6573

DTO High Capacity Heat Pipe Demonstration (J. Gary Rankin/EC2) ← now on STS-8

Purpose/Objective

To provide an in-orbit demonstration of the thermal performance of a high capacity heat pipe designed for future spacecraft heat rejection systems.

Support Requirements

a. Unique Hardware:
   1. DFI pallet, GAS beam, or other available support structure visible from aft flight deck windows.

b. Standard Hardware:
   1. 35mm camera
   2. Cargo bay CCTV

c. Instrumentation
   None

d. Consumables
   None

Placards/Limitations

None

Test Conditions/Activity Required

a. General Notes:

   1. One IVA crewmember required for this test to activate heater power switch and CCTV, photograph temperature sensitive tape through aft flight deck windows using camera, and then to deactivate the heater power switch.

   2. Time of operation of this experiment will be a minimum of 45 minutes and a maximum of 2 hours.

   3. No special attitudes are required for this activity.

   4. Lighting must be sufficient for photographic data acquisition.

b. Specific Activities

   1. During any available portion of the flight (limited only by lighting conditions for photography), the heat pipe heater power will be turned on to activate the experiment.

   2. As the heat is transported to the radiatively cooled condenser, the temperature sensitive liquid crystal displays on the surface of the heat pipe will respond, changing color as the temperature changes. This transient response, as well as the final steady state condition, will be recorded on videotape with the cargo bay CCTV. Color still photos of the experiment will be taken through the aft flight deck window by an IVA crewmember at the beginning, midpoint, and end of the experiment operation.

3. Following attainment and recording of steady state conditions, power to the heaters will be removed, ending experiment operations for the remainder of the mission.

Data Requirements

a. Crew logs and voice tapes (M)

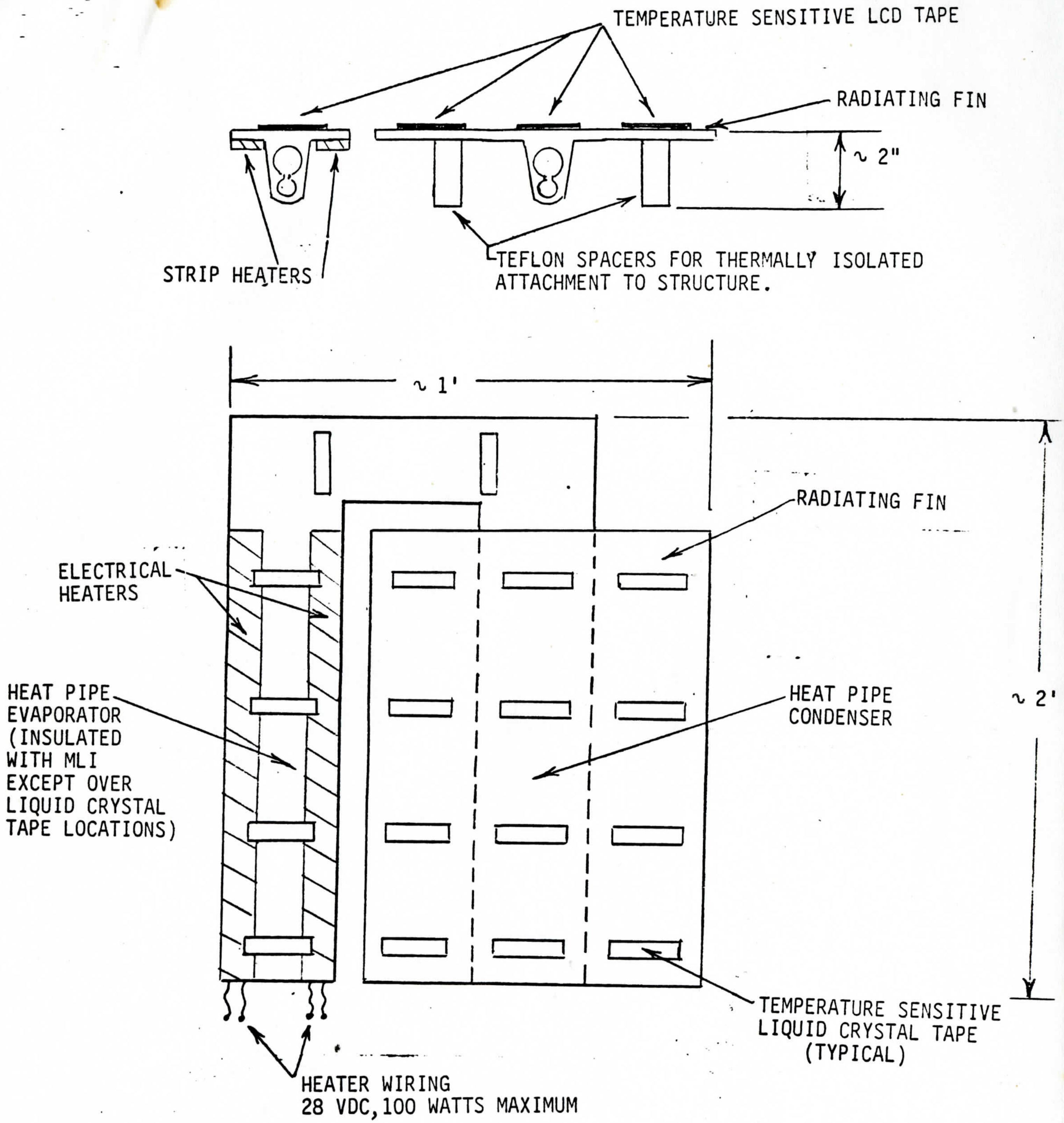
b. Color video photography of experiment in operation (M)

c. Still photography of experiment in operation (M)

d. Orbiter attitude history during experiment operation (M)

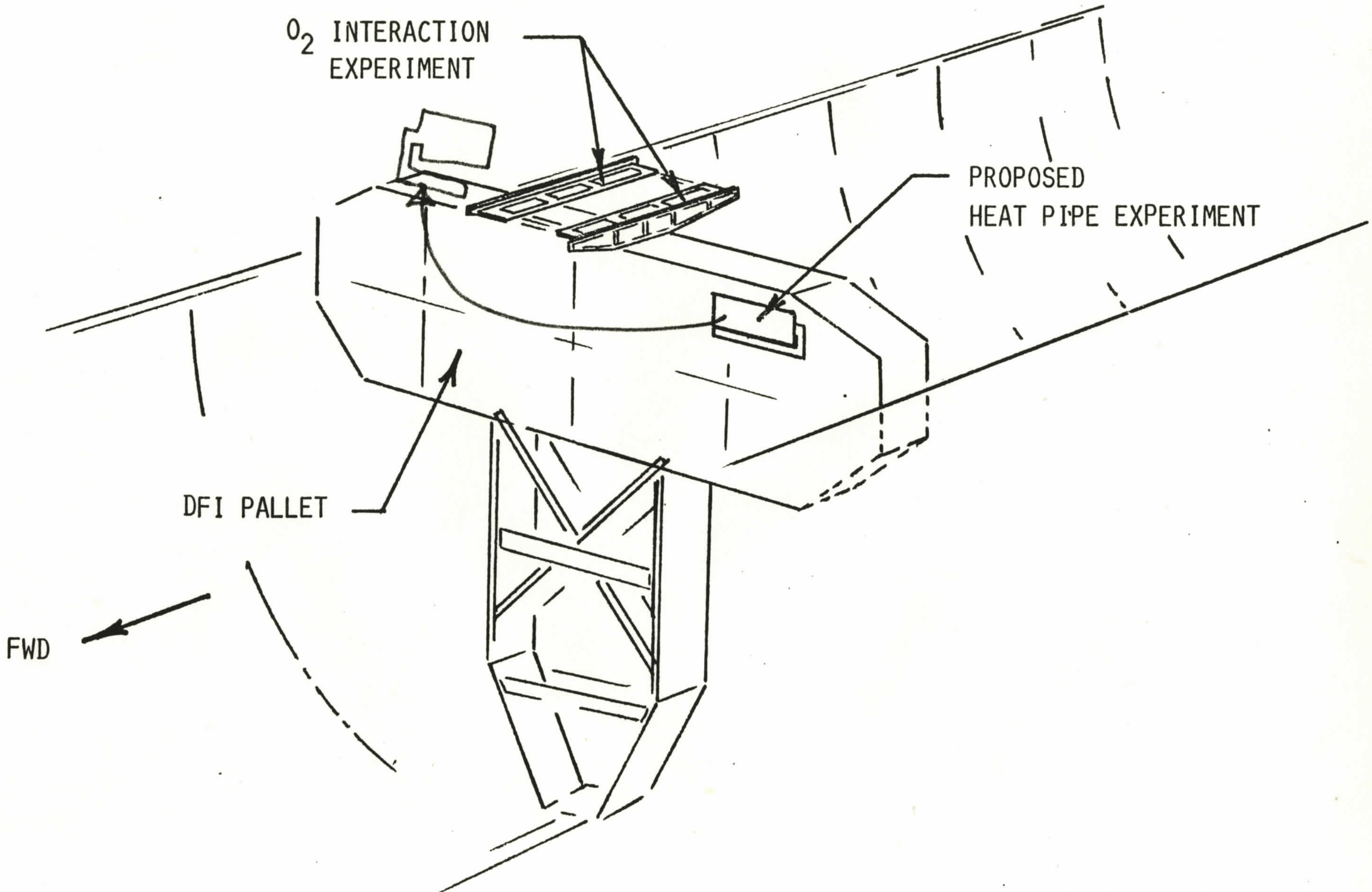
e. Payload bay temperature history during experiment ops (HD)

