CR-184274

FWG

FINAL REPORT

Contract NAS8-37746

CHEMICAL HAZARDS DATABASE AND DETECTION SYSTEM FOR MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF)

FWG ASSOCIATES, INC.

"Continuity with the Future"

(NASA-CR-184274) CHEMICAL HAZARDS DATABASE AND DETECTION SYSTEM FOR MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF) Final Report (FWG Associates) 67 p CSCL 06K

N92-18927

Unclas

G3/54 0071423

Submitted to:

NASA Marshall Space Flight Center
Code EH32/Dr. R.T. Congo
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CHEMICAL HAZARDS DATABASE AND DETECTION SYSTEM FOR MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF)

October 14, 1991

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SECTION I, INTRODUCTION AND PROGRAM OVERVIEW

The Space Station Freedom (SSF) facility, as presently envisioned, will consist of a number of elements including manned modules, unmanned platforms, special structures and vehicles to provide for maneuvering and on-orbit transfer of hardware. The Station will accommodate a multitude of payloads located within the pressurized modules and node, or attached externally on the Station truss. The focus of this study is the payloads accommodated within the Station's pressurized modules.

To accomplish its on-orbit research objective the payloads will require a variety of resources. For example, each experiment/payload will require power to operate, a crewman to perform operational activities, input materials or samples, purge gases and/or liquids, etc. These represent only a small subset of the requirements for successful payload operation. The materials (i.e., samples, gases, consumables, cleaning materials, etc.) used by these payloads in many instances contain toxic chemicals which could create hazardous conditions for personnel and/or contamination of other onboard equipment if accidentally released in the Station. Therefore, to assure personnel safety and avoid any costly catastrophic system failures this chemical hazards database and detection system was developed to identify these hazardous conditions.

The system consists of a detailed listing of the chemicals (i.e., samples material, purge gases, cleaning materials, etc.) required by each payload. The system also contains detailed drawings or schematics of each facility with the potential sources from which the chemical substances could be accidentally released or spilled. Physical and chemical properties of each substance are provided and cross-referenced with each facility. The system consists of numerous application programs allowing the user to perform a variety of engineering analyses or to seek information about chemical properties, corrosivity, detection methods, etc.

These analyses can be performed on a user defined list of hazardous materials. This user defined list could be comprised of any of the following: (1) an individual chemical, (2) a specified list of chemicals, (3) the chemicals required by an individual payload or (4) the chemicals required by every payload in a defined mission set.

The Chemical Hazards Information System reported is developed to allow it to interface with existing NASA Space Station databases. Hazardous materials information obtained from chemical data base systems and from hard copy sources were provided by NASA[1]. This information was modified and formatted as needed, and incorporated with appropriate data base algorithms to provide a user friendly computer system for chemical hazards detection. Thus, the information is now readily available in a Space Station compatible format. The system will allow Space Station Design Engineers to perform numerous comprehensive analyses related to the hazardous materials associated with the many facilities and experiments being considered for deployment with the Space Station.

The present computer system including the hazardous materials information and video image processing systems, complete with a detailed User Operations Manual, was delivered to NASA/MSFC at the close of the contract.

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[1] Much of the technical material contained in the tables in this applications program was obtained from Material Safety Data Sheets (MSDSs) through a license agreement with NASA. It comes from various sources with the primary source being that developed by Occupational Health Services, Inc. Hard copies of these data sheets were provided by the MSFC Contracting Officer's Technical Representative (COTR). All of the original hard copies have been returned to the COTR. The data on these MSDSs were rearranged in a user friendly applications program designed to meet the specific needs of the COTR and the Space Station design engineers. This applications program is described in detail in the User's Operations Manual and is developed for use by NASA. There has been no other utilization of the material obtained from the MSDSs and FWG Associates, Inc. has only retained a copy for its contract records file.

SECTION II, CHEMICAL HAZARDS INFORMATION SYSTEM

The Chemical Hazards Information System (CHIS), whose description lies herein, was designed by FWG Associates as a means for the identification of potential contaminants from experiments performed onboard the Space Station. This computer system provides: (1) a current listing of the materials and/or chemicals of each of the proposed experiments/facilities; (2) information as to the contaminant's physical state; (3) a list of the quantity in grams or volume in liters for each possible contaminant; (4) a database of the toxicological hazards associated with each of the identified contaminants; (5) a means of rapid identification of the contaminants under operational conditions; (6) a means of identification of the possible failure modes and effects analysis related to the experiments; and (7) a fault-tree analysis so that potential hazardous operations of future experiments and chemicals can be identified. Easy to use, menu-driven programs provide fault-tree methods that allow nontechnical users to incorporate new chemicals and experiments and/or revise existing ones.

The system provided consists of one Dell System 310 personal computer with VGA color monitor, 80387-20 math co-processor, 5.25 360KB floppy disk drive, 5.25 1.2MB floppy disk drive, 90MB fixed disk drive, and Panasonic KX-P1524 dot matrix printer. Video imaging hardware and software provided by NASA/MSFC is also incorporated into the system and is fully described in Section III of this report.

The heart of CHIS consists of an off-the-shelf Relational Database Management System (RDMS). Many RDMS packages were evaluated for this task. Whereas selection of hardware was a relatively straightforward process since hardware is reasonably standard and is easily characterized by a few simple parameters, the selection of the database software was much more complicated. This is primarily due to the wide range of characteristics available in a database system which are not easily quantified.

FWG based its primary selection criteria upon the terms of the statement of work for this contract. The following is a list, not in any particular order, of the database package features that were initially determined to be desirable.

a) Must be a high performance database with respect to the current state-of-the-art.

b) Must allow easy interface to external processes including programs and modules developed in other high-level languages.

c) Must provide fourth generation language (4GL) support for the development of menus and forms.

d) Must provide easy set up and modification of the database structure.

e) The database should have the capability to import ASCII textual data files.

f) File and record sizes should only be limited by hardware restrictions (i.e. disk and memory sizes).

g) Database should be inherently user and developer friendly.

h) Customer support should be provided, promptly and professionally.

i) And of course, low cost for equivalent performance was a major criteria.

Initially the selection procedure consisted of reviewing brochures and magazines/journals which had already evaluated many database packages. It seemed to be obvious that PC databases fell into three categories and the selection would be based on which of the three categories would provide the desired type of system. At the low-level, there are many low priced but very limited packages such as "Caddylak Systems" for $130. None of these low level systems were considered. At the mid-range level there are many different possibilities. Systems such as Dbase, Fox, Rbase, and Paradox costing from $500 to $700 were considered for evaluation. At the high-level we have systems such as Oracle, Informix, MDBS, etc. costing from $700 to over $20000. Various selections from both the medium and high levels were evaluated.

Several months were spent in obtaining detailed information packages and demo diskettes for evaluation. The packages and diskettes were reviewed with NASA personnel to eliminate systems that did not meet minimum requirements.

Of the database systems initially evaluated Paradox 386 turned out to be rated highest with respect to the above mentioned criteria. This system fully utilized the 386 microprocessor, was very easy to program and was very compatible with many different forms of data format (including ASCII and Lotus 123 files). Paradox 386 turned out to be a very useful data transfer tool and greatly enhanced the formatting of vast amounts of Space Station related data. It had easy to follow programming instructions and application programs were developed with the Paradox Personal Programmer (PPROG) in the Paradox Application Language (PAL) to aid in the input of ASCII textual data files. However due to its lack of Space Station compatibility FWG Design Engineers realized in mid-1989 that Paradox would not meet the requirements needed to develop sophisticated Engineering Analysis Application Programs that would be compatible with existing NASA database systems.

In the NASA support environment, a system was required to be flexible enough to work on many types of computer systems. These systems include VAX, IBM mainframes and PCs, UNIX and DOS based systems. This was the main reason FWG Associates chose ORACLE as its Space Station solution in October 1989.

No RDMS provides more choices and is more open. It runs on virtually every PC, mini and mainframe, regardless of operating system, software or network. ORACLE's ability to handle massive amounts of data is unmatched. Flexible sorts and selection of specific data groups become easy; and straightforward command procedures accelerate data comparison and manipulation. Equally important, a wide variety of Oracle software tools can be mixed and matched as needed without compatibility problems.

The ORACLE RDMS and related Oracle software tools and products utilize the industry standard language, SQL, to define and manipulate data. SQL pronounced "sequel", is an English-like language consisting of several layers of increasing complexity and capability. End users with little or no experience in data processing can learn SQL's basic features very quickly, yet SQL provides DP professionals with the powerful and complete set of facilities they require.

The key difference between SQL and other data manipulation languages is that SQL is non-procedural. This means the user specifies operations in terms of *what* is to be done, rather than *how* to do it. For example, with a single command a user can update multiple rows in a database, without worrying about their location, storage format, and access path. SQL-based relational database systems take care of these system-level details and allow the user to concentrate on the data.

FWG fully utilized the advantages of the SQL programming environment and took SQL a step farther by designing a user-friendly menu structured interface for CHIS. SQL*Menu is a member of Oracle's integrated family of CASE and application development tools. The User Operations Manual will provide a thorough and descriptive explanation of how to use CHIS to its fullest potential.

For a more detailed description on the development of CHIS refer to Appendix A of this report.

SECTION III, VIDEO IMAGE PROCESSING SYSTEM

The Video Image Processing System (VIPS) has the capability to capture, store, and display video images. The images acquired by FWG and stored for retrieval currently on the VIPS include images of proposed modules of Space Station Freedom (SSF), images of various experiment racks housed inside these modules, and images of facilities. Included with the VIPS are some two thousand lines of C language program code, utilized by FWG to implement a user-friendly menu-type system driver that allows users to view the various images associated with SSF. Also delivered with the system is a video image database program. This will allow users at MSFC to digitize and store photographs on the system. This feature can also be used by NASA/MSFC personnel to enhance various inventory and equipment tracking tasks for multiple programs such as SSME, ET, and SRB.

The Video Image Processing System was delivered to FWG Huntsville Operations during the month of March, 1990. The system consisted of a JVC color video camera, Mitsubishi color monitor and a black & white frame grabber board from Data Translation along with the associated wiring and cables. In order for the system to have the capability of tracking individual components via color, the black & white frame grabber board was exchanged through Data Translation for a color board. This necessitated additional funding support by NASA. The color board was delivered and installed during the last week in May.

The VIPS utilizes the image handling and graphics capabilities of the C programming language. Over two thousand lines of C code are used for the capturing, storing and display of numerous images related to Space Station Freedom. Many of these images were obtained when FWG Design Engineers visited the SSF mock-up located at Marshall Space Fight Center in Alabama.

Schematics for approximately 50 potential Space Station payloads have been obtained from various sources. These payload schematics/drawings range in detail from single or multiple line drawings of the payload to detailed schematics of the electrical system and even actual photographs of some hardware items. Additionally, the Space Station Stage Summary Databook was obtained to provide schematics of the Space Station during the build-up sequence and to identify the payloads which have been manifested to each flight increment.

Appendix B contains a listing of the C code developed by FWG Associates, Inc. to facilitate the handling of various SSF images. Appendix C contains some of the SSF images captured and stored by the VIPS. These images are also available in VIPS for viewing purposes.

SECTION IV, THE DETECTION SYSTEM

Through research and discussions with cognizant NASA representatives, FWG has classified the possible contaminants into four main groups. Each of these groups will require a specific detection method. The four groups are identified as: (1) metal vapors and aerosols; (2) organic solvents and fuels; (3) gases and combustion products; (4) etchants and carbon monoxide.

The major contaminants associated with the first group, metal vapors and aerosols include, but are not limited to, the following:

aluminum
arsenic
beryllium
cadmium
copper
gallium
gallium arsenide
germanium
indium
iron
mercury
nickel
niobium
silicon
tantalum
tellurium
tungsten

Contaminants in the second (organic solvents and fuels) and third (gases and combustion products) groups include, but are not necessarily limited to the substances listed below.

acentonitrile
acetone
acetylene
argon
benzene
butane
carbon dioxide
carbon tetrachloride
chlorodifluoromethane
dimethyl formamide
dimethyl sulfoxide
ethanol
glutaraldehyde
helium
heptane

hydrogen
kerosene
methane
methanol
methyl ethyl keytone
nitrogen
oxygen
propane
sodium azide
toluene
trichlorotrifluoroethane
xylene

The fourth group of identified contaminants includes carbon monoxide as well as the following etchants:

hydrofluoric acid
hydrogen bromide
hydrogen chloride
nitric acid
perchloric acid
potassium hydroxide
sodium hydroxide
sulfuric acid

In order to identify potential contaminants under operational conditions FWG has identified chemical detection methodologies for each of the four classes of materials addressed above.

FWG recommends that graphite furnace atomic absorption spectrographic instrumentation be used for the immediate detection of metal vapor and aerosol contaminants. Appropriate sampling methodologies and sampling locations must be utilized. It is also recommended that gas chromatography/mass spectrometry based instrumentation be used for the detection of organic solvents and fuels. Mass spectrometers should also be used for the detection of gases and combustion products in the modules. However, for the detection of etchants and carbon monoxide, Fourier transform based infrared spectrometers should be used in conjunction with carbon monoxide analyzers. FWG further recommends the purchase of an additional off-the-shelf database called ChemTox for specific analytical chemical detection methodologies. FWG just recently became aware of the ChemTox database capability and has only seen a copy of a demonstration disc. Although only a brief review was available from a demo, ChemTox contains valuable information.

SECTION V, CONCLUSIONS AND RESULTS

In the development and testing of the CHIS numerous analyses were performed by FWG Engineers pertaining to the facilities and experiments proposed for SSF and their associated hazardous materials. In some cases the number of potential hazardous conditions was reduced considerably by substituting different materials for various cleaning fluids and lubricants.

However, the results of these analyses show that all potential safety problems for the SSF laboratory can not be completely eliminated through simple chemical substitutions. Additional modeling analyses are required to track the location and quantity of each chemical in the module to assure that incompatible chemicals do not come in contact. Furthermore, methods of decontamination and clean up procedures must be developed and evaluated for effectiveness on-orbit.

The system outlined in this section, and recommended by FWG, will identify and analyze potential safety problems by (1) identifying alternative procedures to hazardous operations where applicable, (2) identifying decontamination methods, should an accident occur, (3) tracking the location and quantity of all chemicals (samples, by-products, wastes, etc.) in the module, (4) identifying the location of chemical hazards (i.e., glovebox, PMMS, etc.) so that alternative procedures can be developed and (4) simulating the flow of contaminants from any point within the module, (i.e., simulate a spill from the glovebox) to aid in identifying optimum placement of vents and filters.

FWG recommends the development and implementation of a SSF Decontamination and Failure/Flow Simulation model possessing the following capabilities:

(1) Identify methods of decontamination and clean-up procedures for the chemical safety problems identified.

(2) Couple the data base with expert system and application programs (as applicable), schedule on-orbit operations and track usage of the chemicals in the module.

(3) Develop a payload failure simulation model and predict the flow of contaminants from any failure site in the module.

These capabilities will provide an array of additional engineering analyses and design tools, such as:

- Scheduling the on-orbit operations of the payloads and tracking the usage of the chemicals during operations. The model will identify when and where a chemical incompatibility exists. For example, a furnace may be required to vent a purge gas into the PMMS system at the same time another facility is venting a cleaning material into the system, which would cause a hazard. Additionally, the model would track chemicals utilized in the glovebox and in the characterization and support equipment. Particles left in the glovebox from etching may be hazardous to the characterization operations of another experimenter utilizing the glovebox at a later time.

- Identifying ways of cleaning up and decontaminating the laboratory or equipment for each hazard encountered.

- Implementing a payload failure simulation model and predicting the flow of contaminants in the laboratory module by modeling the current design of the air flow system will allow designers to identify the optimum location for floor and ceiling vents and to route the flow of air in the module to minimize the spread of contaminants. Additionally, it will identify optimum sensor locations within the module.

FWG believes that the development and implementation of a SSF Decontamination and Failure/Flow Simulation model possessing the above outlined capabilities is the most cost effective means of developing a safe and productive humanly inhabitable extended orbit space facility.

APPENDIX A

DETAILED STRUCTURE OF CHIS

The identification of experiment contaminants is of paramount importance to the safety of the Space Station. In order to meet this challenge, the Marshall Space Flight Center authorized the development of a Chemical Hazards Data Base and Detection System for the Space Station. This system will rapidly and quantitatively display hazardous compound information from the experiments onboard the Space Station. The system will consist of (1) a data base of proposed flight experiments with their on-orbit chemical constituents and (2) an image processing system which will graphically display the Space Station Freedom, and individual experiments within the U.S. Laboratory module. This system will allow a user to identify a particular facility located on the Station and display physical and chemical constituents of the facility as well as detailed drawings or schematics. Chemical hazards and any impending danger associated with the experiment will also be displayed.

The structure of the Chemical Hazards Information System was developed utilizing ORACLE data base software. The system currently consists of over 60 tables which have been classified into three groups; (1) user specified tables, (2) tables developed to implement the ORACLE application programs (i.e. perform chemical incompatibility, imminent hazards and corrosivity analysis) and (3) tables which contain data/information related to the materials chemical and physical properties and those chemical attributes found in the MSDS files. The following information provides a detailed listing and data description definition of each table (Reference: R. Congo - personal communication).

Table: SCENAR01, SCENAR02, ... SCENAR12

General Table Description: Tables which contain pre-defined mission sets for analysis. The mission sets were identified by the MMPF study for Space Station operations from IOC to PMC.

