WING TIPS

Issued in the interest of the personnel of the Lewis Flight Propulsion Laboratory, NACA

V[illegible]VII *Cleveland, Ohio, September 30, 1949* No. 21

SPEAKERS TO DISCUSS TURBINE AERODYNAMICS

Turbine Aerodynamics will be discussed at the research staff conference on Monday evening, October 3 at 8:00 p.m. in the auditorium.

Speakers will be Chung Wu, Radial Flows and Acceleration; George Costello, Profile Design; Harold Rohlik, Stator Survey and the Torpedo Turbine; Hubert Allen, Hot Wire Anemometry; and Cavour

(Continued on Page 3)

MESSAGE TO STAFF

I have great pride in the success with which the Laboratory staff carried off the recent inspection. Many of the over 1200 distinguished visitors were outspokenly complimentary of the t[illegible] demonstrations and welcomed the us[illegible]ly understood English in presenting technical material.

No one outside the Laboratory can appreciate as well as I do the tremendous and unselfish effort by large numbers of our staff in assembling and presenting such a show. These include the research staff members who write and present the talks and make the demonstrations with perfect confidence and timing; the artists, illustrators and photographers who design the settings and make legible colorful charts, slides and movies; the carpenters who build the models and assemble the setups; the mechanics who prepare the demonstrations and assist during the show; the painters who make our buildings look new and spotless again; the landscapers who give the Laboratory grounds such a well-groomed appearance; the men in the shops who make unusual things in such a hurry so that the show may go on; the caretakers and riggers who transformed the auditorium twice a day; the group leaders and guides who see to it that the visitors are well conducted; the computers, clerks and stenographers who so graciously serve the luncheons; Miss [illegible]mmer and her staff who so capably outdo [illegible]selves in preparing excellent food for over-capacity groups; the girls who so efficiently register the guests; the many individuals who check baggage, handle reservations, provide transportation; those who entertain the guests at the recreation area and help to dispatch our visitors by bus and private airplanes without confusion. To all these and to those who assisted from the sidelines and patiently accepted necessary interferences in their regular work, I say, "Well done."

Edward R. Sharp

Edward R. Sharp,
Director.

1200 INSPECTION GUESTS VIEW RESEARCH PROGRESS

During the three-day inspection last week more than 1200 persons connected with the broad field of aeronautics visited the Laboratory.

Specially conducted tours took the guests to eight demonstration stops where they heard talks and witnessed exhibits planned to inform them of research progress during the past year and to explain current problems under investigation.

One of the basic supersonic problems, how to obtain engines capable of developing the extremely large powers required was discussed for the guests. Models of hypothetical airplanes to fly at speeds up to 1500 mph were displayed. The speeds and altitudes of the models demonstrated the need for engines of greater horsepower. It was pointed out that turbojet and ram-jet engines are being studied intensively because they can handle large quantities of air and because their power increases with speed.

As each group of visitors inspected the 8 by 6 Foot Supersonic Wind Tunnel the techniques and mechanics of its operation were explained. Although the tunnel has been operating only three months much valuable research data has been obtained through its use in the supersonic propulsion program.

In the field of rocket research announcement was made of the intensive search for more powerful rocket fuels. Because the rocket's specific fuel consumption is much greater than that of any of the other engines used, research

(Continued on Page 3)

After-inspection party for all employees at the picnic grounds last Friday featured a surplus of hotdogs and the welcome warmth of a log fire.

Lobby Lines

MIDNIGHT OIL

Edward Shafer (Translation Unit) left the Laboratory on Sept. 23 to attend the University of Chicago. He is entering with advanced standing, and plans to study toward a degree in economics.

Congratulations to *Georgene B[illegible]an* (Neg. Retouch and Comp. U[illegible]) who was the winner of an adult scholarship for part-time study at Cleveland College. The award, tuition for six semester hours of study, was based on a letter on "Why I want to continue my education," and the results of an aptitude test.

BLOOD DONORS REWARDED

The "Gallon Club" members at the Laboratory received tickets for the ball game on Friday, Sept. 23 through the magnanimousness of Bill Veeck.

Orchids to the seven donors who responded to an emergency call from the Red Cross for 0 positive blood on Sept. 13. An ambulance from Crile Hospital for veterans where the blood was needed rushed out to the Laboratory and transported the donors: *Henry Bothe, Ralph Miller*, and *Ed Werner* from the Machine Shop; *Harvey Lewis* from Instrument Shop; *Don Fisher*, Machine Drafting; and *Pat Donoughe* and *Allen Francisco* from C & T.

STORKTISTICS

Bill Martz (Equip. Installation) reports the birth of a daughter, Katherine Ann, born Sept. 15. Mrs. Martz is the former Adelaide Brown who worked in C & T Division office. *Darnold Blivas* (WT&F) is the proud father of a baby girl born Sept. 12. *Bernard Sather* (EP&M) is boasting about his new daughter who weighed in at 10 lbs. on Sept. 19. *Robert Cummings* (C&T) announces the arrival of Trulee on Sept. 17.

FALL VACATIONS

Although the usual vacation season is over, Lab people are still on the go. *John Sanders* (EP&M) has just returned from a trip to Carlsbad Caverns National [illegible]k in New Mexico.

[illegible]ean Neidengard (Library) and husband, Bill (Mech. Serv.) took a weekend plane hop to Clinton, New Jersey.

Peggy Yohner (C & T Computing) and husband, Kenneth are enjoying their vacation at a lake near Roscommon, Mich.

THE WAGNERS CELEBRATE

A group of 25 Lab friends of *George Wagner* (Plant Machinery) and his wife, Anna, held a surprise party for them at their home on W. 94th St. on Sept. 14, the occasion of the Wagners' Golden Wedding Anniversary.

