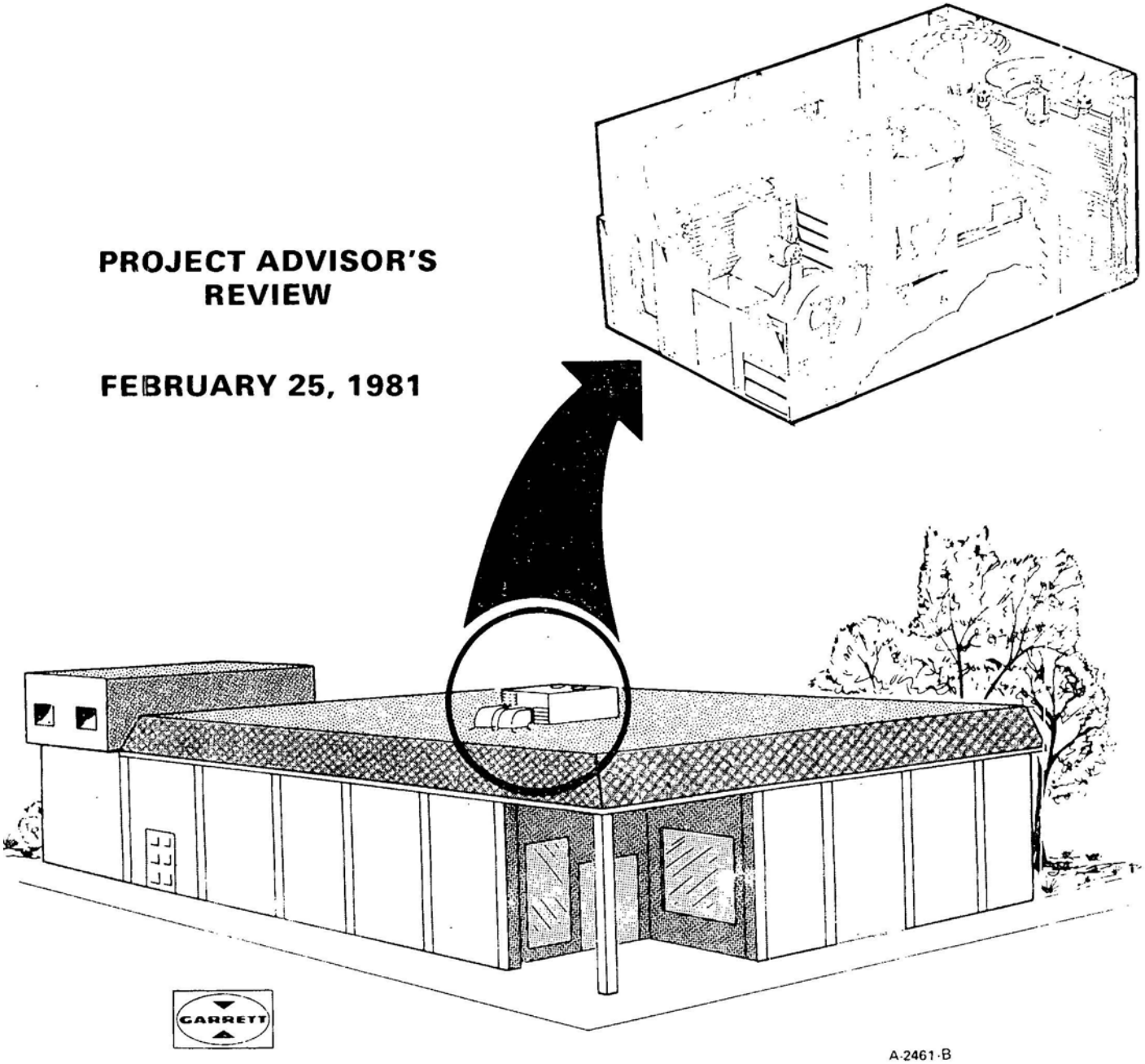
BRAYTON/RANKINE GAS FIRED SPACE CONDITIONING SYSTEM



PROJECT ADVISOR'S REVIEW

FEBRUARY 25, 1981

AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA
A DIVISION OF THE GARRETT CORPORATION
2525 WEST 190TH STREET • TORRANCE, CALIFORNIA 90509
TELEPHONE: (213) 323-9500, 321-5000 • CABLE: GARRETTAIR TORRANCE

February 18, 1981

Mr. John Ryan
Department of Energy
20 Massachusetts Avenue NW
Washington, D.C. 92545

Via: W. Sullivan

Dear Mr. Ryan,

Please find attached the presentation material for the Brayton/Rankine Heat Pump to be presented at the GRI Heat Pump Project Advisors Meeting scheduled for February 25, 1981 in Albany, New York.