These twelve pre-defined scenarios are made up of the following facilities.

Scenario Number	Facilities
1	Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Critical Point Phenomena Facility Electroepitaxy Facility Protein Crystal Growth Facility Vapor Crystal Growth Facility
2	Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Critical Point Phenomena Facility Electroepitaxy Facility Protein Crystal Growth Facility Solid Surface Burning Facility Vapor Crystal Growth Facility
3	Acoustic Levitation Facility Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Droplet/Spray Burning Facility Electroepitaxy Facility Protein Crystal Growth Facility Solid Surface Burning Facility Vapor Crystal Growth Facility

Scenario Number	Facilities
4	Acoustic Levitation Facility Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Droplet/Spray Burning Facility Electroepitaxy Facility Protein Crystal Growth Facility Rotating Spherical Convection Facility Solid Surface Burning Facility Vapor Crystal Growth Facility
5	Acoustic Levitation Facility Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Electroepitaxy Facility Protein Crystal Growth Facility Rotating Spherical Convection Facility Solid Surface Burning Facility Vapor Crystal Growth Facility
6	Acoustic Levitation Facility Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Electroepitaxy Facility Fluid Physics Facility Protein Crystal Growth Facility Rotating Spherical Convection Facility Vapor Crystal Growth Facility
7	Acoustic Levitation Facility Alloy Solidification Facility Bridgman, Small Facility Continuous Flow Electrophoresis Facility Electromagnetic Levitator Facility Fluid Physics Facility Premixed Gas Combustion Facility Rotating Spherical Convection Facility Vapor Crystal Growth Facility

Scenario Number	Facilities
8	Acoustic Levitation Facility Alloy Solidification Facility Continuous Flow Electrophoresis Facility Electromagnetic Levitator Facility Fluid Physics Facility Organic & Polymer Crystal Growth Facility Premixed Gas Combustion Facility Rotating Spherical Convection Facility
9	Alloy Solidification Facility Electromagnetic Levitator Facility Fluid Physics Facility Isoelectric Focusing Facility Latex Reactor Facility Organic & Polymer Crystal Growth Facility Premixed Gas Combustion Facility
10	Electrostatic Levitator Facility Electromagnetic Levitator Facility Fluid Physics Facility Isoelectric Focusing Facility Latex Reactor Facility Organic & Polymer Crystal Growth Facility
11	Bioreactor Incubator Facility Electromagnetic Levitator Facility Fluid Physics Facility High Temperature Furnace Facility Isoelectric Focusing Facility Latex Reactor Facility Organic & Polymer Crystal Growth Facility
12	Bioreactor Incubator Facility Electromagnetic Levitator Facility High Temperature Furnace Facility Isoelectric Focusing Facility Latex Reactor Facility Organic & Polymer Crystal Growth Facility

The following table descriptions define the structure for each of the facilities.

Table Name	Table Description
ALF	List of chemicals for the Acoustic Levitator Facility
ASF	List of chemicals for the Alloy Solidification Facility
BIF	List of chemicals for the Bioreactor/Incubator Facility
BSF	List of chemicals for the Bridgman, Small Facility
CFEF	List of chemicals for the Continuous Flow Electrophoresis Facility
CPPF	List of chemicals for the Critical Point Phenomena Facility
DSBF	List of chemicals for the Droplet/Spray Burning Facility
EF	List of chemicals for the Electroepitaxy Facility
ELF	List of chemicals for the Electrostatic Levitator Facility
EMF	List of chemicals for the Electromagnetic Levitator Facility
FPF	List of chemicals for the Fluid Physics Facility
HTF	List of chemicals for the High Temperature Facility
IFF	List of chemicals for the Isoelectric Focusing Facility
LRF	List of chemicals for the Latex Reactor Facility
OPCGF	List of chemicals for the Organic & Polymer Crystal Growth
PGCF	List of chemicals for the Premixed Gas Combustion Facility
PCGF	List of chemicals for the Protein Crystal Growth Facility
RSCF	List of chemicals for the Rotating Spherical Convection Facility
SSBF	List of chemicals for the Solid Surface Burning Facility
VCGF	List of chemicals for the Vapor Crystal Growth Facility

These listed facilities are all incorporated into the system. When new facilities are defined and need to be analyzed the user defined chemical lists can be used. The chemicals associated with each of the listed facilities are listed below. This chemicals/facility listing was obtained by personal communication with Dr. R.T. Congo, NASA/MSFC.

Space Station Facility	Chemicals Required During On-Orbit Operations
Acoustic Levitator	Argon
	Calcium Oxide
	Ga_2O_3
	Germanium Dioxide
	Helium
	Silicon
	Silicon Dioxide
Alloy Solidification	Acetone
	Air
	Aluminum-Copper
	Aluminum-Lead-Bismuith
	Aluminum Alloys
	Argon
	Ethanol
	$FeCl_3$ $6H_2O$
	Hydrochloric Acid
	Lapping Oil
	Levitated Aluminum
	Nickel Alloys
	Nitric Acid
	Silicon-Arsenide-Tellurium
	Sodium Hydroxide
	Water
Bioreactor/Incubator	Carbon Dioxide
	Cell Medium
	Cells
	Ceramic Beads
	Glass Beads
	Glutaraldehyde
	Oxygen
	Sodium Chloride
	Sodium Hydroxide
	Sodium Nitrate
	Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Bridgman, Small	Acetone Aluminum-Lead-Bismuith Argon Ethanol Cadmium Telluride Acetic Acid Diamond Paste Gallium Arsenide Germanium Hydrogen Peroxide Hydrofluoric Acid Hydrochloric Acid Indium-Gallium-Arsenide Lapping Oil Mercury-Cadmium-Telluride Nitric Acid Lead-Tin-Telluride Selenium Silicon-Carbon Silicon Sodium Hydroxide Sulfuric Acid Water Zinc-Selenium
Continuous Flow Electrophoresis	Biological Raw Material Buffer Solution Glutaraldehyde Sodium Nitrate Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Critical Point Phenomena	Argon Nitrogen Hydrogen Helium Liquid Helium-4 Liquid Helium Liquid Hydrogen Liquid Neon Liquid Nitrogen Liquid Propane Liquid Xenon Neon Propane
Droplet/Spray Burning	Air/Fuel Combustible Products Argon Cabin Air Carbon Dioxide Decane Detergent/Water Dilute Water Fuel Oil Helium Heptane Hexadecane Kerosene Methanol Nitrogen Oxygen Solid Combustible Products

Space Station Facility	Chemicals Required During On-Orbit Operations
Electrostatic Levitator	Acetone
	Air
	Argon
	Calcium Oxide
	Diamond Paste
	Ga2O3
	Germanium Dioxide
	Hydrofluoric Acid
	Nitric Acid
	Lapping Oil
	Silicon
	Silicon Dioxide
	Water
Electroepitaxy	Cadmium Telluride
	Gallium Arsenide
	Germanium
	Nitrogen
	Hydrogen
	Indium-Gallium-Arsenide
	Indium-Antimony
	Mercury-Cadmium-Telluride
	Lead-Tin-Telluride
	Selenium
	Silicon-Carbon
	Silicon

Space Station Facility	Chemicals Required During On-Orbit Operations
Electromagnetic Levitator	Acetone Argon Cadmium Telluride Calcium Oxide Chromium Oxide Dehumidified Air Diamond Paste Ga2O3 Gallium Arsenide GeO2 Helium Hydrofluoric Acid Nitric Acid Lapping Oil Silicon Silicon Dioxide Silver Nitrate Water
High Temperature, Furnace	Air Argon C3H8O3 Carbon Monoxide Chromium Iron-Nickel Water Hydrogen Peroxide Helium Hydrofluoric Acid Nitric Acid Hydrochloric Acid NHNO3 Nickel Alloys Nitrogen-Tungsten Sodium Hydroxide Titanium-Carbon

Space Station Facility	Chemicals Required During On-Orbit Operations
Fluid Physics	Air Ammonium Chloride Argon Carbon Dioxide Acetic Acid Copper Sulfate CuSO4 Decane Ethanol Freon 113 Hydrogen Sulfuric Acid Helium Mercury-Iodine Iodide Methane Methanol Methyl Iodide Ammonium Oxygen Potassium Chloride SiH4 Silane Silicon Oils TGS
Isoelectric Focusing	Acetic Acid Acid Violet 17 Acids Amine Ampholyte Bases Biological Raw Material *Biomaterial* Fat Red 7B Glutaraldehyde Hydrogen NaO3 Oxygen Phosphoric Acid Sodium Hydroxide Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Latex Reactor	Aluminum Salt AMBN Process Initiator Seed Latex Silicon Salt Styrene (Monomer) Water
Organic & Polymer Crystal Growth	Acetonitrile Argon Buffer Solution CH3CN Cleaning Fluids Copper Phthalocyanine Cyanide Tosylate Nitrogen Helium *Methanol* Naphthalene Polydiacetylene Tetraethyl Ammonium Chloroform Toluene Urea Water Xenon
Premixed Gas Combustion	Air/Fuel Combustible Products Ammonia Argon Butane Cabin Air Carbon Dioxide Detergent/Water Ethane Helium Heptane Hexane Hydrogen Methane Nitrogen Propane Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Protein Crystal Growth	2-(N-Cyclohexylamino)Ethanesulfonic Acid
	2-(N-Monpholine)EthaneSulphonic Acid
	2-Methyl-2,4-Pentanediol
	3-Nitropropionate
	Acetic Acid
	Ammonium Hydroxide
	C-Reactive Protein
	Canavalin
	Dithiothreitol
	Ethylenediamine Tetra Acetate
	Glutathione
	Glutaraldehyde
	Human Purine
	Human Serum Albumin
	Isocitrate Lyase
	Magnesium Acetate
	Monobasic Sodium Phosphate
	Nitrogen
	Peptide
	Percine Elastase
	Phospholipase
	Polyethylene Glycol
	Potassium Chloride
	R Interferon
	Renin
	Sodium Acetate
	Sodium Azide
	Sodium Chloride
	Sodium Citrate
	Sodium Sulfate
	Tris (Hydroxymethyl) Aminomethane
	Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Rotating Spherical Convection	(CH3)2CHOH Carbon Tetrachloride CH2Cl3 CH3CHO CH3CN CH3OSO2OCH3 Chlorobenzene Chloroform Cyclohexanol Cyclohexanone Dimethylindolinobenzoprylospiran Ethylene Glycol Formic Acid Nitrogen HCOOH HOCH2CH2OH Isopropyl Alcohol M-Tolunitrile Malachite Levocyanide Nitrogen Water
Solid Surface Burning	Argon Cabin Air Decane Detergent/Water Dilute Water Fuel Oil Helium Heptane Hexadecane Kerosene Methanol Nitrogen Solid Combustible Products Water

Space Station Facility	Chemicals Required During On-Orbit Operations
Vapor Crystal Growth	Air Argon Bromide Ethanol Cadmium Selenide Cadmium Telluride CH3OH CRO3 Gallium Arsenide Germanium Hydrogen Peroxide Sulfuric Acid Hydrochloric Acid Indium Phosphorus Mercury Cadmium Telluride Selenium Silicon-Carbon Silicon Sodium Hydroxide Water Zinc-Tellurium

Menu driven, user friendly programs and forms are included in the system that will allow input of additional chemical data by the user. Instructions for the input of data will be included in the User Operation's Manual.

Also incorporated in the CHIS in an incompatibility analysis that identifies those materials which are incompatible with the material(s) specified by the user (i.e. individual chemicals, lists of chemicals, chemicals required by an individual payload or chemicals required by multiple payloads in a mission set). The analysis identifies the materials which are incompatible and the reason for the incompatibility (i.e. explosion, fire, etc.). The impending hazards analysis takes the incompatibility analysis one step further by cross referencing the incompatible chemicals with those chemicals specified by the user for analysis (i.e. list of chemicals, chemicals required by an individual payload or chemicals required by the payloads in a mission set). The intersection of this cross reference identifies the Impending Hazards. The Corrosivity analysis may be performed on metals or non-metals. Both analyses identify the chemicals which are corrosive with the specified chemical(s) and the various temperature and concentration ranges for the corrosivity.

APPENDIX B

C CODE LISTING OF IMAGE PROCESSING ROUTINES

The following is a program listing of the C code routines developed by FWG to display the stored images of Space Station Freedom.

```
/*****************************************************************
*
*                    Space Station Image Processing Program
*
*****************************************************************
#include     <stdio.h>
#include     "auerrs.h"
#include     "audefs.h"
#include     <graph.h>

#define ON          1
#define OFF         0
#define EXTERNAL    1
#define INTERNAL    0

main ()

{
   int    status;                    /*AURORA Library return status*/
   int    loc;
   int    pl;
   int    sl;
   char   file_name[80];

/* Display Introductory Screen */

_remappalette(0, _BLUE);
_remappalette(7, _LIGHTYELLOW);

/* Initialization */
status=au_err_msgs (ON);            /*enable display of AURORA error
messages*/
status=au_init ();                  /*initalize AURORA resources*/
status=au_display (ON);             /*enable the display*/
status=au_buf_clear(0);             /*clear buffers*/
status=au_buf_clear(1);
status=au_buf_clear(2);
status=au_buf_clear(3);

/* Display Intro Picture */
status=au_set_sync(INTERNAL);
status=au_display(OFF);
status=au_restore (0,0,0,"INTRO.img");
status=au_display (ON);
```

```
printf("\n\n");
printf("                              Space Station Freedom Image
Processing\n");
printf("                                   Hazards Identification
System\n\n\n\n\n");
printf("                             Developed for:\n\n");
printf("                       Marshall Space Flight Center\n");
printf("                          Analytical & Physical Chemistry
Branch\n\n\n\n\n");
printf("                             Developed by:\n\n");
printf("                          FWG Associates, Inc.\n");
printf("                   Space Science and Applications Division");
printf("\n\n\n\n\n");

_settextposition(50,25);
_outtext(" Press 'C' to continue   ");
getch();

/* Display Screen to Select Module */

start: printf("\n\n\n\n\n\n\n\n\n\n");
printf("                     Space Station Payload/Facility Location
\n\n");
printf("                            1) U.S. Laboratory Module\n");
printf("                            2) ESA Columbus Module\n");
printf("                              3) Japanese Experiment Module
(JEM)\n");
printf("                            4) U.S. Habitation Module\n");
printf("                            5) Resource Node \n");
printf("                            6) Exit System \n");
printf("\n\n\n\n\n\n\n\n\n");

/* Display Space Station Picture */

status=au_set_sync(INTERNAL);
status=au_display(OFF);
status=au_restore (0,0,0,"ss.img");
status=au_display (ON);

_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &loc);

/* Display Screen of Selected Location */

if (loc == 6) { goto end; }

status=au_set_sync(INTERNAL);
status=au_display(OFF);

if (loc == 1) {
printf("\n\n\n\n\n\n\n");
printf("                           Space Station Payload/Facility
Listing\n\n");
```

```
printf("                                    1) Acoustic Containerless
Processing\n");
printf("                           2) Advanced Modular Furnace\n");
printf("                            3) Continuous Flow Electrophoresis
System\n");
printf("                           4) Droplet Spray Burning\n");
printf("                         5) Directional Solidification Furnace
\n");
printf("                           6) Float Zone Crystal Growth\n");
printf("                           7) Isoelectric Focusing\n");
printf("                           8) Optical Fiber Pulling\n");
printf("                           9) Protein Crystal Growth\n");
printf("                          10) Solution Crystal Growth\n");
printf("                          11) Solid Surface Burning\n");
printf("                          12) Vapor Crystal Growth\n");
printf("                          13) Previous Menu \n");
printf("\n\n\n");

   status=au_restore (0,0,0,"SS-B.img");
   status=au_display (ON);

_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &pl); }

if (loc == 2) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("Photo not Available ");
     status=au_buf_clear(0);
     status=au_buf_clear(1);
     status=au_buf_clear(2);
     status=au_buf_clear(3);
   status=au_restore (0,0,0,"PNA.IMG");
   status=au_display (ON);
_settextposition(30,25);
_outtext("Press 'C' to Continue  ");
getch();
   goto start; }

if (loc == 3) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("Photo not Available ");
     status=au_buf_clear(0);
     status=au_buf_clear(1);
     status=au_buf_clear(2);
     status=au_buf_clear(3);
   status=au_restore (0,0,0,"PNA.IMG");
   status=au_display (ON);
_settextposition(30,25);
_outtext("Press 'C' to Continue  ");
getch();
   goto start; }
```

```
if (loc == 4) {
printf("\n\n\n\n\n\n\n");
printf("                              Space  Station  Payload/Facility
Listing\n\n");
printf("                                   1)  Acoustic  Containerless
Processing\n");
printf("                           2) Advanced Modular Furnace\n");
printf("                            3) Continuous Flow Electrophoresis
System\n");
printf("                           4) Droplet Spray Burning\n");
printf("                         5) Directional Solidification Furnace
\n");
printf("                           6) Float Zone Crystal Growth\n");
printf("                           7) Isoelectric Focusing\n");
printf("                           8) Optical Fiber Pulling\n");
printf("                           9) Protein Crystal Growth\n");
printf("                          10) Solution Crystal Growth\n");
printf("                          11) Solid Surface Burning\n");
printf("                          12) Vapor Crystal Growth\n");
printf("                          13) Previous Menu \n");
printf("\n\n\n");

   status=au_restore (0,0,0,"SS-B.img");
   status=au_display (ON);

_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &pl); }

if (loc == 5) {
printf("\n\n\n\n\n\n\n");
printf("                              Space  Station  Payload/Facility
Listing\n\n");
printf("                                   1)  Acoustic  Containerless
Processing\n");
printf("                           2) Advanced Modular Furnace\n");
printf("                            3) Continuous Flow Electrophoresis
System\n");
printf("                           4) Droplet Spray Burning\n");
printf("                         5) Directional Solidification Furnace
\n");
printf("                           6) Float Zone Crystal Growth\n");
printf("                           7) Isoelectric Focusing\n");
printf("                           8) Optical Fiber Pulling\n");
printf("                           9) Protein Crystal Growth\n");
printf("                          10) Solution Crystal Growth\n");
printf("                          11) Solid Surface Burning\n");
printf("                          12) Vapor Crystal Growth\n");
printf("                          13) Previous Menu \n");
printf("\n\n\n");

   status=au_restore (0,0,0,"SS-INT.img");
   status=au_display (ON);
```

```
_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &pl); }


/* Display Payload Subsystem Screen */

status=au_set_sync(INTERNAL);
status=au_display(OFF);

payload: if (pl == 13) { goto start; }

if (pl == 1) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 2) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 3) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 4) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 5) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
```

```
getch();
 goto menu1; }

if (pl == 6) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 7) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (pl == 8) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

pcg: if (pl == 9) {
status=au_set_sync(INTERNAL);
status=au_display(OFF);
     status=au_buf_clear(0);
     status=au_buf_clear(1);
     status=au_buf_clear(2);
     status=au_buf_clear(3);
     status=au_restore (0,0,0,"pcg.img");
     status=au_display (ON);
printf("\n\n\n\n\n\n\n\n\n\n\n");
printf("                                Protein Crystal Growth Subsystems
\n\n");
printf("                                 1) Control Unit/Recorder\n");
printf("                                 2) Cell Holder \n");
printf("                                 3) Cell Modules \n");
printf("                                 4) Heating/Cooling Equipment\n");
printf("                                 5) Video Equipment Access\n");
printf("                                 6) Utilities Access\n");
printf("                                 7) Previous Menu \n");
printf("\n\n\n\n\n\n");
_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &s1); }
```

```
if (s1 == 1) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n");
printf("   The Data Recorder and Environmental Control unit (DREC)
\n");
printf(" contains a microprocessor circuit board which can be
programmed\n");
printf(" on orbit, a key pad, an LCD readout and an enunicator
panel for\n");
printf(" interaction with the astronaut; a data recording unit to
read \n");
printf(" and store run data and relay the data to the ground; an
\n");
printf(" electrically driven heat pump for heating and cooling;
fans \n");
printf(" for air handling; regulation equipemnt to ensure low
pressure \n");
printf(" purging; and vibration and sound damping hardware.
\n\n\n\n\n");
printf("                    Schematic of DREC unit not available
\n\n\n\n\n\n\n");
     status=au_display(OFF);
     status=au_restore (0,0,0,"pna.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 2) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("   Cell Holder  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"ch.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,20);
_outtext("Cell Drawer Configuration Plan View  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"cd.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("Cell Configuration Cross Section View  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"ccs.img");
     status=au_display (ON);
_settextposition(50,25);
```

```
_outtext(" Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 3) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("  Cell Module Layout  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"ml.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext(" Cell Module Layout Close Up 1  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"ml1.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext(" Cell Module Layout Close Up 2  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"ml2.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext(" Module Layout Cross Sections  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"mls.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,25);
_outtext("Typical Module Configurations  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"tmc.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext("  Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,20);
_outtext("Typical Module Configuration Close Up 1  ");
     status=au_display(OFF);
```

```
     status=au_restore (0,0,0,"tmc1.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext("  Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,20);
_outtext("Typical Module Configuration Close Up 2  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"tmc2.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext("  Press 'C' to Continue    ");
getch();
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,20);
_outtext("Typical Module Configuration Close Up 3  ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"tmc3.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext("  Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 4) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,9);
_outtext("Schematic for Heating and Cooling Equipment Not Available
");
     status=au_display(OFF);
     status=au_restore (0,0,0,"pna.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 5) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,20);
_outtext("Access to Hand Held CCD Color Camera ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"cam.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 6) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,9);
_outtext("Schematic  of  Space  Station  Utility  Interface  Not
```

