Two Black Brant II rockets launched at Churchill Research Range March 1966

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https://doi.org/10.4224/21275323
Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1967-05

ERB-761

UNCLASSIFIED

NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

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AA-II-103 AND AK-II-104

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ABSTRACT

The engineering aspects of preparing and launching two scientific sounding rockets are described. Vehicles AA-II-103 and AK-II-104 were launched from Churchill Research Range in March 1966 as part of a continuing investigation sponsored by the National Research Council's Associate Committee on Space Research. The report includes a description of the payload structure and of the scientific experiments. In addition, vehicle performance and engineering measurements are discussed.

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TWO BLACK BRANT II ROCKETS LAUNCHED AT CHURCHILL RESEARCH RANGE MARCH 1966

AA-II-103 and AK-II-104

- A. Staniforth, K.A. Steele, and D.H. O'Hara -

INTRODUCTION

Two Black Brant II rockets, AA-II-103 and AK-II-104, were launched at Churchill Research Range in March 1966 to study auroral phenomena. These launchings were a continuation of the series sponsored by the National Research Council's Associate Committee on Space Research. The Space Electronics Section of the National Research Council's Radio and Electrical Engineering Division provided engineering assistance to the experimenters, built the nose cone instrumentation, checked out the system, and provided payload control during the launch phase.

The experimenters participating in these two payloads were: University of Saskatchewan (U of S), University of Alberta, Calgary (UAC), University of Western Ontario (UWO), Upper Atmosphere Research Section and the Cosmic Ray Section of the National Research Council, and the Defence Research Telecommunications Establishment (DRTE).

A summary of the rocket firings is shown in Table I, which lists trajectory data, telemetry performance, and operation of experiments.

PAYLOAD ENGINEERING

Both rockets were standard Black Brant IIA vehicles with Canadair four-fin stabilizers and with a 9-inch extension added to the parallel section of the standard nose cone. The extension consisted of a BB V igniter housing with an adapter ring for fitting to the BB II forward body. To provide improved accessibility, the complete payload, in almost every case, was mounted in a frame structure which was spaced 3/8-inch inside the nose cone shroud or skin. The components were mounted on shelves which were secured to four longitudinal channels using cast aluminum brackets. The complete "layer cake" assembly was then bolted to the skin of the nose cone, which, being of cast magnesium, added considerably to the strength and rigidity. In March 1965, a BB II vehicle was flown successfully with this type of structure in the conical section only, but in the two rockets under discussion the frame construction was also used in the parallel sections, including the 9-inch extension. The forward end of the standard frame terminates at Station 59 (59 inches from the nose tip), but usually an experimenter's package extends the payload to the vicinity of Station 30.

TABLE I

NRC BLACK BRANT FIRINGS - MARCH 1966

Summary of Performance

ITEM	AA-II-103	AK-II-104
Test/OR Number	36.6 B II/170-2	39.6 B II/171-4
Lift-off time	01:07:42 CST, Mar. 27, 1966	22:19:21 CST, Mar. 29, 1966
Time of flight	370 sec	372 sec
Apogee radar (kft)	497	505
Time to apogee	186 sec	188 sec
Roll rate (rps)	1.24	once/90 sec
Cone half-angle	33.7 degrees	--
Cone period (sec)	65.5	--
Angle of cone axis to magnetic field	3.3 degrees	--
Conditions at launch	2 db riometer absorption Visual I	X-ray counts well over 300/sec Visual II on trajectory
Radar tracking beacon only	T+53 sec to impact	T+5 sec to impact
Batteries	All normal	All normal
Link 1 telemetry	Normal through flight	LOS T+43, AOS T+120 sec, and 3 dropouts totaling 42 sec

Summary of Performance (cont'd)

ITEM	AA-II-103	AK-II-104
Link 2 telemetry	LOS T+65 sec, AOS T+115 sec LOS T+324 sec, AOS T+348 sec	Normal through flight
Vehicle performance	As predicted, except for roll rate	As predicted, except for roll rate
Signal transfer	Normal	Normal
I.I. package ejection	Normal	Normal
Probe extensions	Normal	Normal
Magnetometers	Normal	Normal
Altitude switches	Normal	Normal
Accelerometers - Z-axis	15.8 g - normal	15.9 g - normal
Accelerometers - Lateral	Max. swing of 1 g	± 0.2 g very smooth flight
Vibration - Z-axis	Relatively quiet, ± 10 g max. for .04 inch at end of burning	Quiet, ± 8.5 g for .02 inch at end of burning
Vibration - Lateral	± 2.5 g at same time	Quiet, lift-off ± 6 g for .04 inch and ± 2 g at end motor burning
NRC photometer	Good data	Good data
Loss of TLM channels	40 kHz SCO open input	Normal
TLM Subcommutator	Normal	Normal

Summary of Performance (concluded)

ITEM	AA-II-103	AK-II-104
TLM Commutator	Normal	Normal
Ionospheric inhomogenieties	Normal	Signal flutter for first few seconds, then reduced but usable signal
Plasma probes	2 out of 3 - good data	3 out of 4 - good data
Micrometeoroid	--	Mk. III - Some interference Mk. IV - Operated well but no impacts
Cosmic ray	Good data from all but pitch-angle package	--
3914Å Photometer	Data obtained through flight	--
1450Å Ion chamber	Signals at or below threshold of sensitivity	--
SES	Data obtained at one energy level only. Counting rate fairly high	--
Neutron detector	--	Normal
X-ray detector	--	Good signal
Auroral Scanner	--	Operated normally through flight. Signal on down leg only
Galactic X-ray	--	Operation satisfactory
4-Channel auroral photometer (U of S)	Equipment operated normally but no tip ejection - so no signals	--

In AK-II-104 this package consisted of a UAC neutron detector with associated electronics extending up to Station 26, and in AA-II-103 it consisted of a U of S four-channel auroral photometer. In both vehicles the equipment was bolted to the nose cone skin for added strength. The two payloads are shown in Figs. 1 and 2.

Since the skin temperature at the forward end of the nose cone is about 400 degrees F, a heat shield was used in both payloads to protect components mounted forward of Station 59. The instrument frame was wrapped in an insulating blanket material, coated on the outside with a heat reflective material which is an electrical insulator. The material is Scotch Shield Type 75, made by Minnesota Mining and Manufacturing Co. Ltd.

In previous rocket firings there have been several failures attributed to short circuits occurring in the miniature coaxial cable or its connectors during flight. These components, made by Microdot Corporation, were possibly satisfactory if the cable were supported adequately, protected from damage, and connectors perfectly assembled, but this was not always practical. Consequently, all coaxial cabling in AA-II-103 and AK-II-104 was type RG-188/U and coaxial connectors were type Conhex, made by Sealectro Corporation. These components were slightly larger than Microdot but less subject to damage. There were no failures that could be attributed to the coaxial fittings in these two rocket flights.

The U of S auroral photometer in AA-II-103 was designed to look forward along the longitudinal axis of the rocket after removal of the nose tip at an altitude of about 220 kft. To achieve this, a tip separation device was used, designed to eject the first 30 inches of the nose cone at a velocity of about 4.6 ft/sec forward. At a separation of about 5 inches, a weight of $5\frac{3}{4}$ lb was to be ejected laterally, producing a lateral velocity of the tip of about 5 ft/sec. The resulting velocity, relative to the remainder of the nose cone, would have been at 47 degrees to the longitudinal. In ground tests, all stages performed as planned, but in flight, the tip failed to separate, preventing any photometer data from being obtained.

An examination of the telemetry data brought out several points:

a) the tip failed to separate;

b) the timer switch closed at T+49.2 seconds for an interval of 7 seconds, exactly as planned;

c) the "squib" battery monitor, which was separated from the battery by 18 inches of wiring and a connector, indicated 2.85 volts during the time