Regards,

AIRESEARCH MANUFACTURING COMPANY
A Division of The Garrett Corporation

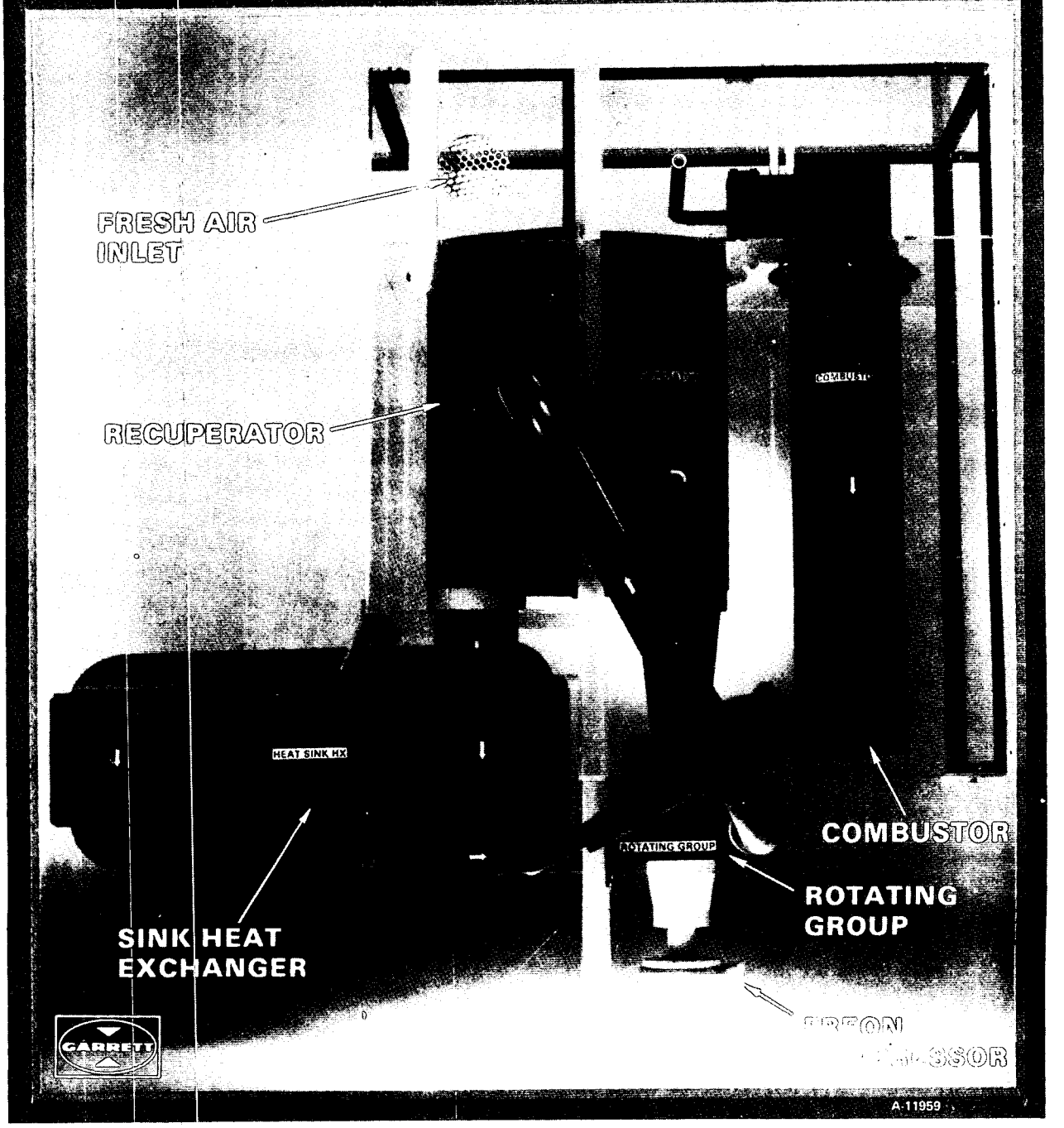
D. W. Friedman

D. W. Friedman
Project Manager Brayton/Rankine Heat Pump

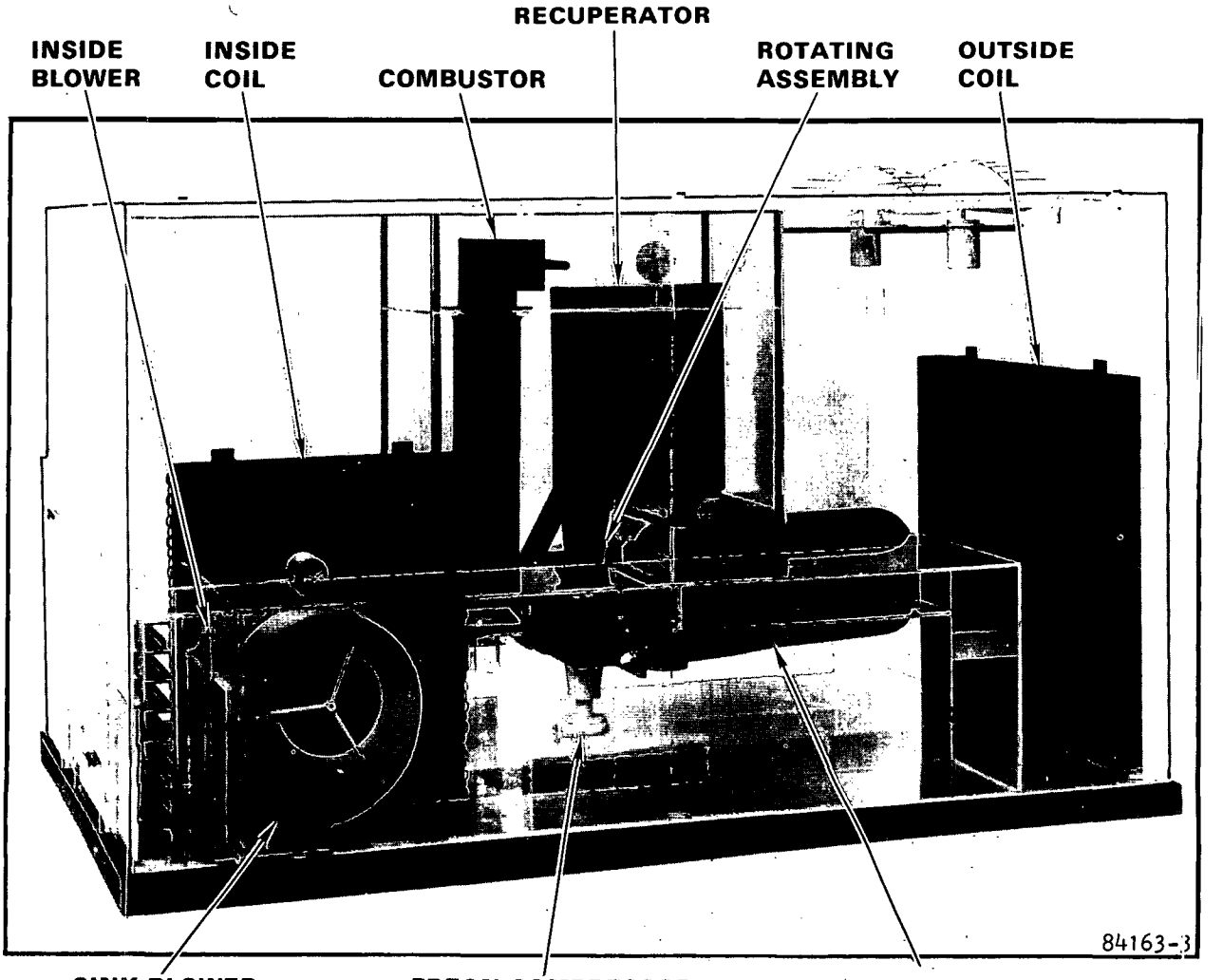
DWF:lmd

