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PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
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PWA F 51

INTER-OFFICE CORRESPONDENCE

PERMANENT MEMORANDUM FOR FILE

PRATT & WHITNEY AIRCRAFT ENGINES

To Mr. W. Doll

From G. N. Frazier

Date September 25, 1963

cc: R. I. Strough
E. R. Dytko
R. W. Kelly
J. W. Heintz
R. M. Meyer
H. C. Gray
G. U. Parks
W. G. Kennedy

Subject Minutes of the September 16, 17 and 18 Meeting to Review the SNAP-50/SPUR Program

Reference: Letter, W. H. Pennington, U. S. Atomic Energy Commission, to W. Doll, Pratt & Whitney Aircraft, dated September 6, 1963

SPECIAL REREVIEW FINAL DETERMINATION Class: 4	Reviewers	Class.	Date
	JBM	4	12-8-81
	JR	4	12-18-81

CONFIDENTIAL — CLASSIFICATION

P. A. Frazier — AUTHORIZED CLASSIFIER

1 — GROUP

9/30/63 — DATE

CLASSIFICATION CANCELLED OR CHANGED TO
BY AUTHORITY OF DIVISION OF CLASSIFICATION
BY: TED REDMON DATE: 11-3-75

This memorandum is a summary of a meeting held at CANEL on September 16, 17 and 18 to review the SNAP-50/SPUR program with representatives of the AEC Division of Reactor Development, SNAP-50/SPUR Office, the USAF Aeronautical System Division, AiResearch Manufacturing Company and AEC - CANEL Project Office. The agenda for the meeting, as outlined in the reference letter was:

1. Discussion of P&WA-CANEL organization with emphasis on the SNAP-50/SPUR program and the heat transfer programs.

2. Discussion of AiResearch organization with emphasis on the SNAP-50/SPUR program and the heat transfer programs.

3. Discussion of contractor responsibilities and relationships for the heat transfer program (moderated by Col. Douthett).

4. Tour of heat transfer facilities and test areas including the proposed prototype boiler test facilities. A discussion of the general arrangement drawings of the boiler test facilities should be presented by P&WA.

5. Discussion of heat transfer program to cover the following items:

   a. Boiler Data

      1. Review in detail available boiler data from P&WA tests.

      2. Discuss new data required.

      3. Discuss analytical techniques and formulate analytical approach to be used in unified program.

b. Review test loops in detail in regard to instrumentation and operation.

c. Resolve any differences that may exist with respect to the thermodynamic, chemical and physical properties of the working fluids.

6. Discussion of comments on Preliminary Design Specifications; CANEL report CNLM-5118 and AiResearch report SY-5570-R, Rev. 1.

7. A general tour of CANEL facilities to begin with a visit to the Machine Shop and the special purpose laboratories as time permits.

Personnel present for the meeting were:

AEC - SNAP-50/SPUR Office	E. Douthett
	H. Rochen
	G. Leighton
	R. Spencer
USAF-ASD, SNAP-50/SPUR	C. Delaney
	R. Self
AEC - CANEL Project Office	H. Pennington
	F. Haines
	C. McFarland
	C. McColley
	R. Egli
AiResearch, Phoenix Division	J. Dannan
	R. Gruntz
	W. Bowler
	D. Walley
AiResearch, Los Angeles Division	J. Killackey
	P. Berenson
	K. Parker
P&WA, CANEL	W. Doll
	N. Frazier
	R. Kelly
	J. Heintz
	R. Strough
	E. Dytko
	H. Means
	A. Centofanti
	J. Murphy
	N. Works
	W. Gray
	D. Randall
	J. Horan
	E. Bernstein
	J. Walton
	P. Perry
	W. Gaffin

The summary is presented as three separate discussions; I) Heat Transfer, II) Powerplant Integration and III) Program Management.

The major decisions made and agreements reached were:

1. CANEL will provide AiResearch with capabilities of the present stainless steel heat transfer stand not later than 10/1/63.

