Pictorial
Sunday MAGAZINE
October 6, 1957

CLEVELAND PLAIN DEALER

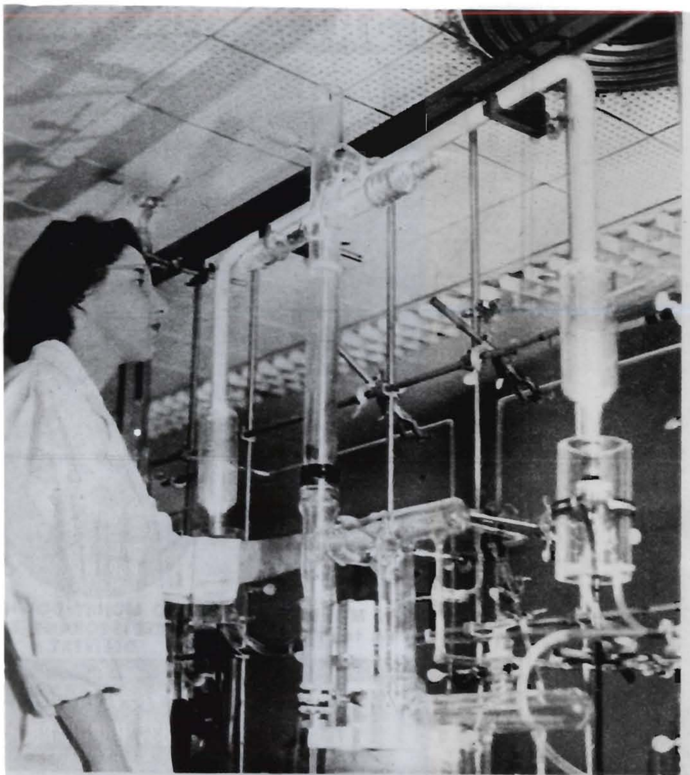
A Journey to Tranquility

NACA Wind Tunnel Test

See Story on Center Pages

10 Years Aft

Supersonic Anniversary Puts Flight Laborat



COMPARING materials under a barrage of atoms to determine which are most resistant to atomic attack and more useful in missile and rocket manufacture. Atoms are produced by passing a gas at low pressures through a high voltage discharge. Fast vacuum pumps make the atoms hit a material test sample.

HIGH above the California desert a young Air Force officer from West Virginia made final adjustments in the cramped cockpit of his tiny, bullet-shaped airplane. Soon, he was hurtling towards the earth far below as his craft dropped away from the snug belly of the B-29 mother plane which had borne him aloft. The man-carrying bullet came to life as its four rocket engines spurted their full power. Now it was the mother plane's and the earth's turn to drop far below. The young man in his bullet shot into the upper reaches of the atmosphere.

Minutes later it was all over. The rocket engines had burned out. Plane and pilot safely glided to a fast power-off landing on the expanse of Rogers Dry Lake. This flight was as significant as that of the Wright Brothers at Kitty Hawk—man had flown faster than the speed of sound. Aviation had entered the supersonic age.

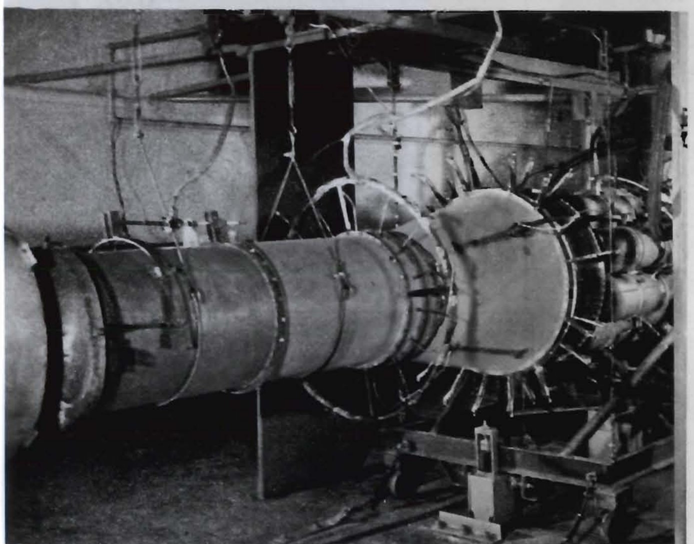
This adventure into the unknown was 10 years ago, October 14, 1947. The pilot was Capt. Chuck Yeager. His plane was the X-1, christened "Glamorous Glennis" after his wife. The X-1 was a triumph of the best engineering talent and teamwork of the Bell Aircraft Corp., Reaction Motor, Inc., Air Force and National Advisory Committee for Aeronautics.

Today, many planes are capable of sustained flight well above that reached by "Glamorous Glennis" but the teamwork between American industry, the military services and the research organizations which made the X-1 performance possible is still functioning to bring forth aircraft of far greater performance.

Significantly on this 10th anniversary of the supersonic era, the attention of American aeronautics is focused on Cleveland this week while the NACA's Lewis Flight Propulsion Laboratory at Hopkins Airport holds its triennial inspection to acquaint the nation's aviation leadership with the trends in aircraft power plant research.

Among the almost 2,000 invited representatives from industrial, military, and scientific institutions will be members of NACA's "board of directors" including: Capt. Eddie Rickenbacker of Eastern Airlines; Fred Crawford of Thompson Products; Lt. Gen. Don Putt, the Air Force's development chief; Vice Adm. William Davis, air chief of the Navy, and Lt. Gen. Jimmy Doolittle, veteran airman and NACA's chairman.

Progress in harnessing the power of new high-energy fuels for air-breat



RED HOT tail pipe of a turbojet engine. Pressure and temperature readings are being taken.

EXPERIMENTAL MISSILE is installed on the launching racks of an F2H "Banshee" airplane by NACA technicians at the Lewis Laboratory. The missile will be flown from Cleveland to NACA's Pilotless Aircraft Research Station at Wallops Island, Va., where it will be launched over the Atlantic Ocean. Electronic tracking equipment will follow the missile's flight and record its performance at speeds greater than five times the speed of sound.

e X-1

ory Here in Spotlight

engines and high-energy rocket propellants will be revealed. Other research areas to be reviewed include those dealing with hypersonic (more than five times the speed of sound) propulsion; high-temperature materials and other problems of aircraft nuclear propulsion; high-Mach number engines and aircraft jet noise reduction.

Research in aeronautics is never finished, and research is the business of NACA. Each major discovery or breakthrough opens a new frontier to be conquered and hatches a new brood of problems to be solved if America is to be first in aeronautics.

Every successful plane since that of the Wrights' has been built around its

(Continued on Page 26)

THE COVER

An experimental supersonic aircraft model is prepared by an NACA research scientist and a technician for operation in the test section of the 10x10-foot Supersonic Wind Tunnel at the NACA Lewis Laboratory. This facility permits testing of advanced design aircraft engines and their components at speeds of 1500 to 2500 mph at simulated altitudes up to 30 miles.

Color photos by EUGENE GICZY

TELEVISION CAMERA is focused by NACA technicians on a ramjet engine model through the schlieren optical windows of the 10x10-foot Supersonic Wind Tunnel's test section. Closed-circuit television enables scientists to view the ramjet, used for propelling missiles, while the wind tunnel is operating at speeds from 1,500 to 2,500 m.p.h.

SMALL SECTION of the sprawling NACA conglomerate of laboratories which represent an investment of more than $100,000,000. This picture shows building housing air drier for 10 by 10 supersonic wind tunnel.

10 Years After X-I

(Continued From Page 25)

power plant. Development of the propulsion system must come before the design of the aircraft in which it is to be installed, otherwise the full potential of neither may ever be realized. In these days of international competition for survival, few errors are permissible. This is equally true in the case of missiles.

The go-power, or thrust, of turbojets, rampets, and rockets is developed by force from fire. Combustion creates super-hot gases which expand at high velocities. The velocity and pressure of these gases combine their effects at the jet engine's exhaust nozzle to produce thrust.

In essence, the work of NACA's Lewis Laboratory is to find new fuels to furnish more energy; find new materials which will withstand the greater temperatures and pressures; then of higher energy fuels find the best means to harness the higher temperatures and pressures.

An example of the problems facing scientists is weight. About 90% of the weight of a rocket-powered vehicle is its propellant. The choice of propellant will, to a large extent, determine the size, weight, and shape of the vehicle. In the present Vanguard project to launch a 20-pound earth satellite, the vehicle to carry it aloft is about 75 feet long. Perhaps a 25,000-pound payload would be required for a manned satellite.

If a 75-foot vehicle is required to launch a 20-pound space satellite, the size of a vehicle to launch a 25,000-pound payload would be ungainly, to say the least. New higher energy propellants would result in obvious weight and size advantages.

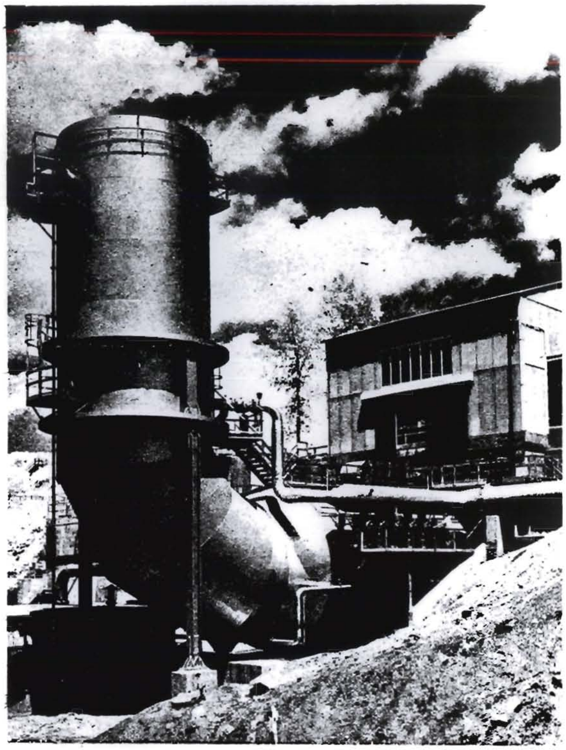
Other problems to be solved include those caused by temperatures, hot enough to change the behavior of matter, induced on a missile's re-entry into the earth's atmosphere, and precise control of missile fuel consumption. The materials to withstand these temperatures and systems to handle the propellants with target-hitting precision are among the many goals of research.

That some of the problems of flight are being solved is evidenced by advances in plane and missile speeds since Capt. Yeager's flight in the X-1. By 1953 manned aircraft had reached 1,650 m.p.h., and last year the X-2 flew about 2,100 m.p.h. The missile speeds of 10 years ago were only somewhat better than those of the World War II, 3,500 m.p.h. German V-2s. By 1949 missiles were in the 5,000 m.p.h. class. Last year, an NACA four-stage, rocket-powered research vehicle reached 6,864 m.p.h. Other rocket-powered research vehicles have since bettered this speed.

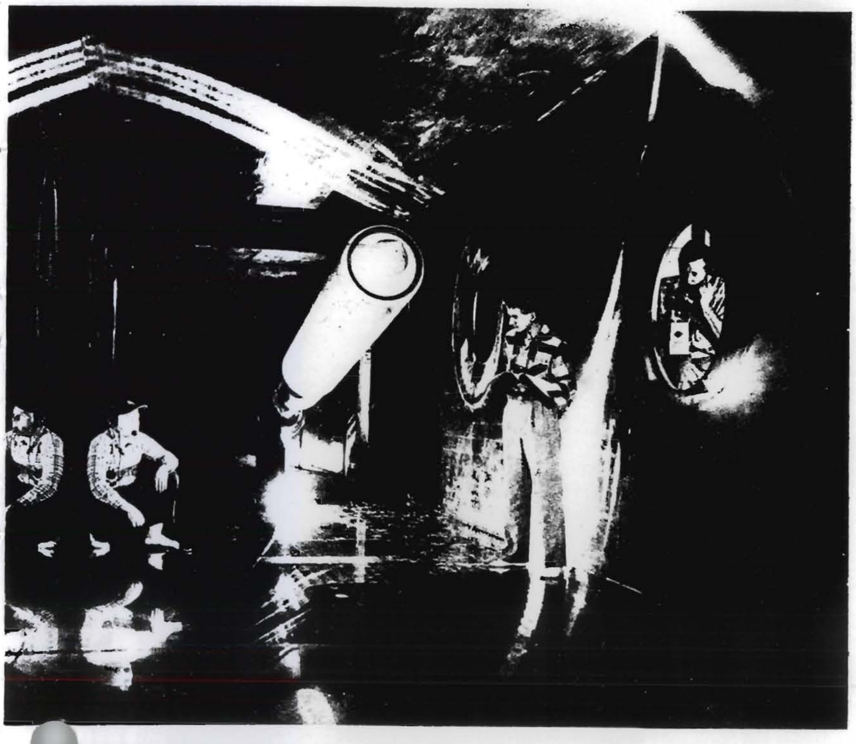
Contributions to the power-plant performance of these aircraft were made by skilled NACA scientists working at Cleveland with complex research facilities. The latest of these will be seen during the Lewis inspection. They are: The 10x10-foot supersonic wind tunnel, completed last year at a cost of 32 million dollars; the 8x6-foot supersonic wind tunnel, on which extensive modifications to extend its speed range were recently completed, and the rocket engine research facility, also completed this summer.

With both wind tunnels, scientists can study full-size plane and missile power plants operating at speeds past 2,500 m.p.h. at simulated altitudes up to 30 miles. The tunnels permit investigation of an engine's thermodynamic and aerodynamic performance, operating temperatures and stresses, control systems, and air inlet and exit performances. Among the contributions of the 10x10 during its first year's operations are supersonic performance data on

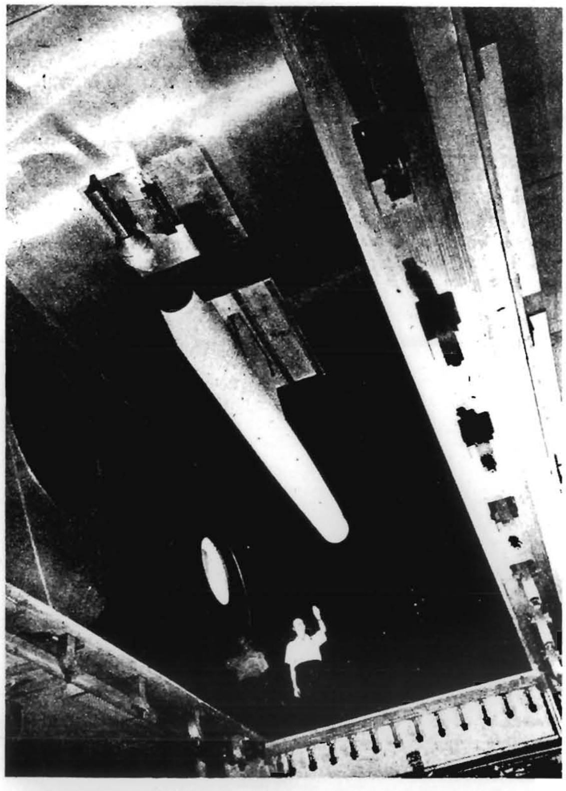
(Continued on Page 28)



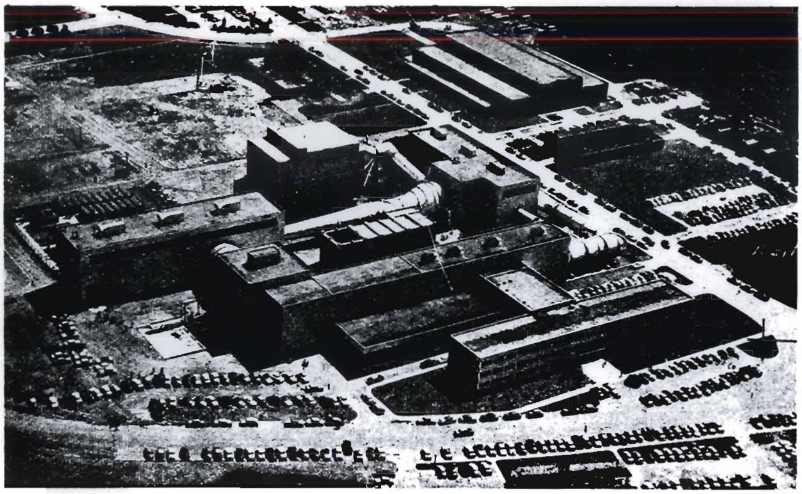
"SCRUBBER" is part of the silencing and exhaust gas disposal system of the new rocket engine research facility at Lewis. Water sprays within the scrubber remove rocket exhaust products. Like a giant automobile muffler, the scrubber also silences sounds of rocket engine operation.



RAM JET TEST. Another view inside the 10x10-foot wind tunnel. Note the mirror-like polish of walls and floor. Men who set up the tests must remove shoes before entering tunnel, or else wrap shoes in towels.



AFT VIEW of a 16-inch ram jet engine in test position, seen through the floor opening of the wind tunnel.



AIR VIEW of the 10x10-foot supersonic wind tunnel. The air force through this tunnel makes a hurricane seem like a gentle summer breeze. It permits high altitude tests of full-scale engine and aircraft models at air speeds three and one-half times the speed of sound.

10 Years After X-1

(Continued From Page 27)

the B-58 engines, various ram-jet engines, and high-energy fuels.

The 10x10 covers an area of about two city blocks. The air which pushes at hurricane speeds through its test section is moved by two large compressors turned by seven electric motors producing 250,000 horsepower. Air enters the tunnel through an air dryer building which is 117 by 84 feet, 82 feet high Here moisture is removed by heat and chemicals at a rate equal to the capacity of about 12,000 home clothes dryers.

Walls of the test section are stainless steel plate, 10 feet wide, 78 feet long, and 1⅜ inches thick. Hydraulic jacks can squeeze portions of these walls as much as two and one-half feet each to form a variable nozzle for different air speeds.

For the benefit of the neighbors, much effort has been expended to operate all Lewis research facilities as quietly as possible. A two-story structure silences the 10x10 tunnel noise as air is exhausted back to the atmosphere. A 24-foot valve also permits recirculation and reuse of the air within the tunnel.

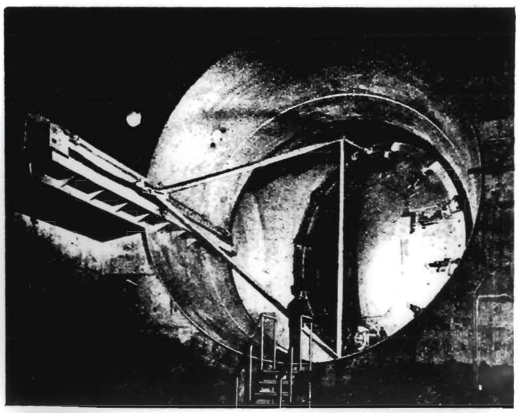
The 8x6-foot tunnel is designed to produce the lower flight speeds in which all aircraft power plants must operate at times. For accurate data at transonic (at or near the speed of sound) speeds, 4,700 holes were bored in the four walls of the test section. The perforations let air "bleed" through the walls. Transonic speeds could not be duplicated in wind tunnels before this "bleeding."

