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Space Physics Program

SEMIANNUAL TECHNICAL NOTE
(1 JULY – 31 DECEMBER 1962)

30 APRIL 1963

Prepared by
SPACE PHYSICS LABORATORY

Prepared by COMMANDER SPACE SYSTEMS DIVISION

UNITED STATES AIR FORCE

Inglewood, California

JUN 27 1963

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SPACE PHYSICS PROGRAM

SEMIANNUAL TECHNICAL NOTE
(1 July - 31 December 1962)

Approved *R. A. Becker*
R. A. Becker, Director
Space Physics Laboratory

AEROSPACE CORPORATION
El Segundo, California

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FOREWORD

This report is submitted to fulfill the contractual reporting requirements for Job Order 3260 for the period 1 July 1962 - 31 December 1962. Six sections will be included, corresponding to the suborders 3260-10, 20, 23, 24, 50, 52. If a Technical Note was written during the reporting period, the section will serve as a reference to the report.

ABSTRACT

A number of experimental techniques were developed
and employed in making measurements of the near-earth
space environment from Program 162 satellites. These
measurements include the identification of the fluxes and
energy spectra of trapped protons and electrons in the
region of space from 200-700 km and provide the first
positive identification that the artificial radiation belt was
produced from bomb electrons. Radiometric measure-
ments were also made of the earth's background radi-
ance in the near infrared and middle ultraviolet regions of
the spectrum. Data are being analyzed to determine the
vertical distribution of ozone in the atmosphere, as inferred
from measurements of the attenuation of radiation in the
middle ultraviolet due to absorption by the oxygen-3 molecule.
Airglow experiments were conducted to study the 5577A
green and the 6300A red lines of atomic oxygen.

CONTENTS

SECTION I

ATMOSPHERIC RESEARCH

SECTION I

ABSTRACT I-1

This section describes the progress made to date in establishing a laboratory capability for research in the millimeter and submillimeter wavelength regions on the absorption spectra of various molecules common to the atmosphere. The equipment being assembled for this purpose is discussed.

ABSTRACT I-2

A photometric experiment was conducted to measure the oxygen nightglow at 6300A (red line) and 5577A (green line) of atomic oxygen. These measurements were made in November 1962 from an Air Force satellite. Preliminary results indicate that good data were limited to only one and one-half orbits because of noise pick-up.

SECTION I

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FIGURES

I. ATMOSPHERIC RESEARCH

I-1. Submillimeter Investigation of Atmospheric Gases

A-1. INTRODUCTION

The initial phase of this program is the planning and development of a broad-banded millimeter wave spectrometer. The final form of this spectrometer cannot be completely predetermined; its development is taking several directions so that any molecule and spectral transition can be studied. The degree of sensitivity necessary can be determined experimentally only for each spectral study. Most of the components of the proposed spectrometer have yet to be built before much useful information can be obtained. There are no commercially available microwave spectrometers in the millimeter or sub-millimeter regions, only a few available millimeter wave components, and no submillimeter components. Klystron sources, cavity wave meters, tuning plungers, attenuators, isolators, and couplers are available down to 3 mm. Commercial detectors and harmonic generators have not been very successful, and absorption cells and frequency standards must be designed to suit the individual spectrometer.

B-1. DISCUSSION

A video spectrometer at 50-75 gc has been assembled, which consists of a tuneable Oki reflex klystron with a maximum output of 80 mw at approximately 60 gc. The klystron feeds some matching devices, a wave meter, and a 1-meter oversized waveguide absorption cell, at the end of which the modulated microwave power is detected by a 1N53 diode. A gas handling system has been constructed to mix, distill, and introduce gases into the absorption cell. By using a 60-cps modulation synchronized with an oscilloscope sweep, it is possible to display resonant absorptions in ordinary gases on the oscilloscope trace.

From this ordinary approach, the extension to higher frequencies (above 100 gc) has been made where commercial components are not available. Point contact harmonic generators driven by the same Oki klystron were used as sources with smaller absorption cell and point contact diode detectors. These point contact devices were designed after those used at the Duke University Microwave Laboratory and were fabricated by the Whitcraft Co. at the same location. The specially doped and bombarded silicon crystals were provided by C.A. Burrus of the Bell Telephone Laboratories.

By curving an Rg-138 absorption cell, 20 cm in length, it was possible to partially immerse the cell in a liquid nitrogen dewar and to regulate its temperature by the liquid N_2 level and the heaters on either end of the cell. The heaters also served to prevent moisture from condensing on the mica windows. After many repointings of the diode's cat whisker by means of an electrolytic etch, and after many attempts at optimizing the pressure and location of the contact between whisker and crystal, on video, a rotational transition in OCS (carbonyl sulfide) which corresponded to the seventh harmonic of the Oki tube (0.70 mm) was observed by simple video detection. By using the laboratory-designed lock-in phase detection amplifier system, it was possible to detect the absorption by OCS of some eighth harmonic power (0.62 mm). These maximum sensitivities were achieved only at low temperatures; at room temperatures usually one less harmonic was observed. This is a result of the Boltzman population distribution which peaks for this molecule, as for most, at high J values (rotational energy quantum states) corresponding to far infrared transitions. By lowering the temperature, it is possible to shift the population peak to lower J values.

Since the objective of this program is atmospheric research, laboratory studies will have to be made of all the atmospheric constituents before possible future satellite data can be interpreted. While there is a good deal of literature on these appropriate spectra covering the long wavelength microwave region down to 3 mm, at present there is almost no spectral data on the atmospheric constituents in the shorter wavelength region. Since techniques

in this region are for the most part nonexistent, the research described above, which repeats earlier work published by others, is necessary in order to evaluate and improve the present sensitivity of the spectrometer.

C-1. CURRENT STATUS

New quantitative studies of absorption by atmospheric gases have not progressed very far because of some delay in acquiring the necessary equipment for measuring. The 1.6-mm absorption line in H_2O has been observed at a high signal-to-noise ratio over a wide range of pressures in a 1-meter-long absorption cell using the third harmonic of the Oki klystron. When measurements are possible, some significant results can be obtained. A search for the submillimeter water absorption lines has yet to reveal anything. These lines have never been observed with coherent techniques, so the search will continue after the spectrometer sensitivity has been improved.

A natural outgrowth of the spectral studies is the fundamental problem of where the predominant limitation occurs when one tries to generate, transmit, and detect higher and higher frequencies. This problem has never been quantitatively evaluated. Therefore, an attempt is being made to observe the output of the harmonic generator with a flat response optical system. By using a flared horn, the harmonic output of the generator can be introduced with mirrors onto a reflection grating, which should give enough resolution to separate and measure harmonics; then, by focusing the output into a Golay cell, the harmonic power will be detected.

I. ATMOSPHERIC RESEARCH

I-2. A Satellite Measurement of the Oxygen Nightglow at 6300A and 5577A

A-2. INTRODUCTION

As the features of the oxygen nightglow have evolved, it has become clear that knowledge of its distribution on a world-wide basis is needed before a comprehensive picture can be formed. A photometric measurement from a polar-orbiting satellite is the best method of obtaining such a world-wide mapping. In November 1962, this laboratory performed an initial survey experiment using a Program 162 satellite, and preparations are now being made to repeat these measurements with more sensitive instruments.

Electrochemical reactions in the upper atmosphere produce atomic oxygen in excited states. Transitions from some of these states by the emission of light quanta are forbidden. However, because of the low density in the upper atmosphere, collisional de-excitation is small, and the forbidden transitions are observed. The intensity of the light is barely visible to the naked eye, and hence the oxygen glow can be observed only in the night sky. Two lines which have been studied extensively are the 5577A green line emitted at about 100 km altitude and the 6300A red line emitted at about 350 km. Barbier (Ref. 1) has made measurements of the night sky during two airplane flights from Paris to Cape Town and has found that the emission at 6300A has peaks in intensity at ±15 deg geomagnetic latitude and has a minimum at the geomagnetic equator. Barbier has designated these peaks as the Tropical Red Arcs. Their intensity is several hundred Rayleighs, that is, one to two orders of magnitude more intense than the normal 6300A background. In the northern hemisphere, they appear every night during the late fall months and every few nights during the spring months, while this seasonal variation is reversed in the southern hemisphere.

Several interesting properties of the oxygen nightglow have been discovered: (1) its intensity increases with increased solar activity, (2) the red and green lines are enhanced in aurorae, (3) the 6300A emission varies systematically with both magnetic latitude and time of year, and (4) the altitude of the layer emitting at 6300A is coincident with the altitude of the F2 peak in the ionosphere, and the intensity of the emission is proportional to the electron density at the F2 peak.

