FOREWORD

This work is the responsibility of the Requirements and Evaluation Branch, Biotechnology Division, Biomedical Laboratory of the 6570th Aerospace Medical Research Laboratories. Capt William F. Mickelson was the project director for the Requirements and Evaluation Branch. The work was performed in support of project 6373, "Equipment for Life Support in Aerospace," and task 637305, "Life Support Accommodation, Integration and Analysis." This work began in October 1960 and is continuing.

The Life Support Systems Evaluator was designed by the 6570th Aerospace Medical Research Laboratories and fabricated by the Fabrication and Modification Division of the Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio.

The author acknowledges the invaluable assistance of those personnel who had an active part in the design, fabrication, and operation of the Life Support Systems Evaluator.

The evaluator instrumentation is described in detail in a companion report entitled, "Life Support Systems Evaluator Instrumentation," AMRL Technical Documentary Report 62-90, by E. E. Beson and M. P. Dickey of Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, under contract AF 33(616)8349 with 6570th Aerospace Medical Research Laboratories.

ABSTRACT

The construction, plumbing, capability, and operation of the Life Support Systems Evaluator are described. The evaluator is a research tool for determining technical feasibility of techniques and principles involved in operation and design of life support equipment by integrated evaluation studies. The evaluator is operational and has provided very good results.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

Jos M Quashnock

JOS. M. QUASHNOCK
Colonel, USAF, MC
Chief, Biomedical Laboratory

FIGURE 1

LIFE SUPPORT SYSTEMS EVALUATOR

LIFE SUPPORT SYSTEMS EVALUATOR

by

William F. Mickelson, Capt, USAF

INTRODUCTION

The Life Support Systems Evaluator (fig. 1) serves as a research tool for determining the technical feasibility of techniques and principles involved in operation and design of life support equipment through integrated evaluation studies. These studies are planned to develop optimal life support systems, including respiratory equipment, nutritional support, and waste management. The broad spectrum of work involved in biologistics and bioastronautics can also be studied.

Viewed from the outside, the evaluator is cylindrical with a conical forward section. The inside of the evaluator is divided into two sections. The aft cylindrical section is 19.1 feet long and has a 7.5-foot inside diameter; the conical nose section has a 7.5-foot inside diameter tapering to 3 feet, and is 8.5 feet long. These two sections are physically connected, but can be operated independent of one another. A second wall, 4 inches from the inner wall, encloses the two primary sections.

This completely double-walled facility provides a low pressure environment immediately surrounding the two inner sections. This configuration insures that any leakage of the inner chambers will be outboard, preventing contamination or dilution of the interior atmosphere by the ambient atmosphere.

CONSTRUCTION

The evaluator is fabricated from 6061ST-6 weldable aluminum alloy. All of the walls are stressed to withstand a minimum of 45 psia pressure differential across the walls from either direction. The inner wall is 1/4-inch thick and the outer wall is 5/16-inch thick. For additional support, the inner and outer walls are secured on a series of H-beams strategically located longitudinally and circumferentially. One-inch diameter bleed holes are spaced approximately 12 inches apart thoughout all bulkheads, and horizontal supports are provided. The bleed holes were omitted on the middle door frame and as indicated on the drawings in the appendix. Bleed holes are located in the door frame between doors 1 and 2, and 5 and 6.

The door design also adheres to the double-wall feature. When the doors are closed, the low-pressure area between the doors provides a seal.

Figure 2 illustrates portions of the evaluator.

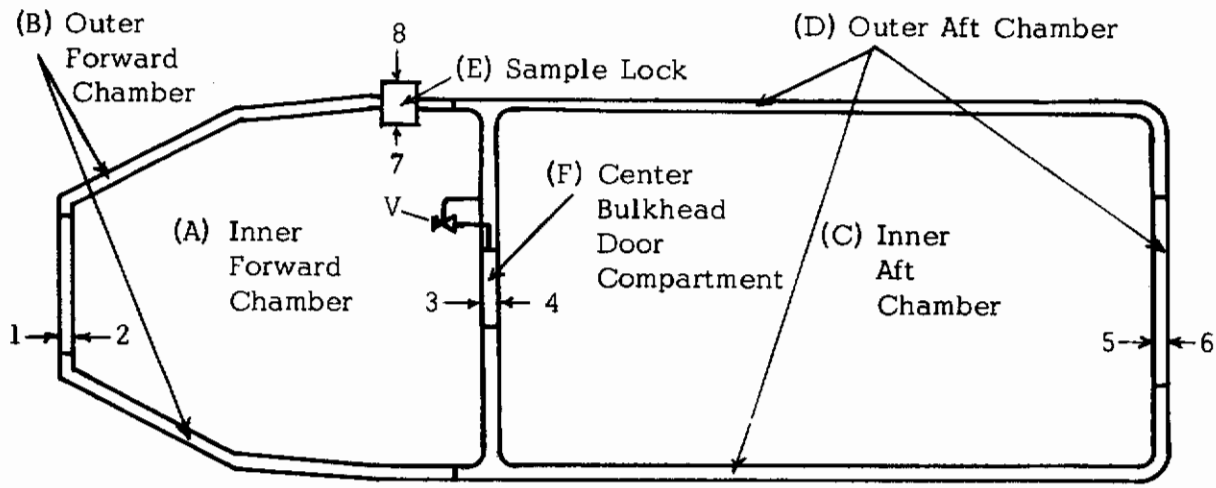
DOORS

(See fig. 2)

Doors 1 and 2 are 35-3/4 inches inside diameter with a double hinge arrangement with suspension at the center of the doors. The locking mechanism is a center screw arrangement allowing the doors to be unlocked and opened from either side. Door 1 swings to the outside and door 2 swings into the inner forward chamber.

Doors 3 and 4 are 20 inches wide and 40 inches long, inside measurement, and are installed on a slide mechanism so that minimum room is required when the doors are open. The door is locked by four lugs, one at each corner of the door. When the pressure between the doors is reduced, the door lugs swing to the open position. These doors can be opened from either side.