Scientists at the new rocket engine research facility will investigate, with practical-sized rocket engines, methods of utilizing high-energy propellants. Versatility of the equipment permits initial studies using low-cost fuels. There is a thrust stand where the rocket engine is securely mounted during tests; propellant supply and storage systems; an exhaust gas disposal system, and silencing equipment.

During operation, 50,000 gallons of water per second are sprayed into the exhaust duct to scrub combustion products from the rocket exhaust and to help silence normal operating noise. Closed circuit TV cameras, also a feature of the two large tunnels, let operators view activities from the control room.

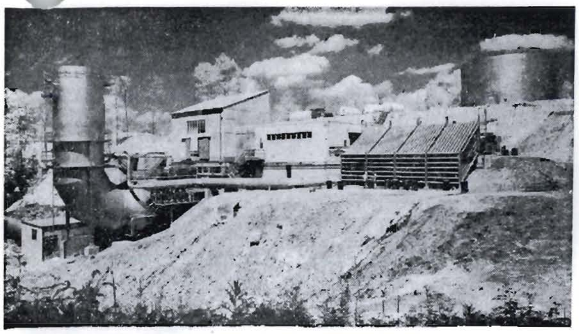
Lewis, on which construction started in 1941, is one of three major research centers operated by NACA. The others are the Langley Aeronautical Laboratory, near Hampton, Va., and the Ames Aeronautical Laboratory, near San Francisco. Smaller NACA research installations are located at Wallops Island, off the Virginia coast, and at Edwards, Calif.

NACA policy is established by the committee itself, a 17-man body whose membership is appointed by the President and serves without pay. There are 28 subordinate committees composed of about 400 specialists who also serve without pay.



SWINGING VALVE. 24 feet in diameter, is one of the key control elements of the Lewis 10x10 wind tunnel. In one position, it seals off the tunnel exhaust, making the tunnel a closed circuit, which is used for aerodynamic testing of models. In its other position, the valve acts as a seal across the tunnel.

CLEVELAND PRESS
October 7, 1957



HIGH-POWERED FUELS for rocket engines that will push missiles thousands of miles an hour at altitudes of 20 miles will be tested in this $2,500,000 base at Cleveland Hopkins Airport.

Develop Fuels Here to Power Planes 4 Times Speed of Sound

By CHARLES TRACY
Press Aviation Editor

Cleveland scientists have perfected fuels that will permit airliners to travel at four times the speed of sound.

This 2600-mph speed would allow a plane to streak from Cleveland-Hopkins Airport to San Francisco in less than an hour, or to New York in a little more than 15 minutes.

The spectacular development was disclosed today as 2000 of the nation's top aircraft experts gathered at the NACA laboratories at Cleveland-Hopkins Airport for the installation's "triennial inspection."

Those present included Lieut. Gen. James Doolittle, chairman of the National Advisory Committee on Aeronautics; Eddie Rickenbacker, board chairman of Eastern Airlines; Fred Crawford, board chairman of Thompson Products, and John Victory, NACA's national secretary.

Edward R. Sharp, director of the 100-million-dollar collection of wind tunnels and laboratories devoted to development of the planes and fuels of tomorrow, took the wraps off a new $2,500,000 rocket engine research facility.

The new laboratory, completed last August, was opened for its first semi-public inspection.

Visiting experts were shown how the facility is equipped to test fuels in full-sized rocket engines roaring at top speed.

Other disclosures by NACA scientists:

HIGH ENERGY FUELS tested here can increase the range of supersonic planes and missiles by 40%. This means that the United States has perfected fuels that make possible the intercontinental ballistic missile or a rocket to the moon.

RESEARCH HAS PRODUCED plans for a new fuselage for aircraft which will permit passenger planes to travel at supersonic speeds. The new fuselage is shaped like a pop bottle, rather than the conventional cigar shape.

The 2600-mph speed for passenger planes made possible by the new fuel would be about 600-mph faster than man has yet traveled through the sound barrier.

AKRON BEACON JOURNAL
Akron, Ohio
October 7, 1957

A[illegible]veland Laboratory

2,600 MPH Plane Fuels Perfected

Special To The Beacon Journal

CLEVELAND—Scientists here have perfected fuels that will permit airlines to travel at four times the speed of sound.

This 2,600 mph speed would permit a plane to streak from Cleveland-Hopkins Airport to San Francisco in less than an hour, or to New York in a little over 15 minutes.

The spectacular development was disclosed today as 2,000 of the nation's top aircraft experts gathered at the National Advisory Committee on Aeronautics laboratories at Cleveland-Hopkins Airport for the installation's "triennial inspection."

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Lewis Flight Propulsion Laboratory (that's the official title of the NACA installation here) experts said the new liquid fuels with a high boron content are now expensive and scarce.

But, they said, new plants under construction will soon make these fuels available for wider use and flight tests, as well as laboratory experiments.

NEWPORT NEWS TIMES HERALD
Newport News, Virginia
October 7, 1957

NACA Missile Achieves Speed Triple Of Sound

TH 7

10-7-57 TIMES-HERALD NEWPORT NEWS

By VERN HAUGLAND

CLEVELAND (AP) — A ramjet test missile burning one of the new high-energy fuels, a boron compound, has flown more than three times the speed of sound, or faster than 2,000 m.p.h.

This was disclosed today at the triennial inspection of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, the top government agency in basic air research.

NACA showed publicly for the first time a 2½ million dollar rocket engine research facility which was completed last August.

The agency said that the spectacular rocket developments of the past few years may be surpassed by even greater gains from the fuel research now under way.

NACA scientists told visitors the laboratory has been studying the effectiveness of various borane fuels and recently has tried them out in full-scale ramjet and turbojet engines.

Officials said the results have been encouraging, but some difficult problems remain. These include:

1. Danger to personnel. Boron compounds can be quite toxic.

2. Combustion deposits inside the engines, which cut down on performance.

NACA officials explained that while the petroleum fuels now burned in jet aircraft are relatively cheap, plentiful and safe, their energy content is too low to satisfy the needs of military planes and missiles.

Since World War II, NACA said, at least 11 U.S. organizations, with increasingly strong encouragement from the armed forces, have been searching for new fuels with higher energy content.

MOST OF the NACA research interests have centered upon boron and its compounds because of its high energy content per pound and its high burning temperature.

The agency said in a report prepared for the triennial inspection that a theoretical study of a ramjet missile flying at 60,000 feet at a speed of 2,100 m.p.h. indicated that the use of boron could extend the range 40 per cent beyond that provided by conventional JP4 jet fuel.

"It is one thing to complete satisfactory use of a radically new fuel type under concisely controlled conditions of the laboratory, and something perhaps entirely different, and much more difficult to achieve similarly happy results in actual flight use," the NACA report said.

"The latter step has already been taken in a small way.

"Speeds greater than a Mach number of three (three times the speed of sound) were recorded in free flight by an experimental full-scale ramjet test missile burning a boron compound fuel.

"Not until the multimillion dollar plants now under construction can produce relatively large amounts of the new high-energy fuels will it be possible to complete the large scale research that remains before these fuels can be effectively applied to aircraft propulsion."

CLEVELAND NEWS
October 7, 1957

A 2,000 Mph Missile! New Fuel Gets Credit

The Lewis Flight Propulsion Laboratory at 21000 Brookpark Road today revealed that a ramjet test missile burning one of the new high-energy fuels has flown more than three times the speed of sound, or faster than 2,000 mph.

The disclosure of the new boron fuel and test flight, was made at the triennial inspection tour attended by more than 500 U.S. government officials, aeronautics experts and scientists. The tour is sponsored by the National Advisory Committee for Aeronautics.

The visitors were told by laboratory scientists that various boron fuels had been studied for their effectiveness and were recently tested in full-scale ramjet and turbojet engines.

Expect Big Gains

The NACA officials said fuel research now underway may result in greater gains and surpass the rocket developments of the past few years.

They said their study of the various boron fuels have been "encouraging" but admitted some difficult problems remain such as danger to personnel because boron compounds can be quite toxic and combustion deposits inside the engines which cut down on performance.

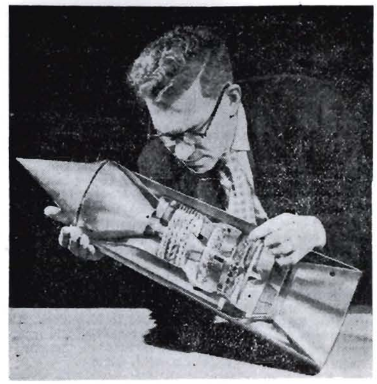
Laboratory officials said NACA research interests have mostly centered upon boron and its compounds due to its high energy content per pound and its high burning temperature.

2,000 to Attend

NACA, the top government agency in basic air research will conduct the tour through Thursday. An expected 2,000 experts from across the nation are expected to attend the various demonstrations in modern flight propulsion.

The visitors were also impressed by the laboratory's new $2,500,000 rocket research engine facility which was completed in August.

The laboratory which deals in scientific research and aeronautics directed toward practical solutions of problems of flight, possesses research equipment and facilities valued at more than $100,000,000.



An aeronautical research scientist at the Lewis Flight Propulsion Laboratory displays a model of a theoretical Mach 4 turbojet engine based on a composite of advanced ideas from component research and cycle analysis.

PALO ALTO DAILY TIMES
Palo Alto, California
Monday, October 7, 1957

Missile flies 3 times the speed of sound

CLEVELAND (AP)—A ramjet test missile burning one of the new high-energy fuels, a boron compound, has flown more than three times the speed of sound, or faster than 2,000 mph.

This was disclosed today at the triennial inspection of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics (NACA), the top government agency in basic air research.

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1. Danger to personnel. Boron compounds can be quite toxic.

2. Combustion deposits inside the engines, which cut down on performance.

NACA officials explained that, while the petroleum fuels now burned in jet aircraft are relatively cheap, plentiful and safe, their energy content is too low to satisfy the needs of military planes and missiles.

WASHINGTON STAR
Washington, D.C.
October 7, 1957

Boron-Fueled Missile Tops 2,000 M.P.H.

CLEVELAND, Oct. 7 (AP).—A ramjet test missile burning one of the new high-energy fules, a boron compound, has flown at more than three times the speed of sound, or faster than 2,000 miles per hour.

This was disclosed today at the triennial inspection of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, the top Government agency in basic air research.

The committee showed publicly for the first time a $2½ million rocket engine research facility which was completed last August.

The agency said the spectacular rocket developments of the last few years may be surpassed by even greater gains from the fuel research now under way.

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THE NEW YORK TIMES
October 8, 1957

DEVICE TO POWER SPACE SHIP SHOWN

U.S. Scientists Display Model of Engine Designed for Use Beyond Atmosphere

By RICHARD WITKIN
Special to The New York Times.

CLEVELAND, Oct. 7—Government scientists demonstrated today "toy" models of an engine they are seeking to develop for flight in outer space.

The engines, known as ion guns, would produce only tiny amounts of thrust. But that would be enough to navigate space vehicles once conventional rocket engines had propelled them to speeds where gravity was neutralized and to altitudes where there was no longer any atmosphere.

They would have an advantage over rocket engines in being able to operate for the extended periods of time that might be needed, for example, for a 26,000-mile-an-hour trip around Mars. Satellites, such as the Soviet Union's "moon" circle the earth at 18,000 miles an hour.

The experimental devices were demonstrated at the Lewis Flight Propulsion Laboratory at Cleveland Hopkins Airport here. This is one of three major research establishments operated by the National Advisory Committee for Aeronautics, the Government's top aviation research organization.

High-Speed Engines Planned

A tour through the Lewis facilities includes these other highlights:

¶N. A. C. A. scientists have concluded from recent research that it should be possible to develop turbo-jet engines for speeds up to four times the speed of sound. That would be 2,600 miles an hour. It was thought such speed might be feasible not only for military craft but for commercial airliners. The engines on the 550-mile-an-hour jet airliners in service in Russia and soon to enter service here are turbo-jets.

¶The problem of suppressing jet-engine noise to piston-engine levels has not yet been licked. Noise suppressors to do part of the job have been developed. The rest of the job could be accomplished through a new kind of cool-burning engine, but these have not yet been perfected, according to the N. A. C. A.

¶There is a grave question whether the highly publicized high-energy boren fuels will ever be used. The fuels, at present, have serious drawbacks in that they are toxic and leave heavy deposits in the engine.

Provisions for Power

The "ion gun" engines for maneuvering satellites or space ships would provide power for propulsion in this way:

Enormous heat must be generated to break down the propulsive material into negatively charged electrons and positively charged ions. The breakdown is essential so that the charged particles can be accelerated to propulsive speeds by powerful magnets or similar devices.

Emission of the stream of particles pushes the vehicle in the opposite direction, just as rocket or jet engines are thrust forward in the opposite direction from their exhausts.

An "ion gun" might provide only about ten pounds of thrust, compared with 130,000 pounds in the rocket engine of a long-range ballistic missile or the bottom stage of an earth satellite vehicle. But ten pounds is useful thrust once a vehicle has attained the 18,000-mile-an-hour speed of a satellite. Centrifugal force at that speed balances the restraining pull of gravity. There is no atmosphere at satellite altitudes to provide air resistance.

The space vehicle presumably would be carried to satellite orbit by rocket engines, as was done with the Soviet satellite. The drawback with rocket engines is that their fuel, once ignited, burns rapidly. A space ship to fly around Mars would want to ration its propulsive energy over a long period of time.

It was estimated today that a ten-ton space vehicle subjected to only a ten-pound thrust for a month's time would increase its speed 25,000 miles an hour over its original speed.

The associate director of the N. A. C. A. laboratory, Abe Silverstein, stressed that the ion population research was in its early stages. He said the experimental devices shown were but two of many different types that might eventually prove generated the required ionizing heat with an intense flame; the other with a high-voltage electric arc.

INDIANAPOLIS NEWS
Indianapolis, Indiana
October 8, 1957

U.S. Test Missile Goes 2,000 MPH

CLEVELAND (AP)—A ramjet test missile burning one of the new high-energy fuels, a boron compound, has flown faster than 2,000 mph.

The flight at more than three times the speed of sound was revealed yesterday by the National Advisory Committee for Aeronautics, the top government agency in basic air research.

WASHINGTON STAR
Washington, D. C.
October 8, 1957

Ion Stream May Power Space Flight

CLEVELAND, Oct. 8 (AP).—The National Advisory Committee for Aeronautics bombarded a small pinwheel inside a glass vacuum-jar with an invisible stream of ions today and made it whirl briskly.

The same ion-stream principle, the committee said, some day may be harnessed to push 10-ton space ships moonward at many thousands of miles an hour once they have reached outer space.

Coupled with atomic energy, such a vehicle might have virtually unlimited range.

The demonstration was part of a four-day public inspection of the NACA's Lewis Flight Propulsion Laboratory which is attracting top scientists to Cleveland this week.

High Temperatures Produced

To simulate the searing temperatures which will be experienced by aircraft and power plants at extreme speeds, NACA has developed a research tool, the electric arc tunnel. It uses a cathode ray and anode nozzle to transmit a spark, much as in the powerful searchlight of an antiaircraft unit.

A fluid injected into the arc chamber, heated by the arc and expanded through the nozzle produces a high-speed stream, or "plasma jet" with temperatures of 10,000 to 20,000 degrees.

"The arc tunnel suggests an attractive propulsion device for outer-space flight," NACA said in a report made public at the demonstration.

"If a stream of ions, as in an arc jet, can be accelerated to high velocities by use of electric or magnetic fields, a small amount of thrust will be produced."

Only Small Thrust Needed

Ions are tiny bits of matter — atoms which have been stripped of some of their electrons and have become electrically charged.

Physicist M. J. Krasnican explained that beyond the earth's atmosphere a vehicle would require only slight power in small increments, to accelerate a great deal.

"For example," he said, "a 10-ton vehicle in outer space, powered by 10 pounds of thrust for only one month, would increase its original velocity by 25,000 miles an hour."

Such a vehicle before its ion acceleration presumably would be traveling at least 18,000 miles an hour, which is the minimum speed for an earth satellite to maintain its orbit. Still greater speed would be required to break away from the earth's pull and escape into space.

WASHINGTON POST
Washington, D.C.
October 8, 1957

Space-Ship Engine Forerunner Exhibited

By John G. Norris
Staff Reporter

CLEVELAND, Oct. 7—A working model of a radically new principle of propulsion that could be developed into an engine for space ships was demonstrated by Government engineers here today.

Employing "ion propulsion," such an engine might be used to enable a manned space satellite to change orbits or to gain the necessary 25,000-mile-an-hour speed to escape the earth's gravity entirely and travel to other planets and return.

The possible forerunner of a space engine was demonstrated to Government officials, scientists and newsmen at the National Advisory Committee for Aeronautics Lewis Flight Propulsion Laboratory here.

NACA engineers also disclosed progress made in development of new "exotic" fuels that could increase the range of jet aircraft by 40 per cent, new type jet engines capable of propelling planes four to seven times the speed of sound, and possible ways of solving the jet noise problem.

May Have Advantages

Abe Silverstein, associate director of the NACA Laboratory, told newsmen that ion propulsion may have advantages over chemical rocket power to drive space ships. Ions are tiny particles formed when the molecular structure of atoms is broken down by great heat — perhaps 50,000 degrees Fahrenheit — and electrons escape. They then can be electrically charged and their great velocity provides thrust which could propel and control a space vehicle. Silverstein said such a power plant would require a source of electric power which could come from solar batteries or radiation pressure.

By ion propulsion speeds of 50,000 miles per hour are possible with such an engine, they declared.

When such a space engine could be ready depends on the amount of effort and money the Government decides to put into the project, Silverstein said. The Russians undoubtedly are working on such propulsion, he added. NACA engineers also said that research demonstrates that turbojet airplanes traveling at four times the speed of sound—2600 mph at high altitudes—are possible, and outlined the probable characteristics of such a plane and its power plant.

Long Pencil Nose

Models of such a plane on view portrayed a delta wing shape with a long pencil nose. Its engines would have to have variable air intake and jet exhaust nozzles to make it efficient. Takeoff speeds would approach 200 mph.

