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POST-FLIGHT THERMAL DATA ANALYSIS OF THE "J-7" SYSTEM

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POST-FLIGHT THERMAL DATA ANALYSIS OF THE "J-7" SYSTEM

1. INTRODUCTION

The previous post-flight thermal data analyses of the "J" systems were based upon the assumption that the data obtained from those temperature sensors attached to the vehicle skin were approximately correct. These data contradicted the temperature predictions based upon the assumed orbital thermal environment and the exterior surface thermal paint mosaic. This discrepancy between the analytical and the empirical data was resolved in favor of the empirical skin-temperature data since (1) the thermal environment can have temporal variations whose magnitudes and frequency are unknown and (2) the exterior surface paint mosaic is subject to surface finish degrading effects of unknown magnitude during the launching phase of operation. It is known that there are errors in the skin-sensor data due to the dissipation of electrical energy within the sensors; this was a major source of error for the sensors located within the vehicle. Assuming perfect thermal contact between the sensor and the skin, the relative magnitude of this error depends upon the relative amount of skin sensor electrical heating of the immediate adjacent skin area as compared to the total heat exchange for that particular area. Since the total heat exchange for most skin sensor positions was very large, involving direct solar radiation, albedo radiation, and earthshine radiation, the relative error was assumed to be small. The skin-sensor data for those vehicle areas not exposed to large heat-exchange rates, that is, those always facing dark space can be expected to be somewhat high[1] since the electrical heat input for those sensors become a significant proportion of the total heat exchange for those skin positions.

The vehicle-skin-temperature-sensor data, tape recorded throughout an orbit, were used in previous flights as the thermal boundary conditions to check the thermodynamic consistency of the internal sensor data. The interior components'

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[1] The Associate Contractor in a verbal communication October 11, 1963, stated that during a HATS test of an entire system that the skin sensors did not follow the skin temperature as indicated by calibration thermocouples in the low temperature ranges.

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temperatures were computed for the thermal environment presented by the vehicle skin as described in Reference 1. With the adoption by the Associate Contractor of the practice of calibrating the temperature sensors for electrical self heating as a function of time prior to flight, the thermodynamic consistency of the sensor data improved considerably. The average variation of the internal temperature data from that computed for the "J-5" system flight was approximately +1° F (Ref. 1, Table II data) while that for the earlier "J-1" flight was approximately +9° F (Ref. 1, Table III data). The flight data, tape recorded through an orbit, were necessary for this type of analysis since the skin temperatures, which vary considerably during an orbital revolution, are used to define an orbital thermal environment for the interior.

The Vidya Division of Itek has not received any tape recorded data for flights "J-9" and "J-7". Following a request of August 27, 1964, to the Associate Contractor by Vidya for the reduction of the "J-7" tape recorded flight data, the Associate Contractor submitted to the customer a cost estimate for that reduction. Vidya was informed September 28, 1964, that the request of the Associate Contractor for funding for the data reduction was denied. The data received, therefore, have been only those acquired at a single orbital position and do not permit a thermal analysis of the previous type since the entire boundary conditions cannot be established.

For the "J-7" post-flight thermal analysis, therefore, it was necessary to assume an average thermal environment due to the solar, albedo, and earthshine radiation heating to which the satellite was subjected during operation. The temperatures expected for various sensors were computed for the assumed thermal environment and for the exterior paint as it was designed. This type of computation can be expected to result in larger differences between the measured and the computed internal temperatures than those for the computations based upon the use of the measured skin temperatures as the

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boundary conditions. This is due to the inclusion of additional variables, the unknown variation in the space thermal environment and the unknown variation, if any, in the exterior thermal paint mosaic. Thus, an assessment of the thermodynamic consistency of the internal sensor instrumentation data and the determination of the sources of thermal errors cannot be accomplished as was done for previous flights (Ref. 13 for example). These difficulties with the current data will be explained in detail in subsequent portions of this report.

This report is the last of a series of six thermal analysis reports following the initial "J" system thermal design report. It is appropriate, then, that a résumé be included in this report describing the contributions made by the thermal analyses performed. This résumé is presented in Section 5.

2. METHOD OF ANALYSIS

The data obtained from the Associate Contractor includes the "J-7" system post-flight thermal data as reduced from the telemetered raw data obtained for a single orbital position corresponding to Vandenberg Air Force Base, the paint mosaic design for the "J-7" system, and the orbital β angle as a function of the number of orbital revolutions of the system. This material is presented in Appendix A.

The 130-node mathematical model of the system, together with the resulting solar absorptivity and thermal emissivity of the skin for the designed paint mosaic, were used to compute transiently the system nodal temperatures over an orbital period. The orbital β angle used for these computations was 40° corresponding to the system orbital revolution number 46 (Appendix A). A detailed description of the computational procedure is given in Reference 3. The heat fluxes for the thermal environment at an orbital β angle of 40° were computed by the methods described in Reference 4; for their computation an average terrestrial reflectivity (or albedo constant) value of 0.39 was used for the near polar orbit of the "J-7" system;

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the orbital inclination with the equator for this flight was 85° (Appendix A).

The orbital position reference point for the computations was the system's emerging transit of the terminator. In order to relate the transiently computed temperatures to the data acquired at Vandenberg Air Force Base, it was necessary to derive a mathematical expression in terms of the orbital parameters furnished to Vidya for the orbital time required for the satellite to traverse the path from the terminator to the data acquisition station. This derivation is presented in Appendix B.

3. RESULTS OF THE ANALYSIS

A comparison of the in-flight measured temperatures for the vehicle interior as obtained from the data acquired at Vandenberg Air Force Base with the computed nodal temperatures for the nodes, which best approximate the system's temperature sensor locations, is presented in Table I. The flight data utilized for comparison is that for orbits 40 and 47. These orbits have β angles of 40.5° and 39.9°, respectively. The temperature differences resulting from their departure from a β angle of 40° should be less than 1° F in the predictions.[2] The positions on the instruments corresponding to the nodal numbers are presented in the Nodal Breakdown Chart of Reference 1.

