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NO. 337

CANADIAN AIR-BLAST MEASUREMENTS ON EVENT MIXED COMPANY (U)

by

J.H.B. Anderson

PROJECT NO. 16-78-10

July 1973

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ACKNOWLEDGEMENTS

The mounting of an experiment for a large free-field blast trial, and the reduction of the data therefrom, involves a great many people. However, thanks are particularly due to Mr. J.J. Vesso and his team, who installed the transducers for the present experiment; to Mr. R.L. Campbell and his team, who recorded and then played back all of the data; to Mr. N.A. Bannister of the Computer Group at DRES for his cooperation; and especially to Mr. F.H. Winfield who did a magnificent job in overseeing and coordinating the on-site operations at the test location under very difficult and trying circumstances.

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ABSTRACT

Results from the Canadian air-blast measurements for Event MIXED COMPANY are presented. Event MIXED COMPANY was the third shot in the MIDDLE NORTH series of free-field high-explosive blast trials, and was carried out on 13 November 1972. The results obtained were quite close to the predicted values; however three large fireball anomalies to the west of the Canadian sector resulted in slightly off-axis flow through the Canadian sector and peak overpressures slightly higher than the values obtained using shock front velocity measurements. (U)

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INTRODUCTION

Event MIXED COMPANY was the third event in the MIDDLE NORTH Series of free-field high-explosive blast trials. The first two events, Event PRAIRIE FLAT (1968) and Event DIAL PACK (1970), were carried out at the Defence Research Establishment Suffield, while Event MIXED COMPANY was carried out on a specially procured site near Grand Junction, Colorado, on 13 November 1972. The charge for Event MIXED COMPANY was identical to that used for the first two events: approximately one million pounds of TNT in the form of rectangular blocks weighing about 32.5 pounds each, stacked in the form of a sphere set tangent to the ground (see Fig. 1).

Canadian participation in Event MIXED COMPANY was divided into four projects. Project C2 involved measuring the aerodynamic drag on simple structural shapes due to the passage of the blast wave, while Projects C3 and C4 involved measuring the structural response of an M22 radome and a TACAN mast, respectively, to the blast wave. Analysis of the results from all of these projects required knowledge

of the parameters of the incident blast wave, and the provision of this knowledge was the objective of Project C1.

This report gives details concerning the planning of Project C1 and the results obtained therefrom. The other projects are reported separately. More general details concerning Canadian participation are given by Winfield (1973).

INSTRUMENTATION

The information on the blast wave parameters which was to be provided by Project C1 was obtained using pressure-time transducers installed at appropriate locations relative to the locations of the other Canadian projects. On previous blast trials, one or more lines of Air Blast Time-of-Arrival Detectors (ABTOADs) were used in addition to pressure-time transducers to obtain the required information; however, the small scale of the Canadian participation in Event MIXED COMPANY, coupled with the high cost of mounting such instrumentation on a safari-type operation, resulted in the decision to use only pressure-time transducers for this event.

The locations of the pressure-time gauges installed for Project C1, along with the locations of the targets associated with the other projects, are shown in Fig. 2. Drag experiments (Project C2) were set up at three distances from Ground Zero, where the peak overpressures were expected to be 25, 10, and 7 psi respectively, and three pressure transducers were deployed at each location. In addition, three gauges were deployed to monitor the blast wave at the location of the M22 radome (Project C3) and a further three gauges at

the location of the TACAN mast (Project C4). These two targets were also placed where the predicted peak overpressure was 7 psi, but they were placed some distance away from each other and from the drag experiment in order to avoid interference.

In addition to these gauges, six additional gauges were deployed on an arc centred on Ground Zero along which the predicted peak overpressure was 10 psi. These gauges were intended to detect any anomalies in the blast wave. Ideally, the blast wave from one of these blast trials is symmetrical in azimuth about Ground Zero, and in such case gauges installed at identical distances from Ground Zero should record identical results. However, past experience has shown that such symmetry is not always present, and some unexplained results obtained from structural response projects on previous blast trials are suspected to have been caused by azimuthal asymmetries in the blast wave. Thus, these additional gauges were deployed in order to allow detection of such behaviour in the blast wave from this event.

The three gauges installed to monitor the blast wave at the location of each blast response experiment were set out on a radial line passing through Ground Zero. Using this arrangement, the difference between the times-of-arrival of the shock wave at successive gauges could be combined with the measured distance between the gauges to calculate the velocity of the shock front; this in turn could be used to calculate the peak overpressure for comparison with the results obtained from individual gauge records.

All gauges fielded for this project were Bytrex Model HFH-100

strain-type transducers. They were installed in aerofoil-type stands such that the sensing element was approximately six inches above the ground surface (see Fig. 3). Each stand was secured to the ground with four long spikes.

RESULTS AND DISCUSSIONS

All instrumentation functioned as planned, and good quality records were obtained.

The time-of-arrival data obtained from the gauge records are summarized in Fig. 4. As noted earlier, six gauges were set out on an arc at the 10 psi pressure level in order to detect any asymmetries in the shock wave; however, the same function was also served by the three gauges at each of three distances from Ground Zero at the 7 psi pressure level. All of the results clearly show that the blast wave appeared to approach the Canadian projects from a point to the west of the actual Ground Zero, thus arriving first at the most westerly gauges and lastly at the most easterly gauges at a given distance from Ground Zero. Using the shock velocity data calculated using time interval measurements between successive gauges, it was found that the flow direction deviated about 2.0^{o} from the expected direction. Examination of the aerial photographs, of which an example is shown in Fig. 5, showed that three large fireball anomalies occurred to the west of the sector containing the Canadian experiments, which would account for the observed effect.

The results obtained from the individual pressure-time records are summarized in Table 1. The overpressures were obtained by

visual examination of the records, while the positive overpressure impulse and the positive duration data were obtained by digitizing the records and using numerical integration techniques. More detail concerning these methods is given by Anderson and Fenrick (1972). Also shown in the table are the overpressure results obtained from the time interval measurements between successive gauges. All of the gauge records are included in the Appendix.

It is seen that, in nearly all cases, the peak pressures read from the individual records were significantly higher than those obtained from the shock wave velocity measurements. It was noted, however, that almost all of the records had a rather unusual character. Each record showed a rapid initial rise to an overpressure value which corresponded quite well with the overpressure values obtained from the applicable velocity measurements. However, the initial rapid rise was followed by a further more gradual rise to the peak overpressure recorded in Table 1. This effect was thought to be due to the presence of the anomalies to the west of the Canadian projects. Approximately one millisecond was required for the overpressure to reach its peak value after the initial arrival of the blast wave.

Slow playbacks of the records showed that the additional overpressure lasted only a few milliseconds at most, after which the overpressure and its rate of decay were more consistent with the peak pressure obtained using the shock velocity measurements.

Except for the effect just described, all of the pressure records exhibited classical waveforms. Several of the records were

noisy due to wet instrumentation cables (Winfield, 1973) but this did not affect the basic validity of the data. The records from the gauges near the position of the M22 radome showed a weak shock following behind the main shock front; this was thought to be caused by a reflection from one of the targets.

The overpressure results were considered to be quite close to the values predicted. The predicted values were based on the results from Operation DISTANT PLAIN Event 6 (Anderson, 1968) and Event DIAL PACK (Anderson and Fenrick, 1972) with appropriate corrections to compensate for the much higher altitude at the MIXED COMPANY test site. The overpressure values obtained from the velocity measurements were slightly below the predicted values at the 25 psi and 10 psi positions, but quite close to the predicted values at the 7 psi positions. However, the effects of the anomalies to the west of the Canadian sector tended to raise all of the peak overpressures, as explained earlier; thus the peak values for overpressures as obtained from the records were quite close to the predicted values at the 25 psi position and somewhat above the predicted values at the 10 psi and 7 psi positions.

