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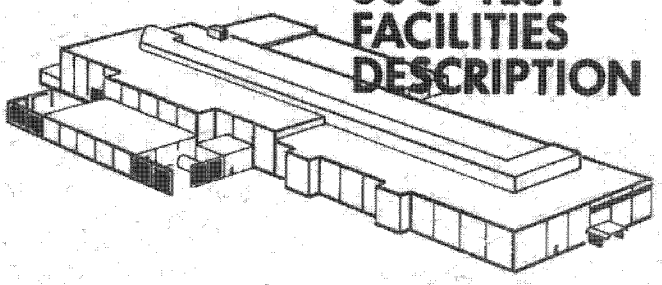
PROJECT MEMORANDUM

PM-1500-X

SSC TEST FACILITIES DESCRIPTION



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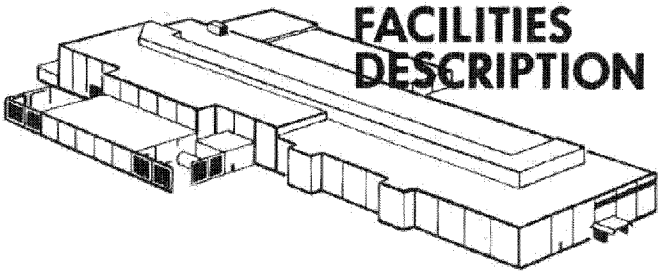

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Project Memorandum Number: 1500-X

Prepared By: J. Campbell **Date:** May 1974

Subject: SSC Test Facilities Description

Publication Review:

C. O. Bryant, Manager, Test Department

C. Karatzas, Director, Engineering

R. W. Jones, Director, Assembly and Test

Abstract:

This document describes the acoustic, vibration, thermal-vacuum, chamber and other test facilities located at SSC.

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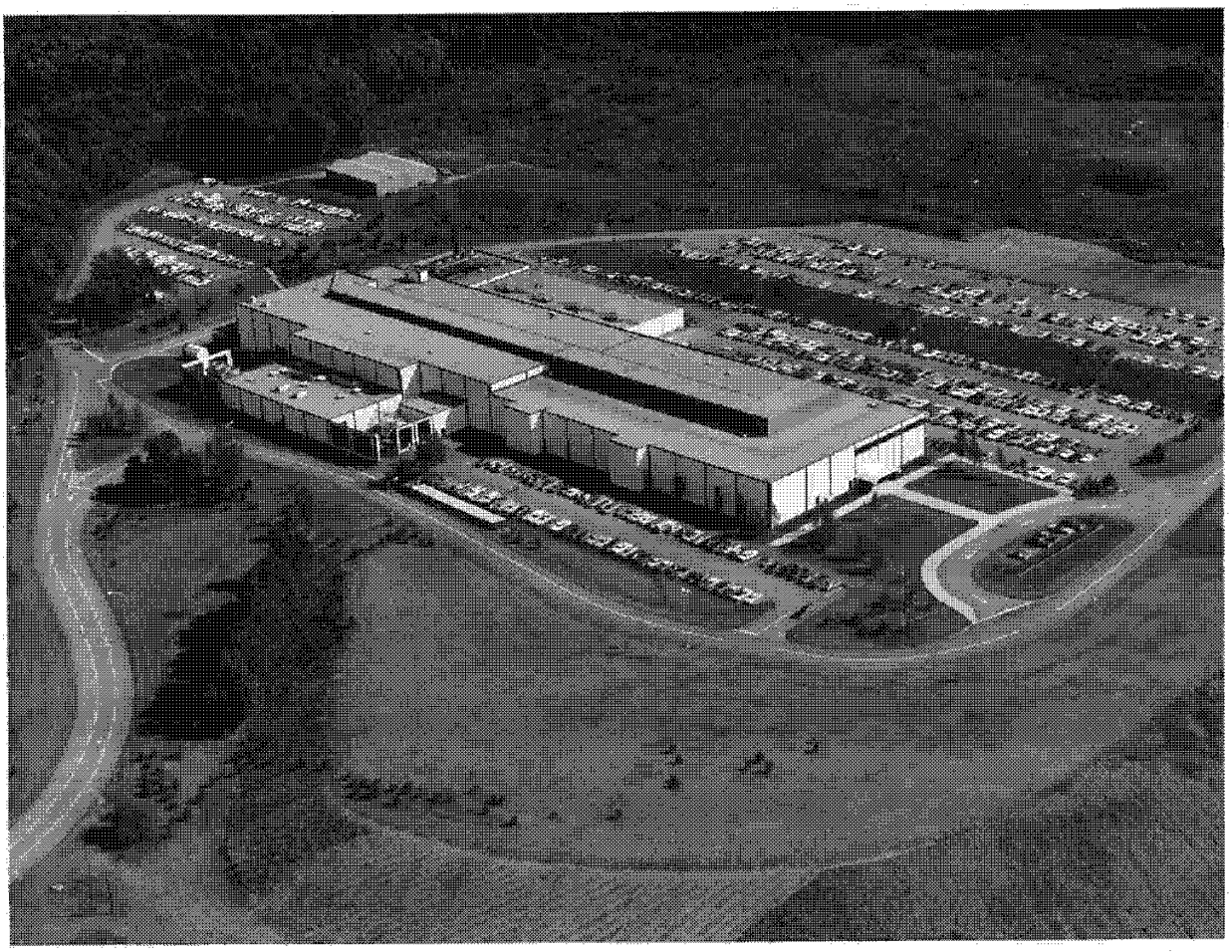


Aerial View of SSC Danbury Facility

TEST FACILITIES DESCRIPTION

1. INTRODUCTION

In OTD's integrated concept of environmental testing, systems or components can be subjected to the full range of simulated space environments in one facility with a minimum of test specimen handling. Thermal-vacuum, EMI/EMC, static loading, and dynamic vibration, acoustic noise, and other tests are performed in a self-contained 65,000 square foot clean room area. About half of this space is "high bay" and the entire facility incorporates monorail and bridge crane supporting structures for specimen and fixture handling. (See Figure 1.)

2. ACOUSTIC TEST FACILITY

Acoustic testing is performed in a 4500 cubic foot reverberant chamber (Figure 2), isolated from the building walls by three inches of cork and serviced by a control room and liquid nitrogen vaporization plant. The internal chamber dimensions (20'L x 16'W x 14'H) are optimized for excitation of a minimum of nine modes in the 1/3-octave band centered at 100 Hz. Modal excitation increases for higher 1/3-octave bands.

A 35-cycle exponential horn couples the acoustic noise source to the chamber at a ceiling corner to maximize-modal excitation. Acoustic noise is generated by modulating a stream of gaseous nitrogen using a Wyle Model WAS 3000 noise transducer. The temperature of the gas fed into the chamber is maintained at 70°F ± 10°F.

