NAVAL AVIATION

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Soviet Naval Air
Rocket Engines
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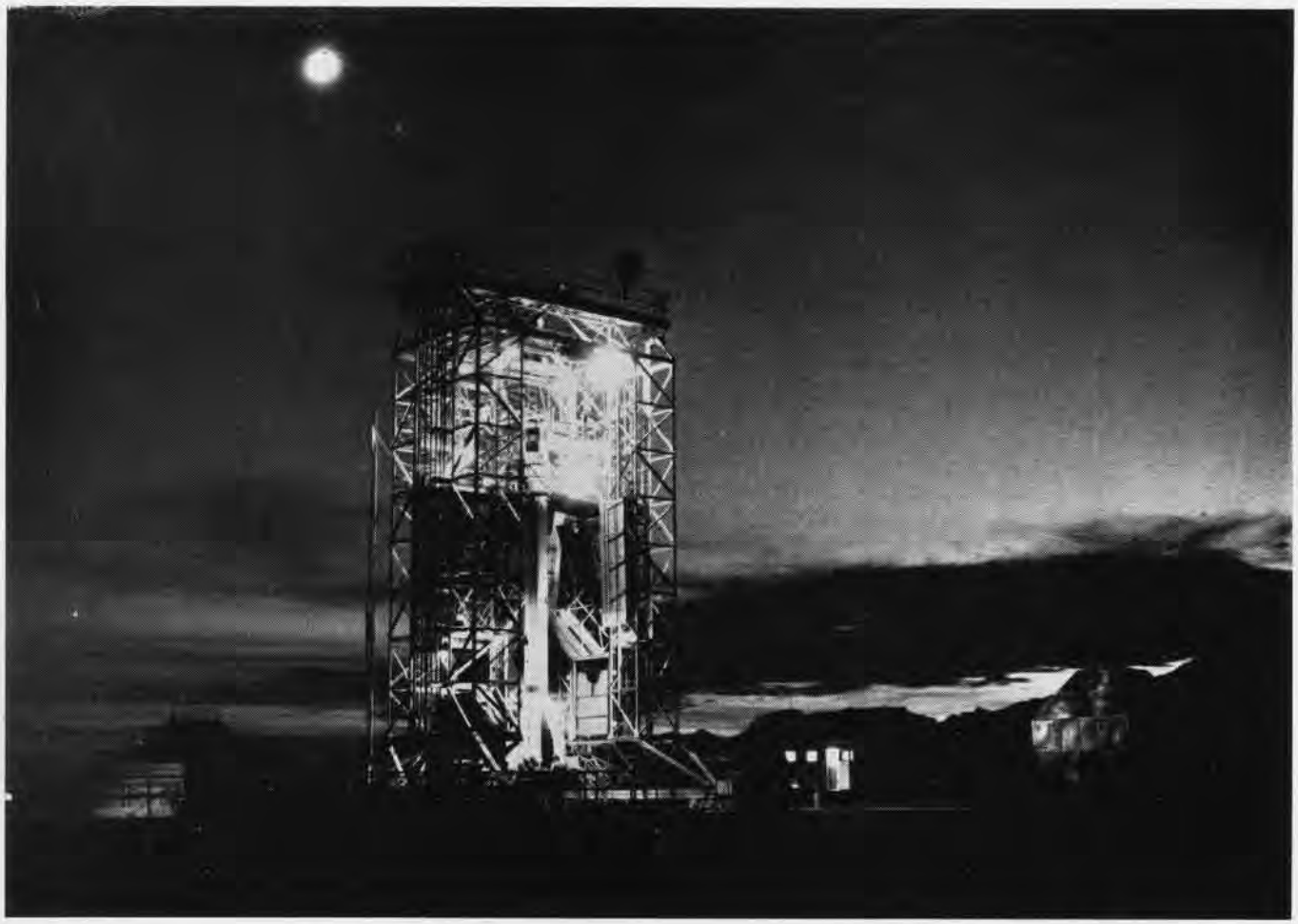


SONG OF THE THRUST

IN THE NEVER ceasing struggle to drive aircraft faster and faster through the air man has experimented with various means of propulsion.