A graphical comparison is shown in Figures 1 and 2 for the measured temperatures on the vehicle skin, barrel and fairing, and the model computed temperatures for the orbital position corresponding to the data acquisition station.

4. DISCUSSION OF THE RESULTS

4.1 "J-7" Interior Temperatures

The data comparison shown in Table I indicates an overall average computed interior temperature that is approximately

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[2] In Reference 1 it is shown that a shift of 53° in β angle produces about a 30° F shift in mean orbital skin temperature. For a linear interpolation this is less than 1° F per degree of β angle shift.

[redacted]

5° F lower than the average of the system interior measured temperatures. By comparison, the temperature level computed for the "J-5" system was within 1° F of the mean of the measured temperatures (Ref. 8). This small difference is expected for the use of measured skin-temperature values as boundary conditions if the interior data is thermodynamically consistent with the skin-temperature data and the thermal behavior of the shielding and interior surface finishes is understood.

Although this agreement to within 5° F between predicted and measured temperatures is quite close considering allowable tolerances of ±10° F about a prescribed mean value, it should not be inferred from these data alone that the mean orbital environmental parameters employed or the skin finish characteristics utilized will always be appropriate. If this were true the agreement to within about 5° F between predictions and actual data should be obtained for each flight. For the purpose of comparing the above results with that for another flight, the flight data for the "J-9" system which had the same external paint mosaic[3] as "J-7" and a similar orbit[4] is compared in Table II. The data presented there are for orbital passes numbers 9 and 16 having β angles of 40.6° and 39.6°, respectively. The equations of Appendix B were used to correlate the orbital position with respect to the terminator for the data with the corresponding computational time in orbit. The predicted temperatures for the data comparison were within 1° F of those computed for the "J-7" flight. The computed temperatures, however, are on the average about 10° F lower than the measured ones. Thus, the "J-9" system average temperature is about 5° F higher than that for "J-7". The differences for the two systems may be due to differing space thermal environments caused by earth-cloud cover variations or they

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[3] Communication from the Associate Contractor.

[4] The orbital inclinations were 85° and 80° and the perigee altitudes were 99 N.M. and 84 N.M. for "J-7" and "J-9", respectively. The apogee altitude for "J-7" was 260 N.M.; for "J-9" it was 261 N.M. This information was obtained from the flight report files of the Itek Field Service at A/P.

may be due to variations in vehicle system parameters such as that caused by degradation of surface finishes, variation in instrumentation performance or to data read-out and reduction errors. Also, a combination of the above factors may be responsible.

From the data currently obtained from the "J" systems and the present state of the knowledge of the space thermal environment, the effects of the above two sources, environment and hardware, on temperature variations cannot be separated even approximately. The possible variations of the system mean temperature level due to the temporal variations of earth-cloud cover from its mean can be only roughly estimated until experimental knowledge is obtained concerning the frequency and magnitude of these variations. This estimate is made in Appendix C and indicates that the "expected" variation of system temperature levels for different flights due to "expected" variations of cloud cover is about +6° F and -4° F.

These estimated environmentally induced temperature variations might well explain the 5° F difference between the mean-temperature levels of "J-7" and "J-9" assuming, of course, that the variations actually occurred and are not instrumentation errors. However, there exists an approximate 10° F difference in level between the theoretical results and the measured results[5] for "J-9". If there were a strong dependency of the theoretical results upon the absolute value of the assumed mean terrestrial reflectivity, or albedo constant, then a strong possibility would exist for an error in the theoretical value of the mean terrestrial reflectivity

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[5] The theoretical results were obtained for the use of a mean solar constant. The actual value of the solar constant during June is smaller than the mean by 3.3 percent. Thus, the actual difference between the theoretical and the measured results should be even greater than 10° F since the computations using a lower heat input to the system would result in a lower mean temperature. All future computations by Vidya Division of this type will include the value of the solar constant existing for that flight date.

used in the computations. However, it is shown in Appendix D that for the "J" systems in an orbit having $\beta = 40^{\circ}$, the mean orbital temperature of the satellite is almost completely independent of the magnitude of the mean or long term value of the terrestrial refelctivity; only temporal variations in the terrestrial reflectivity cause temperature variations. Thus, the hardware parameters or perhaps the data itself must also be suspected as contributing to the above difference between theoretical and measured temperatures. There can be no definite conclusions reached by these arguments, however, since the estimated variations in the mean orbital temperature due to temporal cloud-cover variations are merely estimates. Therefore, as stated above and now rephrased for emphasis, the present dearth of knowledge concerning the frequency and magnitudes of variations in the amount of earth-cloud cover prevents the separation of the causes of satellite temperature deviation from the designed-for value into those causes due to the environment and those due to the actual hardware. The separation of these causes requiresthe experimental determination of the frequency and magnitude of the variations in the extent of cloud cover. If these variations are found to be larger, then the separation of these causes requires the monitoring of the space thermal environment existing for each flight either by the means of devices aboard each "J" system or of a separate, relatively long-life satellite, especially designed for this one task, having approximately the same orbital inclination as that of the "J" systems. A stronger incentive for the improvement of passive thermal control techniques may result if it were shown that the temperature variations from the expected values now experienced by the "J" systems are not due solely to the variations of the space thermal environment from flight to flight. On the other hand, if the variations in the space-thermal environment are shown to be the source of the thermal control difficulties then any improvement in the temperature control will require the use of active thermal control methods.

4.2 "J-7" Skin Temperatures

The graphical comparison of the computed skin temperatures with the measured skin temperatures for the orbital position corresponding to the data acquisition station is presented in Figures 1 and 2.

Qualitatively, these results are about what can be expected for the present model and the current hardware sensor instrumentation. The computed barrel temperatures for the sun side are expected to be somewhat lower than the measured values for a daylight pass over the data acquisition station for the reason explained in Appendix H. It would follow from this same reasoning that the computed temperatures for those same nodes should be higher than the measured values during a night pass; however, the electrical self heating of the skin sensors, discussed in the Introduction, will dampen the rate of the indicated temperature drop during the night pass[6]; consequently, the measured results are probably high.