Control and recording of the testing environment and specimen response is performed in the separate acoustically treated control room. Two closed circuit television cameras mounted in the reverberation chamber permit remote visual monitoring of the tests from the control room.

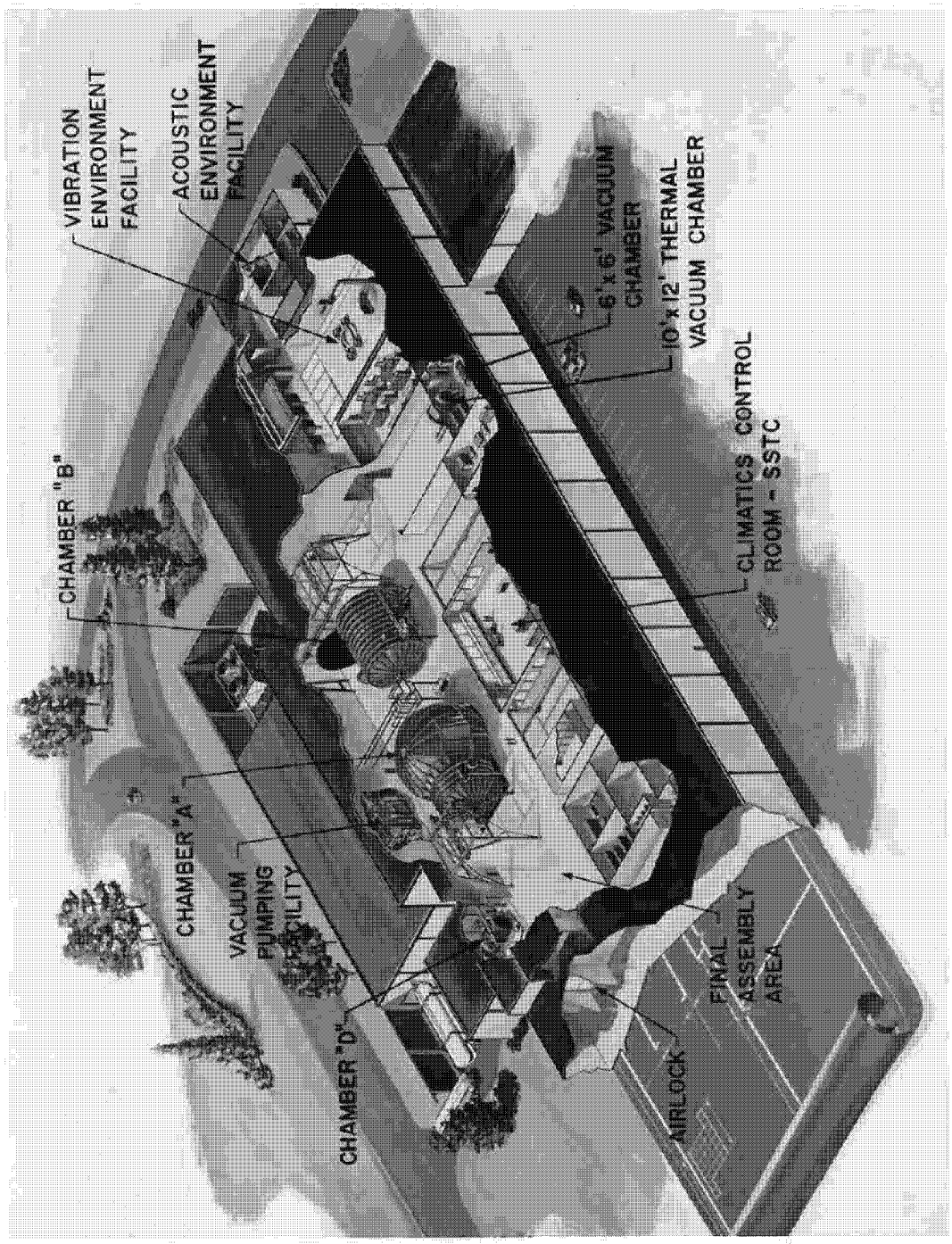


Figure 1. Major Assembly Test Facility

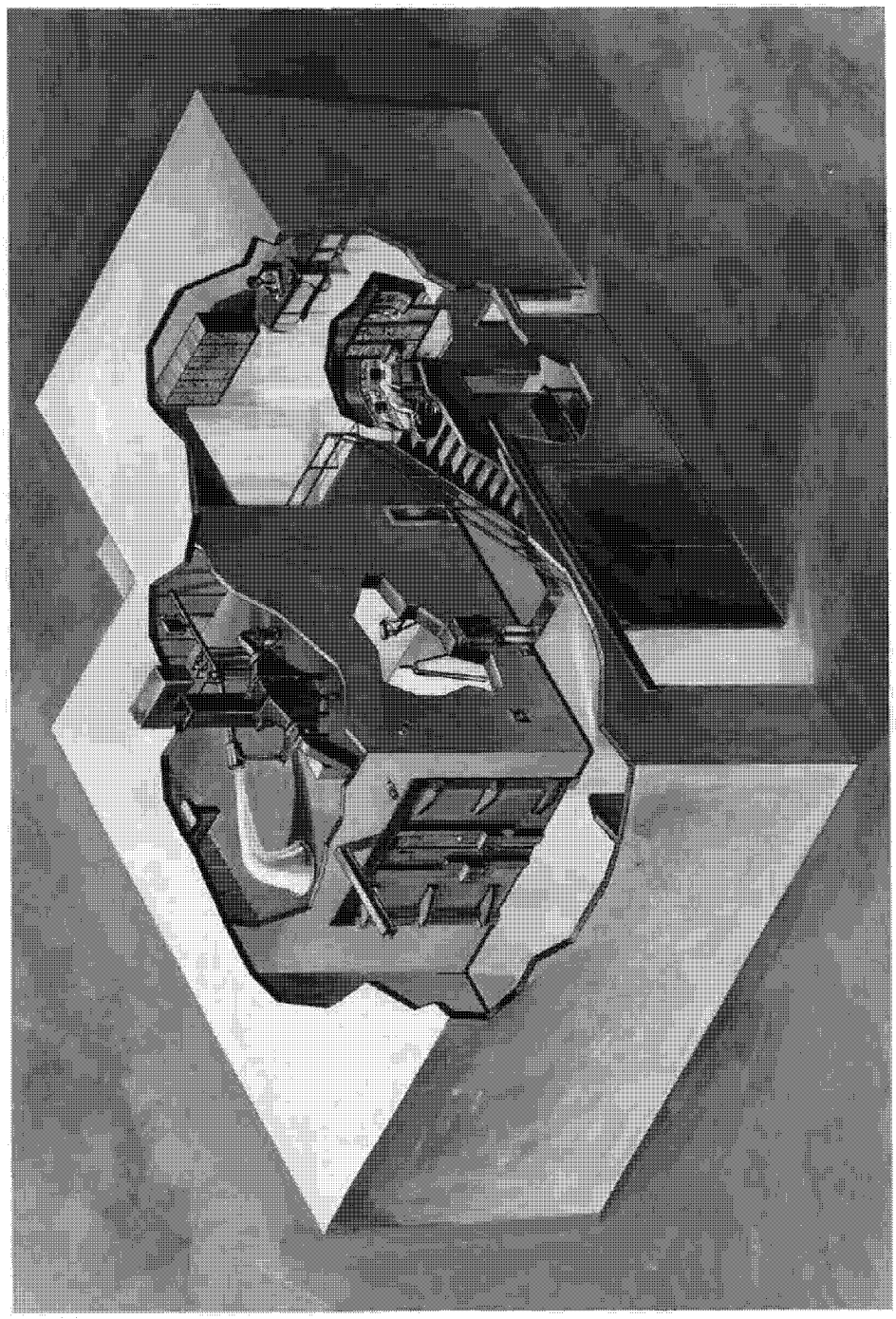


Figure 2. Acoustic Test Facility

Spectrum shaping is accomplished from this control room with a B & K Model 123 1/3-octave band shaper. Overall sound pressure levels of 157 db maximum are attainable with the chamber empty. The spatial distribution within an imaginary sphere 10 feet in diameter centered in the chamber is uniform to within ±1 db. (Spectrum shaping within the empty chamber will conform to MIL-STD-810B Category B.)

The noise spectrum in the chamber is monitored at the control console by taking an average reading from the two to six B&K Type 4134 condenser microphones in the chamber. Individual microphone outputs can also be monitored.

3. VIBRATION TEST FACILITY

A specially-constructed self-contained facility of 5500 square feet (Figure 3), built within the main building walls, is used for vibration testing. Separate areas for test, test setup, storage, power amplifiers, and shaker cooling systems are provided in the facility. Vibration test performance is monitored and