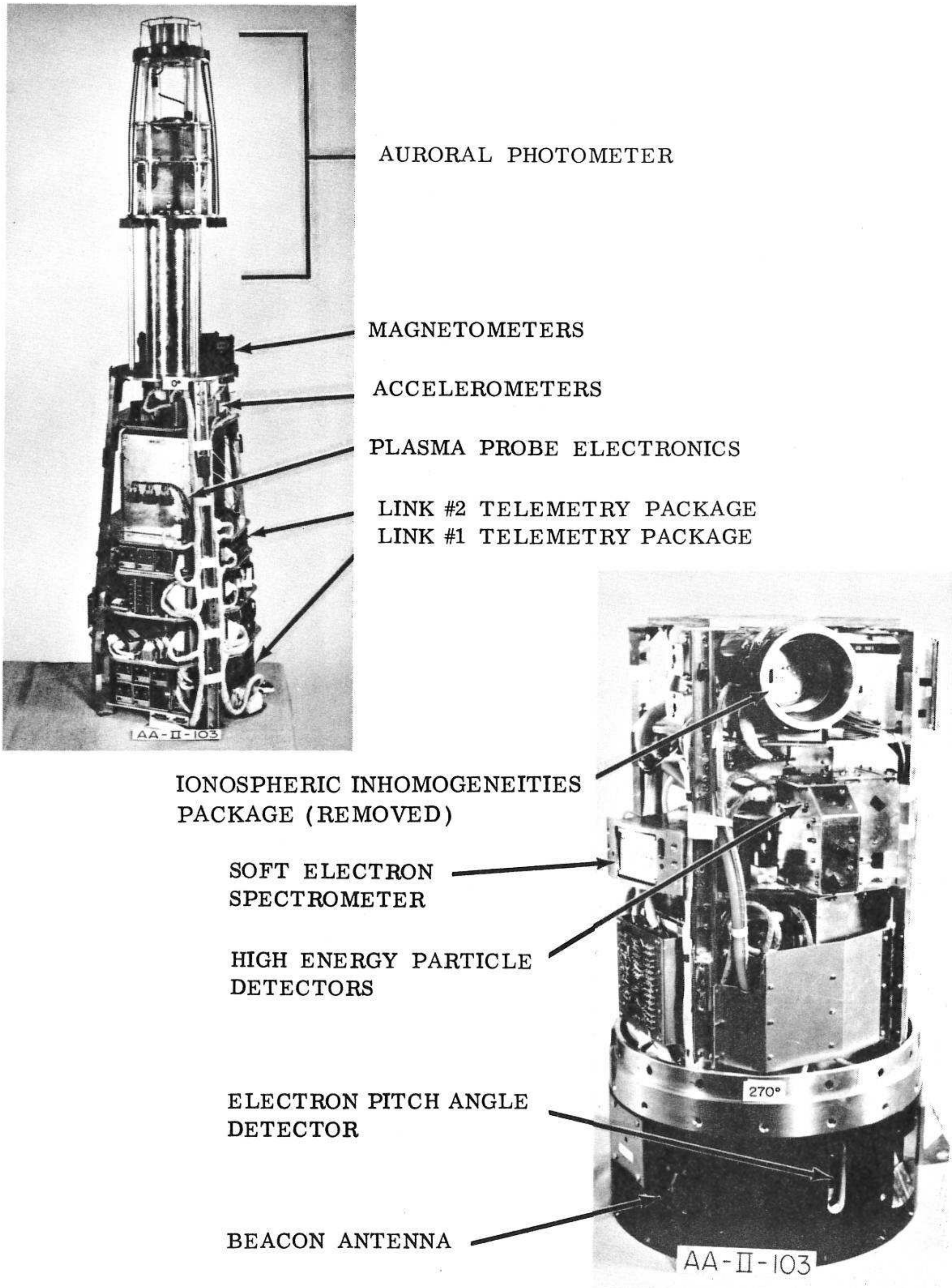

Fig. 1 AA-II-103 payload

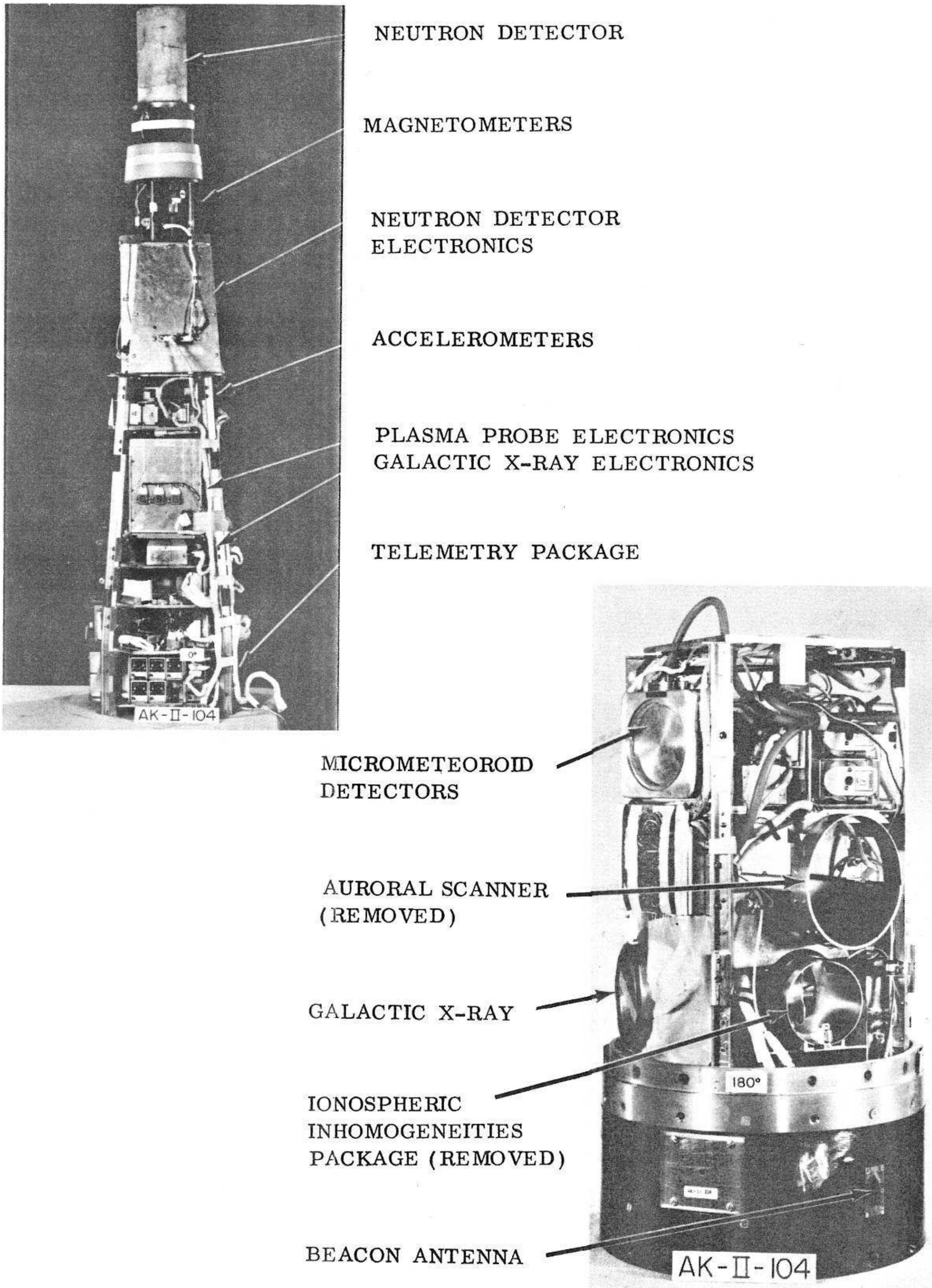

Fig. 2 AK-II-104 payload

the switch was on, and a recovery to 12 volts immediately after the opening of the switch. Twelve volts is normal for 8 cells of HR-1's, when discharged to their plateau. This same battery fired four other bellows actuators during and subsequent to closure of the switch at T + 49.2 seconds;

d) the magnetometers registered a shift in magnetic field precisely for the time interval that the timer contact was closed;

e) a temperature sensor located at Station 32 indicated a short cuircuit at T+21 seconds, when the g-forces would be towards the nose of the rocket. This short circuit cleared at T+303 seconds, at an altitude of 287 kft on the down leg of the trajectory, when the g-forces were towards the rear of the rocket. At 60 kft, T+356 seconds, the short reoccurred when the g-forces were again towards the nose;

f) low-frequency lateral accelerations were about +1 g maximum at T+19 seconds, decaying to zero at T+30 seconds. Lateral vibrations during motor burnout were about $\pm 2\frac{1}{2}$ g maximum. Longitudinal vibrations were about ± 2 g during burning with a 10-msec burst of ± 10 g at T+14 seconds.

The wiring to the bellows actuators and the temperature sensor was Teflon insulated, and was wrapped with Fibreglas tape where it was clamped to the inside of the nose cone. This cable run was the full length of the conical section, terminating at the lower end in connectors on the instrument frame, and at the forward end in Erie filtercon terminals and a 2-ohm, 10-watt resistor at Station 32.

From the telemetry data, we conclude that a short circuit probably occurred in the wiring somewhere between the magnetometer sensors at Station 56, and the tip separation connectors at Station 32.

The most probable cause of the short circuit was a metal object breaking loose and moving forward against exposed terminals at Station 32. This object could have been the top lens housing, or a part of the upper section of frame moving bodily forward.

Another cause of failure may have been a collapse of the frame during lift-off caused by longitudinal g-forces combined with lateral accelerations and vibrations. Although these forces were a little less than those in an average BB II flight, they might possibly have caused the wiring insulation to be cut through at one of the discs forward of Station 56.

If one postulates that the short at the temperature sensor, and the short in the tip release wiring are separate and unrelated events, then the latter fault might have occurred in the wiring in the tip itself at the connections to the bellows actuators.

Whatever the cause, it appears that extra precautions must be taken to ensure that:

a) the frame and components on the frame are securely fastened in place with adequate strength for the rocket environment during flight;

b) the wiring up the inside of the nose cone be protected from mechanical damage as much as possible;

c) all shelves be cut away to allow adequate clearance for cabling even if the frame shifts to one side;

d) all open terminals be insulated with Silastic or covered with a solid shield, leaving protected test points.

The experimenter's package should be tested for vibration and linear acceleration as a completely assembled unit. This was not done with the frame of AA-II-103 since there was not adequate time to make up a fixture that would give meaningful results. In addition, the tip ejection mechanism and the lower instrument frame had been flown successfully in a previous flight (AD-II-52).

In this vehicle, as in previous flights, reliable circuitry consisted of parallel wiring, connector pins, and bellows actuators. For the more important operations it is recommended that two separate circuits be used, including batteries, wiring, and squibs, to ensure that operation will continue even if a short occurs, as long as it occurs in only one circuit.

TRAJECTORY

Several measures of apogee height and time were available on these flights. The results are summarized briefly in Table II and in the following paragraphs.

Radar

In March 1966, the Churchill Research Range was in the process of getting the new FPS-11A radars into operation. As a consequence, only one MPS-19 radar was in operation for tracking the rocket and the only data available were from the real-time plotting boards. Both rockets carried AN/DPN-41 beacons which were tracked by the MPS-19 radar. The beacon output signals shown in Figs. 3 and 4 are an indication of the radar tracking throughout the flight. Azimuth and elevation data were erratic on flight AK-II-104 due to a radar malfunction. The tabulated apogee parameters were obtained following smoothing of the plotting boards data by a computer program. Smoothed trajectory data from the radar are shown in Figs. 5 and 6 for the two rockets.

TABLE II

Apogee Data for AA-II-103 and AK-II-104

	AA-II-103		AK-II-104	
	Apogee height (kft)	Apogee time (sec)	Apogee height (kft)	Apogee time (sec)
Radar	497	186	505	188
50-kft altitude switch	500	187	508	188
70-kft altitude switch	498	188	505	187
Telemetry flight time	491	186	496	187
Flight time to rocket turnover	510	188	-	-
100-kHz Doppler (a)	495	187	497	191
100-kHz Doppler (b)	498	187	504	189

Altitude Pressure Switches

Two 50-kft altitude switches, mounted within the nose cone, and a 70-kft altitude switch, vented directly by a short tube through the nose cone shroud, were carried by both rockets. A correction based on the statistical performance of these units in previous Black Brant II rockets has been applied to the time of apogee tabulated.