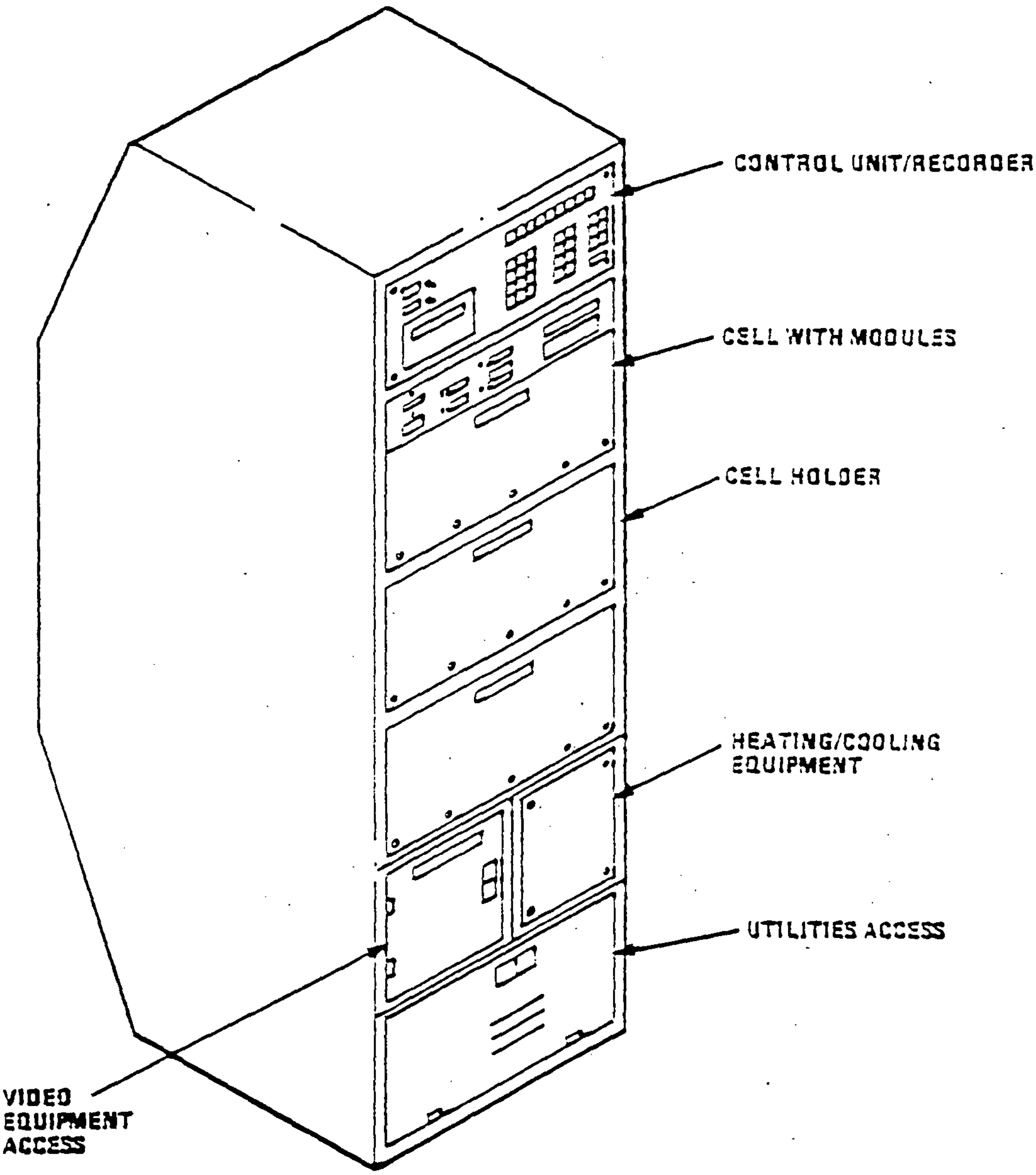
```
Available ");
     status=au_display(OFF);
     status=au_restore (0,0,0,"pna.img");
     status=au_display (ON);
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
     goto pcg; }

if (s1 == 7) {
menu1: printf("\n\n\n\n\n\n\n");
printf("                                Space  Station  Payload/Facility
Listing\n\n");
printf("                                     1)  Acoustic  Containerless
Processing\n");
printf("                            2) Advanced Modular Furnace\n");
printf("                             3) Continuous Flow Electrophoresis
System\n");
printf("                            4) Droplet Spray Burning\n");
printf("                          5) Directional Solidification Furnace
\n");
printf("                            6) Float Zone Crystal Growth\n");
printf("                            7) Isoelectric Focusing\n");
printf("                            8) Optical Fiber Pulling\n");
printf("                            9) Protein Crystal Growth\n");
printf("                           10) Solution Crystal Growth\n");
printf("                           11) Solid Surface Burning\n");
printf("                           12) Vapor Crystal Growth\n");
printf("                           13) Previous Menu \n");
printf("\n\n\n");

status=au_set_sync(INTERNAL);
status=au_display(OFF);

_settextposition(50,25);
_outtext("Enter your Selection  -  ");
scanf ("%d", &p1);
goto payload; }

if (p1 == 10) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

if (p1 == 11) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived  ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
```

```
getch();
 goto menu1; }

if (pl == 12) {
printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,15);
_outtext("   Images for this Payload are Archived   ");
_settextposition(50,25);
_outtext(" Press 'C' to Continue    ");
getch();
 goto menu1; }

end: printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n");
_settextposition(10,7);
_outtext("  Leaving Space Station Payload Image Processing System
");
printf("\n\n\n\n\n");

status=au_display (OFF);                          /*turn display off*/

au_end ();                                               /*release AURORA
resources*/
```

APPENDIX C

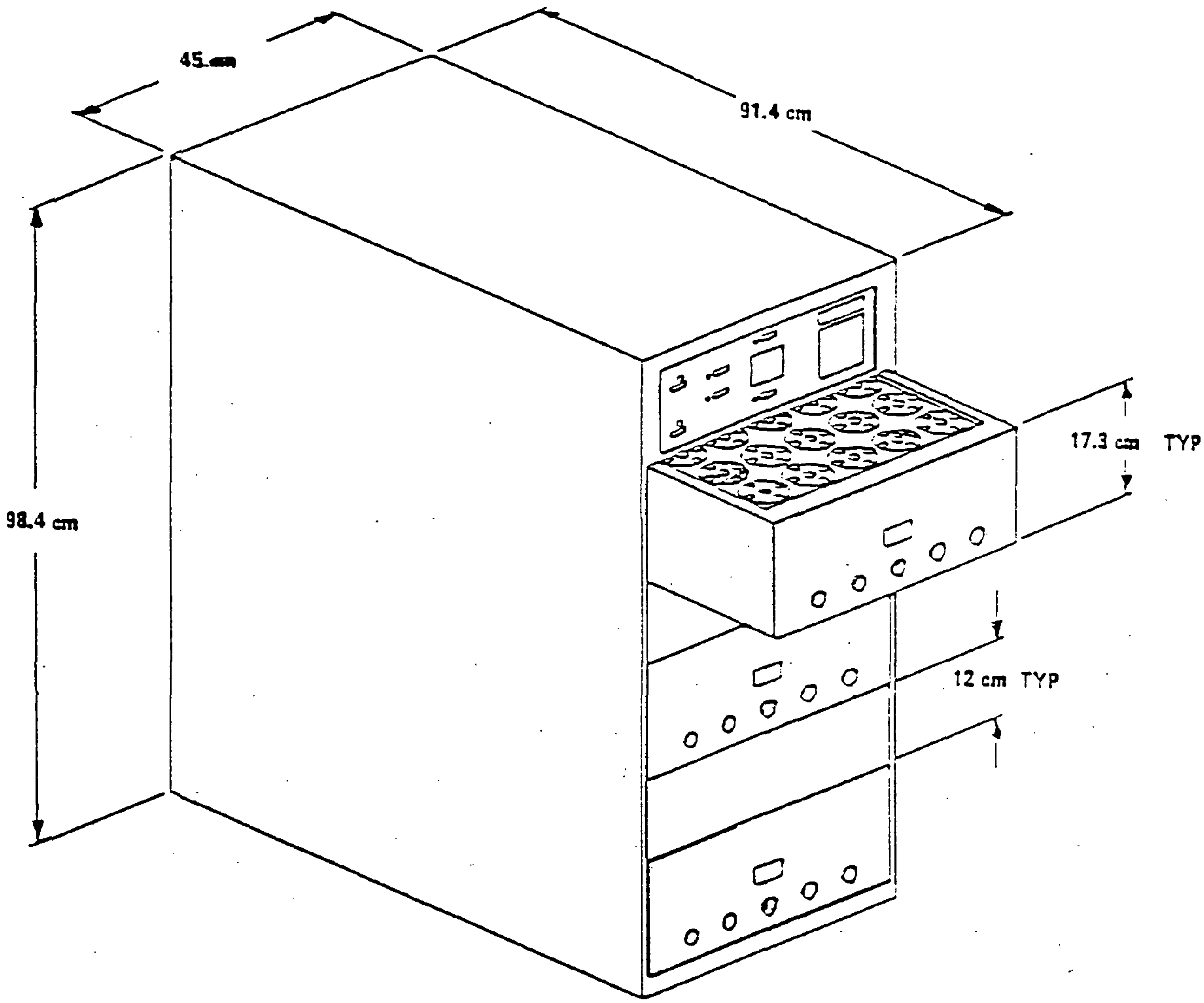
IMAGES AND INFORMATION RELATED TO SSF FACILITIES

The contents of this appendix consist of various images of SSF modules and facilities along with related equipment. All Space Station related figures presented in Appendix C were provided courtesy of NASA.

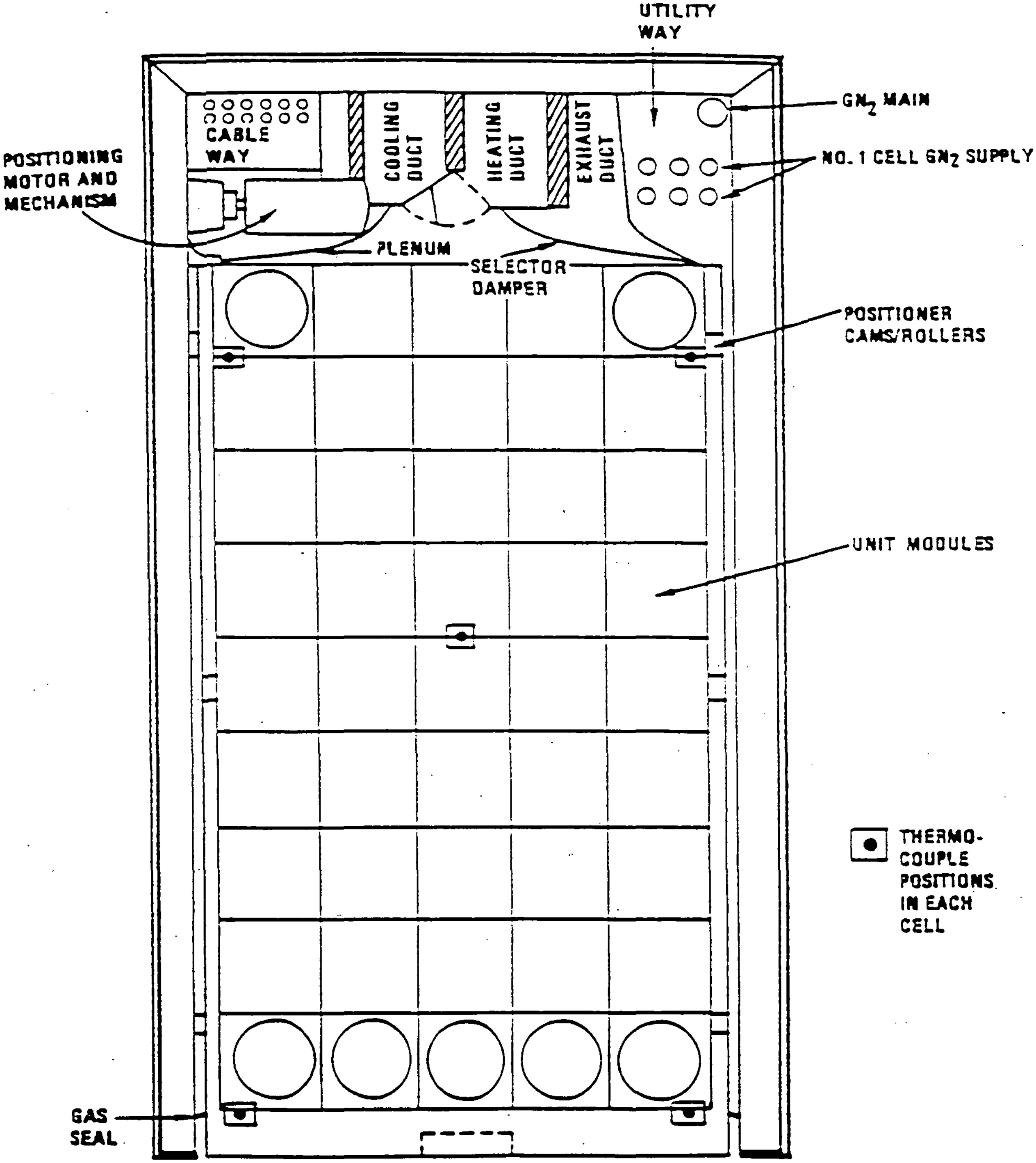


PROTEIN CRYSTAL GROWTH FACILITY OVERVIEW

(courtesy of NASA)