PROPOSED HEAT PIPE EXPERIMENT



- 15 LBS MAX EXPERIMENT WEIGHT
- NO ATTITUDE RQMTS
- EXPERIMENT DURATION: 45 MINUTES MINIMUM, 2 HRS MAXIMUM
- DATA RECORDED BY TAKING COLOR MOVIE OR STILL PHOTOGRAPHS FROM AFT FLIGHT DECK WINDOWS OR VIDEOTAPE FROM CARGO BAY CCTV

PROPOSED STS-8 HEAT PIPE EXPERIMENT INSTALLATION



NASA Lyndon B. Johnson Space Center

Engineering and Development Directorate

HIGH CAPACITY HEAT PIPE DEMONSTRATION	CREW SYSTEMS DIVISION	
	GARY RANKIN	5/6/83

OBJECTIVE

PROVIDE AN IN-ORBIT DEMONSTRATION OF THE THERMAL PERFORMANCE OF A HIGH CAPACITY HEAT PIPE DESIGNED FOR FUTURE SPACECRAFT HEAT REJECTION SYSTEMS

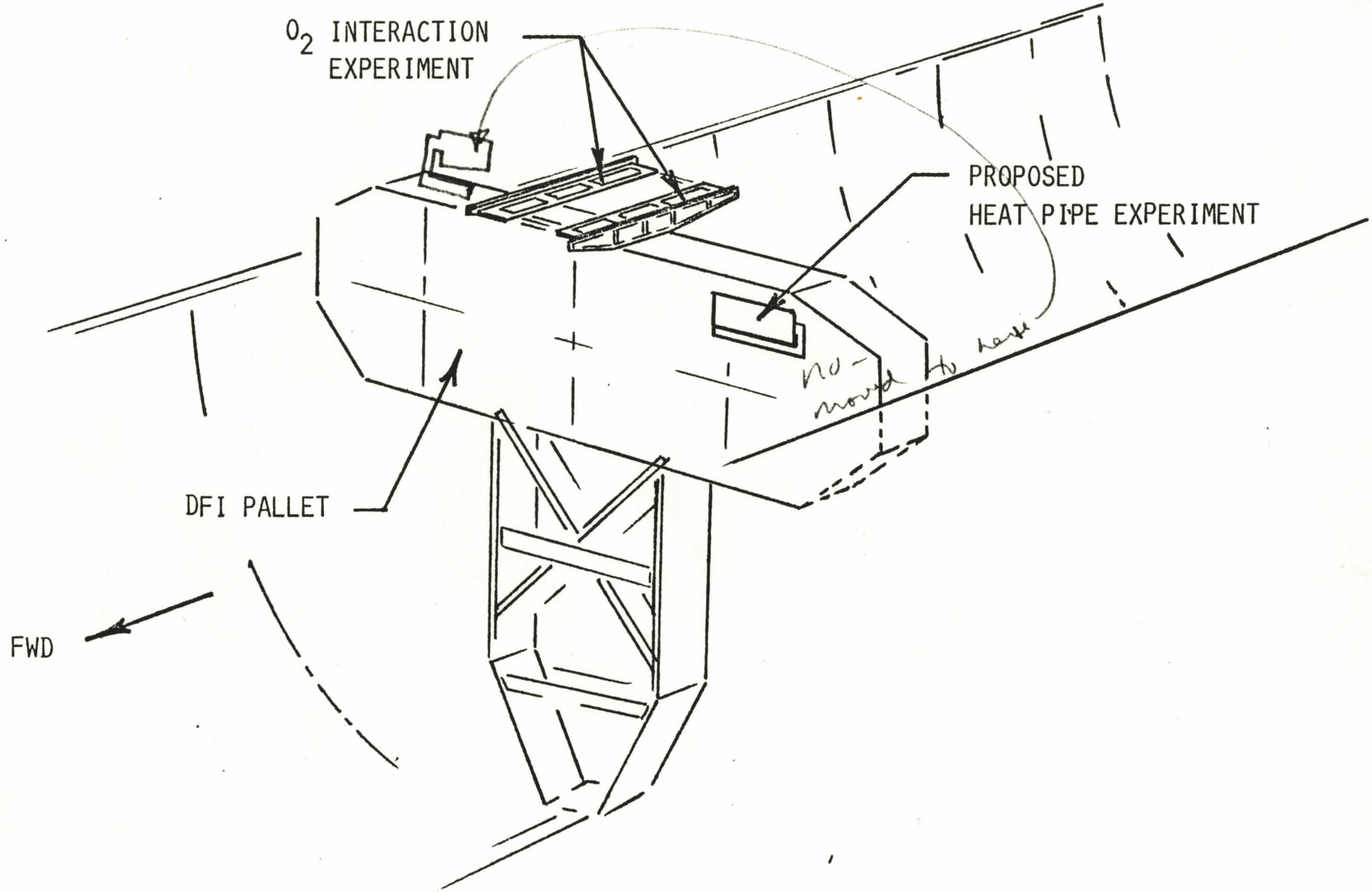
BACKGROUND

- o JSC SPONSORED PROGRAM UNDERWAY SINCE 1979 TO DEVELOP HARDWARE FOR A HIGH CAPACITY HEAT PIPE.
- o FULL SIZE (∿ 50 FT. LONG) HEAT PIPE BUILT AND SUCCESSFULLY TESTED IN 1-G AMBIENT ENVIRONMENT
- o FLIGHT TEST OF FULL SIZE TEST ARTICLE APPROVED AS A PHASE III OEX EXPERIMENT BUT NEVER FUNDED DUE TO OEX BUDGET LIMITATIONS.

