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**AD857160**

**PRELIMINARY DATA REPORT OF THE  
MOL PROTUBERANCE HEAT  
TRANSFER TEST (1A1)**

**VOLUME I**

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# MOL

## MANNED ORBITING LABORATORY

5 FEBRUARY 1969

DAC 62731

### PRELIMINARY DATA REPORT OF THE MOL PROTUBERANCE HEAT TRANSFER TEST (1A11) VOLUME I

AD857160



*Prepared under Contract Number F04695-67-C-0029  
for MOL Systems Office,  
Headquarters Space and Missile Systems Organization  
Air Force Systems Command  
United States Air Force*

IN COMPLIANCE WITH THE REQUIREMENTS OF  
EXHIBIT B, DATA ITEM NUMBER UT-132

*By the MOL Subdivision  
McDonnell Douglas Astronautics Company  
Western Division  
McDonnell Douglas Corporation  
Huntington Beach, California*

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PRELIMINARY DATA REPORT  
OF THE MOL PROTUBERANCE  
HEAT TRANSFER TEST (1A1)

VOLUME 1

This report is MOL Data Item UT132

DAC No. 62731

February 1969

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## INTRODUCTION

The MOL Protuberance Heating Test was conducted for the Air Force Space Systems Division under Contract Number F04695-67-C-0029. An outline of the Protuberance Heating Test was provided in a pre-test report, DAC 58780, dated 26 February 1968 (Reference 1).

The three phases of the test (boundary layer survey, flat plate in undisturbed flow, and protuberance/flat plate combinations) were successfully completed in that the objectives specified in the Fluid Dynamics Test Plan (Reference 2) were accomplished.

This report (Volumes 1 and 2) contains a presentation of the tabulated data obtained from the MOL Protuberance Heating Test and fulfills the requirements for data item UT-132. The report has been divided into two volumes in order to facilitate handling. Volume 1, DAC 62731, contains the primary text of the report. Volume 2, DAC 62732, contains the test data (shadowgraphs and printed data).

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## 1.0 INTRODUCTION

The MOL Protuberance Heating Test (1AL1) was conducted at the Douglas Aerophysics Laboratory (DAL) Four-Foot Transonic Wind Tunnel between January and April 1968.

The test specimens consisted of one-half scale models of the thruster module assembly, VVSA fairing, and equipment fairing. The models were mounted to the floor of the transonic cart; for these tests, the transonic cart served as a supersonic test section. The models and an instrumented section of the floor (consisting of forward, aft, and turntable segments) were constructed of 1/16 inch nominal thickness nickel material. The floor mounting was employed to obtain close simulation of the immersion of the flight articles in the vehicle boundary layer during boost. Testing was conducted between the Mach number range of 2.5 and 5.0. For all practical purposes, these Mach numbers bracket flight vehicle local Mach numbers during the period of maximum heating.

In March 1968 a model failure occurred when the forward and aft skin sections separated from the floor of the transonic cart and blew down the tunnel. The destroyed sections were later replaced with 3/8 inch aluminum plate instrumented with Nanmac thermocouple gages. A photograph of one of these gages is presented in Figure 20.

The remaining test runs were made with the aluminum floor sections; testing was completed on April 16, 1968.

A total of 114.4 wind tunnel hours were expended in accomplishing this test.

## 2.0 MODEL DESCRIPTION

Half-scale models of protuberances unique to the MOL vehicle were constructed and tested. These models included the thruster module assembly, VVSA fairing, and equipment fairing. In addition to these protuberances, a thin floor skin was also constructed. These test items were constructed of 1/16 inch thick high purity nickel. The original floor skin consisted of a forward section, turntable, and aft section (Figures 3 and 4). The turntable contained provisions for mounting the protuberances and for yawing the models to as much as  $\pm 24^\circ$ . Only the thruster module assembly and thruster module assembly-VVSA fairing combination were yawed. Approximate dimensions of the models are included in Figures 8 through 16. Photographs of the models installed in the tunnel are shown in Figures 5 through 7.

Subsequent to failure of the floor skin (Figures 17 and 18), the forward and aft skin sections were replaced with 3/8 inch thick aluminum plates as shown in Figure 19. Instrumentation locations on these plates were essentially the same as on the original skin.

The model construction incorporated a precooling system wherein  $LN_2$  was circulated through the models prior to each run. This lowered the temperature of the models and insured a more pronounced response from the thermal instrumentation to surface heating. The cooling tubes and associated insulation of the floor skin are shown in Figures 1 and 2. A hydraulically actuated shoe protected the model and floor skin instrumentation during the tunnel start.

### 3.0 DATA DESCRIPTION

#### 3.1 Shadowgraphs

Shadowgraphs were obtained by mounting a 35 mm camera and a light source on one side wall of the test section and painting the opposite wall white. Photographs were taken of the shock patterns which were projected on the wall during runs with the protuberances installed. Because of the nature of the physical setup, some distortion is in evidence. All available shadowgraphs are provided in the data section of this report. Each photograph is identified by a run number; the corresponding tunnel flow conditions for specific runs may be obtained from Table 1.

The variation noted in some cases between the identifying run number and those painted on the side wall resulted when consecutive runs were made without opening the tunnel to re-paint the numbers. Shadowgraphs of the shock system generated by the forebody of the equipment fairing were not obtained because of a malfunction in the camera system during these runs.

#### 3.2 Tabulated Data

The tabulated data resulting from all three phases of the test are provided in Volume II. The data are identifiable by the run number printed in the upper right-hand corner of each page. Tabulated output consisted of tunnel freestream parameters plus heat transfer and pressure data for each good run. A summary of acceptable runs is provided in Table 1.

The tabulated data are preceded by a key (Table 0) which provides a description of the pertinent tabular headings for each set of tabular output. In addition to tabulated pressure and heat transfer data, the printed data from the boundary layer runs have also been included.

In order to assess the relative value of the printed data, specific comments for certain runs have been provided.

##### 3.2.1 General Comments on Tabulated Data

The copper constantan thermocouple temperature time histories were curve fitted in two ways. Data point 1 values are the result of curve fitting 31 consecutive measurements immediately after shoe retraction. These data should match exactly the as-run data, for most runs.

### 3.2.1 General Comments on Tabulated Data (cont.)

Under data point 2, the copper constantan thermocouple outputs were curve fitted by skipping the first 14 consecutive measurements, then curve fitting every other measurement out of the next 62. If sufficient readings were not available, point 2 was not printed out.

The NAIMAC thermocouple output was curve fitted over the first 21 consecutive readings immediately following shoe retraction (NAIMACS are confined to those heat transfer data labeled FS and AS subsequent to run 74). The point 2 data for the NAIMACS are invalid.

Data points numbered three or greater should be disregarded in all cases. Scanivalve nookup sheets are provided in Table 5 to aid the user in identifying which model pressures were compromised by a diminishing  $P_{t\infty}$  and loss of flow. If a pressure is flagged in the tab data, it indicates that the pressure did not stabilize.

The pressure ratio  $P/PS$  will suffer reduced accuracy if it happened that tunnel total pressure was dropping at the time a particular model pressure was read, even though flow might still be supersonic. The reason for this is that a PS (PSIA) was stored by the program early in the run. A more accurate  $P/PS$  can be hand calculated by referring to the scanivalve port number that corresponded to the model pressure of interest.

On the first page of the pressure data for each run are listed a group of pressures labelled PR1, PR2, etc. These represent the several ports on each module (channel) of the scanivalves that were connected to a reference pressure. The reference pressure was also read by a separate transducer, and the reading is labelled PREF. When large discrepancies appear between PREF and PRX, model pressures connected to the same channel as the erroneous PRX should be seriously questioned. Usually, discrepancies appear when PREF is much higher than the model pressures, resulting in a pressure lag problem. A majority of the pressure taps were connected to 10 PSIA transducers; therefore, pressures of 10.2, 10.8, etc. may indicate that a transducer is pegged. This condition could result from a transducer or tap either being open to the atmosphere or responding to a high local model pressure. The data have not been reviewed in detail to differentiate between these two conditions. In addition, a small number of transducers used had a range to 15 PSIA.

Table 1 provides a complete summary of runs for which data were provided. All run numbers which are not mentioned in Table 1 were not acceptable, with the exception of runs 72 and 147. At the time this report was readied for print,

### 3.2.1 General Comments on Tabulated Data (cont.)

the test facility was experiencing difficulty in reducing these runs, and it was not known if the data quality would permit an acceptable reduction. In addition, some re-reduction is necessary for runs 62, 96, 138, 139, and 143, although uncorrected data are provided for those runs in this report. In the event all or part of these data eventually becomes available it will be published as an addendum to this report.

In general, the printed data are satisfactory as received; however, there are small deficiencies in the data on certain individual runs. As a result, specific comments regarding these deficiencies have been included as an aid to the user of the data.

### .2.2 Specific Comments on Tabulated Data

#### Run 61

Lost ports 9-13. Lost flow. See scanivalve hookup sheet to identify resulting lost pressures.

Starting with port 7,  $P_{t\infty}$  and  $P_{\infty}$  [PS (PSIA)] were dropping off during the time model pressure data were being taken, so the P/PS column will be in error.

#### Run 62

The point 2 heat transfer data could not be reduced properly and the reason was not discovered.

#### Run 65

Lost flow at port 13.

$P_{t\infty}$  dropping off at port 12.

#### Run 66

Lost tunnel flow at port 13.

$P_{t\infty}$  dropping off at port 12.

#### Run 67

Tunnel flow lost at port 11.

$P_{t\infty}$  dropping off at port 10.

#### Run 72

Reduced data not available due to reduction difficulty.

#### Run 74

The model failure occurred during this run. Consequently no acceptable data were recorded. For all succeeding runs, the forward and aft floor plates were

Run 74 (cont.)

instrumented with NANMAC Chromel-Alumel thermocouples. The only valid heat transfer data are point 1 values in the reduced data for the NANMACS.

Run 76

The heat transfer data are badly scattered, apparently because of inadequate precooling and noise. The reference pressure was very high in comparison to  $P_{\infty}$ , so some pressure readings were invalidated, due to lag time. Reference pressures were misread.

Run 77

The heat transfer data are badly scattered, apparently because of inadequate precooling and noise. The reference pressure was very high in comparison to  $P_{\infty}$ , so some pressure readings were invalidated. Reference pressures were misread.

Run 80

During this run, the signal from many transducers shifted to the channel adjacent to the correct one (e.g., data correctly listed on channel 50 shifted to channel 49). This happened at the time of shoe retraction.

In order to save these data, a tunnel total temperature was estimated from raw data counts and dubbed into the program. This corrected the adiabatic wall temperature. The labels on the tabulated data (FS, AS, TS numbers) were then changed by hand in the reduced data. The point 1 data only are marked up, but succeeding temperature data points require the same correction.

The channel shift problem did not affect the model pressure data or  $P_{t\infty}$  (it is not known why  $P_{t\infty}$  did not print correctly in the heat transfer section of the data). Flow was lost at port 9 and certain model pressures were affected by the high reference pressure, introducing the lag problem. Pressure data for runs 85 to 87 are considered superior (runs 80, 82, and 85 to 87 were all run at the same freestream conditions).

Run 82

Same as comments for #80, except flow was lost at port 7 and  $P_{t\infty}$  started falling off at port 6.

#### Run 84

There was no cooling on the forward plate for runs 84-146, in order to better utilize the available liquid nitrogen. Consequently, any forward skin temperature data for these runs are invalid.

Special 100 H<sub>2</sub> filters were used with the NANMACS starting with run 84 in an attempt to eliminate noise in the data and diminish the scatter in the heat transfer coefficient.

Indications are that starting with run 84, pressure tap AS 1 opened up to the atmosphere and was consequently invalid for the balance of the test.

#### Runs 85-87

There was little or no precooling before these runs, so all heat transfer data are invalid.

An attempt was being made during these runs to raise  $P_{t\infty}$  to insure that there was no air liquifaction present. In this respect, run 87 had the highest  $P_{t\infty}$  and is therefore superior.

The accuracy of the model pressure data was undoubtedly affected by the high reference pressure. The scatter in the data is also a function of the difficulty in measuring such low pressures.

#### Run 88

It is fairly obvious from the heat transfer data that T 44 and T 51 are invalid. Note that on run 90 they are all right. These thermocouples were all connected to the same amplifier, and a characteristic of this setup is that if one thermocouple generates or picks up excessive noise, all thermocouples on that channel may also be affected.

Thermocouples located on the various thruster nozzles were not precooled, so the data from these are generally inferior.

#### Run 90

Flow maintained throughout run, but  $P_{t\infty}$  dropping off starting with port 14, so  $P/P_{t\infty}$  data for pressure taps on ports 14 and 15 will be in error.

#### Run 91

Thermocouples T 44 and T 51 again no good for reason given in comments for run 88. Port 15 was lost, and  $P_{t\infty}$  was falling off for ports 13-15.

#### Run 92

Thermocouples T 44 to T 51 no good for reason given in comments for run 88. Flow

Run 92 (cont.)

was lost for ports 13-15, and  $P_{t\infty}$  was falling off at port 10.

Run 93

Thermocouples T 44 to T 51 may or may not be good for reason given in comments for run 88.

Flow was lost for port 15, and  $P_{t\infty}$  was falling off ports 12-15.

Run 94

$P_{t\infty}$  falling off ports 13-15.

Run 95

Lost flow ports 12-15.  $P_{t\infty}$  dropping off ports 11-15.

Run 96

$P_{t\infty}$  dropping at port 15. The value of  $h_0$  is incorrect (should be 0.0065). Corrected reduced data were not available.