Attachment

BRAYTON ENGINE MODEL



MODEL OF BRAYTON/RANKINE SPACE CONDITIONING SYSTEM



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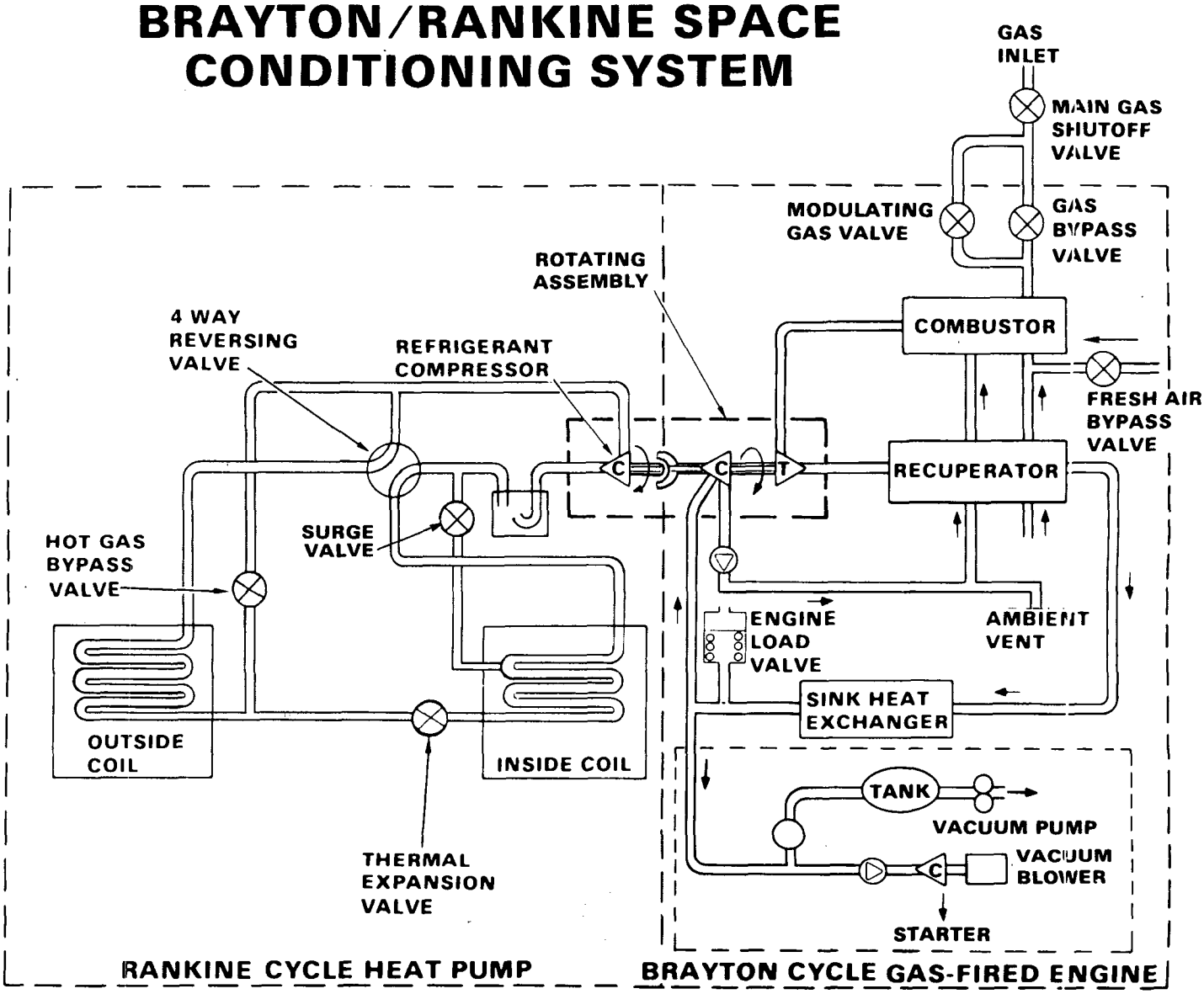
SCHEMATIC DIAGRAM OF BRAYTON/RANKINE SPACE CONDITIONING SYSTEM