controlled from a 1500 square foot computer-floored control room shared with the 70 Channel Dynamics Data System. In the main test area shakers are mounted to an inertia block that is 30 feet x 50 feet in size weighing 1.5 million pounds which acts as a reaction mass for the 60,000 force pound maximum vibration capability.

Six MB Electronics C150 shakers rated at 15,000 pounds force each, are available in the facility. The mobility provided by air bearing bases on these shakers and several readily accessible amplifier and cooling system outlets located around the seismic mass permit a large degree of flexibility in multi-shaker arrangements.

Four MB Electronics automatic sine and random control systems are available for use singly or in combination for multi-shaker tests employing a Chadwick-Helmuth four-channel phase and amplitude control system. All four systems can be programmed for one through four shaker setups at the control consoles through an electrical patch board system.

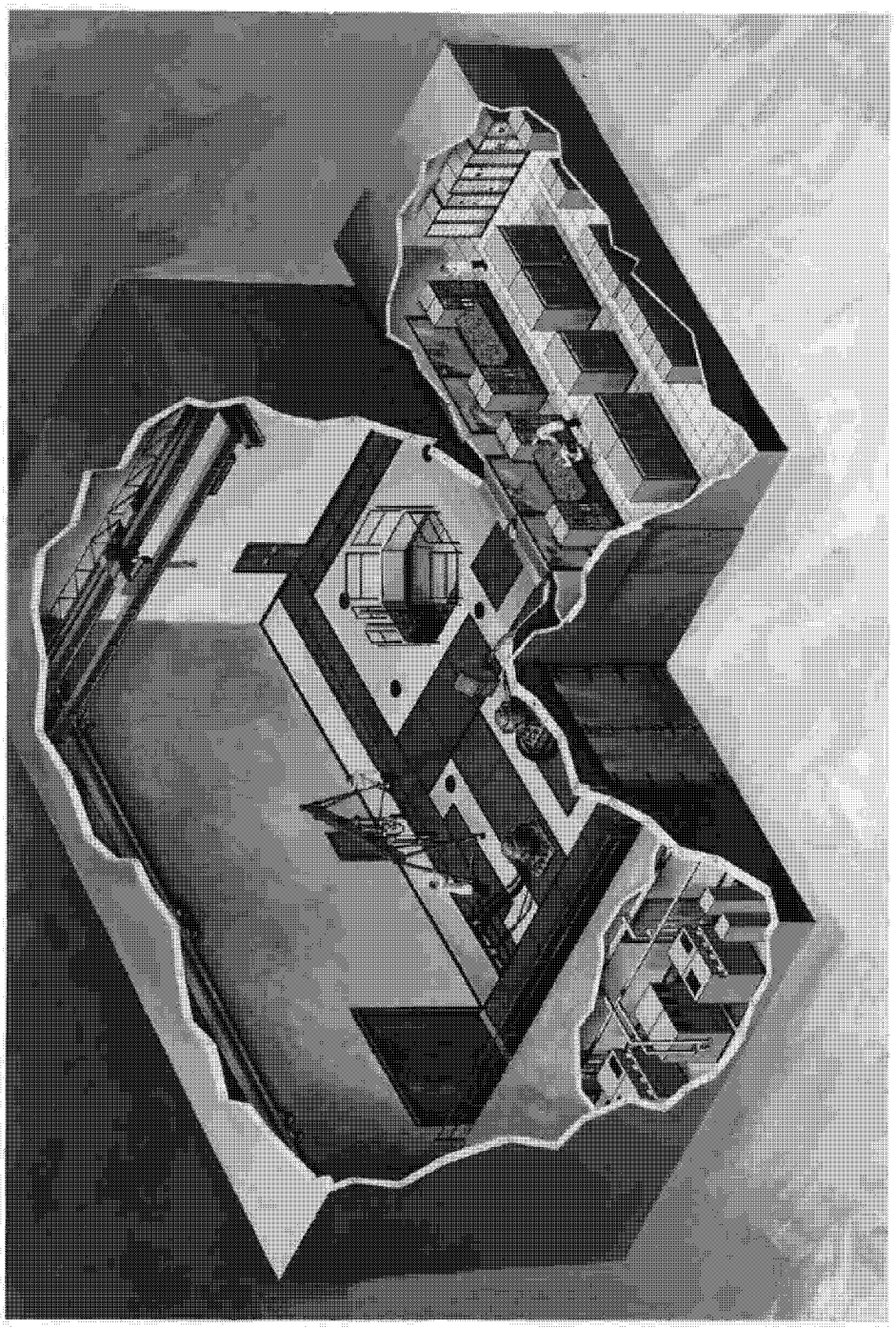


Figure 3. Vibration Test Facility

The facility is well supported by an electronics service staff with the appropriate equipment to permit rapid modification and repair. Rigging equipment, hoists, slip tables and hydrostatic bearings and an Unholtz-Dickie automatic accelerometer calibration system are also included in the facility to support test activities.