Run 98

T 44 and T 51 no good for reason provided in comments for run 88.

Run 99

T 44 to T 51 no good for reason provided in comments for run 88.

Run 101

T 44 to T 51 may or may not be good for reason provided in comments for run 88. Lost ports 7-15.  $P_{t\infty}$  dropping off ports 6-15.

Run 102

The model was not precooled for this run, in order to obtain a complete set of pressure data.

The problem of the reference pressure introducing lag errors apparently recurred during this run. Also a problem here was the difficulty of measuring such low pressures.

Run 103

For runs 103 to 124, T 61 is a dummy.

TS53 and TS54 are both duplicated in runs 103 to 124. The data listed for these are correct (i.e., the duplication does not indicate that some thermocouples are mislabeled in the data).

Thermocouples T 44 to T 51 are no good for reasons provided in the comments for run 88. Lost ports 17-18.  $P_{t\infty}$  dropping ports 16-18.

Run 104

Thermocouples T 44 to T 51 are no good for reasons provided in comments for run 88.  
 $P_{t\infty}$  dropping for ports 17-18.

Run 105

T 44 to T 51 are no good for reasons provided in comments for run 88.  
Many of the model pressures for this run are bad, because the reference pressures were misread. It is suggested that run 135 be used for  $P_{\infty}$  data.

Ports 17-18 were lost.  $P_{t\infty}$  was dropping off ports 15-18.

Run 106

T 44 to T 51 are no good for reasons provided in comments for run 88.  
Lost ports 16-18.  $P_{t\infty}$  dropping ports 14-18.

Run 107

Lost ports 14-18.  $P_{t\infty}$  dropping ports 13-18.

Run 108

Lost ports 17-18. Thermocouples T 44 to T 51 no good for reason provided in comments for run 88.

Run 114

Thermocouples T 44 to T 51 may or may not be good for reason provided in comments for run 88.

Run 115

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.  
Lost ports 13-18.  $P_{t\infty}$  dropping off ports 12-18.

Run 119

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.  
 $P_{t\infty}$  dropping off port 18.

Run 120

Pressure data no good.

Run 121

Temperature data inferior. Model was not precooled.  
Lost ports 17-18.  $P_{t\infty}$  dropping off ports 15-18.

Run 122

Thermocouples T 44 to T 51 no good for reason provided in comments for run 88.

Run 122 (cont.)

Lost ports 8-18.  $P_{t\infty}$  dropping off ports 6-18.

Run 123

Temperature data inferior. Model was not precooled.

Run 124

Temperature data inferior. Model was not precooled.

Run 125

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Run 126

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Lost ports 6-18.  $P_{t\infty}$  falling off ports 5-18.

Run 127

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88. All pressure data are invalid because tunnel flow was lost.

Run 128

Temperature data will be inferior. Model was not precooled.

$P_{t\infty}$  falling off ports 17-18.

Run 129

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Run 130

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Run 132

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Run 135

Lost ports 17-18.  $P_{t\infty}$  dropping off ports 16-18.

Run 136

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Lost ports 13-18.  $P_{t\infty}$  dropping off ports 11-18.

Run 137

Thermocouples T 44 to T 51 no good for reasons provided in comments for run 88.

Lost ports 16-18.  $P_{t\infty}$  dropping off ports 14-18.

Run 138

$h_o$  for this run should be .0055. Corrected reduced data had not been received from the test facility at the time this report was printed.

Lost ports 13-18.  $P_{t\infty}$  falling off ports 13-18.

Run 139

$h_o$  for this run should be 0.0055. Corrected reduced data had not been received from the test facility at the time this report was printed.

Thermocouples T 44 and T 51 no good for reasons provided in comments for run 88.

The temperature data for this run are inferior because the model was not precooled.

Lost ports 15-18.  $P_{t\infty}$  was falling off ports 14-18.

Run 140

Lost ports 14-18.

The second group of reference pressures (PR11, PR12, PR20) were badly misread by the second scanivalve. All pressures on the second scanivalve (refer to scanivalve hookup sheet) should be considered invalid.

Run 141

Run 141 was the first run with the equipment fairing. For runs 141 to 146, the forward skin thermocouples (FS) were not cooled, so data for these are invalid.

Run 143

The  $P_{t\infty}$  print out of run 143 is wrong, so the pressure ratios are incorrect. The heat transfer data are all right.

A corrected reduction had not been received from the test facility at the time this report was printed.

Run 147

For runs 147 to 153, the aft skin (AS) thermocouples were not precooled so they are not printed out. In addition, all forward and aft skin pressure taps were connected to read only the reference pressure, not model pressures.

Run 147 was not provided because of difficulty in reducing the data.

Run 151

Lost ports 7-9.

Run 152

The second scanivalve badly misread all reference pressures, so all pressures on this scanivalve should be considered bad data.

#### 4.0 TEST SUMMARY

The protuberance heating wind tunnel test was conducted for the purpose of determining heating rates and static pressure distributions on and around various protuberances mounted external to the MOL vehicle skin. The protuberances used in this investigation were half-scale models of actual protuberance configurations on the MOL vehicle. Liquid nitrogen was circulated beneath the instrumented floor section and through the models prior to each run in order to augment thermal response of the system. A hydraulically actuated shoe system protected the models and instrumentation prior to each test run. This shoe was retracted after fully developed flow was attained in the test section during each run.

The forward and aft skin sections separated from the floor during run 74 and were subsequently destroyed. Testing continued after replacing these two sections with thick aluminum plate. The thermal instrumentation in this area was replaced with individual NANMAC thermocouple gages and the pressure instrumentation consisted of the same complement of taps originally specified.

Data were taken during the test using a multiblock mode, which made it possible to monitor a maximum of 192 data channels during each run. Data gathering was initiated just prior to shoe retraction in each case; temperature data were recorded first, followed by a scanning of the pressure ports. The amount of time allotted for each data gathering sequence was varied from run to run and was governed primarily by available tunnel run time.

The error in the pressure data is estimated at  $\pm 0.026$  psi for  $P$ , regardless of pressure level. For  $P/P_\infty$ , the error is estimated at  $\pm 3\%$  for Mach 2.5 to  $\pm 25\%$  at Mach 5.0; these errors are estimated for ratios of  $P/P_\infty$  on the order of 1.0 or greater. The accuracy quoted for pressures is approximately  $\pm 0.5\%$  of full scale transducer readings, so the pressure data appear to be of good quality. The accuracy of the heat transfer data is estimated to be  $\pm 33\%$  and is below state-of-the-art quality if state-of-the-art is taken to be  $\pm 20\%$ . This error range is applicable to both the thermocouple and the NANMAC gage instrumentation. In the case of the thermocouples, the major contribution to the uncertainty is the slope,  $dT/dt$ , obtained from different curve fits. The difficulty arises from the low signal-to-noise ratio which existed during this test. In the case of the NANMAC gages, the slope is again the major uncertainty. It should be noted, however, that for the NANMACS the slope is not a linear function.

#### 4.0 Test Summary (cont.)

These quoted accuracies are based on a random error analysis of the instrumentation and recording system and do not include possible errors due either to moisture on the surface of the model skin or to large gradients on the surface from one thermocouple location to another. Measurements taken under unusual conditions, such as a pressure obtained when  $P_{t\infty}$  was unstable, obviously may be outside the quoted accuracy range.

TABLE 1  
RUN SUMMARY

Phase I

| CONFIGURATION        | Run Number | Nominal Mach No. | $P_{t\infty}$ (Psia) | Shadowgraph | Yaw Angle $\beta$ (Deg) |
|----------------------|------------|------------------|----------------------|-------------|-------------------------|
| Boundary Layer Rakes | 35         | 2.5              | 27                   |             |                         |
|                      | 40         | 3.0              | 40                   |             |                         |
|                      | 41         | 3.0              | 30                   |             |                         |
|                      | 43         | 3.5              | 65                   |             |                         |
|                      | 44         | 3.5              | 40                   |             |                         |
|                      | 45         | 4.0              | 95                   |             |                         |
|                      | 46         | 4.5              | 110                  |             |                         |
|                      | 60         | 5.0              | 110                  |             |                         |
| Phase II             |            |                  |                      |             |                         |
| Flat Plate           | 61         | 3.5              | 65                   |             |                         |
|                      | 62         | 3.5              | 65                   |             |                         |
|                      | 63         | 3.5              | 40                   |             |                         |
|                      | 65         | 3.0              | 40                   |             |                         |
|                      | 66         | 3.0              | 35                   |             |                         |
|                      | 67         | 2.5              | 27                   |             |                         |
|                      | 68         | 2.5              | 27                   |             |                         |
|                      | 69         | 4.0              | 95                   |             |                         |
|                      | 76         | 4.5              | 85                   |             |                         |
|                      | 77         | 4.5              | 110                  |             |                         |
|                      | 80         | 5.0              | 110                  |             |                         |
|                      | 82         | 5.0              | 115                  |             |                         |
|                      | 84         | 3.5              | 65                   |             |                         |
|                      | 85         | 5.0              | 110                  |             |                         |
| 86                   | 5.0        | 115              |                      |             |                         |
| 87                   | 5.0        | 110              |                      |             |                         |
| Phase III            |            |                  |                      |             |                         |
| Thruster             | 88         | 3.5              | 65                   | X           | 0                       |
|                      | 90         | 3.5              | 65                   | X           | +12                     |
|                      | 91         | 3.5              | 65                   | X           | -12                     |
|                      | 92         | 4.0              | 95                   | X           | -12                     |
|                      | 93         | 4.0              | 95                   | X           | +12                     |
|                      | 94         | 4.0              | 95                   |             | 0                       |
|                      | 95         | 3.0              | 40                   | X           | 0                       |
|                      | 96         | 2.5              | 27                   | X           | 0                       |
|                      | 97         | 4.5              | 85                   | X           | 0                       |
|                      | 98         | 4.5              | 85                   | X           | +24                     |
|                      | 99         | 4.5              | 85                   | X           | -24                     |
|                      | 100        | 4.5              | 85                   | X           | -24                     |
|                      | 101        | 5.0              | 115                  | X           | 0                       |
|                      | 102        | 5.0              | 115                  | X           | 0                       |

TABLE 1 (cont.)

## RUN SUMMARY

| CONFIGURATION              | Run Number        | Nominal Mach No. | $P_{t\infty}$<br>(Psia) | Shadowgraph | Yaw Angle $\beta$<br>(Deg) |  |
|----------------------------|-------------------|------------------|-------------------------|-------------|----------------------------|--|
| Thrustor & WVSA<br>Fairing | 103               | 3.5              | 65                      | X           | 0                          |  |
|                            | 104               | 3.5              | 65                      | X           | +12                        |  |
|                            | 105               | 3.5              | 65                      | X           | -12                        |  |
|                            | 106               | 3.5              | 65                      | X           | -12                        |  |
|                            | 107               | 3.0              | 40                      | X           | 0                          |  |
|                            | 108               | 2.5              | 27                      | X           | 0                          |  |
|                            | 109               | 4.0              | 95                      |             | 0                          |  |
|                            | 110               | 4.0              | 95                      | X           | +12                        |  |
|                            | 111               | 4.0              | 95                      | X           | +12                        |  |
|                            | 112               | 4.0              | 95                      | X           | -12                        |  |
|                            | 113               | 4.5              | 85                      | X           | 0                          |  |
|                            | 114               | 4.5              | 85                      | X           | +24                        |  |
|                            | 115               | 4.5              | 85                      | X           | +24                        |  |
|                            | 119               | 4.5              | 85                      | X           | -24                        |  |
|                            | 120               | 5.0              | 115                     | X           | -24                        |  |
|                            | 121               | 5.0              | 115                     |             | -24                        |  |
|                            | 122               | 5.0              | 115                     | X           | +24                        |  |
|                            | 123               | 5.0              | 115                     | X           | +24                        |  |
|                            | 124               | 5.0              | 115                     |             | 0                          |  |
|                            | 125               | 5.0              | 115                     | X           | 0                          |  |
|                            | 126               | 5.0              | 115                     | X           | +24                        |  |
|                            | 127               | 5.0              | 115                     | X           | -24                        |  |
|                            | 128               | 5.0              | 115                     | X           | -24                        |  |
|                            | 129               | 4.5              | 85                      |             | -24                        |  |
|                            | 130               | 4.5              | 85                      |             | +24                        |  |
|                            | 131               | 4.5              | 85                      | X           | 0                          |  |
|                            | 132               | 4.0              | 95                      | X           | 0                          |  |
|                            | 133               | 4.0              | 95                      | X           | +12                        |  |
|                            | 134               | 4.0              | 95                      | X           | -12                        |  |
|                            | 135               | 3.5              | 65                      | X           | -12                        |  |
|                            | 136               | 3.5              | 65                      | X           | +12                        |  |
|                            | 137               | 3.5              | 65                      | X           | 0                          |  |
|                            | 138               | 3.0              | 40                      | X           | 0                          |  |
|                            | 139               | 3.0              | 40                      |             | 0                          |  |
|                            | 140               | 2.5              | 27                      | X           | 0                          |  |
|                            | Equipment Fairing | 141              | 2.5                     | 27          |                            |  |
|                            |                   | 142              | 3.0                     | 35          |                            |  |
|                            |                   | 143              | 3.5                     | 40          |                            |  |
|                            |                   | 144              | 4.0                     | 95          |                            |  |
| 145                        |                   | 5.0              | 110                     |             |                            |  |

TABLE 1 (cont.)

