



AEROSPACE TECHNOLOGY DIRECTORATE

POWER TECHNOLOGY DIVISION



Lewis Research Center

Thermal Energy Storage Flight Experiment in Microgravity

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**Presented at the NASA / DOD Flight Experiments Technical Interchange
Meeting, Monterey, California**

October 5-9, 1992

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P. 12

N93-28720

Heat Pipe Performance Experiment

Flight Experiments Technical Interchange Meeting

**Sponsored by
Space Technology Interdependency Group
Flight Experiments Committee**

**October 5-9, 1992
Monterey, CA**

**George Fleischman
Hughes Aircraft Company**

The Hughes logo consists of the word "HUGHES" in a bold, white, sans-serif font, centered within a black rounded rectangular background.

HUGHES

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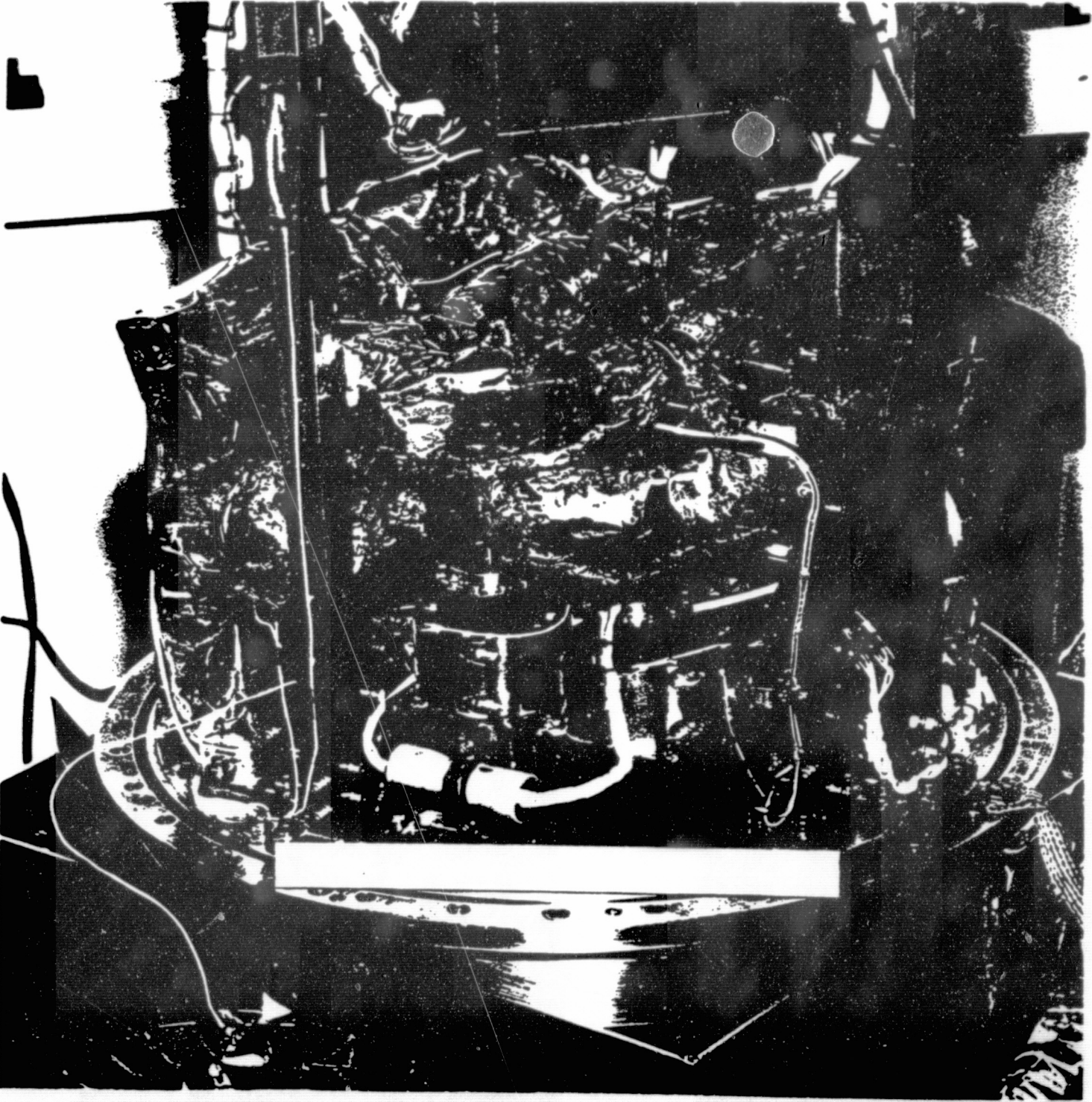