CONCLUSION

Air blast measurements using strain-type pressure-time transducers were carried out on Event MIXED COMPANY. The object of these measurements was to determine the parameters of the blast wave impinging on the blast response projects fielded on this trial by DRES. The results obtained were quite close to those predicted; however, three large fireball anomalies to the west of the Canadian sector resulted in

slightly off-axis flow through the Canadian sector and peak over-pressures slightly higher than the values obtained using shock front velocity measurements.

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Anderson, J.H.B. 1968 "Canadian Air Blast Measurements from Operation DISTANT PLAIN, Events 5A and 6", Suffield Technical Note No. 197. UNCLASSIFIED

Anderson, J.H.B. and W.J. Fenrick 1972 "Canadian Air Blast Measurements on Event DIAL PACK", Suffield Technical Note No. 296. UNCLASSIFIED

Winfield, F.H. 1973 "Event MIXED COMPANY - 500 Ton TNT Blast Trial: Canadian Participation - Logistics", Suffield Memorandum No. 4/73. UNCLASSIFIED

TABLE 1. EVENT MIXED COMPANY - SUMMARY OF RESULTS FROM PRESSURE-TIME TRANSDUCERS

Location and Predicted Peak Overpressure (psi)	Gauge No.	Time of Shock Wave Arrival (ms after zero)	Positive Overpressure Impulse (psi-ms)	Positive Duration (ms)	Peak Overpressure Obtained from Each Record (psi)	Distance from GZ (feet)	Peak Overpressure Obtained from Velocity Calculs. (psi)	Distance Interval Used (feet)
DRAG CYLINDER: 25 psi (Project C2)	22127	163.5	1166.8	184.3	24.9	633.93		
						641.30	24.1	14.73
	22123	171.7	1124.3	167.6	24.2	648.66		
						656.18	22.0	15.03
	22126	180.3	1028.2	137.0	21.3	663.69		
DRAG CYLINDER: 10 psi (Project C2)	15499	356.2	832.3	232.8	10.2	933.25		
						941.08	9.2	15.65
	22131	367.3	776.0	239.3	10.5	948.90		
						956.52	9.0	15.24
	22132	378.3	801.7	229.6	10.6	964.14		
DRAG CYLINDER: 7 psi (Project C2)	39070	508.4	628.2	260.3	8.3	1143.80		
						1151.30	7.1	15.00
	39071	519.6	696.2	258.3	7.9	1158.80		
						1166.30	6.9	15.00
	39072	530.8	682.9	255.4	7.5	1173.80		
MOST EASTERLY:	22133	370.5	891.3	222.7	10.5	949.45		
	22135	369.1	842.9	221.6	11.8	948.72		
LATERAL LINE: 10 psi	22136	368.0	936.3	222.4	11.4	949.31		
	38959	366.4	673.0	197.4	10.4	948.50		
	38962	365.4	866.5	229.8	11.5	948.33		
MOST WESTERLY:	39068	365.7	817.3	238.2	11.4	948.88		
M22 RADOME: 7 psi	39073	505.2	657.0	267.7	8.1	1143.74		
						1151.25	6.8	15.01
	39074	516.4	689.1	259.8	7.5	1158.75		
						1166.25	7.0	14.99
	39077	527.6	624.8	265.0	8.1	1173.74		
TACAN MAST: 7 psi	39078	508.4	612.1	237.7	8.4	1142.80		
						1150.78	7.1	15.96
	39079	520.3	739.9	267.6	8.3	1158.76		
						1165.96	6.9	14.39
	39086	531.1	725.0	262.4	8.1	1173.15		

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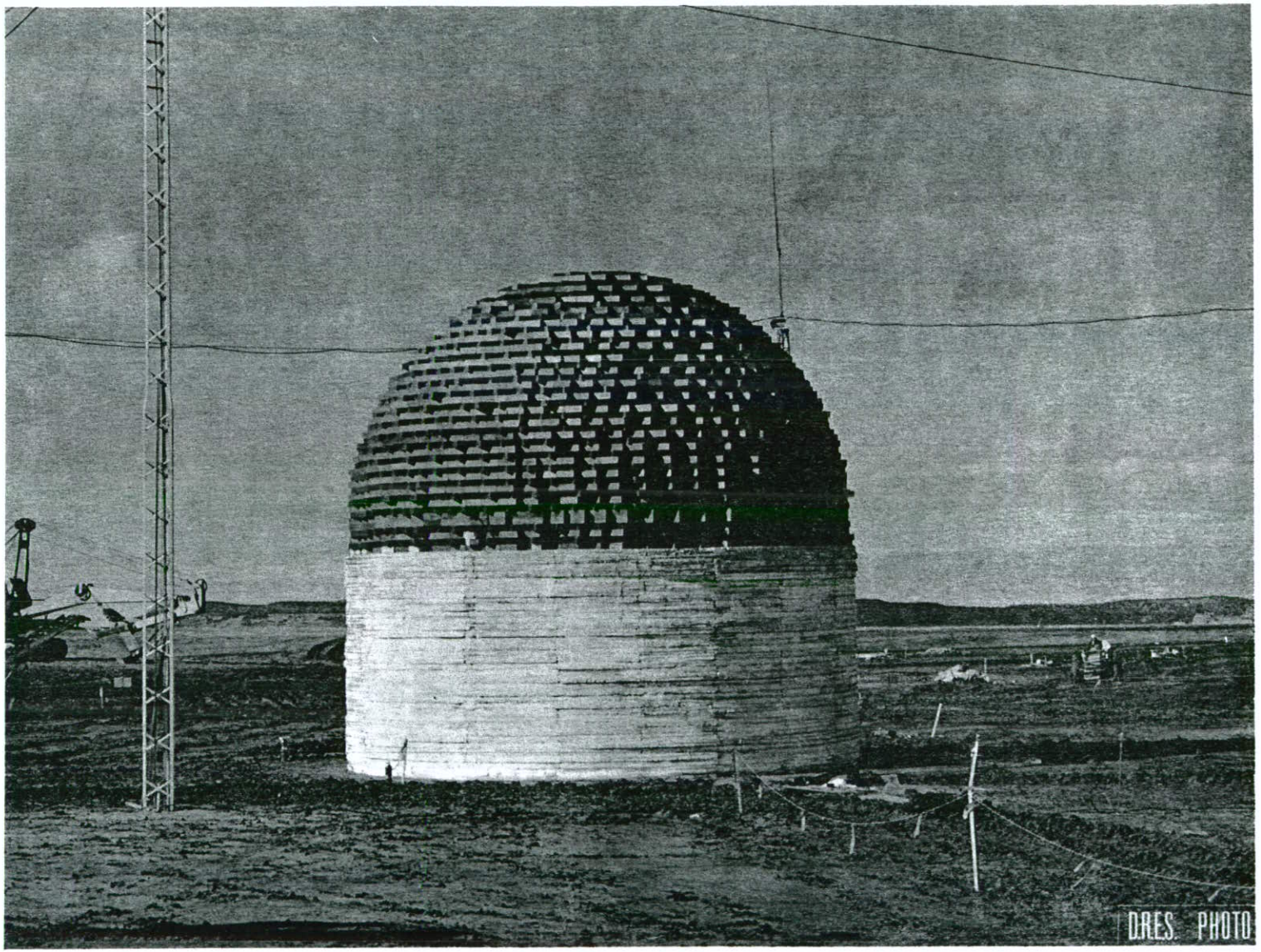


