N91-15935

TOXIC AND REACTIVE MATERIAL HANDLING ON SPACELAB J AND USML-1

By Jack Dashner

Spacelab J and USML-1 provide prime examples of materials which are toxic at ambient conditions or toxic during the processing stages. The materials are used in both life science and material processing experiments.

SPACELAB J

In addition to the experiments, the mission uses Mission Peculiar Equipment required to integrate the payload including a cooling water loop and a vacuum vent system. The vacuum vent plays an important role in toxicity control on Spacelab J.

While each of the experiments provide interesting and unique requirements for hazard control, the Frog Embryology Experiment (FEE), the General Purpose Work Station (GPWS), the FMPT Life Sciences (FMPT-LS) and FMPT Material Experiment Laboratory (FMPT-MEL) are the elements which contain most of the toxic materials.

The Frog Embryology Experiment is an Ames Research Center experiment developed in conjunction with the University of Michigan to study the effects of weightlessness in the development of amphibian eggs fertilized in space. Female African clawed frogs will be flown, ovulation will be induced and frog eggs will be placed in egg chambers. The eggs will be fertilized using testis and sperm prepared immediately before flight. Some chambers will be subjected to a one g centrifuge, Figure 1, to serve as a control group. Many of the chambers will be fixed with formaldehyde at predetermined periods following fertilization while others will be returned for continued ground studies.

This is a terse explanation of a very interesting experiment which will probably be discussed in a later session. From a toxicity standpoint, the fixative formaldehyde has a low maximum allowable concentration (MAC) and requires triple containment to meet the two failure tolerance required for hazards which could be catastrophic. Containment is provided by a syringe, sealed plastic bag, and a hard side sealed container during storage. Operations are performed inside of the General Purpose Work Station (GPWS), Figure 2. The GPWS provides a sealed container (closed environment) and provides the equivalent of a second containment by virtue of the filtering system which uses specially treated charcoal to remove formaldehyde and other toxic materials during the air circulation process. In the event of loss of power or other failures, the GPWS is placed in a closed loop operation which still provides one level of containment.

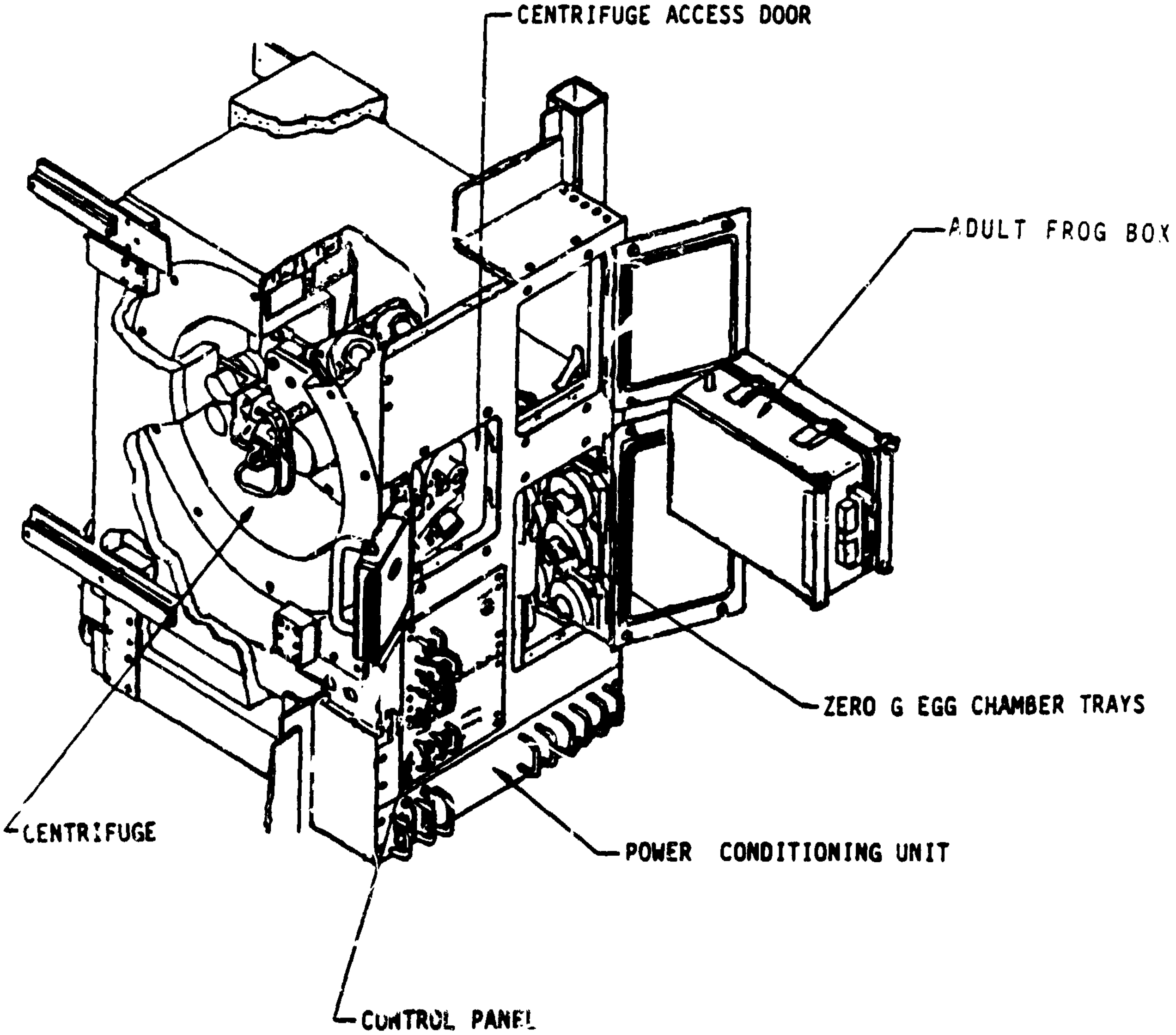


FIGURE 1. FFU EXPERIMENT CHAMBER

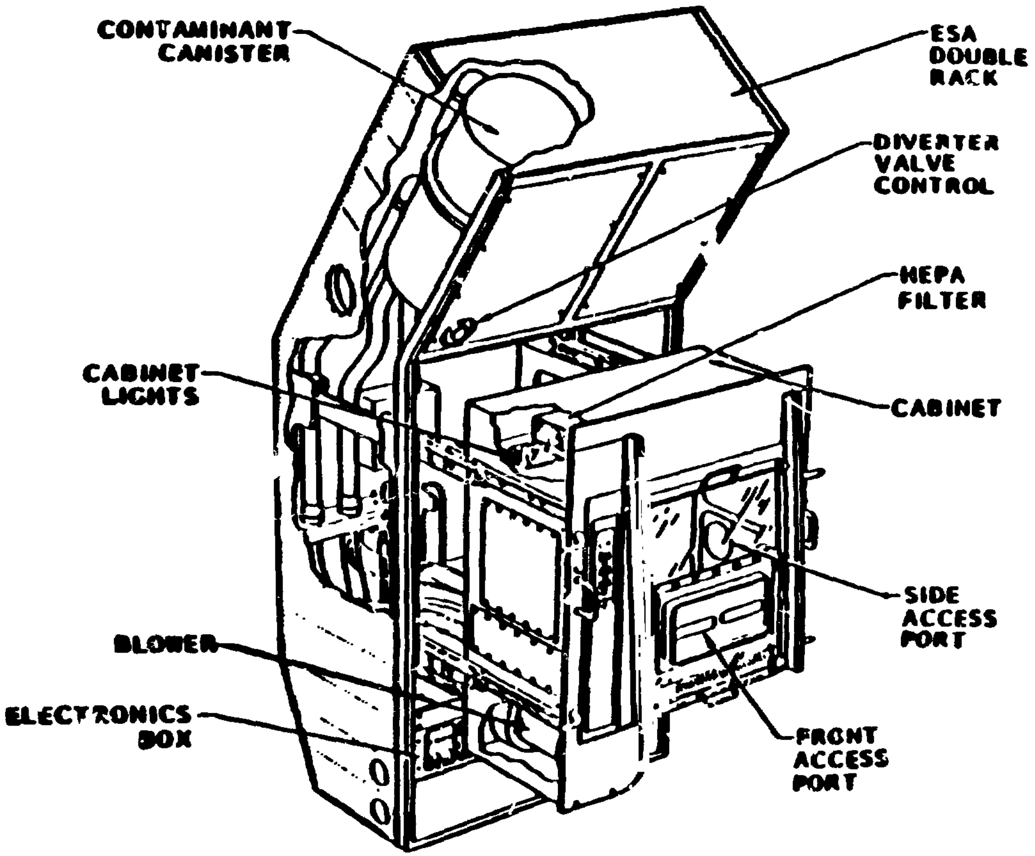


FIGURE 2 GPWS DESIGN OVERVIEW (IN DEPLOYED POSITION)

FMPT Life Sciences

The Japanese experiments use hardware developed by both the Japanese and JSC to conduct 13 experiments including:

Free Flow Electrophoresis Unit (FFEU)
Vestibular Function Experiment Unit (VFEU)
Thermo-Electric Incubator (TEI)
Light Impulse Stimulator (LIS) Equipment
Fungi Growth Chamber
Enzyme Crystallization Kit
Cell Culture Kit
Fly Container
Cosmic Radiation Devices
Egg Rack
Physiological Monitoring System
Urine Monitoring System (UMS) - SL-3

The experiments contain numerous materials including biological materials, fish (2 carp), fungi, enzymes, animal and plant cells, fruit flies, seeds, hen eggs, and urine specimens. While each of the experiments has interesting and unique objectives, the fluids are low or non toxic and use single to dual containment. The cell culture kits present the greatest hazard principally due to the fixative agent glutaraldehyde which fixes samples at various stages of growth. This example has been selected principally to display a rather innovative syringe used to provide dual containment (Figure 3).

The life science experiments have been slighted in order to discuss the material processing facilities.

FMPT - Materials Experiment Laboratory (MEL)

The FMPT-MEL will occupy two double Spacelab racks to house the experiments and support equipment. Figure 4 depicts the configuration and Table 1 identifies the equipment.

The FMPT-MEL consists of 22 experiments performed in 11 different facilities which include 6 different types of furnaces. The experiments and facilities are listed in Table 2.

In addition to the experiment facilities a dedicated vacuum vent facility is required in conjunction with a turbomolecular pump to provide a high quality vacuum. Additionally, high pressure gasses (3000 psi helium, 3000 psi synthetic air, 3000 psi argon, and 1000 psi krypton) are provided for processing, quenching, purging and pneumatic valve operation.

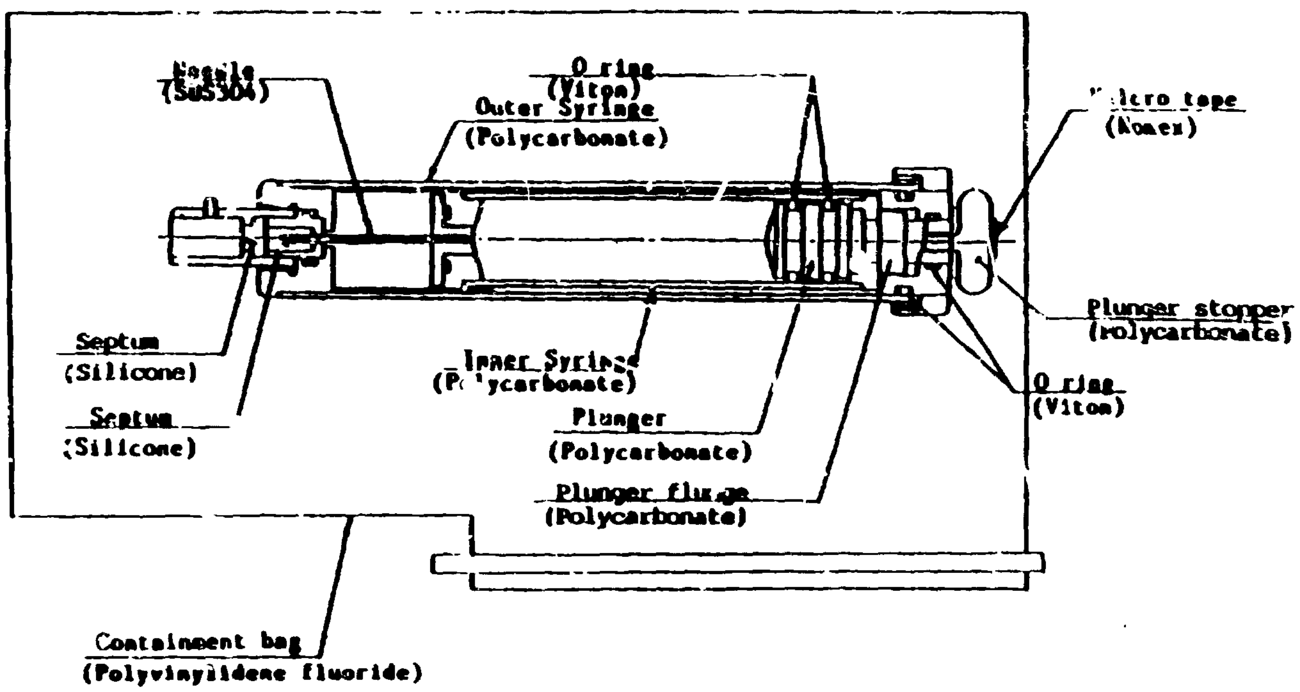
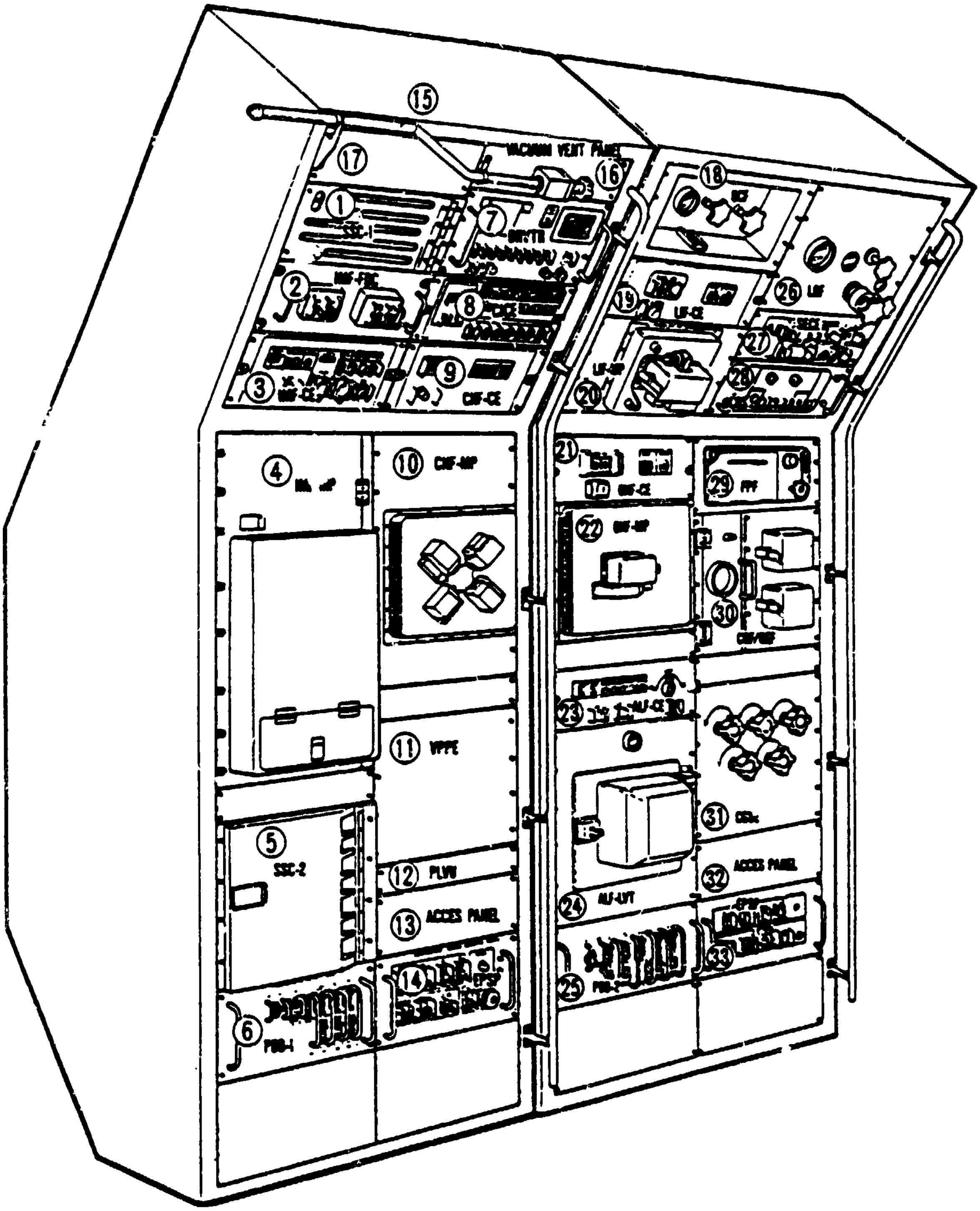


FIGURE 3 GLUTARALDEHYDE CONTAINER (DOUBLE SYRINGE TYPE)

ORIGINAL PAGE IS
OF POOR QUALITY



NOTE: The equipment numbers on this page correspond to the numbers and titles in Table 8-1.

FIGURE 4 FMPT-MEL EXPERIMENT

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 1. FMPT-MEL EXPERIMENT EQUIPMENT IN SPACELAB RACKS 8 AND 10

1 Sample Stowage Container (SSC-1)
2 Image Furnace - Furnace Drive Controller (IMF-FDC)
3 Image Furnace - Control Equipment (IMF-CE)
4 Image Furnace - Material Processing Unit (IMF-MP)
5 Sample Stowage Container (SSC-2)
6 Power Distribution Box-1 (PDB-1)
7 Data Recording Video Tape Recorder (DRVTR)
8 Central Interface and Control Equipment (CICE)
9 Continuous Heating Furnace - Control Equipment (CHF-CE)
10 Continuous Heating Furnace - Material Processing Unit (CHF-MP)
11 Vacuum Pump Package Equipment (VPPE)
12 Pilot Valve Unit (PLVU)
13 Access Panel
14 Experiment Power Switching Panel (Rack 8)
15 Vent Line
16 Vacuum Vent Panel
17 Blank Panel
18 Organic Crystal Growth Experiment Facility (OCF)
19 Large Isothermal Furnace - Control Equipment (LIF-CE)
20 Large Isothermal Furnace - Material Processing Unit (LIF-MP)
21 Gradient Heating Furnace - Control Equipment (GHF-CE)
22 Gradient Heating Furnace - Material Processing Unit (GHF-MP)
23 Acoustic Levitation Furnace - Control Equipment (ALF-CE)
24 Acoustic Levitation Furnace - Material Processing Unit (ALF-LVT)
25 Power Distribution Box-2 (PDB-2)
26 Liquid Drop Experiment Facility (LDF)
27 Specific Experiment Control Equipment (SECE)
28 Intercom Remote Station (ICRS)
29 Fluid Physics Experiment Facility (FPF)
30 Crystal Growth Experiment Facility and Gas Evaporation Experiment Facility (CGF/GEF)
31 Compressed Gas Supply Equipment (CGSE)
32 Access Panel
33 Experiment Power Switching Panel (Rack 10)

TABLE 2. EXPERIMENT PLANNED FOR FMPT-MEL MISSION

Exp	Title	Facility	Remarks
M1	Crystallization of Pb-Sn-Te	GHF	Compound type semiconductor single crystal growth
M2	Zone Melting of Pb-Sn-Te	IMF	Compound type semiconductor single crystal growth
M3	Floating Zone of In-Sb	IMF	Compound type semiconductor single crystal growth
M4	Solidification of Superconducting Materials	CHF	Solidification process of immiscible alloys (Al-Pb-Bi)
M5	Deoxidation of Steels	LIF	Removal of solved oxygen from molten steel
M6	Dispersion - Strengthened Superalloys	LIF	Superalloy matrix reinforced by dispersed fine particles
M7	Mutual Diffusion in Liquid Metals	CHF	Study of diffusion process
M8	Density of Glasses	IMF	Measurement of glass density as function of temperature
M9	Spherical Si Crystals	CGF	Production of spherical Si crystals
M10	Solidification of Immiscible Alloys	GHF	Solidification process of immiscible alloys (Al-In, Cu-Pb)
M11	Composites (Al-Carbon Fibers)	CHF	Al Matrix with 3-dimensional carbon fiber reinforcement
M12	Liquid Phase Sintering	LIF	Production of metal powder by liquid phase sintering
M13	Amorphous Semiconductors	CHF	Production of amorphous semiconductors
M14	Ultra-Fine Powders	GEF	Metallic powders produced by evaporation process
M15	Fluid Dynamics in 3-D Acoustic Field	LDF	Behaviour of liquid drop levitated in acoustic field
M16	Behaviour of Bubbles in Liquid	BBU	Bubble behaviour at liquid-to-crystal interface
M17	Firing of Glasses	ALF	Contactless meeting of very pure glasses
M18	Marangoni Convection and Heat Transfer	MCU	Effects of Marangoni convection on Brigeman process
M19	Solidification of Eutectic Alloys	CHF	Study of solidification process
M20	Floating Zone of Minerals	IMF	Growth of single crystals from Samarskite minerals
M21	Organo-Metallic Crystals	OCF	Growth of crystals from organo-metallic compounds
M22	Crystallization of In-Ga-As	GHF	Compound type semiconductor single crystal growth

Furnace operations generally require installation of experiment samples by hand and automatic processing by computer although manual controls are available for hazardous function control. For all furnaces interlocks and doors are provided to prevent sample removal prior to cooling to touch temperatures of 45°C.

Gradient Heating Furnace (GHF)

The GHF, Figure 5, has been developed for several types of experiments such as crystal growth, melting/solidification, and eutectics. The facility functions by positioning the sample, and after heatup, the furnace translates to provide a moving gradient across the sample. The furnace uses two heating coils at one end and a single coil at the other end. Between the coils is a water cooling chamber. The furnace, which operates at temperatures up to 1100°C, processes the sample in a vacuum. Two samples, M 01 and M 22 of Table 3 provide three levels of containment by the use of two quartz ampoules and a tantalum cartridge. Sample M 10, Figure 6, is encased in an unsealed tantalum cartridge. The metals in this sample will offgas toxic gases during processing. Containment is provided by the furnace (one level) and by use of the vacuum vent line. During processing, the toxic residue is pulled in to the vent line for release to space. Based on partial pressures, the offgas rates are low. In order to use the concept that vacuum venting provides the equivalent of containment there are safeguards required. The furnace pressure is continuously monitored and must remain negative in relation to spacelab ambient pressure. In the event that the furnace pressure approaches module pressure, the furnace automatically shuts down. The sample materials are nontoxic in the solid state and sample M 10 remains in the furnace after processing.

Imaging Furnace (IMF)

The Imaging Furnace, Figure 7 and 8, is designed to accommodate several samples, including crystal growth, by pulling the crystallization zone among the sample Axis. The IMF contains twin ellipsoidal mirrors with one common focus where the sample is located. Two halogen lamps, each located at the focal point of the ellipsoid, provides the heat source. Movement of the melting zone is accomplished by moving the twin mirror furnace along the sample axis. A quartz tube is installed over the samples during processing and an inert gas, argon, flows past the sample. All pressure inside of the furnace, including the argon is at a negative pressure in relation to the module. The pressure is continuously monitored and the furnace automatically shuts down for positive pressure. As in the GHF, the vacuum vent serves as a containment level equivalent. The IMF will process four types of samples. Samples M 02 and M 08 of Table 4 use a quartz ampoule for processing. Figure 9 shows one of the quartz ampoules. Samples M 20 and M 03 (Figure 10) both are naked samples. The naked samples use the sealed IMF and vacuum vent to achieve containment. The IMF is equipped with two view ports to allow visual inspection of the samples to assure that toxic ash or residue has not coated the interior of the furnace. Handling of processed samples requires the use of disposable gloves and samples are placed in sealable bags for storage.

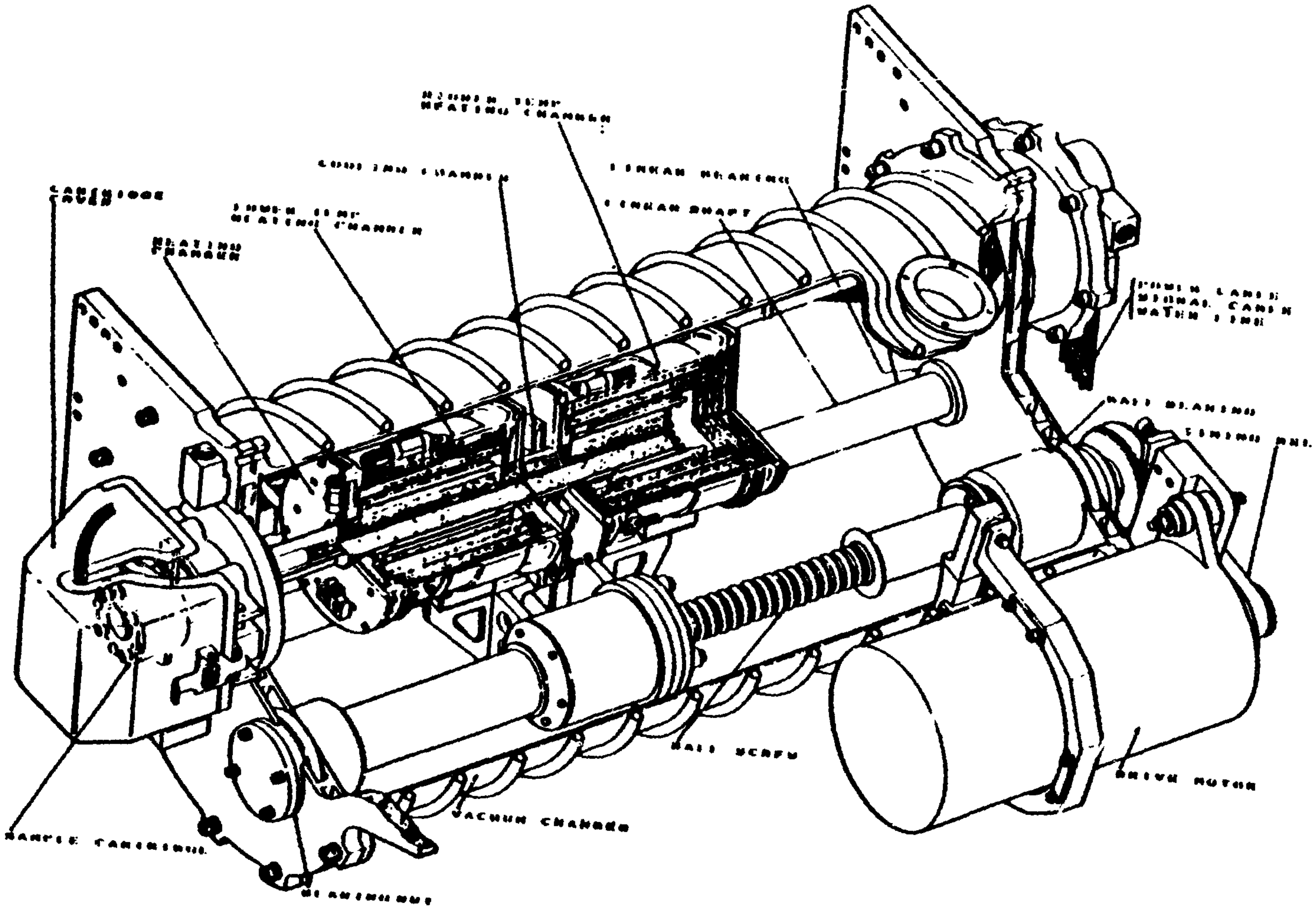


FIGURE 5 GHF-MP FURNACE

Table 3 FMPT · MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m ^{3})	Containment
M01 GHF	Pb Sn Te	91	1000	0.04 0.04 0.02	3 Containments 2 qtz & Ta
M22 GHF	In Ca As	18	1070	0.02 0.5 0.002	3 Containments 2 qtz Amp Ta Cart
M10 GHF	Al In Cu Pb	26.5	1050	2 0.02 0.04 0.04	Unsealed Ta Cart Remains in Furnace

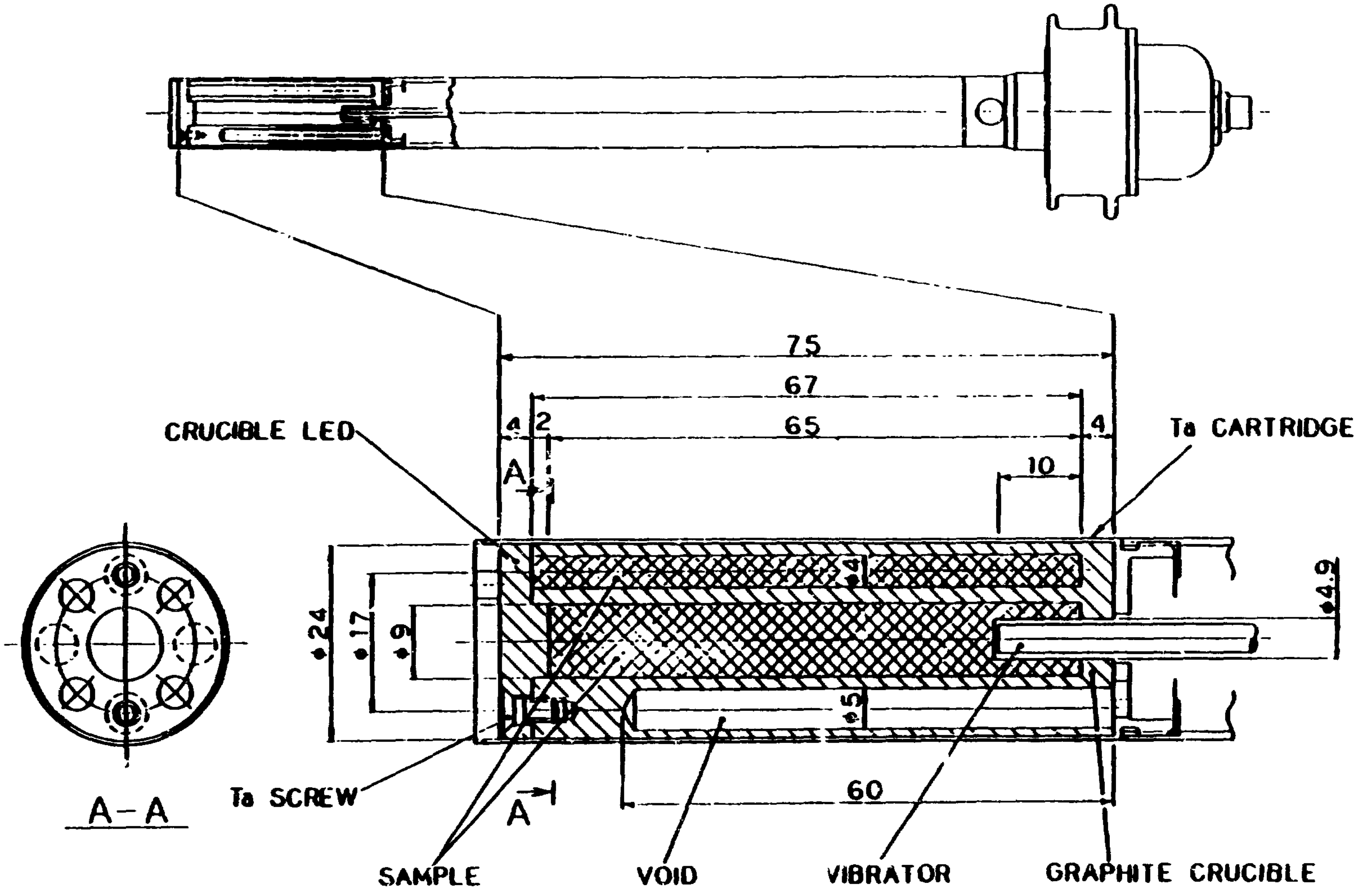


FIGURE 6 FO'MIO SAMPLE

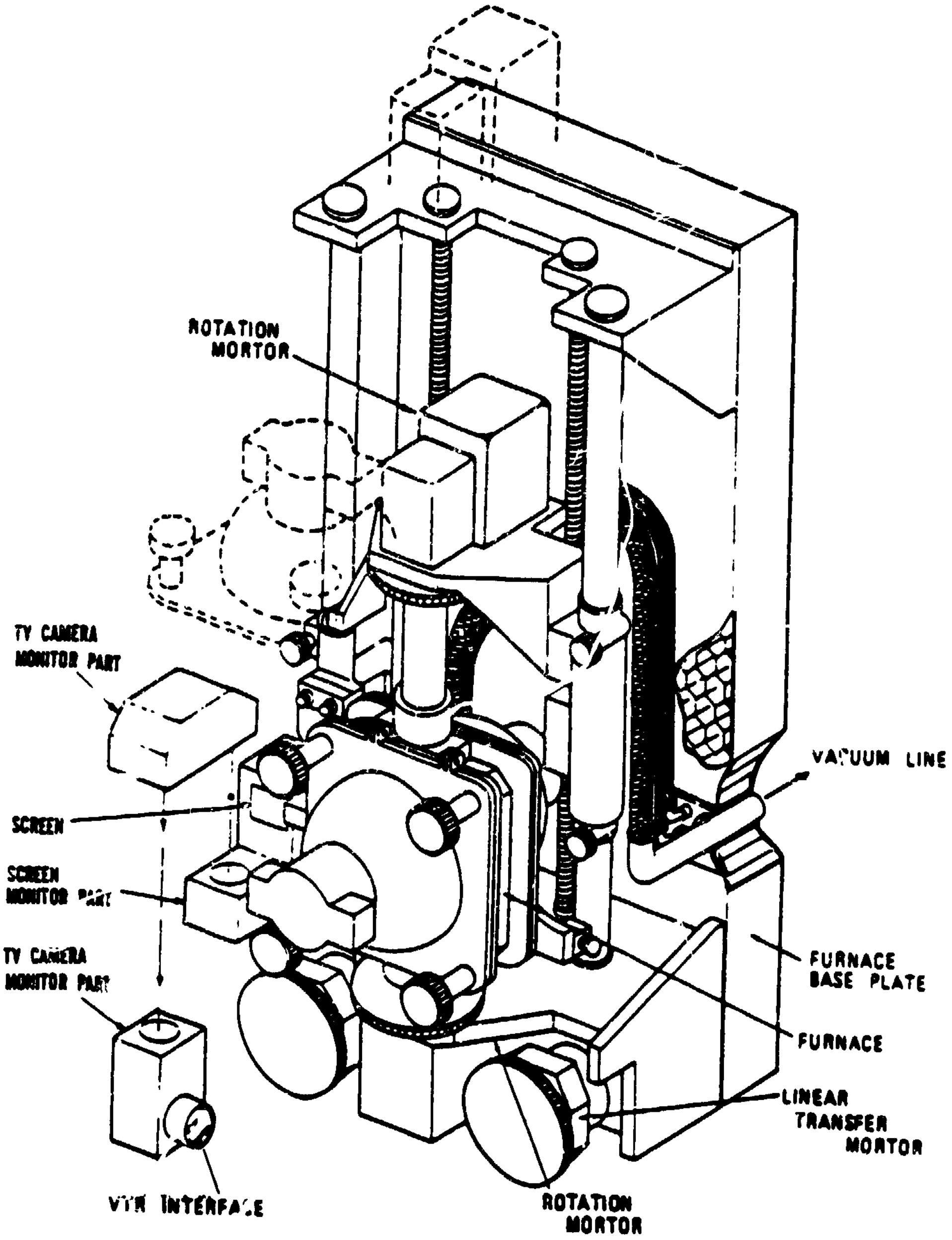


FIGURE 7 IMF-MP FURNACE

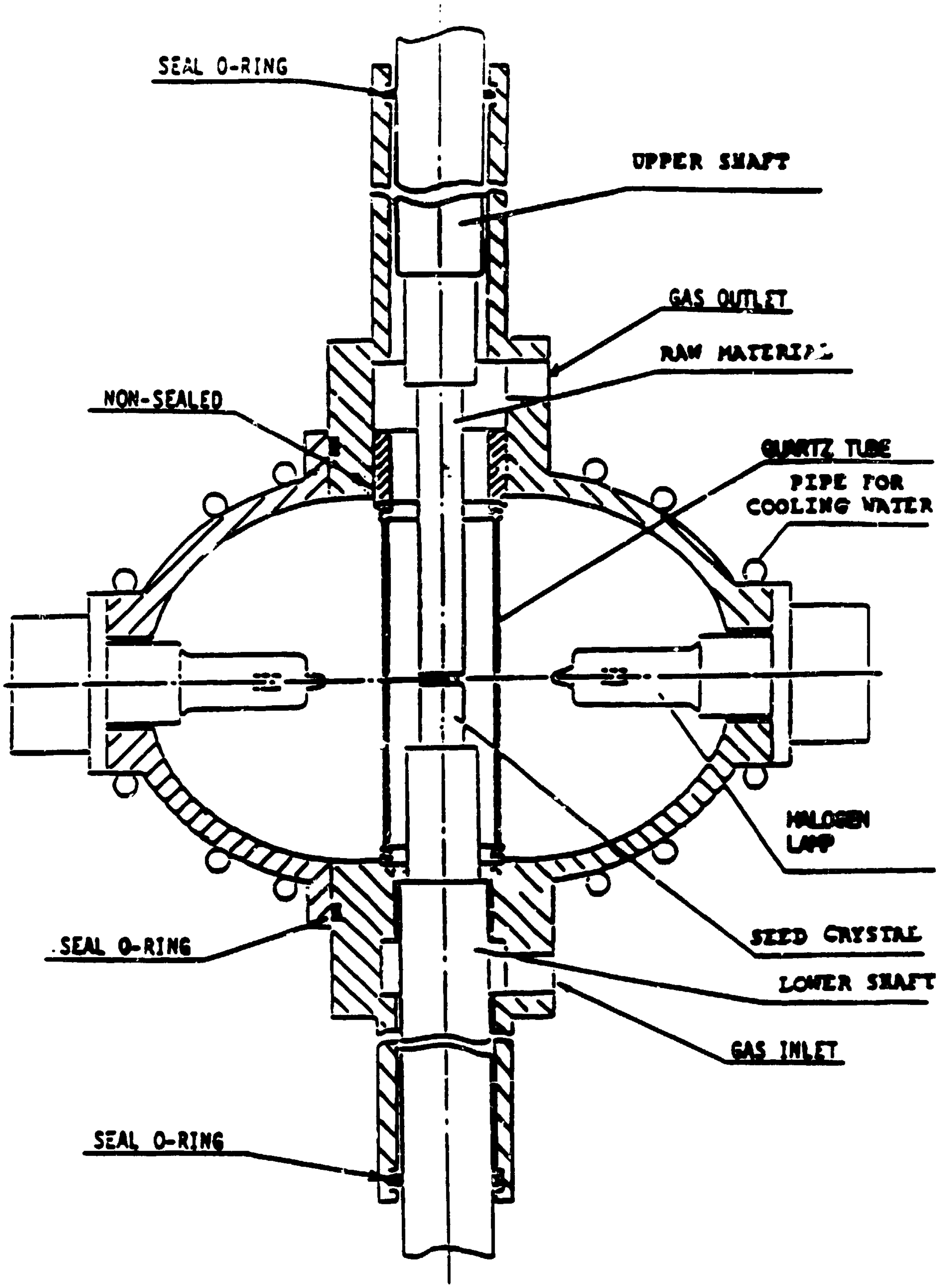


FIGURE 8 INSIDE OF IMF FURNACE

Table 4 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m^3)	Containment
M02	Pb		850	0.04	1 QUARTZ
IMF	Sn			0.04	
	Te			0.02	
M08	Na_2O		1200	0.4	1 QTZ AMP
	B_2O_3			2.0	
IMF	CaO			0 4	
	Co0			0.0254	
	Au			1.0	
		1.162			

Table 4 (cont'd) **FMPT-MEL SAMPLE DATA**

Experiment /Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m^3)	Containment
M20	CaO		1400	0.4	Naked
IMF	UO_2			?	*
	$YO_{1.5}$			0.25	
	FeO			1.0 (Fe_2O_3)	
	$NbO_{2.5}$			0.5	
		1.33			
M03	In		550	0.02	Naked-Furnace 1-Remains in Furnace
IMF	Sb			0.1	
		374.1 (Max.)			