A-4864 -A

PROGRAM OVERVIEW

COMPONENT DEVELOPMENT STATUS

- COMBUSTER ASSEMBLY TESTS COMPLETED SATISFACTORILY
- SINK HEAT EXCHANGER TESTS COMPLETED SATISFACTORILY
- START SYSTEM TESTS COMPLETED SATISFACTORILY
- DETAIL CONTROL ELEMENTS TESTED IN BREADBOARD SYSTEM SATISFACTORILY
- ROTATING ASSEMBLY FABRICATED AND IN TEST
- RECUPERATOR FABRICATED AND IN TEST
- DEVELOPMENT ENGINE ASSEMBLY BEING USED AS TEST BED FOR RECUPERATOR - FABRICATION COMPLETED AND IN TEST
- HEAT PUMP DETAIL DESIGN AT DUNHAM-BUSH IS ESSENTIALLY COMPLETE

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PROGRAM OVERVIEW (CONT.)

- DEMONSTRATION AND LIFE CYCLE HARDWARE STATUS
  - ALL LONG LEAD ITEMS ON ORDER
  - DETAILS FOR COMPONENT ASSEMBLIES TO BE AVAILABLE BY APRIL 1, 1981
  - CHANGES FROM DEVELOPMENT PROGRAM TO BE INCORPORATED
  - TESTING SHOULD COMMENCE IN MID-1981

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PROGRAM OVERVIEW (CONT.)

- MARKETING EFFORT STATUS
  - MARKET SURVEYS ESSENTIALLY COMPLETE
    - — EXCELLENT ACCEPTANCE-BELOW 3-YEAR PAYBACK
    - — CONCERNS INCLUDE RELIABILITY, AVAILABILITY OF REPLACEMENT PARTS, NEED FOR VARIOUS SIZES, NEWNESS-UNPROVEN EXPERIENCE, GAS AVAILABILITY, AND NOISE
  - PRELIMINARY MARKET EVALUATION REPORTS
    - — LENNOX REPORT VERY ENCOURAGING
    - — DUNHAM-BUSH REPORT NOT RECEIVED
    - — AIRESEARCH WILL SUBMIT A COMBINED REPORT ON MARKETING AS SOON AS POSSIBLE
- HARDWARE COST ANALYSIS
  - ROTATING ASSEMBLY PRODUCTION COST EFFORTS IN PROCESS
    - — EMPHASIS ON HIGH TEMPERATURE CASTINGS
  - RECUPERATOR PRODUCTION COSTS HAVE BEEN REANALYZED BASED UPON CURRENT DRAWINGS

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PROGRAM OVERVIEW (CONT.)