FIG I. EVENT MIXED COMPANY. 500 TON TNT CHARGE BEFORE DETONATION

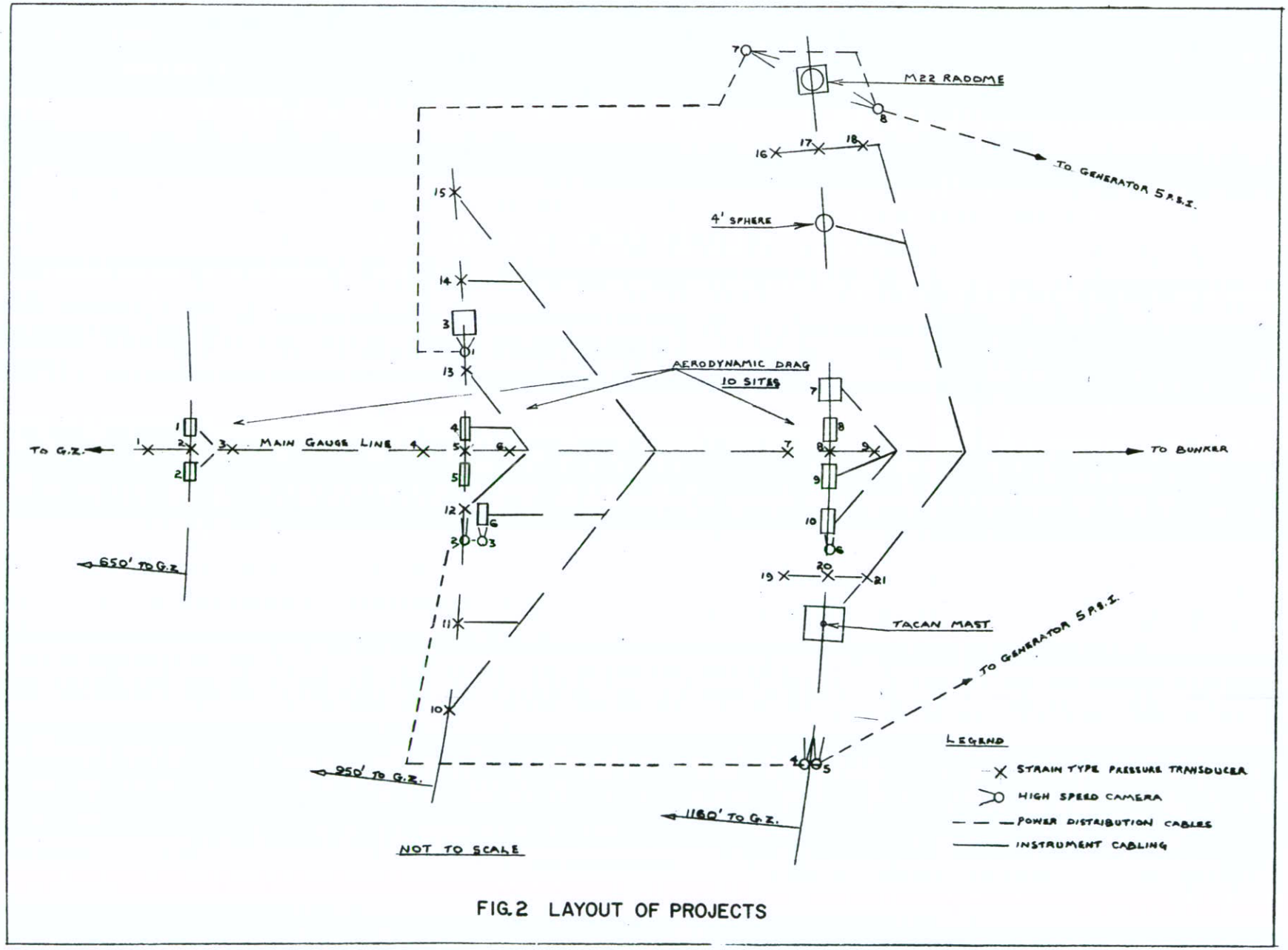


FIG. 2 LAYOUT OF PROJECTS

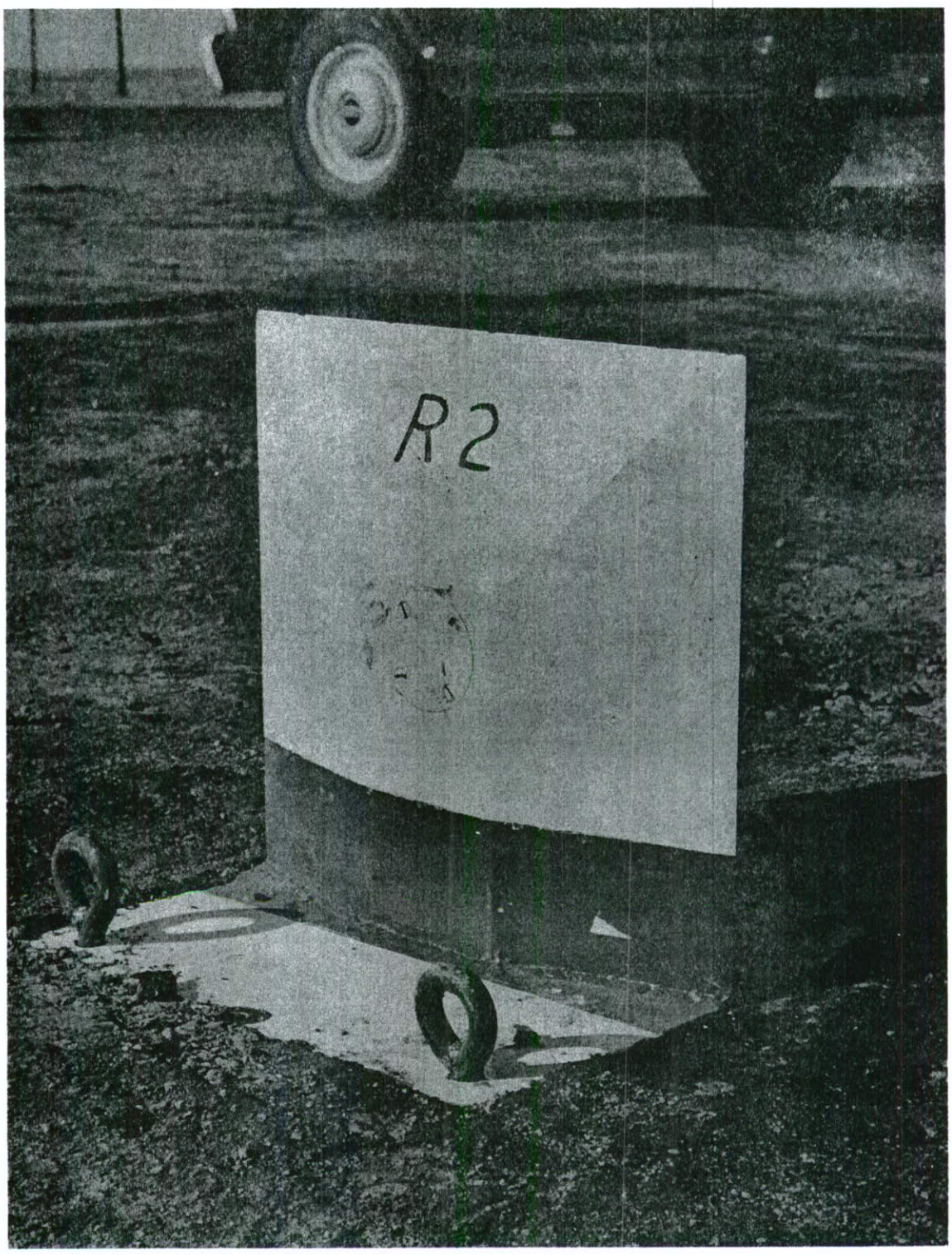


FIG.3 EVENT MIXED COMPANY. MOUNTING USED FOR PRESS-TIME GAUGES

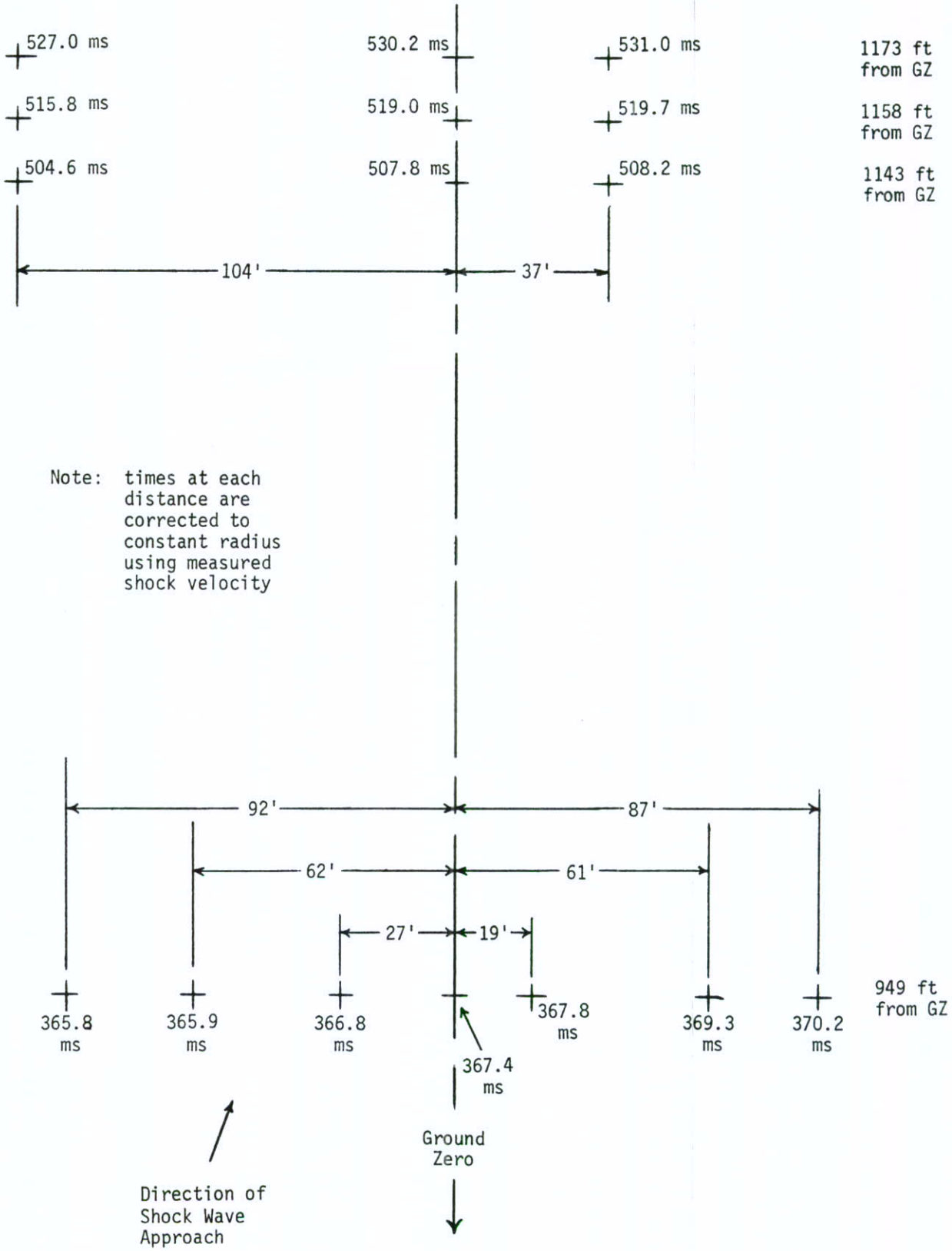


FIG.4 TIME OF ARRIVAL DATA - CANADIAN SECTOR.

