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TITLE

CARDE BLACK BRANT 1 VEHICLE TRIAL FORT CHURCHILL ROCKET RANGE \(U\) - SEPTEMBER 1959

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FORT CHURCHILL ROCKET RANGE (U)

September 1959

by

C.D. Martin, J.R. Cameron and R.P. Blake

DEFENCE RESEARCH BOARD

CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

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ABSTRACT

The first dynamic test of the CARDE Black Brant rocket engine was carried out in four successful launchings at the Fort Churchill Rocket Range. The problems of carrying out the first all-Canadian launchings of a large rocket and the general results obtained from the trial are described.

CONTENTS

INTRODUCTION

The development of rocket engines under the CARDE propulsion programme involves several distinct phases. Initially, the processability and ballistic regularity of selected propellants are verified in small 8 in. engines containing 80 lb of propellant. Following these qualifications, erosive burning data for the propellant may be obtained in an 80 in. engine containing 160 lb of propellant. After full acceptance, a propellant is then considered for the end item use.

The formulation 4760/A5, a polyurethane composite propellant containing 75 per cent crystalline solids, has passed all the above tests. Nine of the 17 in. engines filled with 1800 lb of this propellant, have been statically fired under a variety of temperature conditionings (1). Now the 15KS25000 engine was ready for dynamic tests. For this purpose, an inclined launcher with 15 ft of guide rail had been installed at the Fort Churchill Rocket Range Facility. In this report, the observations and results of the Black Brant I trials carried out in September 1959 are compiled as well as some recommendations for future trials.

OBJECTIVE

The main object of the trial was to confirm by dynamic firings the already acceptable static performance of the CARDE 17 in. rocket engine which had been developed and tested at CARDE. A secondary object was to check the design of the vehicle and launcher. A detailed description of the method of attaining the objectives is included as Appendix I in Section I of Outline of Operations at Fort Churchill Rocket Range Fall 1959.

TRANSPORT TO THE RANGE

About the middle of July 1959 the RCAF airlifted to the range most of the telemetry ground station equipment and a winch for raising the vehicle onto the launcher. Early in August a railway flat car and box car transported vehicle handling equipment, rocket engine temperature conditioning chamber and additional telemetry ground station equipment from CARDE to the range. Late in August the RCAF airlifted the balance of the ground station equipment, photographic equipment and the four test vehicles by means of two C119 and two C47 special flights. Personnel were transported partly by commercial flights and partly by regular RCAF Service Flights from Montreal to Fort Churchill.

RANGE FACILITIES

The range facilities requested from the U.S. Rocket Research Facility at Fort Churchill to carry out the trial are given in the Outline of Operations, Appendix I. Except for vehicle preparation space requested in the Aerobee Preparation Building, all the necessary range facilities were provided to the satisfaction of the CARDE team. Since the U.S. had arranged to launch two

Aerobees in the same two-week period designated by CARDE, it was decided from safety considerations that the CARDE vehicles would have to be assembled in one of the magazines since the rocket engine was relatively an untried item. With some last minute improvisations the change of place was satisfactory although the operations were somewhat laborious. The magazine which was used as a combined rocket engine conditioning and vehicle assembly building is shown in *Figures 16 and 17.*

RANGE PERSONNEL

U.S.	Commanding Officer – Lt Col M. Cunningham
	Plans and Progress Officer – Capt F. Jones
	Range Control Officer – Capt J. Hembree
Canada	Range Safety Officer – Major H. Winters

TRIALS TEAM PERSONNEL

Trial Project Officer	– C.D. Martin	
Launching Officer	– Capt J.H. Letourneau	
Professionals	– H.W. Morewood	
	R. Simpson	
	A.L. Odgers	
Technicians	– D. Routledge	C. Ethier
	S. Palidwor	J.B. Halle
	S/Sgt W. Stovin	G. Gagne
	R. Robinson	L. Charland
	H. Forbes	E. Dostie

OUTLINE OF OPERATIONS AT FORT CHURCHILL ROCKET RANGE

The Outline of Operations (Appendix I) which was submitted in a final form, dated 18 August 1959, to the officer in charge of the U.S. Rocket Research Facility at Fort Churchill, describes the test vehicle and range requirements for the trial. With the exception of the change in the location for assembling the vehicle just prior to launching, as stated before, all services and facility requirements were met through the efforts of the U.S., Canadian Army, Department of Transport, and DRNL. In the matter of meteorological data, the impact prediction group of the U.S. Army Signals Missile Support Agency willingly offered to assist in the CARDE trial. As a result it was not necessary to call upon DOT meteorological office for other than routine weather forecasts and maps. A method of impact prediction prepared by B. Cheers of CARDE was intended to be used; however, since the calculations were time consuming a U.S./A.S.M.S.A. offer to programme the PTV data into its impact predicting computer was accepted and used for all launchings.

SCHEDULE OF EVENTS

Enclosed as Appendix II is the sequence of events which was used to carry out the launching of each vehicle. While the count-down used was more than adequate for the operations, holds, due to tracking radar and range clearance difficulties caused some delay to the target time of launching with the exception of Black Brant I–04 for which the time was able to be advanced by 15 min.

SUMMARY OF LAUNCHINGS

Plans were completed on 2nd September 1959 for the launching attempt of the first vehicle during the afternoon of 3rd September. The schedule of events was carried through to the time when the nose cone was to be placed on the vehicle but inability to obtain a satisfactory radar check with the beacon in the nose cone caused postponement of the firing at 1600 hr owing to approaching darkness.

To avoid confliction with other trials at the range, plans were made on 4th September to launch two vehicles on 5th September, one about 0900 hr and the other about 1600 hr. Black Brant I–01 was launched successfully at 0927 hr CST on 5th September. Good telemetry recording until impact was obtained by the ground station but radar tracking was lost after about 51 sec of flight.

Black Brant I–02 was launched successfully at 1624 hr CST on 5th September. Some of the telemetry recording was unintelligible but a complete record of the performance of the engine was obtained. Radar tracked the vehicle for the entire flight.

The first two vehicles were ballasted to a "maximum telemetry weight condition plus a 10-in. forward shift of the centre of gravity" of the vehicle. Since from the quick-look telemetry records of the lateral accelerometers there was no indication of instability in the first two vehicles, it was decided to launch the last two vehicles in the minimum telemetry weight centre of gravity position at the scheduled engine temperature of 100°F.

Black Brant I–03 was launched successfully at 0914 hr CST on 8th September with the engine conditioned at 100°F for 30 hr. Telemetry was lost about the end of burning of the engine. Radar failed to track the vehicle after a few seconds of flight. Although there was some doubt regarding the stability of the vehicle in the minimum telemetry weight centre of gravity position, the intelligible evidence from the telemetry quick-look records did not point to vehicle break-up.

Black Brant I–04 was launched successfully at 1548 hr CST on 10th September with the engine conditioned as for Black Brant I–03. Good telemetry records were obtained to impact but radar again failed to track the vehicle after a few seconds of flight. There was a small amount of vehicle instability evident at engine burn-out from the transverse accelerometers but the oscillations damped out in a few seconds.

Wind data for the significant time of day before and after the launching of each vehicle are given in Appendix III. Vehicle data are given in Appendix IV.

DISCUSSION

(a) Launcher

Since the 10 hp motor of the winch for elevating the launcher did not have sufficient power, it was planned to use the winch of a D–7 tractor. During dry runs with a dummy vehicle it was found that the use of this winch was not as satisfactory as moving the tractor itself and the latter method was used throughout the trial. There were no problems in the raising of the vehicles onto the launcher by the hand operated launcher winch. The blast from the engine caused no apparent damage or movement of the launcher and no measurable changes were found in the launcher structure after any of the firings. The launcher boom was repainted after completion of the trial.

(b) Handling Equipment

In most respects it was found that the handling equipment was satisfactory for the operations. Use of a magazine for the final vehicle assembly proved to be laborious with the large gantry since the conditioning box and gantry had to be shuffled to provide assembly space. A borrowed and modified dolly was needed to move the nose cone from the Aerobee Preparation Building to the assembly magazine. The need to return engine and nose cone cradles for the second air shipment of vehicles caused some difficulty and indicated the desirability of providing cradles for each vehicle to be fired in a trial.

(c) Vehicle Preparation

Since the CARDE launcher is open to the weather, vehicle assembly has to be carried out in a building. Permission to use the Aerobee Preparation Building for vehicle assembly might have been obtained if the engine could have been armed at the launcher after the nose cone was in place.

The conditioning box for the engine proved to be satisfactory for its role.

Rainy weather during three of the four firings caused difficulties and apprehension while checking out the vehicle at the launcher, but fortunately no breakdowns occurred. Lack of planned shelter for the cameras required extra effort and caused degradation in photographic coverage of the trial.

(d) Nose Cone Instrumentation

Ten temperature transducers in the form of thermistors were employed to measure aerodynamic heating of the nose cone, the dummy telemetry antenna and heating of the head end of the engine from propellant burning. In Black Brant I–03 and I–04 the value of a thin coating of Rokide sprayed as a patch on the nose cone skin to resist aerodynamic heating was determined by temperature transducers. In most instances unsatisfactory temperature recording was obtained possibly due to lack of ruggedness in the thermistors used.

The apparent failure of the DPN–19 radar beacon after launch caused the loss of some vehicle velocities and trajectories; however, in the case of Black Brant I–04 the evidence pointed to the failure of the tracking radar rather than the beacon. The trajectories of Black Brant I–01, extrapolated beyond 50 sec, and Black Brant I–02 are shown in *Figures 1 and 2*.

(e) Ground Station

The telemetry ground station worked satisfactorily but some difficulties were encountered due to range power fluctuations. There was a short break in transmission from Black Brant I–02 after engine burn-out. Signal transmission from Black Brant I–03 dropped below the noise level after burn-out. The signal was audible on the receiver speaker throughout the rest of the flight but its level was too low to convey any intelligence. This could have been caused by loss of antennae but there does not appear to be any reason why this should have occurred. The vehicle antennae pattern was such that, through a large part of the trajectory, a complete null occurred in one orientation. As long as the vehicle spun at more than 15 or 20 rpm, only short drop-outs of RF would be experienced which would not seriously affect the received intelligence. However, it is plausible that the losses of signal on Black Brant I–02 and/or Black Brant I–03 may have been caused by a condition of zero spin with the vehicle oriented so as to present a null to receiving antennae continuously. Complete records were obtained on all four vehicles up to burn-out; to impact on Black Brant I–01 and Black Brant I–04; and on Black Brant I–02 to impact except for a drop-out, approximately 15 sec long, immediately following burn-out.

(f) Engine Performance

Good records of the pressure-time function of the four rocket engines were obtained from the two pressure transducers mounted on the head end of each engine. Records [2] indicate that propellant burning was normal and equivalent to that obtained under similar static firing conditions of the 17 in. engine. *Figures 3, 4, 5, 6 and 7* give the flight data and comparisons with average static records. Temperature transducers mounted on the head end of the engine indicated that there were no failures in the head end insulant. A normal temperature rise of approximately 15°C was recorded.

(g) Vehicle Performance

From the recorded telemetry data there was no evidence of any structural failures in the four firings. Acceleration, times of flight and trajectories for Black Brant I–01 and Black Brant I–02 were in agreement with calculated values of normal performance. Accelerations of Black Brant I–03 and Black Brant I–04 were normal and, based on estimated time of flight of Black Brant I–03 and actual time of flight of Black Brant I–04, the trajectories were apparently in agreement with the calculated ones. *Figures 8, 9, 10, 11, 12, 13, 14 and 15* show the data obtained from the accelerometer records.

RECOMMENDATIONS

1. The 15-hp motor available now at Fort Churchill should be installed prior to the next trial.

2. Modifications should be made to the vehicle saddles and launcher winch to decrease loading time and facilitate the securing of the winch after use.

3. A lighter and more mobile gantry should be provided for the handling of the engine and vehicle in No. 4 magazine. A nose cone dolly should be provided to transport the nose cone from the Aerobee Preparation Building to the assembly magazine.

4. The engine igniter should be modified to permit the installation of the initiating electrical squib when the vehicle is on the launcher.

5. Protection of cameras and vehicles from inclement weather during the launching period must be anticipated.

6. Two additional technicians, one in the airborne instrumentation crew and one in the ground station crew, are needed to properly carry out a trial involving four vehicles in a relatively short period of range time. Two photographers are the minimum requirement to adequately take care of normal work load.

7. Improvements are required in the radar beacons and the tracking radar to obtain reliable trajectory data.

8. Because of the long distance from the ground station to the CARDE launcher, excessive voltage drop occurs on the external power supply required to check out the vehicle prior to launch. A power supply at the launcher which can be switched and monitored from the ground station should be provided including suitable shelter for the unit.

CONCLUSIONS

The primary objective of the trial, the confirmation of an acceptable engine for dynamic firings at normal and elevated temperatures, was attained.