This road has led through reciprocating engines, turboprops, jet engines and rockets.

In accomplishing its part of test and evaluation along these lines the Navy established an aeronautical engine laboratory at Philadelphia for reciprocating engines, and an aeronautical turbine laboratory at Trenton, N. J. for turbojet and turboprop engines. For test and evaluation of rocket power the Navy has now established a Naval Air Rocket Test Station at Lake Denmark, near Dover, N. J.

Although only 35 miles from New York City, Lake Denmark is located in a comparatively wild, hilly region where the noisy activity can proceed apace without complaints from nearby residents.

As with all experimental aeronautical material, the Navy must have some means of testing and evaluating rocket motors and related equipments and propellants. In the long run it will save money and will result in better performance.

While the rocket program was in its infancy, all testing was done by contractors with Navy representatives looking on. There was not enough business to justify a separate activity to provide instrumentation and test equipment. As a result, there was a lack of standardization and many tests were of dubious value in determining whether any one rocket engine or part was worthy of acceptance.

Now that the Navy's rocket interest has broadened and includes a wide variety of rockets, missiles and aircraft, the rocket engines employed in them will be thoroughly tested in the modern laboratory at Lake Denmark. This story is about the Naval Air Rocket Test Station and some of its background.

ONE TYPE of liquid oxygen storage at Lake Denmark is this spherical tank; fluid is transferred by hose from truck to tank

UNLOADING CHEMICALS are Reich, Lowry, Decker, Solomon and Lewis, supervised by R. W. Eater, ADC; note rubber protecting gloves

Rocket Power Is The Oldest Known Means Of Propulsion; Chinese Used It In 1232

ROCKET propulsion is the oldest form of power man has used for aerial flight. Ogdai, son of Genghis Khan, ran into a rocket defense when he laid siege to a Chinese city way back in 1232. Princes in India used rockets in the 18th and 19th centuries. The Royal Navy heckled enemy coastal cities with them in the 19th century.

By present day standards, however, the science is in its infancy. The early days were only seven or eight years ago when jet assisted takeoff was used operationally in World War II. Aircraft, whose jet engines took them only into the transonic speed region, needed rockets to push them into the supersonic realm.

On another front, the guided missile has demanded a propulsive force which could operate without oxygen in the upper reaches of the atmosphere. Ground-to-ground, ground-to-air, and air-to-air missiles have become a major preoccupation in military research. The aeronautical engineers have designed the fast flying bodies; to propel them, the power plant engineers have delved into a fascinating field of liquid and solid propellants.

Until World War II, rocketry was an enthusiasts' hobby. Funds were limited. The American Rocket Society, sparked by a few hardy souls, worked on small, light engines which could produce enormous thrust outputs compared to frontal area. Two projects at the Engineering Experiment Station at Annapolis got the Navy's program underway. From this beginning jet assisted takeoff (JATO) was developed. At the same time air-to-ground and ground-to-ground solid propellant rockets were successful in amphibious assaults. For supersonic planes and guided missiles, however, the liquid propellant power plant has assumed major importance.

One might ask the question why the Navy must have a rocket engine test activity when contractors have their own test stands. It is a matter of economics. Test and evaluation takes a whale of a lot of money. When the government finances construction of expensive test facilities on a contractor's property it commits itself to continuing contracts. With large and small test stands available, the Naval Air Rocket Test Station is able to furnish high quality test facilities to contractors and government activities with inadequate test facilities of their own. The station will be able also to test and evaluate engines and propellants to assure BuAer that contract specifications are being met.

Development of rocket engines is done by the Bureau of Aeronautics through contracts with private manufacturers. As with aircraft, the Bureau, through NARTS, tests and evaluates the engines to insure that they meet contract guarantees as to performance and weight.

The station also provides information from which standards will be set regarding specifications for rocket engines, what parts go into them and what propellants are to be used. The word "propellant" is used since the general term "fuel" is only one element of the heat producing combination in a rocket engine. The other is "oxidizer". In all other aircraft engines oxygen is supplied from the air through which the engine flies. Since rocket engines carry fuel and oxidizer they are independent of the surrounding atmosphere. Thus the rocket engine can operate in very thin atmosphere or in the space beyond.