For the fairing section, the conical section, the computed temperatures are expected to differ from the measured ones, but without specifically including the first recovery unit in the mathematical model the algebraic sign of the difference cannot be predicted. The explanation for this is also presented in Appendix H.

For the cold side of the vehicle, the side not exposed to direct solar radiation and for the opposite side as well during the night pass, the measured temperatures are higher than the computed ones as shown in Figures 1 and 2. The probable reason for this is that given above and, also, previously in the Introduction with the supporting statement of the Associate Contractor (Footnote 1); namely, the electrical self heating of the skin-temperature sensors introduces a

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[6] During the daylight pass this self heating will accelerate the indicated temperature rise, but the total heat exchange rate due to the direct solar radiation is of such a greater magnitude that the effect of the sensor self heating is negligible by comparison.

a positive temperature error in the data for the low temperature ranges.

The above discussed differences between the computed, instantaneous, transient temperatures and measured temperatures at the single, satellite orbital position shown in Figures 1 and 2 are of a magnitude of from 0° to 30° F. The amplitude of the skin's transient temperature over an orbital period is from Figure 1 about 80° F; this is the difference between measured, instantaneous temperatures at a body angle of 60° for the day and night passes for the data acquisition station position. From the 35 percent error in temperature amplitude expected, discussed in Appendix H, p. H-3, an error of about 30° F could be expected in the computed temperatures. Also, in Appendix H it is shown that this error in the computed <u>instantaneous</u> skin temperature results in an error of only about 1° F for the interior temperatures. Thus, the errors in the computation of the transient, skin temperatures result in a negligible error in the computed interior temperatures.

The effects of the variation of cloud cover as discussed above in Section 4.1 will apply to the exterior transient temperatures also.

5. RÉSUMÉ OF THE CONTRIBUTIONS TO THE "J" PROGRAM RESULTING FROM THE THERMAL ANALYSES

5.1 Thermal Design

The thermal design analyses performed by Vidya Division in liaison with the Associate Contractor resulted in a passive thermal control design for the system that would permit system operations at any orbital β angle. With this design, an interior temperature between 70 and 80° F should be maintainable for any β angle (Ref. 1, Table V).

To attain this performance it is necessary to employ a radiation shield liner having a thermal emissivity of about 0.12. It is required that the mean orbital skin temperatures of the vehicle at a $\beta = 53^{\circ}$ be about 110° F. This was pointed out explicitly in the original design report on page 6 of Reference 1. Quoting from that page, "... the best instrument temperature ranges are experienced with a nominal skin temperature of 110° F." The underlined portion is underlined in the original text.

Unfortunately, the thermal radiation shield fabricated for the system, as measured by the Associate Contractor, had an emissivity between 0.2 and 0.4. The variation of thermal performance with the numerical value of this emissivity is nonlinear; the mean value of the emissivity, 0.3, is completely inadequate to provide the required shielding. Computations made by Vidya Division using the 130-node mathematical model show that this shield is but little more effective in providing the desired thermal performance than a black shield would be (Ref. 13, Section 5.1).

For flights more recent than the "J-7" system flight a new radiation shield has been incorporated. This shield appears visually to have a lower thermal emissivity than the value 0.3 described above. However, for the flight thermal results for the first two systems containing this shield as reported qualitatively to Vidya Division, it appears that the designed mean orbital vehicle skin temperature was not in the

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required 110° F range at a $\beta = 53^\circ$, but was much lower instead. The resulting interior temperatures as indicated by the flight data (again, a qualitative report to Vidya Division) were low, in the 45° F range. This kind of result can be expected to be obtained in the future unless the original design philosophy of maintaining high mean skin temperatures is followed[7].

5.2 Post-Flight Thermal Data Analyses

An important contribution to the thermal performance of the "J" systems has been the improvement in the accuracy of the interior temperature sensor data.

Originally, the Associate Contractor noted that, during ground tests, variations as a function of time occurred in the temperatures as indicated by the interior sensors. A test was then performed by the Associate Contractor using a sensor attached to a metal honeycomb specimen and from the temperature-time history data resulting from this test, a calibration curve was obtained to correct the flight data (Ref. 11). Vidya Division also performed a test of a sensor attached to a metal honeycomb specimen having different dimensions from that used by the Associate Contractor (the same type of honeycomb material was used as that used in the fabrication of the instrument main plates). A different temperature-time history for the sensor was obtained by Vidya as compared to that obtained by the Associate Contractor. A mathematical model

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[7] In a recent verbal communication from the Associate Contractor, information was received that the third "J" system having the new low emissivity radiation shield had, in flight, an interior temperature of about 70° F. Also the information relative to the external paint mosaic was that the sun side of the vehicle had an α/ϵ of about the same numerical magnitude as for the previous systems (≈ 1.1) and the shadow side of the vehicle on the side not exposed to the sun was entirely gold covered. An approximate computation by Vidya Division for this thermal mosaic indicates that a mean orbital skin temperature of about 105° F should have been obtained at $\beta = 53^\circ$. Thus, the thermal design for the most currently flown system (circa January 1965) appears to be in line with the original design philosophy. The question remains, however, of why it was necessary to use a trial-and-error method by which the two previously flown systems in which low emissivity shields were employed ran cold, to obtain the thermal design described one and one-half years ago in Reference 1?

[redacted]

of the sensor as attached to a metal honeycomb structure was used to analyze the test results. This analysis revealed that the two tests, Vidya Division's and the Associate Contractor's, were equivalent, the difference between them being introduced by the specimen dimensions used. The basic information obtained from this analysis was that one single sensor calibration could not be used for the system because the amount of sensor self heating was dependent upon the sensor's position on the instruments. The Associate Contractor then began individual sensor calibration in situ during the vacuum chamber tests prior to flight.

The improvement in the accuracy of the interior sensor data is illustrated by the previously reported (page 2 of this report) decrease in the magnitude of the measured temperature level variation from that predicted from thermodynamic principles.

