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12

DESIGN OF SOUNDING ROCKET PAYLOADS

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structures, component packaging, deployment and eject mechanisms, diagnostic components, in-flight sequencing, power systems and control consoles. Also described are electrical and mechanical interfaces with experiments, telemetry systems, attitude control systems, recovery systems and other payload subsystems. A mission description and preliminary design work for the Multi Spectral Measurements Program (MSMP) is also included in this report.

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1.0 INTRODUCTION

Summarized in this report is the work effort performed under Contract No. AF19628-73-C-0152, from 1 March 1973 to 31 May 1976. Contract No. AF19628-73-C-0152 was a continuation and extension of efforts initiated under three previous contracts - i.e., AF19(628)-4361, F19628-67-C-0223, and F19628-70-C-0194. The accomplishments of the previous three contracts can be found in References 1, 2 and 3 of this report.

1.1 Project Summary

Table 1.1 lists the projects worked on during the contract period. Thirty-six (36) of the thirty-nine (39) projects listed were rocket payloads and are described in Section 2 of this report. Two special projects (timers and split-tip) not related to a specific payload are discussed in Section 3. The final project (MSMP) is larger in scope than other projects in this report and was assigned to the contractor in October 1975. The mission profile, scientific experiments and preliminary payload design of this 3-payload program comprise Section 4.

1.2 Launch Summary

The launch vehicles, scientific experiments, launch sites and launch dates of the 26 payloads launched between 1 March 1973 and 31 May 1976 are summarized in Table 1.2 of this report. Many payloads also carried other experiments to supplement the prime experiment data. Section 2 discusses the individual payload configurations.

As indicated in Table 1.2, five different launch vehicles were used to meet the requirements of the various experiment payloads. Details of

Table - 1.1
 F19628-73-C-0152 Project Summary
 1 March 1973 - 31 May 1976

PROJECT	% Complete 28 Feb 73	Start Date	% Complete 31 May 76	Status 31 May 76
A18.006-2	100	---	---	Launched Mar. 73
A03.911-1	95	---	100	Launched Apr. 73
A09.107-4	85	---	100	Launched Dec. 73
A09.214-1	87	---	100	Launched Sep. 73
A09.214-2	30	---	100	Launched Aug. 74
A09.210-1	55	---	100	Launched Jun. 73
A09.210-2	55	---	100	Launched Jun. 73
A07.212-1	42	---	67	Not Scheduled
A07.212-2	42	---	67	Not Scheduled
A07.212-3	42	---	67	Not Scheduled
A07.212-4	42	---	67	Not Scheduled
A16.000-1	---	Mar. 73	100	Launched Aug. 73
A16.313-1	---	Mar. 73	100	Delivered Aug. 73
A16.313-2	---	Mar. 73	100	Delivered Aug. 73
A09.312-4	---	Mar. 73	100	Delivered Aug. 73
A09.312-5	---	Mar. 73	100	Delivered Aug. 73
A18.006-4a	---	May 73	100	Launched Feb. 74
A10.213-1	---	Sep. 73	100	Launched Jan. 75
A09.213-2	---	Sep. 73	100	Launched Jun. 75
A09.303-1	---	Sep. 73	100	Launched Apr. 74
A09.303-2	---	Sep. 73	100	Launched Apr. 74
A09.303-3	---	Sep. 73	100	Launched Mar. 74
A09.303-4	---	Sep. 73	100	Launched Apr. 74
A09.001-3	---	Sep. 73	100	Launched Jun. 74
A09.001-4	---	Sep. 73	100	Launched Jun. 74
Timers	---	Apr. 74	100	Six units flown
A10.403-1	---	Jun. 74	100	Launched Apr. 75
A10.403-2	---	Jun. 74	100	Launched Apr. 75
A10.403-3	---	Jun. 74	100	Launched Apr. 75
A10.304-1	---	Jul. 74	100	Launched Sep. 75
A10.304-2	---	Jul. 74	100	Launched Sep. 75
Split Tip	---	Aug. 74	25	Preliminary Design
A10.001-2	---	Jul. 75	100	Launched Apr. 76
A10.403-4	---	Jul. 75	100	Launched Apr. 76
HERIS	---	Jul. 75	100	Launched Mar. 76
A10.402-1	---	Sep. 75	100	Scheduled 2Q 77
A10.402-2	---	Sep. 75	100	Launched Jan 76
MSMP	---	Oct. 75	10	Preliminary Design
A10.705-1	---	May 76	0	Scheduled 2Q 77

Table 1.2
 F19628-73-C-0152 Launch Summary
 1 March 1973 - 31 May 1976

PAYLOAD NUMBER	LAUNCH VEHICLE	PRIME EXPERIMENT	LAUNCH SITE	LAUNCH DATE
A18.006-2	Black Brant 5C	CVF Spectrometer	PFRR	Mar. 73
A03.911-1	Aerobee 150	U. V. Spectograph	WSMR	Apr. 73
A09.210-1	Ute-Tomahawk	Pos./Neg. M.S.	CRR	Jun. 73
A09.210-2	Ute-Tomahawk	Pos./Neg. M.S.	CRR	Jun. 73
A16.000-1	Black Brant 4B	Vehicle Diagnostic	WOPS	Aug. 73
A09.214-1	Ute-Tomahawk	Vehicle Potential	WSMR	Sep. 73
A09.107-4	Ute-Tomahawk	Neutral M.S.	CRR	Dec. 73
A18.006-4a	Black Brant 5C	CVF Spectrometer	PFRR	Feb. 74
A09.303-3	Ute-Tomahawk	Positive M.S.	CRR	Mar. 74
A09.303-1	Ute-Tomahawk	Ion/Neut. M.S.	CRR	Apr. 74
A09.303-2	Ute-Tomahawk	Ion/Neut. M.S.	CRR	Apr. 74
A09.303-4	Ute-Tomahawk	Negative M.S.	CRR	Apr. 74
A09.213-2	Ute-Tomahawk	Neutral M.S.	WOPS	Jun. 74
A09.001-3	Ute-Tomahawk	Positive M.S.	WOPS	Jun. 74
A09.001-4	Ute-Tomahawk	Positive M.S.	WOPS	Jun. 74
A09.214-2	Ute-Tomahawk	Vehicle Potential	WSMR	Aug. 74
A10.213-1	Paiute-Tomahawk	Neutral M.S.	WOPS	Jan. 75
A10.403-1	Paiute-Tomahawk	Config. "E" M.S.	CRR	Apr. 75
A10.403-2	Paiute-Tomahawk	Config. "E" M.S.	CRR	Apr. 75
A10.403-3	Paiute-Tomahawk	Config. "E" M.S.	CRR	Apr. 75
A10.304-1	Paiute-Tomahawk	Neutral M.S.	WSMR	Sep. 75
A10.304-2	Paiute-Tomahawk	Neutral M.S.	WSMR	Sep. 75
A10.402-2	Paiute-Tomahawk	Neutral M.S.	WOPS	Jan. 76
HIRIS	Sergeant	I.R. Spectrometer	PFRR	Mar. 76
A10.001-2	Paiute-Tomahawk	Config. "E" M.S.	CRR	Apr. 76
A10.403-4	Paiute-Tomahawk	Config. "E" M.S.	CRR	Apr. 76

Launch Sites

- CRR - Churchill Research Range, Manitoba, Canada
- WOPS - Wallops Island, Virginia
- WSMR - White Sands Missile Range, New Mexico
- PFRR - Poker Flat Research Range, Alaska

launch support provided under the contract are listed in Section 5.

1.3 Launch Results

Launch results in Table 1.3 are divided into 4 categories: vehicle performance, payload operation, scientific data and recovery. Considering scientific data the primary objective, 18 of the 26 launches can be considered as completely successful, one as partially successful, and no useful data was obtained from the remaining 7.

The "payload operation" column refers to the direct responsibilities under Contract No. AF19628-73-C-0152. The two payload failures listed were the result of premature separation of the forward ejecting nose cones. These failures prompted a return to the split-tip configuration. Failure analysis is included in Sections 2.3 and 2.9.

Non-ignition of the second-stage motor resulted in no useful data from the launch of payloads A09.001-3 and A10.001-2. A catastrophic motor failure resulted in no useful data from A09.001-4. The partial success of payload A03.911-1 is described in Section 2.2.

Table 1.3
 F19628-73-C-0152 Launch Results
 1 March 1973 - 31 May 1976

PAYLOAD NUMBER	VEHICLE PERFORMANCE	PAYLOAD OPERATION	SCIENTIFIC DATA	RECOVERY (IF APPLICABLE)
A18.006-2	Success	Success	Success	Success
A03.911-1	Success	Partial	Not useful	Success
A09.210-1	Success	Success	Success	N/A
A09.210-2	Success	Success	Success	N/A
A16.000-1	Success	Success	Success	N/A
A09.214-1	Success	Success	Not useful	N/A
A09.107-4	Success	Failure	Not useful	N/A
A18.006-4a	Success	Success	Success	Success
A09.303-3	Success	Success	Success	Success
A09.303-1	Success	Success	Success	N/A
A09.303-2	Success	Success	Success	N/A
A09.303-4	Success	Success	Success	Success
A09.213-2	Success	Failure	Not useful	N/A
A09.001-3	Failure	---	---	N/A
A09.001-4	Failure	Partial	Not useful	N/A
A09.214-2	Success	Success	Success	N/A
A10.213-1	Success	Success	Success	N/A
A10.403-1	Success	Success	Success	Success
A10.403-2	Success	Success	Success	Success
A10.403-3	Success	Success	Success	N/A
A10.304-1	Success	Success	Success	Success
A10.304-2	Success	Success	Success	Success
A10.402-2	Success	Success	Success	N/A
HIRIS	Success	Success	Partial	Success
A10.001-2	Failure	----	----	----
A10.403-4	Success	Success	Success	Success

2.0 PAYLOADS

Included in this section are payload descriptions, unique payload testing programs, and launch data for individual payloads.