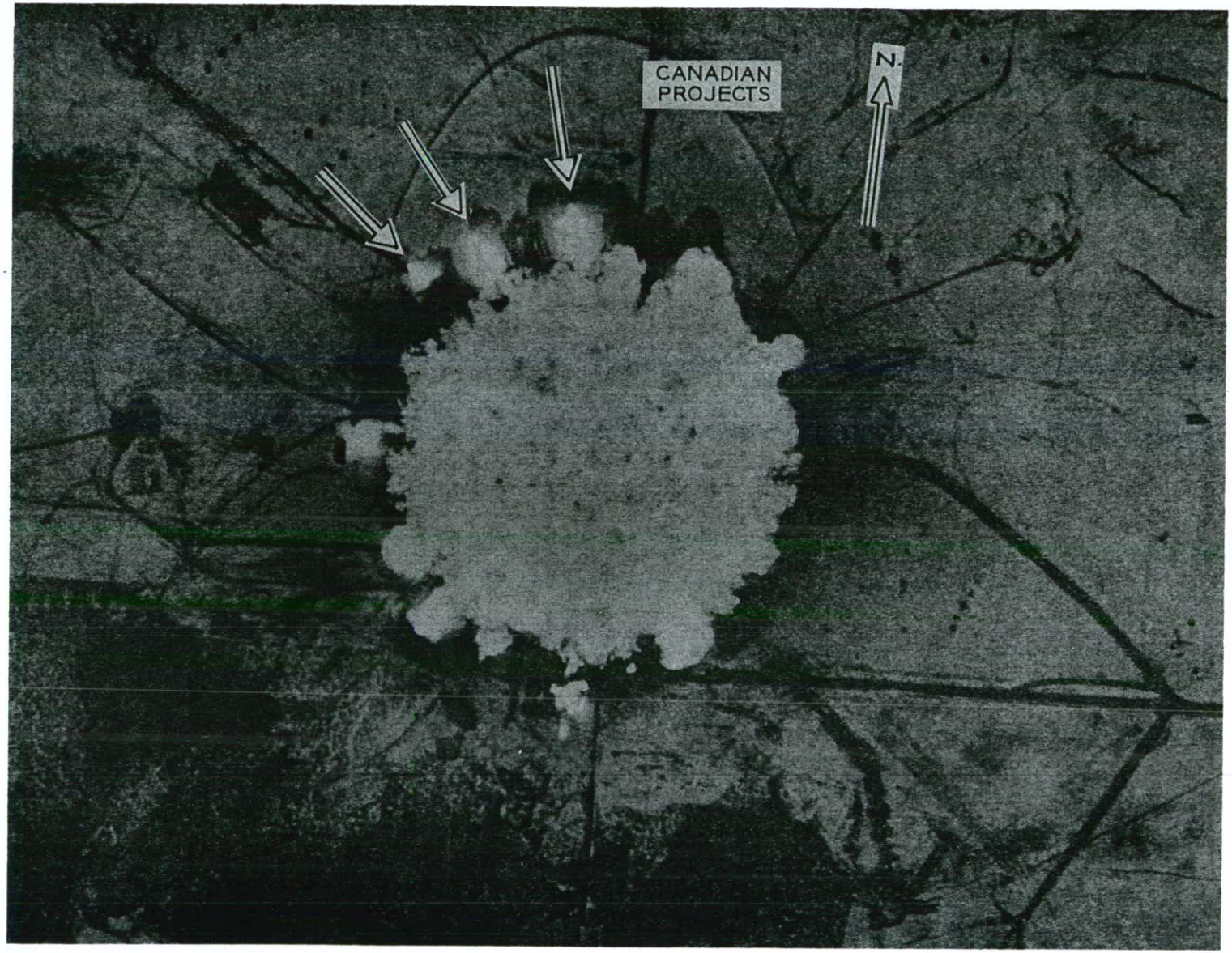
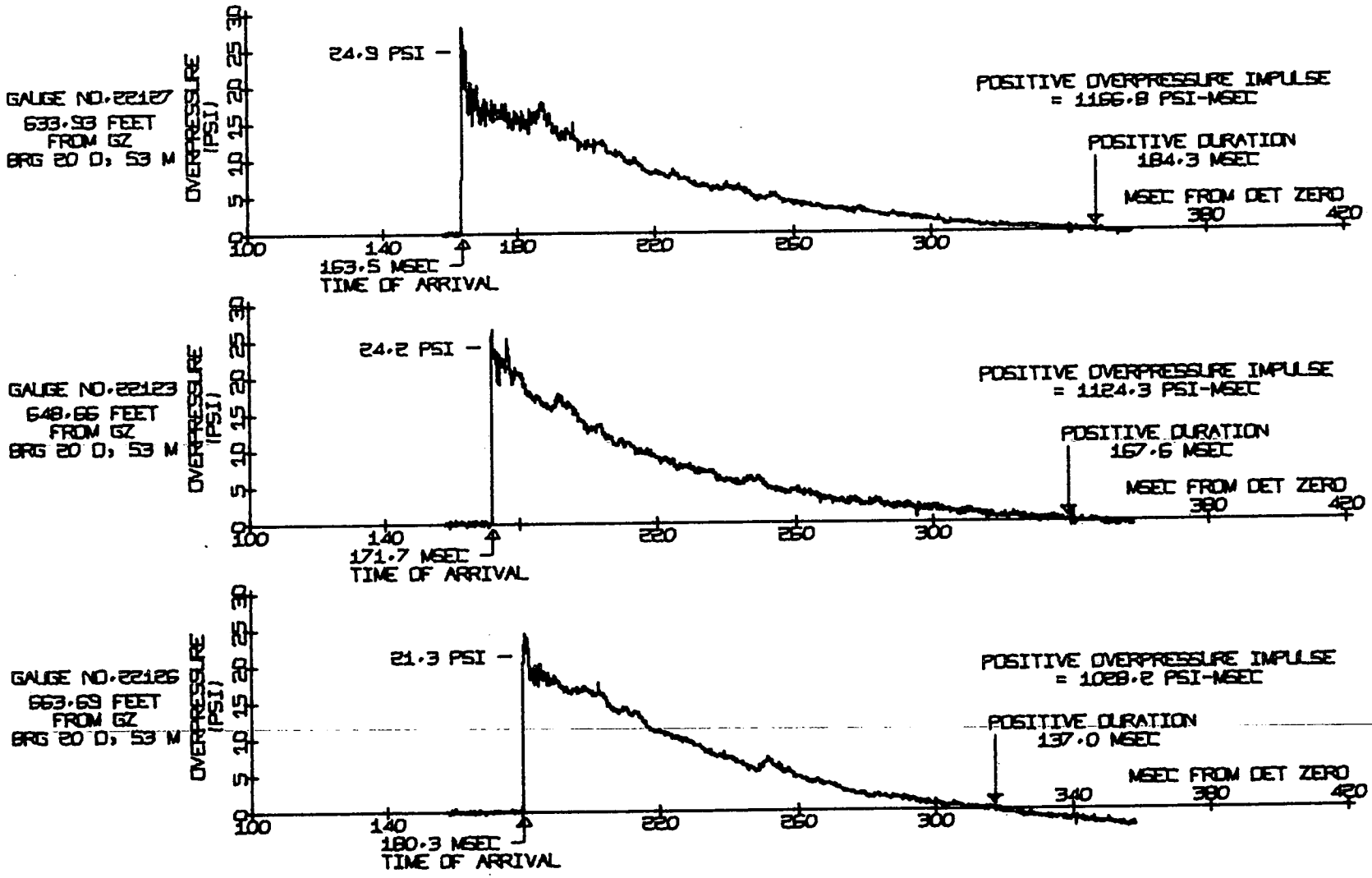


FIG. 5 EVENT MIXED COMPANY. AERIAL VIEW OF THE BLAST AT Z+190 MSecs APPROX. ARROWS INDICATE ANOMALIES AFFECTING THE CANADIAN PROJECTS.
