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THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING
DEPARTMENT OF AEROSPACE ENGINEERING
HIGH ALTITUDE ENGINEERING LABORATORY

Quarterly Progress Report

High Altitude Radiation Measurements

1 July, 1967 - 30 September, 1967

FRED L. BARTMAN

Under contract with:

National Aeronautics and Space Administration
Contract No. NASr-54(03)
Washington, D. C.

Administered through: *January 1968*

OFFICE OF RESEARCH ADMINISTRATION · ANN ARBOR

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Table of Contents

		Page
List of Illustrations		iii
Abstract		iv
I.	Introduction	1
II.	Laboratory Testing and Development of the IRIS Interferometer	1
III.	Preparations for the Next Balloon Flight	2
	A. Texas Instruments IRIS Instrument	2
	B. The Filter-Wedge Spectrometer	3
	C. Other Balloon Gondola Installations	4
	D. Mobile Telemetry Ground Station Installations	4
	E. Programming of Gondola Operations	4
	F. Data Monitoring During the Balloon Flight (By P. A. Titus)	6
IV.	Laboratory Measurements of CO_2 Transmission	9
V.	Report Writing	10
	A. Reports Published	10
	B. Papers Presented	10
VI.	Future Work	10

List of Illustrations

		Page
1.	Exploded view of new mirror drive unit	11
2.	New mirror drive unit assembled	12
3.	Two views of new cold blackbody for T. I. IRIS	13
4.	View of balloon gondola from master programmer side showing position of filter wedge.	14
5.	View of balloon gondola from T. I. IRIS side showing position of filter widge.	15
6.	Schematic diagram showing program of operations for balloon flight 11.	16

Abstract

This report is a summary of project activities during the period 1 July to 30 September 1967. Laboratory testing of the IRIS interferometer, preparations for the next balloon flight and work on laboratory measurements of CO_2 transmission are described.

I. Introduction

This is the 19th quarterly progress report on contract no. NASr-54(03) covering the period 1 July 1967 to 30 September 1967. The project effort during this time was divided among the following tasks:

1. Laboratory testing and development of the IRIS interferometer.
2. Preparations for the next balloon flight.
3. Laboratory measurements of CO_2 transmission.
4. Report writing.

II. Laboratory Testing and Development of the IRIS Interferometer.

The interferometer development effort included work on a new mirror drive unit (for improved resolution of 2.5 cm^{-1}) and on the mylar beam splitter (to enable the existing interferometer to work in the 14-40 micron range).

The new mirror drive unit was assembled. An exploded view is shown in Figure 1 and the assembled unit is shown in Figure 2. It has longer springs, a longer length of carriage between the two sets of springs and separate drive and feedback coils. The increased length of the springs and carriage improve the ability to drive the mirror a longer distance without objectionable mirror rotation. The separate drive and beedback coils make it possible to provide better damping and thus to decrease vibration. Because the unit is larger, new larger magnets are used.

A new drive amplifier, to be used with the new mirror drive unit, is also being developed.

Work on the mylar beam splitter has continued, although at a slow pace because of higher priority work. Several basic problems remain to be solved.

a.) To successfully stretch a 3.75 micron film to a thickness of 2.75 microns.

b.) To clamp the stretched film in the beam splitter holder without distorting the film or the holder.

c.) To prevent acoustical vibration of the thin film.

III. Preparations for the Next Balloon Flight.

A. Texas Instruments IRIS Instrument.

A change has been made in the arrangement of calibration blackbodies for this instrument. The cold blackbody, which was formerly mounted on the space port of the instrument, has been moved to the shroud (instrument container). Since the instrument is mounted on shock mounts inside of the shroud, this change in the mounting arrangement of the cold blackbody improves the isolation of the instrument from balloon gondola vibrations. Vibrations, formerly conducted from the gondola to the instrument, through the copper tubing which is fastened to the cold blackbody, will be eliminated. Two views of the new cold blackbody are shown in Figure 3.

The problem of changing the format of the T. I. IRIS digital data (to make it compatible with the 7090 computer) appears to be solved. Steps involved in processing the data are:

1.) Playback the original magnetic tape recording of serial bi-phase data on the CDC-160A computer at 1/8 of original recording speed. The top portion of the bi-phase signal is inspected by the computer and converted to zeros or ones (they may become inverted in this process). This information is recorded in binary form on another magnetic tape and then printed out on the 7090 computer.

2.) The printed data is inspected, noisy words are edited, word beginnings are located and the necessity for inversion is determined.

3.) A new corrected tape is then produced for input to the 7090 computer.

B. <u>The Filter-Wedge Spectrometer.</u>

The filter widge spectrometer which will be flown on the balloon flight was delivered to the University and its operation was demonstrated on 7 August 1967.

Plans for mounting the instrument on the gondola were checked. The frame used for fastening the instrument to the gondola had to be modified because it interfered with one of the instrument connectors. Mounting holes for the frame were then located and drilled. The entrance aperture door was modified to serve as a blackbody which will be used for in-flight calibration checks once every hour.

The position of the filter wedge spectrometer on the balloon gondola is shown in Figure 4, which shows the position of all apparatus which will be mounted on the underside of the gondola. Figures 4 and 5 show the gondola with the filter wedge spectrometer located in its flight position.

In order to have U. of M. personnel become more familiar with the instrument operating characteristics and to test a portion of the control and data taking system, a set of calibrations of the instrument was made. Another set of calibrations will be made and the results will be reported on in the next progress report.

