NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CALIFORNIA

REYNOLDS AND MACH NUMBERS

Wind-tunnel testing of models plays a prominent part in aeronautical research because it is safer, more economical, and more expedient than flight testing; but caution is needed in using data from such model tests because the model does not always – in fact, usually does not – react to the air stream in exactly the same manner that its full-scale airplane counterpart reacts.

This dissimilarity in flow generally is referred to as "scale effect." To study this scale effect and overcome its disadvantages, use is made of an index called "Reynolds number." Match the Reynolds numbers about the model and the airplane, and the air-flow patterns are matched.

In simplest terms, the Reynolds number is the number obtained by multiplying the size of the model – or airplane – by the air's speed and density and then dividing that number by the viscosity of the air. The larger the model, other factors being equal, the larger its Reynolds number.

By increasing the density in a wind tunnel – some are especially designed to permit this – a larger Reynolds number can be obtained. Also, in the 30- by 60-foot full-scale tunnel at Langley and the 40- by 80-foot full-scale tunnel at the Ames Aeronautical Laboratory, actual aircraft can be tested. This has special significance in the study of the character of high-speed airplanes, because the thin and swept wings now being used present real problems during take-off and landing.

Here it is important to have answers not qualified by scale effect, which is particularly critical in the study of landing and take-off characteristics.

Mach number is a speed index. Mach 1 is the speed of sound, which at sea level is approximately 760 miles per hour. But speed of sound varies with temperature of the air. On a hot summer day at sea level the speed of sound could be as high as 800 miles per hour, while, on a very cold day, it could be as low as 720 miles per hour. At altitudes of 35,000 and higher, Mach 1 - the speed of sound - is approximately 660 miles per hour.

(7/10/50)

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CAL.

For Release:

Saturday, July 8, 1950

AMES LABORATORY HOLDS 1950 INSPECTION NEXT WEEK; MANY DISTINGUISHED GUESTS TO VISIT RESEARCH CENTER

Latest developments in the aerodynamic fields of aviation research will be reviewed for more than 800 distinguished visitors next week when the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics holds its 1950 Inspection at Moffett Field.

On Monday, Tuesday, and Wednesday, July 10, 11, and 12, the NACA and the Laboratory staff, headed by Director Smith J. DeFrance, will be hosts to high ranking officers of the Air Force, Navy, Army and Marines, Government officials, aviation industries representatives, aeronautical scientists and San Francisco Bay Region civic leaders

Touring the Laboratory's various wind tunnels and other installations used in the study of the many phases of aerodynamics, the visitors will hear discussions of the problems which have arisen in this research field - - particularly in the transonic and supersonic speed ranges - - and of the progress which has been made toward solution of the problems. These reports will cover not only work done at Ames during the past two years, but also research results from the NACA Langley Aeronautical Laboratory in Virginia.

Ames research scientists, engineers and technicians will demonstrate the Laboratory's newest equipment and will explain theoretical and experimental techniques which have been developed to facilitate scientific exploration of new frontiers opened up by the advent of flight faster than the speed of sound.

Most of the visitors on the opening day of the inspection will be civilians, including representatives of the administrative design and operating branches of the aircraft manufacturing and air transport industries, members of Congress, officials of Government agencies concerned with aviation, and scientists from other research agencies and from educational institutions. On Tuesday, the majority of the guests will be officers of the armed forces.

The final day of the inspection has been set aside for future leaders of the flying services. One group, comprising 140 faculty members and officer-students, will come by air from the Air Force Institute of Technology at Wright Field, Ohio. Students from other armed forces air training centers and schools will also attend.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CALIF.

For Release

PM's, MONDAY
July 10, 1950

AIRCRAFT MODELS FIRED FROM GUNS IN NEW SUPERSONIC
WIND TUNNEL AT NACA AMES LABORATORY

A new and unusual type of wind tunnel in which models are fired from guns was demonstrated today at the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics. The tunnel already has provided aerodynamic data at eight times the speed of sound, or about 6,000 miles per hour at sea level.