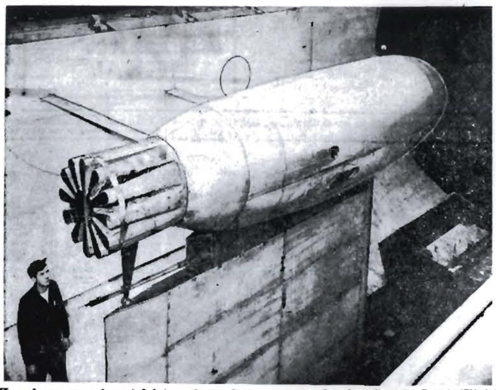
Research on manned aircraft with speeds up to 7 times the speed of sound—4600 m.p.h.—also is under way, utilizing ramjet engines. Much work on overcoming tremendous heat problems, however, is necessary before such planes fly, it was stressed.

Development work on new high-energy fuels, combining the metal boron and hydrogen, was disclosed.

Engineers said the range of ramjet missiles so powered could be extended 40 per cent flying at an altitude of 60,000 feet and at 2100 m.p.h. using such fuel. But the fuels are toxic and produce deposits inside the engine which reduce performance. And boron is expensive.

Research in reduction of jet noise has developed a number of exhaust nozzle shapes which lower the noise level of whining jets. This was shown in actual demonstrations. But all versions so far involve considerable loss in thrust and cost more.

CLEVELAND NEWS
October 8, 1957



Here is an experimental jet engine noise suppressor developed at the Lewis Flight Propulsion Laboratory here. It cuts jet noise from about 120 decibels, almost deafening, to 108, which is loud but not deafening. Scientists hope eventually to develop a suppressor to cut the volume to 100 decibels.

Bright Young Men Work On Own 3 R's at NACA Lab

By DON ROBERTSON

The 100-million-dollar Lewis Flight Propulsion Laboratory is a place of rockets and racket and research.

It is a place where progress is measured in Machs and BTUs, decibels and thrust. It is a place where bright young men develop and test all sorts of things that fly.

These bright young men investigate fuels used to propel aircraft and missiles. They test materials best suited for supersonic flight — materials that won't disintegrate from heat. They experiment with jet engines, with the noise jet engines make. They test the engines' efficiency. They try to determine what is best and what is fastest.

2,000 Will Call

A total of about 2,000 government officials, educators, theoreticians, aircraft manufacturers and newsmen are visiting the lab this week. Their tours are under the sponsorship of the National Advisory Committee for Aeronautics, which operates the lab at 21000 Brookpark Road S. W., adjoining Cleveland Hopkins Airport.

These visitors, who are touring the lab grounds and buildings in groups of about 500 every day through Thursday, spend their day riding around the enormous land space occupied by the facility. They are entering various barn-like structures and listening to lectures by the bright young men.

Here are some of the things—and some of the problems—that are being explained:

JET NOISE—A decibel is a unit that measures noise. The noise of a jet plane in takeoff goes as high as 125 decibels. A human being can stand about 135 decibels before his head begins to split. The men at the lab have determined that the loud noise is caused by fluctuating air currents within the nozzle of the jet. They have experimented with various nozzles, and have come up with one (shaped like the pipes in a pipe organ) that cuts the noise to 108 decibels. A 100-decibel level is considered quiet enough, and so some experimenting remains before the project is a success. (The visitors are being shown an experiment that employs an actual plane. The noise is deafening.)

JET FUELS—Fuels containing hydrogen and boron have been found to be the most efficient and powerful for jet engines. But they are dangerous and hard to produce and leave oxides in the jets that impair efficiency. A lot more work also remains here.

MACH 4—A Mach is the speed of sound. Four Machs is 2,600 miles per hour. Aircraft have reached speeds of Mach 2. Now scientists believe they can develop engines capable of reaching Mach 4. One of the large barriers here is the conflict of thrust vs. drag—that is, power vs. inertia. Special engines are now being developed so that thrust will exceed drag by about 35%. Success of these engines will prevent the airplane from accelerating so slowly that it will consume too much fuel and thus shorten its range.

THE SUN
Springfield, Ohio
October 8, 1957

Scientists Predict Turbojet Aircraft Will Fly At Four Times Speed Of Sound

CLEVELAND, Oct. 7.—(AP)—The federal government's top aeronautic scientists today forecast that high-altitude turbojet aircraft would some day be flying at four times the velocity of sound.

Scientists of the National Advisory Committee for Aeronautics (NACA) unveiled a model of such a "Mach 4" plane of the future at an inspection of the Lewis Flight Propulsion Laboratory here.

The U. S. Air Force has flown an experimental plane at about Mach 3—three times the velocity of sound.

It was just 10 years ago this month that the Air Force broke the sound barrier with the X1.

The scientists disclosed to newsmen, military officers and industry representatives attending the inspection that they even are doing some research on aircraft with potential speeds of up to 25,000 m.p.h.

These would be used for space flight. But the NACA officials said planes beyond the Mach 4—2,600-m.p.h.—range would not be turbojets but rather ramjets or rocket-propelled craft.

Abe Silverstein, associate director of the laboratory, declined to say definitely whether a "Mach 4" plane could be used for commercial flying as well as military purposes.

He said there would be serious problems, such as how to cool the passenger compartment.

But he said such speeds could not be ruled out for airliners of the future.

The model of a "Mach 4" plane produced at the laboratory showed a long, pencil-like fuselage, with heavily swept back wings and the two turbojet power plants nestled up against the fuselage.

The scientists said there were many problems yet to be licked on such a plane. They said it appeared both the inlet and exhaust systems of the engines would have to be designed so that they were variable in their capacities at different speeds.

NACA also revealed that it was concentrating much effort on eliminating the bugs from high-energy fuel which could contribute to greatly increased speeds and range in high-altitude flight. Boron compounds have received much attention in this research. The scientists also discussed the problems involved in developing a successful nuclear-powered plane. Research must develop better and lighter shield materials for the atomic reactor before the project will be successful, they said.

Silverstein told newsmen "there is no question but that one (a nuclear-powered plane) could be made to fly."

But, he added, the question was whether such an effort should be made now in view of the work still needed to develop an efficient plane.

THE WALL STREET JOURNAL
October 8, 1957

Ramjet Test Missile Using Boron Fuel Flies 3 Times Speed of Sound

Top Federal Air Research Agency Shows New Unit, Tells of Rocket Gains

CLEVELAND.—(AP)—A ramjet test missile burning one of the new high-energy fuels, a boron compound, has flown more than three times the speed of sound, or faster than 2,000 m.p.h.

This was disclosed at the triennial inspection of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, the top Government agency in basic air research. The N.A.C.A. showed publicly for the first time a $2,500,000 rocket engine research facility which was completed last August.

The agency said that the spectacular rocket developments of the past few years may be surpassed by even greater gains from fuel research currently under way.

N.A.C.A. scientists told visitors the laboratory has been studying the effectiveness of various borane fuels and recently has tried them out in full-scale ramjet and turbojet engines.

Results Called Encouraging

Officials said the results have been encouraging, but some difficult problems remain. These include danger to personnel as boron compounds can be quite toxic and combustion deposits inside the engines, which cut down on performance.

N.A.C.A. officials explained that while the petroleum fuels now burned in jet aircraft are relatively cheap, plentiful and safe, their energy content to too low to satisfy the needs of military planes and missiles.

Since World War II, the N.A.C.A. said, at least 11 U.S. organizations, with increasingly strong encouragement from the armed forces, have been searching for new fuels with higher energy contents.

Most of the N.A.C.A. research interests have centered upon boron and its compounds because of its high energy content per pound and its high burning temperature.

The agency said in a report prepared for the triennial inspection that a theoretical study of a ramjet missile flying at 60,000 feet at a speed of 2,100 m.p.h. indicated the use of boron could extend the range 40% beyond that provided by conventional JP4 jet fuel.

From Laboratory to Flight Use

"It is one thing to complete satisfactory use of a radically new fuel type under concisely controlled conditions of the laboratory, and something perhaps entirely different, and much more difficult to achieve similarly happy results in actual use," the N.A.C.A. report said.

"The latter step has already been taken in a small way," the report continued. "Speeds greater than a mach number of three (three times the speed of sound) were recorded in free flight by an experimental full-scale ramjet test missile burning a boron compound fuel."

"Not until the multimillion dollar plants now under construction can produce relatively large amounts of the new high-energy fuels," the report added, will it be possible to complete the large-scale research needed before these fuels can be effectively applied.

2,600 M.P.H. Jet Predicted by U.S.

CLEVELAND, Oct. 7.—(AP)—The Federal Government's top aeronautic scientists today forecast that high altitude turbojet aircraft would some day be flying at four times the velocity of sound. Scientists of the National Advisory Committee for Aeronautics (NACA) unveiled a model of such a "Mach 4" plane of the future at an inspection of the Lewis Flight Propulsion Laboratory here.

The United States Air Force has flown an experimental plane at about Mach 3—three times the velocity of sound.

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25,000 M.P.H.

The scientists disclosed to newsmen, military officers and industry representatives attending the inspection that they even are doing some research on aircraft with potential speeds of up to 25,000 miles per hour.

These would be used for space flight. But the NACA officials said planes beyond the Mach 4—2,600 miles per hour—range would not be turbojets but rather ramjets or rocket-propelled craft.

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NACA also revealed that it was concentrating much effort on eliminating the bugs from high-energy fuel which could contribute to greatly increased speeds and range in high-altitude flight. Boron compounds have received much attention in this research. The scientists also discussed the problems involved in developing a successful nuclear-powered plane.

Research must develop better and lighter shield materials for the atomic reactor before the project will be considered, they said.

Silverstein told newsmen "There is no question but that one (a nuclear powered plane) could be made to fly."

But, he added, the question was whether such an effort should be made now in view of the work still needed to develop an efficient plane.

The NACA officials told of their work on ions as "an attractive propulsion device" for outer space flight. Ions are tiny bits of matter, carrying electrical charges formed when an electron is added or removed from an electrically neutral atom.

The officials said that if a stream of ions could be accelerated to high velocities by use of electric or magnetic fields, their energy could give thrust which might propel satellites in flights beyond the Earth's atmosphere.

The scientists disclosed that in addition to dizzying speeds and space flight they also are working on more mundane headaches.

They said one problem which might arise in connection with the jet airliners scheduled to begin service in 1959 was that their engines on the ground sometimes tend to act as mammoth vacuum cleaners.

The engines might pick up pebbles, small tools and debris "with occasional catastrophic results," the scientists said.

NACA is working on methods to prevent these results and has met with some success, they explained.

2,000 mph on New Jet Fuel

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This was disclosed today at the triennial inspection of the Lewis flight propulsion laboratory of the National Advisory Committee for Aeronautics (NACA), the top Government agency in basic air research.

NACA showed publicly for the first time a $2,500,000 rocket engine research facility which was completed last August.

DIFFICULT PROBLEMS.

Officials said the fuel test results have been encouraging, but some difficult problems remain. These include:

1—Danger to personnel. Boron compounds can be quite toxic.

2—Combustion deposits inside the engines, which cut down on performance.

NACA officials explained that while the petroleum fuels now burned in jet aircraft are relatively cheap, plentiful and safe, their energy content is too low to satisfy the needs of military planes and missiles.

While other United States organizations also have been searching for new, higher energy fuels, most of the NACA research interests have centered upon Boron and its compounds because of its high energy content per pound.

The agency said in a report to the triennial inspection that a theoretical study of a Ramjet missile flying at 60,000 feet at a speed of 2,100 m.p.h. indicated that the use of Boron could extend the range 40 per cent beyond that provided by conventional JP4 jet fuel.

Silencer Cuts Down Jet Engine Noise

CLEVELAND, Oct. 7.—(AP)—A new gadget on the tail end of a jet bomber's engine cut the engine's throaty roar down to a comparative whisper today.

The National Advisory Committee for Aeronautics (NACA), which demonstrated the sound suppressor at the Lewis Flight Propulsion Laboratory, said it was promising but still short of practical reality.

The device was demonstrated on one of the six jet engines of a B-47 medium bomber.

The conventional round exhaust pipe of the engine had been replaced by one with a deeply corrugated interior, and made even more effective by combining it with a short, external barrel-like duct called an ejector.

The deep corrugations on the inside wall of the exhaust nozzle serve to break up the flow of the exhaust gasses and slow them down. The exhaust was slowed still further by the ejector which served to scoop outside air through vents forming the outer side of the corrugations, and to mix this air with the exhaust fumes leaving the plane.

Sanders said this device could cut the engine's noise by 13 decibels, reducing it to only 1/16 that of the conventional engine.

CLEVELAND PLAIN DEALER
October 8, 1957

Use of Atomic Airplane for Defense Questioned

A top sciencist of the National Advisory Committee for Aeronautics yesterday questioned whether the atomic-powered plane would ever be needed for U.S. defense.

Abe Silverstein, associate director of the Lewis Flight Propulsion Laboratory, discussed the nuclear-powered plane with newsmen.

"There is no question but that one could be made to fly," Silverstein stid.

He asserted the project should go forward for "research purposes" even if the plane did not figure in future defense. Many experts have claimed that the quided missile will make manned aircraft obsolete for warfare.

Model Shown

Visitors at the triennial inspection at Lewis lab were shown a model of a high-altitude turbojet airplane that someday will be flying at four times the speed of sound.

NACA scientists also said they were doing some research on aircraft with potential speeds up to 25,000 miles per hour. These would be used for "space flight."

The planes to fly at speeds greater than 2,600 miles an hour would be powered by ramjet or rocket engines.

The scientists even spoke of their research with ions as an "attractive" propulsion device for flights into outer space.

Ions are tiny bits of matter, carrying electrical charges formed when an electron is added or removed from an electrically neutral atom.

Great Potential

The scientists said that if a stream of ions could be accelerated to high velocities by use of electric or magnetic fields their energy could give thrust which might propel satellites far beyond the earth's atmosphere.

A less exciting topic also received considerable attention: a noise suppressor for jet engines.

One of the gadgets was demonstrated on an engine of a B-17 bomber. It reduced the "noise power" of the engine to about one sixteenth of an engine without the suppressor.

But the device weighs several hundred pounds and would be "completely unacceptable" to jet plane users, said Newell Sanders of the Lewis lab physics division.

Sanders said that British and U.S. manufacturers were working on the problem together and that similar devices weighing 40 to 50 pounds might be expected.

In the field of high-energy fuels, it was disclosed that a ramjet test missile burning a boron compound has flown faster than 2,000 mph.

Results from boron compounds have been encouraging, the scientists said. But the compounds "can be quite toxic and the products of combustion can produce deposits within the engine which depreciate performance."

Fluorine looks "most desirable" of all oxidizers for rocket engines.

"Fluorine's reactivity with fuels is so strong and the resulting combustion temperatures are so high," said an NACA brochure, "that extraordinary difficulties must be overcome to accomplish successful injection of the fluorine and fuel into the burner chamber.

"Fluorine - supported flames may be 2000 degrees to 3000 degrees (Fahrenheit) hotter than oxygen-jet fuel flames, which reach 5000 degrees (Fahrenheit)."

NEWPORT NEWS TIMES HERALD
Newport News, Virginia
October 8, 1957

10-8-57 NEWPORT NEWS TIMES-HERALD

IONIC ROCKET POWER PLANNED

Model Of Manned Space Ship Revealed By NACA

By ANSEL E. TALBERT
Herald Tribune News Service

CLEVELAND — A hitherto secret working model of an ionic rocket — a new propulsive system intended for manned space ships and earth satellites — was shown yesterday for the first time by the National Advisory Committee for Aeronautics.

The committee also revealed that its current research projects show that high - flying aircraft propelled by combined knure-jet and ram - jet engines can be built to transport human passengers 2,600 miles an hour — four times the speed of sound. The NACA is headed by Dr. James A. Doolittle, former Air Force lieutenant general.

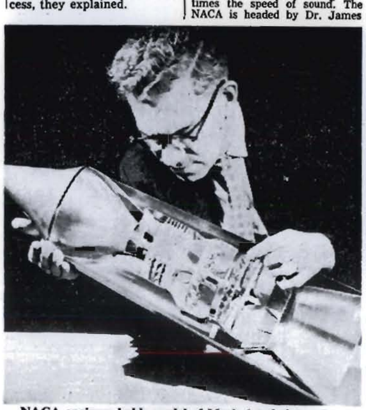
An ionic rocket, known also as an electrical particle accelerator, will make possible speeds of greater than 25,000 miles an hour for long periods of time in outer space, beyond the earth's gravitatonal field, according to scientists working on the project.

The ionic rocket, as demonstrated here in model form, works on the principle of accelerating ions — atoms with some of their electrons stripped off so as to give them a positive charge — by application of electrical or magnetic fields. After this treatment, the ions issue out of an ionic rocket in the same way that hot gases roar out of the exhaust of a conventional jet or chemical rocket engine.

Dr. Abe Silverstein, associate director of the Lewis Flight Propulsion Laboratory, said that there were several other possible sources of propulsion for space ships, including "direct nuclear power."

The ionic rocket is expected by NACA scientists to operate for very long periods in space flight on small amounts of fuel. Dr. Silverstein indicated that nuclear power or solar power, taken directly from the sun's rays, could be harnessed to drive generators which product the electrical fields necessary to accelerate ions to speed at which they would drive a space ship to the moon or some other location in outer space.

The NACA up to now has not been closely connected with the current earth satellite or Vanguard project of the United States, which has just been beaten to completion by the Soviet Union. The U. S. satellite project is a development program based on existing fuels and chemical rocket engines, while the NACA's prime job is one of advanced research.



NACA engineer holds model of Mach 4 turbojet engine.

NEW YORK HERALD TRIBUNE
October 8, 1957

U. S. Reveals a Model Of Space-Ship Rocket

By Ansel E. Talbert
Military and Aviation Editor

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The N.A.C.A. is headed by Dr. James A. Doolittle, former Air Force lieutenant general who holds a doctorate in aeronautical science from Massachusetts Institute of Technology. All its seventeen governing members are scientists distinguished in some field of aeronautical research and appointed by the President.

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(Continued from page one)

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The source of the stream of ions to be used in a full-sized ionic rocket engine was not disclosed by Dr. Silverstein, who only would say that it would have to be drawn from some light material which could be ionized at low temperatures. He emphasized that although the N. A. C. A. had a working model of an ionic rocket engine, the present should be considered as "an early period in the field of this type of propulsion." He also said there were several other possible sources of propulsion for space ships, including "direct nuclear power."

The N. A. C. A. up to now has not been closely connected with the current earth satellite or "Vanguard" project of the United States, which has just been beaten to completion by the Soviet Union. The American satellite project is a development program based on existing fuels and chemical rocket engines, while the N. A. C. A.'s prime job is one of advanced research.