**Does Not Exceed SMAC

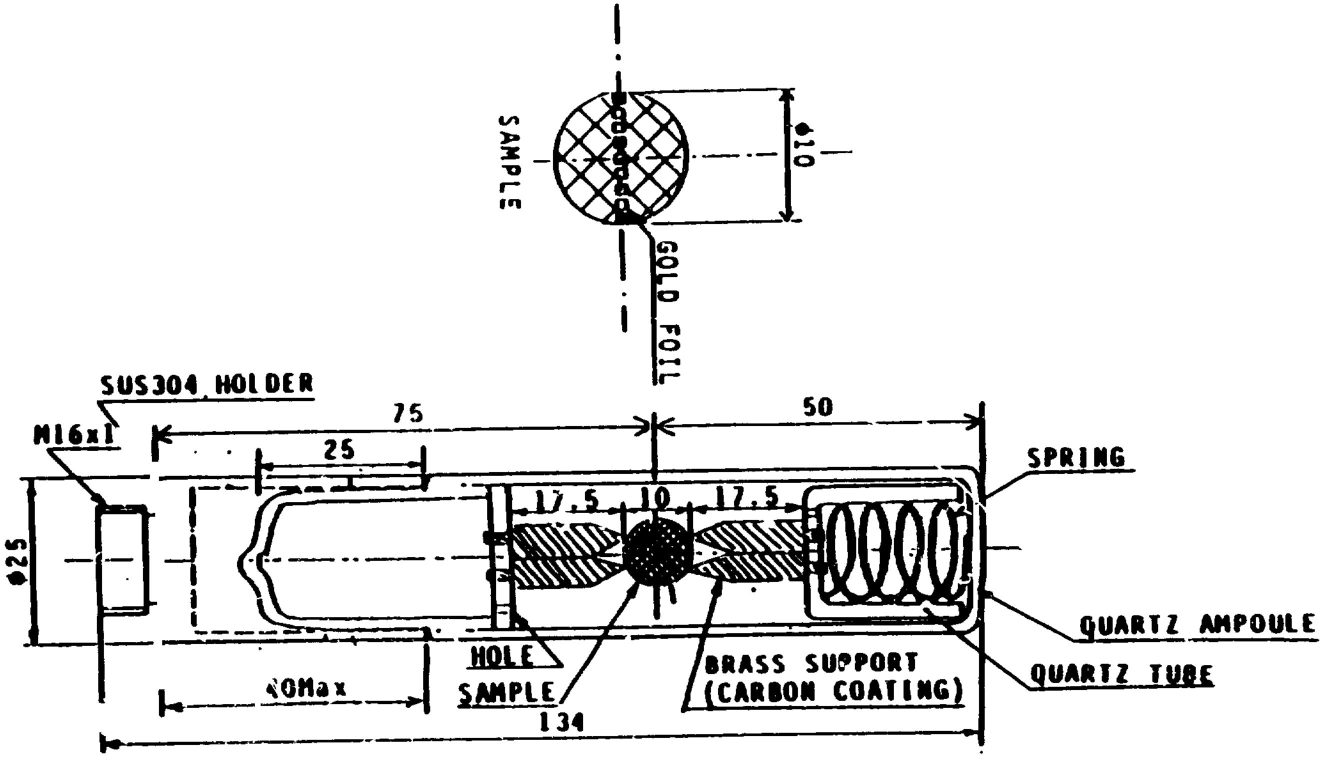


FIGURE 9 FO 108 SAMPLE

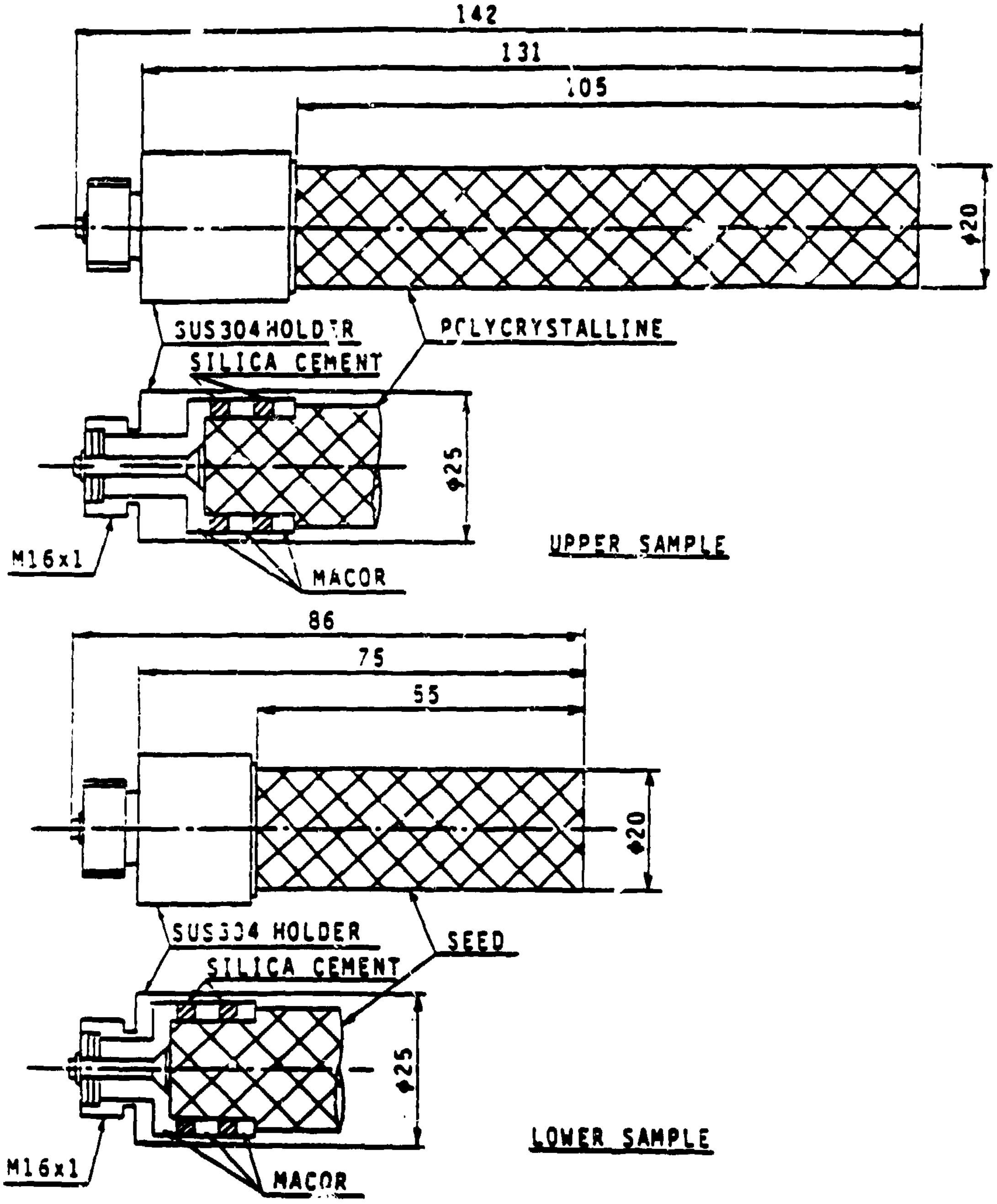


FIGURE 10 FO MO3 SAMPLE

Continuous Heating Furnace (CHF)

The CHF, Figure 11, is a unique vacuum furnace designed to process samples continuously. The CHF combines two heating chambers and two water cooled chambers to achieve continuous heating of two samples and rapid cooling of two samples. The furnace operates at a maximum of 1300°C and can cool two samples from 1200°C to room temperature in approximately 10 minutes. Heating and cooling chambers are alternately arranged. The furnace translates fore and aft to position the chambers over the samples. After heat up and sample processing, the furnace translates aft, rotates 90°, and then translates forward such that samples which were being heated, are then cooled. At the completion of the cooling cycle (touch temperature of 45°C) the cooled samples are replaced with new samples for the next phase. The CHF will process five sample types - M 04, (Figure 12) M 07, M 13, M 19, and M 11 of Table 5. All of the samples provide triple containment except M 11, Figure 13, which provides dual containment. In this case the furnace and vacuum provide the extra levels of containment. All of the containments are somewhat different, however the examples, Figures 12 and 13 are representative.

Large Isothermal Furnace (LIF)

The LIF, Figure 14, is a vacuum heating furnace which operates at temperatures up to 1600°C. Provisions are made to allow pressurization of some sample cartridges at 6 bar (Figure 15). Furnace heat up and processing are accomplished in a vacuum and cooling uses helium gas at pressures which are negative in relation to the module. In the event of positive pressure, the furnace automatically shuts down. Three sample types will be processed - M 05, M 12, and M 06 of Table 6. Both M 05 and M 12 cartridges provide dual containment while M 06 is a naked sample which remains in the furnace after processing. Figure 16 depicts one of the sample cartridges while Figure 17 shows the naked sample.

Crystal Growth Facility (CGF)

The CGF, Figures 18 and 19, consists of two furnace chambers, one for a spherical sample and one for a bar sample. The furnaces operate at temperatures in excess of 1400°C and samples are processed in gaseous argon which is at a negative pressure in relation to the spacelab module. In the event the furnace pressure approaches module pressure, the furnaces automatically shut down. Each furnace chamber will process one naked sample of silicon (Sample M 09 of Table 7) which will remain in the furnace after processing until removal on the ground. Silicon is a low toxic material and the furnace plus the vacuum vent provide adequate containment.

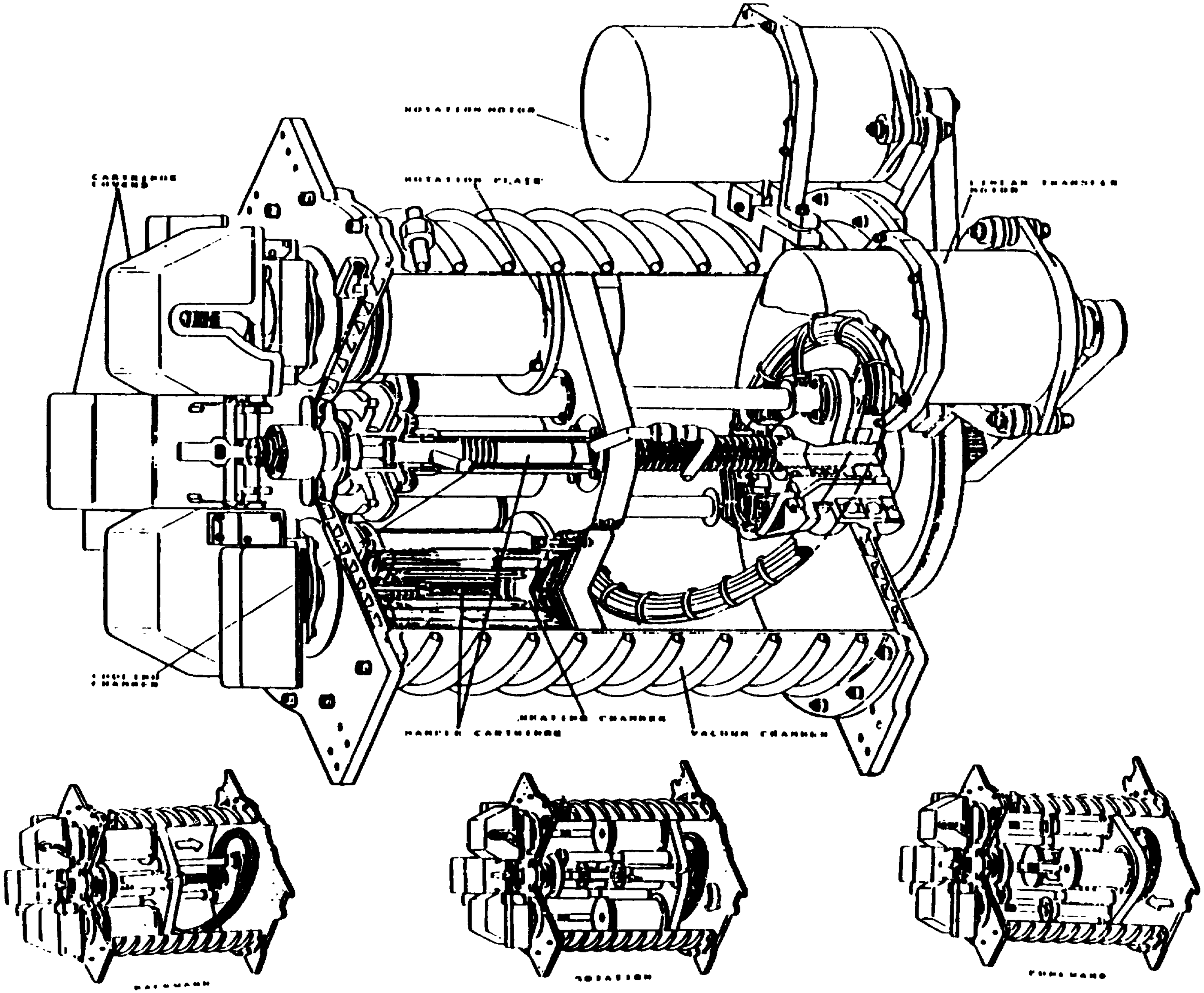


FIGURE 11 CIIF-MP FURNACE

ORIGINAL PAGE IS OF POOR QUALITY

Table 5 **FMPT - MEL SAMPLE DATA**

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m^3)	Containment
M04	Al	a.		2	3 Containments 2 Ta Cap 1 Ta Cart
		b.	1300		
CHF		c.			
	Pb	a.		0.04	
		b.	1300		
		c.			
	Bi	a.		0.5	
		b.	1300		
		c.			
	(total)	a. 6.69 b. 6.69 c. 6.69			

Table 5 (cont'd) **FMPT - MEL SAMPLE DATA**

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m^3)	Containment
M07 CHF	Au Ag	6.9	1300	1 0.02	3 Containments 2 QTZ AMP 1 TA CART
M13 CHF	Si As Te Mn	6 in total	1300	2 0.002 0.02 0.2	3 Containments 2 QTZ AMP TA CART

Table 5 (cont'd) FMPT - MEL SAMPLE DATA

Experiment/ Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m^3)	Containment
M-13 CHF	Si	a. b. c. d. e. f.		2	3 Containments 2 QTZ AMP 1 Ta CART
	--------	--------	1300		
	As	a. b. c. d. e. f.		0.002	
	--------	--------	1300		
	Te	a. b. c. d. e. f.		0.02	
	--------	--------	1300		
	Mn	a. b. c. d. e.		0.2	
	(total)	a. 1.00000 b. 1.00000 c. 1.00000 d. 1.00000 e. 1.00000 f. 1.00000			

Table 5 (cont'd) FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature ^{0}C	SMAC (mg/m^3)	Containment
M 19		2 ea. X			3 Containments 2 QTZ AMP Ta CART
CHF	Al		700	2	
	Cu			0.04	
	(total)	a. 1.40 b. 1.40 c. 1.40			
M 11 CHF	Al In C	6 ea. X 4.51	1550	2 0.02	2 Containments QTZ AMP Ta CART

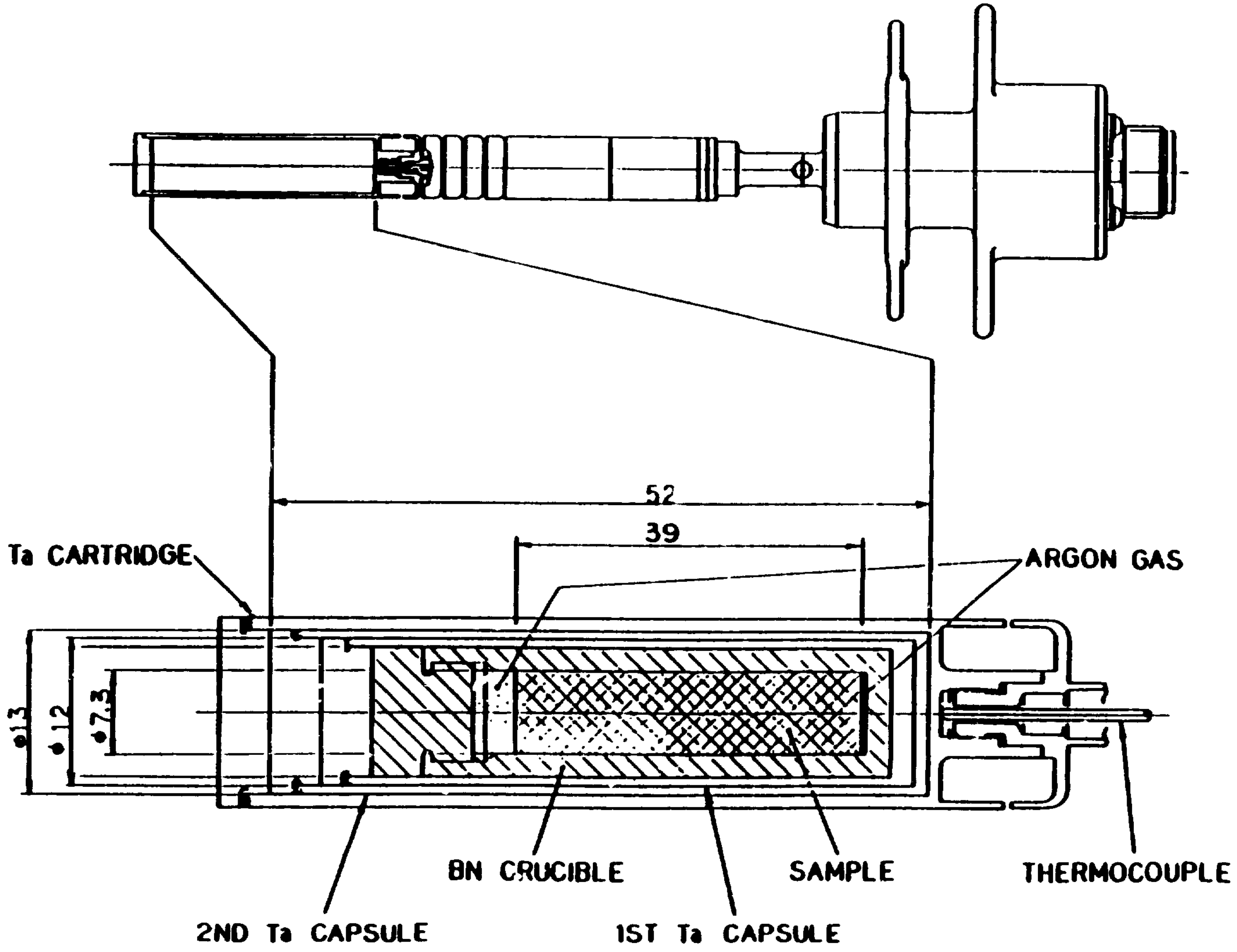


FIGURE 12 FO M04 SAMPLE

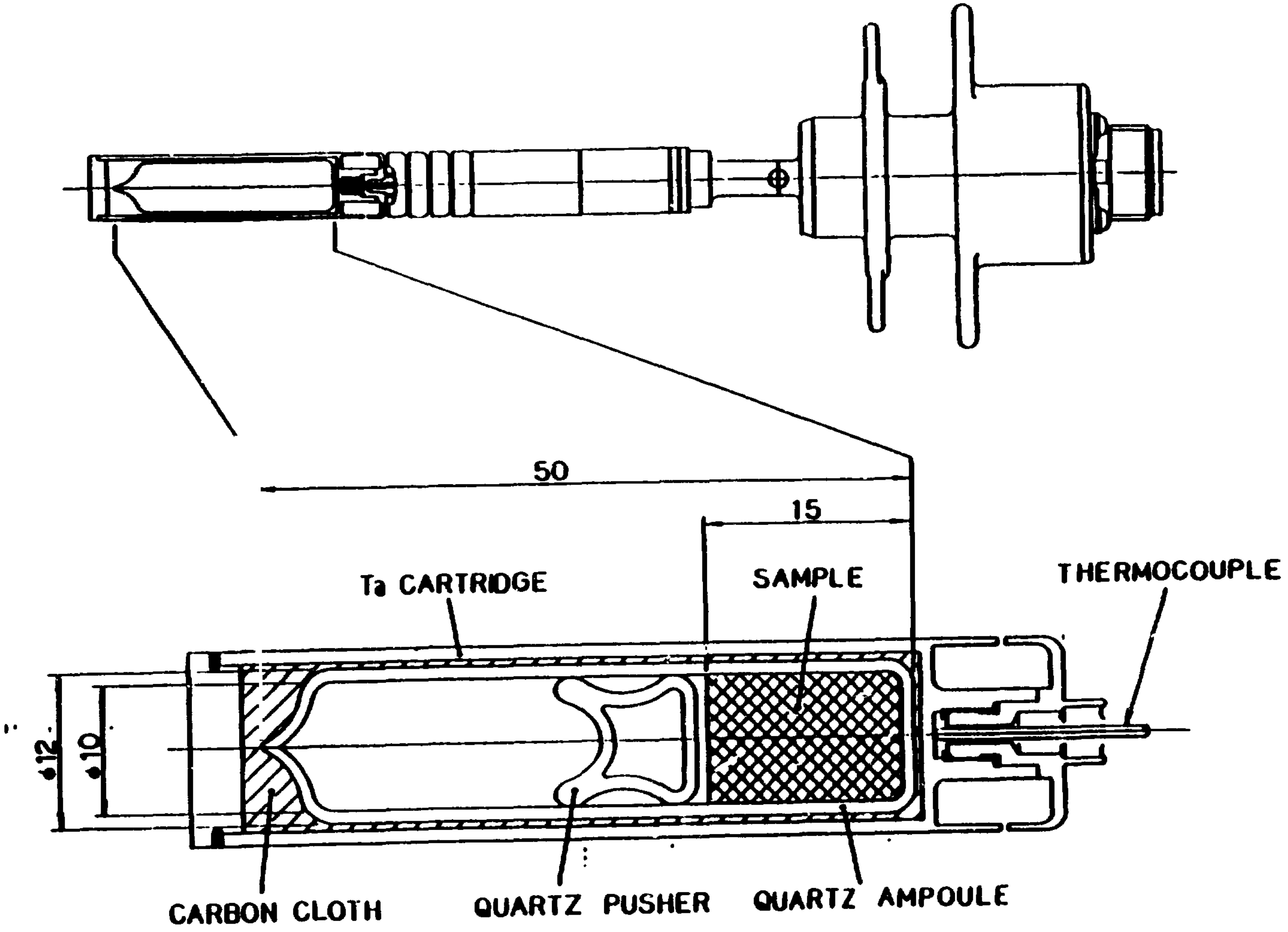


FIGURE 13 FO M11 SAMPLE

Table 6 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m^3)	Containment
M05	Fe			1	2 Containments
	Ni			0.08	MOLY CONT.
LIF	Al		1600	2 .0	Ta CART
	Mn			0.2	
	Si			2	
	O			- -	
		57.6			
M12	W			1	2 Containments
	Ni		1550	0.08	*Ta CAPSULE
LIF		43			Ta CART
M06	Ni			0.08	Unsealed-
	Mo			3	Left in Furnace
LIF	Cr		1380	0.1	
	Co			0.009	
	TiC			3	
		168.98			

Table 6 (cont'd) FMPT - MEL SAMPLE DATA

Experiment/ Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m^3)	Containment
M06	(Glass Sealant)				
(CONTINUED)	SiO_2			?	
	B_2O_3			2	
LIF	Na_2O			0.4	
	Al_2O_3			?	
	K_2O			?	
	Fe_2O_3			?	
		————			
		0.7			