Visitors attending the 1950 inspection at Ames Laboratory at Moffett Field were told that this new research facility, known as the supersonic free-flight wind tunnel, will eventually be capable of operating up to 15 times sonic speed, equivalent to 11,000 mph at sea level. In fact, additional equipment is being procured which will permit future research at such velocities.

The supersonic free-flight tunnel is currently being used to study the characteristics of missile-type configurations at high supersonic (hypersonic) speeds.

An outstanding feature of the new tunnel is the fact that while the models are only a few inches in length, very high test Reynolds numbers are obtainable, making the research results comparable to those for far larger models. Due to the relatively high density of the air in this wind tunnel, a six-inch model tested at a Mach number of 7 would provide data corresponding to that obtained on a 50-foot missile - as large as a V-2 rocket - flying at the same speed at an altitude of 100,000 feet.

By contrast, the same results in a conventional wind tunnel would require a model more than 10 feet long.

The hypersonic speeds in the free-flight tunnel are achieved by generating an air stream of from two to three times sonic speed and launching the model into this oncoming air stream at high velocities. The launching guns available range from .22 caliber through .50, 20mm., 37mm., and 3-inch. Using a .220 sporting rifle, a combined Mach number of 8 already has been achieved. Test barrels are being procured which should permit a Mach number in excess of 15 in the future.

The tunnel is an intermittent, or "blowdown" type, the air being supplied by the adjoining 12-foot pressure tunnel at a maximum pressure of six times that of the atmosphere. In the free-flight tunnel the air flows through the settling chamber, supersonic nozzle, test section and diffuser and thence into the open air. The models are fired from guns located in the diffuser. After passing through the test section, which is 18 feet long, 2 feet deep and 1 foot wide, the models are caught in a steel cylinder packed with cotton waste and backed by wood and steel.

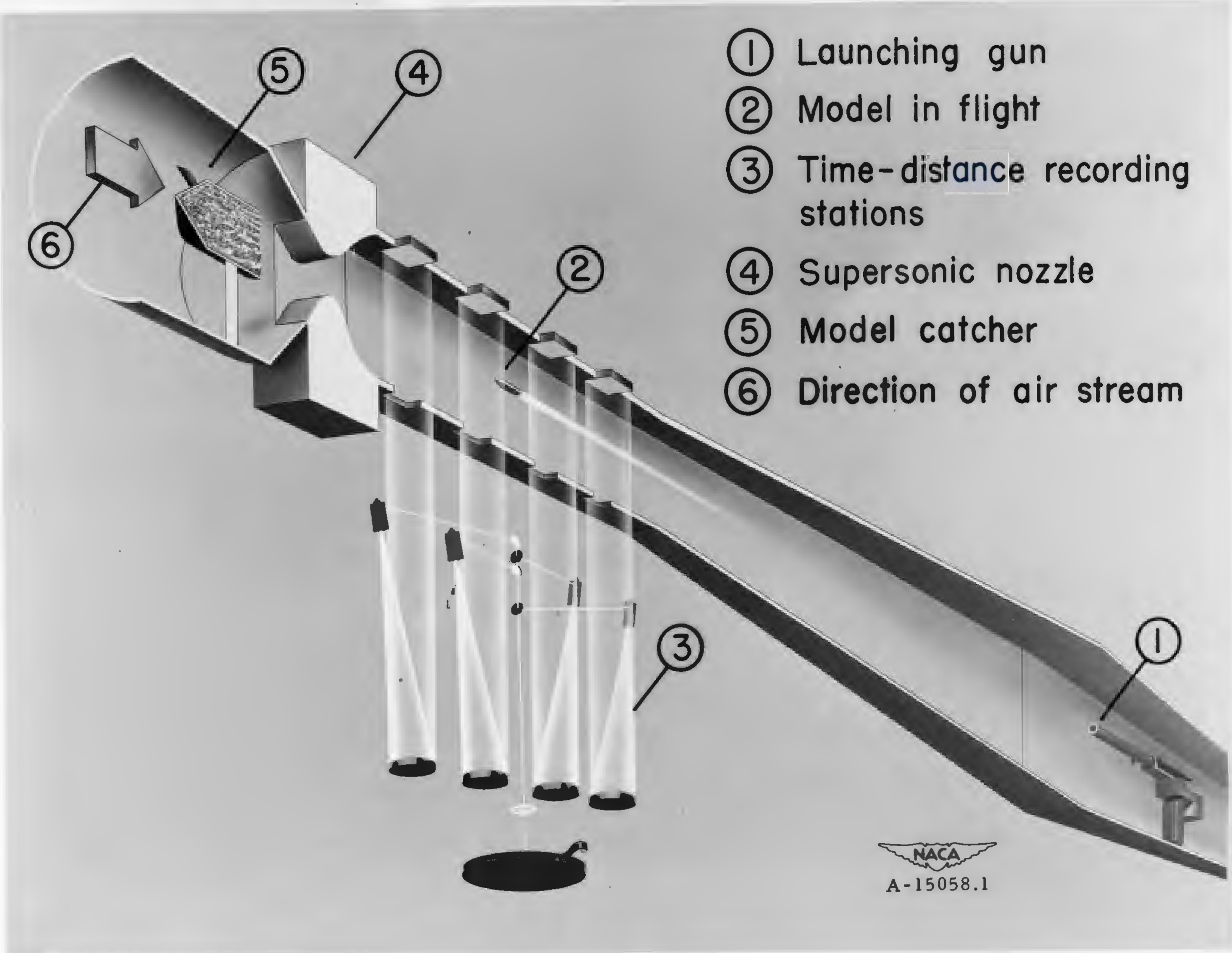
In the gun barrel, the model is housed in a tiny carrier or "sabot," which protects it from the hot discharge gases, keeps it properly alined during launching and acts as a piston. Once out of the muzzle, the sabot falls away, leaving the model free to fly on undisturbed through the wind tunnel.