MARITAL MENTION

William Berkey (Fund. Turbine Res.) resigned from bachelor ranks on Sept. 10 when he married Ruth Jody of Rocky River. They are honeymooning in the South. Word has reached the Laboratory of the marriage of *Teresa McNeeley*, formerly of C & T Computing to Charles Siegwarth. Both are attending Bowling Green State University.

GOOD-BYE AND GOOD LUCK

Joining the back-to-school movement are *Art Hansen* (C & T) who left the Lab to go to the University of Maryland; *John Spaulding* (C & T) who plans to teach and study at Johns Hopkins University; and *Genevieve Miller (C & T Computing) who has enrolled at University of Michigan.* Marcella Wachter *(WT&F Computing) has resigned to devote her time to housekeeping.*

RANDOM NOTES

Virginia White (Mech. Eng'g Div.) is very busy these days getting ready to move into a new home in Fairview Park. She also reports that the Mechanical Division office including herself, *Dick Parisen* and *Harry Kottas* has been moved to Room 106, REB. They may be reached by phone at 2145 or 4284.

C & T Computing welcomes the following new girls: *Lucille Shaffer, Joan Nichol*, and *Margaret Klinect.*

THIRD FINGER, LEFT HAND

Naomi Batchelor (Fiscal) is showing off her engagement ring which she received August 17. She plans to marry Fred Schnell, a Cleveland man, sometime next fall. Also announcing her engagement is *Gertrude Reichel* (C & T Computing) who is the fiancee of Ralph Bassett.

COMPUTERS ESCAPE BURNING NORONIC

The tragedy of the S.S. Noronic, Canadian steamship which burned in dock at Toronto, Ontario on Sept. 17 was experienced by two Laboratory computers.

Trudy Glesher (Fuels and Thermo.) and Dorothy McComb (Eng. Perf. and Materials), who left Cleveland on the Noronic for a week's vacation, were among the first survivors to reach the dock safely.

Here is their account as received in the WING TIPS office:

"We were in our stateroom and smelled smoke. Fortunately we had not gone to bed and we grabbed our purses and fled. We were on "D" deck and had just one main stairway to go down to reach the dock. We were separated and spent an anxious twenty minutes trying to locate each other on the dock. We took a cab into Toronto and spent the rest of the night at a hotel.

The Canadian Red Cross and citizens of Toronto did everything that could have been done for all survivors. The hotel turned rooms over to us and the department stores supplied complete outfits for any one who needed them. Everyone in Canada was wonderful to us. Trudy did not have a coat and had her slippers on, and the Toronto Red Cross provided her with a beautiful new coat and new shoes.

The Steamship Company furnished transportation home; we had a sleeper and arrived home Sunday morning. It was a terrible disaster and a sight we will be remembering for a long time.

Trudy and I would like to express our appreciation to so many friends who have been so thoughtful and kind to us. We are suffering from shock, but hope to return to work soon."

Dorothy McComb and Trudy Glesher

1200 INSPECT LAB

is attempting to secure the highest possible thrust from a unit of fuel. Scientists here have determined the extent to which improved fuels will exceed the specific impulse given by commonly used gasoline-nitric acid fuel.

The Laboratory's attack on the problems which surround the insufficient supply of metals necessary to manufacture large numbers of jet engines in time of emergency was explained to the inspectors. The three-fold program encompasses (1) development of non-strategic or domestically available materials, (2) incorporation of design methods which would reduce the use of critical materials, and (3) development of cooling methods which would make possible the use of lower-temperature non-critical alloys.

These and many other noteworthy trends and impending problems were summarized.

TURBINE AERODYNAMICS

Hauser, Supersonic Discharge Velocities. Illustrative slides will be shown.

This meeting is the first of a series of conferences which have been rescheduled for evening instead of morning hours on alternate Mondays. Two hours, including discussion time following the presentation of each paper, have been allotted.

The purpose of the conferences is to inform staff members of the progress of investigations being conducted in various fields and to present current information not yet available in report form.

Non-research employees are welcome.

LAB TO HOLD THIRD ANNUAL INSPECTION

SEPT. 20,21,& 22 DATES ANNOUNCED

September 20, 21, and 22 have been announced as the dates of the Third Annual Inspection of the Lewis Laboratory.

Some 900 visitors are expected to attend. Among them will be leading representatives of the aircraft industry and educational institutions who will inspect the facilities on September 20; officers of the military and naval services will attend on September 21; and local industrial, business and educational directors will be the guests of the Laboratory on

(Continued on Page 6)

ANNUAL INSPECTION

(Continued from Page 1)

the last day, September 22.

The annual inspections represent a type of reporting different from the NACA Reports and Technical Notes written here, and are not intended for highly technical discussions. The aim is to describe the work of the Laboratory in broad terms, and to indicate the scope of the research done here.

Further announcements to the staff will be made at a later date concerning the cooperative work of employees in preparation for this event.

LAB PREPARES FOR INSPECTION

Preparations for the Third Annual Inspection to be held Sept. 20, 21, and 22 are in full swing throughout the Laboratory. Carpenters are busy constructing platforms to elevate equipment; artists and illustrators are drawing colorful backdrops and charts; and the engineers are preparing talks and demonstrations of current research problems and past achievements.

Not the least of these projects is the over-all clean-up of buildings and grounds. The small jobs to be completed will give the entire reservation a well-ordered appearance.

This year the trade apprentices, numbering about 125, turned out en masse to give the service groups a much-needed lift. For several days early this week, rotating in groups of 30, they worked on the protective mounds near the test stands at the rocket, or High Pressure Combustion Laboratory.

Working as a team they accomplished the sizable task of building six new mounds of earth. After these mounds were seeded, the boys covered them with straw and sprayed water over the entire area.