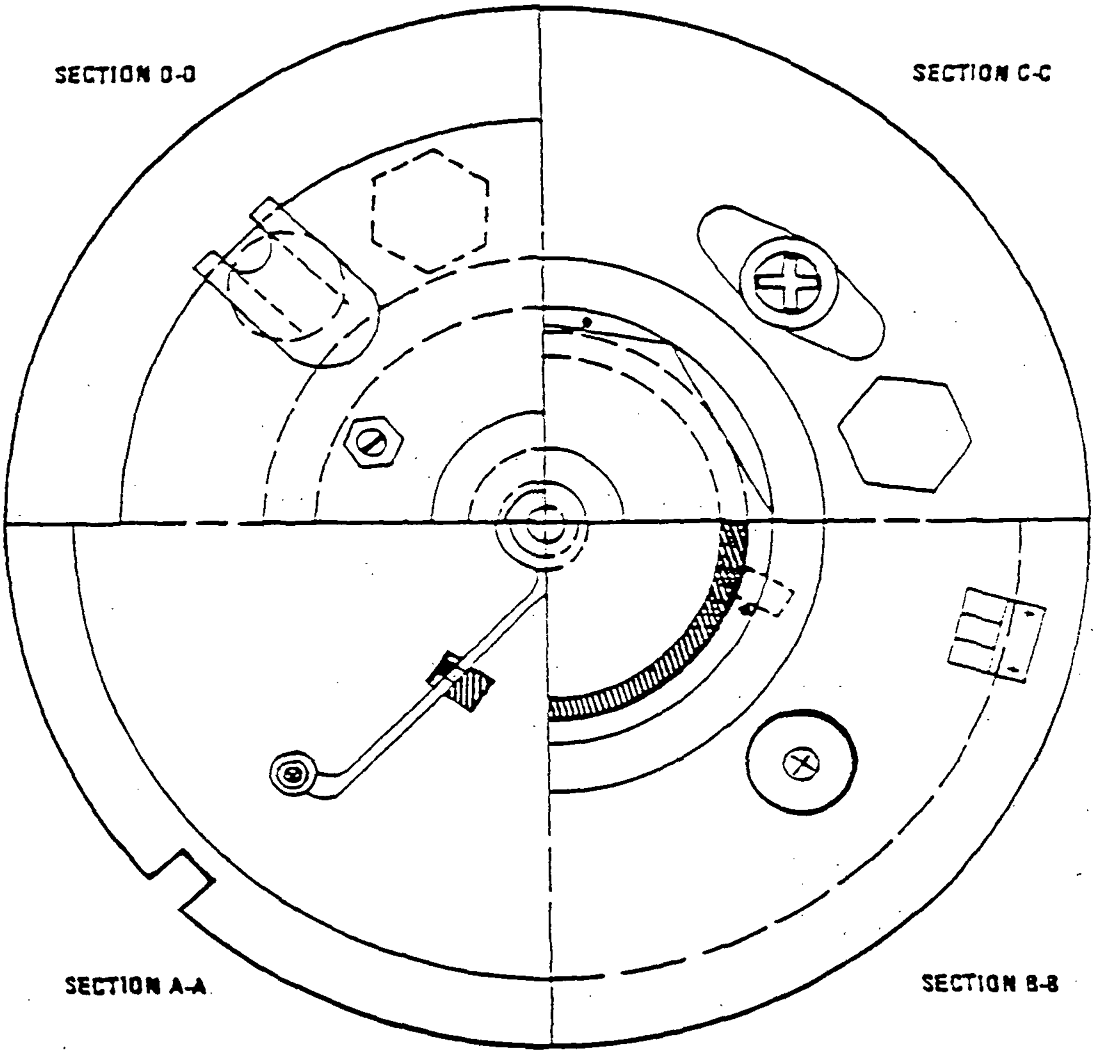


PROTEIN CRYSTAL GROWTH FACILITY CELL HOLDER
(courtesy of NASA)



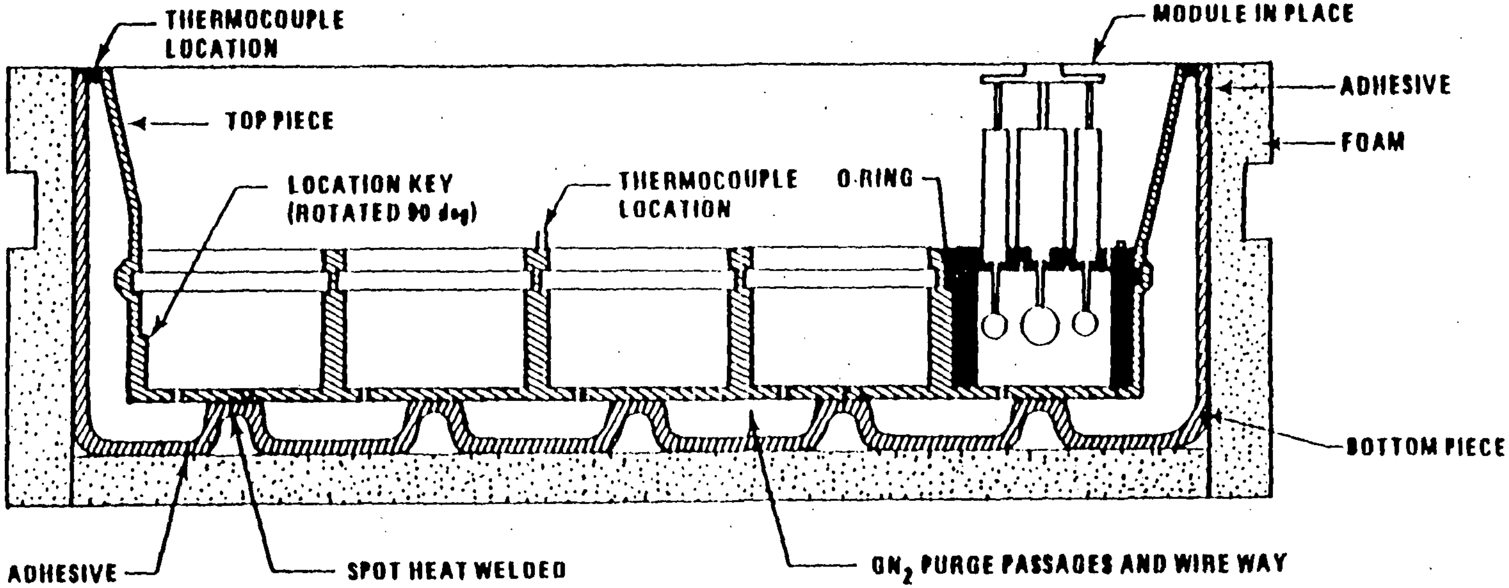
CELL/DRAWER CONFIGURATION PLAN VIEW

(courtesy of NASA)



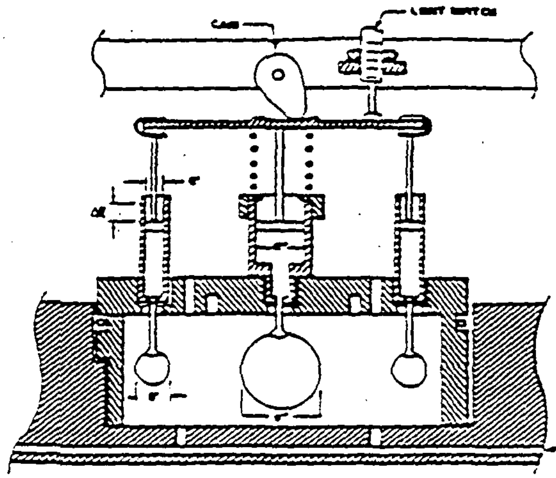
MODULE LAYOUT SECTIONS

(courtesy of NASA)

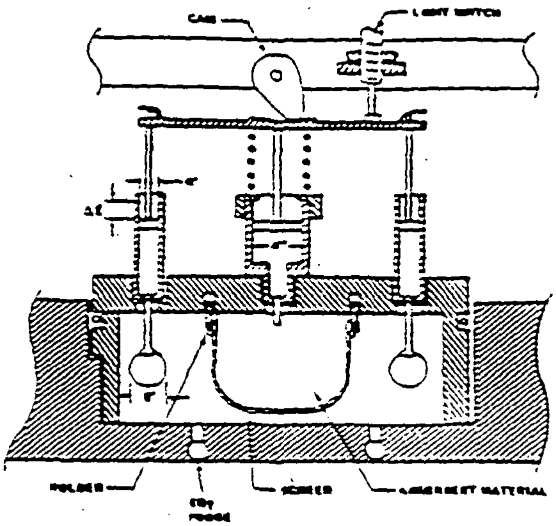


CELL CONFIGURATION SECTION VIEW

(courtesy of NASA)

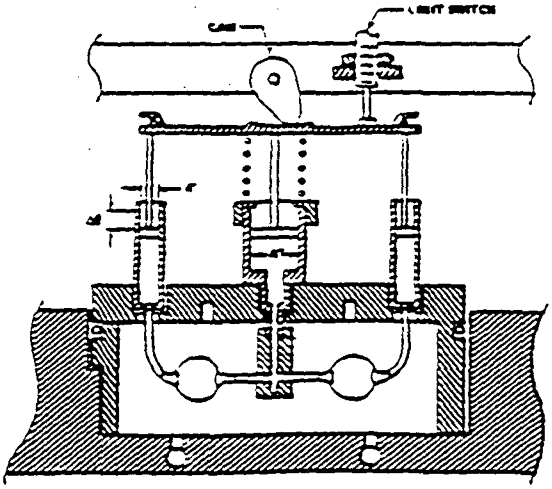


VAPOR DIFFUSION
ARRANGEMENT NO. 1



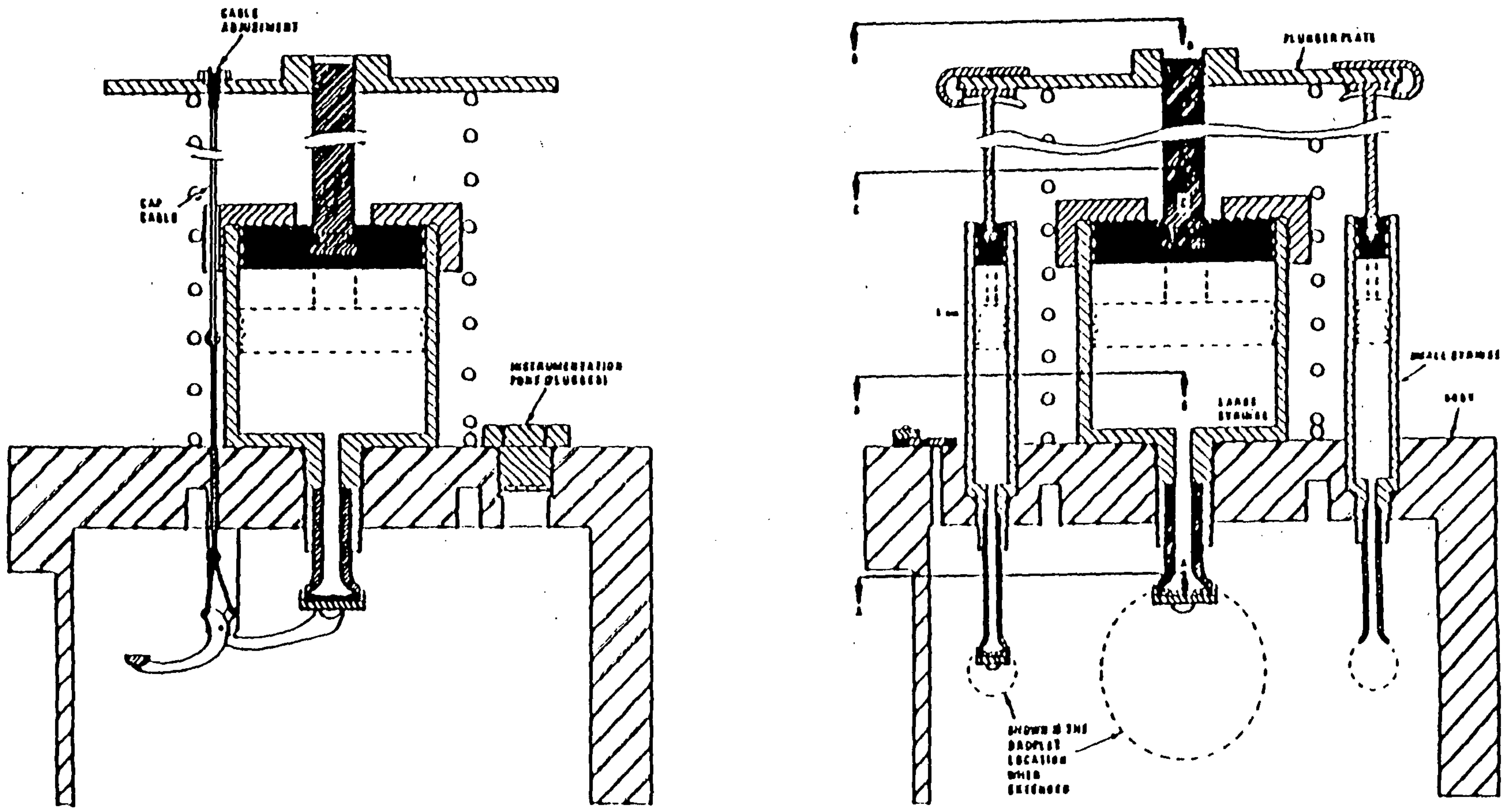
VAPOR DIFFUSION
ARRANGEMENT NO. 2

LIQUID/LIQUID BRIDGE
ARRANGEMENT



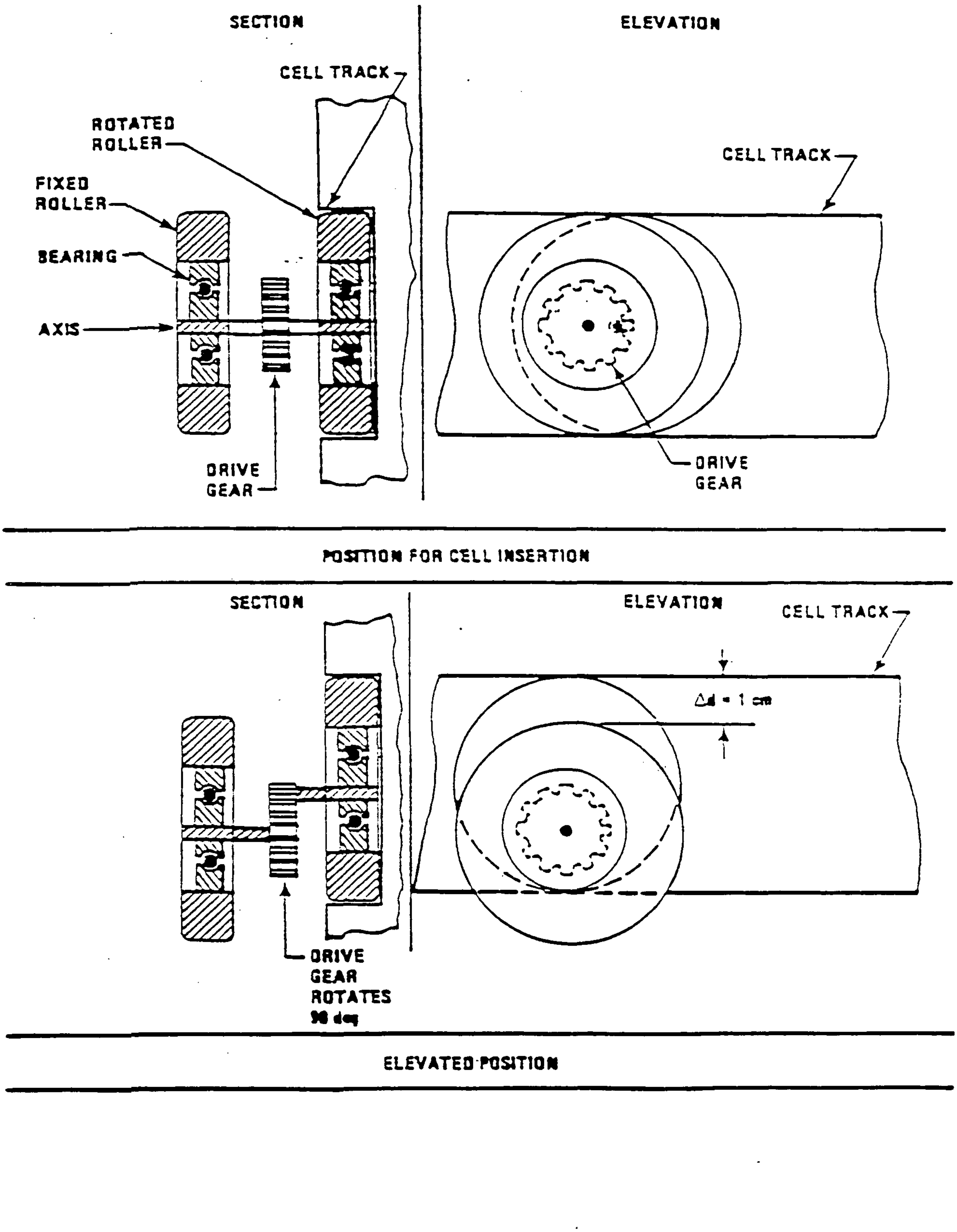
TYPICAL MODULE CONFIGURATIONS

(courtesy of NASA)