REFERENCES

(1) Dickinson L.A. and A.L. Odgers, The Development of a 15KS25000 Rocket Engine (U) CARDE Report 328/60 (Confidential)

(2) Gouge R., Data Reduction Results of Black Brant Trials at Churchill in September 1959 (U) CARDE Technical Letter 1271/60 (Restricted)

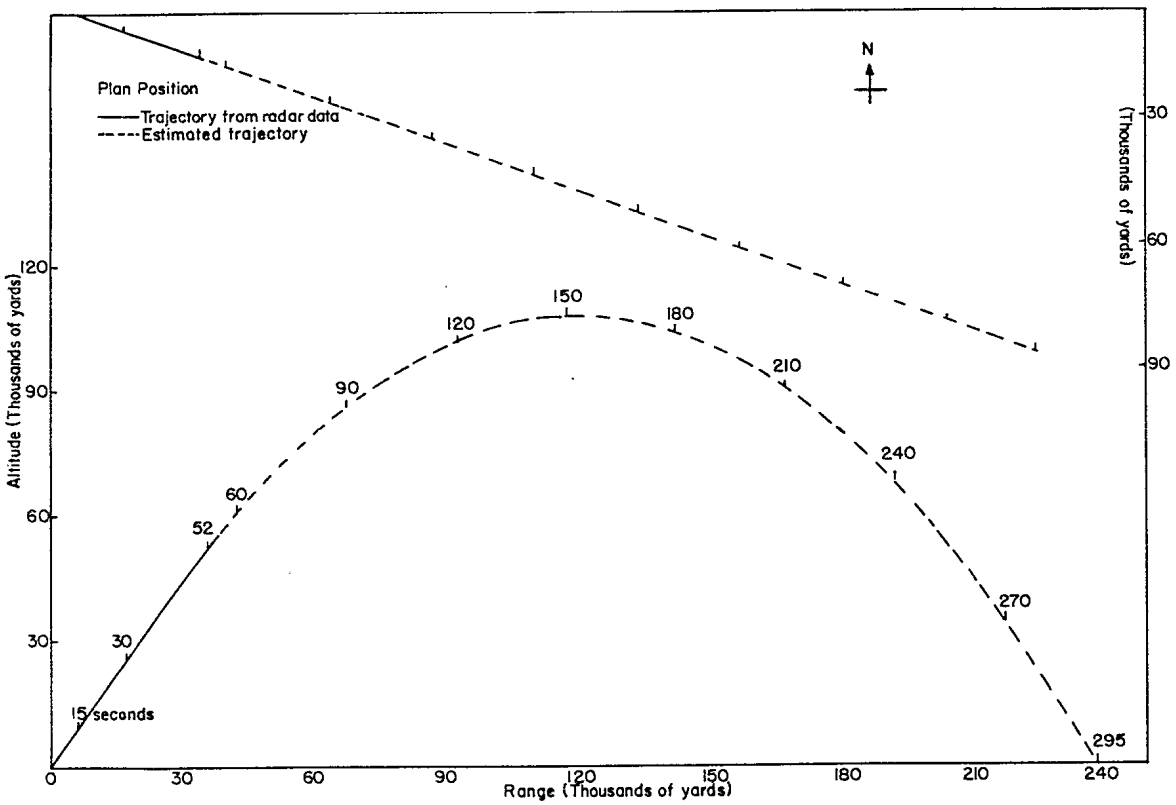

Figure 1 - PTV 1 Trajectory

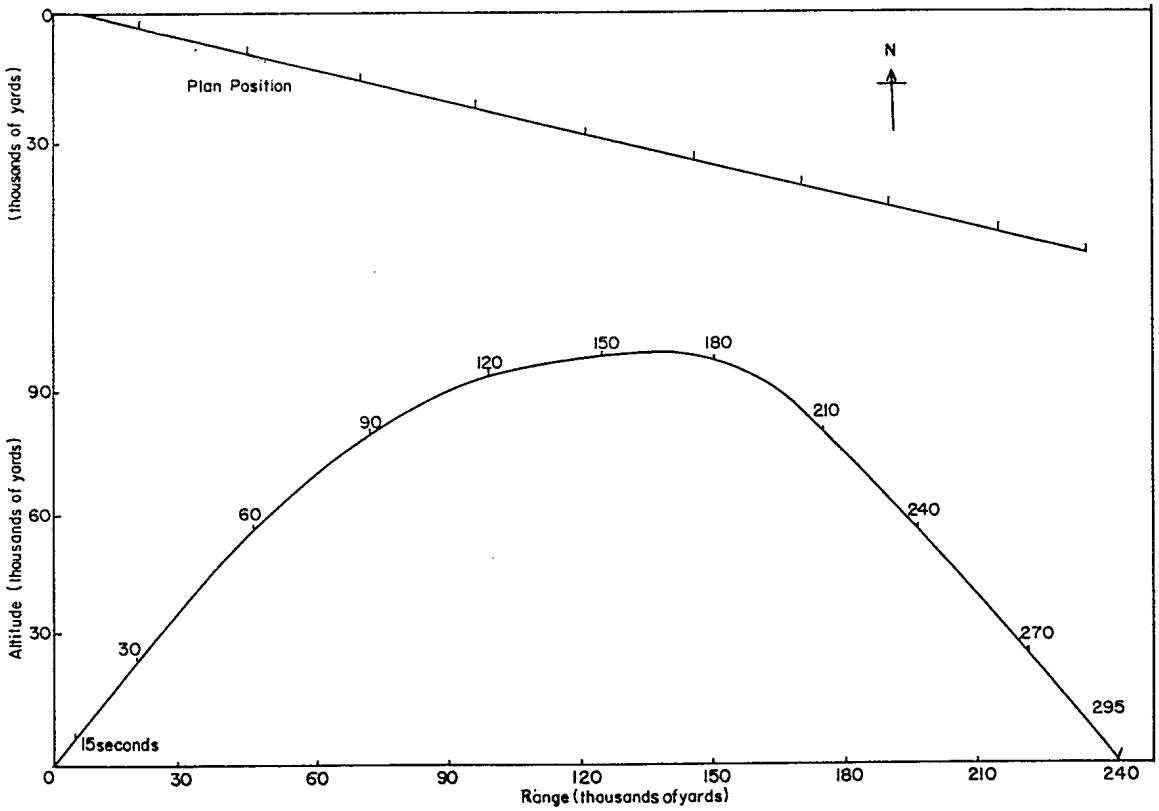

Figure 2 - PTV 2 Trajectory

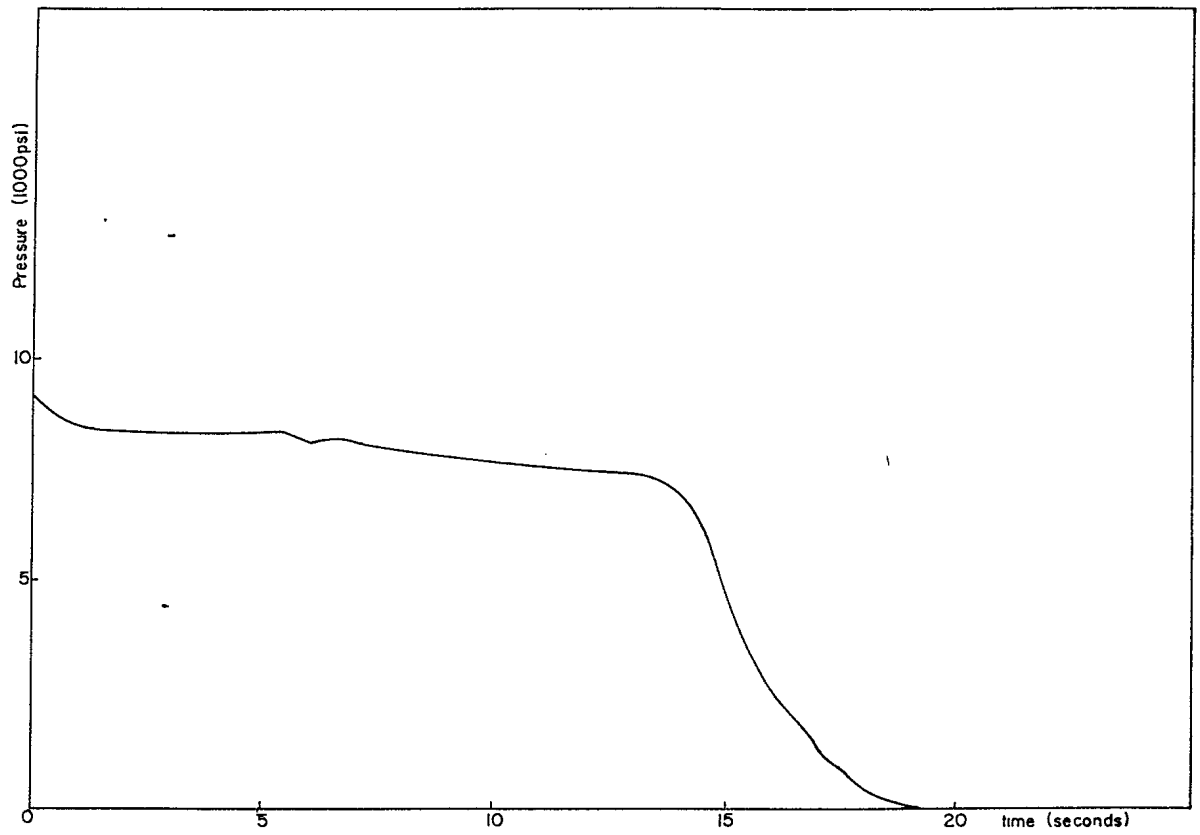