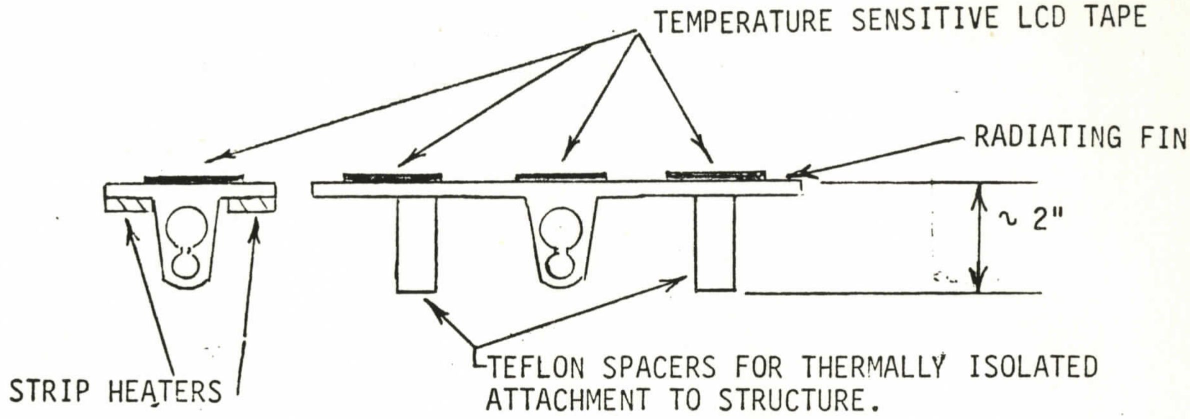
EXPERIMENT REQUIREMENTS

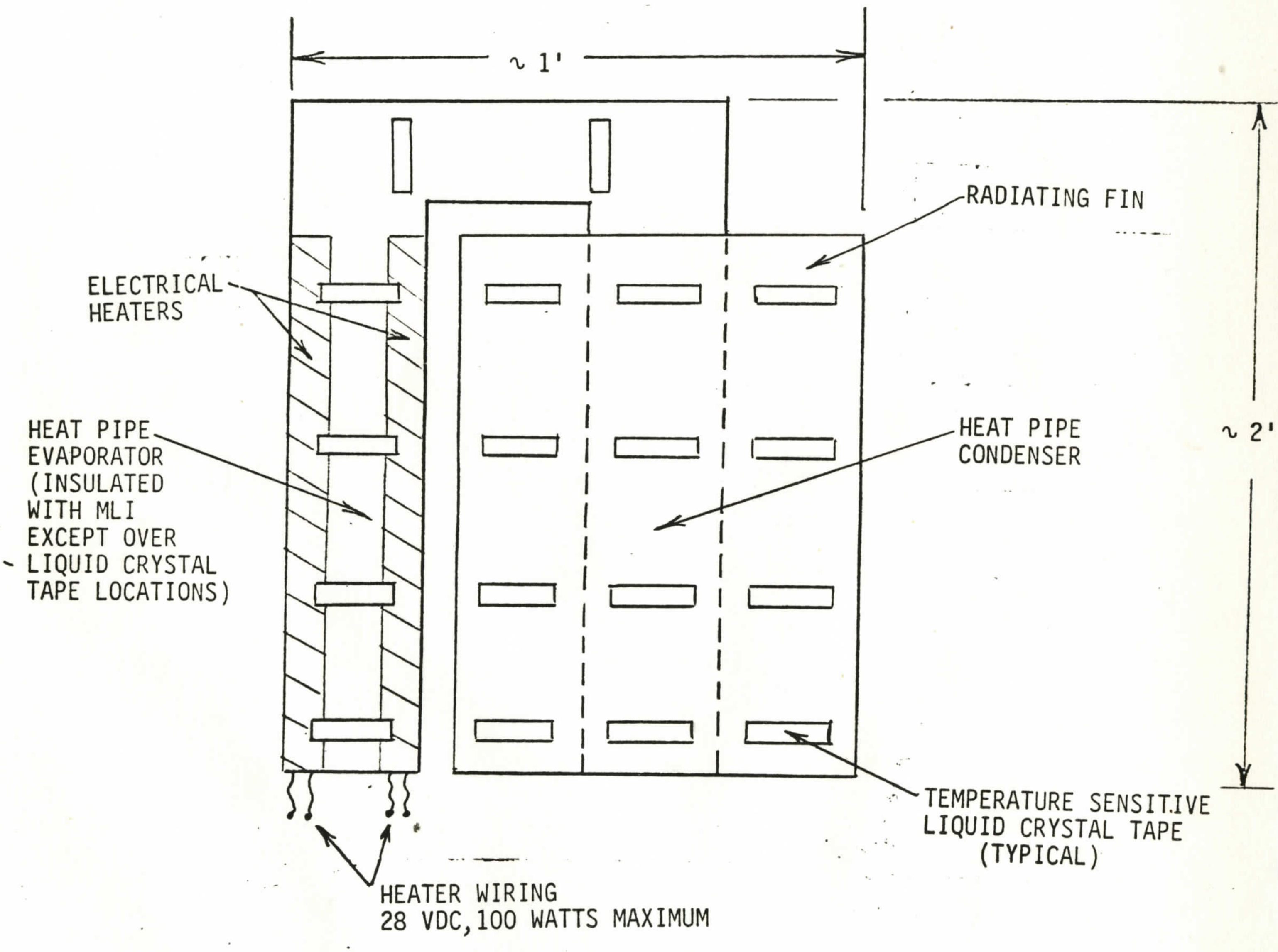
- o ∿ 100 WATTS HEATER POWER FOR UP TO 2 HOURS
- o MOUNTING IN VIEW OF AFT CREW STATION WINDOWS AND CCTV
- o VIDEO RECORDING OF TEMPERATURE SENSITIVE TAPE RESPONSE DURING ACTIVE PHASE, ALONG WITH COLOR STILL PHOTOS BY CREW AT BEGINNING, MIDPOINT, AND END OF ACTIVE PHASE.