A number of theories have been proposed to account for the energy source and the mechanism of excitation of the atmosphere, but in the main, the phenomenon remains unexplained. A current conjecture suggests that the excitation is the result of high-energy particles being lost from the Van Allen belts and subsequently being dumped into the atmosphere. Following are various characteristics of the nightglow:

Altitude of arcs	300-400 km
Location of peaks-intensities	±15 deg geomagnetic latitude
Width of peaks	10 deg latitude
Intensity at peak	100-1000 Rayleighs (R)
Normal 6300A background	50-100 R
OH 9-3 band background (6250-6350A)	40 R
Cinturim background (6250-6350A)	50 R

B-2. DISCUSSION

Three photometer units capable of detecting weak signals of visible radiation have been built and were flown on a Program 162 satellite in November 1962. The satellite had an apogee of 422 km, a perigee of 207 km, and an orbital inclination of 75 deg. The green line photometer (5577A) and one of the red units (6300A) were pointed downward at 10 deg from the nadir; the second red line photometer was oriented to point 180 deg from the first unit. Each unit weighed less than 5 lb and consumed an average of 1 watt of power.

Each photometer employs an interference filter, selected for the wavelength to be detected, a focusing lens, a photomultiplier tube, and appropriate circuitry to supply the telemetry with a dc voltage proportional to the logarithm of the signal intensity. Figure 1-1 is a photograph of the various components, and Fig. 1-2 is a photograph of an assembled photometer.

The photometer optics consists of a 2-in. diam aperture, f/1 lens with a 5 deg field of view. The interference filters for the red line photometer have a 90A bandwidth centered at about 6300A and a 50A bandwidth centered at about 5577A for the green line detector.

The instrument sensitivity, which is limited by the photomultiplier tube dark current, depends on wavelength, but is sufficient through the visible spectrum to detect background levels of most nightglow radiations. The minimum detectable signal with the 6300A photometer was about 300 Rayleighs and that with the 5577A unit, about 100 Rayleighs. To reduce the sensitivity of the instrument to penetrating electrons and bremsstrahlung, the cathode and first few dynodes of the photomultiplier are shielded by an aluminum and tungsten absorber.

In-flight calibration of the photometer occurs at 3-minute intervals. A tungsten bulb excited by a stabilized power source is viewed by the photometer. The timer that sets the calibration interval has a temperature sensitivity which allows monitoring of the temperature of the photometer at all times and which operates from $0^{\circ}F$ to $130^{\circ}F$. Design improvements to be made in the future include the mechanical chopping of the incoming radiation and the addition of electronics to demodulate the resultant ac signal at the anode of the photomultiplier. The chopping system will increase the sensitivity of the photometer, make possible some reduction in weight and improvement in spatial resolution, and considerably reduce the sensitivity of the instrument to high fluxes of energetic particles in the radiation belts.
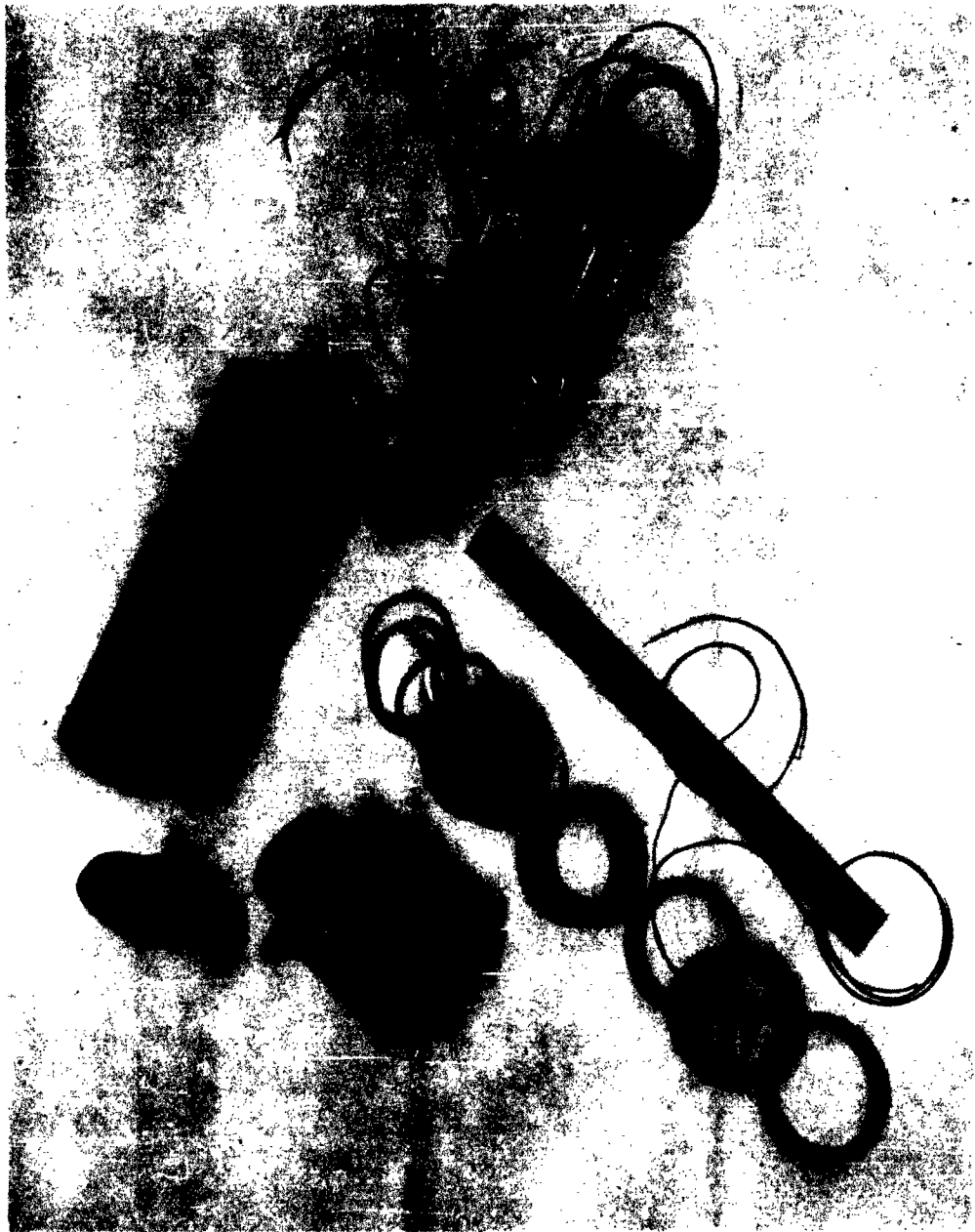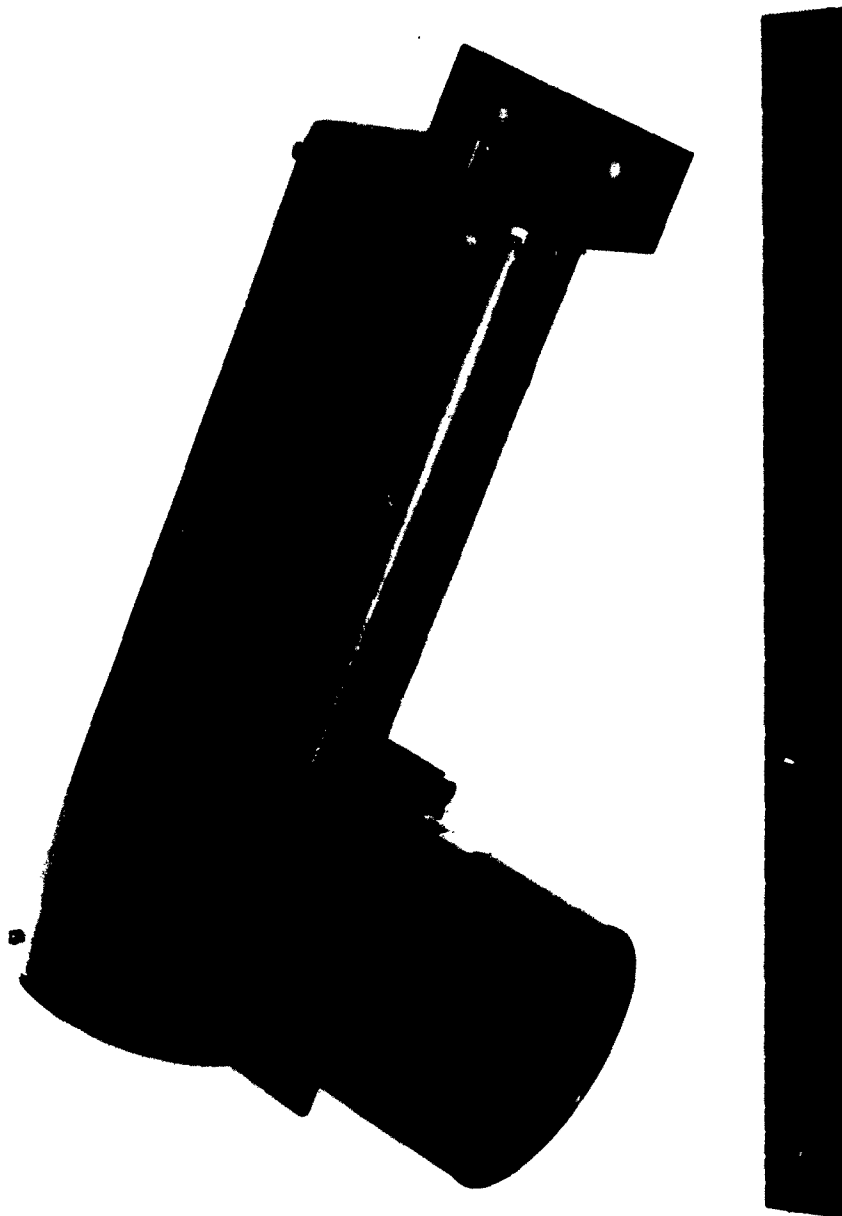
Fig. 1-1. Photometer Components

