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TECHNICAL REPORT

FLIGHT TEST EVALUATION FOR MOD II DECOY SUBSYSTEM - TITAN V-1(U)

Ford Motor Company
AERONUTRONIC DIVISION

SECRET

Ford Motor Company
AERONUTRONIC DIVISION

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TECHNICAL REPORT

FLIGHT TEST EVALUATION FOR MOD II DECOY SUBSYSTEM - TITAN V-1(U)

Prepared for: Ballistic Systems Division
United States Air Force
Norton Air Force Base

Under Contract: AF 04(694)-23

Prepared by: Field Test Department

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16 May 1963

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SUMMARY

The first in a series of two tests to demonstrate compatibility of the Titan I Missile and Aeronutronic's Decoy Subsystem, and to evaluate the performance of the Decoy Ejection Mechanisms (DEM's) and decoys, was conducted at the Pacific Missile Range on 4 April 1963. Liftoff occurred at approximately 2052 Pacific Standard Time(0452, 5 April 1963, Greenwich Mean Time).

The missile, Titan V-1, carried two Mod II DEM's, Serial Numbers PA01039 and PA01040, with their complements of decoys. All of the pressure and fairing motion measurements yielded data which will permit evaluation of the primary objective: determination of missile/decoy subsystem compatibility. Preliminary investigation indicates that the objective was met; however, final determination must await further analysis.

The second objective, to evaluate performance of the ejection mechanisms, was partially accomplished. All instrumentation which could be incorporated in the available telemetry channel space indicated that the operation of DEM 01040 was entirely as planned. However, an electrical malfunction, which occurred within DEM 01039 shortly after power supply activiation, precluded satisfactory functioning of that DEM.

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FOREWORD

The Aeronutronic Division of Ford Motor Company is responsible, under the terms of Contract AF 04(694)-23, for the design, development, fabrication, and test of a missile-borne decoy subsystem for use with Weapon System 107A.

This document is prepared under the requirements of Exhibit A of the contract. It presents the evaluation of the flight test of Aeronutronic's Decoy Subsystem, consisting of Decoy Ejection Mechanisms, serial numbers PA01039 and PA01040, with payloads, which were carried as a part of the test of Titan missile V-1 at the Pacific Missile Range on 4 April 1963.

CONTENTS

ILLUSTRATIONS

TABLES

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SECTION 1

INTRODUCTION

The purpose of this document is to present the results and conclusions of the flight test of Mod II Decoy Subsystem, consisting of DEM's PA01039 and PA01040 and their decoy complements. The subsystem was carried on Titan missile V-1, which was flown over the Pacific Missile Range on 4 April 1963.

The test was conducted in accordance with the Detailed Flight Test Plan, Reference 1.

SECTION 2

ACCOMPLISHMENT OF OBJECTIVES

Table I presents the test objectives, specified in Reference 1, and the degree to which each objective was accomplished. Test objective priorities and terminology are as defined in Reference 1.

TABLE I

SUMMARY OF FLIGHT TEST OBJECTIVE ACCOMPLISHMENT

	Priority			Accomplished			
	1st Order	2nd Order	3rd Order	Fully	Partially	Not	Undetermined
1. Determine compatibility between the decoy subsystem and the missile. This is to ensure that the decoy subsystem and missile combination is compatible and that the configuration generally operates without detrimental interactions. Under this objective are the following subobjectives:							
a. Obtain data on the effects of the actual flight environment experienced by the DEM.	X			X			
b. Determine interactions between the decoy subsystem and the missile.	X			X			
2. Evaluate decoy ejection system performance. This objective is to ensure that the decoy subsystem functions within specifications to eject the decoys at the times and velocities and in the directions preselected. This objective includes:							
a. Demonstrate the operation of the sequential timer.		X		X			
b. Determine the operation of the DEM power supply.		X			X		
c. Determine the ejection of the aerodynamic fairing.		X			X		
d. Demonstrate the orientation of the decoy launch tubes.		X			X		
e. Demonstrate the ejection of the decoys.		X			X		
3. Evaluate decoy performance. This evaluation includes:							
a. Determine the velocity-altitude time history of the decoys during re-entry.		X					X
b. Obtain data to define the survival characteristics of the decoys during atmospheric re-entry.		X					X

TABLE I (Continued)

SUMMARY OF FLIGHT TEST OBJECTIVE ACCOMPLISHMENT

	Priority			Accomplished			
	1st Order	2nd Order	3rd Order	Fully	Partially	Not	Undetermined
c. Determine the radar cross sections of the decoys. Studies of decoy radar cross sections are required at various radar frequencies and aspect angles, to include investigation of the changes in cross section during re-entry.		X					X
4. Establish adequacy of aerospace ground equipment and procedures. This is to ensure proper performance of the aerospace ground equipment (AGE) and procedures which includes:							
a. Establish the safety of the AGE and procedures.			X		X		
b. Obtain data regarding the validity of tests performed on the decoy subsystem with the AGE.			X		X		
c. Establish proper handling and operating procedures.			X		X		
d. Establish the best test sequence.			X		X		
5. Obtain reliability data on the decoy subsystem. The purpose of this is to statistically measure the reliability of the decoy subsystem. This objective includes the following subobjectives:							
a. Obtain data to confirm the ability of the decoy subsystem to consistently eject decoys in the desired direction, at the desired velocities, and at the desired times.			X		X		
b. Obtain data to confirm the consistency of the velocity-altitude time histories of the decoys.			X		X		
c. Obtain data to confirm consistent validity of test performed with AGE.			X		X		

SECTION 3

DESCRIPTION OF TEST ARTICLE

3.1 DEM CONFIGURATION

The Mod II Decoy Subsystem consists of two Decoy Ejection Mechanisms, with decoys, mounted on the surface of the sustainer stage of the missile as shown in Figures 1 and 2. DEM's, Serial Numbers PA01039 and PA01040, were used for this test. Each DEM carried four Model 1032 re-entry decoys and five Model 1028-BP midcourse decoys. The sixth midcourse launch tube (tube number 9) was removed to provide space for the instrumentation junction box. A complete detailed description of the decoy subsystem is presented in Reference 1. The tube position numbering system is shown in Figure 3.

