

Gateway News



American Institute of Aeronautics and Astronautics, St. Louis Section

November 1997

Chairman's Corner

The Nomination Package for the Young Professional Award for 1997-1998 should have now been received by all AIAA members. It is important that members of the Saint Louis Section seek nominees for this important award. In a letter sent to AIAA members by Rudy Yurkovich, as AIAA Deputy Director - Technical for Region V, Rudy discusses the difficulties technical organizations are having in attracting new members. As Vice Chairman of the Saint Louis Section, Rudy is actively working to reverse this trend. An important element in these efforts for the Saint Louis Section is the recognition of the contribution that young AIAA members are making to their employer. We ask all AIAA members to look for young professionals in their organization that are eligible for nomination to the Young Professional Award. Recognition of the contribution of these young members can provide a basis for long term membership and active participation in the AIAA. We ask the support of all AIAA members in recommending

Young Professional Award nominees and in talking with young engineers about the advantages in joining the AIAA as part of their professional growth and ability to meet others that are in the aerospace industry.

The first two meetings for this program year were not the traditional dinner meeting format, but an earlier meeting with an informal sandwich/pizza menu held in Bldg. 100. We had hoped that this format would encourage more students and members to attend. We would like to hear from the membership. We would also ask the membership to express their opinions about this format and if they would like to see more meetings in this format.

We hope to see you at future meetings, and ask your support in seeking new AIAA members from new arrivals to Saint Louis and young professionals. ■

Paul

Early Jet Propulsion Concepts

by John Leonard

Most forms of jet engines today consist of a compressor, followed by a combustion chamber and a turbine that is connected by a shaft to the compressor. These components provide hot air to a nozzle which accelerates it to produce thrust. An afterburner may be added for additional thrust, and part of the compressor may be enlarged into a fan to reduce the fuel consumption.

Early in the development of jet propulsion, other methods were tried. General Electric modified a turbo-supercharger into a jet engine. The Italians and the Russians both developed early jets that used a piston engine instead of a turbine, to drive the compressor. The French combined a jet engine with a ramjet to produce a turbo-ramjet engine. Early research substituted hydrogen for kerosene fuels; however, Pratt & Whitney developed an engine where hydrogen fuel was heated and expanded in a turbine to drive the compressor. These engines differ from today's jet engines and are the subject of this article.

1. GE Turbo-supercharger with Interburning

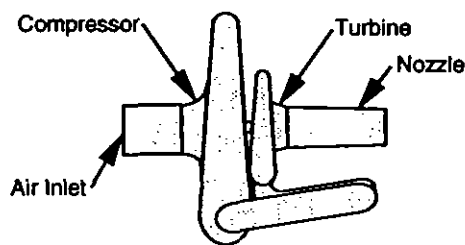
A turbo-supercharger consists of a compressor and a turbine on a common shaft. It extracts energy from the exhaust gas of a piston engine and uses the energy to compress the air going into the engine. The French had turbo-supercharged aircraft flying in World War I. Many aircraft, such as the P-38, P-47, B-17, and B-24, used them in World War II.

An early jet engine was built and flown in the Northrop JB-1 (Jet Propelled Bomb) which had a flying wing design with a 28.3 ft. wingspan. The propulsion system consisted of two General Electric turbo-superchargers each of which had a single combustion chamber inserted between the compressor and turbine as illustrated in the figure. These jets had a rated thrust of 200 lb each. Because of their unusual shape they did not fit in the aircraft very well.

The JB-1 flew only once, and that was on December 7, 1943, from Eglin AFB. It was mounted on a launching sled and, in addition to the two jet engines, used two rocket

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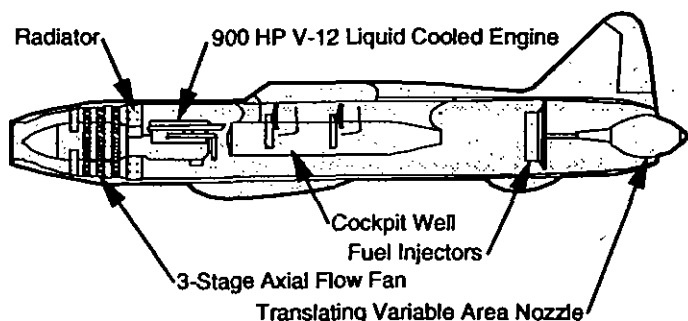
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engines for acceleration down the track. The JB-1 left the sled then pitched up to about a 45 degrees and climbed rapidly for a short distance. The right engine failed and the JB-1 stalled (it is not known which occurred first) and it crashed about 1200 feet from the takeoff point.