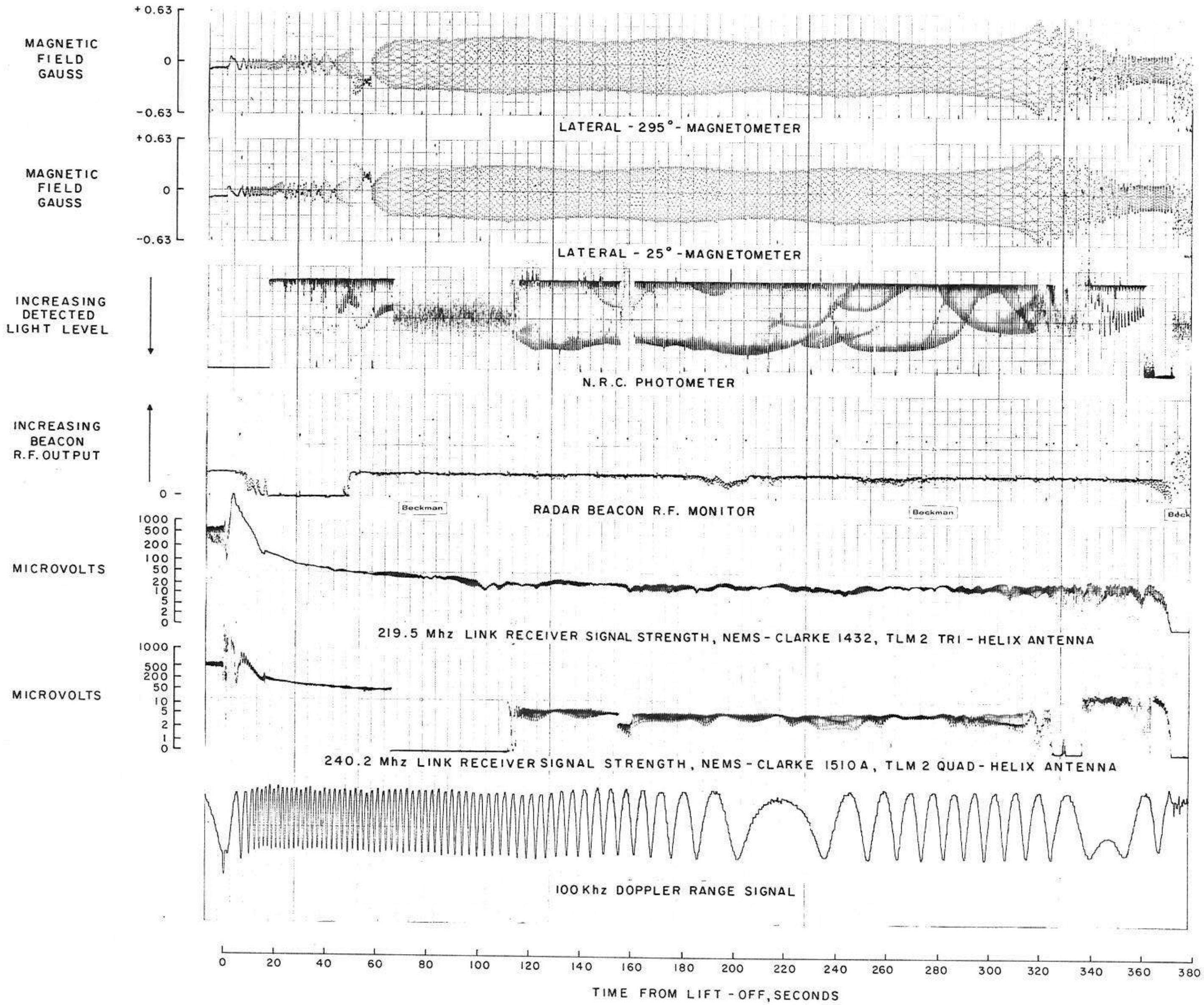

Fig. 3 Telemetry records for rocket AA-II-103

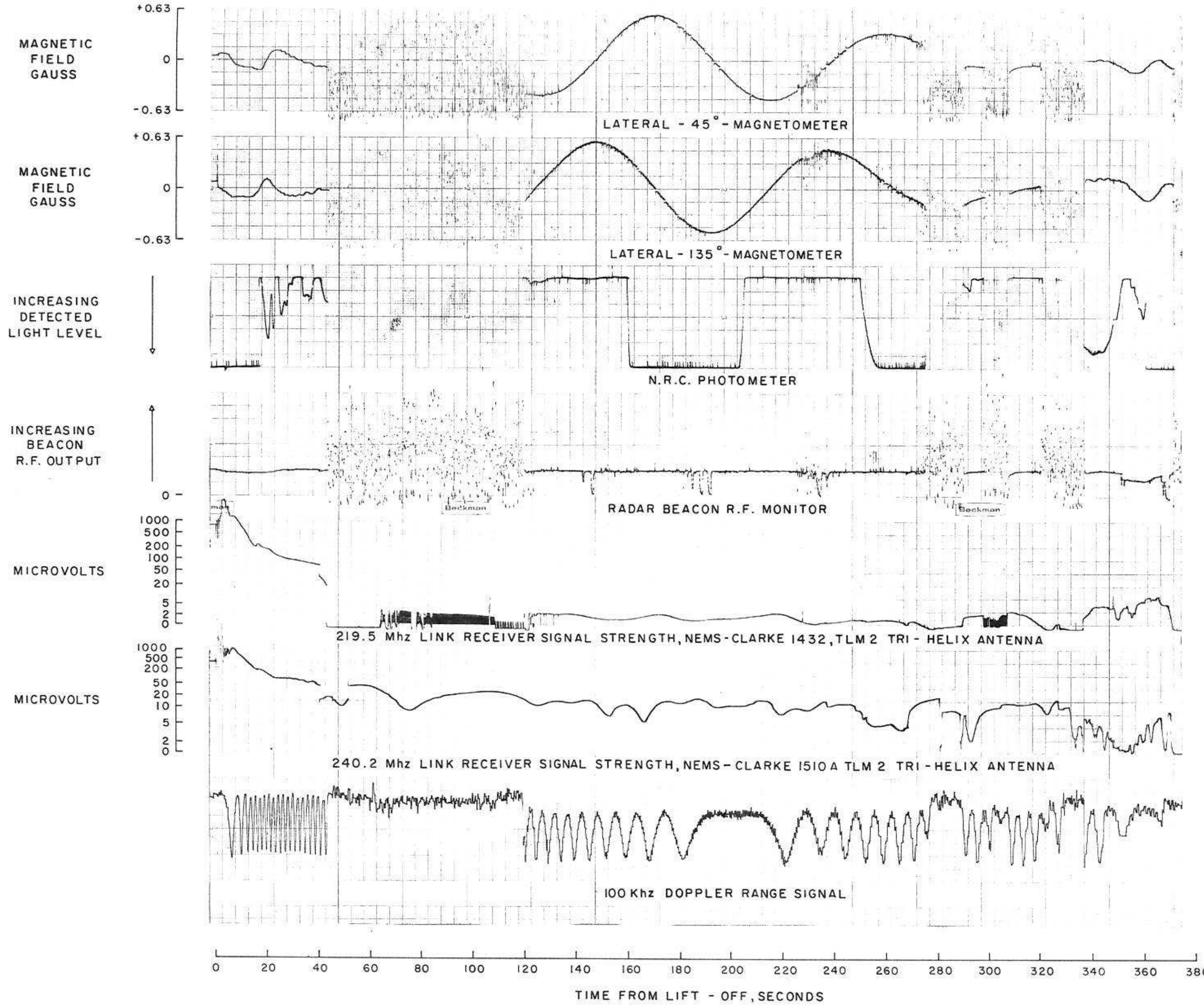

Fig. 4 Telemetry records for rocket AK-II-104

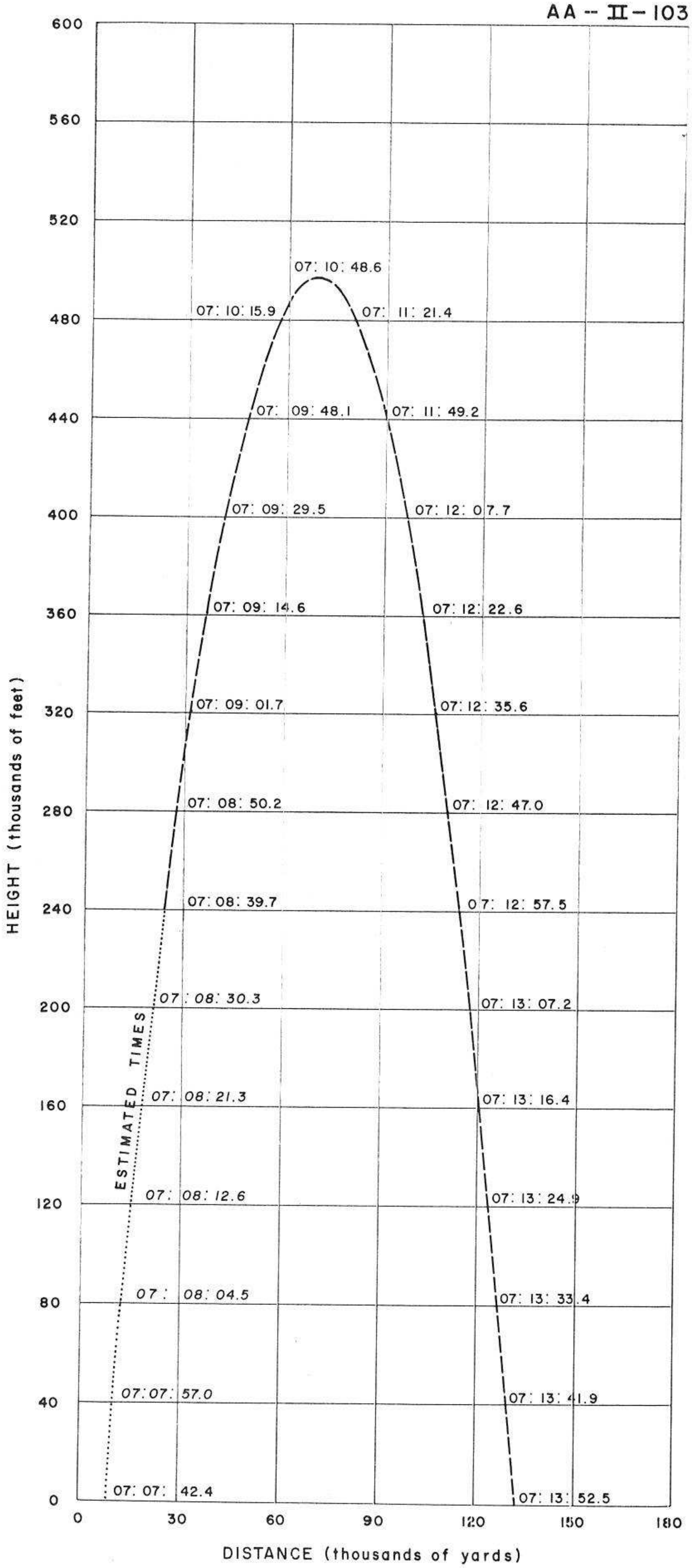

Fig. 5 Smoothed trajectory of rocket AA-II-103

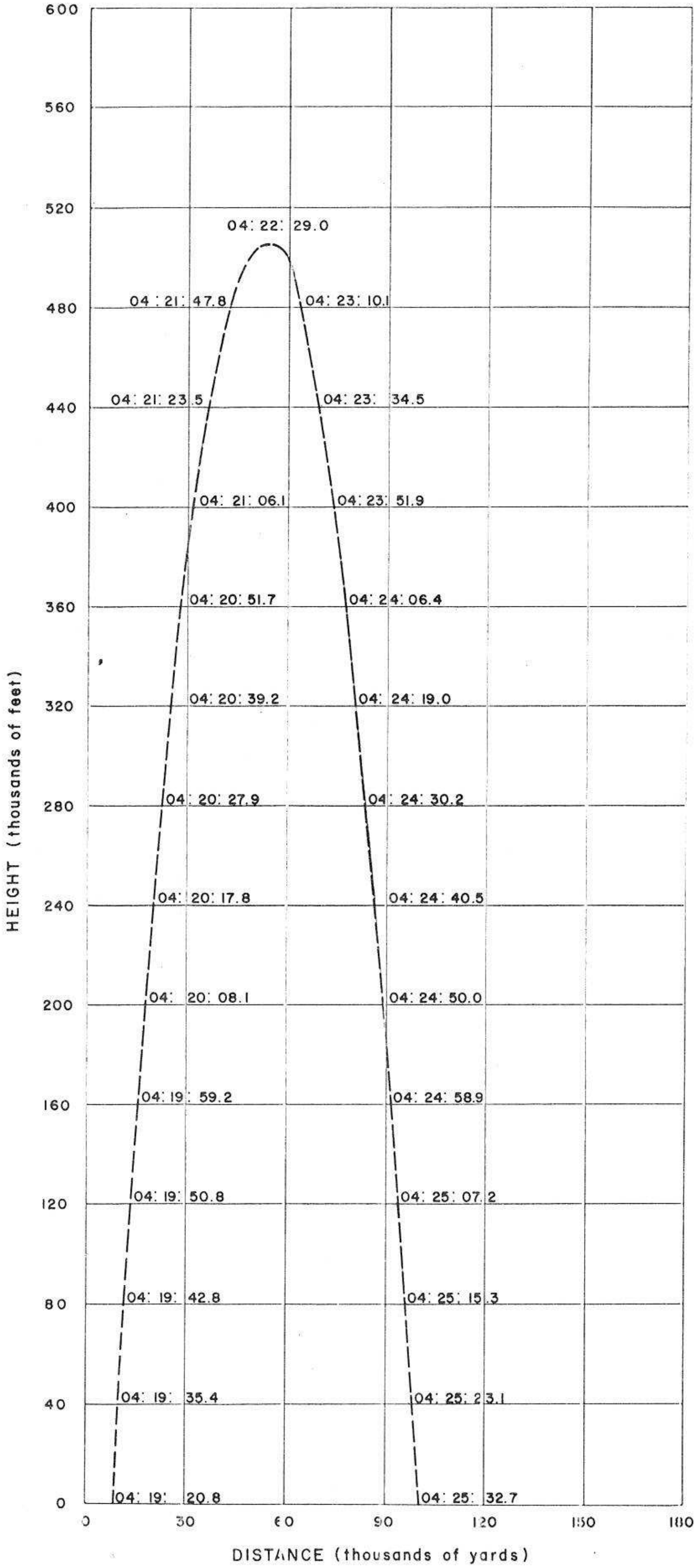

Fig. 6 Smoothed trajectory of rocket AK-II-104

Telemetry Time of Flight and Time to Rocket Turnover

These results are based on the history of previous results determined for Black Brant II flights as measures of apogee. A telemetry loss of signal occurred on rocket AK-II-104, during the time period when turnover normally occurs, so no result was available in this case.

Doppler

Experiments to evaluate Doppler ranging techniques were carried out on both rocket flights. Telemetry link no. 1 (219.5 MHz) utilized an AFC transmitter phase-locked to a crystal oscillator. 100 kHz and 85 kHz stable reference frequencies were also transmitted as modulation on the 219.5 MHz telemetry link.

The Doppler data reduced from the RF transmission was in error by about 15%. It is considered that this error is due to too narrow a bandwidth in the receiving system. The stable 85-kHz signal received by telemetry was recorded on magnetic tape, but without at the same time recording a stable ground-based 85-kHz reference signal. Attempts to recover the Doppler data from the 85-kHz signal on the flight magnetic tape records with sufficient accuracy to yield meaningful results have been unsuccessful. In this work, comparison was made with the ground-based 100-kHz reference recorded on the tape, a procedure which probably suffers from lack of correlation in the effects of wow and flutter on the recorded 85-kHz and 100-kHz signals. No difficulty was experienced in obtaining the Doppler data from the 100 kHz rocket signal recorded, together with a ground-based 100-kHz stable reference, on the magnetic tape.

The 100-kHz data were reduced in two ways: a) from a real-time paper record, and b) from flight data recorded on the telemetry magnetic tapes. The ground-based 100-kHz reference was a separate source for (a) and (b). The analysis in the case of rocket AK-II-104 was considerably more difficult because of several telemetry drop-outs during the flight. The Doppler signals for 103 are shown in Fig. 3 and for 104 in Fig. 4. (See tabulated assessment of the two flights, Table II.)

ATTITUDE

AA-II-103

The following information is based on magnetometer data shown in Figs. 3 and 7.

Roll rate	=	1.24 per second
Roll direction	=	clockwise looking forward
Precession period	=	65.5 seconds
Precession cone	=	33.7 degrees half-cone angle
Angular momentum vector	=	3.3 degrees away from the earth's magnetic field

The lateral accelerometers indicate that roll rate and cone rate were approximately equal during early flight until T+22 seconds (Fig. 7). A possible explanation for this "locked on" condition is that the centre of gravity of the payload was laterally displaced from the geometric axis of the rocket. This condition, with a possible thrust or aerodynamic asymmetry, resulted in the spin axis being at an angle to the longitudinal axis of the rocket. Although this potentially catastrophic condition did not persist, it likely contributed to the large cone angle throughout the remainder of the flight.

AK-II-104

The magnetometer data shown in Figs.4 and 7 indicate that the roll rate of this rocket was very low, approximately one roll cycle per 90 sec, in the CWLF direction. No violent manoeuver is indicated at the normal time of vehicle turnover which suggests that turnover had already occurred.

The flight records suggest the following form of motion: by T+120 sec, the rocket had tipped over until it was within 30 degrees of being horizontal. From then until about T + 280 sec it precessed slowly in a nearly horizontal plane (a flat spin) with a very slow roll motion. The nose tip was oriented downwards from about T+250 sec onward with the angle between the rocket thrust axis and the vertical decreasing to 30 degrees by about T+300 sec and not exceeding 30 degrees for the remainder of the flight.