Through this cooperative effort, each apprentice was away from his training only a few work hours. As the pictorial evidence on page 3 indicates, this tour of duty offered the boys a sun tanning, muscle developing opportunity as emergency laborers.

Trades Apprentices level protective mounds near the Rocket Lab.

LAB TO OBSERVE OPEN HOUSE SUNDAY SEPT. 25

1950 BUDGET ACT INCREASES FUNDS

The Independent Offices Appropriation Act of 1950, Public Law 266, which provides for the allotments of funds for the operation of the Lewis Flight Propulsion Laboratory during the current fiscal year, became effective August 24, 1949.

This Act provides funds for a slight increase in personnel and also furnishes funds for the construction of an instrument research laboratory and for the completion of the Propulsion Sciences Laboratory now under construction in Wright Park.

Increased funds were allotted to meet operating expenses, such as the purchase of equipment and supplies.

Public awareness of the need for research in aviation has been demonstrated by the granting of increased funds to the NACA.

WORKERS TO SEE EXHIBITS FRIDAY

On Sunday, September 25, a Laboratory open house will be observed from 1:00 to 5:00 p. m. for the families and friends of employees.

Although the exhibits and demonstrations of the Annual Inspection will not be given, all buildings will be open. Volunteer attendants will be on duty to guide visitors. Restricted areas will be designated as such or roped off for protective purposes. Each employee is to be responsible for the conduct of his guests.

Invitations may be secured at the division offices. The employee's name should be written on the reverse side. Each guest must be provided with an invitation. No one will be admitted to the grounds after 4:00 p.m.

Refreshments will be sold in the cafeteria and at the lunch counter in the Technical Service Building.

INSPECTION FOR EMPLOYEES FRIDAY

Employees will be excused from duty at 12:00 noon on Friday, September 23 in order that they may attend the exhibits and demonstrations which will be restaged during the afternoon.

Refreshments, including sandwiches, will be served to all employees at the picnic grounds beginning at 5:00 p. m. The lunch is being provided as a gesture of appreciation for the cooperation and effort exerted by the staff in planning, preparing and executing the Third Annual Inspection.

The eight demonstrations and talks will be given continuously during the afternoon. The locations are as follows:

1. Compressor and Turbine Aerodynamics
   W-6, W-10 ERB
2. Turbine Cooling
   W-2 ERB
3. Heat Transfer; Turbojet Fuels
   CW-5 ERB
4. Rocket Research
   Rocket Test Laboratory
5. Supersonic Propulsion Systems
   8-by-6-Foot SWT
6. Inspection and Demonstration of 8-

(Continued on Page 4)

OPEN HOUSE SUNDAY

by-6-Foot Supersonic Wind Tunnel
8-by-6-Foot SWT

7. Turbojet Operation Problems
   Altitude Wind Tunnel Shop
8. Materials, Stresses, and Vibrations
   CE-6 ERB

WING TIPS

Issued in the interest of the personnel of the Lewis Flight Propulsion Laboratory, NACA

Vol. VII *Cleveland, Ohio, September 30, 1949* *No. 21*

SPEAKERS TO DISCUSS TURBINE AERODYNAMICS

Turbine Aerodynamics will be discussed at the research staff conference on Monday evening, October 3 at 8:00 p.m. in the auditorium.

Speakers will be Chung Wu, Radial Flows and Acceleration; George Costello, Profile Design; Harold Rohlik, Stator Survey and the Torpedo Turbine; Hubert Allen, Hot Wire Anemometry; and Cavour

(Continued on Page 3)

MESSAGE TO STAFF

I have great pride in the success with which the Laboratory staff carried off the recent inspection. Many of the over 1200 distinguished visitors were outspokenly complimentary of the talks and demonstrations and welcomed the use of easily understood English in presenting technical material.

No one outside the Laboratory can appreciate as well as I do the tremendous and unselfish effort by large numbers of our staff in assembling and presenting such a show. These include the research staff members who write and present the talks and make the demonstrations with perfect confidence and timing; the artists, illustrators and photographers who design the settings and make legible colorful charts, slides and movies; the carpenters who build the models and assemble the setups; the mechanics who prepare the demonstrations and assist during the show; the painters who make our buildings look new and spotless again; the landscapers who give the Laboratory grounds such a well-groomed appearance; the men in the shops who make unusual things in such a hurry so that the show may go on; the caretakers and riggers who transformed the auditorium twice a day; the group leaders and guides who see to it that the visitors are well conducted; the computers, clerks and stenographers who so graciously serve the luncheons; Miss Zimmer and her staff who so capably outdo themselves in preparing excellent food for over-capacity groups; the girls who so efficiently register the guests; the many individuals who check baggage, handle reservations, provide transportation; those who entertain the guests at the recreation area and help to dispatch our visitors by bus and private airplanes without confusion. To all these and to those who assisted from the sidelines and patiently accepted necessary interferences in their regular work, I say, "Well done."

Edward R Sharp

Edward R. Sharp,
Director.

1200 INSPECTION GUESTS VIEW RESEARCH PROGRESS

During the three-day inspection last week more than 1200 persons connected with the broad field of aeronautics visited the Laboratory.

Specially conducted tours took the guests to eight demonstration stops where they heard talks and witnessed exhibits planned to inform them of research progress during the past year and to explain current problems under investigation.

One of the basic supersonic problems, how to obtain engines capable of developing the extremely large powers required was discussed for the guests. Models of hypothetical airplanes to fly at speeds up to 1500 mph were displayed. The speeds and altitudes of the models demonstrated the need for engines of greater horsepower. It was pointed out that turbojet and ram-jet engines are being studied intensively because they can handle large quantities of air and because their power increases with speed.

As each group of visitors inspected the 8 by 6 Foot Supersonic Wind Tunnel the techniques and mechanics of its operation were explained. Although the tunnel has been operating only three months much valuable research data has been obtained through its use in the supersonic propulsion program.