A continuing flight to flight monitoring of the interior sensor data was conducted by comparing them with the results of the 130-node mathematical model. The measured skin sensor data were used as boundary conditions to ascertain the consistency of the internally measured results with thermodynamic principles. For each flight for which the measured skin data were obtained the results were compared in tabular form, as for example, Tables I and II of this report. The purpose of this monitoring was to provide an independent quality check upon the measured data and thermal performance of the instrument. This is indispensible for a new system since there are nearly always some initial system flaws that must be corrected. The above described temporary correction for sensor self heating (a new system of sensor instrumentation is necessary for a basic correction) is an example of the use of an independent monitoring of the data for the initial break-in period of a new system. Also, this has resulted in an effort to obtain continuity from the initial thermal design effort through this break-in period.

The written reports for this monitoring function are usually quite late in time compared to the system flight schedules. The contents of the reports are not the entire fruits of the work, however, the liaison activity between the two Associate Contractors to improve the system constitutes a large part of the results.

Once the flaws in a new system have been revealed the flight to flight monitoring of the data is no longer necessary. Thus, Vidya does not recommend a continuation of this effort on a routine basis. It is recommended, though, that when changes are made in the internal thermal control surfaces or in the sensor instrumentation that an independent check of the flight data by Vidya be made for the flight of the system in which the changes were incorporated.

Other relatively short-term tasks performed during these post-flight data analyses by Vidya have been the following:

a. An analysis of the thermal effects of air bubbles in the cement used to attach the sensors to the instrument (Ref. 1). (The effects were found to be detrimental to sensor accuracy and a recommendation was made to Itek that tighter quality control be employed in the attachment of the sensors.)

b. An analysis of the effects of the transient exposure of the lens to the exterior environment during operation (Ref. 2). (The resulting temperature changes were found to have a negligible effect upon record quality as measured by the image shift from the record.)

c. An analysis of the effect of temperature level upon record quality (Ref. 2). (This analysis required the use of detailed temperature histories, the tape recorded flight data, for several flights. The detailed thermal data reduction was discontinued beginning with the "J-9" system and this analysis procedure was aborted.)

6. CONCLUSIONS

It is concluded from the results of the analyses of the "J-7" and "J-9" systems that

a. The differences between the mean of the measured temperatures and the mean temperatures computed by Vidya Division for the solar constant's value existing at a given flight date for the "J" systems are due either to temporal variations in the space thermal environment or to variations in the values of the hardware design parameters.

b. In order to evaluate numerically the relative effects of the two causes (Item a above) of the variations in a satellite's thermal performance, it is necessary to determine the magnitude and frequency of the variations in the space thermal environment and possibly to monitor the space-thermal environment during each flight.

c. Should the necessity arise to improve the accuracy of the transient temperature computations for the vehicle skin it will be necessary to increase the number of nodes in the mathematical model to include the skin reinforcing structures as separate nodes.

From the thermal analyses of the first six-system flights it is concluded that[8]

a. The temperature sensor instrumentation should be changed to eliminate the necessity of individual sensor self-heating calibrations[9].

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[8] At the current date (February 1965) the emissivity of the internal radiation shield of the vehicle is on the order of that specified in the initial design report, therefore, these are conclusions not concerning the shield.

[9] In Reference 2, Section 3.3, it is pointed out that the calibrations change as a function of the environmental temperature level; hence, calibrations at one level used for system temperatures at different levels will result in data errors.

b. Air bubbles should be entirely eliminated from the temperature sensor cement (Ref. 13).

c. Greater accuracy in the computation of the internal temperature distribution of the system requires a more detailed nodal breakdown (more nodes), experimentally measured values of the thermal contact resistance across riveted and bolted structural joints, the experimentally measured values of the specular reflectivities of the different surface finishes, and the inclusion of the specular nature of the surface finishes in the computations[10].

d. A post-flight thermal data analysis is not necessary for each future flight of the "J" systems. Periodical analyses should be made however to assure the maintenance of quality control in data acquisition (instrumentation plus data readout and reduction). Also, the results of new sensor instrumentation and new interior surface finishes should be checked by an analysis of the flight results.

From the flight results to date (circa February 1965) and the indications that a period of one and one-half years has been required to attain in the hardware the initially specified design properties for the "J" system, it is concluded that there is considerable room for improvement in the quality of the liaison between design groups and operations groups.

7. RECOMMENDATIONS

The recommendations based upon the conclusions of Section 6 are as follows:

a. That the magnitude and frequency of the variations in the space-thermal environment of the "J" systems be measured experimentally.

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[10] All of these items need not be accomplished simultaneously to improve the accuracy; for example, the increase in the number of nodes will in itself increase the accuracy as explained in Appendix H of this report.

b. That the type of temperature sensor instrumentation existing in the systems through "J-7" should be replaced with instrumentation that eliminates the sensor self-heating error.

c. That post-flight thermal data analyses be made for perhaps only one in ten future flights for the purpose of maintaining an independent check upon the quality of the flight data and thermal design.

d. That post-flight thermal data analysis be made for the flight of a system in which new temperature sensor instrumentation or new internal surface finishes are employed. This analysis should be performed as soon as possible after such a flight in order to permit its results to be applied to the design of the immediately succeeding flight.

e. That post-flight thermal data analyses be performed for any flight for which abnormal thermal performance is suspected from the thermal data.

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10. [redacted]

11. [redacted]

12. [redacted]

13. [redacted]

TABLE I.- COMPARISON OF "J-7" FLIGHT DATA WITH COMPUTATION RESULTS.