PROPOSED STS-8 HEAT PIPE EXPERIMENT INSTALLATION



PROPOSED HEAT PIPE EXPERIMENT





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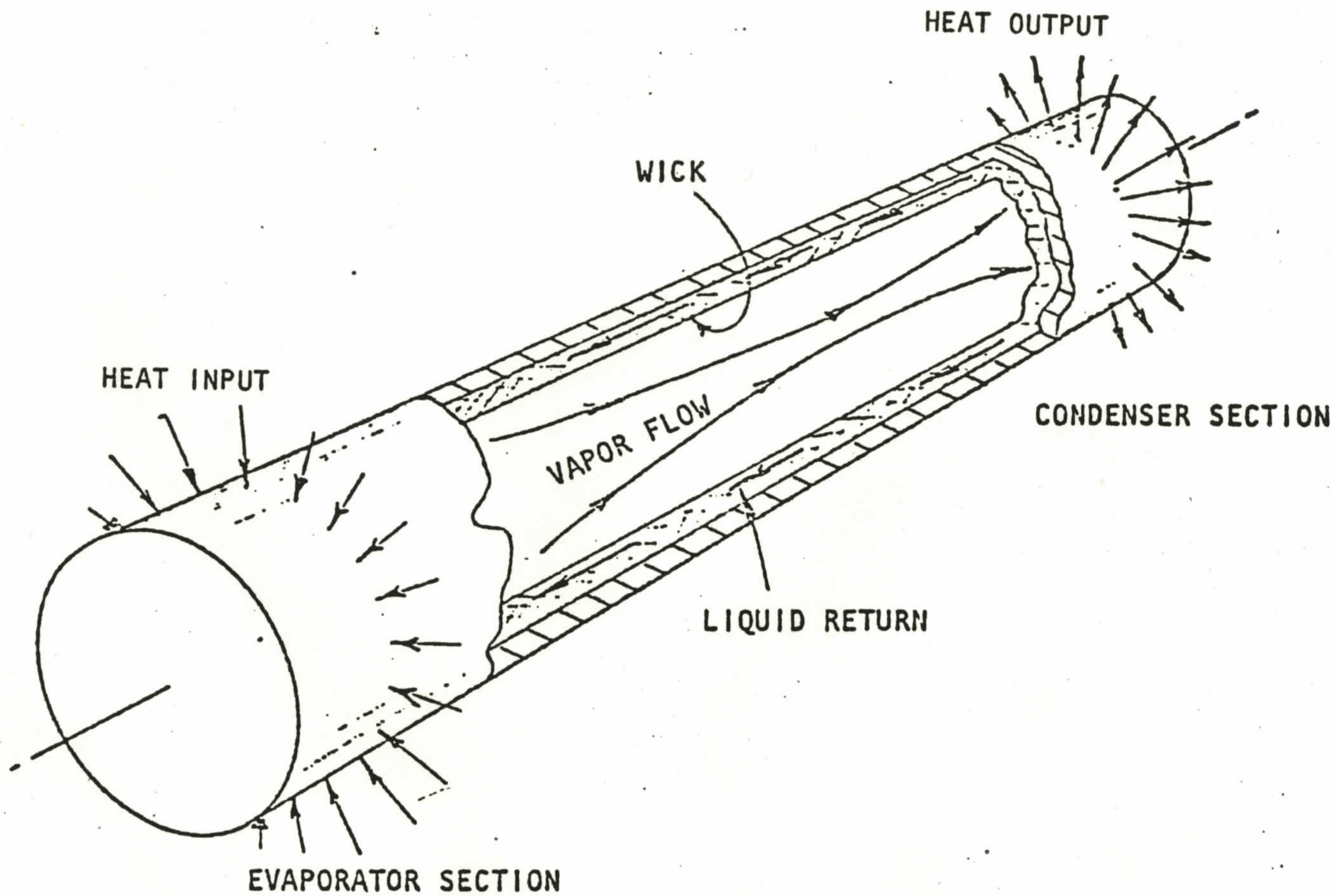
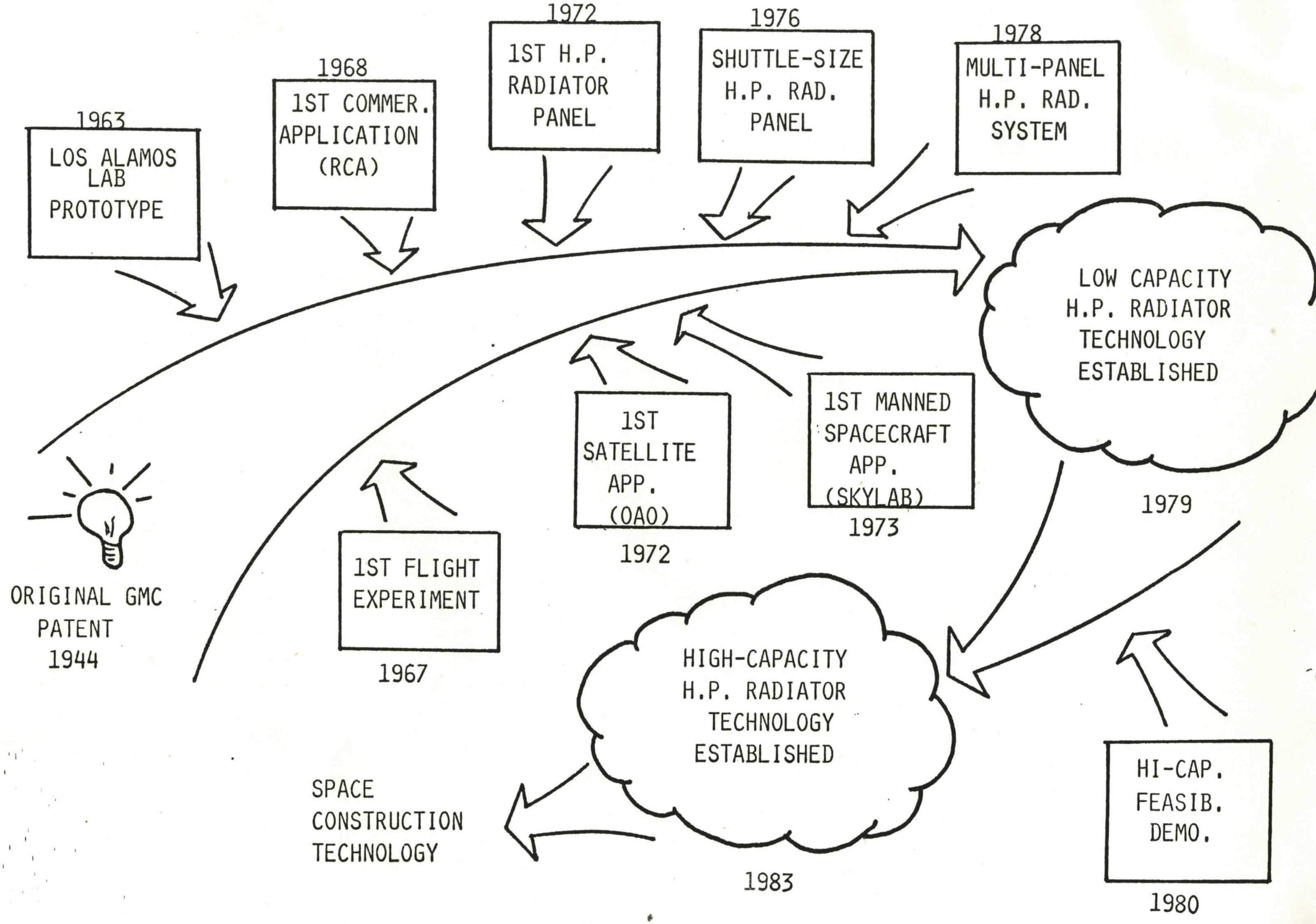
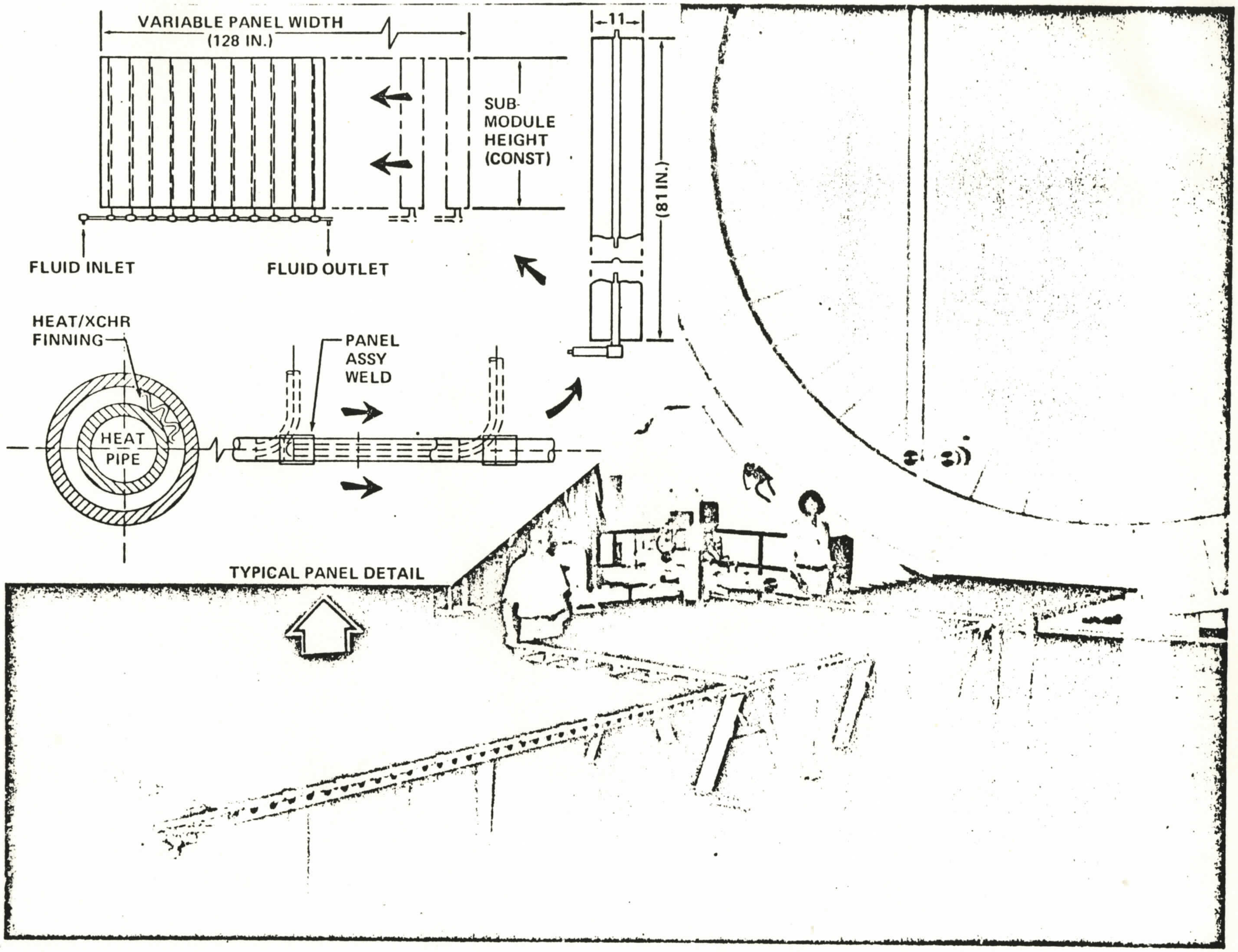
HEAT PIPE
BACKGROUND