2. Caproni-Campini C.C.2

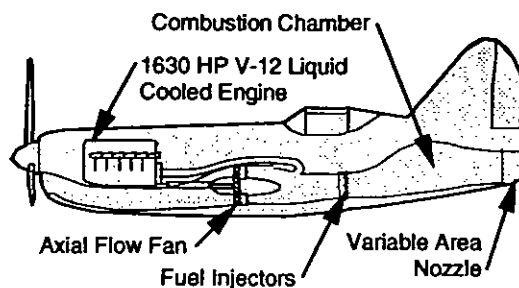
The Italian Caproni-Campini C.C.2 used an early jet propulsion concept that first flew on August 27, 1940. Coincidentally, the Germans had flown their jet-propelled He 178 a year earlier, on August 27, 1939, with traditional jet engines. The C.C.2 had a length of 43 feet, a wingspan of 52 feet, and a maximum takeoff weight of 9250 lb. A piston engine drove a three stage fan, and the blades could be varied in pitch by the pilot. Fan air was ducted to an afterburner with a variable area nozzle. The following diagram illustrates the propulsion system component arrangement. The aircraft could cruise with or without the afterburner operating; however, the afterburner was required for takeoff.



The C.C.2 aircraft had continual growing problems and poor performance. The maximum speed at 10,000 feet was 178 knots without the afterburner and 202 knots with the afterburner. Only one was built.

3. Auxiliary Jet Driven by a Piston Engine

In early 1944 the Soviet Union began trying to build a jet aircraft. Because they did not have a jet engine in production they elected to use a system designed by the Central Institute for Aeroengine Construction. This propulsion arrangement shared the output of a piston engine between a propeller and an axial flow fan that fed a combustion chamber. The Mikoyan and Sukhoi Design Bureaus were given contracts to develop airplanes using this propulsion system. The following figure illustrates the propulsion system as installed in the Mig-13.



All of the engine power was normally provided to the propeller. When greater speed was needed, power was transferred to the axial flow fan and the air was heated in the combustion chamber. This provided a speed increase of 49 kt for the Su-5. The use of the jet propulsion system was limited to 10 minutes. The following table summarizes the characteristics of these two aircraft compared with the 'H' version of the P-51 which was a contemporary propeller-driven fighter plane.

	Mig-13	Su-5	P-51H
Length - ft	26.85	27.91	33.30
Span - ft	31.16	34.64	37.00
Empty Weight - lb	5702	6510	6550
Max TOGW - lb	8110	8384	12544
Number Built	18	2	555
First Flight Date	3 Mar 45	Apr 45	3 Feb 45
Engine Power - hp	1630	1650	1400
Maximum Speed - kt	446	428	410*

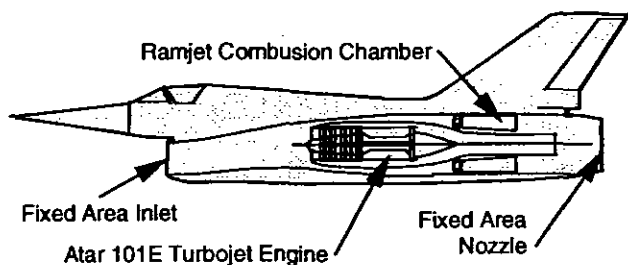
* with water injection

The Mig-13 reached operational status with the Baltic Fleet near Riga but was withdrawn from service in May of 1948 after a short career. Flight tests of the Su-5 ended on 15 July 1945 after two engine failures destroyed the last available engine.

4. Turbo-Ramjet

Ramjets have attracted interest because of their simplicity, but they are not a complete propulsion system because they produce no static thrust. The turbo-ramjet was considered as a propulsion device in the 1950's for both the Republic F-103 and the Nord Griffon II. The French Griffon II configuration used a delta wing with a canard. It had a length of 46 feet, a wingspan of 26 feet, and a maximum takeoff weight of 13,200 lb. The propulsion system consisted of a regular turbojet engine with an annular ramjet around the turbojet nozzle. Both inlet and nozzle were of fixed areas. The following illustration shows the arrangement of the Griffon II propulsion system.