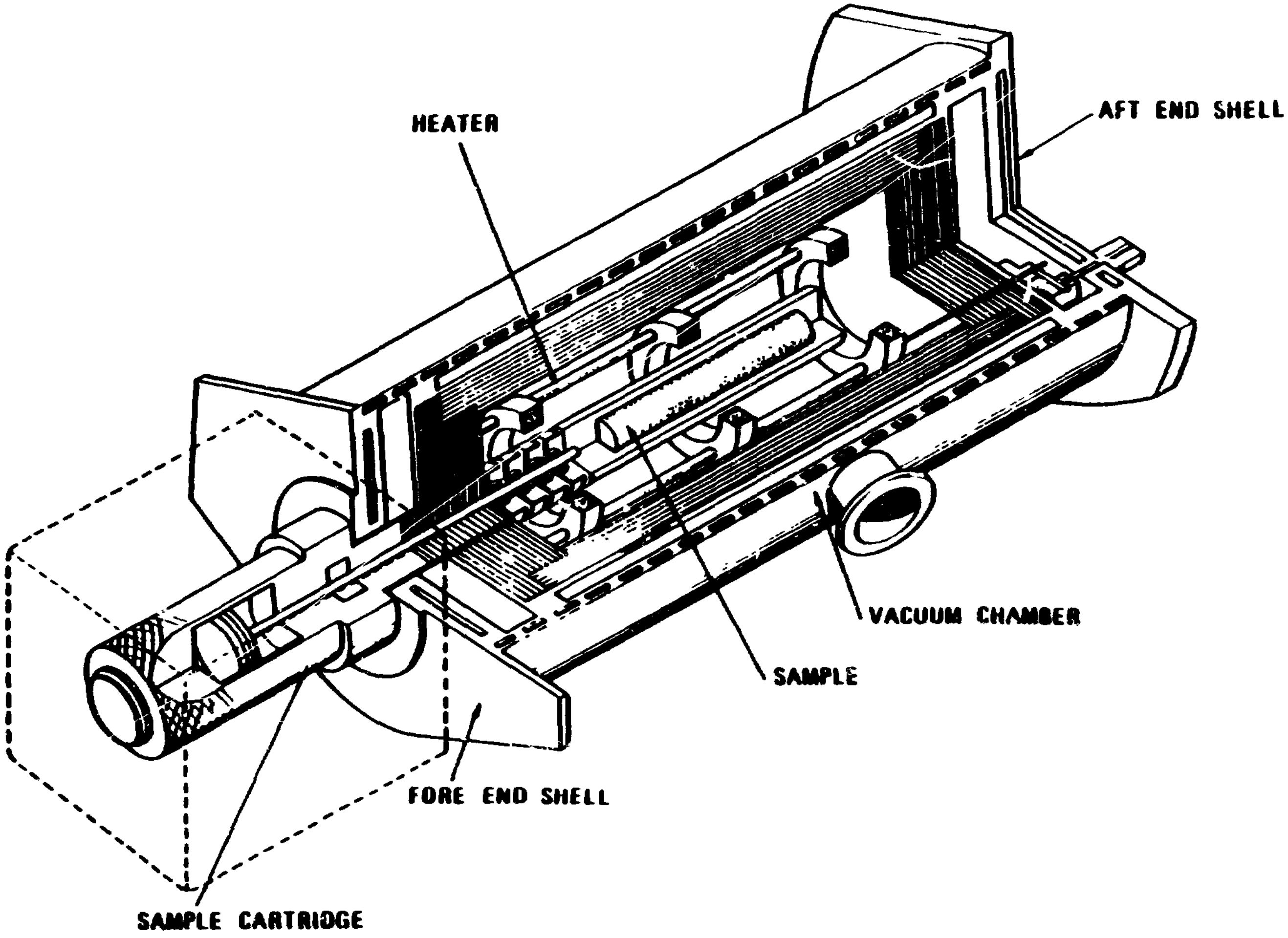


FIGURE 14 LIF-MP FURNACE

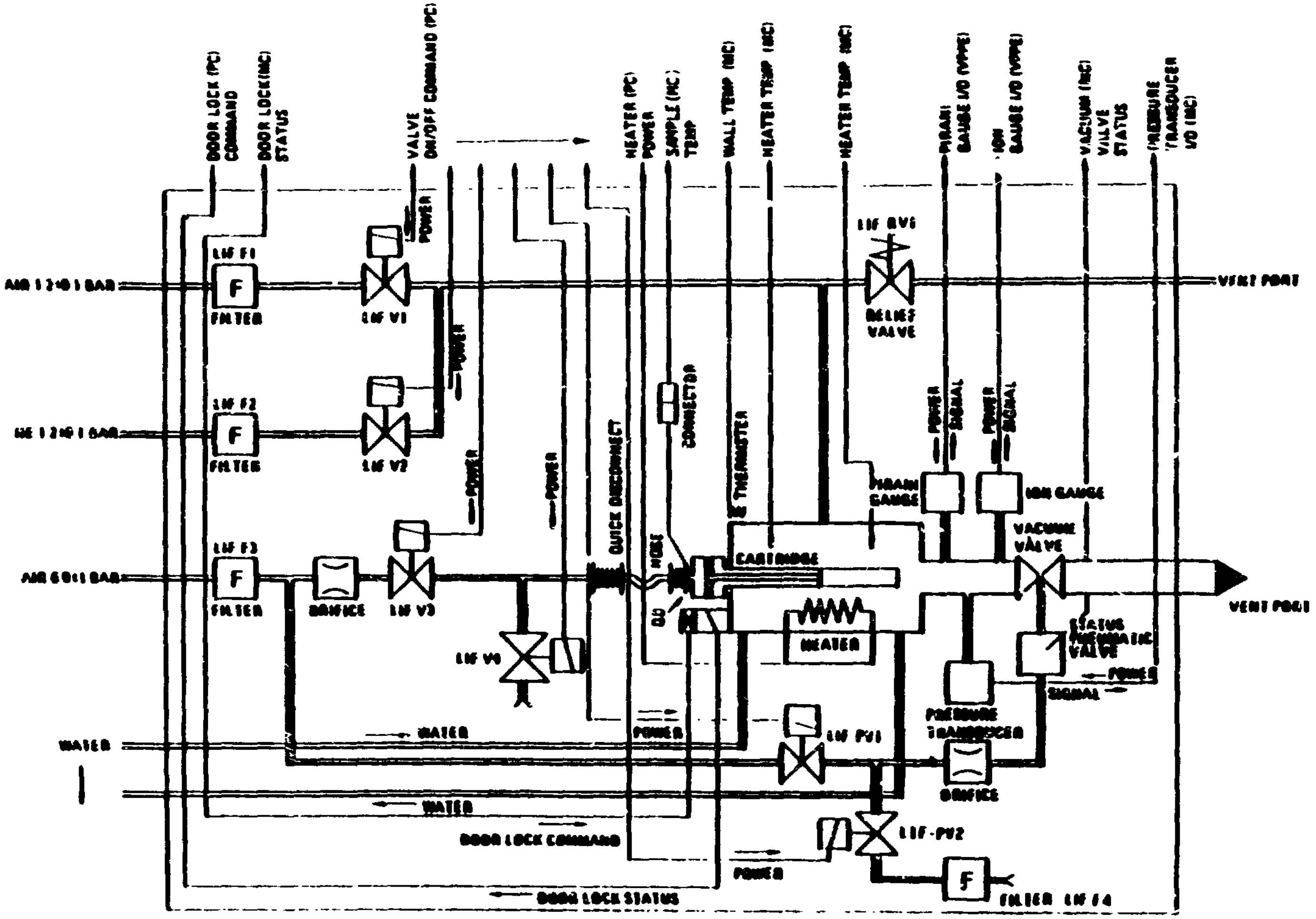


FIGURE 15 LIF-MP FUNCTIONAL DIAGRAM

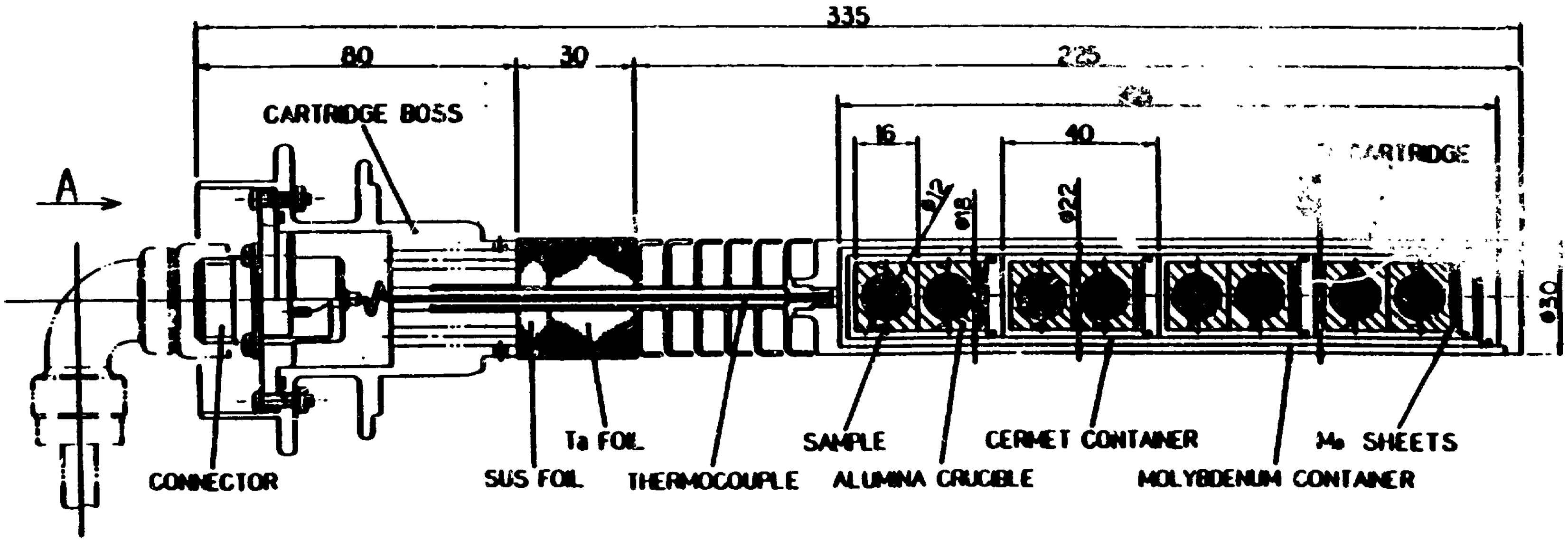


Figure 16 FO MO5 Sample

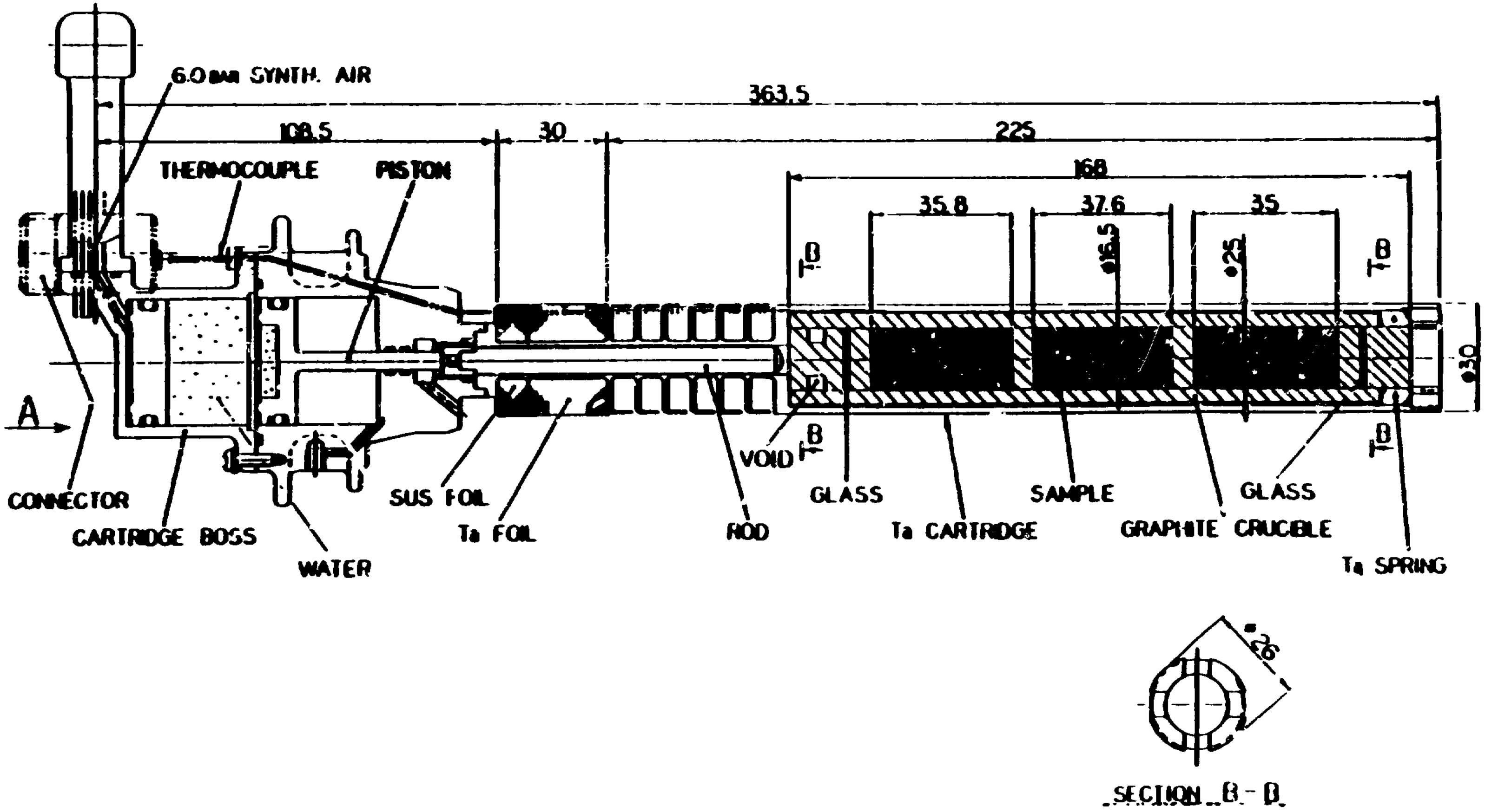


Figure 17 FO M06 Sample

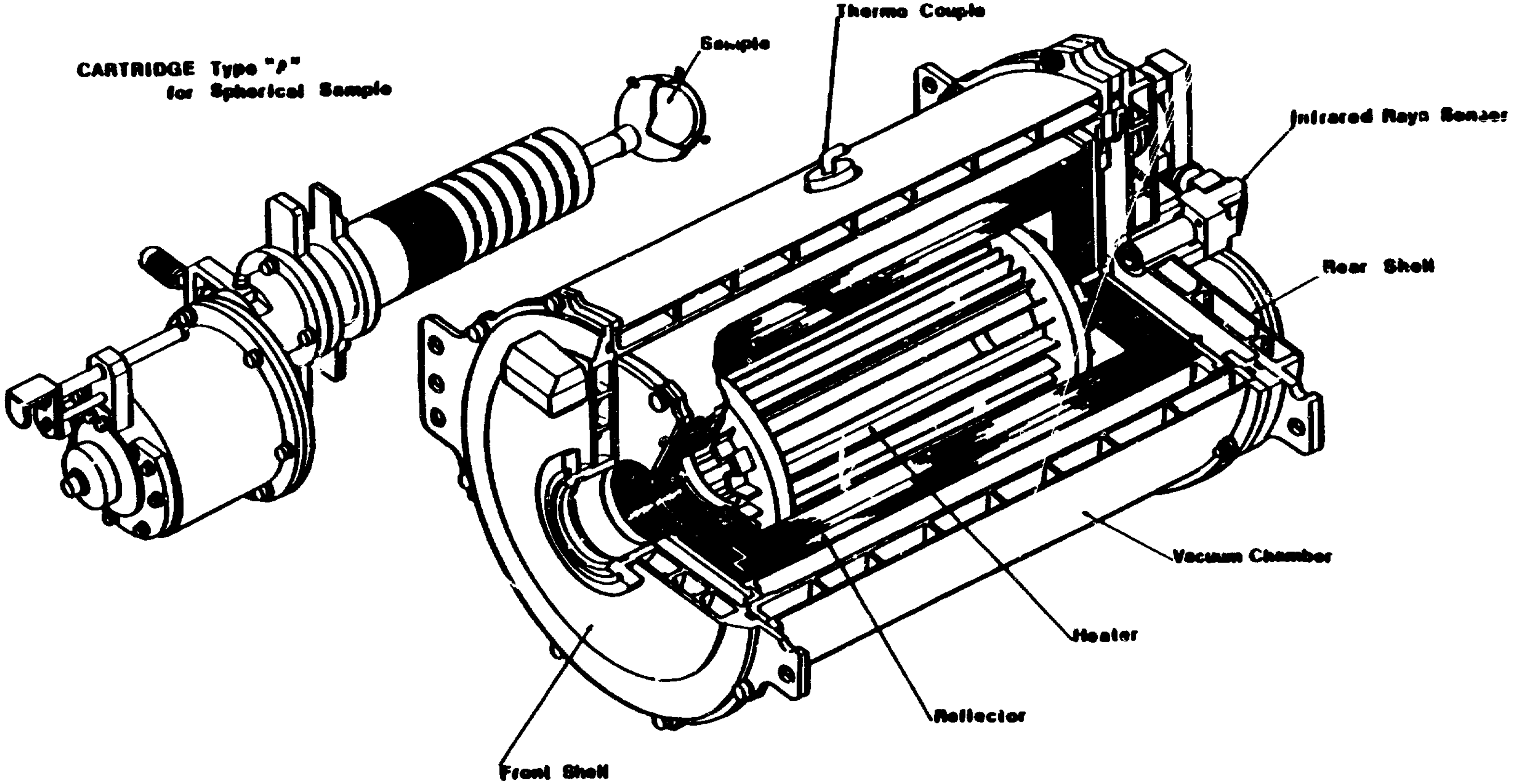


FIGURE 18 CRYSTAL GROWTH EXPERIMENT FACILITY CONCEPT (1/2)
(FOR SPHERICAL SAMPLE)

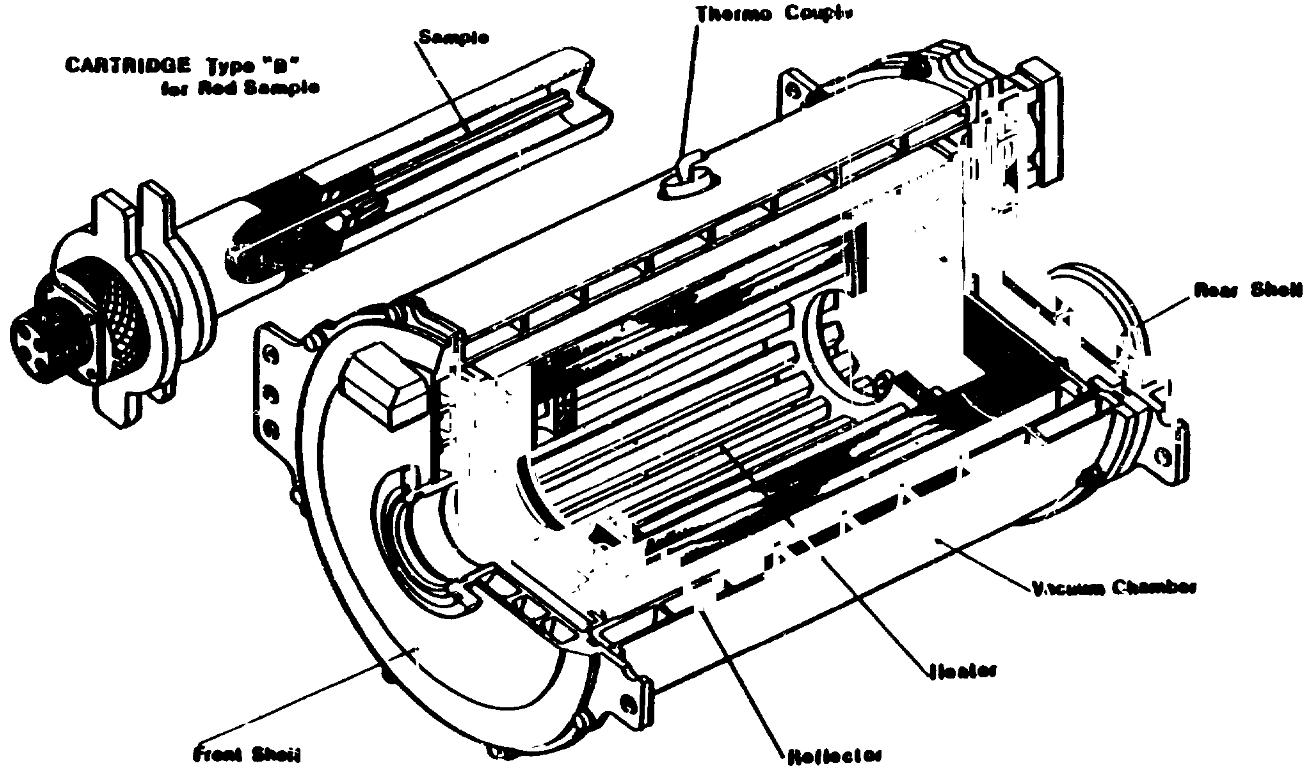


FIGURE 19 CRYSTAL GROWTH EXPERIMENT FACILITY CONCEPT (2/2)
(FOR ROD SAMPLE)

Table 7 **FMPT – MEL SAMPLE DATA**

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m^3)	Containment
M09 CGF	Si		1450	2	Unsealed Ball Sample Unsealed Rod Sample
M17 ALF	CaO	a. b. c.	1400	0.4	** Naked
	CaO	a. b. c.		1.4	
	GeO	a. b. c.		85.6	
	total	a. 2.000 b. 2.000 c. 2.000			

** Does Not Exceed SMAC

Acoustic Levitator Furnace (ALF)

The ALF, Figure 20, is designed for containerless refinement of glass in space. The ALF, which operates at approximately 1400°C, is very similar to the Image Furnace in that halogen lamps, located at the focii of twin ellipsoid mirrors reflect the heat to a common focus point for melting glass. The ALF sample is processed in a krypton gas flow which is at a negative pressure in relation to the module pressure. The pressure is continuously monitored and the furnace is automatically shut down if the internal pressure approaches ambient pressure. The furnace is equipped with a speaker to create an ultrasonic tunnel within the furnace. A sound reflector at the rear of the furnace is adjustable to enable sample positioning. The furnace will process sample M 17 of Table 7 which is a naked glass sample. Toxicity is low and containment will be provided by the furnace and the vacuum vent.

Organic Crystal Growth Facility (OCF)

The OCF Figure 21 is comprised of two experiment cells, a large cell and a small cell. Contents of the small cell are insufficient to result in a toxicity hazard and is controlled by dual containment. Both cells are processed at room temperature. The large cell uses an inner quartz container which has three chambers, one for the donor fluid, one for mixing and one for the acceptor fluid. The anisole, Table 8, is toxic and due to the quantity will require triple containment. The quartz container is located within an aluminum container which is housed in a sealed aluminum box. The quartz container and the inner box have some common penetrations. In order to achieve two containments, it is necessary to use dual sets of "o" rings or seals. A vigorous qualification program including a 14 month leak test is being performed.

Other Processing Facilities

Other experiments include a Bubble Behavior Unit to study fluid movement in space, A Marangoni Convection Unit, a Liquid Drop Facility (acoustic levitation) for fluid drops and a Gas Evaporation Facility. Single or dual containment is provided as required. The containments are interesting, however the experiments do not provide significant toxicity hazards.

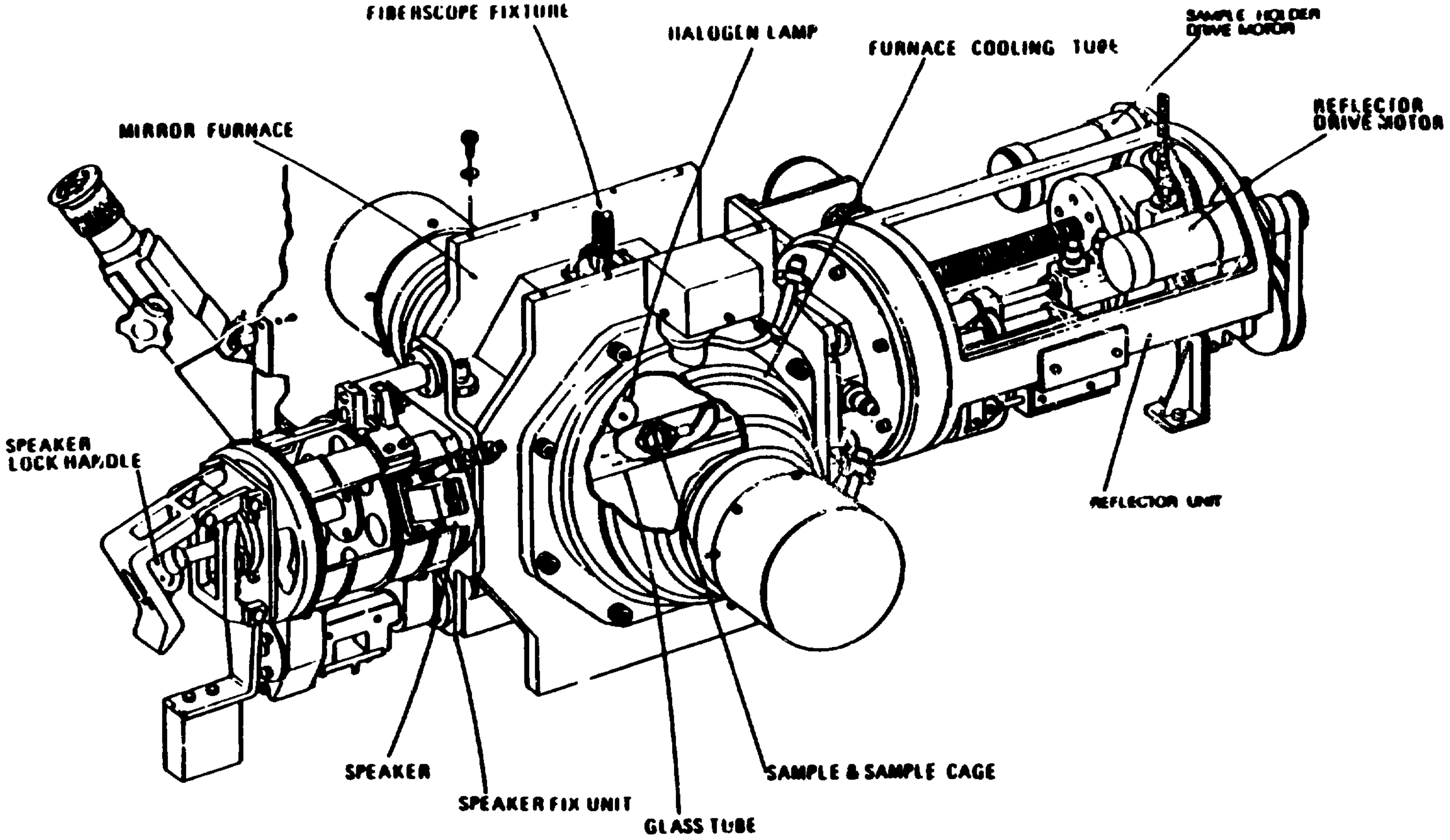


FIGURE 20 ALF-LVT FURNACE

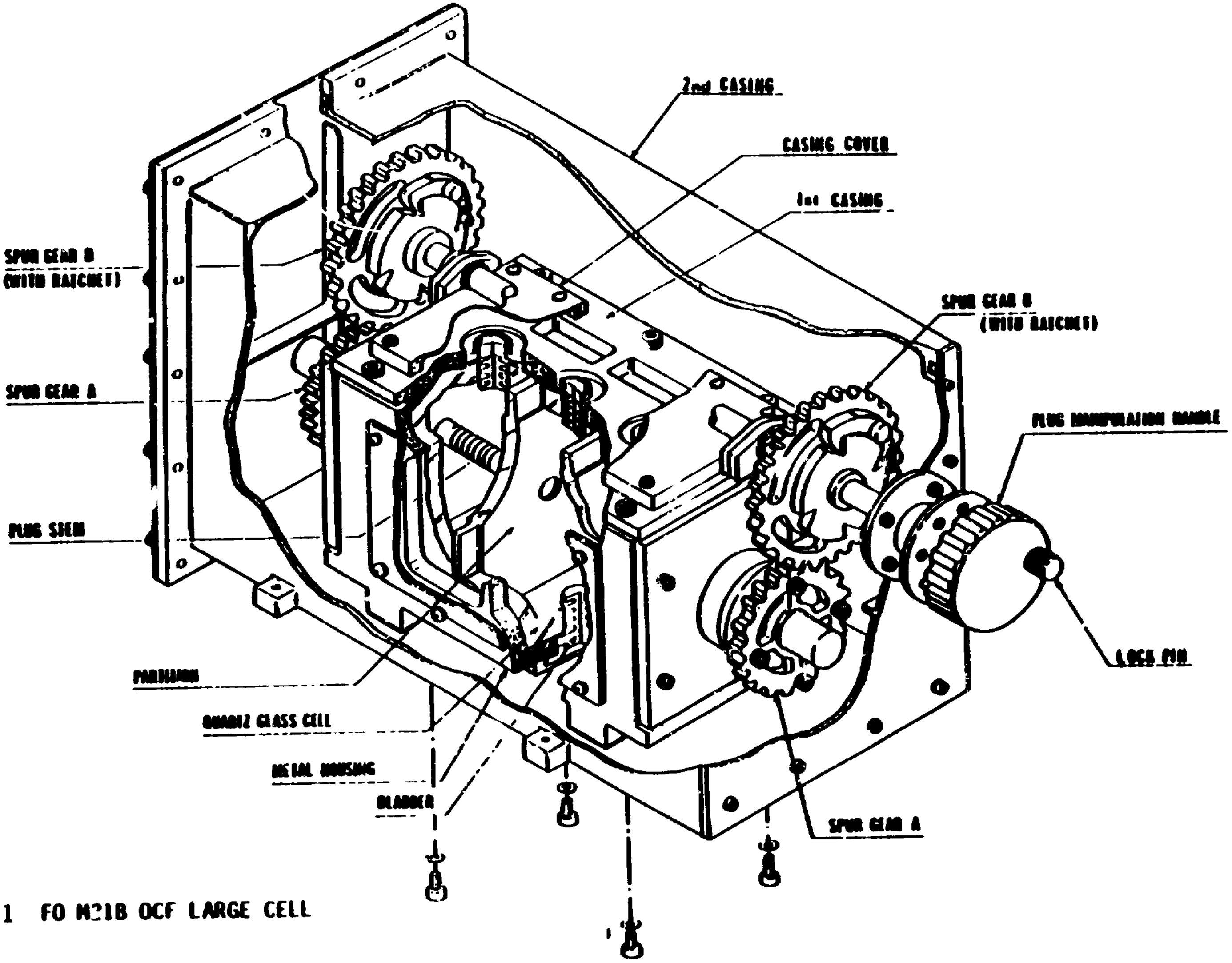


FIGURE 21 FO M21B OCF LARGE CELL

Table 8 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m)	Containment
M21A OCF	Anisole TMTTF TCNQ TMTTF-TCNQ Au	3.3047±03	AMBIENT	8 8 ? ? ? 1	2 Containments Small Cell Qtz. Cell Alum. Case
M21B OCF	Anisole TMTTF TCNQ TMTTF-TCNQ Ag	221.2902	AMBIENT	8 8 ? ? ? 1	3 Containments Large Cell Qtz Cell Alum. Case Sealed Box

USML-1 Spacelab

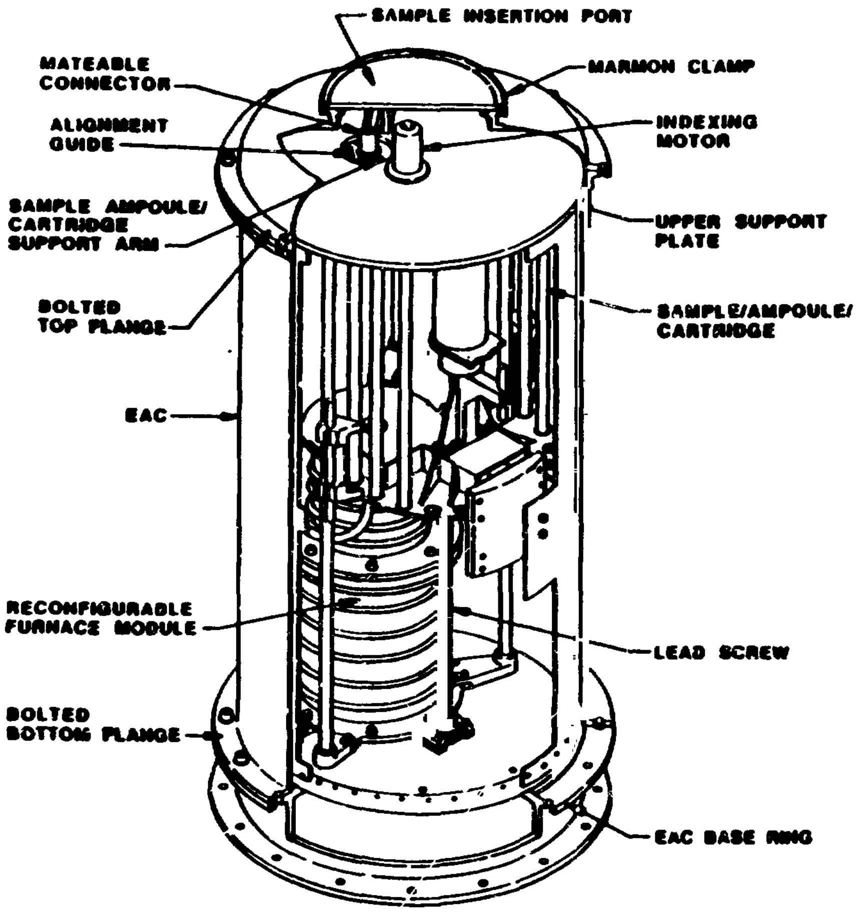
The USML-1 is still in the early design stages and concepts are not as clearly defined as Spacelab J. There will be several material processing facilities including containerless processing by acoustic levitation. Another experiment will be the Crystal Growth Facility, Figure 22, which will process numerous toxic metals at different temperatures. This facility will have some direct bearing on the space station. The facility uses a furnace core which translates along the sample axis. As in the case of some SL-J experiments, the Crystal Growth Facility will use the vacuum vent as a level of containment and will require shut down if the inner pressure becomes positive in relation to the module. Sample change out will be manually performed by the crew. To preclude toxic material release in the module during sample change out, a collapsible glove box will be used. The glove box will seal around the end of the container while the insertion port cover is removed. In the event of toxic residue in the furnace as evidenced by discolorization the cover will be reinstalled and the glove box dumped to the vacuum vent.

Recommendations/Conclusions

° Triple containment is the preferred method for prevention of toxic material release in habitable areas for catastrophic hazards. The containments must be adequate for the intended use and environment.

° When operations preclude triple containment, innovate methods should be explored. While there are several examples of use of the vacuum vent as an equivalent containment, stringent requirements exist to monitor internal pressures and shut the facility down for positive pressure. Materials must be nontoxic at ambient temperatures, and offgassed products must be compatible with the vacuum vent. Offgassed products must also be compatible with each other to the extent that exothermic reactions must not occur which would result in a hazard. It should be noted that a contaminated vacuum vent could result in ground hazards during de-integration activities and will require special procedures. It is usually the responsibility of the experiment developer to decontaminate or replace the vacuum vent after flight.

CGF INTEGRATED FURNACE/EAC ASSEMBLY



KEY FEATURES:

- FURNACE TRANSLATION
- AUTOMATED SAMPLE EXCHANGE MECHANISM (SEM) HAVING CAPABILITY TO PROCESS UP 6 SAMPLES
- CREW INTERACTION WITH THE SEM FOR MANUAL INSERTION/ RETRIEVAL OF SAMPLE(S)
- ARGON ATMOSPHERE INSIDE THE EAC DURING PROCESSING
- TWO LEVELS OF CONTAINMENT PROVIDED BY NEGATIVE OPERATING PRESSURE AND EAC DURING PROCESSING
- APPROXIMATE WEIGHT: 444 LB
- MOUNTING ORIENTATION OPTIONS: HORIZONTAL OR VERTICAL

CRYSTAL GROWTH FURNACE (CGF)

FIGURE 22

SOVIET
MATERIALS PROCESSING
EXPERIENCE AND EQUIPMENT

NICHOLAS L. JOHNSON
ADVISORY SCIENTIST
TELEDYNE BROWN ENGINEERING

29 NOVEMBER 1988

SPACE STATION TOXIC AND REACTIVE
MATERIALS HANDLING WORKSHOP

HUNTSVILLE, ALABAMA

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

TBE8810-497

SCOPE OF PRESENTATION

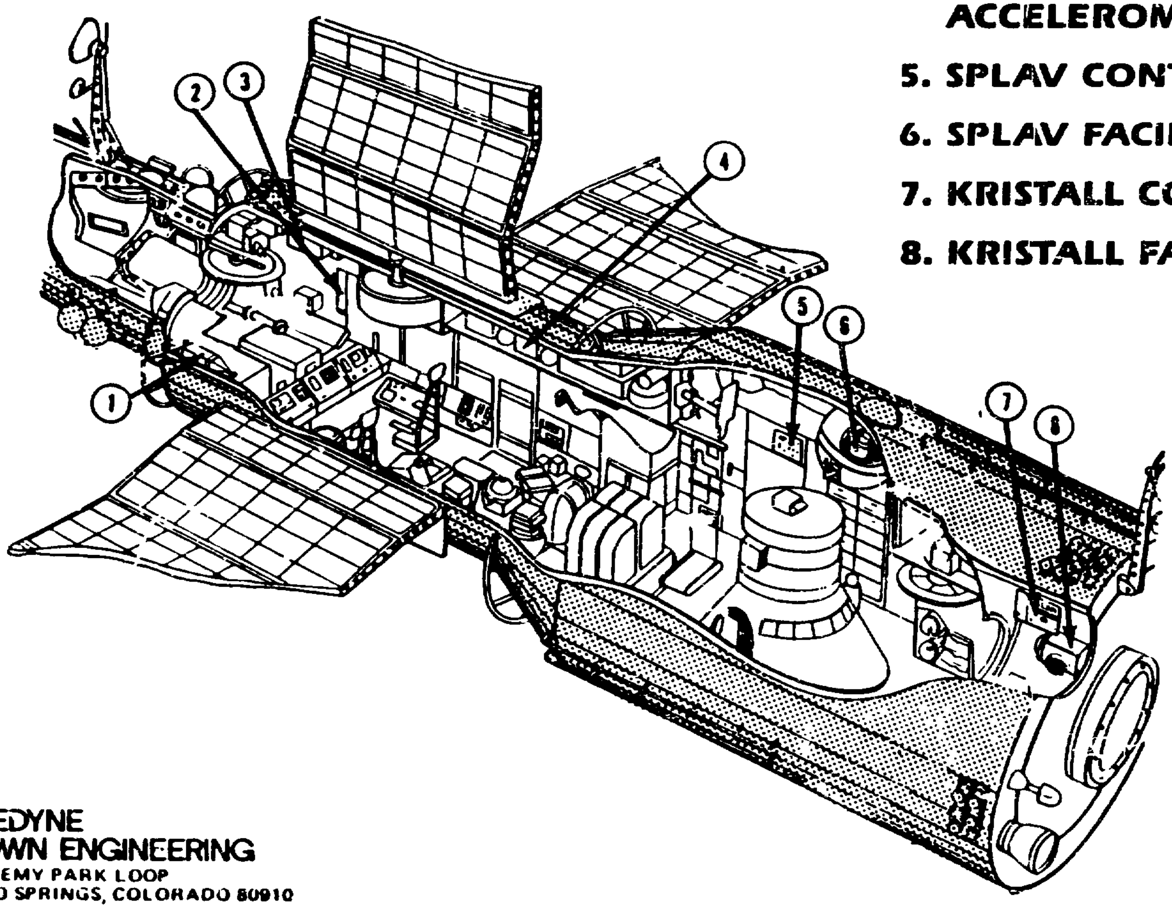
TBE8810-498

- SOVIET SPACE STATION CONFIGURATIONS
- MATERIALS PROCESSING EQUIPMENT
  - ➤ ELECTRIC FURNACES
  - ➤ BIOTECHNOLOGICAL UNITS
- OPERATIONAL PROBLEMS ENCOUNTERED
- PHOTON UNMANNED MATERIALS PROCESSING SPACECRAFT AND EQUIPMENT
- SUMMARY

SALYUT SPACE STATION MATERIALS SCIENCE LAYOUT

TBE8810-499

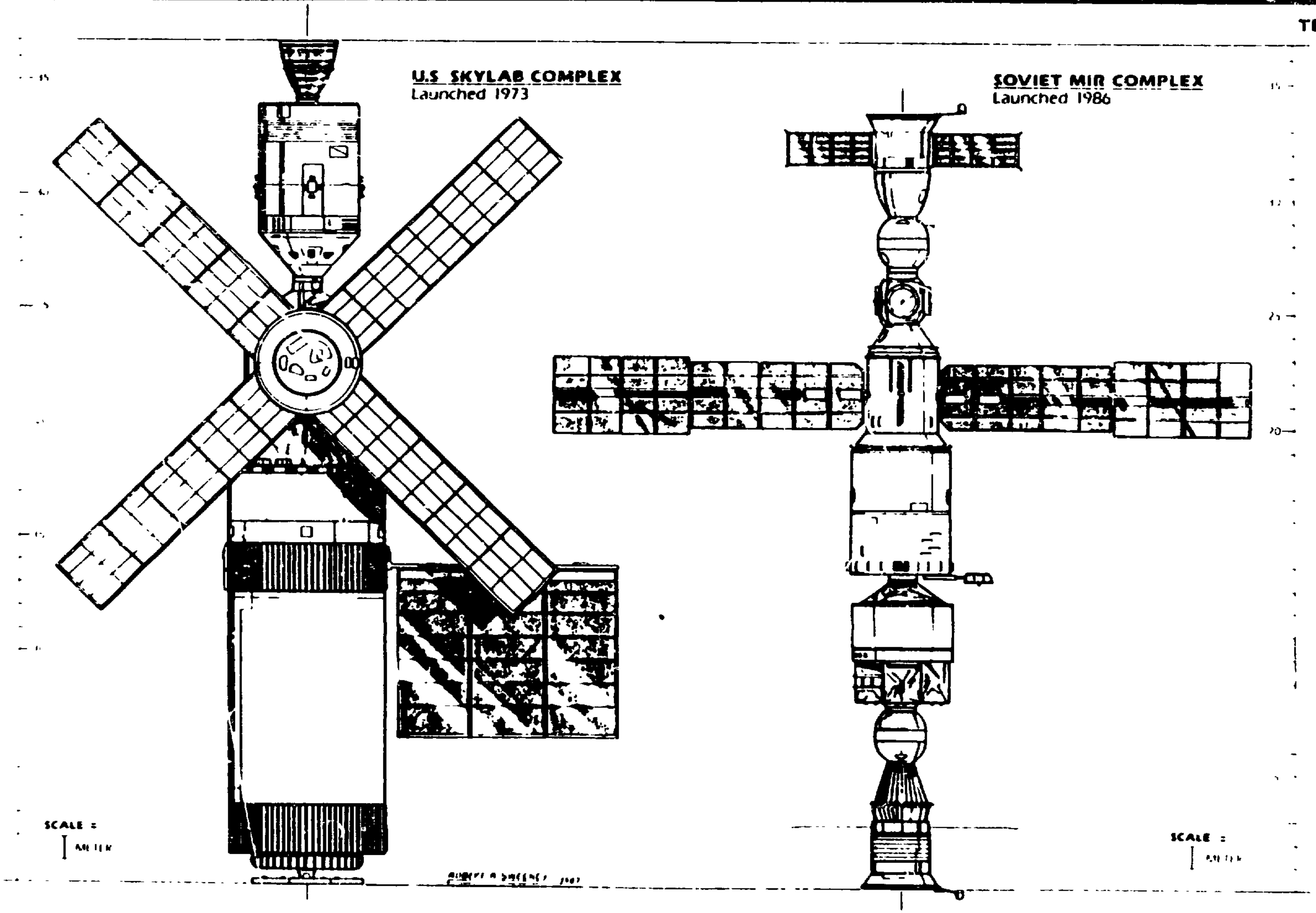
1. PION FACILITY
2. TAVRIYA FACILITY
3. GENOM FACILITY
4. TRIAXIAL HIGH-SENSITIVITY ACCELEROMETER
5. SPLAV CONTROL PANEL
6. SPLAV FACILITY
7. KRISTALL CONTROL PANEL
8. KRISTALL FACILITY



TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

MIR SPACE STATION
PRESENT CONFIGURATION

TBE8810-500



TELEDYNE BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

ORIGINAL PAGE IS
OF POOR QUALITY

PROGRESS UNMANNED RESUPPLY SPACECRAFT

TBE8810-501

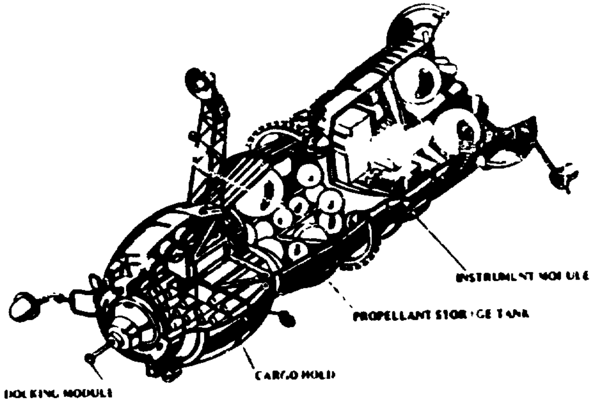
- **SPECIFICATIONS**

  SUCCESSFUL MISSIONS SINCE 1978: 38
  CURRENT FLIGHT RATE: ~6 PER YEAR
  MEAN LIFETIME: 34 DAYS (MINIMUM = 14
  MAXIMUM = 74)

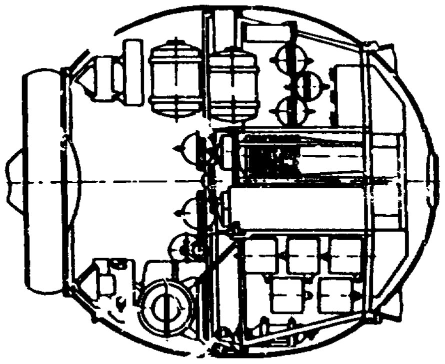
  TOTAL MASS: 7,020 kg
  PAYLOAD MASS: 2,300 kg
  (CARGO HOLD = 1,300 kg)
  (STORAGE TANKS = 1,000 kg)
  NOT RECOVERED