Fig. 1-2. Assembled Photometer

C-2. EXPERIMENTAL RESULTS

Good data from the November 1962 flight of these experiments were limited
to only one and one-half orbits because of noise pick-up. These data are
presently being analyzed; a preliminary examination has shown that only the
green line photometer was sufficiently sensitive to detect the nightglow. Due
to unexpectedly high temperatures in the satellite, the dark current of the
red line photometer reduced the instrument's sensitivity to the point that the
nightglow was undetectable.

SECTION II

RADIATION BELT AND
AURORA RESEARCH

II. RADIATION BELT AND AURORA RESEARCH

See Technical Note submitted entitled <u>Preliminary Analysis of the Flux and</u> <u>Spectra of Trapped Particles Following the Nuclear Test of July 9, 1962,</u> Aerospace Corporation TDR-169(3260-20)TN-1, dated 15 November 1962. Following is the abstract from this report.

Particle detectors have been flown on a low-altitude, polar satellite to measure the fluxes and energy spectra of protons and electrons. In the region of the South Atlantic magnetic anomaly, electrons were observed with a fission-like spectrum above 2 Mev. Comparison of B, L plots of the electron fluxes with those obtained one week after the explosion indicates that the electron lifetime is $\gtrsim$ 20 days. The lifetime and the observed deficiency of fission electrons below 2 Mev are consistent with the loss mechanism of atmospheric interaction. Near $L = 4.5$ and $B = 0.4$ gauss, only natural electrons were observed. The proton flux and spectral measurements yield no evidence that protons were either injected into or removed from the radiation belt by the high-altitude explosion.

SECTION III

FARADAY CUP DETECTOR FOR MEASUREMENTS
OF LOW-ENERGY ELECTRONS AND
PROTONS IN SPACE

SECTION III

ABSTRACT

This report discusses the design and development
of a Faraday Cup detector system for measuring
energetic particles in space. The design goal for
the detector is a system that will alternately meas-
ure proton and electron fluxes from a few to 10^{14}
particles/cm^2-sec at energies up to 50 kev. The
initial version of this instrument weighs 9.5 lb,
requires 5.5 watts of power, and is capable of
detecting particles with energies less than 30 kev.

SECTION III

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FIGURES

TABLES

III. FARADAY CUP DETECTOR FOR MEASUREMENTS OF LOW-ENERGY ELECTRONS AND PROTONS IN SPACE

A. INTRODUCTION

A Faraday Cup detector (Ref. 3-1), similar to a lower voltage system flown on Explorer X, is in the final stages of development. This instrument is designed to measure low-energy proton and electron fluxes in the range from a few to 50 kev. The instrument will respond to omnidirectional fluxes from 10^5 to 10^{11} particles/cm^2-sec and has a time resolution of 0.1 sec. The acceptance solid angle is 0.03 sterad. The initial instrument weighs 9.5 lb, displaces 175 cu in., and consumes 5.5 watts of power at 22 volts input voltage.

B. DISCUSSION

The Faraday Cup detector consists of a structure of several grids, with the voltages applied to two of these grids being variable. A programmer, using a command pulse from a commutator, changes the status of these voltages to allow proton and electron measurements at various energies. Fluxes greater than 10^8 particles/cm^{2}sec^{-1} are measured by a collector grid, and fluxes less than this amount are measured by a photomultiplier. To improve the signal-to-noise characteristics, a 2-kc square wave is used to modulate the voltage on the appropriate grid of the Faraday Cup and to drive phase-sensitive demodulators for the output circuits.

1. The Faraday Cup

The Faraday Cup assembly consists of several fine mesh grids having 100 lines/in. with an 83 per cent open area. Ceramic insulators with a 3/4-in. ID, 1-1/4-in. OD, and 3/4-in. thickness are used to support the high-voltage grids. Four such insulators are used; the two end grids and the central grid are grounded and the remaining two grids are at the programmed positive and negative voltages, as shown in Fig. 3-1.

GRID 1

POSITIVE PROGRAMMED VOLTAGE ———————————————— GRID 2

GRID 3

NEGATIVE PROGRAMMED VOLTAGE ———————————————— GRID 4

GRID 5

GRID 6

−100 V ———————————————— GRID 7

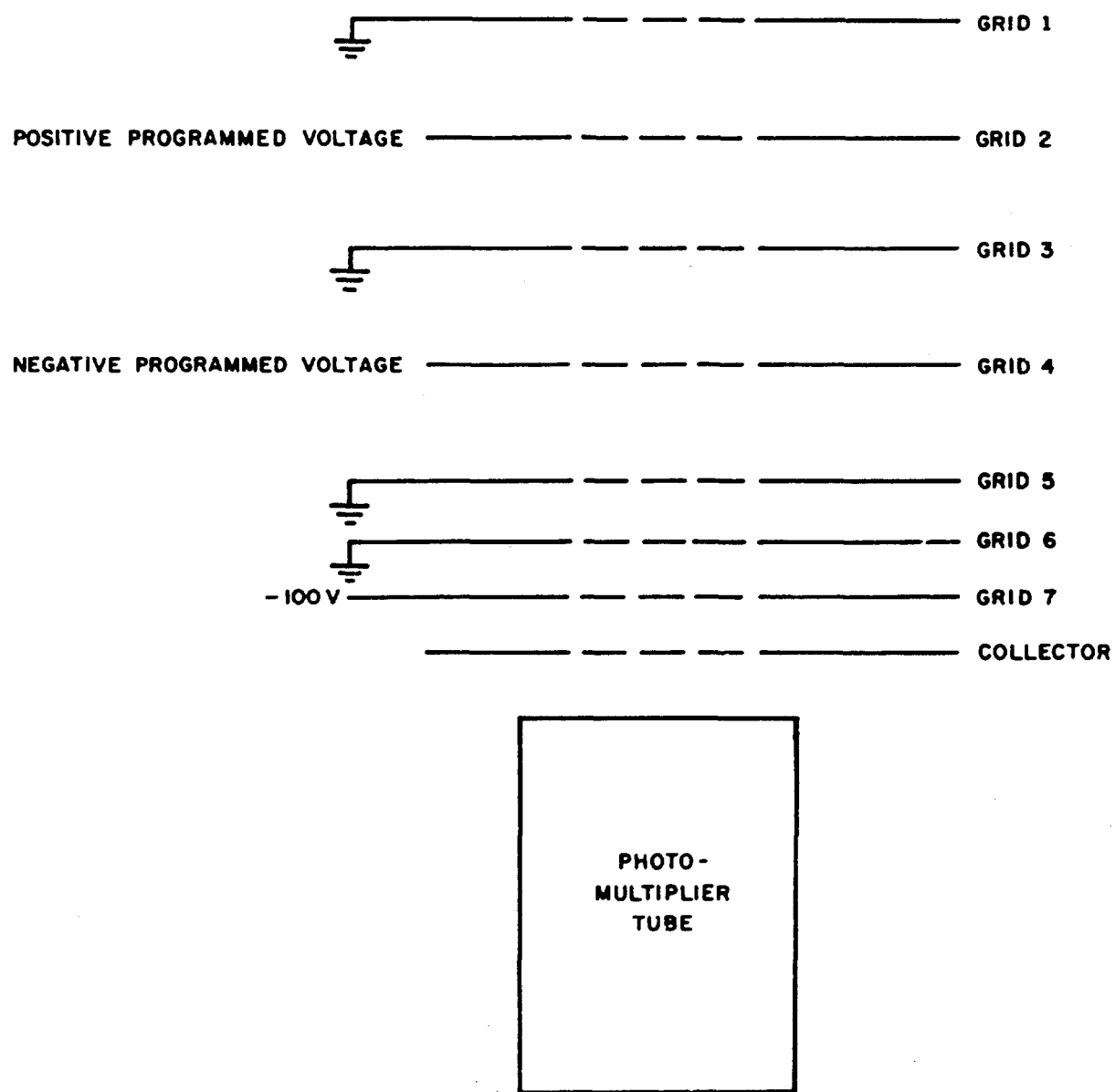———————————————— COLLECTOR

PHOTO-
MULTIPLIER
TUBE

Fig. 3-1. Faraday Cup Assembly

The collector assembly of the Faraday Cup consists of an additional shielding grid, a suppressor grid, and a 3/4-in. diam collector disc with a 1/4-in. diam hole, behind which is a photomultiplier tube with a 1.5-mil cesium iodide crystal, coated with a 3000A evaporated layer of aluminum. The shielding grid serves to eliminate the capacitive pickup of the 5-kv, 2-kc modulating voltage on the high-voltage grids, and the suppressor grid is operated at -100 volts to prevent secondary emission.

