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MEMORANDUM FOR PRS (Contractor/In-House Publication)

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SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-AB-2002-016**
Steve Fentress (P&W); Christine Cooley (P&W); Eric Spero (PRSE), "Advanced Expander Combustor (AEC) Hot Fire Testing Results" ABSTRACT ONLY

38th AIAA/ASME/SAE/ASEE JPC&E **(Statement A)**
(Indianapolis, IN, 07-10 July 2002) **(Deadline: Past due, extended???)**

Short Abstract

Title: Advanced Expander Combustor (AEC) Hot Firing Test Results

Prime Author: Steve Fentress: Pratt & Whitney
Co-authors: Christine Cooley: Pratt & Whitney
Eric Spero : United States Air Force Research Laboratory

This paper summarizes the test results of a full scale copper tubular combustion chamber for application in a high thrust Upper Stage Expander Cycle Engine. The chamber was developed by Pratt & Whitney Liquid Space Propulsion under contract for the United States Air Force Research Laboratory (AFRL). The Advanced Expander Copper Tubular Combustor (AEC) was hot fire tested on Pratt & Whitney's E8 component test facility in July 2001 and demonstrated the necessary heat load capacity and coolant pressure drop characteristics to support future high thrust expander engine applications.

Extended Abstract

Title: Advanced Expander Combustor (AEC) Hot Firing Test Results

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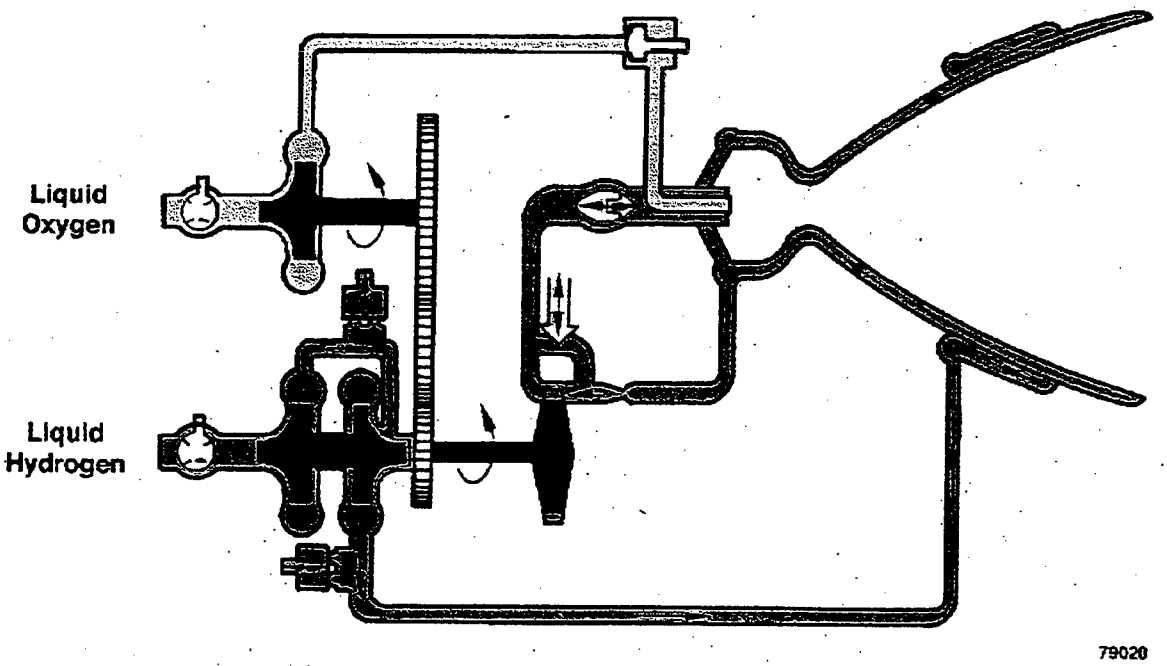
The expander-cycle engine offers the ability of placing payloads into orbit at low cost and with high reliability. An expander-cycle rocket engine cools the chamber/nozzle components with the engine fuel flow. Currently, the growth potential of the RL10 family is limited by the fuel pump discharge pressure which is in turn limited by the heat pickup capacity of the combustion chamber and regeneratively cooled nozzle. While a tubular chamber construction provides higher heat transfer surface area than a flat walled milled channel combustor, the moderate conductivity of the RL10 stainless steel tubes limit the heat load capacity per unit area. The ability to transfer more heat across the chamber cooling wall is essential to providing the increased energy required for higher turbopump output, chamber pressure, and thrust, in the advanced expander cycle.