Sequence timing and ejection details are shown in Table IIA for DEM PA01039 and in Table IIB for DEM PA01040. Figure 4 defines the three-dimensional coordinate system and sign convention for the decoy ejection velocity vector components, X_m, Y_m, and Z_m.

3.2 INSTRUMENTATION

Each DEM was instrumented to determine the flight pressure environment and to obtain data, insofar as telemetry channel space would allow on operation of the DEM's. Table III presents a detailed list of the measurements that were incorporated. As the table shows, circuit switching within the DEM's was utilized to the maximum extent feasible to obtain as much data as possible. Figures 5 and 6 show the locations of pressure and fairing motion transducers.

All measurements were transmitted on two commutated channels through the missile PDM/FM telemetry link on a carrier frequency of 246.3 megacycles. Channel 15 was commutated at 10 samples per second and channel 14 at 5 samples per second. All data were transmitted to the missile telemetry in the form of voltage levels.

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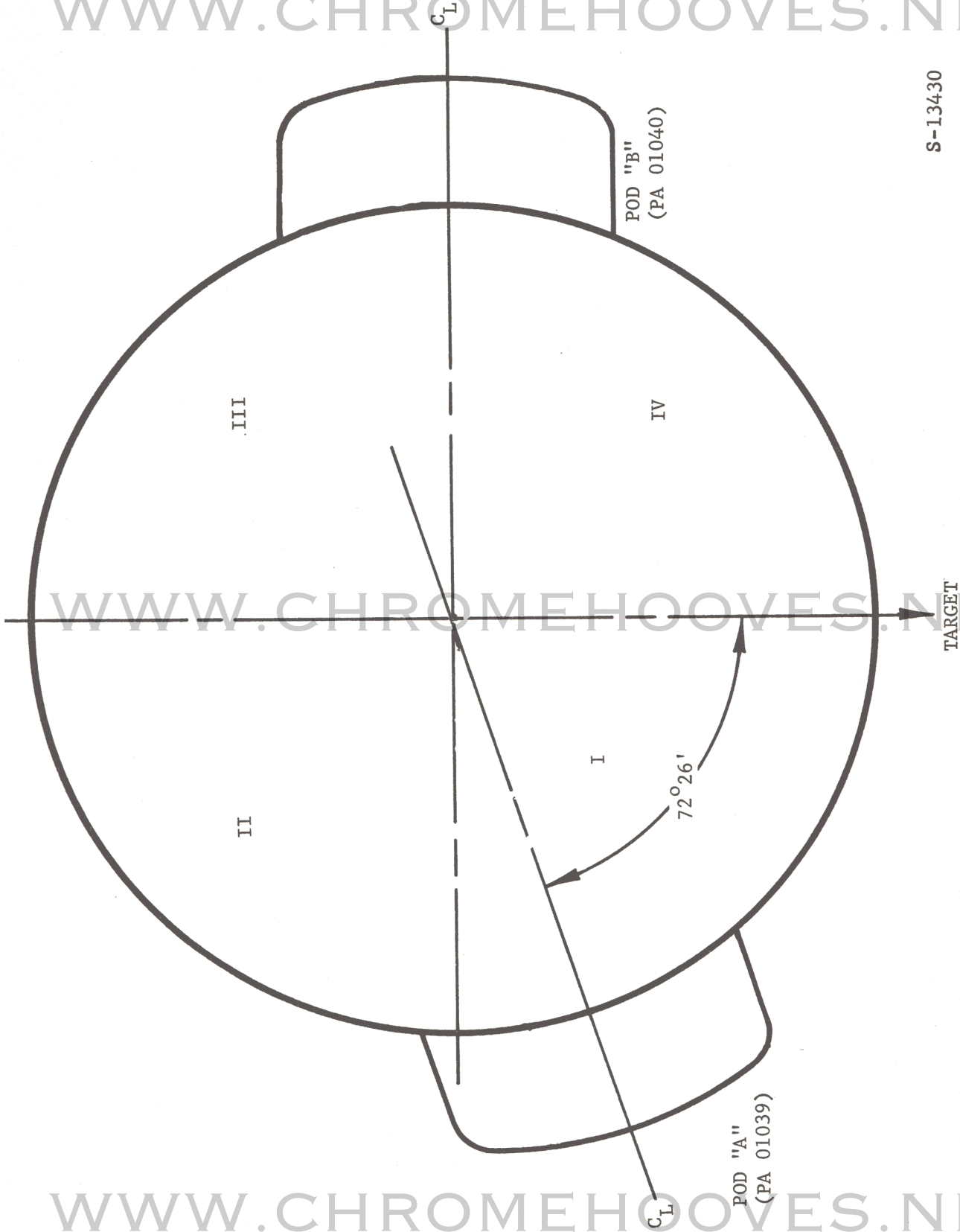