## RUN SUMMARY

| CONFIGURATION                | Run Number | Nominal Mach No. | $P_{t\infty}$ (Psia) | Shadowgraph | Yaw Angle $\beta$ (deg) |
|------------------------------|------------|------------------|----------------------|-------------|-------------------------|
| Equipment Fairing<br>(cont.) | 146        | 4.5              | 115                  |             |                         |
|                              | 148        | 4.0              | 95                   |             |                         |
|                              | 149        | 3.5              | 40                   |             |                         |
|                              | 150        | 3.0              | 35                   |             |                         |
|                              | 151        | 2.5              | 27                   |             |                         |
|                              | 152        | 3.0              | 35                   |             |                         |
|                              | 153        | 5.0              | 110                  |             |                         |

TABLE 2

INSTRUMENTATION LOCATIONS FOR FORWARD FLOOR SKIN

THERMOCOUPLES

| T. C. No. | X      | Y       | T. C. No. | X      | Y      |
|-----------|--------|---------|-----------|--------|--------|
| 1         | 15.000 | +18.000 | 15        | 21.750 | +6.00  |
| 2         | 23.000 | +14.000 | 16        | 35.000 | +2.000 |
| 3         | 21.000 | ↓       | 17        | 33.000 | ↓      |
| 4         | 19.000 | ↓       | 18        | 31.000 | ↓      |
| 5         | 31.000 | + 8.000 | 19        | 29.000 | ↓      |
| 6         | 29.000 | ↓       | 20        | 27.000 | ↓      |
| 7         | 27.000 | ↓       | 21        | 37.000 | 0.000  |
| 8         | 25.000 | ↓       | 22        | 35.000 | ↓      |
| 9         | 23.000 | ↓       | 23        | 33.000 | ↓      |
| 10        | 21.250 | ↓       | 24        | 31.500 | ↓      |
| 11        | 29.000 | +6.000  | 25        | 33.000 | -2.000 |
| 12        | 27.000 | ↓       | 26        | 31.000 | ↓      |
| 13        | 25.000 | ↓       | 27        | 29.000 | ↓      |
| 14        | 23.000 | ↓       |           |        |        |

PRESSURE TAPS

| P. T. No. | X      | Y      | P. T. No. | X      | Y       |
|-----------|--------|--------|-----------|--------|---------|
| 1         | 33.000 | +6.000 | 4         | 27.000 | -2.000  |
| 2         | 31.000 | ↓      | 5         | 23.000 | ↓       |
| 3         | 35.000 | -2.000 | 6         | 15.000 | -18.000 |

TABLE 2 (cont.)

INSTRUMENTATION LOCATIONS FOR FORWARD FLOOR SKIN

NOMINAL DIMENSIONS

Runs 75-87

THERMOCOUPLES

| T. C. No. | X      | Y       | T. C. No. | X      | Y      |
|-----------|--------|---------|-----------|--------|--------|
| 1         | 15.000 | +18.000 | 15        | 21.750 | 6.000  |
| 2         | 21.000 | 16.500  | 16        | 35.000 | +2.000 |
| 3         | 21.000 | 14.000  | 17        | 33.000 |        |
| 4         | 19.000 | 14.000  | 18        | 31.000 | ↓      |
| 5         | 31.000 | 8.000   | 19        | 29.000 |        |
| 6         | 29.000 | ↓       | 20        | 27.500 |        |
| 7         | 27.000 |         | 21        | 37.000 | 0.000  |
| 8         | 25.000 | ↓       | 22        | 35.000 | ↓      |
|           |        |         | 23        | 33.000 | ↓      |
| 10        | 21.250 |         | 24        | 31.500 |        |
| 11        | 29.000 | + 6.000 | 25        | 33.000 | -2.000 |
| 12        | 27.000 | ↓       | 26        | 31.000 | ↓      |
| 13        | 25.000 | ↓       | 27        | 29.000 | ↓      |

PRESSURE TAPS

| P. T. No. | X      | Y      | P. T. No. | X      | Y       |
|-----------|--------|--------|-----------|--------|---------|
| 1         | 33.000 | 6.000  | 4         | 27.000 | -4.000  |
| 2         | 31.000 | ↓      | 5         | 25.500 | -6.000  |
| 3         | 35.000 | -2.000 | 6         | 15.000 | -18.000 |

TABLE 3

INSTRUMENTATION LOCATIONS FOR TURNTABLE SKIN

THERMOCOUPLES

| T. C. No. | X       | Y       | T. C. No. | X       | Y       | T. C. No. | X       | Y       |
|-----------|---------|---------|-----------|---------|---------|-----------|---------|---------|
| 1         | -11.000 | +16.000 | 19        | -5.000  | +12.000 | 37        | +3.000  | +10.000 |
| 2         | - 1.000 | ↓       | 20        | -3.000  | ↓       | 38        | +5.000  | ↓       |
| 3         | + 1.000 | ↓       | 21        | -1.000  | ↓       | 39        | +9.000  | ↓       |
| 4         | + 3.000 | ↓       | 22        | +1.000  | ↓       | 40        | +11.000 | ↓       |
| 5         | -12.500 | +14.000 | 23        | +3.000  | ↓       | 41        | +15.000 | ↓       |
| 6         | -11.000 | ↓       | 24        | +5.000  | ↓       | 42        | -17.000 | + 8.000 |
| 7         | - 9.000 | ↓       | 25        | +7.000  | ↓       | 43        | -15.000 | ↓       |
| 8         | - 7.000 | ↓       | 26        | +9.000  | ↓       | 44        | -11.000 | ↓       |
| 9         | - 5.000 | ↓       | 27        | +11.000 | ↓       | 45        | -9.000  | ↓       |
| 10        | - 1.000 | ↓       | 28        | +13.000 | +10.000 | 46        | -7.000  | ↓       |
| 11        | + 1.000 | ↓       | 29        | -17.000 | ↓       | 47        | -3.000  | ↓       |
| 12        | + 3.000 | ↓       | 30        | -15.000 | ↓       | 48        | -1.000  | ↓       |
| 13        | +11.000 | ↓       | 31        | -11.000 | ↓       | 49        | +1.000  | ↓       |
| 14        | -15.000 | +11.500 | 32        | - 7.000 | +11.000 | 50        | +3.000  | ↓       |
| 15        | -13.000 | +12.000 | 33        | - 5.000 | +10.000 | 51        | +5.000  | ↓       |
| 16        | -11.000 | ↓       | 34        | - 3.000 | ↓       | 52        | +7.000  | ↓       |
| 17        | - 9.000 | ↓       | 35        | - 1.000 | ↓       | 53        | +9.000  | ↓       |
| 18        | - 7.000 | ↓       | 36        | + 1.000 | ↓       | 54        | +13.000 | ↓       |

TABLE 3 (cont.)

INSTRUMENTATION LOCATIONS FOR TURNTABLE SKIN

THERMOCOUPLES

| T. C. No. | X       | Y      | T. C. No. | X       | Y       | T. C. No. | X       | Y       |
|-----------|---------|--------|-----------|---------|---------|-----------|---------|---------|
| 55        | -9.000  | +6.000 | 89        | -7.000  | +2.000  | 123       | -3.000  | -10.000 |
| 56        | -7.000  | ↓      | 90        | -5.000  | ↓       | 124       | -1.000  | ↓       |
| 57        | -5.000  | ↓      | 91        | -3.000  | ↓       | 125       | +1.000  | ↓       |
| 58        | -3.000  | ↓      | 92        | -1.000  | ↓       | 126       | -15.000 | -11.500 |
| 59        | -1.000  | ↓      | 93        | +1.000  | ↓       | 127       | -13.000 | -11.000 |
| 60        | +1.000  | ↓      | 94        | +11.000 | ↓       | 128       | -11.000 | -12.000 |
| 61        | +3.000  | ↓      | 95        | +13.000 | ↓       | 129       | -9.000  | ↓       |
| 62        | +5.000  | ↓      | 96        | +15.000 | ↓       | 130       | -7.000  | -11.000 |
| 63        | +7.000  | ↓      | 97        | +19.000 | ↓       | 131       | -7.000  | -12.000 |
| 64        | +9.000  | ↓      | 98        | -1.000  | +1.000  | 132       | -3.000  | ↓       |
| 65        | +13.000 | ↓      | 99        | -13.000 | ↓       | 133       | -1.000  | ↓       |
| 66        | +15.000 | ↓      | 100       | -11.000 | ↓       | 134       | +1.000  | ↓       |
| 67        | -11.000 | +4.000 | 101       | -9.000  | ↓       | 135       | +3.000  | ↓       |
| 68        | -9.000  | ↓      | 102       | -7.000  | ↓       | 136       | -12.500 | -14.000 |
| 69        | -7.000  | ↓      | 103       | -5.000  | ↓       | 137       | -11.000 | ↓       |
| 70        | -5.000  | ↓      | 104       | -3.000  | ↓       | 138       | -9.000  | ↓       |
| 71        | -3.000  | ↓      | 105       | -1.000  | ↓       | 139       | -7.000  | ↓       |
| 72        | -1.000  | ↓      | 106       | +11.000 | ↓       | 140       | -3.000  | ↓       |
| 73        | +1.000  | ↓      | 107       | +13.000 | ↓       | 141       | -1.000  | ↓       |
| 74        | +3.000  | ↓      | 108       | +15.000 | ↓       | 142       | +1.000  | ↓       |
| 75        | +5.000  | ↓      | 109       | +17.000 | ↓       | 143       | +5.000  | ↓       |
| 76        | +7.000  | +4.500 | 110       | +19.000 | ↓       | 144       | -12.500 | -15.500 |
| 77        | +9.000  | +4.000 | 111       | -17.000 | -8.000  | 145       | -11.000 | -16.000 |
| 78        | +11.000 | ↓      | 112       | -15.000 | ↓       | 146       | -9.000  | ↓       |
| 79        | +13.000 | +4.500 | 113       | -13.000 | ↓       | 147       | -7.000  | -15.250 |
| 80        | +17.000 | +4.000 | 114       | -11.000 | ↓       | 148       | -5.000  | -16.000 |
| 81        | -8.000  | +3.000 | 115       | -3.000  | ↓       | 149       | -1.000  | ↓       |
| 82        | -4.000  | ↓      | 116       | -1.000  | ↓       | 150       | +1.000  | ↓       |
| 83        | -2.000  | ↓      | 117       | -5.000  | ↓       | 151       | +3.000  | ↓       |
| 84        | +1.000  | ↓      | 118       | +13.000 | ↓       | 152       | +5.000  | ↓       |
| 85        | -13.000 | +2.000 | 119       | -17.000 | -10.000 |           |         |         |
| 86        | -11.000 | ↓      | 120       | -15.000 | ↓       |           |         |         |
| 87        | -9.000  | ↓      | 121       | -11.000 | ↓       |           |         |         |
| 88        | -8.000  | +1.500 | 122       | -9.000  | ↓       |           |         |         |

TABLE 3 (cont.)

## INSTRUMENTATION LOCATIONS FOR TURNTABLE SKIN

PRESSURE TAPS

| P. T. No. | X       | Y       | P. T. No. | X       | Y      | P. T. No. | X       | Y       |
|-----------|---------|---------|-----------|---------|--------|-----------|---------|---------|
| 1         | -3.000  | +14.000 | 28        | -3.000  | -4.000 | 55        | -5.000  | -8.000  |
| 2         | +3.000  | ↓       | 29        | -1.000  | ↓      | 56        | +1.000  | ↓       |
| 3         | -9.000  | +10.000 | 30        | +1.000  | ↓      | 57        | +3.000  | ↓       |
| 4         | -13.000 | + 8.000 | 31        | +3.000  | ↓      | 58        | +7.000  | ↓       |
| 5         | -5.000  | ↓       | 32        | +5.000  | ↓      | 59        | +9.000  | ↓       |
| 6         | -11.000 | ↓       | 33        | +7.000  | -4.500 | 60        | +11.000 | ↓       |
| 7         | +17.000 | ↓       | 34        | +9.000  | -4.000 | 61        | +17.000 | ↓       |
| 8         | -19.000 | +6.000  | 35        | +11.000 | ↓      | 62        | -5.000  | -10.000 |
| 9         | -1.000  | -1.000  | 36        | +13.000 | -4.500 | 63        | +3.000  | ↓       |
| 10        | -13.000 | -2.000  | 37        | +17.000 | -4.000 | 64        | +5.000  | ↓       |
| 11        | -11.000 | ↓       | 38        | -13.000 | -6.000 | 65        | +9.000  | ↓       |
| 12        | -9.000  | ↓       | 39        | -11.000 | ↓      | 66        | +11.000 | ↓       |
| 13        | -8.000  | -1.500  | 40        | -9.000  | ↓      | 67        | +15.000 | ↓       |
| 14        | -7.000  | -2.000  | 41        | -7.000  | ↓      | 68        | -5.000  | -12.000 |
| 15        | -5.000  | ↓       | 42        | -5.000  | ↓      | 69        | +5.000  | ↓       |
| 16        | -3.000  | ↓       | 43        | -3.000  | ↓      | 70        | +7.000  | -11.000 |
| 17        | -1.000  | ↓       | 44        | -1.000  | ↓      | 71        | +9.000  | -12.000 |
| 18        | 0       | ↓       | 45        | +1.000  | -5.750 | 72        | +11.000 | ↓       |
| 19        | +11.000 | ↓       | 46        | +3.000  | -6.000 | 73        | +13.000 | ↓       |
| 20        | +13.000 | ↓       | 47        | +5.000  | ↓      | 74        | +3.000  | -14.000 |
| 21        | +15.000 | ↓       | 48        | +7.000  | ↓      | 75        | +7.000  | ↓       |
| 22        | +19.000 | ↓       | 49        | +9.000  | ↓      | 76        | +9.000  | ↓       |
| 23        | -13.000 | -4.500  | 50        | +11.000 | ↓      | 77        | -3.000  | -16.000 |
| 24        | -11.000 | -4.000  | 51        | +13.000 | ↓      | 78        |         |         |
| 25        | -9.000  | ↓       | 52        | +15.000 | ↓      | 79        |         |         |
| 26        | -7.000  | -4.500  | 53        | -9.000  | -8.000 | 80        |         |         |
| 27        | -5.000  | -4.000  | 54        | -7.000  | ↓      | 81        |         |         |