Figure 3 - Pressure-Time Record of PTV 1 Engine

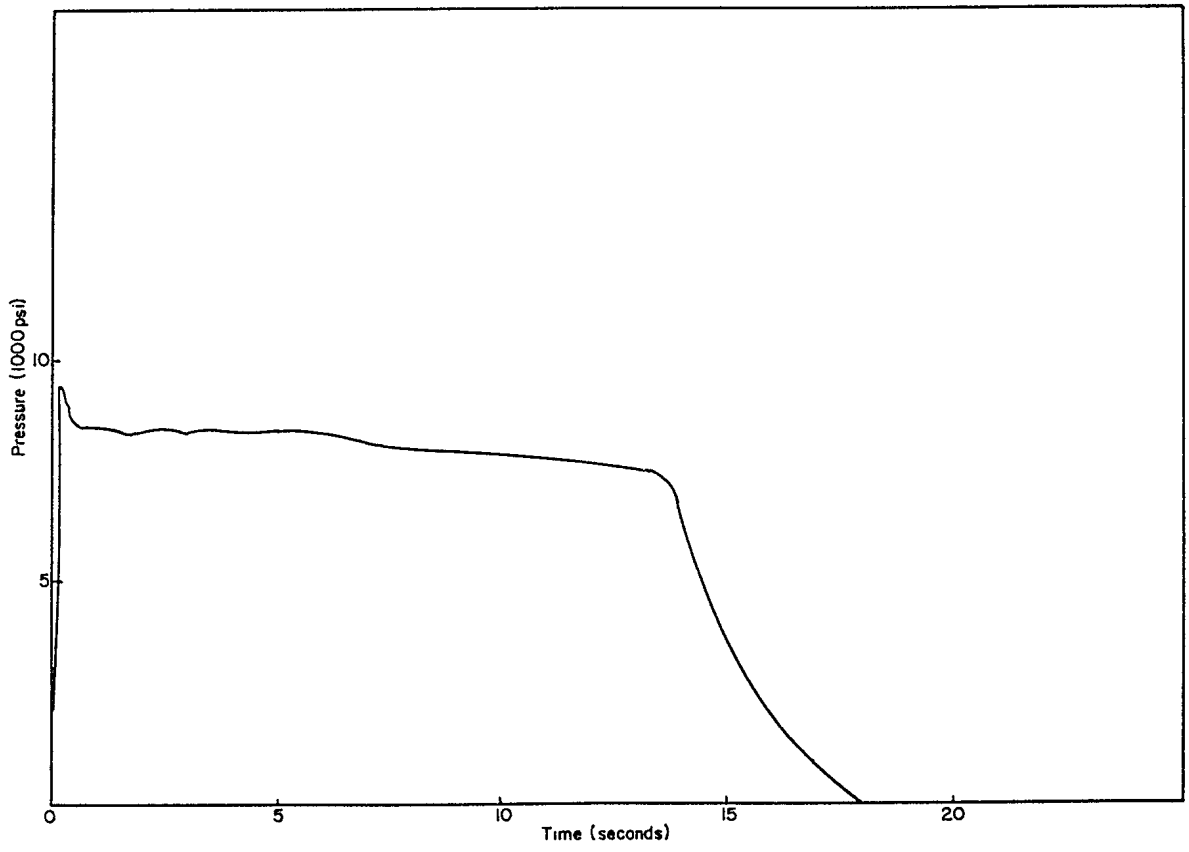

Figure 4 - Pressure-Time Record of PTV 2 Engine

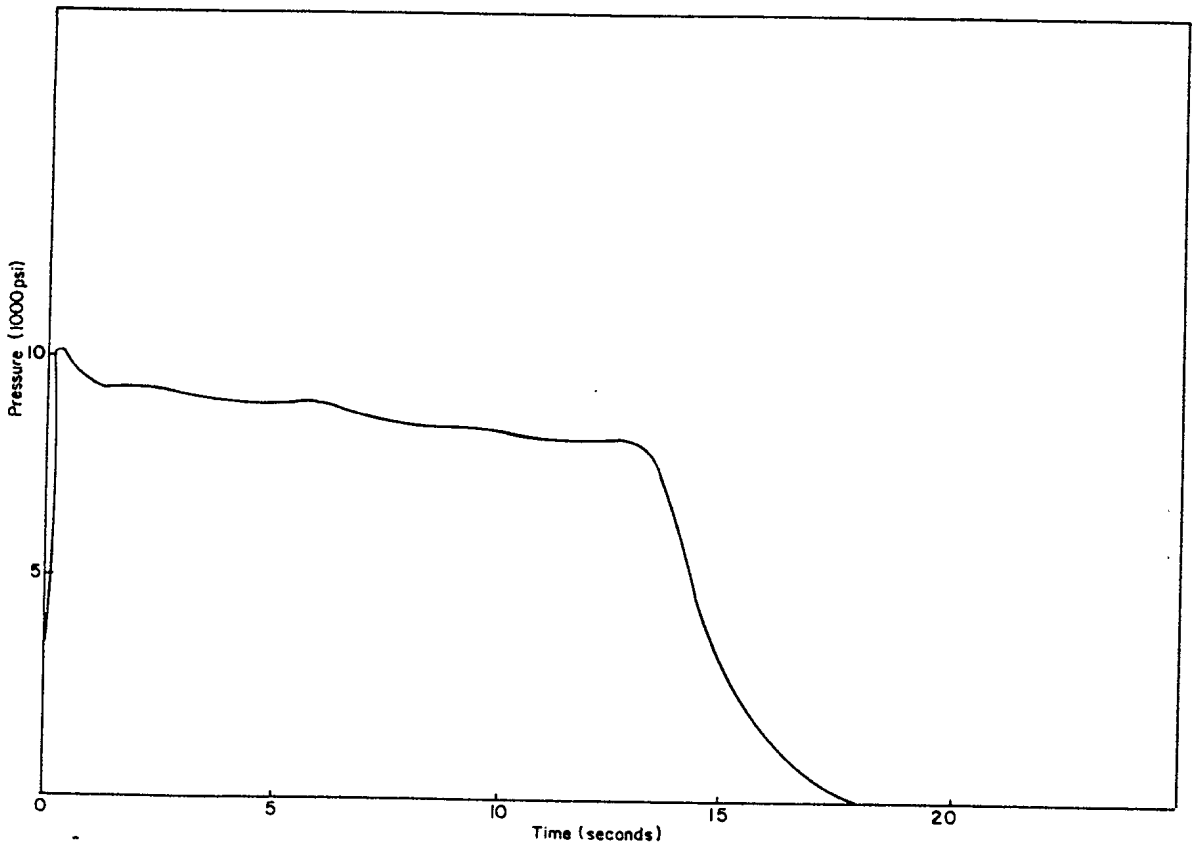

Figure 5 - Pressure-Time Record of PTV 3 Engine

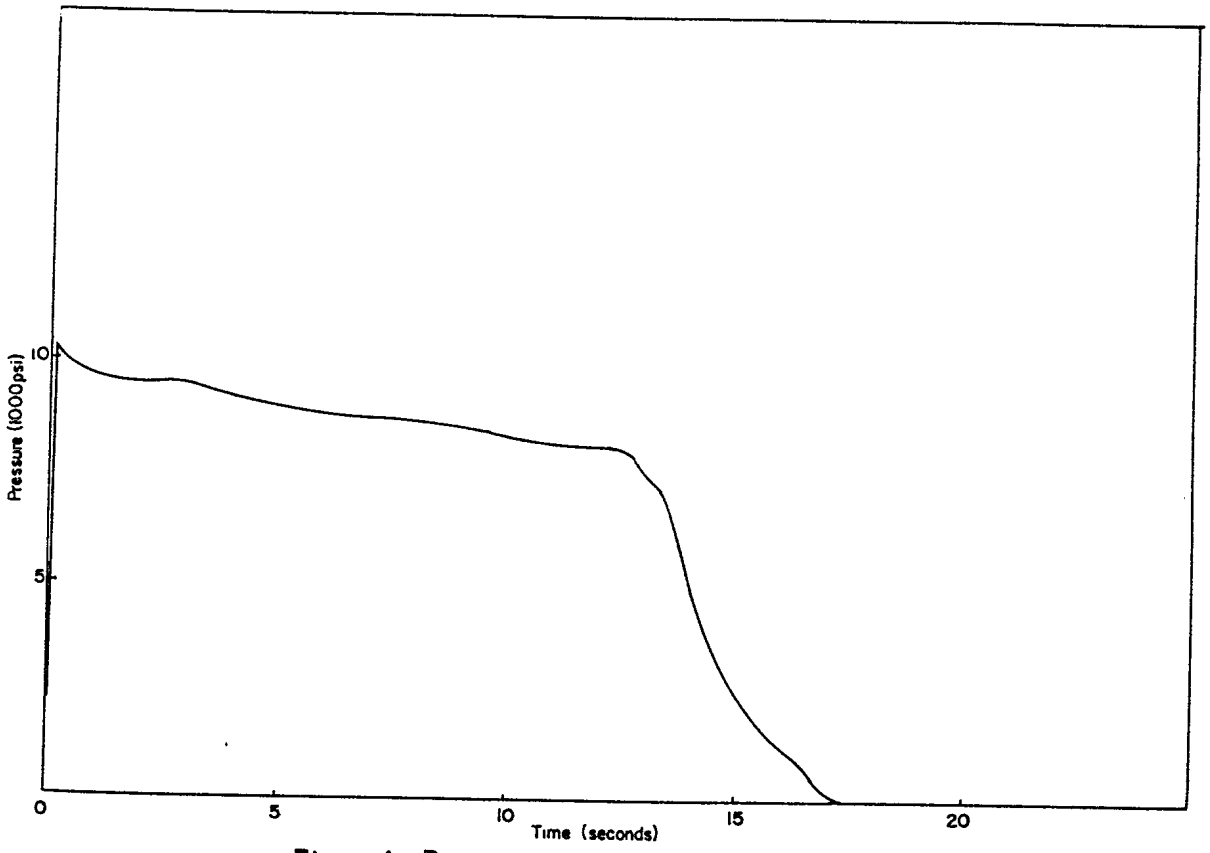

Figure 6 - Pressure-Time Record of PTV 4 Engine

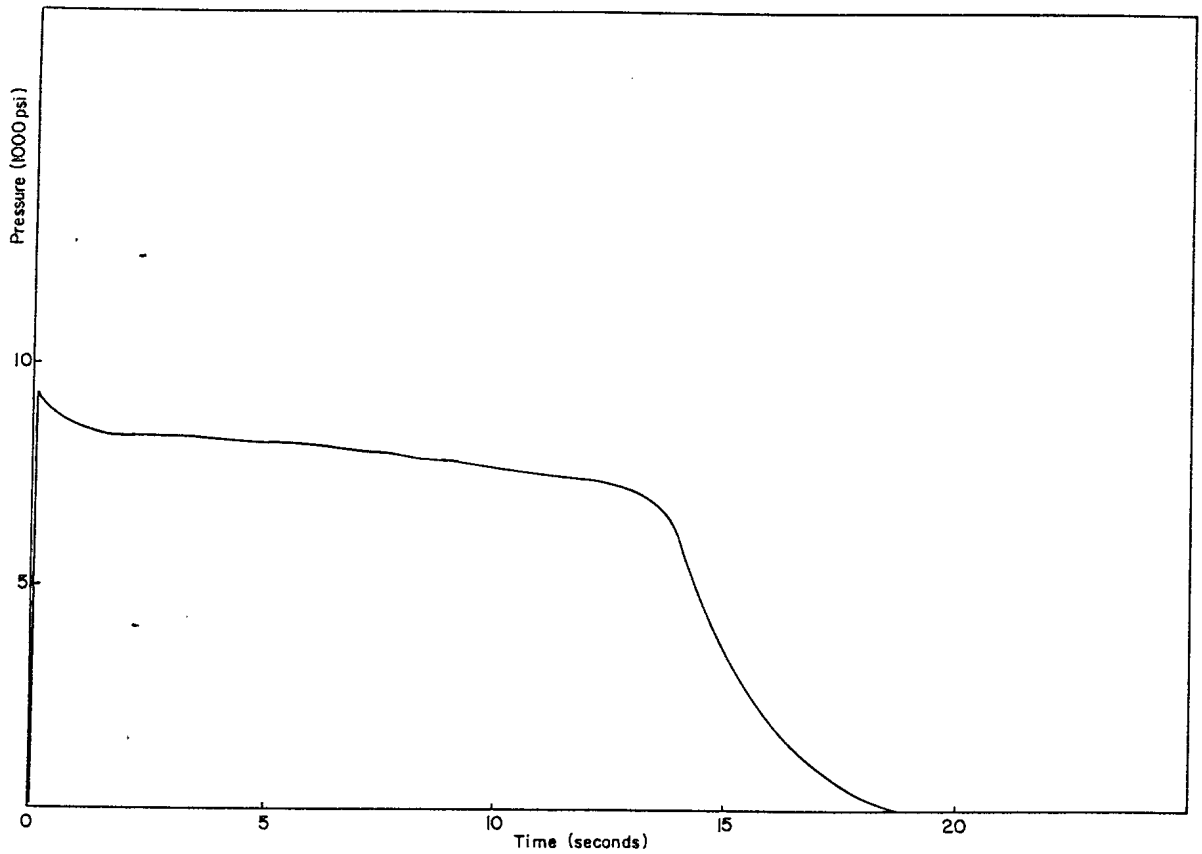

Figure 7 - Pressure-Time Record of 17". Engine Static Firing at 70° F.