FIGURE 1. VIEW LOOKING FORWARD, SHOWING DECOY SUBSYSTEM POSITIONS - TITAN MISSILE V-1

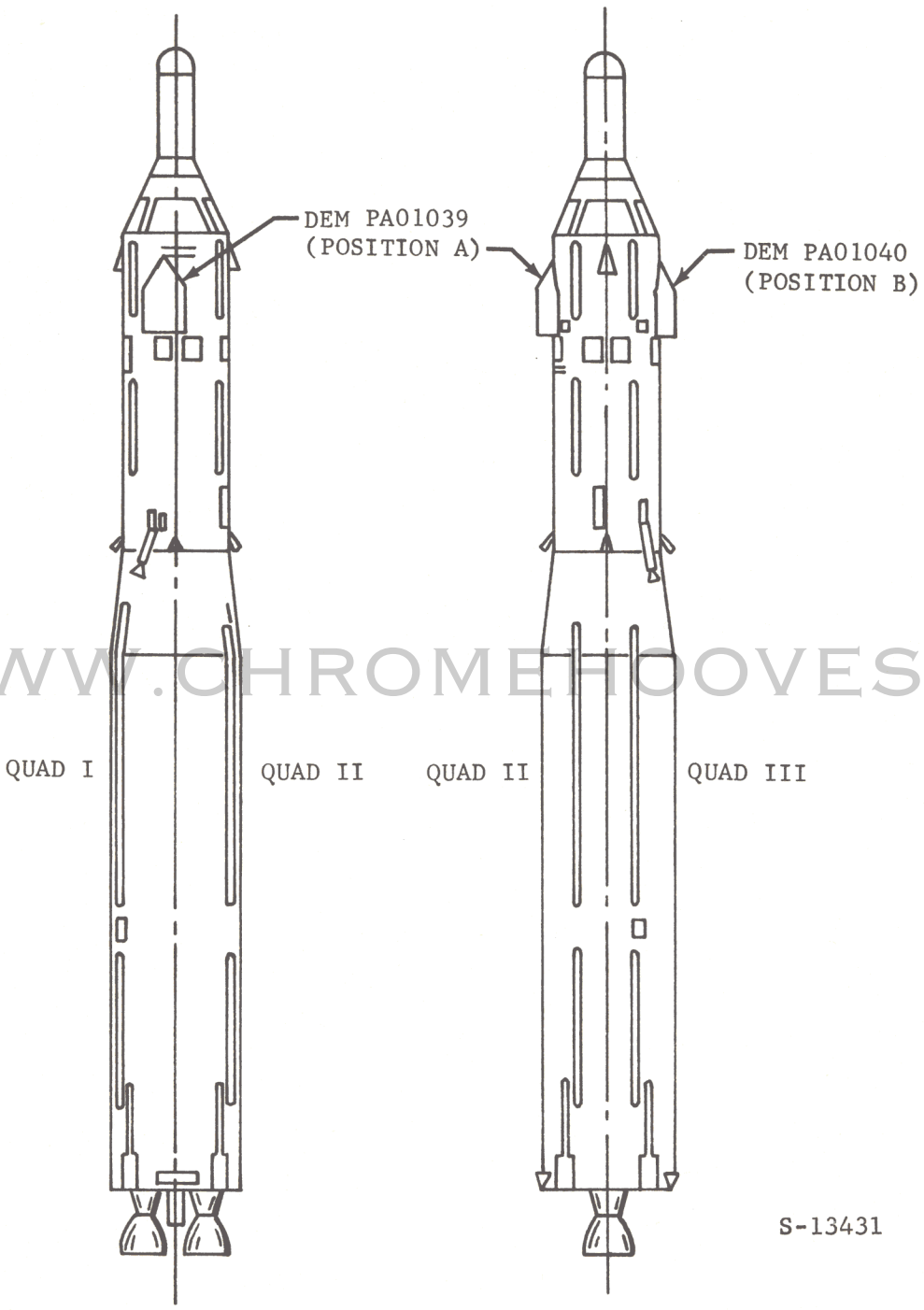

FIGURE 2. LOCATION OF DEMs ON TITAN MISSILE V-1

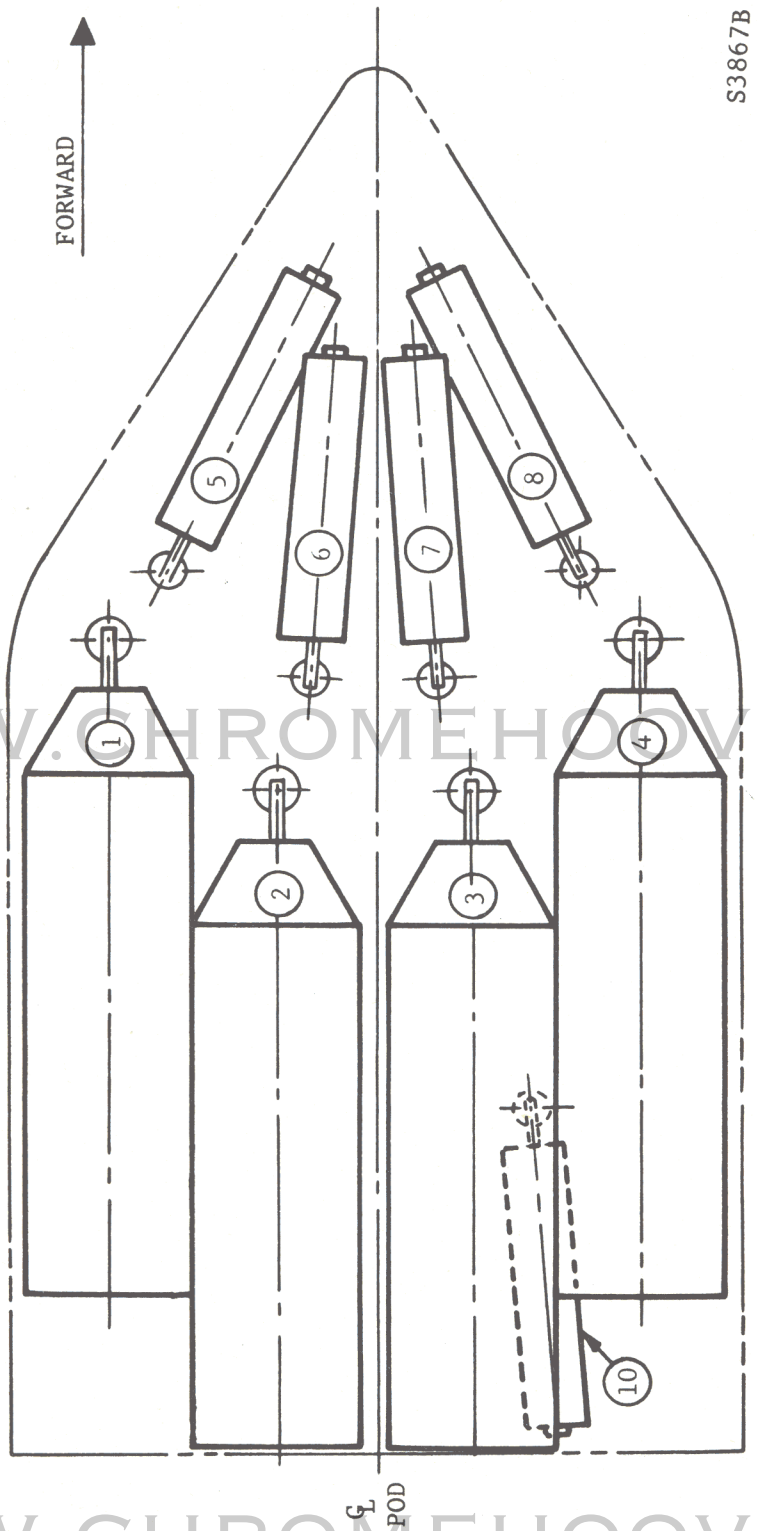

FIGURE 3. PLAN VIEW OF MOD II POD, SHOWING STOWED-TUBE ARRANGEMENT AND NUMBERING SYSTEM

TABLE IIA

POD LOADING, SETTING AND TIMING DATA
POD A, SERIAL NUMBER PA 01039

Launch Tube Number	Decoy Assembly Model Number	Ejection Velocity (fps)	Sequence Timing**			Ejection Angles						Fixture Setting Angles*		
						Ejection Velocity Vectors (Rel. ~~M~~ Axes)			Inboard/ Outboard	Actual Shaft Rotation (Deg)	Half Cone Angle (Deg)	Shaft Rot. Setting (Deg)	Cone Angle Setting (Deg)	CW/ CCW
			Unlatch (a)	Orient (a)	Eject (b)	X_m	Z_m	Y_m						
Re-entry														
1	1032	20	0.25	0.50	2.75	0	+17.56	9.42	Out	178.2	45.0	1.8	135.0	CCW
2	1032	49	1.25	1.50	3.50	0	+32.10	-37.03	Out	99.0	68.4	81.0	158.4	CCW
3	1032	31	1.75	2.00	3.00	0	0	-31.00	Out	95.2	73.2	95.2	16.8	CW
4	1032	20	0.75	1.00	3.25	0	-14.62	-13.60	Out	129.3	51.5	129.3	38.5	CW
Vacuum														
5	1028BP	77	4.75	N.A.	1.50	0	+63.75	-43.23	Out	111.5	70.7	111.2	19.3	CW
6	1028BP	65	3.25	N.A.	2.25	12.45	+54.78	-32.88	Out	109.9	50.5	111.8	39.5	CW
7	1028BP	64	2.50	N.A.	1.75	0	+31.85	-55.54	Out	122.7	55.1	55.6	145.1	CCW
8	1028BP	60	4.00	N.A.	2.50	3.91	+2.54	-59.82	Out	90.0	83.6	90.3	173.6	CCW
9***	-	-	-	N.A.	3.75	-	-	-	-	-	-	-	-	-
10	1028BP	50	7.00	N.A.	2.00	0	-32.40	-25.11	Out	141.1	48.6	141.1	41.4	CW
	Timer Stop		10.75											

* Tolerance: 0.5 Degree