Another phase of the station's mission is the training of military personnel in the operation and maintenance of rocket engines. Regular training of small groups of officers and enlisted men will insure competency when rocket power plants are used operationally in the fleet.

IT WAS THE INADEQUACY and lack of standardized instrumentation on tests that created the need for NARTS. Tests conducted by government personnel would serve as a basis of comparison between engines of various contractors, and would be conducted without preference or bias.

The Rocket Test Station is ideally located. During the postwar cutback period, the Bureau of Ordnance decided to inactivate the Navy ammunition depot at Lake Denmark. Already located there was one rocket engine contractor. The Bureau of Aeronautics timed the establishment of the Naval Aeronautical Rocket Laboratory there in July of 1948 to coincide with the gradual withdrawal by BUORD. By November of 1949 BUORD had almost inactivated its operation and gradually transferred all civilian and administrative personnel to NARL. With the growing importance of the activity it was commissioned as a full fledged Naval Air Test Station with a commanding officer in April of 1950.

Postwar U. S. research has followed the lead established by the Germans who developed big rockets like the V-2, *Enzian, Rheintochter* and HS-293, and a rocket interceptor fighter plane, the ME-163. In this country rockets such as the *Viking,* and others are being developed. One plane is exclusively rocket powered—the Bell X-1. One combines rocket power with turbojets—the Navy's *D-558-II Skyrocket.*

No story about the Navy rocket program could be narrated without mentioning several men whose intense in-

IN CONDUCTING tests a great variety of instrumentation must be provided; James, AE1, and Leach, AEC, repair instrument

terest in the system got research underway. When Capt. (Now RAdm.) C. M. Bolster was head of the Ship's Installation Division of BUAER, two men, Cdr. Robert Truax and Dr. Robert A. Goddard, convinced him that rockets could be a means for accelerating takeoff of large, heavily loaded aircraft. JATO was the result of this first development in the Navy.

Cdr. Truax, who was on duty at NARTS until last summer, began experimenting in his spare time while a Naval Academy midshipman. Utilizing the facilities of the Marine Engineering department, he built a liquid rocket. He wanted to set it up in the foundry for test, but the department head didn't quite agree. Truax' enthusiasm almost ended his Navy career. His persistence caused the department head to explode, "Truax, I have nothing against you personally, but get that ——— ——— thing out of here."

He finally was able to test his gasoline-compressed air engine across the Severn River at the Naval Engineering Experiment Station. His report was sent to BUAER and evaluated.

Upon graduation, he proposed a rocket assist for PBY takeoffs. That project had to wait two years, however, until his two years of sea duty were completed. He later helped guide the JATO program and design of rocket test stands for the Bureau of Aeronautics. He is a former member of the board of directors of the American Rocket Society.

Cdr. D. A. Seiler was Officer-In-Charge of the rocket laboratory when it was first established.

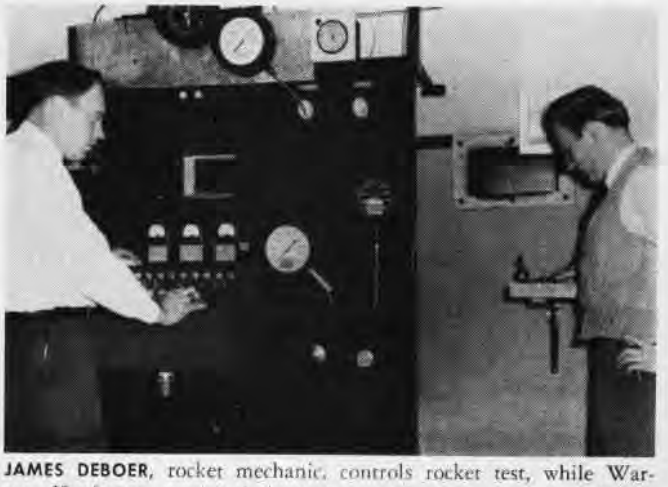
When the facility was upgraded, Capt. Roy Jackson became commanding officer. He was formerly O & R officer at NAS SEATTLE. His postgraduate studies include the Harvard business school. His engineering officer is LCdr. F. C. Durant. Durant was formerly connected with rocket development with Bell Aircraft Corp. in a civilian capacity. He is a director of the American Rocket Society. Present C. O. is Capt. Paul Harrington.