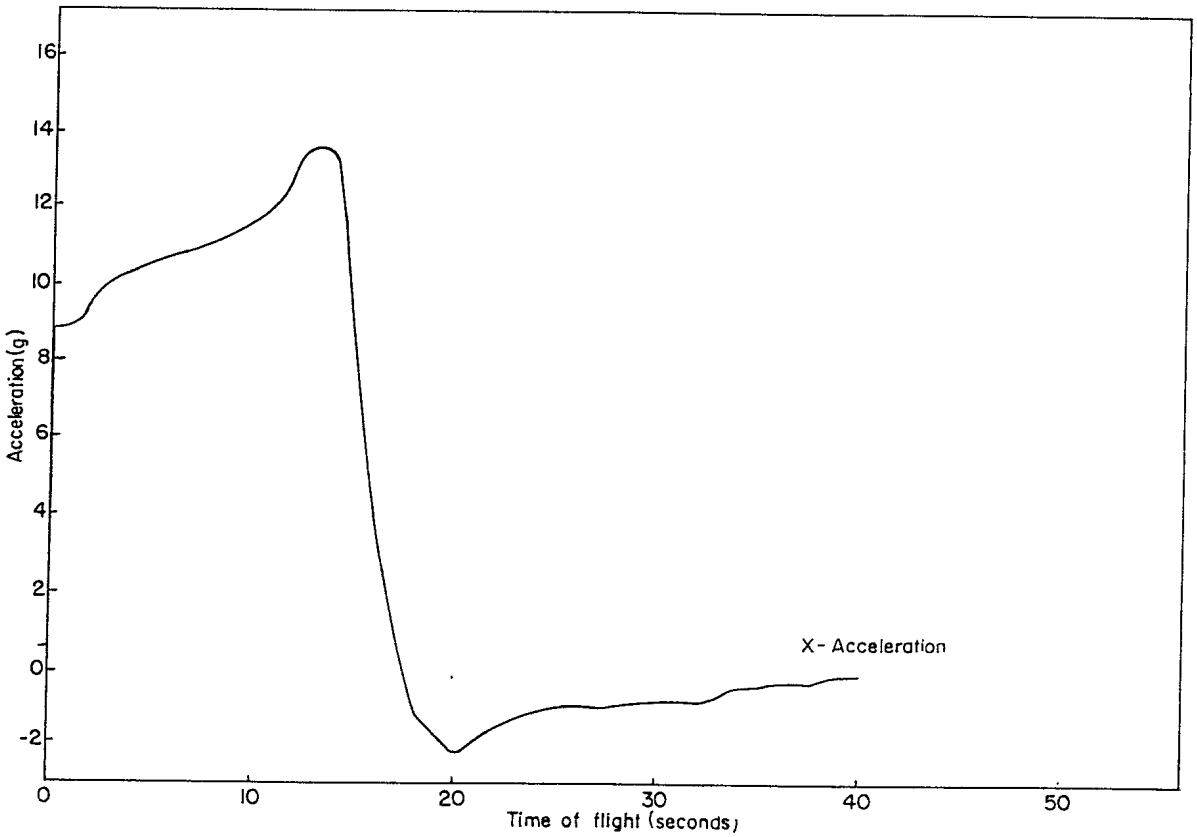

Figure 8 - Longitudinal Acceleration, PTV 1

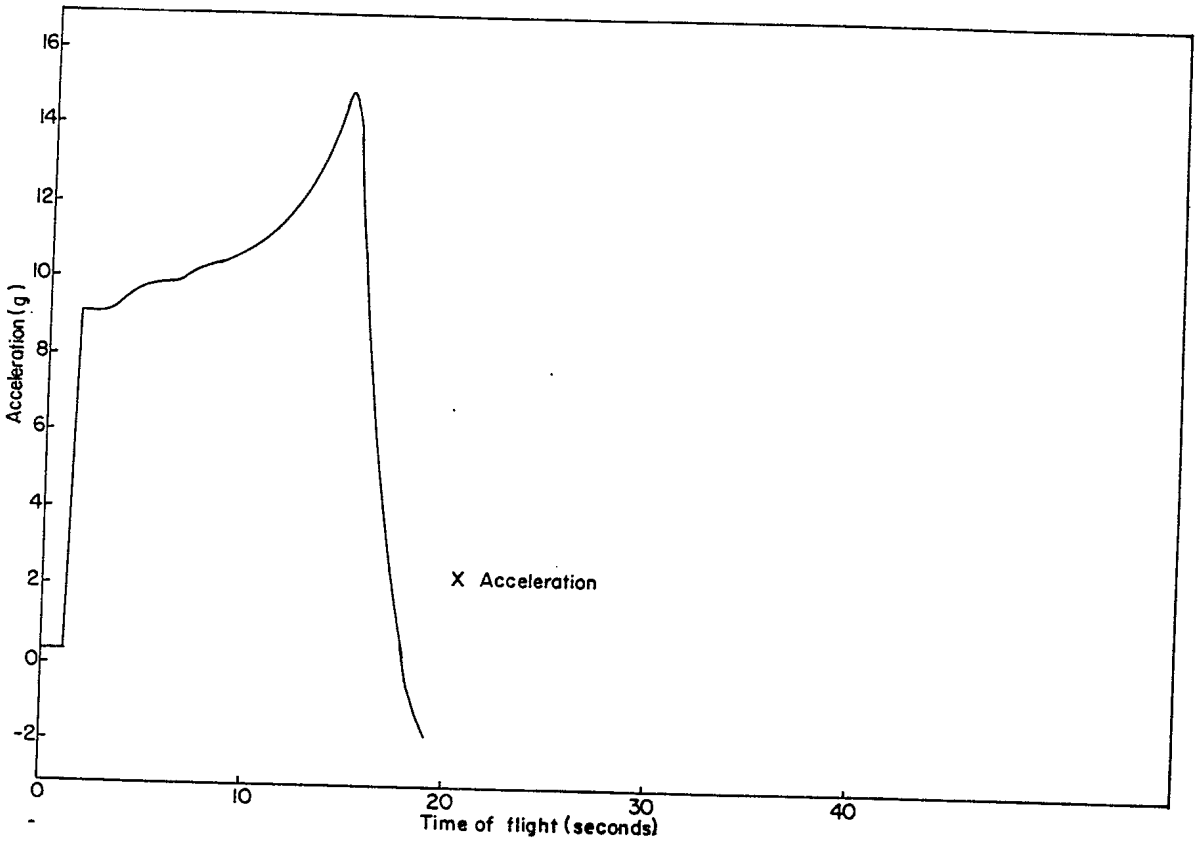

Figure 9 - Longitudinal Acceleration, PTV 2

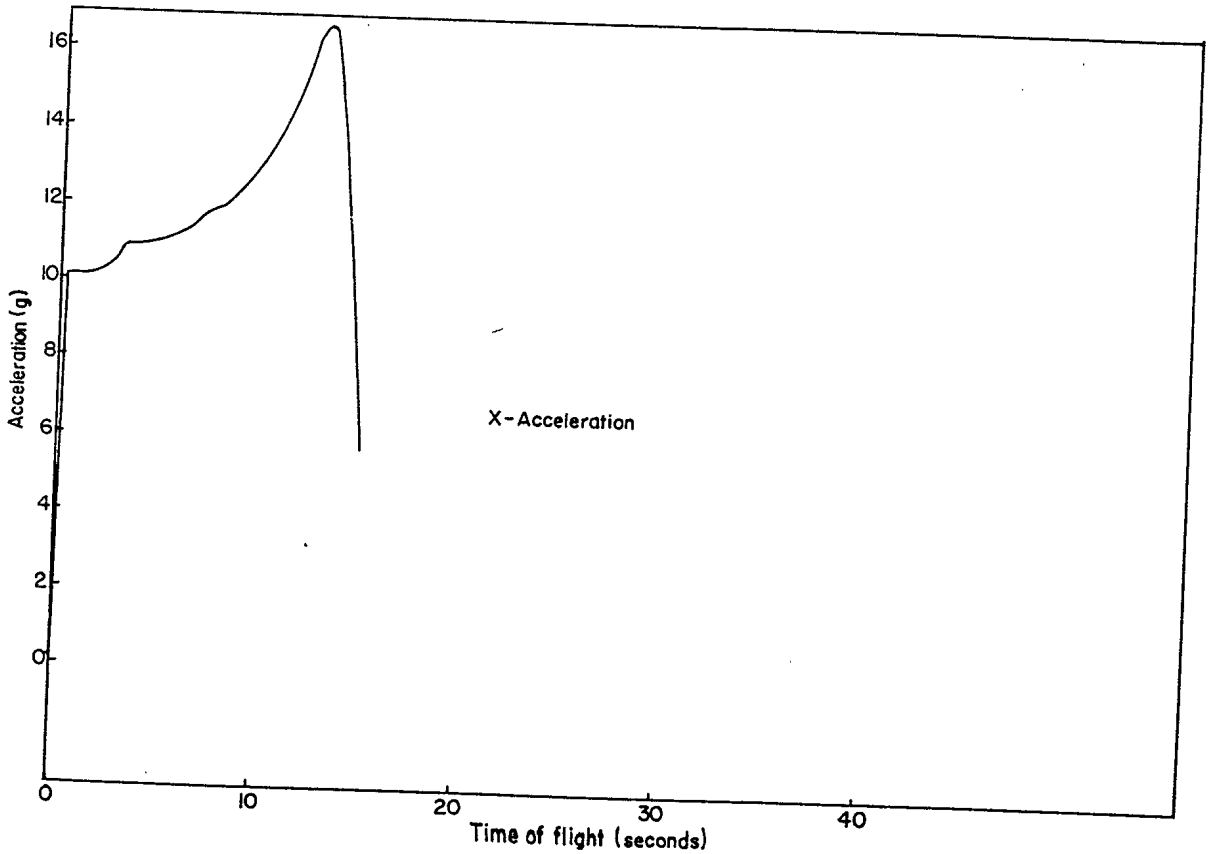

Figure 10 - Longitudinal Acceleration, PTV 3

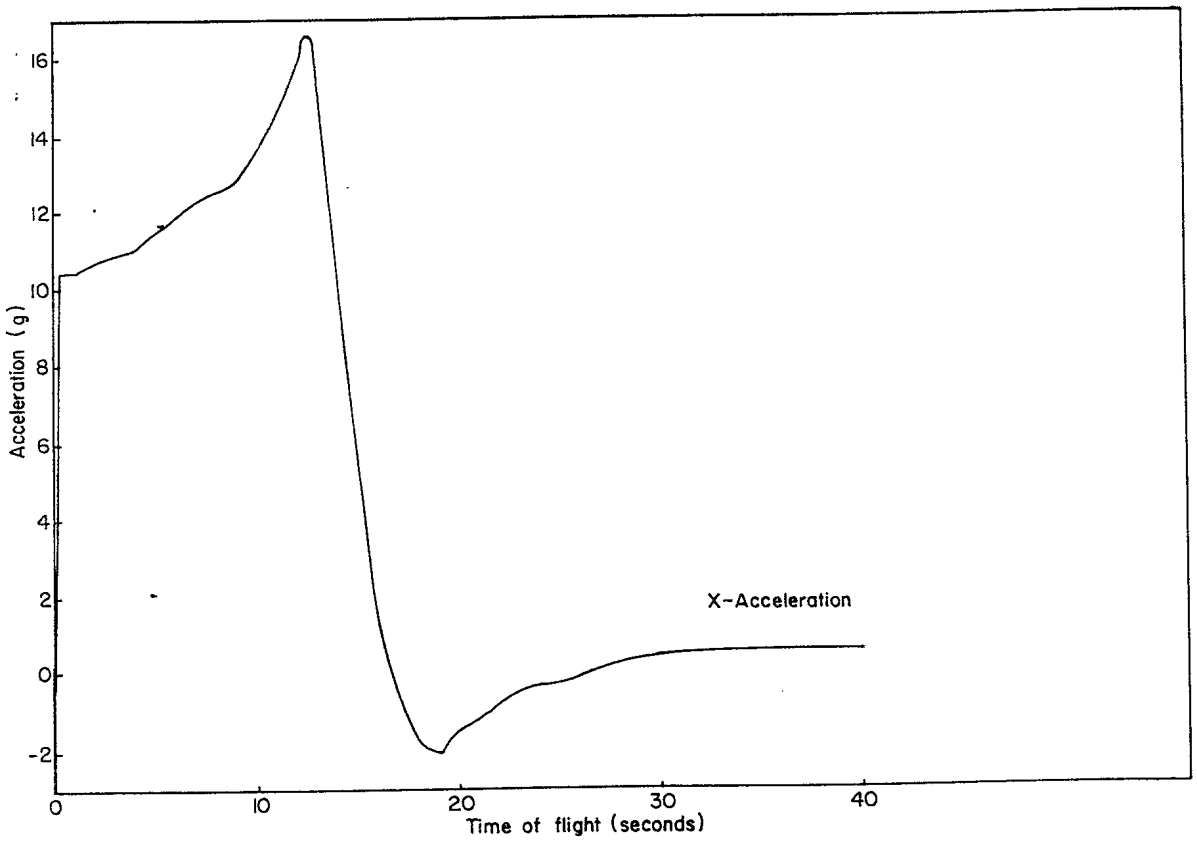

Figure 11 - Longitudinal Acceleration, PTV 4

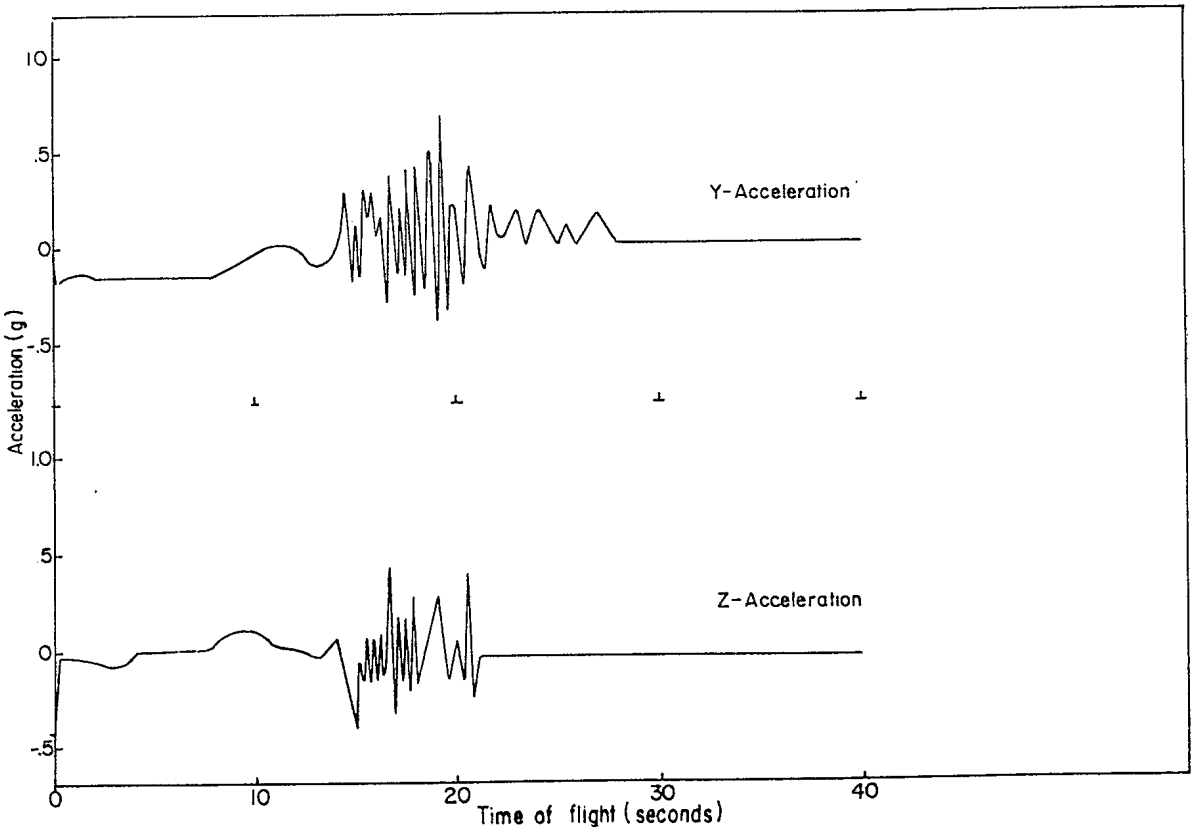

Figure 12 - Lateral Accelerations, PTV 1

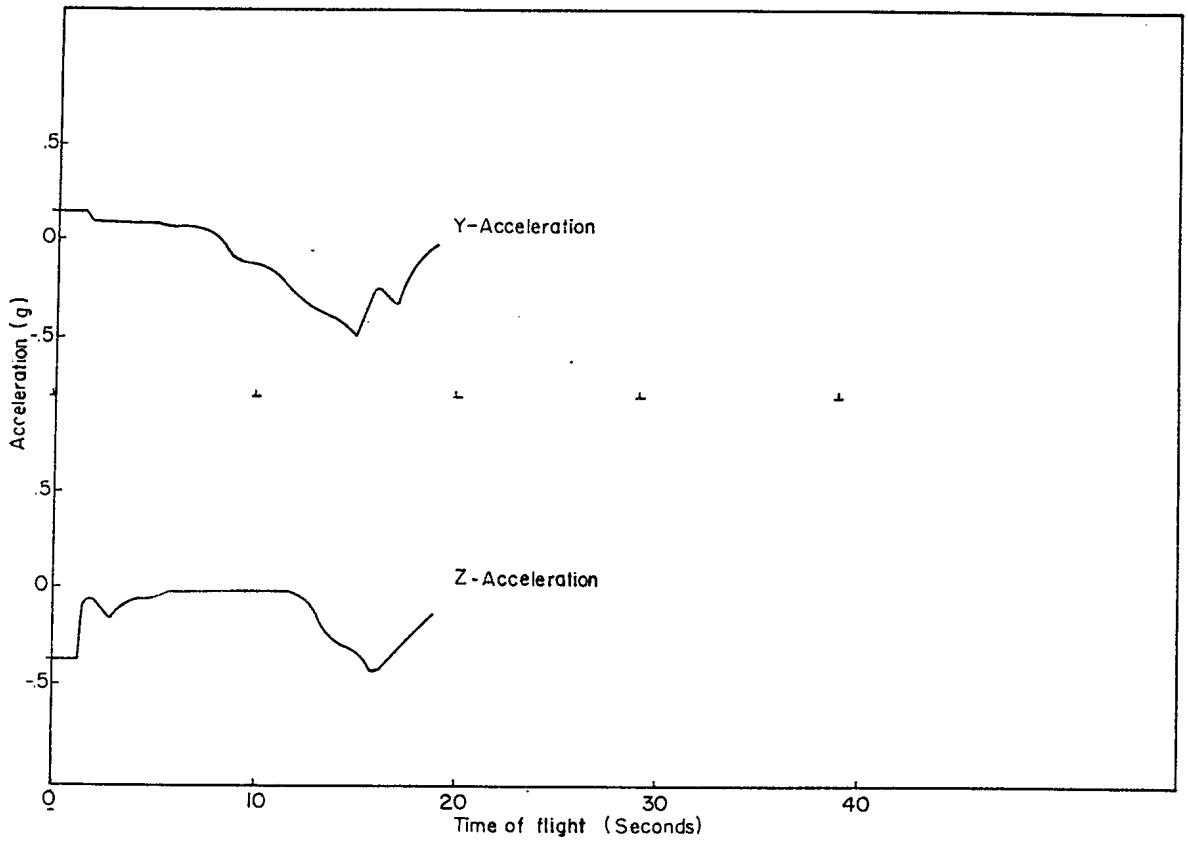

Figure 13 - Lateral Accelerations, PTV 2

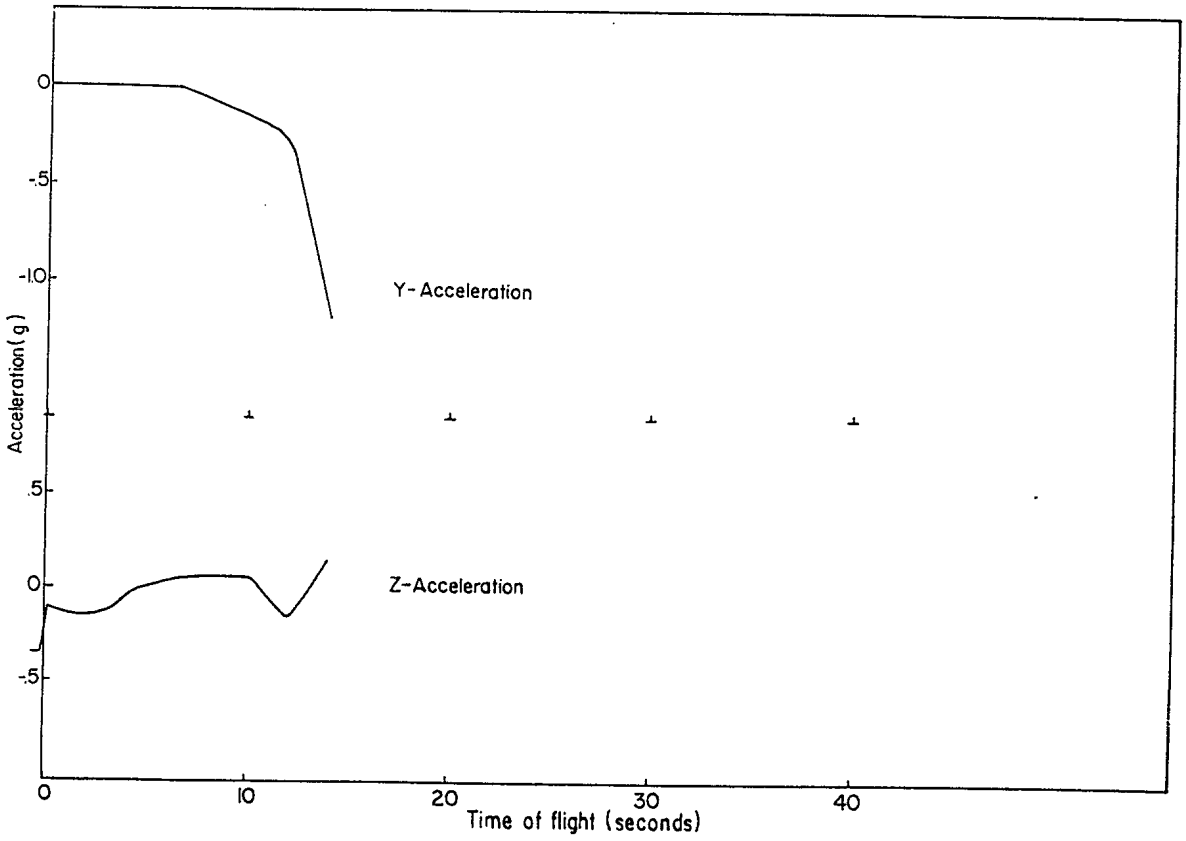

Figure 14 - Lateral Accelerations, PTV 3

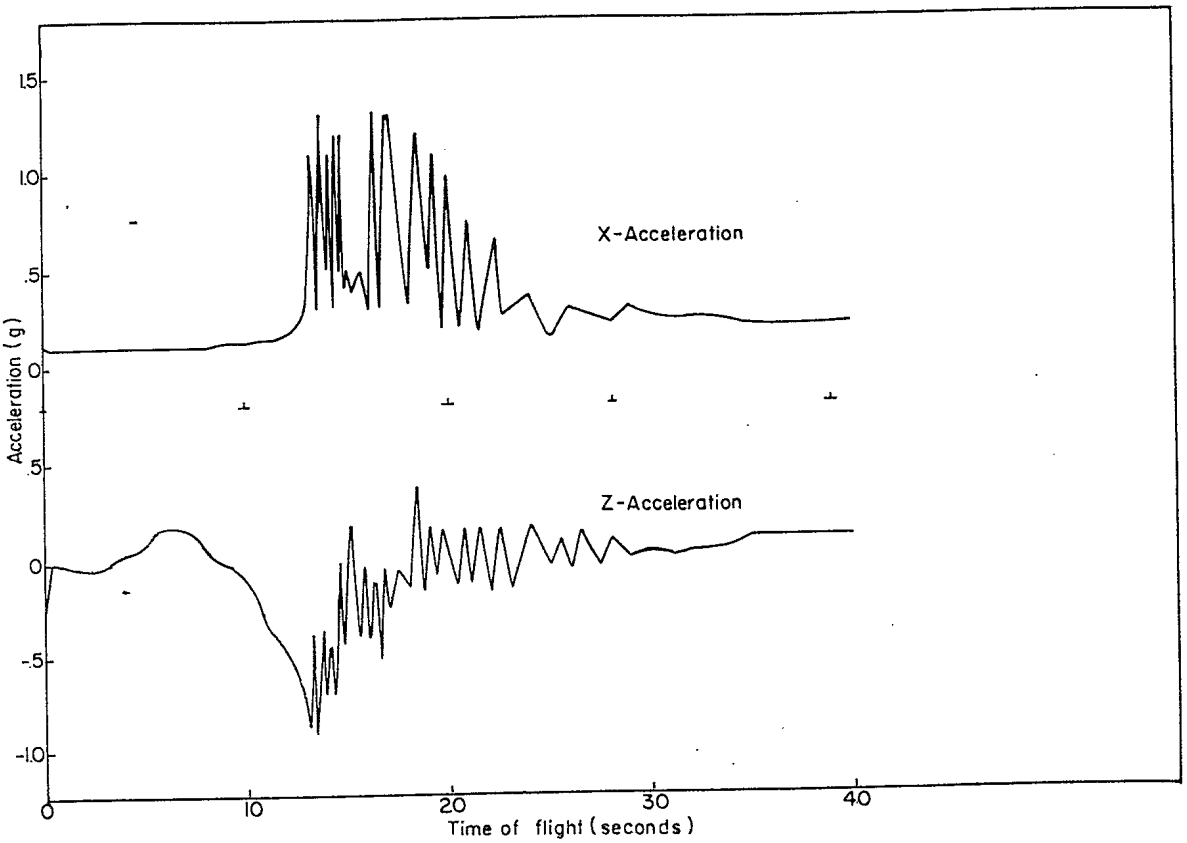

Figure 15 - Lateral Accelerations, PTV 4

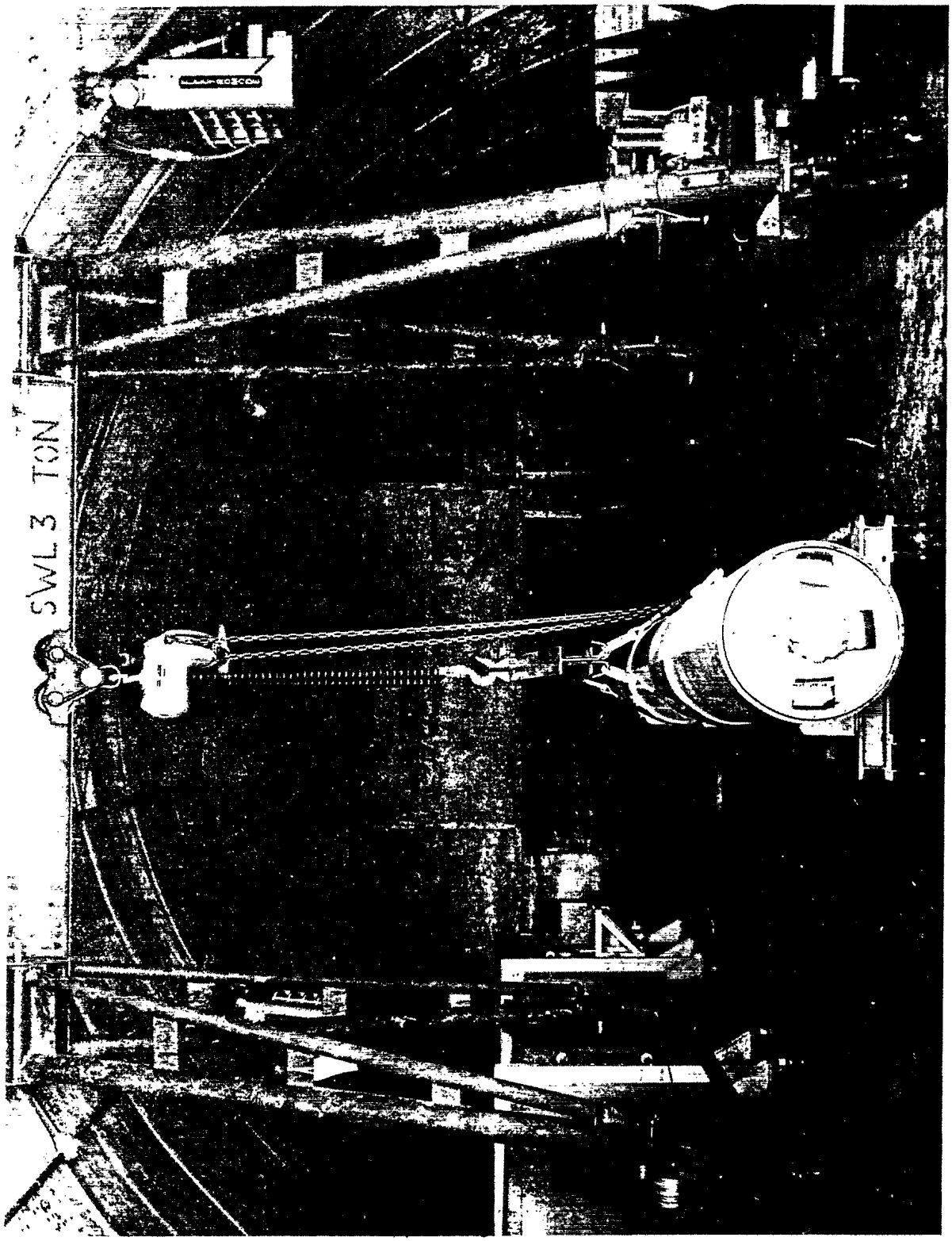

Figure 16 - Magazine Assembly Hut, Conditioning Box at Left

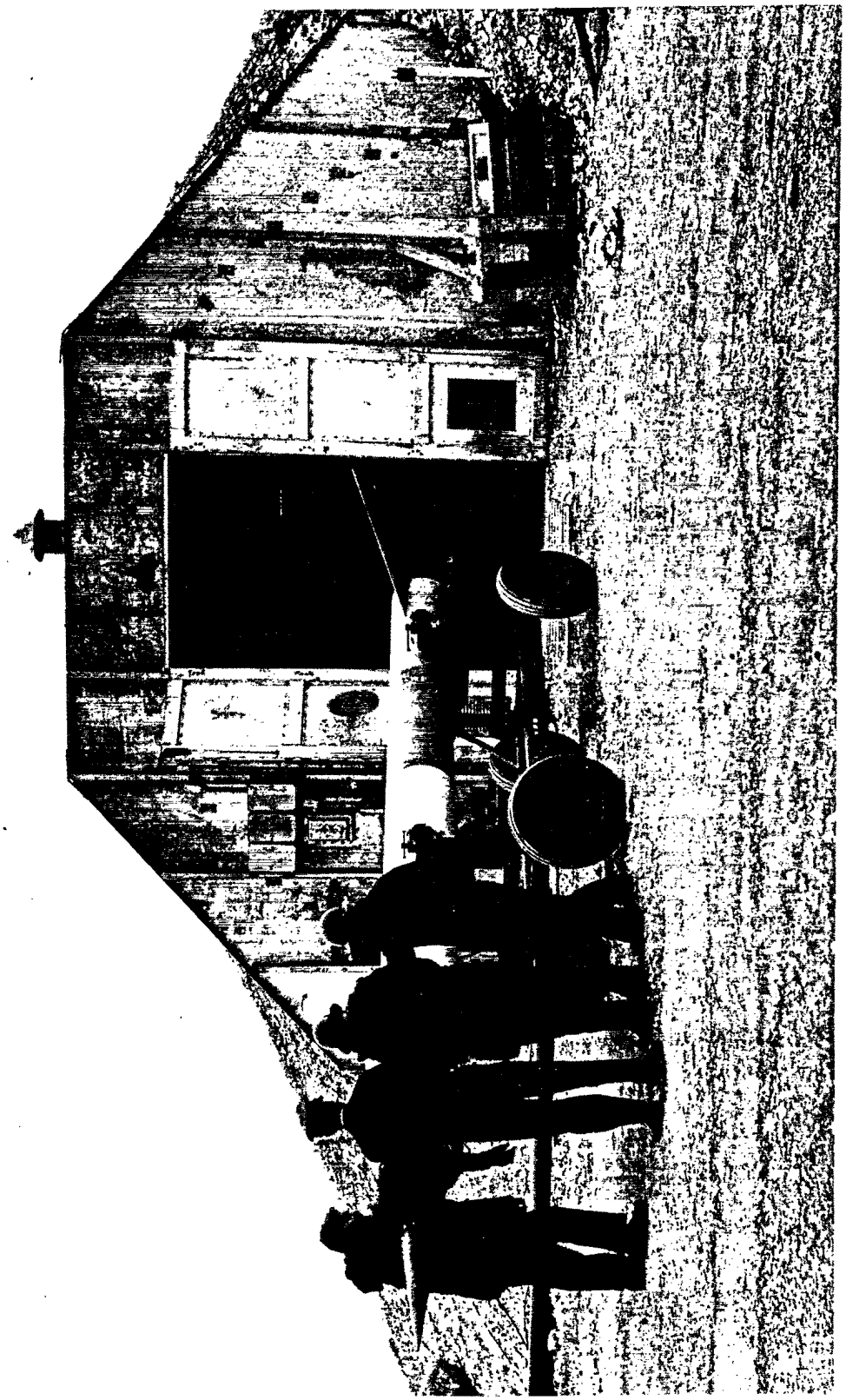

Figure 17 - Assembled Vehicle Outside Magazine

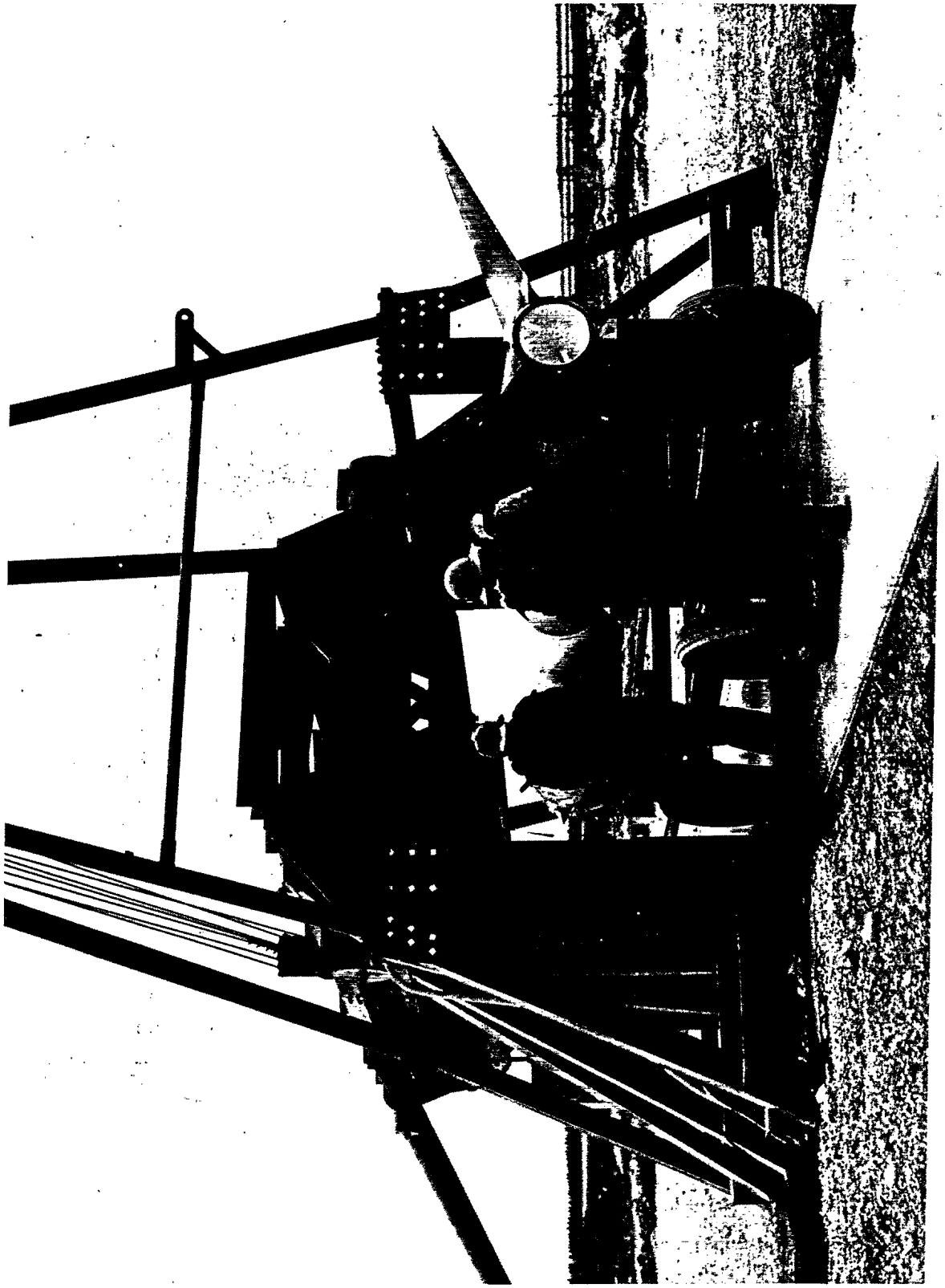

Figure 18 - Moving Vehicle Onto Launcher

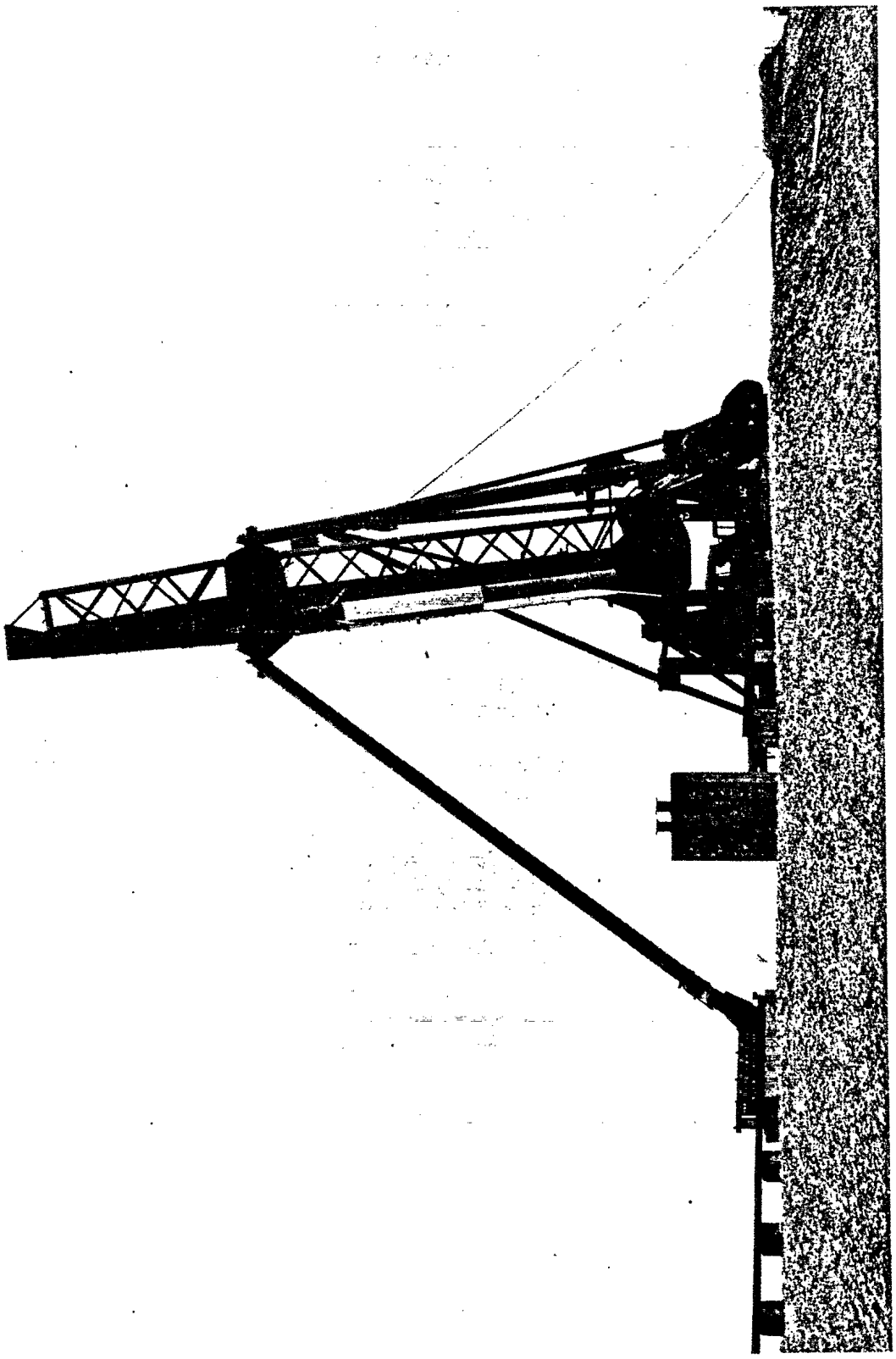

Figure 19 - Elevated Launcher with Vehicle in Position

Figure 20 - Launching of PTV 3

APPENDIX I

Outline of CARDE Propulsion Test Vehicles

Operations at Fort Churchill Rocket Range Fall 1959

Section I – General Operational Information

INTRODUCTION

It is planned to fire four 17-in. diameter test vehicles 'Black' Brant 01, 02, 03, 04 during the first two weeks of September 1959 from an inclined launcher which is located approximately 200 ft south of Nike-Cajun Assembly Building. Launcher elevation may vary between 60 and 70 degrees but the azimuth is fixed at 093 degrees. The vehicles should impact in Hudson Bay at a distance from the launcher of 120 to 160 miles.

A. Firing Plan