(HORIZONTAL FIELD OF VIEW : 3000 Ft approx)



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PRESSURE-TIME RECORDS - 25 PSI FREE-FLIGHT CYLINDER POSITION

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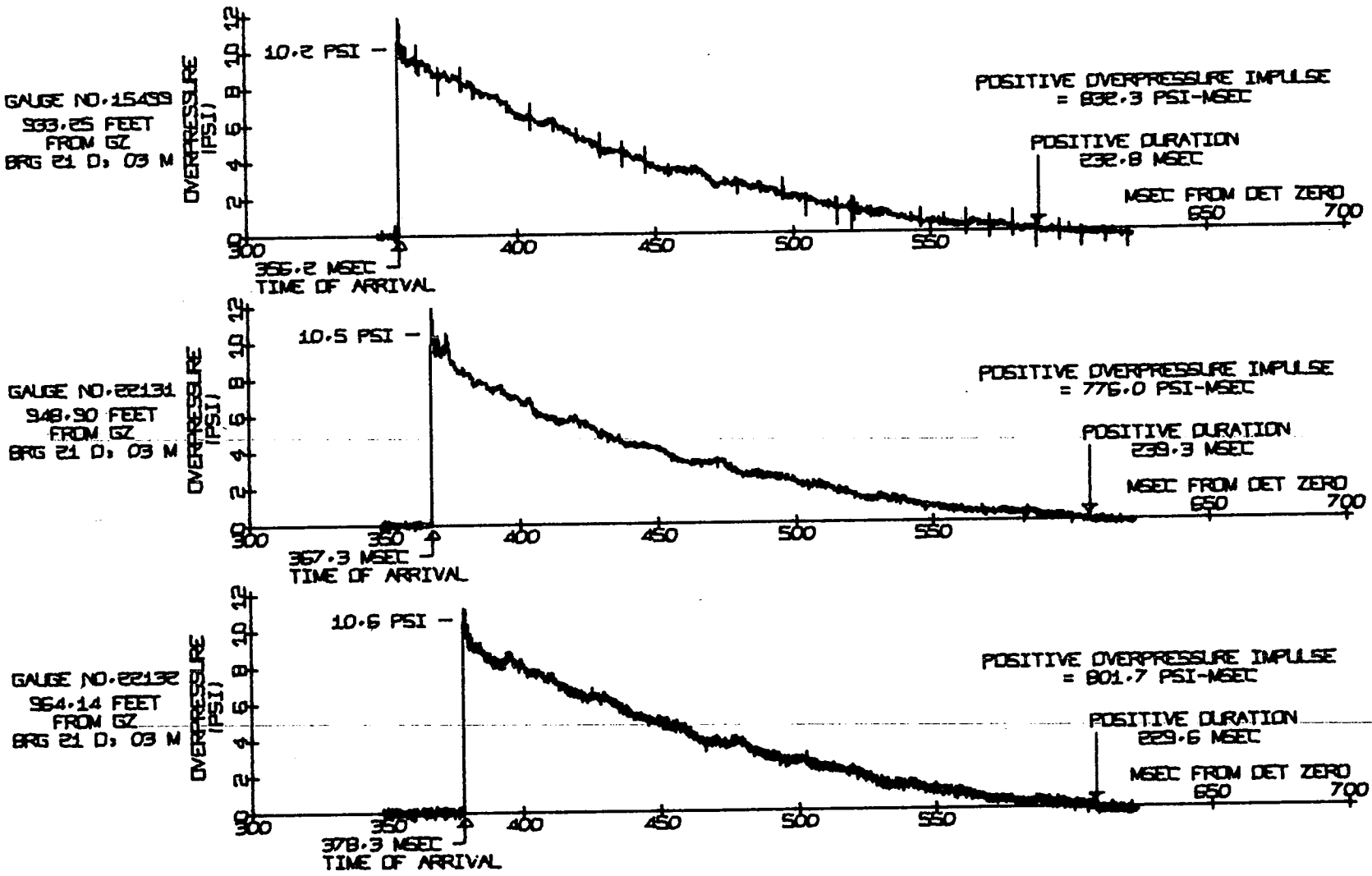