ALL THE civilian engineers and scientists at the Test Station have had experience in rockets and related fields. They are experts in heat transfer, thermodynamics, metallurgy and combustion.

Among them are: Thomas F. Reinhardt, senior civilian engineer; Bertram N. Abramson, head of Power Plants division; Raymond J. Albert, Evaluation Branch head; John D. Clark, Chemistry Branch head; Herman C. Menes, Instruments Branch head; David Brandwein, Test Facilities Branch head; Margaret L. Taylor, Librarian; Joseph V. Primerano, assistant Public Works Officer; Donald K. Holster, Industrial Relations Officer; Roger S. Barr, Quarterman Toolmaker.

NEW TEST stand for higher power rocket engines nears completion; Ex-C.O. Capt. Jackson and Cdr. Seiler, former Exec, study plans

LCDR. FRED DURANT, member of American Rocket Society, inspects control panel to be installed for use with new stand shown above



JAMES DEBOER, rocket mechanic, controls rocket test, while Warren Kaufman, aeronautical engineer, observes through window

ROGER S. BARR, leading man tool maker, and Cdr. Robert Truax, plan layout of test stands, laboratories and control buildings

BASIC RESEARCH plays a great part in the work done at the Naval Air Rocket Test Station; Dr. John D. Clark, physicist, takes text

Chemicals, Engines Tested; East Coast Contractors Make Use Of Navy Facilities

FUNCTIONS OF the station as assigned by the Chief of the Bureau of Aeronautics are:

(a) Undertake test and evaluation projects concerning rocket propellants.

(b) Develop test equipment necessary for instrumentation and test when such is not commercially available.

(c) Make investigations of ideas, devices and propellants in order to provide a basis for future program planning.

(d) Provide engineering services in connection with flight test projects concerned with rocket engines.

(e) Assist the Bureau of Aeronautics in preparation of programs, detailed requirements for rocket engines, their parts, propellants and associated equipment.

(f) Train service personnel in the handling, servicing and operation of rocket engines, their components and associated equipment.

Besides contract specifications tests NARTS evaluates the performance of component parts of rocket engines. Other answers sought concern altitude performance, temperature limitations, number of runs possible on one engine without maintenance, operation of ignition systems after long time storage, ignition delay at extremes of temperature.

By having central test facilities there has been a gain in efficiency. On the west coast the Air Force has a test activity at Edwards Air Force Base, Muroc Dry Lake.

Eastern contractors, such as Reaction Motors, Inc., Rockaway, N. J.; M. W. Kellogg Co., Jersey City; Curtiss-Wright Corp., Caldwell, N J.; General Electric Co., Schenectady, N. Y., and Bell Aircraft Corp., Buffalo, now may make use of facilities of the Naval Air Rocket Test Station at Lake Denmark for some of their testing and service contracts.

ISOLATED, HILLY country is ideal for rocket engine testing; this picture of deer was taken from administration building

NARTS is the central storage and issuing point for liquid rocket propellants on the east coast for all BuAer activities. Fuels and oxidizers are by their nature high energy compounds and generally need careful handling. The isolation of Lake Denmark makes it an excellent location.

All of the east coast contractors lie within 300 miles of Lake Denmark. White Sands and Muroc are 1700 and 2500 miles away respectively. Liaison with the Bureau of Aeronautics in Washington and the Air Materiel Command of the Air Force at Wright-Patterson AFB, Dayton, Ohio, is simplified.

Many unusual propellants are being studied for possible use in rocket propulsion. Much of the data and details are classified information. Some factors affecting utility of rocket propellants are: availability, ease of handling and storage, good ignition qualities over wide temperature ranges, and high density.

Rockets are notoriously high in their rate of propellant consumption. For this reason the more dense a propellant is the more energy can be obtained from a given space.