1. Sept 1 to Sept 4, 1959. Firing of two-test vehicles Nos. 01 and 02 with rocket engine at ambient temperature to check dynamic performance of solid propellant and design of the vehicle and launcher.

2. Sept 7 to Sept 11, 1959. Firing of two-test vehicles Nos. 03 and 04 with engine conditioned at 100°F to check propellant system at that temperature.

B. Flight Objectives

Measurement of the following:

1. Engine performance by pressure transducers.

2. Trajectory and dispersion by radar employing a beacon. The following information should be obtained:
   (a) XYZ co-ordinate information with superimposed time data within accuracy of 500 yd.
   (b) XYZ velocity component data to accuracy of approximately 10 per cent.

3. Longitudinal and lateral acceleration.

4. Nose cone skin temperatures.

C. Flight Information

1. It is required that firings take place during daylight hours under wind conditions of less than 30 ft per sec velocity. Optimum time mid afternoon. Vehicles should be fired without cloud but may be fired with minimum 1000 ft cloud cover if acceptable to range safety officer at Churchill.

2. Velocity of vehicle leaving launcher – 90 ft per sec.

3. Velocity at all-burned – 6900 ft per sec.

4. Altitude range at 70° launch for 30 ft per sec head or tail wind 38-90 miles.

5. Impact range at 70° launch for 30 ft per sec head or tail wind 120-160 miles.

6. Wind sensitivity data of rocket has been forwarded to Commandant, Fort Churchill, Manitoba, by letter on CARDE files 657-130-0, and CARDE 1002-01 dated Aug 13/59.

Section II – Test Vehicle Information

A. Rocket Engine

1. Thrust – 25,000 lb for 15 sec.

2. Outside diameter of Engine – 17 in.

3. Length of Engine 17 ft approximately.

B. Nose Cone

1. 17 in. outside diameter with 15° taper and approximately 7 ft in length.

C. Explosives and Pyrotechnics

1. No explosives will be used.