The photometer viewed a strong light source for at least two relatively long periods of time as seen from the record in Fig. 4. This is consistent with the above analysis of the rocket motion if the photometer was viewing reflected light, such as moonlight, from the earth.

TELEMETRY

There were two significant failures in the rocket-borne telemetry systems carried in the rockets launched in March 1966. Fortunately they

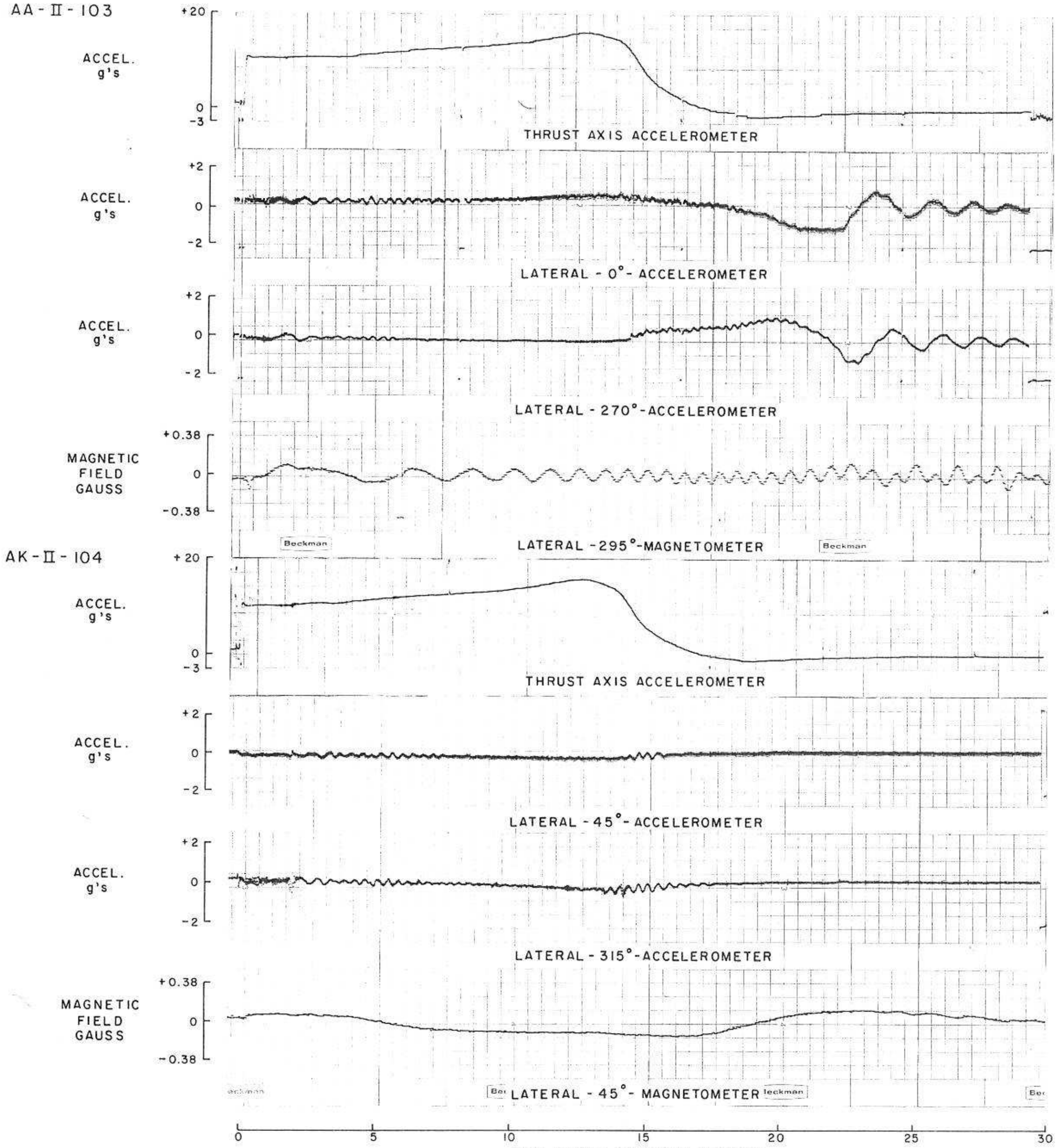

Fig. 7 Magnetometer and accelerometer records for AA-II-103, AK-II-104

occurred separately, one on each flight.

Tests conducted in the laboratory in Ottawa have since shown that both these failures were caused by voltage breakdown in the transmitter initiated by ionization. Neither the transmitter nor the nose cone was pressurized. The laboratory tests were conducted by placing a similar transmitter in an evacuated chamber containing a probe at a potential of about 800 volts relative to the ground plane. When pressure was reduced below 200 μ of Hg, voltage breakdown occurred in the transmitter, causing loss of power and a drop in frequency similar to that occurring during the rocket flights. It appears that the high-voltage probe ionizes the gas, and these ions diffuse into the RF field of the transmitter where they initiate corona breakdown. When a rocket is launched into an auroral event, where there is considerable ionization of the medium, there may be a similar voltage breakdown in the transmitter. Once this breakdown is started it is self-sustaining.

To prevent this breakdown from occurring, the transmitter case was filled with a dielectric material. Several of these materials were tested: DowCorning "Silgard" potting compound, DC-4 grease, and "Eccospheres". The most satisfactory of these materials to date appeared to be the dry powder "Eccospheres Type 51", made by Emerson & Cuming Inc., composed of minute hollow spheres. Leakage of this powder was prevented by sealing the case with plastic sheets and Silastic 731. When the transmitter was filled with this material, no breakdown could be induced in an environmental chamber at any pressure encountered by the BB II rockets.

<u>AA-II-103</u>

The main rocket telemetry link (219.5 MHz) operated satisfactorily with no loss of signal reception at either telemetry station throughout the flight.

Adequate reception did not occur on the 240.2 MHz link for the following periods:

At Launch Site:	At Twin Lakes:
T = 0 at 01:07:42.4 CST	T = 0 at 01:07:42.4 CST
T + 65.0 to T + 110.9 sec	T + 65.0 to T + 102.7 sec
T + 324.1 to T + 335.8 sec	T + 318.3 to T + 320.3 sec
	T + 323.5 to T + 345.6 sec
Total = 61.6 sec	Total = 61.8 sec

Observations at the launch-site telemetry station indicated that the transmitter frequency shifted downward at T + 65.0 sec. When the signal was reacquired, the frequency was lower than 240 MHz and was slowly drifting upwards. The frequency, as indicated by the receiver tuning indicators, averaged about 239 MHz for the remainder of the flight.

AK-II-104

There was no loss of telemetry reception on the 240.2 MHz link at the launch site. Twin Lakes telemetry reception was complete except for a 1.1-sec period commencing at T + 41.8 sec and a 1.5-sec period beginning at T + 46.9 sec.

The 219.5 MHz telemetry link was not received with adequate signal strength during the following periods:

At Launch Site:	At Twin Lakes:
T = 0 at 22:19:20.8 CST	T = 0 at 22:19:20.8 CST
T + 42.7 to T + 119.4 sec	T + 42.7 to T + 124.8 sec
	T + 178.2 to T + 188.2 sec (partial)
	T + 225.5 to T + 233.4 sec
T + 270.0 to T + 289.9 sec	T + 271.2 to T + 283.4 sec
T + 297.8 to T + 307.4 sec	T + 297.8 to T + 307.5 sec
T + 320.4 to T + 336.7 sec	T + 315.8 to T + 325.3 sec
	T + 326.5 to T + 337.0
Total = 122.5 sec	Total = 141.9 sec

Indications of voltage breakdown on the telemetry antennas occurred at the following times:

	219.5-MHz Link	240.2-MHz Link
Breakdown:		
T + 39.85	6.6-db decrease	8-db decrease
Recovery:		
T + 51.0	- -	8-db increase

PAYLOAD IN AA-II-103

This payload consisted of equipment designed to measure various characteristics of the aurora. The primary experiment was provided by the Cosmic Ray Section of the Division of Pure Physics to study energetic particles associated with the aurora. The vehicle was launched into the desired geophysical conditions; i. e., 2-db absorption on the trajectory, measured with the 30-MHz riometer, and visual aurora of IBC intensity 1.

Energetic Particle Detectors

(Cosmic Ray Section, Division of Pure Physics, NRC)

The purpose of the experiments was to study the intensities, spectra, and pitch angle distributions of electrons and protons associated with visual aurora and/or auroral absorption.

The primary type of detector was a CSI scintillator-photomultiplier combination whose output amplitude was selected at levels corresponding to incident electron energies of 25 keV, 40 keV, 70 keV, and 120 keV. There were four of these in this experiment with two mounted with their axes at 90 degrees to the rocket axis, and the other two at 40 degrees to the rocket axis. The output current of one of each pair was also measured, and this gave a measurement of the total energy flux of electrons whose energies exceed about 5 keV. These detectors are also sensitive to protons whose energies exceed 50-100 keV, but it is assumed that the number of protons is negligible compared to the number of electrons.

A second type of detector was a silicon p-n junction particle detector. There were three of these in the experiment, with one mounted at 40 degrees to the rocket axis and two at 90 degrees. They were biased to produce thin depletion depths, which made them far more efficient at detecting protons than electrons. In addition, two detectors had magnetic brooms placed in front to aid in electron rejection. Discriminator levels for the output of these two were set to correspond to proton energies of 200 keV, 350 keV, and 600 keV. The third detector, at 90 degrees to the rocket axis, selected proton energies exceeding about 600 keV or alpha-particle energies exceeding 1500 keV.

The third set of detectors consisted of five thin end window geiger counters in an arc with their axes making angles of 40, 65, 90, 115, and 140 degrees to the rocket axis. These were sensitive to electrons whose energy was above 40 keV or protons with energies above 500 keV. The purpose of the array was to measure the electron pitch angle distribution relative to the magnetic field. The previously mentioned detectors would also measure this, if the rocket spins about its axis and if its axis makes a suitably large angle with the magnetic field.

The experiment provided twenty-three different readings with twenty-one of these commutated on four commutators. The other two were assigned separate SCO frequencies.

With the exception of the pitch-angle experiment, all the packages from the Cosmic Ray Section worked satisfactorily. Although some data were lost from the total energy detector at 40 degrees to the rocket spin axis when the Link 2 transmitter drifted far off frequency for a while, this loss is not considered to be serious because a similar detector at 90 degrees to the axis essentially duplicated the lost data.

The fault in the pitch-angle experiment appeared to be at the input to the 40 kHz SCO. The signal was lost about thirteen seconds after take-off, and returned shortly before impact, indicating a connection that was disturbed by rocket vibration at take-off and re-entry.

Comparison of data from the electron and proton detectors shows that the absorption event was primarily an electron event, with very few protons present with energies exceeding 180 keV. Electron counting rates were good, but not as high as on some previous flights.

Auroral Photometer

(University of Saskatchewan)

The experiment contained two photometers. The primary photometer had two spectral channels each 5 Å in width and separated from each other by 20 Å. These channels were located on the 4278 Å band of the N_2^+ ion. From the combination of these two signals the rotational temperature of the ion can be calculated, and by flying through the aurora, a temperature-versus-height profile can be obtained.

The secondary photometer had two channels also, one looking at the 3914 Å N_2^+ emission, and the other at the 5577 Å OI emission. In addition to telemetering these photometer outputs, signal processing was performed to subtract the mean value of the signal and the remaining "fluctuating component" was also transmitted by telemetry. It was planned to obtain some information about the height of auroral brightness fluctuations.

Data from both photometers can be related to the energy spectrum of auroral electrons as determined by other experimenters on the same flight.

To monitor the operation of the four photometer channels, a calibration light was mounted at the forward end of the system. The light was driven by a multivibrator to give a one-second "on" time at a rate of once per 10 seconds. The telemetry signal indicated that the photometer operated satisfactorily throughout the flight,but with no tip separation there were no useful data. Another monitor light, located in the nose cone tip, failed at about T - 30 seconds, although the battery voltage remained unchanged.

Plasma Probe Experiments

(Upper Atmosphere Research Section, Radio and Electrical Engineering Division, NRC)

These experiments were designed to measure electron and ion densities and electron temperature, and their variations along the trajectory. The objective was to measure these parameters within visual auroral forms and radar aurora, and to correlate the findings with ground-based observations. To achieve correlation with radar aurora, continuous communication was maintained with the Prince Albert radar.

In AA-II-103 there were two $\frac{1}{4}$-inch diameter spherical collecting electrodes and one planar trap. The spherical probes were extended about 6 inches from the surface of the nose cone at T + 50 seconds to reduce the effect of aerodynamic heating. The planar trap mounted flush with the surface on the cylindrical section was not subject to as severe heating. The probes carried a programed voltage to control the collection of ions and electrons from the ambient medium.

The planar trap and one spherical probe produced good data, but one probe developed a broken internal connection.

