THERMAL SYSTEMS

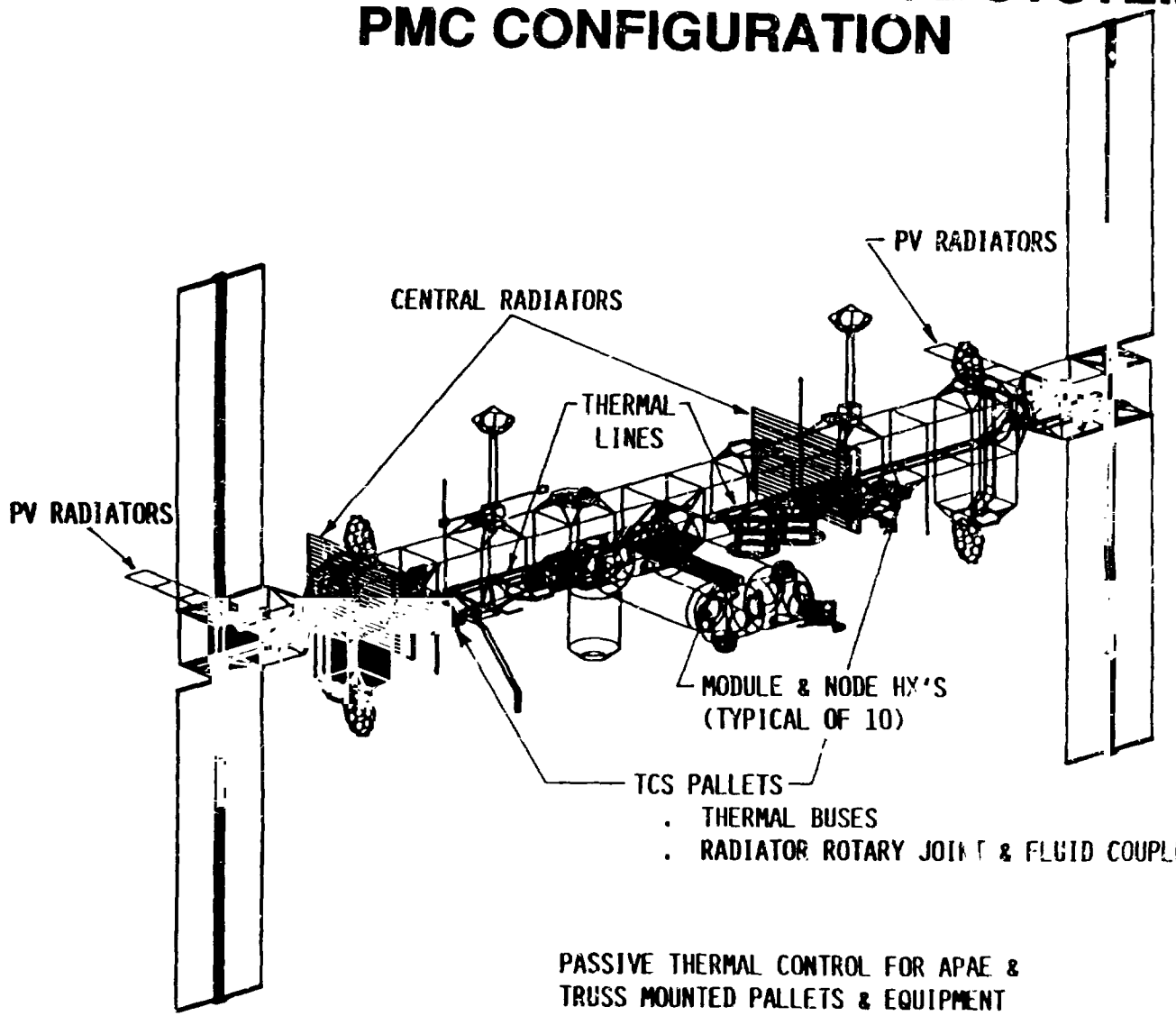
J. E. Rogan

Space Station Freedom — McDonnell Douglas • GE • Honeywell • IBM • Lockheed

THERMAL CONTROL SYSTEM

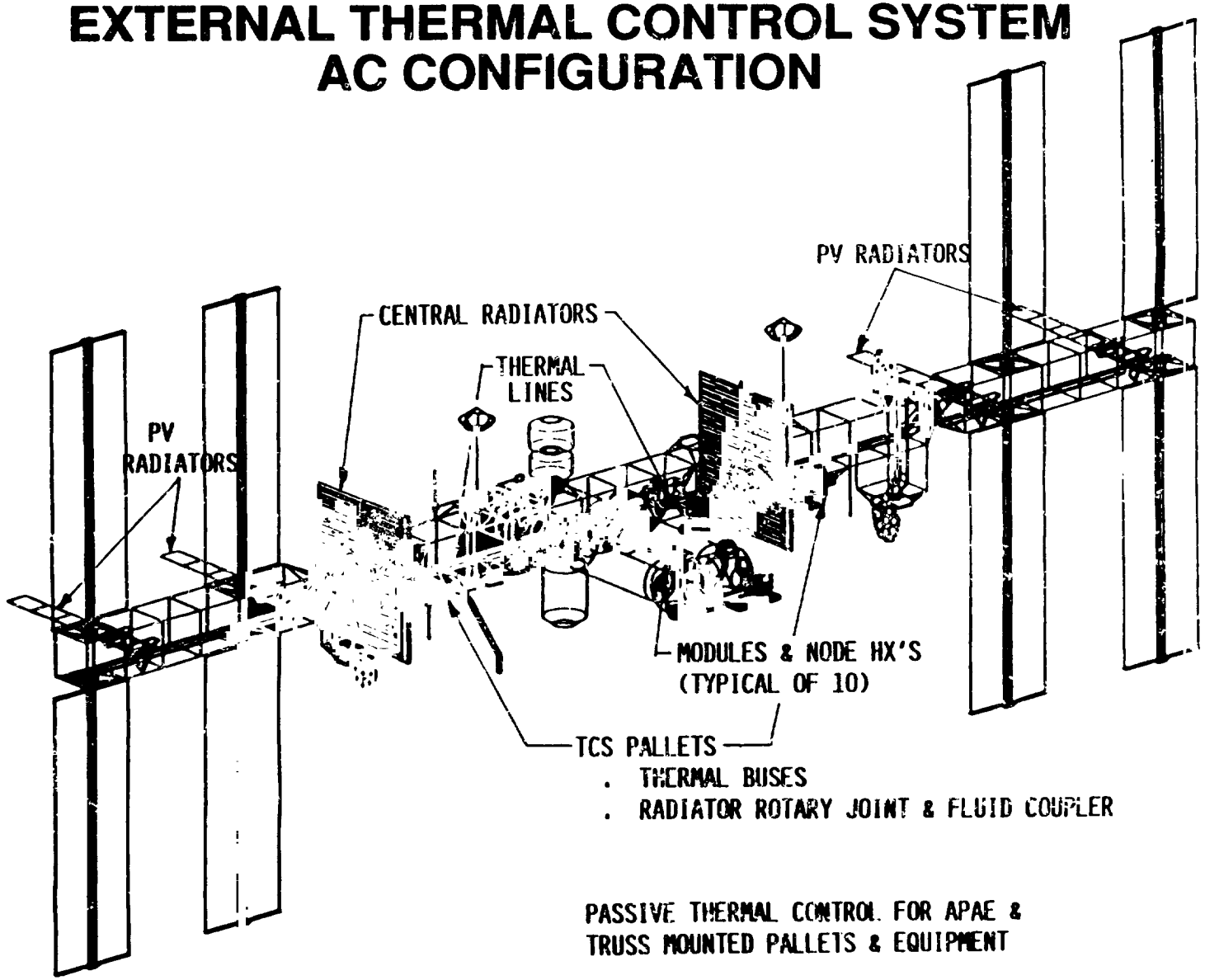
BASELINE CONTENT	REBASELINE PMC	REBASELINE AC
External ATCS		
● Central Radiators (2-Phase Ammonia)	Same (erect only as required)	Same
● Central Thermal Bus (2-Phase Ammonia)		
–Modules and Nodes	Same	Same
–Truss Mounted Pallets	Passive	Passive
Internal ATCS for Pressurized Nodes and Modules (water)	Same	Same
APAE ATCS for Truss-Mounted Payloads	Passive	Passive
PVATCS (1 Phase Fluid and Deployable Radiators)	Same	Same