- **PRIMARY DELIVERY MEANS OF MATERIALS PROCESSING EQUIPMENT AND EXPERIMENT SAMPLES TO SPACE STATION**

- **PRIMARY MEANS OF WASTE DISPOSAL FOR MIR**



PROGRESS SPACECRAFT

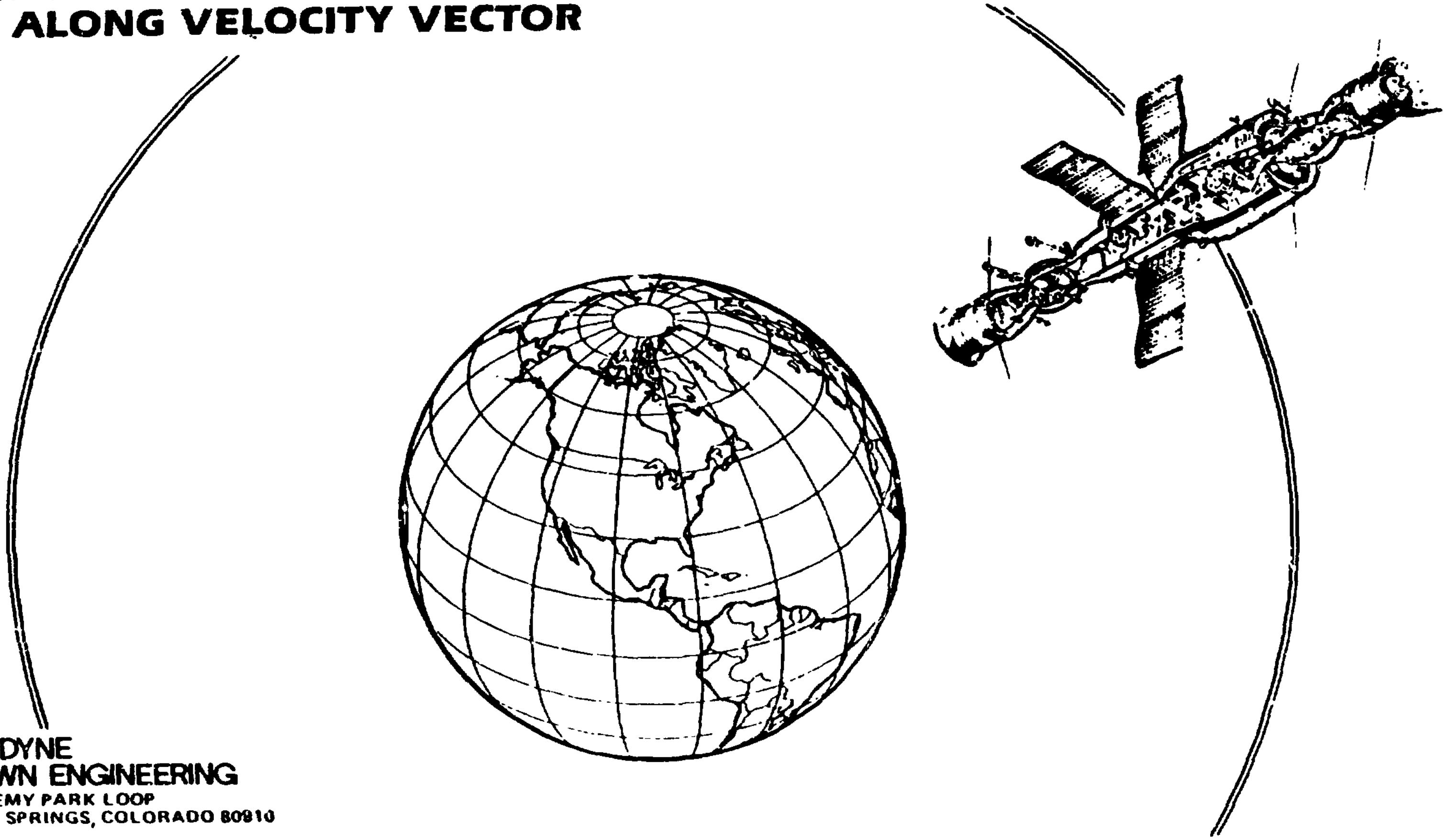


PROGRESS 2
CARGO CONFIGURATION

SPACE STATION STABILIZATION

TDE8810-502

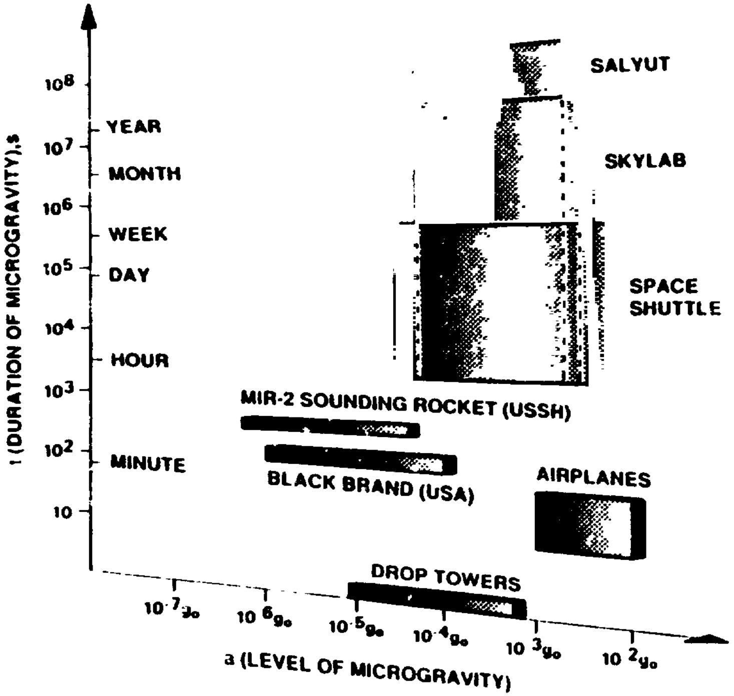
- GRAVITY-GRADIENT STABILIZATION USED FOR MOST MATERIALS PROCESSING EXPERIMENTS
- ROTATIONAL MODES ($\leqslant$ 0.4°/SEC) ALSO TRIED DURING GRAVITY-GRADIENT REGIMES
- SPACE STATION USUALLY ORIENTED WITH LONGITUDINAL AXIS ALONG VELOCITY VECTOR



TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

SOVIET MEASUREMENTS OF MICROGRAVITY CONDITIONS

TBE8810-503



LOW-FREQUENCY ACCELERATION LEVELS UNDER VARIOUS FLIGHT CONDITIONS

PARTICULARS	LOAD FACTOR, g/g_o		
	X-AXIS	Y-AXIS	Z-AXIS
UNMANNED *PROGRESS* MISSION	1×10^{-5} -1×10^{-6}	1×10^{-5} -1×10^{-6}	1×10^{-5} -1×10^{-6}
NORMAL CREW ACTIVITY ON *SALYUT-6*	10^{-1}-10^{-5}	10^{-3}-10^{-5}	10^{-3}-10^{-5}
OPERATION OF *KASKAD* ATTITUDE CONTROL SYSTEM	2×10^{-4}	2×10^{-4}	5×10^{-4}
WITH CREW DOING PHYSICAL EXERCISES	10^{-4}	1×10^{-3} -1×10^{-2}	1×10^{-3} -1×10^{-2}

- **ACCELEROMETERS NOW FOUND ON MIR AND WITHIN MATERIALS PROCESSING EQUIPMENT**
- **5 x 10^{-7} g_o POSSIBLE WHEN COSMONAUTS ASLEEP**

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

ELECTRIC FURNACES ON SOVIET SPACE STATIONS

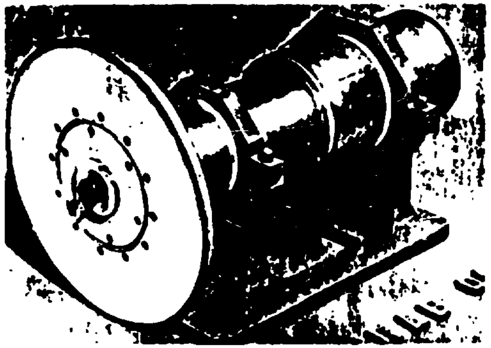
DEVICE	LAUNCHED ON	OPERATED ON	OPERATIONAL PERIOD	MASS (kg)	POWER (w)	CARTRIDGE SIZE (mm)	CARTRIDGE CAPACITY	MAXIMUM TEMPERATURE (c)	VENT TO SPACE
SFERA	SALYUT 5	SALYUT 5	1976	?	10	?	?	< 100	N
SPLAV 1	PROGRESS 1	SALYUT 6	1978-81	23	300	178 x 20.6	1	990	Y
KRISTALL (1) KRISTALL (2)	PROGRESS 2 PROGRESS 5	SALYUT 6 SALYUT 6	1978 1979-81	27	250	175 x 13	1	1,100	N
MAGMA-F (KRISTALL MOD)	PROGRESS 13	SALYUT 7	1982-86	28	250	240 x 21	1	1,000	N
KORUND-1	PROGRESS 14	SALYUT 7	1982	130	720	310 x 33	12	1,270	N
PION-M*	PROGRESS 17	SALYUT 7	1983	41	< 100	140 x 140	1	180	N
KRISTALLIZATOR	KOSMOS 1686	SALYUT 7	1985-86	41	300	140 x 15.8	19	970	N
KORUND-1M	PROGRESS 28	MIR	1987-	136	1,000	310 x 33 (?)	6	1,270	N
KRISTALLIZATOR	PROGRESS 30	MIR	1987-	41	300	140 x 15.8	19	970	N
"MIRROR-BEAM"	PROGRESS 33	MIR	1987	?	250	?	?	1,100	?

* NOT PRIMARILY AN ELECTRIC FURNACE; USED IN 1983 TO GROW CRYSTALS BY STEPANOV METHOD, UNIT TRANSFERED TO MIR IN 1986 BY SOYUZ T-15

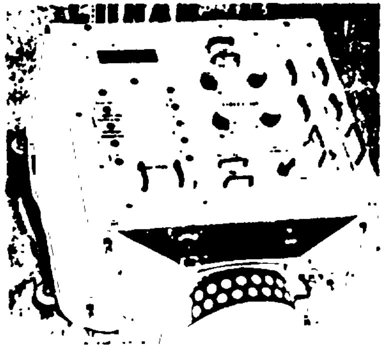
SPLAV 1 DESIGN

TBE8810-505

ELECTRIC FURNACE



CONTROL UNIT



- SPLAV 1 ONLY MATERIALS PROCESSING DEVICE VENTED TO SPACE (FOR HEAT DISSIPATION)
- VENTING NOW DISCOURAGED DUE TO CREW SAFETY CONCERNS

1980 EXPERIMENT ON SALYUT 6

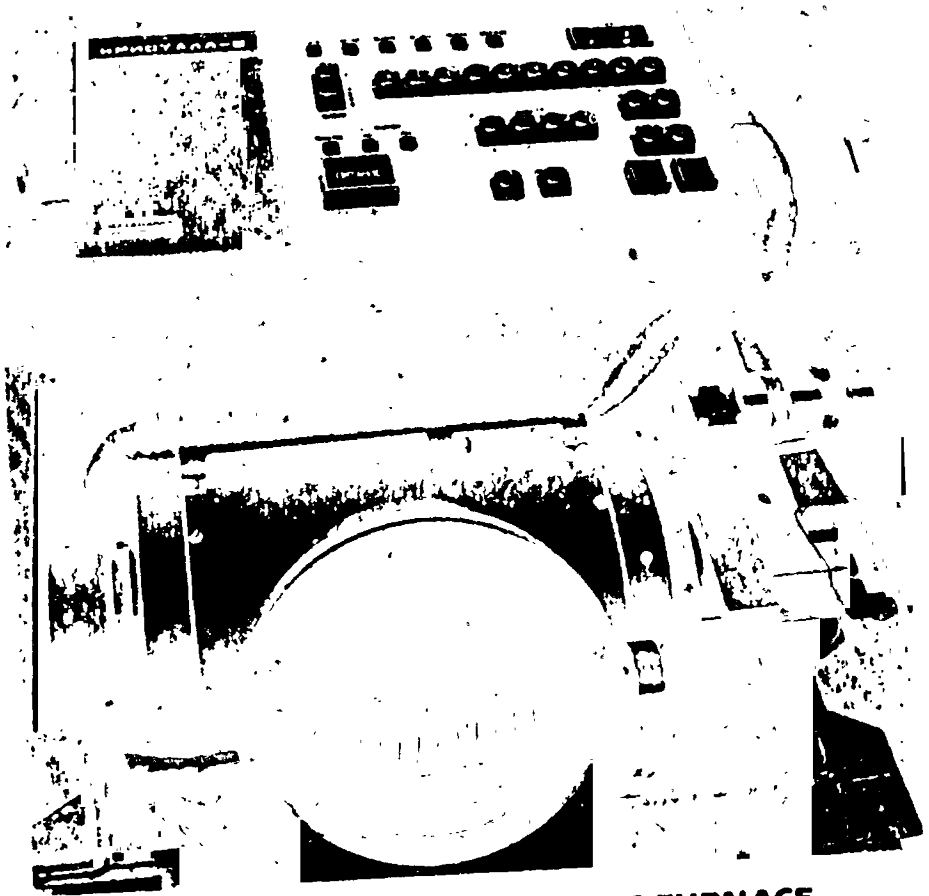
ORIGINAL PAGE IS
OF POOR QUALITY

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

KRISTALL FAMILY OF FURNACES

TBE8810-506

- THREE GENERATIONS
  - KRISTALL: 1978
  - MAGMA-F: 1982
  - KRISTALLIZATOR: 1985
- USED FOR EARLY SCIENTIFIC INVESTIGATIONS OF MICROGRAVITY INFLUENCES
- KRISTALLIZATOR NOW IN USE ON MIR IS A SOVIET-CZECH DESIGN LED BY L.L. REGEL; CAPACITY OF 19 SAMPLES GREATLY REDUCES CREW INTERACTION TIME



ORIGINAL KRISTALL ELECTRIC FURNACE

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

ORIGINAL PAGE IS
OF POOR QUALITY

KORUND PILOT-PRODUCTION FURNACES

TBE8810-507

- **KORUND-1**
  - USED SPARINGLY ON SALYUT 7 IN 1982
- **KORUND-1M**
  - DELIVERED TO MIR IN 1987
  - SAMPLES: ≤ 25 mm DIAMETER
    ≤ 1.5 kg
  - DURATION OF EXPERIMENTS: 6-150 hr
  - PRIMARILY FOR "SEMICONDUCTOR" MATERIALS

KORUND-1 FURNACE AND CONTROL UNIT

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

ORIGINAL PAGE IS
OF POOR QUALITY

BIOTECHNOLOGY UNITS ON SOVIET SPACE STATIONS

TBE8810-508

UNIT	TYPE	SPACE STATION	DEBUTED
TAVRIYA	ELECTROPHORESIS	SALYUT 7	1982
GENOM	ELECTROPHORESIS	SALYUT 7	1984
EFU ROBOT	ELECTROPHORESIS	SALYUT 7 (TRANSFERRED TO MIR IN 1986)	1985
SVETLANA	ELECTROPHORESIS	MIR	1987
RUCHEY	ELECTROPHORESIS	MIR	1987
AYNUR	PROTEIN CRYSTALLIZATION	MIR	1987

ORIGINAL PAGE IS
OF POOR QUALITY

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

OPERATIONAL PROBLEMS ENCOUNTERED

TBE8810-509

- **MICROGRAVITY CONDITIONS**
  - MANY MATERIALS PROCESSING EXPERIMENTS DETERIORATE AT $a \geqslant 10^{-3}g_0$
  - DIFFICULT TO MAINTAIN $a < 10^{-3}g_0$ FOR LONG PERIODS (DAYS) WITH CREW ON BOARD. DAILY EXERCISE REGIME PRESENTS DIRECT CONFLICT
  - a LEVELS ENHANCED IN GRAVITY-GRADIENT STABILIZATION MODE, BUT THIS ORIENTATION CONFLICTS WITH EARTH AND DEEP-SPACE OBSERVATIONS
- **QUANTITY OF RETURNED PROCESSED MATERIALS**
  - PROCESSED MATERIALS MUST COMPETE WITH OTHER EXPERIMENT RESULTS (E.G. NATURAL RESOURCES AND ASTROPHYSICAL FILM CANISTERS) FOR LIMITED SOYUZ TM RETURN PAYLOAD CAPACITY, I.E. 120-150 KG
  - KOSMOS 1443-TYPE RETURN CAPSULE HAD CAPACITY OF 500 KG, BUT THE SYSTEM WAS SINGLE-USE AND HAS NOT BEEN EMPLOYED SINCE 1983

OPERATIONAL PROBLEMS ENCOUNTERED (CONTINUED)

TBE8811-511

- FREQUENCY OF RETURNED PROCESSED MATERIALS
  - ► RETURN OF MATERIALS NOW LIMITED TO 2-3 TIMES PER YEAR WITH SOYUZ TM CREWS
  - ► CONSEQUENTLY, ELECTROPHORESIS EXPERIMENTS ARE NORMALLY CONDUCTED IMMEDIATELY PRIOR TO OR DURING SOYUZ TM VISITATIONS (NOTE a LEVELS MAY INCREASE WITH TEMPORARY CREW AUGMENTATIONS)
- TEMPERATURE CONTROL
  - ► MAINTENANCE OF PRESCRIBED TEMPERATURES HINDERED BY POWER FLUCTUATIONS DURING DAYLIGHT-NIGHTTIME PORTIONS OF ORBIT
  - ► AVAILABLE POWER ALSO AFFECTED BY SUN-ORBIT PLANE ANGLE (INCLINATION = 51.6°) AND BY LIMITED SOLAR PANEL ARTICULATION
  - ► TEMPERATURE UNIFORMITY WITHIN SAMPLE

OPERATIONAL PROBLEMS ENCOUNTERED (CONCLUDED)

TBE8810-511

- **HEAT REJECTION**
  - ► ALL MATERIALS PROCESSING UNITS SINCE SMALL SPLAV 1 FURNACE MUST REJECT HEAT INTO SPACE STATION CABIN
  - ► INSTRUMENT OVERHEATING AND/OR UNCOMFORTABLE CREW ENVIRONMENTAL CONDITIONS MAY RESULT
- **GENERAL -VS- SPECIFIC PURPOSE DEVICES**
  - ► INITIAL TREND TOWARD GENERAL (MULTI) PURPOSE DEVICES TO ADVANCE KNOWLEDGE OF WIDE RANGE OF MICROGRAVITY EFFECTS; CONSEQUENTLY, EXPERIMENT SELECTION WAS SOMETIMES DRIVEN BY INSTRUMENT CAPABILITIES, E.G. KRISTALL FURNACE
  - ► LARGER, SPECIAL PURPOSE DEVICES NOW BEING PRODUCED FOR LIMITED MANUFACTURING

FUTURE OF SOVIET MATERIALS PROCESSING ON MANNED SPACE STATIONS

TBE8810-512

- NEW DEDICATED MATERIALS PROCESSING MODULE EXPECTED IN 1989
- LARGER CAPACITY INSTALLATIONS

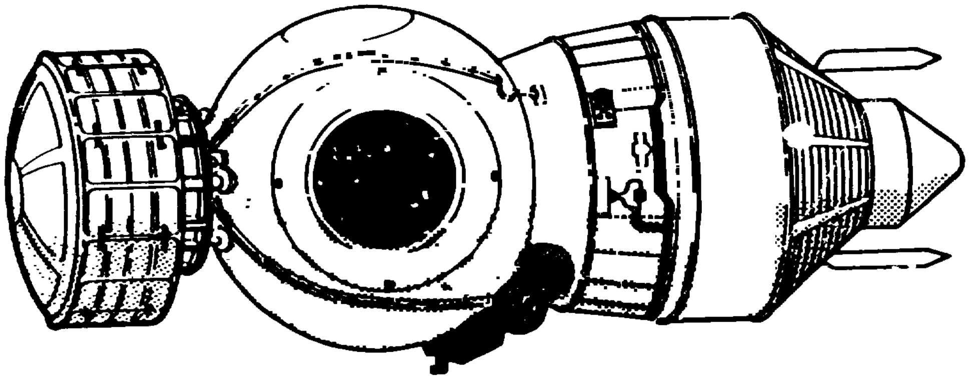
DEVICE	SAMPLE DIAMETER
ORION	25 mm
DYUNA	40 mm
KRATER	50 mm
MENISK	50 mm

- ISSUES
  - STATION STABILIZATION
  - FREE-FLYING MODULE OPERATIONS

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

PHOTON MATERIALS PROCESSING SPACECRAFT

TBE8811-513

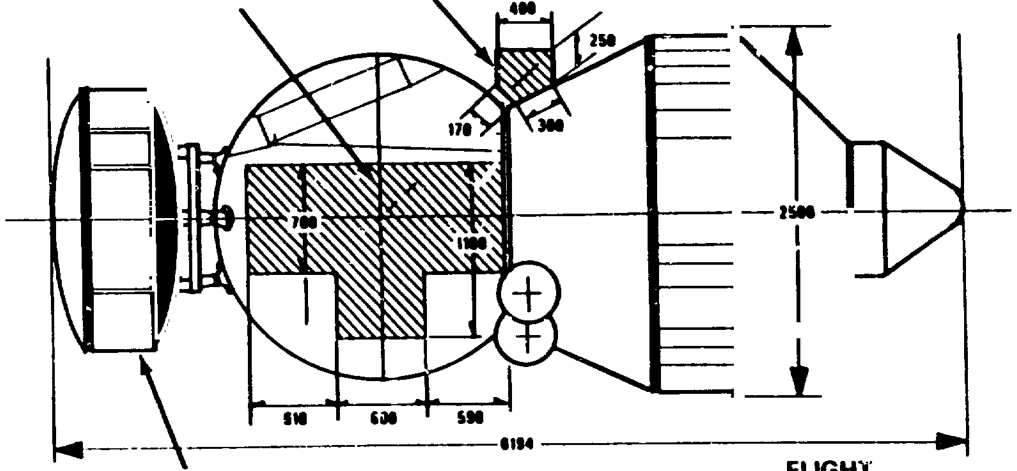


- LAUNCHED ANNUALLY EACH SPRING SINCE 1985

- OFFERED ON A COMMERCIAL BASIS AT $15,000 PER KG PAYLOAD

AREA FOR THE SCIENTIFIC EQUIPMENT OUTSIDE THE STATION

AREA FOR SCIENTIFIC EQUIPMENT INSIDE THE HERMETICAL SECTION



CONTAINER WITH FEEDER BLOCKS FOR SCIENTIFIC EQUIPMENT

FLIGHT DIRECTION

EARTH DIRECTION

- ALL MEASUREMENTS ARE IN MM

TELEDYNE BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

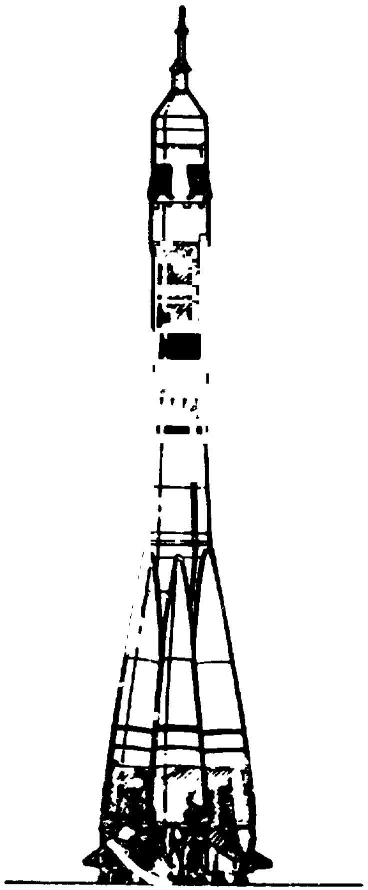
PHOTON SPACECRAFT SPECIFICATIONS

TBE8810-514

- **FLIGHT DATA**
  - LAUNCH VEHICLE: SOYUZ, SL-4
  - FLIGHT DURATION: 14-30 DAYS
  - INCLINATION: 62.8°
  - APOGEE: 300-400 KM
  - PERIGEE: 220-250 KM

- **PAYLOAD DATA**
  - MASS: 500 kg
  - VOLUME: 4.7 m^3
  - AVERAGE DAILY POWER: 400 W
  - PEAK DAILY POWER (1.5 HR/DAY): 700 W
  - IN-FLIGHT DATA TELEMETRY/COMMANDS PERMITTED
  - PAYLOAD RETURNED WITHIN 24 HR OF LANDING
  - MPUs AVAILABLE: ZONA 1, SPLAV 2, KASHTAN
  - MICROGRAVITY LEVELS RECORDED

- **PROCURED FLIGHTS**
  - KAYSER-THREDE (WEST GERMANY): THREE FLIGHTS BEGINNING IN 1989-1990; 50-60 kg PAYLOAD FIRST FLIGHT; 80-100 kg PAYLOAD FOR SECOND AND THIRD FLIGHTS
  - CNES (FRANCE): ONE FLIGHT IN 1989; 20-30 KG PAYLOAD

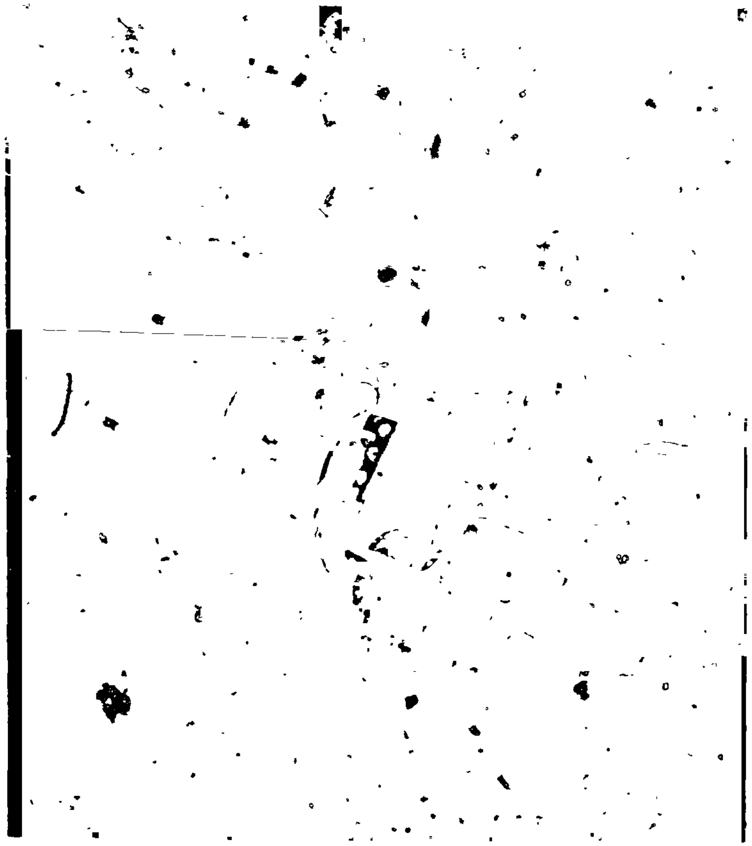


SL-4

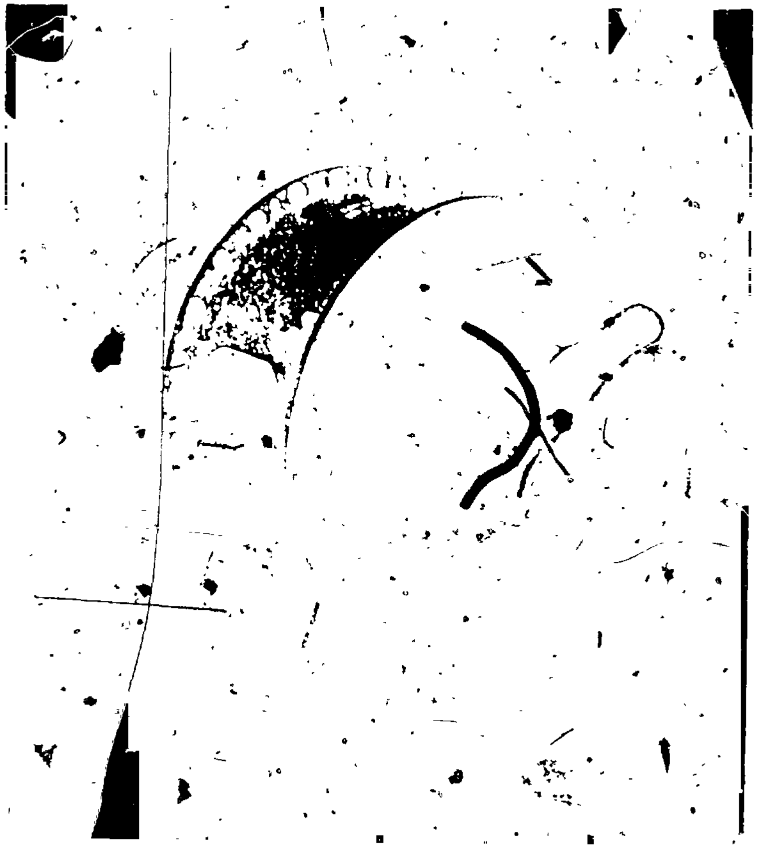
TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

SOVIET MATERIALS PROCESSING UNITS

TBE8811-584



ZONA 1



SPLAV 2

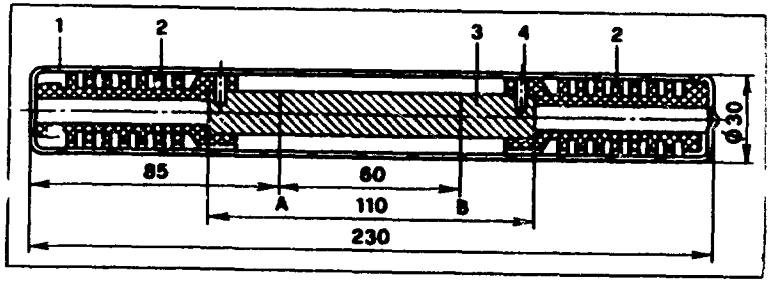
TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO [illegible]

ORIGINAL PAGE IS
OF POOR QUALITY

ZONA 1 SPECIFICATIONS

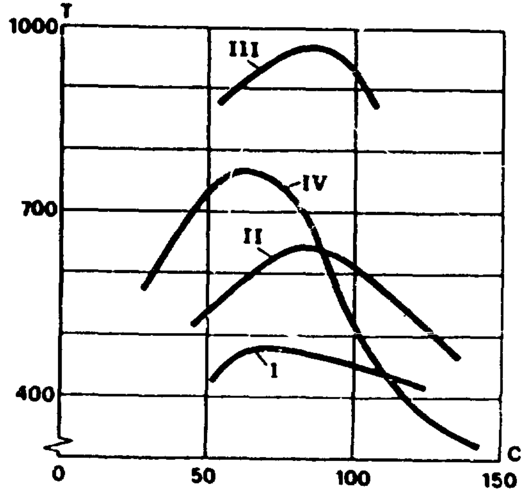
BASIC SPECIFICATIONS OF THE ZONA 01 UNIT

Spacecraft	Photon
Year of Introduction	1985
Mass, kg	90
Power Required, W	300
DIMENSIONS OF OBTAINED SAMPLE, mm:	
length	30
diameter	15
Thermal characteristics, °C:	
heating temperature	400—1,070
temperature increment	5
specified temperature accuracy	±5
temperature maintenance accuracy	±1
Maximum time of temperature maintenance prior to advance, h	2
Advance speed, mm/h	1-15



RESEARCH AMPOULE IN THE ZONA 01 UNIT.
1 - housing; 2 - graphite holder; 3 - material being studied; 4 - retaining pin.
A - initial position; B - final position of the ampoule during operation.

Chart of temperature distribution over the ampoule length depending on the heater
(I, II, III and IV—types of heaters).
T - temperature, °C
C - length, mm.



SPLAV 2 SPECIFICATIONS

TBE8810-517

BASIC SPECIFICATIONS OF THE SPLAV 02 UNIT	
Spacecraft	Photon
Year of Introduction	1985
Mass, kg	120
Power Required, W	350
DIMENSIONS OF OBTAINED SAMPLE, mm:	
length	100
diameter	12
Number:	
of samples in a capsule	3
of capsules in the unit	12
Thermal Characteristics, C°	
heating temperature	400—1,070
specified temperature accuracy	±10
temperature maintenance accuracy	±3
Holding time at a given temperature, H	4.6, 9.2, 13.8, 18.2
Cooling rate, °C/h	2.8, 5.6, 11.3, 22.5
Temperature at the end of cooling, °C	300

ORIGINAL PAGE IS OF POOR QUALITY

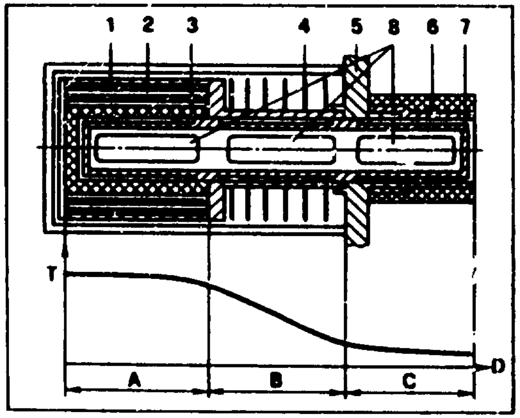
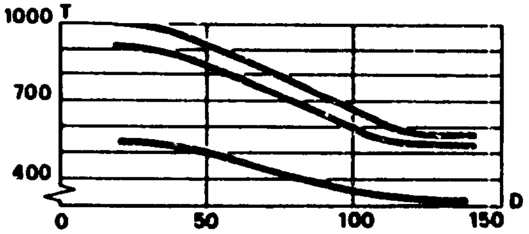


Diagram of the electric heating chamber of Splav 02 and distribution of temperatures in the chamber.

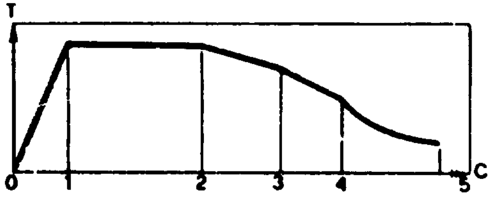
1 - muffle pipe; 2 - heater; 3 - thermoequalizer; 4 - screens; 5 - flange; 6 - casing; 7 - capsule; 8 - ampoules with materials. Zones: A - high-temperature, isothermal; B - transitional; C - low-temperature, isothermal. T - temperature; D - dimensions, mm.



Distribution of temperatures over the length of the capsule of the Splav 02 unit after holding for 4 hours 40 minutes at different specified temperatures of heating in the high-temperature isothermal zone.

T - temperature, °C

D - dimension according to the capsule, mm.



Conditions of carrying out experiments on the Splav 02 unit.

0-1 - heating; 1-2 - holding time; 2-3 - controllable cooling at the rate of S1; 3-4 - controllable cooling at the rate of S2; 4-5 - passive cooling T - temperature; C - time.