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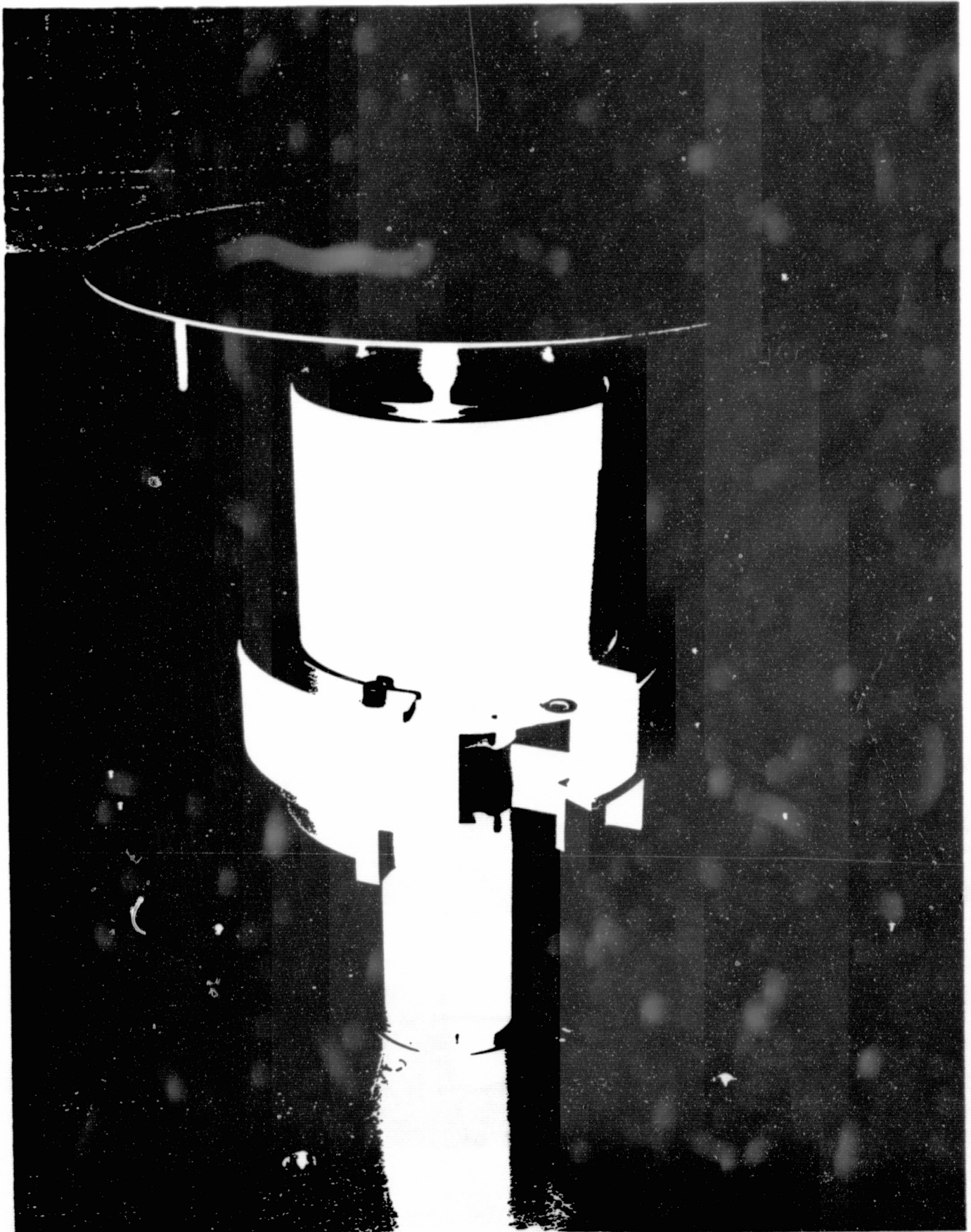
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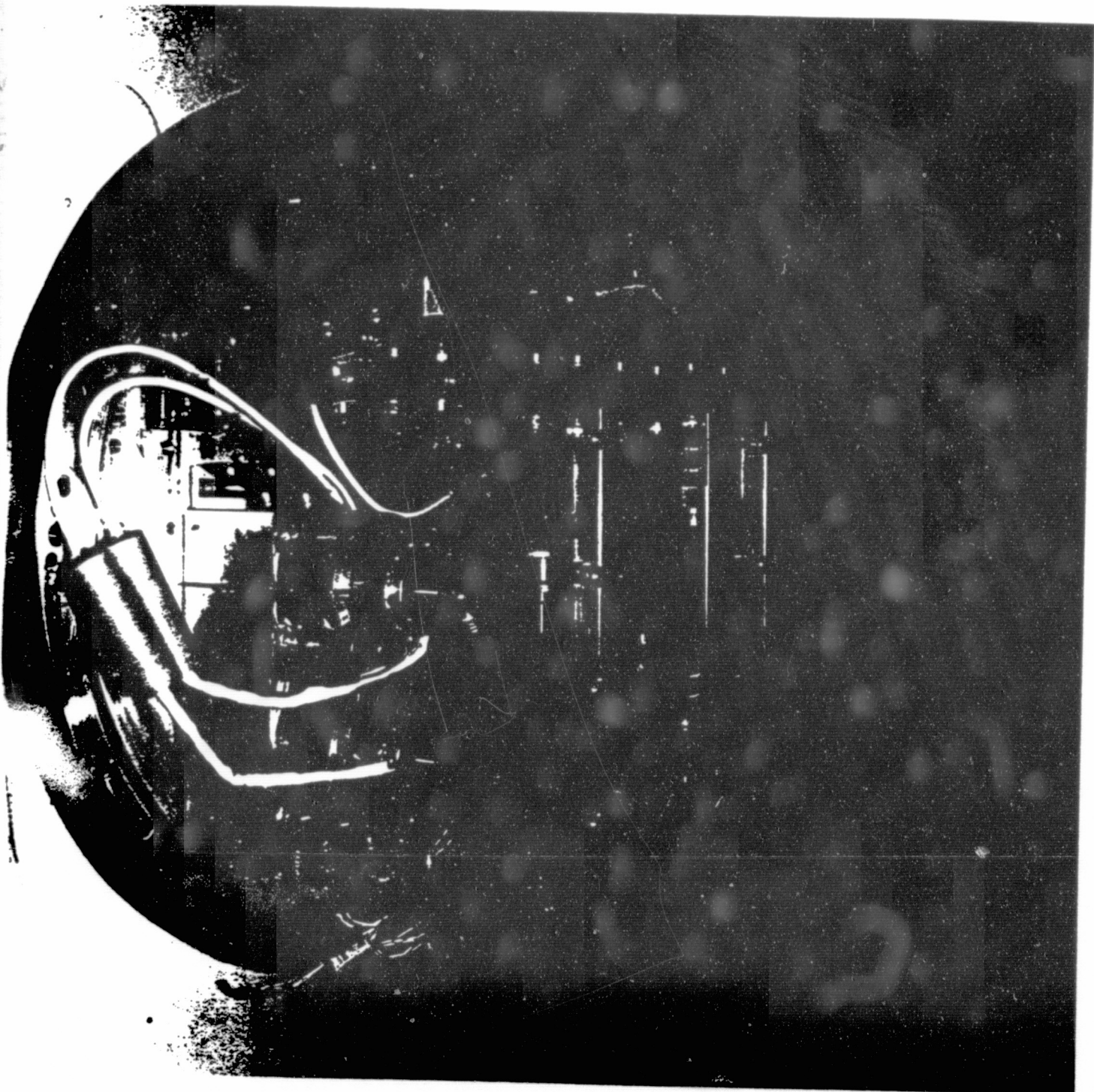
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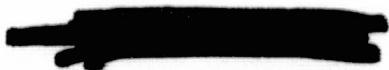
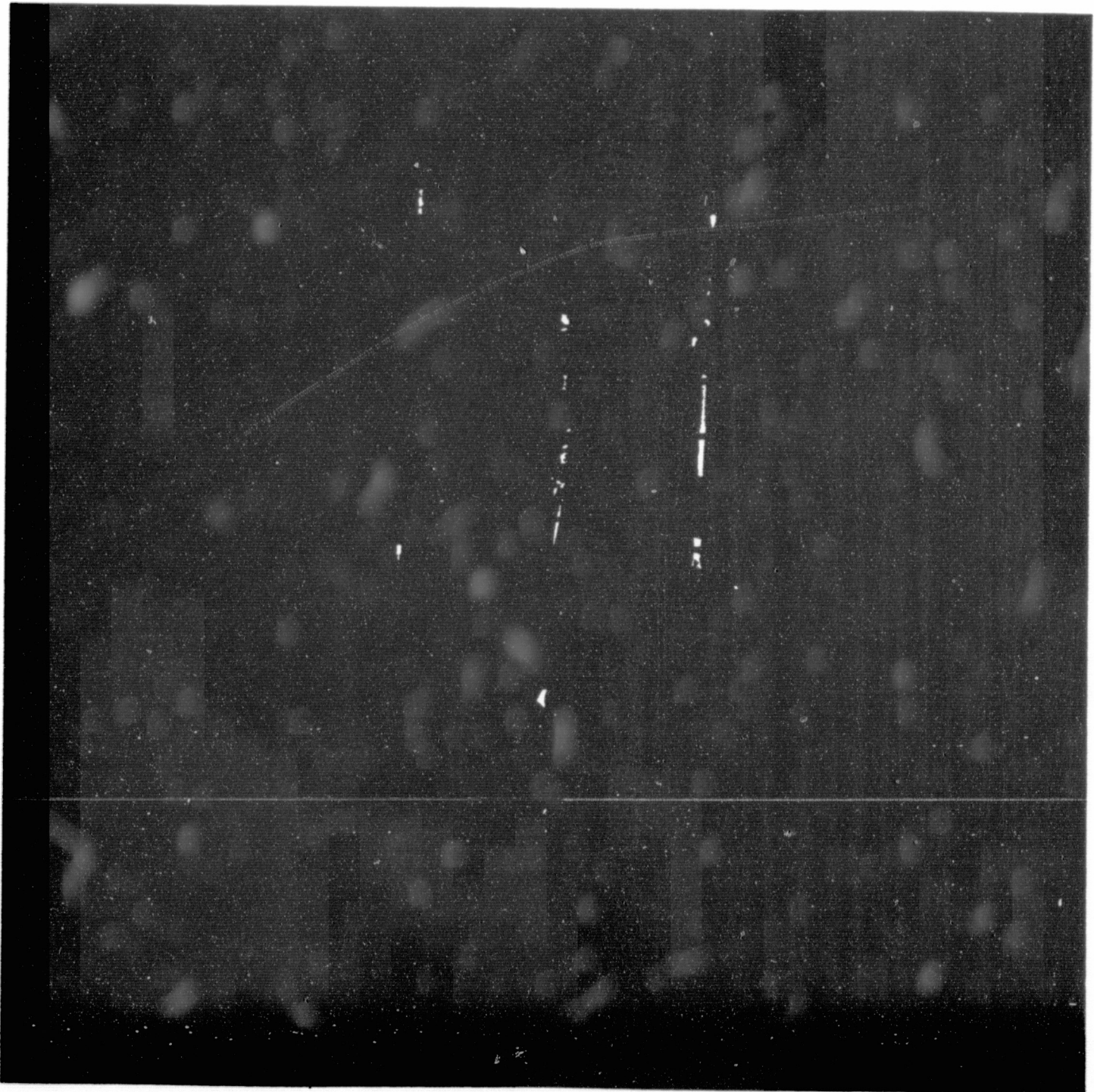
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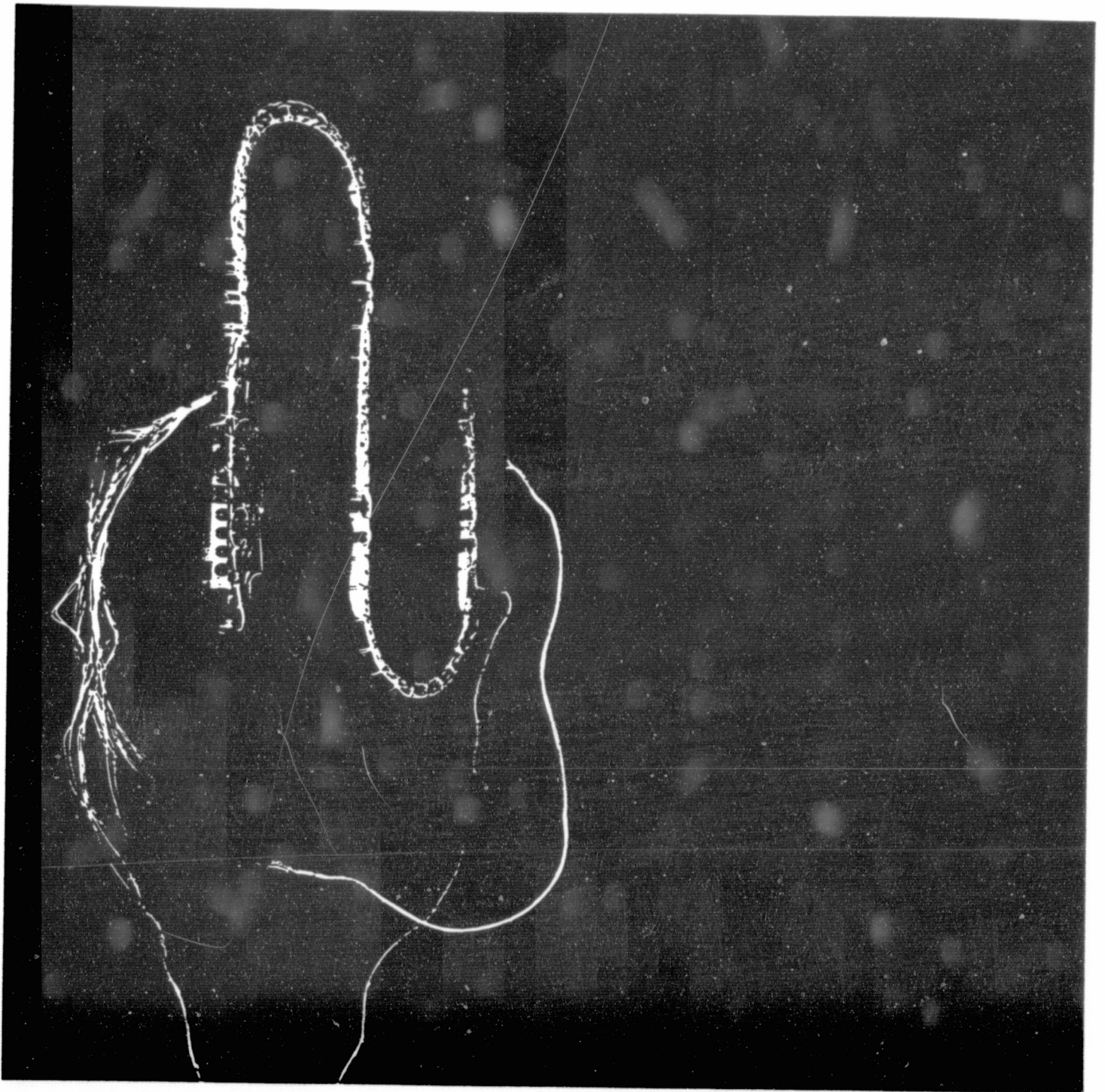