System Sensor	Approx. Node Number	DAY PASS			NIGHT PASS		
		T_S Orbit # 47	T_M Computed $\beta = 40^\circ$	ΔT $T_M - T_S$	T_S Orbit # 40	T_M Computed $\beta = 40^\circ$	ΔT $T_M - T_S$
1-I-3	59	50° F	55° F	+5° F	49° F	56° F	+7° F
1-I-4	42	54	52	-2	59	53	-6
1-I-5	61	57	59	+2	59	60	+1
1-I-6	56	69	63	-6	73	64	-9
1-I-7	52	65	60	-5	66	60	-6
1-I-8	61	61	59	-2	63	60	-3
1-I-9	60	67	63	-4	71	63	-8
1-I-10	52	66	60	-6	64	60	-4
1-I-11	16	66	57	-9	64	57	-7
1-I-12	59	51	55	+4	52	56	+4
1-I-13	15	68	58	-10	70	57	-13
2-I-3	70	76	62	-14	76	62	-14
2-I-4	47	72	69	-4	74	60	-14
2-I-5	72	65	58	-7	66	59	-7
2-I-6	67	60	55	-5	61	56	-5
2-I-7	63	65	57	-8	63	57	-6
2-I-8	72	58	58	0	67	59	-8
2-I-9	71	55	53	-2	58	54	-4
2-I-10	63	66	57	-9	64	57	-7
2-I-11	37	57	58	+1	61	56	-5
2-I-12	70	72	62	-10	72	62	-10
2-I-13	36	64	55	-9	66	55	-11
SP.-1	75	54	59	+5	57	60	+3
SP.-2	75	60	59	-1	63	60	-3
CL.-1	74	70	68	-2	72	72	0
CL.-2	74	72	68	-4	75	72	-3

T_S measured temperature

T_M computed, model nodal temperature

C

[redacted]

TABLE II.- Comparison of "J-9" Flight Data with Computation Results.

System Sensor	Approx. Node Number	DAY PASS			NIGHT PASS		
		T_S Orbit # 16	T_M Computed $\beta = 40^\circ$	ΔT $T_M - T_S$	T_S Orbit # 9	T_M Computed $\beta = 40^\circ$	ΔT $T_M - T_S$
1-I-3	59	55° F	55° F	0° F	57° F	56° F	-1° F
1-I-4	42	62	52	-10	63	53	-10
1-I-5	61	67	59	-8	68	60	-8
1-I-6	56	75	63	-12	79	64	-15
1-I-7	52	76	60	-16	79	60	-19
1-I-8	61	69	59	-10	72	60	-12
1-I-9	60	71	63	-8	76	63	-13
1-I-10	52	73	60	-13	72	60	-12
1-I-11	16	75	57	-18	72	57	-15
1-I-12	59	57	55	-2	59	56	-3
1-I-13	15	77	58	-19	79	57	-22
2-I-3	70	74	62	-12	74	62	-12
2-I-4	47	71	69	-2	73	60	-13
2-I-5	72	65	58	-7	68	59	-9
2-I-6	67	61	55	-6	62	56	-6
2-I-7	63	68	57	-11	68	57	-11
2-I-8	72	63	58	-5	64	59	-7
2-I-9	71	57	53	-4	58	54	-4
2-I-10	63	74	57	-17	70	57	-13
2-I-11	37	58	58	0	60	56	-4
2-I-12	70	66	62	-4	68	62	-6
2-I-13	36	72	55	-17	73	55	-18
SP.-1	75	53	59	+6	55	60	-15
SP.-2	75	61	59	-2	62	60	-2
CL.-1	74	75	68	-7	71	72	+1
CL.-2	74	73	68	-5	69	72	+3

T_S measured temperature

T_M Computed, model nodal temperature

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NO 340-20 DIETZGEN GRAPH PAPER
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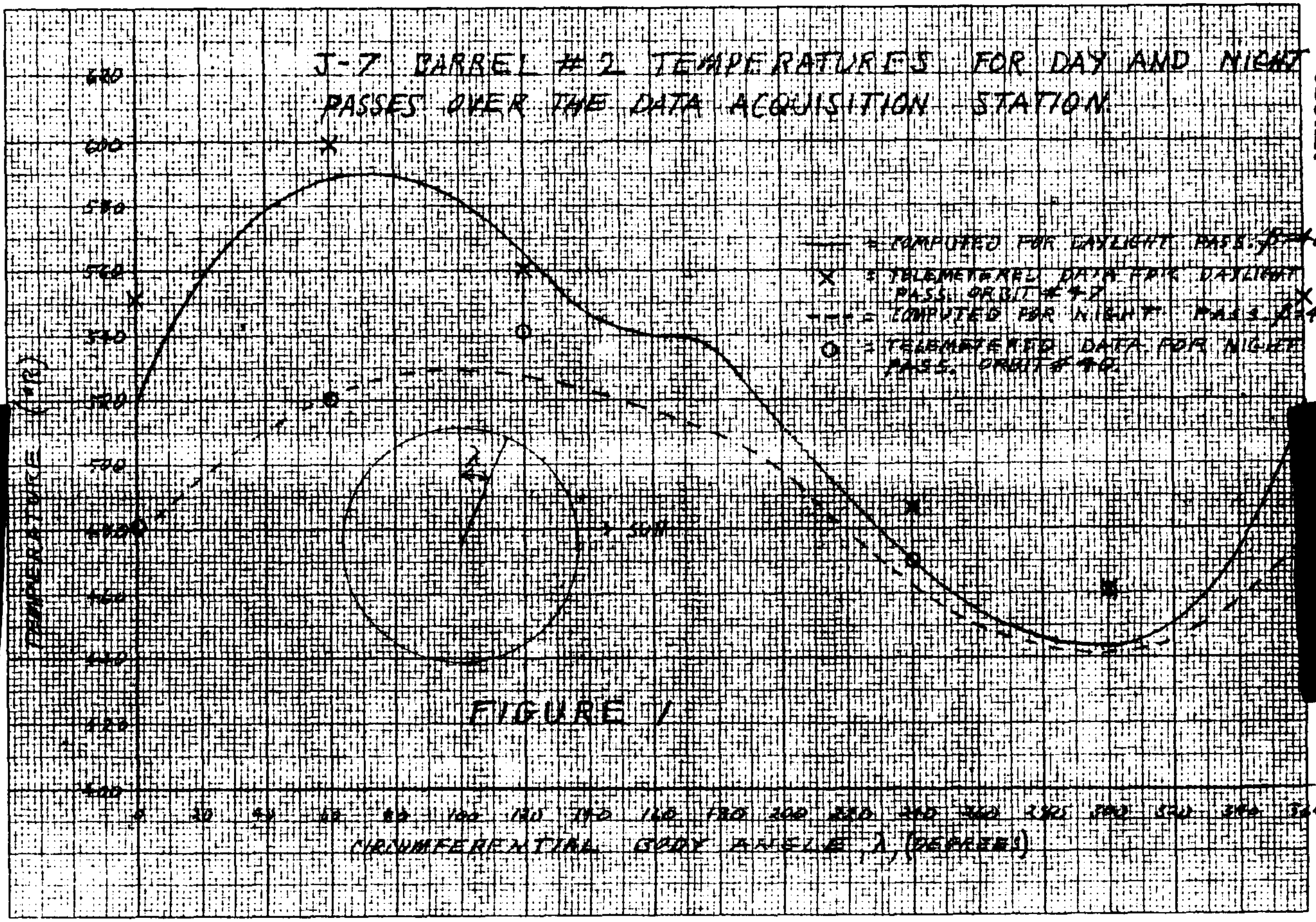