Figure 1 - RL10 Expander Cycle System with Gearbox



To attain the highest thrust in the smallest dimensional envelope, the combustion chamber heat pickup must be maximized. Until recently, no significant improvement in combustion chamber tube thermal conductivity was available without an unacceptable sacrifice in material strength, and oxidation/erosion capability. PWA 1177 tube material was developed by Pratt & Whitney to meet this challenge.

Development of an advanced-technology combustion chamber that increased chamber pressure and overall engine performance with high reliability and operability were the primary goals of the Advanced Expander Combustor (AEC) Program undertaken by both Pratt & Whitney and the United States Air Force Research Laboratory. The AEC, using PWA 1177 tubes, became the first full scale, hydrogen cooled, copper tubular chamber to be designed, fabricated and hot fire tested.

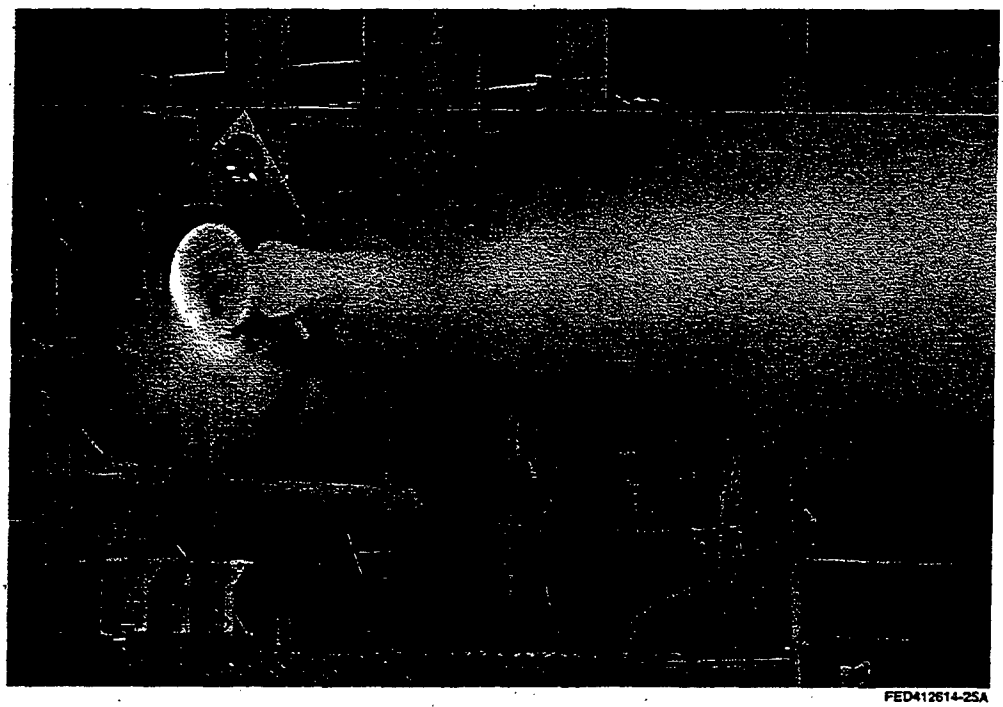
The design goal for the AEC was to maximize coolant heat pick-up with a minimum coolant pressure drop, chamber weight and production cost. The accommodation of high heat flux levels required thermally compliant chamber materials and geometries.

The AEC was designed and verified during test to provide:

- Tubular geometry & construction with maximum surface area and heat pick-up,
- A naturally compliant copper tubular pressure vessel with acceptable strain levels in response to thermal stresses,
- Acceptable pressure losses of the hydrogen coolant.

The AEC hot fire occurred in July 2001. Post test data analysis verified the additional heat load capacity required to achieve the high chamber pressure of a 60-65K thrust expander engine.

Figure 2 - Hot Fire Test of Advanced Expander Combustor (AEC)



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