2.1 A18.006-2 and A18.006-4a Payload Descriptions

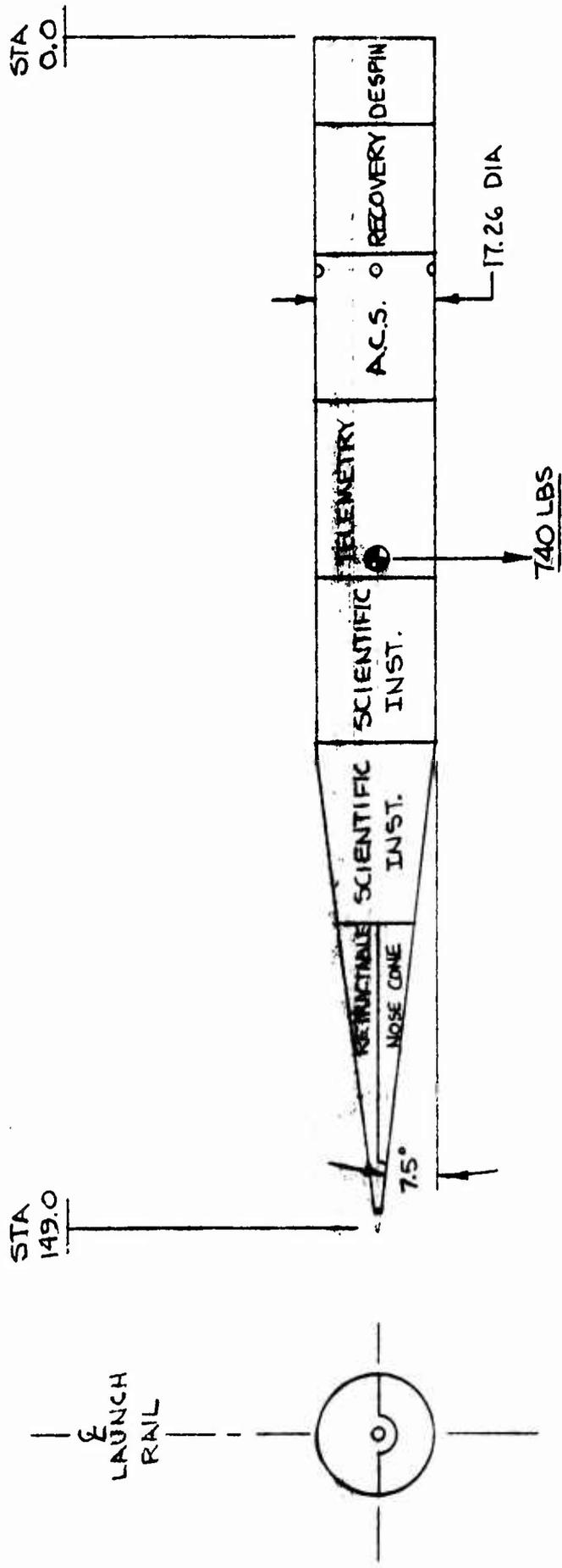
Payloads A18.006-2 and A18.006-4a were designed to carry one circular variable filter spectrometer (CVF), one forward looking photometer, and one dust detector system. The launch vehicle for these payloads was a Bristol Black Brant 5C. The total payload included a three-axis altitude control system (ACS), and a recovery and despin system.

Payloads A18.006-2 and A18.006-4a were designed by Northeastern University to have recyclable nose tips - i.e., the nose tip opens after burnout and closes prior to recovery. The entire payload, except for the nose tip, was designed to be "dust tight" with each joint sealed. This configuration also applies to payload A18.006-5, which was successfully flown on 5 Dec. 1972 (Reference 3).

The recyclable nose tip design consisted of a split tip deployed by a single ball bearing screw actuator driven by an electric motor. The nose tip halves are deployed so that the CVF has an unobstructed 180 degree field of view. The nose tip was designed to operate under a condition of 1 g and a 1 rps (60 rpm) spin rate, with an opening time of about three seconds at zero spin rate. Figure 2.1 of this report is a configuration drawing of the complete A18.006-2 payload.

2.1.1 A18.006-2 Launch Data

Payload A18.006-2 was successfully launched, as part of "Ice Cap '73", from the Poker Flat Research Range, Alaska, on 22 March 1973, into a



PAYLOAD NO. A18.006-2

(FIGURE 2.1)

steady 10 kilo-Rayleigh aurora. Data evaluation indicated that all systems functioned normally through most of the flight. An apparent program timer failure caused the nose tip to remain open during re-entry and recovery, which did not provide the final orientation signal for the ACS. Post flight acceleration checks of the recovered timer circuit components and an analysis of the telemetry flight data confirmed the failure of the down leg timer.

Experimental data for the entire flight of payload A18.006-2 was obtained from the dust detector system, the photometer, and the CVF, which functioned beyond all the scientists' expectations. Although the nose tip did not recycle properly during the down leg portion of the flight, this malfunction permitted useful data to be gathered by the instrumentation to a much lower altitude than would have been possible with a properly functioning nose tip. For further information regarding payload A18.006-2 see References 3, 4, 6, and 7.

2.1.2 A18.006-4a Payload Modifications

A18.006-4a was a refurbished version of payload A18.006-5 (Reference 3) and payload A18.006-2. Structurally the only new parts manufactured for A18.006-4a were the split nose halves, the recovered ones being unusable. Parts utilized from A18.006-5 included the main forward nose section which houses the experiment, experiment electronics and the tip actuating mechanisms. Payload A18.006-2 yielded the entire telemetry-support section and the ACS. Because of a larger capacity, a new recovery-despin system was obtained from Bristol Aerospace Limited. A modification which was incorporated in payload A18.006-4a

to assure the functioning of the down leg timer (Section 2.1.1), utilized an external acceleration switch to provide a bypass of the program timer internal holding circuit.

2.1.3 A18.006-4a Launch Data

On 13 February 1974, payload A18.006-4a was successfully launched from the Poker Flat Research Range as part of "Ice Cap '74". Recovery of the payload was accomplished on 15 February 1974. Flight records indicated that all systems functioned properly throughout the flight and that useful scientific data was received from the experimentation. Additional information regarding payload A18.006-4a can be found in References 4, 6, 7, 8 and 9.

2.2 A03.911-1 Payload Description

This recoverable Aerobee 150 payload consisted of a single experiment - a spectograph designed to determine the amount of free oxygen existing in the atmosphere at different altitudes. The spectograph consisted of a light source powered by a high voltage supply, a mirror, a slit, a grating, and a ten-exposure film cassette. Payload A03.911-1 was designed to have a forward ejecting nose tip, exposing the light source-to-mirror-to-slit portion of the experiment. The nose tip was retained by a marmon clamp manacle ring, which was released using a squib bellows actuated piston. A single compression spring was utilized to impart a separation velocity of about 10 feet per second to the nose tip. The slit-to-grating-to-film cassette section of the experiment was exposed by ejecting one half of the cylindrical portion of the

payload. The other half of the payload cylindrical portion housed the high voltage supply for the light source, support electronics and batteries, as well as the telemetry equipment.

2.2.1 A03.911-1 Launch Data

On 27 April 1973, payload A09.311-1 was successfully launched at the White Sands Missile Range in New Mexico. All systems functioned properly up to approximately 30 seconds into the flight, at which time the high voltage failed. This was determined through the telemetry readout of the photocell monitor on the experiment light source. As a result of this failure, no useful data was obtained from the flight. On 28 April 1973, payload A03.911-1 was recovered and found to be in fairly good physical condition - i.e., the mirror was unbroken, although the tripod supporting it was crumpled, and the spectograph was intact. Examination of the support section revealed heat damage to the high voltage leads, to coils, and wire in the low voltage circuit. All recovered components functioned in a post flight check when the damaged wires were replaced, indicating that the failure of the high voltage system was due to arcing in the high voltage cable. The reason for the arcing during flight has not been established, but one possible explanation is the pressurizing of the entire high voltage system. Further information regarding payload A03.911-1 can be found in References 3, 4 and 6.

2.3 A09.107-4, A09.213-2, A09.213-1 (A10.213-1). Payload Descriptions

Payloads A09.107-4, A09.213-2 and A09.213-1 were all designed to carry forward-looking helium-cooled neutral mass spectrometers as their

primary experiments. Because of the high spin rate expected for these Ute-Tomahawk payloads, they were designed to have a forward-ejecting nose cone, rather than the clam shell split tips usually flown on mass spectrometer payloads. The forward-ejecting nose cone was designed to be held in place prior to ejection with a marmon clamp manacle ring located forward on the cylinder, immediately aft of the cone to cylinder transition. In order to achieve an exposure of the top of the mass spectrometer and the removal and retention of the mass spectrometer seal cap, the manacle ring was designed to be released by a bellows actuated piston located forward of the plane of the manacle ring. Eight die cast compression springs, located equi-angularly at the plane of separation, were used to impart a separation velocity to the nose cone of about eleven feet per second.

2.3.1 A09.107-4 Launch Data

The launch of payload A09.107-4 occurred at the Churchill Research Range of 10 December 1973. No useful data was obtained from the flight. Monitors indicated an earlier-than-programmed nose tip separation at about the time of second stage burnout - i.e., T+26 seconds. From the data available it was not possible to firmly establish the cause of this failure. Additional data regarding payload A09.107-4 can be found in References 3, 4, 6 and 8.

2.3.2 A09.213-2, A09.213-1 Tip Tests

Because of the failure of A09.107-4, extensive structural and ejection tests were performed on the A09.213-2, -1 manacle ring assemblies prior

to shipment to Wallops Island. A complete nose tip assembly was subjected to bend tests, followed by a shake test. The bend test consisted of applying a 65,000 in-lb moment to the manacle ring separation plane in each quadrant successively - i.e., the moment was applied four times, at ninety degree increments. No structural deformation or failure was detected after the bend tests. The assembly was then subjected to shake tests, consisting of 60 seconds of 5g sine, 20 to 20 kHz at 2 octaves per minute. The manacle ring was then successfully deployed. The reassembled nose cone, with the forward separation springs removed to simulate a no-load condition, was spin tested to a level of 8 rpm (480 rps). The manacle ring did not malfunction.

2.3.3 A09.213-2 Launch Data

Payloads A09.213-2 and A09.213-1 (A10.213-1), as well as payloads A09.001-3 and A09.001-4 (Section 2.7), were scheduled to be part of program "ALADDIN '74". The acronym ALADDIN stands for Atmospheric Layering And Density Distribution of Ions and Neutrals.

On 29 June 1974, payload A09.213-2 was launched from Wallops Island, Virginia. No useful neutral mass spectrometer data was retrieved due to the apparent premature removal of the nose tip at approximately T+28 seconds. This time corresponds to second-stage burn-out, but accelerometer data indicated no abnormalities at this time. Further information regarding payload A09.213-2 can be found in references 4, 8 and 9.

2.3.4 A10.213-1 (A09.213-1) Payload Modifications

Payload A10.213-1 (initially designated A09.213-1) was designed with a configuration "D" helium pumped mass spectrometer as its primary experiment, and two self-contained piggy-back experiments. One piggy-back experiment was an "E field" package from the University of London. The other self-contained package was a photometer from AFGL. Originally this payload was designed to use a forward-ejecting nose tip identical to the one flown on A09.213-2. The payload was restructured to utilize a standard 9-inch diameter clam shell nose tip. The launch vehicle was also changed from a Ute-Tomahawk to a Paiute-Tomahawk, hence the designation change from A09.213-1.

2.3.5 A10.213-1 Launch Data

A10.213-1 was successfully launched on 17 January 1975, at Wallops Island at 1835 hrs. EST. The primary experiment and all support instrumentation functioned as programmed. However, no useful data was obtained from either of the self-contained piggy-back experiments. Additional information regarding payload A10.213-1 (A09.213-1) can be found in References 4, 8, 9, 11, 12 and 13.

2.4 A09.214-1 and A09.214-2 Payload Descriptions

Payloads A09.214-1 and -2 were designed to carry out an experiment in vehicle potential stabilization, using Ute-Tomahawks as the launch vehicles. The experimentation carried on both payloads were an electron emission system, two thermal emission probes, two Langmuir probes, and two skin probes. These payloads were designed with a forward-ejecting

nose cone section which was retained by a marmon clamp manacle ring similar to that used on payloads A03.911-1, A09.107-4, and A09.213-1, except that the ring was located about one diameter aft of the cone to cylinder transition. The manacle ring was released by a bellows-actuated piston system similar to the one used on payload A03.911-1 - i.e., the piston was located on the separation plane which was aft of the cone-cylinder junction. A separation velocity of about 10 feet per second was delivered to the nose cone section by a single compression spring.

