REPORT

THE PERKIN-ELMER CORPORATION

NORWALK, CONNECTICUT

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N62-10760

ELECTRO-OPTICAL DIVISION **PE** THE PERKIN - ELMER CORP.

ENGINEERING REPORT NO. 5972

TITLE: ROCKET-UV SPECTROMETER

COPY NO. ________ **DATE:** July 17, 1961

PREPARED FOR: PRINCETON UNIVERSITY OBSERVATORY

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SECTION I

INTRODUCTION

This is a report of the second three months (March-May 1961) of a program to design and fabricate an ultraviolet spectrometer and fine guidance control for use in an Aerobee-Hi rocket. The work is being done under Subcontract No. 1 under Contract NASr-3 between Princeton University and the National Aeronautical and Space Administration. The design goals for this instrument are described in the report for the first three month period (Perkin-Elmer Engineering Report No. 5906).

The accomplishments of the second three month period include the solution of certain design problems, the establishment of an effective liaison system with personnel at Goddard Space Flight Center, and the completion of certain design and fabrication tasks.

Close liaison has been maintained with the staff of the Princeton University Observatory. As a matter of fact, members of this staff, Dr. Lyman Spitzer, Dr. John Rogerson, and Dr. Kurt Dressler have participated most generously and effectively in solving many design problems as they have arisen.

SECTION II

DESIGN PROBLEMS

A. BACKGROUND RADIATION

During the early part of this program, it had been proposed to limit the extent of the sky seen by the spectrometer and by the guidance system through the use of a captive door which was stopped at a particular angle when opened. Some doubts were entertained concerning the reliability of this mechanism so the design was changed to a jettisoned door. At this time it was noted that for this flight a star would be chosen for viewing which had few other stars of comparable magnitude nearby. In addition, a "spectrum plane" would be chosen through the viewed star which contained no stars with predictable ultraviolet radiation above the detection threshold. All stars outside this plane will produce spectra on the focal plane which lie above or below the ends of the slit. Even if this plane turned to include a known star (other than the program star) with known emission lines, these signals could be predicted and subtracted from the spectral data. However, a star with a continuum spectrum or background radiation from the sky in this "spectrum plane" could not be separated from the desired spectrum of the program star.

Three Aerobee flights — by Kupperian at White Sands and Wallops Island and by Fastie at Fort Churchill — have indicated ultraviolet background radiation, possibly of an auroral nature, even when the sky appears dark in the visible. In the worst case this was reported as 1×10^{-3} ergs $sec.^{-1}$ cm^{-2} $ster.^{-1}$ in a 50Å band near 2500Å. Since one photon at that wavelength is about

8. x 10^{-10} ergs, this radiation represents 2.5 x 10^{6} photons sec.$^{-1}$ cm^{-2} ster.$^{-1}$ Å^{-1}. Assuming a 400 cm^{2} grating area and a 2Å bandpass, this becomes 2. x 10^{9} photons sec^{-1} ster.$^{-1}$.

If the slit height subtends .002 radians and the grating can see 1.5 radians of sky in the "spectrum plane," the exit slit will receive 6. x 10^{6} photons sec.$^{-1}$ from the sky, assuming it is glowing evenly with the previously mentioned brightness. The continuum of a first magnitude B star in that spectral region (2500Å) will yield only one twelfth that many photons per second.

As a corrective step it was decided to install baffles which would limit the sky which may be viewed by the grating by a factor of about fifteen. Any greater limitation would affect the fine guidance range. It is hoped that sky background at the level quoted is an unusual condition.

B. GLOW DISCHARGE AROUND THE BENDIX PHOTOMULTIPLIER

One of the radiation detectors to be used is an envelopeless phototube which require 2000 volts to operate. At some of the atmospheric pressures to be encountered early in the flight, a glow discharge could initiate and a destructive arc occur. The obvious solution is to connect the 2000 volts after the pressure has fallen to a safe level. It is an easy matter to determine the altitude and time interval at which the external pressure is safe. It is more difficult to determine when the pressure within the Bendix detector is safe. Outgassing of many devices and substances may contribute to the local pressure for a considerable period of time.

It was determined to remove gas from the detector volume as quickly as possible by opening holes in both the nose cone and the spectrometer structure and to protect the detector volume as much as possible from gas given off by nearby objects by a clean metal shield which will form a conical channel from the detector to the outside.

In order to prevent charged particles from entering and adding to the detector dark current, two screens will be placed in the cone and given polarities above and below the potential of the metallic frame.

