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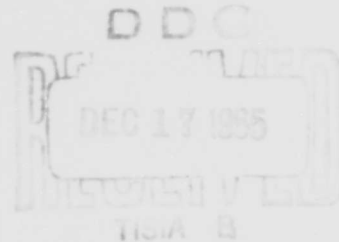
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ENVIRONMENTAL CONTROL AND INSTALLATION OF  
A PRECISION AERIAL CAMERA

Charles W. Fortney, Captain, USAF

TECHNICAL REPORT NO. RADC-TR-65-375  
November 1965



Space Surveillance and Instrumentation Branch  
Rome Air Development Center  
Research and Technology Division  
Air Force Systems Command  
Griffiss Air Force Base, New York

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**FOREWORD**

**This final report was prepared under Project 6512, Task 651201, System 760B for the period 1 August 1964 through 30 June 1965.**

**Captain Charles W. Fortney, USAF, of RADC (EMASI) was the Project Engineer.**

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## ABSTRACT

A precision aerial camera used in radar evaluation was installed in an aircraft. Installation factors which contribute to the camera system errors were studied to minimize the additional errors introduced when the camera is operated at high altitudes in an unprotected area of an aircraft. The selection of the aircraft camera window and an environmental chamber along with its temperature control system are discussed. It is shown that temperature regulation is essential, while variations in pressure produce negligible errors. Camera stabilization and isolation from the aircraft was not necessary in these tests to prevent degradation of the camera resolution. Test data show that preheating the camera chamber prior to flight, along with regulated heat input, is essential to provide a uniform camera temperature for the duration of the flight. It is concluded that the required camera system accuracy of  $\pm 10$  microns on the photo scale can be achieved when the installed camera, including the camera window, is calibrated and operated in a temperature-controlled environment. Schematics and blueprints of a typical installation are included.

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## SECTION I

### INTRODUCTION

One of the critical problems associated with the development and evaluation of a ground-based radar is to determine the radar system accuracy. Analytical photogrammetry using the resection technique and employing a precision aerial camera mounted in a target aircraft was used at RADC to evaluate the ASFIR system (Active Swept Frequency Interferometer Radar). This technique provides an independent, accurate, and reliable method for determining the spatial coordinates of the target aircraft (1). The modified KC-1B aerial camera used in this evaluation and the errors attributed to the camera fabrication tolerances are discussed in a forthcoming RADC-TDR (2).

The purpose of this report is to describe camera installation and the considerations that went into the final design.

The effectiveness of the evaluation system is dependent on the integrated camera system accuracy; therefore, the camera must be thoroughly calibrated to provide a record of both radial and tangential distortions.

The calibration is valid only when the camera is operated in an environment similar to that in which the calibration was performed. Changes in temperature or temperature gradients will produce corresponding changes in the orientation of the interior elements resulting in variations in the relationship between image coordinates and the corresponding object space cone of rays. In addition, the quality of the window through which the photographs are taken influences the amount of image displacement and blurring. This, along with the effects of aircraft motion, will be discussed in detail to demonstrate the importance of camera installation engineering and design in achieving the required accuracy of  $\pm 10$  microns on the photo scale.

## SECTION II

### DISCUSSION

The general design requirements imposed on installing the camera system in an aircraft are cost, weight, accessibility, and ease of maintenance. The over-all system errors determine what trade-offs will be allowed to optimize the installation engineering. In this case the location of the aerial camera had to be established to within a standard error of  $\pm 8$  feet in x, y, z coordinates relative to a system of photoidentifiable ground control points for altitudes up to 80,000 feet. This limited the over-all system errors to the  $\pm 10$  microns previously mentioned.

A review of KC-1B aerial camera calibration certificates revealed that in most lens assemblies the radial and tangential distortions each approach, and occasionally exceed, 10 microns. Therefore, the required accuracy cannot be achieved unless the integrated camera system, including the high quality window, is calibrated.

A star calibration of the camera, in which several hundred stars optimally spaced over the entire field of view are photographed through the window, can provide a window-camera accuracy of  $\pm 2$  microns in both tangential and radial distortions (3).

### SECTION III

#### AIRCRAFT CAMERA WINDOW

The selection of the aircraft camera window is the first installation factor considered. The significant glass properties for this application are striae, bubbles, surface finish, and thermal coefficient of expansion (4).

Obtaining glass with no visible striae and acceptable bubble dimensions is not overly difficult. However, the cost of surface finishing increases rapidly with the degree of parallelism and flatness. It is, therefore, important to establish a minimum acceptable level. Figure 1. Aircraft Camera Window Surface Flatness, relates the lens system resolution and focal length to the necessary window surface flatness, showing, for example, that for a 6-inch focal length camera with 40 lines/mm. resolution, the window surface may contain up to 11 fringes (5). This is well below the military specifications for aerial mapping camera windows (4).

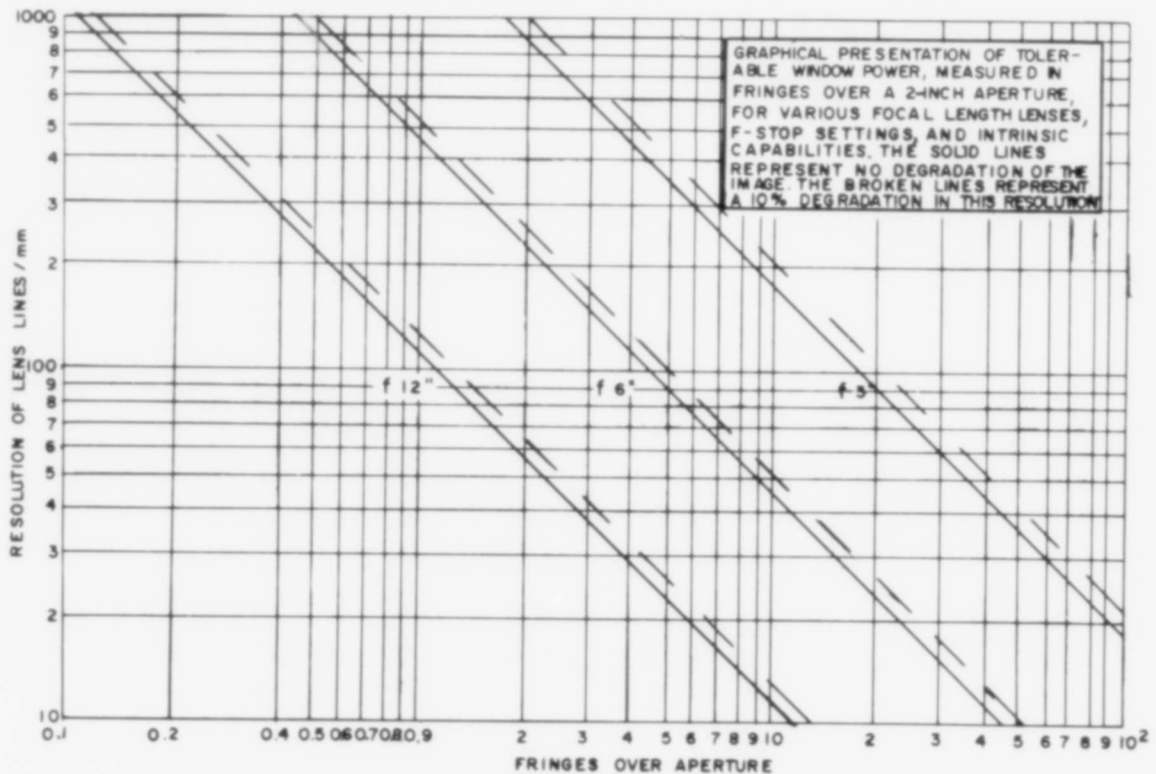


FIGURE 1. AIRCRAFT CAMERA WINDOW SURFACE FLATNESS

Glass has a positive thermal expansion coefficient which varies from  $5.6 \times 10^{-7}$  in./in. $^{\circ}$ C for fused silica to  $5 \times 10^{-6}$  in./in. $^{\circ}$ C for typical crown optical glass. Fused silica composition, with its low thermal coefficient, would be best for the window as it produces less curvature due to the thermal gradient through the window experienced at high altitudes. Unfortunately, fused silica is expensive. Analysis of the greater errors produced when the less expensive crown glass was substituted, revealed that the image displacement due to the greater curvature could be properly identified by the star calibration. Also, the image blur did not degrade the photography resolution excessively.

A 23"×13"×1/2" crown glass window is used in the ASFIR evaluation system. This window, shock-mounted in a metal frame, was installed in a hole cut into the bomb door of a B-57B aircraft. It is desirable to have the window parallel to the camera lens to avoid introducing another variable into the optical system. Flights were conducted at the evaluation altitude and airspeed to determine the aircraft's angle of attack and, consequently, the angle between the bottom surface of the bomb door and the horizontal. These tests disclosed that the window should be mounted with a  $2^{\circ} 45'$  declination toward the nose of the aircraft. (Reference Figure 2. Camera Window.)