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CRYOGENIC HEAT PIPE EXPERIMENT FY 93 PLANS

- **SUPPORT FLIGHT OPERATIONS**
- **REDUCE FLIGHT DATA AND RESOLVE ANY ANOMALIES**
- **PERFORM POST FLIGHT TESTS ON EXPERIMENT AND HEAT PIPES**
- **INCORPORATE RESULTS INTO GROOVE ANALYSIS PROGRAM
AND SUBMIT TO COSMIC**
- **COMPLETE FINAL REPORT**

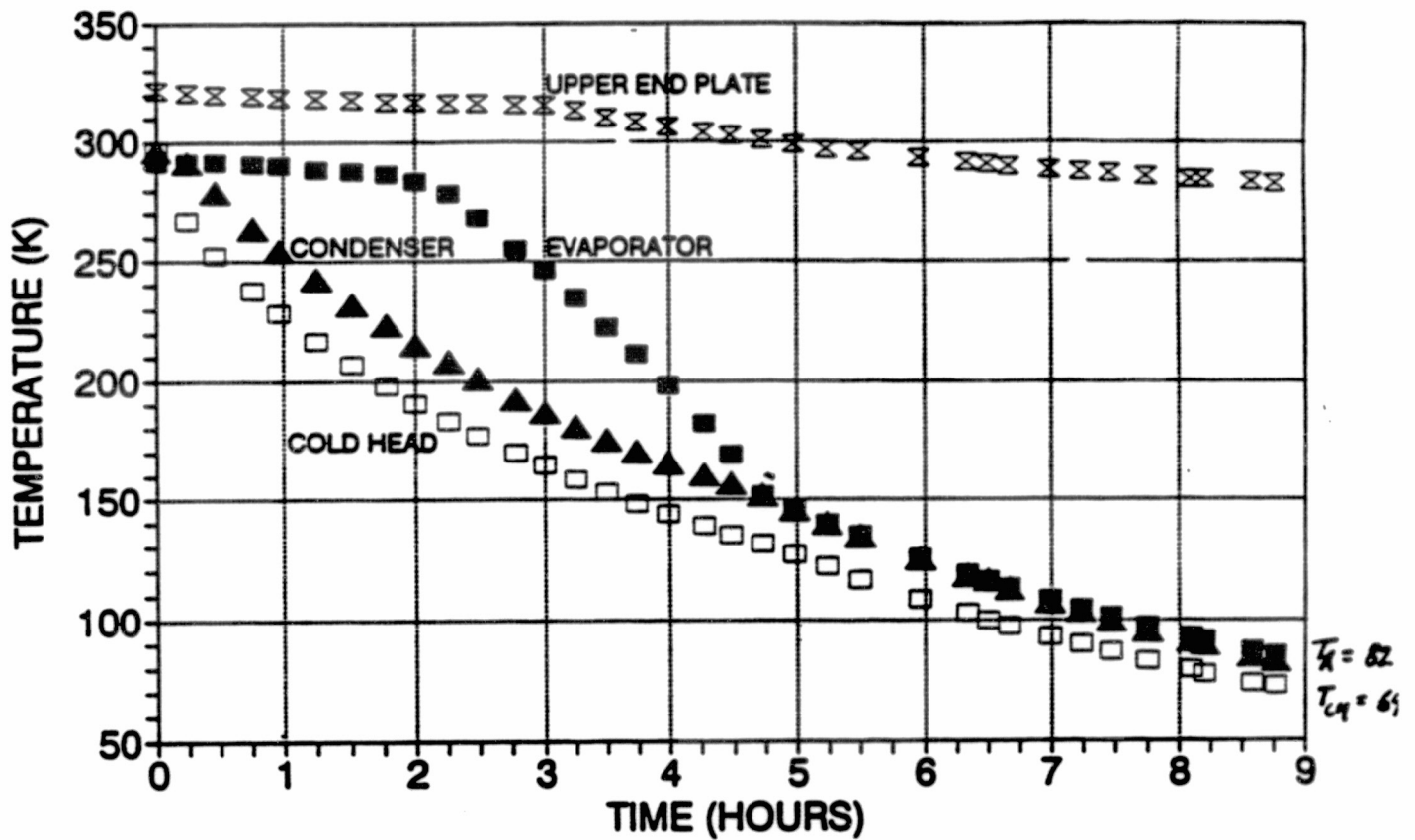
CRYOGENIC HEAT PIPE EXPERIMENT CURRENT STATUS

- **DELIVERED TO KSC AND INSTALLED ON SHUTTLE**
- **FINAL INTERFACE VERIFICATION TEST COMPLETED**
- **ALL DOCUMENTATION COMPLETE**
- **LAUNCH DUE ON NOVEMBER 16, 1992**