2. No pyrotechnics will be used.

D. Nose Cone Installations

1. ASCOP TK-M4/DC-M4 – Telemetry transmitter. Frequency 226.5 MC. Power Output 5 W.

2. AN/DPN – 19 radar transponder beacon
   Received frequency 2877 MC
   Transmitted frequency 2907 MC

3. Battery Power Supply.

Section III – Experiments

1. No experimental equipment will be employed.

Section IV – Range Instrumentation Facilities

A. Telemetry Ground Station

1. Equipment ASCOP PWM/FM and FM/FM ground station complete with 'quick-look' recorders are to be supplied, installed and operated by CARDE personnel at Churchill.

2. *Space Requirements* – Space at least 12 ft by 6 ft is required for telemetry ground station which should be near the launcher. The Aerobee assembly building as arranged is satisfactory. As this equipment will be required for DRTE experiments later in the fall of 1959 as well as in the following year for a later phase of the CARDE program, it is highly desirable to have a relatively permanent location for this station. CARDE is planning to purchase a suitable trailer for this purpose.

3. *Power Requirements* – Power will be required at location of telemetry station to operate telemetering ground station namely 15 KVA at 115 V AC, 60 cycle. Single Phase.

4. *Scheduling of Installation* – Installation of telemetering equipment will commence about 19 August by CARDE personnel.

5. DOVAP System will not be required.

B. Radar

1. Radar tracking is required.

2. AN/DPN – 19 beacons are to be installed and checked out in test vehicles by CARDE personnel.

3. Canadian Army surveillance radar to meet D.O.T. requirements complete with normal Army staff to operate the radar and to arrange to be in communication with range safety officer for range clearance before each firing.