2. All parties to the meeting agreed to the responsibilities of AiResearch and P&WA-CANEL with regard to development of the boiler and condenser as the responsibilities are presented in Section III of these minutes.

3. CANEL will provide AiResearch with a copy of CNLM-5050, SNAP-50 Powerplant Development Plan by 10/1/63.

4. AiResearch will provide CANEL with envelope information on the boiler, turbo-alternator and condensers in time for incorporation in the 11/15/63 preliminary powerplant design.

5. AiResearch materials personnel will visit CANEL to discuss and establish material and process specifications. Date to be established.

6. Working relationships between contractors agreed to are covered in Section III of these minutes.

I. Heat Transfer

The heat transfer meeting held on September 16 and 17, 1963, was concerned primarily with items 4 and 5 of the referenced letter. The meeting was attended in part or in total by the listed attendees with the exception of C. E. McColley of the AEC-CANEL Project Office and W. Doll, W. O. Gaffin, P. I. Perry, J. W. Walton, and N. J. Works of P&WA-CANEL.

The September 16 session began with a presentation by H. E. Means of heat exchanger development at Pratt & Whitney Aircraft and was followed by a tour of the Heat Exchanger Laboratory conducted by R. W. Kelly. Past and present installations and proposed modifications for two boiler test facilities were discussed. K. Parker of AiResearch presented a preliminary design layout of the proposed SNAP-50/SPUR boiler for review and comments. D. G. Randall presented the status of the boiler test program at CANEL and results. This presentation was followed by a tour of the General Laboratory and of heat transfer test rigs in the Shop Laboratory. The remainder of the meeting was spent discussing heat transfer and physical properties data of the working fluids.

On September 17, the heat transfer discussions were continued and were followed by a tour of the Machine Shop to review the columbium fabrication procedures and facilities.

Pertinent details of the meeting follow:

1. Heat Exchanger Development

The development program for liquid-to-liquid heat exchangers over the past 9 years at Pratt & Whitney Aircraft was presented. In

particular, the transition from the first Z- and U- shaped exchangers to the current hockey stick design was discussed and reasons for the adoption of the current design, primarily fabrication difficulties, were presented. Tube-to-header joint development during the same period was also presented. Photographs and physical specimens of current joint techniques were shown.

The current heat exchanger program, including the columbium heat exchangers currently on test as part of the non-nuclear system test, was described. Heat exchanger components and an assembled exchanger of the current design were displayed and a brief explanation of current fabrication procedures was given. Finally, the procedures for maintaining cleanliness of the columbium parts during fabrication were presented, (Enclosure I-1).

2. Tour of Heat Exchanger Laboratory

A review of previous heat exchanger tests depicting equipment and piping was presented. A schematic of the present columbium and stainless steel systems was also presented and a tour of the building was made to review the present installation. Modifications required to the laboratory for two boiler test facilities and the schedule for the completion of the facility and start of testing were discussed. A line flow schematic representing components and functional operation of the system and an isometric piping drawing showing installation of the piping and boiler into the test chamber were presented.

3. Presentation of AiResearch Boiler Design

K. Parker presented a preliminary layout of the proposed U-shaped SNAP-50/SPUR boiler design for comment and an oral critique was made during the meeting. The U-shaped design was proposed for reasons of flow distribution and ability of the U-tube to compensate by axial growth for thermal stresses due to the increase of wall temperature resulting from oscillation of the liquid vapor interface along the tube. R. W. Kelly pointed out some of the fabrication problems that CANEL had experienced in the fabrication of this type boiler. K. Parker felt that the shell could be bent into shape such that reasonable tolerances would permit sliding it over the tube bundle. He also pointed out that for stable operation each tube would be orificed to compensate for the required different length tubes. K. Parker left the boiler layout with R. W. Kelly for information.