EXTERNAL THERMAL CONTROL SYSTEM
PMC CONFIGURATION



PASSIVE THERMAL CONTROL FOR APAE & TRUSS MOUNTED PALLETS & EQUIPMENT

EXTERNAL THERMAL CONTROL SYSTEM AC CONFIGURATION



PASSIVE THERMAL CONTROL FOR APAE & TRUSS MOUNTED PALLETS & EQUIPMENT

EXTERNAL THERMAL CONTROL SYSTEM REQUIREMENTS

Functional Requirements

- Waste heat acquisition/transport

Performance Requirements

- Collect waste heat from each pressurized element or carrier
- Size for 37.5 kW (PMC) and 75 kW (AC) Plus electrical conversion losses, metabolic and environmental heat loads
- Accommodate modular growth, on-orbit assembly
- Provide simple user interface and location flexibility
- Low and moderate temperature loops (35°F and 70°F)
- Quiescent operation (10% of full load)
- Leak detection, isolation, and repair

EXTERNAL THERMAL CONTROL SYSTEM REQUIREMENTS (CONT.)

Functional Requirements	Performance Requirements
■ Heat rejection	● Accommodate modular growth, on-orbit assembly ● Limited degradation due to damage or failure ● Replaceable radiator
■ Truss mounted pallets and equipment, APAE and Structures	● Passive thermal control
■ APAE payloads	● Provide own independent thermal control

IMPLEMENTATION APPROACH

- **Truss mounted pallets and equipment, APAEs and structures - passive thermal control**
  - **Insulation and coatings**
    - **Multi-layer high performance insulations**
      - **Utility distribution lines**
      - **Resource pallets**
      - **Airlock**
      - **Mobile Transporter**
      - **APAE/payload (WP-3)**
      - **Modules (WP-1)**
      - **Nodes (WP-1)**

IMPLEMENTATION APPROACH
(Continued)

- Selective absorptivity/emissivity optical surface coatings
  - Radiators
  - Truss
  - Resource pallets
  - APAE/payload (WP-3)
  - Modules (WP-1)
  - Node (WP-1)

- **Heaters**
  - Electrical radiant-type or conductive
    - Utility distribution lines
    - Propulsion Pallet
    - Mobile Transporter
    - APAE/payload (WP-3)

IMPLEMENTATION APPROACH
(Continued)

- Isolators
  - Low conductivity material
    - Mobile transporter components
    - Airlock
    - Resource Pallets
    - APAE/payload (WP-3)
- Passive Radiators
  - Structural surface area viewing space
    - Resource pallets
    - Mobile Transporter
    - Antennas and cameras
    - APAE/payload (WP-3)

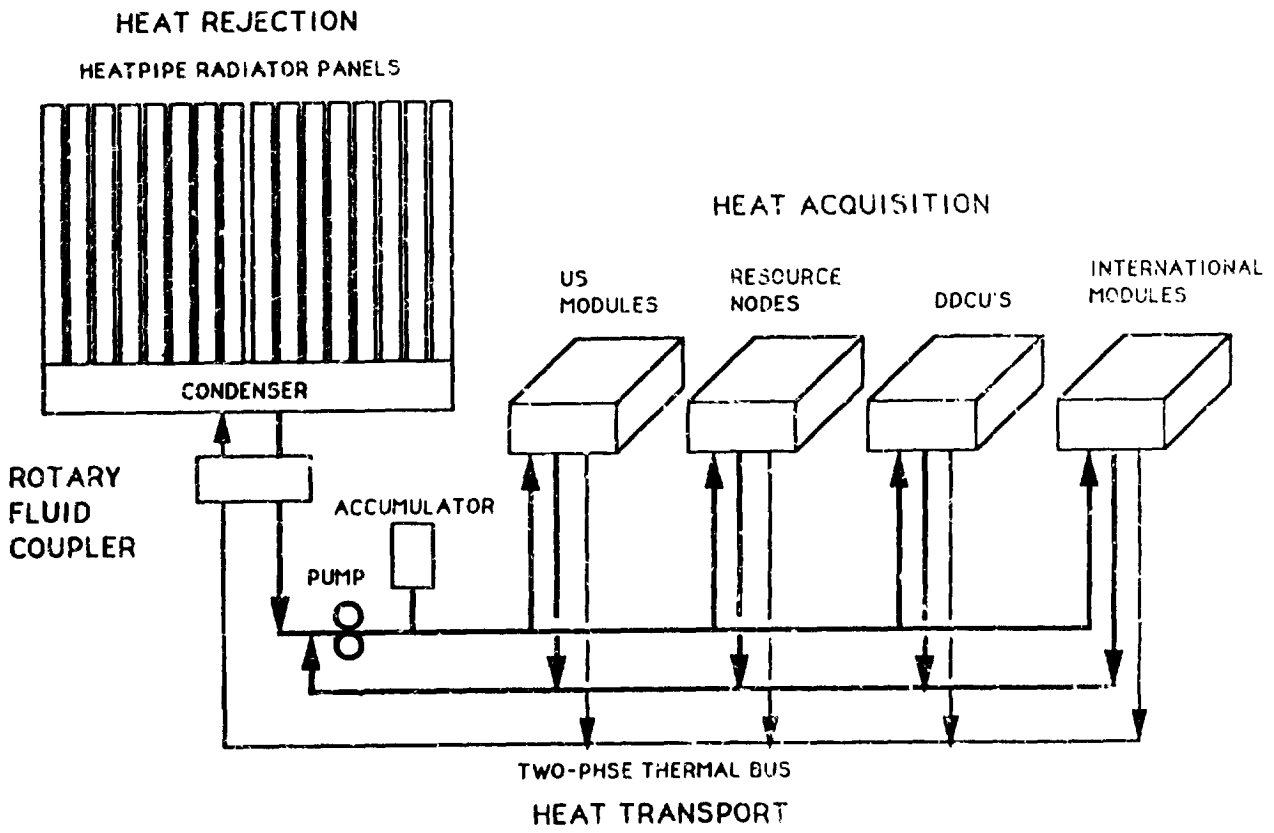
IMPLEMENTATION APPROACH
(Continued)