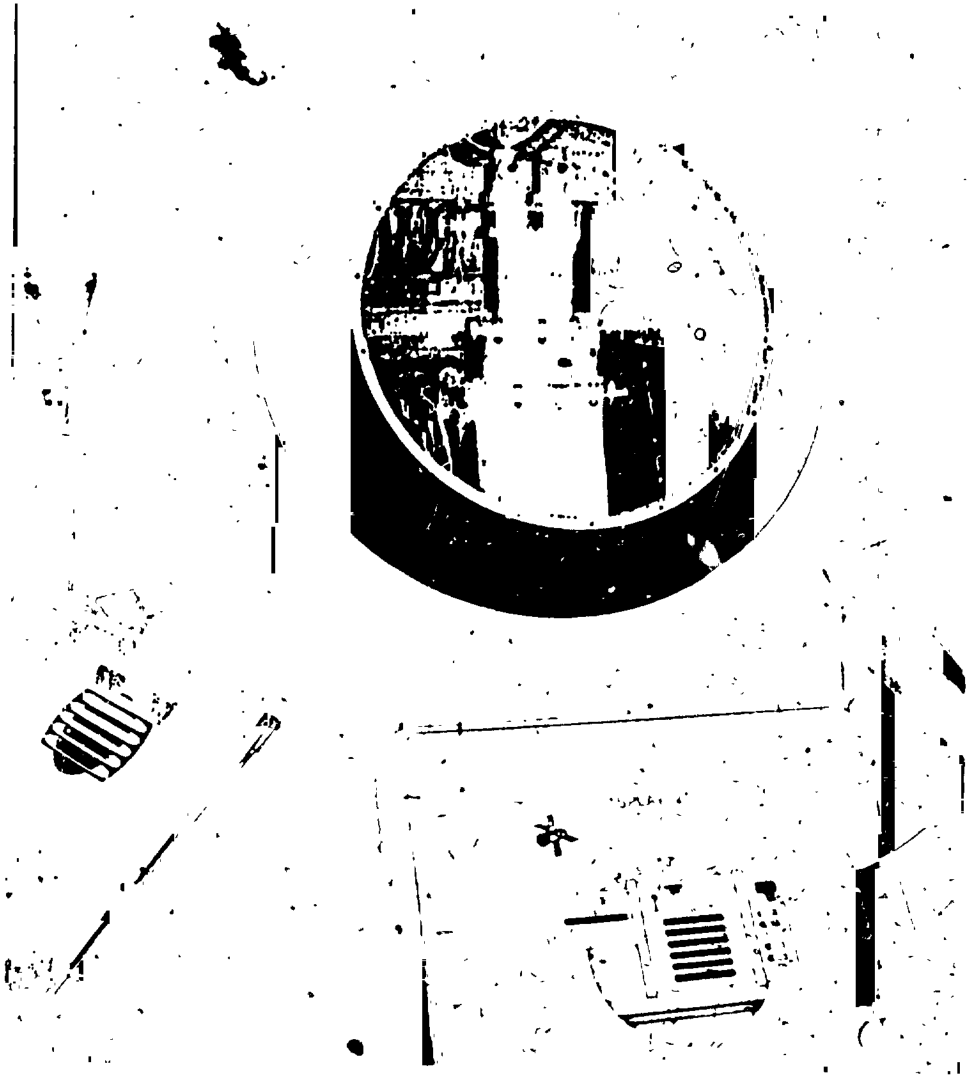
TELEDYNE BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

KASHTAN SPECIFICATIONS

TBE8310-S18

BASIC SPECIFICATIONS OF THE KASHTAN UNIT

Spacecraft	Photon
Mass, kg	60
Power Required, W	100
Electrode Voltage, V	500—5,000
Separation Chamber Length, mm	1,200
Cross-section of Separation Chamber mm²	5x5 or 10x5
Separation Chamber Capacity, ml	35 or 70
Single cell capacity, ml	0.7 or 1.4
Maximum Isolated Cells	49
Thermostatic Control Temperature, °C	5-25
Photographic Rate, Exposures/min	1



TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

ORIGINAL PAGE IS
OF POOR QUALITY

SUMMARY

TBE8810-519

- SOVIET MATERIALS SCIENCE PROGRAM IN SPACE CAN BE DIFFICULT TO ASSESS ACCURATELY DUE TO SYNTAX, INCONSISTENT DEFINITIONS, AND ERRORS IN SOVIET DOCUMENTS
- PROGRAM RETAINS HIGH PRIORITY AND IS CHARACTERIZED BY LARGE QUANTITY OF EXPERIMENTS ALTHOUGH DIVERSITY AND QUALITY SOMETIMES SUFFER
- EXPERIMENTS ON MIR ARE STILL RESTRICTED UNTIL DEDICATED MATERIALS PROCESSING MODULE ARRIVES — PROBABLY 1989
- MATERIALS SCIENCE EXPERIMENTS ON SOVIET SPACE STATIONS ACCOUNT FOR ONLY A SMALL PORTION OF CREW ACTIVITY
- UNMANNED MATERIALS PROCESSING SPACECRAFT (E.G. PHOTON) WILL CONTINUE DESPITE SPACE STATION ACTIVITIES

TOXIC AND REACTIVE MATERIALS   HANDLING WORKSHOP
29 NOVEMBER 1988

MODULAR CONTAINERLESS PROCESSING FACILITY
E.H. TRINH
JET PROPULSION LABORATORY

MODULAR CONTAINERLESS PROCESSING FACILITY

OUTLINE

- . MCPF GENERAL DESCRIPTION
  - - PRIMARY FUNCTIONS
  - - RATIONALE FOR CONTAINERLESS EXPERIMENTS
  - - FACILITY EQUIPMENT
  - - RELEVANT SCIENTIFIC DISCIPLINES
- . MCPF GENERIC EXPERIMENT TIMELINE
  - - CHAMBER PREPARATION / ENVIRONMENT CHARACTERIZATION
  - - SAMPLE PREPARATION / DEPLOYMENT
  - - ENVIRONMENT CONTROL ACTIVATION / SAMPLE PROCESSING / DATA ACQUISITION
  - - POST-PROCESSING FUNCTIONS
  - - CHAMBER PREPARATION / CHARACTERIZATION
- . GENERAL CLOSING REMARKS

EHT 11/88 JPL

MCPF GENERAL DESCRIPTION

PRIMARY FUNCTIONS:

TO PROVIDE THE

. CONTROLLED ENVIRONMENT

. SAMPLE HANDLING DEVICES

. DATA ACQUISITION, STORAGE AND TRANSFER DEVICES

. CREW AND GROUND CONTROL INTERFACES WITH THE PAYLOAD

NECESSARY FOR THE PERFORMANCE OF CONTAINERLESS SCIENTIFIC OR TECHNOLOGICAL EXPERIMENTS IN MATERIALS SCIENCE, FLUID PHYSICS, BIOTECHNOLOGY, AND EXOBIOLOGY IN MICROGRAVITY

E.H.T 11/88 JPL

MCPF GENERAL DESCRIPTION

RATIONALE FOR CONTAINERLESS EXPERIMENTS IN MICROGRAVITY

. USE OF LOW MAGNITUDE POSITIONING FORCES POSSIBLE

. STUDY OF SMALL MAGNITUDE CAPILLARY PHENOMENA ON FREE LIQUID SURFACES

. POTENTIAL FOR PROCESSING OF HIGH PURITY MATERIALS

. POTENTIAL FOR PROCESSING HIGH TEMPERATURE AND HIGHLY REACTIVE MATERIALS

. POSSIBILITY FOR NON-CONTACT SHAPING OF MELTS AND MANUFACTURE OF APPLICATION-READY PARTS

. OPPORTUNITY TO DEVELOP NON-CONTACTING DIAGNOSTIC TECHNIQUES TO REFINE GROUND-BASED TECHNOLOGY

. SPACE STATION OPPORTUNITY: LONG DURATION, MANY REPETITIVE CYCLES EXPERIMENTS

MCPF GENERAL DESCRIPTION

MULTI-MODULE FACILITY:

- . HIGH TEMPERATURE ACOUSTIC POSITIONER
- . HIGH TEMPERATURE ELECTROMAGNETIC POSITIONER
- . ELECTROSTATIC-ACOUSTIC HYBRID POSITIONER
- . GAS-GRAIN MODULE (*)

PRECURSOR FLIGHT HARDWARE :

- . 3 AAL (61C)
- . ACES (41C)
- . DDM (51B)
- . EML (61C)
- . SAAL (D1)

SHUTTLE/SPACELAB PREVIOUSLY FLOWN EQUIPMENT

FUTURE EQUIPMENT FOR USML / IML SPACELAB FLIGHTS:

- . DROP PHYSICS MODULE (DPM, CODE EN)
- . ACOUSTIC LEVITATION FURNACE (ALF, CODE EN)
- . MODULAR ELECTROMAGNETIC LEVITATOR (MEL, CODE EN)
- . TEMPUS (~~ESA~~) (*)
  DFVLR

EHT 11/88 JPL

MCPF GENERAL DESCRIPTION

SCIENTIFIC DISCIPLINES SERVED:

- GLASSES AND CERAMICS: CRYSTAL NUCLEATION, GLASSIFICATION, PHASE TRANSFORMATION AND SEPARATION, ULTRA-HIGH TEMPERATURE GLASSES PROPERTIES, SPECIAL PROPERTY GLASSES AND CERAMICS

- METALS AND ALLOYS: NUCLEATION STUDIES, METASTABLE STRUCTURES, HIGH TEMPERATURE PROCESSING AND PROPERTIES, HIGH PURITY, CONTROLLED REACTIONS EXPERIMENTS

- ELECTRONIC MATERIALS: HIGH TEMPERATURE MELT PROPERTIES

- FLUID PHYSICS: FREE LIQUID SURFACE BEHAVIOR, THERMO-CAPILLARY PHENOMENA, NONLINEAR DYNAMICS, TURBULENCE, GEOPHYSICAL MODELLING

- BIOTECHNOLOGY: CONTAINERLESS PROTEIN CRYSTAL GROWTH, POLYMERIZATION STUDIES

- EXOBIOLOGY: METEORITICS MODELLING, PLANETARY ATMOSPHERES NUCLEATION STUDIES

EHT 11/88 JPL

MCPF GENERIC EXPERIMENT TIMELINE

A. CHAMBER PRPEARATION / ENVIRONMENT CHARACTERIZATION

B. SAMPLE PREPARATION / DEPLOYMENT

C. ENVIRONMENT CONTROL ACTIVATION / SAMPLE PROCESSING / DATA ACQUISITION

D. EXPERIMENT REPETITION

E. POST-PROCESSING SAMPLE RETRIEVAL / CHARACTERIZATION / STORAGE

F. CHAMBER PREPARATION / PURIFICATION / CHARACTERIZATION

EHT 11/88 JPL

MCPF GENERIC EXPERIMENT TIMELINE

A. CHAMBER PREPARATION / ENVIRONMENT CHARACTERIZATION

. HIGH VACUUM --------- (VENTING)

. VACUUM BAKEOUT ---------(GAS TRAPPING, POWER)

. INERT GAS BACKFILL (1 BAR OR >1 BAR)-----(HIGH PURITY GAS SUPPLY AND MONITORING)

. PARTICULATE CONTAMINATION MONITORING AND CONTROL ------- (DIAGNOSTIC INSTRUMENTATION)

MCPF GENERIC EXPERIMENT TIMELINE

B. SAMPLE PREPARATION / DEPLOYMENT

. NO PREPARATION (SAMPLE DIRECTLY DEPLOYED BY MCPF DEVICE)

. SAMPLE CHARACTERIZATION (PREPARATION REQUIRED IN MANNED ENVIRONMENT) --------- (MATERIALS SCIENCE GLOVEBOX, SAMPLE TRANSPORT AND HANDLING PROCEDURES, CREW)

. SAMPLE IS PREPARED PRIOR/ AFTER CHAMBER PREPARATION

. SAMPLE SIZES : 500 MICRONS TO 2 CM

. SAMPLE NUMBER: SINGLE, MULTIPLE, OR SAMPLE SWARM (LESS THAN 500 MICRONS SIZE)

. SAMPLE STATE: LIQUID OR SOLID, GASES ALSO DEPLOYED

. SAMPLE DEPLOYMENT (INSERTION INTO CHAMBER) ------(CREW)

MCPF GENERIC EXPERIMENT TIMELINE

C. SAMPLE PROCESSING

. ENVIRONMENT CONTROL ACTIVATION ------ (FURNACE POWER, THERMAL OVERLOAD CONTROLS, STATIC PRESSURE CONTROL, GAS COMPOSITION MONITORING, PARTICULATE CONTAMINATION MONITORING)

. FACILITY DIAGNOSTICS ACTIVATION ------ (DATA ACQUISITION, STORAGE AND DOWNLINK)

. SAMPLE MANIPULATION (MELTING, SUPERHEATING, ROTATION, OSCILLATION, ETC...) -------- (SAMPLE OBSERVATION / DOWNLINK)

. PROPERTIES MEASUREMENT --------- (DATA ACQUISITION, STORAGE, AND DOWNLINK)

. RADIANT (BEAM) HEATING ACTIVATED ------- (BEAM POWER, SAFETY CONTROLS)

. SAMPLE SOLIDIFICATION ---------(HEAT REMOVAL)

. END OF EXPERIMENT (SAMPLE RETRIEVAL OR EXPERIMENT REPEAT)

. FLUID REMOVAL AND TRAPPING (GASES AND LIQUIDS) ----(PMMS)

EHT 11/88 JPL

MCPF GENERIC EXPERIMENT TIMELINE

D. EXPERIMENT REPETITION

- . MULTI-CYCLE RUNS --------(POWER, PMMS)

MCPF GENERIC EXPERIMENT TIMELINE

E. POST-PROCESSING SAMPLE RETRIEVAL / CHARACTERIZATION / STORAGE

. SAMPLE RETRIEVAL (LIQUID, SOLIDS, SUSPENSION)------ (SAMPLE HANDLING, CREW)

. SAMPLE NOT ANALYZED ------ (STORAGE IN MCPF OR IN USL FACILITY)

. SAMPLE CHARACTERIZATION (SEM, ETCHING, MICROSCOPY,...)--- USL COMMON FACILITIES, CREW)

MCPF GENERIC EXPERIMENT TIMELINE

F. CHAMBER PREPARATION / PURIFICATION / CHARACTERIZATION

. ANALYSIS OF ENVIRONMENT PRIOR TO SAMPLE REMOVAL ----- (MCPF OR USL DIAGNOSTICS)

. CHAMBER EVACUATED ------------(VENTING, GAS TRAPPING)

. CHAMBER PURIFIED (BAKEOUT OR PURGING) ------ (POWER, VENTING)

. CHAMBER CHARACTERIZATION

Modular Containerless Processing Facility

MCPF EXPERIMENTS NOT YET DEFINED

- Experiments & Principal Investigators are selected by orderly process
- Selection based upon responses to NASA Announcement of Opportunity (AO)
- MCPF work now based upon capabilities
  - Capabilities include most known candidate experiments

R. Grumm

Huntsville November 29, 1988 ToxicWSExper

Modular Containerless Processing Facility

MCPF Conducts Multiple Experiments

- Baseline configuration has three (3) experiment modules at PMC
  - Experiment modules may have multiple chambers
  - Additional experiments may be added
    - Simple and small experiments not in reference set
    - Quick-is-Beautiful class to be defined later
    - Get Away Special class
    - Commercial experiments that can use the facility
    - MCPF engineering development
    - Any other relevant experiments that make good use of facility
- Experiments can run concurrently

NASA JPL

Modular Containerless Processing Facility

MCPF Experiments Change
- MCPF is Modular so it can change on-orbit

MCPF is Evolutionary

- MTC Phase Experiments
  - Remote and automatic without crew
  - Power to fit whats available
  - Data to fit capability
- Early PMC
  - Start Experiment changeout
    - New experiment every 90 days
- PMC + 1 year
  - Changeout of experiments complete
  - This is the MCPF version described at Payload Accommodations Workshop
    - Guntersville, Jan 1988

R Grumm
ToxicWSChange

Huntsville November 29, 1988

NASA JPL

Modular Containerless Processing Facility

FLEXIBILITY

- Not just a manifestation of uncertaintly
- Its a requirement

NEED

- An orderly process
- Face-to-face contact with Work Package contractors
  - Who are they?
  - When do they need what?
- Plan
  - AO is major milestone
    - When is AO needed to match Work Package needs?

R. Grumm

Huntsville November 29, 1988

ToxicWSNews

11. SPACE STATION FURNACE FACILITY

NOTE: No hardcopy of this presentation was provided for the Workshop Proceedings.

SPACE STATION
TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

HUNTSVILLE, ALABAMA
NOV 29, 30 & DEC 1, 1988

OVERVIEW
OF
MODULAR COMBUSTION FACILITY

NASA
LEWIS RESEARCH CENTER
CLEVELAND, OHIO

ENGINEERING DIRECTORATE P.M.	RON CHUCKSA
SPACE EXPERIMENTS DIV P.M.	BOB THOMPSON
FACILITY PROJECT SCIENTIST	KURT SACKSTEDER
STUDY TEAM MEMBER (PMMS)	DON PERDUE

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

PRECEDING PAGE BLANK NOT FILMED

MODULAR COMBUSTION FACILITY

OBJECTIVE: DEVELOP A MODULAR, MULTIUSER MICROGRAVITY SCIENCE FACILITY ,FOR USE BY THE COMBUSTION SCIENCE COMMUNITY ON BOARD THE SPACE STATION FREEDOM LABORATORY

CURRENT EFFORT: DEFINITION STUDY & CONCEPTUAL DESIGN

APPROACH:

- START WITH A REPRESENTATIVE LIST OF POTENTIAL MICROGRAVITY SCIENCE EXPERIMENTS FOR COMBUSTION OVER A BROAD RANGE OF CONDITIONS/REQUIREMENTS
- WORK WITH REPRESENTATIVES OF EACH OF THESE POTENTIAL EXPERIMENTS TO DETERMINE REQUIREMENTS
- GENERATE PRELIMINARY CONCEPTUAL SCHEMATIC DIAGRAM FOR EACH POTENTIAL EXPERIMENT AS IT MIGHT EX[illegible] IN THE USL ENVIRONMENT
- GENERATE A DATABASE OF EXPERIMENTAL REQUIREMENTS
- EXTRACT COMMON SYSTEMS TO FORM THE BASIS FOR A HOST FACILITY
- MERGE COMMON SYSTEMS REQUIREMENTS WITH KNOWN SPACE STATION REQUIREMENTS/CAPABILITIES TO FORM A HOST FACILITY

NASA
NATIONAL AERONAUTICS &
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

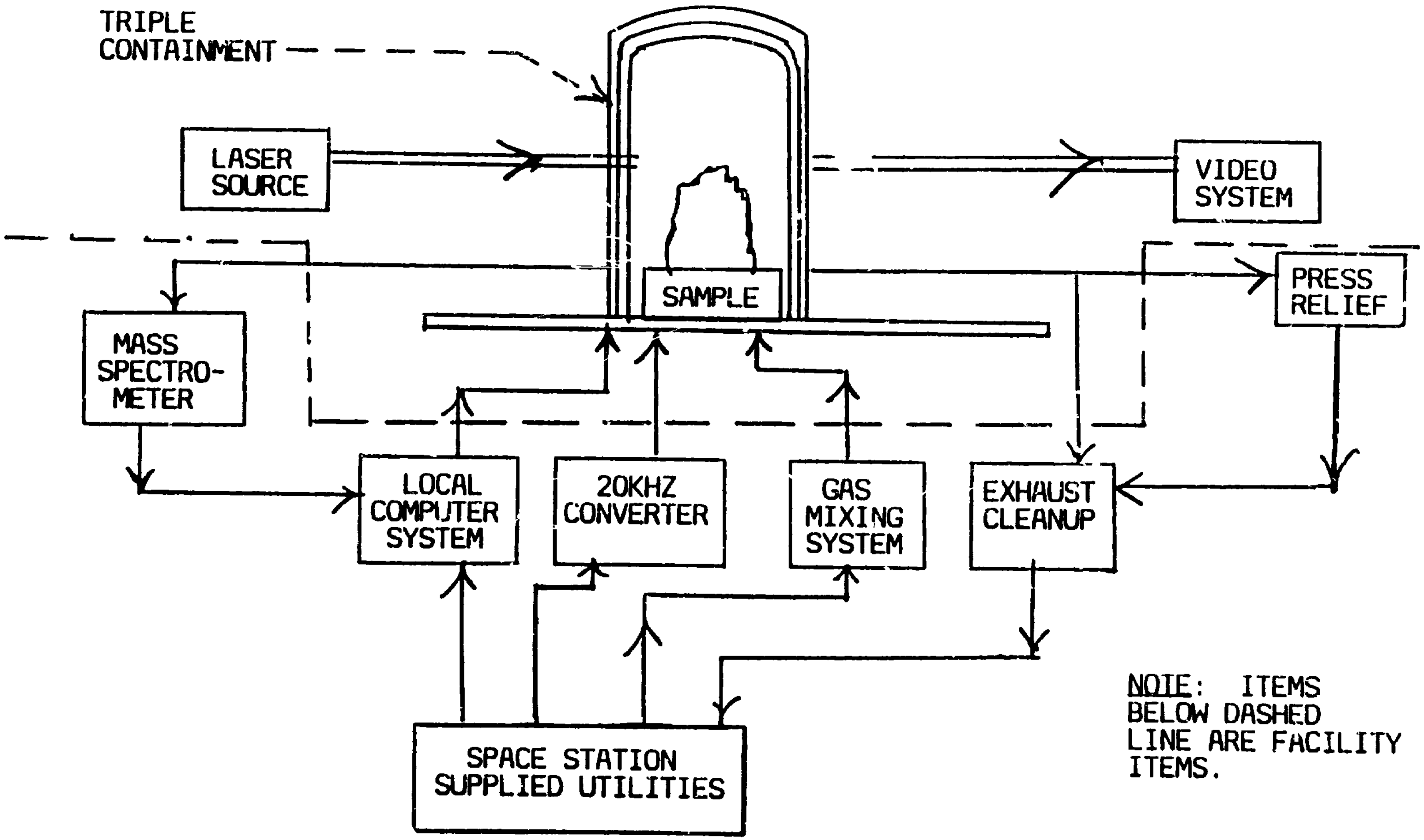
MODULAR COMBUSTION FACILITY (MCF)

REFERENCE EXPERIMENT SETS

[C01]	GASEOUS FUEL COMBUSTION	STOCKER - LeRc
[C02]	FLAMING AND SMOLDERING COMBUSTION IN LOW VELOCITY FLOWS	OLSON - LeRc FREIDMAN - LeRC SACKSTEDER - LeRc
[G03]	POOL FIRES	ROSS - LeRc
[C04]	EFFECTIVENESS OF CANDIDATE EXTINGUISHANTS FOR USE ON SMOLDERING OR FLAMING COMBUSTION IN LOW GRAVITY	FREIDMAN - LeRc
[C05]	DROPLETS COMBUSTION	SACKSTEDER - LeRc
[C07]	METALS COMBUSTION	BENZ - WHITE SANDS

REVISED 11 AUG 88

BLOCK DIAGRAM FOR TYPICAL COMBUSTION EXPERIMENT

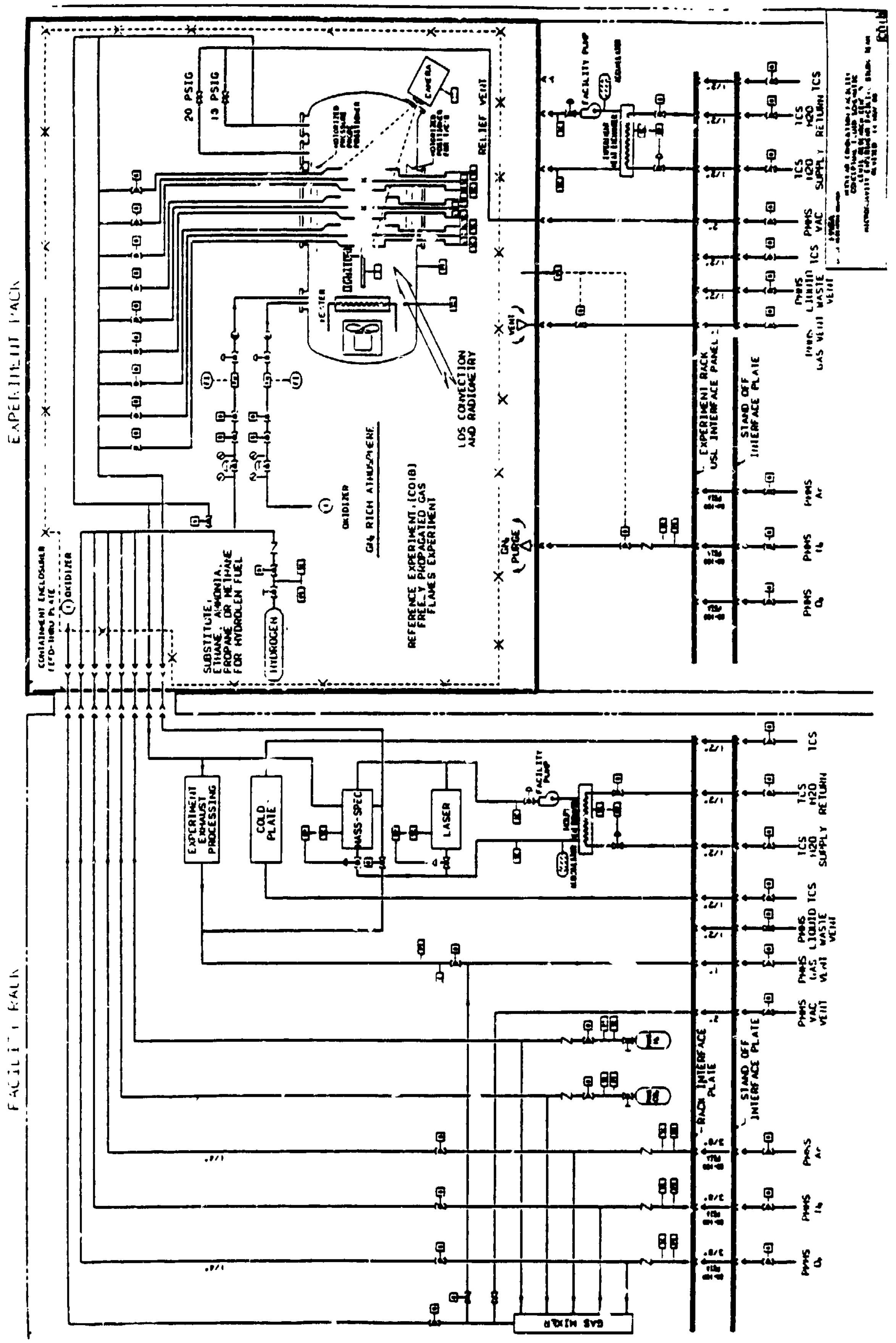


NOTE: ITEMS BELOW DASHED LINE ARE FACILITY ITEMS.

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO



ORIGINAL PAGE IS OF POOR QUALITY

MODULAR COMBUSTION FACILITY

EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 1.1: GENERAL INFORMATION

EXPERIMENT NAME [NO.] / UPDATED	S R C	SOURCE OF REQUIREMENTS		EXPERIMENT DESCRIPTION
		CONTACT PHONE NUMBER	ORGANIZATION	

SECTION 1.2: GENERAL INFORMATION

EXPERIMENT NAME [NO.] / UPDATED	S R C	TOTAL NUMBER OF RUNS REQ'D	SETUP		PRE-TEST		TEST		POST-TEST		SHUTDOWN		COMMENTS
			TIME REQ'D	% CREW TIME	TIME REQ'D	% CREW TIME	TIME REQ'D	% CREW REQ'D	TIME REQ'D	% CREW REQ'D	TIME REQ'D	% CREW REQ'D	

SECTION 1.3: GENERAL INFORMATION

EXPERIMENT NAME [NO.] / UPDATED	S R C	ITEMS IN CURRENT CEI SPEC			
		LSE NO.	LAB SUPPORT EQUIPMENT ITEM TITLE	N	D

S R C	ITEMS NOT IN CURRENT CEI SPEC		
	LAB SUPPORT EQUIPMENT ITEM TITLE	N	D

2.1: ELECTRIC POWER DISTRIBUTION

EXPERIMENT NAME [NO.] /UPDATED	S R C	SUBSYSTEM	LOAD DESCRIPTION	VOLTAGE (volts)	FREQUENCY (hZ)	NUMBER OF PHASES	PEAK POWER (watts)	DUTY FACTOR	AVE. POWER (watts)	COMMENTS

NASA
NATIONAL AERONAUTICS &
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 3.1· TRANSDUCERS & SIGNAL CONDITIONERS

EXPERIMENT NAME (NO.) /UPDATED	S R C	GENERIC MEASUREMENT TYPE	NO. CHAN PER TYPE	RANGE	TOLERANCE	TRANSDUCER			SIGNAL CONDITIONER			ON-BOARD DISPLAY REQ'D
						DESCRIPTION	OUTPUT TYP & LVL	EX REQ'D TYP & LVL	DESCRIPTION	OUTPUT TYP & LVL	LOCATION	

SECTION 3.2: VIDEO SYSTEMS

EXPERIMENT NAME (NO.) /UPDATED	S R C	VIDEO QUALITY REQ'D (RS170, SUB RS170 OR N NF)	NUMBER	FIXED	COLOR	CAMERA START/ STOP SIGNAL	CAM. AMBT. TEMP. RANGE (C)	GRAY SCL.	SUB FRAME REQ'D (Y/N)	SPAT. RES. pels	FRAME RATE (fps)	STORED FRAMES PER RUN/ FLIGHT	EQ. ISO	SPEC RESP	NO. VIEW PER CAM- ERA	DATA ANNO. REQ'D (Y/N)	ON-BOARD DISP. REQ'D (Y/N)	DOWNLINK REQUIREMENTS			SPECIAL OPTICS
																		DOWN- LINKED FRAMES PER RUN	MAX. ACCEPT. DOWNLINK TIME	CALC'D REQ'D DATARATE (bps)	

SECTION 3.3 - FILM CAMERA SYSTEMS

EXPERIMENT NAME (NO.) /UPDATED		NO. OF CAM- ERAS	FORMAT SIZE 35mm-STILL 70mm-STILL 16mm-MOTN	COLOR OR B&W (C/B)	FIXED OR HAND- HELD (F/H)	DEPTH OF FIELD (cm @ cm)	FIELD OF VIEW (deg)	FRAMES PER RUN	AMBIENT OR ARTI- FICIAL LIGHT	SPECTRAL RESPONSE	NO. VIEWS PER CAMERA	DATA ANNO- TATION REQ'D (Y/N)	COMMENTS

SECTION 3.4 - DATA ACQUISITION

EXPERIMENT NAME (NO.) /UPDATED	S R C	ANALOG LINES IN	ANALOG LINES OUT	DIGITAL LINES IN	DIGITAL LINES OUT	SERIAL LINES (RS232 ETC.)	SAMPLES PER SECOND (MAX)	DATA RATE BITS PER SECOND (MAX)	MASS STORAGE (KB) PER RUN	VIDEO	DATA ENCRYP- TION	HIGH RATE DATA LINE	COMMENTS

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 3.5: LASER DIAGNOSTIC SYSTEMS/OPTICAL MEASUREMENTS

EXPERIMENT NAME [NO.] /UPDATED	S R C	GENERIC MEASUREMENT TYPE	RANGE	TOLERANCE	PROFILE	SPATIAL RESOLUTION	TIME RES.	SUITABLE TECHNIQUES	LIMITATIONS	SPECIAL REQUIREMENTS	POWER NOMINAL/PEAK	DATA PROCESS.	OUTPUT	
					POINT BULK		DATA RATE DURAT'N		DEVELOPMENT ISSUES			REAL TIME OR DEFERRED	FORMAT	DISPLAY

SECTION 4: ELECTRIC CONTROLS

EXPERIMENT NAME [NO.] /UPDATED	S R C	CONTROLLED DEVICE OR SUBSYSTEM TITLE	CONTROL SIGNALS						REQUIRED FAILURE TOLERANCE LEVEL			ALL SUB-SYSTEM REQUIREMENTS MET (YES-NO)
			OUTPUT		INPUT			CLOSED LOOP XDCR	MISSION CRITICAL (YES-NO)	SAFETY CRITICAL (YES-NO)	FAILURE TOLERANCE LEVEL (0,1 OR 2)	
			DISCRETE	ANALOG VALUE	DISCRETE	ANALOG VALUE	S/W OR TIME					

SECTION 5.1 - CONSUMABLES

EXPERIMENT NAME [NO.] /UPDATED	S R C	MATERIAL NAME AND FORMULA	GAS LIQUID SOLID OR OTHER	NUMBER OF RUNS PER 90 DAYS (min/max)	TYPICAL RUN DURATION (minutes)	MASS FLOW (kg/run)	VOLUME FLOW (l/min)	TOTAL MASS CONSUMED/90-DAYS (kg)	USL SUPPLIED (yes/no)	TEST CHAMBER PRESSURE (Kpa)	TEST CHAMBER TEMP (K)

SECTION 5.2: WASTE DISPOSAL

EXPERIMENT NAME [NO.] /UPDATED		MATERIAL NAME AND FORMULA	VAPOR MASS PER RUN (kg)	LIQUID MASS PER RUN (kg)	SOLID MASS PER RUN (kg)	SOLID PARTICULAT SIZE MICRONS	TOTAL MASS PER 90-DAYS (kg)	RISK ASSESSMENT	TEMP. OF WASTE (K)	PRESS. OF WASTE Kpa	HAZARD LEVEL

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 5.3: VENTING

EXPERIMENT NAME [NO.] /UPDATED	S R C	MATERIAL NAME AND FORMULA	TOTAL MASS TO VENT PER 90-DAYS (kg)	MASS FLOW (kg/run)	VENT FLOW (l/min)	VENT INITIAL PRESSURE (Kpa)	VENT FINAL PRESSURE (torr)	VENT FLUID TEMP. (K)	COMMENTS

SECTION 5.4: THERMAL COOLING

EXPERIMENT NAME [NO.] /UPDATED	S R C	HEAT LOAD PER RUN (kw)	TEMPERATURE RANGE (K)	COOLING METHOD			MASS FLOW OF COOLANT (kg/min)	VOLUME FLOW OF COOLANT (l/min)	MINIMUM COOLING FLUID TEMP. (K)	COOLANT FLUID PRESSURE (KPa)	COMMENTS
				AVIONICS AIR COOLING	COLDPLATE	LIQUID/ GAS HEAT XCHANGER					

SECTION 6.1: TEST SECTION

EXPERIMENT NAME [NO.] /UPDATED	S R C	TYPE (i.e. PRESSURE VESSEL, SEALED)	DIMENSIONS			VOLUME (cubic meters)	MASS (kg)	FEATURES		MECHANISMS	COMMENTS
			WIDTH meters	LENGTH meters	DEPTH meters			WINDOWS	DOORS		

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 6.2: ITEMS OTHER THAN TEST SECTION

EXPERIMENT NAME [NO.] /UPDATED	S R C	ITEMS TO BE 'NCLUDED IN EXPERIMENTAL SPECIFIC VOLUME	DIMENSIONS			VOLUME (cubic meters)	MASS (kg)	COMMENTS
			WIDTH meters	LENGTH meters	DEPTH meters			

SECTION 6.3 - ADDITIONAL EXPERIMENT PECULIAR STRUCTURAL REQUIREMENTS IN RACK

EXPERIMENT NAME [NO.] /UPDATED	S R C	VIBRATION ISOLATION	EMC (ELECTROMAGNETIC CONTROL)	THERMAL INSULATION	CONTAINMENT REQUIRED FOR SAFETY	OTHERS

SECTION 7.1: ACCELERATION

EXPERIMENT NAME [NO.] /UPDATED	S R C	DIRECTION	SUSTAINED ACCELERATION			TRANSIENT g -sec	ALIGNMENT REQUIREMENTS	COMMENTS
			g/g	hz	duration			

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

PRESENT FACILITY CONCEPTS

- MODULAR CONCEPT

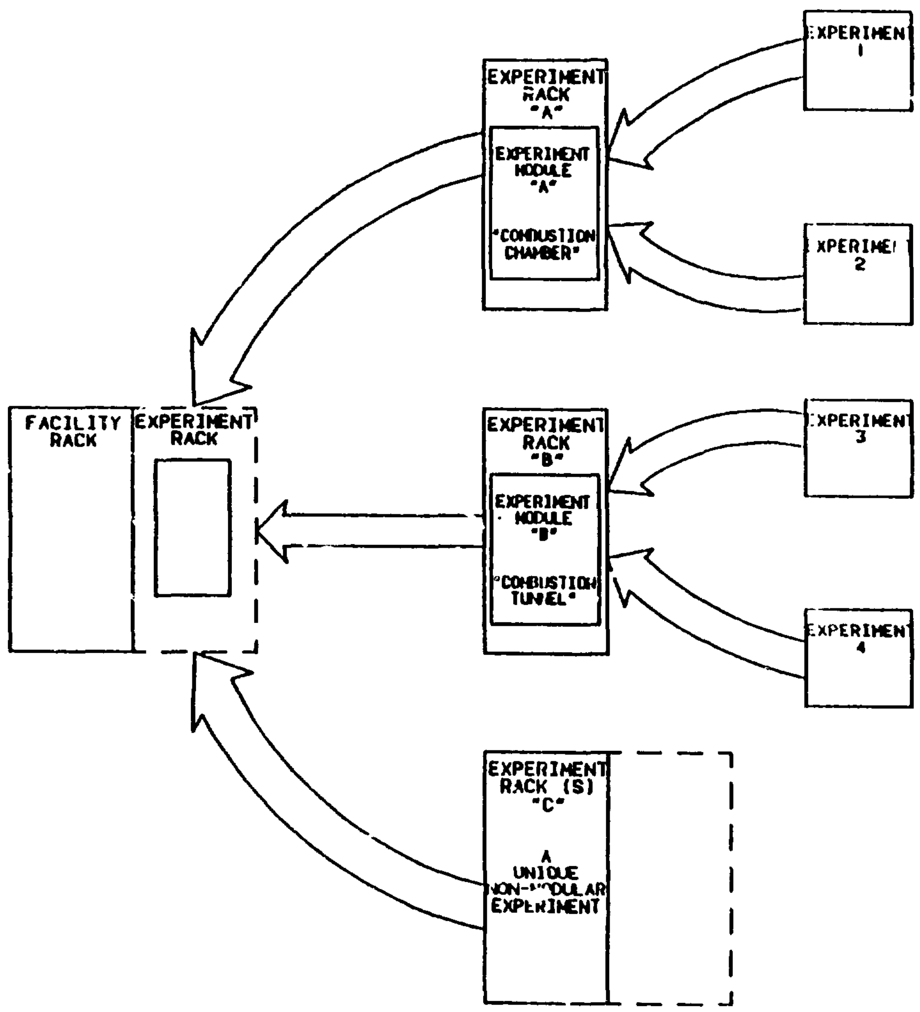
- TWO RACK FACILITY
  - PERMANENT FACILITY RACK
  - INTERCHANGEABLE EXPERIMENT RACK