4. Status of Boiler Test Program

D. G. Randall presented the status of the boiler test program at CANEL. The essence of this presentation may be found in CNLM-5224 except for additional heat transfer data that was presented.

K. Parker inquired into what tests were planned for the existing heat transfer rigs. D. G. Randall explained that CANEL is considering ribbon-tube and other shapes, such as dual diameter tubes and internal finned tubes. G. Leigleton asked if boiling on the shell side had been considered. J. J. Horan stated that a high fluid velocity would exist

if boiling took place and that it would require an extended development program to obtain a boiler for this condition. P. Berenson asked where the conductivity of lithium values were obtained and was provided with a list of physical properties data compiled and recommended by S. Kapelner of CANEL. AiResearch requested specifications for the CANEL stainless steel heat transfer rig and R. Kelly agreed to supply them. Following these discussions, a tour of the General Laboratory and boiling heat transfer rigs was made.

The remainder of the meeting was spent discussing data reduction procedures and physical properties data to be used for both fluids. AiResearch discussed briefly their program for diffusion bonding ribbons inside tubes by swaging tubes onto the ribbon and then heat treating. The program of Cb tube-to-header joints was presented by V. P. Treciokas. D. G. Randall presented a preliminary layout of the sine wave boiler for comments and the layout was given to AiResearch representative for review.

J. Kilackey and K. Parker toured the CANEL Machine Shop to review the columbium machining, welding, inspection, heat treating and cleaning facilities. P. Treciokas elaborated on the importance of maintaining controlled atmosphere while welding columbium. He pointed out that an inert atmosphere of less than 2.5 ppm of O_2 and 10 ppm of moisture must be maintained during welding to prevent weepage through the weld during high temperature operation in lithium.

II. Powerplant Integration

The meetings were held September 16, 17, 18, 1963 to discuss in detail the critique of CNLM-5118, Preliminary Powerplant Specifications and to discuss problems relating to overall powerplant design and control. The meetings were attended at various times by:

USAF-ASD	C. Delaney
CANEL AEC	R. Egley
AiResearch	J. Dannan W. Bowler D. Walley R. Gruntz
CANEL (P&WA)	S. Murphy W. Gray N. Works J. Heintz J. Walton W. Gaffin P. Perry N. Frazier

The specific topics discussed are summarized below with conclusions, where applicable.

1. Boiler preheater - The discussions centered on three areas: a) The possible increase in cycle efficiency and decrease in powerplant weight

and radiator area; b) Improvement of boiler stability; and c) The structural problem of boiler design with a high ΔT across the potassium inlet tube sheet. The boiler design personnel felt that the structural problem could be effectively designed around and that the preheater outlet temperature, using potassium as the heating fluid, was not high enough to enhance boiler stability. The improvement in efficiency, weight and area due to the preheater is modest and does not seem to warrant the added complexity caused by addition of the preheater to the potassium circuit. For these reasons, the preheater was eliminated from the powerplant.

2. Redundant radiators - The radiator segmentation criteria to be used for the first flight powerplant will be a 0.9 probability of 3/4 power in 10,000 hours. Vehicle consideration may limit the allowable radiator area that can be carried and are the predominant consideration in this decision. P&WA will determine the powerplant conditions resulting from radiator segment failures.

3. Powerplant frequency - The AEC program office has designated the user frequency as 3200 cps. It was agreed that a lower frequency is required within the powerplant for pump drive motors and other auxiliary equipment and that this frequency would be supplied by an additional alternator on the main turbo-alternator shaft. P&WA expressed the desire that this lower frequency be 400 cps in order to increase the motor development flexibility, permit the use of EM pumps in the powerplant should current studies indicate their feasibility and permit the use of 400 cps technology and equipment throughout the development program. AiResearch will study the mechanical design of a two pole 400 cps generator at 60 KW, 0.6 power factor for this application and will advise P&WA within a month as to its feasibility.