4. DYNAMIC DATA SYSTEM

Both acoustic and vibration testing are serviced by a Dynamic Data System (DDS) occupying one half of the vibration control room. The DDS is used to acquire, record, analyze, and display the response signals from the specimens in the acoustic or vibration environments. The 20 instrument cabinets comprising the system, provide six major functions during the conduct of an indivual test.

The Signal Conditioning section of the system can accommodate up to 32 eight-wire, resistance type strain gages and up to 66 piezoelectric accelerometers and 12 channels of all purpose buffer amplifiers.

Up to 70 Mark 4000 multiplexed channels of DC to 4 KHz information on a single magnetic tape can be recorded with the system. In addition, 14 wideband FM channels of DC to 20 KHz information can be recorded simultaneously. The reproduction instrumentation can simultaneously recover up to 15 multiplexed signals and all of the FM channels.

The DDS has the capability of analyzing sine and random vibration signals and third-octave acoustic signals. In addition, transfer function and phase angle plots can be readily produced by the DDS.

The DDS has a four bay console from which an operator may monitor any major function of the data system utilizing oscilloscopes, meters, and frequency counters. Two Irig "B" Time Code Generator/Translators are incorporated in the console which visually and electrically display either real time or tape.

5. EMC TEST FACILITY

The Electromagnetic Compatibility (EMC) Test Facility (Figure 4) is capable of testing a wide variety of specimens to the most recent military specifications. Test specimens have successfully been subjected to the requirements of MIL STD 461A, MIL STD 462, MIL E-6051C-D and MIL STD 826A.

The shielded enclosure is composed of two adjacent rooms; a control area which houses all the electronic equipment or the controls for remote operation of those equipments which must be located nearby the test specimen; and a test area, the dimensions of which are 16 feet high, 20 feet wide, 35 feet long. The two rooms may be RF isolated from each other.

The test equipment consists of semi-automatic spectrum surveillance receivers (Fairchild Electro-Metrics FSS-250D and Singer EMA-910) which allow spectrum monitoring from 30 Hz through 10.5 GHz. Various oscillators and tuned power amplifiers allow electric and magnetic field generation from 30 KHz through 12.4 GHz with adequate power to perform to Standard Mil Spec requirements.

Filtered (30 Hz - 12 GHz) power sources for the facility include 25 KVA of 400 Hz three phase power, 60 Hz three phase power and greater than 5 KW DC capability.

In all phases of the design of this facility, personnel and test specimen safety was of paramount importance.

6. THERMAL-VACUUM LABORATORY

There are five chambers in OTD's thermal/vacuum chamber complex. The two largest include a sphere fifty feet in diameter designated "Chamber A", and a cylinder thirty feet in diameter by thirty-three feet long designated "Chamber B". (See Figures 5 and 6.)

The shells of both chambers are fabricated from stainless steel and contain numerous flanged penetrations for cabling, viewports, cooling lines, etc.