- FACILITY RACK
  - INTERFACE BETWEEN USL & EXPERIMENT
  - HOUSES SUPPORT SYSTEMS
    - POWER CONVERSION & DISTRIBUTION SYSTEM
    - DATA ACQUISITION & CONTROL COMPUTER SYSTEM
    - GAS MIXING & DISTRIBUTION SYSTEM
    - EXPERIMENTAL BY-PRODUCTS CONDITIONING SYSTEM
    - LASER DIAGNOSTIC SUPPORT SYSTEM
    - HIGH RESOLUTION HIGH FRAME RATE VIDEO SUPPORT SYSTEM
    - MASS SPECTROMETER
    - SAFETY SYSTEMS
    - OPERATOR INTERFACE PANEL

- EXPERIMENT RACK
  - RACK INTEGRATED ON GROUND
  - POSSIBLE CHANGE-OUT EVERY 12 TO 18 MONTHS
  - HOUSES CONTAINMENT ENCLOSURE
  - VARIOUS EXPERIMENT MODULES
    - COMBUSTION CHAMBER
    - VERY LOW SPEED COMBUSTION TUNNEL

MODULAR COMBUSTION FACILITY

MODULAR CONCEPT



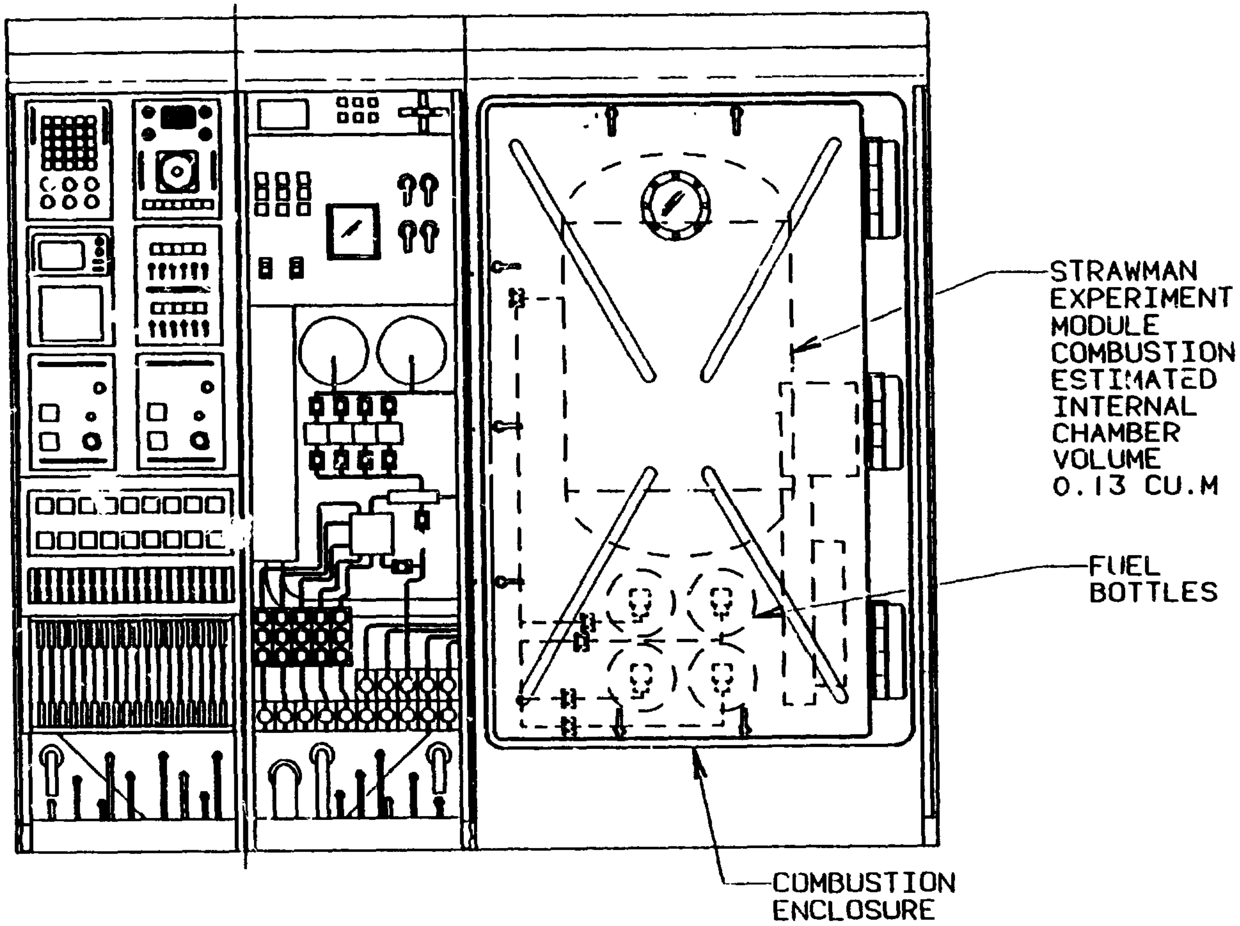
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

(SHOWN WITH STRAWMAN COMBUSTION CHAMBER EXPERIMENT MODULE INSTALLED)



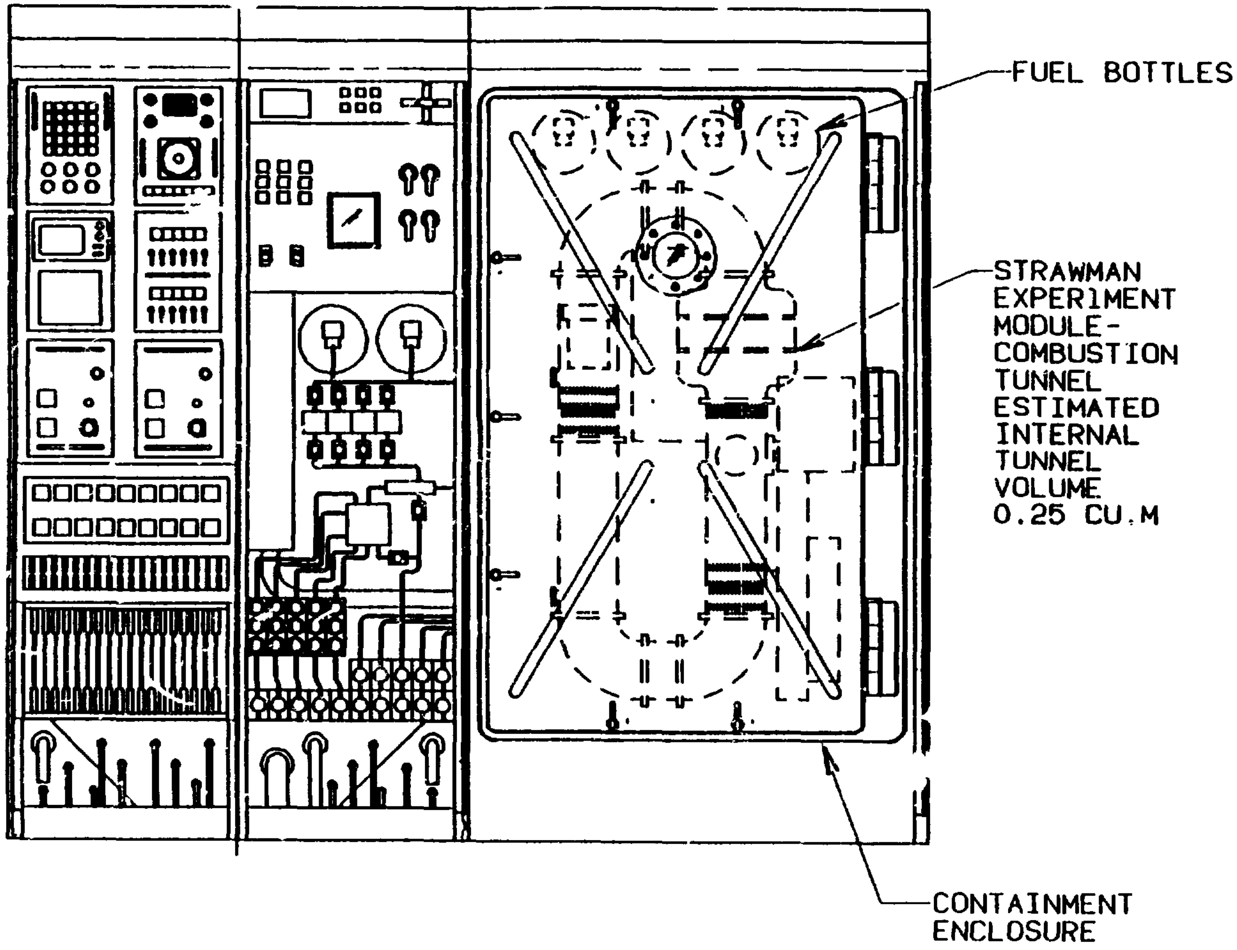
NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

(SHOWN WITH LOW-SPEED COMBUSTION TUNNEL EXPERIMENT MODULE INSTALLED)



NASA
NATIONAL AERONAUTICS &
SPACE ADMINISTRATION

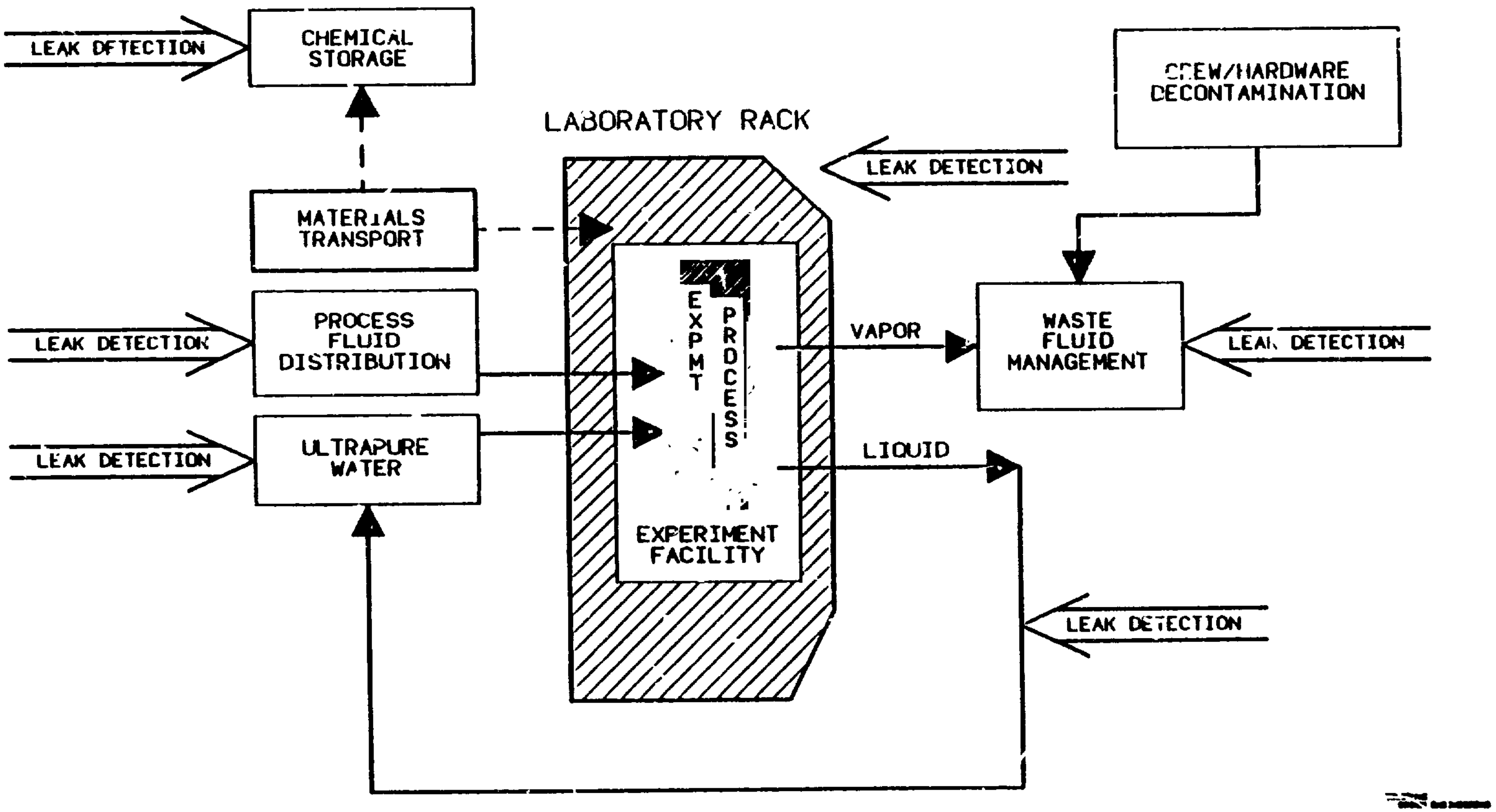
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

U.S. LABORATORY REVIEW WORKSHOP

(HUNTSVILLE - AUGUST 1988)

PMMS FUNCTIONAL DIAGRAM



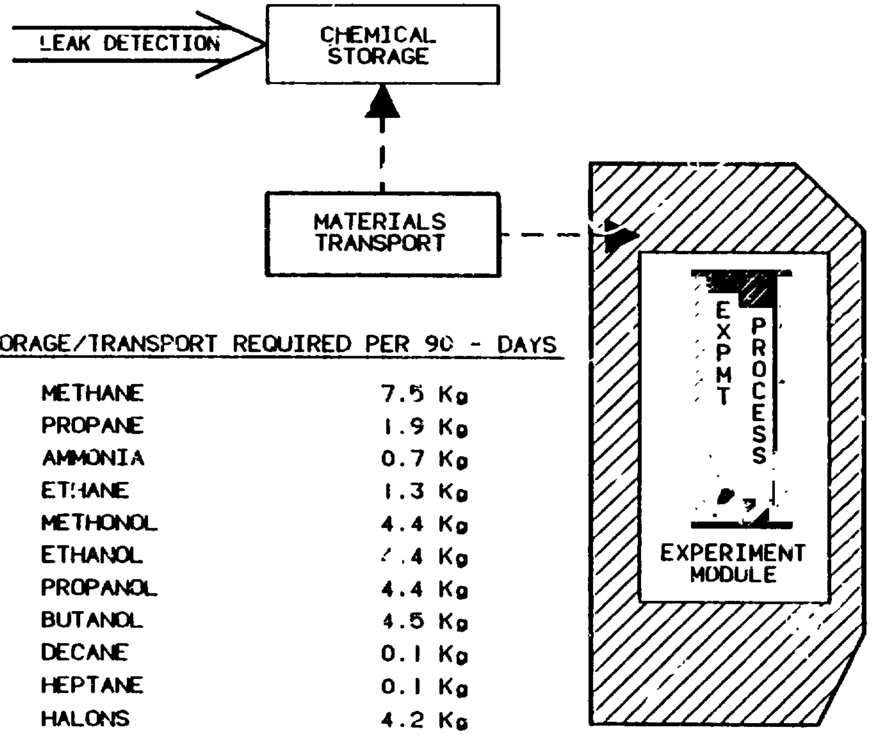
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

CHEMICAL STORAGE & MATERIALS TRANSPORTS USAGES



STORAGE/TRANSPORT REQUIRED PER 90 - DAYS	
METHANE	7.5 Kg
PROPANE	1.9 Kg
AMMONIA	0.7 Kg
ETHANE	1.3 Kg
METHONOL	4.4 Kg
ETHANOL	4.4 Kg
PROPANOL	4.4 Kg
BUTANOL	4.5 Kg
DECANE	0.1 Kg
HEPTANE	0.1 Kg
HALONS	4.2 Kg
MULTI COMPONENT FUELS	1.6 Kg
PLEXIGLASS	2.6 Kg
PAPER	1.1 Kg

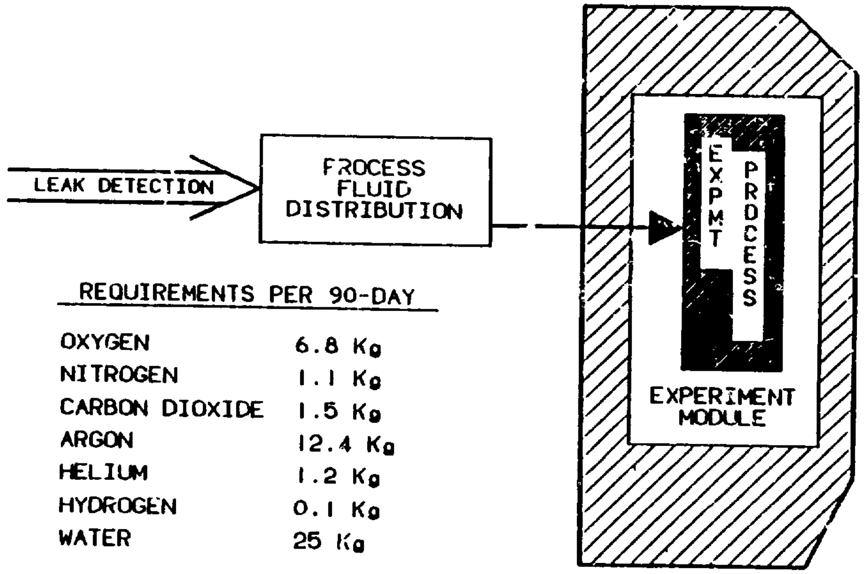
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

USL SUPPLIED CONSUMMABLES USAGE



REQUIREMENTS PER 90-DAY	
OXYGEN	6.8 Kg
NITROGEN	1.1 Kg
CARBON DIOXIDE	1.5 Kg
ARGON	12.4 Kg
HELIUM	1.2 Kg
HYDROGEN	0.1 Kg
WATER	25 Kg

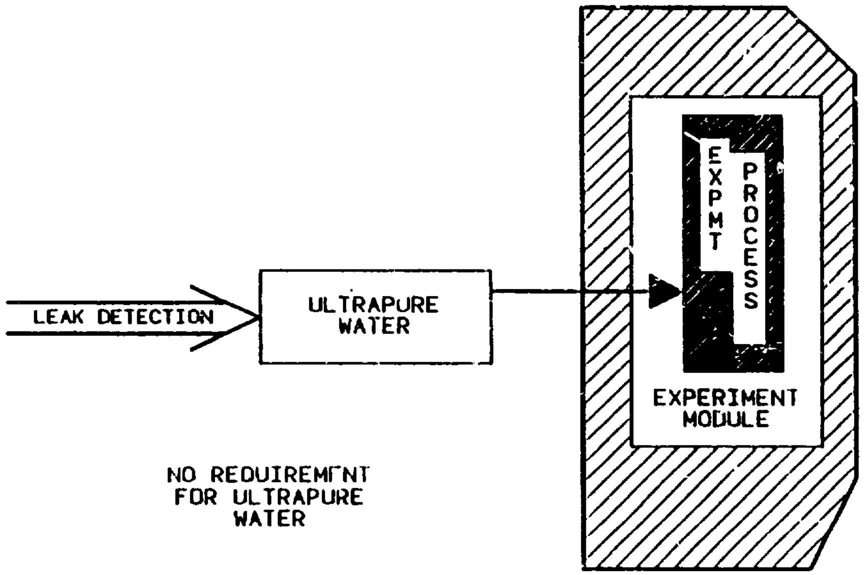
NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

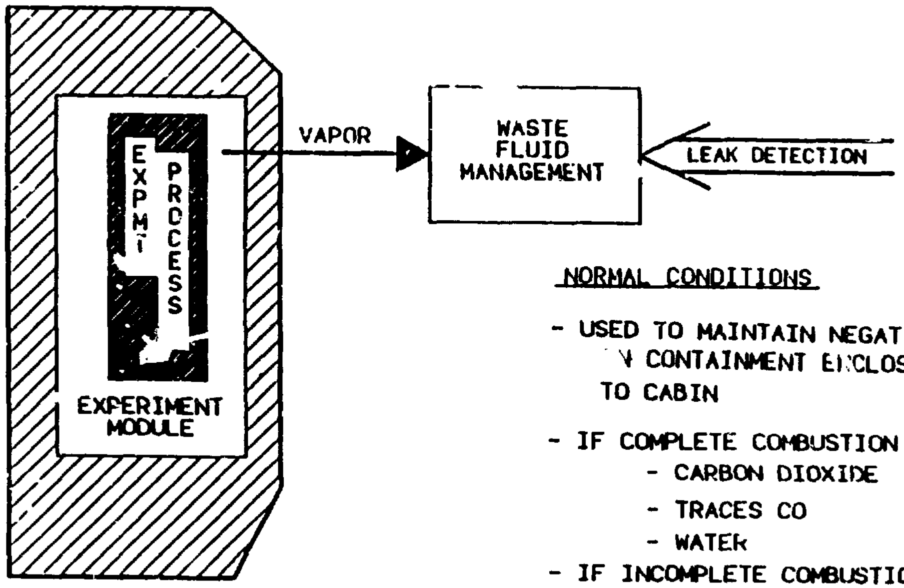
ULTRAPURE WATER USAGE



NO REQUIREMENT
FOR ULTRAPURE
WATER

MODULAR COMBUSTION FACILITY

WASTE FLUIDS MANAGEMENT USAGE



NORMAL CONDITIONS

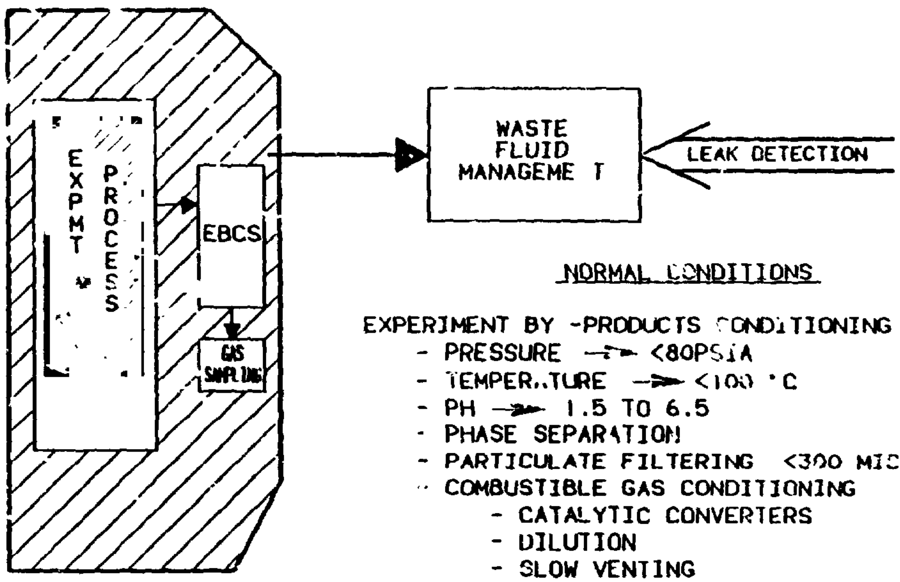
- USED TO MAINTAIN NEGATIVE PRESSURE IN CONTAINMENT ENCLOSURE RELATIVE TO CABIN
- IF COMPLETE COMBUSTION GET:
  - CARBON DIOXIDE
  - TRACES CO
  - WATER
- IF INCOMPLETE COMBUSTION GET:
  - UNBURNT FUEL - (PROPANE, METHANE, ETC.)
  - SMALL PERCENT CO2, CO & WATER
  - SOOT (CARBON)
- IN EITHER CASE
  - COULD GET EXTINGUISHANTS ADDED
    - HALONS
    - WATER
    - CO2
  - TOXICS FORMED
    - IF TEMPERATURE HIGH ENOUGH
    - NITROGEN & SULFUR COMPOUNDS
    - ADDITIONAL STUDY REQD

ABNORMAL CONDITIONS - (EXAMPLE, NO IGNITION)

- UNBURNT FUELS - (PROPANE, METHANE, ETC.)

MODULAR COMBUSTION FACILITY

CONCEPT DESIGN



NORMAL CONDITIONS

EXPERIMENT BY -PRODUCTS CONDITIONING SYSTEMS
- PRESSURE → <80PSIA
- TEMPERATURE → <100 °C
- PH → 1.5 TO 6.5
- PHASE SEPARATION
- PARTICULATE FILTERING <300 MICRONS
- COMBUSTIBLE GAS CONDITIONING
  - CATALYTIC CONVERTERS
  - DILUTION
  - SLOW VENTING

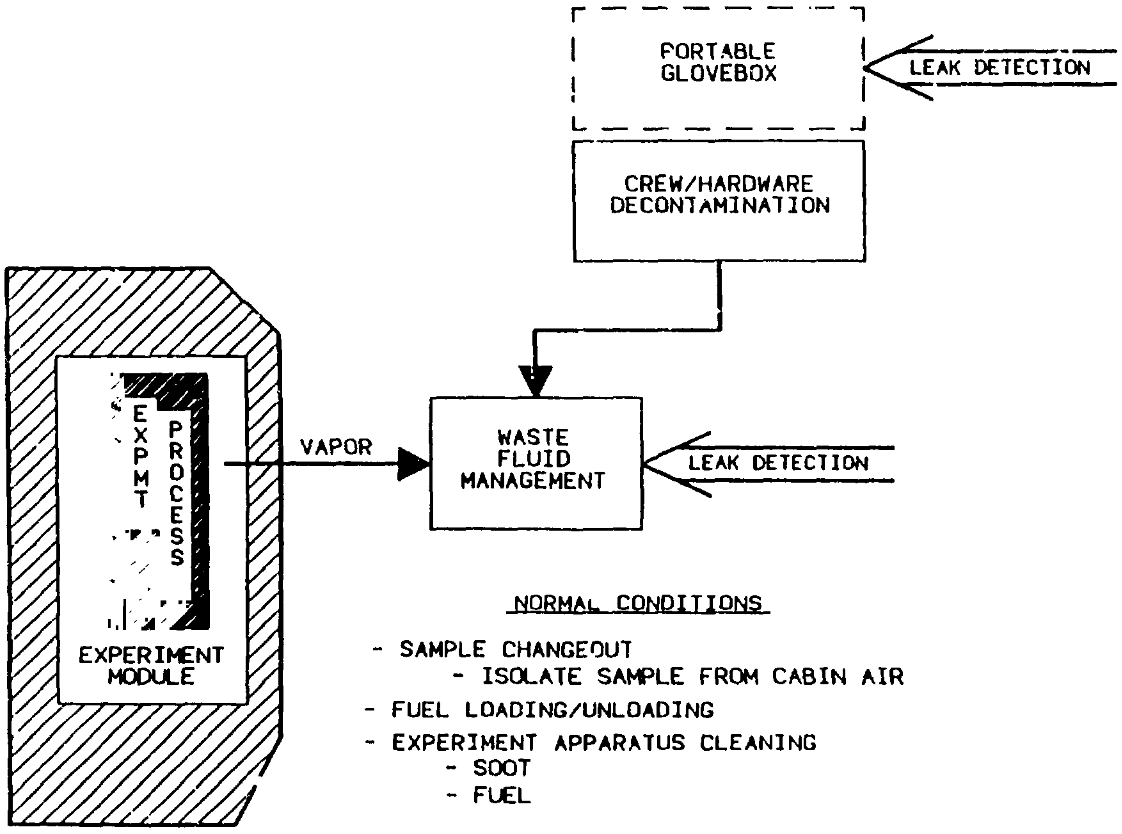
NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

"PORTABLE GLOVEBOX USES"



NORMAL CONDITIONS

- SAMPLE CHANGEOUT
  - ISOLATE SAMPLE FROM CABIN AIR
- FUEL LOADING/UNLOADING
- EXPERIMENT APPARATUS CLEANING
  - SOOT
  - FUEL

ABNORMAL CONDITIONS

- MAJOR CLEANUP
- POSSIBLE APPARATUS CHANGEOUT

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

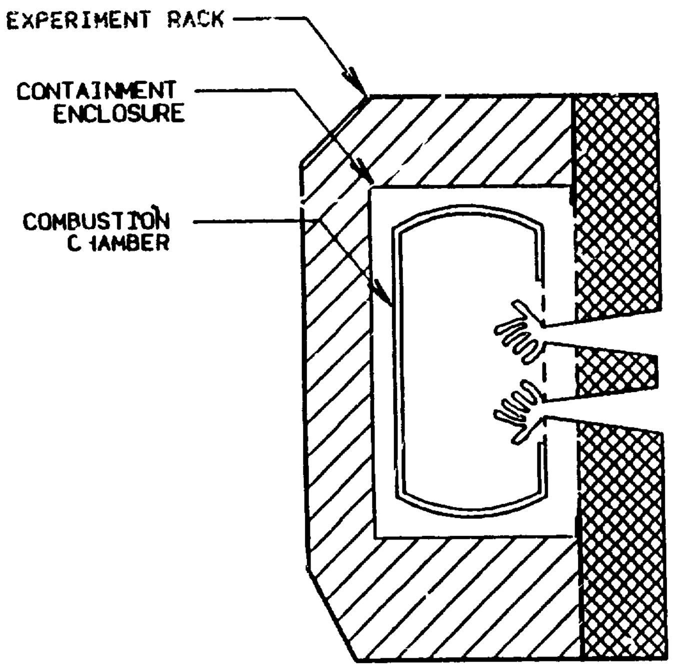
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT I FIXED FORM STANDARD ATTACHMENT TO ENTIRE RACK



POSTIVE FEATURES

- STANDARD INTERFACE TO ALL RACKS

NEGATIVE FEATURES

- DOES NOT ISOLATE CONTAINMENT ENCLOSURE FROM REST OF RACK
- DIFFCULT PROBLEM WITH CONTAINMENT ENCLOSURE & CHAMBER ACCESS DOOR
- MAY BE UNABLE TO REACH ALL PARTS OF CHAMBER

POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX
- ADAPTERS

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

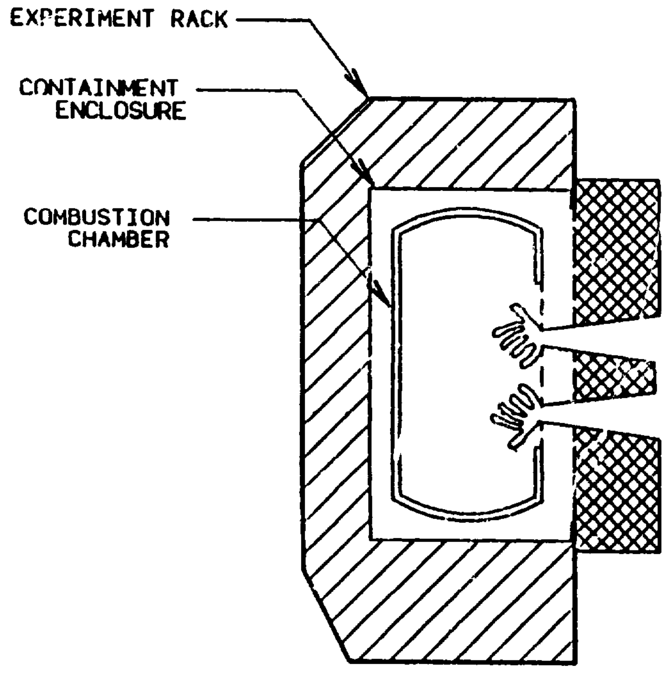
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT II FIXED FORM ATTACHMENT TO USER'S CONTAINMENT ENCLOUSURE



POSITIVE FEATURES

- FLAT FIXED ATTACHMENT SURFACE

NEGATIVE FEATURES

- DOES NOT ISOLATE CONTAINMENT ENCLOSURE FROM CHAMBER
- DIFFCULT PROBLEM WITH CONTAINMENT ENCLOSURE & CHAMBER ACCESS DOORS
- MAY BE UNABLE TO REACH ALL PARTS OF CHAMBER

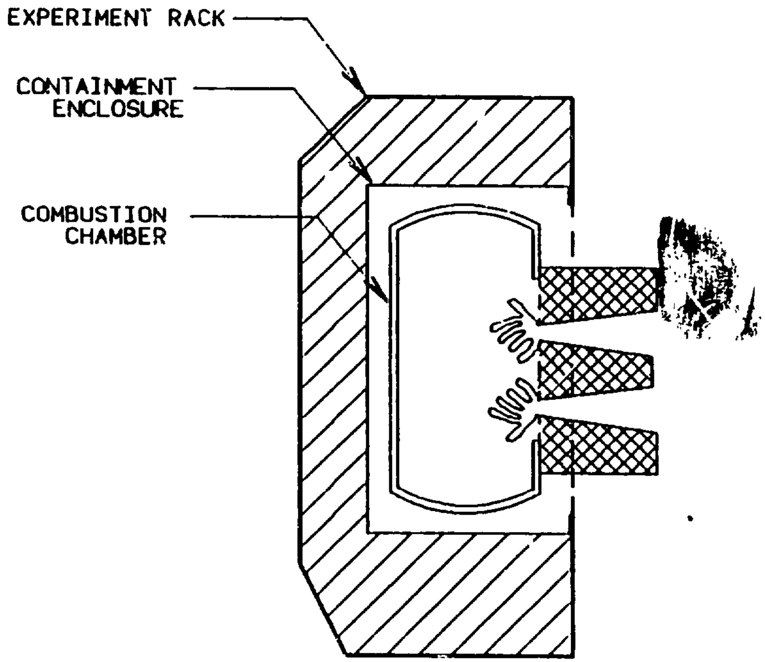
POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX
- ADAPTER

MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT III FIXED FORM ATTACHMENT TO USER'S CHAMBER



POSTIVE FEATURES

- SMALLER
- ISOLATES CHAMBER

NEGATIVE FEATURES

- ROUND VARIABLE ATTACHMENT SURFACE
- DIFFICULT PROBLEM WITH CHAMBER ACCESS DOOR
- BETTER- BUT REACHING BACK OF CHAMBER MAY BE A PROBLEM

POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX

NASA
NATIONAL AERONAUTICS &
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY

ISSUES AND CONCERNS

- MULTI-RACK FACILITY - INTER-RACK CONNECTIONS
- CONTAINMENT
- PMMS AVAILABILITY
- USL SUPPLIED FLUIDS
- EMERGENCY/CREW RESPONSE, ETC.
- PORTABLE GLOVEBOX
- USER INTERFACE WITH WP-01
- TECHNOLOGY DEVELOPMENT OF SYSTEMS
- COMPATIBILITY WITH JEM , COLUMBUS & CDSF

SPACE STATION
TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

HUNTSVILLE, ALABAMA
NOV 29, 30 & DEC 1, 1988

OVERVIEW
OF
FLUID PHYSICS/DYNAMICS FACILITY

NASA
LEWIS RESEARCH CENTER
CLEVELAND, OHIO

ENGINEERING DIRECTORATE P.M. : RON CHUCKSA
SPACE EXPERIMENTS DIV P.M. : BOB THOMPSON
FACILITY PROJECT SCIENTIST : JACK SALZMAN
STUDY TEAM MEMBER (PMMS) : DON PERDUE

NASA
NATIONAL AERONAUTICS &
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

FLUID PHYSICS/DYNAMICS FACILITY

OBJECTIVE: DEVELOP A MODULAR, MULTIUSER MICROGRAVITY SCIENCE FACILITY ,FOR USE BY THE FLUID/DYNAMICS SCIENCE COMMUNITY ON BOARD THE SPACE STATION FREEDOM LABORATORY

CURRENT EFFORT: DEFINITION-STUDY & CONCEPTUAL DESIGN

APPROACH:

- START WITH A REPRESENTATIVE LIST OF POTENTIAL MICROGRAVITY SCIENCE EXPERIMENTS FOR FLUIDS OVER A BROAD RANGE OF CONDITIONS/REQUIREMENTS
- WORK WITH REPRESENTATIVES OF EACH OF THESE POTENTIAL EXPERIMENTS TO DETERMINE REQUIREMENTS
- GENERATE PRELIMINARY CONCEPTUAL SCHEMATIC DIAGRAM FOR EACH POTENTIAL EXPERIMENT AS IT MIGHT EXIST IN THE USL ENVIRONMENT
- GENERATE A DATABASE OF EXPERIMENTAL REQUIREMENTS
- EXTRACT COMMON SYSTEMS TO FORM THE BASIS FOR A HOST FACILITY
- MERGE COMMON SYSTEMS REQUIREMENTS WITH KNOWN SPACE STATION REQUIREMENTS/CAPABILITIES TO FORM A HOST FACILITY

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

FLUID PHYSICS/DYNAMICS FACILITY

REFERENCE EXPERIMENT SETS

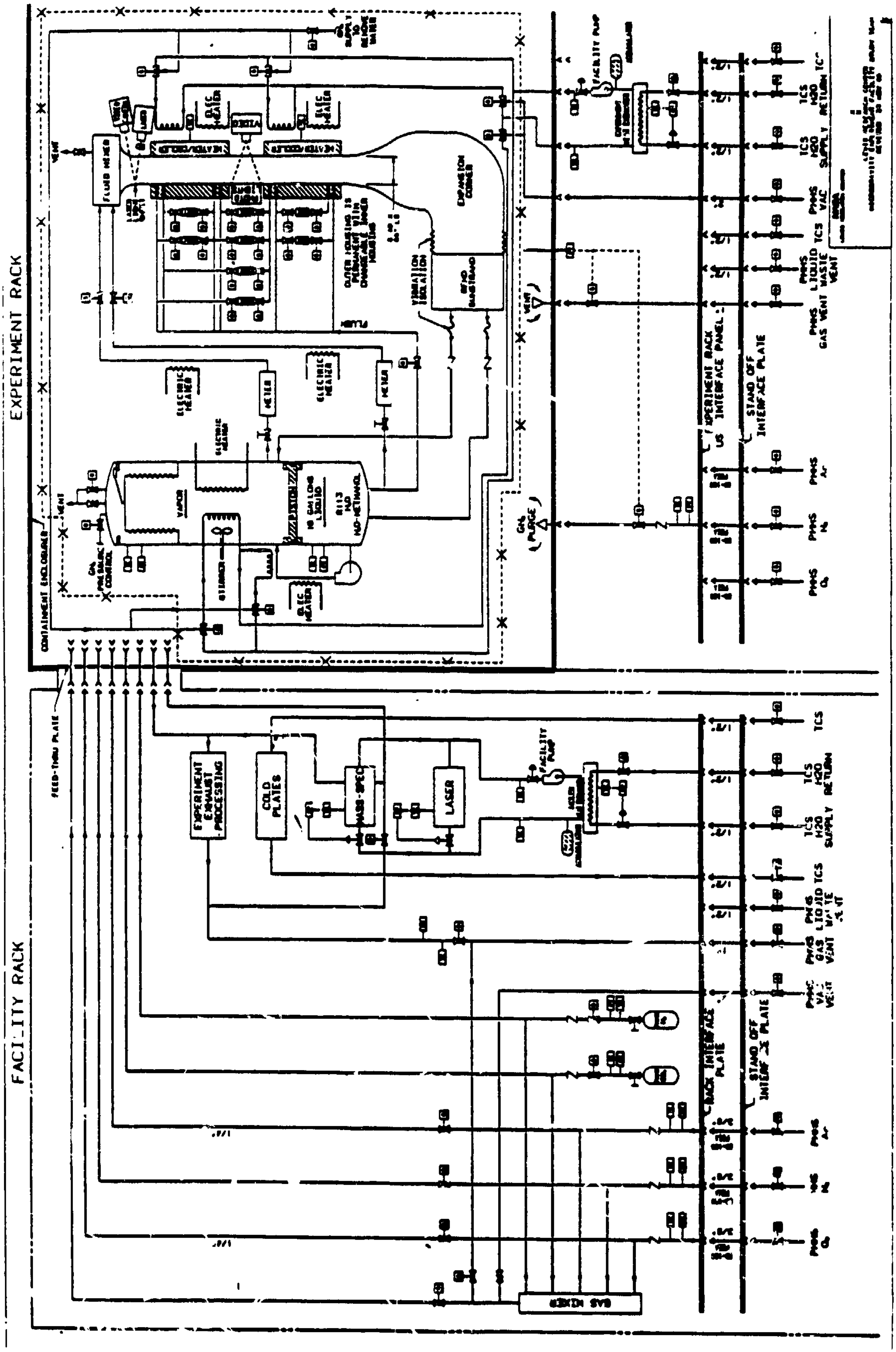
[F01A]	SURFACE TENSION INDUCED INSTABILITIES AND FLOW	CHAI - LeRc
[F01B]	SURFACE TENSION DRIVEN CONVECTION	PLINE - LeRc
[F02]	FREE SURFACE PHENOMENA	CHAI - LeRc
[F03]	IMMERSED BUBBLE/DROPLET DYNAMICS AND INTERACTIONS	BALA - LeRc
[F04]	THERMAL AND DOUBLE-DIFFUSIVE NATURAL CONVECTION	KASSEMI - LeRc
[F05]	MULTIPHASE FLOW	McQUILLEN - LeRc
[F06]	FIRST ORDER PHASE TRANSITIONS	CHIARAMONTE - LeRc
[F14]	CHEMICAL VAPOR DEPOSITION (CVD)	CLARK - LaRc
[F16]	THERMAL GRADIENT EFFECTS ON ENTRY FLOW DEVELOPMENT	CLARK - LaRc
[F17]	QUANIFICATION OF FLUID PHENOMENA THAT OCCUR DURING SOLIDIFICATION	McCAY - UTSI/MSFC
[F18]	FLUIDS MIXTURES HEAT AND MASS TRANSFER	GIARRATANO - NBS

REVISED 16 NOV 86

NASA
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO



FP4-1.