4. Parallel versus series flow reactor coolant pumps in modular powerplants - AiResearch has proposed the use of two reactor coolant pumps in series in multi modular powerplants. This will be studied further by P&WA. No conclusions were reached.

5. Startup - A general discussion of startup was held and centered about whether or not the turbo-alternator could be liquid filled during start up. It was concluded that a great deal of further effort is required in this area and studies will be continued.

6. Radiator configuration - A discussion of cylindrical and planar radiators, including shield effects, was carried out but no conclusions were reached. Since powerplant support is involved in this decision, vehicle contractor input is required. Powerplant studies of both configurations will be continued to define relative advantages and to identify the constraints imposed by each configuration.

7. Condenser - Jet Pump - Agreement was reached on a parallel segmented condenser arrangement. The jet pump requirements in the power conversion loop were discussed but no conclusions were reached.

8. Auxiliary Cooling System - It was agreed that segmentation in the auxiliary cooling system was desirable. Studies will be carried out by P&WA to determine the best method of obtaining segmentation con-

sistent with the main radiator.

9. Powerplant weight - It was agreed that reports on powerplant characteristics would include a tabulation of powerplant weight. This tabulation will contain only those components which are part of the mission weight with the powerplant operating.

10. Program planning - AiResearch provided P&WA with a copy of report SY-5447-R "Spur Development Plan." P&WA is to send to AiResearch a copy of CNLM-5050 "SNAP-50 Powerplant Development Plan." It was agreed that the flight test goals require further definition.

11. Control - AiResearch has assumed the need for a full power parasitic load to handle significant instantaneous electrical load changes. This reduces, somewhat, the complexity of a control system since reduction in reactor power and temperature with reduced electrical load would not be required except to conserve fuel burnup. These comments will be considered in the P&WA design effort on the powerplant control.

12. Powerplant Design - P&WA drawing L-101842 was reviewed breifly. AiResearch will furnish P&WA with envelope drawings of the boiler, condenser and turbo-alternator so that they may be incorporated in the preliminary powerplant design to be completed by 11/15/63.

III. Program Management

The meeting was held on September 17, 1963 with limited attendance, to discuss contractor responsibilities for SNAP-50/SPUR and the general procedures to be followed by the contractors in fulfilling these responsibilities.

The meeting was attended by:

AEC SNAP-50/SPUR Office	Col. Douthett L. Leighton H. Rochen Major R. Spencer
AEC CANEL Project Office	H. Pennington R. McFarland C. McColley
USAF-ASD-SNAP-50/SPUR	J. Self
AiResearch Manufacturing Company	J. Dannan W. Bowler D. Walley
P&WA - CANEL	W. Doll R. Strough N. Frazier

(This meeting was preceeded by a meeting attended generally in which W. Doll and J. Dannan presented respective organizations. No minutes will be presented of the meeting on organization but applicable functional organization charts are enclosed. See Enclosures II-1 and III-2).

Col. Douthett opened the meeting at about 12:00 by presenting the responsibilities of AiResearch and P&WA - CANEL with respect to the boiler and condenser programs. (Enclosure III-3). J. Self questioned CANEL's responsibility for approving the boiler and condenser designs. A general discussion was held and Col. Douthett stated that the responsibility would stand as written.

The subject of working relationships between AiResearch and CANEL for the purpose of powerplant integration was discussed. A recommended list of working procedures was presented by R. I. Strough. These were:

1. The technical interface at CANEL will be N. Frazier. This will include powerplant design, system problems, changes to component parameters, etc. It will also include component development interface problems on initial contact; detailed work to be accomplished by engineers directly involved once working relationships have been established. For the boiler program, AiResearch will deal directly with R. Kelly and his group. J. Dannan designated D. Walley at Phoenix as the liason man for AiResearch and K. Parker at Los Angeles as the AiResearch project engineer for the boiler program.

2. Meetings, visits and correspondence will be conducted as required to accomplish the designated responsibilities. These will be handled on a direct basis between AiResearch and P&WA-CANEL.