J-7 BARREL #2 TEMPERATURES FOR DAY AND NIGHT PASSES OVER THE DATA ACQUISITION STATION

— = COMPUTED FOR DAYLIGHT PASS. β = 40

X = TELEMETERED DATA FOR DAYLIGHT PASS. ORBIT #48

- - - = COMPUTED FOR NIGHT PASS. β = 40

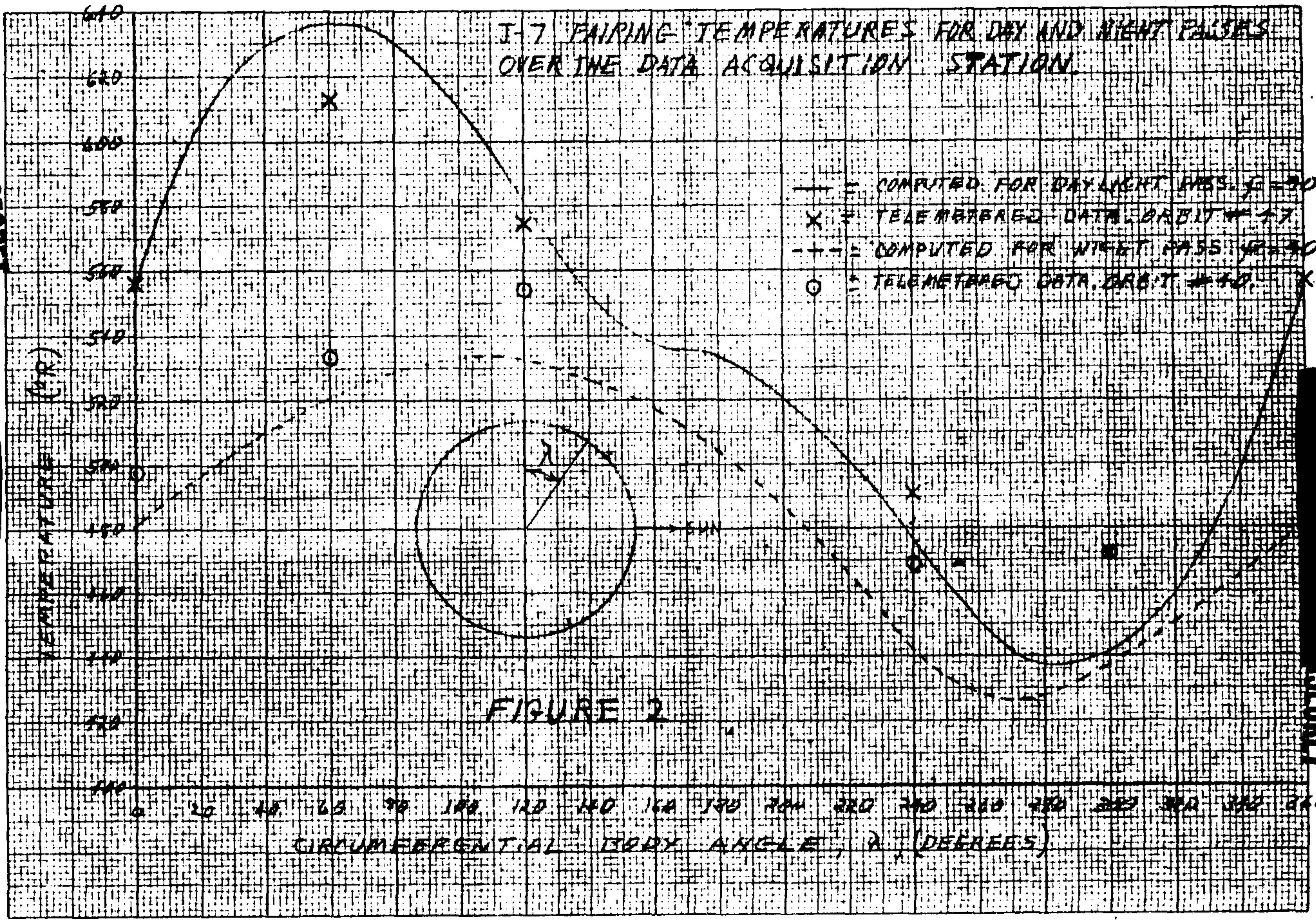
○ = TELEMETERED DATA FOR NIGHT PASS. ORBIT #48

FIGURE 1

[redacted]

SECRET

[redacted]



I-7 FAIRING TEMPERATURES FOR DAY AND NIGHT PASSES
OVER THE DATA ACQUISITION STATION

FIGURE 2

[redacted]

[redacted]

APPENDIX A

THE "J-7" SYSTEM POST-FLIGHT DATA RECEIVED FROM THE ASSOCIATE CONTRACTOR

[redacted]

SEP 28 1964

[redacted]

~~SECRET~~

[redacted]

[redacted]

[illegible]

