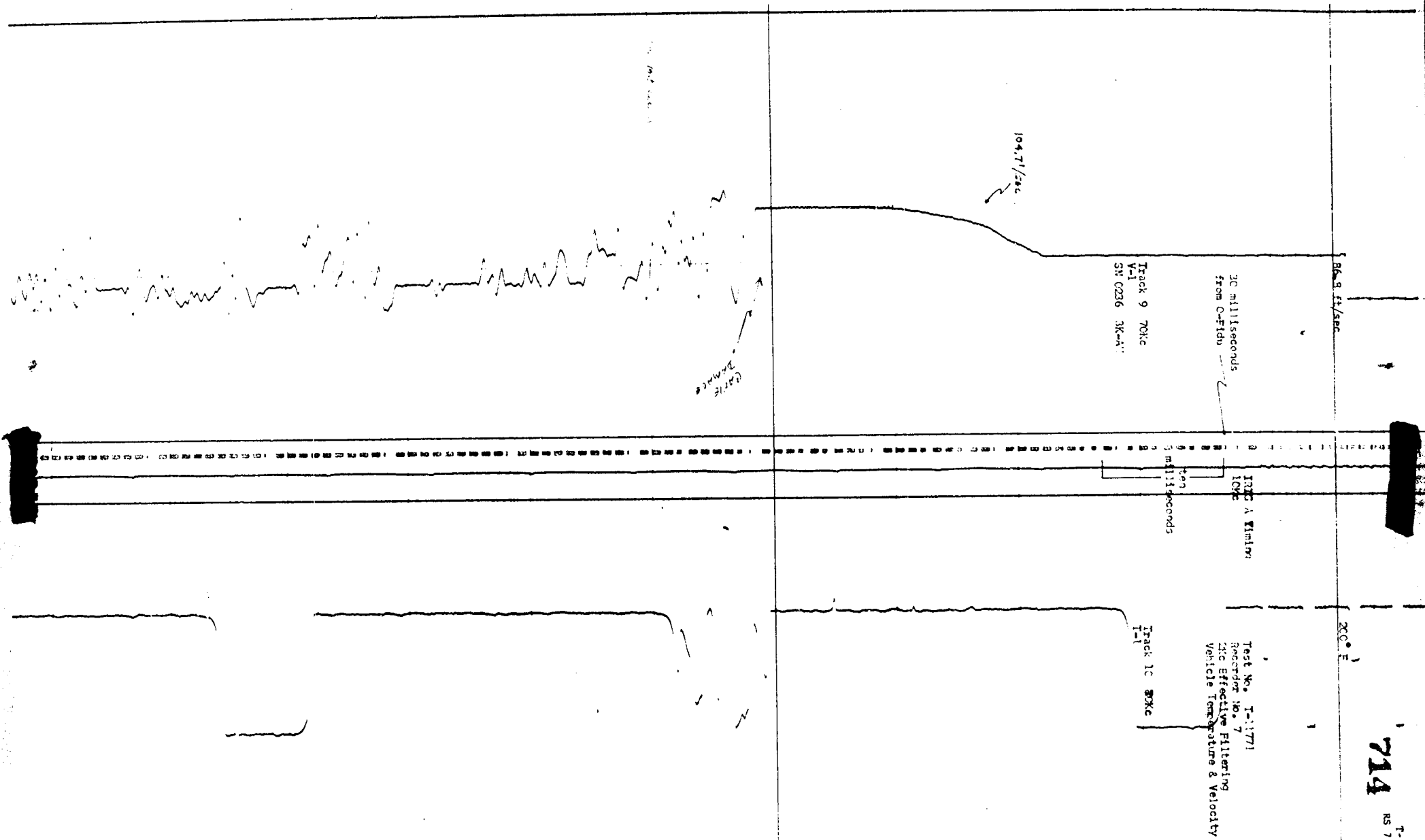

FIGURE 14 -- Annotated Playback of Vehicle Temperature and Velocity.