Doors 5 and 6 are 33 inches wide and 61 inches long. They are installed on a double hinge mechanism to permit the doors to seat squarely on the seal without damaging the tongue and groove construction. Door 5 swings into the inner aft chamber; door 6 swings to the outside ambient room. These doors are closed by four lugs, which swing free to the open position when a low pressure is applied between the doors. Each door lug shaft and the center screw have a double O-ring to prevent leakage between chambers. All the doors have a latex seal poured around the perimeter of each door.



(R) Room (ambient, sea level)

(Doors: 1-8)

VOLUMES

A	-	Inner Forward Chamber	= 292 cu ft
B + E	-	Outer Forward Chamber	= 62 cu ft
C	-	Inner Aft Chamber	= 837 cu ft
D + F	-	Outer Aft Chamber	= 204 cu ft
A+C+F	-	Inner compartments with doors 3 and 4 open	= 1131 cu ft

VOLUME RATIOS

$$\frac{A}{B + E} = 4.70 \qquad \frac{A+C+F}{B + E} = 18.24$$

$$\frac{C}{D + F} = 4.10 \qquad \frac{A+C+F}{D} = 5.60$$

$$\frac{C}{A} = 2.86$$

Figure 2. Schematic of Evaluator Components and Interior Volumes

PLUMBING

A schematic (fig. 3) of the plumbing identifies the line valves, dump valves, bypass valves, and solenoid valves and their locations. The schematic also shows the location of the four adapter sections. The adapters are sections of pipe approximately 19 inches long, through which all of the electrical leads, plumbing leads, and sample lines enter the main plumbing lines and, through them, the inner chambers. This method was selected to reduce the number of penetrations through the double wall.

The line and dump valves are Walworth, manually operated, plug type. The solenoid valves were made by Meehanits.

Valve "V" on figure 2 isolates area F from area D so doors 3 and 4 can remain open. When doors 3 and 4 are closed and a seal is desired, the valve is opened and area F is integrated with area D.

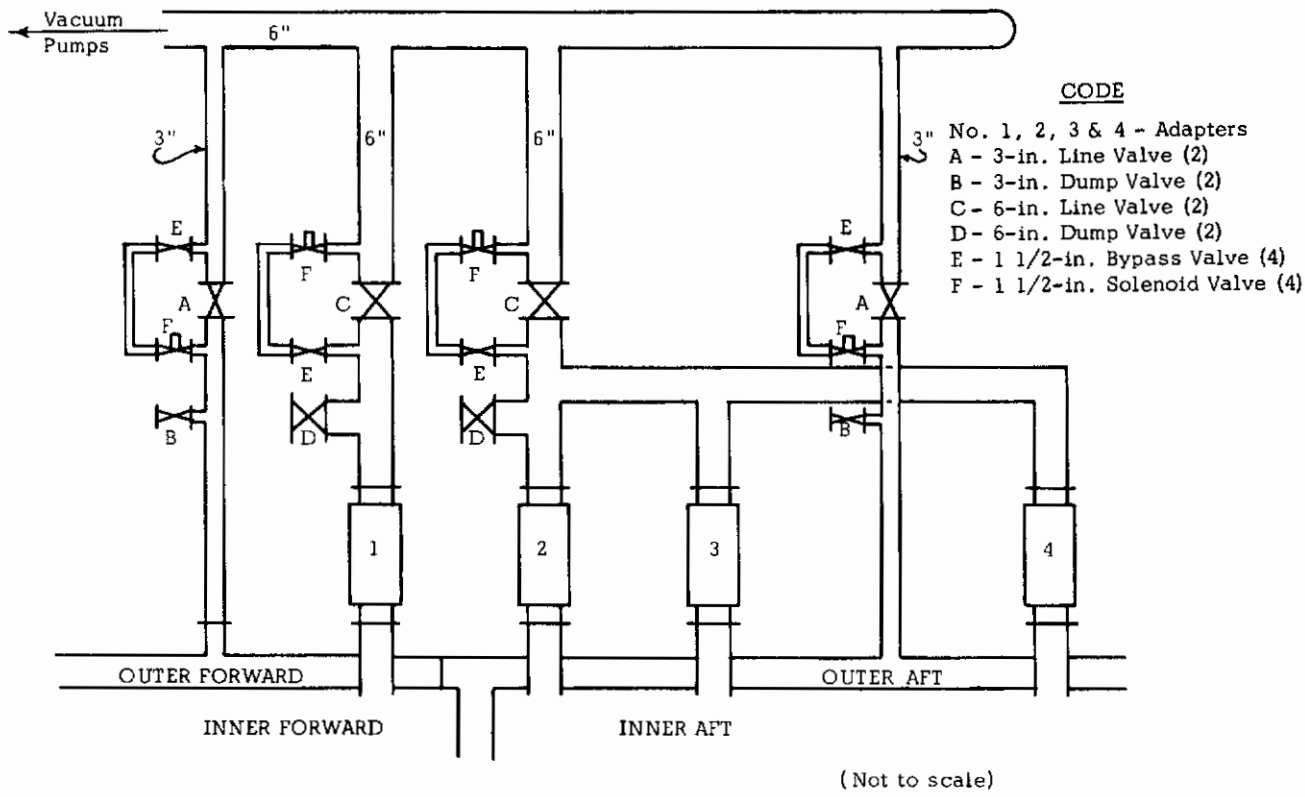


Figure 3. Schematic of Plumbing

VACUUM PUMPS

Both the outer chamber and the inner chambers are connected, for evacuation, to a 375-cfm Beach-Russ, class B, type RP, rotary piston, high-vacuum pump. This pump can evacuate the outer chamber to 8 mmHg (equivalent to 100,000-foot altitude) in 7-1/4 minutes and the inner chambers, to the same pressure in 14 minutes.