During today's tour of the Lewis Flight Propulsion Laboratories, an inspection held only once every three years, the N. A. C. A. announced that its experiments "in actual flight on full-scale ram-jet engines" show that new high-energy fuels for planes and missiles are in the offing. These should be capable of increasing the range of supersonic aircraft and guided missiles by as much as 40 per cent, it was disclosed.

Laboratory scientists also disclosed that their confidence that jet engines will be suitable for flight speeds up to four times the speed of sound "is based on research on the major engine components and also on N. A. C. A. analyses of future engine characteristics." A "mach 4" airplane (one flying four times the speed of sound) will have to combine the advantages from the most advanced concepts in aerodynamics, airplane structures and power plants—all of which mutually influence one another, they said. And they also emphasized that certain obstacles still stand in the way of actual design and development.

A new $2,500,000 addition to research equipment available to N. A. C. A. aeronautical scientists specializing in propulsion —the Lewis Rocket Engine Research Facility—was shown publicly for the first time today to representatives of the aircraft industry, the military services and various top scientific organizations. The new facility permits scientists to use full-sized rocket engines in their search for means to utilize new high energy propellants now under developments.

CLEVELAND PRESS
October 8, 1957

Pave Way Here for Space Travel

By CHARLES TRACY, *Aviation Editor*

Vital research in the U. S. race to send American airmen orbiting through space ahead of the Russians is going on in NACA's Air Lab at Cleveland Hopkins Airport.

Top scientists in this fantastic phase of aeronautics today described their work to the nation's air leaders inspecting the 100-million-dollar government research facility.

They disclosed that:

ROCKET RESEARCH is being rushed to perfect high energy fuel for launching a man-carrying satellite designed to orbit in space at an altitude of 1050 miles.

SUPER-HOT temperatures of 20,000 degrees Fahrenheit are being created to simulate friction of atmosphere on space ships.

OUTER SPACE FLIGHT propulsion devices using a stream of ions for thrust are being operated.

Aviation's historic events for 20 years have been predicted a decade in advance by NACA experts.

Heat is their main barrier for future accomplishment. In tests it is melting the insides of rocket, ramjet and turbojet engines; it is burning away the wings and surfaces of planes and space rockets at the speeds needed for progress. New materials and cooling systems are the great need in today's research, they say.

Future aircraft will be exposed to temperatures up to 30,000 degrees Fahrenheit when re-entering the earth's atmosphere. To study materials at such extreme heat, new facilities were devised.

Highly explosive fluid was sprayed through an electric arc with the resulting explosion directed through a nozzle to produce a high-speed stream of white-hot flame at 20,000 degrees Fahrenheit.

Models made of various heat-resistant materials then were placed in the searing breath of such tunnels to test their stamina.

Deadly fluorine gas is being used in fuel for rockets designed to launch the man-carrying satellite and for intercontinental ballistic missiles. It is mixed with hydrogen, reduced to a liquid by chilling to 425 degrees below zero.

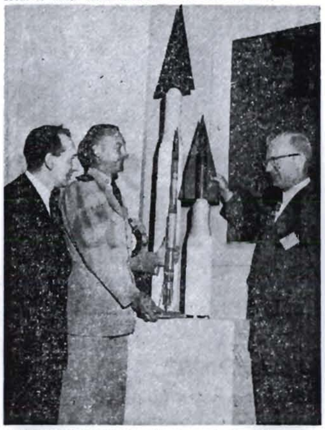
The hotter a rocket fuel burns, the more power it has, say the scientists. That's why they're using fluorine and are determined to overcome its dangerous handling qualities. They say its flames are 8000 degrees F., 3000 degrees hotter than any other known fuel.

The best metals today, however can only take temperatures of 3100 degrees F.

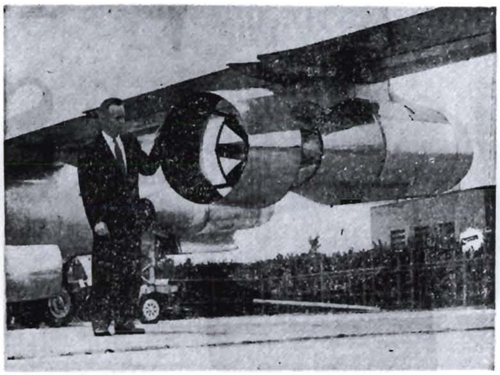
In flight tests, NACA's twin-jet Canberra bomber is used to launch a two-stage rocket at 50,000 feet over the Atlantic Ocean. Top speed of the rocket has been 7000 mph.

In future planes, turbojet engines will be used up to 2600 mph, where ramjets take over for faster flights up to 4600 mph. The air-breathers stop there and rockets, independent of air, take over for flights on up into thousands of miles an hour into space.

ATOMIC PLANE'S SHIELDING, made of lead and paraffin, is installed in test model by NACA nuclear scientist, James Blue, for NACA visitors Capt. Russell Langlois (center), of the Air Force research staff in Washington, and Air Commodore R. C. Cameron, Royal Canadian Air Force liaison officer in Washington.



SATELLITE MODELS with wings, designed to carry a man 1050 miles up into outer space, are displayed to NACA visitors C. C. Weismann (left), and Lieut. C. W. Stoddard, from the Office of Naval Research, Washington, by Rocket Engineer Edmund Jonash. The winged models are man-carriers while the slender model held by Lieut. Stoddard is a copy of the Vanguard satellite to be launched next spring.



PROGRESS IN REDUCING JET PLANE NOISE—one of aviation's major modern problems—was demonstrated today at NACA laboratories. One engine of this B-47 jet bomber created 121 decibels of noise when fired up. But another engine of the same plane, equipped with a "noise suppressor," recorded only 107 decibels—slightly above the 100 decibels of a propeller-driven plane. Warren North, flight test pilot, displays the suppressor.

NEW YORK HERALD TRIBUNE
October 8, 1957

U. S. Reveals a Model Of Space-Ship Rocket

By Ansel E. Talbert
Military and Aviation Editor

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Continued on page 4, coli ɪɪn 3

Space Ship-Rocket Model

(Continued from page one)

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The source of the stream of ions to be used in a full-sized ionic rocket engine was not disclosed by Dr. Silverstein, who only would say that it would have to be drawn from some light material which could be ionized at low temperatures. He emphasized that although the N. A. C. A. had a working model of an ionic rocket engine, the present should be considered as "an early period in the field of this type of propulsion." He also said there were several other possible sources of propulsion for space ships, including "direct nuclear power."

The N. A. C. A. up to now has not been closely connected with the current earth satellite or "Vanguard" project of the United States, which has just been beaten to completion by the Soviet Union. The American satellite project is a development program based on existing fuels and chemical rocket engines, while the N. A. C. A.'s prime job is one of advanced research.

During today's tour of the Lewis Flight Propulsion Laboratories, an inspection held only once every three years, the N. A. C. A. announced that its experiments "in actual flight on full-scale ram-jet engines" show that new high-energy fuels for planes and missiles are in the offing. These should be capable of increasing the range of supersonic aircraft and guided missiles by as much as 40 per cent, it was disclosed.

Laboratory scientists also disclosed that their confidence that jet engines will be suitable for flight speeds up to four times the speed of sound "is based on research on the major engine components and also on N. A. C. A. analyses of future engine characteristics." A "mach 4" airplane (one flying four times the speed of sound) will have to combine the advantages from the most advanced concepts in aerodynamics, airplane structures and power plants—all of which mutually influence one another they said. And they also emphasized that certain obstacles still stand in the way of actual design and development.

A new $2,500,000 addition to research equipment available to N. A. C. A. aeronautical scientists specializing in propulsion—the Lewis Rocket Engine Research Facility—was shown publicly for the first time today to representatives of the aircraft industry, the military services and various top scientific organizations. The new facility permits scientists to use full-sized rocket engines in their search for means to utilize new high energy propellants now under development.

THE JOURNAL
Wilmington, Delaware
October 8, 1957

New Gadget on Tail End of Jet Engine Cuts Roar to Comparative Whisper

CLEVELAND, Oct. 7 (AP) — A new gadget on the tail end of a jet bomber's engine cut the engine's throaty roar down to a comparative whisper today.

The National Advisory Committee for Aeronautics, which demonstrated the sound suppressor at the Lewis Flight Propulsion Laboratory, said it was perhaps the most promising device of its kind, if developed, but is still far from practical reality.

Newell Sanders, chief of the laboratory's physics division, told visitors that so far as the jet plane's noise problem is concerned, "we feel that the solution is not far away, and that we can look forward to greatly reduced engine noise."

The device was demonstrated on one of the six jet engines of a B-47 medium bomber parked beside a laboratory building.

Corrugated Interior

The conventional round exhaust pipe of the engine had been replaced by one with a deeply corrugated interior, almost as though the smooth inner wall had been fitted with somewhat flattened organ pipes.

One of several designs being studied here, the device was made even more effective by combining it with a short, external barrel-like duct called an ejector.

The deep corrugations on the inside wall of the exhaust nozzle serve to break up the flow of the exhaust gasses and slow them down.

The speed of the exhaust emerging from the airplane engine was slowed still further by the ejector which served to scoop outside air through vents forming the outer side of the corrugations, and to mix this air with the exhaust fumes leaving the plane.

The scientists forecast high-altitude turbojet aircraft would some day be flying at four times the velocity of sound and unveiled a model of such a "mach 4" plane of the future.

The Air Force has flown an experimental plane at about mach 3—three times the velocity of sound.

It was just 10 years ago this month that the Air Force broke the sound barrier with the X-1.

The scientists disclosed that they even are doing some research on aircraft with potential speeds of up to 25,000 MPH.

These would be used for space flight. But the NACA officials said planes beyond the mach 4 — 2,600-MPH — range would not be turbojets but rather ramjets or rocket-propelled craft.

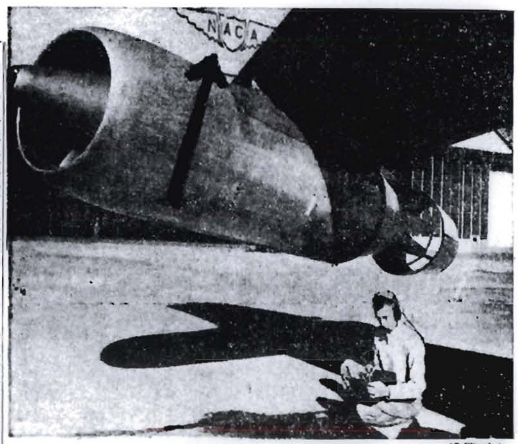
Abe Silverstein, associate director of the laboratory, declined to say definitely whether a "mach 4" plane could be used for commercial flying as well as military purposes.

Serious Problems

He said there would be serious problems, such as how to cool the passenger compartment.

NACA officials told of their work on ions as "an attractive propulsion device" for outer space flight. Ions are tiny bits of matter, carrying electrical charges formed when an electron is added or removed from an electrically neutral atom.

The officials said that if a stream of ions could be accelerated to high velocities by use of electric or magnetic fields, their energy could give thrust which might propel satellites in flights beyond the earth's atmosphere.



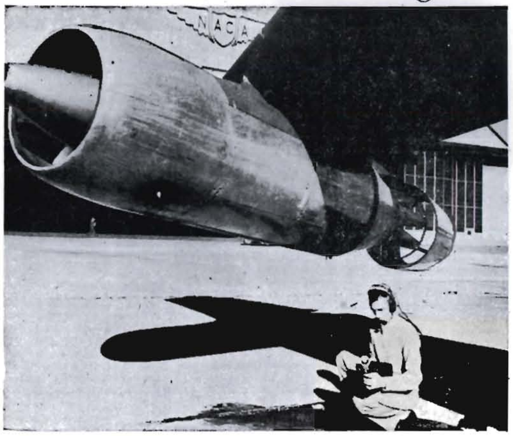
AP Wirephoto

NOISE SUPPRESSOR—An experimental turbojet noise suppressor nozzle mounted on a J-47 engine of a B-47 Stratojet on display at the National Advisory Committee for Aeronautics Lewis Flinht Propulsion Laboratory, Cleveland.

THE INDIANAPOLIS STAR
October 8, 1957

ROAR BECOMES WHISPER

Jet Noise War Shows Progress



An experimental turbo-jet noise suppressor nozzle mounted on a J-47 engine of a B-47 Stratojet was on display yesterday at the National Advisory Committee for Aeronautics Lewis Flight Propulsion Laboratory at Cleveland, O. Difficulties are encountered in the design of such nozzles, to keep drag, weight and engine performance penalties at a minimum while at the same time accomplishing the desired noise reduction. (AP Wirephoto)

Cleveland (AP)—A new gadget on the tail end of a jet bomber's engine cut the engine's throaty roar down to a comparative whisper yesterday.

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One of several designs being studied here, the device was made even more effective by combining it with a short, external barrel-like duct called an ejector.

The deep corrugations on the inside wall of the exhaust nozzle serve to break up the flow of the exhaust gasses and slow them down.

The speed of the exhaust emerging from the airplane engine was slowed still further by the ejector which served to scoop outside air through vents forming the outer side of the corrugations, and to mix their air with the exhaust fumes leaving the plane.

THE SPECIALLY fitted engine was run up first, and emitted a modest amount of noise. Then one of the other General Electric J-47 engines was operated without the equipment to demonstrate the difference.

Sanders said this device could cut the engine's noise by 13 decibels.

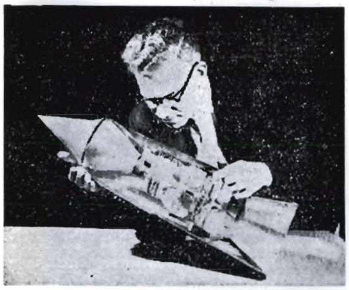
He said this meant that the noise power of the specially fitted engine was only 1-16th that of the conventional engine.

The physicist explained that the greater part of the noise of a jet engine comes not from the flying of its compressor blades or the rapid combustion of fuel but from the mixing of the exhaust jet with the atmosphere.

He said the hot gas and air roll up into irregular swirls producing fluctuating pressures that radiate sound waves..

SPRINGFIELD (OHIO) NEWS
October 8, 1957

Model Turbojet Engine



—(AP) WIREPHOTO

CLEVELAND, Oct. 8.—An engineer holds a model of a theoretical turbojet engine designed for speeds in the Mach 4 (four times the speed of sound) range. Scientists at Lewis Flight Propulsion Laboratory here said they are confident a working turbojet engine can be built despite "formidable obstacles."

* * * * * * * *

Ion Bombardment May Serve As Power Source For Future Space Ships

CLEVELAND, Oct. 8.—(AP)—The National Advisory Committee for Aeronautics bombarded a small pinwheel inside a glass vacuum-jar with an invisible stream of ions today and made it whirl briskly.

The same ion-stream principle, NACA said, some day may be harnessed to push 10-ton space ships moonward at many thousands of miles an hour once they have reached outer space.

Coupled with atomic energy, such vehicle might have virtually unlimited range.

The demonstration was part of a four-day public inspection of the NACA's Lewis Flight Propulsion Laboratory which is attracting top scientists to Cleveland this week.

In order to simulate the searing temperatures which will be experienced by aircraft and power plants at extreme speeds, NACA has developed a research tool, the electric arc tunnel. It uses a cathode ray and anode nozzle to transmit a spark, much as in the powerful searchlight of an anti-aircraft unit.

A fluid injected into the arc chamber, heated by the arc and expanded through the nozzle produces a high-speed stream, or "plasma jet," with temperatures of 10,000 to 20,000 degrees.

"The arc tunnel suggests an attractive propulsion device for outer-space flight," NACA said in a report made public at the demonstration.

"If a stream of ions, as in an arc jet, can be accelerated to high velocities by use of electric or magnetic fields, a small amount of thrust will be produced."

Ions are tiny bits of matter—atoms which have been stripped of some of their electrons and have become electrically charged.

Physicist M. J. Krasnican explained that beyond the earth's atmosphere a vehicle would require only slight power in small increments, to accelerate a great deal.

"For example," he said, "a 10-ton vehicle in outer space, powered by 10 pounds of thrust for only one month, would increase its original velocity by 25,000 miles an hour."

Such a vehicle before its ion acceleration presumably would be travelling at least 18,000 miles an hour, which is the minimum speed for an earth satellite to maintain its orbit. Still greater speed would be required to break away from the earth's pull and escape into space.

Krasnican said the model of an ion engine "may be one more link in the chain of events leading to future space flight."

Abe Silverstein, associate director of the Lewis Laboratory, said nuclear energy is an attractive possibility for flight propulsion because of the tremendous energies available in each pound of fuel and the very high temperatures that may be attained.

He said the major disadvantages are the heavy shielding required for protection of the crew of a nuclear aircraft, and the damaging effect of radiation upon airplane materials.

"There is no question but that we can make an atomic airplane that will fly," Silverstein said.

"The question is, for what purpose do we want the plane and will it be satisfactory for that purpose?

Asked when such a plane might be developed, Silverstein said the atomic airplane was still "in the early stage of growth."

October 8, ... **Aviation DAILY** Page 2

NACA FACILITY WORKS ON MACH 4 TURBOJET

The National Advisory Committee for Aeronautics announced its Lewis Flight Propulsion Laboratory in Cleveland is now working on the preliminary development of a Mach 4 turbojet engine capable of driving an aircraft 2,600 mph at high altitudes.

Occasion of the NACA announcement was the triennial inspection of the $100,000,000 Lewis Research facility -- one of the three major NACA facilities. Lewis conducts research in all advanced areas of aircraft and missile propulsion, including turbojets, ramjets and rocket engines, fuels and oxidizers, structural materials and operating problems.

Reporters attending the inspection were told that a Mach 4 turbojet engine might have only a three-stage compressor, compared to the 12 to 15 stages in present engines, and that it would have much a smaller combustor section than present powerplants, leading to considerable compactness.

Such a high-speed engine would require variable air inlets and exhaust nozzles in order to operate over the broad range of speeds from take-off to Mach 4. Without such variable geometry, NACA said, the engine would probably be unable to fly faster than Mach 1.4 and the takeoff itself would be "marginal."

"Although it appears that aerodynamics and combustion principles of a Mach 4 engine are being worked out, practical construction will be difficult because of the high temperature environment in which engine components must operate," NACA said.

"The compressor temperature of a Mach 4 turbojet is so high that its construction will require the use of alloy currently being used for turbine blades."

High Ram Air Temperatures Troublesome

NACA scientists explained that the high ram temperatures encountered by a Mach 4 engine,about 1,200°F.,will be principally responsible for the more difficult materials involved in such an engine. While the strength and temperature of compressor blades must be increased, the turbine blades themselves might have even greater strength and temperature resistance. Engine bearings and seals also present difficult problems because of the high level of ram air temperatures.