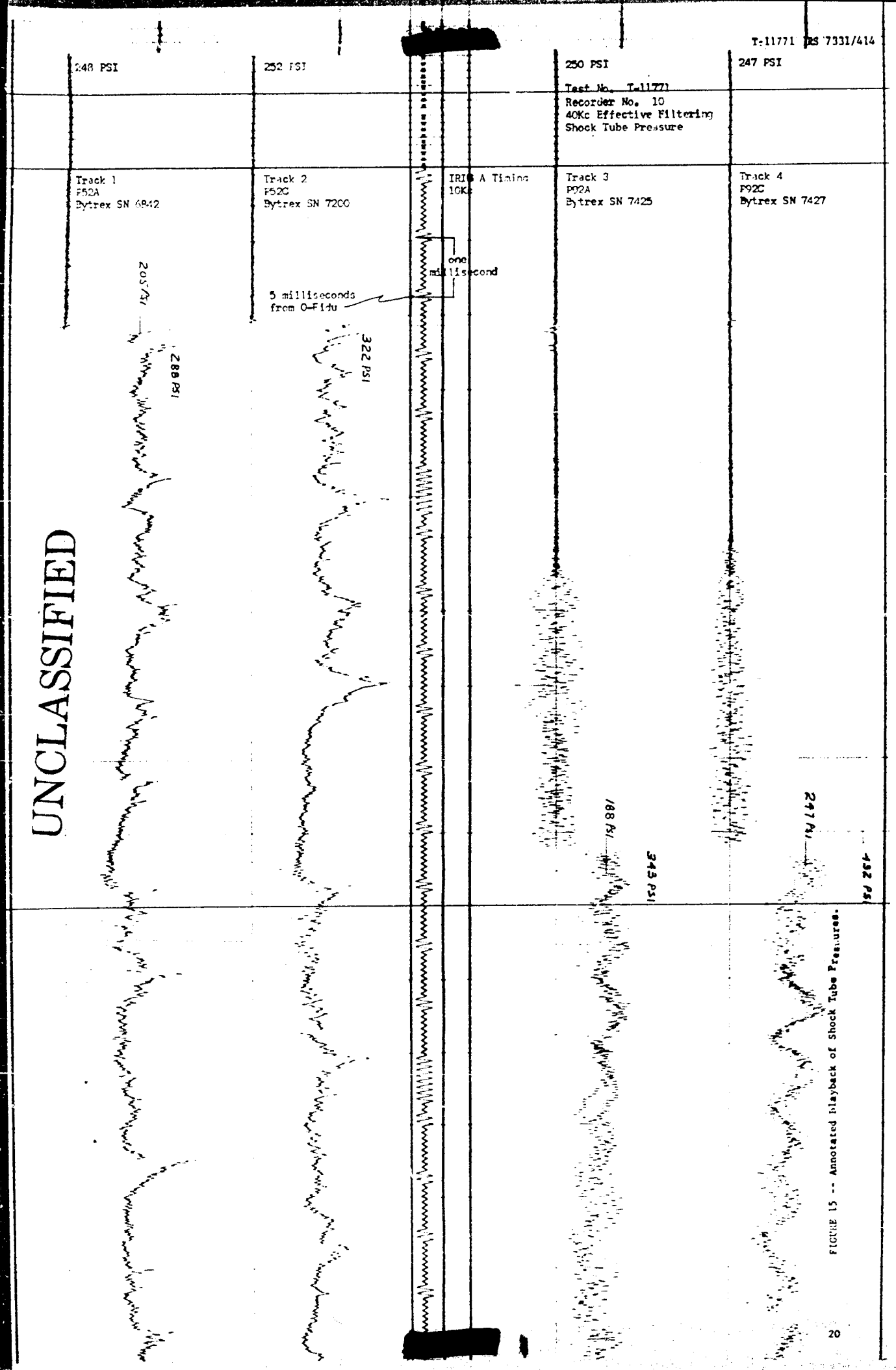

FIGURE 15 -- Annotated Playback of Shock Tube Pressures.