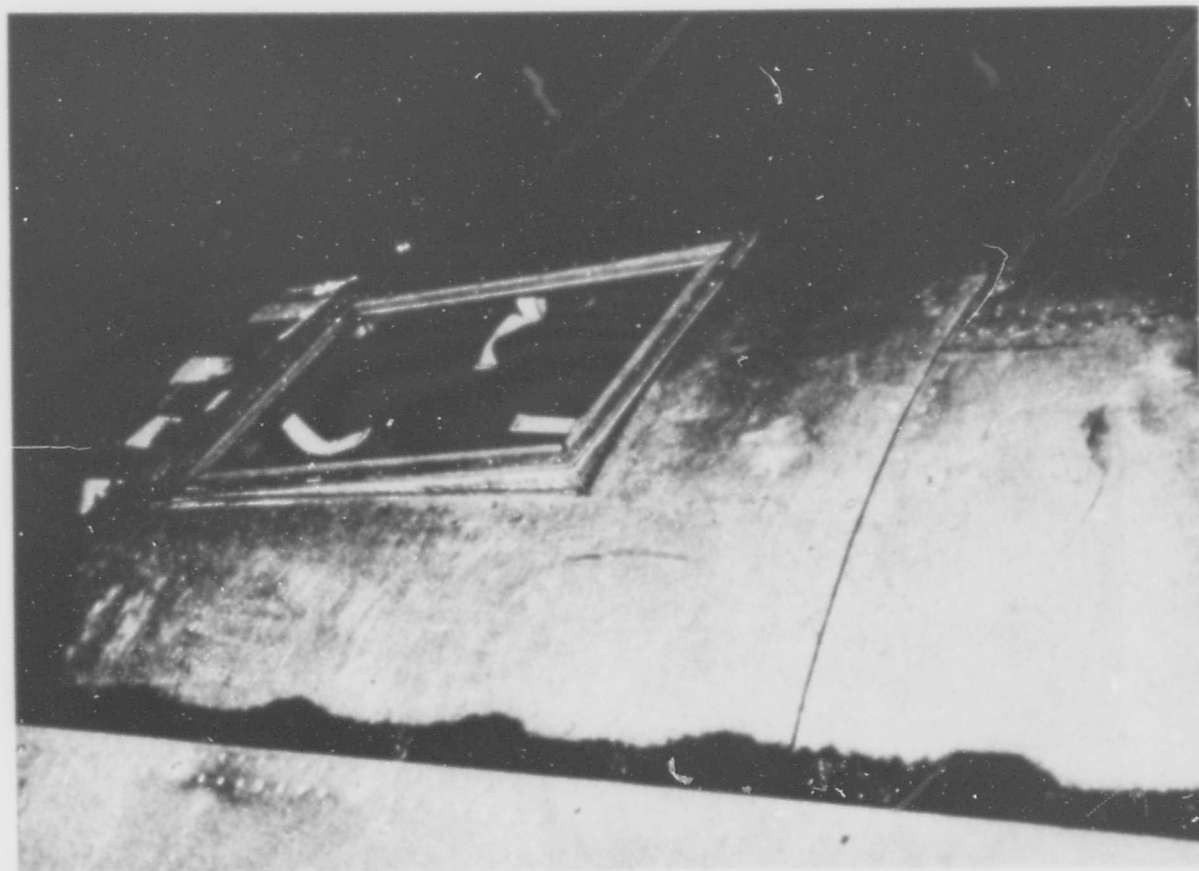


FIGURE 2. CAMERA WINDOW

## SECTION IV

### CAMERA STABILIZATION

It was anticipated that the aircraft's roll and pitch angular velocities would have a serious degradation on the camera system resolution unless the camera were isolated from the aircraft motion.

Camera stabilization was accomplished by placing the camera on an ART-25 Gyro-Stabilized Vertical Mount. This platform has the capability of maintaining the camera to within 22 arc minutes of vertical for 90% of the operating time. (Reference Figure 3. ART-25, Verticality Error.)

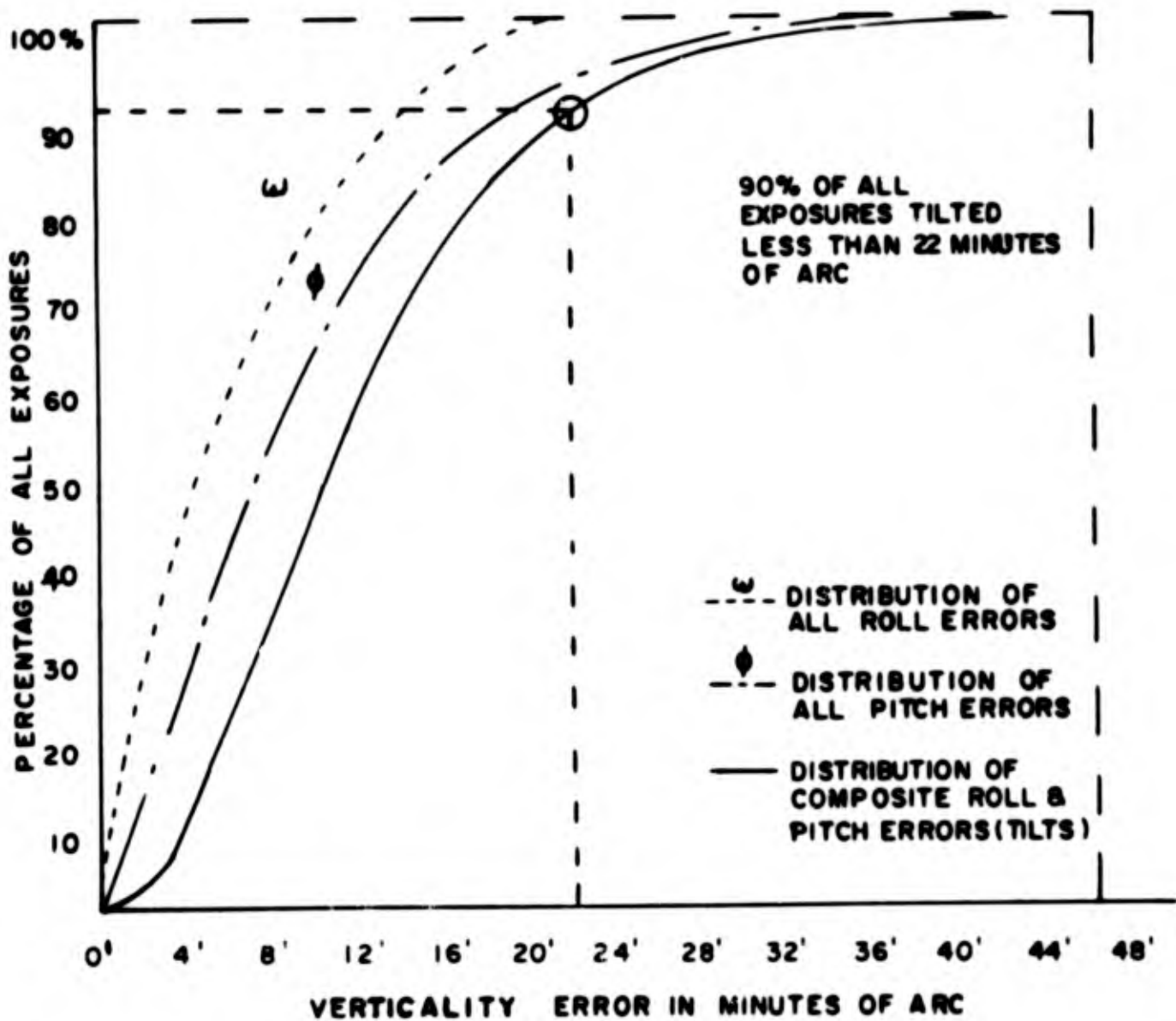


FIGURE 3. ART-25, VERTICALITY ERROR

The camera has a wide-angle (90°) lens; therefore, it is important to place the camera close to the window to keep the window diameter minimal. This necessitated cutting a 34"×43" hole (large enough to accommodate the camera and mount) in the 10" thick bomb door and then appropriately re-enforcing the door to compensate for the removal of this material. The mount was then attached to the door structural members at the sides of this hole through phenolic blocks which thermally insulate the camera and mount from the bomb door, thus greatly reducing the conductive heat losses.

## SECTION V

### CAMERA CHAMBER DESIGN

The camera must be operated in a controlled environment for the calibration to remain valid. The ideal environment should precisely duplicate the star calibration temperature and pressure of 21°C. and 14.7 psi. respectively. However, maintaining sea level pressure at 45,000 feet results in a differential pressure of 12.5 psi. This produces an outward force of approximately 16,000 pounds on each wall of the environmental chamber surrounding the camera and mount. A chamber that could withstand this pressure would be difficult to implement in a variety of an aircraft.

The effects on the system accuracy when the camera area is not pressurized was examined with Mrs. Norton (6). It was determined that the bowing due to differential pressure across the window would produce greater system errors than the effects of reduced pressure in the camera area. Since none of the internal components of the camera is sealed, the pressures within the camera will equalize and the only significant effect will be the decrease in the index of refraction of the enclosed air. A study of atmospheric indices of refraction obtained from radiosonde data taken at both Buffalo and Rome, New York, during 1964 revealed an average value of 1.000323 on the surface to an average value of 1.000053 at 45,000 feet. This small change in index through the short distance between the camera platen and the aircraft window produces no significant image shift on the film.

Since pressurization of the camera area is not necessary, two approaches for maintaining a constant camera temperature were explored. One possibility is to wrap a heating blanket around the camera. This type blanket is available through several commercial sources. The advantage of using a blanket is its simplicity. However, this approach would not provide uniform heating over the entire camera; the lens area must remain unobstructed, and the mount covers a three-inch wide band around the body of the camera. The rate of heat transfer into the mount and through the lens area would be much higher than from the blanketed areas. This results in unknown temperature gradients in the camera which would be significantly different at 45,000 feet from those present during the star calibration performed on the ground. A second approach obviated these problems by placing the camera and mount in a temperature-controlled chamber. A chamber was designed and fabricated for this application at RADC. (Reference Figure 4. ASFIR Evaluation Camera Environmental Chamber and Aircraft.)