TABLE 4

INSTRUMENTATION LOCATIONS FOR AFT FLOOR SKIN

THERMOCOUPLES

| T. C. No. | X      | Y       | T. C. No. | X      | Y      |
|-----------|--------|---------|-----------|--------|--------|
| 1         | 28.000 | +14.000 | 13        | 44.000 | +2.000 |
| 2         | 36.000 | ↓       | 14        | 24.000 | 0.000  |
| 3         | 44.000 |         | 15        | 26.000 |        |
| 4         | 21.000 | + 6.000 | 16        | 28.000 |        |
| 5         | 28.000 | ↓       | 17        | 30.000 |        |
| 6         | 36.000 |         | 18        | 32.000 |        |
| 7         | 44.000 | ↓       | 19        | 34.000 |        |
| 8         | 24.000 | + 2.000 | 20        | 36.000 |        |
| 9         | 28.000 | ↓       | 21        | 38.000 |        |
| 10        | 32.000 |         | 22        | 40.000 |        |
| 11        | 36.000 |         | 23        | 42.000 |        |
| 12        | 40.000 | ↓       | 24        | 44.000 | ↓      |

PRESSURE TAPS

| P. T. No. | X      | Y      | P. T. No. | X      | Y       |
|-----------|--------|--------|-----------|--------|---------|
| 1         | 24.000 | -2.000 | 8         | 28.000 | -6.000  |
| 2         | 28.000 | ↓      | 9         | 36.000 |         |
| 3         | 32.000 |        | 10        | 44.000 |         |
| 4         | 36.000 |        | 11        | 28.000 | -14.000 |
| 5         | 40.000 |        | 12        | 36.000 |         |
| 6         | 44.000 | ↓      | 13        | 44.000 | ↓       |
| 7         | 21.000 | -6.000 |           |        |         |

TABLE 4 (cont.)

INSTRUMENTATION LOCATIONS FOR AFT SKIN

NOMINAL DIMENSIONS

Runs 75-153

THERMOCOUPLES

| T. C. No. | X      | Y      | T. C. No. | X      | Y     |
|-----------|--------|--------|-----------|--------|-------|
| 1         | 28.000 | 14.000 | 13        | 44.000 | 2.000 |
| 2         | 36.000 | ↓      |           |        |       |
| 3         | 44.000 |        | 15        | 26.000 | 0.000 |
| 4         | 21.000 | 5.000  | 16        | 28.000 | ↓     |
| 5         | 28.000 | 6.000  | 17        | 30.000 |       |
| 6         | 36.000 | ↓      | 18        | 32.000 |       |
| 7         | 44.000 |        | 19        | 34.000 |       |
| 8         | 26.000 | 2.000  | 20        | 36.000 |       |
| 9         | 28.000 | ↓      | 21        | 38.000 |       |
| 10        | 32.000 |        | 22        | 40.000 |       |
| 11        | 36.000 |        | 23        | 42.000 |       |
| 12        | 40.000 | ↓      | 24        | 44.000 | ↓     |

PRESSURE TAPS

| P. T. No. | X      | Y      | P. T. No. | X      | Y       |
|-----------|--------|--------|-----------|--------|---------|
| 1         | 26.000 | -2.000 | 8         | 28.000 | -6.000  |
| 2         | 28.000 | ↓      | 9         | 36.000 |         |
| 3         | 32.000 |        | 10        | 44.000 | ↓       |
| 4         | 36.000 |        | 11        | 28.000 | -14.000 |
| 5         | 40.000 | ↓      | 12        | 36.000 | ↓       |
| 6         | 44.000 |        | 13        | 44.000 |         |
| 7         | 21.000 | -6.000 |           |        |         |









TABLE 6

DESCRIPTION OF SELECTED SYMBOLS ON  
 REDUCED BOUNDARY LAYER DATA  
 (Phase I)

| <u>SYMBOL</u>                       | <u>DESCRIPTION</u>   | <u>UNITS</u>  |
|-------------------------------------|--|---------------|
| RUN                                 | Refers to run number   | --            |
| DEL P                               | P Plenum minus P/N/21  | psi           |
| PREF                                | Scanivalve check pressure; tabulated data incorrect; subtract atmospheric pressure for correct reading | psia          |
| PW/PR                               | Local static wall pressure/rake pitot pressure   | dimensionless |
| MR                                  | Mach number computed using PW/PR   | dimensionless |
| MR/ME                               | $MR/M_{\infty}$  | dimensionless |
| UR/UE                               | $\frac{MR}{ME} \sqrt{\frac{TR}{TE}}$   | dimensionless |
| DELSTAR                             | $1 - \frac{TE}{TR} \cdot \frac{UR}{UE}$  | dimensionless |
| THETA                               | $\frac{TE}{TR} \cdot \frac{UR}{UE} \left(1 - \frac{UR}{UE}\right)$                                     | dimensionless |
| T/TE                                | TR/TE  | dimensionless |
| $\Delta(U/UE)$                      | Difference between a calculated and a measured velocity ratio  | dimensionless |
| ME                                  | Freestream Mach number   | dimensionless |
| PTE, PTE/PT,<br>FZT, FC,<br>FRTHETA | Data not applicable  | --            |
| N                                   | $1/n$<br>$N \approx (y/\delta)$  | --            |
| DELTA                               | A calculated boundary layer thickness  | in            |
| TE                                  | Static temperature at edge of boundary layer   | °R            |
| TR                                  | Static temperature at an orifice on the rake   | °R            |
| UR                                  | Velocity at an orifice on the rake   | ft/sec        |
| UE                                  | Velocity at the edge of the boundary layer   | ft/sec        |
| DATE                                | Date of data reduction   | --            |

TABLE 6 (cont.)

DESCRIPTION OF SELECTED SYMBOLS ON  
 REDUCED HEAT TRANSFER AND PRESSURE DATA  
 (Phases II and III)

FREESTREAM PARAMETERS

| <u>SYMBOL</u>        | <u>DESCRIPTION</u>                           | <u>UNITS</u>          |
|----------------------|--|-----------------------|
| MACH                 | Mach No. from tunnel calibration             | dimensionless         |
| PT                   | Freestream total pressure                    | psia                  |
| PS(PSIA)             | Freestream static pressure                   | psia                  |
| Q(PST)               | Freestream dynamic pressure                  | psia                  |
| TT(R)                | Freestream total temperature                 | $^{\circ}\text{R}$    |
| RE/IN/M              | Unit Reynolds No. $\times 10^{-6}$           | $\text{in}^{-1}$      |
| DP1, DP2<br>DP3, DP4 | Differential pressures across floorplate     | psid                  |
| PSW                  | Tunnel sidewall static pressure              | psia                  |
| PTJ                  | Ejector total pressure                       | psia                  |
| RHOT                 | Freestream total density                     | slugs/ft <sup>3</sup> |
| RINF                 | Freestream static density                    | slugs/ft <sup>3</sup> |
| UINF                 | Freestream velocity                          | fps                   |
| TINF                 | Freestream static temperature                | $^{\circ}\text{R}$    |
| PN21                 | Static pressure at nozzle exit               | psia                  |
| MSW                  | Freestream Mach No. computed from PT and PSW | dimensionless         |
| DATE                 | Date of data reduction                       | ---                   |

HEAT TRANSFER DATA

|       |   |  |
|-------|---|--|
| HO    | Average heat transfer coefficient from flat plate reference runs                                    | Btu/ft <sup>2</sup> -sec <sup>o</sup> -F |
| ID*   | Model thermocouple identifier   | --                                       |
| T(R)  | Model thermocouple temperature  | $^{\circ}\text{R}$                       |
| SLOPE | $dT/dt$ calculated at the midpoint of a quadratic determined from 11 or 21 consecutive measurements | $^{\circ}\text{F}/\text{sec}$            |
| Q     | Local heating rate  | Btu/ft <sup>2</sup> -sec                 |

(TABLE 6 (cont.))

HEAT TRANSFER DATA

| <u>SYMBOL</u>           | <u>DESCRIPTION</u>  | <u>UNIT</u>                 |
|-------------------------|---|-----------------------------|
| H                       | Local heat transfer coefficient calculated from model thermocouple data | Btu/ft <sup>2</sup> -sec°-F |
| PREF                    | Reference pressure read on a transducer removed from scanivalves        | psia                        |
| PR1, PR2,<br>. . . PR20 | PR1/PREF, PR2/PREF, etc.  | dimensionless               |
| ID*                     | Model pressure tap identifier   | --                          |
| P(PSIA)                 | Model pressure  | psia                        |
| P/PS                    | Model pressure to freestream static pressure ratio                      | dimensionless               |
| CP                      | Coefficient of pressure   | dimensionless               |

\* Model thermocouple and pressure tap ID number prefixes are defined as follows:

|    |                          |
|----|--------------------------|
| FS | Forward skin             |
| TS | Turntable skin           |
| AS | Aft skin                 |
| T  | Thruster and VVSA models |
| A  | Equipment fairing model  |



Figure 1. Turntable Base and Floor Skin Cooling System.