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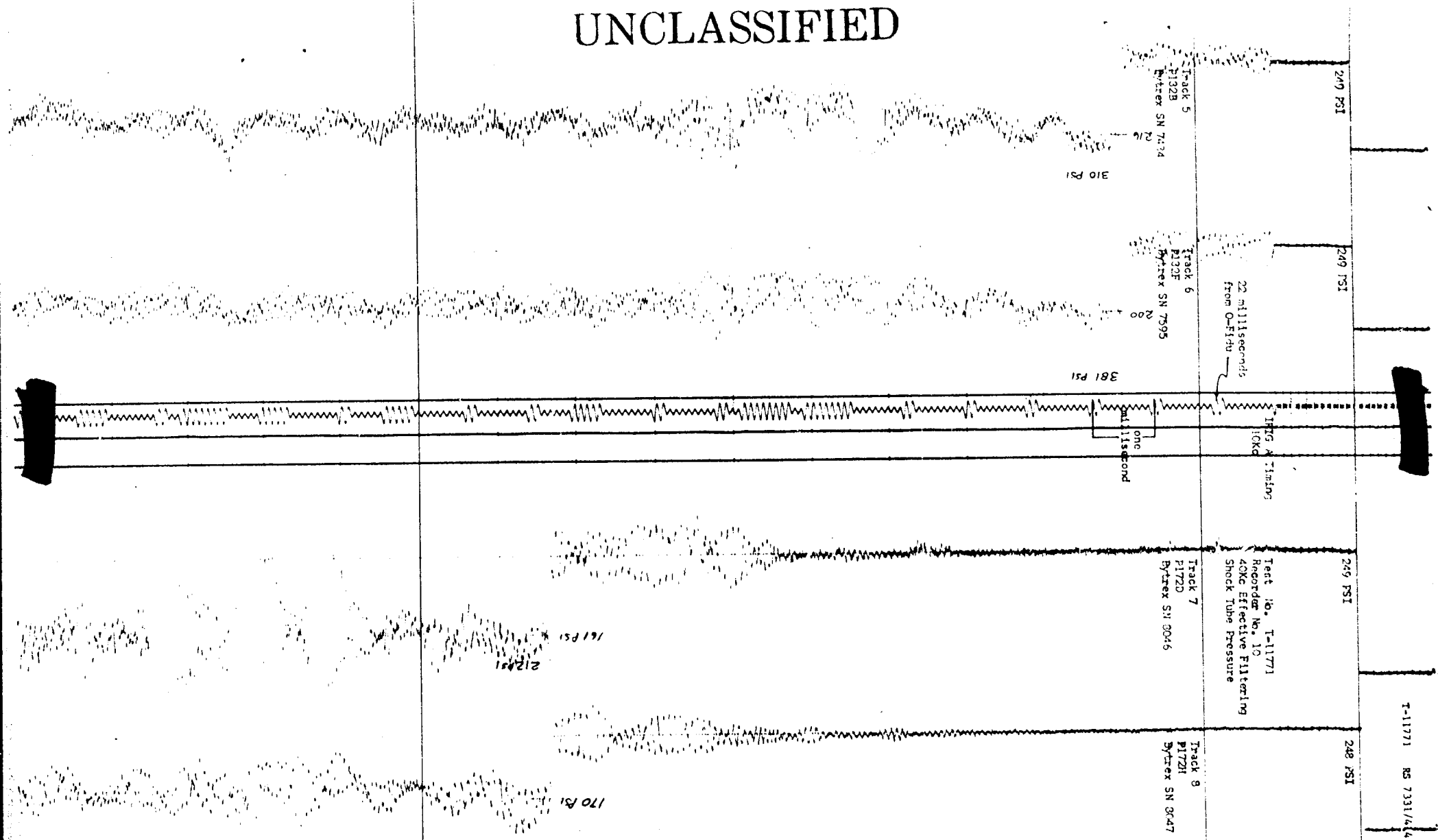

FIGURE 16 -- Annotated Playback of Shock Tube Pressures.