BASIC HEAT PIPE OPERATION



HEAT PIPE TECHNOLOGY IS MATURE





Modular heat pipe radiator panels.

SPACE STATION
ACTIVE THERMAL CONTROL
PROBLEM/SOLUTION

W. E. ELLIS 5/9/83

PROBLEMS WITH SHUTTLE-TYPE THERMAL SYSTEMS

- <u>LOW LONG TERM RELIABILITY</u>
  - MICROMETEOROID/SPACE DEBRIS SENSITIVITY
  - COMPLEXITY - LARGE NO. OF VALVES, CONTROLS, FLUID LINES, REDUNDANT COMPONENTS
  - DEPENDENCY ON ROTATING EQUIP. - HIGH CAPACITY PUMPS

- <u>COMPLEX/INFLEXIBLE USER INTERFACES</u>
  - MECHANICAL INTERFACE REQUIRES VERY CONSTRAINED USER PRESSURE DROPS, LEAKAGE SPECS, CLEANLINESS SPEC., ETC.
  - EACH SUBSYSTEM/PAYLOAD MUST BE PRECISELY LOCATED IN CIRCUIT FOR PROPER CONTROL TEMP.
  - CONTROL TEMP. LEVEL VARIES DEPENDING ON WHAT UPSTREAM EQUIPMENT IS OPERATING

- <u>DIFFICULT TO MAINTAIN</u>
  - MUST BREAK/MAKE FLUID CONNECTIONS
  - ENTIRE SYSTEM MUST BE SHUTDOWN TO SERVICE (REQUIRES AT LEAST ONE REDUNDANT SYSTEM)

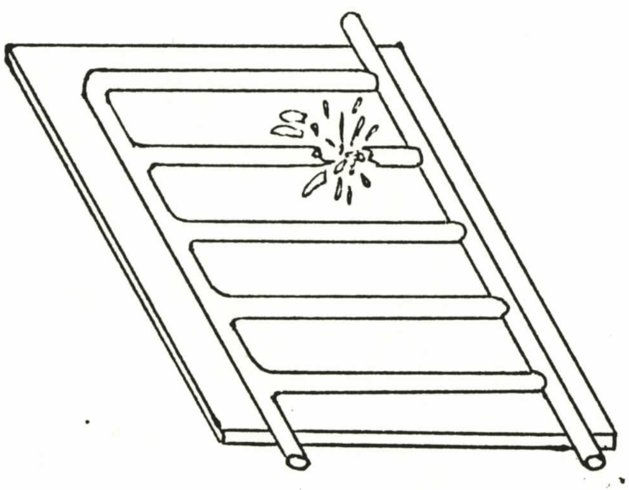
- <u>HIGH POWER CONSUMPTION</u>
  - PUMPING POWER $\sim$ 5% OF GENERATED POWER
  - HIGH CAPACITY PUMPS ARE EXPENSIVE

HEAT PIPES SOLVE RADIATOR PROBLEMS

- REDUCES METEOROID PENETRATION EFFECTS
- SIMPLIFIES CONTROLS
- REDUCES PUMPING REQUIREMENTS
- MAKES ON-ORBIT CONSTRUCTION/MAINTAINABILITY REASONABLE