SAMPLE LOCK

A sample lock (fig. 4) is integrated into the right side of the nose section. It is 12 inches long and has a 10-inch inside diameter. This lock can be operated independently by using small auxiliary vacuum pumps or being plumbed into the outer forward chamber. The doors are secured by three hand-tightened locks. Each door contains a single O-ring seal. Figure 4 shows the sample lock placement including valves, pumps, and plumbing. Any item smaller than the sample lock can be transferred through the sample lock without appreciably affecting the habitable atmosphere. The valving and pumping sequence can be established so that the interior chamber atmosphere is unaffected after the sample lock has been used, i.e., ambient atmosphere entrapped in the lock is evacuated to the room, and cabin atmosphere entrapped in the lock is evacuated to the cabin.

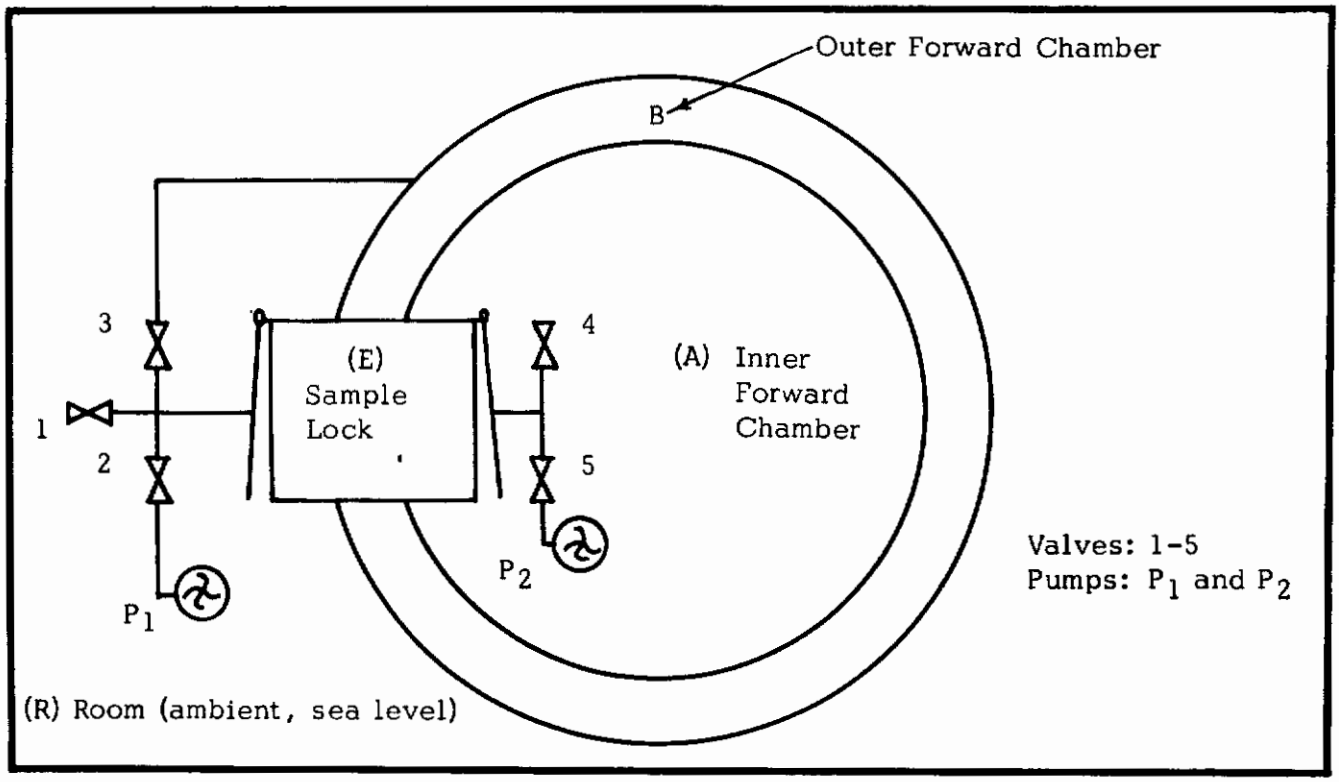


Figure 4. Schematic of Sample Lock

ELECTRICAL

The evaluator is serviced with the following:

110/220 volt AC, single-phase, 60-cycle, wired "Y"

28 volt DC

220 volt AC, three-phase, 60-cycle, wired "Δ"

A circuit-breaker panel inside the evaluator provides the necessary protection against electrical shorts and malfunctions. The two inner chambers are identical and independently serviced. Plug recepticles are provided at strategic locations within each chamber. The main power ON-OFF switches are located outside of the evaluator for maximum protection.

OPERATING CAPABILITY

Pressure

The double-wall construction feature provides the two primary chambers with a low-pressure sink immediately external so that any leakage will be outboard. This feature makes the evaluator unique. This feature isolates the crew compartment from ambient contamination. The pressure in the various chambers can be reduced to as low as that at 100,000 feet, or 8 mmHg, independent of the other chambers. The pressures in the various chambers can be selected and maintained as desired. Of course, the proper doors and valves must be opened or closed to simulate the desired operational conditions.

Manual valves on top of the evaluator are operated to achieve and maintain the desired pressure.

Temperature

The inside temperature is controlled by an environmental conditioning unit located outside the evaluator. This unit provides an essentially static atmosphere (no moving air). If forced ventilation is desired, a unit inside the evaluator can be used. The temperature is maintained at 78° F ±8°.