C. Other Balloon Gondola Installations.

A mechanical recording 3 axis accelerometer which will record launch and impact shocks has been designed and built. The acceleration snesors are mass-spring-damper assemblies with a pencil attachment which scribes a line on paper mounted on a clock driven drum. Further development of the recording mechanism is required, because the frictional force required for recording is too large.

A new linear induction motor to drive the T. I. IRIS warm blackbody has been received. A new D-C to A-C convertor was also procurred to provide the larger power requirements of this motor. The units have been tested in the laboratory and operate satisfactorily. Environmental tests have yet to be run.

The center of gravity of the balloon gondola, with all instruments in flight position, has been calculated. Although this is not a precise calculation because of unknown cable and balloon flight control equipment weights and locations, the c.g. appears to be close enough to the geometrical center of the gondola ($x = -0.24$ inches, $y = -0.68$ inches) to allow proper leveling with the gondola suspension system.

D. Mobile Telemetry Ground Station Installations.

The PDP-8 computer has been installed in the bus. Special mounting arrangements have been provided for the teletype printers and for tape storage.

A trial run has been made with the bus to shake-down all of the equipment. There was no equipment failure during this trial run.

E. Programming of Gondola Operations.

Figure 6 is a schematic diagram (not yet completed) which indicates the program of operations for the next balloon flight. The multiplexing of signals in the telemetry system and commands generated in two control units, the Master Programmer and the IRIS Control Box are indicated in the main block at the top of the diagram. The program of delayed operations, eight groups of housekeeping functions which are monitored and miscellaneous notes are shown on the right side.

The 200 Kiloherz crystal oscillator which is the clock for the programming system is contained in the IRIS Control Box. The following signals and commands are generated in this unit.

a.) 200 Kiloherz, 5 Kiloherz and 400 Herz signals required for interferometer operation.

b.) Command signals for control of the interferometer scan mirrors and the T. I. IRIS warm blackbody linear actuator.

c.) Pulses to actuate the scan of the interferometer movable Michelson mirrors.

d.) A one Herz signal for use in the Master Programmer.

e.) One pulse every 256 seconds to shift telemetry channels B, E, and 13 from one interferometer to the other.

The Master Programmer accepts the 1 Hertz signal from the IRIS control box and generates a control signal with a basic period of 16 seconds. A cycle of twenty 16 second periods is set up as a basic timing interval for all equipment on the balloon gondola except the interferometers.

The total length of the chart is the least common multiple of 256 seconds (the basic timing interval of the interferometer control signals) and 320 seconds (the basic timing interval of the Master Programming Unit). This least common multiple (2560 seconds) is the interval for one unique cycle of events in the program of gondola operations. The number of 16 second intervals in such a cycle is given at the left hand side of the diagram. The number of an interval within the 20 step basic timing interval of the Master Programmer is indicated in the second column.

The time during which data is telemetered for a given instrument or housekeeping data group is indicated by black shaded areas on the diagram.

Delayed operations can be programmed to occur at intervals as long as 24 hours after the start time. The times indicated on the diagram are not necessarily final, they can be adjusted as required by final operation plans.

F. Data Monitoring During the Balloon Flight. (By P. A. Titus)

During the balloon flight, balloon gondola operations and the operation of radiation measuring instruments is monitored in the Mobile Telemetry ground station by visual inspection of the analog signals recorded on direct writing recorders or displayed on the face of a cathode ray oscilloscope.

In addition the housekeeping data recorded on IRIG channel 2 is processed digitally so that operating conditions on the balloon gondola are known quite precisely. Each of the housekeeping functions in Thermister Group #1, Thermister Group #2, MRIR Monitors and General Monitors is digitized. Telemetry voltage calibrations, voltage ratio corrections and sensor calibration data are applied in the PDP-8 computer. The results of this processing (battery voltages, instrument temperatures and signals indicating various operations on the gondola,) are printed out on the teleprinter along with time data (EST and elapsed time from start of operations). Data taken in one 16 second interval is printed out in the next 16 second interval.

The data processing system which consists of a time-code generator, multiplexer, analog-to-digital converter, two teleprinters and the PDP-8 computer became operable on 11 August 1967. Programming of the computer has been carried out in machine language for best efficiency of computer operation.

The following subroutines necessary for this data processing have been written.

TCG - Time Code Generator:

Read and store these 12-bit TCG words; process and print hours, minutes, seconds, and milliseconds. The words are read at the beginning of each 5 min., 20 sec. data cycle; time is printed during the following 16 seconds.

ELT - Elapsed Time (plus ELS and ELP):

One-second pulses from the gondola timer via IRIG ch. 3 and comput interrupt are counted and accumulated throughout the flight. Hours, minutes, and seconds are printed right after TCG printout, and on the same line.

ADC - Analog to Digital Converter (plus Multiplexer)

Convert 16 readings of an analog voltage taken at a 50/second rate to digital values, compute the average voltage, and store.

Ec_i - Calibration Voltages (relative)

Compute $1/2\ (\bar{Ec}_{i,1} + \bar{Ec}_{i,2}) = \bar{\bar{Ec}}_i$

where i = -5, -4, . . . , Ø
1 = calib. supply 1
2 = calib. supply 2

Compute $\bar{\bar{Ec}}_i - \bar{\bar{Ec}}_{i+1} = \Delta Ec_i$. and if one of the calibration supplies should become unusable during the flight, the good set of $\bar{Ec}_i$ will be stored in $\bar{\bar{Ec}}_i$ locations.

$\bar{Ec}_{i,1}$ $\bar{Ec}_{i,2}$ and $\bar{\bar{Ec}}_i$ will be printed in their actual form in three rows of six words each. Printout will occur during the remainder of the first 16 second interval and the second 16 second interval.