ORIGINAL PAGE IS OF POOR QUALITY

FLUID PHYSICS/DYNAMICS FACILITY

PRESENT FACILITY CONCEPTS

- NOW REVIEWING EXPERIMENTAL REQUIREMENTS AND JUST STARTING CONCEPT DESIGN

- MODULAR CONCEPT

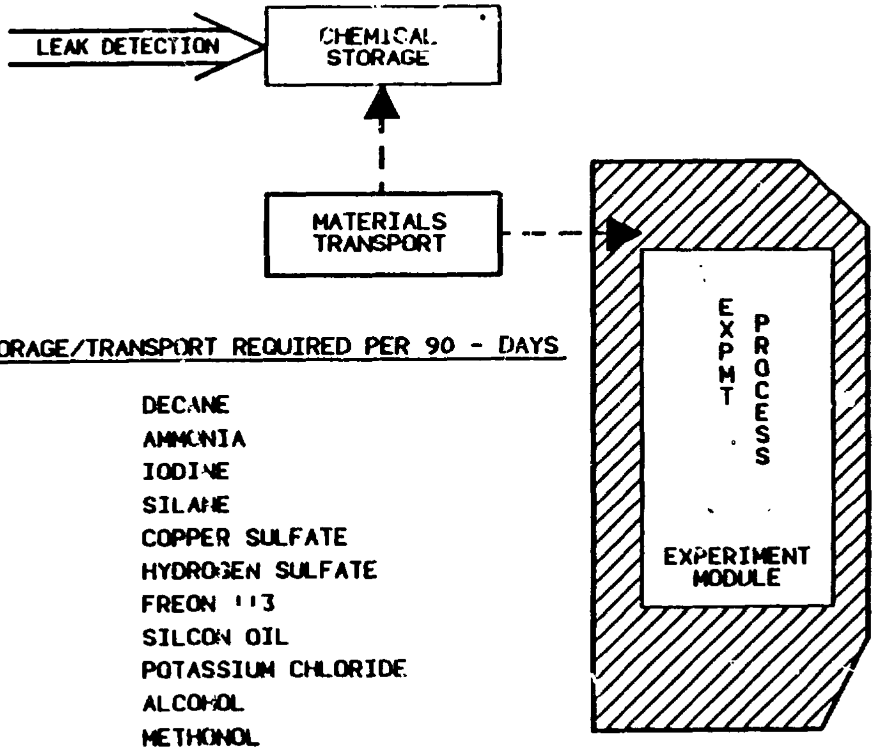
- TWO RACK FACILITY
  - PERMANENT FACILITY RACK
  - INTERCHANGEABLE EXPERIMENT RACK

- FACILITY RACK
  - INTERFACE BETWEEN USL & EXPERIMENT
  - HOUSES SUPPORT SYSTEMS
    - POWER CONVERSION & DISTRIBUTION SYSTEM
    - DATA ACQUISITION & CONTROL COMPUTER SYSTEM
    - LASER DIAGNOSTIC SUPPORT SYSTEM
    - HIGH RESOLUTION HIGH FRAME RATE VIDEO SUPPORT SYSTEM
    - MASS SPECTROMETER
    - SAFETY SYSTEMS
    - OPERATOR INTERFACE PANEL

- EXPERIMENT RACK
  - RACK INTEGRATED ON GROUND
  - POSSIBLE CHANGE-OUT EVERY 12 TO 18 MONTHS
  - HOUSES CONTAINMENT ENCLOSURE
  - VARIOUS EXPERIMENT MODULES
    - MULTI-PHASE FLOW LOOP

FLUID PHYSICS/DYNAMICS FACILITY

CHEMICAL STORAGE & MATERIALS TRANSPORTS USAGES



STORAGE/TRANSPORT REQUIRED PER 90 - DAYS

DECANE
AMMONIA
IODINE
SILANE
COPPER SULFATE
HYDROGEN SULFATE
FREON 113
SILCON OIL
POTASSIUM CHLORIDE
ALCOHOL
METHONOL

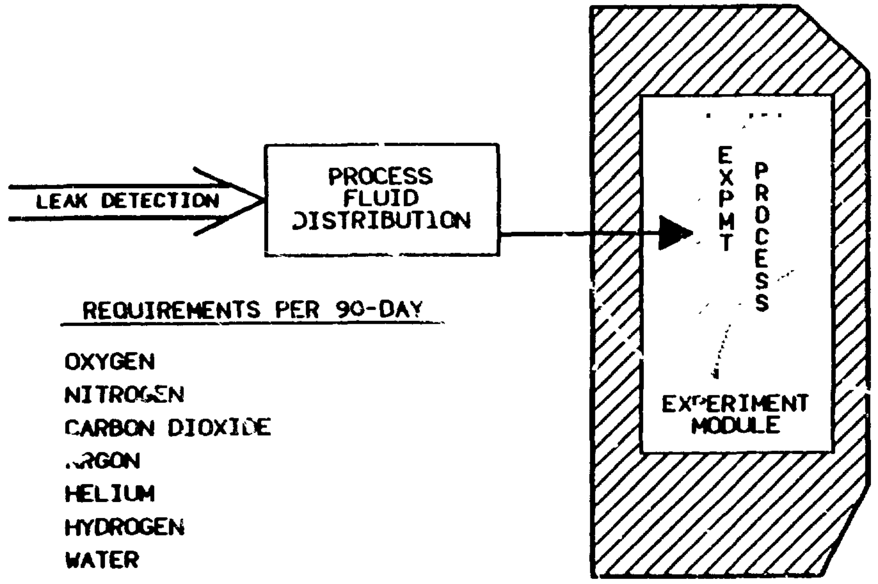
NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER
CLEVELAND, OHIO

FLUID PHYSICS/DYNAMICS FACILITY

USL SUPPLIED CONSUMMABLES USAGE



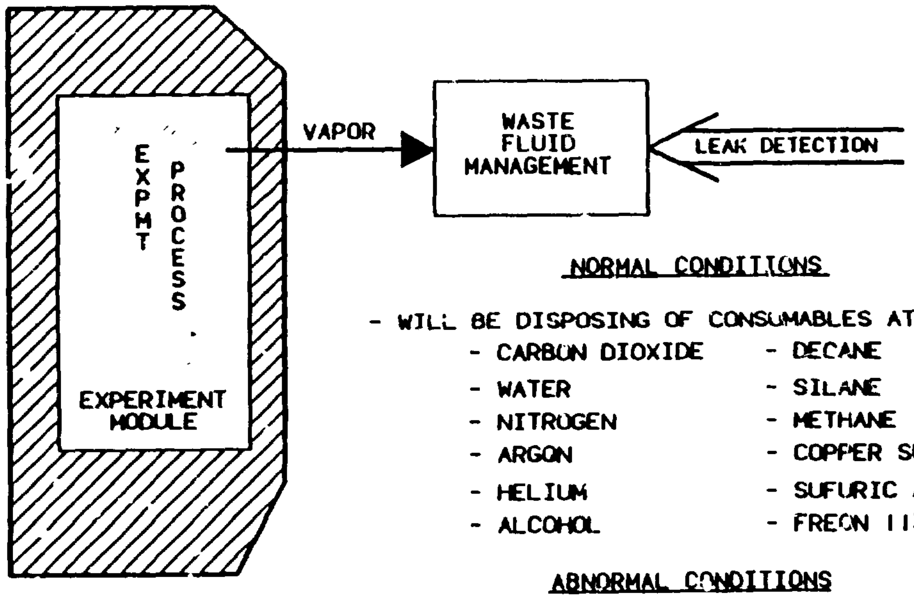
REQUIREMENTS PER 90-DAY

OXYGEN
NITROGEN
CARBON DIOXIDE
ARGON
HELIUM
HYDROGEN
WATER

- AMOUNTS WILL BE IN DATABASE

FLUID PHYSICS/DYNAMICS FACILITY

WASTE FLUIDS MANAGEMENT USAGE



NORMAL CONDITIONS

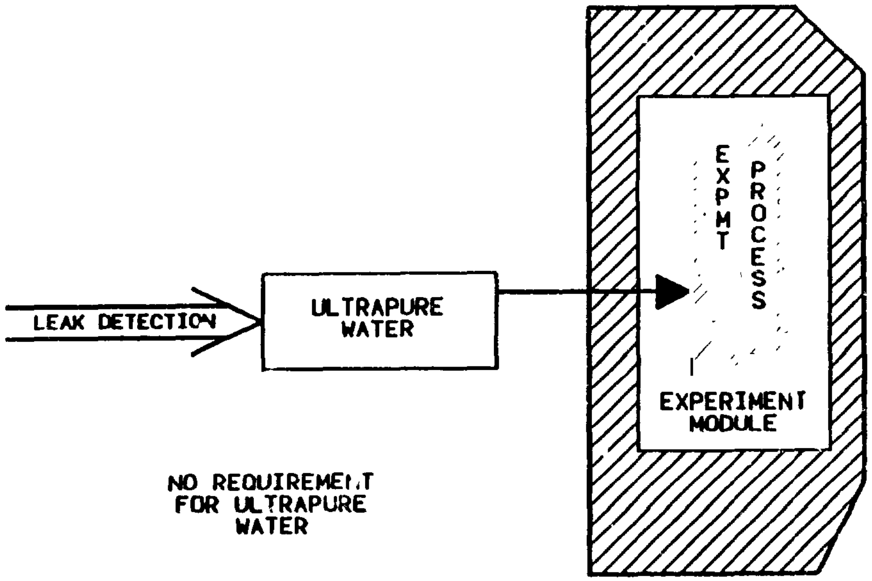
- WILL BE DISPOSING OF CONSUMABLES AT END OF EACH RUN:
  - CARBON DIOXIDE
  - WATER
  - NITROGEN
  - ARGON
  - HELIUM
  - ALCOHOL
  - DECANE
  - SILANE
  - METHANE
  - COPPER SULFATE
  - SUFURIC ACID
  - FREON 113

ABNORMAL CONDITIONS

- IF A SEALED CELL WERE TO LEAK
  - AMMONIA CHLORIDE
  - IODINE
  - SILCON OIL
- AMOUNTS WILL BE IN DATABASE

FLUID PHYSICS/DYNAMICS FACILITY

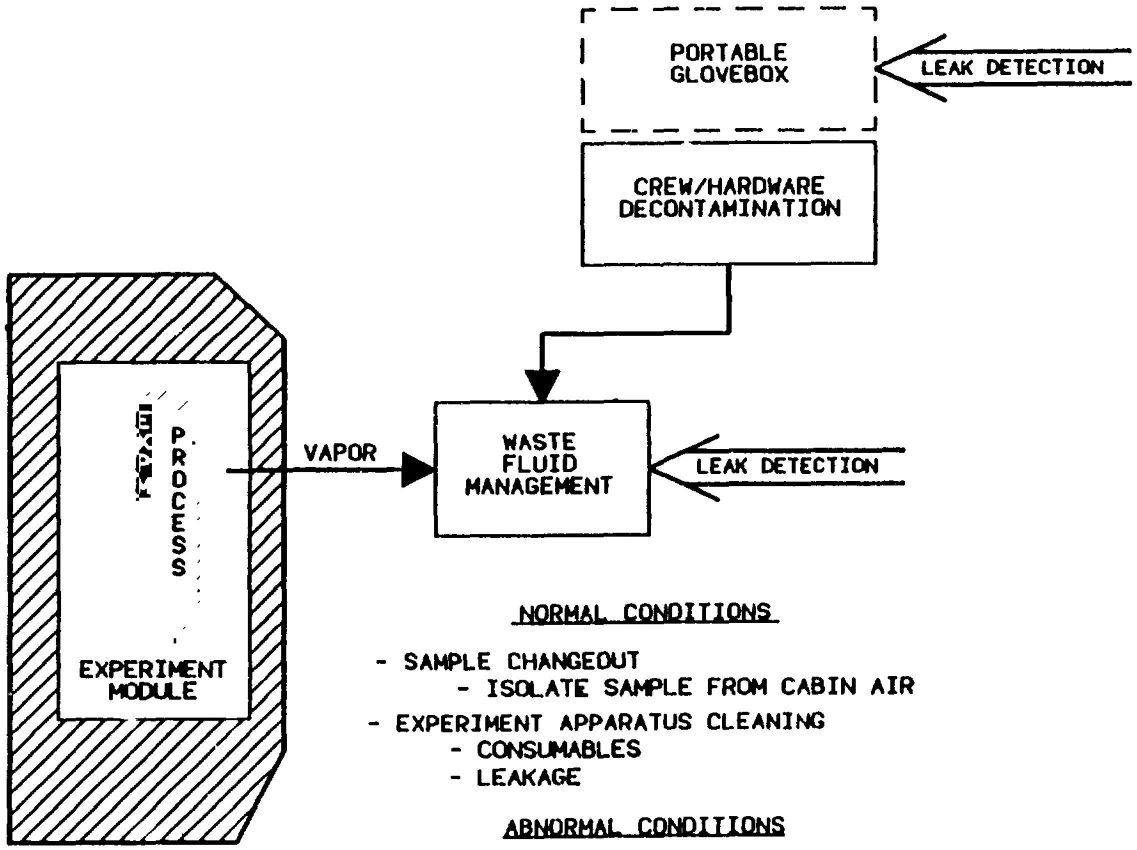
ULTRAPURE WATER USAGE



NO REQUIREMENT FOR ULTRAPURE WATER

FLUID PHYSICS/DYNAMICS FACILITY

"PORTABLE GLOVEBOX USES"



PORTABLE GLOVEBOX

LEAK DETECTION

CREW/HARDWARE DECONTAMINATION

WASTE FLUID MANAGEMENT

LEAK DETECTION

VAPOR

PROCESS [illegible]

EXPERIMENT MODULE

NORMAL CONDITIONS

- SAMPLE CHANGEOUT
    - ISOLATE SAMPLE FROM CABIN AIR
- EXPERIMENT APPARATUS CLEANING
    - CONSUMABLES
    - LEAKAGE

ABNORMAL CONDITIONS

- MAJOR CLEANUP
- POSSIBLE APPARATUS CHANGEOUT

FLUID PHYSICS/DYNAMICS FACILITY

ISSUES AND CONCERNS

- MULTI-RACK FACILITY - INTER-RACK CONNECTIONS
- CONTAINMENT
- PMMS AVAILABILITY
- USL SUPPLIED FLUIDS
- EMERGENCY/CREW RESPONSE, ETC.
- PORTABLE GLOVEBOX
- USER INTERFACE WITH WP-01
- TECHNOLOGY DEVELOPMENT OF SYSTEMS
- COMPATIBILITY WITH JEM , COLUMBUS & CDSF

ADVANCED PROTEIN CRYSTAL GROWTH

Robert S. Snyder
Space Science Laboratory
Marshall Space Flight Center

ADVANCED PROTEIN CRYSTAL GROWTH FACILITY (APCGF)

OBJECTIVES:

Grow large, high-quality crystals of proteins and other biological materials for use in studies of molecular structure

Analyze crystals in space by high resolution optical techniques and x-ray diffraction (as an optimum goal)

Investigate the kinetics of protein crystallization from solution by incorporating experiment diagnostics into the APCGF

CHARACTERISTICS OF PROTEIN CRYSTALS

- Small size 0.5 mm
- 30 to 80% solvent
- Few intermolecular contacts - mechanically unstable
- Sensitive to temperature changes
- Sensitive to pH changes
- Sensitive to solvent loss or changes in solvent composition
- Weak to moderate diffraction observed
- Sensitive to x-rays
- Finite lifetimes

PCG DEVELOPMENT

Most protein crystals are grown by variations of the hanging drop method

Handheld PCG space apparatus esssentially duplicates this laboratory's vapor diffusion apparatus

Deficiencies of experiment in space include:

- Uncertain initial conditions of experiment
- Unpredictable protein crystal growth operations and environment in space
- Relatively short growth time
- Delay in collecting and analyzing crystals

PRESENT PCG REQUIREMENTS

- Load samples onboard within 24 hours of launch
- Provide a method of carrying proteins and growth initiator separately, and observing deployment and mixing of each as required
- Initiate crystallization as soon as possible after reaching orbit.
- Maintain low gravity conditions to prevent droplet loss and optimum crystal growth conditions
- Maintain constant temperature ($4^{o}C$ or $22^{o}C$)
- Limit temperature excursions ± 0.5 degrees C
- Provide manned access for operation and monitoring
- Carry as many samples as possible (60 or more)
- Retract sample into syringe as late as possible before re-entry
- Remove from orbiter within approximately 2 hours after landing

FLIGHTS OF HANDHELD PCG EXPERIMENTS

o	STS 51-D	April 1985
o	STS 51-F	July 1985
o	STS 61-B	November 1985
o	STS 61-C	January 1986

FLIGHTS OF PCC EXPERIMENTS WITH GANGED DEPLOYMENT

o	STS-26	September 1988
O	STS-29	February 1989

TRANSITION FROM HANDHELD TO PRESENT GANGED MECHANISM

New flight hardware incorporates:

- Initial stages of automation of experiment operation
- Accommodation in constant temperature flight enclosures
- Control of nucleation and growth based upon extensive laboratory research and testing
- In-flight crystal growth analysis by photography

PROTEIN CRYSTAL GROWTH EXPERIMENTS ON THE SPACE STATION

- o Requests for protein crystals grown in space exceed our capability to process them

- o Protein crystal growth is a dynamic flight program

  - Present flight experiments are flexible to stay ahead of the technology development on Earth

  - The dominant processes controlling protein crystallization are not known

  - Although hardwarse and operations are evolving as we gather information, basic facilities can bae outlined

- o Space Station should provide the laboratory for preparing the protein solutions and analyzing the grown crystals by x-ray diffraction

EXPERIMENT PLAN FOR SPACE STATION

- Protein samples will be prepared on orbit
  - Most proteins will be carried to orbit as frozen pellets or lyophillized
  - Mixing proteins with buffers, precipitants, etc., will be done at experiment initiation
- Protein Crystal Growth facility will incorporate techniques such as:
  - Vapor Diffusion
  - Liquid-Liquid Diffusion
  - Dialysis
  - "Containerless"
  - Epitaxy
- Most isothermal experiments will be done at 4 degrees C and 22 degrees C; some experiments will require temperature gradients
- Experiment duration will extend from several days to many weeks
- Some analysis of the crystals will have to be done on orbit

UTILIZATION OF LABORATORY FACILITIES AND UTILITIES

APCGF will need:

- Controlled temperature storage for the proteins (before the experiment) and grown crystals (before analysis and/or transport)
- Glovebox for handling toxic proteins
- High resolution video of critical crystallization steps
- Facilities for analyzing crytals
    - Microscopy
    - X-ray Diffraction

TOXIC AND REACTIVE MATERIALS

Many proteins of interest are toxic, e.g., scorpion toxin and sea anemone toxin flown on STS-51D

Quantities required for growing crystals are small (less than 1 milligram per 40 microliter drop)

Handling requirements will depend on facility and operations selected for the Space Station

CONCLUSIONS

Protein Crystal Growth on the Space Station will involve handling of fluids, some containing toxic proteins

Robotic systems are available for multiple samples in the laboratory but goal of these systems is control over repetitive operations not limitation of toxic material handling

Telescience can be designed and developed to monitor and transfer proteins from solution to growth to analysis

System flexibility must be retained, however, as the APCG Science Working Group defines the goals, requirements and facility capabilities for the Space Station

Biotechnology Facility
and
Bioreactor Sterilization

Presented at:

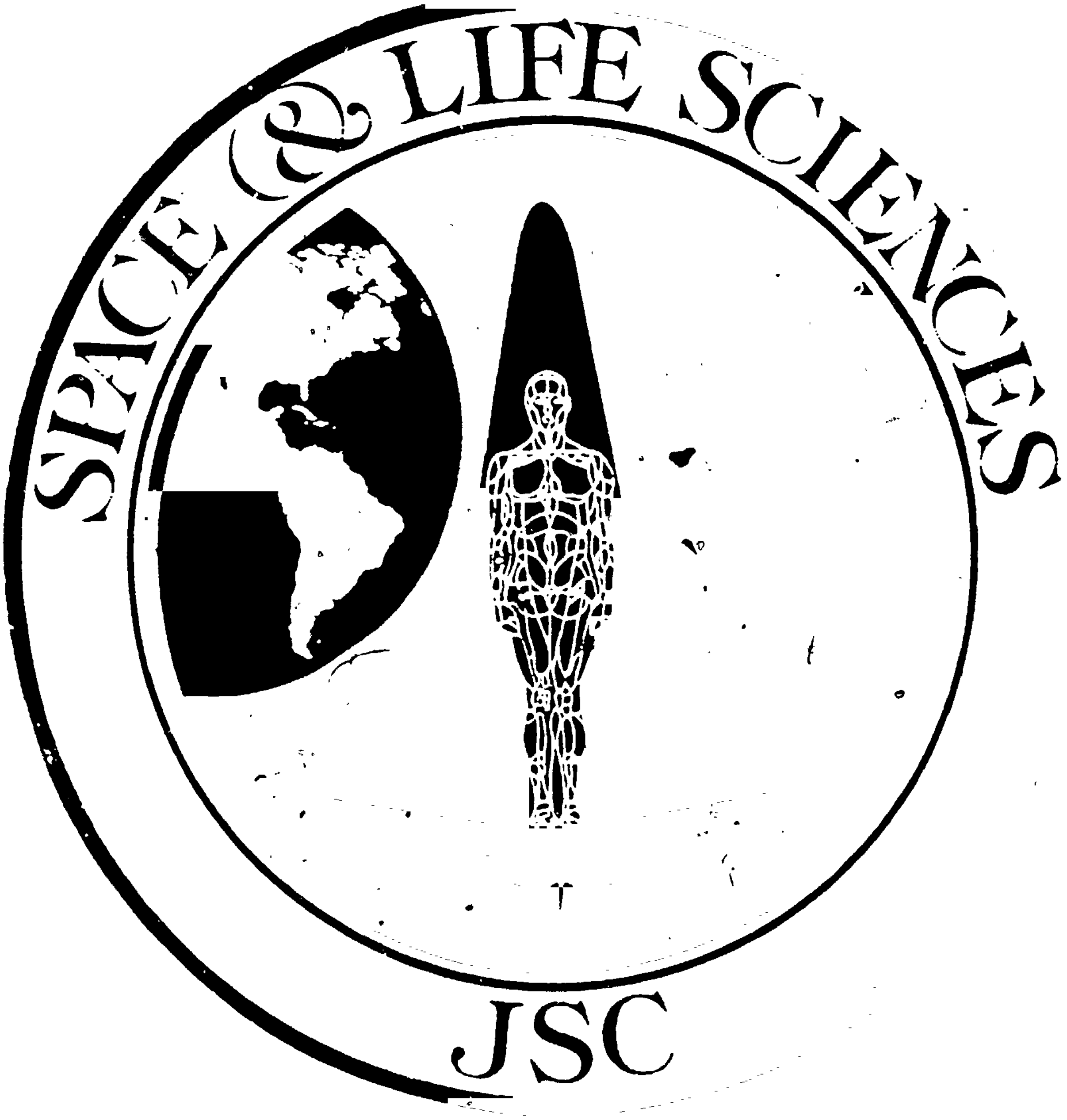
Space Station Freedom
Toxic and Reactive Materials Handling Workshop

Nov. 1988

William H. Bowie M.S.
Krug International
(presenter)