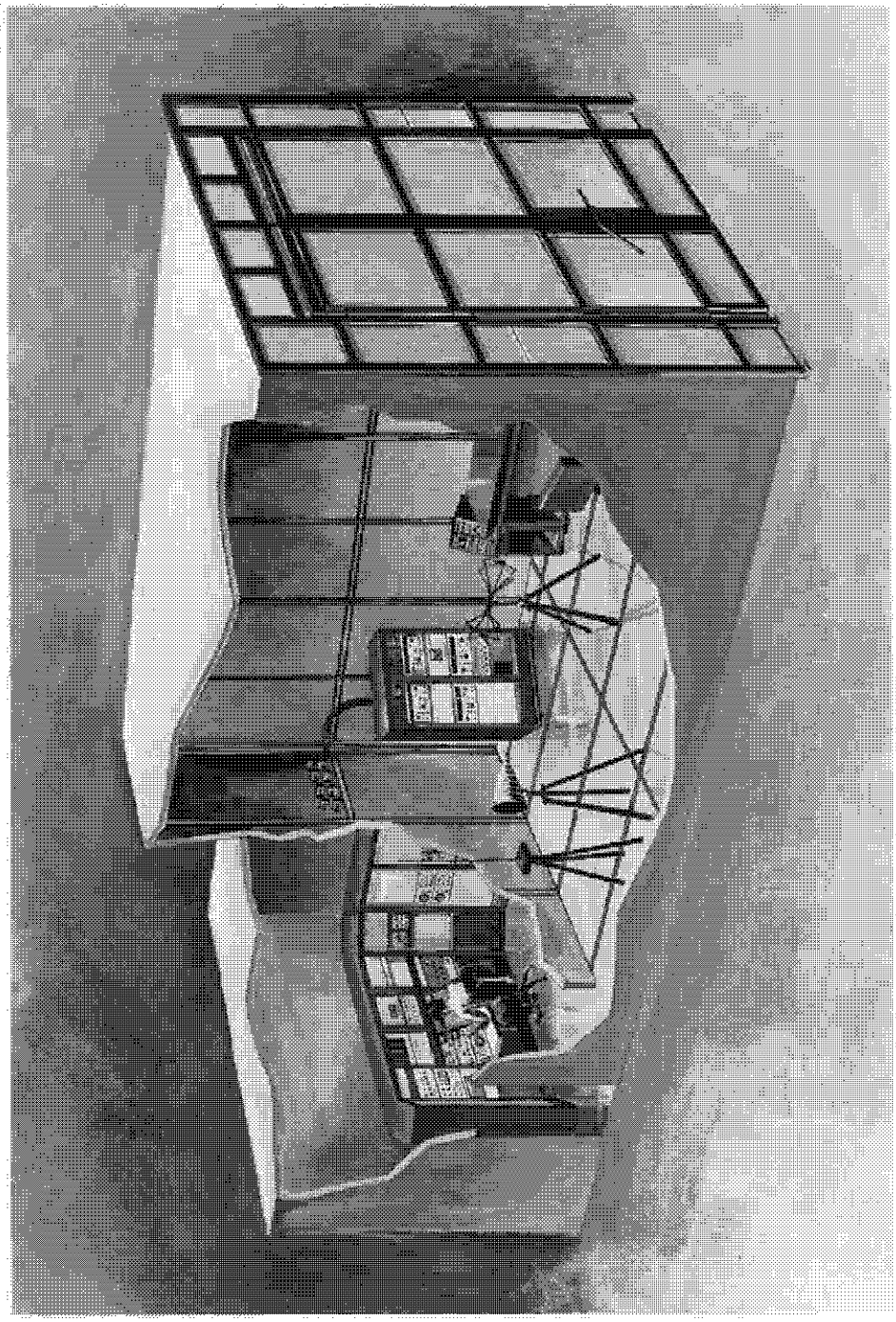


Figure 4. Electromagnetic Compatibility Test Facility

Figure 5. Thermal Vacuum A

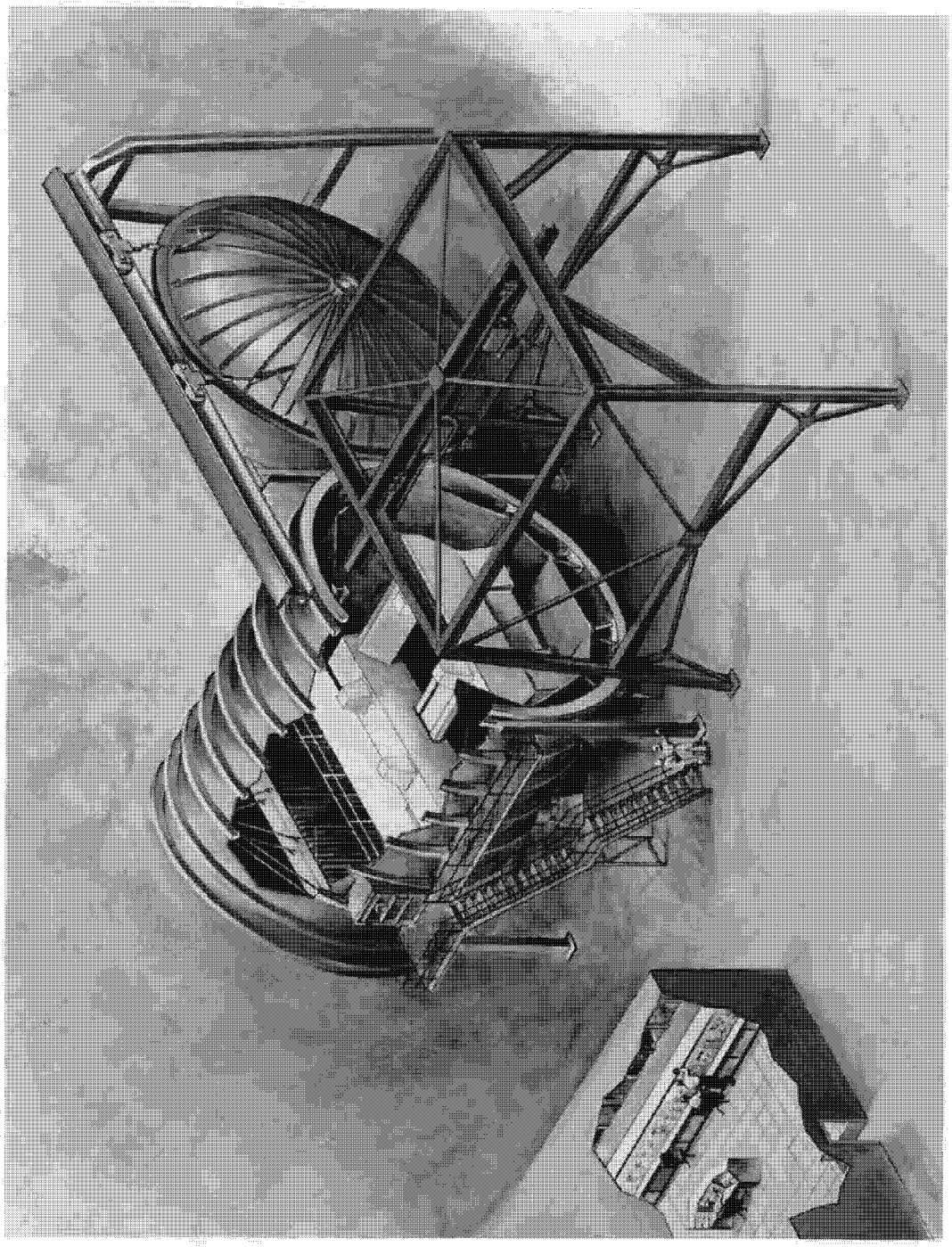


Figure 6. Thermal Vacuum B

Both chambers are equipped with 30-foot diameter removable heads, fully automated, which fully open to allow horizontal test specimen entry into each chamber.

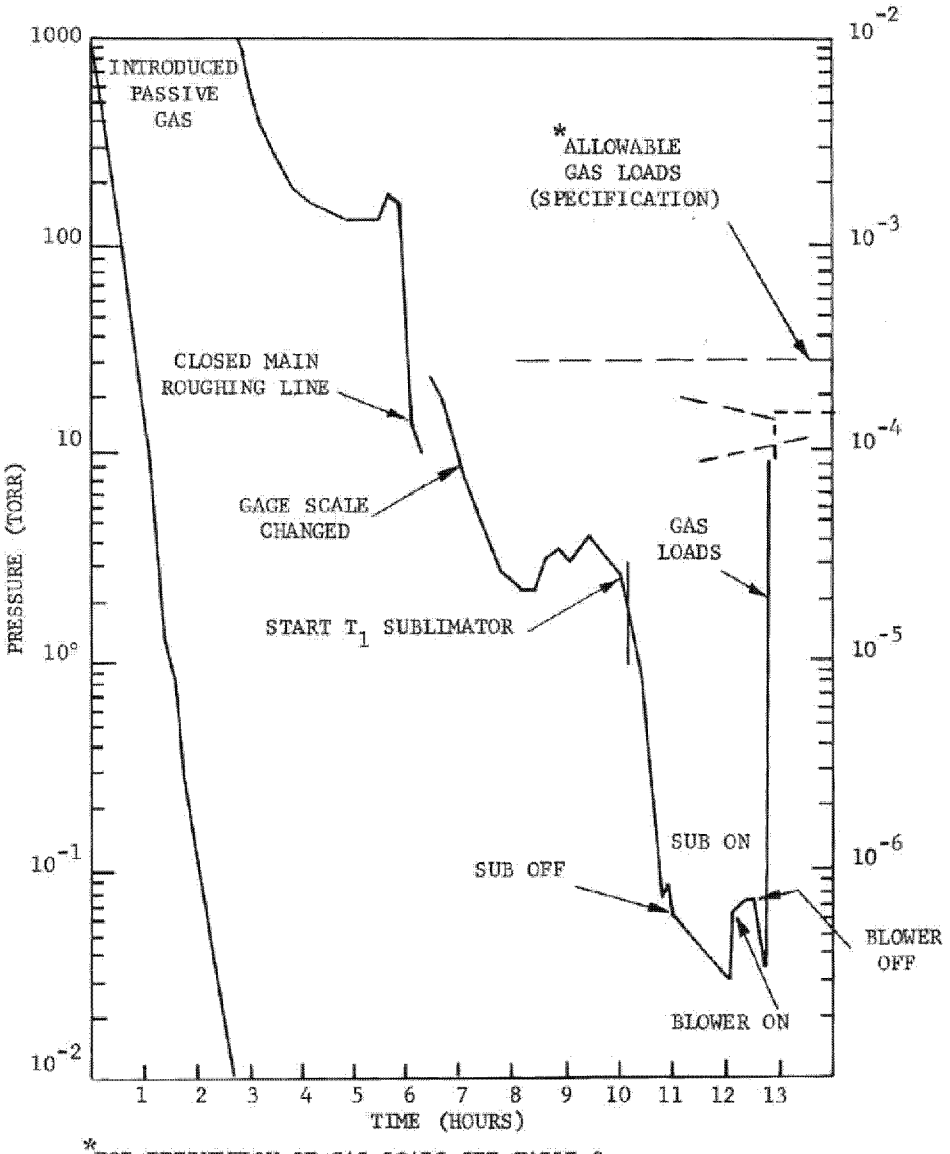
Each chamber is equipped with a monorail system capable of transporting test specimens weighing up to 12-1/2 tons into their respective chambers.