CAD - Calibration Voltage Detector

Following TCG and ELT at the start of the 5 min., 20 sec. data cycle, the signal on IRIG ch. 2 is sampled at the A/D free-running rate and tested to see if it is $\geq$ 4.9V. If for 5 successive readings the test is true, the signal is assumed to be $Ec_{-5,1}$ and "the data cycle is right." However, if for 10 successive readings, the test is false, control is returned to the interrupt to try again.

POL - Interpolate Using $\bar{\bar{Ec}}_i$ and ΔEc

Store sign, integar, and fraction of monitor voltage.

MPY - Multiply

The product of two signed 11-bit words is a double-signed 22-bit product.

DIV - Divide

A double-signed 22-bit dividend divided by a signed 11-bit divisor yields a signed 11-bit quotent and a signed 11-bit remainder.

.4s - 0.4 Sec Delay Loop

BCDI, BCDF - Binary to Binary-Coded Decimal Conversion

Prepares binary words for decimal printout: a signed two-ditit integar and a three digit fraction.

DEC	-	decimal no. printout, 3 characters at a time.
CR	-	commands carriage return.
LF	-	commands line feed.
SP	-	prints space.
$\ominus$	-	prints minus sign.
Λ	-	prints period.
(:)	-	prints colon.

OCT - Prepares a stored binary word for printout and prints it as a four character octal word.

IV. Laboratory Measurements of CO_2 Transmission. (By Henry Reichle)

During this period, work has been directed toward:

a. Refurbishing the 40 meter cells.

b. Obtaining a suitable method of sample gas analysis.

c. Developing a magnetic tape data recording system for the spectrophotometer.

The 40 meter long path cells were disassembled and cleaned, the mirrors were recoated, and the cells were reassembled. Except for alignment (to be performed at the time of installation) the cells are now ready for use.

The problem of analyzing the sample gas mixture has been studied in some detail. After examining the feasibility of using various analysis techniques, including mass spectroscopy, gas chromatography and chemical methods, it was decided that the technique described by Melfi and Wood in NASA TN-D 1597, The Use of an Ionization Gage as a Quantitative Analyzer for Bi-Gaseous Mixtures would be most suitable for our purposes. This technique has been used with good results at Langley for the analysis of various binary gas mixtures. The Langley Research Center has agreed to loan a special Alphatron Ionization Gage to the High Altitude Lab. for use as a gas analyzer. The spectophotometer has been modified (by the addition of potentiometers) for remote data recording, and signal conditioning equipment has been designed and built. The data system has been tested and performs as expected.

During the next report period it is expected that the alphatron gage will be received from Langley and the gas analyzer assembled and calibrated, computer programs for digitizing and processing the analog magnetic tape data will be written, and hardware for the end to end calibration of the measuring system will be built. It is anticipated that the first data using the complete data recording system will be obtained during this period.

V. Report Writing.

A. Reports Published

Quarterly reports were brought up to date. Four quarterly reports were written. The report numbers, quarterly periods covered and the date of publication are:

05863-15-P, 1 July 1966-30 September 1966, July 1967
05863-16-P, 1 October 1966-31 December 1966, August 1967
05863-17-P, 1 January 1967-31 March 1967, August 1967
05863-18-P, 1 April 1967-30 June 1967, September 1967

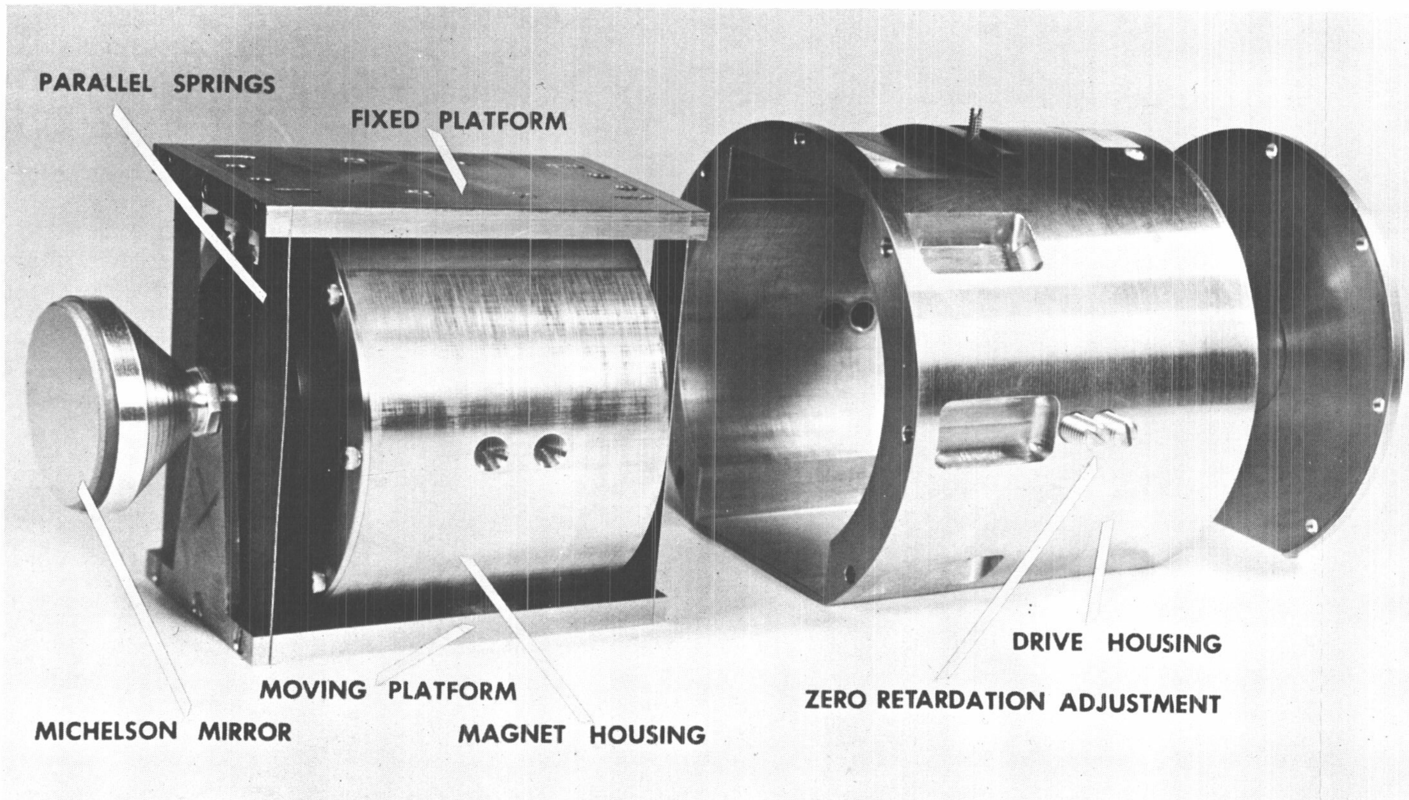
B. Papers Presented and Lectures Given.