SUMMARY

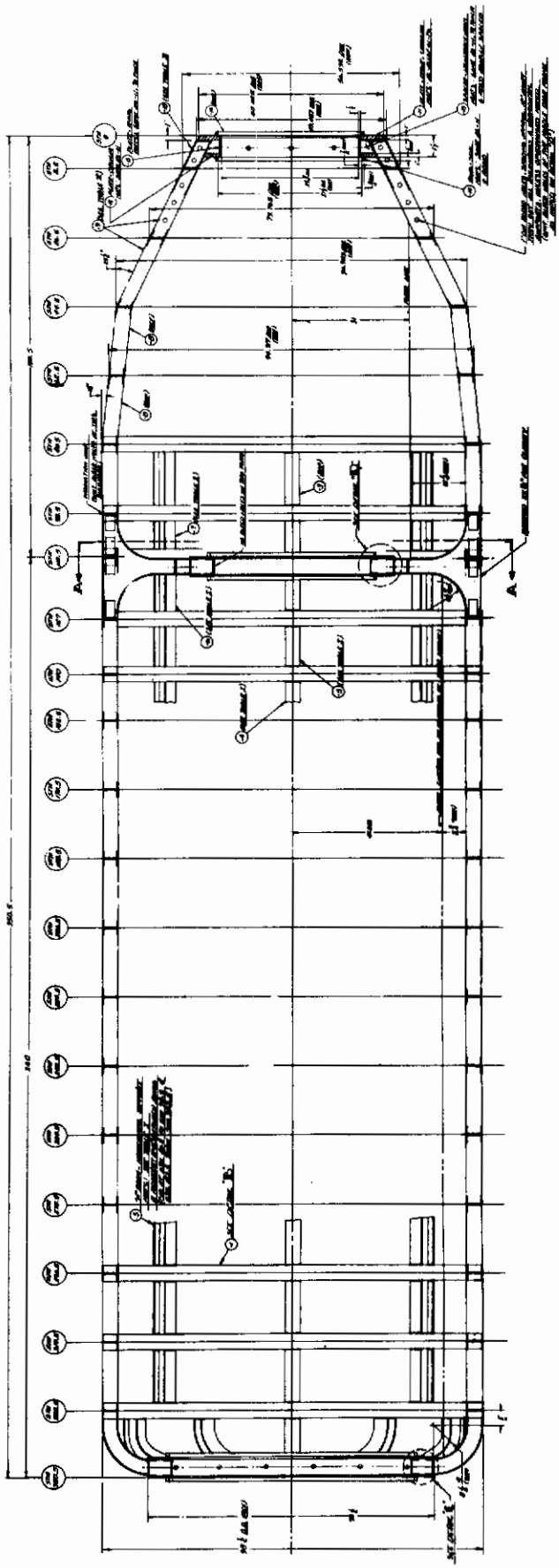
The Life Support Systems Evaluator is a research tool that can be used to determine the technical feasibility of techniques and principles involved in life support equipment of contract and 6570th Aerospace Medical Research Laboratories designed items by integrated evaluator studies.

The double-walled construction provides a low-pressure sink, thereby assuring that any leakage of the inner chambers will be outboard, preventing contamination or dilution of the habitable atmosphere by the ambient atmosphere.

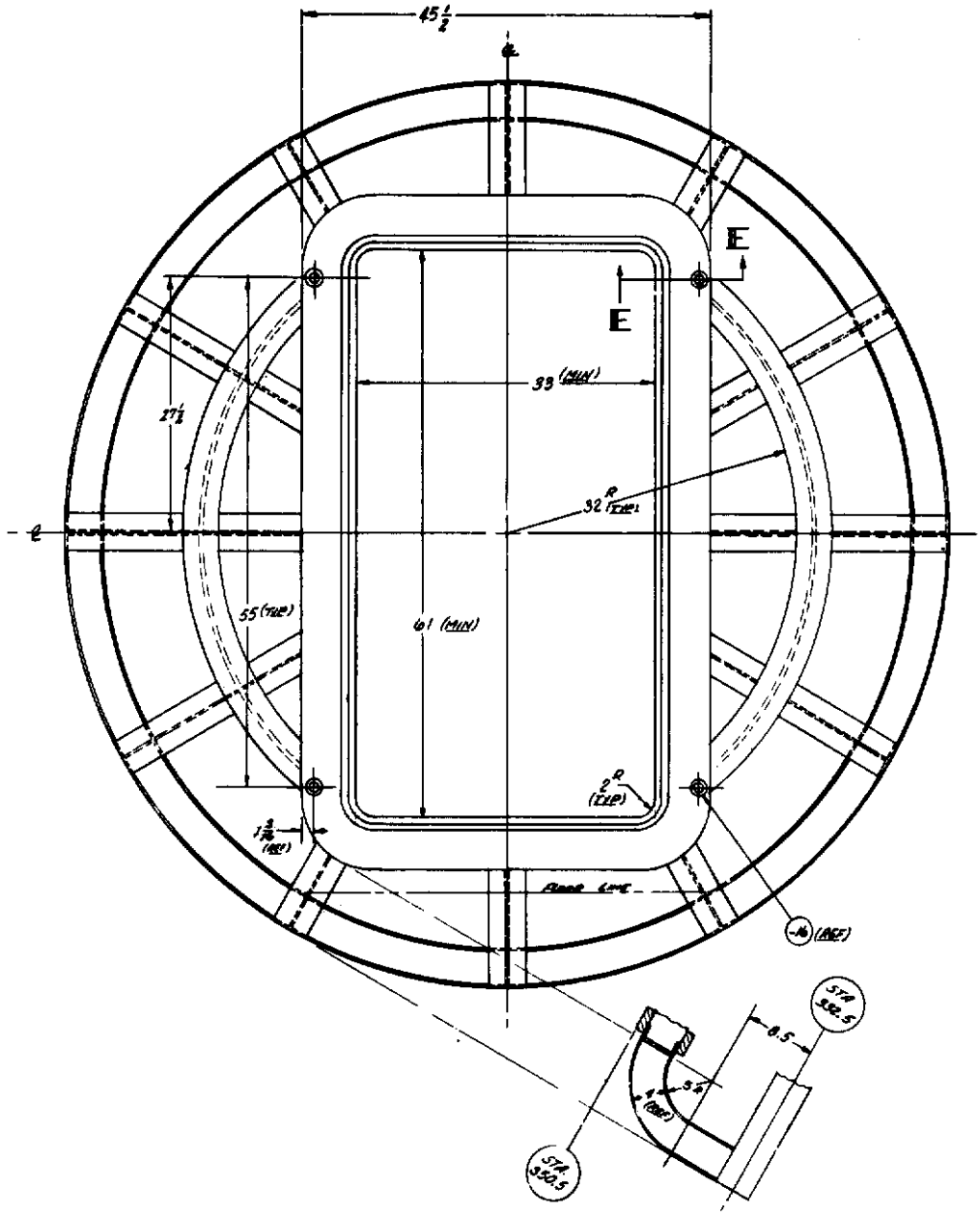
The evaluator is operational and, in initial tests, it has proved to be practical and to produce useful results.