2. The Programmer

The programmer is a scale of 16 counter, using 4 binary counters. A Schmidt trigger senses the passing of the wiper arm through two adjacent points on a 1/2-rps commutator. The resulting pulse triggers a 1-sec univibrator, which in turn adds one count to the programmer. The univibrator prevents multiple counting of the programmer caused by possible noise in the vehicle.

Four outputs are derived from the programmer: control voltages for the positive and negative dc supplies, and square wave modulation voltages for the positive and negative dc supplies. At present the cycle is as shown in Table 3-1.

3. The High-Voltage Power Supplies

The modulation voltage for the Faraday Cup is supplied by a magnetically coupled multivibrator using an Orthonol core about 1-1/4-in. OD with a saturable flux of 1.4 webers/m^2. At a frequency of 2 kc, a 5-kv peak-to-peak square wave is obtained from a 20-volt input. At these voltages no breakdown problems exist in the secondary winding. New insulation techniques are being tried to generate a 10-kv peak-to-peak square wave.

The same power supply could be used with a voltage multiplier of the required number of stages to generate the necessary dc voltages. With appropriate biasing in the primary circuit, the output voltage at the secondary is directly

Table 3-1. Programmer Outputs

Status	Positive		Negative	
	dc	Modulation	dc	Modulation
0	V_0	ON	V_7	OFF
1	V_0			
2	V_1			
3	V_2			
4	V_3			
5	V_4			
6	V_5			
7	V_6			
8	V_7	OFF	V_0	ON
9			V_0	
10			V_1	
11			V_2	
12			V_3	
13			V_4	
14			V_5	
15			V_6	

3-4

proportional to the input primary voltage. This system has one undesirable characteristic: the frequency of the magnetically coupled multivibrator is also directly proportional to the input voltage.

Due to the dependence of the frequency upon the input voltage, a driven core is used to obtain the dc voltage. A frequency of 500 cps is used with driving pulses of 40-μsec duration. The driving frequency is one-fourth that of the modulation frequency. The duration of the drive pulse is set by univibrators and is limited by the time required to charge the stray capacitance of the secondary winding. This circuit has two advantages: the frequency is in phase with the modulation frequency, and the short duration of the drive pulse allows fewer turns on the cores.

4. Flux Measurements

The geometrical factor for the collector disc is 2×10^{-2} cm^2-sterad, and that for the photomultiplier tube is 1.5×10^{-3} cm^2-sterad. Correcting for the transmission of the grids, the following relations are found:

$$I_c = J \times 3.1 \times 10^{-21} \text{ amps}$$

$$N_{pm} = J \times 1.5 \times 10^{-3} \text{ counts/sec}$$

where I_c is the collector current, N_{pm} the number of particles/sec in the photomultiplier, and J the directional flux in particles/cm^2-sec-sterad. For an isotropic flux distribution

$$4\pi J = \phi_{OMNI}$$

where ϕ_{OMNI} is measured in particles/cm^2-sec.

Omnidirectional fluxes for electrons and protons with energies above 40 kev have values of 10^8 particles/cm^2-sec-sterad. However, angular distributions and the lower energy range of this detector suggest that a factor of 10^2 to 10^3 should be introduced, and hence J values of 10^9 to 10^{10} particles/cm^2-sec-sterad are expected for omnidirectional fluxes of 10^8 particles/cm^2-sec-sterad.

The collector preamplifier can detect currents as low as 5×10^{-12} amps, corresponding to J values of 1.6×10^9 particles/cm^2-sec-sterad. A logarithmic amplifier extends the range of this channel to 8×10^{11} particles/cm^2-sec-sterad.

The photomultiplier output has two channels, a low-level channel which counts from 500 to 20,000 counts/sec by counting the individual pulses, and a high-level channel which counts from 10^4 to 5×10^7 counts/sec by measuring the current from the photomultiplier. These counting rates correspond to J values of 3×10^5, 1.2×10^7, 6×10^6, and 3×10^{10} particles/cm^2-sec-sterad.

Detector Channel	Range $(cm^{-2}sec^{-1}sterad^{-1})$	
Photomultiplier		
Low-Level	3×10^5	1.2×10^7
High-Level	6×10^6	3×10^{10}
Collector	1.6×10^9	8×10^{11}

The signals from the collector and photomultiplier are demodulated in a phase-sensitive detector and are then integrated with a 1/20-sec time constant for the telemetry output.

5.   Telemetry Cycle

A command pulse with a 1/2-rps commutator is used to adjust the dc and
modulation voltages. One second later the readout begins, with the three
channels of output being read four times each at 1/4-sec intervals and the
status of the power supplies being read once each revolution. Thus 16 com-
mutator points are required for the readout. Five or six temperatures and
voltages are monitored at intervals with a subcommutator.

C.   CURRENT STATUS

At present all the individual components have been designed and tested. The
prototype assembly is nearly complete, and the few shielding problems
encountered are being corrected. The components for two flight units are
being assembled, and final construction will begin as soon as the prototype
is completed.

The completed units will be calibrated with 0-30 kev electrons at Aerospace
Corporation and with 0-30 kev protons at Electro-Nuclear Laboratories in
Mountain View, California.

Effort will be expended in four main areas in the near future to: 1) extend the
energy range from 3-30 kev to 3-50 kev, 2) decrease the weight from 9.5 lb,
3) decrease the power requirement from 5.5 watts, and 4) re-evaluate and
improve the circuitry.

D.   REFERENCES

1.   Flight-Type Faraday Cup Detector, TDR-930(2260-23)TR-1,
      Aerospace Corporation, El Segundo, California (30 March 1962).

SECTION IV

PARTICLE RADIATION MAPPING (PRAM)

SECTION IV

ABSTRACT

This section briefly discusses progress to date on the Aerospace Corporation Particle Radiation Mapping program (PRAM). This program is designed to measure particle radiations in space from 300 to 5000 km as a function of position, time, and solar activity. Included are details on and references to the vehicle system, scientific payloads, operating details, and data reduction and analysis.

SECTION IV

CONTENTS

FIGURES

TABLES

IV. PARTICLE RADIATION MAPPING (PRAM)

A.   INTRODUCTION

The Particle Radiation Mapping program (PRAM, Ref. 4-1) is designed to measure the space particle radiation environment from 300-5000 km as a function of position, time, and solar activity. The first of three subsatellites (Ref. 4-2), designated as Program 11, will be launched in May 1963 from an Agena D vehicle of the Program 162 series. Carrying an estimated 40 lb of scientific instrumentation, the subsatellite can be kicked off the Agena D near apogee (approximately 300 km) and, with a small solid propellant rocket motor, boosted into an eccentric orbit with an apogee of approximately 5000 km. The orbital inclination of approximately 80 deg will establish the maximum latitude at which measurements can be made.

The scientific payload will consist of six experiments: three phoswitch type spectrometers, a solid-state omnidirectional spectrometer, a Faraday Cup detector, and a combination search-coil/flux-gate magnetometer. These instruments will measure the fluxes and energy spectra of protons from a few kev to more than 100 Mev and of electrons from a few kev to 5 Mev. One of the later payloads may include a solid-state mass identifier which will resolve the mass and energies of the energetic hydrogen and helium isotopes.