- PROGRAM EXPANSION
  - LENNOX DEVELOPMENT EFFORT
  - OSAKA/TOKYO GAS PROJECT
  - SOLAR APPLICATIONS
  - RALPHS SUPERMARKETS

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MARK III ROTATING ASSEMBLY DEVELOPMENT STATUS

- FREON COMPRESSOR
  - TESTED UP TO SPEEDS OF 80,000 RPM, TOTAL TIME ACCUMULATED = 63 HOURS
  - PROBLEM
    - RUPTURED TORLON DIAPHRAGM
    - HIGHER THAN EXPECTED VIBRATION LEVELS
- BRAYTON TURBOCOMPRESSOR
  - TESTED TO 80,000 RPM AND TEMPERATURE OF 1500°F, TOTAL TIME ACCUMULATED = 24 HOURS
  - PERFORMANCE OF UNIT APPEARS GOOD
  - PROBLEM AREAS
    - STABILITY AT SPEED
    - LEAKAGE
    - BALANCE
    - COMPRESSOR WHEEL RUB

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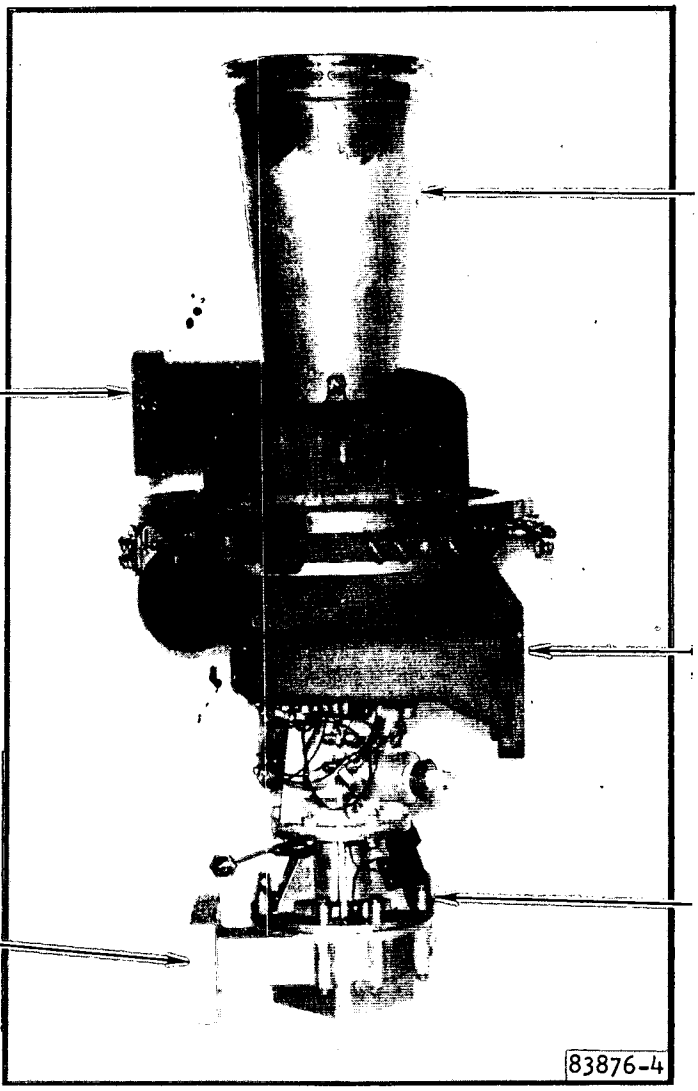
MARK III
BRAYTON/RANKINE ROTATING ASSEMBLY



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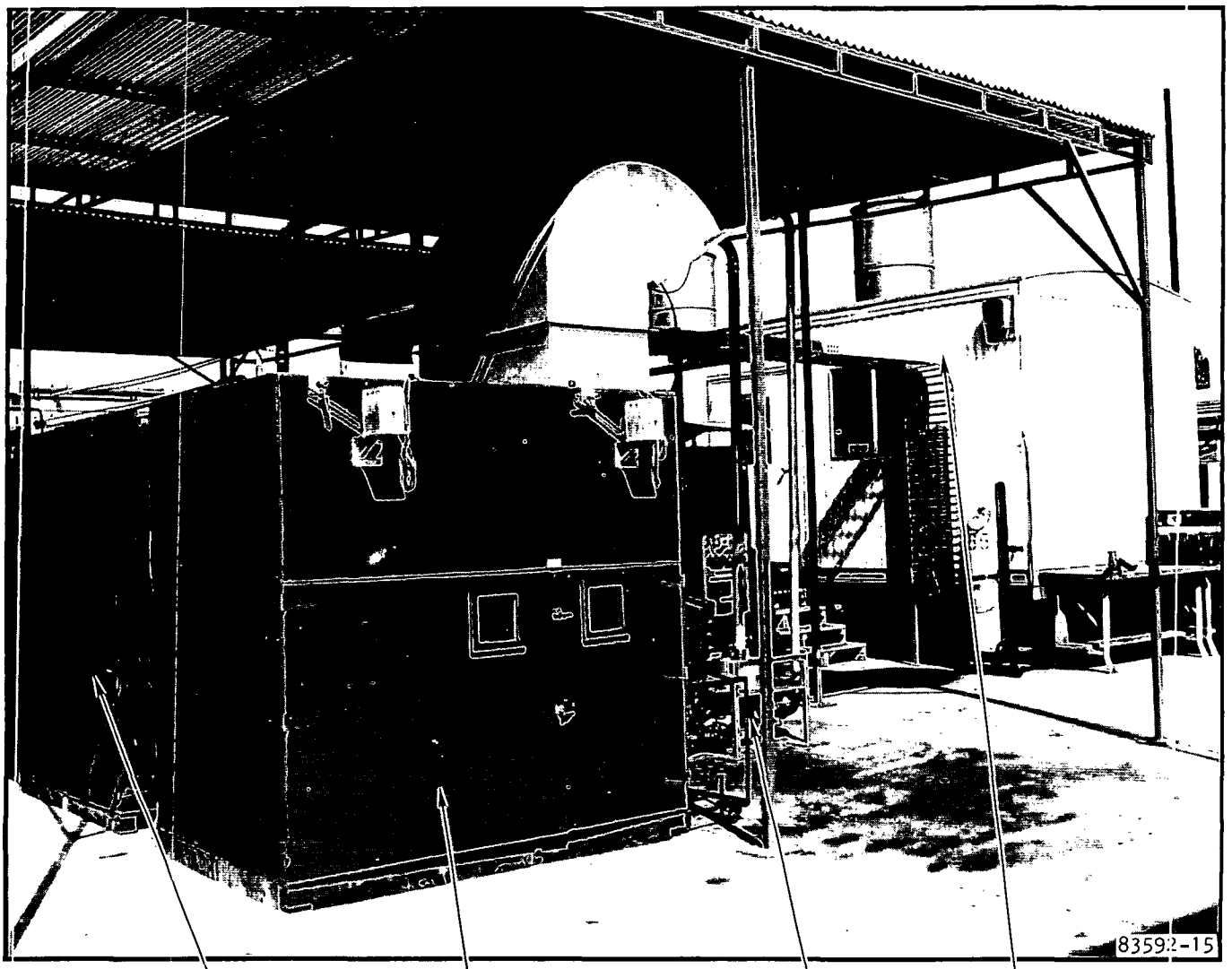
A-12322