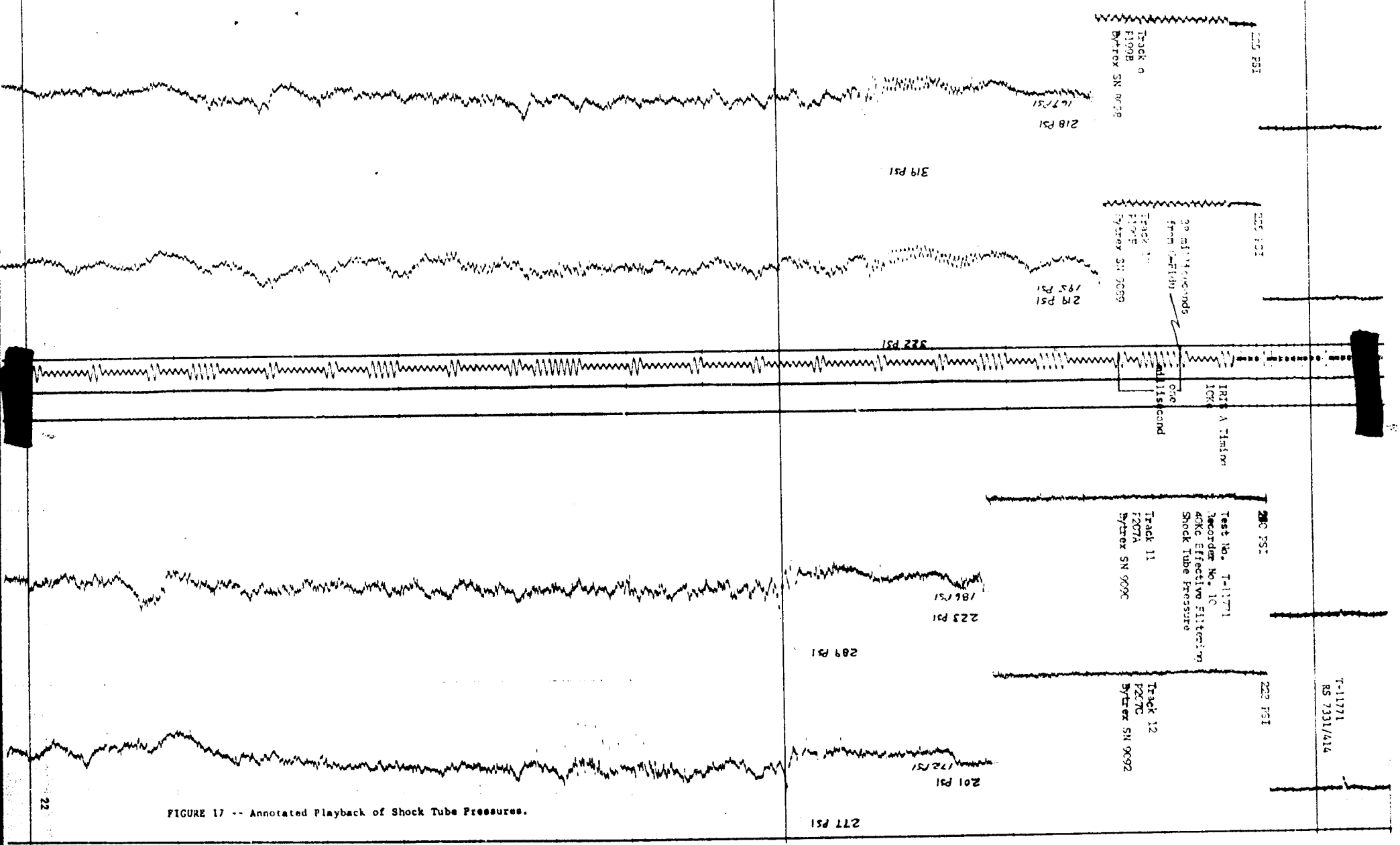

FIGURE 17 -- Annotated Playback of Shock Tube Pressures.