2.4.1 A09.214-1 Launch Data

A successful launch of payload A09.214-1 occurred on 11 September 1973, at the White Sands Missile Range, New Mexico. As the flight progressed, it was noted that the program timers were running, the Langmuir probes had deployed and the nose cone section was ejected; but the primary experiment was not functioning. Post flight examination of the telemetry data indicated a normal flight and proper operation of the support instrumentation and all mechanical functions. Signals from the experiment channels became erratic 28 seconds after launch and did not recover. The reasons for the failure were never established. References 3, 4, 6, 7 and 8 present additional information regarding payload A09.214-1.

2.4.2 A09.214-2 Payload Modifications

The major differences between A09.214-1 and A09.214-2 existed only in the experimental instrumentation. The -2 payload utilized a new experiment battery box fabricated out of G-10 fibre glass and skin current probes with a surface area an order of magnitude larger than that used on the A09.214-1 payload.

2.4.3 A09.214-2 Launch Data

A successful launch of payload A09.214-2 was accomplished at the White Sands Missile Range on 16 August 1974, at 2200 hrs. local time. During the launch the aft skin current probe failed to operate, but all other payload systems functioned normally, and useful data was obtained. The main experiment functioned throughout the flight. The thermal emission probes worked, making this the first successful flight for this particular experiment. Further information is available on payload A09.214-2 in References 3, 4, 5, 6, 7, 8, 10 and 11.

2.5 A09.210-1 and A09.210-2 Payload Description

The primary experiment carried by these two Ute-Tomahawk payloads was an ion mass spectrometer. In addition, payloads A09.210-1 and -2 were designed to carry a scintillation counter mounted at a look-angle of 30 degrees to the horizon, and a plasma frequency probe (PFP) as secondary experiments.

All joints of previous mass spectrometer payloads were of lap-butt design, often allowing large gaps to exist in the joint area.

A09.210-1 and -2 were the first Northeastern University designed payloads to have tension joints. An investigation of electron beam welding of coupling rings to machined skins was accomplished. The results indicated that this process was acceptable structurally and financially. Utilizing the technique of electron beam welding enabled Northeastern University to eliminate post welding heat-treating and machining of the skins and coupling rings.

2.5.1 A09.210-1 Launch Data

Payload A09.210-1 was assigned to carry a positive mass spectrometer as its primary experiment.

On 12 June 1973, payload A09.210-1 was successfully launched from the Churchill Research Range, Manitoba, Canada. All systems, except for the plasma frequency probe, performed as expected. Post flight examination of the telemetry records revealed that the PFP had not latched into its erected position. At the proper programmed time for probe deployment, a current surge was detected by the on-board magnetometer. This current surge is an indication that the PFP door guillotine was fired. Because the plasma frequency probe did deploy during the down leg portion of A09.210-1's flight, it was hypothesized that thermal expansion during ascent caused the PFP door to hang up.

2.5.2 A09.210-2 Launch Data

Payload A09.210-2, carrying a negative ion mass spectrometer, was successfully launched on 13 June 1973. The PFP door and skin were modified prior to launch to give an additional 0.12 inch clearance at the leading edge of the door. All systems performed properly. References 3, 4, 6 and 7 give additional information regarding payloads A09.210-1 and -2.

2.6 A07.212-1 through -4 Payload Descriptions

Work on these four NIRO payloads began, at a very low priority level, in December 1971, under Contract No. F19628-70-C-0194. Payloads A07.212-1 and -2 were scheduled to carry positive mass spectrometers and Langmuir

probes. A07.212-3 and -4 were scheduled to carry negative ion mass spectrometers. Support racks and skins for these four payloads were fabricated and almost completely wired when it was decided to facilitate the preparation of payloads A09.001-3 and -4 and A09.303-3 and -4. The greater scientific priority of these latter payloads and structural similarity to A07.212-1 through -4, dictated this change.

The A07.212 support racks were assigned as follows:

A07.212-1 to A09.001-3,

A07.212-2 to A09.001-4,

A07.212-3 to A09.303-3,

A07.212-4 to A09.303-4.

Additional information concerning payloads A07.212-1 through -4 can be found in References 3, 6, 7 and 8.

2.7 A09.303-1 and A09.303-2 Payload Descriptions

Payloads A09.303-1 through -4 were assigned to be part of the Auroral Ionosphere Program to be conducted at the Churchill Research Range, Manitoba, Canada.

A09.303-1 and -2 were designed to carry unpumped switched ion-neutral mass spectrometers, "E" configuration, as their primary experiments. Other instrumentation carried by these payloads included a scintillation counter and plasma frequency probes. The launch vehicle used was the Ute-Tomahawk. Both of these payloads utilized standard ejectable 9-inch diameter clam shell nose tips to be ejected at a zero spin rate. The design of these payloads was similar to payloads A09.210-1 and -2, successfully flown in June 1973 (reference Section 2.5).

2.7.1 A09.303-1 Launch Data

On 2 April 1974, payload A09.303-1 was successfully launched at 21:46:55 CST. The payload performed as designed, except for the PFP which did not latch into position. However, worthwhile data was obtained from the plasma frequency probe during the flight of A09.303-1.

2.7.2 A09.303-2 Launch Data

A09.303-2 was successfully launched at 23:20:36 CST on 8 April 1974. All systems of payload A09.303-2, including the PFP, performed as designed. References 4, 8, 9 and 10 present additional information regarding payloads A09.303-1 and -2.

2.8 A09.303-3 and A09.303-4 Payload Descriptions

These two recoverable Ute-Tomahawk payloads were designed with the standard ejectable 9-inch clam shell nose tips. The primary experiments assigned to these payloads were nitrogen pumped, positive and negative ion, configuration "A" mass spectrometers. Each payload also carried Langmuir probes.

2.8.1 A09.303-3 Launch Data

On 27 March 1974, at 10:05:50 CST, payload A09.303-3 was successfully launched at the Churchill Research Range, Manitoba, Canada. All payload systems performed as designed during the flight. Payload A09.303-3 was recovered in good condition on 28 March 1974.

2.8.2 A09.303-4 Launch Data

Payload A09.303-4 was successfully launched at 13:18:00 CST on 2 April 1974. All payload systems performed as designed during the flight, with the payload being successfully recovered the same day. Additional information regarding payloads A09.303-3 and -4 are presented in References 4, 5, 8, 9 and 10.

2.9 A09.001-3 and A09.001-4 Payload Descriptions

Nitrogen pumped positive ion mass spectrometers, configuration "A", were the primary experiments carried by these two Ute-Tomahawk payloads. Payloads A09.001-3 and -4 were constructed to be part of "ALADDIN '74". Program "ALADDIN'74" was conducted at Wallops Island on 29-30 June 1974. Each payload carried Langmuir probes as their secondary experiments. These payloads incorporated the standard 9-inch clam shell ejectable nose tips successfully flown on previous payloads. (reference Sections 2.5 and 2.7).

2.9.1 A09.001-3 Launch Data

Payload A09.001-3 was launched on 29 June 1974, and all payload systems functioned properly. However, the second-stage motor, the Tomahawk, did not ignite. The low apogee attained by the payload due to launch vehicle failure precluded the collection of any useful data.

2.9.2 A09.001-4 Launch Data

This payload was launched on 30 June 1974. The accelerometer record from this flight indicated an unusually sharp drop-off in acceleration

at second stage burn-out. It was later determined that the rocket motor exploded causing catastrophic failure of most systems and no useful data was obtained. References 4, 5, 8, 9 and 10 present additional pertaining to payloads A09.001-3 and -4.

2.10 A10.403-1, A10.403-2 and A10.403-3 Payload Descriptions

These three Paiute-Tomahawk payloads were designed to be part of "Exercise Paradise AEOLUS". The acronym AEOLUS stands for Auroral Excitation of Oscillation and Layering of the Underlying Species. "Exercise Paradise AEOLUS" was conducted at the Churchill Research Range, Manitoba, Canada, during April 1975.

Each of the payloads was designed to carry configuration "E" unpumped mass spectrometers as their primary experiment. Secondary experiments on each payload were a scintillation counter and a plasma frequency probe. The payloads were equipped with the standard 9-inch ejectable clam shell nose tips. The nose tips were scheduled to be ejected after second-stage burnout, and the payload was de-spun to 0 - 1/2 revolutions per second (0 - 30 rpm).

Payloads A10.403-1 and -2 were designed to be recovered. Payload A10.403-3 was constructed to carry a self-contained piggy-back package designed to conduct an electric field experiment.

All three payloads were designed to utilize a solid state program timer (Section 3.1) as the primary timer, with an electro-mechanical timer (made by Datametric) as the back up.

2.10.1 A10.403-1 Launch Data

Payload A10.403-1 was successfully launched on 20 April 1975. All systems performed as designed, and the payload was successfully recovered.

2.10.2 A10.403-2 Launch Data

On 24 April 1975, payload A10.403-2 was successfully launched, with all systems performing as expected. Payload A10.403-2 was successfully recovered.

2.10.3 A10.403-3 Launch Data

Payload A10.403-3 was successfully launched on 10 April 1975. All systems performed properly, although the payload was only de-spun to a spin rate of 1 1/2 rps (90 rpm) instead of the expected 0-1/2 rps. Additional information regarding payloads A10.403-1 through -3 can be found in References 5, 11, 12 and 13.

2.11 A16.000-1 Payload Description

Payload A16.000-1 was a diagnostic round launched by a Black Brant 4B booster. Included in this payload was an angle-of-attack gauge designed by AFGL and fabricated by Northeastern University. In addition to the boost vehicle test, this launch provided a flight evaluation of several new payload components, e.g., a timer, commutator, and a 10-bit resolver used in conjunction with the MIDAS gyro platform.

2.11.1 A16.000-1 Launch Data

A successful launch of payload A16.000-1 occurred on 9 August 1973, from Wallops Island, Virginia. The vehicle performance was as predicted, and all payload components functioned properly. References 4, 6 and 7 present additional information regarding payload A16.000-1.

2.12 A16.313-1 and A16.313-2 Payload Descriptions

These two Black Brant 4A payloads were essentially identical in design to payload A16.010-4, which was designed and fabricated by Northeastern University under contracts F19628-67-C-0223 and F19628-70-0194. These payloads were designed to carry an experiment intended to measure the propagation of very low frequency (VLF) transmissions through the ionosphere. The experiment consists of an antenna housed in a fibreglass nose cone and associated electronics.

Fabrication of these payloads was completed by Northeastern University's contractors during August 1973. The complete payload structure was delivered to the experimenter's contractor (Aerospace Research, Inc. of Brighton, MA) on 20 August 1973. Northeastern University provided no launch support for these payloads. Additional information regarding payloads A16.313-1 and -2 as well as their predecessor A16.010-4 can be found in References 3, 4, 6 and 7.

2.13 A09.312-4 and A09.312-5 Telemetry Sections

Northeastern University was assigned the mechanical design, packaging, and fabrication of telemetry sections for Ute-Tomahawk payloads

A09.312-4 and A09.312-5. These sections include rack structures for component mounting, external skin sections, and the forward and aft coupling rings.

Fabrication was completed, and the telemetry sections were delivered in August 1973. No launch support was provided for these payloads. References 4, 6 and 7 present further information regarding these payloads.