In the field of rocket research announcement was made of the intensive search for more powerful rocket fuels. Because the rocket's specific fuel consumption is much greater than that of any of the other engines used, research

(Continued on Page 3)

After-inspection party for all employees at the picnic grounds last Friday featured a surplus of hotdogs and the welcome warmth of a log fire.

1200 INSPECT LAB

is attempting to secure the highest possible thrust from a unit of fuel. Scientists here have determined the extent to which improved fuels will exceed the specific impulse given by commonly used gasoline-nitric acid fuel.

The Laboratory's attack on the problems which surround the insufficient supply of metals necessary to manufacture large numbers of jet engines in time of emergency was explained to the inspectors. The three-fold program encompasses (1) development of non-strategic or domestically available materials, (2) incorporation of design methods which would reduce the use of critical materials, and (3) development of cooling methods which would make possible the use of lower-temperature non-critical alloys.

LANGLEY MEMORIAL AERONAUTICAL LABORATORY
LANGLEY FIELD, HAMPTON, VA.

AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CALIF.

FLIGHT PROPULSION RESEARCH LABORATORY
CLEVELAND AIRPORT, CLEVELAND 11, OHIO

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
1724 F STREET NORTHWEST
WASHINGTON 25, D. C.

TELEPHONES: EXECUTIVE 3515, 3516, 3517

September 23, 1949.

Dr. Edward R. Sharp, Director,
Lewis Flight Propulsion Laboratory,
Cleveland Airport,
Cleveland 11, Ohio.

Dear Dr. Sharp:

On behalf of the NACA and for myself I wish to compliment you and your staff on the excellence of last week's inspection of the Lewis Laboratory and for setting a new high mark in clarity of expression and unity of theme.

The flawless team work among your staff and the background of liaison with the other laboratories in the mechanics of preparing for this inspection provide wholesome evidence to our visitors of a capable organization. The talks reflect a clear understanding of the problems of research and a sound approach to their solutions.

The value of each inspection is evident by the good will and cooperation engendered in those we serve, as well as by the continued support of our research activities by the public.

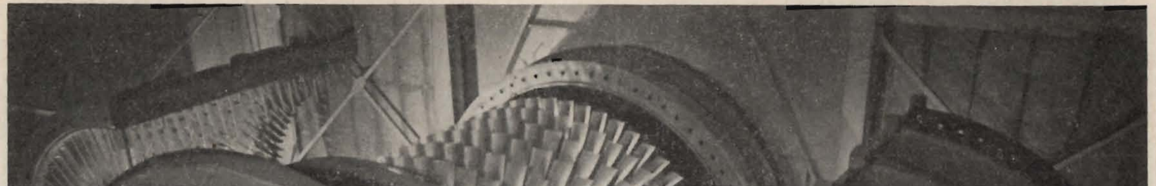
Sincerely yours,

J F Victory

John F. Victory,
Executive Secretary.

Vol. 59
No. 5

NOVEMBER
1949



Capable of handling 2 million cfm air, this is the compressor of the 8 by 6 Supersonic Wind Tunnel at the Lewis Labs. The two halves of the stator-blade housing have been opened to show rotor blades

FLIGHT PROPULSION RESEARCH

THE National Advisory Committee for Aeronautics last month was host to 1300 scientists, educators, civilian and military Government representatives at the Annual Inspection of the Lewis Flight Propulsion Laboratory at the Cleveland Muncipal Airport, Cleveland, Ohio. The Laboratory, named in honor of Dr. George W. Lewis, Past Director of Aeronautical Research for NACA, is the newest of three operated by NACA. It formerly was known as the Flight Propulsion Research Laboratory.

The annual three-day tour of inspection of the establishment gave members of the aviation press an unprecedented opportunity to see and hear about the progress of research in aircraft propulsion. Highlight of the event was display of the Laboratory's new, 6-*ft* x 8-*ft* supersonic wind tunnel, built at a cost of $7 million, in actual operation.

Dr. Hunsaker Speaking

Welcoming the visitors, Dr. Jerome C. Hunsaker, Chairman of the NACA, spoke of the work at the Lewis Laboratory as encompassing "the broad range of problems associated with the propulsion of aircraft."

"In attacking these problems," he said, "both theory and experiment are employed to accumulate the basic knowledge necessary for the continued development of engines. The frontiers of such basic aeronautical information are being pushed ever forward. The gains we make often are unspectacular in and of themselves, but this steady enlargement of the area of scientific knowledge, increment by increment, totals a significant annual gain."

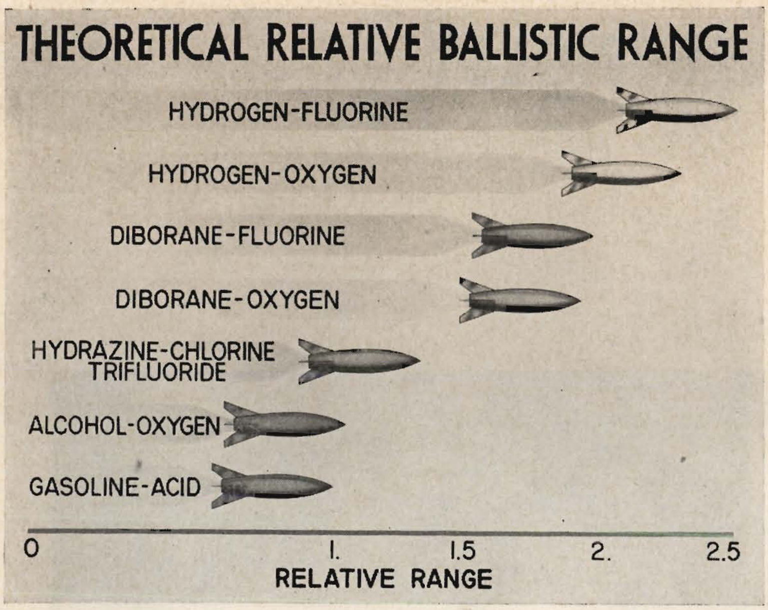


Figure 1

The inspection came hardly ten years after attainment of practical jet propulsion, an event which touched off a revolution in the world of aviation. Less than eight years ago, America's first jet-powered airplane had taken off on its maiden flight from the lake bed at Muroc. The chain-reaction consequences stemming from the first jet flight, August 27, 1939, were of great significance, and it is difficult to contemplate the further advances which wait only on man's daring and industry for exploitation, except in terms which seem exaggerated.