SYSTEM TEST FACILITY NO. 2



OUTDOOR COIL CONTROL CHAMBER

INDOOR COIL CONTROL CHAMBER

FREON COMPERSSOR TEST ASSEMBLY

TEST CONTROL PANELS

A-12474

RECUPERATOR AND ENGINE PACKAGE DEVELOPMENT STATUS

RECUPERATOR

- PRESSURE DROP DATA SLIGHTLY BETTER THAN PREDICTED
- UNIT OPERATED TO DESIGN TEMPERATURE AND PRESSURE
- PERFORMANCE UNDER EVALUATION

ENGINE PACKAGE

- ASSEMBLY WITH RECUPERATOR COMPLETED
- ALIGNMENT AND THERMAL EXPANSION VERIFIED ACCEPTABLE DURING TEST
- HIGH LEAKAGE NOTED - BYPASSING RECUPERATOR

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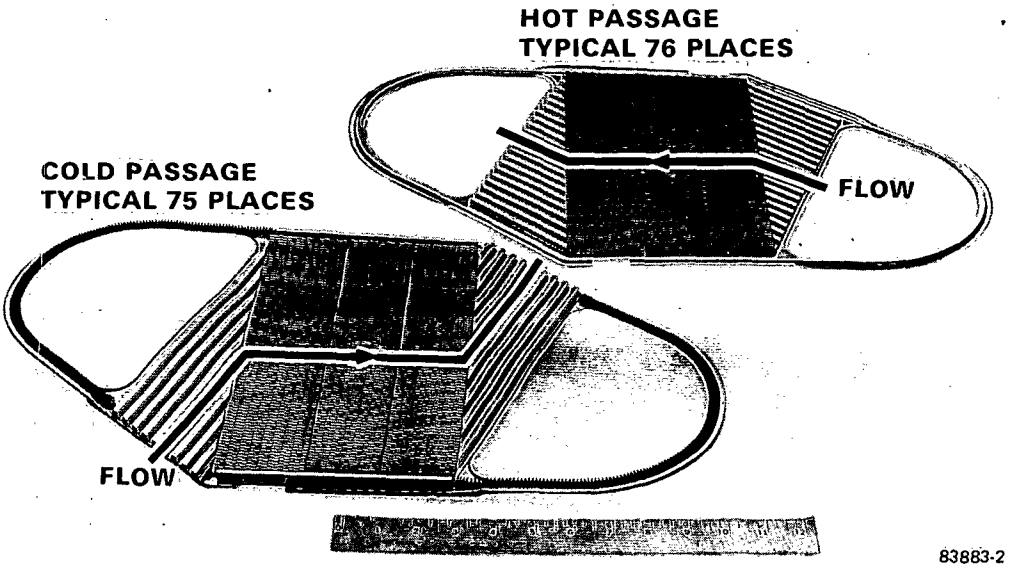
10-TON BRAYTON/RANKINE SYSTEM
RECUPERATOR

- EFFECTIVENESS $\simeq$0.90
- DESIGN POINT $\Delta P \simeq$2.15 IN. H_2O
- COUNTER FLOW
- NICKEL BRAZED
- MATERIAL-409 SS
- WEIGHT-216 LBS