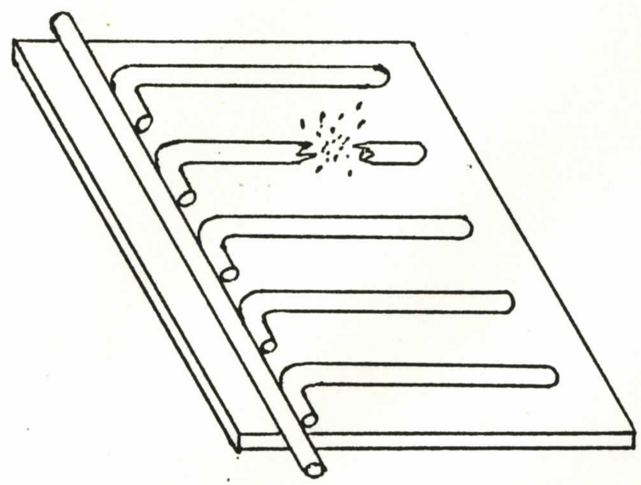
FLUID SYSTEM

1 METEOROID PUNCTURE
LOSE 100% RADIATING AREA
(AT LEAST ONE REDUNDANT CIRCUIT REQUIRED)



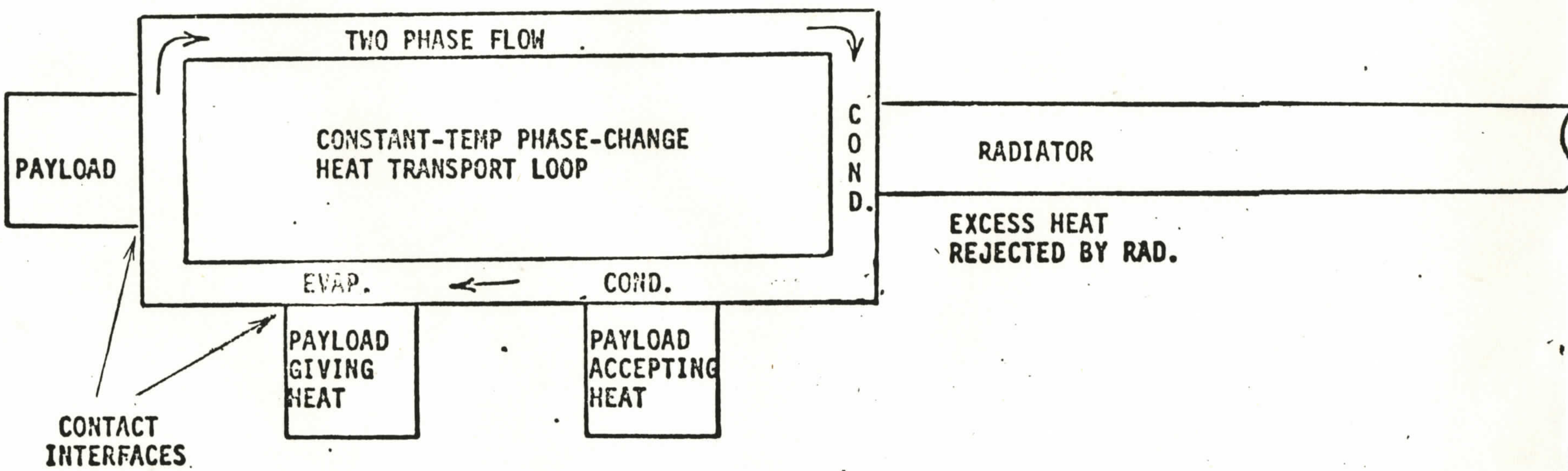
HEAT PIPE RADIATOR

1 METEOROID PUNCTURE
LOSE 5% RADIATING AREA
(REDUNDANCY NOT REQUIRED)



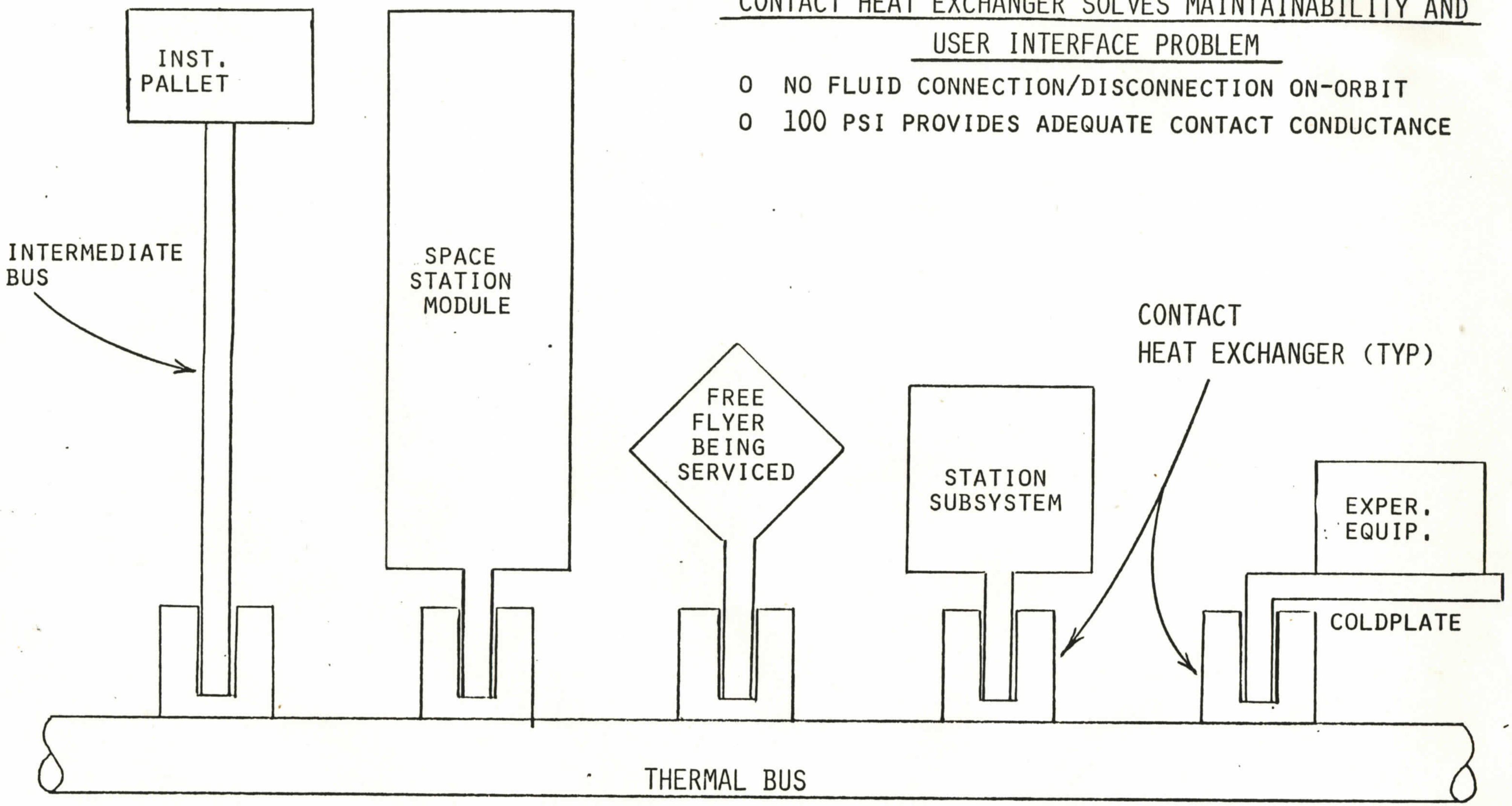
TWO-PHASE THERMAL BUS SOLVES HEAT TRANSPORT AND USER FLEXIBILITY PROBLEM

- REDUCES PUMPING POWER BY FACTOR OF 50 (USES SMALL-LOW POWER PUMP TO ASSIST)
- SEQUENCING OF HEAT GENERATING EQUIPMENT NOT REQUIRED (CONSTANT TEMP. SINK)
- TWO-PHASE COLDPLATES 10 TIMES AS EFFICIENT (LIGHTER/SMALLER)
- WASTE HEAT READILY AVAILABLE
- ENHANCES MAINTAINABILITY (SMALLER FLOWS REDUCES LRU SIZES)
- INCREASES RELIABILITY (SMALLER, LESS COMPLEX LRU'S