B.   DISCUSSION

1.   Scientific Instrumentation Development and Fabrication

The Aerospace scientific payload will consist of five experiments: a high-energy proton spectrometer (HEPS); a low-energy proton spectrometer (LEPS); an electron spectrometer (ES); an omnidirectional proton and electron spectrometer (ODPS); and a Faraday Cup (FC) electron and proton detector. Figure 4-1 is a photograph of the five-experiment payload, and Fig. 4-2 shows the prototype instruments mounted on the satellite structure. The first four of these experiments have been developed and successfully flown as parts of
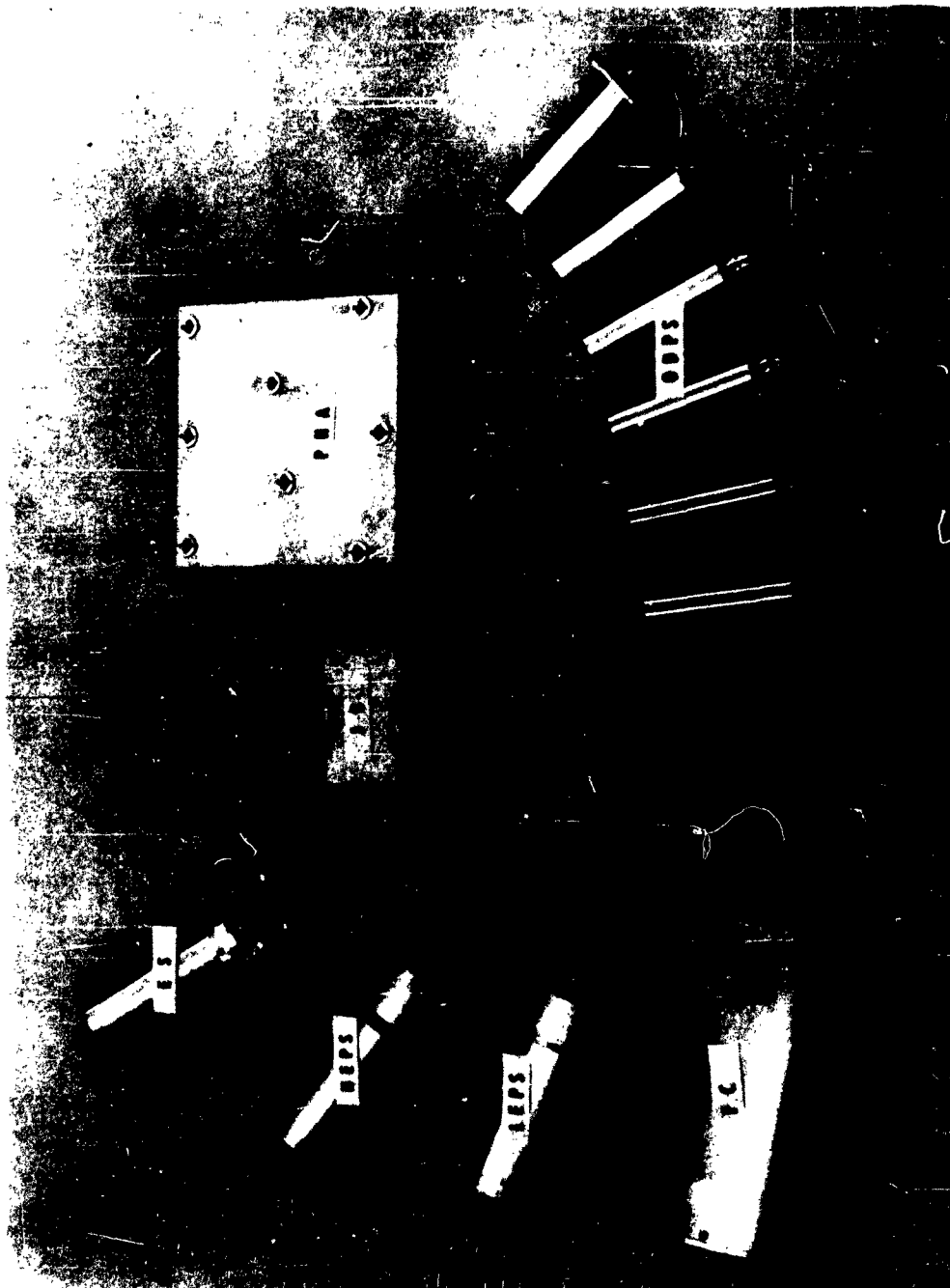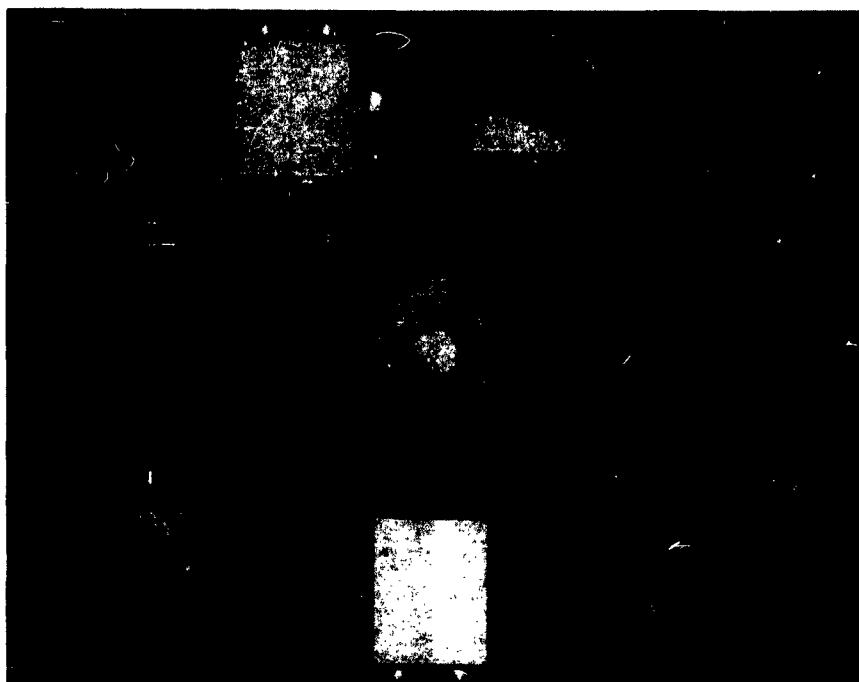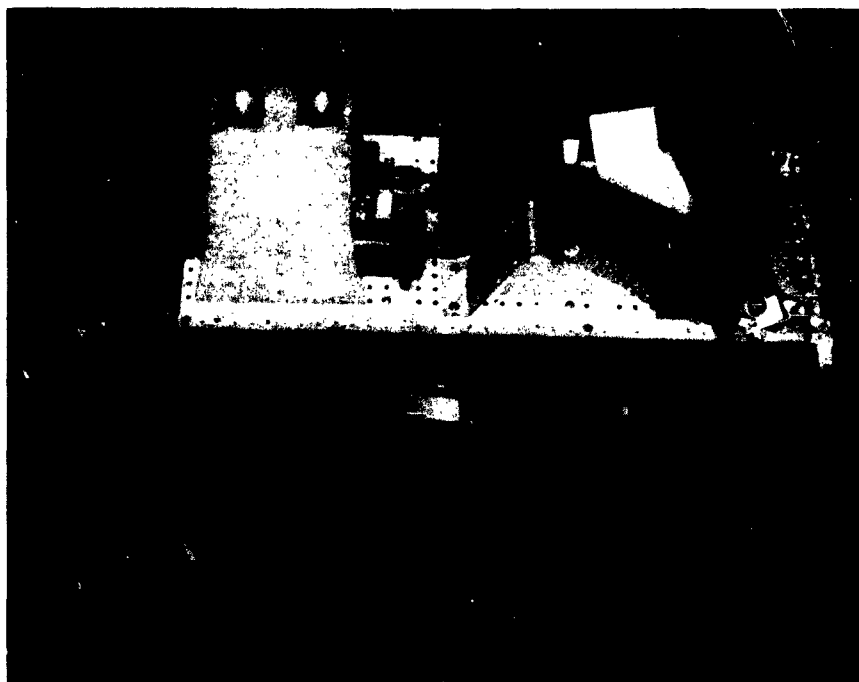
Fig. 4-1. Five-Experiment Payload

View B. Aft End

View A. Front End

Fig. 4-2. Prototype Instruments Mounted on Satellite Structure

the secondary payloads on three Program 162 satellites (Refs. 4-3 and 4-4). A number of design optimization changes have been made on the basis of knowledge gained from these flights. Fabrication of the first payload and backups has been completed, and the other two payloads are presently being built.

The initial version of the Faraday Cup detector is in the final stages of development. (The original design goal to measure particles with energies up to 50 kev has been compromised so that this detector will measure particle energies from about 3 to 30 kev.)

The sixth experiment, the search-coil/flux-gate magnetometer, will be supplied by Space Technology Laboratories, Inc., under authorization of the basic AFSSD Program 11 Vehicle Contract AF 04(695)-75 with Lockheed Missile and Space Company (LMSC). The magnetometer will provide data on the detector inclinations relative to the earth's magnetic field (but not on the absolute direction), on short-term time variations of the field, and on the magnitude of the field. These data will make it possible to correlate the directional dependence of the particle fluxes with the magnetic field.

Table 4-1 is a summary of the properties of the flight instruments and Table 4-2 shows their capabilities and weight, power, and telemetry requirements.

2.   Instrument Calibration and Checkout

The initial phases of calibration for the first payload and backups were carried out at Aerospace using natural radioactive sources. The lack of high- and low-energy proton and electron sources at Aerospace has made it necessary to rent accelerator time at various universities and government and industrial laboratories.