** Time in seconds from (a) first or (b) second timer start; tolerance ± 5 percent plus a starting delay of 0.1 to 0.3 second.
*** Tube 9 removed to provide space for instrumentation junction box on R&D pods.
N.A. Not Applicable

TABLE IIB

POD LOADING, SETTING AND TIMING DATA
POD B, SERIAL NUMBER PA 01040

Launch Tube Number	Decoy Assembly Model Number	Ejection Velocity (fps)	Sequence Timing**			Ejection Angles						FIXTURE Setting Angles*		
						Ejection Velocity Vectors (Rel. M Axes)								
			Unlatch (a)	Orient (a)	Eject (b)	X_m	Z_m	Y_m	Inboard/ Outboard	Actual Shaft Rotation (Deg)	Half Cone Angle (Deg)	SHAFT Rot. Setting (Deg)	Cone Angle Setting (Deg)	CW/ CCW
Re-entry 1	1032	31	0.25	0.50	3.25	0	0	31.00	In	92.4	78.3	92.4	11.7	CW
2	1032	41	1.75	2.00	3.00	-0.61	-27.46	30.44	In	123.0	53.0	123.0	37.0	CW
3	1032	56	1.25	1.50	3.50	0	+52.71	18.97	Out	152.3	46.7	152.3	43.3	CW
4	1032	33	0.75	1.00	2.75	0	+32.39	-6.09	Out	178.3	45.0	178.3	45.0	CW
Vacuum 5	1028BP	50	4.75	N.A.	1.50	2.82	-27.28	36.93	Out	108.0	69.6	107.7	20.4	CW
6	1028BP	68	3.25	N.A.	2.25	2.97	+33.80	58.93	In	99.0	61.9	79.4	151.9	CCW
7	1028BP	68	2.50	N.A.	1.75	9.13	+55.84	37.71	Out	130.0	48.2	48.1	138.2	CCW
8	1028BP	92	4.00	N.A.	2.50	11.89	+64.17	64.84	Out	115.0	63.7	65.3	153.7	CCW
9***	None	None	6.50	N.A.	3.75	-	-	-	-	-	-	-	-	-
10	1028BP	86	7.00	N.A.	2.00	0	+85.10	12.44	Out	157.2	46.2	157.2	43.8	CW
	Timer Stop		10.75											

* Tolerance: 0.5 Degree
** Time in seconds from (a) first or (b) second timer start; tolerance ± 5 percent plus a starting delay of 0.1 to 0.3 second.
*** Tube 9 removed to provide space for instrumentation junction box on R&D pods.
N.A. Not Applicable