One oxidizer in common use is fuming nitric acid. If the fumes are inhaled in quantity they can cause pulmonary edema—fluid in the lungs which can result in asphyxiation. Another oxidizer is hydrogen peroxide, much more concentrated than the household item. In the presence of a catalyst it decomposes almost explosively, forming steam and oxygen. Both compounds can be safely handled if known rules are obeyed.

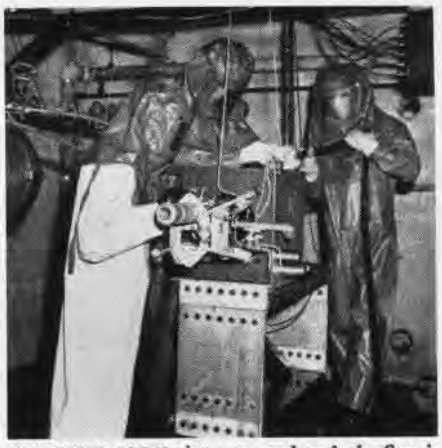
The medical department is ready for any emergency and recommends safeguards in handling. Special physical examinations are given. Blood testing equipment is on hand to detect and measure the danger if a hazardous substance has entered a person's bloodstream.

Compared with some other chemicals, storage of liquid oxygen is simple. In high school physics and chemistry laboratories the teacher brings in the pale blue liquid in a thermos bottle. It boils rapidly. At the test station it is shipped in by railroad tank car. Percentage losses are of a low order because of large bulk storage, since heat can enter only through the tank skin.

Test stands at Lake Denmark range over a wide area. They are pointed in different directions to provide safety barriers

POTENTIOMETERS PLAY important part in tests; Feldkotter, AE2, adjusts recorder

WITH A DEAFENING roar, flame rushes from jet nozzle at more than a mile per second



PROTECTED FROM dangerous chemicals, Suraj, Gardner, Westover, prepare engine for test

between stands. Testing casualties thus can be isolated.

When a rocket engine is set up for a test complete instrumentation is installed to see just what the engine and propellants are capable of doing.

Since the temperatures and flow rates of rocket gases are so high (over 5,000° F. and a mile per second) and the propellants frequently corrosive and hazardous, special instrumentation is often required. Often many days are spent setting up an engine for test and checking the calibrating instruments. Once set up, however, dozens of tests may be made in one day.

Electronic methods have taken the place of older pressure measurements in recording performances.

A test run is preceded by a warning horn. There is a momentary pause. Then a deafening roar begins as smoke and brilliant flames rush from the rocket nozzle. The ground in the path of the motor trembles and rocks and dirt are picked up and tossed by the blast. No person is considered effete if he uses ear plugs or cotton in his ears.

The silence at the end of the run is as positive as the noise was. During the run data has been automatically recorded which includes engine thrust, chamber pressure, propellant pressures, flow rates and temperatures.

Cooling of rocket engines may be accomplished by having either fuel or oxidizer flow through a jacket surrounding the engine. Sometimes propellants are forced into the combustion chamber by means of a turbine driven pump. Other systems employ high pressure gases, forcing propellant flow.

There are other projects underway at Lake Denmark which include the investigation of adding other chemicals to propellants to improve their temperature or corrosion characteristics, the design of special purpose rocket test stands, the evaluation of relative advantages of solid and liquid propellant engines for a specific missile, and evaluation of performance of rocket power plants under wide ranges of operating conditions.

SINCE THE Rocket Test Station is a new activity its growth and development will be affected by the extent of the national defense program. It is growing now.

New construction at NARTS includes larger test stands. The engine in the *Viking*, rated at 20,000 lbs. thrust, was tested there first. Now a new, larger stand is almost complete and even greater stands are planned.

Lake Denmark is located in wild terrain. Witness the picture of the deer accompanying this article. In such a remote location noise and fumes will not bother neighbors. The construction program there is only a beginning. Modern warfare requires a continuing research program and the Naval Air Rocket Test Station is the Navy contribution to unified effort in rocket development. Its work will be evidenced by increased reliability in future rocket engines and their eventual appearance in the fleet.

ISOLATED LOCATION OF NAVAL AIR TEST STATION AT LAKE DENMARK, N. J., ALLOWS NOISY TESTS WITHOUT DISTURBING NEIGHBORS