1. Bartman, F. L., "Earth Reflectance Patterns Measured by Radiometer on High Altitude Balloon Flights," paper presented at the International Conference on Ultilization of Balloons for Scientific Research, Centre National D'Etudes Spatiales, Paris, France, 10-13 July 1967 (Proceedings are to be published).

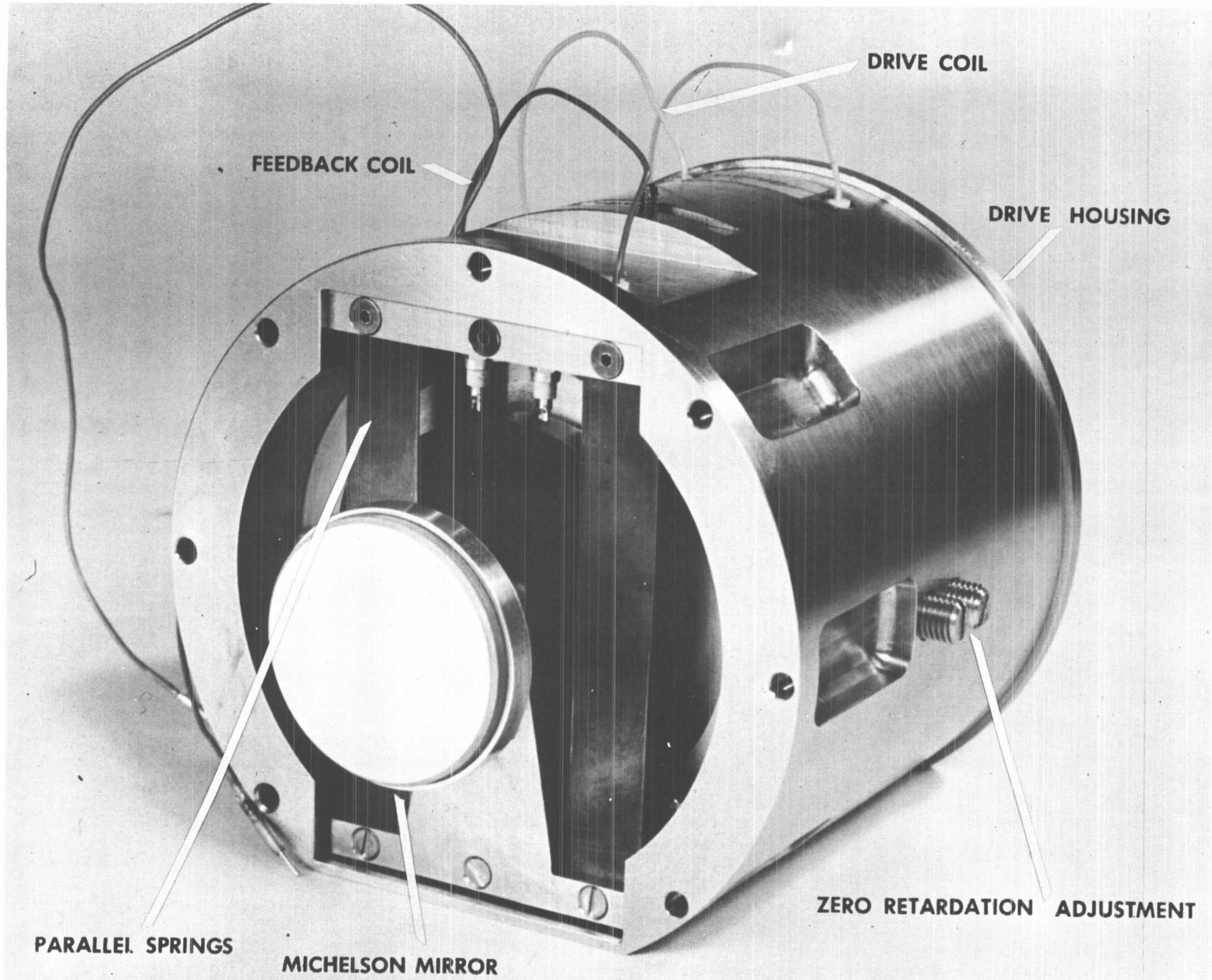
VI. Future Work

During the next quarter, work will continue on laboratory testing and development of the IRIS interferometer, preparations for the next balloon flight and laboratory measurements of CO_2 transmission.