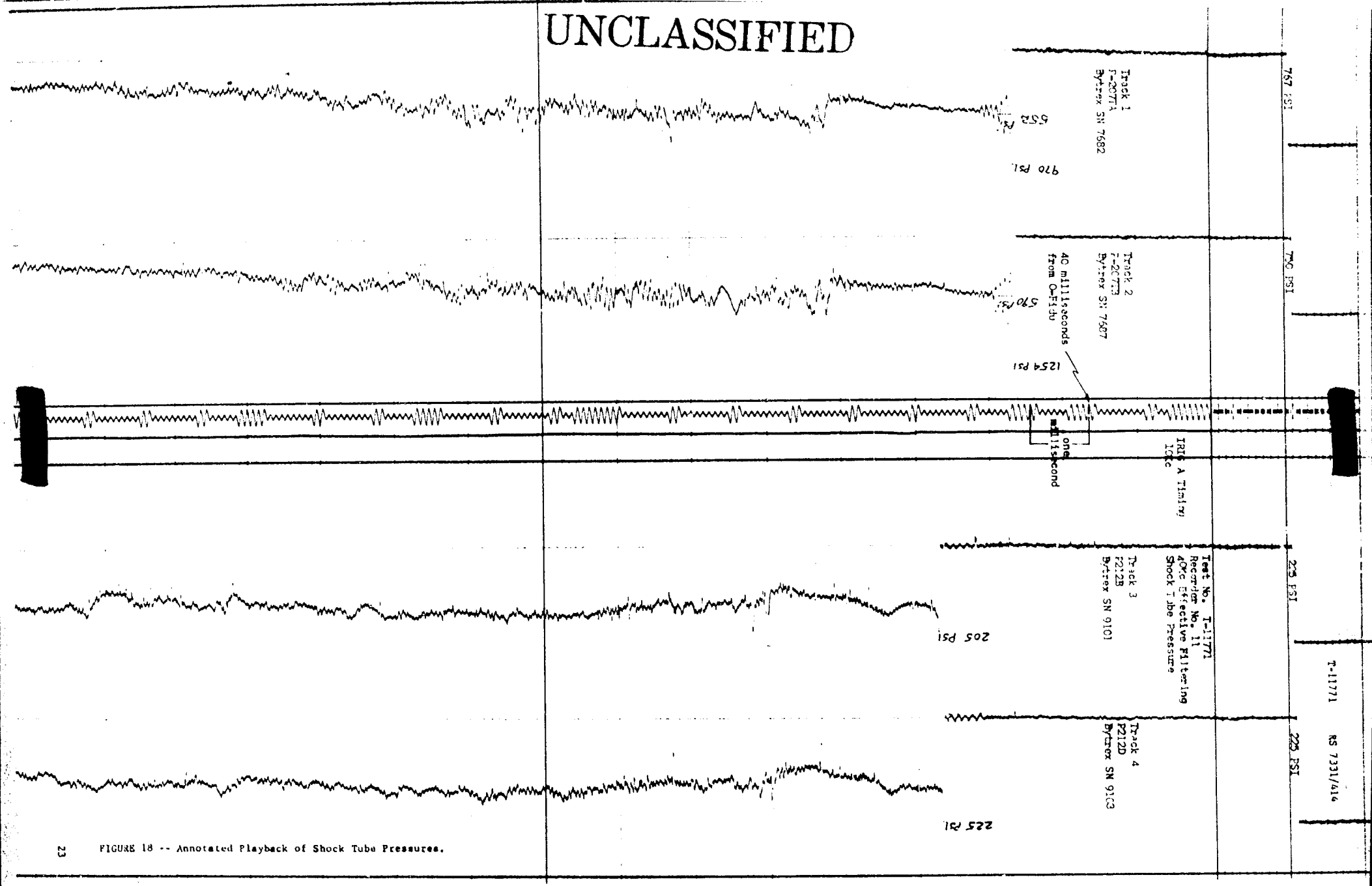

FIGURE 18 -- Annotated Playback of Shock Tube Pressures.