FIGURE 4. ASFIR EVALUATION CAMERA ENVIRONMENTAL CHAMBER AND AIRCRAFT

Initial design considerations for the chamber were (1) keep size as small as possible to minimize the volume of air requiring temperature control, (2) maintain heat transfer at an acceptable level, (3) non-interference with normal camera operation, (4) allow adequate access to camera and mount.

The mount and the required camera clearance dictate the minimum allowable chamber size. Based on these considerations, a configuration was chosen to have the following dimensions: length 43", depth 26", and width 34" (reference Figure 5. Camera Chamber Construction.) The amount of heat loss through the chamber wall is primarily dependent on the insulating material. Polystyrene foam plastic with a thermal coefficient of 0.021 was selected. A thickness of 1.5" provides adequate

insulation while still allowing an acceptable wall thickness. The lower skin of the bomb door was used as the bottom of the chamber. Polystyrene insulation 1-1/2" thick was carefully fitted around the window to fill the remaining bottom surface of the chamber. (Reference Figure 6. Bottom View of Chamber.) The outer and inner walls were made of 0.063" sheet aluminum which provided adequate strength and rigidity while keeping weight minimal. The entire top of the chamber is removable to permit proper access to the camera and mount. (Reference Figure 7. Camera Chamber.) A three-inch diameter hole was cut through the forward wall to allow pressure equalization during ascent and descent and to provide a means of passing the necessary cabling into the chamber. Rubber flaps on both the outer and inner surfaces covered the hole to limit air flow when the internal and external pressures equalized.

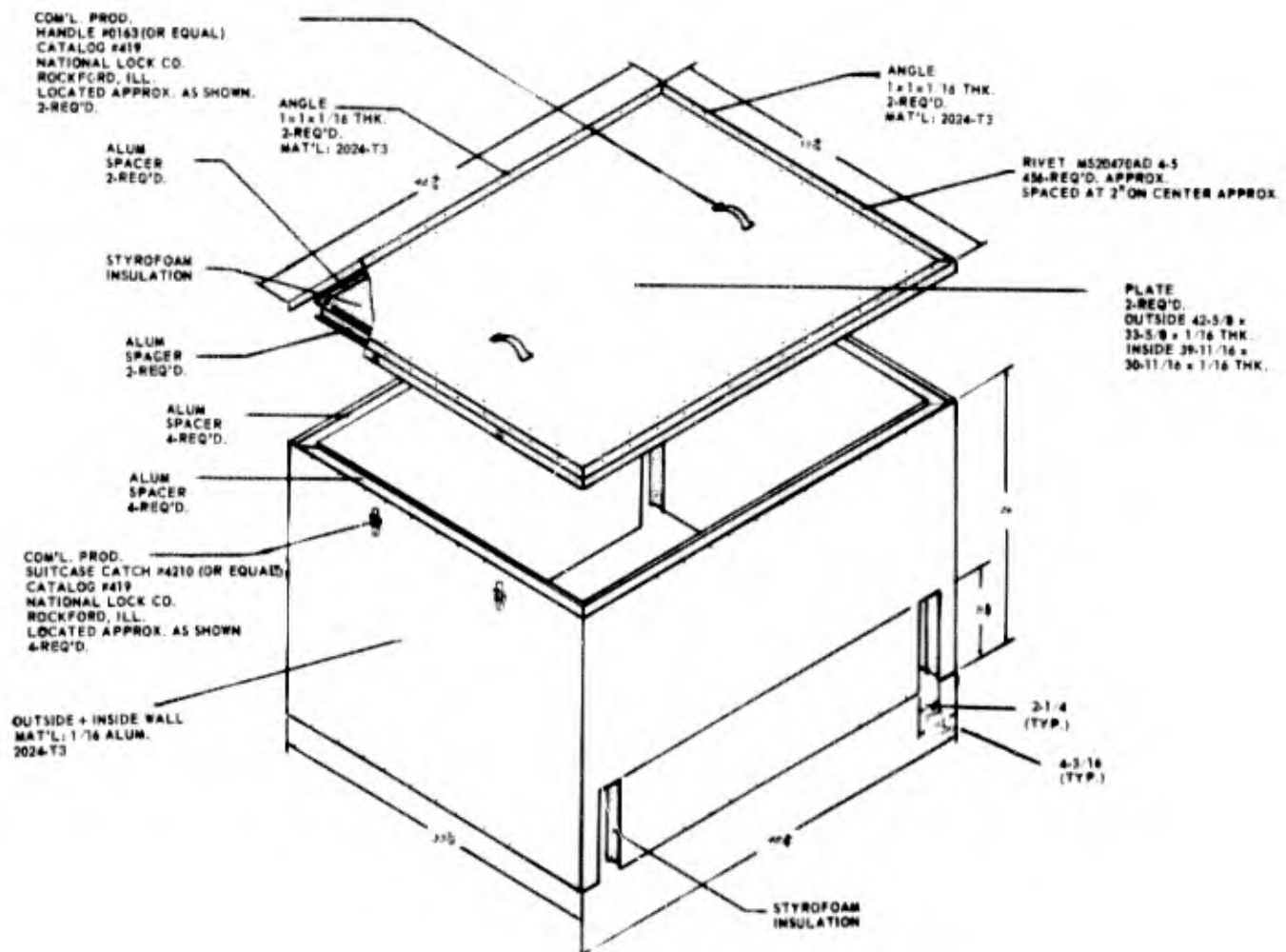


FIGURE 5.1. CAMERA CHAMBER CONSTRUCTION

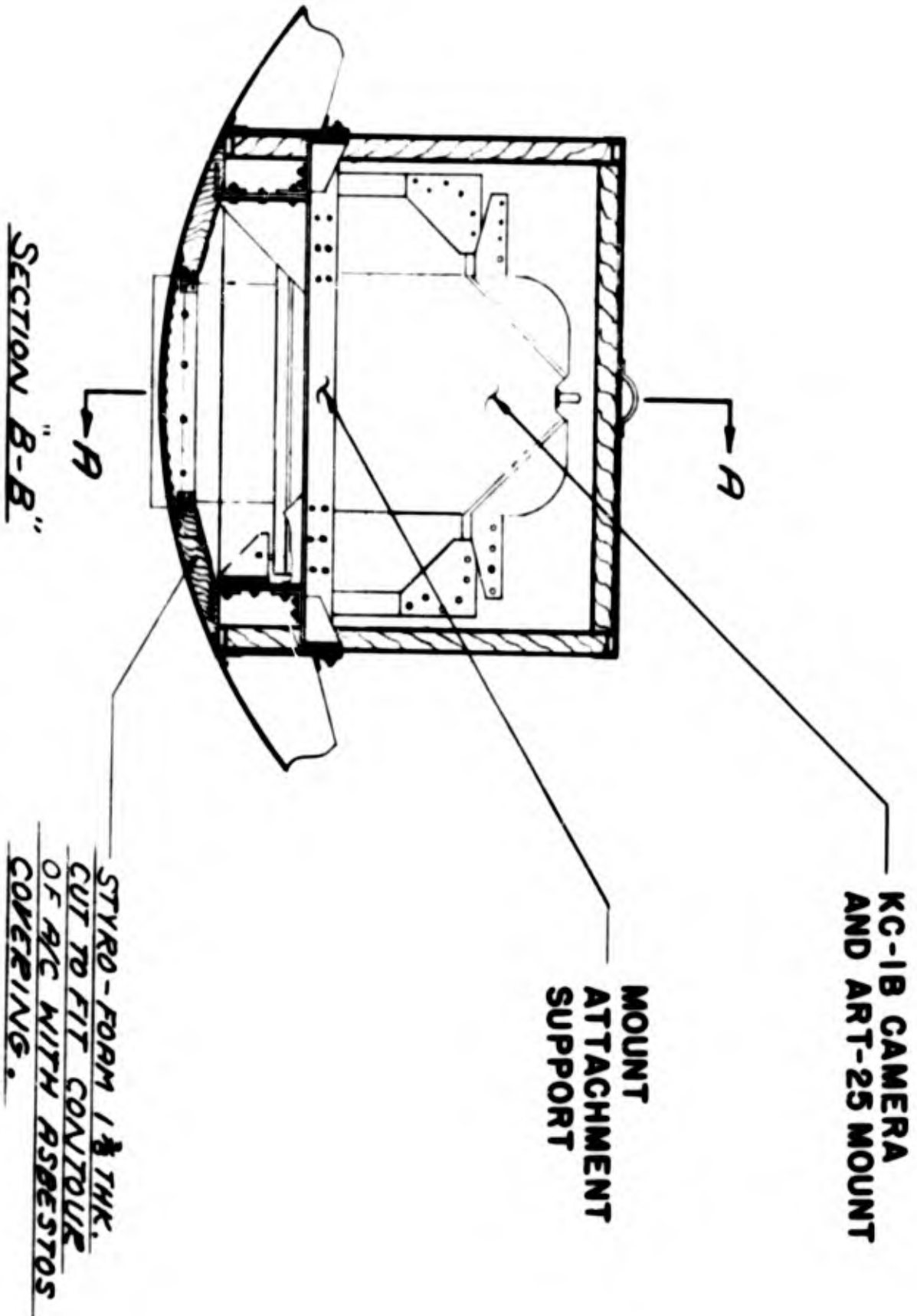


FIGURE 5.3. CAMERA CHAMBER CONSTRUCTION (END VIEW)