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PRESSURE-TIME RECORDS - 10 PSI FREE-FLIGHT CYLINDER POSITION

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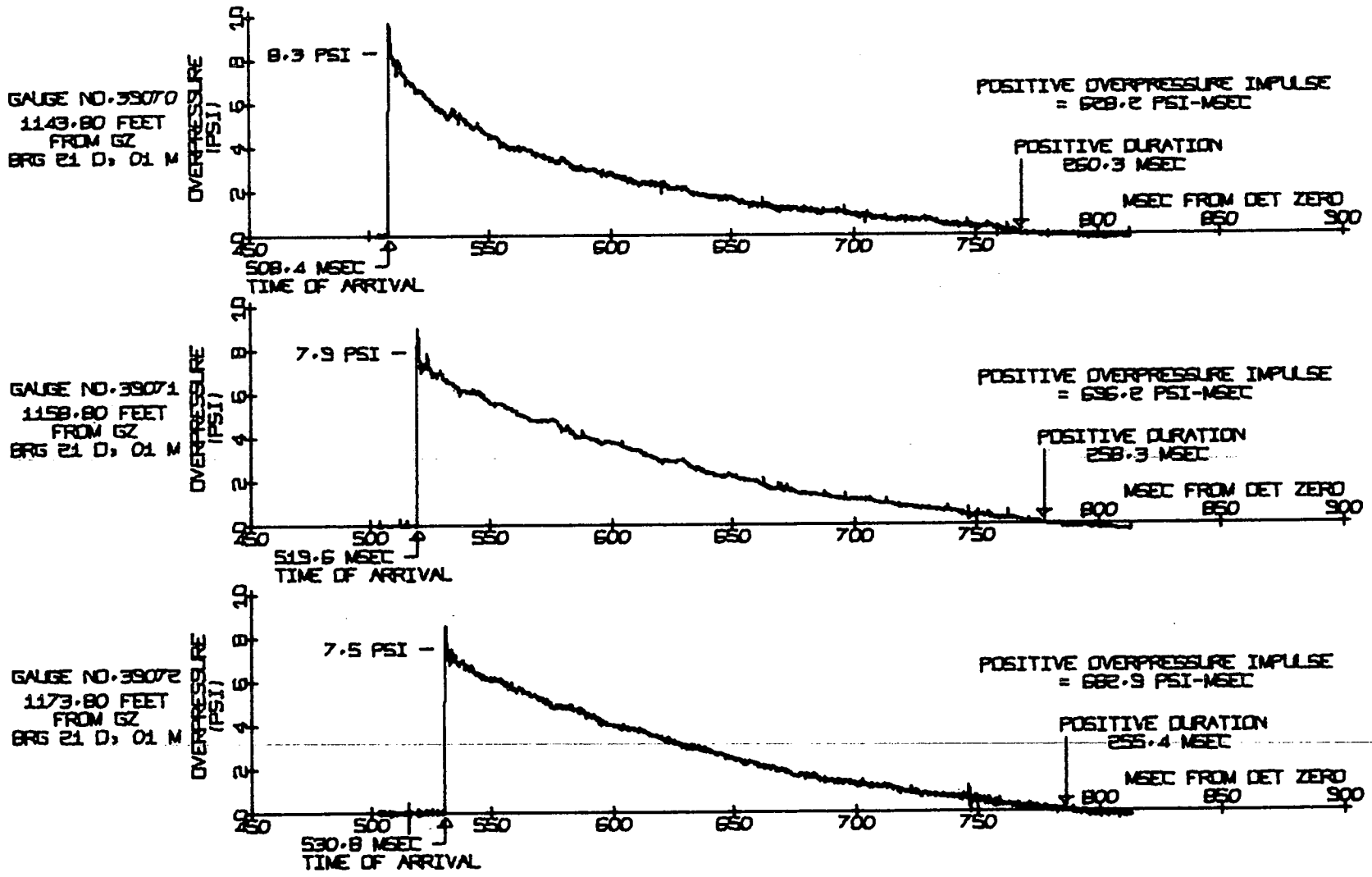

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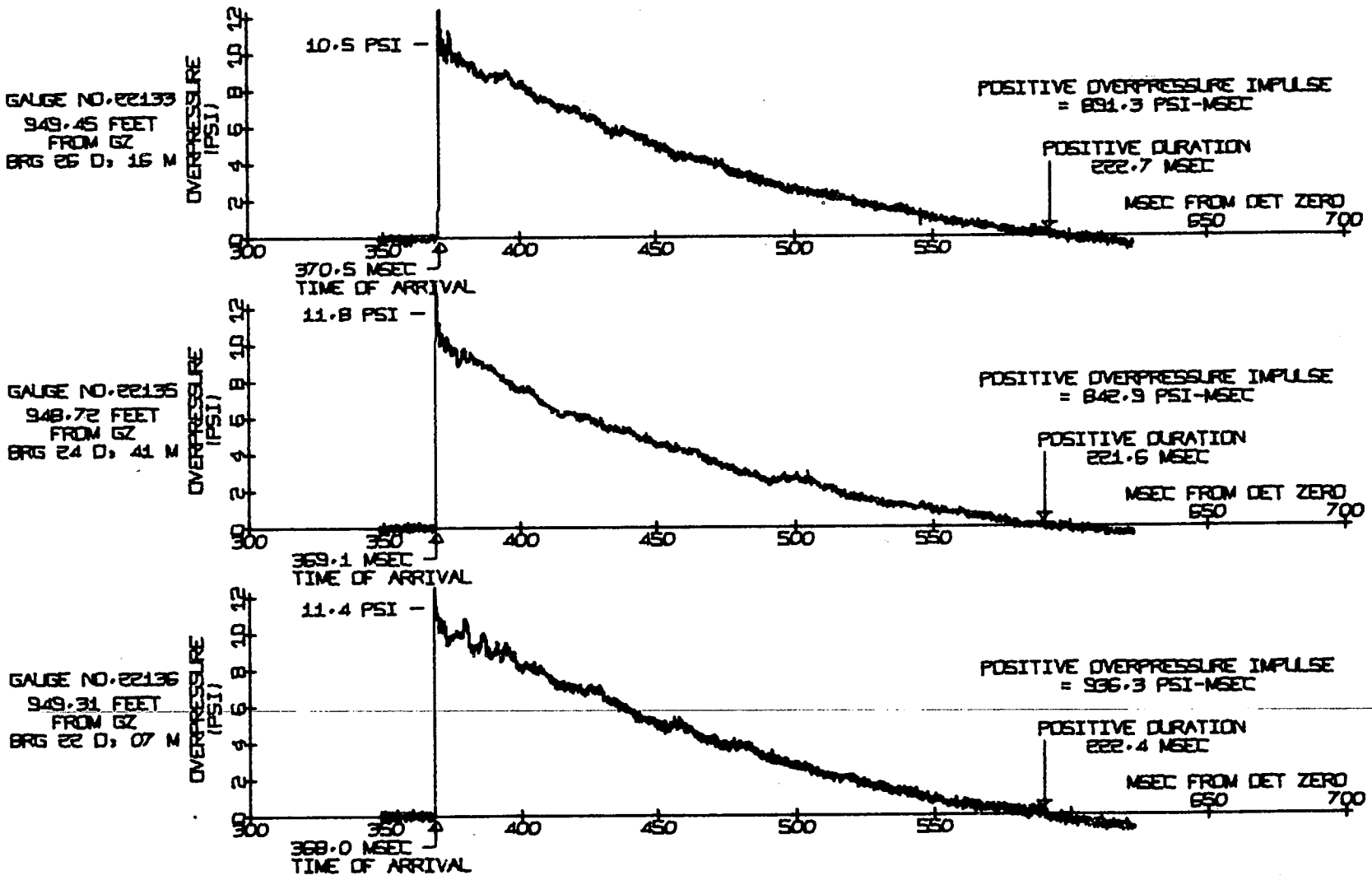