2.14 A10.304-1 and A10.304-2 Payload Description

Payloads A10.304-1 and A10.304-2 are designed to carry neutral mass spectrometers. These two recoverable Paiute-Tomahawk payloads consist of a standard 9-inch ejectable clam shell nose tip and a 9-inch diameter mass spectrometer section. The support instrumentation, telemetry, and attitude control sections are 12 inches in diameter. A ballast section enables the addition of from 30 to 100 pounds to achieve the desired trajectory.

System design allows for interchanging electro-mechanical program timers to solid state timers in future flights of these payloads. The model 50 timer (reference Section 3.1 of this report) was being evaluated at the time of A10.304-1 and -2 design. The electrical harness also provides an interface for additional experiment packages at a later date. The scientific objective of this program is the study of mid-latitude composition by launches 3 hours before sunset and 3 hours after sunset at White Sands Missile Range.

2.14.1 A10.304-1 Launch Data

Payload A10.304-1 was launched on 18 September 1975, at 1400 hours, from White Sands Missile Range, New Mexico. The vehicle and all payload systems functioned normally, and good data was received. A10.304-1 was recovered on 18 September in good condition. Ballast was added to attain the required 418-pound payload weight.

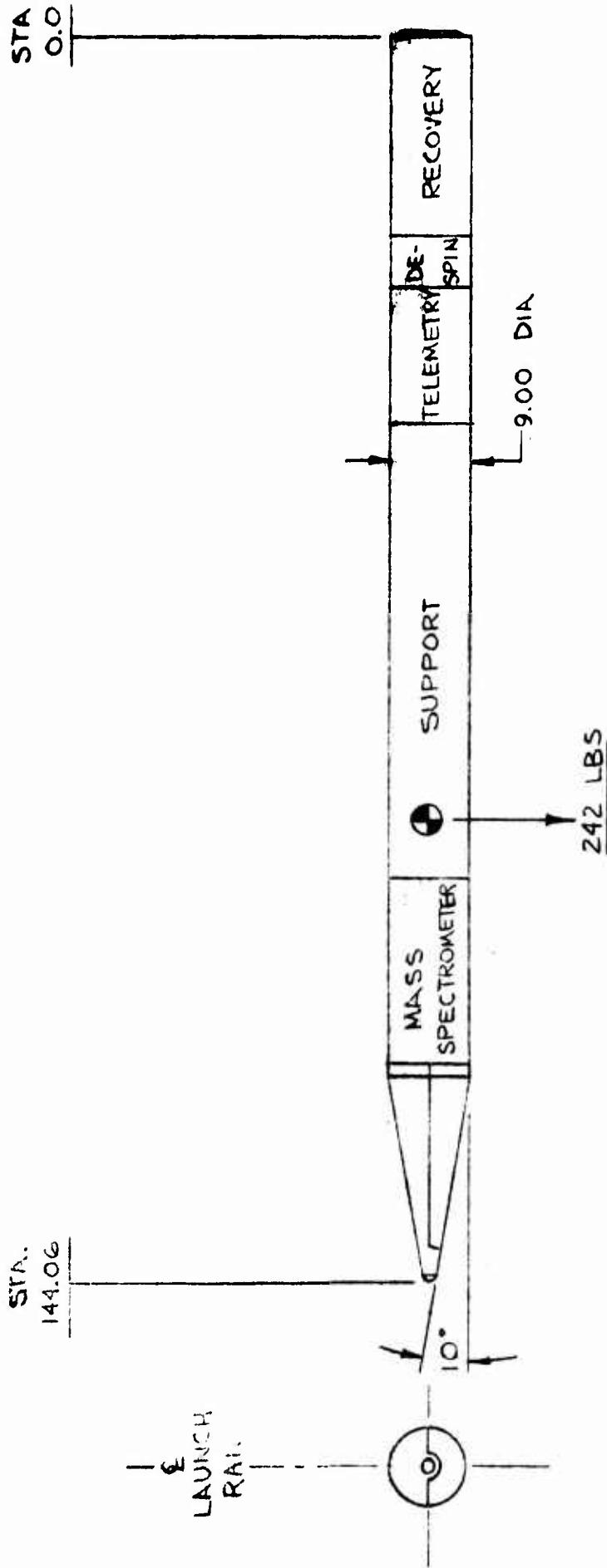
2.14.2 A10.304-2 Launch Data

A successful launch of payload A10.304-2 occurred on 18 September 1975 at 2000 hours from White Sands Missile Range. This payload was also ballasted to 418 pounds and was recovered in good condition on 19 September. References 5, 11, 12, 13, 15, 16 and 17 present additional information regarding payloads A10.304-1 and A10.304-2.

2.15 A10.001-2 and A10.403-4 Payload Descriptions

Payloads A10.001-2 and A10.403-4 are refurbished form the recovered payloads A10.403-1 and A10.403-2. The original payloads were launched and recovered from Churchill Research Range during April 1975, and are discussed in Section 2.10 of this report.

A configuration 'E' unpumped mass spectrometer was the prime experiment on these payloads. Plasma frequency probes and a scintillation counter were also included in this 9" diameter package. The recovery packages were also refurbished for use with A10.001-2 and A10.403-4. Figure 2.2 is a configuration drawing of payload A10.403-4. The configuration is typical of many of the mass spectrometer payloads discussed in this report.



PAYLOAD NO. A10.403-4

(FIGURE 2.2)

Refurbishing payloads requires replacement of batteries and hardware components (i.e., ejection systems, nose cones, mass spectrometer cap systems, etc.) normally expended in flight. In addition, the recovered structure and all components are checked.

The scientific goal of this program is to launch one payload into an auroral event and the second during quiet upper atmospheric conditions for polar dynamic measurements.

2.15.1 A10.001-2 Launch Data

Payload A10.001-2 was launched on 26 April 1976, at 0047 hours CDT, from Churchill Research Range, into an auroral event. The second stage of the Paiute-Tomahawk failed to ignite, and no useful data was obtained.

2.15.2 A10.403-4 Launch Data

Due to the failure of A10.001-2, it was necessary to launch A10.403-4 into an auroral event. This launch occurred on 29 April 1976, at 2335 hours, and all systems functioned properly.

Payload A10.403-4 was recovered on 1 May 1976, in good condition. References 16, 17 and 18 present additional information pertaining to payloads A10.001-2 and A10.403-4.

2.16 HIRIS Payload Description

The high resolution interferometer spectrometer (HIRIS) instrument is the prime experiment on this payload. The ejectable nose cone section, forward of the service module, houses the HIRIS instrument and the 3914 Angstrom photometer. The service module section includes payload support electronics, telemetry system and vehicle diagnostic instrumentation.

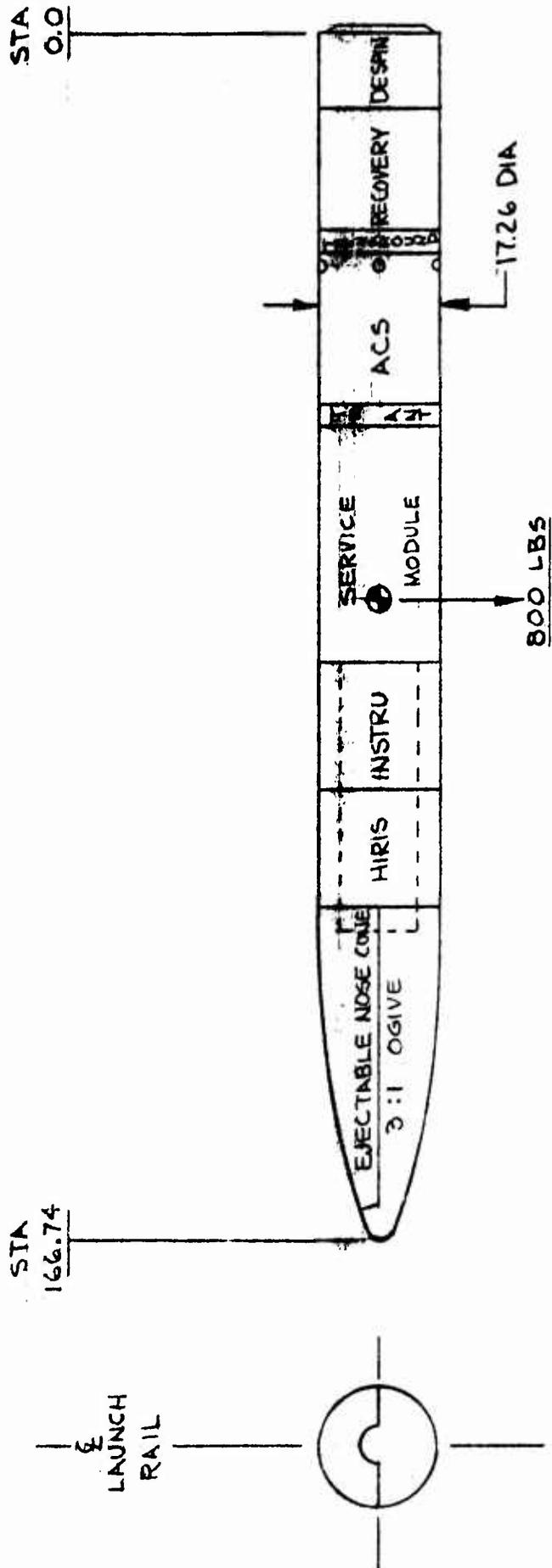
Aft of the service module are an attitude control system, a payload inverter/recovery system and a payload despin module. Figure 2.3 of this report is a configuration drawing of the entire HIRIS payload. The scientific objective of this payload is to develop a high resolution longwave infrared spectral instrument to support the "High Altitude Effects Simulation" (HAES) program. A single-stage Sergeant is the boost vehicle for this 800 lb. payload.

2.16.1 HIRIS Launch Data

The HIRIS payload was launched from Poker Flat Research Range on 31 March 1976, at 1005 hours. All payload systems, except the attitude control system, functioned as predicted, and data was received. The function of the attitude control system is to orient the payload after burn-out of the boost vehicle.

At approximately T+80 seconds the payload began a controlled tumble in the pitch plane after having attained the desired vertical position. A steady pitch rate of approximately 11 degrees/second continued throughout the data portion of the flight. Useful data was obtained, but the extent of degradation due to the tumble has not yet been determined.

The HIRIS payload was recovered in good condition on 1 April 1976, and returned to the launch complex. Post-flight tests were then conducted, and all systems functioned normally. The reason for the attitude control failure was not determined. References 16, 17 and 18 present additional information regarding the HIRIS payload.



PAYLOAD HIRIS

(FIGURE 2.3)

2.17 A10.402-1 and A10.402-2 Payload Description

Recovered payloads A10.304-1 and A10.304-2 were refurbished and designated A10.402-1 and A10.402-2. The original payloads were launched from White Sands Missile Range during September 1975, and are discussed in Section 2.14 of this report.

In addition to the normal refurbishing procedure (Section 2.15) modifications were made to the aft interface to delete the attitude control system and add a MIDAS gyro platform to the telemetry section. The overall configuration — Paiute-Tomahawk launch vehicle, neutral mass spectrometer, 9-inch ejectable clamshell, and 12-inch diameter support sections — remained the same as A10.304-1 and -2.

2.17.1 A10.402-2 Launch Data

Payload A10.402-2 was successfully launched from Wallops Island on 23 January 1976. This payload was one of a series in the "Winter Anomaly" program. The program objective was to launch two similar series of payloads, one series into anomalous conditions, and a second series during normal atmospheric conditions. The series of payloads, including A10.402-2, were launched into normal conditions.