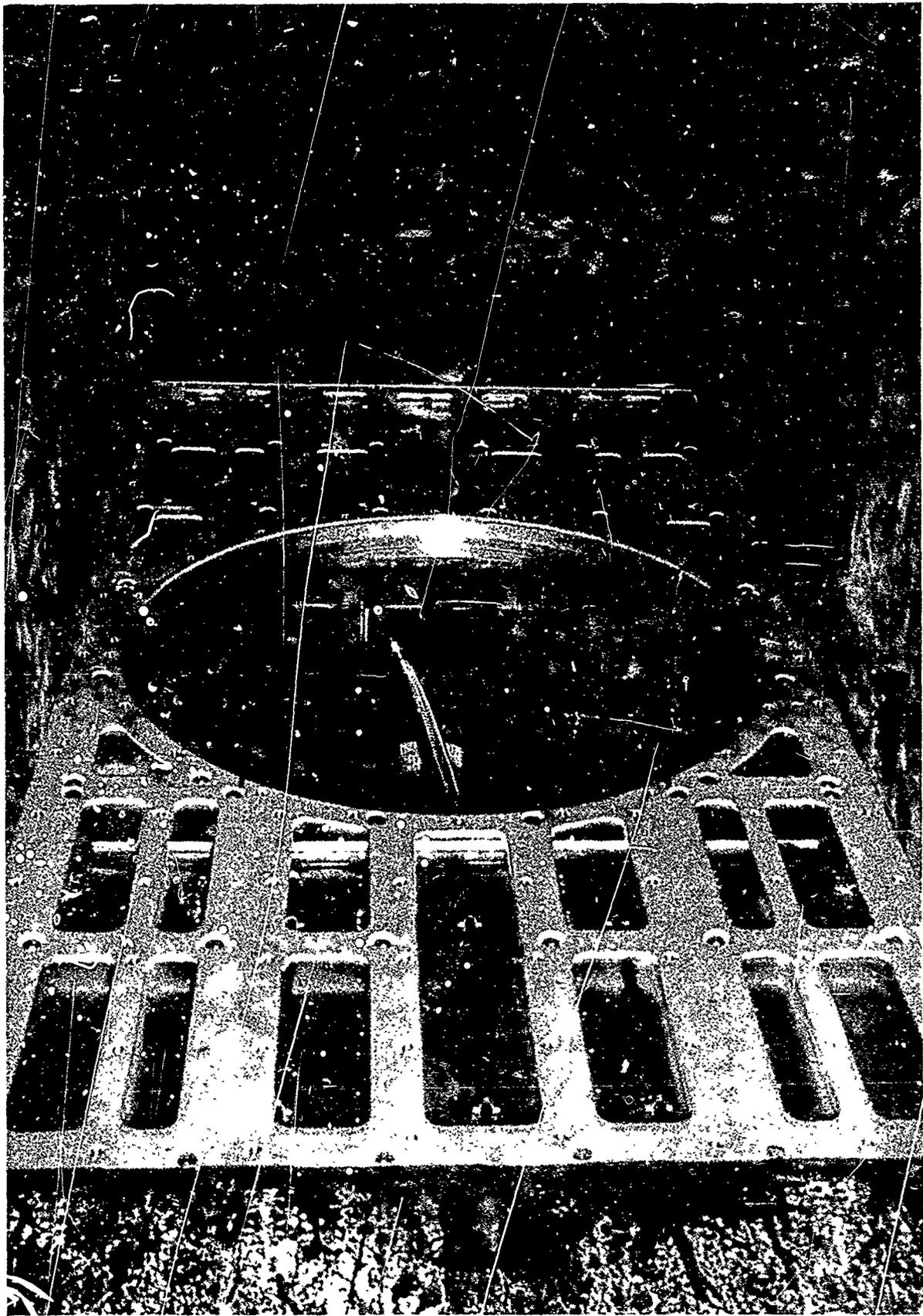


Figure 2. Floor Skin Insulation

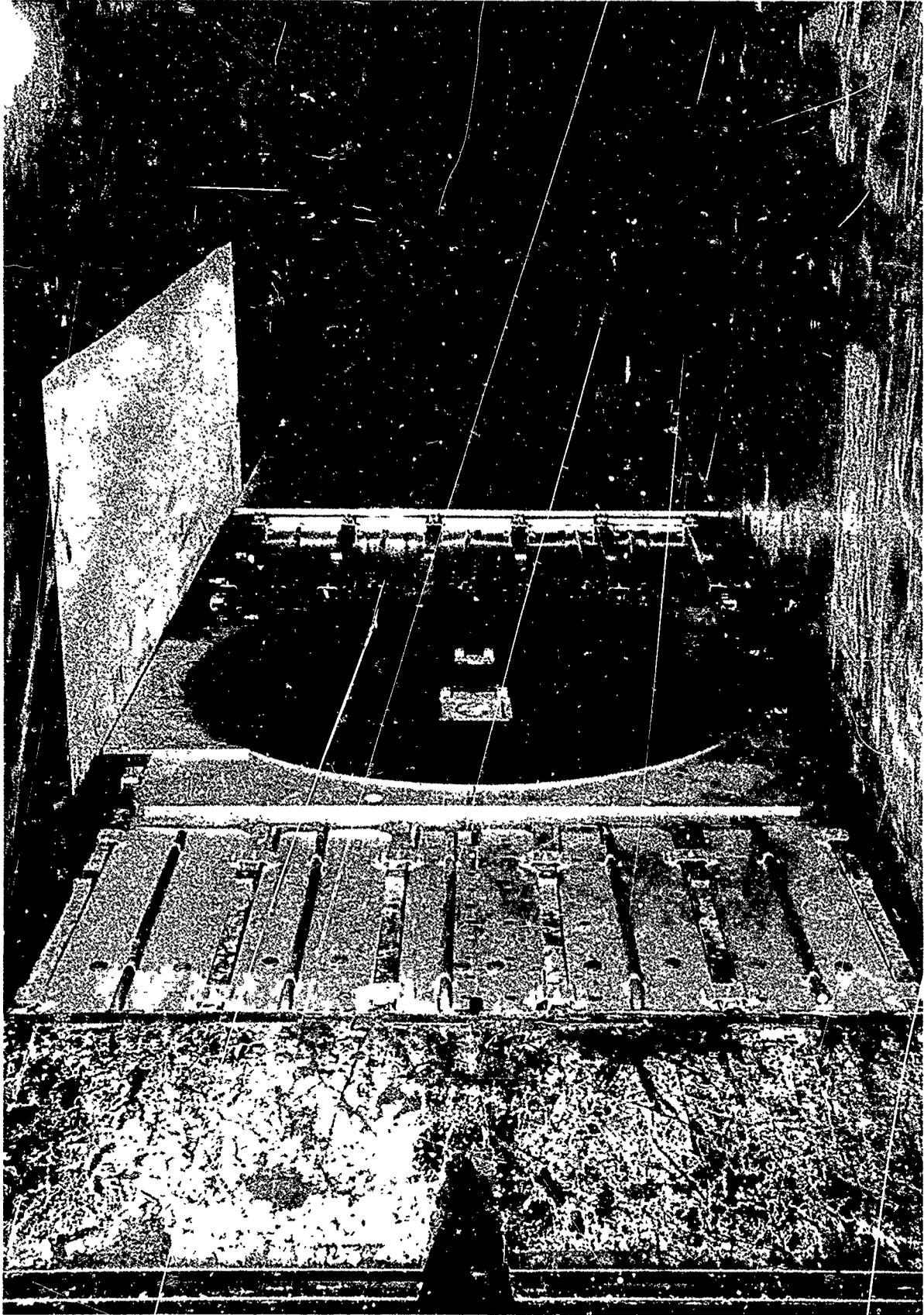


Figure 3 Turntable Installation



Figure 4. Complete Floor Skin Installation

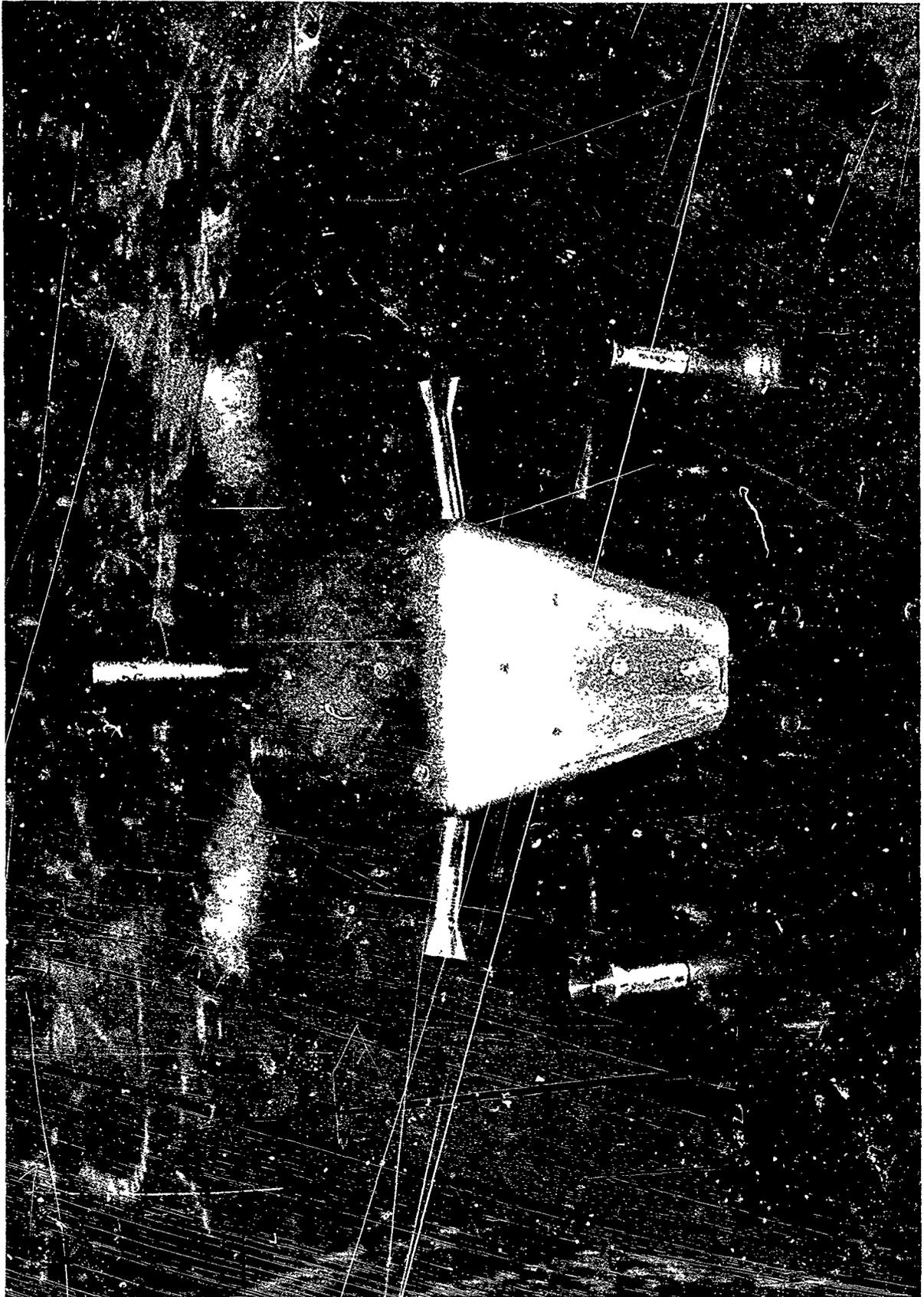


Figure 5. Thruster Module Assembly Model

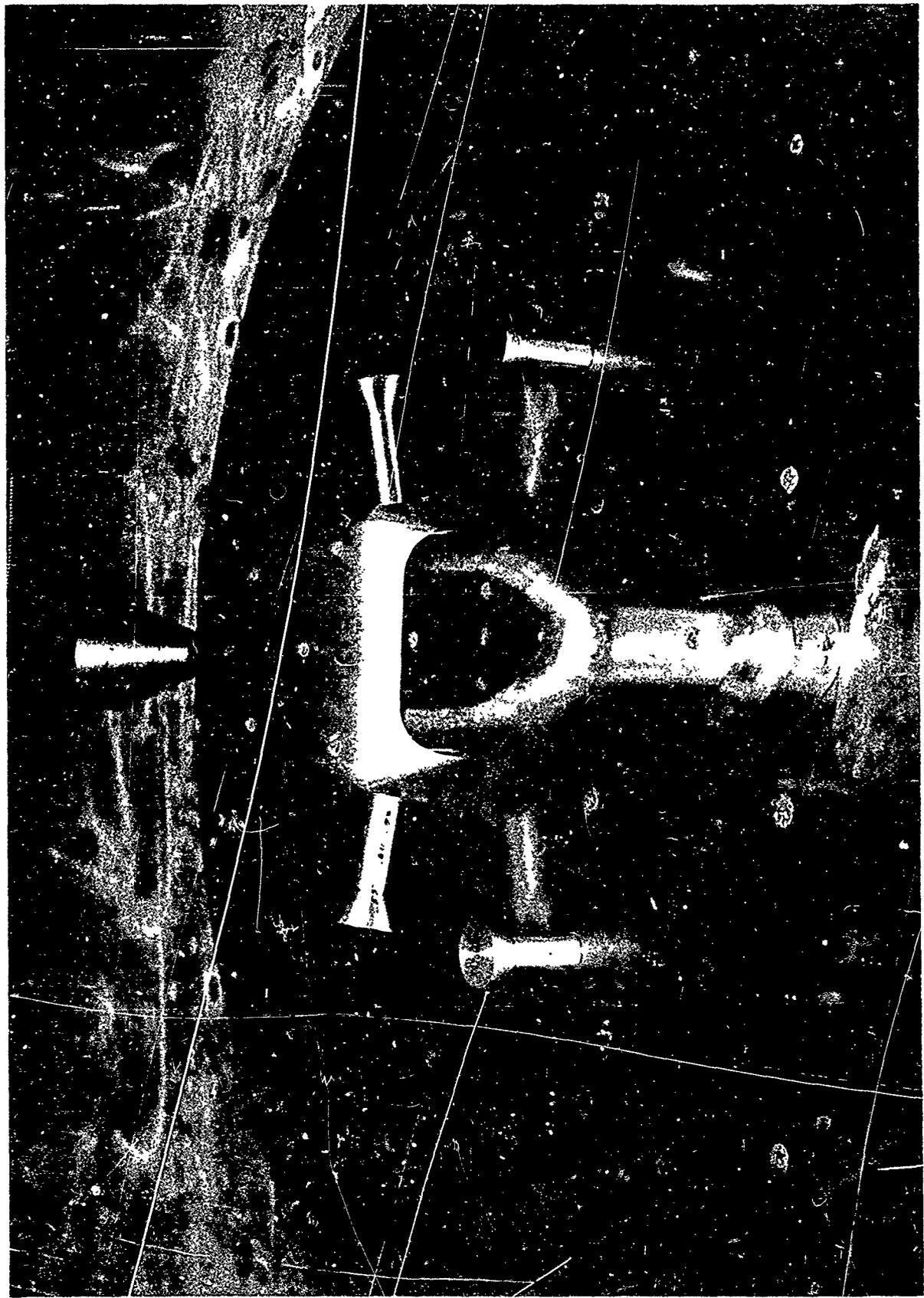
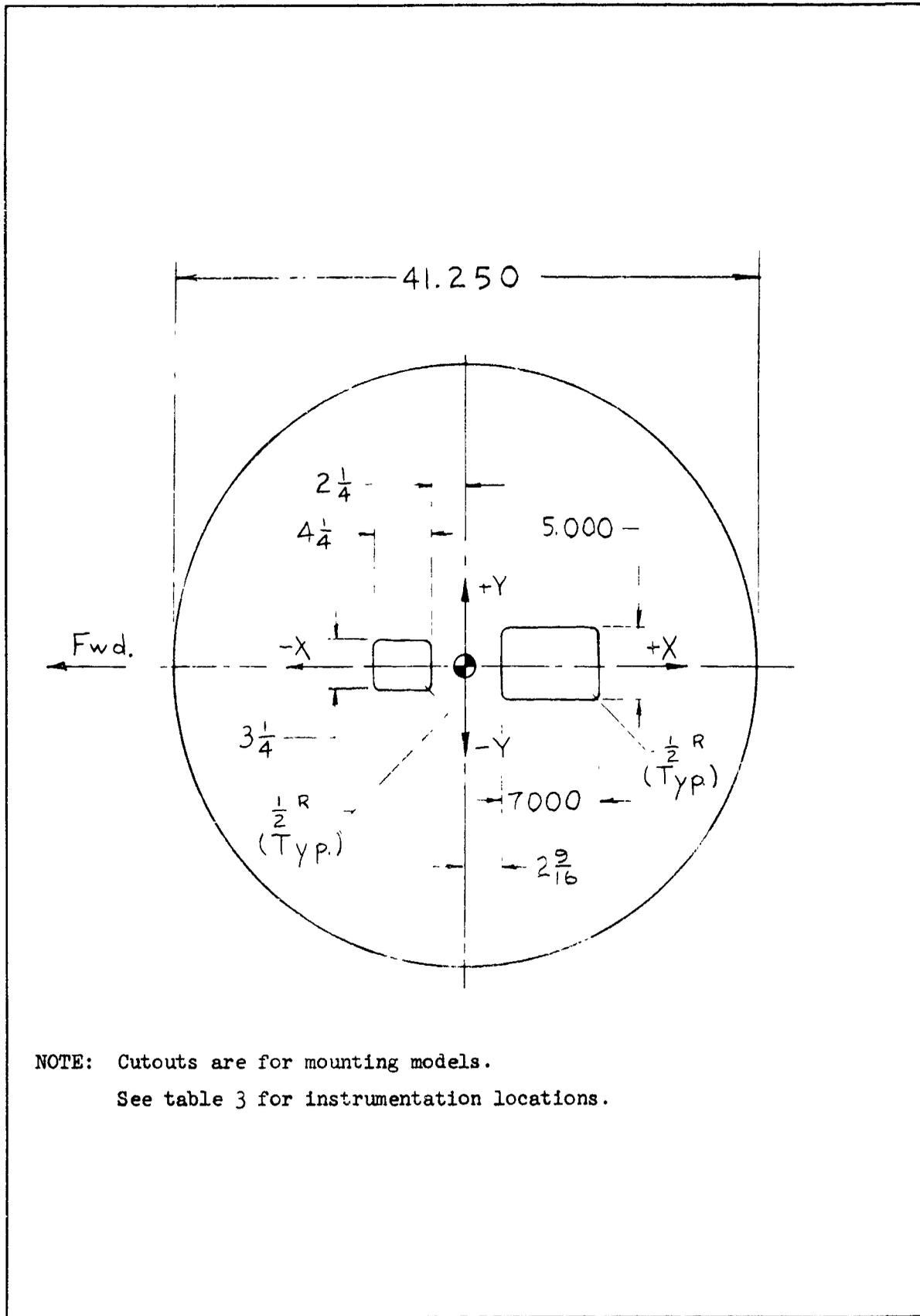