1450 Å Ion Chamber and 3914 Å Photometer

(Defence Research Telecommunications Establishment)

This experiment was designed to measure the intensity of auroral nitrogen emissions in the vacuum ultraviolet region using a photo-ionization chamber, and to compare the results with the visual intensity of the aurora measured with a photometer.

The 3914 Å photometer and 1450 Å ion chamber package appeared to function as designed. Data were obtained throughout the flight from the 3914 Å photometer. Very preliminary analysis suggests that the rocket did not pass directly through any appreciable aurora. The 1450 Å detector was at or below its threshold of sensitivity and it may serve only to define an upper limit to the auroral radiation in that spectral region.

Soft Electron Spectrometer (SES)

(Defence Research Telecommunications Establishment)

The SES equipment was designed to measure the spectrum of electrons in the energy range between 50 eV and 10 keV. This energy range is of special importance in producing visual aurora.

The soft electron spectrometer experiment developed a malfunction following the application of high voltage at T + 80 seconds in that the energy selector ceased to function. The data obtained throughout the flight above 100 km were thus taken at a single electron energy level rather than by scans through the designed energy range of 50 eV to 10 keV. The counting rate was fairly high and time and spatial variations were recorded. From this standpoint the experiment can be considered as partially successful.

NRC Photometer

(Radio and Electrical Engineering Division, NRC)

This instrument uses a type 1P21 photomultiplier columnated to a conical beam width of about 16 degrees pointing at right angles to the rocket axis. The high voltage is turned on after lift-off by 50 kft altitude switches which protect the photomultiplier from being desensitized by strong lights near the launcher.

The data are used for two purposes:

1) to indicate the general direction of visual aurora for correlation with plasma probe data;

2) as an aid in the determination of vehicle attitude history, particularly if the moon is visible.

The photometer in this rocket worked well, giving good data throughout the flight.

Ionospheric Inhomogeneities

(University of Western Ontario)

The purpose of this experiment was to measure scintillation of a 108-MHz signal in the lower region of an aurorally disturbed ionosphere. The airborne part of the experiment consisted of a 250-mW CW transmitter at a frequency of 108 MHz mounted in a small cylinder which was ejected from the rocket at T + 55 sec, at an altitude of 230 kft and was then free to fly on an independent ballistic trajectory. The antenna system on the airborne package consisted of crossed dipoles made from a flexible steel measuring rule. Each of the four sections was wrapped with Fibreglas tape at the root ends to increase damping and reduce the tendency to break from whipping motion. The ground receiving equipment, which measured the relative phase and amplitude of the signal, was provided and operated by UWO personnel.

In this flight the package was ejected and turned on as planned and a good signal was received during the complete trajectory.

PAYLOAD IN AK-II-104

This payload was made up of experiments designed to measure characteristics of the aurora and associated X-rays. The vehicle was launched into the desired geophysical conditions of at least 300 X-ray counts per second measured by an X-ray detector in a balloon at an altitude of approximately 100 kft, and an aurora of IBC intensity 2. There was no absorption on the 30-MHz riometer. The balloon, the X-ray detector, and balloon telemetry were all operated by the UAC group.

Plasma Probe Experiments

(Upper Atmosphere Research Section, Radio and Electrical Engineering Division, NRC)

These experiments were designed to measure electron and ion densities, electron temperature, and their variations along the trajectory. The objective was to measure these parameters within visual auroral forms and radar aurora, and to correlate the findings with ground-based observations. To achieve correlation with radar aurora, continuous communication was maintained with Prince Albert radar.

In this rocket there were two $\frac{1}{4}$-inch diameter spherical probes which extended about 6 inches from the conical surface on flexible supports, and one $\frac{1}{4}$-inch diameter spherical probe on a rigid support which extended about 9 inches from the cylindrical surface of the vehicle. These probe supports were programed to extend at T + 45 sec to reduce aerodynamic heating. In addition, there was a planar trap mounted flush with the surface of the cylindrical section. The probes carried a programed voltage to control the collection of ions and electrons from the ambient medium.

The planar trap and two spherical probes produced good data, but one of the spherical probes on the 6-inch flexible support had no data as a result of a broken internal connection.

NRC Photometer

(Radio and Electrical Engineering Division, NRC)

This instrument was identical with the one in AA-II-103. The photometer worked well but data quantity was limited by the low spin rate, resulting in very little scanning.

Ionospheric Inhomogeneities

(University of Western Ontario)

This equipment was similar to that in AA-II-103, with the exception that the package was ejected from the rocket at T + 45 sec at an altitude of about 190 kft.

For the first few seconds after ejection, there was considerable signal flutter, after which the signal became relatively steady, but at a reduced strength. However, the signal was at a high enough level to produce satisfactory data at the ground receiving station operated by UWO. Since ejection was at an altitude of about 40 kft lower than that in AA-II-103, the disturbance in the signal was probably caused by aerodynamic forces which twisted the antennas and either broke them off or tangled them in some manner.

Neutron Detector

(University of Alberta, Calgary)

The purpose of this experiment was to record neutrons in the energy range 1 to 10 MeV. This was a continuation of measurements made in several previous rocket flights, designed to improve the statistics on the exponent of the neutron energy spectrum above the atmosphere. The detector consisted of a Cerenkov-scintillator combination followed by shape discrimination and coincidence circuitry to separate neutron pulses from charged particles and gamma rays. The detector was located near Station 30 in the nose cone,and was thermally insulated and shielded from the remainder of the payload with a block of polyethylene to reduce the effect of albedo neutrons produced in the rocket.

Operation of the equipment was satisfactory and good data were obtained.

Micrometeoroid Detectors

(Upper Atmosphere Research Section, Radio and Electrical Engineering Division, NRC)

This apparatus involves the detection of micrometeoroid impacts on a surface by sensors tuned to a narrow band of ultrasonic frequencies. The sensor is followed by a signal processing circuit so that the data can be sampled at ten samples per second in the telemetry system.

In this rocket there were four detectors:

1) Two Mk III types tuned to 800 kHz, and mounted 6 inches apart on the conical section of the nose cone, which is used as the sensing surface.

2) Two Mk IV types, each having its own isolated sensing surface about 4 inches in diameter. They were located diametrically opposite each other in the cylindrical section with protective covers which were blown off at T + 40 seconds.

During pre-flight check-out of the Mk III system, some electrical interference was found to be caused by the turning on of the event oscillators at 1-second intervals. Capacitive by-passing at the input to the event oscillators made no improvement, but the interference was reduced to an acceptable level by tightening all coaxial connectors and slightly reducing the gain of one channel.

In flight, the magnitude of the interference increased so that the ability of the Mk III systems to detect small micrometeoroids was limited, although there are some events recorded. Comparing records of previous flights, a low level of activity is indicated. The Mk IV worked throughout the flight and covers came off as planned, but no impacts were recorded, indicating a low micrometeoroid density.

Galactic X-Ray

(University of Alberta, Calgary)

The purpose of this equipment was to measure galactic X-rays, but in rocket 104 the system was flown to check its ability to withstand a rocket environment and to measure auroral X-rays. The detector was mounted with its axis at right angles to the rocket longitudinal axis with a heavy lead shield surrounding all but the window. The data were converted to an 8-bit word pulse code. In addition, the X-ray events were scaled down by 2^{10} and mixed with the coded data at the input to the 70 kHz subcarrier oscillator.

A quick look at the data indicated that the equipment operated satisfactorily.

Auroral Scanner

(University of Alberta, Calgary)

The scanner consisted of a 5577 Å photometer which viewed a rotating mirror. The rotating mirror caused the photometer to scan in an arc starting from a direction parallel to the rocket axis toward the tail of the rocket, sweeping upwards until it looked straight out perpendicular to the rocket axis, and continuing upwards until parallel to the axis in the direction of the nose tip. At this point, the other side of the rotating mirror began another scan from the bottom. An optical trigger system provided a sync pulse each time a new sweep began. To provide an unobstructed field of view for the scanner, the entire instrument was pushed out several inches beyond the skin after motor burnout.

The video signal from the photometer was fed into a logarithmic amplifier which provided an output ranging from 2 to 5 volts. Sync pulses were amplified and shaped, then brought out on a separate line.

The motor turned at 3000 rpm, and this provided one complete sweep each 10 msec. The photometer had an angular resolution of 2 degrees, providing about 100 picture elements for each sweep. The dwell time on each picture element was thus 100 μsec. As the vehicle spun, the entire sky was scanned, producing pictures of the visual aurora at rocket altitudes.

A cathode-ray tube display system was fabricated by NRC so that a 35-mm film record could be made during this flight. A vertical sweep was generated and synchronized to the scanner trigger pulses. Horizontal scanning was achieved by continuously moving the film at a constant rate. The scanner video signal was used to modulate the intensity of the CRT display, thus reproducing a picture of the visual aurora as seen by the scanner in real time.

One of the aims of this experiment was to study the correspondence between regions of high auroral luminosity and regions of X-ray sources of energies greater than 15 keV.

Since this vehicle had a very slow spin rate (a period of about 90 seconds) coupled with a slow flat spin, there was a very limited scanning of the sky. Since the calibration pulses and the trigger pulses were normal, the auroral scanner system appeared to have operated well over the complete flight. However, there was no auroral signal until about T + 240 sec.

There are two possible reasons for this delay in received signals:

1) The scanner was looking at dark sky

2) The cover did not come free until T + 240 sec

The second reason is possible, although not very probable since the bellows actuators operated as planned at T + 40 sec.

X-Ray Detector

(University of Alberta, Calgary)

The equipment was designed to detect auroral X-ray events with energies between 15 keV and 150 keV. The detector, a Harshaw scintillator, was encased in a lead shield about 1/8-inch thick, leaving a window about 1-inch in diameter so that X-rays were detected from one direction only. The signal pulses were fed into a 2^6 scaler giving a total count. They were also fed into circuits which accepted pulses with amplitudes corresponding to X-rays within the desired energy band, then to a pulse stretcher which resulted in 50-μs pulses, followed by a minimum space of 50 μs; i. e. a maximum rate of 10k pulses per second.

These signals, together with the output of the auroral scanner, each modulated a subcarrier oscillator, and were then combined to modulate link no. 2 telemetry transmitter as follows:

Signal	SCO	Discriminator Output Bandwidth
X-ray pulses	Band E (70 kHz)	8 kHz - 5% amplitude resolution
Auroral scanner video	Band C (40 kHz)	3 kHz
X-ray scaler	Band A (22 kHz)	3 kHz
Auroral scanner trigger pulses	Direct modulation	10 kHz

In-flight calibration is provided from a 100 pps multivibrator of constant amplitude and a small amount of Cs 137 on the detector face. Before the flight, the upper and lower discriminator levels are calibrated relative to an external voltage source. For external calibration the multivibrator rate is speeded up to 1000 pps and pulse height is proportional to the external calibrate voltage. A 60-cycle ripple voltage is superimposed on the external dc control levels. At each discriminator level this provides a 60-cycle off-on modulation on the pulse display, which simplifies the setting of these two levels. The ac ripple voltage was very effective in laboratory check-out and prelauncher checks at the Churchill Research Range, but was not so successful when the payload was on the launcher, owing to interference pick-up in the long umbilical lines.

In AK-II-104 this equipment operated satisfactorily recording several periods of greatly increased counting rates during the rocket flight. The X-ray detector in the balloon which was at float altitude (100 kft) at this time was also detecting counting rates of 300 to 500 per second.

HOUSEKEEPING DATA

The following subsections deal with the performance of portions of the payloads which are the responsibility of the Space Electronics Section. These include such items as batteries, event timers, power supplies, temperature monitors, and vehicle performance monitors.

Batteries

Battery performance in both vehicles was satisfactory. Fourteen battery packages were used in each. Details of battery allocation are given in the work sheets of Appendix no. 1. The major portion of payload energy was provided by silver-zinc and nickel-cadmium cells. Mercury cells were used in three experimenters' packages, but in each case battery life was adequate for check-out and launch, and therefore did not require replacement.

Wet discharged silver-zinc cells were used in these payloads. One exception was a dry-charged cell used for trigger and calibration lamps in the auroral scanner in AK-II-104. In that case, no external charge-discharge line was available for the cell and using a dry-charged cell avoided problems associated with the peroxide peaks on wet-discharged type cells. No silver-zinc cells were charged after installation in the payload. Nickel-cadmium batteries were charged as required to keep them near their peak capacity.

The squib battery, eight HR-1's, in AA-II-103, was heavily overloaded for 7 seconds commencing at T + 50 sec. No estimate of current is possible, but voltage monitored about 18 inches away was approximately 3.0 volts. It is postulated that an excessive current was drawn by a short circuit on the line to the tip ejection bellows actuators. Although heavily loaded, this battery had sufficient energy to fire bellows actuators to release plasma probes and the ionospheric inhomogeneities package at T + 50 and T + 55 sec, respectively. The battery recovered quickly to 12.0 volts when the timer contacts opened again.