NACA also disclosed that it has conducted successful test flights at its Wallops Island, Va. research station with experimental ramjet vehicles burning a high-energy boron-compound fuel. One vehicle attained a velocity "greater than a Mach number of 3," NACA said.

The Lewis Laboratory is giving considerable attention to the problem of hypersonic flight--at speeds of more than Mach 5, or 3,300 mph. At this speed, NACA said, air temperatures reach 2,000° F. on engine surfaces, while at Mach 7 they reach 4,000° F. Much research is now directed at the problem of cooling engines operating in these speed ranges, including the possibility of using fuel as a coolant.

The Lewis laboratory also showed off a $2.5 million rocket engine research facility completed in August. It will permit tests of rocket engines up to 20,000 lbs. in thrust and will be particularly valuable in the study of higher energy rocket propellants like fluorine and liquid hydrogen.

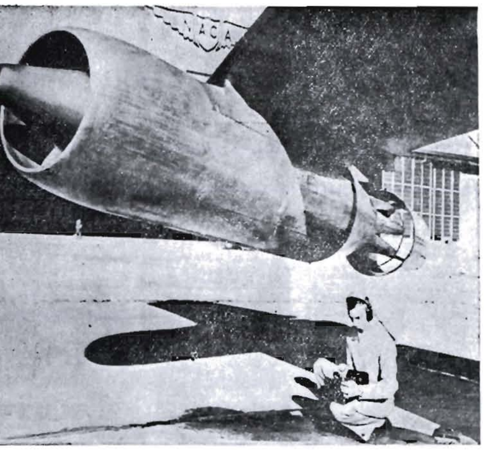
Other areas under study at Lewis include:

1 - Jet noise - experiments are aimed at the redesigning the exhaust nozzles of jet engines to reduce the velocity of the exhaust jet and thus cut noise. One promising area is the possibility of designing engines with lower jet velocity in combination with special nozzle shapes to minimize exhaust turbulence.

2 - Operating problems - Jet engines create vortexes at the inlet which behave like gigantic vacuum cleaners and suck up all manner of dirt, tools and other foreign matter. NACA is studying various methods of avoiding engine damage of this type.

3 - Materials - NACA wants to increase turbojet engine operating temperatures from the present 1,650° F. to more than 2,000° F. within the next few years. To achieve this, new, more heat-resistant materials are necessary. Lewis is now looking into a variety of possibilities for getting greater heat-resistance, including the use of ceramics, new alloying methods and new kinds of alloys which resist oxidation.

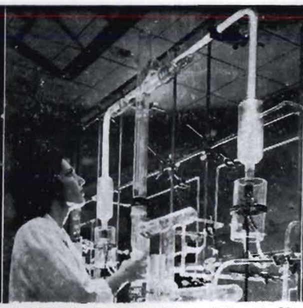
San Jose Evening News Tuesday, Oct. 8, 1957 15



Goal—Noise Reduction

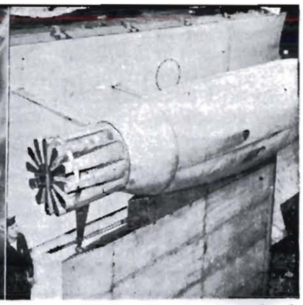
An experimental turbo-jet noise suppression nozzle mounted on a J47 engine of a B47 Stratojet was on display today at the National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory at Cleveland, Ohio. Difficulties are encountered in the design of such nozzles to keep drag, weight and engine penalties at a minimum while at the same time accomplishing the desired noise reduction. (AP Wirephoto)

ATOM EFFECTS—During trienniel inspection of Cleveland NACA, cloud chamber research shows how radiation affects aircraft.



LAB SKY—Simulating high atmosphere is this rocket-missile experiment. Dr. E. R. Sharp, a native of Hampton, headed Lewis research.

WIND TUNNEL—Emphasis at Lewis is on air propulsion. Here, scientists prepare an aircraft model to test in 10 by 10 2,500 mph tunnel.



NOISE MUFFLER—Many Langley NACA officials are at Lewis inspection and will see model of turbojet noise suppressor, here on engine.

Section 2 **THE TIMES-HERALD** Section 2

THURSDAY, OCTOBER 10, 1957 PAGE 13

NACA Lectures Concerned With New Engines

New engines with high strength at extreme temperatures generated in hypersonic flight was one of the major points being discussed at the trienniel inspection of the Lewis Laboratory of the National Advisory Committee for Aeronautics in Cleveland, O.

The inspection, similar to the one held last October at Langley Air Force Base for the NACA, has drawn a number of local NACA officials.

Director of the Lewis Lab, which was established in the early 1940's, is Dr. E. R. Sharp, a Hampton native who initially joined the NACA at Langley and who has been director at the Lewis Lab since it was established.

WITH EXTREME heating the atomic structure of a metal changes, causing it to creep or deform. By locking the atomic structure of the materials in place with refractory particles that do not melt, deformation can be prevented. Some of the conventional metal alloys dissolve these particles and thus lose strength under intense heating, but there are others that possess greater heat resistance and chemical inertness. Mixtures of small amounts of finely divided aluminum oxide in nickel are being studied as one means of improving heat strength. In the Lewis research program, it was found that this type of alloy retains strength at significantly higher temperatures, and no undue brittleness occurs.

Columbium, tungsten, and other high-melting point base metals offer another approach to the heat-resistant problem, although these have serious oxidation properties. With a melting point in excess of 6,000 degrees F, tungsten retains considerable strength at 3,500 degrees. Study is being directed toward improving the oxidation resistance of tungsten and like materials. Some progress has been made with columbium, in reducing the rate of oxidation and altering the type of oxide formed.

REFRACTORY ceramics suggest still another means of combatting the temperature problem. These have worthwhile resistance to heating and oxidation, but they are too brittle. Therefore, they would fail under thermal and mechanical shocks likely to be encountered in missile re-entry, and in propulsion system operations.

Brittleness of ceramics is not completely understood but some studies indicate that certain ones may be inherently ductile except for surface imperfections. Some of the investigations of this subject in the laboratory have shown, in a limited way, that elimination of surface imperfections can help maintain ductility. By surface treatment of single crystals of magnesium oxide and sodium chloride ductile ceramics have been created in the Lewis laboratory.

Much research on the whole problem of heat resistance in materials remains to be accomplished, the Lewis spokesmen said in their demonstration. Although results have been encouraging, considerable more work needs to be done before the highly advanced materials for use in engines or structural aircraft and missile parts will be available.

SAN FRANCISCO CHRONICLE Wednesday, Oct. 9 1957

New Gadget Cuts Down Jet's Roar

CLEVELAND, Oct. 8 (AP) A new gadget on the tail end of a jet bomber's engine cut the engine's throaty roar down to a comparative whisper this week.

The National Advisory Committee for Aeronautics, which demonstrated the sound suppressor at the Lewis flight-propulsion laboratory, said it was perhaps the most promising device of its kind.

The device was demonstrated on one of the six jet engines of a B-47 medium bomber parked beside a laboratory building.

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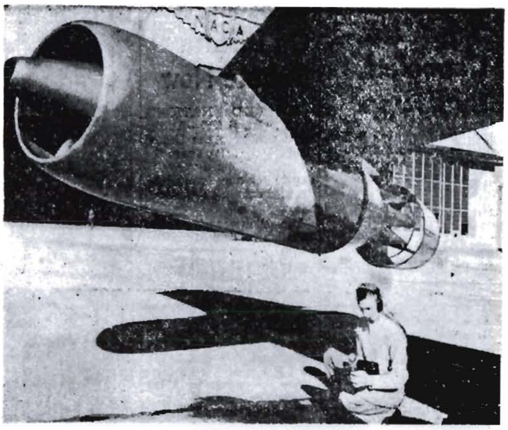
One of several designs being studied here, the device was made even more effective by combining it with a short external barrel-like duct called an ejector.

The deep corrugations on the inside wall of the exhaust nozzle serve to break up the flow of the exhaust gasses and slow them down.

Sanders said this device cut the engine's noise to only one sixteenth that of the conventional engine.



A. P. Wirephoto

The gadget mounted on the J-47 engine of this B-47 Stratojet cut down the typical jet roar, but experimenters said the device is not yet practical.

FUEL RESEARCH—Major Lewis Lab effort of NACA in past decade has been research in high energy fuels for all aircraft.

CLEVELAND PRESS October 9, 1957

Predict Manned Planes at 25,000 MPH

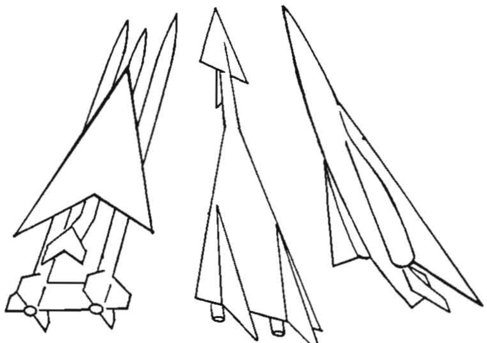
By CHARLES TRACY
Aviation Editor

Evolution of the manned airplane from the fading turbojet to the 25,000-mph rocket was foretold today by scientists at the NACA Air Lab, Cleveland Hopkins Airport.

They saw the end of the development of the turbojet engine within a few years, addressing 2000 of the nation's aeronautical experts, here this week to inspect Lewis laboratories.

The present turbojet fighter plane has nearly reached the peak of its development today, the aviation scientists agreed.

Refinements during the next few years will speed it up 2600 mph but that's about the limit for pure jet engines.



AIRPLANES OF THE FUTURE will look like these sketches of NACA models. The ramjet (left) will succeed the turbojet (right), then comes the hypersonic rocket (center) cruising at 25,000 mph.

Ramjets Next

Ramjets will follow the turbojets and speed planes from 2600 to 4600 mph.

Getting its power and its name from air rammed into its front end, the ramjet has no moving parts, becomes more powerful the faster it goes.

But the ramjet doesn't start producing until boosted along at 500 mph. It must fly within air regions of the earth.

NACA experts suggest twin rocket engines be used for launching the ramjet plane to the 500-mph starting speed. As the rockets are expended and dropped away, the plane flies free on its ramjets.

Continuing up the corridor of continuous flight, scientists have designed a "hypersonic" aircraft to fly 25,000 mph at altitudes of 50 to 150 miles. These will reach orbital speed 75 miles up and can cruise like satellites. But they have delta wings and control surfaces to fly back to earth.

These will be powered by rocket engines using new high-energy fuels still to be developed.

Temperatures of the new hypersonic craft will rise to 3000 degrees Fahrenheit as it drops back into the earth's atmosphere. The plane and its engines will have to be made of metals or ceramics not yet discovered to withstand the heat inside and out.

More conservative uses for the dying turbojet engine in airliners, cargo planes and private commercial craft will continue for many years, the scientists predict.

THE AIRMAN, OFFICIAL JOURNAL OF THE AIR FORCE, October 1957

KING-SIZE PROPULSION

Earlier this month, in Cleveland, Ohio, the National Advisory Committee for Aeronautics played host to a group of the Nation's leading scientists, educators and writers at their Lewis Laboratory.

One of three NACA labs which are opened for a select audience on a rotating triennial basis, Lewis Lab is concerned directly with experimental propulsion systems—turbojet, ramjet, rocket, and nuclear.

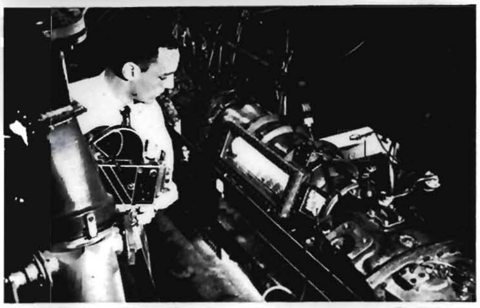
Operational altitudes of 150 miles and speeds in excess of 25,000 m.p.h. were among future possibilities discussed during the tour. Strangely enough, contrary to the majority of present day opinion concerning a declining need for aircrews, these figures were advanced for manned space satellites.

Among top attention-getters was a detailed discussion of high energy aircraft fuels ranging from boron-hydrogen compounds, reputed to possess nearly double the thrust capabilities of present fuels, to ionic drive. Power sources included solar energy and nuclear reaction.

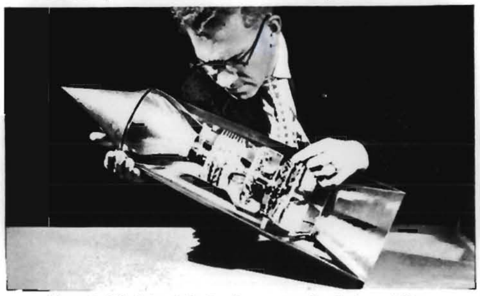
Closer to the realm of present day working hardware was the talk centering around turbojet engines. Previous conclusions had placed their top speed capabilities at Mach 2.5. Lewis scientists now express confidence that a Mach 4 (2,600 m.p.h. at altitude) powerplant could successfully be constructed and placed in operation.

The Lewis Flight Propulsion Lab, named for the late Dr. George Lewis, first director of NACA, was established in 1941 adjacent to Hopkins Airport. It boasts a staff of 2,700 professional and technical employees, and is headed by Dr. Edward R. Sharp. ★

A small wheel is jet-operated by means of an ion-propulsion model.



High energy fuels are burned in combustion test apparatus at Lewis.



Theoretical Mach 4 turbojet, based on a composite of advanced ideas.

CHRONICLE-TELEGRAM
Elyria, Ohio
October 14, 1957

2,500 Tour NACA On 4-Day Inspection

By NORMA HIGGINS

James "Jimmy" Doolittle and Edward V. "Capt. Eddie" Rickenbacker were among the 2,500 persons who toured the Lewis Flight Propulsion Laboratory (NACA) during the triennial four-day inspection last week.

During a coffee break in the morning tour, Doolittle commented that the Russian's earth circling satellite is both "bad and good." "Bad, because of their progress," he said because American scientists were not first, but good because it will "shake us loose from our complacency."

Doolittle spoke complimentarily of NACA scientists and engineers, describing the wonders of aircraft research on display. "With such as these, how can we miss?" he said.

Doolittle is chairman of the National Advisory Committee for Aeronautics. Lewis Laboratory is one of three major research establishments operated by the NACA. Created by Congress in 1915, NACA is the top aeronautical research organization of the federal government. Doolittle is chairman on NACA's board of directors whose 17 members are appointed by the president of the United States, and serve without pay.

Men Needed

Capt. Rickenbacker, referring to a change of service and comparing war-time activity to the present, he pointed to the future plans in guided missiles, remarked "It's hard to conceive," he said, "but it still depends on men. Can't do anything without them."

During the four-day program, at least 2,500 persons toured NACA to see the increased operation efficiency, turbo-jet, rocket and ram-jet propelled aircraft demonstrated by cut-away sections and models of actual aircraft, or simulated tests.

One of the more vividly demonstrated tests was the noise suppression program where a dial indicates the number of decibles (noise indicators) both with and without suppression equipment. The importance of the results of these tests are awaited by commercial airlines as well as government installations. The roar of jets cut down scientifically is of great importance to the community near an airfield, especially as a "good neighbor" policy.

The high-melting point metals, so important to the aircraft of tomorrow when speed many times faster than that of sound will be common, are also being tested for durability and endurance.

The necessity of using heavy shields in planes using nuclear fuel, because of radiation, is another problem to be overcome. Scientists are now working on a light, but effective shield that will allow for adequate or increased fuel or pay loads on air carriers, and yet allow the use of nuclear fuel. One pound of nuclear fuel will produce approximately the same amount of energy as 2 million gallons of present-day aircraft fuel.

Illustrated Lectures

Included in the tour were illustrated lectures on aircraft noise reduction, propulsion research for hypersonic flight, high energy rocket propellants, aircraft nuclear propulsion, research newsreel of the eight by six foot supersonic wind tunnel, high energy aircraft fuels, high temperature materials, and a visit to the high temperature 10 by 10 foot supersonic tunnel.

A $2.5 million addition to research equipment available to NACA aeronatucial scientists, the Lewis Rocket Engine Research Facility, was shown publicly for the first time. Completed in August, the facility was viewed by representatives of the aircraft industry, military services, government and scientific organizations during the inspection.

The new facility permits scientists to use practical-sized rocket engines in their search for means to utilize new high-energy rocket propellants. This versatile research tool also allows realization of economics gained through use of low-cost fuels during initial studies of design ideas before investigations are made with scarce, more expensive fuels.

CLEVELAND PLAIN DEALER
October 13, 1957

Today's Siftings Shape Tomorrow's Realities

ARMY NAVY AIR FORCE JOURNAL
October 12, 1957

NACA Scientists Cite Mach 4 Speeds

High-flying turbojet-propelled aircraft traveling at speeds up to four times the velocity of sound—about 2600 mph at altitude—are envisioned by scientists of the National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory at Cleveland, Ohio. At the NACA Triennial Inspection this week Lewis scientists discussed research which indicates that the turbojet has Mach 4 speed capabilities.

Formidable obstacles stand in the way of actual design and development of a turbojet capable of nearing the hypersonic speed region, but Lewis scientists who have conducted extensive research on aircraft propulsion systems and their components are confident that a Mach 4 turbojet can be built.

During the 15 years since the turbojet engine was first flown in the United States, significant progress has been made in its development. The United States has a number of turbojet-powered aircraft capable of sustained flight above twice the speed of sound. Even faster airplanes powered by turbojets are in the experimental stage.

A large portion of the Lewis research effort has been expended on the study of turbojet engine problems. In comparison with gas turbines in existence at the end of the war, today's engines have more than three times the power; at least twice the efficiency, and far more dependability.

An important factor in the success of any Mach 4 turbojet engine will be the design of inlet and exhaust systems. Although the basic turbojet may be capable of producing more than enough thrust to satisfy flight requirements under ideal conditions, thrust can be dissipated by installation details. Thrust is reduced primarily by pressure losses in air intake systems, drag due to inlet flow condition, and shock or over-expansion losses in the exhaust nozzle. Furthermore, variable inlets and exhaust nozzles will be necessary on an engine of this speed capability, even though these devices add weight and complexity. A Mach 4 engine with fixed inlet and exhaust nozzle may be unable to fly faster than Mach 1.4. Takeoff itself would be marginal.

Considerable Mach 4 inlet and exhaust nozzle research is in progress at Lewis, including a special program to determine the best principles for designing inlets having high pressure recovery and low drag over a range of flight speeds up to Mach 4. Several research models devoted to the study of the complex inlet problem were shown during the Inspection.