C. Central Timing

1. Central timing equipment is required including elapsed time code and continuous scale of 10 pulses per second from range central timer for recording on tape (Ampex model 500) and possibly on a Brush Recorder. The latter equipment is part of CARDE telemetering facilities.

D. Communications

1. In addition to normal range communications, a link to CARDE telemetry station and CARDE launcher is required.

E. Check-Out

1. Bench space approximate area 15 by 15 ft with 110 V, 60 cycle power for normal cone check-out is required in Aerobee Assembly building.

F. Data Requirements

1. Radar – Plotting board record and/or tabular and plotted data or X, Y, Z, V_X, V_Z, versus time – 2 copies.

2. Telemetry – Magnetic tape record, Brush record of selected channels.

3. Timing (a) Take-off time (absolute).
   (b) Time interval from first motion to clear launcher rails.
   (c) Burn-out and peak times determined from telemetry and radar.

Section V – Facilities and Services Requirements

A. Range

Ground Instrumentation and facilities with operating staff as described in Section IV.

B. Launching and Assembly Team

CARDE is to supply a team consisting of a launch Officer and three Technicians for preparation and assembly of test vehicles. This team will also act as a launch team.

C. Instrumentation Team

CARDE is to supply an instrumentation team consisting of eight personnel as follows:

1. Airborne telemetry and power supply – 2

2. Airborne beacons – 1

3. Ground Telemetry – 3

4. Photography instrumentation – 1

5. Supervision – 1

D. Transportation

Suitable transportation is required from camp to launch site for CARDE personnel during working hours.

E. Housing and Messing Facilities

It is planned to send teams at two different times to Churchill for which housing and messing facilities are required.

1. Seven CARDE personnel to arrive week of August 17. Nine more to arrive week of August 24, 1959.

2. During the preparation and launching period from approximately August 17 to September 12 housing and messing is required for the a/m personnel. The exact number with names will be forwarded at a later date.

3. There will be a requirement for noon meals at the range for CARDE personnel during period outlined in 1 and 2 above.

F. Laboratory Space and Storage

1. Laboratory space for telemetry station (See Section IV, A–2).

2. Laboratory space in Aerobee Assembly building for nose cone check-out. (See Section IV, E–1).

3. Storage space for two-rocket motors and a temperature conditioning box in one of the magazines at the launch site, approximate area 45 ft by 20 ft.

4. Vehicle preparation space in Aerobee Assembly building approximate area 45 ft by 30 ft.

G. Photography

1. One high speed camera at a fixed location close to launcher, to observe burning, launcher, and measure time on launcher.

2. One high speed fixed camera located to cover launch and beginning of trajectory.

3. One medium speed tracking camera located to cover launch and as much of trajectory as possible.

4. Still black and white general coverage during the preparation phases, approximately 25 shots.

5. Cine, 16 mm color, general coverage of the preparation phases, and launch, approximately 500 ft of film.

It is planned to have CARDE supply, install and operate cameras in (1), (2) and (3) above, but it has been arranged that the Officer in Charge of DRNL provide for (4) and (5). CARDE will supply the firm and/or cameras and/or process the film for (4) and (5) if required.

H. Meteorological Data

(a) A synoptic weather map and weather forecast as provided by the RCAF Aviation Forecast Office at Fort Churchill plus local ground temperature, pressure and humidity.

(b) Wind data from surface to 2,000 ft above surface at launcher site from single theodolite observations of 30-gram balloons. Azimuth and elevation angles to be taken at 10-sec intervals. Four balloons per firing are requested with the final balloon approximately 30 min prior to launching of the vehicle.

(c) Wind data from a mast mounted anemometer located near the vehicle launcher. Anemometer should be mounted 50 ft above ground, clear of local building effects. Readings required up to 30 min prior to launching of the vehicle.

(d) Wind data from 2,000 ft to 100,000 ft from radiosonde observations as normally provided by DOT, for duration of launch program.

In addition, one further observation, launched at a time such as to enable the final data to be available by 1400 hr Churchill time on each day of a proposed firing.

J. Auxilliary Equipment

1. Towing truck for CARDE trailer which is to be used to transport the filled propulsion test vehicles from airfield to assembly/launch site.

2. Vehicle for transportation of equipment from rail head or airfield at Churchill to assembly launch site.

3. M62 wrecker or equivalent to unload vehicles and equipment at assembly/launch site.

4. Electrical power to operate elevating motor of launcher at launch site 15 hp, 440 V 3 phase, if required.

5. Use of U.S. Navy Mobile Gantry in Aerobee Assembly building during launch period.

APPENDIX II

Schedule of Events

PTV's 01, 02, 03, 04

Start Time	Operation	Responsibility
X-1 day	Physical inspection of motor and all associated stores	Launch Team
	Install casting and nozzle	Launch Team
	Continuity check on firing circuit	Launching Officer
	Firing check of firing circuit (squib)	Launching Officer
	Check elevation of launcher	Launch Team
X-9 hr 30 min	Activate batteries and load testing	Instrumentation
X-4 hr 10 min	Command net ON	
X-250 min	Install battery pack	Instrumentation
	Connect telemetry antennae	Instrumentation
	Electrical check-out of beacon	Instrumentation
	Electrical check-out of telemetry	Instrumentation
	Wind prediction of firing time	Met. Group
	Warning light Amber	
X-80 min	All range transmitters OFF except Command Hot Loop	ALL
	Check cameras	Photo Group
	Insert igniter in motor (leads shorted)	Launching Officer
X-145 min	Move nose cone to magazine	Launch Team
	Install nose cone to motor	Launch Team
	Install fins	Launch Team
X-1 hr 45 min	Set road block	Launching Officer
	Warning light RED	Launching Officer
X-105 min	Move PTV to launcher (Driver & Launching Officer only) all personnel clear of launcher area except Launch Team	Launching Officer
	Place PTV on launcher (Secure winch cables and remove saddle)	Launch Team
	Insert umbilical plug	Instrumentation

Start Time	Operation	Responsibility
X-80 min	Switch to external telemetry power	Instrumentation
	Insert telemetry shorting plug	Instrumentation
	Install break wires for travel-time on launcher	Instrumentation
	Momentary change to internal power	Instrumentation
X-60 min	Time check	Signal Corps
X-50 min	Announce predicted impact	Launching Officer
X-50 min	Elevate launcher	Launch Team
X-40 min	Record launcher elevation	Launch Team
X-35 min	Vertical electrical test	Instrumentation
X-25 min	Beacon test	Instrumentation
X-20 min	ALL personnel to Block-House	Launching Officer
X-15 min	Connect igniter firing line	Launching Officer
X-5 min	Arm firing circuit	Launching Officer
X-5 min	Instrumentation to ON external	Instrumentation
X-4 min		
X-3 min	Switch to internal power	Instrumentation
X-2 min		
X-1 min		
X-30 sec	ALL Stations ready or announce hold	ALL
	a) Telemetry	
(By seconds)	b) Beacon	
	c) Flight safety	
X-29 sec	Telemetry recorder ON	Instrumentation
X-1 sec	Fastax ON	Photo Group
X-0	FIRE ROCKET – Maintain SILENCE	Launching Officer
X+25 sec		
X+ 6 min	Range Clear – All recorders OFF	
	Warning light GREEN	Instrumentation
X+10 min	Announce true firing time	Launching Officer

By request from Launching Officer: ALL stations report to Launching Officer on results of flight

APPENDIX III

Meteorological Tables

TABLE I

ANEMOMETER RECORDING OF WIND SPEED AND DIRECTION

PTV 01

5 Sept 1959

Time CST	Wind Speed MPH	Direction in Deg
0630	13.0	147
0700	10.5	149
0730	13.0	151
0801	16.5	146
0858	12.0	160
X-60 Sec	12.5	153
X-45 Sec	10.5	145
X-30 Sec	10.0	156
X-15 Sec	11.0	160
X-Time (0927 hr 21.5 sec)	9.5	149
X+15 Sec	10.0	154
0937	12.0	150

PTV 02

5 Sept 1959

Time CST	Wind Speed MPH	Direction in Deg
1324	6.0	135
1429	6.0	135
1526	6.5	120
X-60 Sec	4.5	105
X-45 Sec	0.5	105
X-30 Sec	0.5	105
X-15 Sec	8.5	120
X-Time (1624 hr 48 sec)	3.0	120
X+15 Sec	8.0	115
1630	6.0	115

PTV 03

8 Sept 1959

Time CST	Wind Speed MPH	Direction in Deg
0542	13.0	282
0647	20.0	290
0730	26.0	303
0815	36.0	310
0823	25.0	312
X-60 Sec	25.0	300
X-45 Sec	25.0	300
X-30 Sec	23.0	313
X-15 Sec	29.0	306
X-Time (0914 hr 25.2 sec)	28.0	306
X-15 Sec	26.0	291
0922	27.0	310

PTV 04

10 Sept 1959

Time CST	Wind Speed MPH	Direction in Deg
1300	20.0	190
1353	24.0	195
1435	17.0	192
1512	20.0	162
X-60 Sec	29.0	159
X-45 Sec	26.0	155
X-30 Sec	25.0	162
X-15 Sec	23.0	157
X-Time (1548 hr 35 sec)	24.5	152
X-15 Sec	22.0	162
1555	23.0	168

TABLE II

PIBAL WIND DATA

PTV 1

5 Sept 1959

Layers in Ft	Release Time 0858 (CST) Mean Wind Components in MPH N	S	E	W	Release Time 0937 (CST) Mean Wind Components in MPH N	S	E	W
0 – 120	–	12.0	5.0	–	–	7.0	4.5	–
120 – 240	–	16.5	2.5	–	–	9.0	7.0	–
240 – 360	–	20.5	8.5	–	–	12.0	7.5	–
360 – 480	–	22.5	4.5	–	–	16.5	8.0	–
480 – 600	–	28.0	4.5	–	–	18.5	3.5	–
600 – 720	–	21.0	–	1.0	–	20.0	–	1.0
720 – 830	–	23.0	–	4.0	–	19.0	–	1.0
830 – 940	–	26.0	0	0	–	20.0	0.5	0
940 – 1050	–	24.0	3.0	–	–	19.5	1.0	–
1050 – 1160	–	26.0	5.0	–	–	21.0	2.0	–
1160 – 1270	–	24.0	4.0	–	–	24.0	1.0	–
1270 – 1380	–	28.0	4.0	–	–	22.0	4.0	–
1380 – 1490	–	30.0	6.0	–	–	31.0	5.0	–
1490 – 1600	–	30.0	8.0	–	–	28.0	6.0	–
1600 – 1710	–	30.0	6.0	–	–	32.0	6.0	–
1710 – 1820	–	32.0	8.0	–	–	28.0	4.0	–
1820 – 1930	–	28.0	6.0	–	–	32.0	8.0	–
1930 – 2040	–	36.0	8.0	–	–	30.0	16.0	–

PTV 2

5 Sept 1959

	Release Time 1526 (CST)				Release Time 1630 (CST)			
0 – 120	–	2.0	20.0	–	–	4.5	15.0	–
120 – 240	–	11.5	33.0	–	–	7.5	19.0	–
240 – 360	–	14.0	32.0	–	–	9.0	20.0	–
360 – 480	–	17.0	30.5	–	–	14.0	14.5	–
480 – 600	–	22.0	40.0	–	–	10.0	13.5	–
600 – 720	–	18.0	24.0	–	–	10.0	15.5	–
720 – 830	–	14.0	26.0	–	–	8.5	12.0	–
830 – 940	–	10.0	19.0	–	–	9.0	12.0	–
940 – 1050	–	12.0	21.0	–	–	17.5	12.0	–
1050 – 1160	–	12.0	16.0	–	–	23.5	7.0	–
1160 – 1270	–	12.0	17.0	–	–	20.0	5.0	–
1270 – 1380	–	12.0	13.0	–	–	23.0	6.0	–
1380 – 1490	–	12.0	20.0	–	–	29.0	–	1.0
1490 – 1600	–	12.0	12.0	–	–	28.0	0.0	0.0
1600 – 1710	–	16.0	14.0	–	–	24.0	5.0	–
1710 – 1820	–	16.0	10.0	–	–	32.0	7.0	–
1820 – 1930	–	20.0	16.0	–	–	36.0	3.0	–
1930 – 2040	–	Balloon Entered Clouds				38.0	0.0	–

TABLE III

PIBAL WIND DATA

PTV 3

8 Sept 1959

Layers in Ft	Release Time 0823 (CST) Mean Wind Components in MPH N	S	E	W	Release Time 0922 (CST) Mean Wind Components in MPH N	S	E	W
0 – 120	19.5	–	–	27.0	12.0	–	–	24.0
120 – 240	14.0	–	–	20.0	14.0	–	–	22.5
240 – 360	10.0	–	–	15.5	11.0	–	–	20.0
360 – 480	10.0	–	–	20.5	6.0	–	–	14.0
480 – 600	8.5	–	–	22.0	5.5	–	–	12.5
600 – 720	8.0	–	–	18.0	5.5	–	–	12.0
720 – 830	8.0	–	–	17.0	8.0	–	–	16.0
830 – 940	6.0	–	–	20.0	8.0	–	–	14.0
940 – 1050	11.0	–	–	25.0	12.0	–	–	17.0
1050 – 1160	11.0	–	–	29.0	15.0	–	–	22.0
1160 – 1270	10.0	–	–	24.0	16.0	–	–	20.0
1270 – 1380	9.5	–	–	24.0	12.0	–	–	20.0
1380 – 1490	9.0	–	–	27.0	11.0	–	–	18.0
1490 – 1600	16.0	–	–	34.0	14.0	–	–	17.0
1600 – 1710	12.0	–	–	32.0	14.0	–	–	20.0
1710 – 1820	16.0	–	–	35.0	14.0	–	–	22.0
1820 – 1930	12.0	–	–	28.0	11.0	–	–	20.0
1930 – 2040	12.0	–	–	30.0	5.0	–	–	20.0