2.17.2 A10.402-1 Status

Payload A10.402-1 was prepared for launch at Wallops Island during the January 1976, "Winter Anomaly" program. Satisfactory anomalous conditions did not occur, and the second series of launches was cancelled. Payload A10.402-1 is presently at Northeastern University

and tentatively scheduled for launch during the second quarter of 1977. Additional information regarding payloads A10.402-1 and A10.402-2 can be found in References 11 and 12.

3.0 FLIGHT COMPONENTS

Most design efforts on Contract No. AF19628-C-73-0152 are directly applicable to specific rocket payloads and are discussed in Section 2. The two projects in this section—program timers and retained split tip—are defined as flight components, since they are not directly related to a specific payload.

3.1 Payload Timers

Procurement and engineering problems with the electro-mechanical program timers, used as part of the support instrumentation of sounding rocket payloads, led to an investigation of alternatives. The purchased units used in all recent payloads are no longer available, and an adequate replacement could not be found. Specifications were defined, and development of a solid state program timer was begun under the present contract during the third quarter of 1974.

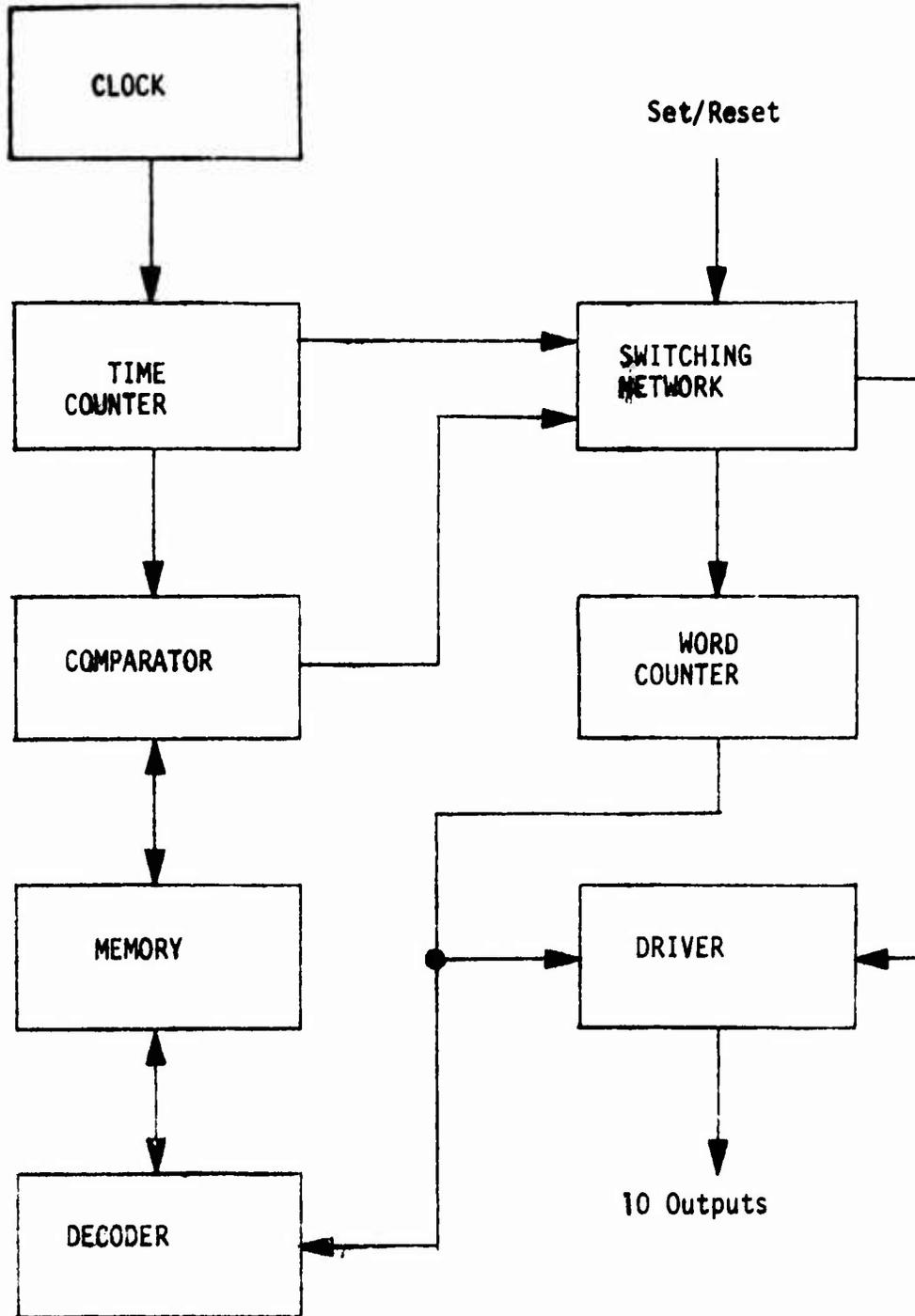
3.1.1 Timer Operation

Table 3.1 presents specifications for the Model 50 program timer which meets or exceeds all the design requirements initially established. As indicated, this timer provides ten discrete outputs 0.4 second increments, with a total timing capability of up to 1.6 seconds. The memory is an electrically alterable, non-volatile, 256-bit array. Clocking is accomplished with a 20,480 Hz oscillator which drives binary counters. Magnitude comparators trigger relay drives when binary counter data and programmed memory data are bit-for-bit compatible. Figure 3.1 is a functional block diagram of the timer.

TABLE 3-1
SPECIFICATIONS
PROGRAM TIMER - MODEL 50

Timing Capability:	0 to 1,638 seconds.
Timing Increment:	0.4 seconds (program panel is in 0.1 second increments for ease of programming.)
Timing Outputs:	10 discrete outputs are available.
Programming:	A program panel is required for setting times through an interface connector on the package.
Relay Control Signals:	28 VDC at 0.5 amps for 12.5 ms (signals are provided to relays external to the timers package).
Input Power:	28 VDC + OR - 4 VDC.
Power Interrupt:	Power loss of up to 50 seconds will cause only a loss of time equal to the time of interruption.
Initiation:	No internal actuation is provided.
Reset Provision:	Grounding of reset line, provided at interface connector, will reset the timers.
Package Size:	7 in. X 3 in X 1 1/2 in.
Package Description:	A single wire wrap board with plug in DIP components and two interface connectors on 7 in side, 3/8 in wide mounting flanges provided on 7 in side.
Interface Connectors:	DBM-25 connectors. One connector provides payload interfacing the other is for programming.
Operating Temperature:	-40°C to +70°C .
Vibration:	40G for 20 to 20,000 Hz on 3 axis.
Shock:	150G for 6ms on 3 axis.
Options:	Alternatives to the timing capabilities, timing increments, and number of outputs can be attained in the standard package.

FIGURE 3.1
BLOCK DIAGRAM
PROGRAM TIMER - MODEL 50



3.1.2 Timer evaluation

A prototype timer was completed in the fourth quarter of 1974 and tested to the specifications defined in Table 3.1. Minor modifications were made to the circuit, and a final package was designed.

Six timers were fabricated during 1975. Three were packaged in payloads A10.403-1, A10.403-2, and A10.403-3 (reference Section 2.10) and evaluated during pre-launch integration and environmental checks. The three units then functioned as the primary flight program timers during the successful flight of these three payloads in April 1975. To date 6 units have performed successfully during launches, and 4 recovered units have been refurbished for future use.

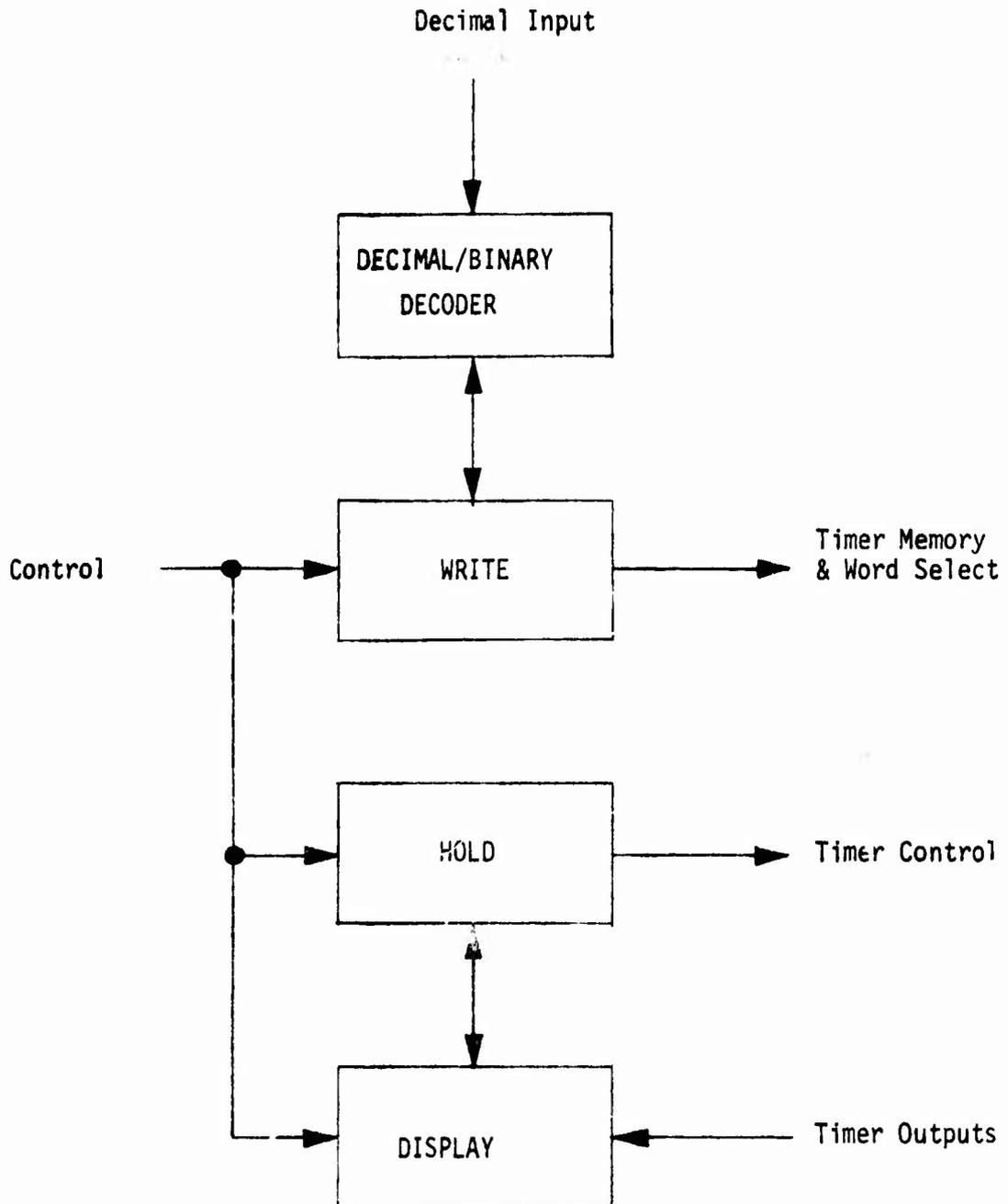
3.1.3 Timer Programmer

An external programmer, required for setting the Model 50 timer, was designed and fabricated during the fourth quarter of 1974. The programmer consists of control circuits, a decimal-to-binary decoder circuit, a write circuit, a hold circuit, and a display circuit. Figure 3.2 is a functional block diagram of the timer programmer. Scientific Report No. 3 of this contract (Reference 14) presents a complete summary of the design and development of the Model 50 program timer. Additional information is included in References 5, 11, 12, 13 and 15.