Thermal shrouds on the inside of the chambers provide a heat sink capability of absorbing up to 300 KW under steady state conditions. Chamber "A" is further equipped with an infrared lamp array which is capable of providing thermal energy from near zero to greater than 200 watts per square foot over a 24 foot long cyclindrical test zone and a diameter to 11 feet.

The chamber vacuum systems are capable of providing environmental pressures down to 3×10^{-7} torr. (See Figure 7.)

Internal walkways, ladders and platforms allow access to all areas of the chambers. Man doors, with safety interlocks, provide ingress to the chambers when the main 30 foot diameter heads are closed. Access locks are built onto the chamber. They are small (7 feet x 9 feet) cylindrical chambers connected to the main chamber by a thirty inch diameter doubly flanged penetration which may be fitted with a variety of valves to allow air-lock capability. External platforms, walkways and ladders are provided to allow access to penetrations and various areas of the chamber shells.

Chambers A and B each have an Isolation System consisting of a master support fixture mounted on a cruciform assembly with a large ballast container. Articles to be tested are mounted on this fixture. The purpose of the isolation system is to minimize relative motion between the system under test and monitoring or measuring devices. (System tests have demonstrated that relative motion between test article and monitoring devices do not exceed 2.2×10^{-5} rad/sec.)



*FOR DEFINITION OF GAS LOADS SEE TABLE 2.

Figure 7. Chamber Pressure Profile, Passive and Active Gas Load Test (11 March 1969)

This system is isolated from ground-borne vibration by Barry Pneumatic Isolators, and from chamber-borne vibration by rubber diaphragms encircling the master fixture legs at the point of entry into the chamber. The Barry Isolators provide the system with a rigid body natural frequency of 1.5 cps, and a damping ratio of 50 percent of critical damping. All structural members were designed with natural frequencies of 30 cps. These boundary values allow for quiet system operation in a critical region of 5 - 15 cps.

Chamber A has a system of six collimators with targets which can be utilized to evaluate camera systems at simulated space thermal and vacuum conditions. The collimators are located at various scan and field angles and are mounted on a vibration-free isolation system which is an integral part of the chamber test article support system.

Each collimator displays test targets at distances simulating space orbit. The target assembly contains resolution, focus, and density targets and other special features utilized in evaluating the performance of a camera system. The targets are illuminated through a light pipe from a lamp system located outside the chamber and controlled by a console located in the control room.

The collimator is a Cassegrain all reflective type optical system with an effective focal length of 420 inches and a 22-inch aperture and is constructed from Cer-Vit material. The secondary mirror is motorized and controlled remotely from the control room. The collimator system is located in a benign area to minimize temperature effects.

In addition, each collimator has a verification system to obtain interferometric data in order to evaluate the quality of the wavefront and the location of the focal plane. The verification system consists of a scatterplate interferometer, an optical flat retroreflector on the target assembly and a recording camera. A closed circuit television is also provided for remote viewing of the interferogram and is utilized whenever the secondary mirror is adjusted to optimize alignment of the optical system.

A four point mounting system is located on the mass support fixture to provide alignment of the test article to the test collimators.

As shown in Figure 8 the aft mounting points are composed of manually operated screw jacks assemblies. These jacks provide leveling adjustments (up and down) and are also capable of two axis translation. The jack-article interface is made via a spherical bearing which permits the two aft mounts to be used as a pivot.

The two forward mounts have motor driven screw jacks to provide up-down positioning of approximately ±7.5 inches. This permits the test article to be pitched ±2.5 degrees. Each of the driven jacks are equipped with manually operated jacks (mounted "piggyback") to provide additional vertical adjustment for initial leveling. This insures that the range of the driven jacks is maintained.

Remote positioning of the article is accomplished via a control and display console located in the control room. The console provides motor command signals and contains a digital and analog display corresponding to the height position of each jack. Reference to Figure 8 shows that these jacks are direct coupled and driven from a single motor. Thus, barring some form of decoupling, the two jacks track each other with a high degree of accuracy. Further, since each jack is monitored independently such a malfunction would be readily observed.

Additional diagnostics monitored and displayed to enhance fail-safe operation include temperature at critical points of the mechanism and pitch limit stops. It should be noted that if the drive motor exceeds its rated temperature or if the maximum pitch angle is exceeded, the drive mechanism is automatically shut off. Detail design parameters are included in Table 7.

A Low Level Vibration Detection System (VDS) is used with Chamber A which can detect and record up to fifteen independent vibration signals. When used in conjunction with its associated transducer/amplifier sensors and the Dynamic