Man first flew faster than sound October 14, 1947, utilizing the rocket type of jet propulsion, and in an especially designed research airplane. Subsequently, the inevitability of faster-than-sound flight by tactical military aircraft has been underlined by the near 700-*mph* speeds of production-model fighter aircraft, and already bombers are flying so fast, so high, and so far that adequate interception has become critically urgent.

Dr. E. R. Sharp, Laboratory Director, observed at the inspection that, "The advent of supersonic speed—yesterday in research airplanes, tomorrow in other aircraft—has given added urgency to the quest for information which will enable design and manufacture of the more powerful engines needed in the attainment of sustained faster-than-sound flight."

Teamwork

Responsible partners in executing the mandate to keep America preeminent in aviation are the Department of Defense, the nation's aircraft and engine industry, the nation's educational institutions and the National Advisory Committee for Aeronautics. Each has specific, vital functions to perform; cooperation means integrated effort.

From its earliest days, NACA has studied propulsion problems. In 1923, an NACA report by Edgar Buckingham of the Bureau of Standards considered the future of jet propulsion, a prospect which at that time looked dim because speeds faster than 250 *mph* were hard to envision. In following years, propulsion research was continued, centering on the problems which in retrospect seem relatively simple but that were complex enough during the actual perfection of the reciprocating engine.

Wartime requirements demanded immediate extension of the power potential of the reciprocating engine, which industry was equipped to build in the needed numbers, and, during its early years, the Lewis Laboratory devoted much of its energy to this work. None the less, the Laboratory, from the very first, conducted research on problems created by the revolution in propulsion technology which resulted in the jet engine. To an even greater degree, the research emphasis was shifted, until finally virtually all research effort was concentrated on the new problems.

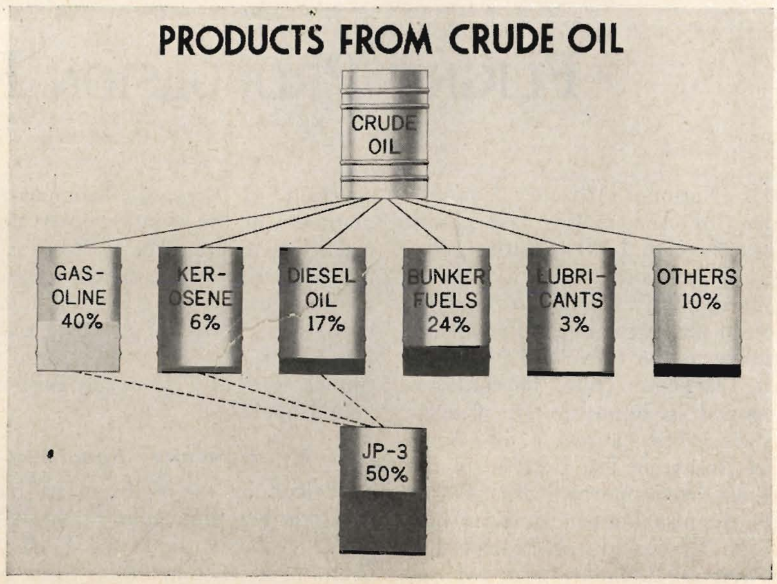
What They're Trying to Do

Among prime research projects of the Lewis Laboratory are efforts to obtain data with the aid of which compressors and turbines may be improved in design, thus to produce engines having higher power, lower weight, lower specific fuel consumption, lower manufacturing costs and lower operating costs. Progress has been made in this general direction, and it is now more evident that the principal improvements in gas-turbine engine performance will come from increasing the engine-pressure ratio, and by turbine cooling which permits increasing the maximum-cycle temperatures.

There is an increasing awareness that peak-engine performance requires designing the engine for a particular application rather than seeking to use a single engine for a wide range of service requirements. Sufficient fundamental knowledge of the flow conditions in compressors and turbines is needed to bring about the design of engines for particular use, *i.e.*, in small fighters or large, long-range bombers, greatly reducing the expensive time-consuming program of development.

(Continued on page 102)

Figure 2



to power the DH.104 Type-3 *Dove.*

Not strictly classifiable as a turboprop, but of great interest, are the projects of one British firm which has acquired patents for combined piston-*cum*-jet engines, wherein the normal engine is combined with compressor and turbine; and thus the engine acts as the "combustion chamber" for the gas turbine. This is in contrast with the idea of the present compound engine having an exhaust turbine.

In a relatively new field, existing turboprops have been "paired" to form a higher-powered unit. Turboprops lend themselves to coupling much more easily than do piston engines.

The largest of these turbines is the BPtC.1 coupled *Porteus,* fitted to the Bristol *Brabazon* (the Mk.2) and the Saro *Princess.* The unit delivers a total of 6400 *shp* and consists of two *Proteus* arranged side-by-side with reduction gear removed and replaced by a coupling gearbox to which the engines are bolted.

The starting sequence is similar to that on the single unit. As one engine starts, the propellers rotate, causing a rotation of the power turbine of the second unit. A second starting sequence brings in the second turbine, adding its power to the first.