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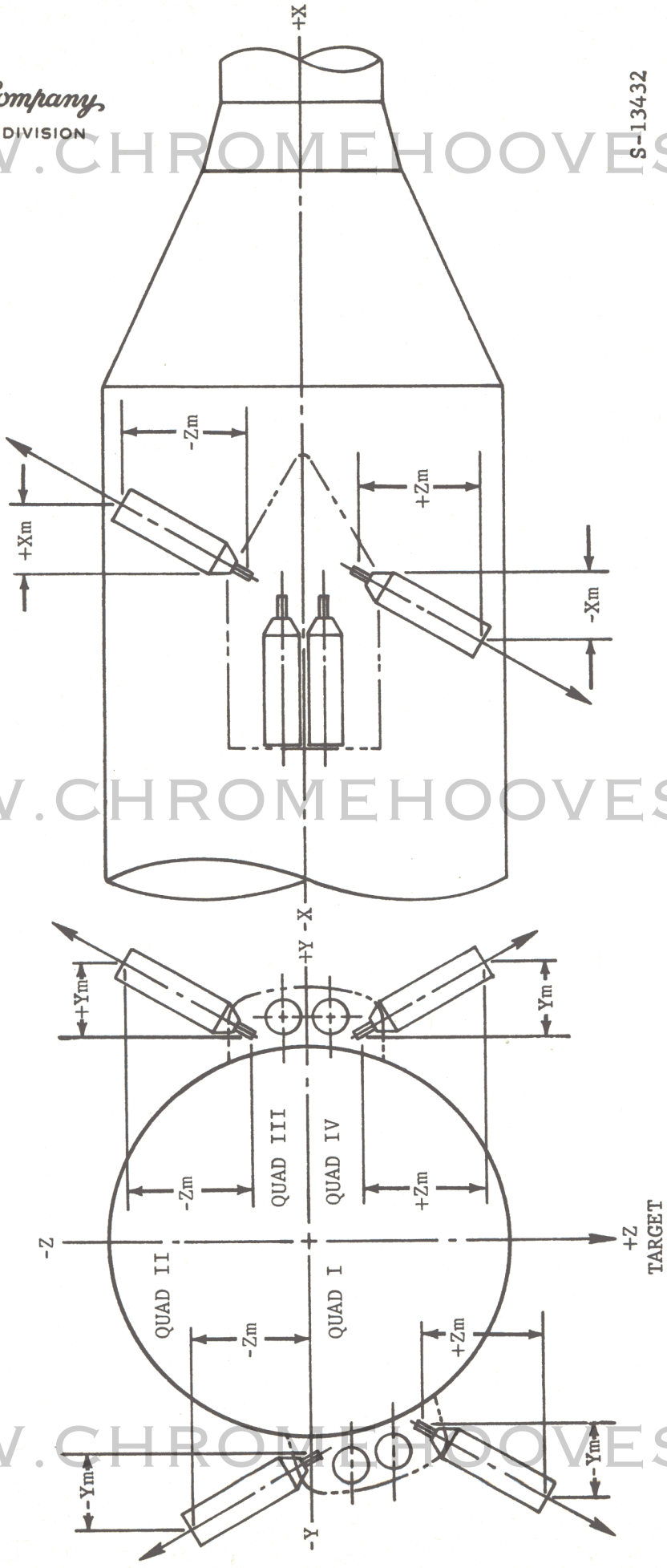

FIGURE 4. DEFINITION OF EJECTION VELOCITY VECTOR COMPONENTS AND SIGN CONVECTIONS

TABLE III

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FLIGHT TEST TELEMETRY INSTRUMENTATION LIST

Aeronutronic Item Number	Aeronutronic Parameter Number	Parameter Name (DEM Position A, S/N PA01039)	TMC Meas. Number	Interface Connector Pin	Link, Channel and Segment
1	A221	Pressure, DEM internal static	85	F	1-15- 4
	*A740	Relative Motion, base structure/fairing nose	85	F	1-15- 4
	**A305	Angle, shaft rotation, gimbal number 5	85	F	1-15- 4
	***A725	Eject Sure, tube number 5	85	F	1-15- 4
	A726	Eject Sure, tube number 6	85	F	1-15- 4
	A727	Eject Sure, tube number 7	85	F	1-15- 4
2	A223D	Pressure, aft vent differential static	86	H	1-14-12
	*A741	Separation, fairing nose strap	86	H	1-14-12
	**A306	Angle, shaft rotation, gimbal number 6	86	H	1-14-12
	***A728	Eject Sure, tube number 8	86	H	1-14-12
	A730	Eject Sure, tube number 10	86	H	1-14-12
3	A204D	Pressure, fwd. vent differential static	87	K	1-14-13
	*A731	Timer Function: start, stop, restart	87	K	1-14-13
	A732	Timer Function: "g" sensor	87	K	1-14-13
4	A210D	Pressure, fairing static differential, LH aft	88	M	1-14-14
	*A802	Voltage, power supply, squibs and motors	88	M	1-14-14
5	A211D	Pressure, fairing static differential, RH aft	89	P	1-14-15
	**A301	Angle, shaft rotation, gimbal number 1	89	P	1-14-15
	***A721	Eject Sure, tube number 1	89	P	1-14-15
6	A212D	Pressure, fairing static, differential, LH fwd	90	n	1-14-16
	**A302	Angle, shaft rotation, gimbal number 2	90	n	1-14-16
	***A722	Eject Sure, tube number 2	90	n	1-14-16
7	A213D	Pressure, fairing static, differential, RH fwd	91	q	1-14-17
	**A303	Angle, shaft rotation, gimbal number 3	91	q	1-14-17
	***A723	Eject Sure, tube number 3	91	q	1-14-17
8	A737	Relative Motion, fairing/base structure, long.	92	s	1-14-18
	**A304	Angle, shaft rotation, gimbal number 4	92	s	1-14-18
	***A724	Eject Sure, tube number 4	92	s	1-14-18
		(DEM Position B, S/N PA01040)			
9	B221	Pressure, DEM internal static	93	F	1-14-22
	*B740	Relative Motion, base structure/fairing nose	93	F	1-14-22
	**B301	Angle, shaft rotation, tube number 1	93	F	1-14-22
	***B721	Eject Sure, tube number 1	93	F	1-14-22
	B722	Eject Sure, tube number 2	93	F	1-14-22
	B723	Eject Sure, tube number 3	93	F	1-14-22
10	B223D	Pressure, aft vent differential static	94	H	1-14-23
	*B741	Separation, fairing nose strap	94	H	1-14-23
	**B302	Angle, shaft rotation, gimbal number 2	94	H	1-14-23
	***B724	Eject Sure, tube number 4	94	H	1-14-23
	B728	Eject Sure, tube number 8	94	H	1-14-23
	B730	Eject Sure, tube number 10	94	H	1-14-23
11	B204D	Pressure, fwd vent differential static	95	K	1-14-24
	*B731	Timer Function: start, stop, restart	95	K	1-14-24
	B732	Timer Function: "g" sensor	95	K	1-14-24
12	B737	Relative Motion, fairing/base structure, long.	96	M	1-14-25
	**B305	Angle, shaft rotation, gimbal number 5	96	M	1-14-25
	***B725	Eject Sure, tube number 5	96	M	1-14-25
	B726	Eject Sure, tube number 6	96	M	1-14-25
	B727	Eject Sure, tube number 7	96	M	1-14-25
		# Instrumentation Ground		U	
		# Instrumentation Ground		T	
		# Shield Carry Through		S	
		# 24 Volt Instrumentation Power Supply		X	
		# 5 Volt Instrumentation Power Supply		Z	
		0 Volt Reference Level			1-14-27
		5 Volt Reference Level			1-14-28

NOTE:

* Indicates function is switched in at BECO (T_1 signal).
** Indicates function is switched in at BECO plus 40 seconds.
*** Indicates function is switched in at R/V separation (T_2 signal).
# Functions so indicated are typical for both DEMs.