Figure 6. Thrustor Module Assembly and VVSA Fairing Models

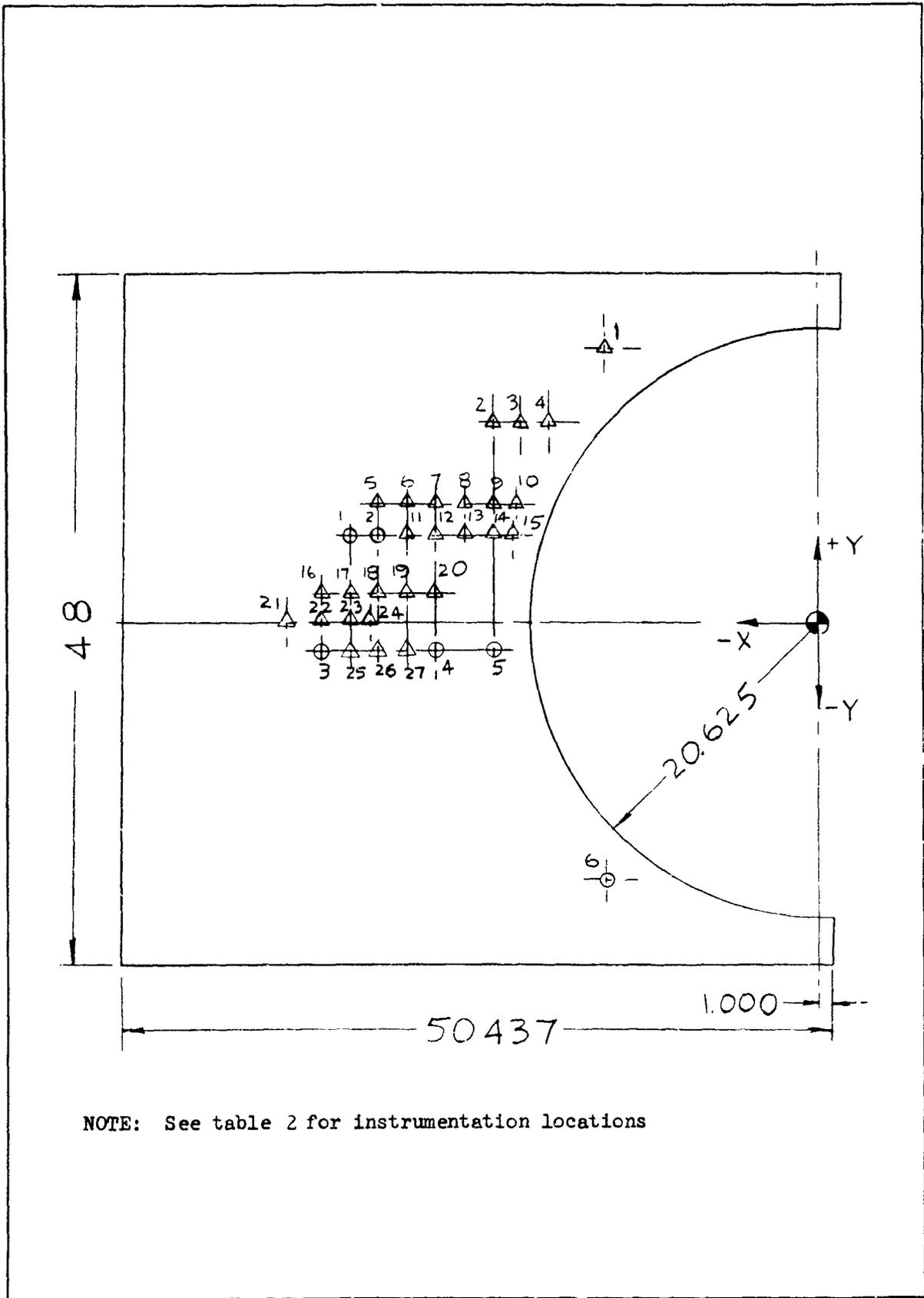


Figure 7. Equipment Fairing Model



NOTE: Cutouts are for mounting models.  
 See table 3 for instrumentation locations.