Timed Events

Both payloads used two Raymond mechanical timers, operated in parallel, to initiate timed events. These units had been modified to limit contact closure to 7 seconds. As it turned out, this was a wise precaution since the short circuit in AA-II-103 occurred at the second event in the sequence. If this short had not been removed by timer contact opening, partial failure of the third cam events would likely have occurred. In future, all timer closures will be limited.

The first of three times on both sets of timers were used to multiplex telemetry channels at T + 30 sec. The events and times initiated by the timers for the two payloads are shown in the Work Sheets in Appendix No. 1, and operation in the vehicles is summarized below.

AA-II-103

Three events were scheduled for T + 50 sec – extension of two $\frac{1}{4}$-inch plasma probes and ejection of nose cone tip. Both probes erected as planned but the nose cone tip was not ejected due to a suspected short in the wiring to the bellows actuators. A description of possible causes for this failure is given in the section dealing with the 4-channel auroral photometer.

The T + 55 sec cam initiated two events. The first, the ejection of the ionospheric inhomogeneities package occurred as planned. The second event is slightly more complex and results are confused. At T + 55 sec the contact closure was to fire a bellows actuator to release the extension mechanism for the soft-electron spectrometer detector and to energize a relay to initiate a further 25-second delay. After the second delay, the high voltage to the detector was turned on. Detector extension was to be indicated by a transient signal super-imposed on the experimental data. No such indication was seen. However, the high voltage did come on about T + 80 sec. Further analysis of SES data will be required to determine whether the detector extended or not, but it seems certain that power was connected to the bellows actuator. In addition, the high counting rate recorded indicates that the detector did extend, otherwise the rocket skin would have provided excessive shielding.

AK-II-104

At T + 40 sec, bellows actuators were fired to release the extension mechanism for the auroral scanner and to release doors over micrometeoroid detectors. These events apparently occurred as planned. Telemetry event oscillators confirm that the micrometeoroid doors came off but there is no event indication of the auroral scanner extension. Since an output signal was obtained from the scanner, it is probable that the mechanism did extend.

The telemetry monitors of events occurring at T + 45 sec were obscured by a signal drop-out. Signal strength records for the I.I. package indicate that the package did eject at the correct time. After the reacquisition of signal, event monitors indicated that the I.I. ejection and galactic X-ray door ejection had occurred. The monitor on the rigid $\frac{1}{4}$-inch plasma probe does not indicate full extension until T + 368 sec; however, partial extension apparently occurred early in flight, since useful data were obtained from this probe.

Temperature

The vehicles were instrumented with sensors for in-flight temperature measurements. In addition, each payload had a sensor to measure frame temperature in the payload via the umbilical.

Both rockets were launched from the outside Black Brant launcher. This is an open launcher. When on the launcher the rocket is kept warm by enclosing it in a polyethylene bag and pumping heated air in at the base of the bag. This system worked too well, and blowers had to be turned off periodically to keep the payload temperature from rising too high.

Vehicle AK-II-104 had two temperature sensors: one, consisting of two RN-100 Rdf Stikon sensors connected in series, was mounted on a shelf fastened to the skin at Station 20, and the second, a 100-kΩ thermistor, was mounted on the electronics card in the auroral scanner. Skin temperature reached 460°F at T + 140 sec and near end of flight a maximum temperature of 560°F was reached. Temperature in the scanner electronics remained constant at 95°F throughout flight.

In AA-II-103, a BN-200 Rdf Stikon temperature sensor was mounted on the tip release fixture at Station 32 and a 100-kΩ bead thermistor was mounted on a shelf at Station 47. The BN-200 sensor was shorted just after T + 20 sec until T + 303 sec. The temperature at Station 32 was 87° F just prior to the short circuit, and maximum temperature near end of flight was 340 °F. Temperature of the shelf increased uniformly throughout flight from 67° F at lift-off to 94° F just before impact.

High Voltage Supplies

Since both payloads were flown in unpressurized nose cones special consideration had to be given to high-voltage supplies for photomultipliers. The solution selected was to enclose the high-voltage portion of the supply - the voltage multipliers and regulator - in a pressurized container. The case was a cylinder with one end permanently sealed and the other end, which supports the circuitry and connectors, was sealed with an "O" ring. Each unit contained a pressure switch to indicate loss of pressure. A total of six units were flown in the two payloads without failures.

The diaphragm in the pressure switches for these units was porous so that after standing for periods longer than a few days, the switch indicated a false pressure failure. A better pressure switch is now being sought for future units.

Vibration Transducers

Each payload was instrumented with two vibration transducers. In general, both flights were quite smooth with no prolonged periods of vibration, nor were levels excessive. In AA-II-103 the longitudinal vibration transducer was mounted on a shelf in the forward body at approximately Station 100, and about 4 inches from the shelf support. The lateral vibration transducer was mounted on the support leg of the structure at the same station. Longitudinal axis vibration at T + 3.1 sec, T + 14.3 sec, and T + 15.2 sec reached levels of 5.4 g, 10.6 g, and 7.0 g, each for periods less than 0.05 second. The lateral accelerometer showed levels of 2.5 g at T + 14.3 and T + 15.2 sec. For a period of 8 seconds after T + 2 sec, the vibration levels on the longitudinal accelerometer were about 2.5 g. The dominant frequency was about 200 cps with less significant levels at 170 and 130 cps. Frequencies up to 1200 cps were present but at relatively low amplitudes.

In AK-II-104 the longitudinal-axis accelerometer transducer was mounted on the annular support ring for the instrument frame in the conical section of the nose cone at Station 87. The lateral transducer was mounted on the support chute for the auroral scanner package at Station 101.

Vibration levels were also quite low in this payload. The maximum level on the longitudinal axis transducer was about 8.5 g at T + 19.4 sec for a period of .03 sec. Before this, at T + 1.4 and T + 1.9 sec, two bursts occurred at about 4 g. From T + 3 to T + 13 sec vibration was continuous at about 0.5 g with bursts to 2.0 g. Frequencies present were again 100 and 200 cps with higher frequencies around 1000 cps.

A similar pattern of vibration is recorded on the lateral transducer, but bursts are more frequent and last longer. Peak levels at T + 1.4 and T + 19.4 sec are 6 g and 3.0 g. During the period from T + 3 to T + 13 sec peak levels of the bursts reach 5.0 g and are typically about 4.0 g.

Low-Frequency Accelerometers

Longitudinal acceleration in AA-II-103 had a maximum of 15.85 g at T + 12.5 sec, and first zero crossing occurred at T + 17 sec. Lateral accelerations were moderate; peak levels were about 1 g.

In vehicle AK-II-104 the longitudinal accelerometer showed maximum of 15.9 g at T + 12.7 sec and first zero crossing at T + 17 sec. The lateral accelerometer indicates levels less than 0.4 g peak-to-peak.

Component Failures

A few failures occurred in components standard to all payloads, however only one caused loss of experimental data. The components that failed were two magnetometers, an in-flight telemetry calibrator, and a subcarrier oscillator. A second subcarrier oscillator is suspected of failing; however, since this failure was during flight, definite confirmation is not possible. Faults in the two magnetometers and one subcarrier oscillator were found during check-out at the range and these units were replaced. Intermittent operation of one magnetometer and one subcarrier oscillator was caused by apparent physical deformation of circuitry when mounting screws were tightened. This is considered a design fault of the units since screw travel is not limited and the case is not rigid enough to protect the compact circuitry.

Telemetry indication is that the SCO that failed in flight swung to beyond the upper IRIG band edge. Another SCO had failed in the same manner, during pre-flight tests and was replaced at Churchill.

The in-flight telemetry calibrator failed before launch, but failure was not detected. The calibrator inserts upper and lower-band edge alternately at 10-second intervals. Only upper-band edge calibration was present.

CONCLUDING DISCUSSION

During this trip to the Churchill Research Range it was originally planned to launch three Black Brant II rockets - AA-II-103, AK-II-104, and AA-II-105. However, only the first two were fired, and the third one was returned to Ottawa for firing at a later date. There were two major reasons for this decision:

1) the partial loss of telemetry signal;

2) the wide deviation of spin rate from the predicted design value.

The exact cause of the telemetry failure was not known at that time, although some effect from low pressure was suspected.

The spin rate was set at a nominal value of 0.65 cps, but AA-II-103 spun at 1.24 cps and AK-II-104 at .011 cps. This wide variation of spin rate reduced the amount of data obtained from those experiments that employed scanning systems. When several sensors are used on a time shared basis, or when some parameter is programed, such as a sweep voltage, a spin rate higher than the predicted value causes loss in data. When spatial scanning relies upon rocket spin, of course, a very slow spin rate also causes loss of data. In addition, the hours of astronomical darkness each night were rapidly diminishing, limiting the time available for correcting the faults at Churchill. As a result, it was decided to return to Ottawa so that these faults in the rocket could be thoroughly investigated and corrected before attempting to launch AA-II-105.

Useful data were obtained from most of the experiments in both rockets with the exception of the University of Saskatchewan photometer, because of the failure of the nose tip to separate. This failure emphasizes the need for adequate redundancy in critical parts of a payload system.

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Operations Requirement for Black Brant Rocket AA-II-103, OR-170, NRC Report ERB-721, October 1965

Operations Requirement for Black Brant Rocket AK-II-104, OR-171, NRC Report ERB-722, October 1965

ENG.WORK SHEET: GENERAL REQUIREMENTS		ROCKET: AA-II-103
STATUS: ISSUE - 3	PREP.DATE: 3/12/65	EXP.DATE:	FIR.DATE: MAR/66

TRIAL COORDINATOR:

PROJECT SCIENTIST:
E. BUDZINSKI NRC

ROCKET CONFIGURATION:

15KS2500 MOTOR
BB II NOSE CONE & EXTENSION
BB II CANADAIR FINS (4)
ROLL RATE 0.4 rps

LAUNCH CONDITIONS:

1. 30 mc RIOMETER 2db and VISUAL AURORA INTENSITY I ON TRAJECTORY
OR
VISUAL INTENSITY III ON TRAJECTORY.

ELEV: AZ. RECOVERY

PRIMARY EXPERIMENTS:

COSMIC RAYS (NRC)
PLASMA PROBES II (NRC)
AURORAL PHOTOMETER (U of S)
SOFT ELECTRON SPECTROMETER (DRTE)
IONIZATION CHAMBER (DRTE)
IONOSPHERIC INHOMOGENEITIES (UWO)
PHOTOMETER (NRC)

ROCKET EVENTS:

	TIME	T/M LINK
MULTIPLEX	T+30	LINK #1
2 of 1/4 PLASMA PROBE	T+50	LINK #1-2
NOSE TIP EJECTION	T+50	LINK #1
DRTE S.E.S.	T+55	LINK #1
I.I. EJECTION	T+55	LINK #3

FREQUENCY UTILIZATION:

	LINK NO.	Tx.	POWER	FREQ.	MOD.	ANT.	POL.
NOSE CONE T/M #1	1	CBA	1	219.5	FM/FM	QUAD	LIN.
BEACON	—	DPN-41	100	2900 Tx	PULSE	QUAD	LIN
NOSE CONE TLM #2	2	CBA	1	240.2	FM/FM	QUAD	LIN.
IONOSPHERIC INHOMOGENEITIES	3	UWO	250 mw	108	C.W.	TAPE	LIN

ENG.WORK SHEET: Telemetry *Link #1* | ROCKET: *AA-II-103*

STATUS: *ISSUE - 3* | PREP.DATE: *3/12/65* | EXP.DATE: | FIR.DATE: *MAR/66*

EXPERIMENT:	POWER	SUB-CAR. CHANNEL
TIP RELEASE (CONN.)		400 cps
TIP RELEASE (CONN.)		560 cps
NRC. PHOTOMETER PRESSURE		730 cps
70 kft. ALT. SW.		960 cps
I.I. EJECTION		1.3 Kc
TIP EJECTION		1.7 Kc
LINEAR ACC ±5G 0° 4278A PHOT. CH.A EMISSION		3.9 Kc BW 59
LINEAR ACC ±5G, 270° CWLF COSMIC RAY		5.4 Kc BW 81
LINEAR ACC $\pm\frac{20}{3}$G Z-AXIS 4278A PHOT. CH.B REFERENCE		7.35 Kc BW 110
* COSMIC RAY		10.5 Kc BW 160
* COSMIC RAY		14.5 Kc BW 220
PLASMA PROBE SPHERE DC		22 Kc BW 330
* VIBRATION LATERAL COSMIC RAY		30 Kc BW 450
* COSMIC RAY		40 Kc BW 600
* VIBRATION Z-AXIS DRTE SPECTROMETER		52.5 Kc BW 790
COMMUTATOR 10x30		70 Kc BW 1050