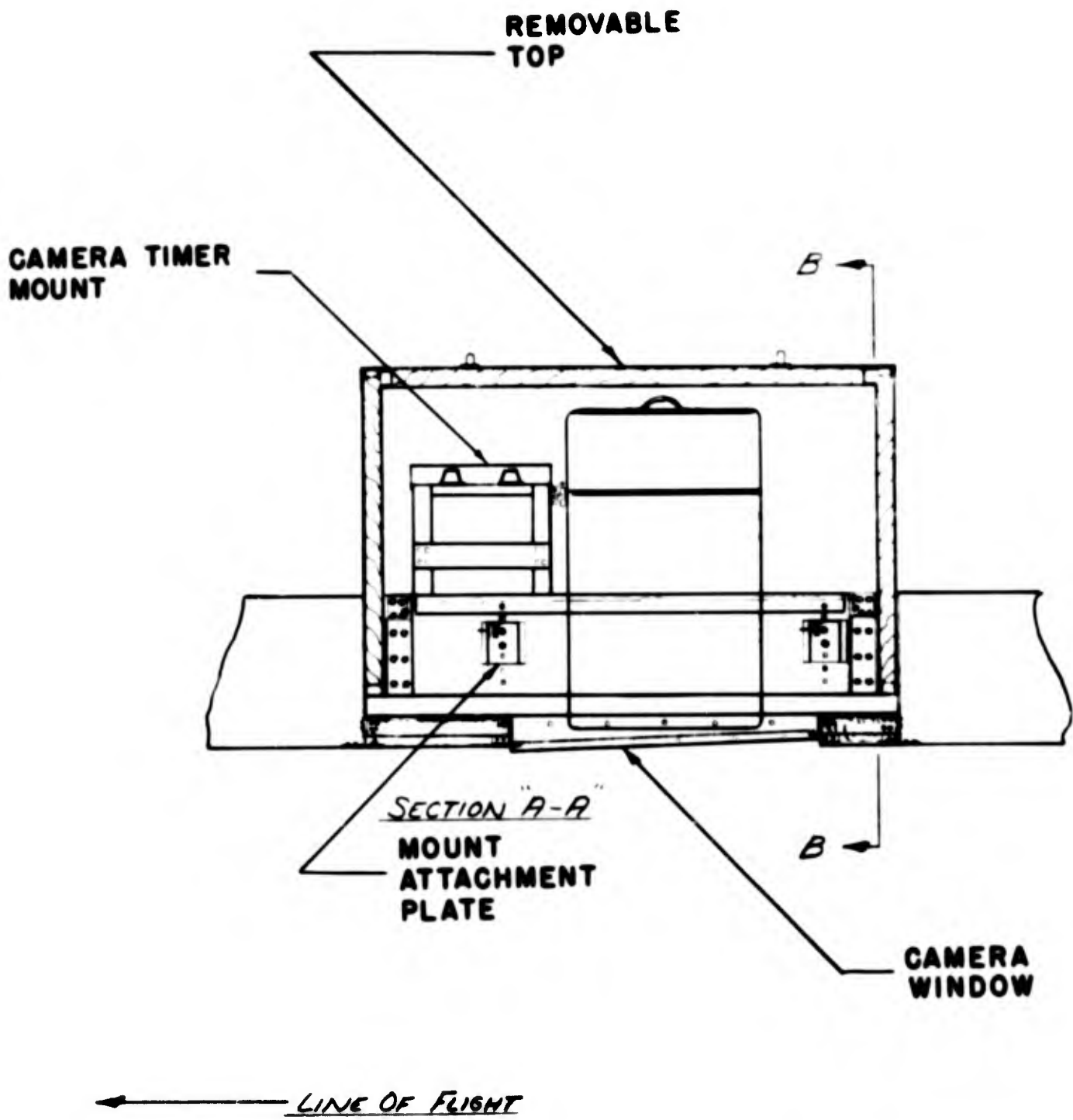


FIGURE 5.2. CAMERA CHAMBER CONSTRUCTION (SIDE VIEW)