- **Heat Rejection**
  - **Individual radiator elements incorporating self-contained, high capacity heat pipes**
    - **Each element completely independent of all others**
    - **Facilitates easy handling for on-orbit assembly**
    - **Allows interfacing radiator with transport circuit through non-invasive technique**
    - **Allows replacement of elements to maintain indefinite life**

IMPLEMENTATION APPROACH
(Continued)

- Heat acquisition and transport
  - Thermal bus applies heat pipe technology to heat transport
    - Liquid to user interface evaporated. Vapor to radiator interface for condensation
    - All equipment receives the same temperature regardless of location in the circuit
    - Phase change process allows approximately 50 times less fluid to be circulated
- Rotary fluid coupler
  - Allows articulation of radiator to minimize area

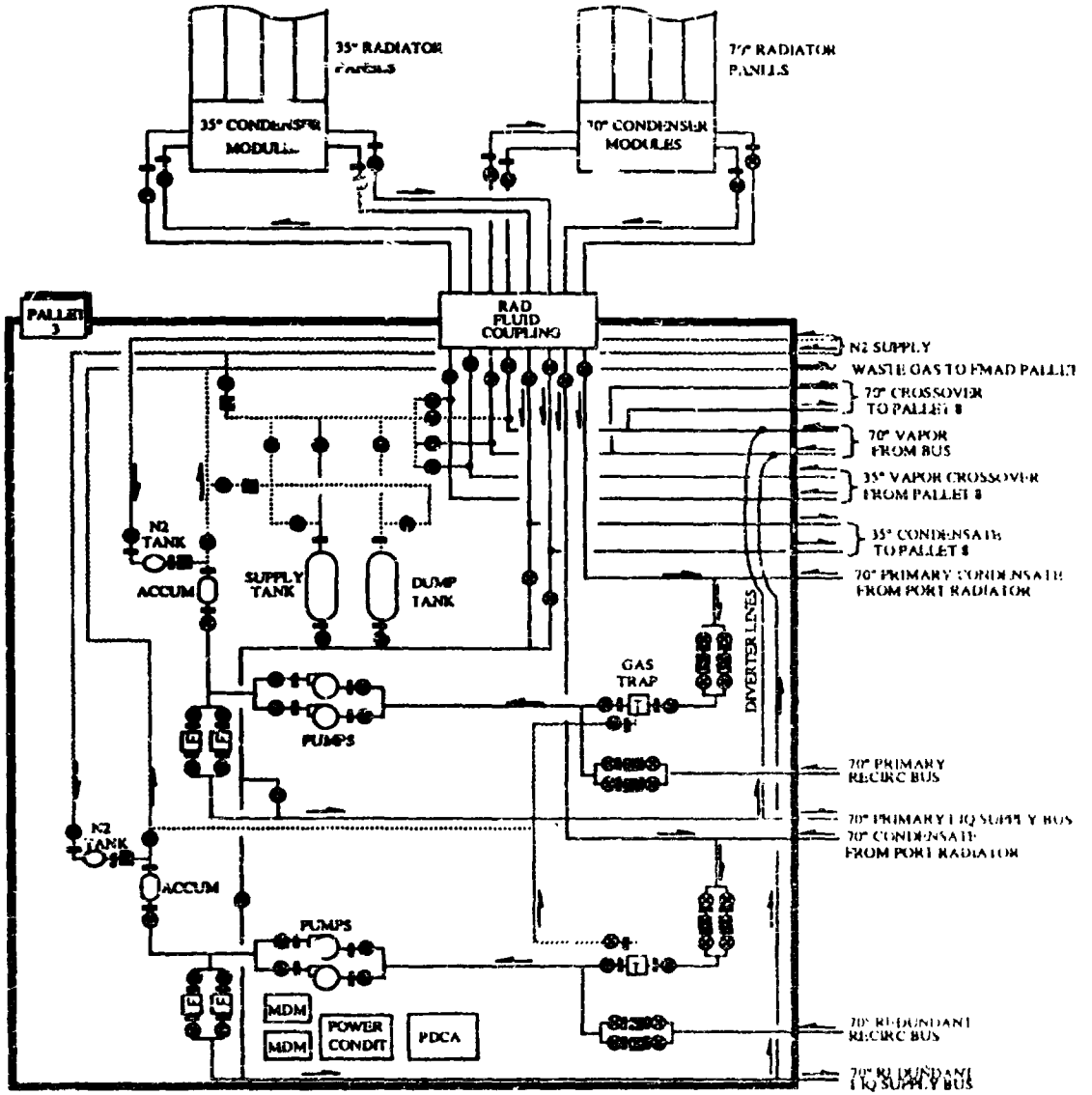
EXTERNAL THERMAL CONTROL SYSTEM



- 35°F AND 70°F TEMPERATURE LOOPS
- BOTH LOOPS REDUNDANT
- BOTH TEMPERATURE LOOPS SERVICE PORT AND STARBOARD SIDES OF SSF

LMSC PALLET 3 EQUIPMENT

(FOR CONCEPT EVALUATION ONLY)



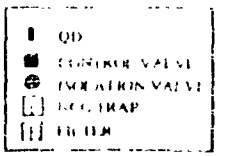
339

ECS EQUIPMENT

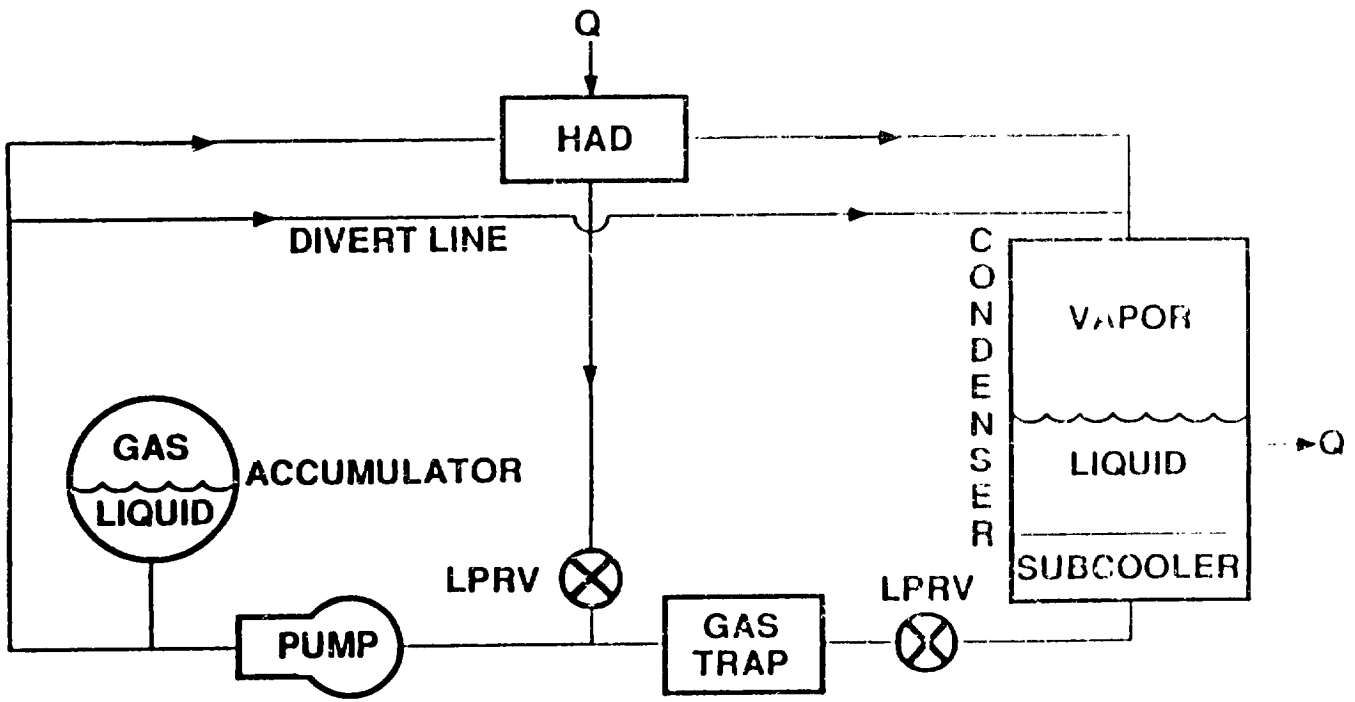
- 2 ACCUMULATORS
- 1 SUPPLY TANK
- 1 DUMP TANK
- 4 PUMPS
- 4 HEATERS
- 2 N2 TANKS
- 2 NCG TRAPS
- 8 CONTROL VALVES
- 60 G/L ISOLATION VALVES
- 17 N2/WASTE GAS ISOLATION VALVES
- 4 N2 PRESSURE REGULATORS
- INTERCONNECT LINES
- POWER LINES
- SENSORS
- 48 NEU QDS
- 10 N2/WASTE GAS QDS
- TBD CONDENSER MODULES