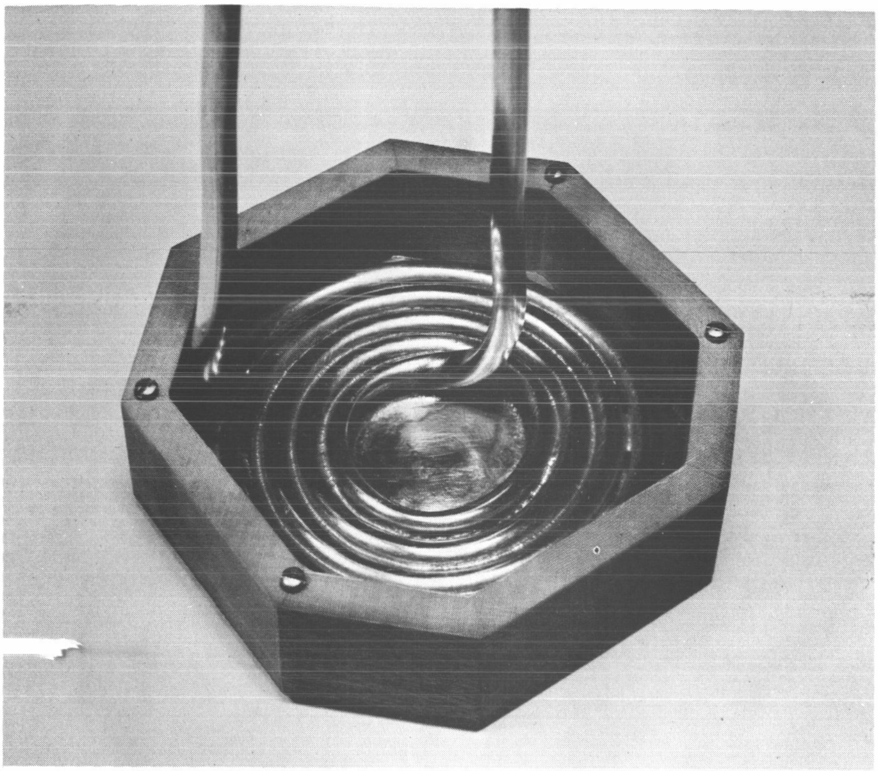
The theoretical study of earth's albedo will be resumed.