Full use is made of the propeller slipstream ram in the air-intake system as the two entrances are fitted in the leading edge of the wing directly in line with the most effective part of the propeller system. The weight of the unit is 8100 *lbs* dry, length 149.33 *in,* and fuel consumption will be .63 *lb/shp/hr* at maximum-power output.

Two of the medium turboprops have been coupled to form the *Double Mamba* and *Coupled Naiad.* The *Mamba* installation is slightly more bulky than the *Naiad* and the two engines are entirely self-contained units, driving separate co-axial counter-rotating airscrews. Either engine can be run independently of the other and each has a complete fuel, lubrication and control system. Maximum takeoff power is 2540 *shp,* plus 770 *lbs* of jet thrust.

The first application of the *Double Mamba* is military, as it is mounted on the prototype Fairey 17 two-seat, anti-submarine aircraft only recently completed. It employs a bifurcated jet pipe.

The *Coupled Naiad* (makers designation E.128D, experimental designation NNaC.1) is smaller in frontal area than the *Double Mamba,* due to the arrangement of the common gearbox, and presents a flat oval shape of pleasing lines, the accessories being grouped around the compressors within the diameter of the cowling. Each *Naiad* is controlled by a single lever and either can be operated separately.

Maximum power is 2970 *bhp* for takeoff, plus 482 *lbs* of thrust at 18,250 *rpm* with a fuel consumption of 258 *gph.* Maintenance is facilitated in that either unit can be disassembled or worked upon without affecting the other.

FLIGHT-PROPULSION RESEARCH

(Continued from page 16)

Beginning with theoretical work, problems are divided into their basic elements and the characteristics of each are studied. At those points where present theories reach their limits, fundamental experimental research is carried on in cascades (small wind tunnels especially adapted for study of blades), where flow details can be investigated readily and economically. Research then moves to single-stage and finally to full-scale investigations. In addition to supplying data for aerodynamic design, this coordinated research provides a better knowledge of the flow conditions necessary for improved turbine cooling.

Throughout the study of pressure ratios, weight flow and work output of compressors and turbines, it is necessary to determine exactly the paths of flow and the velocities of the fluid (air) at every point in the machine. Known mathematical methods will not permit solution of the problem, so simplifying assumptions must be used. Progress is being made; within recent months a method has been developed for computing the thickness of the boundary layer at any point along the blade when the perfect-fluid velocity is known. Study is being made also of flow velocities which are greater than sound, and of the shock waves and their interactions which result.

Encouraging performance on a service-type centrifugal compressor, using information from this program, also has resulted, reduction gearing that has a helical, high-speed train and a final spur-gear drive. Again, the cowling is of small diameter (38.5 *in*) and the oil tank is cast around the intake, integral with the casing. RDa.3's power the production *Viscount 700*, and in addition a *Dart* has been fitted to the Avro *Athena* with a belly efflux, and experimentally to a Vickers-Armstrongs *Wellington* bomber.

Last of the trio is the Napier *Naiad*, also produced in three versions—the NNa.1, 2 and 3, each of 1500 *shp* plus 241 *lbs* of jet thrust. The *Naiad* (known as the E.128) has an axial-flow, 12-stage compressor, five combustion chambers and a two-stage turbine with a long-chord, ducted spinner. The advantage of the last-named is claimed to be an increase in aerodynamic efficiency as the spinner slows down the airflow before it reaches the propeller blades, the roots of which are not always of ideal section.

The *Naiad* has been test-flown on two *Lincolns* and a *Wellington*. Although no plans for future installations have been announced, the engine has been considered for several machines such as the Airspeed *Ambassador* and Vickers-Armstrongs *Viscount*. The *Mamba, Dart* and *Naiad* all feature low-drag cowlings and exceptional ease of maintenance.

"Theseus" and "Proteus"

Two higher-powered units emanating from the Bristol Company are the *Theseus* and the *Proteus*. First versions of the *Theseus* were BTh.1 and 2 of 1950 and 1675-*shp* respectively, leading to the BTh.3 *Theseus 1* of 1975 *shp* and the BTh.4 of 2200 *shp*. In August of this year, a third type certificate (the first was in 1946 for 1950 *bhp*) was granted for 2450 *ebhp*.

With a diameter of 54 *in*, the engine is compact, having eight axial-compressor stages, a single centrifugal stage and eight combustion chambers. Being a "free turbine," the first two-stage turbine drives the compressor; a single-stage rear turbine drives the propeller through reduction gearing. A version with a heat exchanger was experimented with, but was dropped.

Avro *Lincolns*, with *Theseus* turbines in the outer nacelles, have been operating with the RAF Transport Command on Britain-Egypt routes since April 1948 and have proved their reliability. The *Theseus*-powered Handley Page *Hermes 5* is now flying successfully and should provide much data.

Scheduled for use in the outer nacelles of the Saunders Roe 45 *Princess* flying boat, and as an alternative unit for the Bristol 175 Medium Range Empire transport, the *Proteus* "free turbine" has a compressor of 12 axial stages and one centrifugal, followed by eight combustion chambers and two turbines. Flight tests are to start shortly. Thus far, three types have been announced—the BPt.1, 2 and 3; the BPt.2 delivering 3200 *shp* plus 800 *lbs* jet thrust at 10,700 *rph*. A layout of two *Proteus* was prepared for the Airspeed *Ambassador*, with a semi-annular intake and efflux over the wings.

Little has been released concerning a small series of low-power turboprops, the Bristol *Janus*, Napier *Nymph* and deHavilland *H.3*. The *Janus* and *Nymph* are quoted as being dropped, but it is known that the H.3 has been bench-tested and was intended and in the work with supersonic axial-flow compressors, practical units have been developed, utilizing blades thicker and sturdier than the finely-machined, razor-like blades of earlier such machines.