Figure 8. Turntable Skin Dimensions



NOTE: See table 2 for instrumentation locations

Figure 9. Forward Floor Skin Dimensions

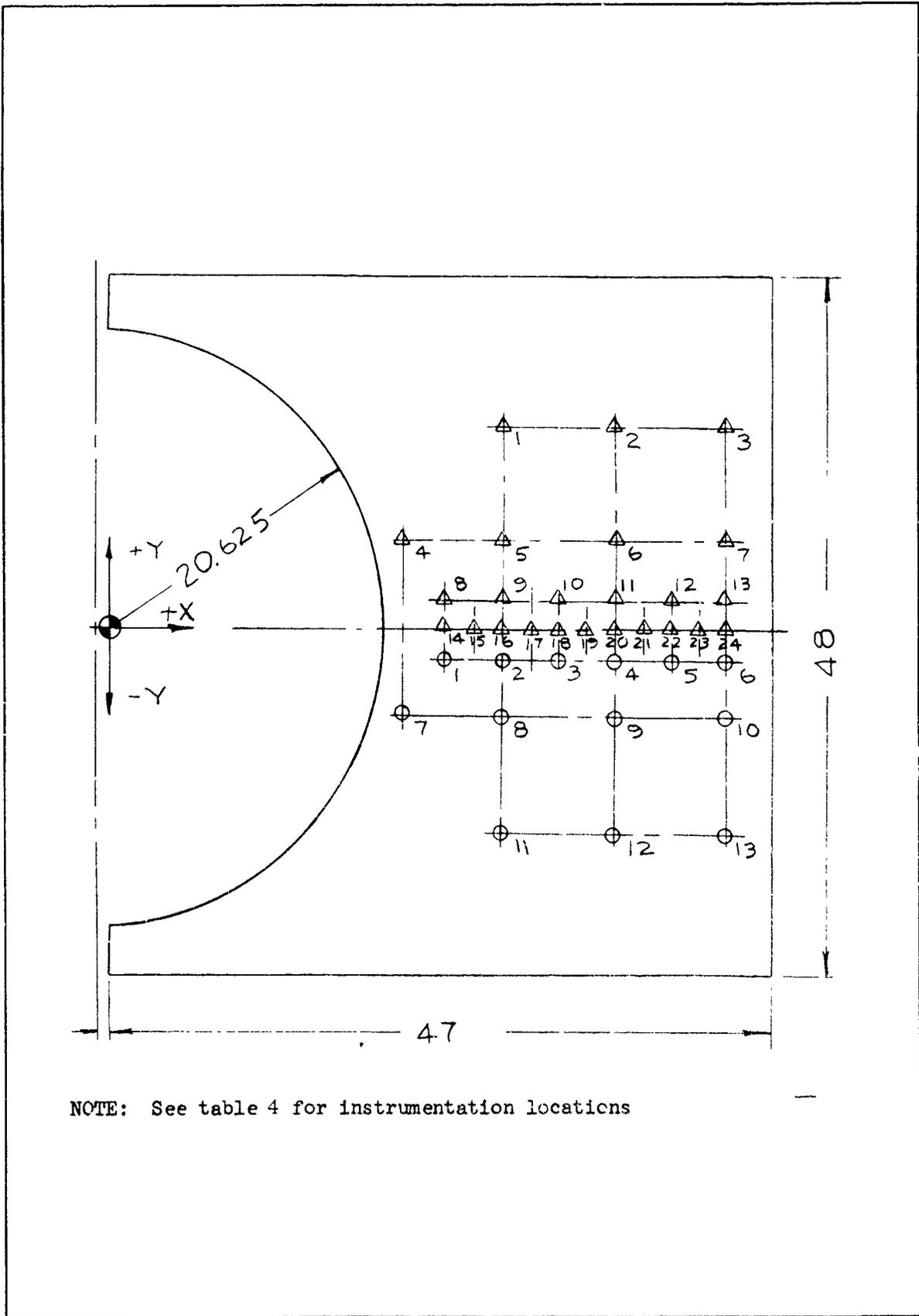


Figure 10. Aft Floor Skin Dimensions

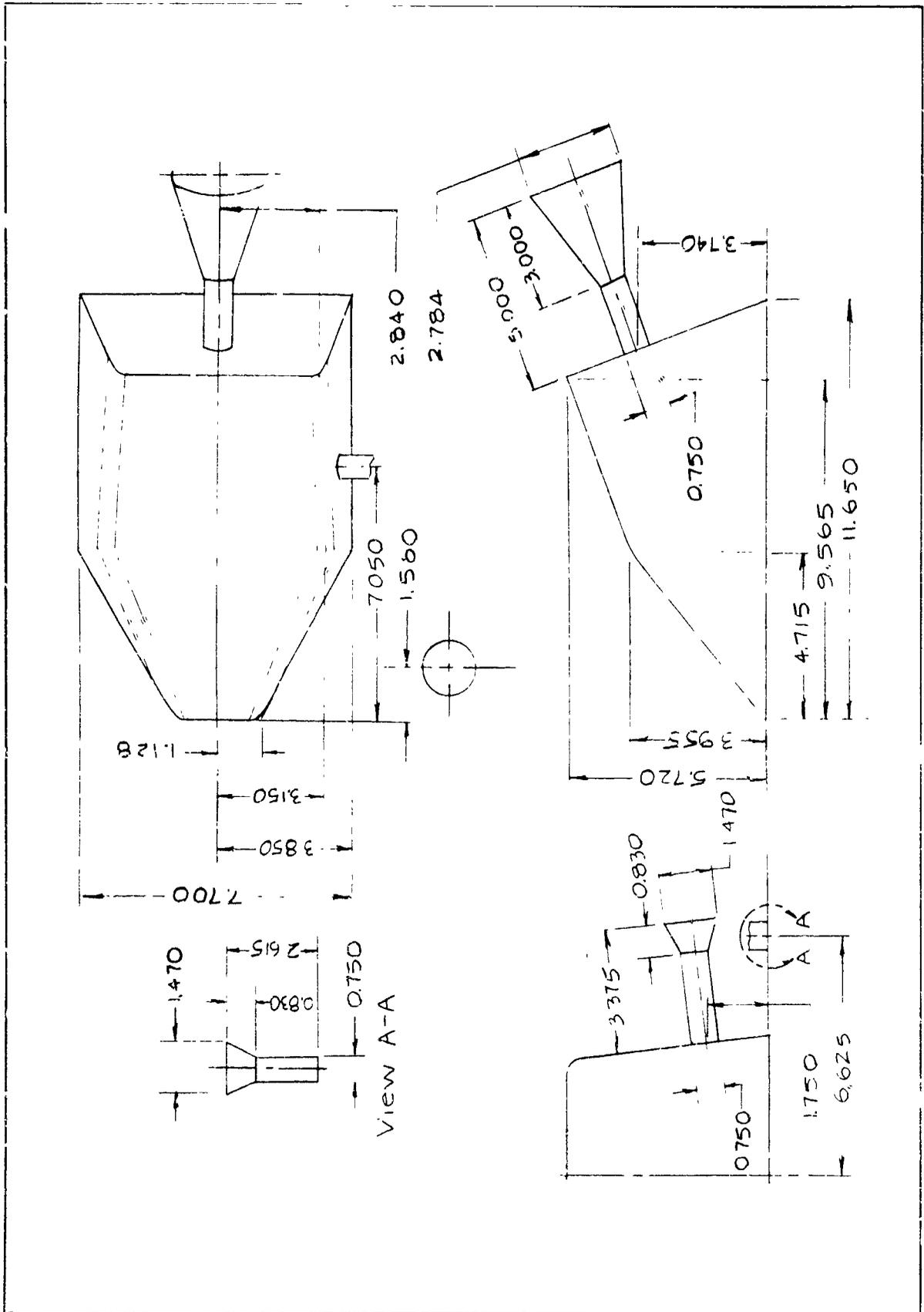


Figure 11. Thrustor Module Assembly Model Dimensions

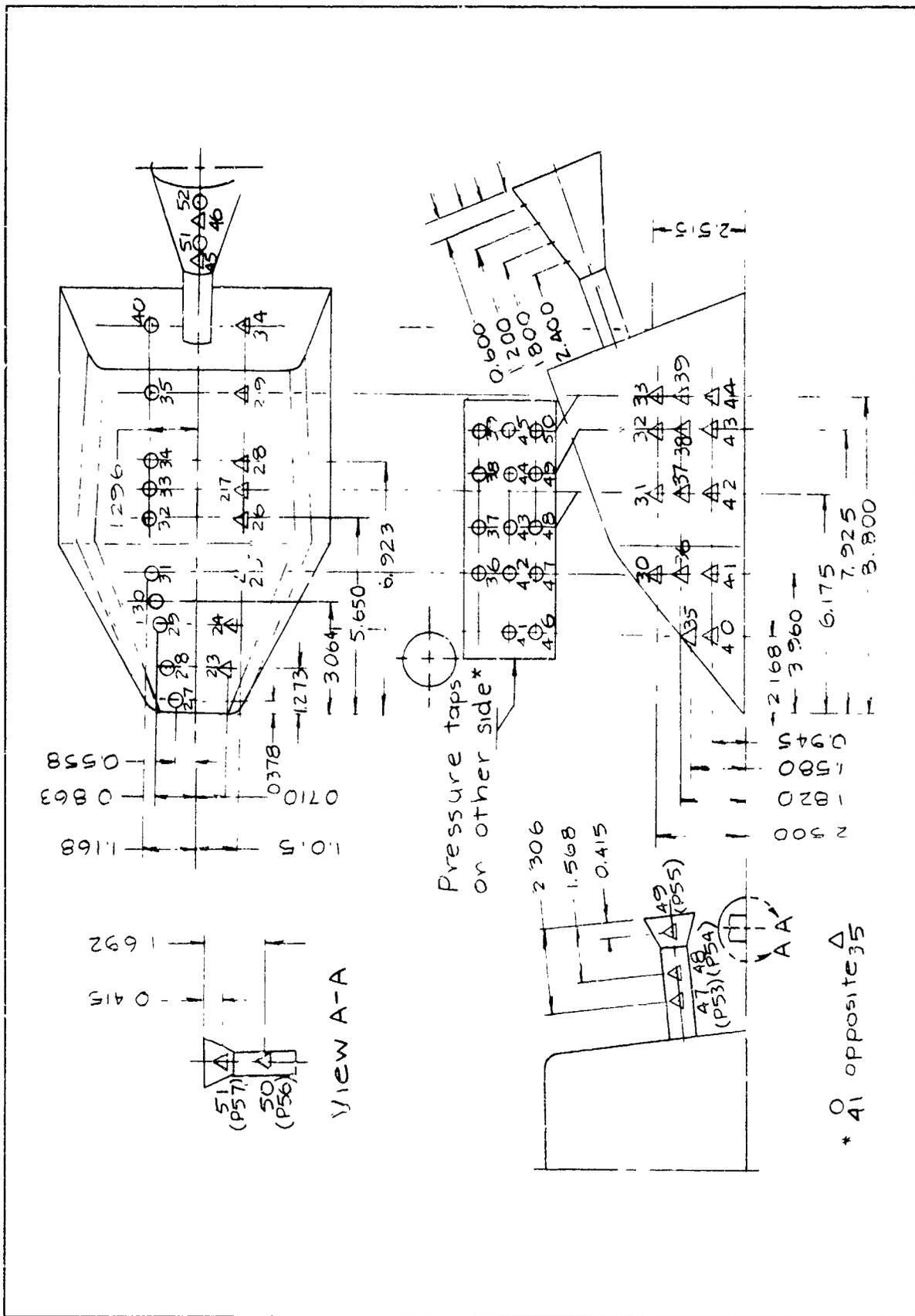


Figure 12. Thruster Module Assembly Model Instrumentation Locations

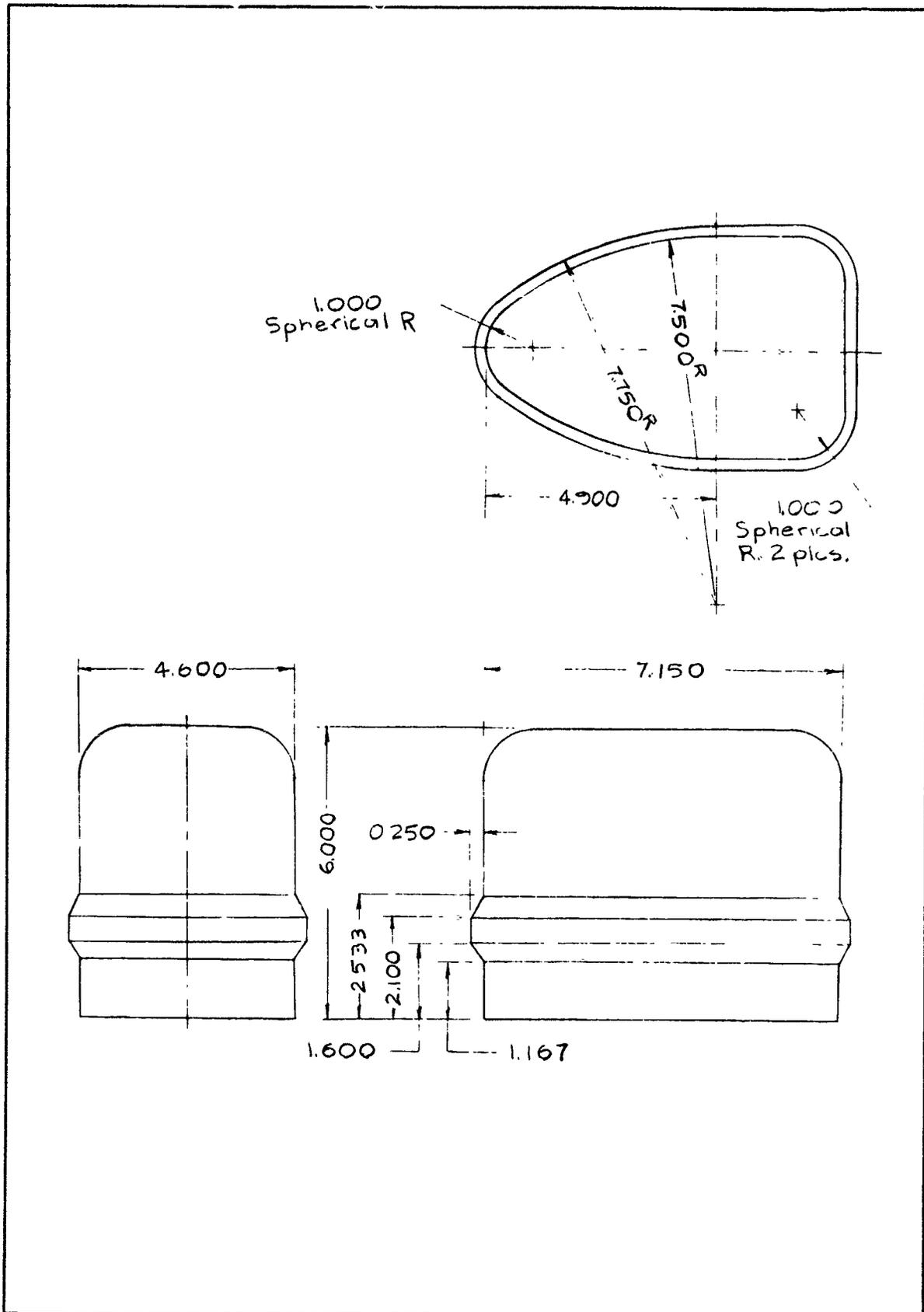


Figure 13. VVSA Fairing Model Dimensions



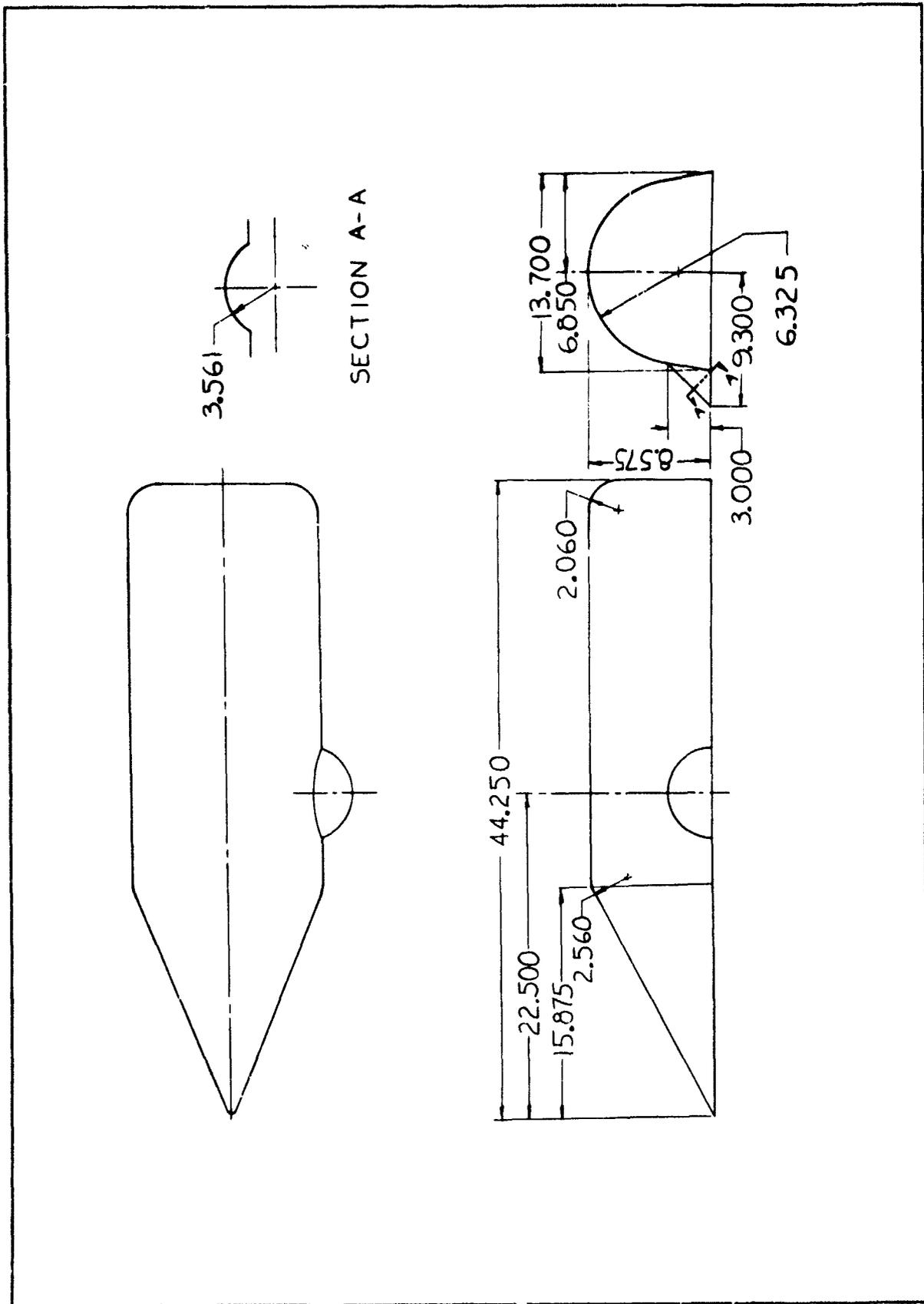


Figure 15. Equipment Fairing Model Dimensions

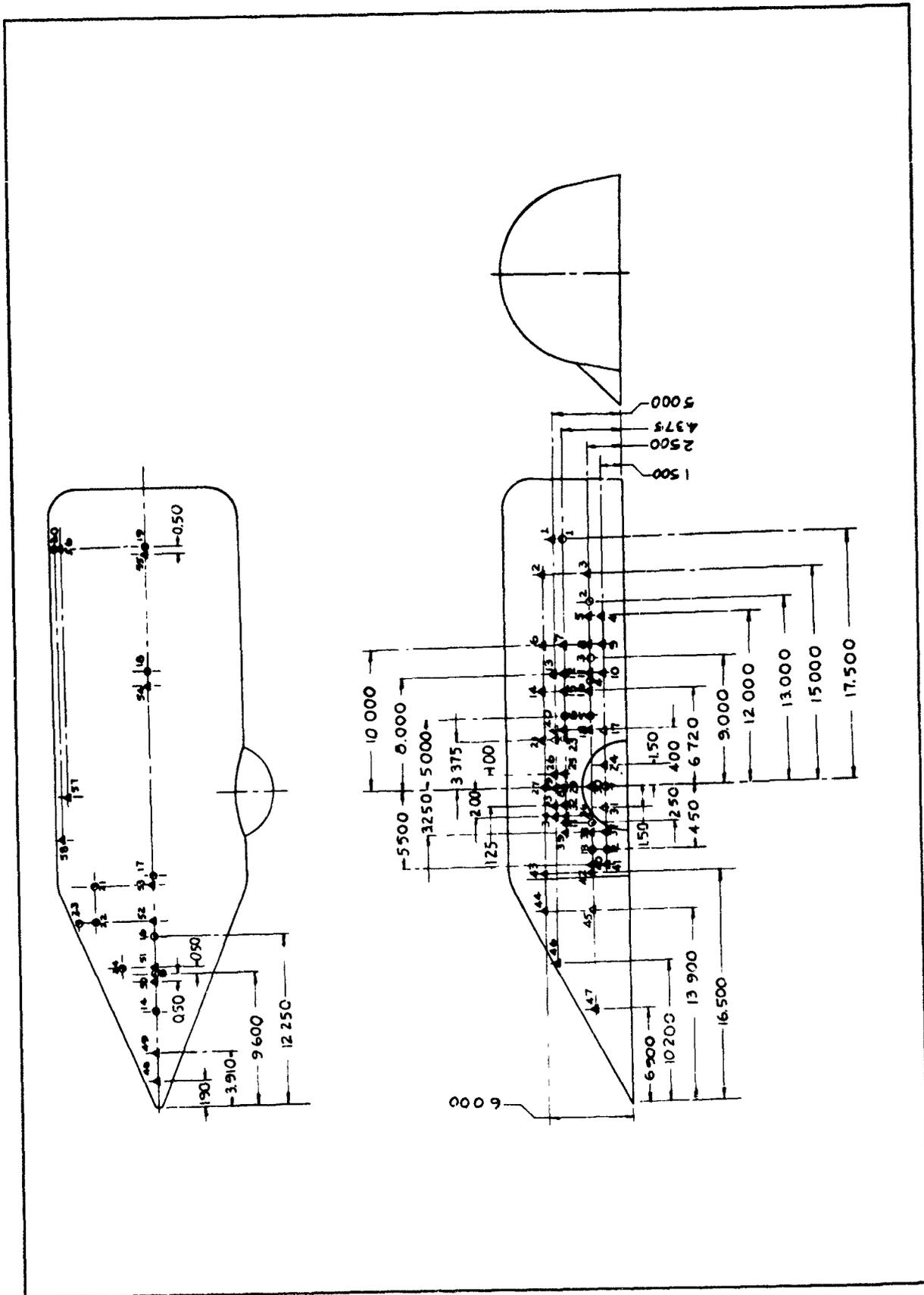