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PRESSURE-TIME RECORDS - 10 PSI LATERAL LINE, EAST SIDE

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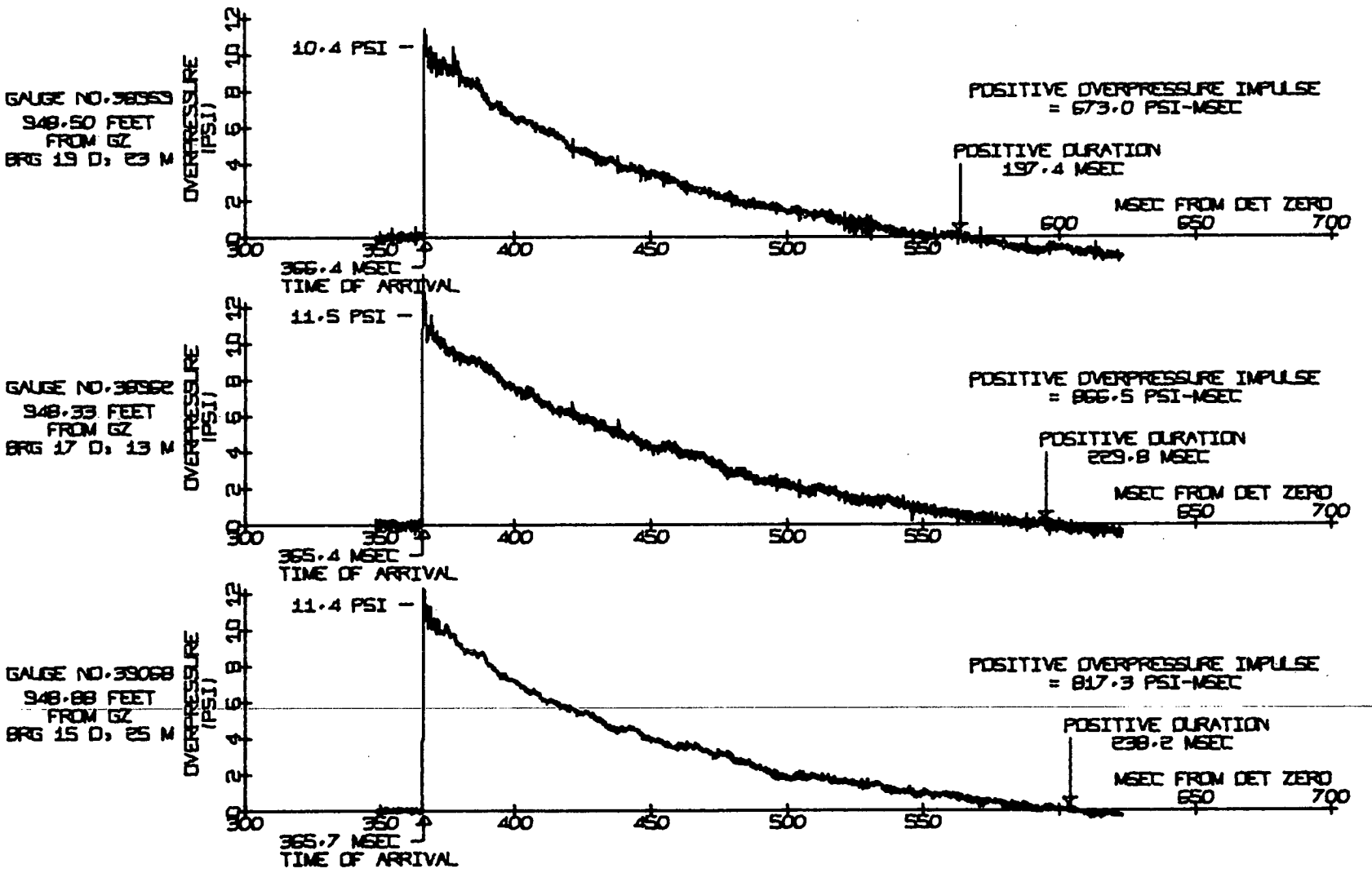

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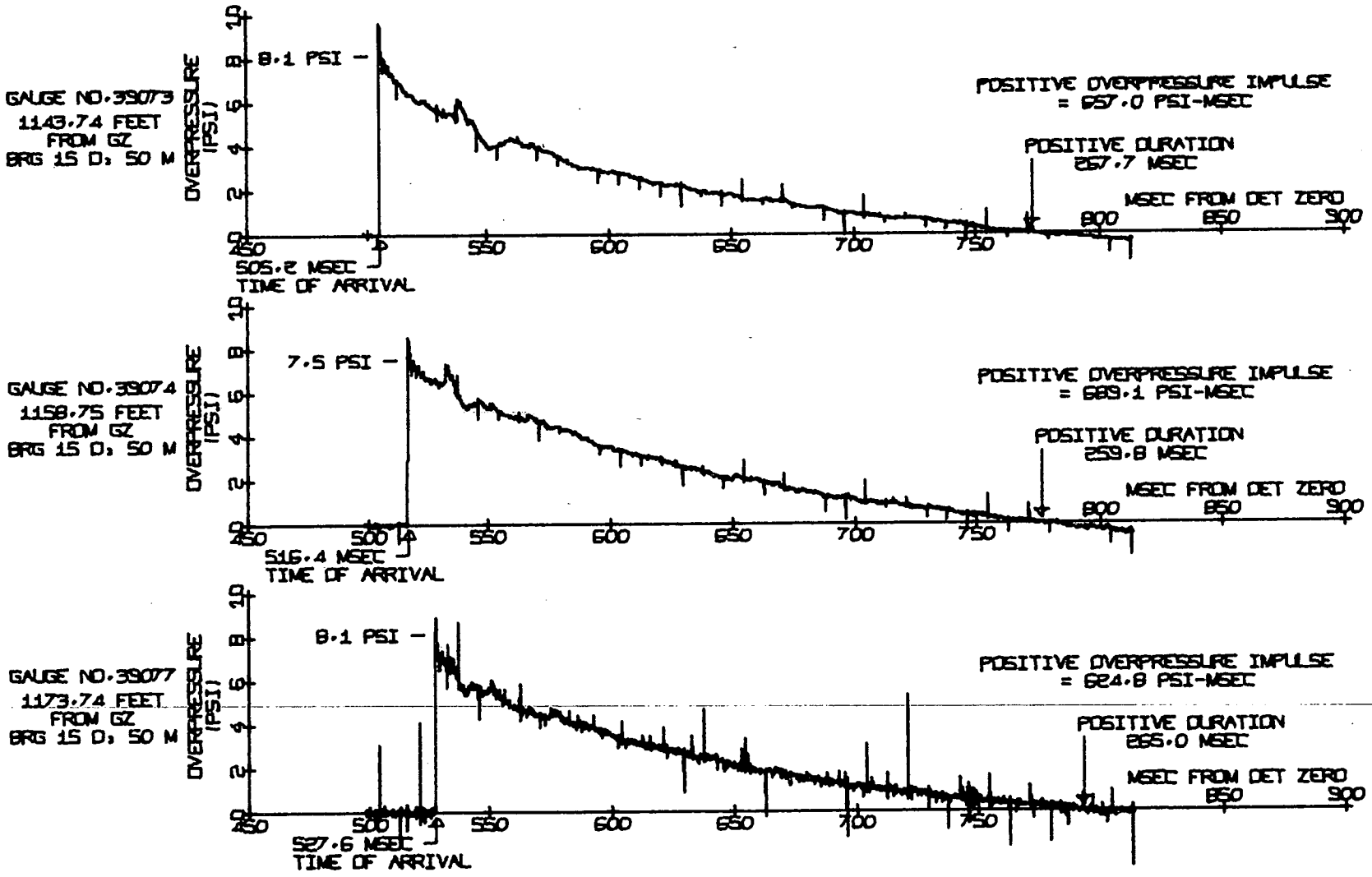