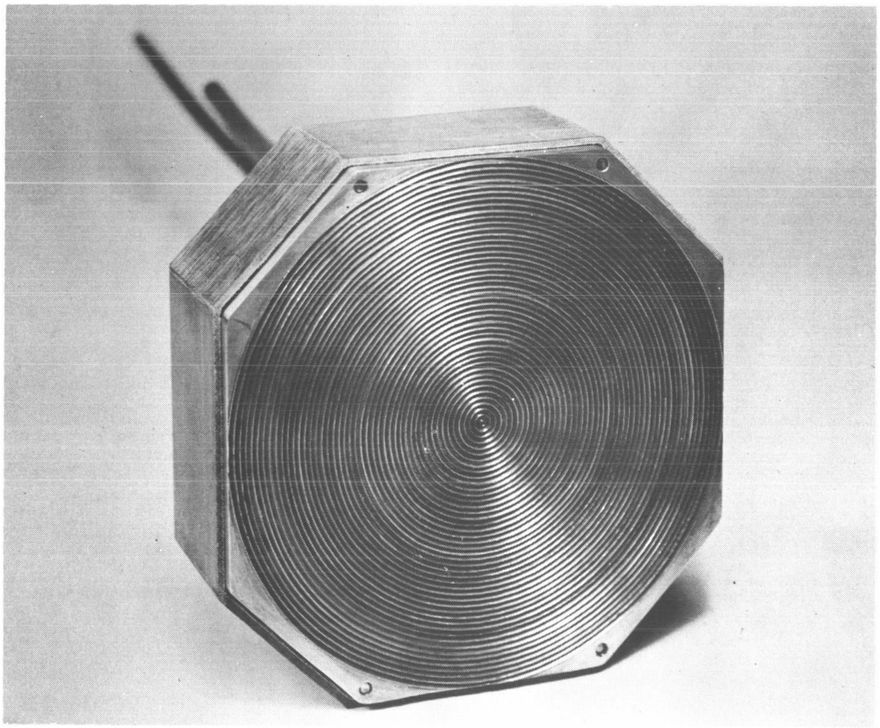


Exploded view of new mirror drive unit

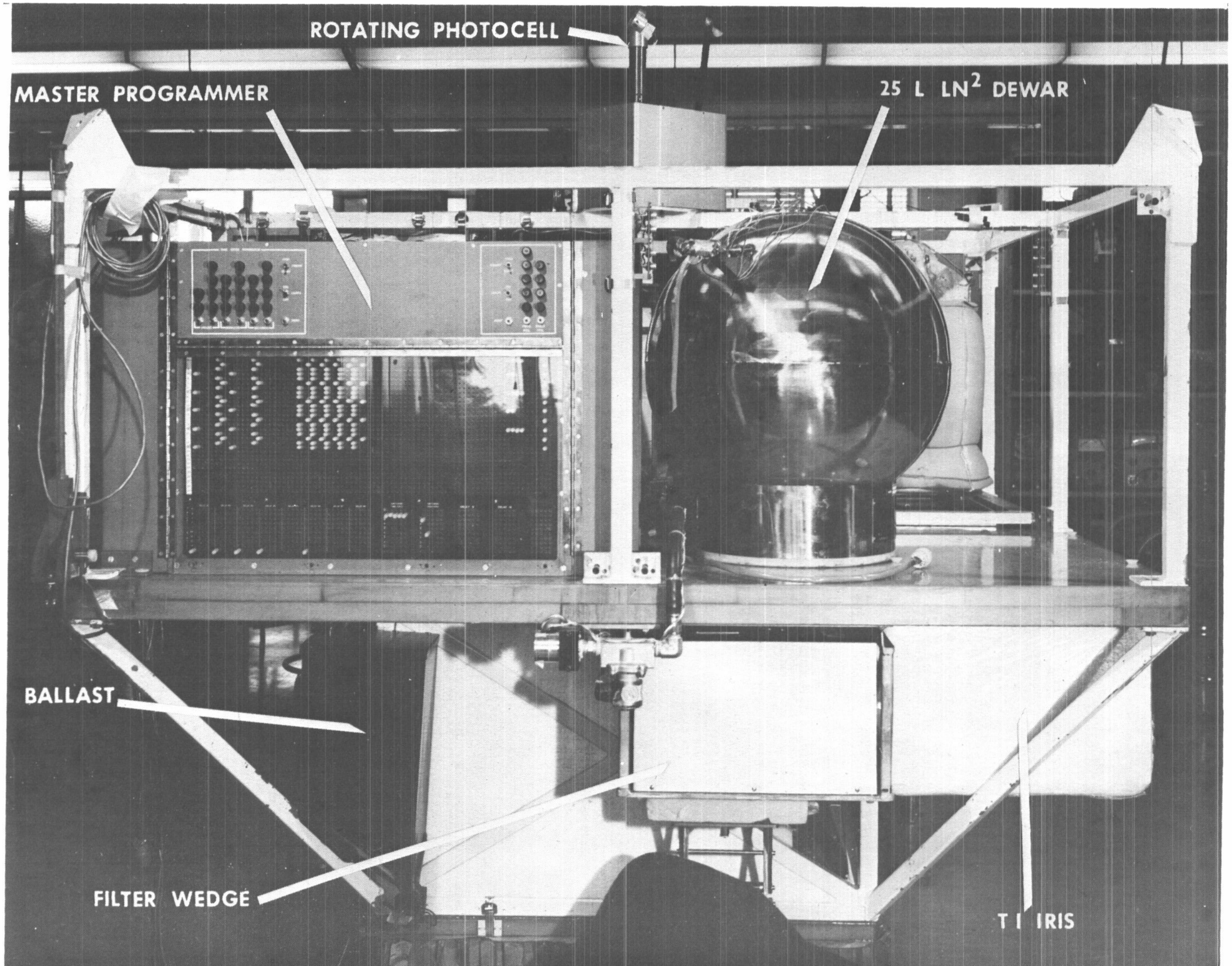


New mirror drive unit assembled

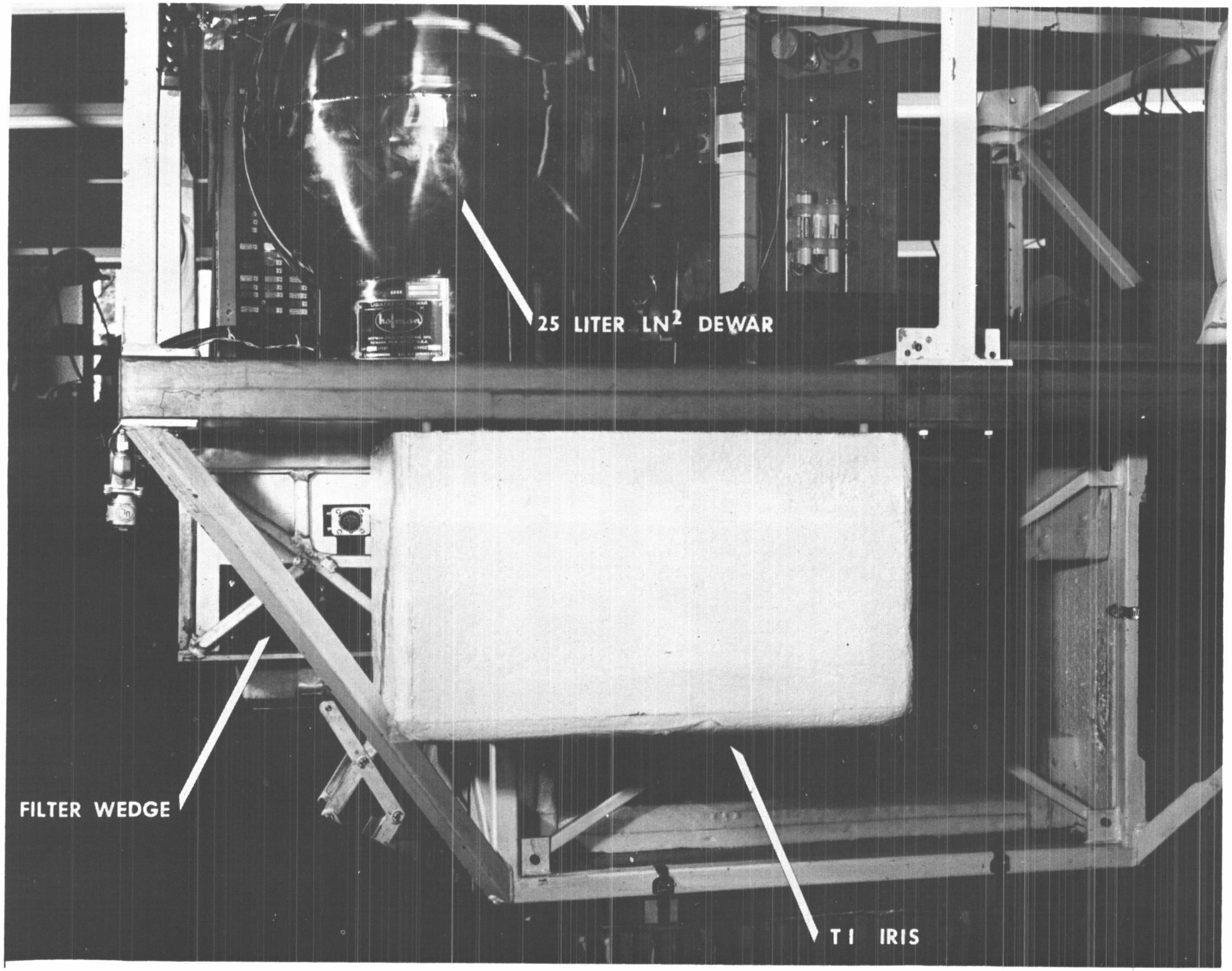




Two views of new cold blackbody for T. I. IRIS