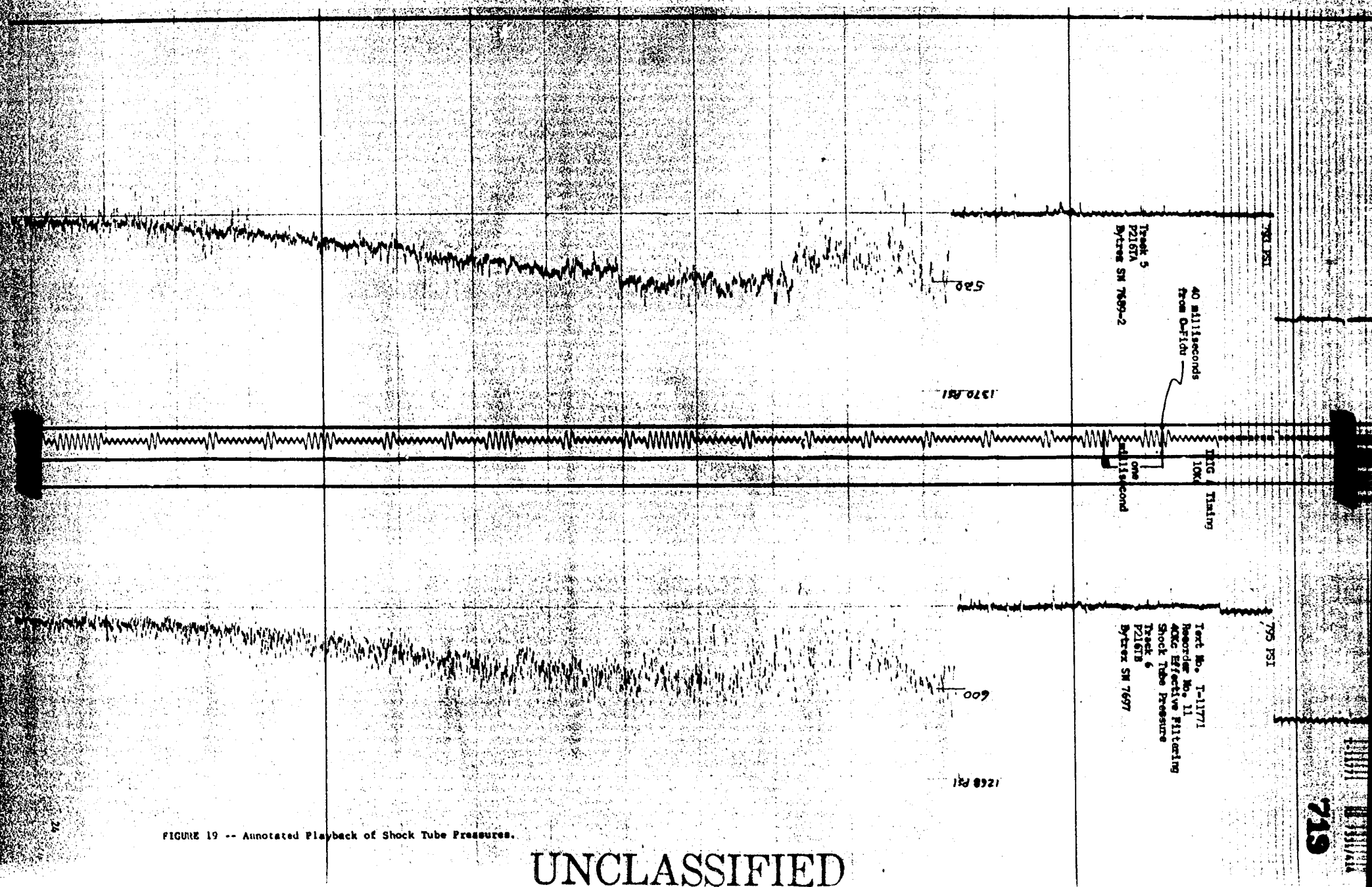

FIGURE 19 -- Annotated Playback of Shock Tube Pressures.