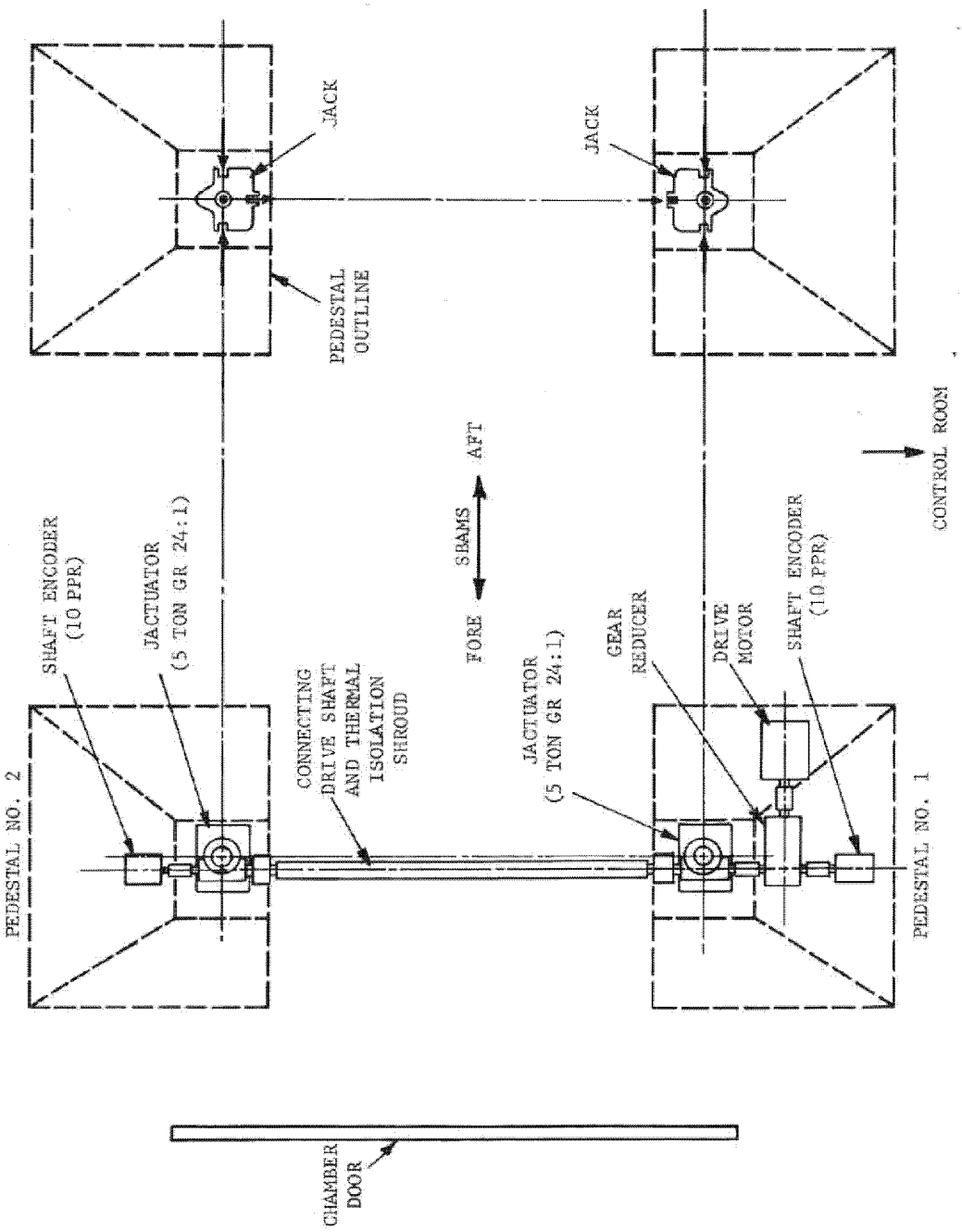


Figure 8. Plan Layout, Pitch Mechanism

Data System the VDS can produce engineering unit data from vibratory inputs in the 10^{-5} inches/second range. The VDS can also be used to detect, record, reproduce and compare the translational and rotational motion of two independent structures.

The VDS can accept analog signals which range from ±5000 millivolts to ±5 millivolts full scale.

Controls for operating Chambers A and B and performing tests are located in a central control room adjoining the high-bay chamber area. Chamber controls are integrated in a single large control console.

The remaining chambers in the thermal vacuum complex include Chamber "D" which is equipped with an internally mounted platform, supported on an air suspension system, isolating it from the chamber-support equipment and the shell. Exterior to this chamber are two large masses that can be used to mount sensitive alignment equipment through clear penetrations. Adjustable platforms are located both inside on the stable platform and external on the large masses.

Chamber "E" has a highly versatile six-zone thermal shroud. Each zone is independently capable of simulating a black body at a different temperature or a black body with a programmed temperature profile.

Chamber "F" is a 6'D x 6'L high vacuum chamber used for subassembly testing.

7. CHAMBER DETAILS

The specific details of Chambers A, B, D, E and F are summarized in Tables 1 through 7.

TABLE I

CHAMBER A DETAILS

Configuration	Spherical with attached horizontal cylinder that includes door.
Chamber Volume	7.2×10^4 ft^3
Test Envelope	26'D x 40' L cylinder
Shroud Capability	300 KW heat capacity @ liquid nitrogen temp. 0.9 or better surface emissivity.
Pumpdown Times	10^{-5} Torr range in 5 hrs. with loads. 8×10^{-8} torr range in 10 hours.
Pumping Systems	Mechanical and Roots blowers - 6000 cfm. Liquid nitrogen cryopump - 10^{+7} liters H_2O/sec @ 10^{-5} Torr range. 20°K cryopump - 10^6 liters N_2/sec @ 10^{-5} Torr range - 2400 watts @ 20°K Ion pumps - 2000 liters air/sec @ 10^{-5} Torr range. Titanium sublimation - 1 gram hr. onto LN_2 surface. Auxiliary Roughing - 3000 cfm.

TABLE 1 (Continued)

Warmup	Gaseous nigrogen warmup system for liquid nitrogen shrouds.
Thermal Simulation	12 zone infrared heat flux simulator (300 KW) 19 zone thermal interface control system.
Control Console	Central control console. Complete pressure gauging system - atmos, to 10^{-10} Torr with recording. Temperature indicators and recording for chamber data.
Equipment Handling	Monorail system exterior and interior of chamber capable of 25,000 lbs.
Specimen Mounting	Four hardpoints which are an integral part of large seismic mass which is vibration isolated from chamber, support equipment, and building.
Airlock	Airlock provides capability to insert or remove items from environment during test - pumped by auxiliary roughing system.

TABLE 2

CHAMBER A THERMAL CAPABILITY

Test Article Diameter	A minimum of 6 feet or less in special cases. A maximum of 11 feet.
Test Article Length	Very short lengths can be accommodated subject to the mounting requirements. Maximum of 24 feet if only the array is used. Maximum of 44 feet if the array and auxiliary headers are used.
Incident Radiant Heat Flux	From near 0 to greater than 200 watts/ft^2 over the 24 foot long test space.
Auxiliary Heater Zones	Six (6) zones @ 5 KW Thirteen (13) zones @ 2 KW
Thermal Instrumentation	48 IR Array Control Thermocouples 80 Auxiliary heater control thermocouples 226 General Temperature Data Thermocouples without array. 178 General Temperature Data Thermocouples with array. 36 pairs of copper leads for use with calorimeters, thermopiles, etc., available within chamber. 206 pairs of spare copper leads can be made available at chamber for use with additional thermocouple or other data signals.