3.2 Split Tip

During the third quarter of 1974, Northeastern University was assigned the responsibility of designing a split nose cone (clam shell type) in

FIGURE 3.2
BLOCK DIAGRAM
TIMER PROGRAMMER



which the split halves are retained after deployment. The design constraints imposed were as follows:

- a) External payload diameter of 17 inches,
- b) The experiment instrument to have an external diameter of 15 inches,
- c) The experiment instrument would be forward looking and to have an unobstructed 180 degree field of view when in operation,
- d) The payload would have a roll rate of zero at time of tip deployment,
- e) The nose tip halves are to be retained after deployment.

The capability of closing the tips prior to reentry was to be an option of the design and not a requirement.

Several designs were considered and preliminary layouts completed. A concept employing a ball bearing screw assembly driven by an electric motor was most practical. This is similar to the mechanism used successfully by Northeastern University on payloads A18.006-2, -4, and -4a. (Section 2.1 and Reference 3) Both open and close cycles can be provided.

The disadvantage of the original system (A18.006-2) is that the drive mechanism was located in the center of the 17-inch payload, along the longitudinal axis. Modifications overcame this problem by providing a bubble on the side of the payload to accommodate the drive mechanism. This concept is feasible and will be developed further if a specific application is defined.

4.0 MULTI SPECTRAL MEASUREMENTS PROGRAM (MSMP)

A single stage Aries vehicle will boost the MSMP payload, which consists of a sensor module and a target engine module. At approximately 90 km altitude the sensor module and the target engine module will be separated and individually controlled on different trajectories. Both attitude control systems will be pre-programmed and updated with an on-board tracking system.

After separation, the sensor module will be oriented such that the optical instruments will be pointed at the plume of the target engine as it proceeds through a number of burn during the course of its trajectory. Mission plans will be established to vary target engine burns and trajectories for each launch.

The program presently calls for launch and recovery of 3 Aries vehicles with similar payloads from White Sands Missile Range. A follow-on program for the recovered payloads, using a different launch vehicle, is anticipated.

4.1 MSMP Scientific Experiments

The scientific objective of MSMP is the measurement of infrared radiance and ultraviolet radiance from a 316 lb. thrust target engine.

A total of 11 scientific instruments will be included in the sensor module to measure the desired spectrum:

Infrared Sensors

1. Full Field Radiometer
2. Narrow Field Radiometer

3. Spatial Radiometer
4. Circular Variable Filter Spectrometer

Ultraviolet Sensors

1. High Sensitivity Photometer
2. Medium Sensitivity Photometer I
3. Medium Sensitivity Photometer II
4. Medium Sensitivity Photometer III
5. Vacuum Ultraviolet Spectrometer
6. Electrographic Camera I
7. Electrographic Camera II

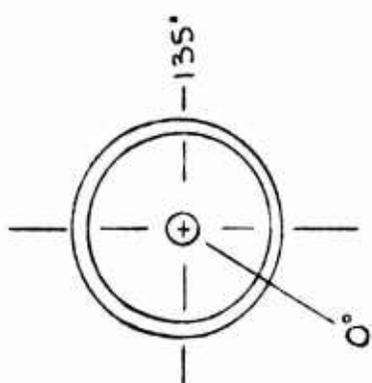
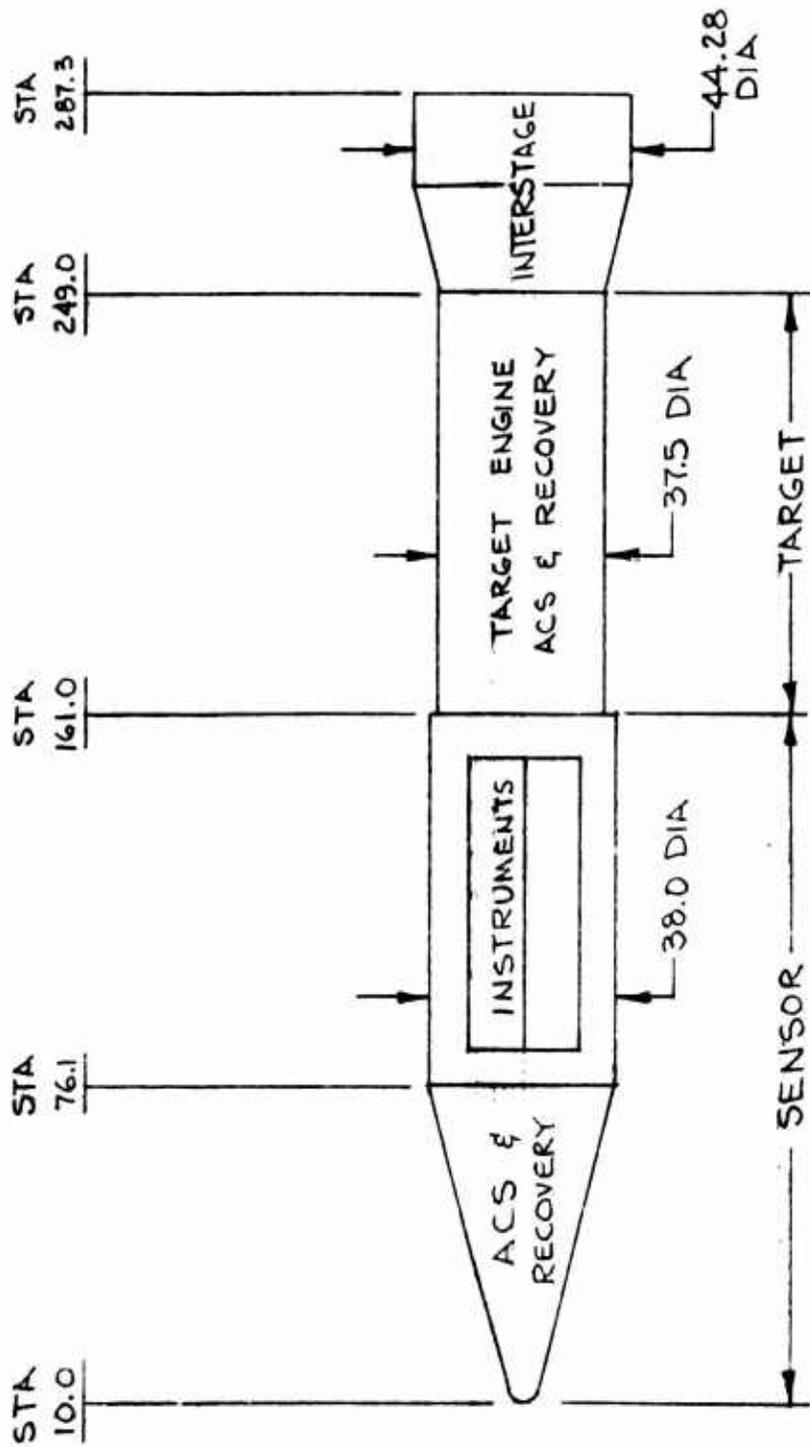
All instruments and related electronic packages have been packaged in the sensor module. Hard-mount O-ring clamping or soft-mount silicone rubber gaskets will be used at the dust shield to maintain the cleanliness level required for the sensors.

4.2 MSMP Sensor Module

Northeastern University is responsible for the electrical and mechanical integration of the sensor module, excluding the attitude control system and the recovery package. Figure 4.1 is a configuration drawing of the MSMP payload.

4.2.1 Sensor Module Structure

As indicated in Figure 4.1, the 38"-diameter sensor section will be approximately 85" long. Motor-driven doors are required to expose the sensors at altitude and protect instruments during boost and re-entry.



PAYLOAD MSMP
(FIGURE 4.1)

The basic structure consists of a dust shield for mounting the optical sensors, television camera, 35 mm camera, and tracker. This shield is located behind the doors. A perimeter and butting edge seal around the doors will maintain the necessary clean environment in the area between the dust shield and the doors. Back panels on the opposite side of the sensor module provide access for removal and electrical interfacing of the sensors, cameras, and trackers. Two structural side support plates are used to mount the beacon, telemetry components, diagnostic components, sequencer and power transfer system. Batteries are located on the forward and aft deck plates, as well as on side support plates. Access panels are also provided for components on the side plates.

4.2.2 Sensor Module Sequencer

All sensor module timing functions will be accomplished with a sequencer, consisting of a timer unit and a logic interface system.

4.2.2.1 Sequencer Logic

Relays in the sequencer logic system provide an interface between the timer unit and the required functions. For many functions a timer by-pass control line allows direct control of sequencer logic from the ground support console. This feature enables exercising and checkout of individual systems without requiring a complete flight sequence from the timer unit.

4.2.2.2 Sequencer Timer

Design of an electronic timer for the MSMP program has been completed. A prototype model of the timer is being constructed. Also, the design of a portable programmer to set the timer to the required event sequence has been finished. Construction of the programmer is nearing completion.

In the timer design reliability, timing sequence flexibility, power consumption, and size were given primary consideration in that order. The basic approach chosen for the timer was the one where a clock driven counter generates the time base. Event sequence control then is achieved by encoding the counter output and presenting it as a parallel binary word on the control lines. Failure to produce an appropriate code on the output lines at any given time may stem from a catastrophic failure of a component, from a broken connection or from a noise induced erroneous count presented to the encoder. The probability of a timer malfunction due to the first two failure modes may be reduced by simply connecting two such timers in the logic OR function. The noise induced failure can not be eliminated in this dual redundant system. Advanced count would produce an event command regardless of the status of the second timer. A system incorporating majority logic reduces the probability of such a failure. As was implied in the foregoing discussion, the place where a short duration noise may leave a long lasting effect is the counter section of the timer. Short duration pulses originating in the other parts of the system and consequently on the output lines would not be able to switch the electro-mechanical

relays used to control payload functions. Therefore, after consideration of the system complexity and the probability of a component failure, the majority logic approach was applied only to the counter section. In the design three counters were driven from three separate synchronized clock signals. The outputs of the counters were presented through majority gates to the encoder. The clock signals were derived from two crystal controlled oscillators combined through logic gates such that a single component failure could affect only one counter circuit. Erasable programmable read only memory (EPROM) was chosen as the encoding element. Ten address lines allow a selection of one of the 1024 eight bit words stored in the memory to appear on the output lines. Since more than 24 control lines may be required, four such EPROMs were incorporated in the design.

This design approach allows the timer commands to appear on the output lines regardless of any sequence. Repeated commands or commands longer than the basic timing interval are also possible. To add more flexibility to the system the smallest timing interval may be varied in binary steps from 250 msec to 32 seconds. This is accomplished by programming an EPROM with an appropriate code on three output lines set aside for that purpose. The ability of the timer to produce many short duration commands and then to slow down the clock rate during inactive periods extends the total timing interval of the device beyond that achievable with a single basic timing period.