APPENDIX

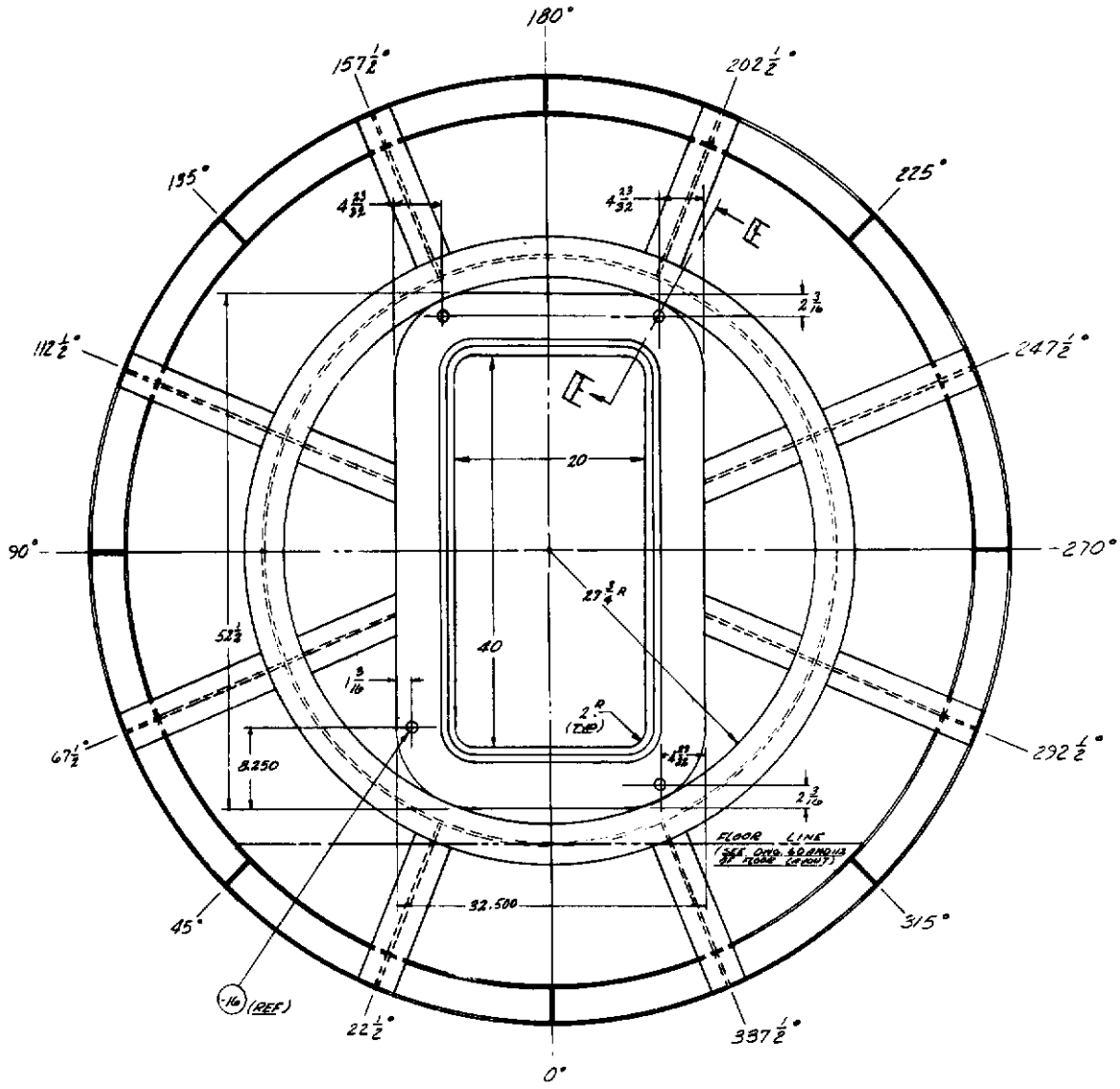
ENGINEERING DRAWINGS
OF THE
LIFE SUPPORT SYSTEMS EVALUATOR



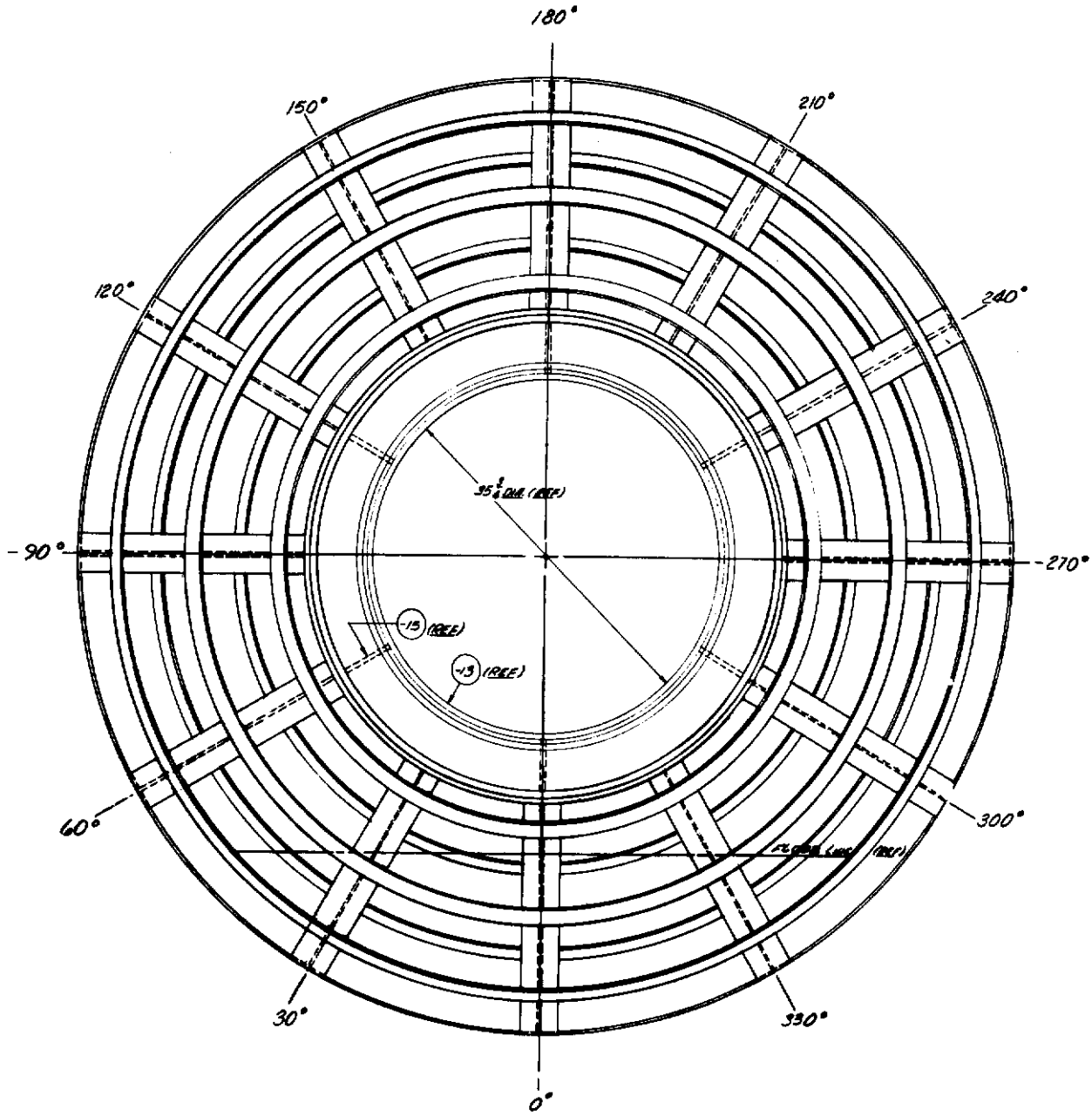
SIDE VIEW: LIFE SUPPORT SYSTEMS EVALUATOR



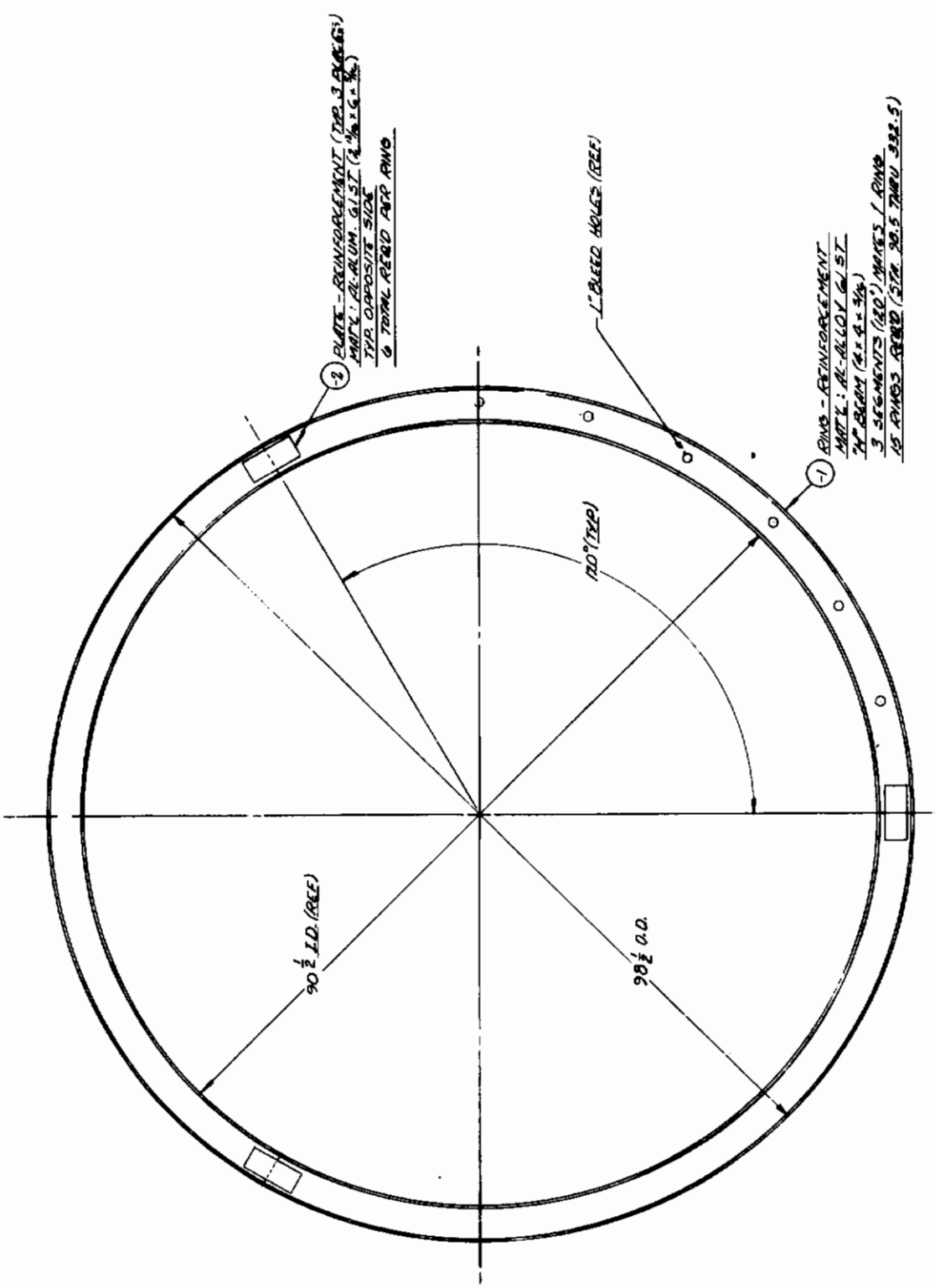
LEFT END VIEW: BEAR DOOR SECTION