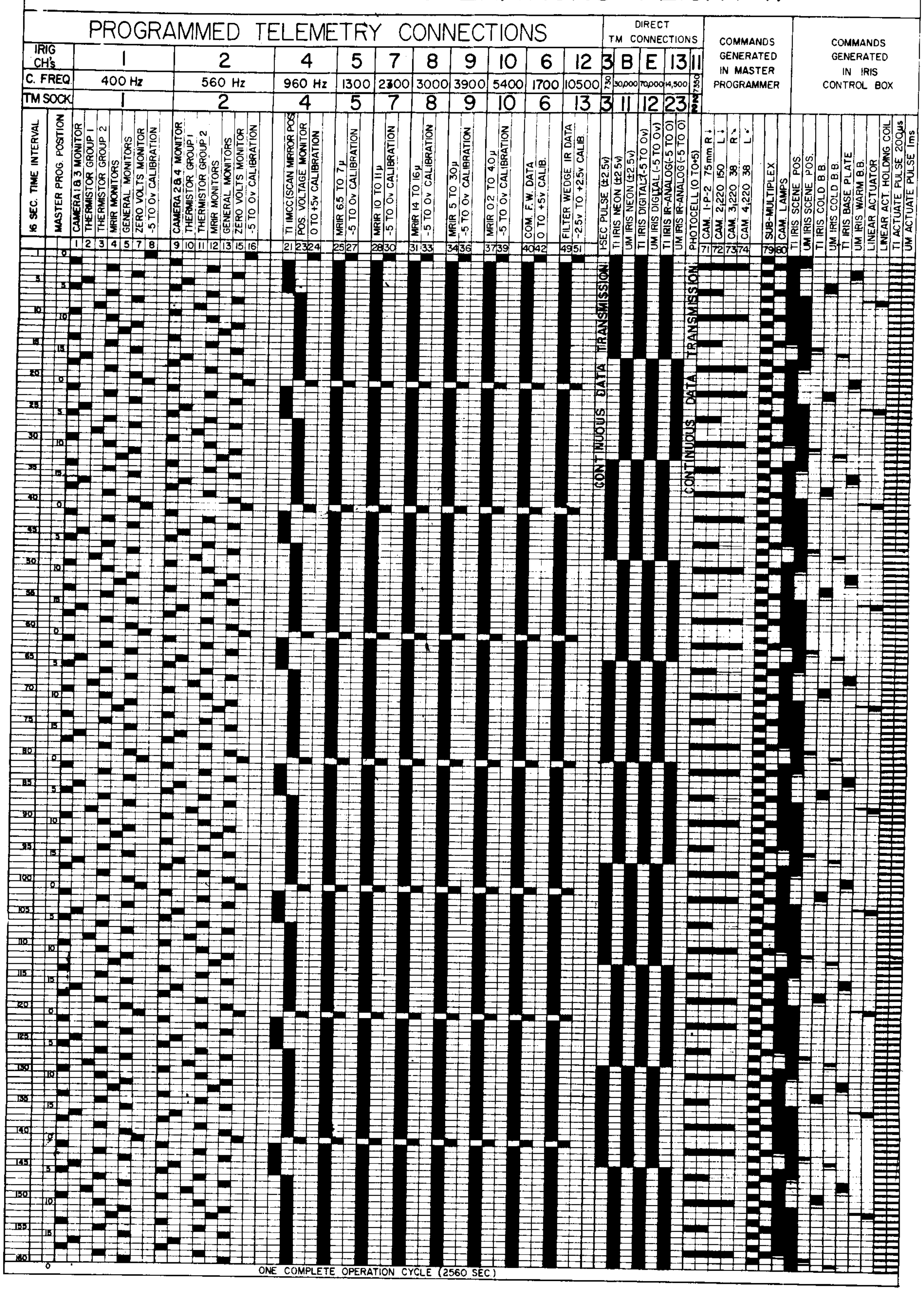


View of balloon gondola from master programmer side showing position of filter wedge.



View of balloon gondola from T. I. IRIS side showing position of filter widge.