Table 4-1. Properties of Flight Instruments

Instrument	Type	Entrance Aperture Area (cm^2)	Acceptance Angle	Absorber Shell Thickness (gm/cm^2)	Detector Size (mm)
Low-energy proton spectrometer	Phoswitch	0.0437	10 deg	NA*	NA
High-energy proton spectrometer	Phoswitch	0.177	43 deg	NA	NA
Electron spectrometer	Phoswitch	0.126	5.2 deg	NA	NA
Omnidirectional spectrometer	Solid-state detector	NA	2π sterad	—	—
Detector 1	—	—	—	1.2 x 10^{-3} (Al mylar)	1 x 1 x 1
2				0.167 Al	1 x 1 x 1
3				0.565 Al	1 x 1 x 1
4				1.490 Al	2 x 2 x 2
5				3.070 Al	3 x 3 x 3
6				11.700 Cu	3 x 3 x 3
Faraday Cup	NA	NA	NA	NA	NA

*NA - Not Applicable

Table 4-2. Capabilities and Weight, Power, and Telemetry Requirements

Instrument	Measurement	Energy Interval		Vol. (in.³)	Weight (lb)	Power (watts)	Telemetry Commutator Points
		Protons	Electrons				
Low-energy proton spectrometer	Flux and energy spectrum of protons in 12 steps	100 kev to 4 Mev	—	108	5.0	0.5	Time share 36 points through sub-commutator
High-energy proton spectrometer	Flux and energy spectrum of protons in 12 steps	4 Mev to 100 Mev	—	108	5.0	0.5	Time share 36 points through sub-commutator
Electron spectrometer	Flux and energy spectrum of electrons in 12 steps	—	40 kev to 4 Mev	108	5.5	0.5	Time share 36 points through sub-commutator
Pulse-height analyzer	Pulse amplitude analysis of output of spectrometers 1-3 in 12 channels	—	—	162	5.0	2.0	NA*
Omnidirectional spectrometer Detector 1 2 3 4 5 6	Identifies and measures integral flux and energy spectrum of both protons and electrons	5 to 20 Mev 12 to 25 22 to 30 35 to 60 50 to 95 100 to 150	>0.3 Mev >0.7 >1.4 >2.6 >5.0	150	9.0	3.5	21
Faraday Cup detector	Identifies and measures the flux and energy spectrum of protons and electrons	1 to 50 kev	Same	200	9.5	5.5	16

*Not Applicable

The responses of the electron detectors to high and low fluxes of electrons in the 0.2-1.2 Mev range were determined using a Van de Graaff generator at Space Technology Laboratories, Inc., and the fission beta-ray spectrum from uranium was used in an experimental arrangement at the Atomic Energy Commission laboratory at Los Alamos. The proton spectrometers were calibrated using: 3-Mev protons from the Van de Graaff generator at California Institute of Technology; 32-Mev protons from the linear accelerator at the University of Southern California; and 50-Mev protons from the cyclotron at the University of California at Los Angeles. A similar procedure will be followed for the other two payloads when completed.

Final checkout of the first payload is currently being performed at Aerospace; this consists of such operations as making the final external sets to the electronics to compensate for amplification gain change:, etc., that may have developed due to aging of components. This work will be completed and the first payload delivered to LMSC, Sunnyvale, sometime in March 1963.

3.   Operation

The Aerospace scientific payload will require about 12 watts of 22-29 dc power while in operation. Energy will be provided by solar cells and a rechargeable nickel-cadmium battery. Because the vehicle is electrically power-limited, the operating duty cycle of the instrument will be restricted to about 10 percent of the day, i.e., 2.4 hours, which approximates the expected 2.3-hour orbital period.

The instrument outputs consist of 0-5 volt signals which are fed to one of two commutators: a 1-rps, 60-point unit, and a 1/2-rps, 60-point unit. This combination yields a 90 points/sec input to a two-channel tape recorder and two VCO channels which modulate an FM/FM UHF telemetry transmitter. The tape recorder will store 180 minutes of data and has a playback speed of 12:1, i.e., it requires 15 minutes to read out. A ground command system will make it possible to control the on-off times for the payload, real-time readout, and tape recorder playback.

4. Data Reduction and Analysis

The Aerospace Computation and Data Processing Center is preparing the necessary programs for reducing and analyzing the data. The raw information will come to Aerospace on magnetic tapes and will have to be decommutated, digitized, and put into an acceptable format for the IBM 7090 before any data analysis can be performed.

The analyses[*] basically consist of determinations of the particle intensities for various discrete energy intervals, E, as a function of 1) time, 2) latitude, 3) longitude, 4) altitude, and 5) the equivalent values in B, L, and Θ coordinates. The data will also be sorted by E, B, L, and Θ coordinates.

It is assumed that 300 hours of data will be obtained from each flight. This figure is based on about 100 days of active transmission life and will probably be a function of the tape recorder and solar cell reliabilities. It has been estimated that 125 hours of IBM 7090 time will be required to process these 300 hours of experimental data.

C. PROPOSED FY 64 FOLLOW-ON ACTIVITY

A proposal has been made to the Office of Aerospace Research (OAR) that SSD/Aerospace be assigned satellite payload space for flying the above experiments (ODPS, HEPS, LEPS, ES, and FC), as well as two new mass identifier experiments designed to determine the mass and energy distribution of hydrogen and helium isotopes in the radiation belts and solar flares. OAR has tentatively indicated that 1-1/2 orbiting Blue Scout payloads will be assigned for this purpose in FY 64.

In addition, proposals will continue to be made for flying new experiments as parts of the secondary payloads on Program 162 satellites. Experience has shown that this program provides an excellent opportunity for flight-testing instruments, as problems can be eliminated during these tests without wasting valuable payload space on long lifetime satellites.

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[*]IOC from R. S. White to A. B. Troesch dated 7 December 1962 sets forth the analyses requirements on the "P-11 Program."

D.   REFERENCES

1.   Particle Radiation Mapping, Program Plan for the Space Physics
     Laboratory, Aerospace Corporation, El Segundo, California
     (1 July 1962).

2.   Detail Specification Covering Flight Test Vehicle Program 11,
     LMSCA051977, Lockheed Aircraft Corporation, Sunnyvale, California
     (12 July, 30 August, 14 November 1962).

3.   Secondary Payload Particle Radiation Experiments for Program 622A
     Satellites, TDR-69(2260-20)TN-1, Aerospace Corporation, El Segundo,
     California (14 September 1962).

4.   Mozer, F. S., Elliott, D. D., Mihalov, J. D., Paulikas, G. A.,
     Vampola, A. L., Freden, S. C., Preliminary Analysis of the Flux
     and Spectra of Trapped Particles Following the Nuclear Test of
     July 9, 1962, TDR-169(3260-20)TN-1, Aerospace Corporation,
     El Segundo, California (15 November 1962).

SECTION V

OPTICAL RADIATION MEASUREMENTS RESEARCH

V. OPTICAL RADIATION MEASUREMENTS RESEARCH

See Technical Note submitted entitled <u>Ultraviolet Radiometer Experiment</u> <u>for the Target Measurement Program (TRUMP)</u>, Aerospace Corporation TDR-169(3260-50)TN-1, dated 6 February 1963, the abstract of which is printed below.

The Space Physics Laboratory has developed an ultraviolet radiometer which will be flown on a Nike-Cajun rocket as part of the Target Radiation Measurement Program (TRUMP). The instrument consists of a compound filter arrangement and an ASCOP 541F photomultiplier tube which yields a 300A bandpass at the 50 percent point (2700A). The design and calibration data of the instrument are given.

See also Technical Note submitted entitled <u>Experiment and Preliminary</u> <u>Results of Satellite Determinations of the Vertical Distribution of Ozone and</u> <u>of the Albedo in the Near Ultraviolet</u>, Aerospace Corporation TDR-169(3260-50)TN-2, to be published in May 1963; an abstract of this report is printed below.

This report describes a satellite experiment to determine both the vertical distribution of ozone above 70 km and the radiance or back-scattered solar radiation from the top of the ozonesphere at the center of the absorption band at 2550A. Two successful flights have been made, which have resulted in measurements of the vertical distribution between 60 and 85 km and the radiance of the nadir for sun angles from 90 deg to nearly 49 deg. The vertical distribution data agree with previous results below 70 km and with theoretical predictions to 85 km. The radiance, which had not been previously measured, is observed to have a maximum value of $2.0 \pm 0.3 \times 10^{-9}$ w/cm^2-sterad A for a solar angle of 49 deg. This value is also in agreement with the theoretical prediction.

SECTION VI

PRELIMINARY RESULTS OF SATELLITE MEASUREMENTS
OF THE NEAR INFRARED BACKGROUND
RADIATIONS FROM THE EARTH

SECTION VI

ABSTRACT

This section presents the results of the preliminary, "quick-look" data obtained from the 4-color infrared background radiance experiment conducted in December 1962 on an Air Force satellite. A sample of the measured radiance values for the four channels (1.4μ, 1.8μ, 2.2μ, and 2.7μ) as a function of system time is included. A detailed analysis of the data is in process and a full report will be published in the near future.