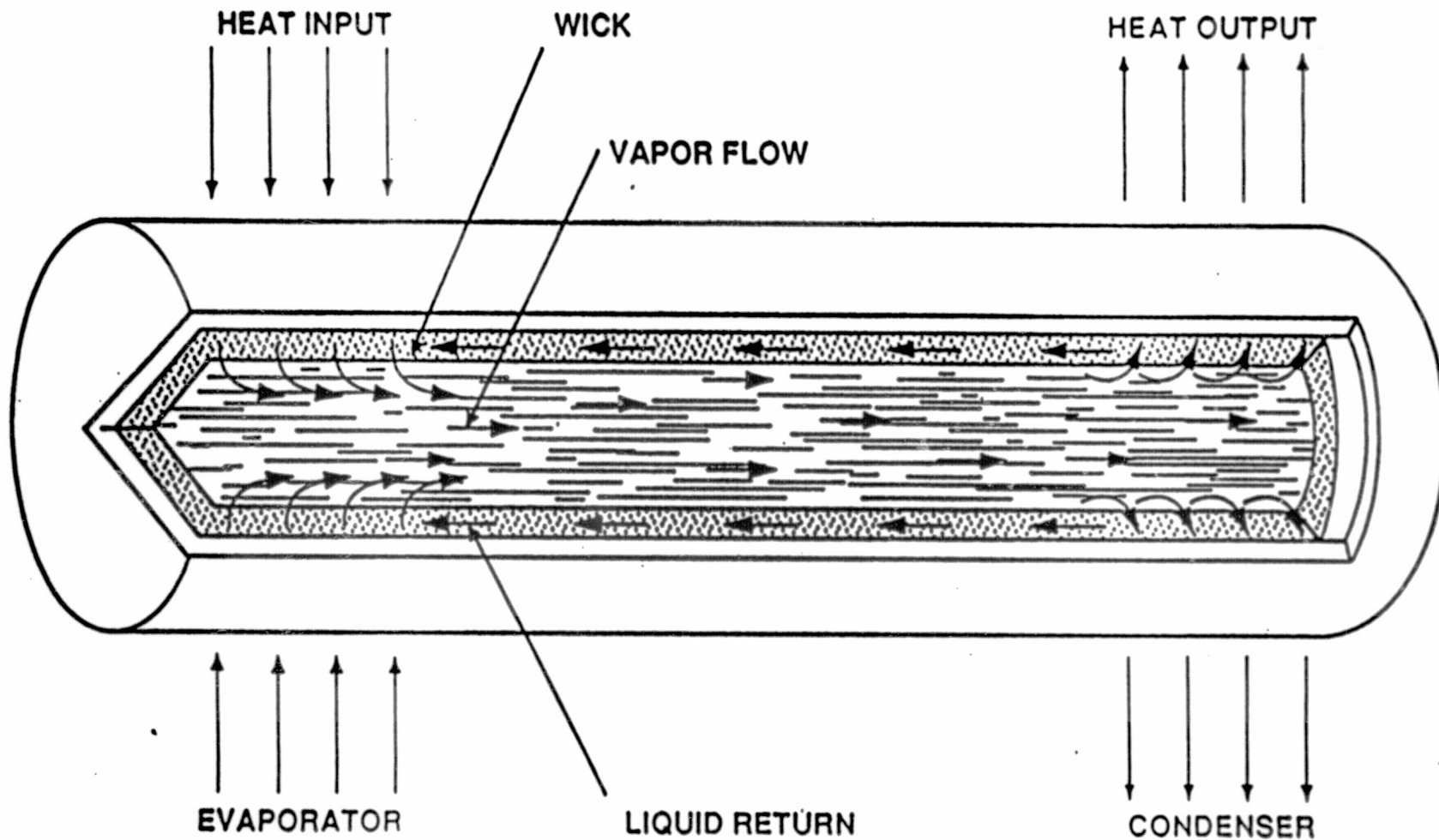
CRYOHP INSTRUMENTATION

<u>TYPE</u>	<u>QUANTITY</u>	<u>LOCATION</u>
Platinum Resistance Thermometers (PRTs)	26	13 each heat pipe system
Thermistors	24	UEP, EBP, pillars, heat pipe structure, cryo-coolers, electronics
Thermistors	9 (HH)	EBP, Canister, & CECM Mounting Brackets
Pressure Transducers	1	Canister Internal Pressure
Current Monitors	13	CECM
Voltage Monitors	18	1 for bus voltage, 17 for temperature calibration
Heaters (Kapton foil)	11	4 per heat pipe, 3 survival
Thermostats	33	Tri-series circuit for each heater

