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DIVISION

TECHNICAL MEMORANDUM

PREPARED BY: E. F. Perez, D. L. Forrest

ABSTRACT

WEIGHT-AREA TRADE-OFF STUDY FOR A FLAT SNAP-8 RADIATOR

An analysis was made to permit evaluation of the trade off between radiator area and weight. A method was developed to determine the optimum manner in which the radiator projected area can be reduced with a minimum increase in radiator weight.

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C. C. Ross

NOTE: This document is considered preliminary and is subject to revision as analysis progresses and additional data are acquired. The general reader may encounter internal reference not available to him.

Aurist-General

WEIGHT-AREA TRADE-OFF STUDY FOR A FLAT SNAP-8 RADIATOR

I. INTRODUCTION

The radiator area of the four-loop system is significantly greater than the area for the former two-loop system for the following reasons:

More heat is being rejected

Cycle heat rejection is accomplished at a lower average temperature

Two low-temperature sections have been added for component cooling.

Therefore, for system and vehicle integration considerations, there is interest in determining the weight penalties associated with a reduction in radiator area.

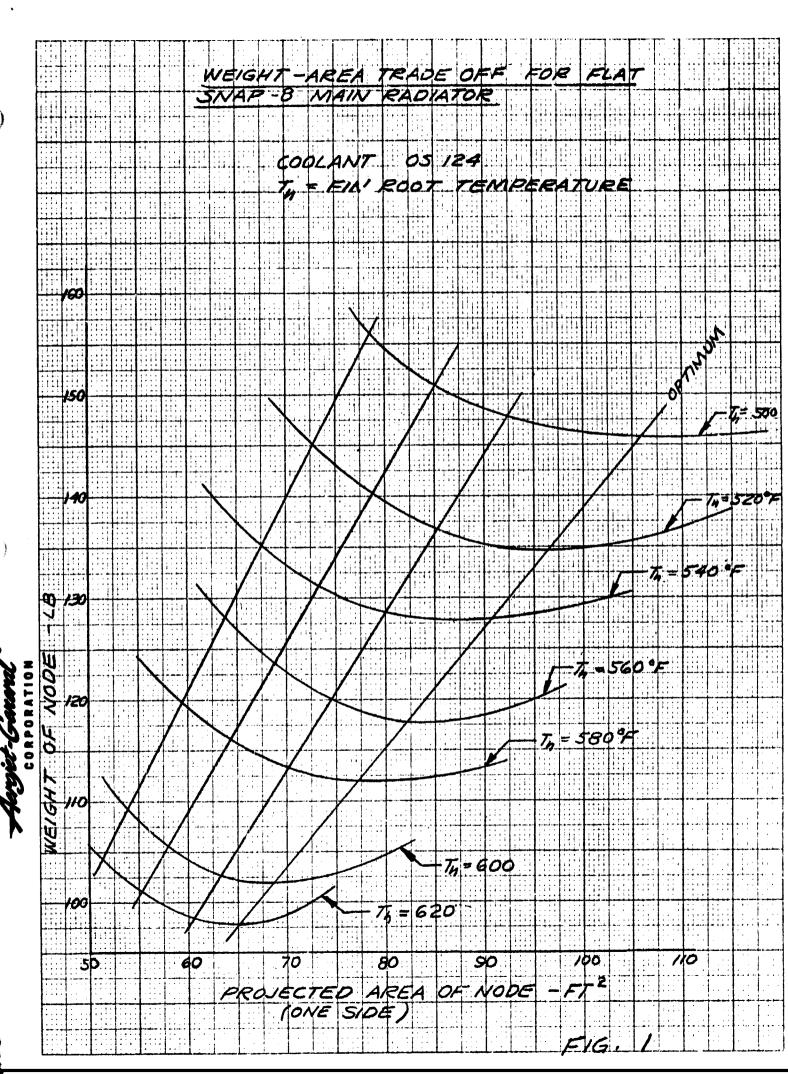
This study is based on a tube-and-fin type radiator with the use of OS-12h as the radiator heat-transfer fluid.

II. DISCUSSION

An analysis has been made to permit evaluation of the trade off between radiator area and weight. A method was developed for determining the optimum manner in which the radiator projected area can be reduced with a minimum increase in radiator weight. The development of this method is included in the Appendix and is described briefly as follows:

The radiator is considered to consist of several equal heat-rejection nodes of decreasing temperature. The average tube surface temperature for each node is used for evaluating the heat radiated to space. The number of nodes is determined by the accuracy desired. Heat rejection from the fins is evaluated by using the data of Mackay and Bacha, Reference 1. The parameters for each node, including tube length and fin dimensions, are optimized for a specified heat rejection, temperature level, tube diameter, fin taper ratio, and several projected areas. Weights are calculated and plotted as a function of projected area. This procedure is repeated for each of the nodes. Data for the main

radiator are presented in Figure 1. Next a locus of points having equal $\frac{dw}{da}$ are plotted and a composite radiator is constructed in which each node has an equal weight-for-area trade off. The weight and area for each composite radiator are computed and weight is plotted as a function of area. Figure 2 is a plot for the main radiator, which shows that for a 25% decrease in area from the optimum weight configuration, the weight increase in approximately 8%.