PROGRAM OF OPERATIONS-FLIGHT II



MONITOR GROUPS

1 -5v TO 0v CALIB	2 0v TO +5v CALIB	3 -2.5v TO +2.5v CALIB	4 POS. VOLT. MON.
-5V	0V	-2.5V	Camera Battery
-4V	1V	-1.5V	+10V Battery
-3V	2V	-0.5V	Photocell Battery
-2V	3V	+0.5V	Telemetry Battery
-1V	4V	+1.5V	MRIR Mirror Position
0V	5V	+2.5V	
-5V	0V	-2.5V	
-4V	1V	-1.5V	
-3V	2V	-0.5V	
-2V	3V	+0.5V	
-1V	4V	+1.5V	
0V	5V	+2.5V	
TI IRIS Door	Calib. Supply 1+		
FAT Th. L	Calib Supply 2+		
FAT Th. R			

5 THERMISTOR GROUP I	6 THERMISTOR GROUP 2	7 MRIR MONITORS	8 GENERAL MONITORS
Pres. Alt. Box	Reg. Power Supply	Chop. Th. 1	FAT Boom L
Telem. Xmitter	Maurer Cam. 2	Chop. Th. 2	FAT Boom R
MRIR Door Motor	Maurer Cam 3	Hsg. Th. 1	IRIS Door
UM IRIS Base Pl.	Maurer Cam 4	Hsg. Th. 2	Filter Wedge Door
MRIR Cont. Box	Bat. Comp. Upper	Module Th.	Reg. Th. Sup. Bat.
TI IRIS Cont. Box	MRIR Door	MRIR Reg. Th. Sup.	-10V Battery
Master Program.	Bat. Comp. Lower	Chopper Monitor	-20V Battery
Telem. P.S.	MRIR Door	-10V Supply	-5.4V Battery
TI IRIS Base Pl.	Wollensak Cam.	-24.5V Supply	TI IRIS Base Plate T.
Gondola F.A.T.	F.W. Door	Calib. Sup. 1-	TI IRIS Detector T
F.W. Plate	Maurer Cam. 1	Calib Sup. 2-	TI IRIS Elect. Mod. T.
UM IRIS Elect.	Photocell	Calib. Sup. 3-	TI IRIS Warm B.B.
Reg. Th. Sup.	Reg. Th Sup	FAT Th. Sup.	MRIR Door
FAT Th. L	FAT Th L	FAT Th. L	FAT Th. L
FAT Th. R	FAT Th. R	FAT Th. R	FAT Th. R

TI IRIS — INSTRUMENT SCAN MIRROR POSITION TIMES:

SCENE	220 SEC.
COLD BLACK BODY	12 SEC
BASE PLATE B.B.	12 SEC
WARM BLACK BODY	12 SEC.

UM IRIS — INSTRUMENT SCAN MIRROR POSITION TIMES:

SCENE	188 SEC
WARM BLACK BODY	28 SEC
COLD BLACK BODY	28 SEC

FILTER WEDGE DOOR OPERATES EVERY 2 HRS 4 MIN AFTER THE HOUR. DOOR IS CLOSED FOR 56 MIN. DOOR MOTOR IS ENERGIZED FOR 10 SEC. IN BOTH DIRECTIONS

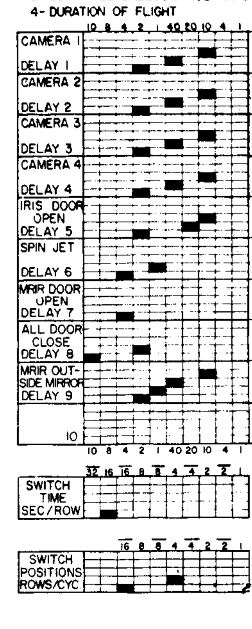
FREE AIR TEMPERATURE PROBES ARE LOWERED FROM VERTICAL TO HORIZONTAL POSITION AT 5000 FT ALTITUDE IN 60 SEC.

UPWARD LOOKING WOLLENSAK TAKES A PICTURE EVERY 15 MIN. STARTING AT 0 TIME.

PRESSURE ALTITUDE WOLLENSAK TAKES A PICTURE EVERY MINUTE ABOVE 25000 FT. ALTITUDE

DELAY PROGRAM BASED ON:

1- START OF MASTER PROGRAMMER PRIOR TO LAUNCH **2hrs 10m.**
2- TIME OF LAUNCH WITH RESPECT TO SUNRISE **40 min.**
3- ESTIMATED BALLOON RISE RATE **1000 FPM.**
4- DURATION OF FLIGHT **10 hrs.**



FIRST PHOTOGRAPH **63** CYC POS **122**

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PROGRAM POSITION AT TIME OF DOOR OPERATION **58** CYC STEP **40**

SPIN JET FIRING TIME 20 MIN. AFTER HR. STARTING FROM GIVEN DELAY TIME DURATION OF FIRING 10 SEC

PROGRAM POS AT TIME OF DOOR OPERATION 90 CYC DOOR OPEN 27 SEC AFTER START OF 91ST CYCLE

TIME OF DOOR CLOSURE: END OF **270** CYC.

MRIR OUTSIDE MIRROR OPERATES 50 MIN. AFTER THE HR. FROM GIVEN DELAY TIME.

ONE PIN REQUIRED "NOT" BAR POSITION

IRIG CHs	1 2 4 5 6 7 8 9 10 12
PROG. TEST POS.	1 2 4 5 10 6 7 8 9 13

Schematic diagram showing program of operations for balloon flight 11.