HAC HEAT PIPE TRANSIENT COOLDOWN TEST DATE : 04-09-92



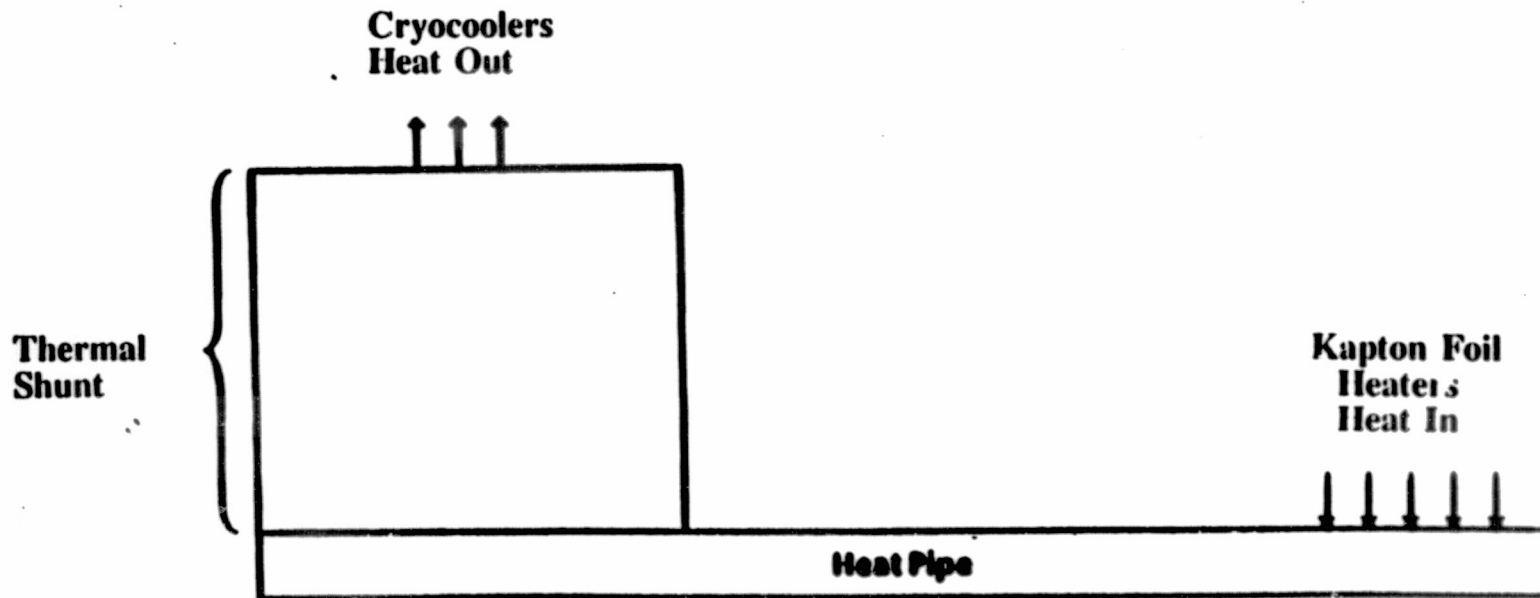
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HEAT PIPE - CONCEPT



SCHEMATIC -- CRYOHP OPERATION

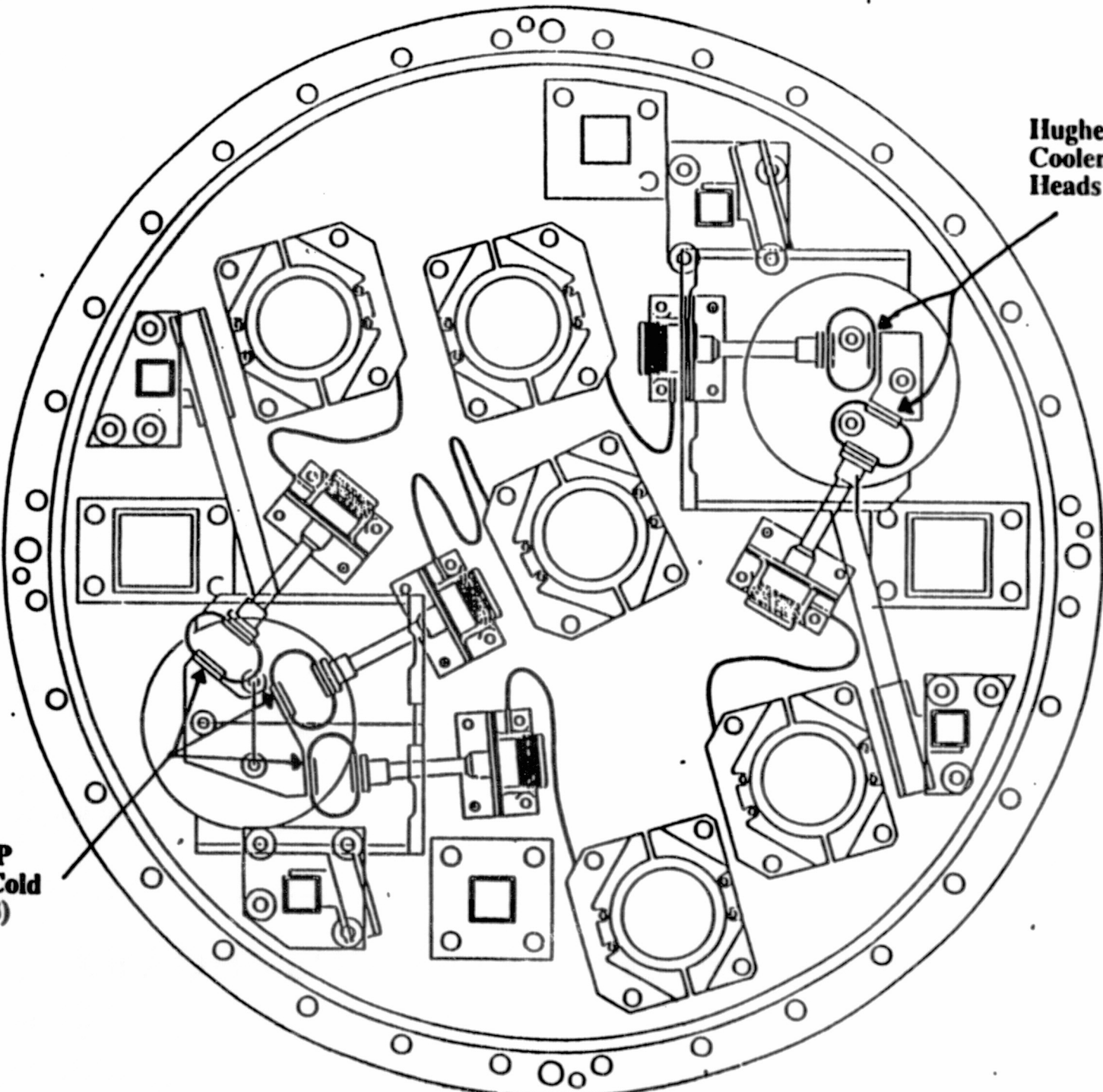


CRYOHP OPERATIONS SCENARIO

- ASCENT - Vent to 2 PSIA
- ORBIT - Hitchhiker Avionics On
- Survival Heaters On
- Vent to 10^{-4} Torr or Less
- CRYOHP On
- Cooldown TRW Heat Pipe
 - o Start Up
- Cooldown
 - o Transport/Recovery
- Cooldown
 - o Transport/Recovery/Minimum Temperature
- Cooldown Hughes Heat Pipe
- Repeat
- Cooldown TRW Heat Pipe
- Repeat - Total Five Cycles Each Pipe
- CRYOHP Off
- Descent