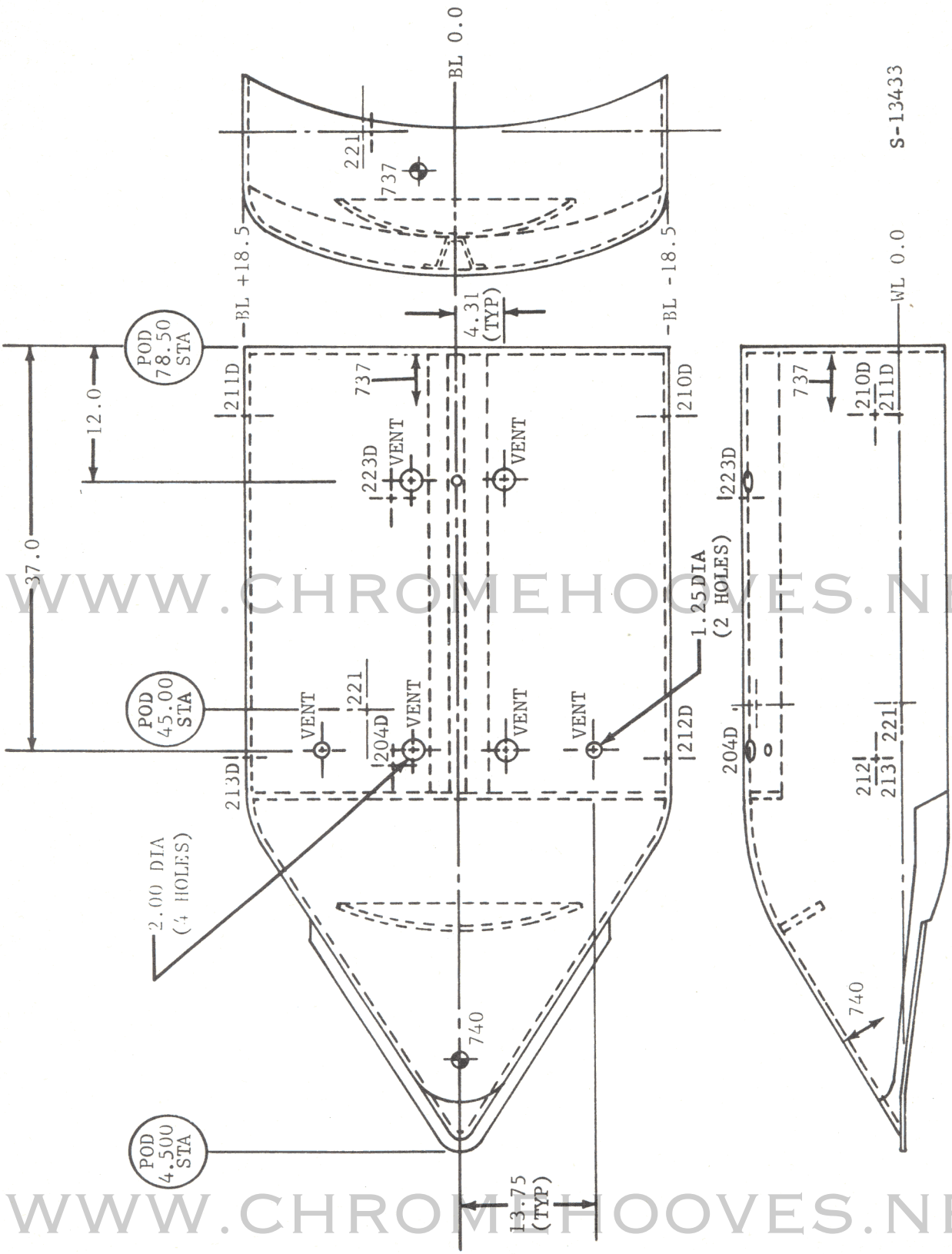


FIGURE 5. POD PA 01039 FAIRING INSTRUMENTATION

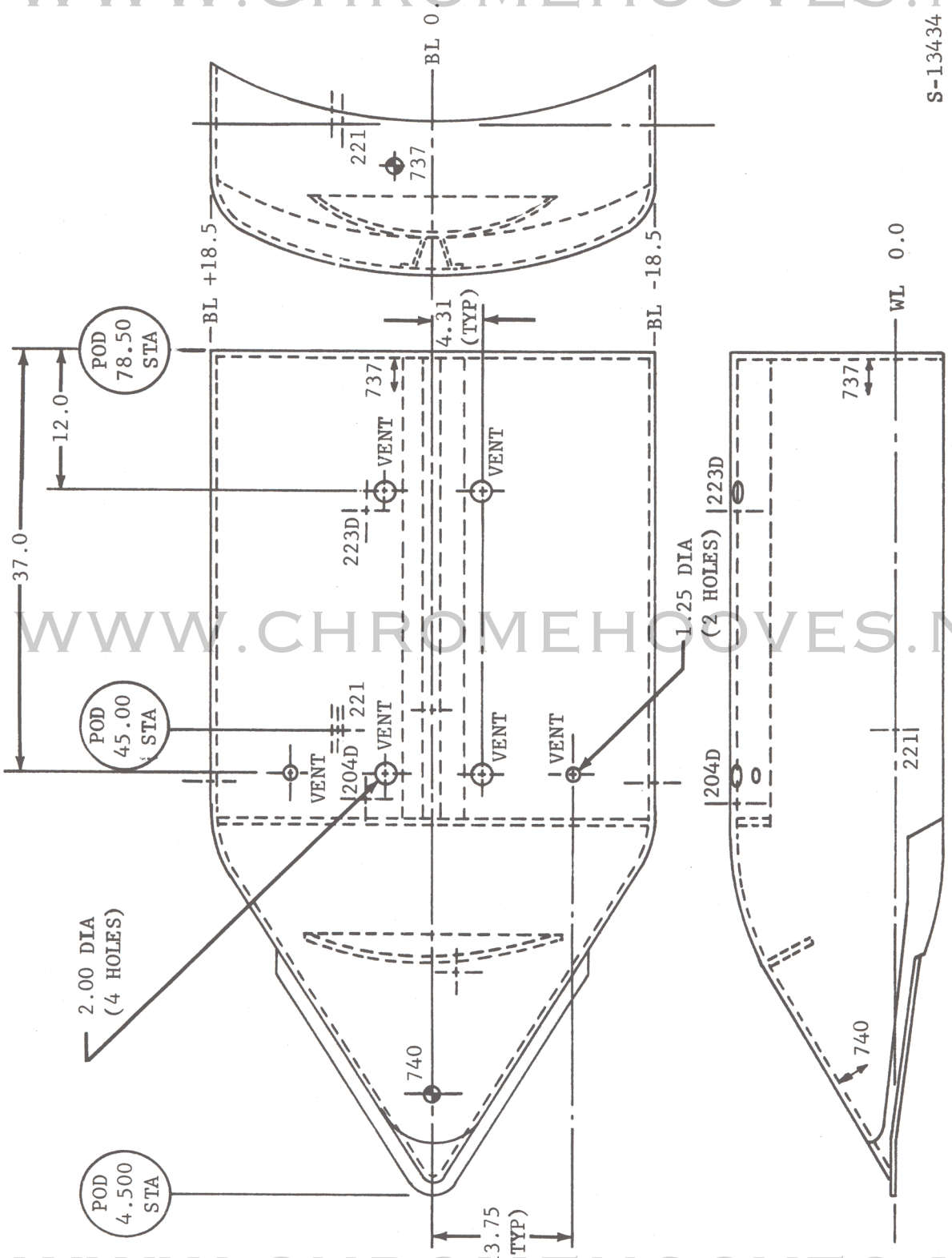


FIGURE 6. POD PA 01040 FAIRING INSTRUMENTATION

SECTION 4

PREPARATION FOR AND CONDUCT OF TEST

4.1 NEWPORT BEACH OPERATIONS

Before shipment of DEM's 39 and 40 to the Pacific Missile Range, complete mechanical and electrical checkouts were conducted on each. A few minor discrepancies were corrected as a result of these checkouts, which were completed on 17 January (DEM 01039) and on 24 January 1963 (DEM 01040).

4.2 FIELD OPERATIONS - VANDENBERG AIR FORCE BASE

DEM's serial numbers PA01040 and 01039 were received at the Aeronutronic Field Office, Building 8425, at Vandenberg Air Force Base on 31 January 1963 and 16 February 1963, respectively. (DEM 01039 was previously shipped to Denver for a preliminary fit and interface checkout.) The equipment was unpackaged immediately upon receipt and checked for completeness and shipping damage. No damage was found. Pyrotechnic devices were stored at the ordnance storage area until they were required for final assembly.

The DEM's were checked for mechanical fit on the V-1 missile at Site 395-A, Launcher Facility No. 1, on 26 February 1963. The pods were brought to within 6 inches of the missile attach interface by Martin Marietta Company (MMC) personnel with Aeronutronic personnel monitoring. Aeronutronic personnel completed the installation of the Decoy Subsystem on the missile.

All four outrigger pads of DEM 40 were in 100-percent contact with the missile skin. The two forward outriggers on DEM 39 exhibited a gap of approximately 0.030 inch between pads and missile skin. An 0.028-inch elastomer shim was added to each pad to correct the fit. The fit of the seals of both pods appeared to be identical to the fit obtained during the previous check conducted with the missile at MMC, Denver.

A number of holes in the missile skin under the fairing were noted, and were then sealed by MMC personnel. Also, the instrumentation interface cable for DEM 40 was too short and was replaced by a cable 2 inches longer.