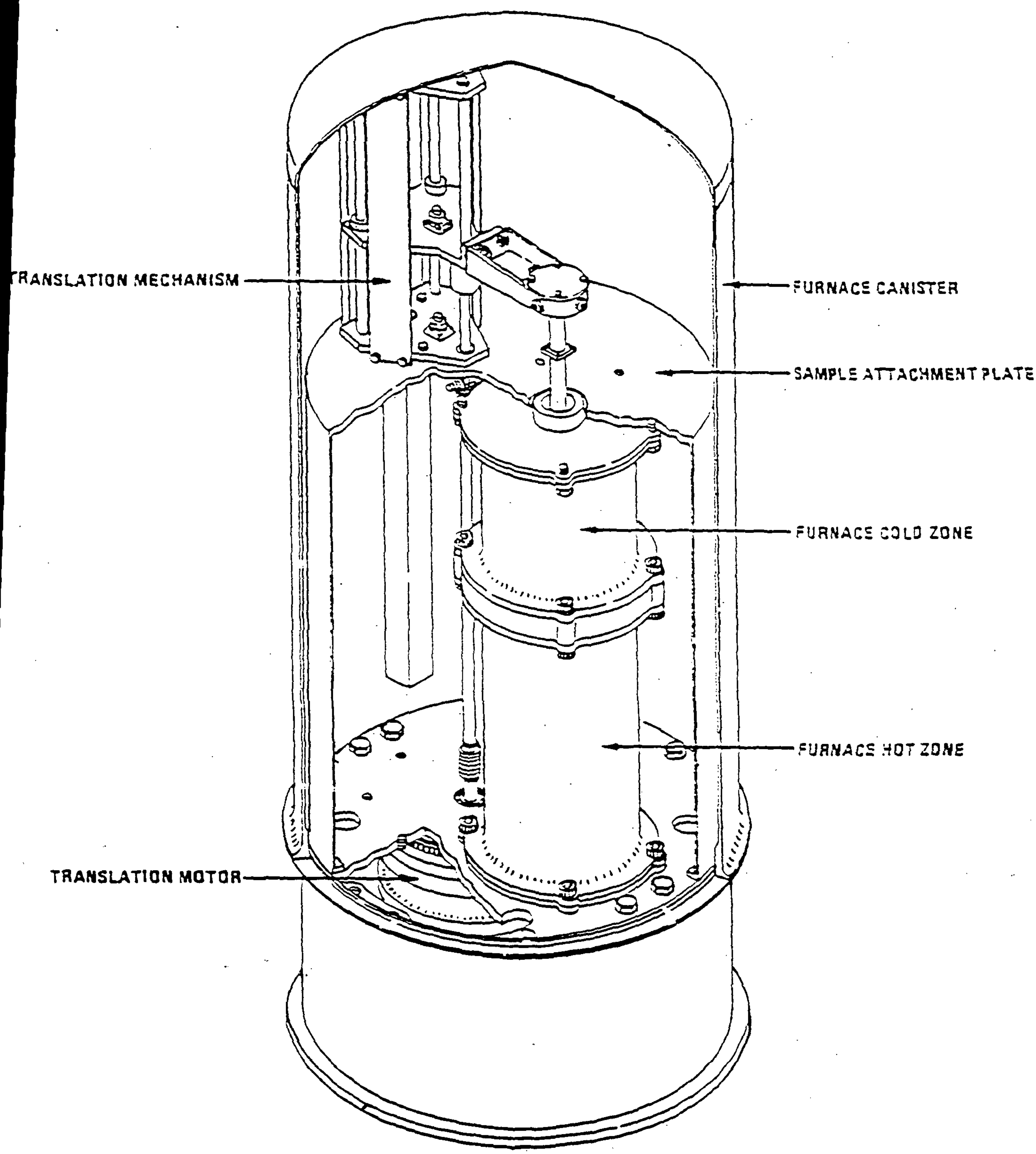
MODULE LAYOUT

(courtesy of NASA)



ROLLER-POSITIONER ASSEMBLY

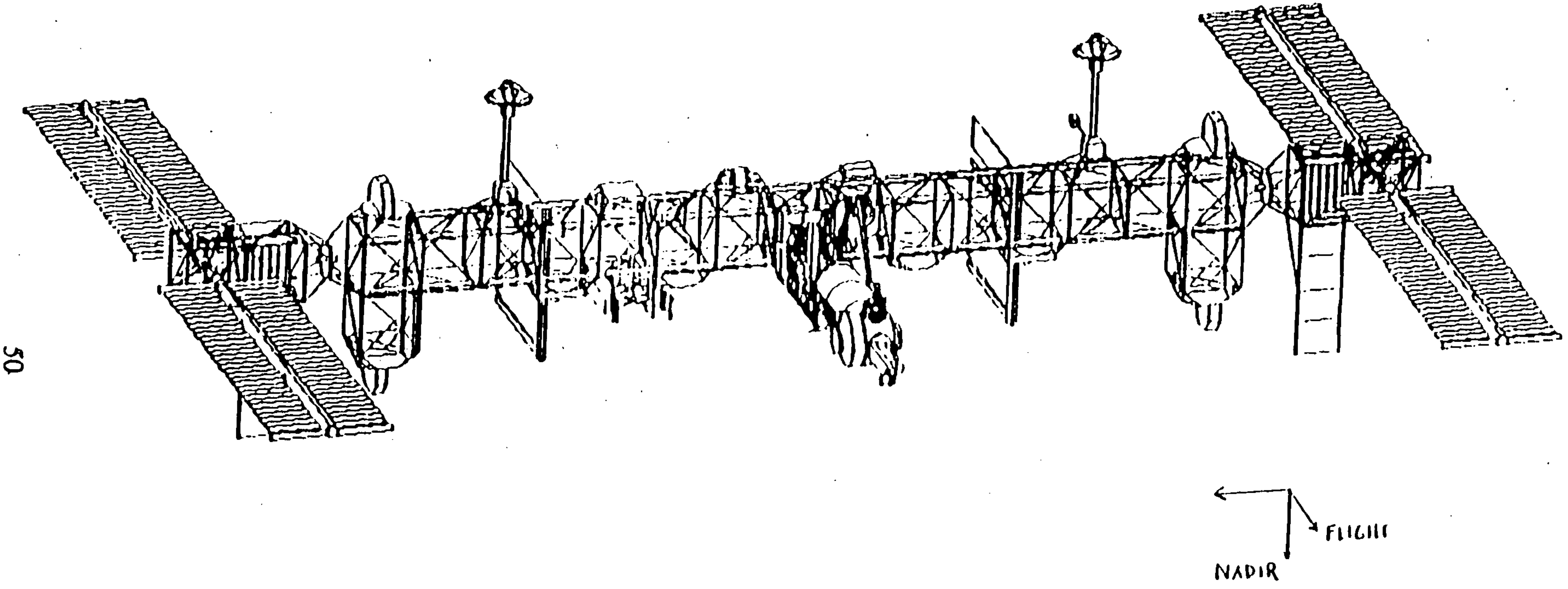
(courtesy of NASA)



(FIGURE NOT DRAWN TO SCALE)

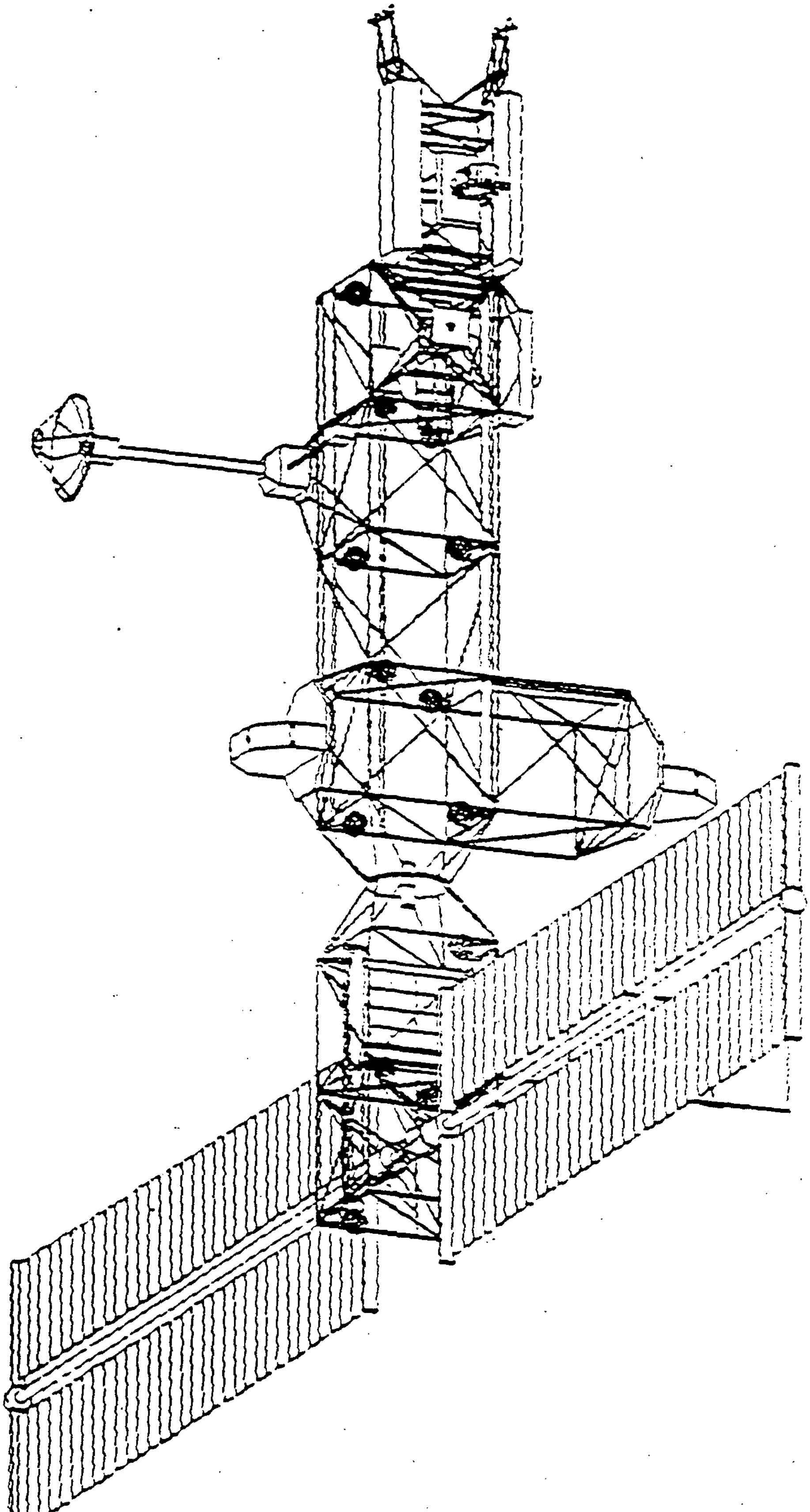
BLF TRANSLATION MECHANISM AND FURNACE ASSEMBLY

(courtesy of NASA)

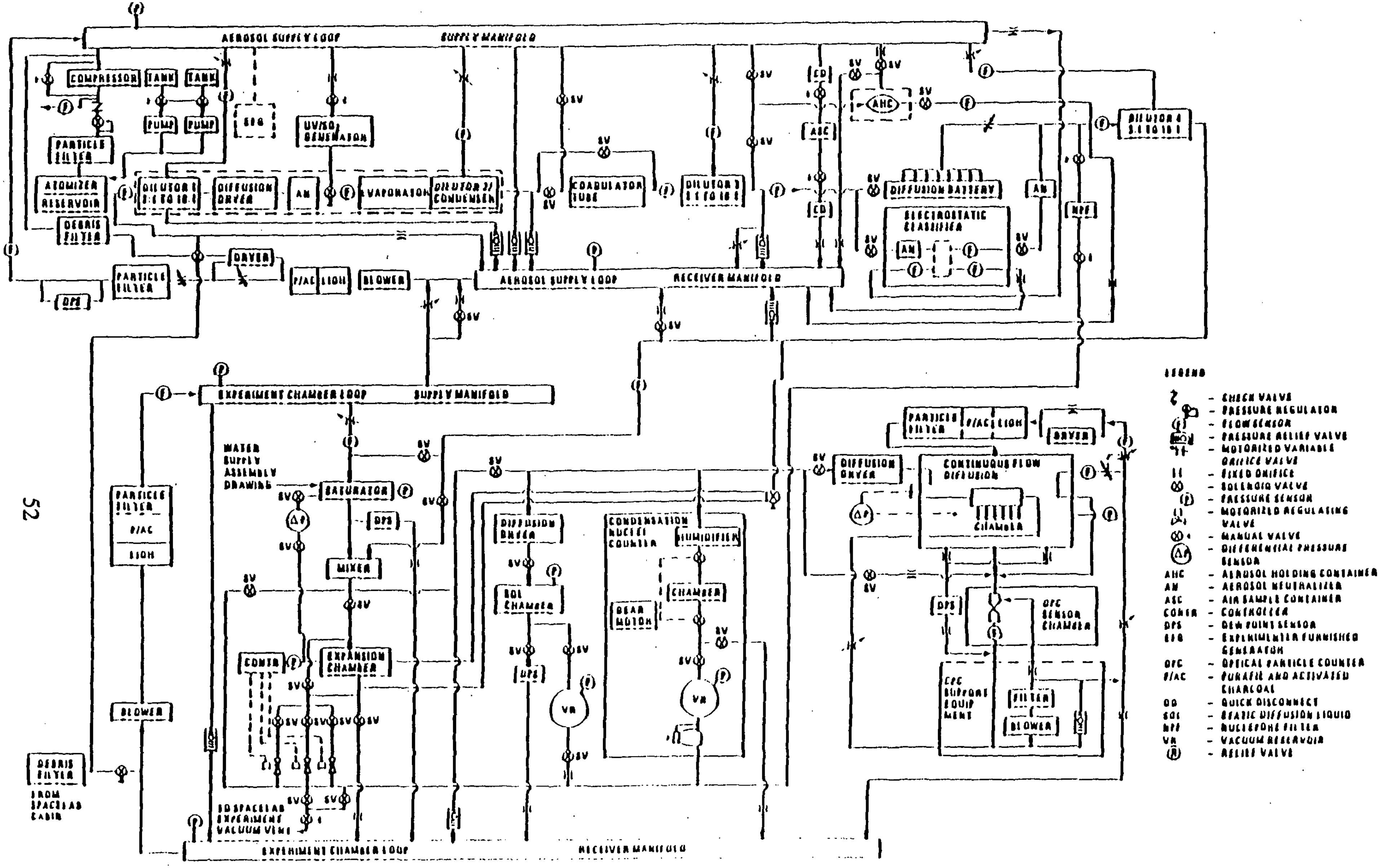


Stage 8 OF-1

(courtesy of NASA)

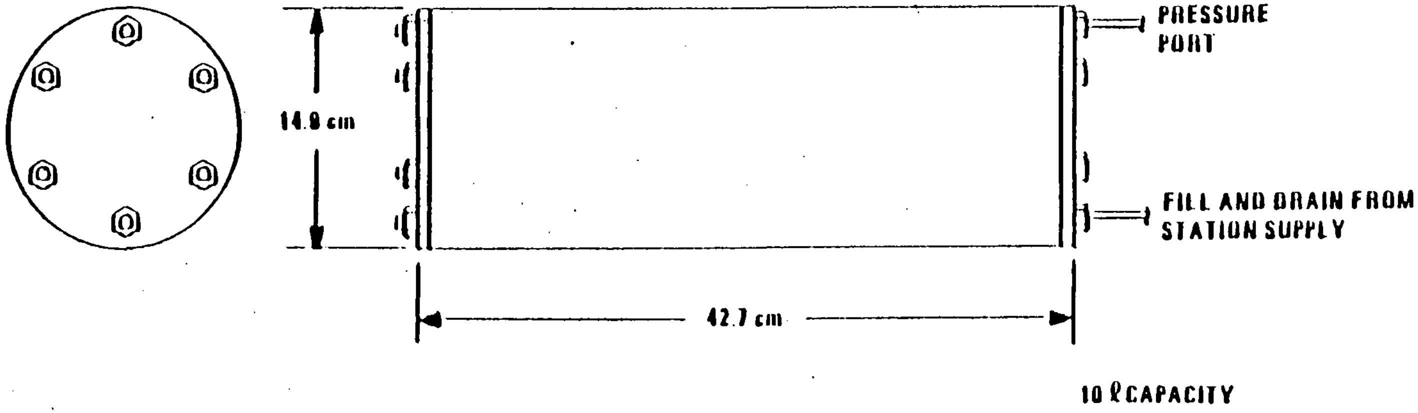


Stage 2 MB-2
(courtesy of NASA)