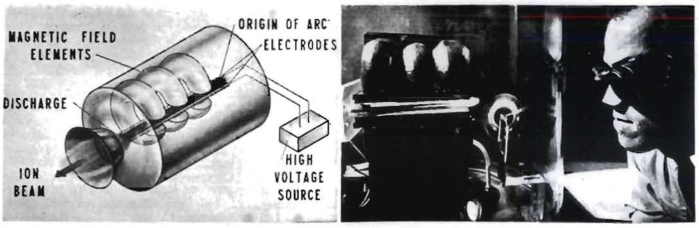
U. S. NEWS & WORLD REPORT, Oct. 18, 1957

Now Science Has a Way To Cut Noise of Jets

CLEVELAND–Earsplitting noise may cease to be a feature of the jet plane if a new device fulfills its promise.

The noise suppressor was demonstrated on one of six jet engines of a B-47 bomber last week by the National Advisory Committee for Aeronautics. The device is a sort of corrugated exhaust pipe with a special "ejector" that slows down the flow of exhaust gases.

NACA scientists at the Lewis Flight Propulsion Laboratory said the suppressor cut noise by 13 decibels–or the difference between the noise made by a jet plane and the noise of a propeller-driven Constellation.



FIRST NACA study model of an ionic propulsion unit drives a small turbine (right) to show it is producing thrust (about 1/4,200 lb.). Unit is operating inside an evacuated bell jar. Schematic of its operation is shown at left.

How NACA Views Future for Propulsion

By J. S. Butz, Jr.

Cleveland, Ohio—Present problems and future development possibilities of aircraft and space propulsion systems—including Mach 4 turbojets and ionic engines—were discussed here during the Triennial Inspection of the NACA's Lewis Flight Propulsion Laboratory.

The ionic engine, a low-thrust powerplant for use in space, is a fundamental investigation and the project is in its infancy. But it has the same long range purpose as all NACA work: to provide basic data which can be applied to actual design problems by the nation's engineers.

Other activity in progress at the Lewis Laboratory:

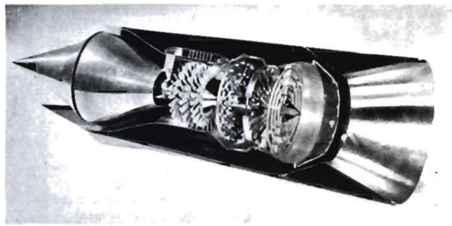
- Turbojet operation up to Mach 4.
- Hypersonic propulsion (above Mach 5).
- High temperature materials.
- High energy fuel-oxidant combinations for rocket engines.
- High energy fuels for air-breathing engines.
- Atomic powerplants for aircraft.
- Turbojet noise.

Mach 4 Turbojet

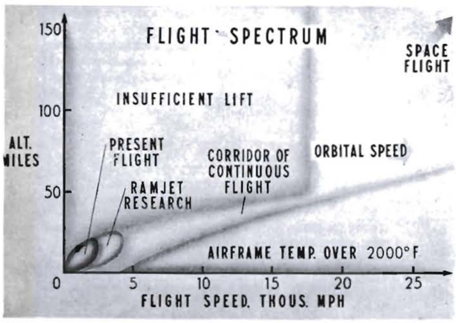
NACA believes that the speed capability of turbojets, once thought to be limited to subsonic levels operationally, can be pushed to about four times the speed of sound—about 2,600 mph. at altitude. This speed, NACA believes, may be the ultimate capability of turbojets.

This Mach 4 engine will differ significantly from today's turbojets. Its inlet and exhaust systems will have to have variable geometry to maintain acceptable efficiency over its whole operating range.

The engine's effective thrust can be severely limited by pressure losses in



MACH 4 turbojet model reflects NACA studies. It has variable geometry inlet and exit, three stage compressor, and very short combustion chamber and afterburner.



NACA estimates that aircraft will have to stay in the continuous flight corridor (above) to be aerodynamically and economically efficient. Flight above the corridor requires very large engines and wings. Structural cooling problems are too prominent below the corridor.

the air intake system, drag due to air spilling out of the inlet, and improper expansion in the exhaust nozzle. These effects can be minimized at all speeds with variable geometry systems.

The compressor section will have perhaps three rotating stages compared to 12 or 15 for some of today's engines. Ram compression in the inlet will be so high that a small pressure rise across the compressor will be sufficient. Transonic design principles have been clarified and have improved the compressor efficiency in this range. Compressor blades will have to be made of high temperature material similar to the turbine blades.

Combustion chambers and afterburners will be much shorter than present ones. Improvements in fuels as well as combustion chamber design make this possible.

Hypersonic Propulsion

NACA also is studying hypersonic propulsion, which involves systems for delivering continuous power to vehicles at speeds above Mach 5.

In broad terms the NACA sees such vehicles traveling in the continuous flight corridor illustrated on page 73. This corridor is the region in which very high speed, very high altitude flight is considered aerodynamically and economically feasible. Flight in the area above the corridor requires greater wing area, structural weight and larger engines lowering the vehicle's range markedly. Below the corridor structural soundness of the aircraft would be jeopardized by aerodynamic heating.

The only air breathing engine presently considered for use at hypersonic speeds is the ramjet. The NACA is studying its behavior from 2,700 to 4,600 mph. Two problems are paramount in this study. One is the cooling of engine parts, and other is conversion of the energy released by burning fuel into useful thrust.

Ramjet Cooling

Cooling problem is illustrated by conditions in the ramjet at a forward speed of 3-4,000 mph. Temperature in the combustion chamber is about 5,000F which is above the melting point of most of today's metals. NACA studies of cooling these internal parts show that the best way is to use fuel and then burn it in the combustor.

The other problem of producing thrust from the burning fuel grows more complicated as velocity increases. Below Mach 2 thrust in a jet engine is generated by increasing the temperature and consequently the velocity of the air passing through the engine. NACA estimates that at a flight speed of 6,300 mph. the temperature rise that the fuel can impart to the air will

be zero. However, this does not mean that the engine can no longer produce thrust.

At a flight speed of 6,300 mph. all of the air entering the combustion chamber has been heated to its dissociation temperature. The energy released by the burning fuel is all consumed in the dissociation process, which splits the bonds holding the atoms of the various gas molecules together. The only way to recover the fuel energy consumed by dissociation and make it produce usable thrust is to have the atoms recombine into their molecules within the engine. Recombination takes place when the air is expanded and its temperature lowered.

Nozzle Geometry

The proper length and geometry for a nozzle with maximum recombination benefits are being studied by the NACA.

Dissociation losses begin to be a major consideration in ramjet and turbojet design just above Mach 2. They can amount to a 50% loss in thrust at about 5,000 mph.

Ionic propulsion studies which have recently been initiated by the NACA are intended for use on vehicles which have reached orbital velocity. They are low-thrust engines which might have use on long voyages into space because of their very low fuel consumption. Primary drawbacks are heavy weight and need for electric power.

Their operating cycle consists of striking an electric arc in a gas. The arc ionizes the gas and these charged particles are accelerated by a magnetic field producing a thrust. The thrust of a feasible unit would probably be very small. However, its specific impulse would be very high and its fuel consumption low. The electricity required by the ionic rocket for space travel would probably be produced by a unit using atomic or solar power.

Weight Problem

The ionic rocket could possibly become attractive for space travel when its total motor weight approached the total motor weight for a chemical rocket or other competitive powerplant. If this is achieved, a great advantage would lie with the ionic rocket because most of its motor weight is heavy electrical machinery in contrast to the great propellant weight of a chemical rocket. If many flights were to be made with the space vehicle the fuel resupply problem of the ionic rocket would be practically nil. With the chemical rocket however it would be tremendous.

The very low thrust of the ionic engines is a serious disadvantage and would have to be weighed against the refueling and other benefits. Low thrust greatly increases travel times in space, but very great velocity changes can be effected and control problems of the space ship's trajectory would be minimized because of the long burning times. Some figures on the low-thrust, long-burning time approach were given in an NACA example. If a 10 ton space vehicle were powered by a 10 lb. thrust engine for one month, it would increase its original velocity by over 25,000 mph.

The small ionic unit demonstrated during the Lewis tour is the first one constructed at the laboratory. It produced about 1/4,200 lb. thrust, needed 1,000 volts to start, operated at about 500 volts and .5 amps. It was run in a bell jar evacuated to simulate an altitude of 80,000 to 100,000 ft. In this way air was used as the fuel. In space a gas would be carried along as fuel. The stream of ions drove a small turbine made of several sheets of mica to show that it was producing thrust.

Plasma jets operating on this same principle are also used by the NACA to test materials in the type of high temperature ionized gas stream that they would encounter during re-entry. The plasma jet is also a feasible low-thrust, low fuel consumption device for space propulsion.

High Temperature Materials

Progress with all types of propulsion units is largely waiting on improved structural materials. Some goals of metallurgical research are to raise maximum use temperatures of:

- Turbojet blade materials from about 1,650F to 2,500F.
- Ramjet materials from 2,500F to 3,100F.
- Nuclear rocket materials to 5,000F

One method of increasing high temperature strength of current nickel and cobalt base alloys is to suspend hardening particles in the material. These particles have roughly the same effect on the strength of the alloy as the dispersion of gravel does in cement. The effect of these high temperature hardening particles is demonstrated by the results achieved by suspending finely divided stable ceramic-aluminum oxide in a nickel matrix. This raises the use temperature of the nickel base alloy from the current figure of about 1,650F to as high as 2,100F.

Use of a refractory powder in aluminum alloys has raised the capabilities of aluminum several hundred degrees.

The use of nickel and cobalt base materials is limited, however, by their low melting points. The nickel base alloys are liquid at about 2,600F. Other metals with higher melting points must be used as base materials for higher temperature alloys.

Two metals currently being considered as base materials are columbium with a melting temperature of 4,500F and tungsten which melts at 6,100F

Tungsten alloys can be expected to sustain 10,000 psi. stress at temperatures 1,700F higher than nickel alloys.

The entire class of high melting point metals have the very serious problem of rapid oxidation. When heated the surface atoms of these metals slip free and combine rapidly with oxygen.

Oxidation rate is greatly increased in an atmosphere of ionized air such as would be found around a high speed missile nose cone or in an atomic engine. Rise in oxidation rate is due to the more active nature of the air after its molecules have been dissociated into charged particles. These particles want to recombine into more stable molecules and this is done against the metal. Recombination releases heat, further raising the metal temperature and increasing oxidation still more. Metals oxidize about 400 times faster in the presence of dissociated air than in normal air. NACA research in this area to date has been to define the problem, now measures of countering this severe oxidation are being studied.

Another group of materials being investigated at Lewis are ceramics which have very high melting points and good oxidation resistance but are handicapped by brittleness.

One of the most serious effects of brittleness is susceptibility to thermal stresses which are high in many missile and atomic applications.

Research at Lewis and elsewhere indicates that some ceramics may be inherently ductile and that their brittleness is due to surface imperfections.

Careful treatment and polishing of ceramic surfaces have greatly increased their ductility. This work has essentially just begun and practical methods of treating large sections of ceramic are not available.

High Energy Propellants

NACA's rocket research effort is almost completely centered about high energy fuels and oxidizers. Experimentation includes the most highly reactive and dangerous substances which are potentially the best propellants.

Practical studies are being made of the difficulties of using hydrogen fluorine combination. This is typical of the work at Lewis Laboratory.

Fluorine is the most powerful oxidizer known and consequently reacts readily with most materials, often violently. One problem in its use is to find material for tanks, valves and lines in the fuel feed system which will contain the fluorine. Rocket combustion chamber and nozzle construction problems are magnified by use of fluorine.

Hydrogen is most difficult to keep in the liquid state as it boils at −423F. Well insulated tanks and lines are needed to keep the hydrogen supply system working properly.

ARMY-NAVY-AIR FORCE JOURNAL
October 19, 1957

Research for Tomorrow. The nearly 2,000 representatives of the Armed Services, industry, and members of Congress who participated in the Triennial Inspection of the Lewis Flight Propulsion Laboratory in Cleveland last week most certainly went away more impressed than ever before with the vital importance of giving the utmost support to our research organizations and facilities.

Shown at this laboratory of the National Advisory Committee for Aeronautics were such promising projects as research into high-energy fuels promising increases in the range of supersonic aircraft and missiles by as much as 40 per cent, new fuel-oxidant combinations which could vastly advance rocket performances, new engine materials which could retain high strength at the extreme temperatures general in hypersonic flight, and many other fields significant to the national defense.

Each of the new fields into which research scientists are now just peeking eventually will be entered and conquered. The nation that first reaps the benefits of such explorations will have a definite advantage. Russia's recent accomplishments leave no doubt of the efficacy of her research which, unlike ours, is unhampered by budgetary considerations.

Two years ago Dr. Jerome C. Hunsaker, then NACA chairman, reported that "The current trend toward leveling off expenditures for scientific research in aeronautics is forcing hard decisions to slow down or to defer indefinitely research projects essential to the timely development of new weapons." His warning went unheeded. The advice he gave then needs repeating today with emphasis—"It is now wise to accelerate scientific progress. In the long run, scientific research is the best insurance that there will be 'value received' from the country's whole aircraft program."

Confidence in our future and its security depends in great measure upon the support in money and authority which we are willing to give to research organizations such as the National Advisory Committee for Aeronautics.

NEWSWEEK
October 21, 1957

JETS:

Beyond the 'Ultimate'

For fifteen years jet-propulsion engineers have been squeezing more and more speed out of the turbojet engine. But at Mach 2.5 (about 1,660 miles per hour) it was thought that it had reached its ultimate speed. Last week the National Advisory Committee for Aeronautics announced in Cleveland that a still speedier future lies ahead for the turbojet. Their latest studies, said the committee, indicate that the turbojet—with vital changes—is capable of propelling an aircraft four times the speed of sound, or about 2,600 mph.

The most crucial rearrangement of the turbojet's physique will not be in its hot, whining insides but in its inlet and exhaust nozzles, usually the concern of noise-reduction engineers. Both openings, now smaller than the diameter of the engine, will be enlarged. Their size will be variable in flight, so the engine can adapt itself to the wide range of speeds and altitudes a Mach 4 airplane will encounter before reaching "design flight conditions" at 85,000 feet.

Newsweek—Bremen

Ion Power 'Attractive' Prospect, A-Plane Doubtful Bet, NACA Says

By BILL FOSS

CLEVELAND. — **Optimistic predictions of an ion propulsion rocket for future space ships but doubts about the worth-whileness of the atomic-powered aircraft were made by government scientists and engineers here.**

The occasion was the triennial inspection of the National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory. The laboratory here studies aircraft powerplant problems, including the special aerodynamics of high-speed flight propulsion.

NACA scientists demonstrated their working model of an ionic rocket—an "attractive" propulsion device for flights into outer space.

The ionic rocket, known also as an electrical particle accelerator, would enable a manned space ship to reach the 25,000 mile per hour speed necessary to escape from the earth's gravitational pull into outer space.

Once away from earthly domain, the ionic engine of the space craft would be cut off, allowing the craft to coast through outer space on its own escape speed of 25,000 miles per hour.

The use of a low, 10-pound thrust engine over a period of a month could increase this speed to 50,000 miles per hour, the NACA engineers said.

Proof that they weren't just dreaming but actively doing research on possible space engines was given by the NACA engineers.

They demonstrated a small working unit of the ion propulsion rocket. The unit inside a vacuum-jar, with an invisible stream of ions, turned a wheel about three inches in diameter.

Ions are tiny bits of matter, carrying electrical charges formed when an electron is added to or removed from an electrically neutral atom. Thrust comes from a stream of ions, accelerated to high velocities in the same way as hot gases are ejected from the exhaust of the conventional jet or chemical rocket engines.

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ABE SILVERSTEIN, associate director of the Lewis Flight Propulsion Laboratory, said that while the ion-engine would be able to operate in a vacuum, the laboratory is just experimenting with the unit and it may be many years before such an engine will become a reality.

He conceded that the Russians, who have won the satellite race with their Sputnik satellite, may well be working on a similar ion propulsion system.

Dr. Silverstein said there were several other possible sources of propulsion of space ships, including radiation pressure—the use of sun power—and "direct nuclear power."

NACA scientists and engineers expressed doubts about the progress being made on the nuclear-powered aircraft.

The main obstacles are the weight problem of the shielding which must be provided to protect the crew from radiation. Very little payload is left after the weight of reactor and its shielding is allowed for.

Dr. Silverstein wasn't sure that the country would want a nuclear-powered aircraft. He said the building of a nuclear aircraft would depend on the nation's future defense policy—what type of plane is needed and how much money the nation is willing to spend to develop and build the plane.

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NACA SCIENTISTS also disclosed that they are confident that high-flying turbojet-propelled aircraft can attain speeds up to four times the speed of sound—about 2600 miles per hour.

The future Mach 4 airplane (one flying four times the speed of sound) must combine the advantages from the most advanced concepts in aerodynamics, airplane structures, and powerplants—all of which mutually influence each other.

Several research models devoted to the Mach 4 plane were shown during the inspection.

For still higher flight speeds, up to seven times the speed of sound, NACA scientists predicted that the ramjet engine would supplant the turbojet.

High-energy fuels and heat-resistant materials needed by the faster-flying planes and rockets get close scrutiny by NACA scientists. They have tested high-energy fuels capable of increasing the range of supersonic aircraft and missiles by as much as 40 percent.

Liquid fuels containing boron have been favored because of their high energy content, which provides the increased aircraft range. NACA engineers calculate that the range of a boron-fueled ramjet missile flying at an altitude of 60,000 feet and 2100 miles per hour could be extended 40 percent over the same missile using jet fuel.

NACA is planning expanded full-scale turbojet and ramjet engine research with these fuels.

• • •

IMPROVED HEAT resistant materials for advanced missiles and aircraft are urgently needed. The laboratory seeks gas turbine materials which will keep their strength at 2000 degrees Fahrenheit, ramjet materials for operation at 3000 degrees F, and nuclear rocket materials that are strong at 5000 F. By comparison pure iron melts at about 2700 degrees F.

The current temperature levels are about 1650 degrees F in the turbojets and 2500 degrees F in the ramjet engines.

Among those being considered as base metals for future alloys are columbium and tungsten.

The jet noise problem has also been studied by the NACA.

Committee scientists are trying to tone down the "big noise" created outside the engine by the exhaust jet as it mixes with the atmosphere.

That they've attained some measure of success was shown during demonstration here.

N.Y. World Telegram
and Sun Oct. 8, 1957

Ions May Hold Space Travel Key

By the Associated Press.

CLEVELAND, Oct. 8.—The National Advisory Committee for Aeronautics bombarded a small pinwheel inside a glass vacuum-jar with an invisible stream of ions today and made it whirl briskly.

The same ion-stream principle, NACA said, some day may be harnessed to push 10-ton space ships moonward at many thousands of miles an hour once they have reached outer space.

Coupled with atomic energy, such a vehicle might have virtually unlimited range.