C. PERKIN-ELMER ELECTRONIC EXTENSION

It had been intended originally to place the electronic circuits around the inside surface of the spectrometer structure just outside the light beam. It became apparent that in order to do this successfully the circuits would have to be subdivided into very small units and many connecting wires added.

In order to mount these circuits more efficiently, it was decided to request the use of a 9.4 inch extension just behind the nosecone.

Station	
0 - 87.	Nose cone, spectrometer, pressure and temperature transducers, batteries.
87. - 88.	Pressure bulkhead.
88. - 98.	Signal circuits, measurement circuits, control circuits, power supplies.

Station	
98. - 113.	Telemetry transmitter, cutoff receiver, calibrator, distribution box, gages, commutators.
113. - 120.	Attitude control system.

D. BATTERIES

It seemed desirable to have a type of battery which could be kept charged by being connected to a suitable charging circuit for an indefinite period of time. This is not recommended for the silver cadmium cells originally chosen to power the Perkin-Elmer electronics. Nickel cadmium batteries may be used in this way. It was decided to change to the latter even though there would be a weight increase.

At the same time the total battery capacity was increased from a ten minute to a twenty-five minute supply.

SECTION III

TASKS COMPLETED

A. DESIGN AND DRAFTING

Fourteen assemblies or layouts and one hundred thirty two details have been approved and released. This corresponds to about seven eighths of the total design effort.

B. FABRICATION

All parts released have been ordered. Probably a third of these have been completed.

C. ELECTRONICS

1. Guidance Electronics Circuitry

This has changed little in the past three months since freezing must await data on how rapidly the coarse guidance system accelerates the rocket and also what we run into when we apply the servo to the final two-axis system. The DC shunt wound nutating motor shows better operation at about 4000 rpm than 1800 so we plan to run it at about 4000 which will automatically ease the servo stability problem. This will mean a carrier frequency of 536 cycles and a nutating signal of 67 cycles per second. Also a full wave discriminator probably will be used since its ripple frequency would be double that of a half wave unit and lower ripple amplitude, requiring less filtering, further relieving problem of stability.

2. Power

Batteries have been chosen and ordered. They are nickel-cadmium in pressure tight cans which may be charged anytime (unlike the silver cells). Also their discharge curve is flatter, which will keep nutating speed closer to constant, allowing them to drive the motor directly instead of thru Zener diode regulators. This is simpler and presents a considerably better source voltage regulation (lower source impedance) to the motor than even the Zeners could provide.

Battery capacity has been enlarged about 2-1/2 to 1, from 10 to 25 minutes since it was considered too tight. The weight penalty of shifting to nickel cadmium and raising capacity is 3 to 4 pounds, about equally divided.

A decision will need to be made soon between using truly hermetically sealed cells and mechanically sealed ones. The penalty for true hermetics is $1000 per system and 6 months lead time. We plan to test mechanically sealed cells soon in vacuum, to see how much gas leakage there is. The maker certifies them for vacuum operation but they might still leak too much.

3. Cabling and Interconnections

These are well enough established so wire and connectors have been ordered. Connectors will be used only at the interface with the rocket, (the manual test-set connectors to the 10 inch Perkin-Elmer electronics extension), and connectors from nose cone to Electronics extension, where crowding in space and number of wires (48) coupled with the problem of going through an air tight bulkhead, preclude direct soldering.

POWER CONNECTIONS

Input	Circuit or Item	Output	
		Channel	Multiplex
36 0	Guidance AC Amp. (2)		
36 0	Position Sensor Amp.		1
36 0	Mag. Relays (4)		
36 0	Thermal Relays (12)		
36 0	Explosive Squib (3)		
24 -6	Guidance Signal Pre-amp (2)		
24 -6	Pressure Sensor Amp (2)		2
24 0	Pressure Sensor Supply (2)		
24 0	Scan Current Sensor		1
24 0	Nutate Current Sensor		1
12 -18	Nutate Motor Field		
6 0	Nutate Motor Armature		
6 0	Scan Motor	1	2
6 0	Guidance PMT Supply		1
6 0	Temperature Sensor Supply		
6 -6, -18	Generator Power Amp.		1
0 -18	Guidance DC Power Amp (4)		
0 -6	Guidance Drivers (4)	2	2
	Carrier Frequency Sensor		1
	Error Sensor		1
	Temperature Sensor		4
	Battery Voltage		6

All interconnections within the nose cone will be soldered and cables will be securely supported.