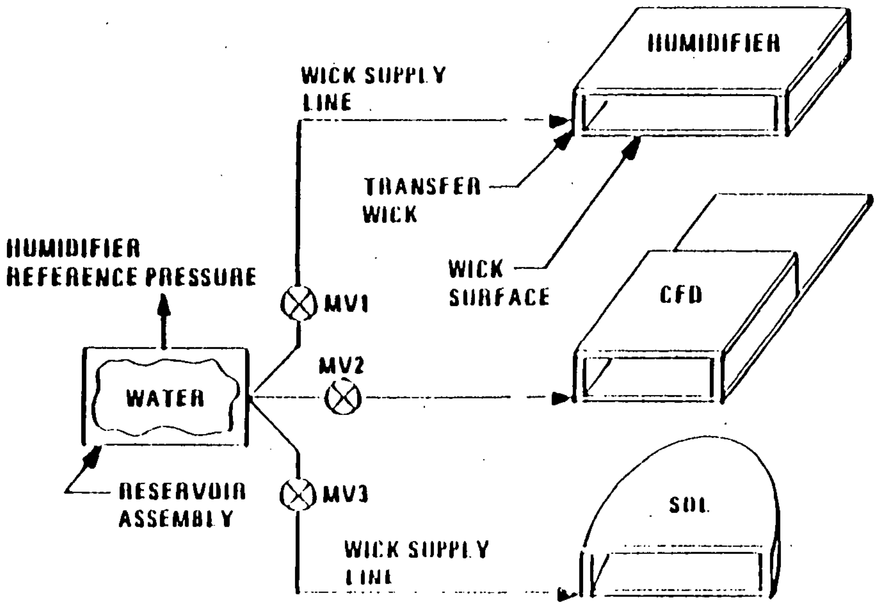


FLUID SYSTEM FLOW SCHEMATIC

(courtesy of NASA)

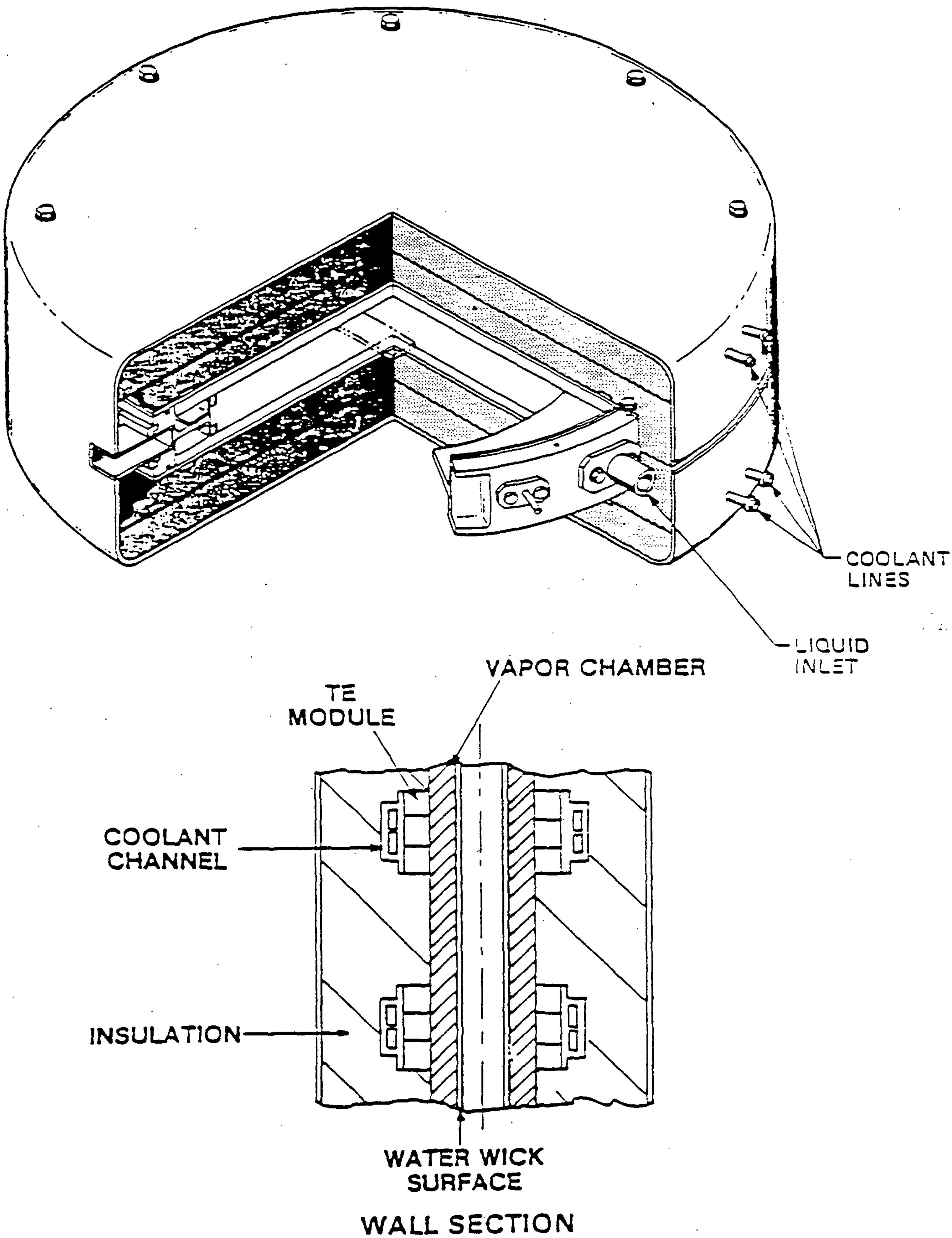


BLADDER TYPE WATER RESERVOIR DIMENSIONS



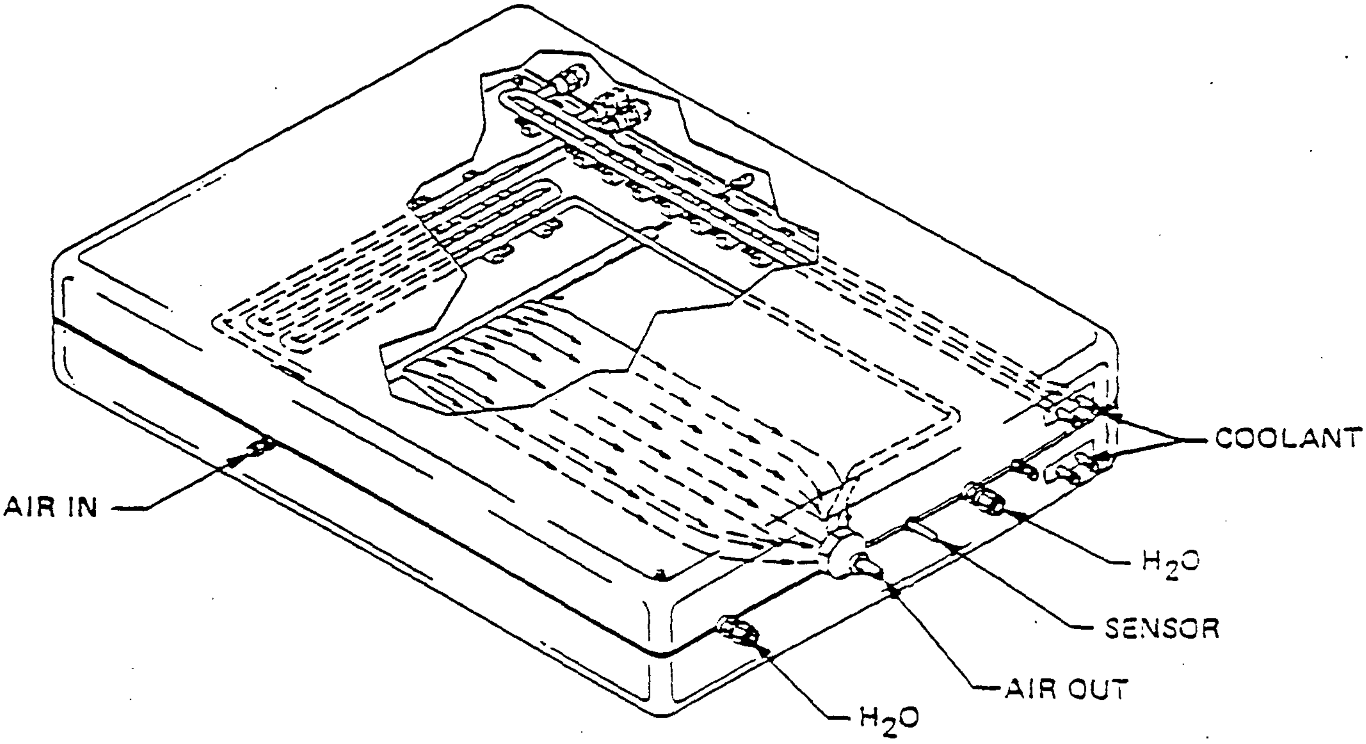
WICKED WATER SURFACES SUPPLY ASSEMBLY AND DETAILS

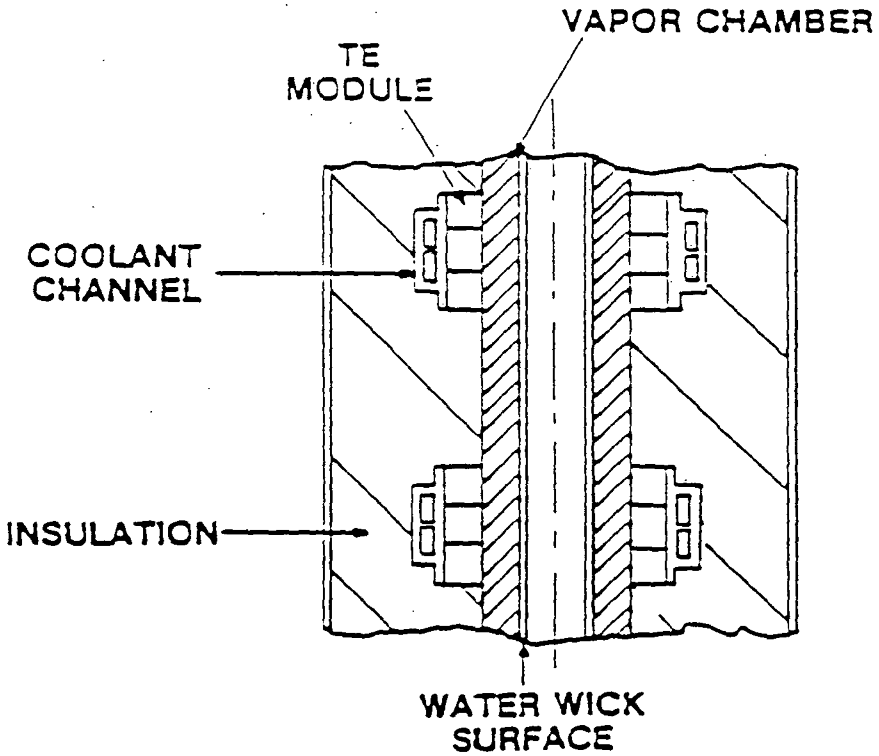
(courtesy of NASA)



STATIC DIFFUSION LIQUID CHAMBER CONFIGURATIONS

(courtesy of NASA)