The demonstration was part of a four-day public inspection of the NACA's flight propulsion laboratory, which is attracting top scientists to Cleveland this week.

"If a stream of ions, as in an arc jet, can be accelerated to high velocities by use of electric or magnetic fields, a small amount of thrust will be produced." Ions are tiny bits of matter—atoms which have been stripped of some of their electrons and have become electrically charged.

Physicist M. J. Krasnican explained that beyond the earth's atmosphere a vehicle would require only slight power in small increments, to accelerate a great deal.

"For example," he said, "a 10-ton vehicle in outer space, powered by 10 pounds of thrust for only one month, would increase its original velocity by 25,000 miles an hour."

Abe Silverstein, associate director of the laboratory, said "There is no question but that we can make an atomic airplane that will fly. The question is, for what purpose do we want the plane and will it be satisfactory for that purpose?"

N.Y. World Telegram
and Sun Oct. 8, 1957

Space Engine Under Study By Scientists

NACA Forecasts Ionic Propulsion

By the United Press.

CLEVELAND, Oct. 8.—The government's top aviation research agency disclosed today that it has started basic research on "space engines" for future interplanetary flight.

Officials of the National Advisory Committee for Aeronautics emphasized that practical results are years in the future. But their work has reached the point where they consider ionic propulsion "attractive for outer space flight."

There has been much published speculation about the use of "streams of ions," or tiny bits of matter with electrical charges, in "space engines." But the NACA gave the most tangible evidence yet of the government's serious interest in the technique.

Outlining some of the NACA's research on engines "capable of operating in a vacuum" beyond the earth's atmosphere, Eugene J. Manganiello described the current Russian satellite and the future American one as "short duration vehicles."

Besides its work with such futuristic "engines," NACA made these disclosures at a tour of its $100 million laboratory here for government, industry and scientific groups:

1. Ramjet test missiles recently have made flights with high energy fuels which may increase the range of supersonic planes and missiles by as much as 40 percent.

The fuels are boron-hydrogen compounds or boranes, which can be made in liquid form. At present they cost several hundred dollars a pound, but production plants now are being built looking toward a day when such fuels become practical for military aircraft.

2. Research now indicates that jet engines can be made to power planes at 2600 miles an hour, or four times the speed of sound, whereas it once was thought their limit would be below sonic speed.

In discussing ionic propulsion, the NACA said that accelerating ions to high speeds would provide useful energy for satellites, and added:

"Development and improved efficiency of such a propulsion device may lead to its application in flight beyond the atmosphere."

THE NEW YORK TIMES
October 20, 1957

AVIATION: 2,600 M. P. H.

Jet Engines Capable of a Speed Four Times That of Sound Are Forecast

By RICHARD WITKIN

GOVERNMENT scientists think the potential of the turbojet engine has been underrated. They have become convinced that jet engines can be designed for speeds up to 2,600 mils an hour, or four times the speed of sound.

Such a figure does not have the fantastic ring it used to have before the appearance of ballistic missiles and round-the-world flights of a thing called the sputnik. Yet, for a vehicle with a man aboard, 2,600 miles an hour—coast to coast in a little more than an hour—would still be a remarkable rate of travel.

It is 400 miles an hour faster, for example, than the current record for manned flight—about 2,200 miles an hour in the Air Force's X-2 rocket research plane. It is more than four times as fast as the jet airliners already in service on Russia's airline, Aeroflot, and those soon to be introduced by this country's carriers.

Word that a 2,600-mile-an-hour engine was technically feasible came early this month from the National Advisory Committee for Aeronautics, the Government's top-ranking research agency in the aeronautical field. Scientists at the agency's Lewis Flight Propulsion Laboratory in Cleveland noted that, when the jet engine first was perfected, its maximum speed potential was put below the speed of sound, which at normal cruising altitudes would be about 660 miles per hour.

The estimate was progressively raised to Mach 1.5 (one and a half times sonic speed) and then Mach 2.5. Now the talk is about Mach 4 and speculations have been made that the engines could be used on conventional airliners as well as military craft.

Heat-Resistant Metals

The reassessment of the turbojet's ultimate capabilities is due largely to two engineering accomplishments: one is the advance in metallurgy that apparently opens the way for design of compressor blades and other engine parts able to withstand new plateaus of heat without melting or deforming; the other is the mastery of a new technique for designing the engine's air inlet and exhaust nozzles.

For Mach 4 speeds, these passageways must be designed with "variable geometry." In other words, they must be able to change size and shape with changes in the plane's speed. Otherwise, at high speeds, shock waves would impede the smooth flow of air and exhaust gases through the engine.

The effect would be to slow down the plane, just as shock waves at the speed of sound were a serious drag on jet fuselages until an N. A. C. A. scientist named Richard Whitcomb evolved the "area rule," better known as the "wasp waist design."

Variable geometry inlets already are in use on some of the nation's advanced supersonic fighter planes.

While playing with the Mach 4 engine, the N. A. C. A. is not overlooking some difficulties still encountered with the prosaic jet engine in the Mach 1 to Mach 2 category. These engines' most vexing trouble, perhaps, is their noise. They do a fine job, but they do it at the expense of people who happen to live near airfields.

Like a lot of engine and airframe manufacturers here and abroad, the N. A. C. A. has been experimenting with various methods of toning down the jets without materially cutting their efficiency.

There have been some optimistic statements in recent months that the jet-noise problem is just about licked. The most optimistic has come from the Boeing Airplane Company, whose 707 jet airliner will start this country's commercial jet operations early in 1959.

Boeing's energetic efforts to deal with the noise problem have been stimulated partly by warnings from scattered communities—notably New York, speaking through the Port of New York Authority—that jets will not be tolerated unless their roars are subdued at least to piston-engine levels.

Cause of Serious Work

There is wide belief that the Port Authority will have to back down if the noise problem proves not to be so tractable. But at least the agency's stern demeanor has helped generate some serious work on the matter.

Boeing's degree of optimism is not general in the industry. The N. A. C. A. group in Cleveland proved more pessimistic than most when it said without equivocation that the noise problem had not been solved.

To back its point, it demonstrated an advanced noise suppressor on the engine of a B-47 medium bomber. The device, a corrugated nozzle fitted on the tail pipe, reduced the decibel level from 121 to 107½. That was half a dozen decibels short of what was necessary, the N. A. C. A. said, to match the comparative quiet of piston engines.

The rest of the improvement, it has been suggested, might be accomplished by designing a "cool" engine. Cooling the exhaust temperature would mean slowing the velocity at which the hot exhaust spewed into the cold atmosphere. Since the tubulent mixing of hot exhaust and cool air is the prime producer of noise, lower velocity would mean fewer decibels.

Loss of thrust from lower velocity would have to be recovered, however, by increasing the total flow of air through the engine. Something of this sort is done in a bypass engine, such as the Rolls Royce Conway that has been ordered by some foreign airlines for their American jet airliners.

But the straightaway "cool" engine has not yet been developed, the N. A. C. A. adds.

The next word on the controversial subject of noise is expected, from Boeing, which has started a series of flight tests with all four 707 engines equipped with suppressors.

Turbojets Are Theoretically Capable of Mach 4 Speeds

By J. S. Butz, Jr.

Cleveland, Ohio—Extension of the useful speed of turbojet engines to Mach 4 will provide a much greater latitude in the design of future aircraft than has been expected.

Widening the choice of powerplants will make it easier to optimize 2,600 mph. aircraft for a definite mission requiring relatively great range, or speed, or some other specific performance.

National Advisory Committee for Aeronautics scientists at the Lewis Flight Propulsion Laboratory here believe that current aerodynamic and combustion knowledge indicates that Mach 4 turbojets are feasible. They point out, however, that practical construction of such an engine will require a major research and development effort mainly because of the high temperature performance required of engine components. Mach 2.5 is about the upper limit for present-day turbine engines.

Types of Powerplants

If the Mach 4 turbojet is developed, the powerplants available at that speed will also include turbojets, ramjets, dual-cycle engines, rockets and various combinations of these. The turbojet would retain the advantage it has today. It would be the smallest, least complicated engine installation capable of delivering continuous power to an aircraft through its entire flight. Each of the other engine types will undoubtedly be superior in this speed range for certain missions.

NACA sees Mach 4 as the probable ultimate speed of the turbojet. Ramjets will have rather clear advantages among air-breathing engines above that speed even though they cannot function during landing, takeoff and initial climb.

Overall problem of selecting a powerplant involves many interdependent factors concerning the aerodynamic and structural design of the aircraft as well as the engine. Since it is impossible to separate these considerations, engine studies at Lewis Laboratory include the mutual interaction of the powerplant installation on the airframe.

Hypothetical Case

A generalized example of such a study was presented during a recent Triennial Inspection of the Lewis Laboratory. Thrust requirements of a Mach 4 turbojet over its whole speed range were determined by considering the drag of a hypothetical aircraft representing the most advanced aerodynamic and structural thinking. The aircraft was designed for a speed of Mach 4 at about 85,000 ft. Adequate thrust was stated to be 35% more than the drag, at every speed. This insured good acceleration throughout the speed range. With a smaller thrust margin, excessive amounts of fuel would be consumed during acceleration and the aircraft's range would be seriously reduced.

Main value of this example study was to show the importance of the engine's inlet and exhaust nozzle design. The conclusion is that such systems must have variable geometry if the engine is to deliver adequate thrust during the whole flight. Even if the basic engine is capable of delivering much more thrust than the design requirement, it can be rendered inadequate by a poor installation. Thrust losses of the installation are primarily from pressure losses in the air intake system, drag due to inlet flow conditions and shock or overexpansion losses in the exhaust nozzle.

Example study is illustrated on pp. 86-87. Upper figure shows a fixed geometry installation meeting the design conditions of Mach 4 speed at 85,000 ft. The thrust-available curve of this installation superimposed on the thrust-required curve of the aircraft shows that it would be impossible for the airplane to ever accelerate to Mach 4 because thrust is inadequate at the intermediate speeds.

Inadequate Thrust Cause

This inadequate thrust around Mach 2 is primarily due to two things:

- **High drag** caused by air spilling around inlet. Engine requires about 66% less air at Mach 2 than it does at Mach 4. Excess air is deflected around inlet.
- **Overexpansion** of air in exhaust nozzle, causing strong shock waves which slow down exit velocity. Exit area of nozzle, which is correct for Mach 4, is too large for Mach 2.

The next figure shows that using a variable geometry nozzle will still not correct the thrust deficiency around Mach 2, although it will bring subsonic thrust up to the prescribed 35% increase over aircraft drag.

When variable geometry is added to the inlet system the engine and its installation are able to produce the necessary thrust over the whole speed range, as shown in the lower figure.

Variable geometry mechanism of this inlet system would have to include means of varying the angle of the ramps ahead of the duct as well as an efficient by-pass to bleed excess air in the duct to the outside airstream.

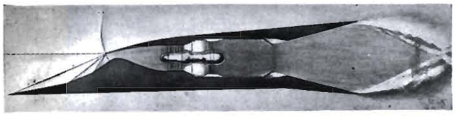
Inlet Function

Inlet system shown in this example is but one of those currently being investigated by NACA, other research agencies and aircraft manufacturers. Function of these inlet systems is to slow and compress air entering the aircraft. Air should enter the turbojet's compressors at less than half the speed of sound.

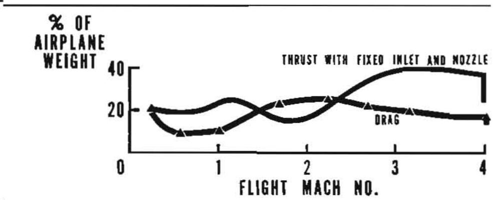
Ideal inlet system accomplishes this diffusion with a minimum loss of total pressure in the air stream and with minimum drag. Both of these losses serve to decrease the effective thrust of the engine.

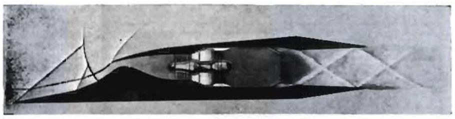
There are generally two methods for slowing a supersonic air stream. One is an external diffusion system and the other internal. The one used in the previous example was an external system. Both slow the supersonic flow to a low supersonic Mach number by contracting the air stream and then diffusing it to subsonic speed by means of a normal shock wave.

External system generally uses a series of ramps (or cones if the inlet is circular) which create oblique shock waves to slow the air; then the normal shock is located across the mouth of the inlet

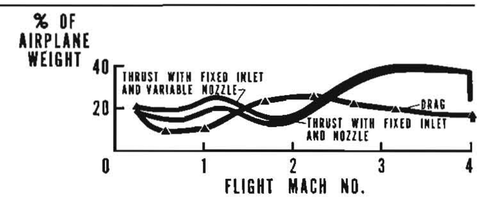


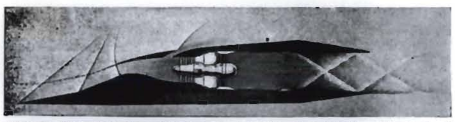
INSTALLATION above is typical of inlet and exhaust systems for Mach 4 turbojets. It has fixed geometry designed for Mach 4, but so dissipates power at the intermediate speeds that typical aircraft would not be able to exceed Mach 1.5 (right).



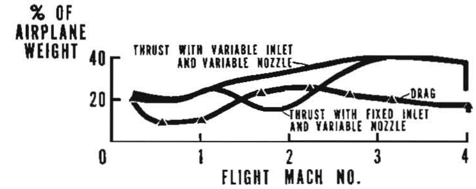


DRAWING above shows flow conditions at Mach 2 with a variable geometry exhaust nozzle. Large nozzle expansion ratio is not needed below Mach 2. Nozzle changes alone are not sufficient to make the installation acceptable (right).





FURTHER ADDITION of a variable geometry inlet gives the installation adequate thrust over the entire speed range. Inlet shown here is of the external compression type. Number of possible solutions to the variable geometry problem are being investigated.



in the ideal case. Air velocity becomes subsonic across this shock and enters the duct at less than Mach. 1.

Internal System

With the internal system, air enters the duct at supersonic velocity. The duct contracts to a throat where normal shock occurs and the stream becomes subsonic. Duct then expands to slow the subsonic stream.

Trouble arises with the external system when the inlet is too large and more air is taken into the duct than the engine needs. The excess air then spills around the inlet causing a large drag. If the inlet area is too small, the engine sucks the normal shock at the inlet back down the duct causing a decrease in flow density and an increase in pressure loss. Very accurate and sensitive controls are needed to keep the shock pattern and inlet area adjusted so that neither of these two excessive losses will occur.

Trouble with internal systems centers around making the normal shock wave start at the inlet and move down the duct to the throat. This movement of the normal shock depends on the ratio of the inlet area to the throat area. The pressure recovery also depends on this area ratio. Unfortunately, a minimum pressure loss and high duct efficiency demands such a small throat area in relation to the inlet area that the normal shock won't move down the duct to the throat. It stands out in front of the duct, creating a large drag. If the throat is opened up to allow the normal shock to move back to the throat, then a loss in total pressure must be accepted. This type of internal system is also very sensitive to back pressure. If the engine surges or in any way creates a sudden back pressure, the shock may pop out of the duct. Starting the shock back up the duct requires the proper combination of Mach number, back pressure, etc. Sometimes an unstable flow is set up that is difficult to stop.

Corrections Devised

These problems of internal diffusers have been largely corrected. The forward or supersonic portion of the diffusers have been perforated, making the ducts much easier to start and much less susceptible to back pressure.

Variable area throats make the internal ducts capable of operating over a wide Mach number range. Both internal and external systems are being developed and have their enthusiasts.

In addition to having a more elaborate form of variable inlet and exhaust nozzle than current turbojets, the Mach 4 engine will also have a different design in almost every major component.

The compressor will have about three stages instead of 12 to 15 that are on

NACA scientist holds model of Mach 4 turbojet. Model has cone type variable geometry inlet, three stage compressor, very short combustion chamber and afterburner, and variable area inlet.

some current engines. This is possible because pressure rise per stage has been raised and because much of the compression is accomplished in the inlet duct instead of the compressor.

Better fuels as well as improved combustion design will greatly shorten combustion chambers and afterburner.

Temperature Comparison

NACA predictions of the temperature within the Mach 4 turbojet illuminate some of the development problems facing the engine. For comparison, the temperatures in a typical Mach 2 engine will be given first:

- Compressor inlet—240F
- Entrance to combustor—875F
- Turbine inlet—1,650F
- Turbine outlet—1,000F
- Discharge exhaust—3,000F

On the Mach 4 turbojet these same temperatures will usually be:

- Compressor inlet—1,230F
- Entrance to combustor—1,330F
- Turbine inlet—1,450F
- Turbine outlet—1,350F
- Discharge exhaust—3,300F

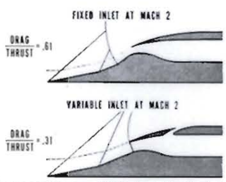
Temperature Difficulties

Most serious temperature problems will be encountered in the compressor and the main engine bearings and seals. The compressor will require the use of the most advanced alloys now used in turbines to withstand the combination of high temperature and high stress. The turbine on the Mach 4 engine is operated below the turbine temperature of the Mach 2 engine because the stresses in the turbine have been raised to match the aerodynamic capabilities of the compressor.

Environmental temperature of bearings and seals in the Mach 4 engine will be above present limits of such materials because of the heating of the ram air as well as temperatures within the cycle.

NACA studies indicate that the ramjet will be definitely superior to the turbojet above Mach 4. This conclusion is based on the fact that around Mach 3 the turbine begins to extract more pressure from the cycle than the compressor puts in. This detrimental effect of the turbine-compressor unit on the thrust increases with speed. The ramjet obviously doesn't have this handicap and is more efficient above Mach 3.

In terms of a typical military mission however, the turbojet is still competitive up to Mach 4. Using ramjets, the aircraft cruising at Mach 4 can be much smaller than an aircraft with similar range using turbojets. However, the smaller ramjet-powered plane would need some sort of boost arrangement to take off. The weight of this booster would bring the total weight of the ramjet aircraft up to that of a turbojet version, if rockets were used for the boost.



TOP sketch shows Mach 4 inlet in Mach 2 flow. Air spills around inlet causing high drag. If spillage air is exhausted behind the inlet (below) drag is reduced.

OCTOBER 21, 1957—VOL. 21, NO. 11

AMERICAN AVIATION

AMERICAN AVIATION, OCTOBER 21, 1957

NACA studies new ways of cutting jet noise

SPECIAL EXHAUST SHAPES developed by NACA attenuate noise level of jet engines. Experimental shape shown brought the 121-decibel level of J47 to 107 decibels.