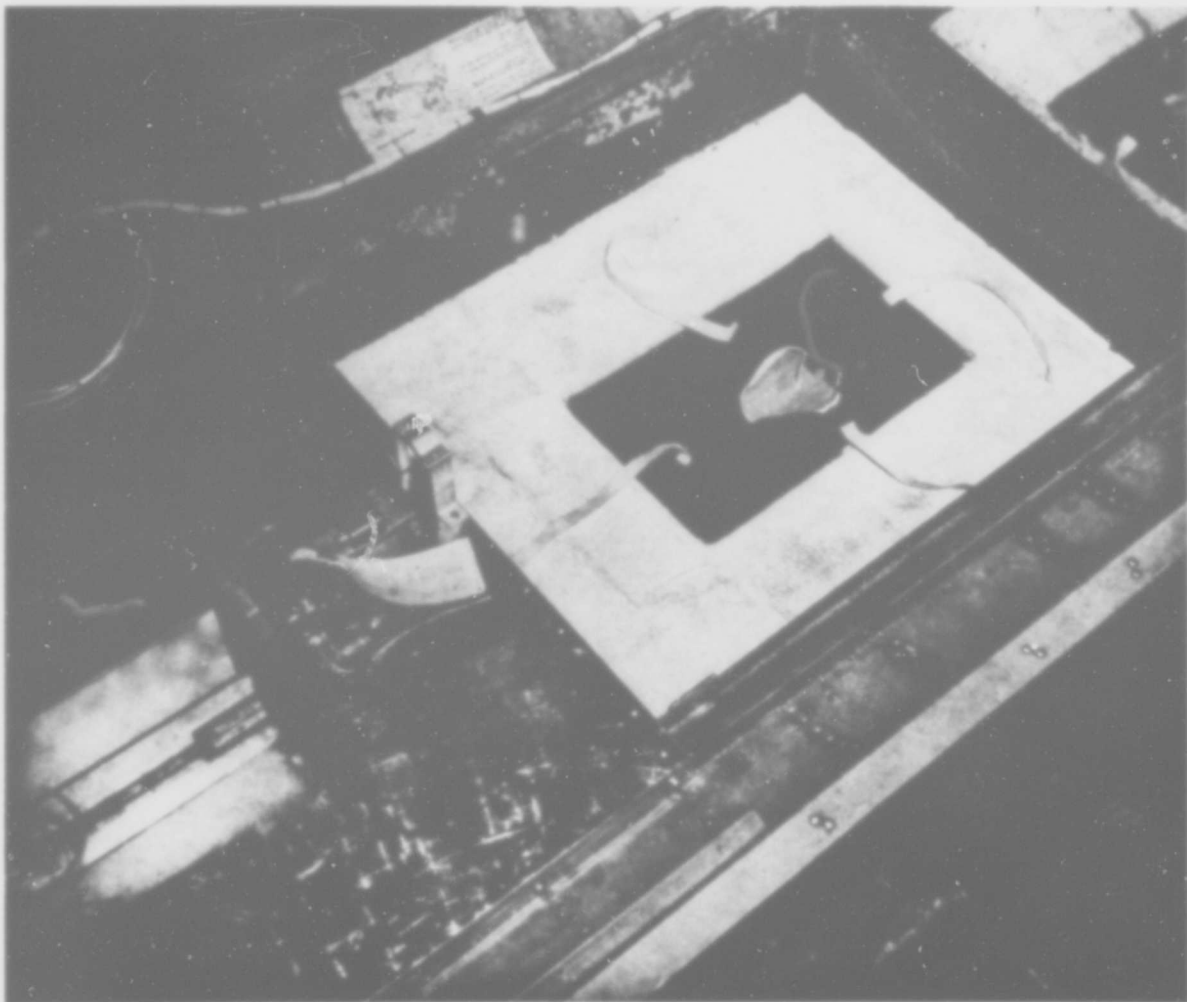


FIGURE 6. BOTTOM VIEW OF CHAMBER

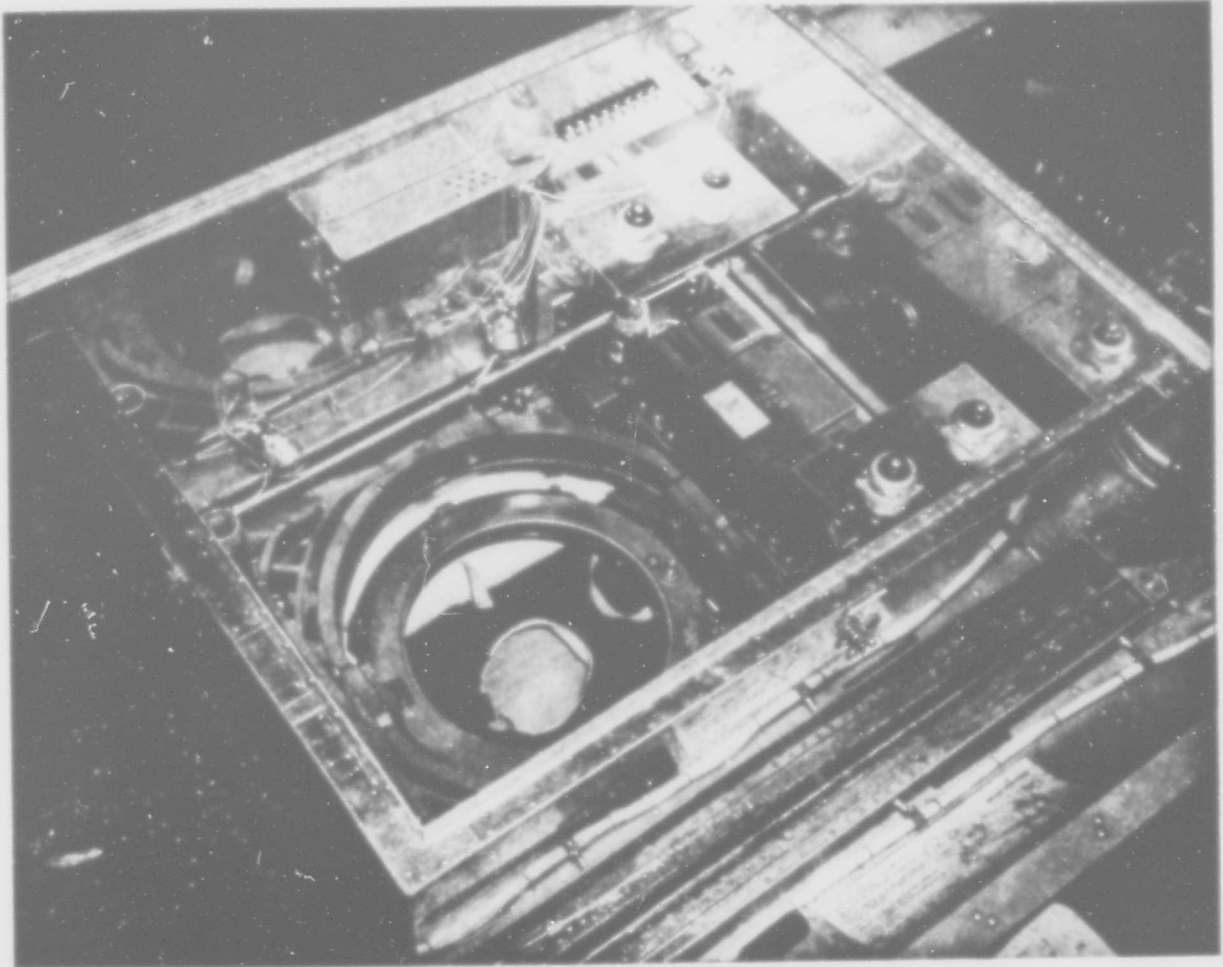


FIGURE 7. CAMERA CHAMBER



The theoretical total heat loss from this chamber was calculated to be 548 watts. A complete analysis is contained in the Appendix, "Theoretical Chamber Heat Losses."

A completely solid-state temperature control unit was designed and fabricated at RADC. This unit is reliable, rugged, insensitive to pressure variations, and provides precise temperature regulation. (Reference Figure 8. Temperature Control Unit.) Powered by the aircraft's 28 vdc supply, the control generates 28 volt square pulses whose width depends on the relationship between the setting of the unit's cutoff temperature (21°C. in this case) and the existing internal chamber temperature. A thermistor, with its inverse temperature-resistance characteristic (Reference Figure 9. Thermistor Resistance) is utilized in a bridge network as a temperature sensor for the control unit.

This sensor was originally located inside the camera on the lens assembly, but this location resulted in temperature oscillations in the chamber. It requires appreciable time for the temperature within the camera to change when the camera surface temperature increases or decreases. The thermistor was subsequently located on the precision timer platform to the rear of the camera. This keeps the chamber air, as well as the camera, at a nearly constant temperature.

The power transistors were originally located within the chamber, but the high currents that had to be handled necessitated adding a cooling blower which generated 112 watts of uncontrollable heat. This resulted in a temperature rise in the chamber above the calibrated value whenever the heat transfer from the chamber dropped below 112 watts. The power transistors operate at full power or are cut off; therefore, they are not temperature dependent. They were relocated outside the chamber where the ambient temperature varies from the existing ground level temperature to -55°C. at high altitudes. Subsequent operation proved satisfactory.

Ten 70 watt incandescent lamps, connected in parallel, were used as the chamber heating elements (reference Figure 10. Thermal Control Wiring Diagram). Incandescent lamps were selected due to their simplicity and because heat transfer is in the form of radiant energy. This characteristic is important at high altitudes where the air density is very low and heating by convection decreases proportionately.

The temperature of the camera and chamber can be continuously monitored in flight from the aircraft cockpit using three sensors located inside the camera and one in the chamber. Two of the three camera sensors are thermistors, one attached to the lens assembly and the other against the registration frame. Each is calibrated to reflect the lens and film area temperatures. By incorporating the sensors into a bridge network, a nullimeter was instrumented to indicate the variation from the calibrated temperature of 21°C. This meter has three ranges with full-scale deflections of  $\pm 3^\circ\text{C}$ .,  $\pm 30^\circ\text{C}$ .,  $\pm 100^\circ\text{C}$ .. (Reference Figure 11. Lens and Film Temperature Monitor Circuit.) The third camera sensor is a thermocouple attached to the inner body of the camera to permit monitoring of the camera surface temperature. The final sensor, another thermocouple, is located in the chamber to allow observation of this air temperature in flight. These thermocouples are wired to another cockpit indicator which reads directly in degrees centigrade. (Reference Figure 12. Camera and Chamber Temperature Monitor Wiring Diagram.)