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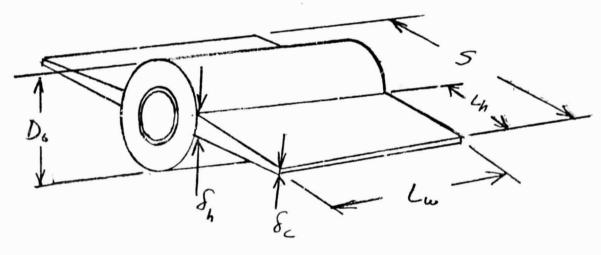
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BJECT		PRENDIX	BY_D.L.	F. JEP.	WORK ORDER_		
	RADIATOR		FOR	AREA	TRADE	DIEF	
	ANALYSIS						

IN THIS ANALYSIS A METHOD IS DEVELOPED FOR MODIFYING THE RADIATOR PROJECTED AREA, FROM THE OPTIMUM WEIGHT CONFIGURATION, WITH A MINIMUM INCREASE IN WEIGHT.

IF WE CONSIDER THAT THE RADIATOR IS MADE UP OF SEVERAL EQUAL HEAT REJECTION NODES, FOR WHICH THE AVERAGE TEMP. WILL ACCURATELY DESCRIBE THE HEAT RADIATION, AND THAT HEAT REJECTION FROM THE FINS CAN BE DETERMINED BY USING THE DATA OF MACKAY & BACH REF. I, THEN THE RADINTOR MAY BE ANALAYZED IN THE FOLLOWING MANNER



PROJECTED AREA

S = Do + 264 (SPAN BETWEEN TUBES)

REF. 1. D.B. MACKAY, C.P. BACHA SPACE RADIATOR DESIGN & ANALYSIS PART I" ASD TECH. REPORT 61-30 OCT. 1961

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NOMENCLATURE

A RADIATOR PROJECTED AREA (ONE SIDE)

B VARIABLE DEFINED IN EON. YO

C, PARAMETER USED IN REFERENCE (1)

C. PARAMETER USED IN REFERENCE (1)

E ENVIRONMENTAL PARAMETER

K THERMAL CONDUCTIVITY OF FIN MATERIAL

LA FIN HALF WIDTH

LW LENGTH OF FIN AND TUBE

9 HEAT REJECTED FROM THE FLUID IN THE RADIATOR

S SPAN BETWEEN TUBES

TH TEMPERATURE AT ROOT OF FIN

WR WEIGHT OF RADIATOR TUBE AND FINS

WI WEIGHT PER FOOT OF TUBE AND ARMOR

SA THICKNESS OF FIN AT ROOT

& THICKNESS OF FIN AT TIP

PENSITY OF FIN MATERIAL

5 PARAMETER DEFINED IN REF (1)

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$$S_{h} = \frac{c_{1} T_{h}^{3} L_{h}^{2}}{K_{h} S_{p}} \tag{3}$$

$$B = \frac{K_1 C_1 T_{13}^3 \left(1 + \frac{S_c}{S_H}\right)}{K_{AL} S_p} \tag{42}$$

$$\frac{d^{2}L_{1}}{dL_{1}} = \frac{5}{2Lw}$$

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SUBSTITUTING INTO (5) AND EQUATING TO ZERO FOR OPTIMUM WEIGHT.

SUBSTITUTING FOR S AND REARRANGING

$$L_{3}^{3} + \frac{3}{4} D_{0} L_{4}^{2} - \frac{W_{7}}{28} = 0 \tag{6}$$

TYPICAL NUMBERS FOR DO AND B INDICATE
ONE POSITIVE REAL ROOT FOR (6)

HEAT REJECTED FROM THE FLUID

$$L_{w} = \frac{q}{\left[\left(\frac{\pi}{2} - E\right)D_{o} + 2 \cdot \Gamma L_{h}\right]C_{f} T_{h}^{\mu}}$$
 (7)

THEREFORE IF WE TAKE A TUBE AND
FIN SECTION WITH IN NODES AND EACH NODE
IS AT AN AVERAGE TEMPERATURE THO, AND
WE SPECIFY &, Ut, Do, Se WE CAN CACULATE
WEIGHT AS A FUNCTION OF AREA USING
EQUATIONS (1), (3), (4), (40), (6) AND (7)

AS SHOWN IN THE FOLLOWING SKETCH

SUBJECT

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WE CAN THEREFORE CONSTRUCT A RADIATOR IN
WHICH ALL THE SECTIONS HAVE EQUAL AT

AND THE FIN DIMENSIONS AND TUBE LENGTH
HAVE BEEN OPTIMIZED FOR MINIMUM WEIGHT

AND WIDTH WILL VARY ALONG THE LENGTH.

IF WE TAKE ALTERNATE CONFIGURATIONS

DIFFERENT FROM THE OPTIMUM (LINE C)

WE CAN DO SO WITH A MINIMUM INCREASE

IN WEIGHT