To conserve power CMOS logic circuits were used in the design where possible. The four EPROMs under worse case conditions may consume over

13 watts of power from a 28 volt battery. This includes the conversion losses incurred while obtaining the required voltages. This power consumption may be reduced to less than two watts if switching of EPROM power is employed. Every time the counter circuits change the memory address, power to the EPROM is applied for approximately 100 microseconds. Allowing approximately 30 microseconds of settling time, a strobe signal transfers the EPROM outputs into CMOS latches for storage. Then, the power to the EPROM's is again removed until the next change of the address. The price paid for this power reduction includes 13 CMOS packages and only slightly more complicated control and power supply circuits. If the higher power consumption can be tolerated only these additional circuits need be removed and two preregulator transistors must be introduced into the power supply to absorb part of the load. The power supply circuits also have been designed with dual redundancy such that a failure of a single component will not affect the operation of the system. The actual size has not been determined, but a box of 8 X 5.5 X 2.5 inches should be more than adequate to house the timer.

4.2.2.3 Timer Programmer

A portable programmer has been designed to store information in the INTEL 2708 erasable and electrically reprogrammable read only memory (EPROM). These EPROM's are used to store a required sequence of events to be reproduced in flight by the timer designed for the MSMP program. Therefore, the programmer has been designed not only to program and test the memories, but also to test the operation of the timer.

It is expected that the final timer setting adjustments will be made in the field during the payload preparation. To minimize the programming and the testing time the programmer was designed to accommodate four 2708 memories at one time. The programming is accomplished in two steps. First a random access memory (RAM) is manually programmed, then the information is automatically transcribed into the EPROM. This approach was dictated by the programming requirements of the 2708 unit. The EPROM requires more than 100 consecutive passes through all of the word addresses to store the information. This process takes approximately 206 seconds. The manual programming time will depend on the complexity of the timing requirements and the skill of the operator. To reduce manual programming effort a provision has been included to preset the RAM to the most prevailing state as required by the particular application and to program only the minority bits. Circuits have been designed to minimize the possibility of accidental introduction of errors or erasures. Controls not being used in a particular operation are disabled. Word location being programmed, as well as, the information stored at that location are displayed. Programmed RAM may be checked by recalling and displaying the information stored at any address. The information stored in the volatile RAM is protected against power interceptions by a NiCd battery included in the programmer. The battery will allow sufficient time to transcribe information from the RAM into the EPROM's for preservation during a power failure. Means are included in the programmer to transfer the data back from the EPROM into the RAM.

The operation of the timer may be tested in two modes. The timer may be allowed to proceed to a predetermined address and then stopped to display the stored data. Or, the timer may be allowed to proceed until a stored event is detected. Once the data has been inspected the timer may be commanded to advance until another event is encountered.

Other monitor circuits of the programmer allow for determining the status of all three redundant circuits in the timer. Tests circuits for timer control and power supply status are also included in the programmer.

4.2.3 Sensor Module Cameras

A transmitted television signal and a recoverable 35 mm. still camera are required in the MSMP sensor module.

4.2.3.1 Television Camera

The final selection has been made of the television camera that will look at the MSMP target engine module from the Sensor Module during engine burn periods of the flight profile. The camera selected is a Cohu Model 4510-013 with a high grade silicon vidicon Model 4532A tube. A 25 mm F/.78 lens, Cohu Model AL-156 is utilized and results in a field of view of 28° X 21°. Preliminary test data leading to the selection of this TV Camera can be found in References 17 and 18. Two cameras were received during the latter phase of this contract. Laboratory tests have been performed to assure that all manufacturers specifications have been adhered to. The basic results of these tests are shown in Table 4.1.

TABLE 4.1
Television Camera Evaluation

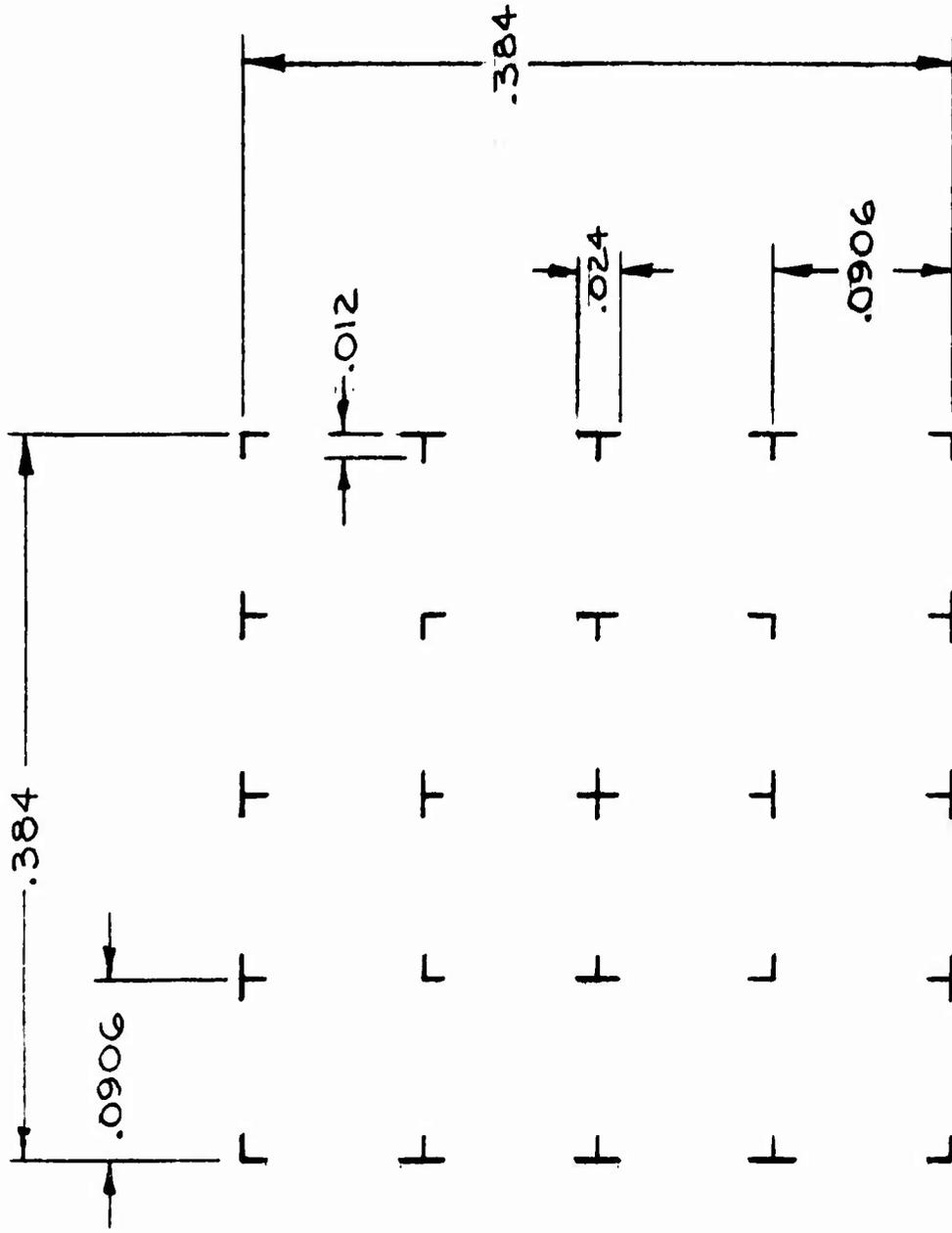
Test Performed	Range of Results
1 - Input Voltage Variation	22.0 Vdc to 30.0 Vdc.
2 - Input Current	580 ma to 660 ma.
3 - Input Power	14.3 W to 17.4 W.
4 - Warm-up Time	12 sec to 15 sec.
5 - Resolution	700 lines to 900 lines. 5 min. arc to 3 min. arc.
6 - Sensitivity	3.7×10^{-9} LUX to 4.0×10^{-9} LUX.
7 - Video	Standard TV & in range.
8 - Sync	Standard TV & in range.
9 - Pressure	No appreciable drop in internal ambient after 18 hours in an evacuated chamber.
10 - Distortion	(see discussion).

The resolution was measured two ways with similar results. The first way was by using two point light sources (LED's) and measuring the smallest separation that could be detected from a distance of 10 meters. This minimum was between 0.5 and 1 cm for both cameras. The second method was by using a test pattern supplied with the cameras. The test patterns have a grid of lines for measuring resolution.

The sensitivity was measured by finding the minimum current through an LED that made the LED visible on the monitor when the LED to lens distance was 10 m. At the minimum current the LED's produced a light level of about a magnitude 7 star. Eight co-workers were tested using this system and the average minimum was magnitude 6.3. Magnitude 6 is considered the normal minimum. The LED was visible on the monitor well below the level that anyone tested could see.

A measurement of picture distortion was attempted but no data could be recorded. Both cameras had very low distortion. No measurements could be taken because the monitor distortion far exceeded the camera distortion.

The MSMP-TV Camera will be used to determine in what direction the sensor module is pointing and if the target engine module (TEM) is centered in the field of view. Most systems have some geometric distortion, therefore in order to make accurate measurements in star position, and TEM location a grid pattern is desirable. There are several standard patterns available and RCA Pattern 902 has been selected. This pattern is shown in Figure 4.2, and is placed on the silicon target to minimize any distortions.



LINE WIDTH .001

STANDARD GRID PATTERN
 RCA #902
 (FIGURE 4.2)

Transmission and reception of the video signal requires a minimum of 2 MHz to resolve two small light sources displaced by an angle of 10 minutes of arc. The final recommendation of the bandwidth required will be determined in further tests conducted under the follow-on contract.

Further effort is also required to prepare the camera electronics to withstand the launch environment including conformal coating of all circuit cards.

4.3.3.2 35 mm Camera

An F2 Nikon 35 mm camera with remote motor drive and a 250 exposure film capacity has been selected and purchased for this application. The standard Nikon lens was not suitable, and a Nye Optical, 150 mm. super telephoto lens was adapted to the F2 camera.

Frame annotation will be required and is not available in the F2 camera. Several annotating schemes are being considered. Light emitting diodes, driven by binary counters correlated with film advance, seems most practical.