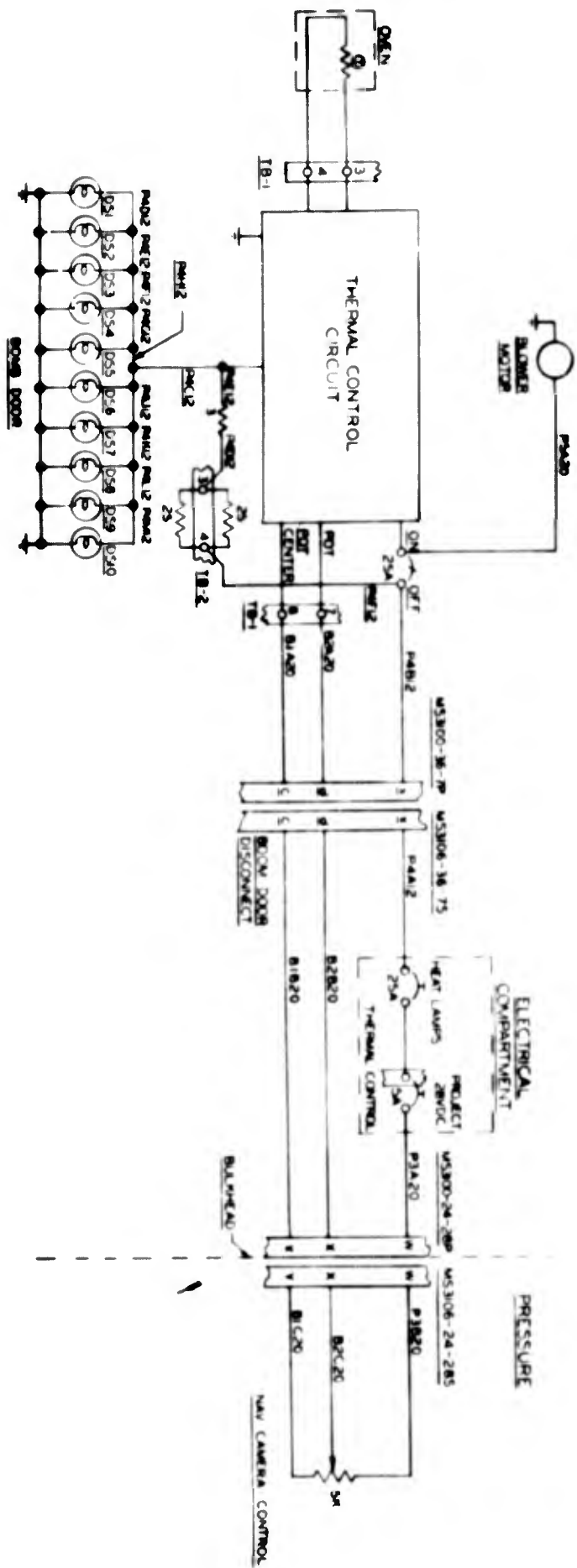


FIGURE 10. THERMAL CONTROL WIRING DIAGRAM

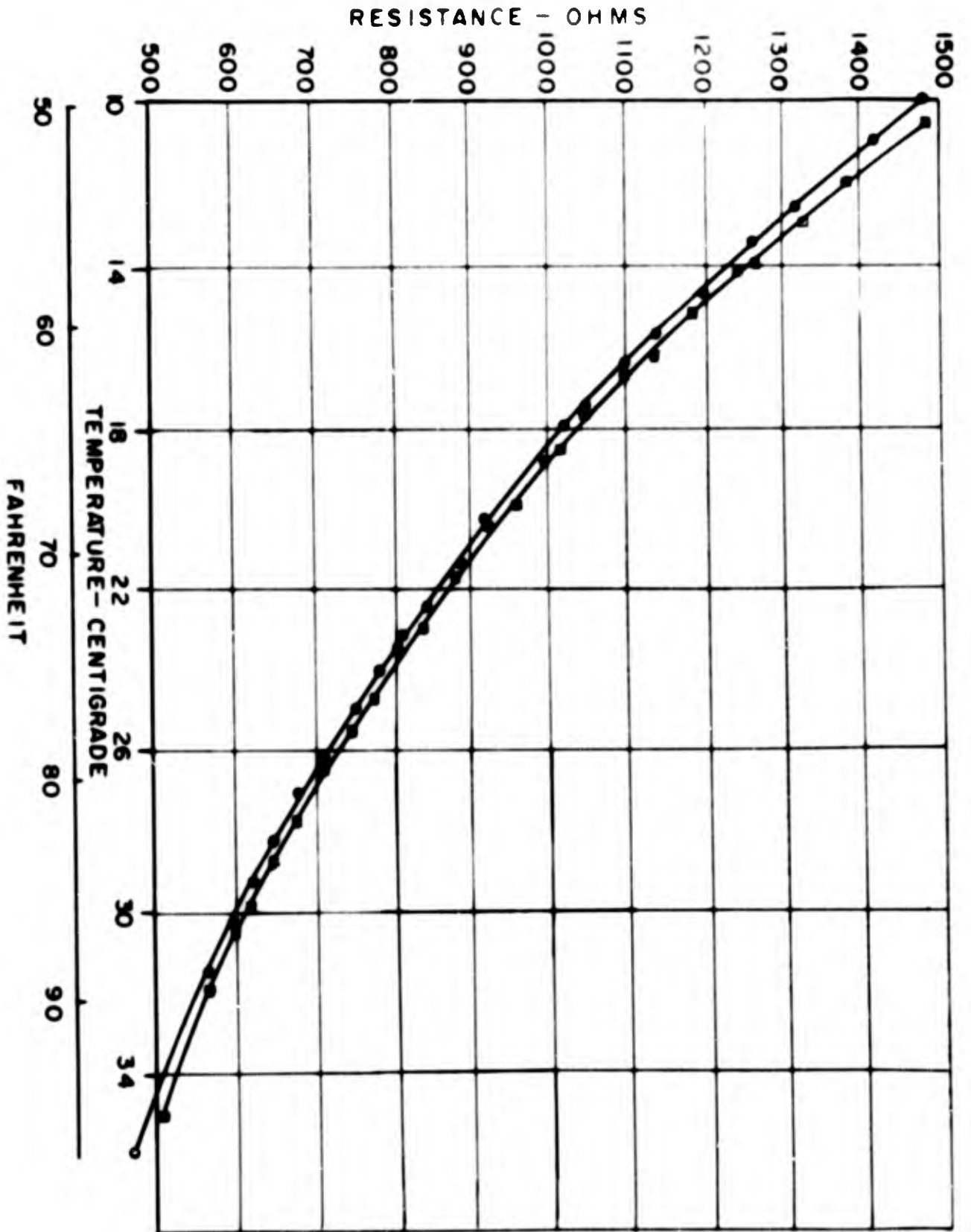


FIGURE 9. THERMISTOR RESISTANCE



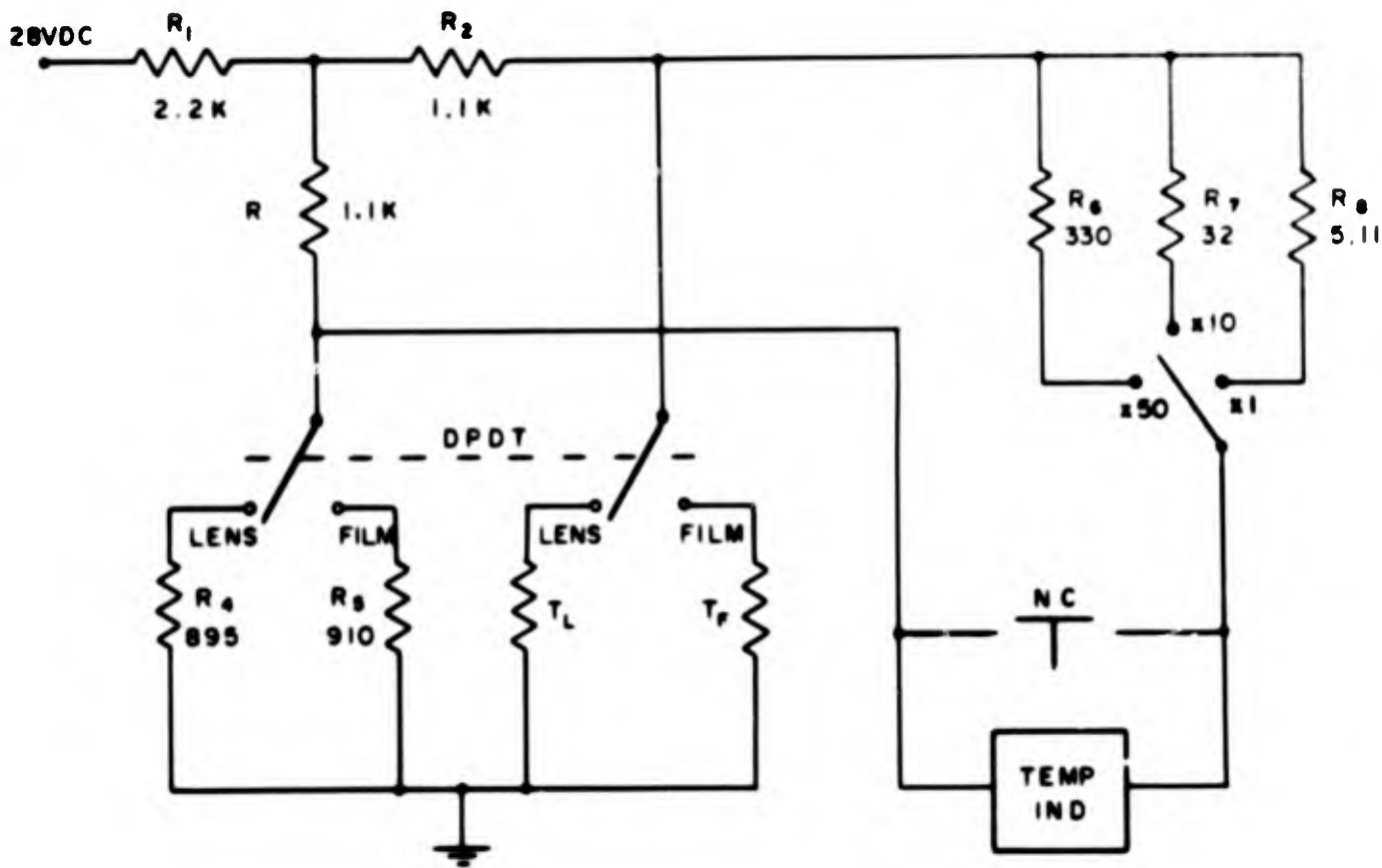


FIGURE 11. LENS AND FILM TEMPERATURE MONITOR CIRCUIT

A small 28 vdc, 1/4 amp, blower is attached to the inner wall of the chamber to provide moderate circulation of the air within the chamber preventing vertical temperature gradients.

A fabric light shield is attached to the camera lens cone neck and the camera window to prevent any light emanating from the bulbs and reflecting off the window to enter the camera optics. (Reference Figure 6. Bottom View of Chamber.) This light diaphragm isolates the air next to the window from the other chamber air, thereby creating an insulation area above the window, which reduces the heat transfer through the window. This shield has an adverse effect in that it prevents the circulating air from flowing across the inner surface of the window. It was anticipated that this would result in frosting of the window; however, test flight data indicate frosting is not a problem.

## SECTION VI

### TEST RESULTS

Test data from flights conducted at 45,000 feet are contained in Figures 13, 14, and 15, showing chamber and camera temperatures. Figure 13 indicates that when the chamber is not preheated, but heat is supplied in flight, three hours are required to reach a stabilized temperature. Figure 14 shows that the temperature remained constant for the duration of the flight when the aircraft and chamber, with the top removed, were heat soaked at 21°C. overnight prior to flight, and heat supplied during flight. Figure 15 reveals that under the condition of preheating to 21°C., but no additional heat supplied in flight, the camera temperature dropped 11°C. and the chamber air temperature dropped 20°C. while the outside air temperature at 45,000 feet was -55°C. Note that when heat is supplied by the lamps in flight, the camera temperature is 4°C. higher than the surrounding air.

These flights also revealed a major limitation associated with the camera stabilizing mount. Test data taken over the 20-mile square ground-control areas indicated a serious lag in mount response (7). Photographs were taken while flying directly over the center of subrange 6. At the completion of the first run, the pilot reverses course for another run in the opposite direction, again over the center of the area. This pattern is repeated for the duration of the evaluation flight. The gyro limits of the mount are  $\pm 8''$  while the average angle of bank of the aircraft while reversing course is 30°. This forced the camera 22° off vertical between each run. The maximum erection rate of the ART-25 mount is 4° per minute with an average rate of 2.5° per minute. It takes 6 to 9 minutes for complete erection resulting in excessive delays between data-acquiring periods.

In an attempt to circumvent this costly delay, several evaluation flights were conducted with the mount locked parallel to the camera window. A study of these photographs revealed that the pilots could hold the aircraft's attitude to within  $\pm 2^\circ$  of level flight. This is compatible with the verticality limits of the photogrammetric resection technique. In addition, the uncontrollable pitch and roll velocities of the aircraft were small enough so that the resulting image blur was not excessive. Comparator analysis revealed very little increase in image blur when compared to photographs taken from the stabilized mount.