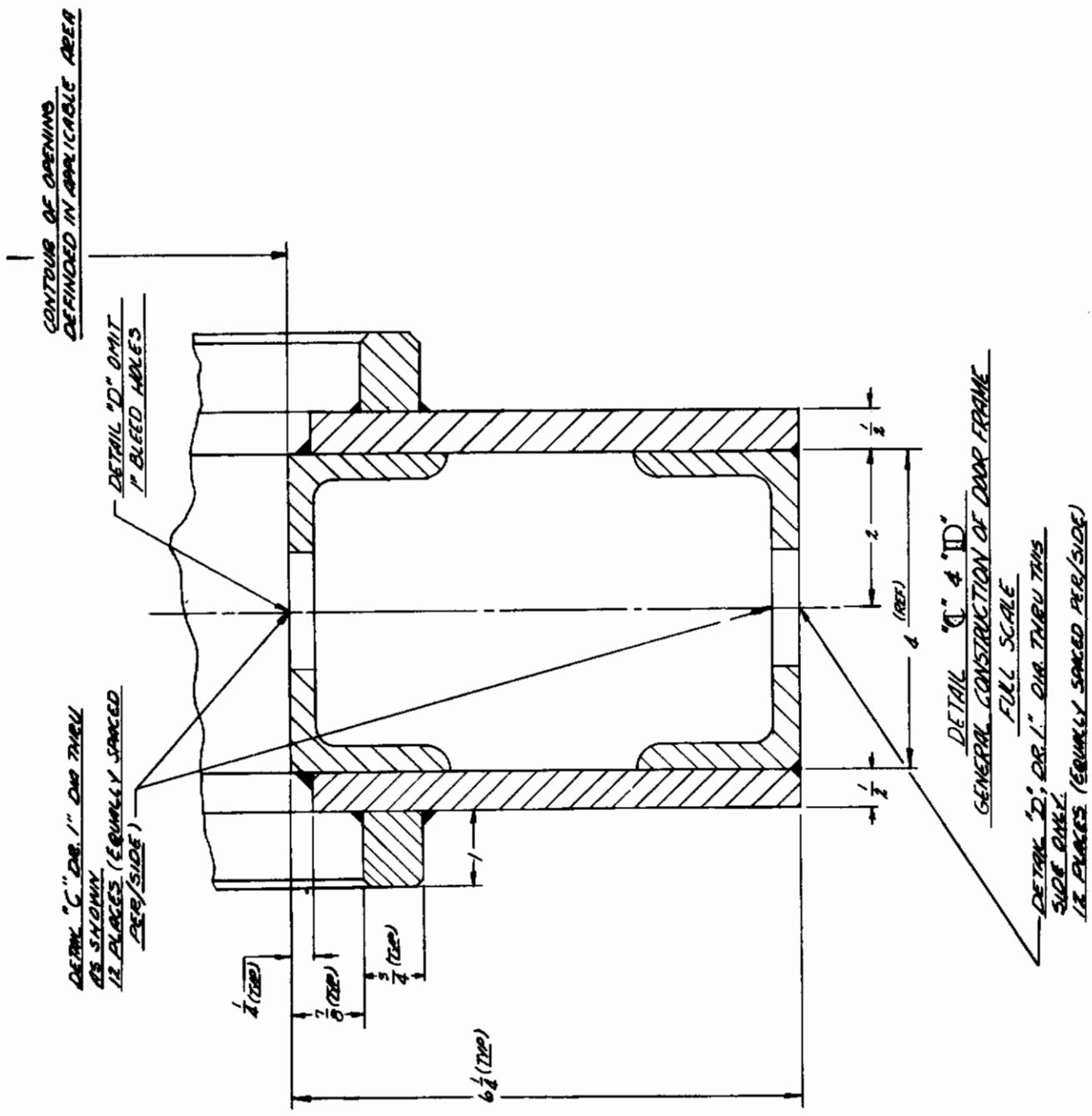
SECTION A-A
VIEW SHOWING BULKHEAD RIBS
CONSTRUCTION TO DOOR FRAME

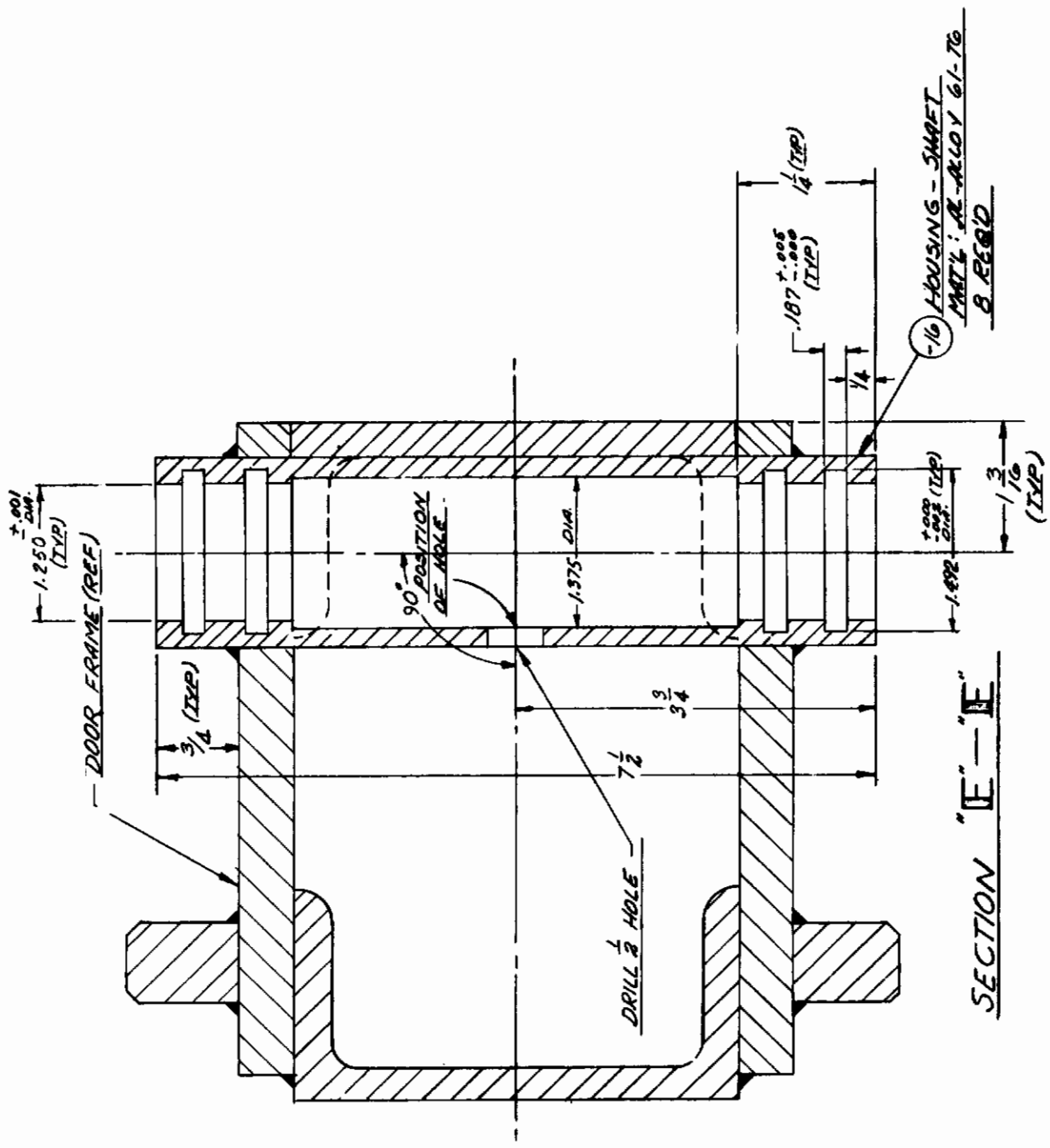


RIGHT END VIEW: NOSE DOOR SECTION

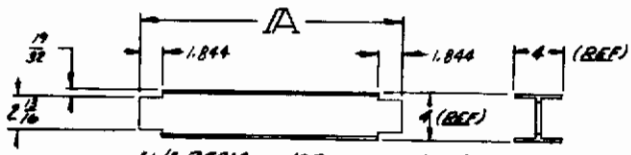


DETAIL "B"
RING REINFORCEMENT STA 98.5 THRU STA 332.5