TABLE 2 (Continued)

IR Array Control	Steady state by manual set-point or automatic proportional temperature feedback. Time-variable temperature by chart programmer with choice of cycle time.
Auxiliary Heater Controls	Steady state by manual set-point or automatic proportional temperature feedback. Will accept external Temp-Time program signal.
Temperature Data Acquisition	L&N 576 channel data acquisition and scanning system with 0.1°F resolution, digital data display, commutable dual level alarms, printer and paper tape punch data output.
Temperature Data Access	3264 pin patchboard system for direct access to all data/control signals using precision measuring equipment. 816 pin patchboard system for control signal selection.

TABLE 3

CHAMBER B DETAILS

Configuration	Horizontal cylinder with full opening door.
Chamber Volume	$2.7 \times 10^{+4}$ ft^3.
Test Envelope	26'D x 28'L Cylinder.
Shroud Capability	Temperature control 40°F to 100°F. Heating and cooling rate is 0.2°F/min to 2.0°F/min. Glycol heat exchange fluid.
Pumpdown Times	10^{-5} Torr range in 10 hrs in gas loads. 5×10^{-6} Torr range in 12 hours.
Pumping Systems	Mechanical and roots blowers - 6000 cfm. Liquid nitrogen cryopump - 1.4×10^6 liters H_2O/sec @ 10^{-5} Torr range, 300 KW. 20°K cryopump - subcooler 10^6 liters N_2/sec @ 10^{-6} Torr range, 2400 watts @ 20°K. Ion pumps - 2000 liters air/sec @ 10^{-6} Torr range. Titanium sublimation - 1 gram/hr. sublimation rate onto liquid nitrogen cooled surface. Auxiliary roughing - 3000 cfm.

TABLE 3 (Continued)

Warmup	Gaseous nitrogen warmup for liquid nitrogen panels.
Control Console	Central control console. Complete pressure gauging - Atmos to 10^{-10} Torr with recording.
Thermal Instrumentation and Control	None presently installed. However, Chamber A Thermal Instrumentation and control capabilities can be extended to cover Chamber B for a Nominal cost.
Equipment Handling	Monorail system exterior and interior of chamber capable of 25,000 lbs.
Specimen Mounting	Four hardpoints which are an integral part of large seismic mass which is vibration isolated from chamber, equipment, and building.
Airlock	Airlock provides capability to insert or remove items from environment during test - pumped by auxiliary roughing system.

NOTE: Chambers A and B share common 300 KW subcooler, 6000 cfm roughing skid, two 1200 watt 20°K helium refrigerators, and GN_2 warmup systems. Both systems can operate simultaneously.

TABLE 4

CHAMBER D DETAILS

Configuration	Horizontal orientation, full opening door 12' x 12' isolated platform.
Chamber Volume	12.5' diam. by 13' straight shell plus 6' diam. by 4' protuberance at right angle to main shell. Overall length 17.8 ft. Total volume 2200 ft^3
Test Envelope	10' long x 3.25' high x 3.1' wide inside shroud oriented perpendicular to main chamber axis.
Temperature Capability	Range - 40°F to 100°F nominal 26°F to 130°F actual Temp. Gradient - ± 2° dynamic ± 1° static Rate of Change: 0.2°F/min to 2.0°F/min continuously variable. Internal Heat Load: 3000 watts.
Pumpdown Times	atm to 10μ 1 hour (rough pump only). atm to 5 x 10^{-4} Torr - 2 hours with loads. atm to 5 x 10^{-5} Torr - 13 hours.
Pump Systems	Roughing System: Model 412 mechanical pump - 300 cfm. Model 615 blower - 1250 cfm. Diffusion Pumps: Two (2) NRC Model HS20 Diffusion Pump type 165 inlet diameter: 21.25 inches Maximum pumping speed: 17,500 l/sec air 21,000 l/sec helium DP Baffle: Double chevron LN_2 baffle. 5 tier water cone baffle. Holding Pump: Welch Model 1397 - 425 Liters/min.

TABLE 4 (Continued)

Special Incident Energy System (SIES)	Energy Source: 10 KW water cooled xenon lamp temperature controlled fused silicon diffuser. Beam: 26" diameter of diffuse radiation in a plane 6" from diffuser. Intensity Range: 5 to 25 watts/ft^2 continually adjustable plus 0 to 140°F diffuser plate temperature. Uniformity: ±5% in area; ±2% in time temp: ±2° in set point; 0.1°F across diffuser plate. Spectrum: filtered xenon source. Energy Distribution: ±15% of Lambertian.
Other Special Features:	32" auto collimating mirror on 2 axis positioner (azimuth and elevation). Laser interferometer on 3 axis positioner capable of positioning to within 0.5 micron (5×10^{-7} inches). Isolated table 12' x 12'. 2 axis camera mount exterior to chamber. Pedestal mounted T-2 theodolite exterior to chamber.

TABLE 5

CHAMBER E DETAILS

Configuration	Horizontal cylinder with full opening door.
Test Envelope	10'D x 12'L cylinder
Shroud Capability	6 zone shroud, each zone capable of operation from -65°F to 200°F. Each zone programmable.
Pumpdown Times	Atmos. to 10^{-7} in 8 hours. Atmos. to 30 microns in 30 min. with loads. Atmos. to 1 x 10^{-5} Torr in 2 hours with loads. Atmos. to 1 x 10^{-6} Torr in 4 hours with load.
Pumping Systems	Mechanical and roots blowers. Two each 10" NRC diffusion pumps with LN_2 baffle. Liquid nitrogen cryopump. 20°K cryopump - 200 watts @ 20°K.
Control Console	Central control console. Instrumentation to measure and record atmos. to 10^{-9} Torr. Contains the thermal programmers and readouts for the 6 thermal zones.
Specimen Mounting	On rail inside. Door mounting to 1000 lbs.

TABLE 6

CHAMBER F DETAILS

Configuration	Horizontal cylinder.
Test Envelope	6'D x 6'L
Pumping System	Mechanical pumps and roots blower. Two 10" diffusion pumps with LN_2 baffles and valves.
Pumpdown Time	atmos. to 10^{-5} Torr in 1 hr.
Ultimate pressure	1×10^{-6} Torr.
Control Console	Control of all pumping equipment. Pressure gauging from atmos. to 10^{-9} Torr.

TABLE 7

CHAMBER A PITCH MECHANISM DESIGN PARAMETERS

1. Load drive capability - 4200 pound/jack

2. Drive rate at maximum loading

3. Low speed 0.15 deg/min
   High speed 0.30 deg/min

3. Pitch angle range - ±2.5 degrees

4. Positioning accuracy (initial alignment)

   Pitch ±15 arc-seconds
   Roll ±18 arc-seconds
   Yaw ±10 arc-seconds

5. Pitch angle accuracy - ±15 arc-seconds over maximum range

6. Deviation in roll and yaw during operation ±15 arc-seconds