A rework on the fitting which mounts the missile electrical interface receptacle to the missile was required because the original round-head screws interferred with the shell of the DEM cable connectors and prevented installation of the cables. The fitting was reworked by MMC personnel to permit the use of flush screws.

An electrical systems checkout on 5 March 1963 showed that sequence timing of both DEM electrical systems was in agreement with the results of tests made at Newport Beach and that both electrical systems were operating within requirements.

Instrumentation interface checks were performed on 13 March 1963 using the Mod II instrumentation simulator connected to the missile instrumentation interface. These checks consisted of applying discrete voltages to the missile/DEM telemetry interface and reading voltages at the telemetry signal conditioner with a digital voltmeter. The checks showed that the correct continuity existed through interfaces but the cable locations had been reversed within the missile: the cable for DEM 40 was routed to DEM 39, and vice versa. The wiring within the missile was then revised by MMC to conform to the Flight Test Directive (Reference 4). Subsequent instrumentation interface checks showed that this rework provided proper connections.

An electrical interface check on 13 March 1963 showed that the T_1 and T_2 signals from the missile flight controller were within the required voltage tolerances and of the proper polarity.

An instrumentation system hangar checkout was performed on each DEM on 14 March 1963. Instrumentation voltage readouts were within tolerance and were in agreement with the results of the checkout previously performed at Newport Beach.

Final assembly of the DEM's was begun on 16 March 1963. Launch tubes with decoys and varijectors were installed first. A squib circuit stray voltage check was then conducted and the pyrotechnic devices installed when the results of that test were satisfactory. The fairing and fairing ejector were then installed on the base structure. A status check of the electrical system and an instrumentation ambient voltage check were made after the pod was assembled.

The DEM's were removed from the rollover work stand and a weight and balance check was conducted with the following results:

DEM	WEIGHT	C.G. LOCATION
PA01039	261.05 lb	Station 52.68
PA01040	257.87 lb	Station 52.64