PTV 4

10 Sept 1959

	Release Time 1512 (CST)				Release Time 1555 (CST)			
0 – 120	–	15.0	10.0	–	–	18.0	8.0	–
120 – 240	–	19.5	8.0	–	–	25.0	8.0	–
240 – 360	–	27.0	13.0	–	–	25.0	9.0	–
360 – 480	–	32.0	13.0	–	–	27.0	10.0	–
480 – 600	–	37.0	13.0	–	–	32.0	8.0	–
600 – 720	–	34.0	13.0	–	–	37.0	7.0	–
720 – 830	–	34.0	14.0	–	–	41.0	5.0	–
830 – 940	–	36.0	11.0	–	–	44.0	5.0	–
940 – 1050	–	34.0	3.0	–	–	48.0	5.0	–
1050 – 1160	–	26.0	2.0	–	–	56.0	4.0	–
1160 – 1270	–	26.0	0.0	–	–	48.0	2.0	–
1270 – 1380	–	20.0	–	2.0	–	45.0	–	4.0
1380 – 1490	–	25.0	–	4.0	–	46.0	–	4.0
1490 – 1600	–	28.0	–	5.0	–	40.0	–	4.0
1600 – 1710	–	32.0	–	4.0	–	40.0	–	2.0
1710 – 1820	–	33.0	–	6.0	–	36.0	–	3.0
1820 – 1930	–	36.0	–	4.0	–	Clouds		
1930 – 2040	–	38.0	–	8.0				

TABLE IV

COMPARISON OF WINDS AT GROUND REGION

AND 1000 FT REGION FROM PIBAL DATA

Date	Time (CST)	Mean Wind Components in MPH 0 – 120 Ft				Mean Wind Components in MPH 940 – 1050 Ft			
		N	S	E	W	N	S	E	W
Sept 5/59	0630	–	9.5	8.5	–	–	19.0	–	5.0
Sept 5/59	0700	–	10.0	8.0	–	–	19.0	–	4.0
Sept 5/59	0730	–	8.5	7.5	–	–	24.0	–	–
Sept 5/59	0801	–	15.5	11.5	–	–	21.0	11.0	–
Sept 5/59	0858	–	12.0	5.0	–	–	24.0	3.0	–
Sept 5/59	0937	–	7.0	4.5	–	–	19.5	1.0	–
Sept 5/59	1324	–	6.0	7.5	–	–	25.0	13.0	–
Sept 5/59	1429	–	5.0	11.0	–	–	23.0	–	5.0
Sept 5/59	1526	–	2.0	20.0	–	–	12.0	21.0	–
Sept 5/59	1630	–	4.5	15.0	–	–	17.5	12.0	–
Sept 8/59	0542	1.0	–	–	12.0	8.0	–	–	31.0
Sept 8/59	0647	0.5	–	–	19.5	18.0	–	–	41.0
Sept 8/59	0730	11.5	–	–	20.5	17.0	–	–	26.0
Sept 8/59	0815	30.0	–	–	42.0	26.0	–	–	40.0
Sept 8/59	0823	19.5	–	–	27.0	11.0	–	–	25.0
Sept 8/59	0922	12.0	–	–	24.0	12.0	–	–	17.0
Sept 10/59	1300	–	16.0	–	3.0	–	13.5	–	4.0
Sept 10/59	1353	–	21.0	–	3.0	–	28.0	–	9.0
Sept 10/59	1435	–	22.0	–	4.0	–	21.0	–	3.0
Sept 10/59	1512	–	15.0	–	10.0	–	34.0	3.0	–
Sept 10/59	1555	–	18.0	–	8.0	–	48.0	5.0	–

TABLE V

RAWIN DATA

PTV 1

5 Sept 1959

Layers in Thousands of Ft	Release Time 0545 (CST) Mean Wind Components in MPH				Release Time 1200 (CST) Mean Wind Components in MPH			
	N	S	E	W	N	S	E	W
2 – 3	–	15.0	2.0	–	–	22.0	14.0	–
3 – 4	–	25.0	1.0	–	–	26.0	15.0	–
4 – 5	–	33.0	–	2.0	–	24.0	10.0	–
5 – 6	–	38.0	–	5.0	–	25.0	5.0	–
6 – 7	–	41.0	–	13.0	–	28.0	–	1.0
7 – 8	–	36.0	–	19.0	–	40.0	–	5.0
8 – 9	–	35.0	–	15.0	–	43.0	–	8.0
9 – 10	–	34.0	–	22.0	–	47.0	–	10.0
10 – 12	–	28.0	–	25.0	–	47.0	–	12.0
12 – 14	–	20.0	–	27.0	–	44.0	–	13.0
14 – 16	–	28.0	–	39.0	–	41.0	–	12.0
16 – 18	–	37.0	–	47.0	–	39.0	–	13.0
18 – 20	–	30.0	–	48.0	–	36.0	–	14.0
20 – 25	–	38.0	–	53.0	–	33.0	–	16.0
25 – 30	–	22.0	–	48.0	–	38.0	–	22.0
30 – 35	–	22.0	–	49.0	–	47.0	–	34.0
35 – 40	–	34.0	–	70.0	–	35.0	–	42.0
40 – 50	–	25.0	–	65.0	–	21.0	–	34.0
50 – 60	–	7.0	–	30.0	–	15.0	–	22.0
60 – 70	–	0	–	14.0	–	19.0	–	22.0
70 – 80	–	5.0	–	7.0	–	1.0	–	21.0
80 – 90	10.0	–	6.0	–	–	3.0	–	9.0
90 – 100	6.0	–	0	0	–	–	–	–

TABLE VI

RAWIN DATA

PTV 2

5 Sept 1959

Layers in Thousands of Ft	Release Time 1200 (CST) Mean Wind Components in MPH				Release Time 1626 (CST) Mean Wind Components in MPH			
	N	S	E	W	N	S	E	W
2 – 3	–	22.0	14.0	–	–	23.0	3.0	–
3 – 4	–	26.0	15.0	–	–	28.0	–	1.0
4 – 5	–	24.0	10.0	–	–	26.0	0	0
5 – 6	–	25.0	5.0	–	–	27.0	0	0
6 – 7	–	28.0	–	1.0	–	26.0	–	8.0
7 – 8	–	40.0	–	5.0	–	27.0	–	9.0
8 – 9	–	43.0	–	8.0	–	29.0	–	10.0
9 – 10	–	47.0	–	10.0	–	32.0	–	12.0
10 – 12	–	47.0	–	12.0	–	32.0	–	13.0
12 – 14	–	44.0	–	13.0	–	26.0	–	11.0
14 – 16	–	41.0	–	12.0	–	25.0	–	10.0
16 – 18	–	39.0	–	13.0	–	27.0	–	12.0
18 – 20	–	36.0	–	14.0	–	33.0	–	13.0
20 – 25	–	33.0	–	16.0	–	36.0	–	16.0
25 – 30	–	38.0	–	22.0	–	39.0	–	11.0
30 – 35	–	47.0	–	34.0	–	46.0	–	11.0
35 – 40	–	35.0	–	42.0	–	30.0	–	34.0
40 – 50	–	21.0	–	34.0	–	24.0	–	32.0
50 – 60	–	15.0	–	22.0	–	17.0	–	25.0
60 – 70	–	19.0	–	22.0	–	4.0	–	16.0
70 – 80	–	1.0	–	21.0	–	7.0	–	10.0
80 – 90	–	3.0	–	9.0	–	–	–	–
90 – 100	–	–	–	–	–	–	–	–

TABLE VII

RAWIN DATA

PTV 3

8 Sept 1959

Layers in Thousands of Ft	Release Time 0455 (CST) Mean Wind Components in MPH				Release Time 0915 (CST) Mean Wind Components in MPH			
	N	S	E	W	N	S	E	W
2 – 3	15.0	–	–	43.0	22.0	–	–	27.0
3 – 4	20.0	–	–	44.0	26.0	–	–	27.0
4 – 5	20.0	–	–	41.0	26.0	–	–	27.5
5 – 6	14.0	–	–	42.0	23.5	–	–	30.0
6 – 7	13.0	–	–	44.0	21.0	–	–	34.0
7 – 8	12.0	–	–	43.0	21.0	–	–	37.0
8 – 9	13.0	–	–	46.0	26.0	–	–	38.0
9 – 10	15.0	–	–	55.0	24.0	–	–	37.5
10 – 12	19.0	–	–	60.0	14.0	–	–	37.5
12 – 14	15.0	–	–	54.0	12.0	–	–	42.0
14 – 16	18.0	–	–	56.0	10.0	–	–	42.5
16 – 18	21.0	–	–	58.0	8.5	–	–	50.0
18 – 20	25.0	–	–	59.0	5.0	–	–	47.0
20 – 25	21.0	–	–	59.0	2.0	–	–	50.0
25 – 30	18.0	–	–	59.0	2.5	–	–	70.0
30 – 35	15.0	–	–	63.0	7.0	–	–	94.0
35 – 40	8.0	–	–	62.0	4.0	–	–	80.0
40 – 50	–	1.0	–	50.0	–	2.0	–	57.0
50 – 60	–	6.0	–	34.0	–	9.0	–	32.0
60 – 70	–	7.0	–	21.0	–	11.0	–	20.0
70 – 80	–	5.0	–	18.0	–	10.0	–	8.0
80 – 90	3.0	–	–	21.0	0	0	4.0	–
90 – 100	–	–	–	–	–	4.0	4.0	–

TABLE VIII

RAWIN DATA

PTV 4

10 Sept 1959

Release Time 1205 (CST)

Layers in Thousands of Ft	Mean Wind Components in MPH			
	N	S	E	W
2 – 3	–	16.5	–	6.5
3 – 4	–	14.5	–	17.0
4 – 5	–	10.5	–	22.0
5 – 6	–	3.5	–	21.0
6 – 7	2.0	–	–	23.0
7 – 8	2.5	–	–	25.5
8 – 9	4.5	–	–	26.5
9 – 10	9.0	–	–	30.0
10 – 12	13.0	–	–	36.0
12 – 14	18.0	–	–	37.5
14 – 16	18.5	–	–	37.5
16 – 18	19.0	–	–	42.0
18 – 20	22.0	–	–	56.0
20 – 25	18.0	–	–	67.0
25 – 30	27.0	–	–	75.0
30 – 35	28.0	–	–	74.0
35 – 40	15.0	–	–	60.0
40 – 50	–	3.0	–	41.0
50 – 60	–	8.0	–	21.0
60 – 70	–	10.0	0	18.0
70 – 80	–	4.0	–	10.0
80 – 90	–	3.0	–	1.0
90 – 100	–	–	–	–

APPENDIX IV

VEHICLE DATA

PTV 1

Maximum telemetry weight plus
10-in. forward shift of C of G

PTV 2

Maximum telemetry weight plus
10-in. forward shift of C of G

WEIGHTS AND CENTRE OF GRAVITY

	PTV 1 Without Propellant		PTV 1 With Propellant		PTV 2 Without Propellant		PTV 2 With Propellant	
	Weight lb	C of G Station	Weight lb	C of G Station	Weight lb	C of G Station	Weight lb	C of G Station
Complete vehicle instrumentation and ballast	967.5	149.48	2799.0	164.83	969.0	150.39	2760.0*	163.72
Engine casing, nozzle and igniter	416.0	104.57	2249.0	96.70	413.0	109.28	2201.5*	94.64
Nose cone assembly, instrumentation and ballast	356.5	40.84	356.5	40.84	360.8	41.10	360.8	41.10
Fin assembly	193.0	29.67	193.0	29.67	194.0	29.64	194.0	29.64

* Less nozzle

INERTIAS

	PTV 1 Without Propellant	PTV 1 With Propellant	PTV 2 Without Propellant	PTV 2 With Propellant
	Slugs, ft^2	Slugs, ft^2	Slugs, ft^2	Slugs, ft^2
Roll inertia	19.06	34.28	18.99	not done
Pitch or yaw inertia	2107.30	3327.61	2146.30	3235.33

WEIGHTS AND CENTRE OF GRAVITY

	PTV 3 Maximum telemetry weight plus 10-in. forward shift of C of G				PTV 4 Maximum telemetry weight plus 10-in. forward shift of C of G			
	Without Propellant		With Propellant		Without Propellant		With Propellant	
	Weight lb	C of G Station	Weight lb	C of G Station	Weight lb	C of G Station	Weight lb	C of G Station
Complete vehicle instrumentation and ballast	949.0	149.52	2753.0*	163.46	943.5	150.01	2748.0*	163.78
Engine casing, nozzle and igniter	400.0	106.56	2195.0*	94.55	395.0	108.16	2198.5*	95.18
Nose cone assembly, instrumentation and ballast	355.0	41.07	355.0	41.07	353.6	40.98	353.6	40.98
Fin assembly	192.8	29.72	192.8	29.72	193.8	29.56	193.8	29.56
Nose cone assembly, instrumentation and ballast as launched	244.0				242.6			

* Less nozzle

* Less nozzle

INERTIAS

	PTV 3 Maximum telemetry weight plus 10-in. forward shift of C of G		PTV 4 Maximum telemetry weight plus 10-in. forward shift of C of G	
	Without Propellant	With Propellant	Without Propellant	With Propellant
	Slugs, ft^2	Slugs, ft^2	Slugs, ft^2	Slugs, ft^2
Roll inertia	18.88	not done	18.87	not done
Pitch or yaw inertia	2090.85	3236.27	2083.19	3247.66

Unclassified

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JDP.

#382987

Copy # 2: Ref. File
3: DWR
4: SES
5: DRCL
6: DRNL
(glue)

Circ.: UK L/O.

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