The locked mount has several advantages; the camera lens and window remain parallel for all photographs, and the attitude of the aircraft at the time of exposure is directly recorded on the photograph which is an important aspect in evaluating a precision radar.

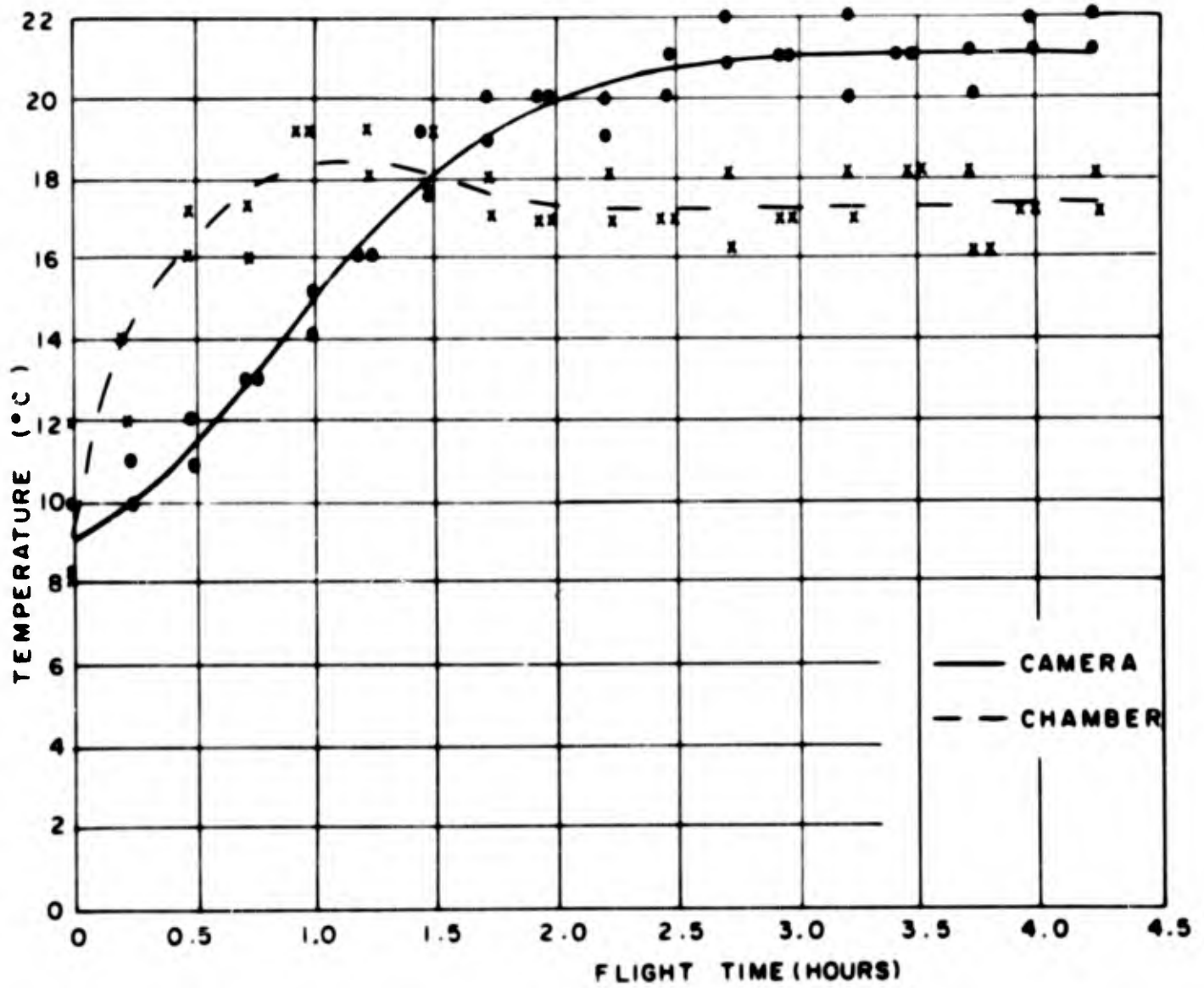


FIGURE 13. CHAMBER-CAMERA TEMPERATURE, NOT PREHEATED

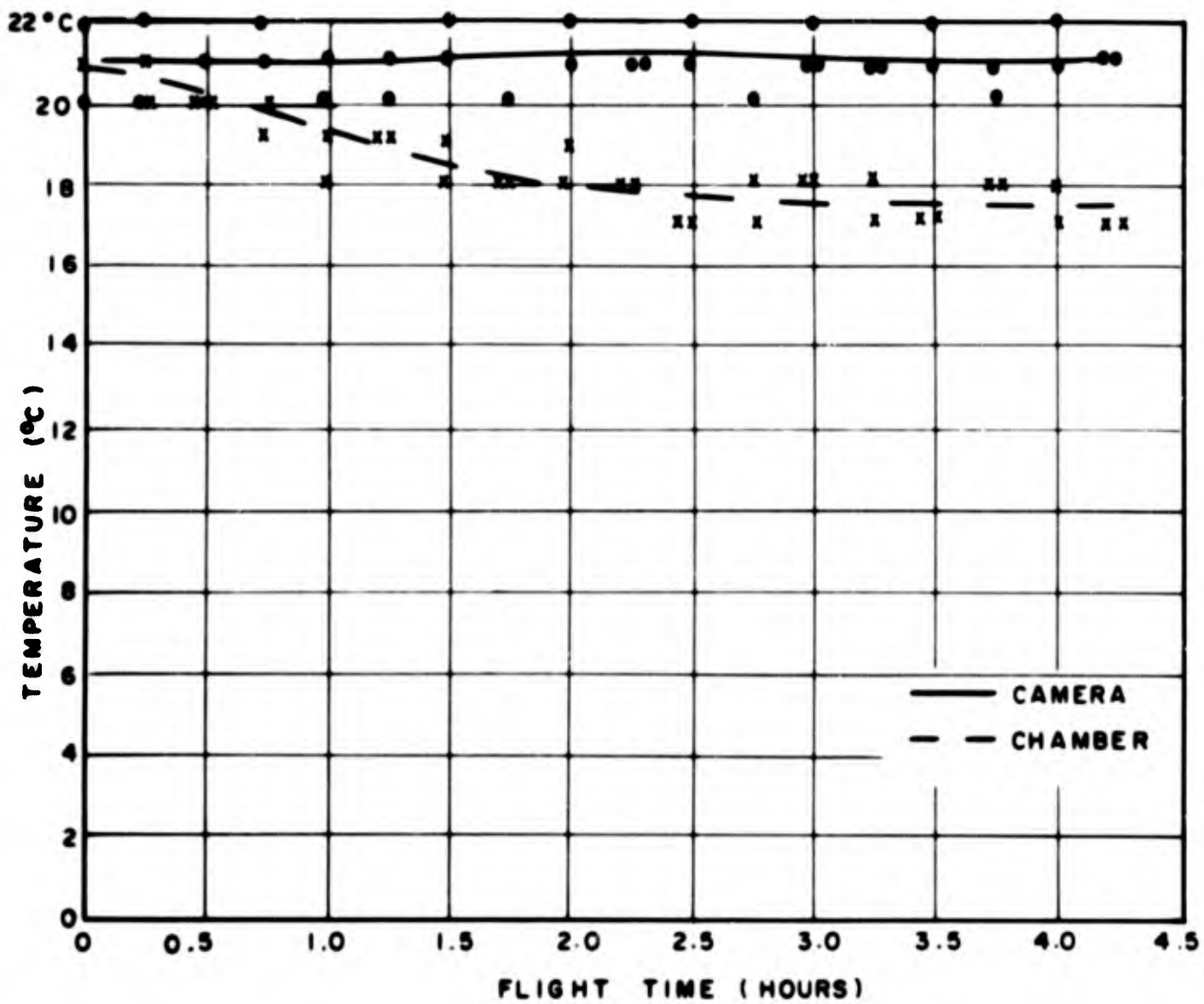


FIGURE 14. CHAMBER-CAMERA TEMPERATURE, PREHEATED

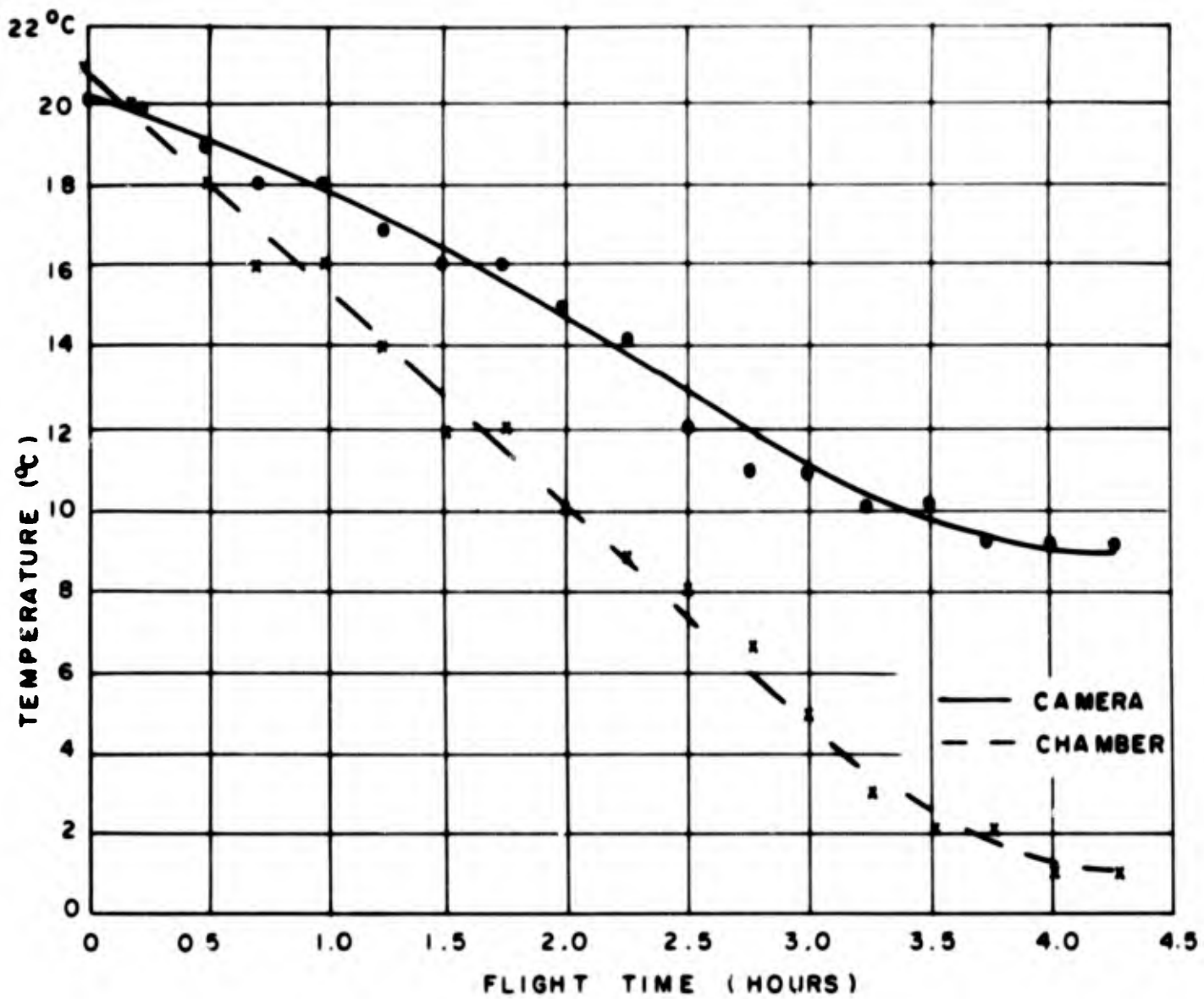


FIGURE 15. CHAMBER-CAMERA TEMPERATURE, NO INFLIGHT HEATING

**SECTION VII**  
**CONCLUSIONS**

1. Calibration of an aerial camera adequately identifies distortion errors resulting from camera fabrication tolerances. The calibration must include the camera window and must be performed under precise temperature control. This calibration is valid only when the camera is operated at the calibration temperature; however, changes in pressure produce no significant errors.
2. The required window surface flatness is dependent upon the lens system resolution and camera focal length. Stock Air Force mapping windows are satisfactory for most precision aerial camera installations.
3. A chamber surrounding the entire camera provides a more uniform temperature control than a heating blanket wrapped around the camera.
4. Heat losses from a properly insulated chamber can be maintained at an acceptable level for any flight altitude.
5. Thermal insulation between camera mount and the aircraft is necessary to limit the conductive heat losses at high altitudes.
6. A solid-state temperature control unit is reliable, rugged, insensitive to pressure changes, and provides precise temperature regulation.
7. Incandescent lamps are satisfactory as chamber heating elements. The radiant energy emitted by the lamps raises the camera temperature 4°C. above the surrounding chamber air.
8. Heat soaking the chamber and camera at the calibration temperature for four hours is required to prevent excessive delay in flight while the camera temperature stabilizes. Regulated heat input in flight is necessary or the camera temperature drops at the rate of 3°C. per hour.
9. It is essential to have complete control of the input heat to the chamber to maintain a constant camera temperature while operating in the wide range of temperatures encountered between ground and flight altitudes.
10. It is not necessary to circulate heated air across the inner surface of the camera window to keep it frost free in flight.
11. Camera stabilization and isolation from the aircraft is not required in all installations to prevent degradation of the camera system resolution.

## APPENDIX

### THEORETICAL CAMERA CHAMBER HEAT LOSSES

The flow of heat from the chamber is expressed as:

$$Q_t = Q_i + Q_w + Q_m \quad (1)$$

where  $Q_i$  = loss through the insulated walls,  $Q_w$  = loss through the window, and  $Q_m$  = loss through the mount attachments to the aircraft.

Each of the individual losses is calculated from the general expression:

$$Q = CAU (t_1 - t_2) \quad (2)$$

for steady state condition, where  $C$  = conversion factor from BTU to watts,  $A$  = surface area in square feet,  $U$  = over-all coefficient of heat transmission in BTU/(hr.) (sq. ft.) ( $^{\circ}$ F),  $t_1$  = temperature of the air within the chamber in  $^{\circ}$ F, and  $t_2$  = temperature of the air outside the chamber in  $^{\circ}$ F.

The over-all heat transfer coefficient ( $U_i$ ) for the insulated chamber, excluding the window, is composed of the terms in the restricting flow barriers such that:

$$U_i = \frac{1}{\frac{1}{h_i} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + \frac{1}{h_o}} \quad (3)$$

where  $h_i$  = inside surface film conductance coefficient,  $x_1 = x_3$  = thickness of inner and outer aluminum skin in feet,  $k_1 = k_3$  = coefficient of thermal conductivity of aluminum,  $x_2$  = thickness of polystyrene insulation in feet,  $k_2$  = coefficient of thermal conductivity of polystyrene, and  $h_o$  = outside surface film conductance coefficient.