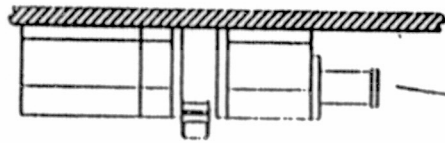
CRYOHP -- FIVE COOLER ARRANGEMENT

**Hughes HP
Cooler Cold
Heads (2)**

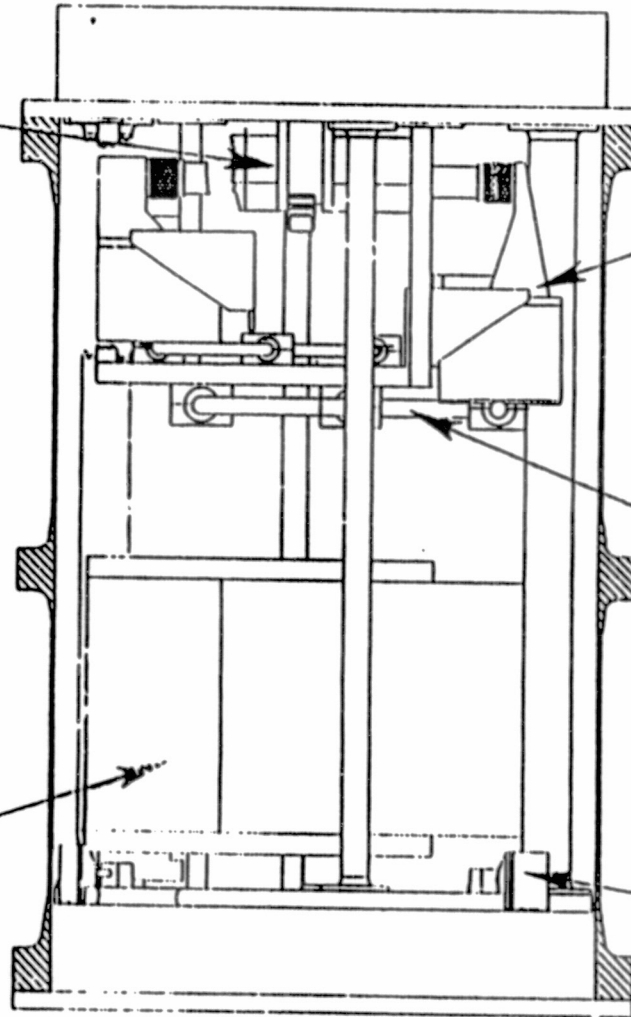


**TRW HP
Cooler Cold
Heads (3)**

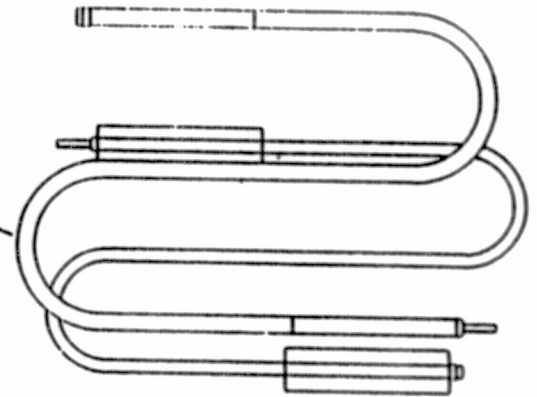
CRYOHP SUBSYSTEM IMPLEMENTATION



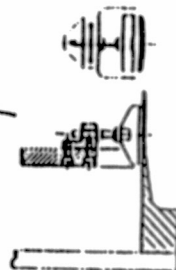
Cryogenic Coolers



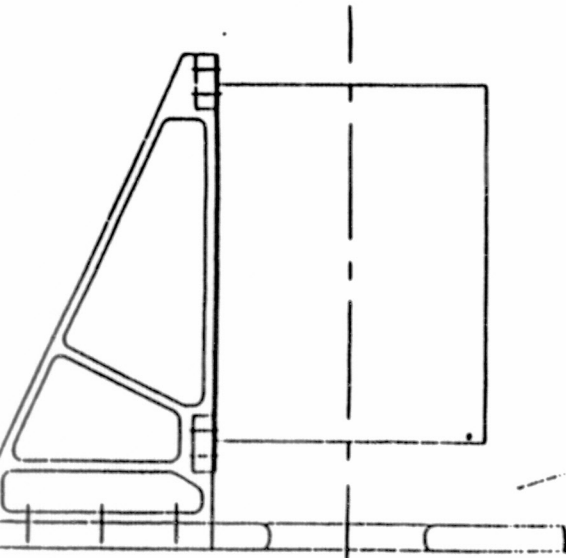
Cryogenic Cooler/
Heat Pipe Interface



Heat Pipes



Bumper
Assembly



Electronic Module

CRYOHP DESCRIPTION (cont.)

- **Heat Pipes**
 - **Two Independent Designs**
 - **Axially Grooved Aluminum Extrusion**
 - **TRW**
 - **Hughes**

- **Cryo-Coolers**
 - **Five Split Stirling Cycle Coolers**
 - **Hughes Model No. 7044H**
 - **3.5 Watts Each @ 80K**
 - **Mounted to HH Canister UEP**
 - **Helium at 450 Psia Maximum**
 - **95 W Power, 7.5 Amp Startup for 100 Millisecond Max.**

CRYOHP DESCRIPTION

- o Shuttle/HH Carrier Flight Experiment (Minus Avionics) Less Than 345 lbs
- o HH Canister
 - Modified Upper End Plate (UEP)
 - o Thermal Mass
 - o Radiator
 - o Flown on CPL/GAS and CPL/HH-1
- o Uninsulated Top Plus Sides
- o Vented Can (Valves in Lower End Plate (LEP))
 - 16 Psia Prior to Launch
 - 2 Psia Differential Pressure Relief Valves on Ascent
 - Solenoid and Butterfly Valves Provide Flight Vacuum
- o HH Avionics
 - Provides Power, Signal, Command, and Data
 - 3 HH Ports Required

CRYOGENIC HEAT PIPE EXPERIMENT OBJECTIVE

CONDUCT A SHUTTLE EXPERIMENT TO DEMONSTRATE THE RELIABLE OPERATION OF TWO OXYGEN HEAT PIPES IN MICROGRAVITY.