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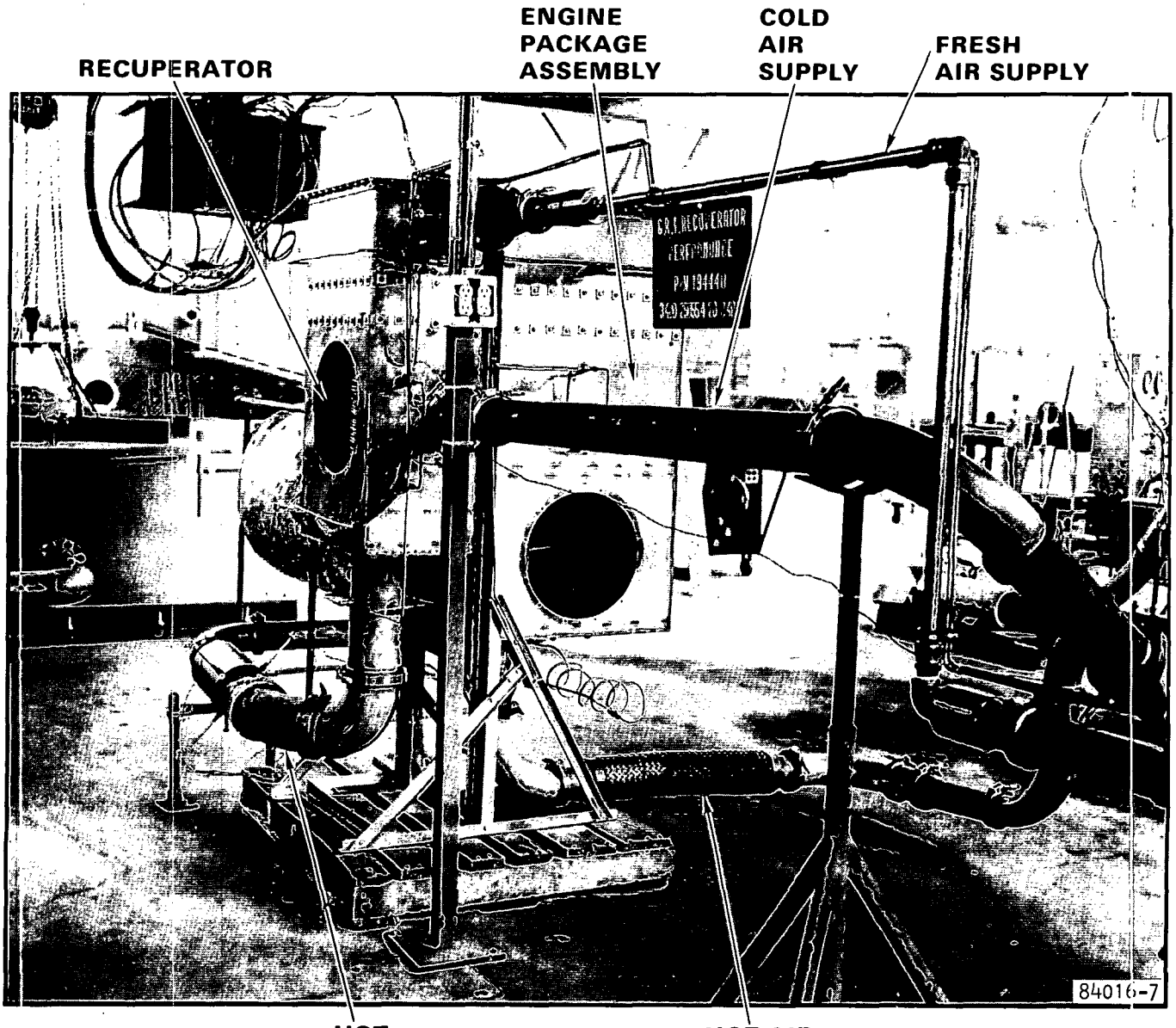
A-10107

RECUPERATOR TEST FACILITY



A-12473

COMMERCIALIZATION STUDY

OBJECTIVES

- SIMPLIFY AND OPTIMIZE DESIGN FOR MINIMUM PRODUCTION COST AT 4000/YEAR RATE
- ESTABLISH CREDIBLE ESTIMATE FOR PRODUCTION COST
- IDENTIFY REQUIRED TOOLING AND ESTIMATE COST
- IDENTIFY REQUIRED FACILITIES

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A-9216-A

ROTATING ASSEMBLY COMMERCIALIZATION STUDY

FACTS

- GIVEN ADEQUATE TOOLING, UNIT COST BECOMES ASYMPTOTIC TO MATERIAL COST WHEN PRODUCING LARGE QUANTITIES
- EXAMPLES OF HIGH PRODUCTION UNITS

AIRESEARCH TURBOCHARGERS	DIRECT COST	
	MATERIAL	LABOR
245,000/YEAR	70%	30%
60,000/YEAR	65%	35%
GT601 TRUCK GAS TURBINE (EST)		
10,000/YEAR	70%	30%

- MATERIAL COSTS ARE RISING SIGNIFICANTLY, PARTICULARLY FOR THE MORE EXOTIC ALLOYS

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ROTATING ASSEMBLY COMMERCIALIZATION STUDY (CONT.)