The following values were obtained from the Sixth Edition of Marks Mechanical Engineers Handbook:

$$h_i = 2 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F})$$

$$k_1 = k_3 = 117 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F}) (\text{ft.})$$

$$k_2 = 0.021 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F}) (\text{ft.})$$

The outside surface film conductance coefficient ( $h_o$ ) is assumed to be infinite for the bottom of the chamber where it is exposed to the slip stream air velocity of about 400 knots.

These values produce an over-all thermal coefficient ( $U_1$ ) for the chamber, excluding the window, of 0.155 BTU/(hr.) (sq. ft.) ( $^{\circ}$ F). The chamber surface area, excluding the window is 45.5 sq. ft. The heat loss through this area is:

$$Q_1 = 289 \text{ watts}$$

The over-all thermal coefficient ( $U_w$ ) for the window is:

$$U_w = \frac{1}{\frac{1}{h_i} + \frac{x_4}{k_4} + \frac{1}{h_o}} \quad (4)$$

where  $x_4$  = thickness of camera window in feet, and  $k_4$  = 0.59 for crown glass.

$$U_w = 1.75 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F})$$

$$Q_w = 187 \text{ watts}$$

The conductive heat loss through the phenolic insulating blocks which attach the mount to the bomb door, based on the following:

$$k_{ph} = 0.218 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F}) (\text{ft.})$$

$$A_{ph} = 0.5 \text{ sq. ft.}$$

$$U_m = 3.49 \text{ BTU/(hr.) (sq. ft.) } (^{\circ}\text{F})$$

is:

$$Q_m = 72 \text{ watts}$$

The total heat loss from the chamber is:

$$Q_t = 548 \text{ watts}$$

## REFERENCES

1. Merchant, D. C., Space Surveillance System Evaluation by a Method of Photogrammetric Resection, RADC-TDR-62-442, October 1962.
2. Aeroflex Labs, Precision Aerial Camera (Modified KC-1B), unpublished report.
3. Schafer, F. J., ASFIR Evaluation System Data Reduction, unpublished report.
4. Military Specification, MIL-G-1366, Glass Window, Aerial Photographic.
5. Air Force Avionics Laboratory, Research on Photographic Window Problem in Supersonic and Hypersonic Aircraft, RTD-TDR-63-4098, March 1964.
6. Mrs. Chairece L. Norton, Director, Camera Calibration Laboratory, Fairchild Camera and Instrument Corporation, Syosset, L. I., N. Y.
7. Crouth, J. L., Photo-Identifiable Marker Design for Radar Calibration System, unpublished report.

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10 AVAILABILITY/LIMITATION NOTICES Distribution of this document is unlimited		
11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Rome Air Development Center (EMASI) Griffiss AFB, NY. 13442	
13 ABSTRACT A precision aerial camera used in radar evaluation was installed in an aircraft. Installation factors which contribute to the camera system errors were studied to minimize the additional errors introduced when the camera is operated at high altitudes in an unprotected area of an aircraft. The selection of the aircraft camera window and an environmental chamber along with its temperature control system are discussed. It is shown that temperature regulation is essential, while variations in pressure produce negligible errors. Camera stabilization and isolation from the aircraft was not necessary in these tests to prevent degradation of the camera resolution. Test data show that preheating the camera chamber prior to flight, along with regulated heat input, is essential to provide a uniform camera temperature for the duration of the flight. It is concluded that the required camera system accuracy of $\pm 10$ microns on the photo scale can be achieved when the installed camera, including the camera window, is calibrated and operated in a temperature-controlled environment. Schematics and blueprints of a typical installation are included.		

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KEY WORDS

KC-1B Camera (Modified) Environmental Control  
KC-1B Camera (Modified) Aircraft Installation

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