CONTACT HEAT EXCHANGER SOLVES MAINTAINABILITY AND USER INTERFACE PROBLEM

- O NO FLUID CONNECTION/DISCONNECTION ON-ORBIT
- O 100 PSI PROVIDES ADEQUATE CONTACT CONDUCTANCE



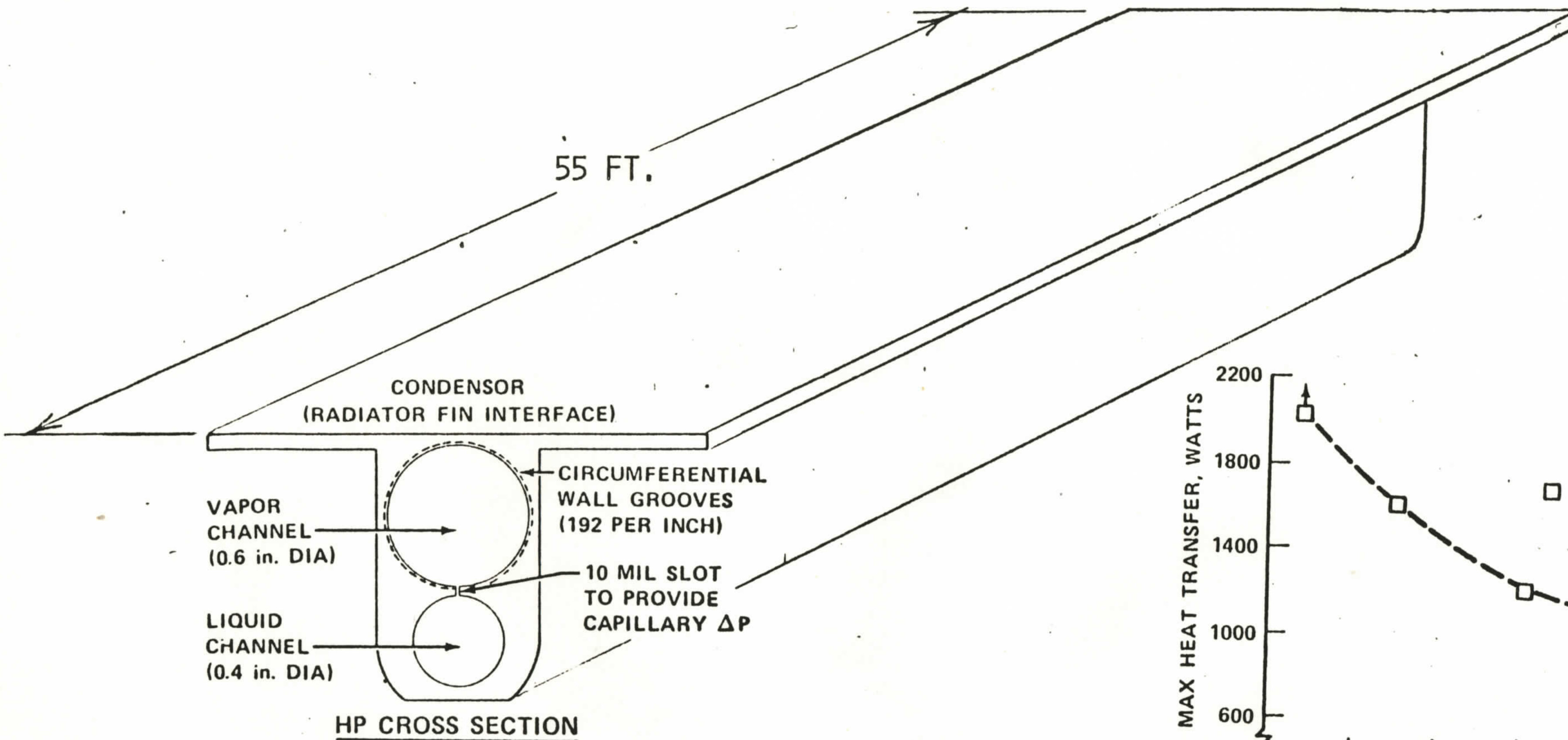
SPACE STATION
MISSION STUDY RESULTS
IN
THERMAL AREA

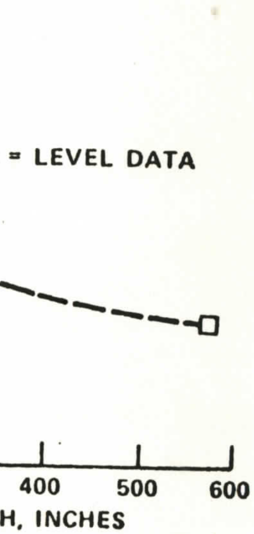
- RI
  - DEPLOYED RADIATOR
  - HEAT PIPE RADIATORS
  - TWO-PHASE HEAT TRANSPORT
- BOEING
  - DEPLOYED RADIATOR
  - HEAT PIPE RADIATOR
- MARTIN
  - DEPLOYED RADIATOR
  - HEAT PIPE RADIATOR KEY TECHNOLOGY
  - TWO-PHASE HEAT TRANSPORT HIGH PAYOFF
  - CONTACT HEAT EXCHANGER HIGH PAYOFF
- GRUMMAN
  - BODY MOUNTED RADIATORS
  - HEAT PIPE RADIATORS
- MDAC
  - DEPLOYED RADIATOR
  - LIQUID DROP RADIATOR DEMONSTRATION
- LMSC, TRW, G.D.
  - DEPLOYED RADIATOR

SUMMARY
OF
THERMAL TECHNOLOGY STATUS

- o BASIC HIGH CAPACITY HEAT PIPE TECHNOLOGY TO BE FULLY DEMONSTRATED THIS YEAR (ACCOMPLISHED IN 3 YEARS)
  - . PROVIDES CAPABILITY FOR LARGE RADIATORS
  - . PROVIDES BASIC THERMAL BUS CAPABILITY
- o SPACE CONSTRUCTABLE RADIATOR TECHNOLOGY WELL UNDERWAY
- o HIGH CAPACITY THERMAL BUS TECHNOLOGY PROGRAM INITIATED
  - . EXPECTED TO BE PROVEN WITHIN 3 YEARS IF EFFORT SUSTAINED (FY83 FUNDS TO BE ESSENTIALLY EXPENDED IN MAY, PROGRAM WILL BE LARGELY ON HOLD UNTIL FY84)
- o CONTACT HEAT EXCHANGER TECHNOLOGY UNDERWAY
  - . FUTURE EFFORT NEEDS TO BE DIRECTED TOWARD OPTIMIZING SUBSYSTEM/PAYLOAD INTERFACES
- o INTEGRATED TWO-PHASE <u>SYSTEM</u> EFFORT NEEDS TO BE INITIATED
  - . WILL PROVIDE FOR TRANSFER OF TECHNOLOGY TO STATION DEVELOPMENT
- o SPACE EXPERIMENT WOULD BE TECHNICALLY PRUDENT AND PROVIDE NECESSARY MANAGEMENT CONFIDENCE IN TWO-PHASE READINESS
  - . USE OF ORBITER RMS STOWAGE VOLUME MINIMIZES MANIFESTING PROBLEM

HIGH CAPACITY, EXTENDED LENGTH HEAT PIPE





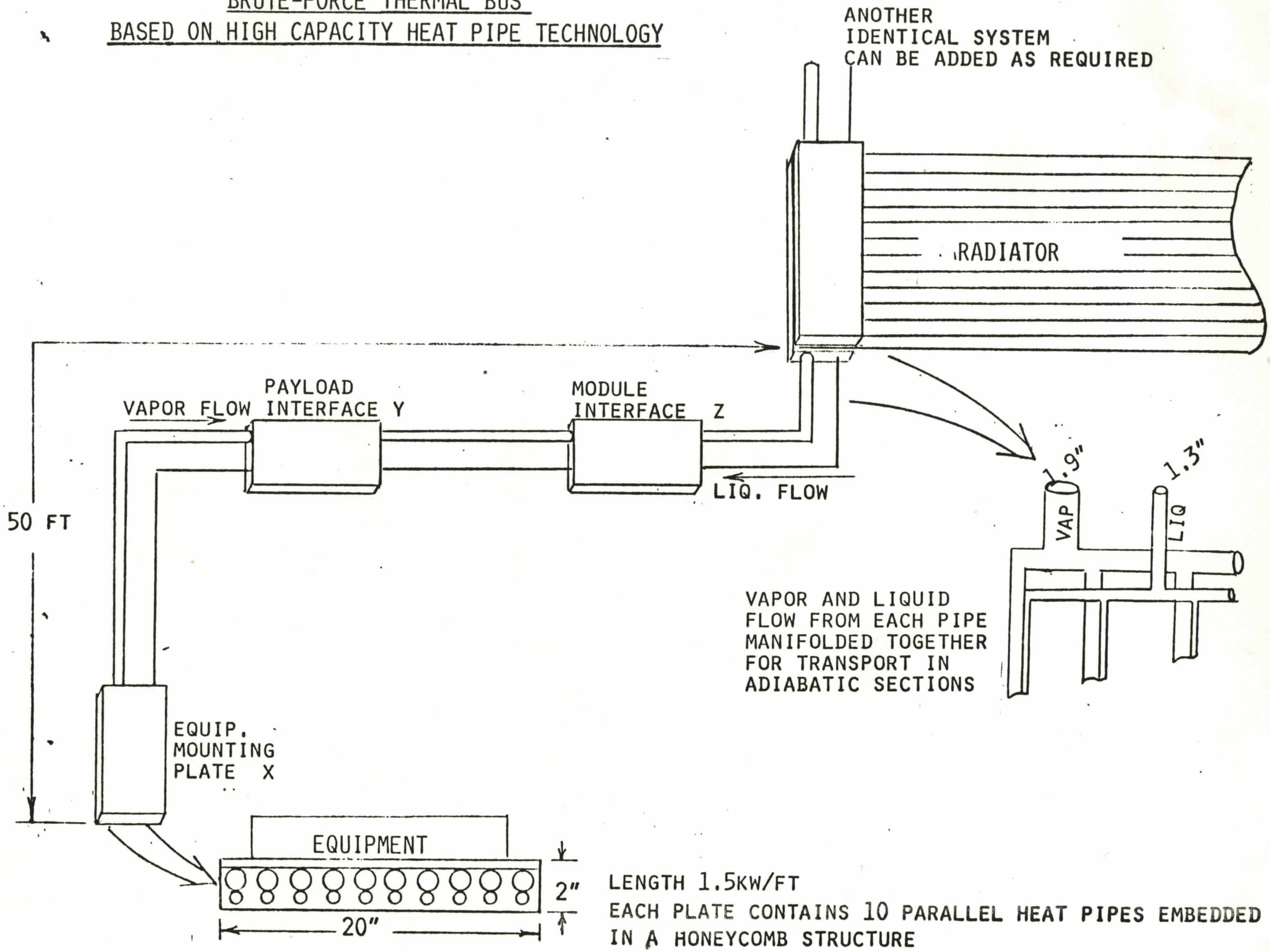
- o VERY HIGH CAPACITY - DUE TO SEPARATE, LOW PRESSURE DROP LIQUID FLOW CHANNEL
- o VERY LIGHTWEIGHT - ESSENTIALLY AN AL TUBE
- o VERY SIMPLE CONCEPT - NO WICKS, NO VARIABLE CONDUCTANCE CONTROLS, NO ION PUMPS
- o RELATIVELY EASY TO MANUFACTURE - PRIMARILY AN EXTRUSION
- o CAPABLE OF BEING TESTED AT NEAR FULL CAPACITY IN ONE-G
- o RELATIVELY EASY TO ANALYZE - DUE TO SIMPLICITY OF DESIGN