EXPERIMENT:	POWER	COMMUTATOR CHANNEL
FLUCTUATION PHOT. CH #2 DC		1
55" SQUIB MON.		2
MAGNETOMETER 295° CWLF		3
DRTE IONIZATION CHAMBER		4
50" SQUIB MON.		5
PLASMA SWEEP MON		6
AURORAL PHOTOMETER CAL. LIGHT MON.		7
FLUCTUATION PHOT. CH. #1 DC		8
PLASMA PROBE DC		9
MAGNETOMETER 25° CWLF		10
DRTE IONIZATION PHOTOMULT		11
0V		12
BEACON RCVR.		13
BEACON R.F.		14
BEACON BATT -6.5V		15
CH.		16
SQUIB +12V MONITOR		17
MAGNETOMETER 295° CWLF		18
DRTE IONIZATION CHAMBER		19
NRC PHOT. PWR MON.		20
PLASMA SWEEP MON.		21
5V		22
CH. 8		23
PLASMA RECTIFIED AC		24
MAGNETOMETER 25° CWLF		25
DRTE IONIZATION PHOTOMULT.		26
SUBCOMM		27
SUBCOMM.		28
MASTER		29
MASTER		30

* NO IN-FLIGHT CALIBRATION

ENG.WORK SHEET:	SUBCOMMUTATOR *Line #1*	ROCKET: *AA-II-103*

STATUS: *ISSUE - 3*	PREP.DATE: *3/12/65*	EXP.DATE: :	FIR.DATE: *MAR/66*

INPUT	DC 25 PIN	SEQUENCE	INPUT	DC 25 PIN	SEQUENCE
TLM #1 +12V	1	1	±15V for U.V.S PHOTOMETER	11	11
TLM #2 +12V	2	2	4278 PHOTOMETER H.V	12	12
LATCH IND.	3	3	FLUCTUATION PHOTOMETER H.V	13	13
TLM #2 +29V	4	4	PLASMA PROBE B1 - B2	14	14
TLM #2 - 6V	5	5	PLASMA PROBE B3 - B4	15	15
TLM #1 - 6V	6	6	PLASMA PROBE B5	16	16
GENERAL SUPPLY +26	7	7	TEMPERATURE TIP RELEASE FIXTURE BN200	17	17
GENERAL SUPPLY -18	8	8	DRTE + 14V	18	18
TLM #1 +29V	9	9	DRTE - 19V	19	19
TLM 5V CAL.	10	10	TEMP SHELF I. K109 200°F	20	20
WIPER 1 to 10	13		WIPER 11 to 20	14	

MARKED, IF USED, GROUNDS ON POSITION 1 ONLY

ENG.WORK SHEET:	Telemetry LINK #2	ROCKET: AA-II-103.
STATUS: ISSUE - 3	PREP.DATE: 3/12/65	EXP.DATE:

FIR.DATE: MAR/66

EXPERIMENT:	POWER	SUB-CAR. CHANNEL
NRC PHOTOMETER.		3.9 Kc BW 59
COSMIC RAY		5.4 Kc BW 81
FLUCTUATION PHOT. CH. #1 AC SIGNAL		7.35 Kc BW 110
		10.5 Kc BW 160
		14.5 Kc BW 220
		22 Kc BW 330
PLASMA PROBE TRAP DC		30 Kc BW 450
PLASMA PROBE AC SIGNAL		40 Kc BW 600
FLUCTUATION PHOT. CH. #2. AC SIGNAL		52.5 Kc BW 790
		70 Kc BW 1050

EXPERIMENT:	POWER	COMMUTATOR CHANNEL
		1
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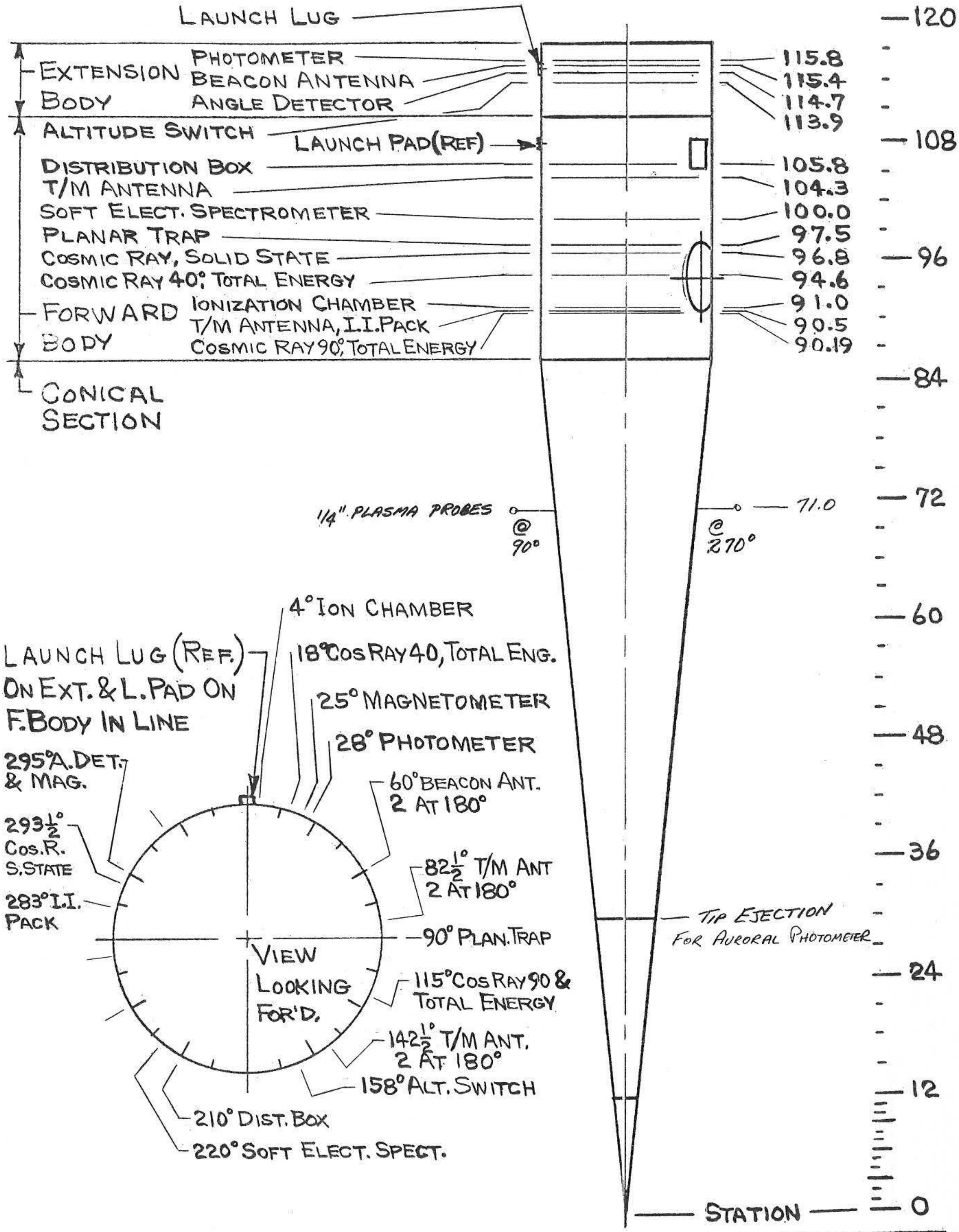
ENG. WORK SHEET: Umbilical | ROCKET: AA-II-103

STATUS: ISSUE - 3 | PREP.DATE: 3/12/65 | EXP.DATE: | FIR.DATE: MAR/66

EXPERIMENT:	FUNCTION:	GND	NO.	EXPERIMENT:	FUNCTION:	GND	NO.
BEACON	+150V PLATE		1	PLASMA PROBE	B3(+)		26
"	-22.5V BIAS		2	"	B4(-)		27
"	-6.5V MON.		3	"	B5(+)	×	28
"	GND		4	DRTE PKG's	IONIZATION CHAMBER PWR OFF		29
"	EXT. PWR -6.5V		5	"	SPECTROMETER PWR OFF		30
"	LEDEX CONTROL		6	TLM #2	EXT -12V		31
"	INDICATOR		7	H-FRAME TEMP			32
COSMIC RAY	LATCH CONTROL (+) INT (-) EXT.		8	SUBCOMM.	POSITION IND		33
TLM #2	EXT +30V		9	SUBCOMMUTATOR	+26V TO STAIRCASE		34
"	(+) INT/(-) EXT LATCH CONTROL		10	"	EXT. +26V STEPPING CONTROL		35
"	EXT. LINE RELAY CONTROL		11	"	EXT. LINE. LATCH IND / SIGNAL		36
TIP DEFLECTION SQUIB BATT.	EXT. LINE		12	COMM. /CALIB. BATT. & SUBCOMM.	LATCH CONTROL (+) INT /(-) EXT.		37
AURORAL PHOTOMETER & GEN SUPPLY	LATCH CONTROL (+) INT /(-) EXT		13	COMM. /CALIB. BATT	EXT. LINE		38
"	EXT -18V		14	TLM	MULTIPLEX RELAY; (-) FLIGHT (+) TRANSFER		39
"	EXT +26V		15	COMM. /CALIB BATTERY	EXT. LINE RELAY CONTROL		40
"	EXT. LINE RELAY CONTROL		16	TLM	COMMUTATOR PWR OFF		41
DRTE PKG's	EXT LINE +14		17 ×		EXT. LINE -12V		42
"	EXT LINE -20		18 ×		EXT. LINE RELAY CONTROL		43
"	LATCH CONTROL (+) INT (-) EXT.		19		GND		44
"	EXT. LINE RELAY CONTROL		20 ×		EXTERNAL LINE (-) +29V		45
PLASMA PROBE	LATCH CONTROL (+) INT /(-) EXT.		21		LATCH CONTROL (+) INT /(-) EXT.		46
"	EXT LINE RELAY CONTROL		22		EXT. CALIBRATE SIGNAL		47
"	B1 (+)		23 ×		RELAY CONTROL CALIBRATE.		48
"	B2 (-)		24		CALIBRATOR (+) ON /(-) OFF		49
	PWR. GND.		25	"	PWR. GND.		50

ENG.WORK SHEET: Batteries 30.11.65			ROCKET: AA-II-103.						
STATUS: ISSUE # 3			PREP.DATE: / EXP.DATE:				FIR.DATE: Mar. '66		
NO.	BATTERIES TYPE	BATTERIES VOLTS	EXPERIMENT	LOAD MA.	LIFE ON LOAD	TEMP. RANGE °F	UMBILICAL CH'RG	UMBILICAL ON/OFF	UMBILICAL MON'T.
1	20 x HR-1½	+29V	TLM #1	1200			✓	✓	✓
2	10 x 225BH	-12V	TLM #1	50			✓	✓	✓
3	25 x 1.2 SC	+30V	TLM # 2	800			✓	✓	✓
4	10 x 225BH	-12V	TLM # 2	50			✓	✓	✓
5	22 x 500 BH	+26.4	COMMUTATOR	30			✓	✓	✓
			SUBCOMMUTATOR	120					
			CALIBRATOR	50/300					
			MULTIPLEX RELAYS	30	/230				
6	8 x HR-1½	+12V	BELLOWS - T+50	6000			—	—	✓
			T+55	3000					
7	22 x 500 BH	+26.4	MAGNETOMETERS	70			✓	✓	✓
			VIBRATION ACC.	40					
			NRC. PHOTOMETER ELEC. / H.V.	25 / 110					
			AURORAL PHOTOMETER U/S	125	/370				
8	15 x 500 BH	-18V	MAGNETOMETER -6V TAP	15			✓	✓	✓
			NRC PHOTOMETER H.V.	110					
			AURORAL PHOTOMETER U/S	40					
			VIBRATION ACC. AMP.	45					
			TEMP BN200	10	/220				
9	12 x 1.2 SC	+14V	DRTE. PACKAGES.	440			✓	✓	✓
10	17 x 1.2 SC	-20V	DRTE. PACKAGES	735			✓	✓	✓
11	5 x HR-5½	70V	BEACON	3500			—	✓	✓
12	Hg MALLORY CSR-136		COSMIC RAY				—	—	—
13	Hg		IONOSPHERIC INHOM.				—	—	—
14	225BH	±12V	PLASMA PROBE				✓	✓	✓

ENG. WORK SHEET: NOSE CONE			ROCKET: AA-II-103
STATUS: ISSUE 3	PREP. DATE: 3/12/65	EXP. DATE:	FIR. DATE: MAR/66



ENG. WORK SHEET: GENERAL REQUIREMENTS		ROCKET: AK-II-104	
STATUS: ISSUE - 3	PREP. DATE: 3/12/65	EXP. DATE:	FIR. DATE: MAR/66