(ALTERNATE SPLICED JOINTS WITH RESPECT TO ONE ANOTHER BY 60°)





SECTION "E"-"E"



"H" BEAM - HORIZONTAL SUPPORT
MAT'L: AL-ALLOY 6151T
(4 × 4 × 5/16)

TABLE I		
DASH NO.	A	TOTAL NO. REQ'D
-3	17 11/16	88
-4	12 3/16	8
-5	12 11/16	8
-6	16 3/16	8
-7	11 11/16	8

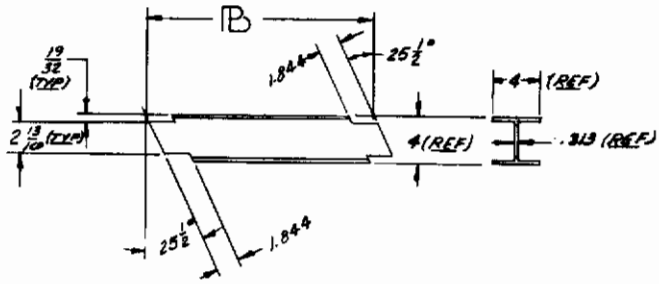
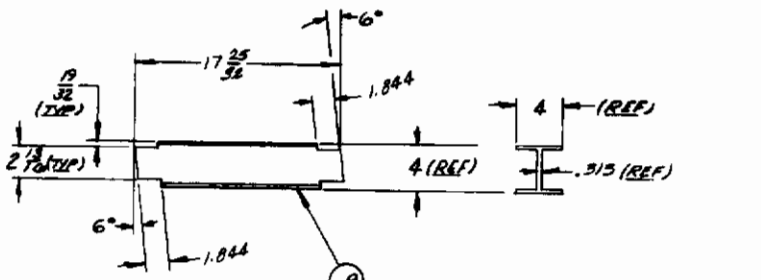


TABLE II		
DASH NO.	B	TOTAL NO. REQ'D
-9	19 5/8	24
-10	8	12

(-9) (-10) "H" BEAM - HORIZONTAL SUPPORT
MAT'L: AL-ALLOY 6151T (4 × 4 × 5/16)



(-8) "H" BEAM. HORIZONTAL SUPPORT
MAT'L: AL-ALLOY 6151T (4 × 4 × 5/16)
24 - REQ'D