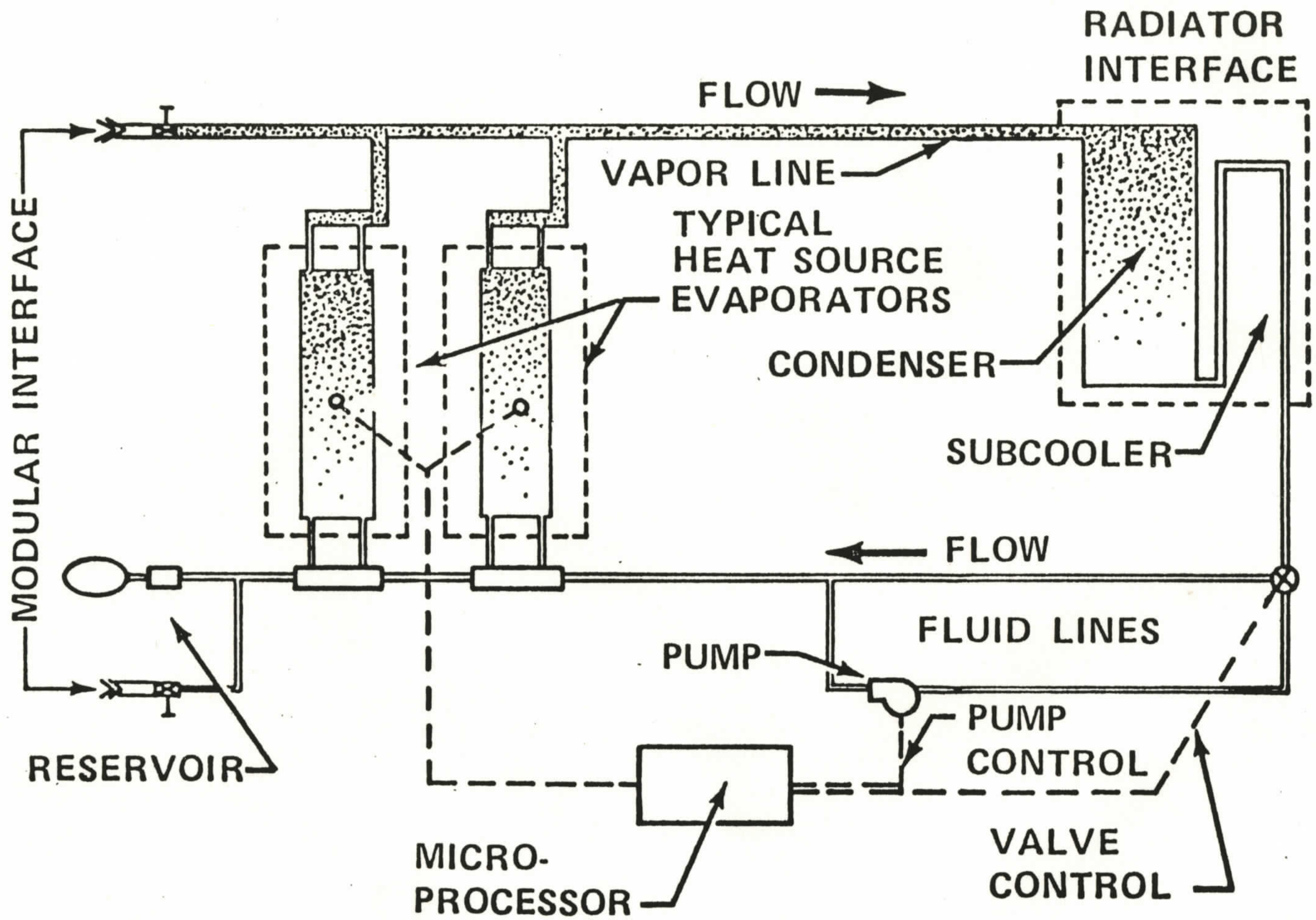
THERMAL BUS

- o BASIC FUNCTION
  - . ACQUIRE AND PROVIDE HEAT AT VARIOUS LOCATIONS
  - . TRANSPORT THE HEAT TO THE REMOTELY LOCATED RADIATOR
- o SIMPLIFIED BUS APPROACH
  - . HEAT PIPES CAN ACQUIRE AND PROVIDE HEAT AT ANY LOCATIONS
  - . HIGH CAPACITY HEAT PIPE CAN TRANSPORT 2KW FOR 50 FT.
  - . THEREFORE, HIGH CAPACITY HEAT PIPE IS A 2KW, 50 FT. THERMAL BUS
  - . SEVERAL HIGH CAPACITY HEAT PIPES IN PARALLEL COULD PROVIDE A 50 FT. THERMAL BUS OF ANY DESIRED CAPACITY

  THUS, A THERMAL BUS IS SIMPLY AN EXTENSION OF HEAT PIPE TECHNOLOGY
- o MORE EFFICIENT, LIGHTER WEIGHT, LESS G SENSITIVE, LONGER TRANSPORT DISTANCE CAPABILITY THERMAL BUS'S ARE DESIRED FOR SPACE STATION
  - . AUGMENTING HEAT PIPE CAPILLARY FORCE WITH A SMALL PUMP IS A PROMISING TECHNIQUE

BRUTE-FORCE THERMAL BUS
BASED ON HIGH CAPACITY HEAT PIPE TECHNOLOGY





HIGH CAPACITY TWO-PHASE THERMAL BUS SYSTEM

CONCLUSION

A HIGHLY VERSATILE THERMAL SYSTEM CAN BE AVAILABLE FOR THE SPACE STATION WHICH WILL FULLY MEET THE LONG-LIFE, USER FLEXIBILITY AND GROWTH REQUIREMENTS OF THE STATION.