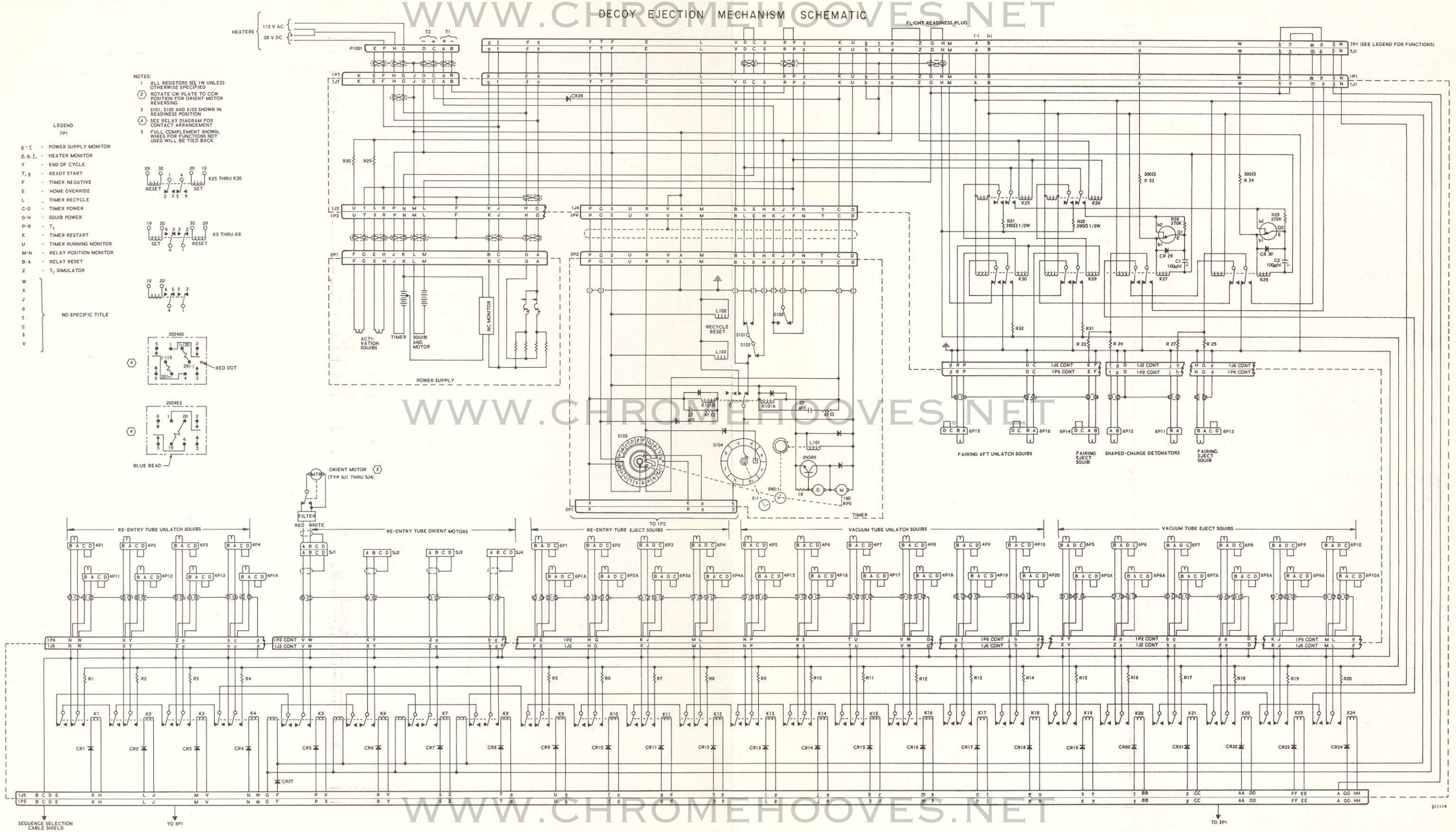
The final status check showed the resistance between pins M and N of connector 7J1 on pod 40 (see Figure 7) to be 4.5 ohms instead of zero ohm. This resistance was still 4.5 ohms after the pod was installed on the missile on 18 March 1963. On 20 March 1963, after a delay of the test was called by range safety, this resistance had increased to 11.37 ohms. The value had increased to 14.15 ohms on 22 March 1963 when the test was halted because of range problems. On 25 March 1963, after the test was halted because of missile problems, the circuit was measured again and the resistance found to be 34 ohms.

At this point, it was determined that the test would be delayed long enough to allow the removal of DEM for replacement of the sequence distribution box (serial Number 023). It was replaced by SDB serial Number 025, originally intended for use on DEM PA01042. Sequence distribution box 023 was returned to Newport Beach, where it was found that the high resistance discussed above was caused by an improperly soldered joint. During the time DEM 01040 was removed from the missile, a gap between the aft fairing seal and the longitudinal fairing seal was closed by applying a layer of polyurethane over the gap. This gap was first noted when the completed DEM was installed on the missile on 18 March 1963.

DEM 40 was reinstalled on missile V-1 on 28 March 1963. A status check of the electrical system and an instrumentation ambient level check was made with satisfactory results.

No further preparation activities were performed on the DEM's until T-6 hours in the countdown on 4 April, when a final status check of the electrical system was made. It was found that resistance between pins U and V of connector 7J1 of DEM 40 was 3.91 ohms instead of zero. It was determined that this condition was not detrimental to DEM operation, and a decision was made to proceed with the test. Immediately following the final status checks, a final instrumentation check with missile telemetry was performed. AlL DEM measurements were found to be at normal ambient levels.

DECOY EJECTION MECHANISM SCHEMATIC



LEGEND
7P1

g - f	-	POWER SUPPLY MONITOR
d, g, f,	-	HEATER MONITOR
Y	-	END OF CYCLE
T, s	-	READY START
F	-	TIMER NEGATIVE
E	-	HOME OVERRIDE
L	-	TIMER RECYCLE
C-D	-	TIMER POWER
G-H	-	SQUIB POWER
P-R	-	T_1
K	-	TIMER RESTART
U	-	TIMER RUNNING MONITOR
M-N	-	RELAY POSITION MONITOR
B-A	-	RELAY RESET
Z	-	T_1 SIMULATOR
W, X, J, g, t, s, S, V	-	NO SPECIFIC TITLE

NOTES:
1. ALL RESISTORS 5Ω, 1W UNLESS OTHERWISE SPECIFIED
2. ROTATE CW PLATE TO CCW POSITION FOR ORIENT MOTOR REVERSING
3. S101, S102 AND S103 SHOWN IN READINESS POSITION
4. SEE RELAY DIAGRAM FOR CONTACT ARRANGEMENT
5. FULL COMPLEMENT SHOWN, WIRES FOR FUNCTIONS NOT USED WILL BE TIED BACK

K25 THRU K30

K5 THRU K8

202480 — RED DOT

202482 — BLUE BEAD

FIGURE 7. DECOY EJECTION MECHANISM SCHEMATIC MOD II ELECTRICAL SYSTEM