Figure 16. Equipment Fairing Model Instrumentation Locations

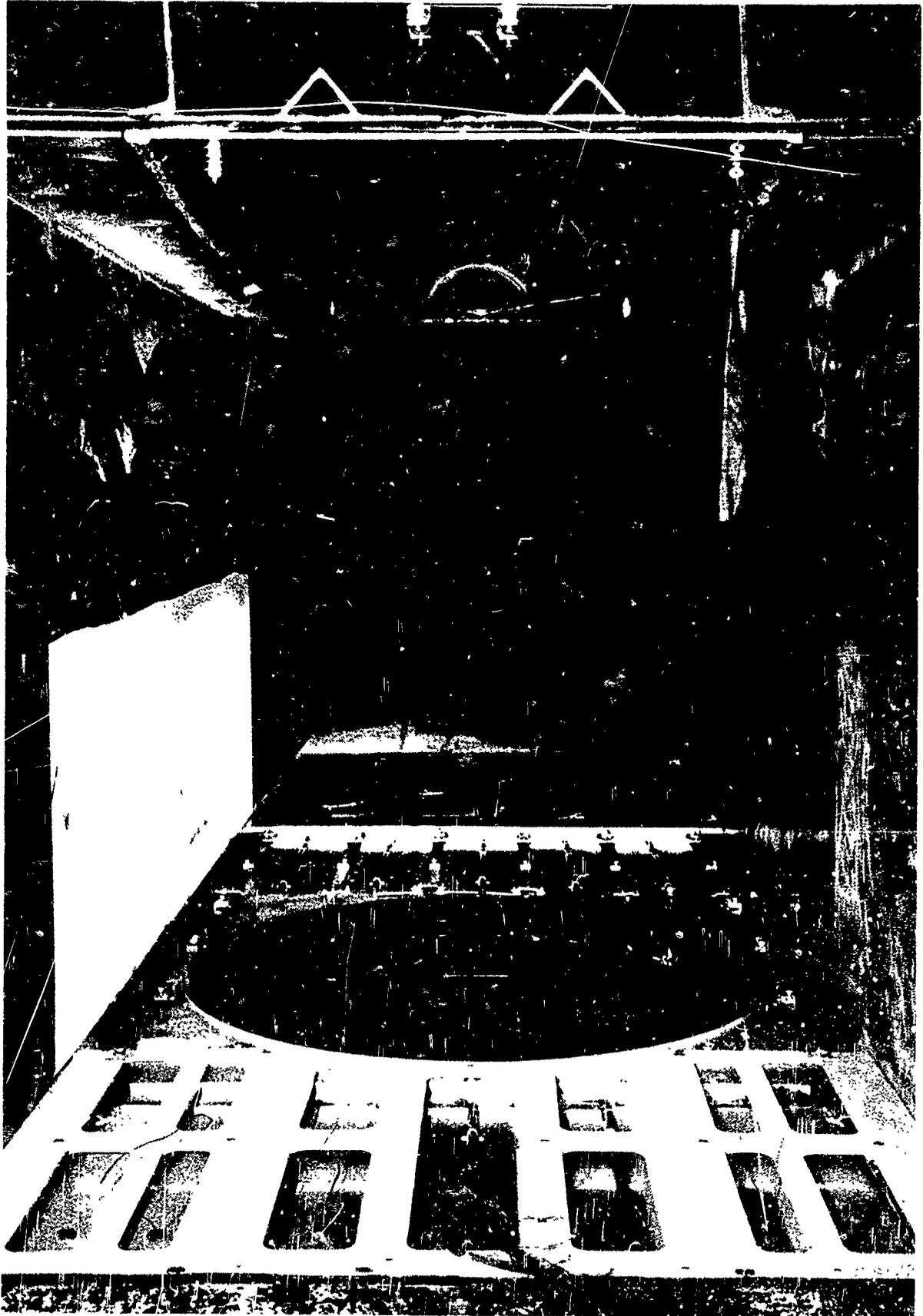


Figure 17. Tunnel Floor After Skin Failure



Figure 18. Failed Skin

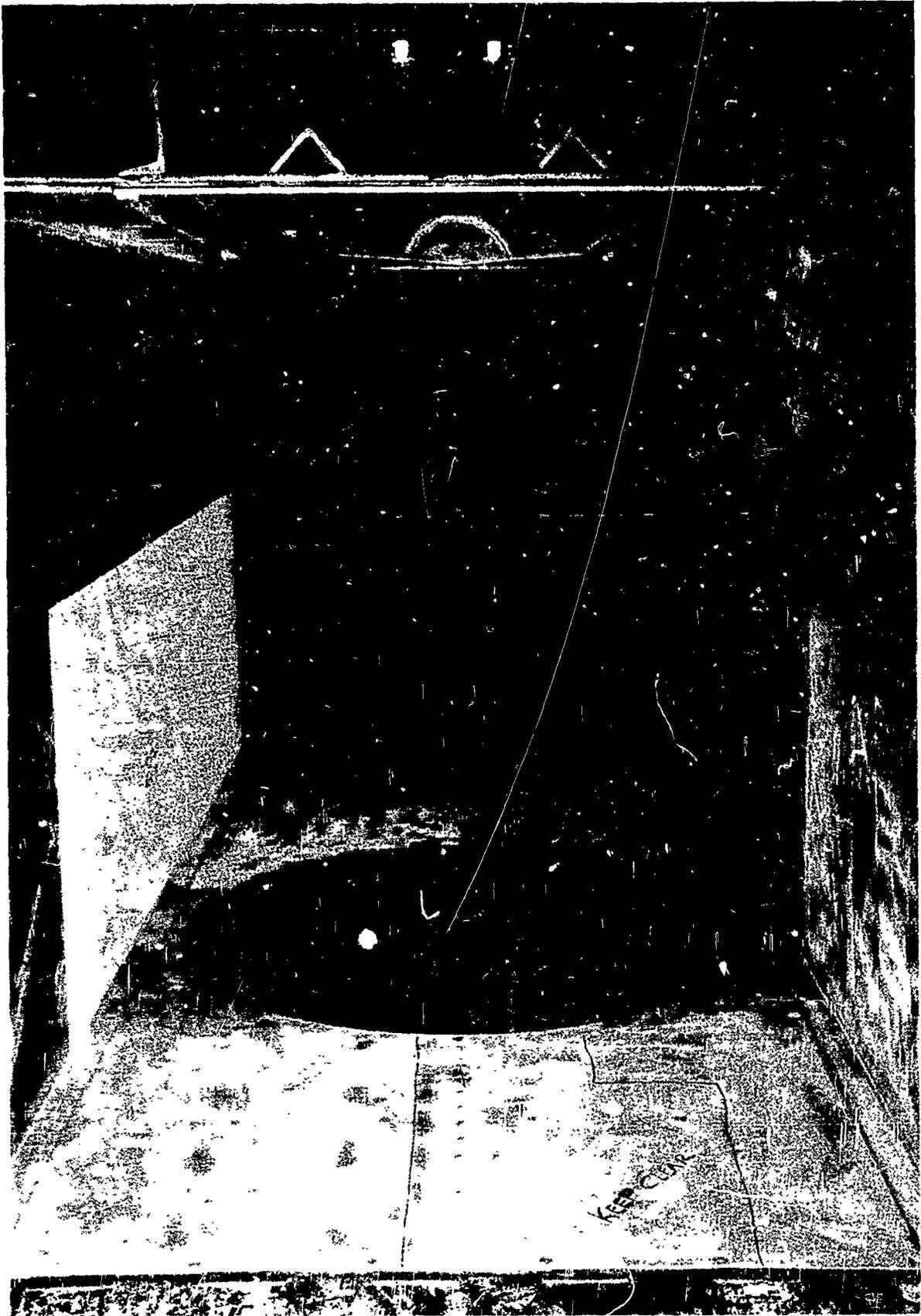


Figure 19 Aluminum Plate Replacement After Failure

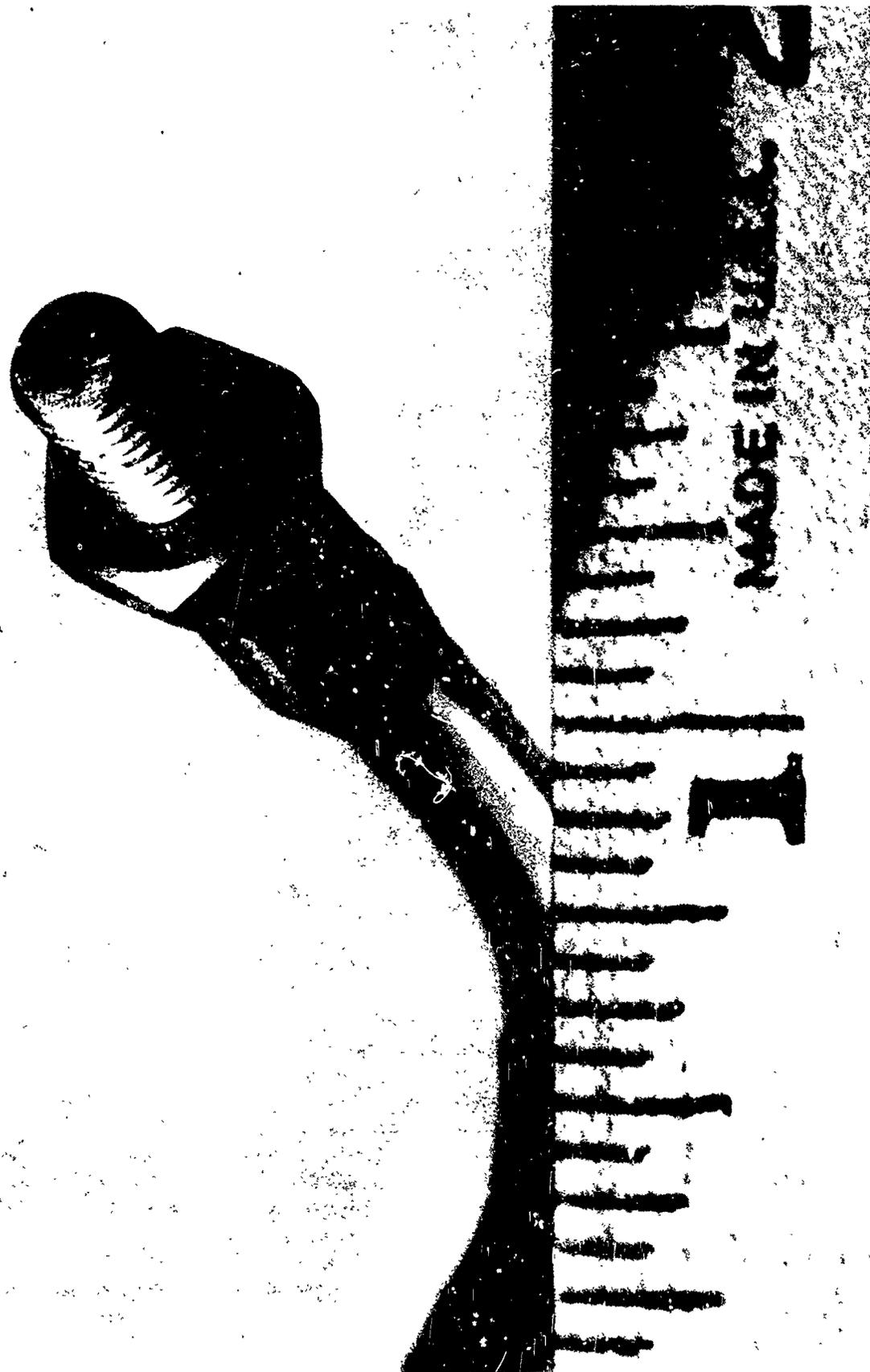


Figure 20. Closeup of NANMAC Gage

## 5.0 REFERENCES

1. Haldane, G. F., "Fluid Dynamics Test Pretest Report - MOL Protuberance Heating," DAC 58780, dated 26 February 1966
2. SAFSL Exhibit 21010, "Fluid Dynamics Test Requirements Study and Test Plan," dated 1 September 1966, revised May 3, 1967