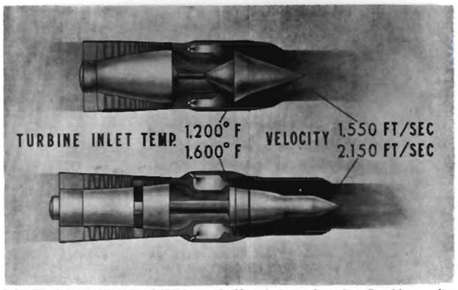
Ways to attenuate jet engine noise are being intensively studied by National Advisory Committee for Aeronautics engineers at the Lewis Flight Propulsion Laboratory in Cleveland.

Originally, it was suspected that the "big" noise of jet engines comes from the combustion of fuels at tremendous rates, and the windage of the whirling compressor blades. It was found, though, that the largest noise component is created by the exhaust jet as it mixes turbulently with the atmosphere. Fluctuating pressure waves are created, which result in a broad band of acoustic waves.

One way to decrease the noise is to lessen turbulent mixing of the jet stream, or the size and strength of the eddies. Various nozzle shapes have been studied which give substantial reductions in the noise level. However, the design changes needed usually bring increased airplane drag, engine weight and decreased engine performance.

Another approach to the problem is to reduce the velocity of the exhaust jet. This would decrease the energy in the jet stream and also the noise level. However, current military jet engines demand high jet velocities for maximum performance. If such performance were not needed, then an economical and efficient engine could be designed with lower exhaust velocities. Such an engine would also operate at lower turbine inlet temperatures and therefore could be made lighter and more compact.

If a special nozzle shape were combined with an engine having a relatively slow-speed jet exhaust, NACA engineers feel that the target 15-decibel drop would be obtained. This 15-decibel figure is based on an average jet noise of 116 decibels as compared with propeller noise of 101 decibels.



LOWER EXHAUST VELOCITIES can significantly lessen jet noises. Resulting smaller turbine inlet temperature brings about a more compact engine design.

NACA reveals details of Mach 4 turbojet

SUPERSONIC turbojet engines capable of sustaining flight at Mach 4 are within our reach, according to engineers at the Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics. A cutaway view of a model of such an engine, which could power aircraft cruising at 2,600 miles an hour and 85,000 ft. altitude, was displayed at NACA's triennial inspection of the Lewis facilities.

NACA engineers say the Mach 4 turbojet is the ultimate capability for this type engine. But even this capability could not be obtained, they say, unless the engine is equipped with variable inlet and exhaust nozzles. If fixed nozzles were used, then the supersonic turbojet could not fly faster than Mach 1.4, and even takeoff would be marginal.

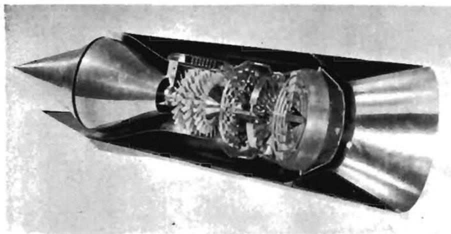
One proposed aircraft configuration calls for installing the Mach 4 engines in under-wing pods pressed closely against the fuselage. This geometry is said to minimize interference effects.

It was admitted that the basic turbojet engine is capable of yielding more than enough thrust to propel a craft at Mach 4. This thrust should be about 35% more than the thrust required. However, design problems at lower speeds would keep the craft below Mach 1.4 unless some ingenious steps were taken.

Studies show that a Mach 4 turbojet would have very little pressure rise across either its compressor or its combustion chamber. Thus, NACA conceives of the engine with only a three-stage compressor instead of the 12- to 15-stage compressors used in today's engines. In addition, satisfactory combustion can be obtained with much smaller combustor sections than in present-day jet engines. Thus, a smaller compressor plus smaller primary and afterburner combustion chambers contribute to compactness.

Above Mach 3, the rotating parts in the engine do little or negative work. Here, the afterburner is the thrust-generating element. At Mach 4, then, the turbojet engine approximates a ramjet engine. Above Mach 4, the pure ramjet engine has the field to itself insofar as air-breathing powerplants are concerned.

NACA engineers are confident that the proposed powerplant can be built. They say that if the engine is operated at its designed speed, it will have a thermal efficiency of about 42%. This compares with the 28% efficiency of a Mach 2 engine, and the 33% efficiency characteristic of steam-electric stations.



CUTAWAY VIEW of model of possible Mach 4 turbojet engine shows three-stage compressor and small combustor chambers, which result in a highly compact powerplant.

The efficiency is the result of an extremely high pressure in the engine cycle. The expansion ratio, based upon internal and ambient pressures, is over 100.

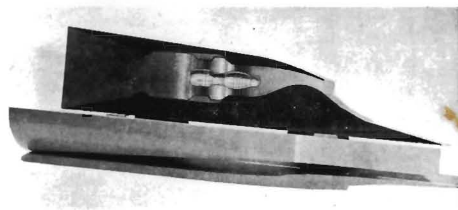
The Mach 4 turbojet engine derives its greatest advantages from its variable inlets. As an example, a fixed inlet at Mach 2 would give a drag-thrust ratio of 0.61, because of the spillage pattern. If a variable inlet were used at the same Mach number, the drag-thrust ratio would be cut almost in half, to 0.31.

Similarly, a fixed Mach 4 exhaust nozzle would be woefully deficient at Mach 1 because of over-expansion of the exhaust gases. Here, the efficiency would be about 70% as compared with the 97% efficiency for a variable exhaust nozzle.

AIRPLANE DRAG characteristics call for variable inlet and exhaust nozzles to achieve speeds over Mach 1.4.

Although the aerodynamic combustion principles are being satisfactorily worked out, severe practical problems exist because of the high temperature in which the engine components must operate. The inlet temperature is pegged at 1,240°F, which rises to a temperature between 3,500°F and 4,000°F in the afterburner. This temperature rise is smaller than in present jet engines. However, temperature of the compressor is so high that it will need alloys currently being used in turbine blades.

Development of engine bearings and seals comprise other design problems that must be met by the fabricators of this engine, according to NACA.



TYPICAL ENGINE POD is slung under wing and next to fuselage. Note large exhaust nozzle needed for Mach 4 operation. Air inlet ramp is at right.

THE IRON AGE, October 17, 1957

WIND TUNNEL TEST: Scientist checks an experimental aircraft model in a supersonic wind tunnel at Lewis Flight Propulsion Laboratory in Cleveland. Air stream can be whipped up to 3½ times the speed of sound.

Heat Blocks Way To Faster Aircraft

Engineers are making slow but steady progress toward a 2600 mph airplane.

The primary problem: Finding a suitable high-temp material.

▪ Aircraft and rocket engineers in Cleveland aren't bashful about showing designs for aircraft which will go 2600 mph hour. Yet they are pinned down by the heat barrier where progress is still measured in inches.

Some of its awesome problems were outlined last week at a triennial inspection of the National Advisory Committee for Aeronautics' $100 million Lewis Flight Propulsion Laboratory.

Progress Review — In the 10 years since the first supersonic flight by Capt. Charles Yeager in the Bell X-1, designers have had a net gain of only 300°F to work with, spokesmen said. They currently have turbine blading which will withstand 1650° without losing necessary strength. This is up from 1350° in 1947. But in the next 10 years they are hoping for 1850° to 2500° materials for gas turbines. For ramjets they need 2500-3100° and for a nuclear powered rocket, 5000° material.

Possibilities are nickel with sintered aluminum alloys, columbium and tungsten. Ceramics hold some hope. Lewis research men have been able to impart a measure of ductility to ceramics by eliminating surface imperfections by water polishing. Ductile ceramics developed so far are magnesium chloride and sodium chloride.

Fuel Problems — The materials problem is the most pressing at Lewis, but there are others. With high energy fuels already tested, engineers hope to extend the range of supersonic aircraft and missiles by 40 pct. Liquid fuels containing boron are the most promising so far, but excessive deposition cuts efficiency.

Atomic energy powered aircraft seems still a long way off. The weight of pilot shielding necessary is still the top problem. Engineers are chipping away at it through better shaping, split shielding and searching for new materials. Decomposition of the metal through radioactivity is still another hurdle.

NACA Studies Ways to Soften Jet Noise

By J. S. Butz, Jr.

Cleveland, Ohio—Three basic approaches to bringing turbojet noise down to piston-engine levels are being investigated by the National Advisory Committee for Aeronautics at the Lewis Flight Propulsion Laboratory here. Considerable progress is reported even though no definite solution has been reached and each noise reduction method has its disadvantages.

The general areas of study are:

• **Mechanical suppressors** (various nozzle shapes, etc.).
• **Engine design.**
• **Climb procedures.**

This NACA work is devoted solely to decreasing noise during takeoff and much of it involves the study and extension of ideas originating with various manufacturers and research groups here and abroad.

Main Drawback

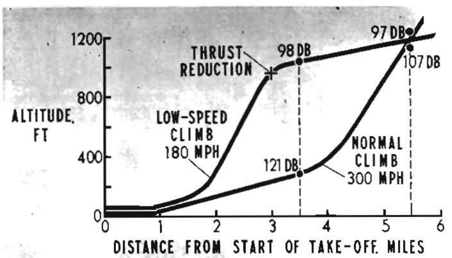
Many types of mechanical supressors have been tried and their main drawback has been that they reduce engine thrust while cutting noise. To the airlines this could mean a revenue loss through reduced passenger loads.

However, the NACA has a nozzle-ejector combination that reduces noise to the required level without the customary thrust losses. The only drawback of this installation is that the ejector will increase the drag of the aircraft and cut its range down.

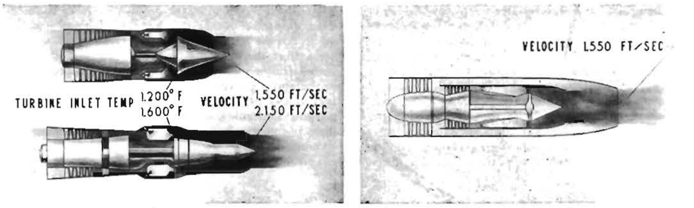
The whole project is in the experimental stage and efforts are now being made to make the ejector both retractable and light.

Current study of this nozzle-ejector has given the NACA considerable hope that a workable answer to the noise situation will be reached through a relatively simple mechanical device. Much work still remains before this practical device is achieved.

CORRUGATED nozzle in combination with annular sheet metal ejector is most promising noise suppressor being studied by the NACA. Ejector eliminates thrust loss due to the corrugated nozzle, but it has a large drag which would lower aircraft range.



TAKEOFF and climbing procedures especially tailored for each airport and its surrounding communities can do much to lower jet noise in populated areas. Typical climb procedure and the noise it creates on the ground (in decibels) is compared to a proposed low-speed, low-noise climb.



JET ENGINE noise can be reduced by lowering turbine temperature and exhaust velocity. Using new design techniques, low-temperature, low-noise engines can equal the power and efficiency of today's high-temperature jets. More efficient high-temperature engines could also be built with the new design methods. Exhaust velocity and noise of by-pass engine (right) is reduced by low energy by-pass flow. By-pass engine has about same noise level as the low temperature engine (above, left).

These mechanical suppressors are designed to alleviate the two conditions in the high velocity exhaust of a jet engine which are the primary causes of its noise. First are the turbulent eddies which are created as the high speed exhaust mixes with the low speed outside air. These eddies produce fluctuating pressures which radiate sound waves.

The second major source of noise is the shear at the edge of the jet blast which results from the steady components of the exhaust velocity. This velocity shear greatly amplifies the acoustic output of the turbulent eddies in the jet blast.

Suppressor Method

Mechanical suppressors all attempt to reduce the intensity of these two noise sources by:

• **Increasing** downstream mixing of the jet to attenuate the strength of the eddies.
• **Increasing** contact area of the jet blast with the outside air to reduce velocity shear.

Many nozzle shapes have been studied. One is the "organ pipe" type which passes the engine exhaust through a number of small pipes. Another nozzle uses deeply folded convolutions or corrugations to spread the exhaust. Parallel slots have also been tried on nozzles.

All of these types can produce the required jet noise reduction of 15 decibels to bring a four jet transport passing directly overhead at 100 ft. with full power to the noise level of a plane with four piston engines under the same conditions.

They are all faced with the same serious disadvantage however; they build up back pressure on the engine and slow its exhaust velocity, causing a thrust loss.

Ejector Reduces Loss

This back pressure and thrust loss can be eliminated while achieving the required sound reduction by surrounding a corrugated nozzle with an ejector, according to the NACA. The ejector is a form of jet pump. High velocity engine exhaust air passing through the ejector pulls low speed secondary air around the jet blast. This reduces pressure in the jet stream and gives the velocity shear gradient surrounding it a more gradual character. As mentioned previously, this promising unit is being developed further to decrease its weight and the drag of the ejector.

Another basic approach to the noise problem is a change in turbojet design so that engine exhaust velocities could be efficiently reduced. Lowered jet velocities would have added benefits because the engine would run cooler, with longer life and greater safety.

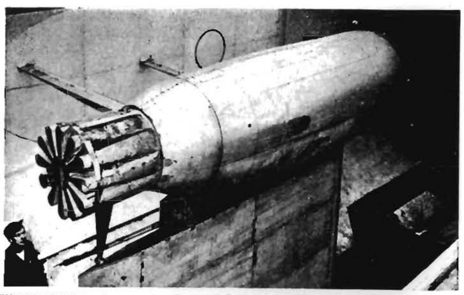
Current transport engines which are based on military designs require high turbine temperatures and exhaust velocities to operate efficiently. Improved design techniques developed since these engines entered production make it possible to build low temperature, low jet velocity engines which are as efficient as today's jet transport powerplants. These engines would result in about a nine decibel sound reduction which is a large step in the right direction.

Quiet vs. Efficiency

Main arguing point against such low temperature engines is the fact that the improved design techniques could be used to produce a more efficient engine with no reduction in noise. The low temperature engine is also slightly larger then its noisier counterpart and would thereby tend to increase aircraft drag in some installations.

One current type of turbojet, which is as efficient and as quiet as the low temperature engine, is the by-pass engine. Noise reduction on this powerplant is achieved in much the same manner as the nozzle-ejector combination except that the mixing of the low energy secondary flow with the high speed jet exhaust takes place within the engine. The air which is ducted around the combustion chamber, turbine and part of the compressor on the by-pass engine is mixed with the main jet in the tail pipe. This gives the resultant jet exhaust a lower velocity and less noise. Velocity is especially reduced in the shear area between the jet and the outside air.

The third method that the NACA is considering for reducing noise is by varying the aircraft flight technique. Chart on page 73 shows the normal



EXPERIMENTAL noise suppressor is mounted on a test engine at the NACA Lewis Laboratory. Nozzle design lowers noise level effectively but also reduces engine thrust.

climbing procedure for a jet transport and its associated noise. It also shows one of the recommended flights paths resulting from NACA test.

Noise Reduction Technique

The normal technique is to take off in the jet transport, hold it down until it accelerates to about 300 kt. and then begin the climb. This is the best climbing speed and gives the minimum time to climb to altitude.

The alternate procedure, which results in less noise for people on the ground, is to take off and begin climbing almost at once at an airspeed of only 180 kt. This climb is maintained at maximum power until an altitude of 1,000 ft. is reached. Then the pilot throttles back to 50% power and brings the nose down to the point that will allow him to maintain 180 kt. speed. As shown on the chart, this procedure makes it possible to reduce the sound on the ground by 23 decibels at a point 3.5 mi. from take off.

It is impossible to make any hard and fast rules about how such climbing techniques will reduce noise in communities. Local conditions vary too much for this, but it is probable that each separate airport can devise its own take off rules to greatly reduce the noise in neighboring populated areas.

There is the further possibility of combining all three of these general approaches to the noise problem to achieve a single, economical solution. Cost, thrust losses and weight are all factors of the greatest importance when considering devices and procedures to be used by commercial airlines. While effective noise reduction methods may be presently available they require much more development before they will be acceptable to the airlines.

Chicago Daily Tribune
Tuesday, October 8, 1957

Scientists Predict Ionic Beam Engine May Carry Man on Flights in Space

BY LLOYD NORMAN
[Chicago Tribune Press Service]

Cleveland, Oct. 7 — Man should be able to leap 1,000 miles into outer space in a rocket powered ship and stay up there for months with the help of "ionic beam" engines, government flight research scientists said today.

Eugene J. Manganiello, assistant director of the Lewis flight propulsion laboratory of the national advisory committee for aeronautics, said that "sustained satellite" flight would be the next step after the launching of an earth satellite. He said the United States Vanguard earth satellite is expected to be launched next spring for a short flight.

Effective in Outer Space

He referred to still undeveloped "ionic beam" engines using magnetically accelerated subatomic fragments to power space ships on long range flights. These engines would be effective in outer space where there is no air to slow up vehicles. A 10 pound thrust ionic engine could boost a 10 ton vehicle already traveling at gravity escape speed of 25,000 miles an hour to 50,000 miles an hour for a month, experts said.

Manganiello spoke at the opening of the inspection of the 150 million dollar laboratory here. The inspection is held every three years to acquaint the aircraft industry and flight scientists with latest engine developments.

Abe Silverstein, associate director of the laboratory, told reporters that he could not forecast when the United States could attempt manned space flight. He said this accomplishment would depend upon "the effort, money, and priority we put on it."

Could Have Been First

He said the Russian launching of the first earth satellite last week did not necessarily imply that soviet aviation research was ahead of the American effort. He said the earth satellite problems involved more development and engineering complexities than basic research. He noted that the United States has the necessary research knowledge to launch a manmade "moon," and presumably could have been first into space if the money and priority had been applied to being first.

NACA scientists described a two engine rocket that could launch a man-carrying satellite into space 1,000 miles above the earth. The final rocket vehicle would resemble an arrowhead plane.

They estimated that such a rocket might weigh more than 10,000 tons, using current space rocket fuels of kerosene and liquid oxygen.

Rely on New Fuels

By using high energy fuels, the scientists predicted that some day the launching rockets could be reduced as much as 50 per cent in size.

Oncet he man-bearing space ship attains the 25,000 mile an hour speed to escape from the earth's gravity pull, it will require a smaller "putt-putt" engine to keep it flying in frictionless space. This engine, Silverstein said, may take years to develop. It will use a principle already developed and tested in the laboratory—the use of ions [electrically charged particles of atoms] to provide thrust. Ions could be created in the engine by a powerful electrical spark, by atomic heat, or other energy source generating heat of 50,000 degrees Fahrenheit.

The ionic engine requires powerful magnets to concentrate the ions into a beam and accelerate them at a speed sufficient to propel the rocket vehicle thru outer space, the scientists said. The magnets would need an electric power source, or atomic power might become available eventually, Silverstein said. Only a few pounds of thrust could push a huge space vehicle thru the heavens at high speeds, because there is no atmosphere gases at that altitude to create drag.