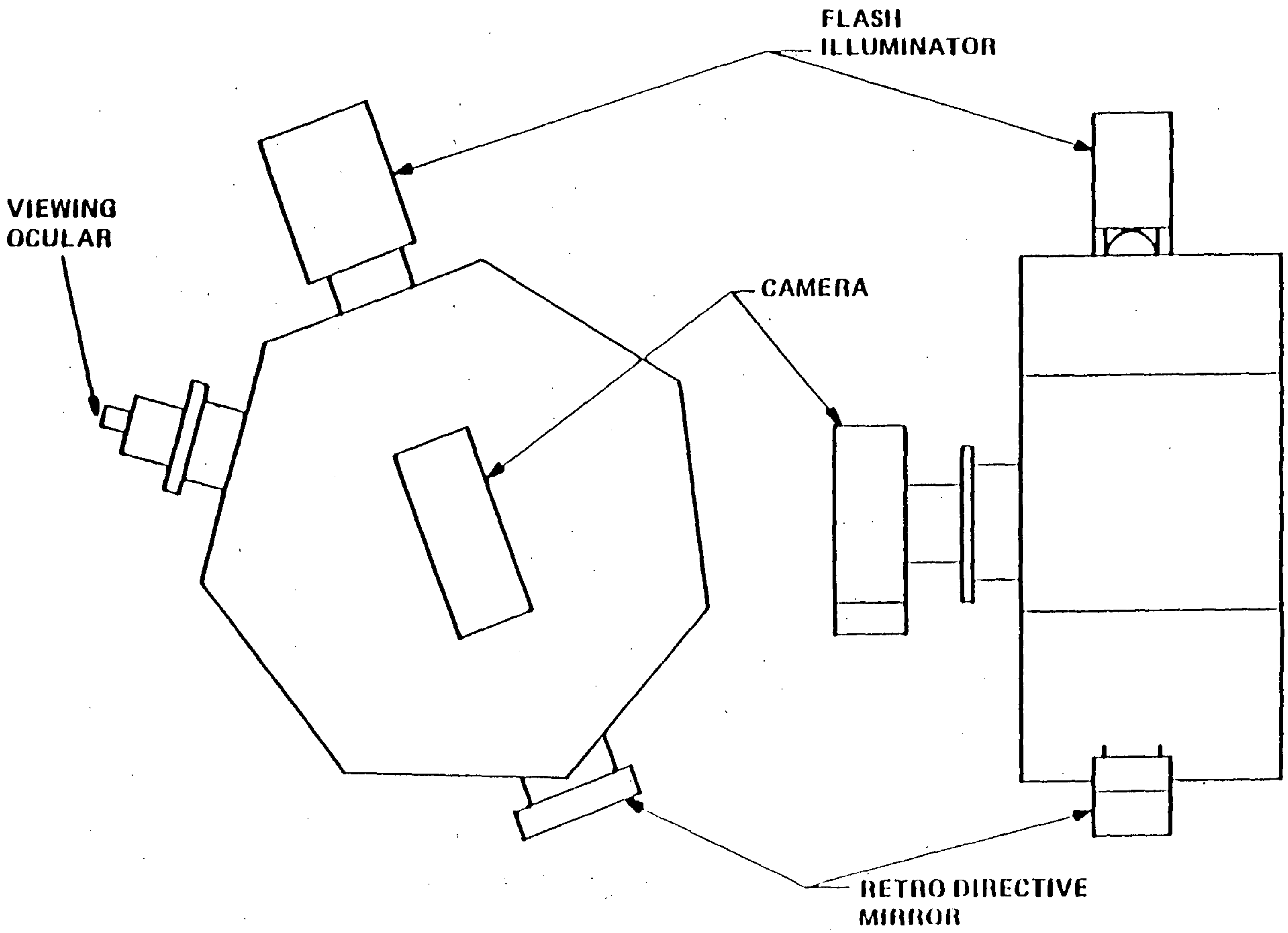




WALL SECTION

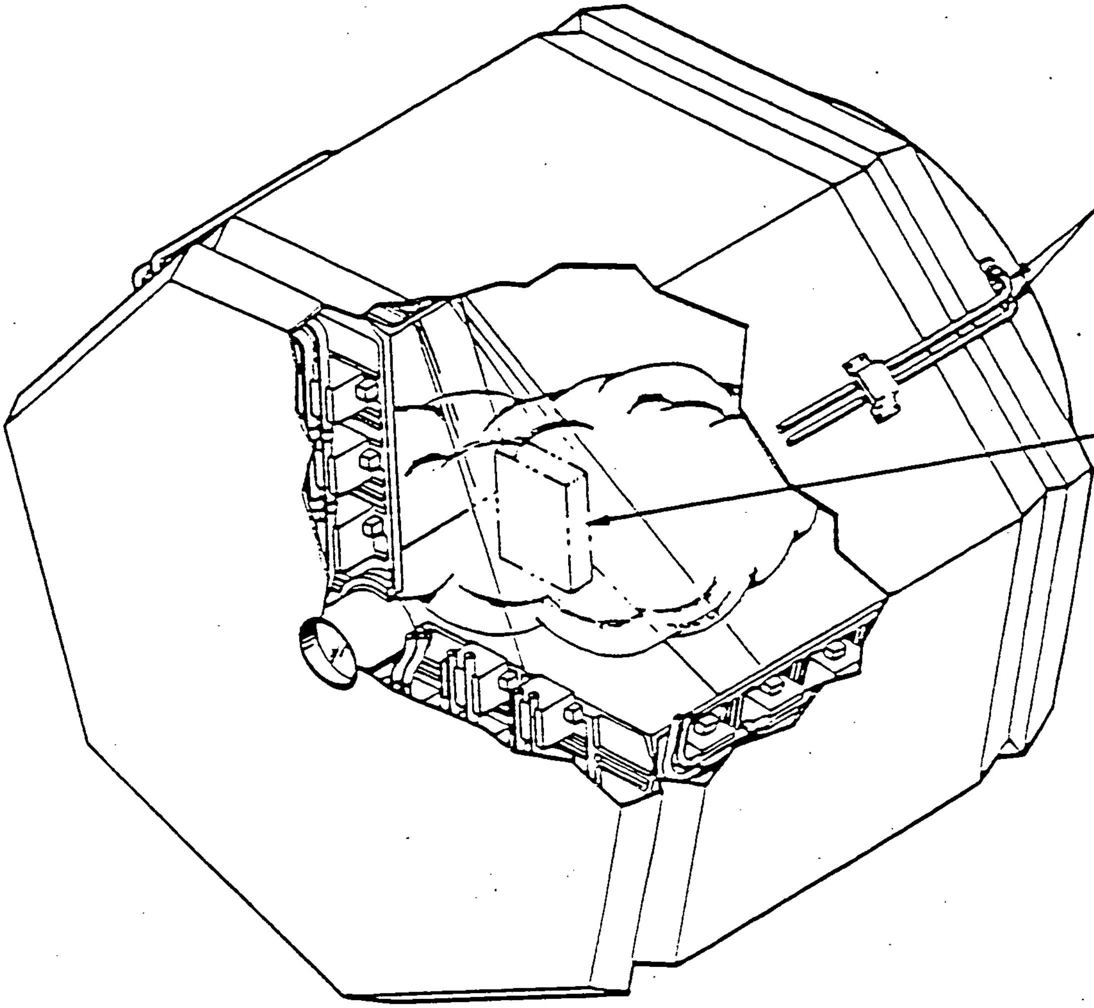
CONTINUOUS FLOW DIFFUSION CHAMBER CONFIGURATION

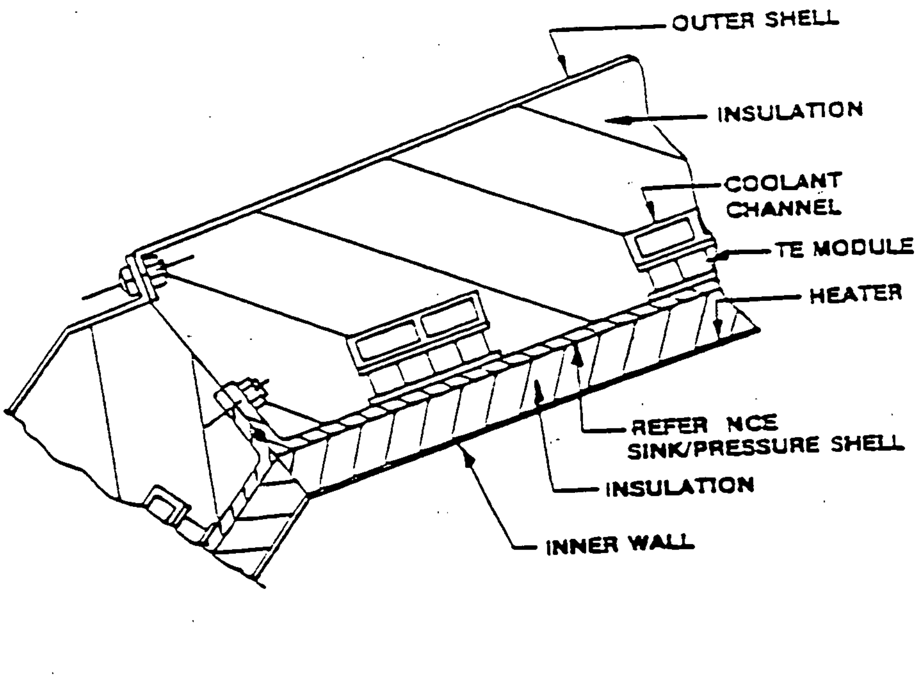
(courtesy of NASA)



CHAMBER CAMERA AND VIEWING SETUP

(courtesy of NASA)

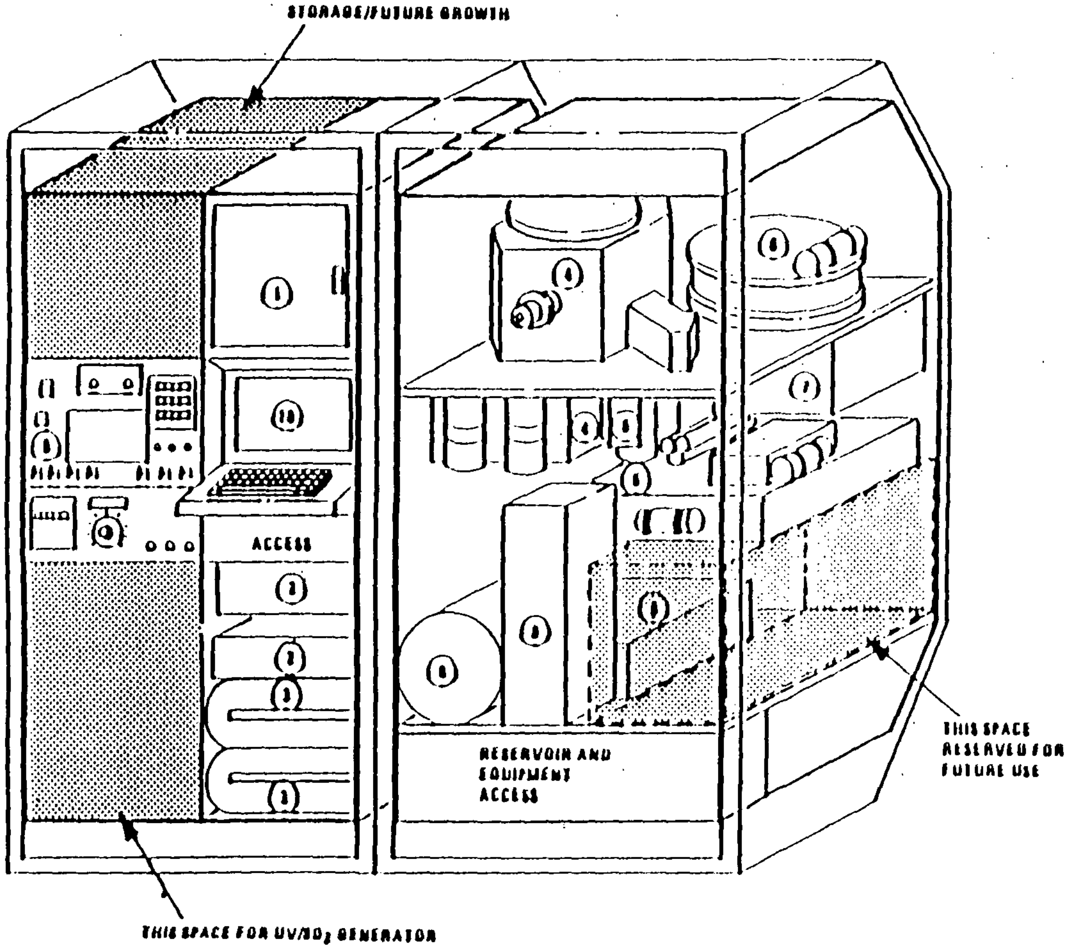




WALL SECTION

EXPANSION CHAMBER CONFIGURATION

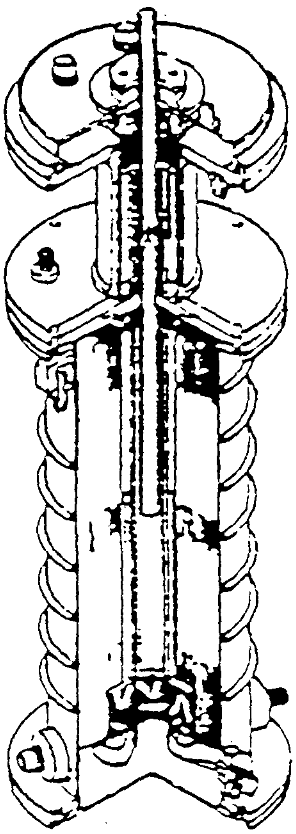
(courtesy of NASA)



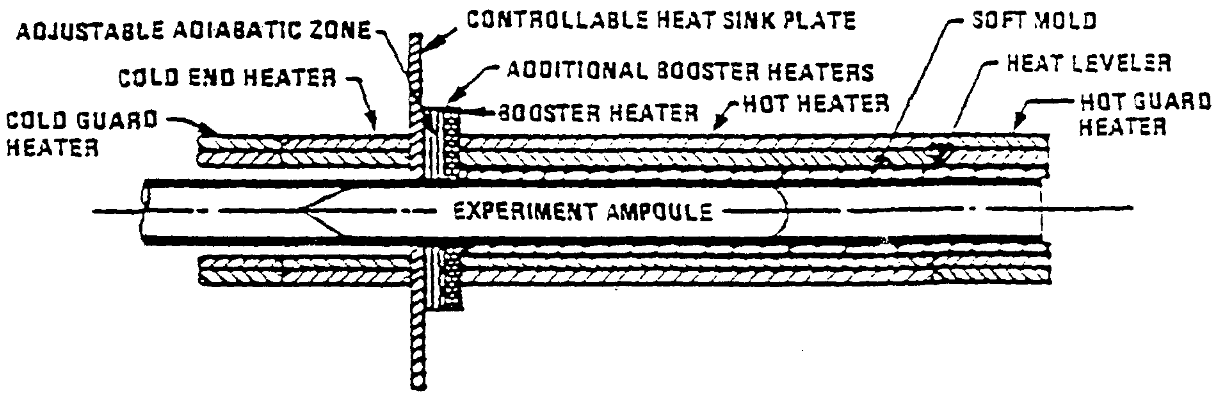
1. Cameras and Optics Storage Center
   - Protects sensitive equipment during launch and re-entry
2. High Humidity Flow Generation and Air Cleaning Module
   - Flow control and air cleaning components for preparation of chamber air
3. Low Humidity Flow Generation and Air Cleaning Module
   - Flow control and air cleaning components for preparation of experiment aerosol
4. Expansion Chamber Assembly
   - Research chamber which simulates formation of real (adiabatic) clouds
5. Continuous Flow Diffusion Chamber Assembly
   - Research chamber which determines cloud condensation nuclei (submicrometer aerosol) characteristics
6. Static Diffusion Liquid Chamber Assembly
   - Research chamber which provides an environment for cloud droplet growth experiments
7. Saturator Assembly
   - Humidifies air and aerosol samples
8. Aerosol Generation Condition and Characterizations Module
   - Generates and conditions particulates to provide required size and concentration for experimentation
   - Counts, sizes, and establishes total mass of aerosol entering the research chambers
9. Electronic Assemblies/Air Flow Control
   - Data management auxiliary equipment
   - Power control and conditioning equipment
   - Power supplies
   - Air pumping and storage equipment
10. Data Display Unit (DDU)
   - Process controller
   - Data acquisition/recording
   - Display/input equipment

ATMOSPHERIC MICROPHYSICS FACILITY IN SPACE STATION RACK CONFIGURATION

(courtesy of NASA)



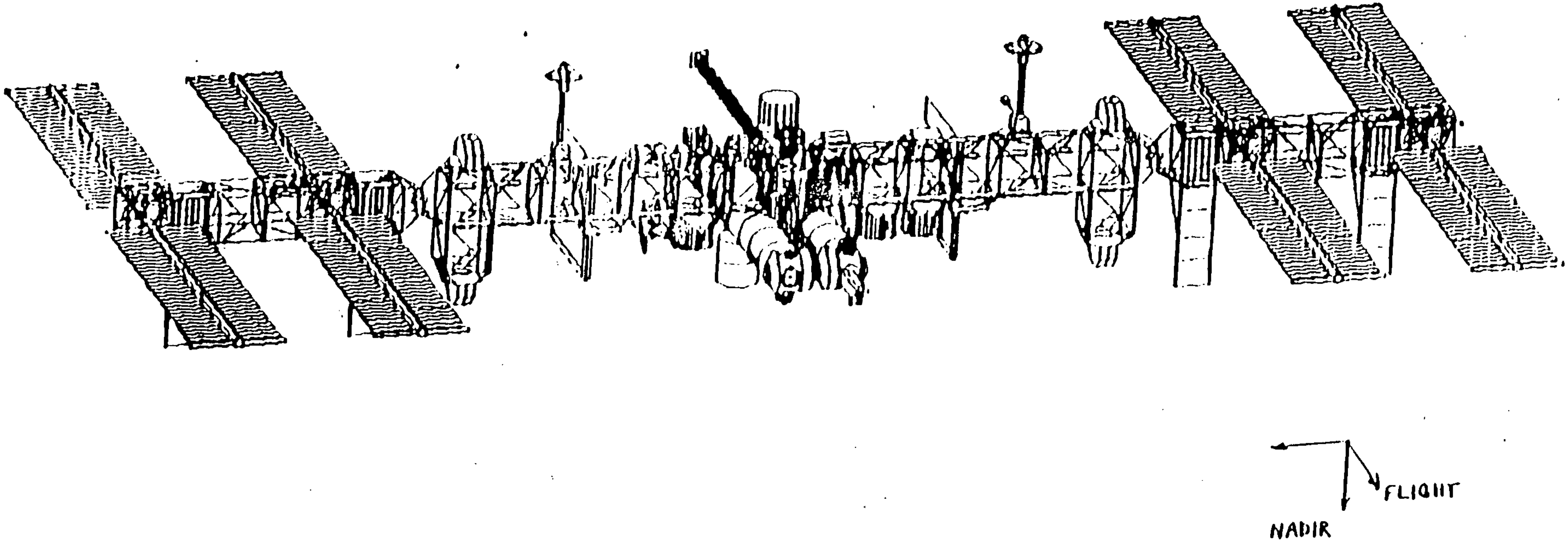
(a) FURNACE MODULE



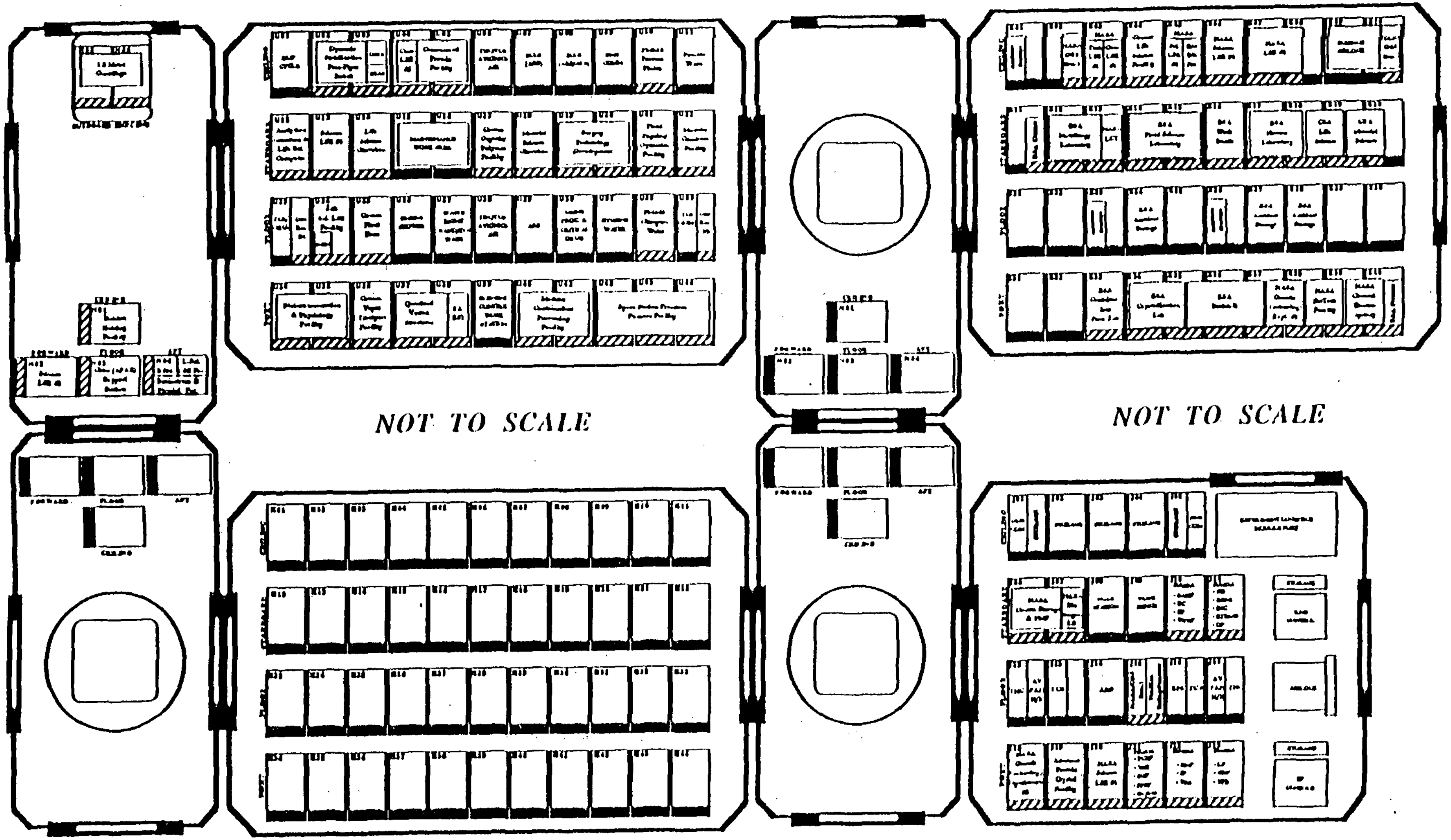
(b) FURNACE SECTION

BLF FURNACE MODULE

(courtesy of NASA)



Stage 25 OF-3
(courtesy of NASA)