TRIAL COORDINATOR: A. STANIFORTH

PROJECT SCIENTIST: C.D. ANGER

ROCKET CONFIGURATION:

15 KS 25000 MOTOR

STD BB II NOSE CONE

0.4 RPS ROLL

BB II CANADAIR FINS (4)

REF. AZIMUTH IS L. LUG PAD

L. LUG AT 315°

LAUNCH CONDITIONS:

1ST TWO NIGHTS
1) INTENSITY III AURORA IN TRAJ. OR
2) 3db 30MC RIOMETER ABS. IN TRAJ. OR
3) BALLOON X-RAY 1000 CTS/SEC. OR
4) 300 CTS/SEC AND 2DB ABS. OR II AURORA

AFTER TWO NIGHTS
1) BALLOON X-RAY 300 CTS/SEC OR
2) 150 CTS/SEC AND 1 DB ABS. OR I AURORA

ELEV. 85° AZ. N/R RECOVERY N/R

PRIMARY EXPERIMENTS:

NEUTRON DETECTOR U of A

PLASMA PROBES NRC

PHOTOMETER NRC

GALACTIC X-RAY

IONOSPHERIC INHOMOGENEITIES UWO

X-RAY DETECTOR & AURORAL SCANNER

MICROMETEORITE MK III (2) + MK IV (2)

ROCKET EVENTS:

	TIME	T/M LINK
MULTIPLEX	T+30 SEC	#1
AURORAL SCANNER EXTENSION	T+40 SEC	#2
M.M. DOORS OFF	T+40 SEC.	#1
1/4" DIA. PLASMA PROBES (3) EXTENSION	T+45 SEC	#1
I.I. EXIT	T+45 SEC	#3
GAL. X-RAY DOOR RELEASE	T+45 SEC	#1

FREQUENCY UTILIZATION:

	LINK NO.	Tx.	POWER	FREQ.	MOD.	ANT.	POL.
NOSE CONE T/M	1	CBA	1	219.5 Mc	FM/FM	QUAD	LIN.
BEACON	—	DPN-4L	100 W	2900 Tx	PULSE	QUAD	LIN.
X-RAY & AURORAL SC.	2	CBA	1	240.2	FM/FM	QUAD	LIN
I.I.	3	UWO	250 mw	~108	CW	FLEX TAPE	LIN

ENG.WORK SHEET:	Telemetry LINK #1	ROCKET: AK-II-104	
STATUS: ISSUE 3	PREP.DATE: 3/12/65	EXP.DATE:	FIR.DATE: MAR/66

EXPERIMENT: * NO IN-FLIGHT CALIB.	POWER	SUB-CAR. CHANNEL
AURORAL SCANNER EXIT X-RAY EHT PRESSURE	EVENT	400 cps
I.I. EXIT	"	560 cps
M.M.#1 DOOR RELEASE GAL. X-RAY EHT PRESSURE	"	730 cps
M.M.#2 DOOR RELEASE PHOTOMETER PRESSURE	"	960 cps
70 K ALT. SWITCH	"	1.3 kc
P.P. EXTENSION GAL. X-RAY DOOR	"	1.7 kc
NRC PHOTOMETER		3.0 kc
* LINEAR ACC. LATERAL 45° CWLF $\pm$5G NEUTRON DETECTOR, A		3.9 Kc BW 59
* LINEAR ACC. LATERAL -45° $\pm$5G NEUTRON DETECTOR B		5.4 Kc BW 81
PLASMA PROBE SWEEP MONITOR		7.35 Kc BW 110
LINEAR ACC. Z-AXIS $^{+20}_{-3}$G PLASMA PROBE CYLINDRICAL "1/4" AC		10.5 Kc BW 160
PLASMA PROBE TRAP DC		14.5 Kc BW 220
PLASMA PROBE TRAP AC		22 Kc BW 330
PLASMA PROBE SWEPT PROBE		30 Kc BW 450
STA. 101 130° VIBRATION LATERAL PLASMA PROBE 1/4" AC		40 Kc BW 600
* COMMUTATOR		52.5 Kc BW 790
* STA. 87 215° VIBRATION Z-AXIS GALACTIC X RAY		70 Kc BW 1050

EXPERIMENT:	POWER	COMMUTATOR CHANNEL
0		1
5V		2
MAGNETOMETER 45 REF. L.L.P. CWLF		3
MICROMETEORITE MK III -2		4
MICROMETEORITE MK IV A1		5
PLASMA PROBE CYC. DC		6
BEACON RCVR.		7
BEACON R.F.		8
MICROMETEORITE MK IV A2		9
MAGNETOMETER 135° REF. LLP. CWLF		10
BEACON BATT.		11
MICROMETEORITE MK IV A3		12
PLASMA PROBE CON. DC		13
PHOTOMETER 50K ALT. SW.		14
PLASMA PROBE CON. AC.		15
MICROMETEORITE MK IV B1		16
TLM #1 +29V		17
MAGNETOMETER 45°		18
TLM #2 +30V		19
MICROMETEORITE MK IV B2		20
PLASMA PROBE CYC. DC.		21
40 SECOND SQUIBS		22
MICROMETEORITE MK IV B3		23
45 SECOND SQUIBS		24
MAGNETOMETER 135°		25
SUBCOMM.		26
MICROMETEORITE MK III.1		27
SUBCOMM.		28
MASTER		29
MASTER		30

ENG.WORK SHEET:	SUBCOMMUTATOR		ROCKET: AK-II-104		
STATUS: ISSUE - 3	PREP.DATE: 3/12/65		EXP.DATE:	FIR.DATE: MAR/66	

INPUT	DC 25 PIN	SEQUENCE	INPUT	DC 25 PIN	SEQUENCE
TLM #1 +12 V	1	1	MM IV B+	11	11
SQUIB BATT. MONITOR	2	2	P.P. B_1/B_2	12	12
LATCH INDICATE (COMM. +26 V 500 BH)	3	3	P.P. B_3	13	13
AURORAL SCANNER TEMPERATURE	4	4	P.P. B_4	14	14
NOSE CONE TEMPERATURE	5	5	P.P. B_5	15	15
NEUTRON EHT	6	6	GENERAL +26 V & AURORAL SCANNER PRESSURE	16	16
X-RAY EHT	7	7	GENERAL -18 V	17	17
AURORAL SCANNER EHT	8	8	A/S LIGHT MONITOR	18	18
GALACTIC X-RAY EHT	9	9	A/S MOTOR BATTERY MONITOR	19	19
TLM #1 -6 V	10	10	NEUTRON PRESSURE	20	20
WIPER 1 to 10	13		WIPER 11 to 20	14	

MARKED, IF USED, GROUNDS ON POSITION 1 ONLY

SUPPLEMENT TO ENG. WORK SHEET: ISSUE No 3 TELEMETRY LINE #2-240.2 ROCKET - AA-II-104

PREP. DATE. ISSUE No.

DATA.	CHANNEL
X-RAY PULSE	70Kc SCO BAND E
X-RAY SCALAR	22kc SCO BAND A
AURORAL SCANNER VIDEO	40kc SCO BAND C
AURORAL SCANNER TRIGGER.	DIRECT MODULATION

ENG. WORK SHEET:	Umbilical			ROCKET: AK-II-104			
STATUS: ISSUE - 3	PREP. DATE: 3/12/65			IMP. DATE:	FIR. DATE: MAR/66		
EXPERIMENT:	FUNCTION:	GND	NO.	EXPERIMENT:	FUNCTION:	GND	NO.
BEACON	+150^V PLATE		1	PLASMA PROBES	B_1 (+)		26
"	-22.5^V BIAS		2	"	B_2 (-)		27
"	-6.5^V MON.		3	"	B_3 (+)		28
"	GND		4	"	B_4 (-)		29
"	EXT. PWR. -6.5^V		5	"	B_5 (+)		30
"	LEDEX CONTROL		6	GALACTIC X-RAY	POWER OFF		31
"	INDICATOR		7	H-FRAME TEMP.			32
NEUTRON & EVENT SW.	POWER OFF		8	SUBCOMMUTATOR	POSITION IND.		33
TLM #1	+5^V MON.		9	"	+26^V to STAIRCASE		34
TLM #2	EXT. LINE +30^V		10	"	EXT. +26^V STEPPING CONTROL		35
"	LATCH CONTROL (+) INT / (-) EXT		11	"	EXT. LINE LATCH IND. / SIGNAL		36
"	EXT. LINE RELAY CONTROL		12	COMM. BATT. SUBCOMM.	LATCH CONTROL (+) INT. / (-) EXT.		37
GENERAL SUPPLY	LATCH CONTROL (+) INT / (-) EXT		13	COMM. / CALIB. BATTERY	EXT. LINE		38
"	EXT. -18^V		14	TLM.	MULTIPLEX RELAYS (-) FLIGHT / (+) TRANSF.		39
"	EXT. +26^V		15	COMM. / CALIB. BATTERY	EXT. LINE RELAY CONTROL		40
"	EXT. LINE RELAY CONTROL		16	TLM	COMMUTATOR OFF / ON		41
X-RAY	TEST OSCILLATOR LEVEL CONTROL		17	"	EXT. LINE -12^V		42
"	TEST OSCILLATOR EXT. ON		18	"	EXT. LINE RELAY CONTROL		43
"	X-RAY PKG POWER OFF		19	"	GND		44
AURORAL SCANNER	PWR OFF		20	"	EXTERNAL LINE +29^V		45
"	EHT OFF		21	"	LATCH CONTROL (+) INT. / (-) EXT.		46
"	MOTOR & LIGHT (+) ON / (-) OFF		22	"	EXT. CALIBRATE SIG.		47
PLASMA PROBES	RELAY CONTROL EXT. LINES		23	"	RELAY CONTROL CALIBRATE		48
PLASMA PROBES M.M.	LATCH CONTROL (+) INT / (-) EXT		24	"	CALIBRATOR (+) ON / (-) OFF		49
	GND		25	"	GND		50

ENG. WORK SHEET:			Batteries		ROCKET: AK-II-104				
STATUS: ISSUE 7			PREP. DATE:	EXP. DATE:			FIR. DATE:		
NO.	BATTERIES TYPE	BATTERIES VOLTS	EXPERIMENT	LOAD MA.	LIFE ON LOAD	TEMP. RANGE °F	UMBILICAL CHRG	UMBILICAL ON/OFF	UMBILICAL MONT.
1	20XHR-1	+29	TLM#1	1200			✓	✓	✓
2	10X225BH	-12V	TLM#1	50			✓	✓	✓
3	22X500BH	+26.4	COMMUTATOR	30			✓	✓	✓
			CALIBRATOR	50/200					
			SUBCOMMUTATOR	120					
			MULTIPLEX RELAYS	30	/230				
4	8XHR-1	+12V	BELLOWS ACTUATORS	7000			—	—	✓
5	22X1.25C	+26.4	MAGNETOMETERS (2)	70			✓	✓	✓
			VIBRATION ACC. AMP. (2)	30					
			NRC PHOTOMETER H.V. ELEC.	110 25					
			GALACTIC X-RAY H.V. ELEC.	110 100					
			NEUTRON DETECTOR H.V ELEC.	110 100					
			EVENT SWITCHER	25	/680				
6	15X1.25C	-18V	MAGNETOMETER -6V (2)	5			✓	✓	✓
			VIBRATION ACC. AMP.	30					
			NRC PHOTOMETER H.V. ELEC.	110 0					
			GALACTIC X-RAY H.V. ELEC.	110 110					
			NEUTRON DETECTOR H.V. ELEC.	110 110					
			X-RAY ELEC.	50					
			AURORAL SCANNER ELEC.	30	/665				
7	5XHR-3	-6V	BEACON	3500			—	✓	✓
8	1XHR-1	+1.5V	AURORAL SCANNER LIGHTS	750			—	✓	✓
9	4XHR-1	+6V	AURORAL SCANNER MOTOR	100			—	✓	✓
10	25X1.25C	+30	TLM #2 Tx	500			✓	✓	✓
			X-RAY H.V. ELEC.	110 10					
			AURORAL SCANNER H.V ELEC.	110 30					
			SCO'S	40	/800				
11.	Hg - EXPERIMENTER		IONOSPHERIC INHOMOGENEITIES	—	—		—	—	—
12.	Hg - 9X RM1438		MICROMETEOROID MK III	—			—	✓	✓
13	Hg - 9X RM1438		MICROMETEOROID MK IV	—			—	✓	✓
14	225BH	±12V	PLASMA PROBES	—			✓	✓	✓

ENG. WORK SHEET:	NOSE CONE		ROCKET: AK-II-104
STATUS: ISSUE-3	PREP. DATE: 3/12/65	EXP. DATE:	FIR. DATE: MAR/66