Advantages looked for in turbine cooling include increased power, economy and reliability of operation, and conservation of strategic materials now used in turbine manufacture. If operating temperatures are increased from 1500°*F* to 3000°*F*, power can be more than doubled. Today, even with the use of heat-resisting alloys having up to 96% content of scarce elements, operating temperatures are generally limited to about 1500°*F* because of stress limitations.

Possibilities include the use of hollow blades and internally-finned hollow blades, and additional cooling by use of air or water. Even allowing for the power drop because of cooling losses, cooling with either water or air results in substantial net power gains as operating temperatures are raised to 3000°*F*. When cooled blades, containing only 2% strategic materials, are used, it is still possible to operate with gas temperatures of over 200°*F*.

Assuming the possibility of an emergency that would call for manufacture of jet engines at the rate, say, of 100,000 per year (in a single year of the last war, 257,000 reciprocating engines were built), review of the metallic elements used in the manufacture of these engines is required. If these elements should be critical in supply—and columbium, tungsten, cobalt, chromium, and nickel are high on such a list—then other approaches to the problem of fabricating certain engine parts must be made.

NACA's contributions to the problem, as discussed at the inspection, are a three-pronged attack. One is research leading to the development of non-strategic materials suitable for jet-engine manufacture. Another is establishment of design methods resulting in reduction in use of critical materials; and a third, mentioned above, is development of cooling methods.

Similarly, growth in the number of jet engines used causes development of fuel specifications which will be adequate, quantitatively, to the needs of an emergency period. This has resulted in the JP-3 fuels specification, which assumes a maximum availabilty equaling 50% of the products refined from a barrel of crude petroleum.

During the past war, less than a third of the petroleum products available was used for aviation *(fig. 2)*. In time of emergency, aviation will be but one of several heavy users of such products. Because of the likelihood of tight supply, continuing studies are being made to determine the minimum requirements for satisfactory jet fuels with regard to supply availability.

The rocket engine's ability to provide super performance—although for only short periods—has caused it to be used as a primary powerplant for military missiles and upper-atmosphere research vehicles. It has been used as an auxiliary powerplant for launching missiles, especially those powered by a ramjet, because the latter is incapable of delivering appreciable thrust except at high speeds. The rocket has been used for assisting takeoff of aircraft and for thrust augmentation for high climb rates or high speeds. The rocket permits long ranges for vehicles that are brought to high speed and then allowed to coast, following a trajectory path like a projectile.

A major rocket-engine problem is to secure the highest possible thrust from a unit of propellant. Lewis Laboratory researchers have determined, both on paper, experimentally in the laboratory, and with engines, the extent to which improved fuels will exceed the specific impulse given by the gasoline-nitric acid propellant which is rated at 1—(alcohol-oxygen is rated at 1.08). This program has included work with hydrazine-chlorine trifloride, diborane-oxygen, diborane-fluorine, hydrogen-oxygen and hydrogen-fluorine, and is being expanded to include the study of propellants with even higher energy potentials *(fig. 1)*.

Consideration is being given to such properties as ignitability, density, boiling and freezing points, stability, toxicity and availability. Other rocket-powerplant research at Lewis includes chamber cooling—both by circulation of propellants over the engine surfaces prior to injection and also by film cooling in direct contact with the hot gases —altitude starting, and the phenomenon of "chugging."

With accomplishment of short-duration supersonic flight speeds by full-scale research airplanes and with the imminence of sustained supersonic flight speeds, research effort is being intensified at the Lewis Laboratory to solve the basic supersonic-propulsion problem, how to obtain engine types capable of developing the extremely large powers required.

Turbo-ram and ramjet engines, because of their ability to handle large quantities of air relative to their size and because their power increases with flight speed, are suitable for supersonic flight. Problems common to supersonic engines are, efficient compression of the air, combustion of the fuel, aerodynamic efficiency of the engine and interrelated effects between the engine and the airplane.

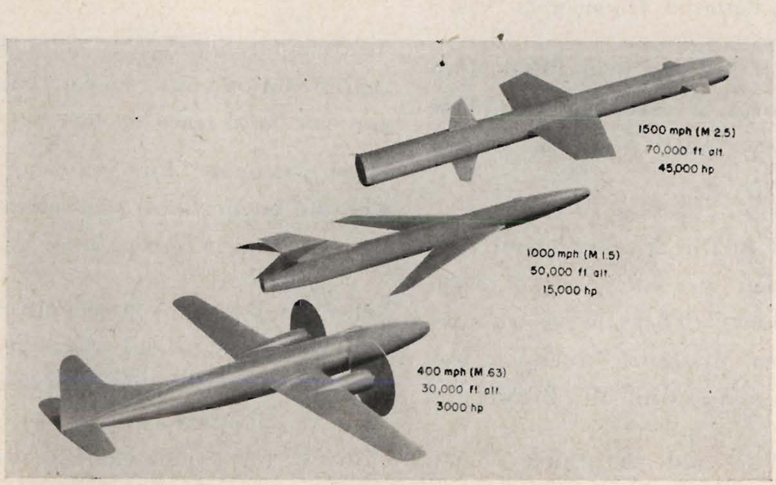
Efficient conversion of the heat energy of the fuel to useful propulsive energy requires that the process shall occur with the highest possible compression of the combustion air. In the ram-jet engine, compression is obtained by slowing the air from flight velocity at the inlet to a low speed in the combustion chamber. In slowing down, the air converts its velocity energy to pressure energy. This ram compression increases with flight speed, and special inlet designs are necessary to obtain efficient compression at supersonic speeds by reducing shock losses at the inlet. Investigation of this compression problem is being done also at the Langley and Ames Laboratories and, although considerable improvement at all speeds has been achieved, research continues to bring actual compressions even closer to the theoretical maximum compressions.