3. N. Frazier and D. Walley will be notified of all visits and meetings between any parts of the two organizations before the fact.

4. N. Frazier is responsible for notifying the CANEL AEC Project Office of such meetings and/or visits. D. Walley will have the responsibility for notifying USAF-ASD Office.

5. Copies of all written correspondence involving technical information and/or decisions will be sent to N. Frazier, J. Dannan, R. McFarland (AEC - CANEL Project Office), Col. Douthett, and C. Armbruster, AF-ASD, Wright Field.

6. Oral communications involving technical information and/or decisions will be followed by written confirmation within 5 working days and copies as above.

7. All meetings and visits to be documented by host organization within 5 working days with copies as above.

8. A log of meetings and visits will be maintained by the appropriate working groups. It will contain date, place, attendees, subject and conclusions.

9. Powerplant design review meetings will be held at CANEL every three months. The first such review is scheduled for 12/10/63. This date has been changed from the date of 12/17/63 originally discussed because of travel difficulties in late December. If no objection to the date is voiced prior to 11/1/63, it will be assumed valid. Design review meetings other than scheduled

times will be held at the request of either contractor or of the government agencies.

10. CANEL will receive AiResearch reports as part of normal distribution and vice versa. CANEL will assume the responsibility of keeping the AEC informed of the status of the powerplant through existing reporting systems.

11. PERT will be the means of establishing programs and monitoring progress. Details will be worked out between CANEL and AiResearch for every application of PERT to the SNAP-50/SPUR program.

12. All remarks apply to radiator and vehicle contractors when designated.

13. It is recognized that resident engineers may be required at either or both locations. These will be provided as required by the job being done.

These procedures are listed as they were accepted after discussions.

The December date was questioned as the first design review date. It was explained that this date was selected as consistent with the date of 11/15/63 for completion of the preliminary powerplant design and revision to the design specifications. It was concluded that the December date was acceptable.

Program planning was discussed and R. I. Strough stated that CANEL personnel were in the process of studying possible programs as a function of major goals and projected funding. At an appropriate time, a recommended program will be presented to the AEC.

AiResearch was asked if they could indicate development programs including schedules and costs, for components designated AiResearch responsibility. J. Dannan provided CANEL (N. Frazier) with a copy of report SY-5447R which had been prepared at the request of the Air Force. The information contained in the report will be used for planning purposes.

The materials work at ORNL was discussed and it was agreed that ORNL would work directly with AiResearch on work associated with the Cb - stainless steel bi-metallic joint.

The need for a vehicle contractor was discussed since vehicle constraints affect the powerplant arrangement and may affect component designs. Col. Douthett established AiResearch as responsible for vehicle information in conjunction with radiator work now in progress.

W. Doll assured AiResearch that CANEL was open to AiResearch personnel for the purpose of sharing CANEL's engineering, fabrication and test experience. Col. Douthett inquired about establishing material specifications. N. Frazier stated that such specifications are included in CNLM-5118. It was agreed that AiResearch metallurgists will visit CANEL to discuss specifications and that CANEL specifications will be made available for study. A set of accepted specifications, agreed to by both contractors, will be issued by CANEL. The meeting was closed at 1310.

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G. N. Frazier

GNF:gpb
Contract AT(30-1)-2789

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CB-ALLOY PROCUREMENT, WELDING & ANNEALING TECHNIQUES

Material specifications closely control interstitial content (oxygen, nitrogen, carbon and hydrogen) as well as other elemental additions. Close liaison is maintained between the materials laboratory and vendors supplying the various refractory alloy mill products.

Incoming material to be used for liquid metal application is 100 percent inspected by non-destructive techniques including X-ray, ultrasonic, fluorescent penetrant and mechanical inspection. Spectrographic and chemical analyses are made on each heat or lot material.