The Griffon II made its first flight on January 23, 1957, and the ramjet was first used in April. It exceeded Mach 1 in May, 1957. The aircraft made more than 200 flights. The best performance was Mach 2.1 at 61,000 feet, and it was



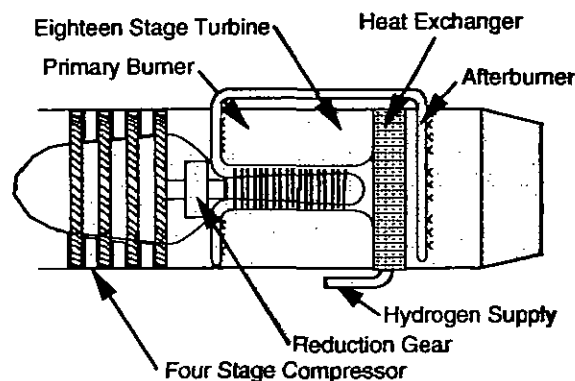
still accelerating. The speed was restricted by thermal limitations on the airframe.

5. Suntan Hydrogen Engine

Hydrogen is an interesting fuel because it contains so much energy per pound. Major drawbacks of hydrogen are its low density and the low temperature required to keep it a liquid. Early experiments with hydrogen fuel included flight testing in a slightly modified B-57, and ground testing a more extensively modified J57 engine. However, modifying an existing turbojet could not optimize the advantages of hydrogen. By mid-August 1956, Pratt & Whitney engineers had designed a new engine to use hydrogen and designated it Model 304. The power for this engine was derived by heating the hydrogen and expanding it through an 18-stage turbine. This turbine was 1.5 feet in diameter, and produced 12,000 hp. After exiting the turbine, the hydrogen was burned in a combustion chamber or in an afterburner. The combustion chamber was followed by a heat exchanger which heated the incoming liquid hydrogen. The power derived from the turbine drove a 4-stage (and later a 5-stage) compressor that was 6.6 feet in diameter. A gearbox was placed between the compressor and turbine so each component could rotate at an optimum speed. The following figure illustrates the arrangement of the engine.

Four Model 304 engines were built and tested, and a fifth engine was nearing completion when the program was canceled. The first engine began testing on 11 September 1957, and about 25 hours of operation with hydrogen fuel had been completed by the end of September 1958 when the testing ended. The engine had a sea level static thrust of

about 13,000 pounds, and two of them were intended to power the Lockheed CL-400 reconnaissance aircraft. Although this aircraft was 150 feet long, it weighed only 70,000 pounds at takeoff, and it was designed to fly at Mach 2.5 at 100,000 feet.



Observations

Although traditional turbojet engines are apparently the best arrangement for most applications, other arrangements are possible and may occasionally be superior in a few specialized applications. However, the cost of developing these specialized engines may work against their use.

References:

1. Northrop Flying Wings by Gary R. Pape
2. Enemy Jet History by D. R. Maguire, A Paper of the Royal Aeronautical Society
3. Mig - Fifty Years of Secret Aircraft Design by R. A. Belyakov and J. Marmain
4. OKB Sukhoi by Vladimir Antonov, Yefim Gordon, Nikolai Gordyukow, Vladimir Yakovlev, and Vyacheslav Zenkin
5. The Griffon Aircraft and the Future of the Turbo-Ram-Jet Combination in the Propulsion of Supersonic Aeroplanes by General Noel Daum, The Journal of the Royal Aeronautical Society, June 1959
6. NASA SP-4404, Liquid Hydrogen as a Propulsion Fuel, 1945-1959

Membership Opportunities

Webmaster needed for the St. Louis Section Web Page. A web page is in work for early 1998 and a local webmaster is needed. Contact: Rudy Yurkovich 314-233-2563

Engineering Education Evaluators needed to support ABET campus visits. Boeing is spearheading a program to improve engineering education in the United States. As part of this effort, Industry evaluators are needed to visit various universities and confirm accreditation. Contact: Steve D'Urso 314-233-5441

Web Sites of Interest

Invention Software
<http://www.invention-machine.com>

Invention Techniques-Triz
<http://w3.advn.com/~semyon.triz0000.htm>

Nurfluegel (Flying Wings)
<http://www.teleport.com/~dbullard/nurfluegel/>

Free Flight Indoor Model Airplanes
<http://www.ultranet.com/~davisson/indoor.htm>



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Future AIAA Events

AIAA Council Meeting

Monday, 8 December

5:00 PM to 9:00 PM

Building 100, Level 2 South
Conference Room