SECTION VI

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FIGURES

TABLES

VI. PRELIMINARY RESULTS OF SATELLITE MEASUREMENTS OF THE NEAR INFRARED BACKGROUND RADIATIONS FROM THE EARTH

A. INTRODUCTION

A radiometer, designed to measure the earth's background radiation in the near infrared, was recently flown on an Air Force Agena satellite. Since complete analysis of the data obtained from this experiment will require considerable time, this preliminary, "quick-look" report is being issued to satisfy the large number of inquiries regarding the results of the measurements. All radiance values quoted in this report should be qualified to the extent described in the section on results. A detailed report, including a description of the calibration procedures, will be issued upon completion of the data analysis.

B. DISCUSSION

1. The Radiometer

A simple radiometer was designed to measure the background radiance in four spectral regions: the 2.7μ, 1.8μ, and 1.4μ water vapor absorption bands and the 2.2μ atmospheric window. Four uncooled lead sulfide detectors cemented over with narrow-band interference filters were used. The detectors were in the form of four parallel bars, each with a 0.025 x 0.025 rad field of view. The detectors were all directed toward the nadir and, by virtue of the forward motion of the satellite, scanned a path 0.025 rad wide. Less than one second elapsed between the time at which the first detector saw a given background patch and the time at which the last detector saw the same patch; hence, all cells viewed the same area at effectively the same time.

The lens used was a 4-in. diam, 6-in. focal length, silicon lens with the rear surface aspherized. A sector disc, rotating in front of the detectors, chopped the incident radiation at 600 cps so that absolute radiance was measured. A stable internal calibration lamp periodically illuminated the detectors to provide a check on the stability of the system.

Figure 6-1 is a photograph of the radiometer. The radiometer proper, which houses the optics, detectors, choppers, calibration lamp, and four linear preamplifiers, is the unit on the left; the electronics box, housing the four output amplifiers which drive the telemetry, is on the right. These amplifiers were designed to be approximately logarithmic in order to compress an input dynamic range of about 1000 into the allowed telemetry dynamic range of 50.

2.   The Vehicle and Its Orbit

The radiometer was flown on a Program 162 vehicle launched from Vandenburg AFB in December 1962. The apogee was 248 km, the perigee 171 km, and the orbital inclination 71 deg. Data were obtained during 10 good daylight passes in the first 14 orbits. The vehicle was earth-stabilized to within ±3 deg so that the radiometer was pointed continuously toward the nadir.

C.   EXPERIMENTAL RESULTS

A thermistor was mounted on the ceramic cell holder to monitor the detector temperature throughout the flight. Detector temperature varied from 21°C early in the second orbit to 44°C later in the flight. The maximum temperature fluctuation during a single pass over the sunlight side of the earth was 15°C during the second orbit and typically 8°C for the remaining passes.

At the present time, only a few data points for a 31°C detector temperature have been reduced. Table 6-1 shows vehicle longitude, latitude, and background radiance for various points. The last two columns of this table show the length of the record inspected and if the value quoted is a maximum, minimum, or approximate average over the record. Radiance values in Table 6-1 are probably accurate to within a factor of 2, and coordinates are given to the nearest degree.

A strong correlation between the four wavelengths viewed was noted for background features greater than 4 miles in extent. Further data reduction will be necessary to determine if this correlation extends to smaller features. Figure 6-2 shows time/voltage plots of the output of the logarithmic amplifiers for the various channels.
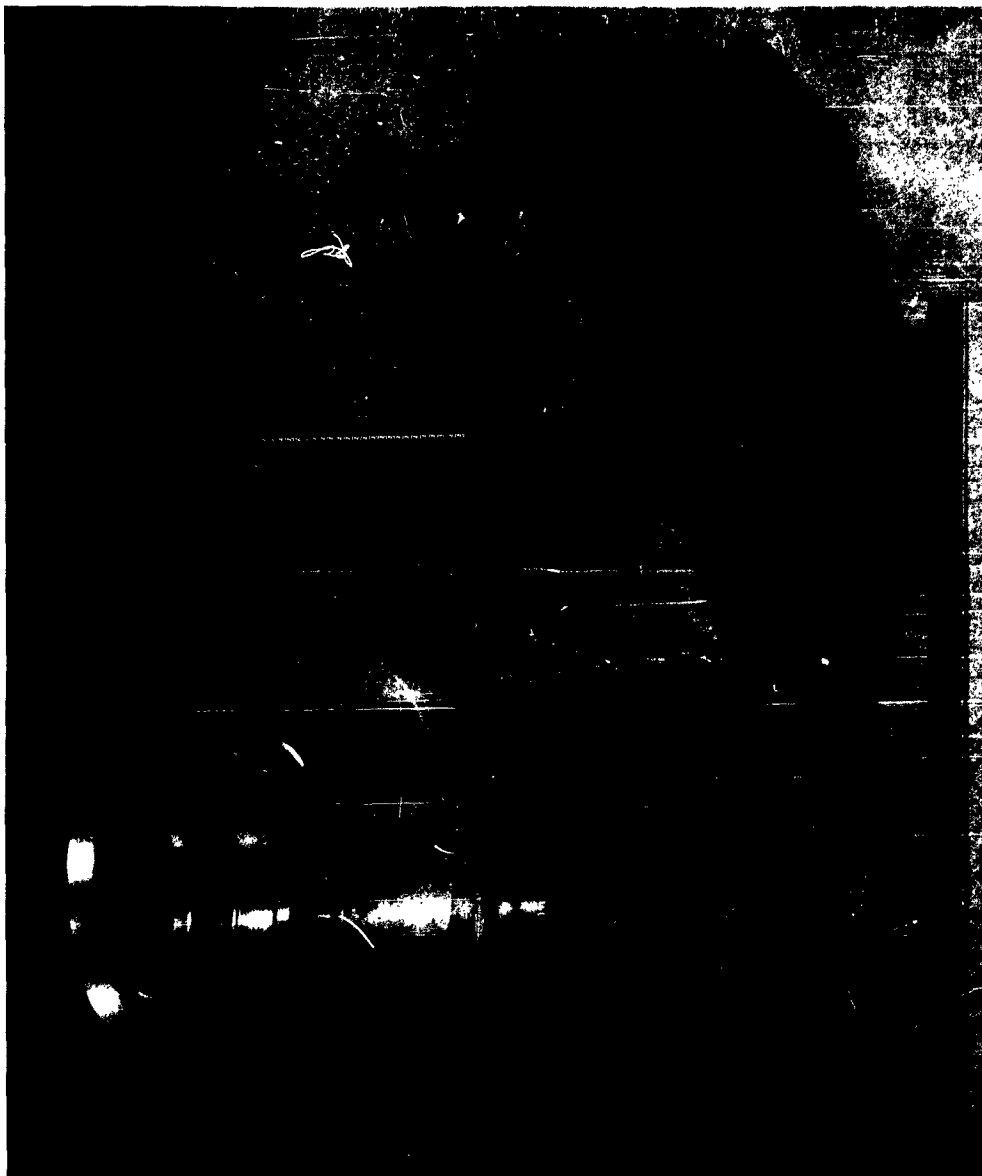
Fig. 6-1. Infrared Radiometer