Material is thoroughly cleaned prior to welding and heat treat operations by vapor degreasing, alkali immersion, acid pickling, domestic and demineralized water rinsing. Drying is accomplished by use of argon gas and of infra red lamps. Cleaned material is wrapped in argon filled polyethylene bags. Personnel handling cleaned parts wear clean white nylon gloves. Packaging, assembly, loading of welding chambers and heat treat retorts are accomplished in a clean room having controlled temperature of 72 ± 2F, relative humidity of less than 20 percent and a particulate matter content not to exceed 100 airborne particles per cubic foot.

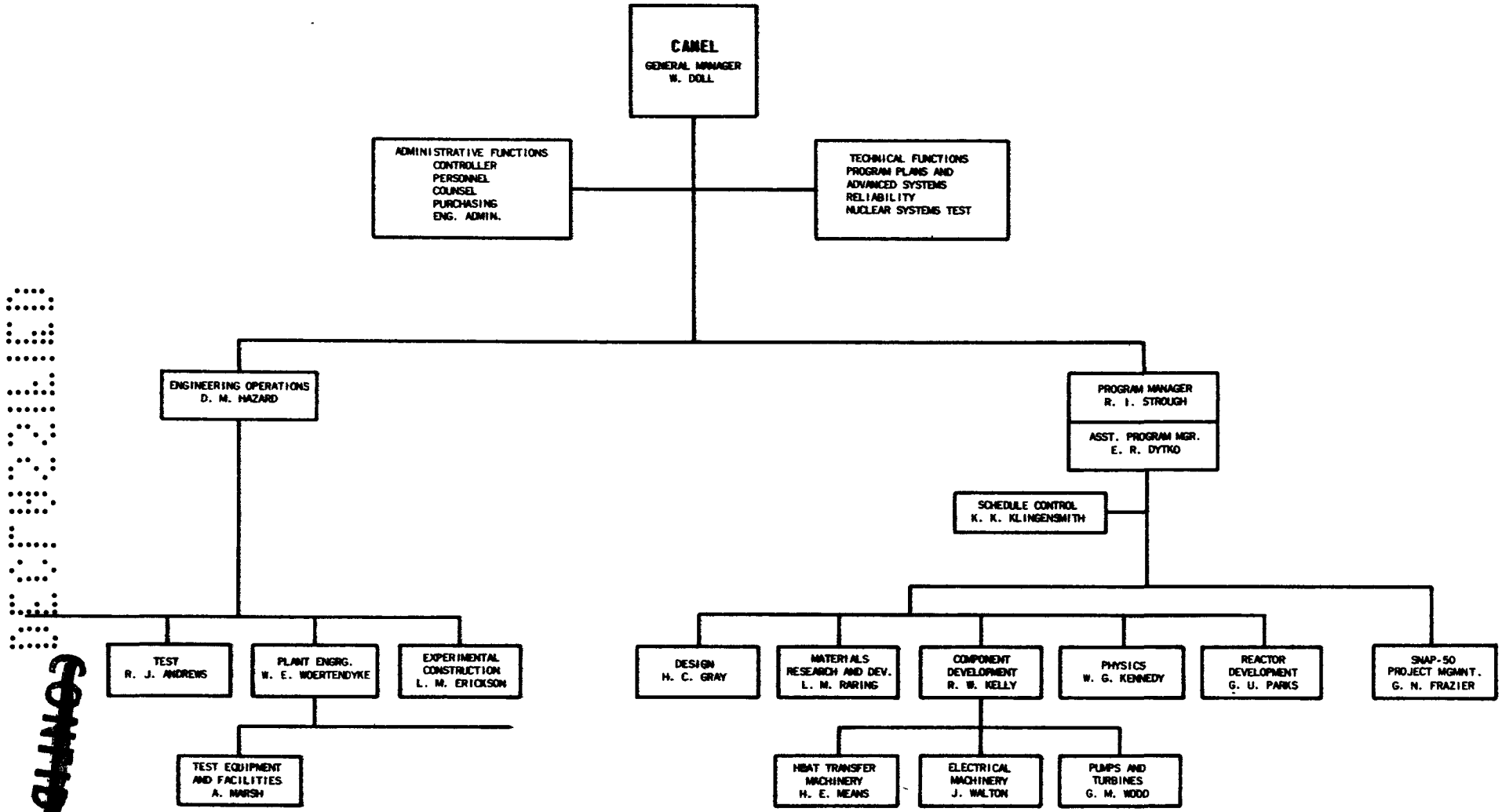
Welding is accomplished in atmosphere chambers using manual and semi-automatic tungsten arc inert gas shielded processes (T.I.G.). Two techniques are employed, dependent on chamber size to attain and maintain high purity inert atmospheres during the welding cycle. The larger room type chambers are equipped with recirculating purification systems employing titanium sponge and molecular sieve units for removal of oxygen, nitrogen and moisture.