SENSOR	ORBIT															
Master	1	8	16	24	31	40	47	56	63	71	79	87	94	103	110	119
3	69	54	49	48	45	49	50	48	45	44	41	44	40	43	45	43
4	73	61	45	54	52	59	54	55	51	50	45	48	45	48	49	47
5	64	63	59	58	54	59	57	58	53	53	48	52	48	52	51	52
6	64	77	71	72	69	73	69	71	65	67	59	66	60	65	62	65
7	64	71	67	65	63	66	65	66	62	60	57	58	57	59	60	59
8	71	67	62	64	59	63	61	62	58	59	53	58	53	57	56	58
9	70	75	68	70	66	71	67	67	63	65	57	57	58	62	60	62
10	69	69	67	63	65	64	66	66	64	59	58	57	58	57	62	58
11	90	66	75	65	70	64	66	64	67	58	60	56	58	55	62	54
12	75	57	52	51	49	52	51	51	47	47	43	46	43	46	47	53
13	71	76	72	70	68	70	68	70	65	63	60	60	59	60	63	59
Slave																
3	67	81	78	75	76	76	76	75	72	71	56	68	68	68	71	67
4	69	77	73	72	71	74	72	73	69	70	64	68	64	68	66	67
5	67	71	66	65	63	66	65	66	62	61	57	59	57	61	61	61
6	63	67	60	60	58	61	60	60	56	57	52	56	52	56	55	56
7	63	71	66	64	63	63	65	63	62	61	57	58	57	58	59	57
8	68	70	64	65	62	67	58	65	61	63	57	61	57	60	59	60
9	67	61	56	57	52	58	55	57	52	53	48	51	49	52	50	52
10	65	71	69	64	66	64	66	66	64	59	60	56	58	56	61	58
11	89	59	58	58	56	61	57	61	57	59	55	56	54	56	57	59
12	70	76	73	70	71	72	72	72	69	69	64	66	63	65	65	66
13	64	69	65	64	62	66	64	66	62	62	57	59	57	58	60	61
Supply Spool																
1	57	72	55	54	53	57	54	57	55	55	54	54	51	53	53	53
2	62	60	61	60	60	63	60	63	60	60	58	58	54	57	57	57

~~SECRET~~

[redacted]

Fairing & Barrel #1	1	8	16	24	31	40	47	56	63	71	79	87	94	103	110	119
1	OBH	38	107	38	99	38	96	38	101	7	23	7	23	7	31	3
2	OBH	15	24	12	18	12	12	12	18	0	0	0	0	0	12	-3
3	OBH	12	-	9	31	9	31	12	28	13	96	10	88	13	104	13
4	OBH	-	-	-	-	-	-	-	-							
5	OBH	102	132	94	122	94	114	88	113	43	143	40	131	40	142	37
6	OBH	80	177	70	166	73	153	71	160	61	93	55	87	51	95	45
										- - - - - - F A I R I N G - - - - - - -						
Barrel #2																
1	165	87	115	81	106	81	100	77	99	66	92	58	89	56	94	53
2	150	67	158	61	150	61	139	54	144	51	141	47	130	45	138	41
3	186	21	101	18	99	21	91	21	98	18	90	18	91	18	104	18
4	189	0	10	-2	4	1	1	0	1	-2	-2	-2	-2	-6	9	-2
5	165	10	35	10	26	10	26	10	26	4	20	4	20	4	28	4
[redacted] **onic Adapter**																
1	160	61	100	61	90	61	85	57	87	45	81	43	73	38	81	38
lock																
1	96	70	75	70	72	72	70	72	72	68	62	62	60	60	65	62
2	101	72	77	72	72	75	72	72	72	64	64	62	62	62	65	62
hrustcone																
1	OBH	50	50	45	45	46	44	45	43	50	48	48	44	47	47	47
2	84	75	71	68	64	68	63	66	63	64	64	62	63	59	61	59
Stellar Index																
1	96	75	75	72	75	75	72	75	75	72	68	68	68	68	74	68
2	84	72	66	69	69	69	63	69	63	52	45	48	45	45	50	48
Slave Cassette (Recovery System #1)																
1	96	53	45	42	41	44	41	47	46			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Recovery Battery (Recovery System #2)																
1	71	70	71	65	67	65	65	67	67	78	83	79	78	81	80	81

[redacted]

ENCLOSURE #9

[redacted]

[redacted] 1964/… ~~SECRET~~ NOV 2 1964 1/4

[redacted]

Flt. 1609 (J-07)

Launched: 4:18 PM PDT on 19 June 1964

Rev 1 $i = 85.0°$, $T = 91$ min, $h_p = 99$ nm, $h_a = 260$ nm
$\epsilon = .022$

Recovery: Phase A – Rev 65

Phase B – Rev 128

β's

REV	i	Ωt	$\delta_\odot$	$\alpha_\odot$	$\lambda_\odot$
1	85.0	141°30'	23°26'	$5^h 54.3^m$	88°35'
51	85.0	139°12'	23°26'	$6^h 6.8^m$	91°42'
101	85.0	136°55'	23°22'	$6^h 19.3^m$	94°49'

$$\cos\eta = -\cos i \sin\delta_\odot + \sin i \cos\delta_\odot \sin(\Omega t - \lambda_\odot)$$