Table 6-1. Background Radiance as a Function of Longitude and Latitude

Channel	Radiance ($w/cm^2 sterad \mu$)	Latitude	Longitude	Quantity	Record Length (sec)
2.7µ	9.0×10^{-5}	21°N	162°W	max	154
	1.1×10^{-5}	25°N	163°W	min	154
	4.5×10^{-5}			ave	154
	9.7×10^{-5}	20°S	127°W	max	400
	9.0×10^{-6}	60°S	101°W	min	400
	4.7×10^{-5}			ave	400
2.2µ	1.9×10^{-3}	21°N	162°W	max	154
	3.0×10^{-4}	25°N	163°W	min	154
	1.0×10^{-3}			ave	154
	2.6×10^{-3}	19°S	119°W	max	400
	3.0×10^{-4}	60°S	101°W	min	400
	1.1×10^{-3}			ave	400
1.8µ	1.7×10^{-3}	21°N	162°W	max	154
	4.0×10^{-4}	25°N	163°W	min	154
	1.1×10^{-3}			ave	154
	4.0×10^{-3}	20°S	127°W	max	400
	3.4×10^{-4}	60°S	101°W	min	400
	1.6×10^{-3}			ave	400
1.4µ	5.0×10^{-3}	21°N	162°W	max	154
	6.6×10^{-4}	25°N	163°W	min	154
	1.7×10^{-3}			ave	154
	1.0×10^{-2}	40°S	119°W	max	400
	6.6×10^{-4}	62°S	96°W	min	400
	3.3×10^{-3}			ave	400
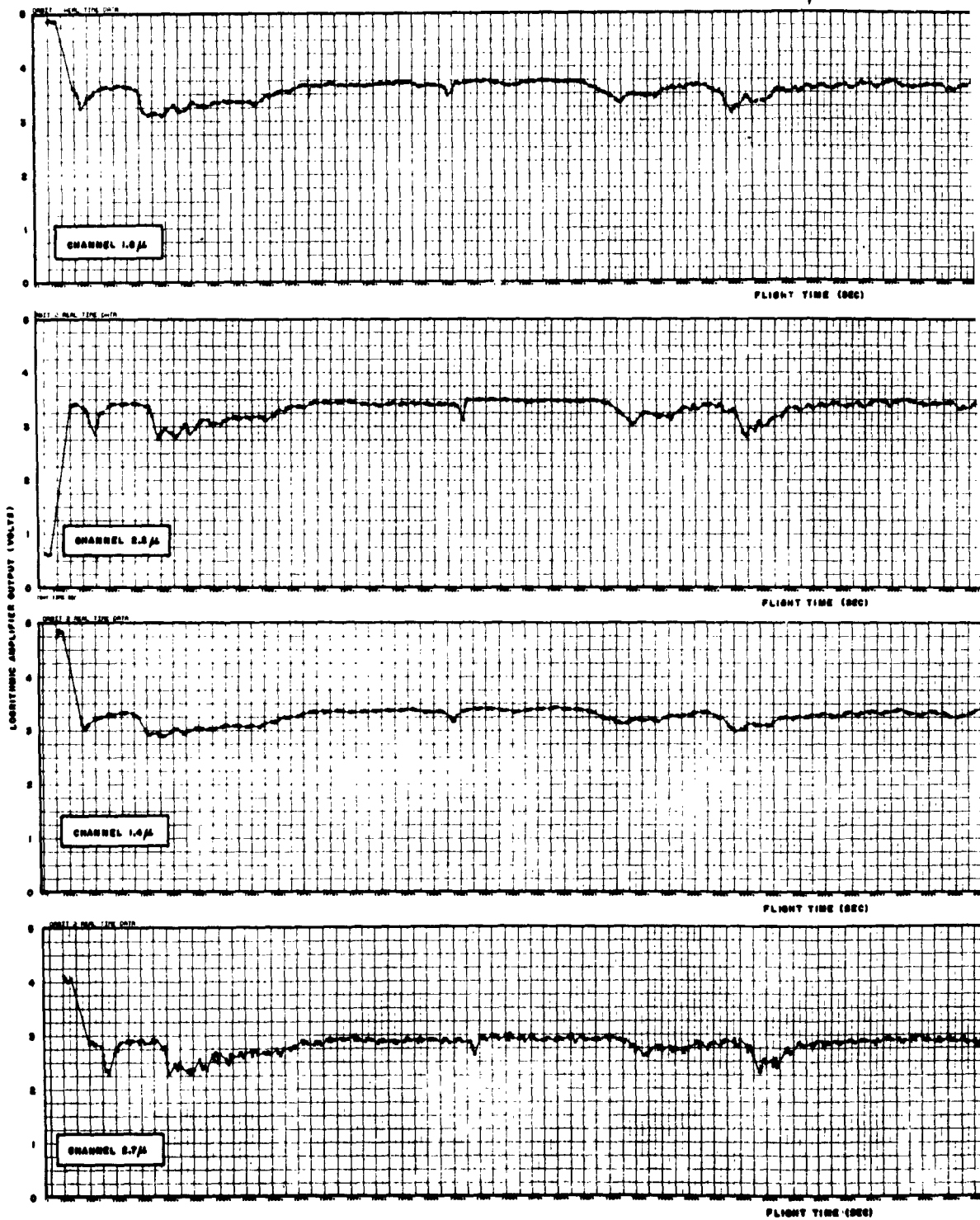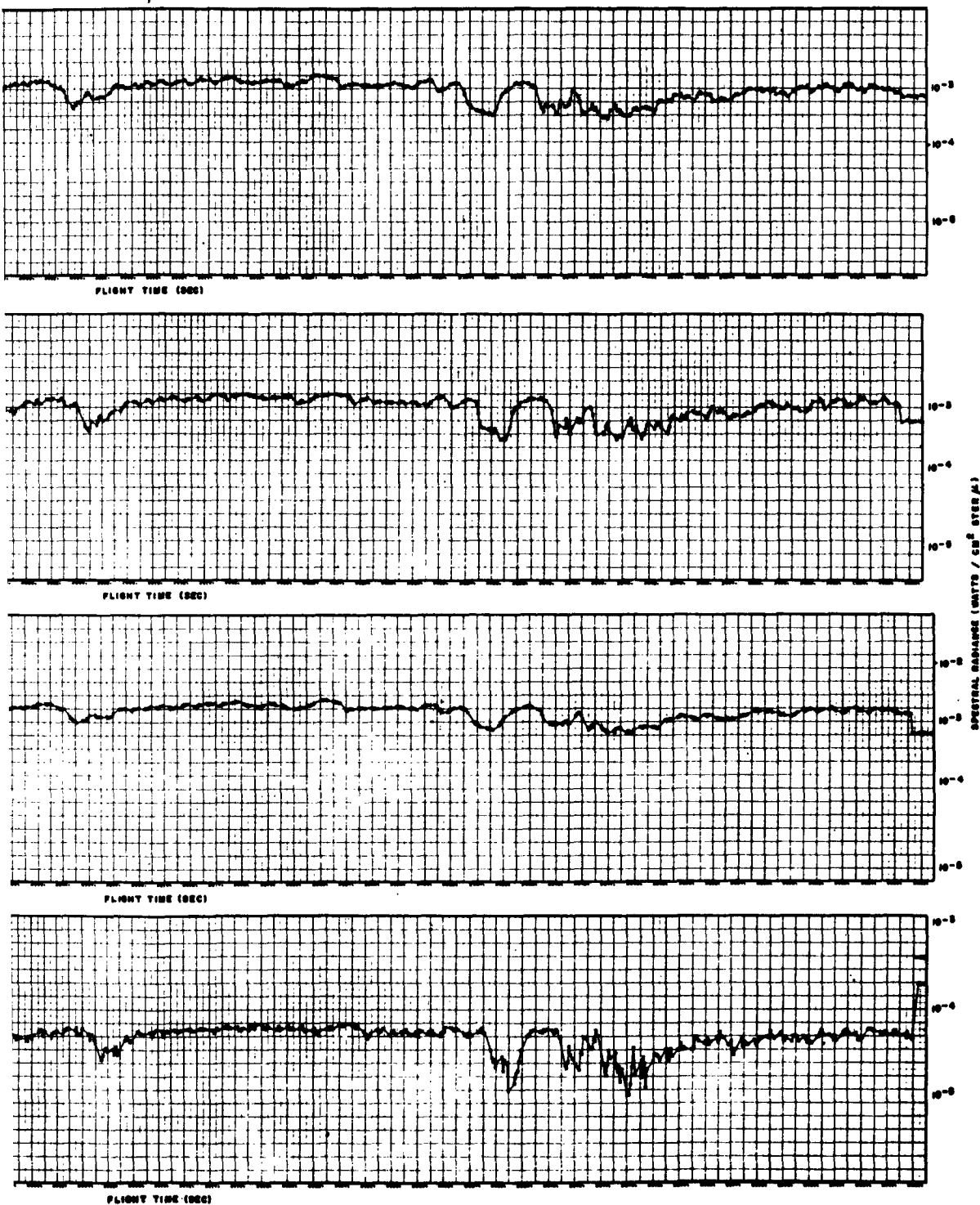
Fig. 6-2. Time/Voltage Plots
of Log Amp Output

Aerospace Corporation, El Segundo, California.
SPACE PHYSICS PROGRAM. SEMIANNUAL
TECHNICAL NOTE, 1 July - 31 December 1962,
prepared by Space Physics Laboratory. April 1963.
[64]p. incl. illus.
(Report TDR-169(3260)TN-1; SSD-TDR-63-77)
(Contract AF 04(695)-169   Unclassified report

A number of experimental techniques have been
developed and employed in making measurements
of the near-earth space environment from Program
162 satellites. These measurements include the
identification of the fluxes and energy spectra of
trapped protons and electrons in the region of space
from 200-700 km and provide the first positive
identification that the artificial radiation belt was
produced from bomb electrons. Radiometric meas-
urements have also been made of the earth's back-
ground radiance in the near infrared and middle
ultraviolet regions of the spectrum. Data are being
(over)

analyzed to determine the vertical distribution of ozone in the atmosphere, as inferred from measurements of the attenuation of radiation in the middle ultraviolet due to absorption by the O_3 molecule. Airglow experiments were conducted to study the 5577A green and the 6300A red lines of atomic oxygen.