Walls of smaller and intermediate size chambers are of double wall construction to allow steam heating to temperatures of 250F to 300F during chamber evacuation to vacuums of 0.1 micron or better to accomplish off gassing of adsorbed moisture on parts of chamber surfaces. During the welding cycle walls are cooled by circulating cold water to prevent heat up and thus inhibit further off gassing. These techniques maintain inert atmosphere in the chambers to a maximum oxygen content of 2.5 ppm and a maximum moisture content of 10 ppm. Oxygen and moisture content of chamber atmosphere is continuously monitored throughout the entire welding cycle to insure the above limits are not exceeded.

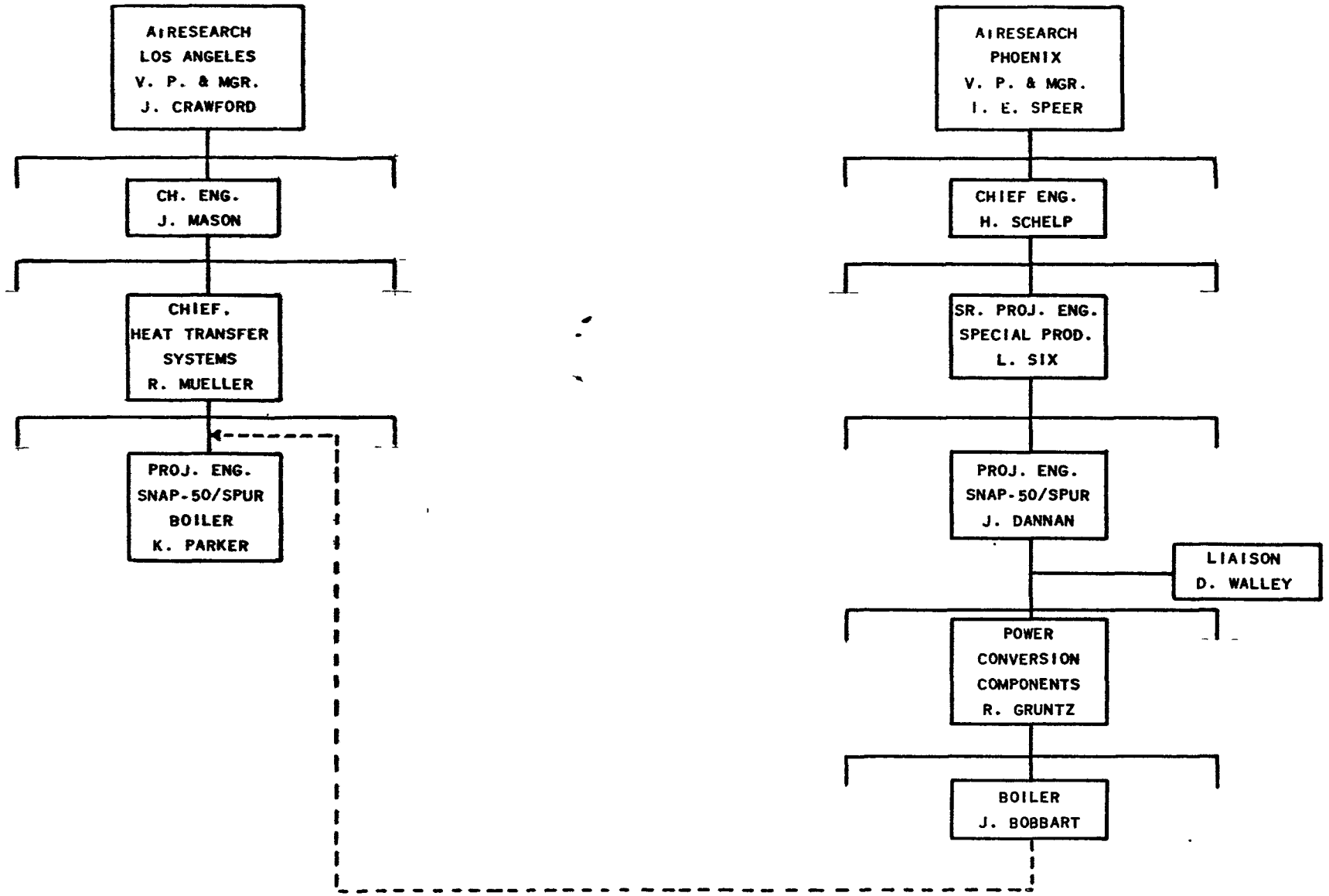
All welds are heat treated at 2200F for 2 hours in an argon atmosphere for the threefold purpose of 1) reducing welding stresses 2) overaging fusion zone to prevent an aging phenomenon and subsequent loss of ductility in the range 1500F to 1700F and 3) enhancing corrosion resistance to certain liquid metals by effecting grain boundary micro-structural changes.