1. $\cos\eta = -(.08716)(.39768) + (.99619)(.91752)(.79776)$

$= -(.03466) + (.72917) = 0.69451$; $\eta = 46°1'$, $\beta = 43°59'$

2. $\cos\eta = -(.08716)(.39768) + (.99619)(.91752)(.73728)$

$= -(.03466) + (.67389) = 0.63923$; $\eta = 50°16'$, $\beta = 39°44'$

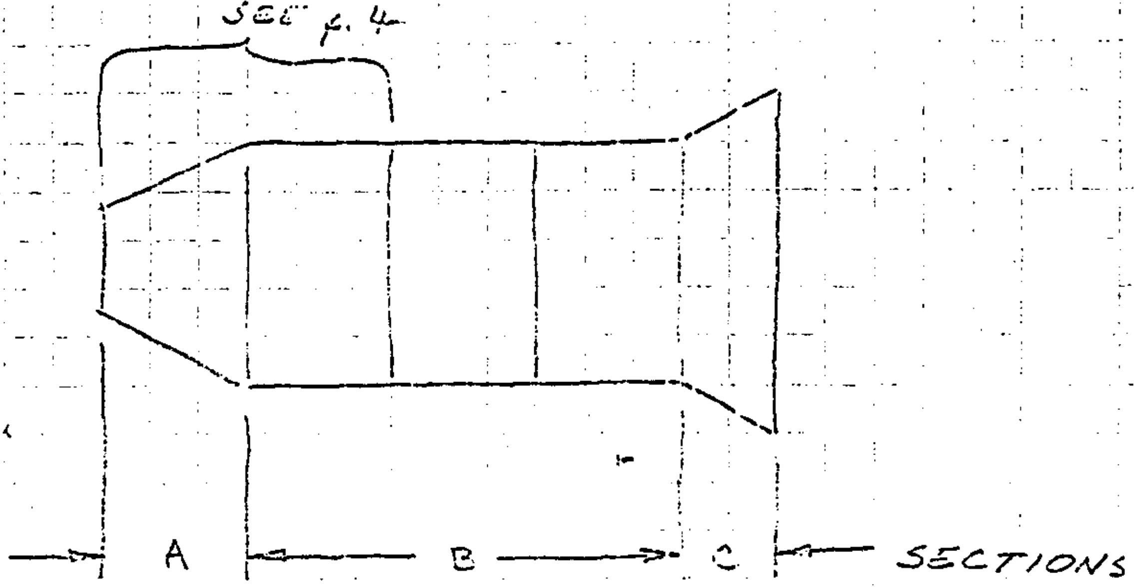
3. $\cos\eta = -(.08716)(.39661) + (.99619)(.91799)(.67043)$

$= -(.03457) + (.61310) = 0.57853$; $\eta = 54°39'$, $\beta = 35°21'$

~~SECRET~~ [redacted]

[redacted]

PAINT PATTERN - FLT 1339 (J-97)



EACH SECTION HAS 48 EQUALLY SPACED (ON 7½° ℄'s) LONGITUDINAL STRIPES OF SILICONE SILASTIC EXCEPT AS NOTED ON p. 4.

SECT	STRIPE WIDTH
A	0.50"
B	1.00"
C	0.97"

SILICONE SILASTIC : $\alpha_s/\epsilon = .22/.88$

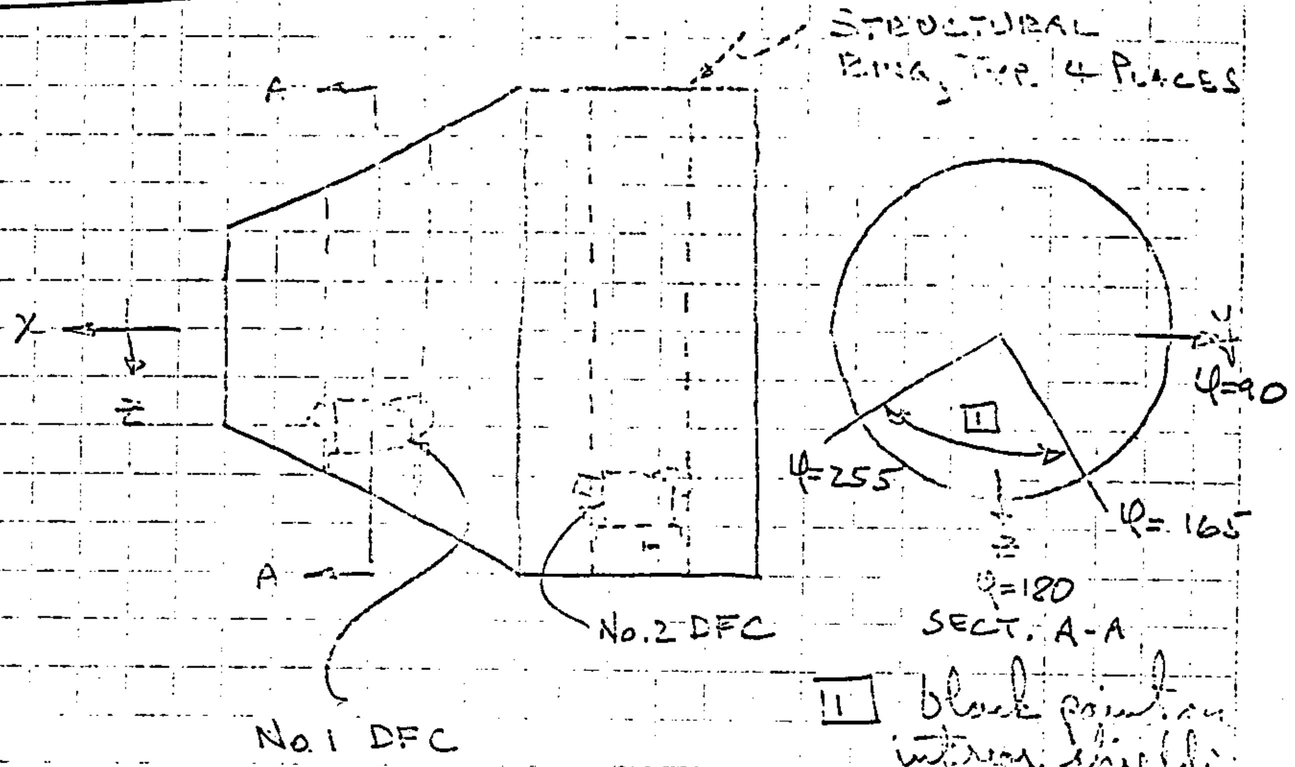
GOLD : $\alpha_s/\epsilon = .45/.12$

[redacted]

[redacted]

[redacted]

S/I TAPE & PAINT



[1] black paint on interior shielding between structural rings

No. 1 DFC

FRONT SURFACE (FACING +X) & STELLAR SURFACE (FACING +Y) ARE TAPED WITH Al FOIL ; OTHER SURFACES BLACK

No. 2 DFC

TOP SURFACE (FACING −Z) IS 50% TAPE & STELLAR SURFACE (FACING +Y) IS 100% TAPE ; OTHER SURFACES BLACK

[redacted]