APPROACH

- **REDUCE MATERIAL COST**
  - SEPARATE DESIGN FUNCTIONS WHERE FEASIBLE
  - ONLY USE HIGH COST ALLOY WHERE ABSOLUTELY REQUIRED
  - SIMPLIFY CASTINGS TO USE MINIMUM AMOUNT OF METAL
  - CONSIDER FOUNDRY PROCESS IN DESIGN OF ALL CAST PARTS
- THEN LOOK TO MACHINING SIMPLIFICATIONS
  - CONSIDER ADVANCED PRODUCTION TOOLING WHERE APPLICABLE
- SIMPLIFY ASSEMBLY AND FUNCTIONAL TEST PROCEDURES

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A-9217-A

RECUPERATOR COST REDUCTION

- AUTOMATION OF PROCESSES
- DELETE MANIFOLD SUPPORT FINS
  - REQUIRES HORIZONTAL BRAZE FIXTURE
  - DEVELOPMENT OF PROCESSES FOR FIELD TEST HARDWARE

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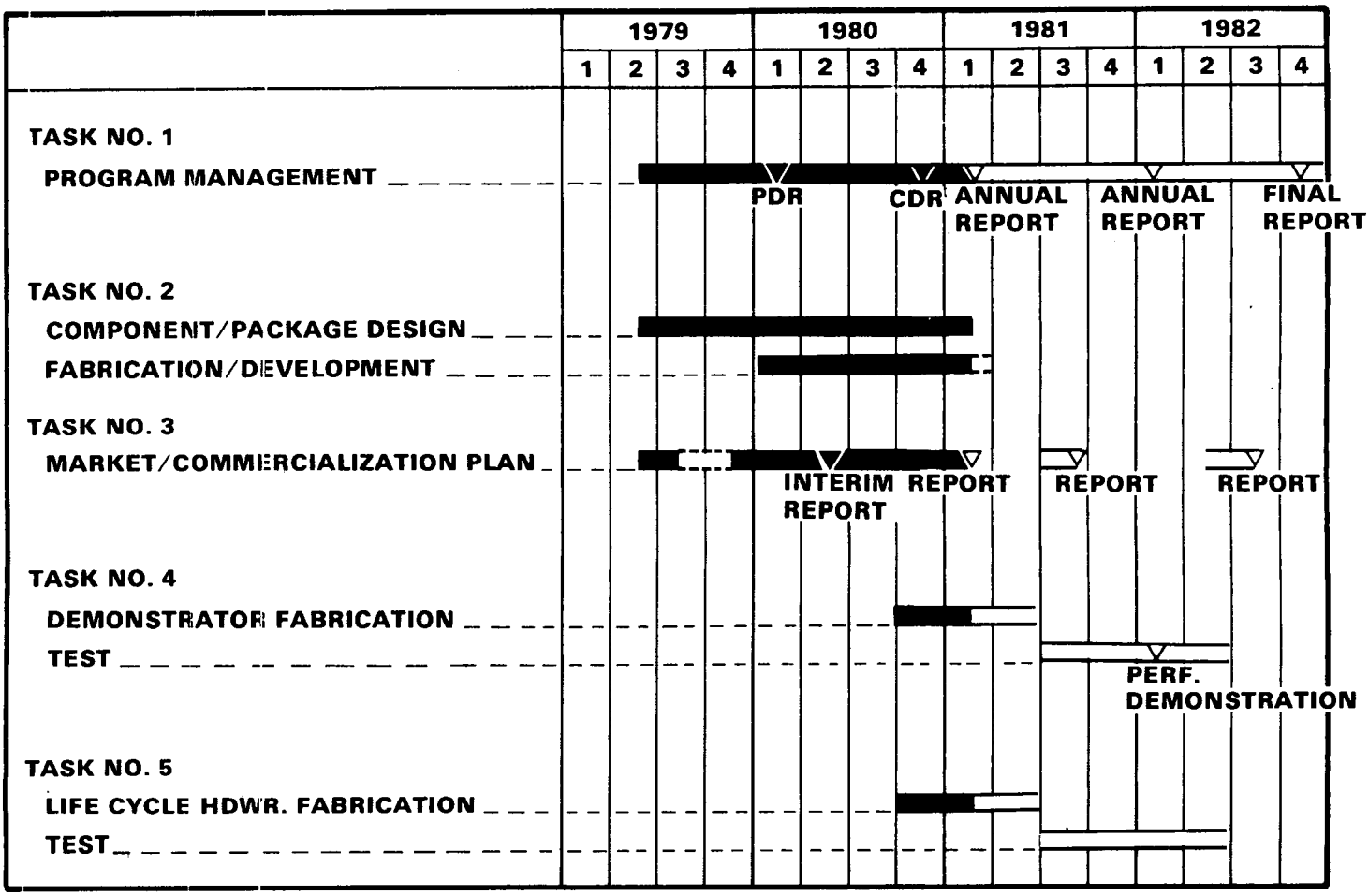
BRAYTON/RANKINE 10-TON SPACE CONDITIONING SYSTEM
SCHEDULE



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