1. DEMONSTRATE STARTUP OF THE PIPES FROM THE SUPER-CRITICAL STATE.
2. MEASURE THE HEAT TRANSPORT CAPACITY OF THE PIPES
3. MEASURE EVAPORATOR AND CONDENSER FILM COEFFICIENTS
4. WORK SHUTTLE SAFETY ISSUES

APPROACH

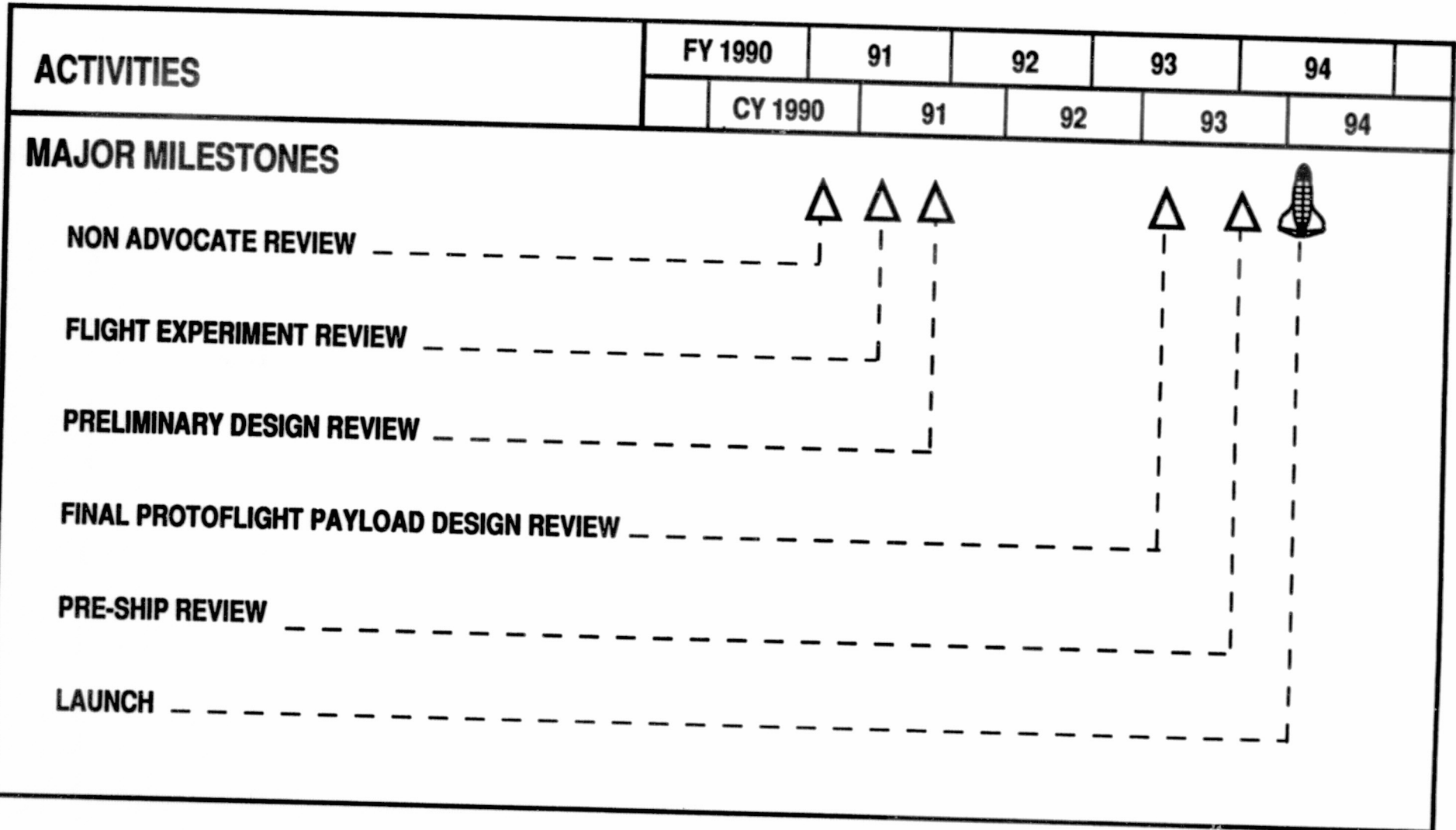
- ✓ FLY TWO AXIALLY GROOVED OXYGEN HEAT PIPES ATTACHED TO MECHANICAL STIRLING CYCLE TACTICAL COOLERS
- ✓ INTEGRATE EXPERIMENT IN HITCHHIKER CANISTER
- ✓ FLY ON SHUTTLE AND CONTROL FROM GROUND

CRYOGENIC HEAT PIPE EXPERIMENT BACKGROUND

- NO MICRO-GRAVITY DATA AVAILABLE FOR OXYGEN OR NITROGEN HEAT PIPES
- POOR WICKING AND LOW TRANSPORT MAKE 0-G EXTRAPOLATION DIFFICULT
- RELIABLE START UP FROM SUPER CRITICAL TEMPERATURE NEEDS TO BE DEMONSTRATED
- MICRO-GRAVITY INFORMATION ON CRYO (<100 K) HEAT PIPES IDENTIFIED AS CRITICAL TECHNOLOGY NEED BY NASA AND THE AIR FORCE - 1988 THERMAL FLUIDS IN SPACE WORKSHOP AND IN STEP 88 WORKSHOP
- OXYGEN AND NITROGEN PIPES BUILT AND EVALUATED



TES FLIGHT SCHEDULE



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