They will also be identified by name and function, tagged, and coded to permit lead tracing and reduce confusion during assembly. A combination cabling and block diagram shows individual cables and major details of them. An exact wiring list will be made to provide all the rest of the details.

4. Secondary Data

All information, both status and primary, which is to be telemetered must be expressed as a DC signal from 0 to +5 volts DC. Bendix will provide the spectral data and the status data from their electronics and Perkin-Elmer will provide all the rest, amounting to 26 separate pieces of information.

All circuits to translate data into the zero to +5 volt code have been designed. About 90 percent have been built and testing and revision have started. A calculated risk was taken in skipping the breadboard stage since the final packages are so simple that even if we waste a third of them, we shall still be ahead. The usual oversights are showing up but there appear to be no fundamental difficulties.

Calibration of the secondary data circuits is also started. It will take the form of a two channel paper tape recording of the code signal level with calibration marks and with adequate notes written directly on the tape. Formal records will also be set up.

5. Test Sets and Procedure

A complete preliminary main test set schematic is done and has been submitted for approval of the main ideas. This one set will provide for all preliminary tests as well as permit charging the batteries. It does not provide signals for guidance operation tests or detector tests. When the system is physically assembled, a light source of some kind will be provided to furnish "starlight" for a simple test for guidance operation. It should be fairly easy to do this.

We probably shall want a small additional test set for use in the block house to monitor batteries, relays, and some other status data right up to firing time and this set has yet to be worked out.

Test procedures must also be formalized, especially those near firing time when pressure and lack of time impede memory and thought.

A more complete schedule must be written which will include the non-automatic events like starting dry nitrogen flush, nitrogen cooling, battery topping off, and status tests run from the block-house.

SCHEDULE OF EVENTS

Time	Event	Relays	
-45 min.	Power on EMI Detector	K1, Th1, Th2	Manual Switch
-5 min.	Power on PECO Electronics	K3, Th5-9	Manual Switch
+1 min.	Power on guid. detector, motor	K4, Th10, Th11	Timer DRW-13
+1.5 min.	Open door	S1	Timer DRW-13
+1.83 min.	Power on Bendix Detector, scan motor, free gimbal	K2, Th3, Th4 Th12 S2, S3	Timer DRW-13

D. WEIGHT CHECK

Latest revision of experiment weight:

Support structure	7.8 pounds
Paraboloidal mirror assembly	12.2
Gratings and mount	14.4
Bendix detector support	.6
EMI detector chamber	3.3
Mirror and arm assembly	.5
Guidance system and supports	3.3
P-E batteries	5.7
Bendix batteries	5.5
Remaining experiment parts	7.7
Interconnecting wires	4.0
Pressure bulkhead	5.5
9.4" Extension	4.4
P-E electronics	7.0
Bendix electronics	5.5
	87.4 pounds

E. LIAISON WITH GODDARD SPACE FLIGHT CENTER

At a conference at GSFC on 17 April 1961, attended by J.B. Rogerson, R.H. Noble, G.E. MacVeigh, E.E. Bissell, and E.C. Pressly, a take-off date of May 1962 was indicated. (This has since been suggested for April 1962.) The requirements for the experiment were reviewed.

In addition to the ACS extension, a fifteen inch extension is to be furnished by GFSC to contain:

Telemetry transmitter

Cut-off receiver (DRW-13)

Calibrator

Distribution box

Commutator (two double pole, 30 segments)

Gages

Timer

All telemetry is at GSFC disposal until 90 seconds. After that time Princeton requires:

9 channels full (formerly 10)

4 channels commutated (2 double pole)

Nose cone will be flushed with dry prepurified nitrogen (dew point, minus 90°F). Detector (EMI) will be flushed with a stream of gas from a Dewar of liquid nitrogen, (furnished by Princeton). Princeton will require thirteen pins on pull-away plug for block-house tests. Work will proceed toward a February 1962 date for GSFC checkout and environmental test.

SECTION IV

PROGRAM FOR THE NEXT QUARTER

A. DESIGN AND FABRICATION

All design will be completed.

All parts will be completed.

Assembly will commence and be one-fourth complete.

B. ELECTRONICS

Test sets will be two thirds completed.

Detail wiring lists will be done and cabling one-fourth complete.

Work on the guidance circuits will not be resumed until they can be checked on the assembled unit during September.

Calibration of secondary data circuits will be complete.

C. ENVIRONMENTAL TESTING

The gimbal assembly will be tested to 7.5 g and 3000 C/S and resonances noted.