The problem is made more difficult by the great sensitivity of inlets at supersonic speeds to operation at altitudes and speeds other than those for which the engine has been designed (off-design point). This sensitivity is expressed largely as compression loss and increased engine drag. Research is directed to evaluating the off-design characteristics of different supersonic inlets to determine how they influence the utility of engines of fixed design.

Previous investigations showed that pressure pulses associated with combustion may reduce ram compression seriously. Indications are that engine design and operating conditions influence this pulsing problem. Research is now under way at the Lewis Laboratory to learn how the pulsations occur and whether the problem is an inlet or combustion phenomenon.

Because air in a ramjet engine passes through the combustion chamber at high velocity, there is a tendency for the flame to blow out. Operating the engines at high altitudes with resulting low pressures also makes combustion difficult. Since 1945, the velocities at which good combustion efficiencies can be maintained have been increased almost threefold, and further progress is anticipated. Similarly, progress has been made increasing the altitude limits for satisfactory combustion, a result of intensive research on flame-hold devices, fuel-injection method and combustion-chamber designs.

At supersonic speeds, the problem of designing engines having the lowest possible drag becomes important, and much research on this subject is required. Air-flow disturbances induced by the engine inlet or exhaust jet may seriously alter the effectiveness of the lifting and control surfaces of the airplane, whether the engine be located in a nacelle or totally submerged in the fuselage. Supersonic-propulsion systems no longer can be isolated for separate study but must be investigated with the complete aircraft configuration.



Hypothetical models show that an airplane flying at 1500 mph at 70,000 ft would need 15 times the power of an aircraft of the same weight making 400 mph at 30,000 ft. Similarly, an aircraft flying at 1000 mph at 50,000 ft would require five times the power of the 400-mph ship

Orientation Study

To conduct this work, the engine nacelle must be submerged completely in a supersonic airstream, and reliable data can be obtained only with large-scale models. Especially valuable in this work is the Lewis Laboratory's 8- by 6-*ft* supersonic wind tunnel, which already, during the brief period it has been operating, has made possible obtaining valuable data. This tunnel is capable of speeds up to 1500 *mph*, although the actual speed of the air at the low temperatures of the tunnel test section reaches only about 1380 *mph.*

Solution of one problem gives rise to others, equally fundamental. They, in turn, must be explained if the primary answers are to be found to the continuing question —how to design more and yet-more powerful engines. These solutions, these research gains, are not easily won. Sometimes it is necessary to buttress partially formulated theory with experiment, this to achieve tentative answers which must suffice until the ultimate theory can be developed.

The increment gains, in this enlargement of the area of knowledge about propulsion, often in and of themselves are unspectacular, especially when charted against time; but in the sun they represent steady progress.

1949 INSPECTION OF THE NACA LEWIS LABORATORY

PUBLICITY RESULTING FROM THE INSPECTION

The releases to press and radio of photographs and written material prepared by Walter Bonney, and the press conference with Dr. Sharp and Abe Silverstein at the end of the first day of inspection resulted in more publicity than has been obtained at previous Lewis Laboratory Inspections.

The press group displayed unusual interest throughout the day and many were grateful to find typewriters and an experienced Western Union teletypist so their stories could be filed with their papers before leaving.

The press emphasis was on the imminence of sustained supersonic flight, the enormous power required, the critical shortage of high-temperature-resistant materials, the need for new materials and better fuels in quantity for an emergency. Clippings from the major newspapers are on file in the Lewis Laboratory Scrap Book. For convenience the sources, headlines and by-lines of these clippings are included in the following Summary:

(See Page 2 attached)

SUMMARY OF NEWS CLIPPINGS

9/20 Cleveland News - "Doolittle and Lonnquist visit Airlab" (Photo)

9/20 Cleveland Press - "Flight Lab Seeks 1500 MPH Speed" - by Charles Tracy (Includes photo of 3 models used at 8 x 6 Sup. Tunnel)

9/20 Cleveland News - "Lab Here Sees Future Plane as 'Tube' Flying 1,500 MPH" (Photo of typical Ram Jet Airplane)

9/20 N.Y. Herald Tribune - "1,500-Mi Speed for U.S. Planes Called in Sight". "Nation's Air Advisers Hear Forecast as Talks Start at Cleveland Lab" - by Ansel E. Talbert.

9/21 Cleveland Plain Dealer - "Long Hops Seen at 1,000 MPH". "Extended Flights Imminent Say NACA Technicians" - by James D. Hartshorne.

9/21 Cleveland News - "Race Time Here to Develop New Metals for Jet Engines" - by Ralph Platt.

9/21 Buffalo Evening News - "45,000-hp Engines Needed to Fly Planes at Superior Speeds" - by Bob Watson.

9/21 Chicago Daily Tribune - "Longer Flights at Supersonic Speed Forecast". "Sustained Travel Held Imminent".

9/21 New York Times - "Supersonic Flight of Hour Predicted". "Cleveland Research Director Says U. S. Planes Must Fly Faster, Higher, Farther" by Frederich Graham.

9/22 New York Times - "New Jet Metals and Fuels Sought". "U.S. Scientists Grapple With 2 Problems That Would Limit Warplanes in Emergency" - by Frederich Graham.

9/22 Chicago Daily Tribune - "Science Hunts New Materials for Jet Planes". "Seeks to Solve Problem of Scarce Metals".

9/22 Cleveland Plain Dealer - "Supersonic Winds Now Here to Test New Jet Designs".

It is known that NBC carried the NACA story widely over the air. The Cleveland outlet was on WTAM, the Sohio News at 11:00 p.m. on 9/20. No record was obtained of other broadcasts.

The Fairchild Engine and Airplane Company house organ, the Pegasus, carried an illustrated feature story prepared by Walter Bonney in its October issue, copy of which is attached. Other articles and reviews were n ot collected.