OTHER SYSTEMS

- 1 PDCA
- 1 RADIATOR FLUID COUPLING
- 2 MDMs
- MLI/ORDID SHIELD
- INSULATION
- 17 FLUID INTERFACE LINES
- POWER/DATA INTERFACE CABLES
- 1 POWER CONDITIONING UNIT



LMSC SYSTEM SCHEMATIC



DEVELOPMENT ISSUES

Key Technical Challenges Heat Rejection	Approach to Challenges
■ High capacity heat pipe radiator	● Two technology options (GAC and LMSC) ● Thermal test bed ● KC-135 tests ● STS-8 concept flight test (OAST) ● STS-29 SHARE* technology flight test (Advanced Development) ● STS-43 SHARE II* Development Flight Test (Prime)
■ On-orbit assembly	● EVA and RMS Ooptions ● WETF evaluations ● RMS ground test facility evaluations ● STS-61 SRAD* verification flight test (Prime)

*SHARE - Station Heat Rejection Advanced Radiator Element
SHARE II - Station Heat Rejection Advanced Radiator Element
SRAD - Shuttle Radiator Assembly Demonstration

DEVELOPMENT ISSUES
(Continued)

Key Technical Challenges Heat Acquisition/Transport	Approach to Challenges
■ Two phase thermal bus	● Three technology options (Boeing, GAC, LMSC) ● Thermal test bed ● KC-135 tests ● STS-61 TPITS verification flight test (Prime)
■ Rotary fluid coupler	● Three technology options (Boeing, LaRC, LMSC) ● Thermal test bed
■ Leak detection, isolation, and repair	● Thermal test bed

THERMAL FLIGHT EXPERIMENTS

- **SHARE - Station Heat Rejection Advanced Radiator Element**
  - One 50 ft advanced development heat pipe radiator panel performance
  - STS-29 (3/89)
- **SHARE II - Station Heat Rejection Advanced Radiator Element**
  - Two 43 ft station development heat pipe radiator panels performance
  - STS-43 (1/91)
- **SRAD - Shuttle Radiator Assembly Demonstration**
  - Three heat pipe radiator panels assembled on-orbit by RMS and EVA
  - Thermal performance
  - Accepts heat from simulated or TPITS two-phase thermal bus
  - STS-61 (11/92), manifested with TPITS
- **TPITS - Two-Phase Integrated Thermal System**
  - 5 kW thermal bus performance
  - Reject heat to Orbiter payload heat exchanger or SRAD-erected radiators
  - STS-61 (11/92), manifested with SRAD