TABLE I

SHOCK TUBE VELOCITIES

Group #1 (upper right quadrant) Gage	Feet Dis.	Location Angle	Δs	m/s Arr. Time	m/s ΔT	Succ. Δ's Δ s	Succ. Δ's Δ t	ft/sec. Velocity
P-52A	52.77	15°30'	0.00	5.7651	0.0000	0.00	0.0000	
P-92A	92.77	12°42'	40.00	17.3171	8.8520	40.00	8.8520	4519
P-132B	132.80	47°32'	80.03	23.4574	17.9923	40.03	9.1403	4380
P-172H	172.87	89°15'	120.10	32.6702	27.2051	40.07	9.2128	4349
P-199B	199.40	84°45'	146.63	39.3085	33.8434	26.53	6.6383	3997
P-207A	207.10	45°0'	154.33	41.2340	35.7689	7.70	1.9255	3998
P-212B	212.10	90°0'	159.33	42.5635	37.0984	5.00	1.3295	3759
P-216TA	215.96	90°0'	163.19	43.5380	38.0729	3.86	0.9745	3963
Group #2 (lower left quadrant)								
P-52C	52.77	195°48'	0.00	5.4017	0.0000	0.00	0.0000	
P-92C	92.77	192°54'	40.00	14.2431	8.8414	40.00	8.8414	4524
P-132F	132.80	225°59'	80.03	23.3617	17.9600	40.03	9.1186	4390
P-172D	172.87	359°17'	120.10	32.7234	27.3217	40.07	9.3617	4280
P-199F	199.40	265°0'	146.63	39.2341	33.8324	26.53	6.5107	4075
P-207C	207.10	225°0'	154.33	41.1702	35.7685	7.70	1.9361	3977
P-212D	212.10	270°0'	159.33	42.4999	37.0982	5.00	1.3297	3759
P-216TB	215.96	270°0'	163.19	43.4958	38.0941	3.86	0.9959	3876

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TABLE II -- CHANNEL IDENTIFICATION

TAPE CHANNEL NUMBER	GAGE LOCATION NUMBER	GAGE TYPE AND S/N	GAGE CALIB.	CHANNEL TYPE	CHANNEL NOISE	GAGE DAMAGE	oscil. #	COMMENTS
7-1	P1	Bytrex 6354	266 psi	216 kc	OK	None		
7-2	P2	Bytrex 6882	249 psi	216 kc	OK	None		
7-3	P3	Bytrex 6356	266 psi	216 kc	OK	None		
7-4	P4	Bytrex 6871	266 psi	216 kc	OK	None		
7-5	P5	Bytrex 6959	264 psi	216 kc	OK	None		
7-6	P6	Bytrex 8065	265 psi	216 kc	OK	None		
7-7	P7	Bytrex 7587	269 psi	216 kc	OK	None		
7-8	P8	Bytrex 7591	266 psi	216 kc	OK	None		
7-9	V-1	3K-AH 0236	86.8 F/S	70 kc	OK	None		
7-10	T°1	Thermister	200°	70 kc	OK	None		Unit internal Temp. °F
10-1	P52A	Bytrex 6842	248 psi	216 kc	OK	None		
10-2	P52C	Bytrex 7200	252 psi	216 kc	OK	None		
10-3	P92A	Bytrex 7425	250 psi	216 kc	Excessive	None		
10-4	P92C	Bytrex 7427	247 psi	216 kc	Excessive	None		
10-5	P132B	Bytrex 7434	249 psi	216 kc	Excessive	None		10 kc Noise
10-6	P132F	Bytrex 7595	249 psi	216 kc	Excessive	None		10 kc Noise
10-7	P172D	Bytrex 8046	249 psi	216 kc	OK	None		
10-8	P172H	Bytrex 8047	248 psi	216 kc	OK	None		
10-9	P199B	Bytrex 8028	225 psi	216 kc	Abnormal	None		
10-10	P199F	Bytrex 9089	225 psi	216 kc	Abnormal	None		
10-11	P207A	Bytrex 9090	230 psi	216 kc	OK	None		
10-12	P207C	Bytrex 9092	228 psi	216 kc	OK	None		
11-1	P207TA	Bytrex 7682	767 psi	216 kc	10 kc	None		10 kc On Signal
11-2	P207TB	Bytrex 7687	750 psi	216 kc	10 kc	None		10 kc On Signal
11-3	P212B	Bytrex 9101	225 psi	216 kc	Normal	None		
11-4	P212D	Bytrex 9103	225 psi	216 kc	Normal	None		
11-5	P216TA	Bytrex 7689-2	793 psi	216 kc	Poor	None		Data Questionable
11-6	P216TB	Bytrex 7697	795 psi	216 kc	Poor	None		Data Questionable
1-1								Shock Velocity Crystals
1-3								Shock Velocity Crystals

ALL TAPES: Timing Irig "A" 200 kc
Ch #14 Irig "B" 40 kc
Voice 25 kc
100 kc

Ch #13---Zero Fidu

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