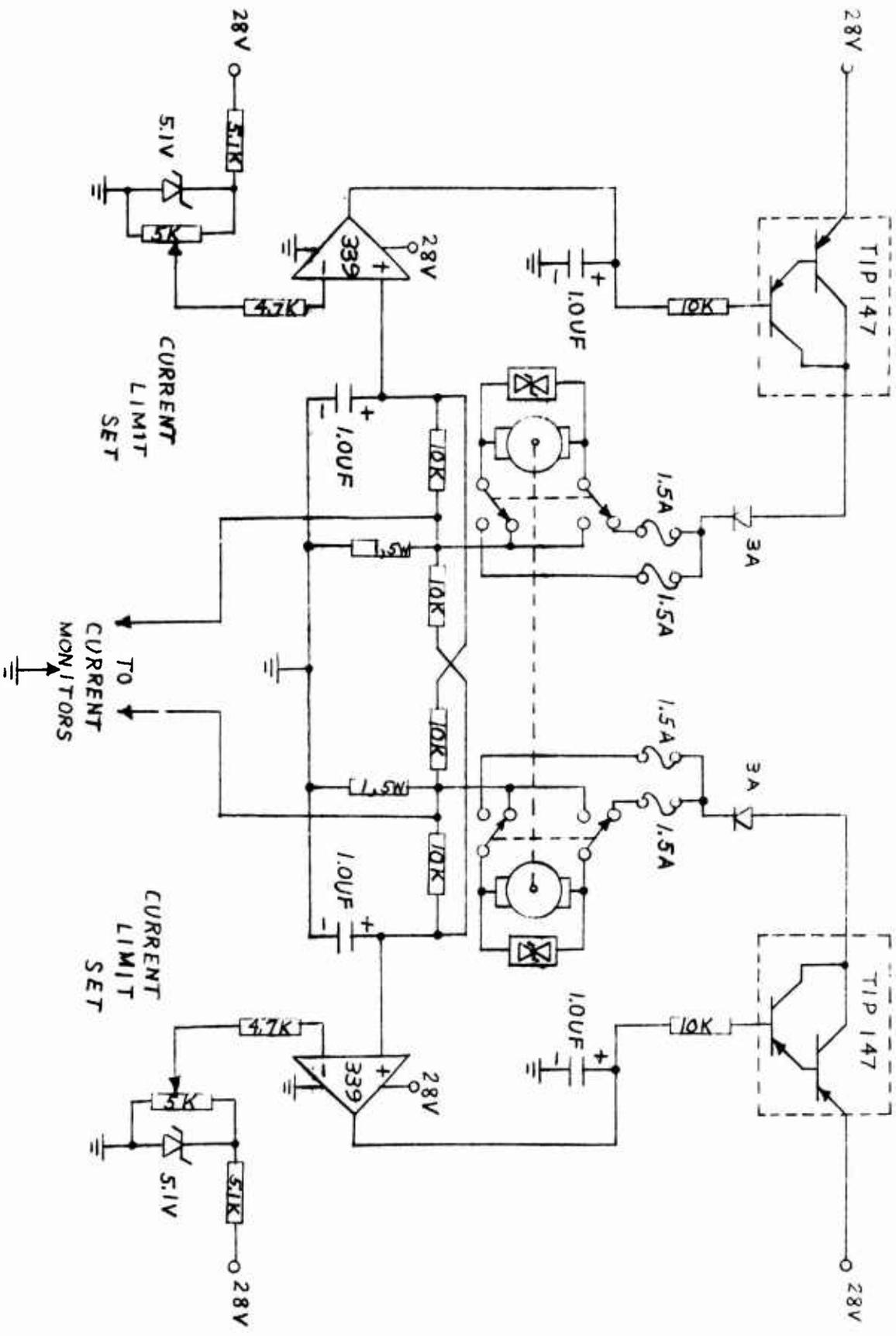
4.2.4 Sensor Module Motor Drive Systems

The two doors which provide protection for the MSMP instrumentation while the payload is in the atmosphere are controlled by four sets of motors. Each door has a mechanism for opening and closing and there are mechanisms, top and bottom, for securing the doors firmly once they are shut. These mechanisms are driven by pairs of motors which are

constructed on a single drive shaft for redundancy. Each motor is driven by a separate control circuit. These control circuits provide a constant voltage during opening and closing functions and are current limited so that the mechanisms can be allowed to go to a hard mechanical stop under power without damage to the motor or mechanism. This eliminates the need for limit switches which require fine adjustments to operate satisfactorily.

The control circuitry, shown in Figure 4.3, provides a cross coupled drive for each set of motors. Each motor, in a set, is capable of driving the mechanism properly. The 1 ohm five watt resistors sense the motor current and drive voltage comparators through resistive adding networks. When the voltage at the summing point reaches the current limit set point voltage, the current can no longer increase. This feature allows control of the sum of currents in the motors and thus limits the maximum torque produced to a safe level.

Since a failure in the current limiting circuit could destroy the motors or the gearing within the mechanism, redundancy is introduced by the use of high reliability aerospace equipment rated fuses. (Shock and vibration tested to MIL-STD-202). Fuses are not thought, usually, to supply operational redundancy, but in this particular circuit the blowing of a fuse would not be catastrophic. Two fuses are used, one in the opening direction and one for closing. If we assume a current limiter failure the following would occur. When opening, the door would reach the end of its travel stalling the motor. Without current



MOTOR CONTROL
 FIGURE 4.3

limiting the fuse would blow instantaneously (less than .01 seconds). When the closing command is given the motor power is applied through the other fuse and the door would close to the end of its travel, stall the motor, and blow the remaining fuse.

The motors have transient suppressors across their terminals to prevent high inductive kickbacks. A power diode is used to prevent shorted generator action in case of a ground fault occurring in the control circuitry.

External current monitors provide operational checks at all times to insure that all redundant circuits are operational.

The motor for the door openers have been ordered and delivery is expected in mid June 1976. One set of motors for the door latch has been purchased and received for testing. Having performed satisfactorily, the remainder of these motors have been ordered.

4.3 MSMP Status

The MSMP program was assigned to this contract in October 1975, and preliminary electrical and mechanical interface requirements were received from experimenters and other support groups at that time. Information has been updated, primarily through periodic design review meetings of the MSMP working group. Northeastern University has participated in three such meetings, at which each agency discusses his status and problem areas. The meetings were as follows:

16, 17 October 75	AFGL, Hanscom Field, Bedford, MA
28 January 76	Rocketdyne, Canoga Park, California
19 May 76	Honeywell Radiation Center, Lexington, MA

As of 31 May 1976, the service module structure design is complete. Fabrication of portions of the internal support structure is in process, including longerons, side support panels, base rings and top rings. Packaging of the scientific instruments is complete, and final definition of support systems will allow completion of the sensor module housing. Electrical interface drawings are complete for all experiments and the power transfer system. Details of the encoder, sequencer, motor drive, and diagnostic interfaces are not defined. Wiring is scheduled to begin in September 1976, in anticipation of a March 1977, launch for the first payload. Subsequent launches are scheduled for May 1978, and October 1978.

5.0 TRAVEL

Presented in this section is a summary of travel by Northeastern University personnel for technical support and coordination of the sounding rocket programs. Table 5.1 details travel to launch sites for pre launch testing and launch support of specific projects.

Man-days of travel in this category total 589.

One trip during the contract period was not for launch support and is not included in Table 5.1. The MSMP design review meeting at Rocketdyne (Section 4.3) was attended by E. Leiblein and R. Morin from 27 January 1976 to 29 January 1976.

Travel in conjunction with Contract No. F19628-73-C-0152 from 1 March 1973 to 31 May 1976 totalled 595 man-days.

Table 5.1

F19628-73-C-0152 Launch Support

1 March 1973 - 31 May 1976

PROJECT	LAUNCH SITE	STAFF	TRIP DURATION
A18.006-2	PFRR	Fonteyn Markussen Morin	3/9/73 - 3/24/73 3/9/73 - 3/24/73 3/9/73 - 3/24/73
A03.911-1	WSMR	McElhinney Tracy	4/17/73 - 4/28/73 4/17/73 - 4/28/73
A09.210-1	CRR	Anderson Healey	6/6/73 - 6/15/73 6/6/73 - 6/15/73
A16.000-1	WOPS	Morin	8/6/73 - 8/10/73
A09.214-1	WSMR	Anderson Tracy	9/5/73 - 9/12/73 9/5/73 - 9/12/73
A09.107-4	CRR	Anderson Healey	12/2/73 - 12/12/73 12/2/73 - 12/12/73
A18.006-4a	PFRR	McElhinney Morin	2/2/74 - 2/15/74 2/2/74 - 2/15/74
A09.303-1	CRR	Anderson	3/19/74 - 4/10/74
A09.303-2	CRR	Healey	3/29/74 - 4/10/74
A09.303-3	CRR	Tracy	3/19/74 - 4/2/74
A09.303-4	CRR		
A09.001-3	WOPS	Anderson	6/3/74 - 6/13/74
A09.001-4	WOPS	McElhinney	6/3/74 - 6/30/74
A09.213-2	WOPS	Morin Rickets Tracy	6/3/74 - 6/13/74 6/3/74 - 6/30/74 6/3/74 - 6/30/74
A09.214-2	WSMR	Anderson Morin	8/8/74 - 8/17/74 8/8/74 - 8/17/74
A10.213-1	WOPS	Anderson Healey	1/5/75 - 1/18/75 1/5/75 - 1/18/75
A10.403-1	CRR	McElhinney	3/25/75 - 4/28/75
A10.403-2	CRR	Tracy	3/25/75 - 4/28/75
A10.403-3	CRR		

Table 5.1 cont.

PROJECT	LAUNCH SITE	STAFF	TRIP DURATION
A10.304-1	WSMR	Anderson	9/8/75 - 9/20/75
A10.304-2	WSMR	Tracy	9/8/75 - 9/20/75
A10.402-2	WOPS	Anderson	1/5/76 - 1/31/76
		Tracy	1/5/76 - 1/31/76
HIRIS	PFRR	Morin	2/17/76 - 3/4/76
			3/24/76 - 4/4/76
A10.001-2	CRR	Anderson	4/12/76 - 5/2/76
A10.403-4	CRR	Tracy	4/12/76 - 5/2/76

Launch Sites

CRR - Churchill Research Range, Manitoba, Canada
WOPS - Wallops Island, Virginia
WSMR - White Sands Missile Range, New Mexico
PFRR - Poker Flats Research Range, Alaska

6.0 PERSONNEL

The following Northeastern University staff members have contributed to the work described in this report.

J. Spencer Rochefort, Principal Investigator from 1 August 75 to 31 May 76.

Lawrence O'Connor, Acting Principal Investigator, July 1975.

Alvin J. Yorra, Principal Investigator from 1 March 73 to 31 June 75.

Robert Anderson

Walter Benulis

Francis Bonanno

Robert Fonteyn

Richard Healey

William Hedly

Edward Leiblein

Robert Markussen

John McElhinney

Richard Morin

Roger Ng

Harold Noyce

Norman Poirier

Daniel Ricketts

Paul Sevigney

Raimundas Sukys

Willard Thorn

Frederick Tracy

Harry Tweed

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5. Design of Sounding Rocket Payloads - Scientific Report No. 2, 26 March 1975, Contract F19628-73-C-0152, Northeastern University.
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7. Quarterly Status Report No. 2, 1 June 1973 through 31 August 1973, Contract F19628-73-C-0152.
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9. Quarterly Status Report No. 4, 1 Dec. 1973 through 28 February 1974, Contract F19628-73-C-0152.
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12. Quarterly Status Report No. 7, 1 Sept. 1974 through 30 November 1974, Contract F19628-73-C-0152.
13. Quarterly Status Report No. 8, 1 Dec. 1974 through 28 February 1975, Contract F19628-73-C-0152.
14. Program Timer - Model 50, Scientific Report No. 3, June 1975, Contract F19628-73-C-0152, Richard L. Morin, Northeastern University. (AFCRL-TR-75-0328)

15. Quarterly Status Report No. 9, 1 Mar. 1975 through 31 May 1975,
Contract F19628-73-C-0152.
16. Quarterly Status Report No. 10, 1 Jun. 1975 through 31 Aug. 1975,
Contract F19628-73-C-0152.
17. Quarterly Status Report No. 11, 1 Sep. 1975 through 30 Nov. 1975,
Contract F19628-73-C-0152.
18. Quarterly Status Report No. 12, 1 Dec. 1975 through 29 Feb. 1976,
Contract F19628-73-C-0152.