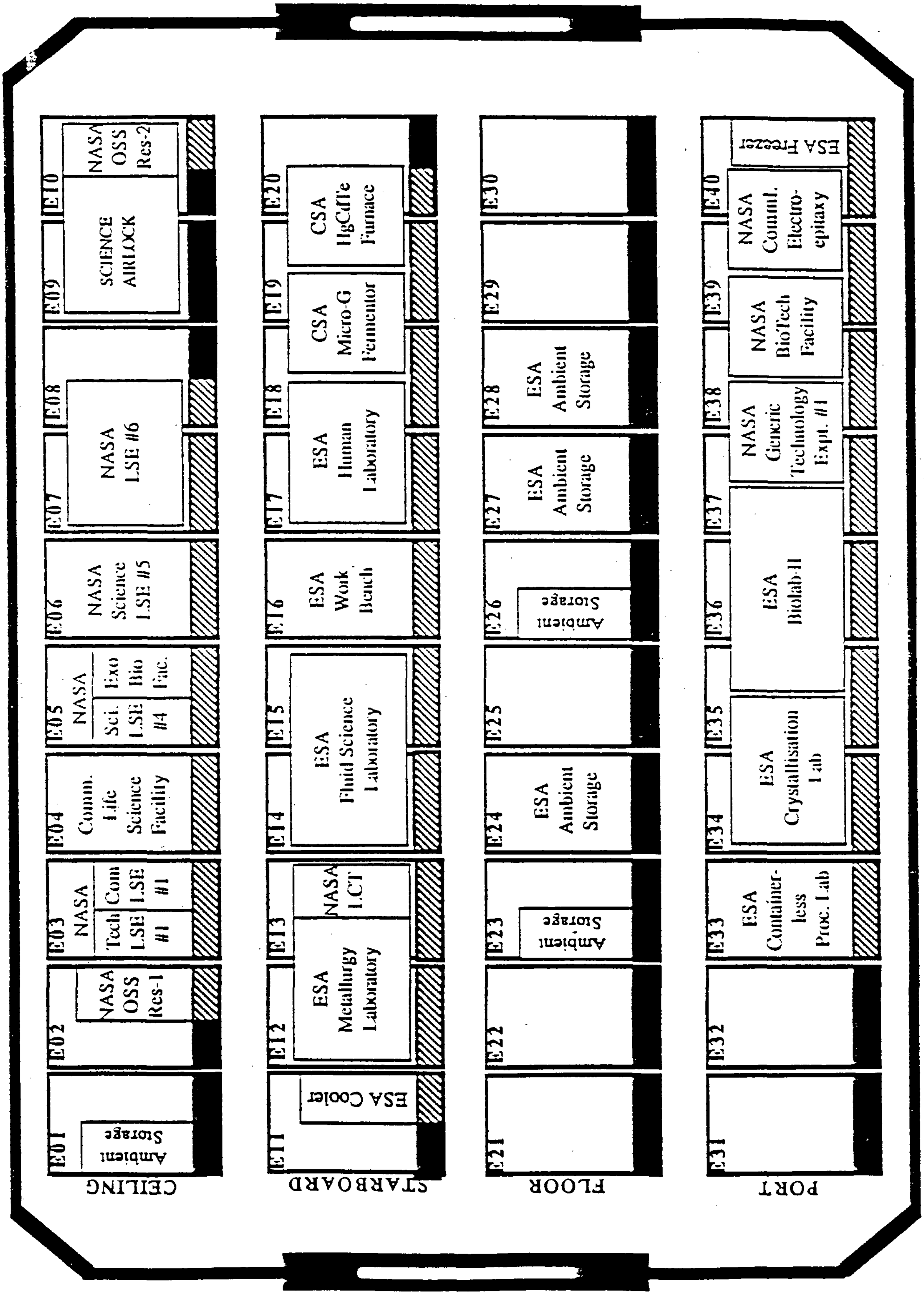


VOLUME ALLOCATION SUMMARY:

	STATION SYSTEMS	USER P/Ls	TOTAL
NASA LAB	[illegible]	[illegible]	[illegible]
ESA LAB	[illegible]	[illegible]	[illegible]
NASDA LAB	11	11	22
HABITAT	44	-	44
NODE 1*	-	4	4
NODE 2	4	-	4
NODE 3	4	-	4
NODE 4	4	-	4
TOTAL	[illegible]	[illegible]	[illegible]

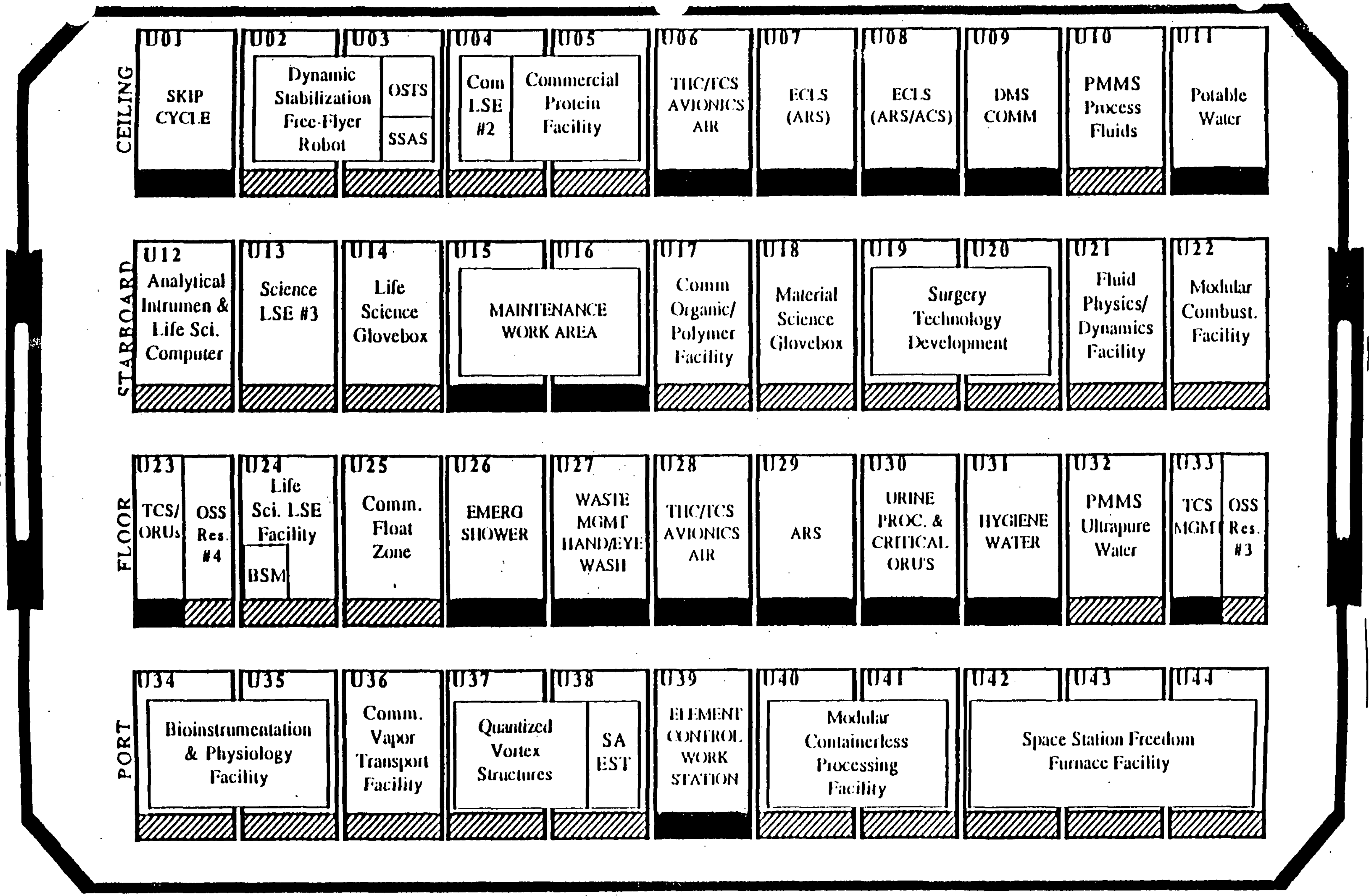
* Animal Life Sciences accommodation currently under study; allocation to Node 1 is illustrative.

(courtesy of NASA)



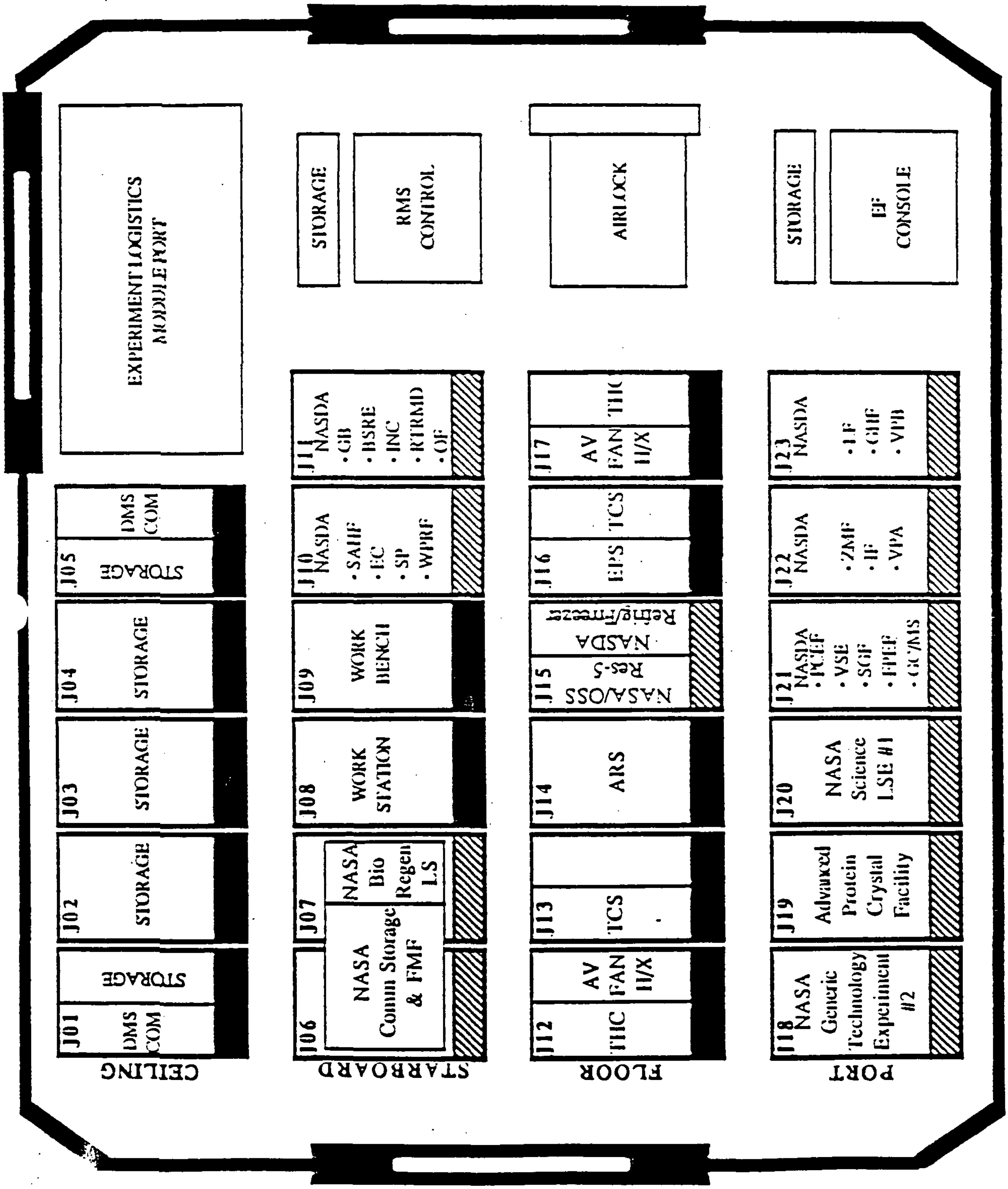
Columbus Attached Laboratory

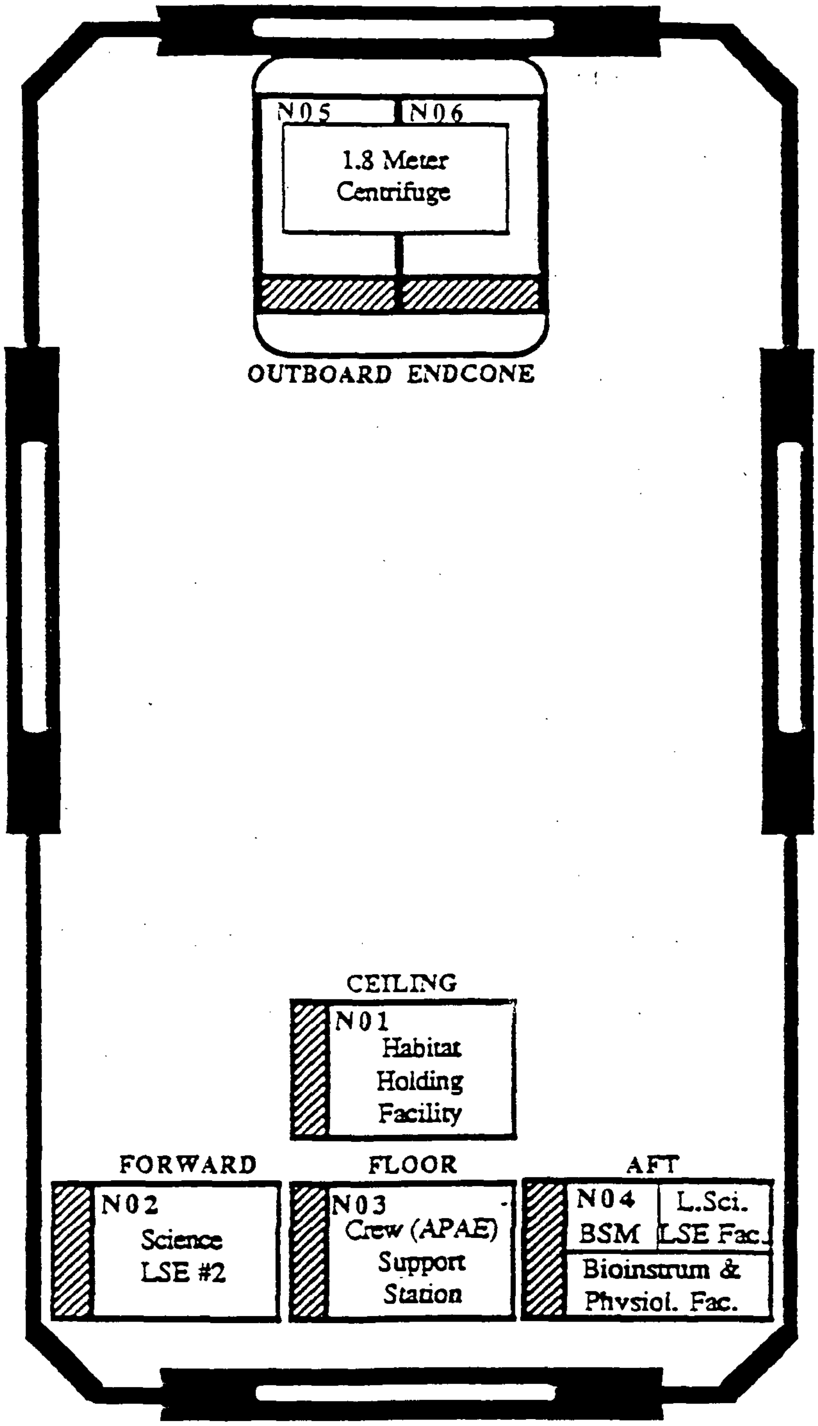
(courtesy of NASA)



U.S. Laboratory Module

(courtesy of NASA)


CEILING
STARBOARD
FLOOR
PORT
EXPERIMENT LOGISTICS MODULE PORT
STORAGE
RMS CONTROL
AIRLOCK
STORAGE
EF CONSOLE
J01 DMS COM STORAGE
J02 STORAGE
J03 STORAGE
J04 STORAGE
J05 STORAGE DMS COM
J06 NASA Comm Storage & FMF
J07 NASA Bio Regen LS
J08 WORK STATION
J09 WORK BENCH
J10 NASDA • SAHF • EC • SP • WPRF
J11 NASDA • GB • BSRE • INC • RTRMD • OF
J12 THC AV FAN H/X
J13 TCS
J14 ARS
J15 NASA/OSS Res-5 NASDA Refrig/Freezer
J16 EPS TCS
J17 AV FAN H/X THC
J18 NASA Generic Technology Experiment #2
J19 Advanced Protein Crystal Facility
J20 NASA Science LSE #1
J21 NASDA • PCEF • VSE • SGF • FPEF • GC/MS
J22 NASDA • 2MF • IF • VPA
J23 NASDA • IF • GHF • VPB



NASDA Laboratory Module

(courtesy of NASA)

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle

Chemical Hazards Data Base and Detection System for Microgravity and Materials Processing Facility (MMPF)

5. Report Date

October 14, 1991

6. Performing Organization Code

FWG Associates, Inc.

7. Author(s)

Jimmy Steele
Robert E. Smith

8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address

FWG Associates, Inc.
217 Lakewood Drive
Tullahoma, TN 37388

11. Contract or Grant No.

NAS8-37746

13. Type of Report and Period Covered

Final Report

12. Sponsoring Agency Name and Address

NASA Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The ability to identify contaminants associated with experiments and facilities is directly related to the safety of the Space Station. A means of identifying these contaminants has been developed through this contracting effort. The delivered system provides a listing of the chemicals/materials associated with each facility, information as to the contaminants physical state, a list of the quantity and/or volume of each suspected contaminant, a database of the toxicological hazards associated with each contaminant, a recommended means of rapid identification of the contaminants under operational conditions, a method of identifying possible failure modes and effects analysis associated with each facility, and a fault tree-type analysis that will provide a means of identifying potential hazardous conditions related to future planned missions.

17. Key Words (Suggested by Author(s))

chemical hazards
detection methodologies
engineering analyses
hazardous materials database
chemical incompatibility

18. Distribution Statement

Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	66	

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