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PRESSURE-TIME RECORDS - RADOME POSITION (7 PSI)

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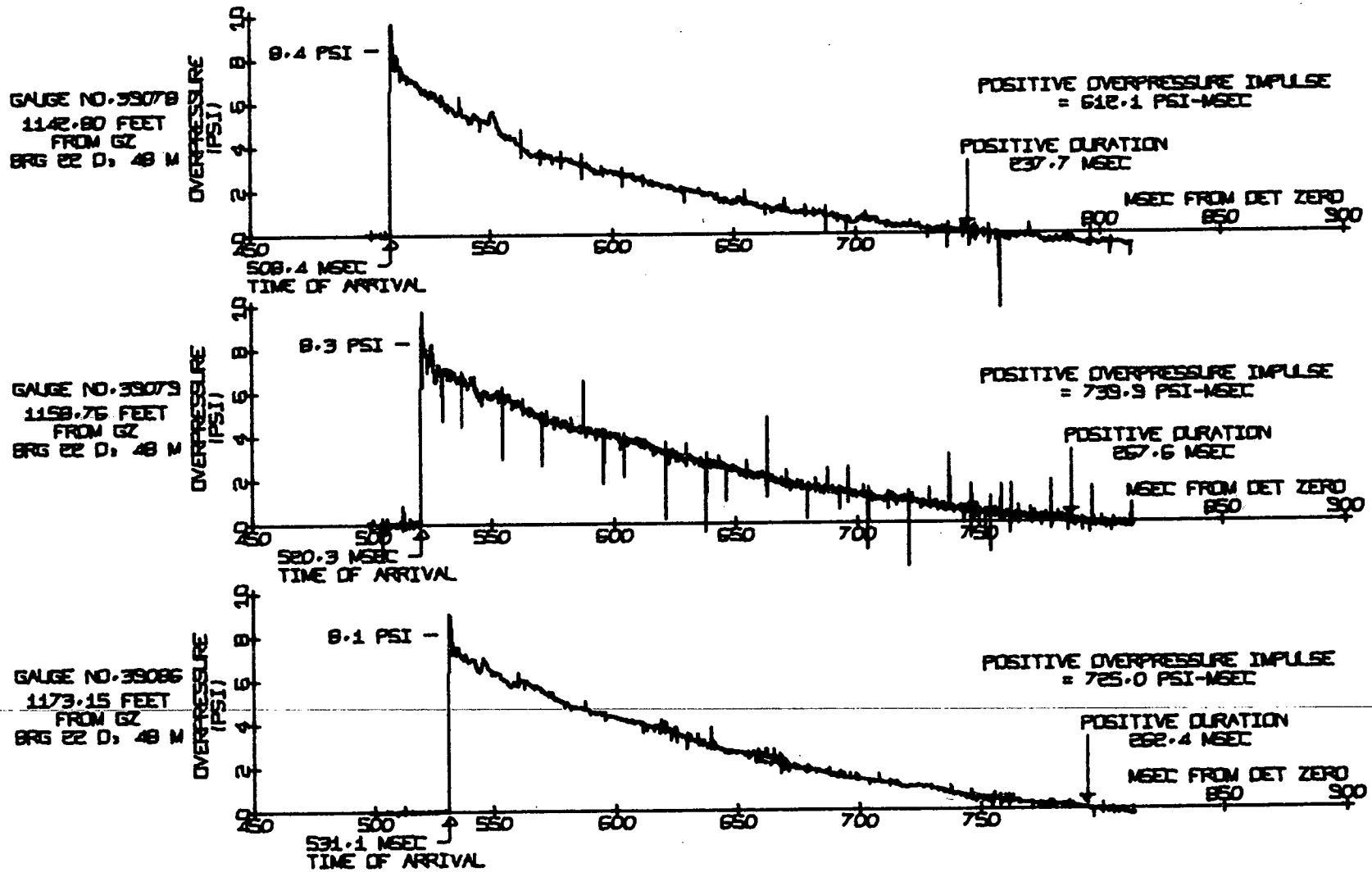

EVENT MIXED COMPANY

PRESSURE-TIME RECORDS - TACAN MAST POSITION (7 PSI)

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2 - NRC/Aero

1 - NRC Building Research

1 - NRC/National Science Library

1 - Dr. J.H.T. Wu, Director Supersonic Gas Dynamics Research Lab., McGill University, Montreal

1 - University of Calgary, Dept. of Mech. Eng.

1 - AECL

1 - CEM/TL

1 - CO, CFNBC School

1 - Chief, CDRS (London)

3 - NRC/CB Library, Mr. Wolchuk

1 - Air Services, Meteorological Division, Department of Transport, Toronto.

1 - University of Toronto, Institute of Aerophysics (Dr. Patterson)

1 - Computing Devices of Canada, P. O. Box 508, Ottawa, Ont.

1 - Southern Alberta Institute of Technology, 13th Avenue & 10th St., N. W. Calgary, Attn: A. R. G. Leckie.

2 - McGill University, Prof. McCutcheon

BRITAIN

MINISTRY OF DEFENCE

2 - DRIC

1 - Rocket Propulsion Dept. (Wescott)

2 - Royal Aircraft Establishment

1 - Aircraft, R&D (Research) (ADARD)

1 - Royal Radar Establishment

1 - National Gas Turbine Estab.

1 - English Electric Co.

1 - Aeronautical Research Council

1 - College of Aeronautics

1 - University College London, Dept. of Mechanical Engineering, Gower St., London W. C. 1.

10 - Serial 7

1 - DG of Arty

1 - DGFVE

2 - MVEE

1 - RARDE

2 - AOSR(5) 1 for DOAE

1 - RMC of Science

2 - MOD (Army) Library 1-MGO(Nuclear)

7 - Serial 9

2 - DSCD Colchester

1 - MVEE

3 - AMD 5

1 - Army School of Health

1 - Royal Army Medical College

1 - AMD 8

2 - AWRE Foulness, Essex, England
Attn: Superintendent

1 - Naval Construction Research Estab.

1 - Admiralty Research Lab.

1 - DG Ships

1 - Admiralty Research Lab.

1 - Chief Scientist RAF

BRITAIN DIRECT

1 - Atomic Energy Research Establishment
Atomic Energy Authority

1 - National Physics Lab.,
Aerodynamics Dept.