and

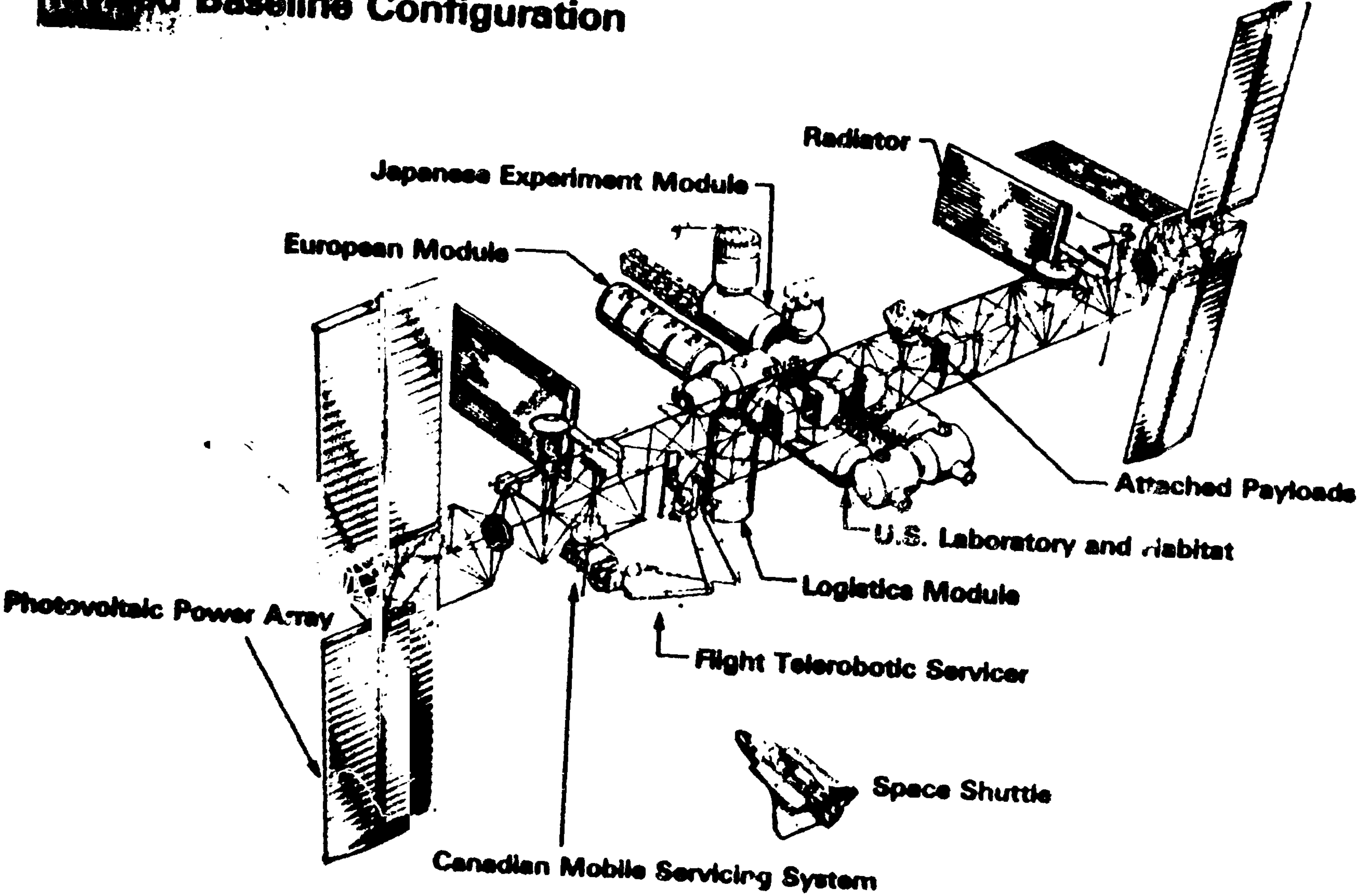
Steve R. Gonda Ph.D.
NASA / JSC

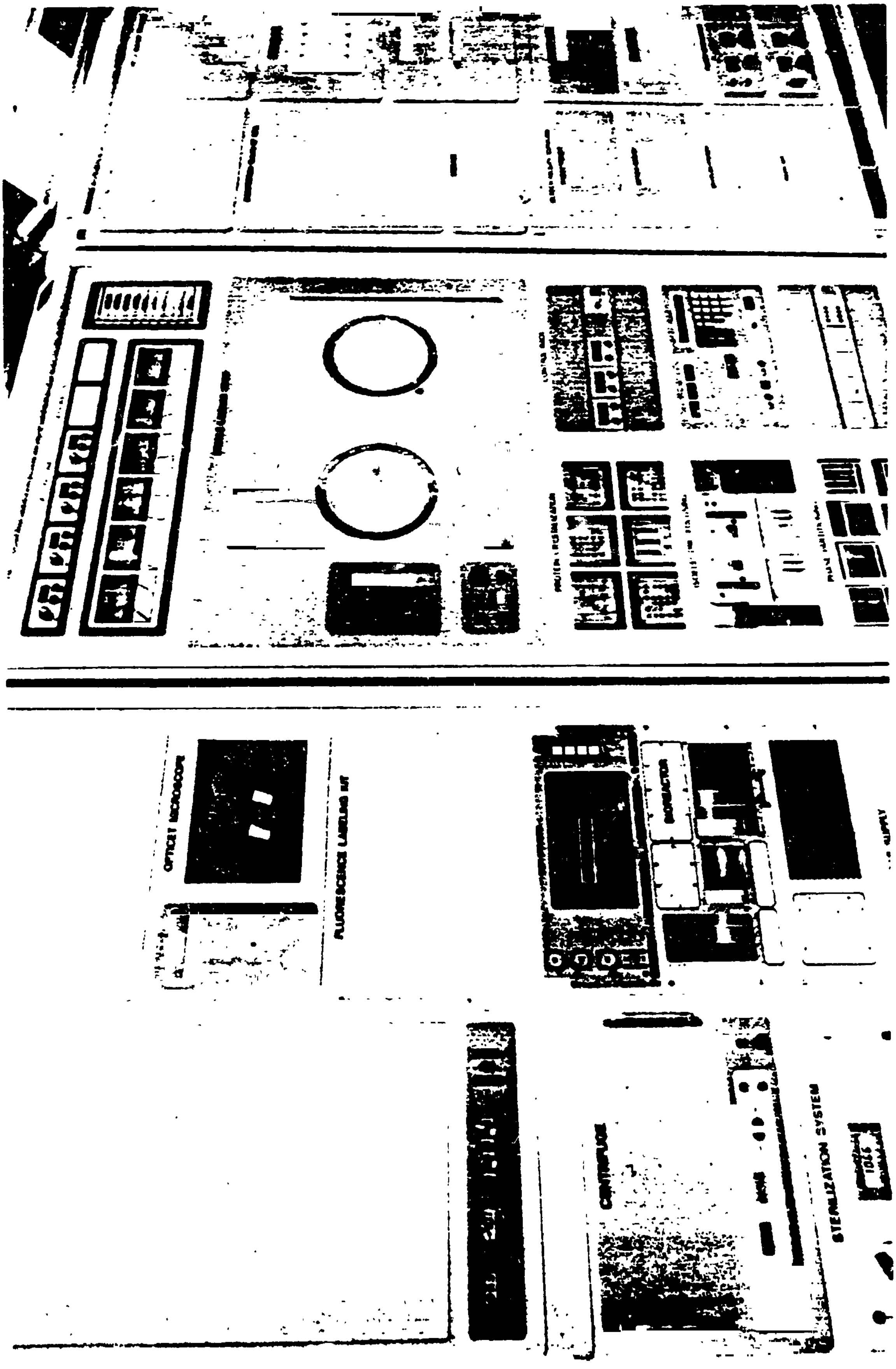

SPACE & LIFE SCIENCES
JSC

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

Revised Baseline Configuration



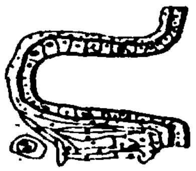

OPTICAL MICROSCOPE
FLUORESCENCE LABELING KIT
INCUBATOR
SUPPLY
CENTRIFUGE
STERILIZATION SYSTEM

BIOREACTOR USES

BIOREACTOR SYSTEM PROVIDES

BIOLOGICALS

Cells and tissues



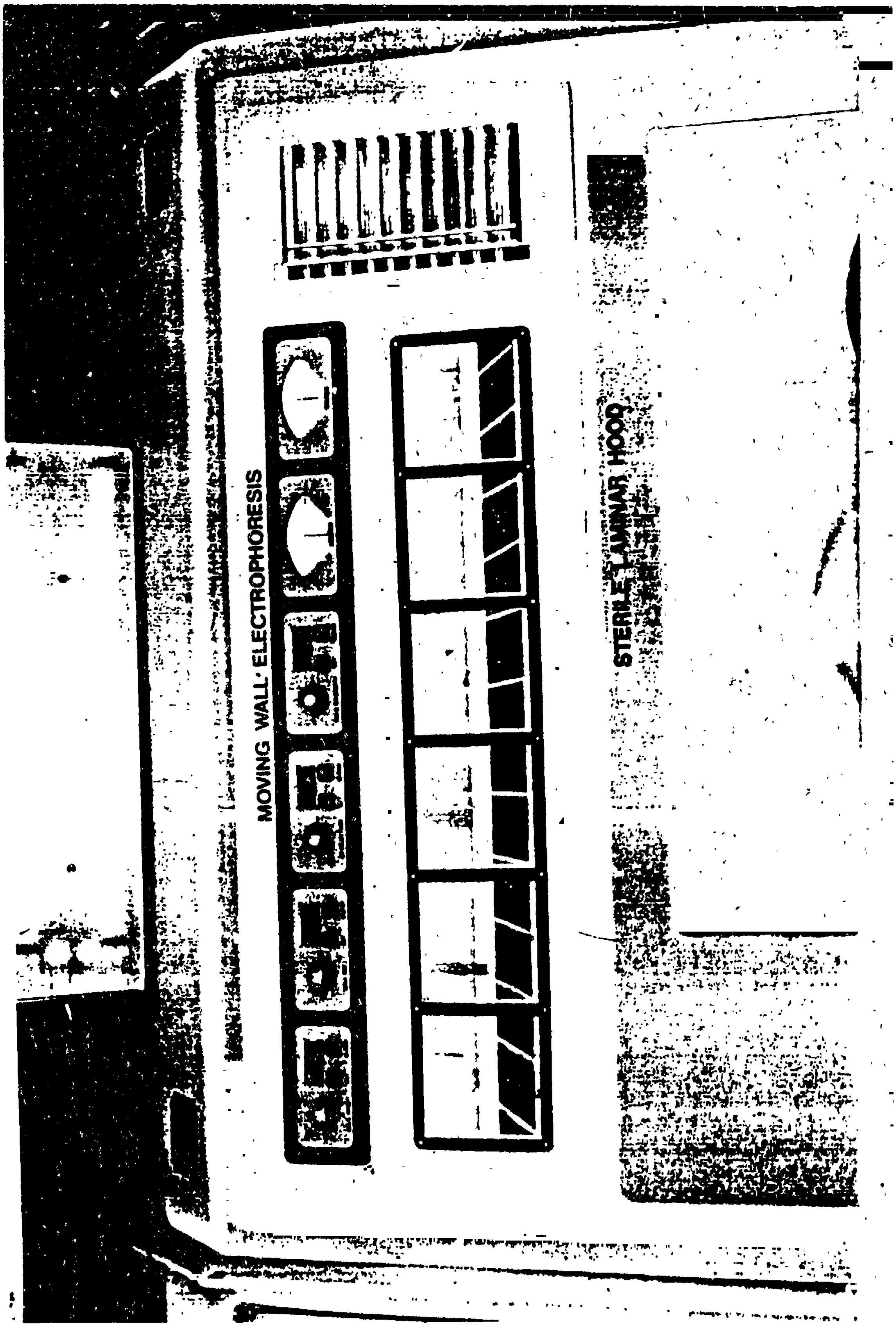
colon tissue showing crypt structure

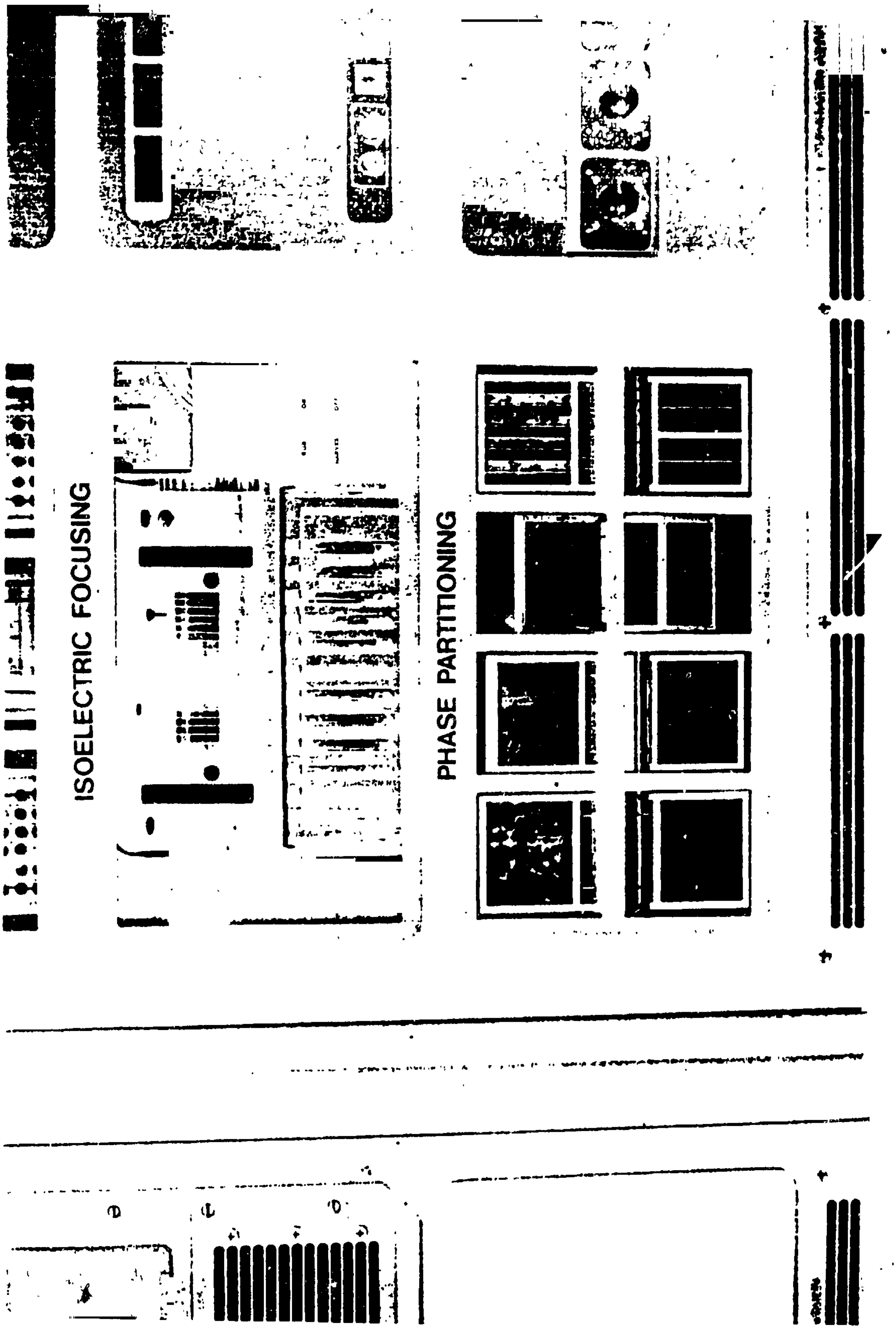
AN APPARATUS IN WHICH TO STUDY THE EFFECTS OF

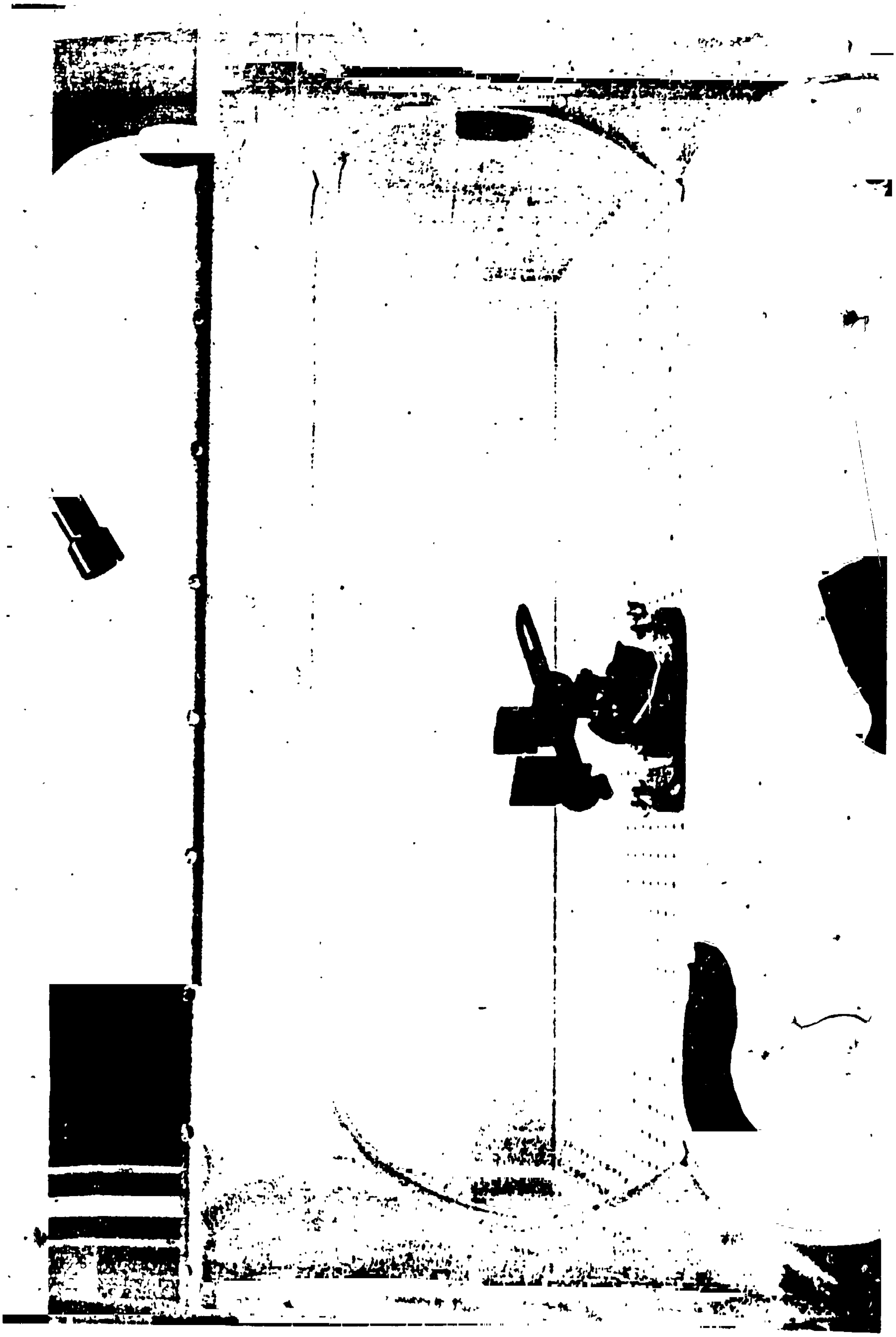
Shear, turbulence, and mixing

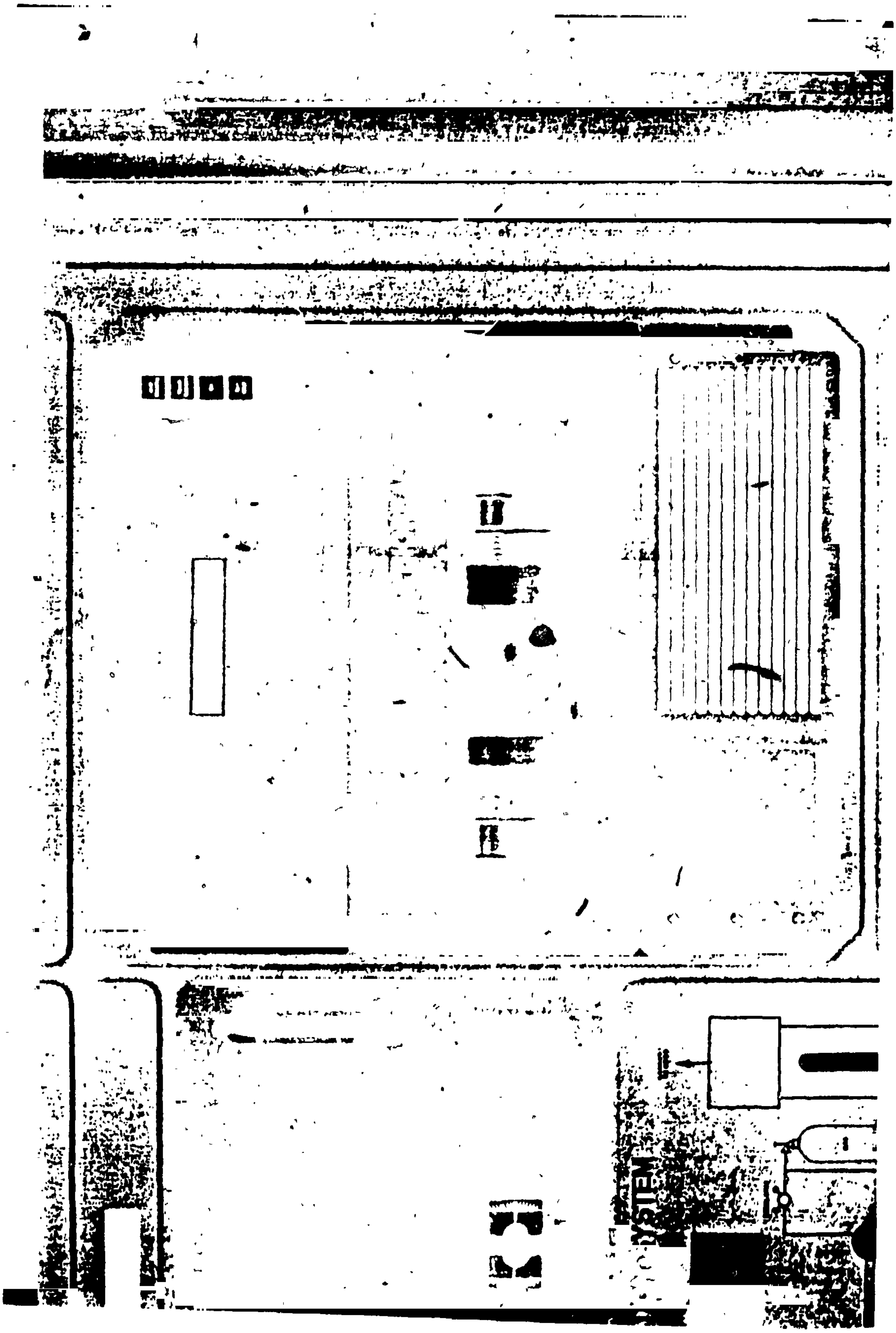
RAW MATERIAL FOR PRODUCT EXTRACTION

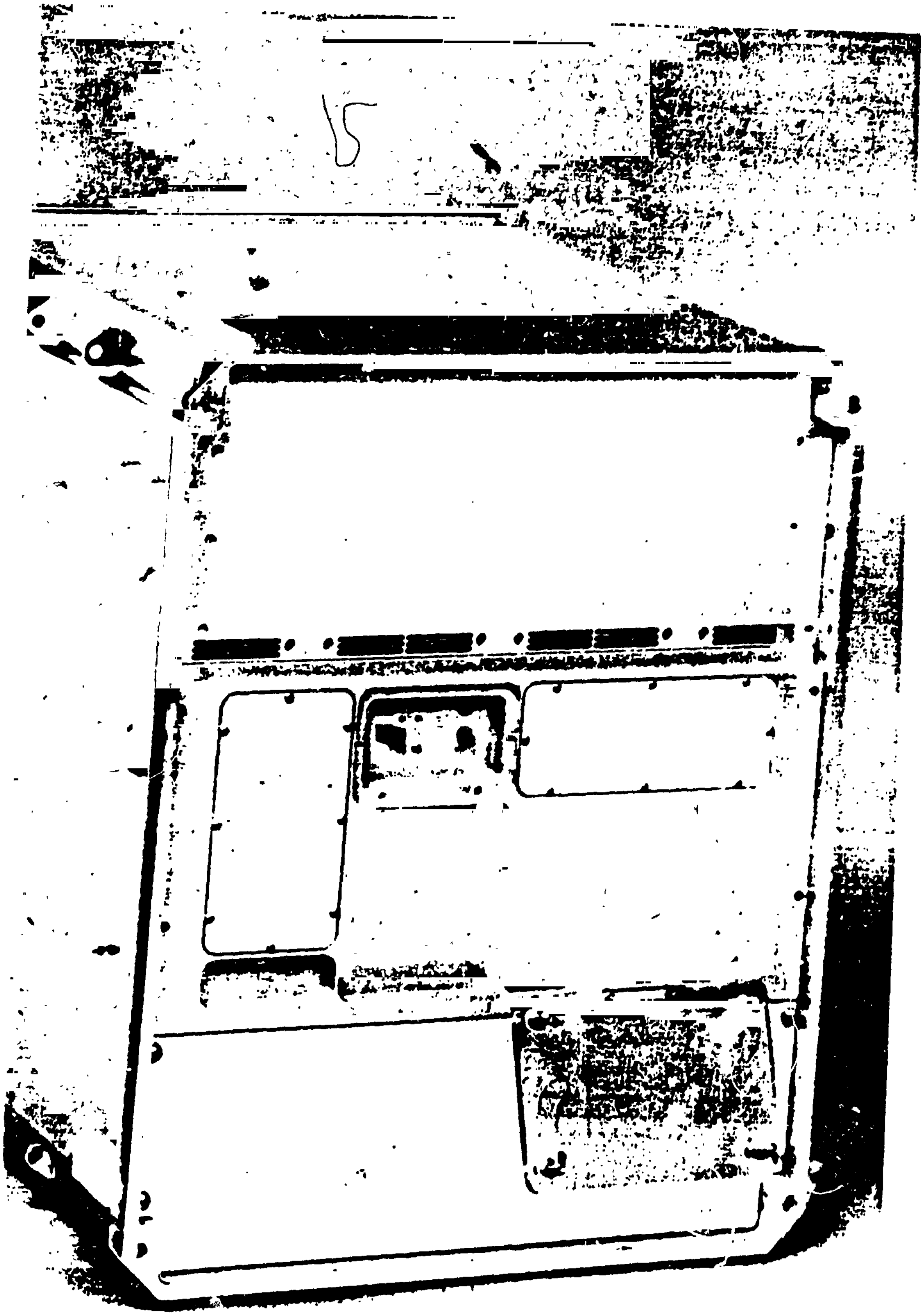
Cell and Tissue secretory and excretory materials


MOVING WALL ELECTROPHORESIS
STERILE LAMINAR HOOD


ISOELECTRIC FOCUSING
PHASE PARTITIONING




SYSTEM



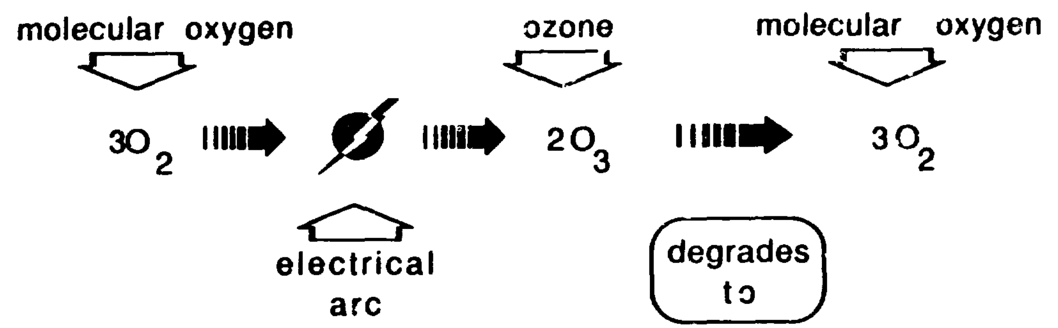
15

ORIGINAL PAGE IS
OF POOR QUALITY

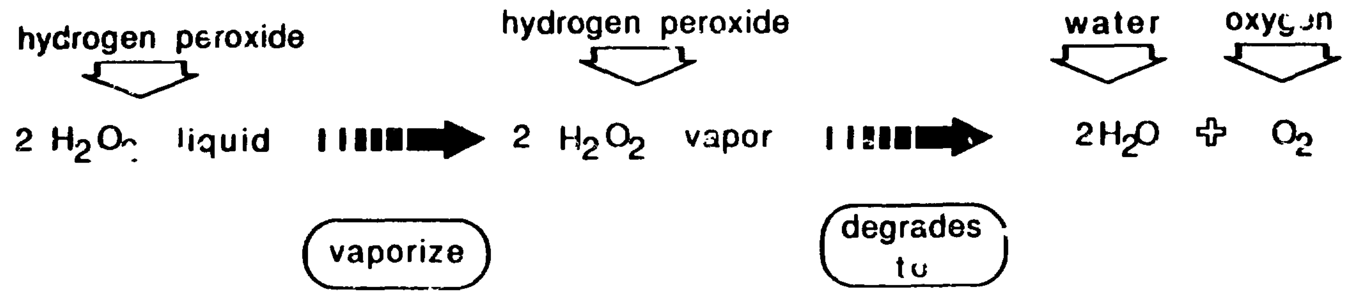
Circumstance	Compound	SMAC	Use	Hazard
Biorack FE VC	Sulfuric ether (Diethyl ether)	242.0		Irritant, CNS depressant
Spacelab D2	Triethanolamine	10.0	buffer component	Low level irritant and toxicity
	Dimethyl sulfoxide	200.0	carrier	Mild resp irritant
Refrigeration	Freon R-502	100.0 ppm	cooling	displace cmpds from scrubber
Fixative VC	gluteraldehyde	0.2 - 0.4	tissue processing	Irritant
	Formaldehyde	0.1 - 0.12	tissue processing	Irritant
Batteries	dimethyl sulfite	1.0	electrolyte	
	arsenate	0.002		
	Terechlorate (ClO_2)	0.083		Irritant
	Molecular iodine	0.1		Irritant, pulmonary edema
CR	Ag_2CrO_4	0.03		Corrosive
Sterilants, disinfectants	Alcide A (ClO_2)	0.03 ppm	CFES	
	(Cl_2)	0.03 ppm	CFES	Toxic irritant
	Ethylene oxide	0.2 ppm	Floreactor	carcinogen
	Glutaraldehyde			Irritant
Acids CR	Acetic acid	7.4	tissue processing	Irritant, chemical burns
	Phosphoric acid	[illegible]		Irritant
	Sodium Cacodylate (dimethyl asrsenic acid sodium salt)	0.18	tissue processing	
	Propionic		CFES	
Metals	arsenic	0.1	Tissue processing	
Stains	methylene blue		RBC fix stain	
	OsO_4	0.0004	tissue processing	Irritant, stain [illegible]dect.
Alcohols FE	ethanol	940	Tissue processing	
VC	Butanol	121.0	Phase partitioning	
Metabolic studies R	^3H-uridine	1000 u Ci		carcinogen
R	^{14}C-thymidine	100 u Ci		carcinogen
	colchinin (colchicine)	0.5 (fine mist)		Mild eye irritant
Electrophoresis	Urea		CFES	
	diethanolamine	5.0	CFES	skin, eye irritant
	Sodium azide		perservative	Irritant, lower BP, headache
Others	$AgNO_3$	0.008		
	potassium oxalate		RBC fix stain	
	potassium cyanide		RBC fix stain	

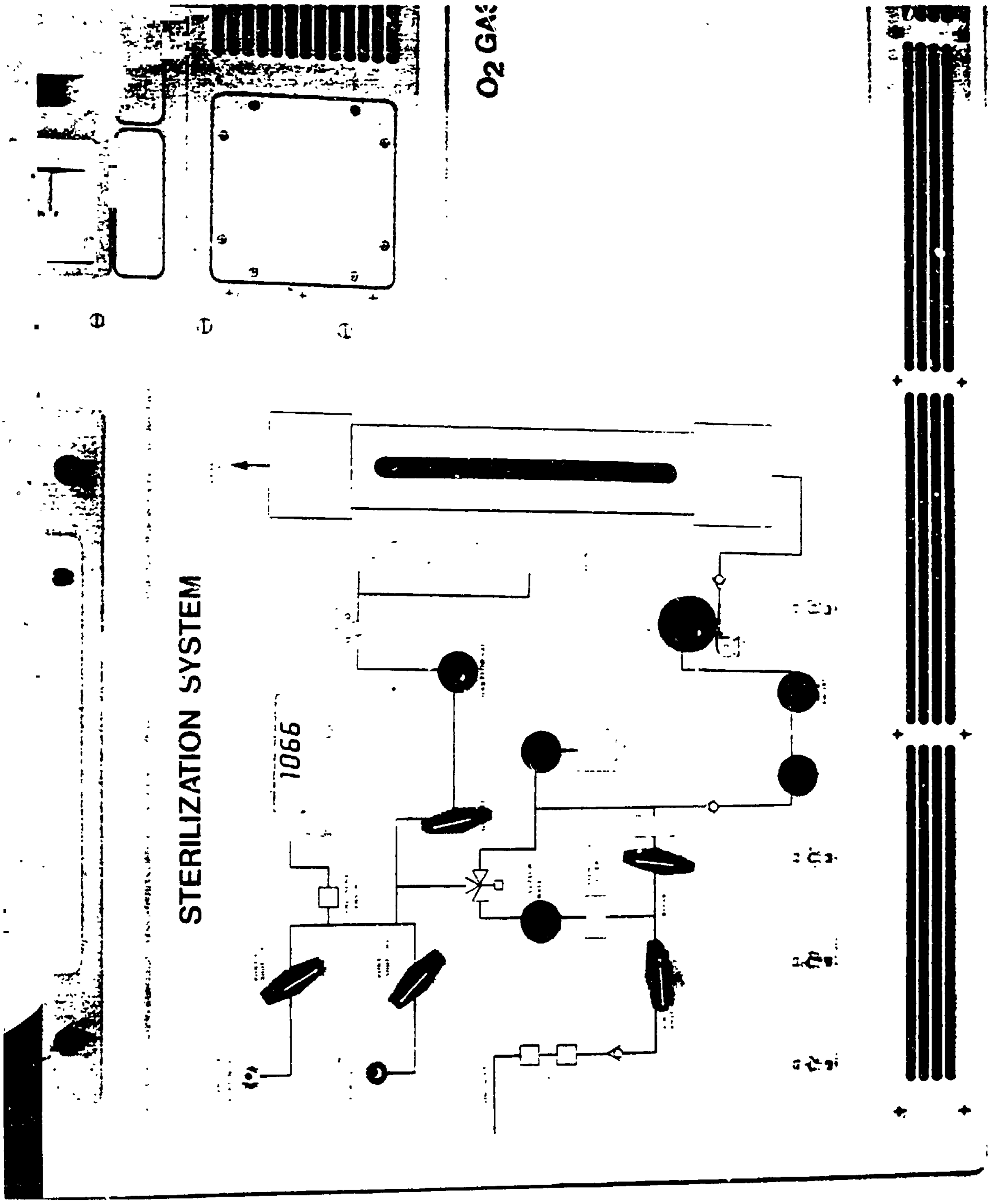
OTHER STERILIZATION OPTIONS

OZONE



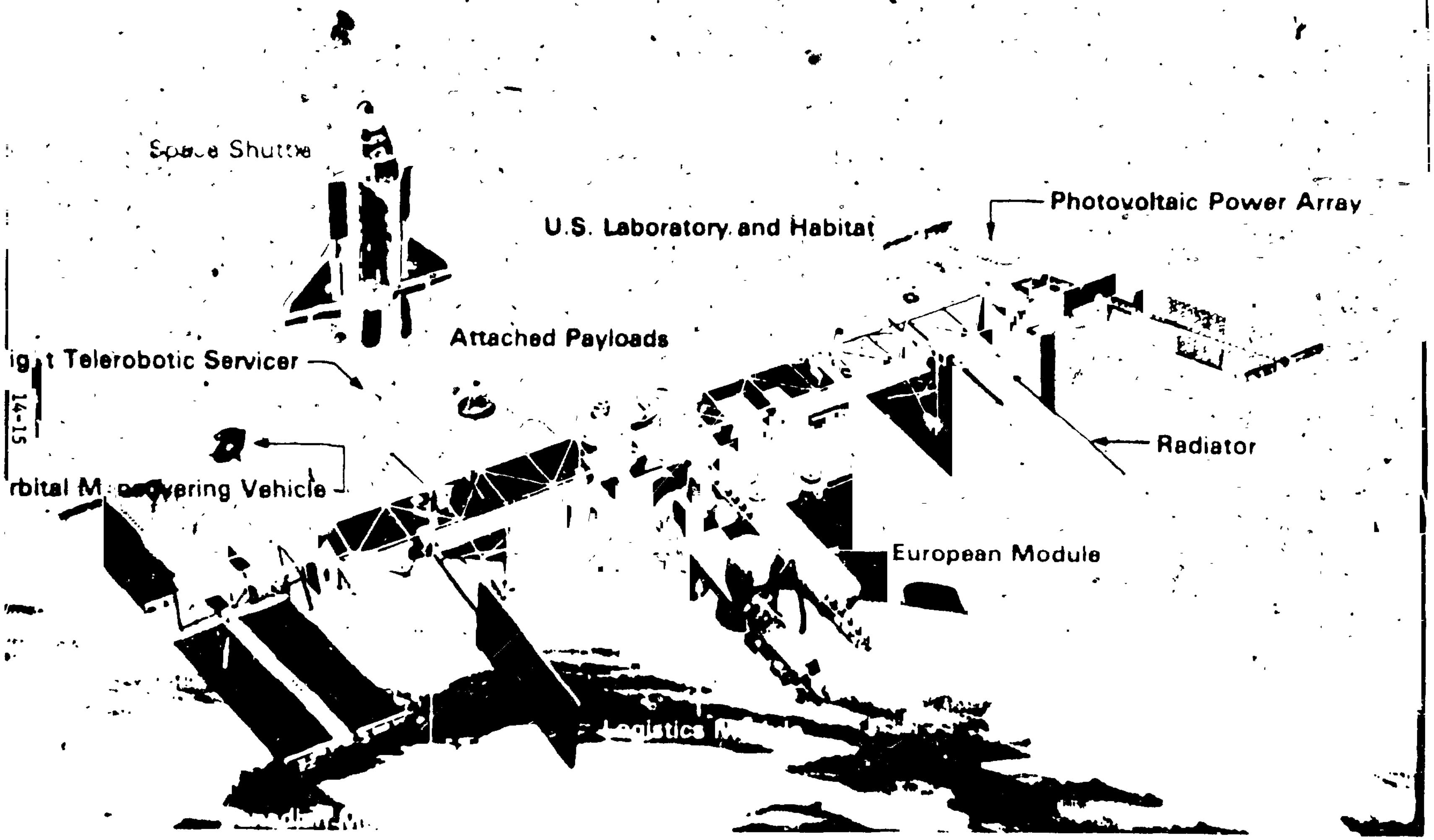
VAPOR PHASE HYDROGEN PEROXIDE





ORIGINAL PAGE IS
OF POOR QUALITY

Revised Baseline Configuration



TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

NON-HUMAN LIFE SCIENCE PAYLOADS

CONDUCTED IN THE

1.8 METER CENTRIFUGE FACILITY

CATHERINE C. JOHNSON
BIOLOGICAL RESEARCH PROJECT OFFICE
NASA/AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA
NOVEMBER 29, 1988

OUTLINE

- 1.8 M CENTRIFUGE FACILITY
- OPERATIONS
- INTERFACES
- ISSUES
- RECOMMENDATIONS
- SUMMARY

1.8 M CENTRIFUGE FACILITY

- 1.8 METER CENTRIFUGE
- ZERO-G HOLDING FACILITY
- LIFE SCIENCES GLOVEBOX
- SPECIMEN CHAMBER SERVICE UNIT (SCSU)
- MODULAR HABITATS FOR CENTRIFUGE AND HOLDING FACILITY
  - PLANTS
  - RODENTS
  - SMALL PRIMATES
  - GENERAL BIOLOGY

SCIENCE DISCIPLINES

- CALCIUM HOMEOSTASIS
- CARDIOVASCULAR SYSTEM
- MUSCLE STRUCTURE AND FUNCTION
- ENDOCRINOLOGY/FLUID AND ELECTROLYTES
- HEMATOLOGY
- IMMUNOLOGY
- METABOLIC REGULATION
- NEUROSCIENCES
- PLANT PHYSIOLOGY
- RADIOBIOLOGY
- REPRODUCTION AND DEVELOPMENT

LIFE SCIENCES OPERATIONS

- ANIMAL TRANSFER BETWEEN FACILITIES
- SPECIMEN CHAMBER AND WASTE TRAY CHANGE OUT
- ANIMAL FOOD CHANGEOUT
- PLANT CHAMBER CLEANING
- PLANT NUTRIENT SOLUTION REPLENISHMENT
- SPECIMEN BLOOD DRAW
- URINE AND FECES COLLECTION
- ANIMAL INJECTIONS
- COMPLETE ANIMAL AND PLANT DISSECTIONS
- SNAP FREEZING OF TISSUE SAMPLES
- CHEMICAL FIXING OF TISSUE SAMPLES

LIFE SCIENCES OPERATIONS (cont.)

- MASS MEASUREMENT OF TISSUE SAMPLES
- MASS MEASUREMENT OF PLANT AND ANIMAL SPECIMENS
- VISUAL OBSERVATION OF PLANT AND ANIMAL SPECIMENS
- ANIMAL ANESTHESIA
- MUSCLE BIOPSY
- SALIVA COLLECTIC
- SPECIMEN LABELING
- MICROSCOPY
- SEED "PLANTING"
- PLANT MANIPULATION FROM GERMINATOR TO PLANT CHAMBER
- PLANT HARVEST

REPRESENTATIVE RODENT SCENARIO

- PREPARE GLOVEBOX
- UNSTOW AND TRANSFER NECESSARY EQUIPMENT
  - SMALL MASS MEASUREMENT DEVICE
  - RODENT SUPPORT EQUIPMENT
  - SPECIMEN STORAGE SUPPLIES
  - SNAP FREEZER
- TRANSFER HABITAT TO GLOVEBOX AND REMOVE ANIMAL
- PERFORM OPERATIONS
  - WEIGH ANIMAL
  - DRAW BLOOD
  - SACRIFICE, DISSECT
  - PRESERVE SAMPLES (FIXATIVE OR SNAP FREEZE)
- TRANSFER SAMPLES TO REFRIGERATOR, FREEZER, ETC.
- STOW EQUIPMENT
- SANITIZE/DECONTAMINATE GLOVEBOX
- BAG AND TRANSFER TRASH TO TRASH MANAGEMENT SYSTEM

ANTICIPATED CHEMICALS

- FIXATIVES
  - FORMALDEHYDE
  - FORMALIN
  - GLUTARALDEHYDE
- CORROSIVES
  - HYDROCHLORIC ACID
  - SODIUM HYDROXIDE
  - ACETIC ACID
- OTHER
  - ETHANOL
  - EDTA
  - HOAGLAND'S SOLUTION
- DRUGS
  - ACEPROMAZINE
  - ATROPINE
  - KETAMINE HYDROCHLORIDE
  - OXYMORPONE HYDROCHLORIDE
  - PENTAZOCINE (TALWIN)
  - PENTOBARBITAL SODIUM
  - XYLAZINE (ROMPUN)
- RADIOISOTOPES

  ^{3}H, ^{51}Cr, ^{59}Fe, ^{125}I

S. S. FREEDOM SERVICES AND SUPPORT FUNCTIONS

- PMMS
  - TRASH MANAGEMENT
    - BIOSTABILIZED MATERIALS
    - RADIOACTIVE WASTES
  - WATER REQUIREMENT
    - ELECTRONIC GRADE FOR PLANTS
    - HYGIENE QUALITY FOR SCSU
  - WASTE WATER
    - CONDENSATE FROM HABITATS
    - BRINE FROM SCSU
    - SPENT NUTRIENT FROM PLANTS
  - LN_2
  - CO_2, O_2

S.S. FREEDOM SERVICES AND SUPPORT FUNCTIONS (cont.)

- ECLSS
  - O_2 RESUPPLY AND $C0_2$ REMOVAL FOR ANIMALS
  - POTABLE WATER FOR ANIMALS
- LAB FACILITY EQUIPMENT
  - REFRIGERATOR
  - FREEZERS, -20° C, -70° C
- LAB SUPPORT EQUIPMENT
  - CRYOFREEZER (SNAP AND STORAGE)
  - FREEZE DRIER
  - GAS CHROMATOGRAPH/MASS SPEC.
  - HIGH PERFORMANCE LIQUID CHROMATOGRAPH

ISSUES

- INCREASED BIOBURDEN
  FROM CREW TO SPECIMEN
- TRACE CONTAMINENTS
  FROM CABIN TO SPECIMEN CHAMBER
- SPILLS/CLEANUP
- REPLACEMENT UNITS
- HUMIDITY RANGE

RECOMMENDATIONS

- BUILD ON "LESSONS LEARNED" FROM SPACELAB
- CLOSE COORDINATION BETWEEN CFP AND PMMS DESIGNERS
- GOOD OPERATIONAL PROCEDURES
- CHEMICAL PACKAGING
- CONTINGENCY PLANNING

SUMMARY

- 1.8 M CENTRIFUGE FACILITY PROVIDES BIOISOLATION
- ALL ANIMAL PROCEDURES IN GLOVEBOX
- ALL CHEMICALS HANDLED IN GLOVEBOX
- PMMS DESIGN CRITICAL TO CFP OPERATIONS