Tantalum foil wrapping of cleaned parts and the use of columbium chips as gettering media in the heat treat retorts in conjunction with continuous monitoring of atmosphere allow the heat treating of columbium alloys without contamination pickup. A combination of baking, purging and retort evacuations at 400F and 600F is used to exhaust the majority of adsorbed moisture prior to elevated temperature exposure. During heat treat cycle maximum oxygen and moisture limits are controlled to 2.5 ppm and 14 ppm respectively.

The argon header system contains gas having a total contamination level for oxygen and moisture of approximately 1.5 ppm.



ENCLOSURE III-1



ENCLOSURE III-2

September 6, 1963

RESPONSIBILITIES FOR SNAP-50 BOILER DEVELOPMENT

P&WA

1. Overall powerplant system design to include the specification of lithium pressures, temperatures and flow rates to AiResearch for use in the boiler design.

2. Testing of the full-scale refractory metal boilers and condensers in the Boiler Test Facility at CANEL, using AiResearch engineers to monitor and assist the testing. This includes responsibility for preparation of test procedures utilizing AiResearch test plans.

3. Operation of existing boiling liquid metal test loops at CANEL. Tests to be performed will be coordinated with AiResearch and modified so that the results of these tests contribute directly to the AiResearch development program.

4. Review and approval of the AiResearch boiler and condenser design from the standpoint of system compatibility, fabricability, component integrity, and safety of operation.

AiRESEARCH

1. Boiler and condenser design and development.

2. Providing design parameters for the assigned components to Pratt & Whitney Aircraft for review and modification as required for integration into the total powerplant and control system design.

3. Development through the design of full-scale refractory metal components, to include fabricating and testing of prototype models (glass-freon, and Haynes-25-potassium).

4. Providing the instrumentation necessary for performance and endurance testing of the full-scale units.

5. Providing Pratt & Whitney Aircraft the test plans for the full-scale refractory metal components.

6. To monitor and assist Pratt & Whitney Aircraft in the necessary testing of the full-scale refractory metal components.

7. Approval of the Boiler Test Facility design from the standpoint of adequacy to test the AiResearch-designed components.