Aerodynamic characteristics of a model are studied by techniques which parallel those employed in aero-ballistic ranges. As the model moves through the test section it actuates a series of stations equipped with light beams, photoelectric cells, high-intensity sparks, mirrors and mercury arc lamps which record a time-distance history of its flight in shadowgraph images and chronograph readings.

Measurements of drag have already been obtained in the wind tunnel and work is being directed toward measurements of lift and moment. The latter data can be secured by disturbing the model on launching, and observing the resulting motions in flight.

Extreme accuracy is required in the recording instruments. In some cases, distance measurements are within a few thousandths of an inch and time measurements are accurate to a tenth of a microsecond - a time interval so brief light travels only 100 feet.

(7-10-50)



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

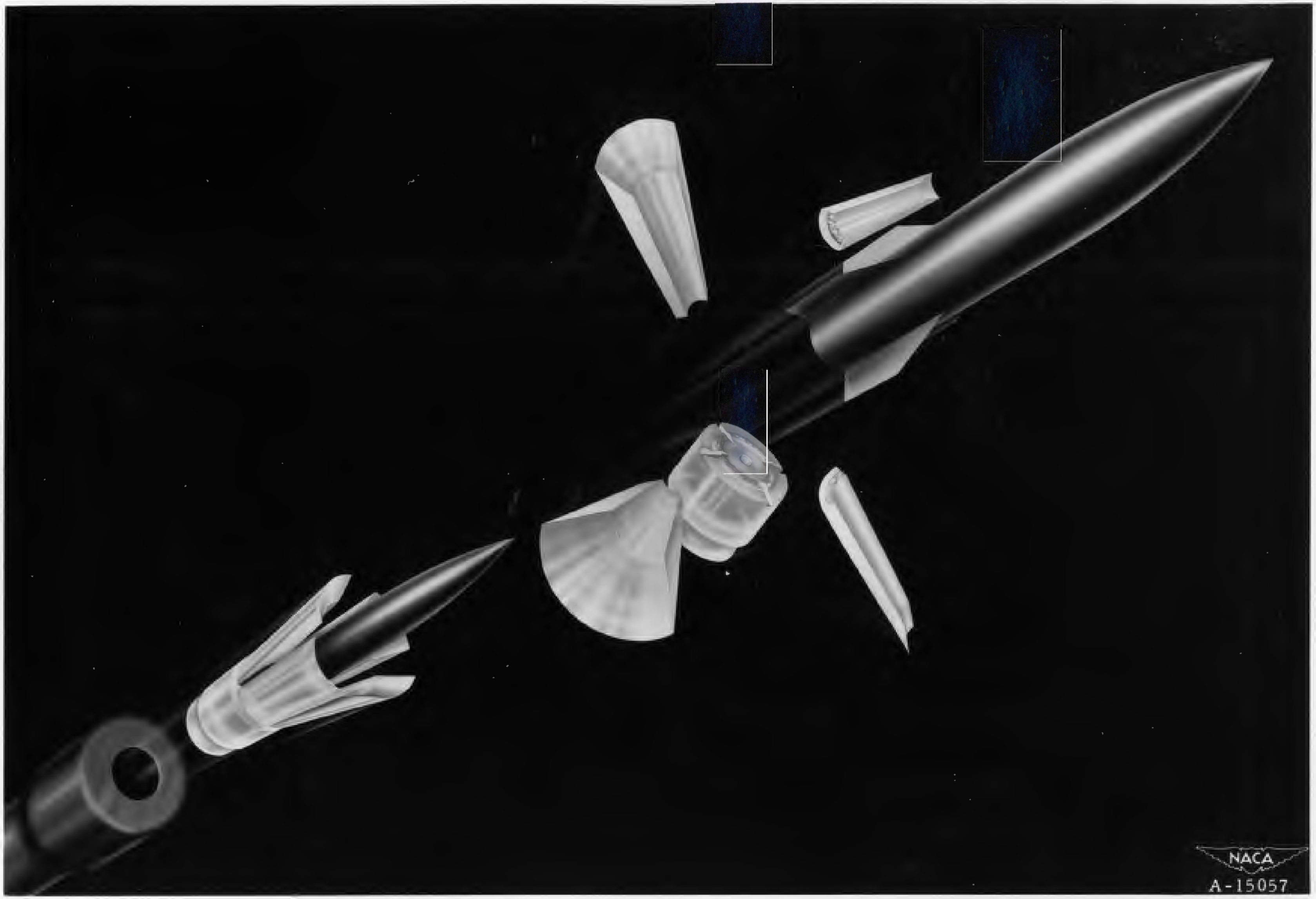
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

AMES AERONAUTICAL LABORATORY

MOFFETT FIELD, CALIFORNIA

A-15058.1

Cutaway drawing explaining the major operating features of the new supersonic free-flight wind tunnel at the Ames Aeronautical Laboratory of the NACA. Fired from guns at one end of the wind tunnel, models fly through an air stream speeding in the opposite direction. Very high test speeds result, reaching velocities equivalent to more than 6,000 mph at sea level in the test section.



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

AMES AERONAUTICAL LABORATORY

MOFFETT FIELD, CALIFORNIA

A-15057

Models launched from guns in the new supersonic free-flight wind tunnel at the Ames Aeronautical Laboratory of the NACA are protected in the gun barrel by plastic "sabots" which keep the models correctly aligned and act as pistons on firing. This drawing shows what happens when the model leaves the gun muzzle. Note how the sabot separates and falls away, leaving the model free to continue its flight through the test section, where measurements are made.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CALIF.

For Release:

AM's, TUESDAY
July 11, 1950

2000 - 5000 MPH SPEED RANGE COVERED IN NEWEST
WIND TUNNEL AT AMES LABORATORY

Capable of supplying aerodynamic data over the wide range of 2.75 to more than 7 times the speed of sound, a new research tool known as the 10- by 14-inch supersonic wind tunnel is now in operation at the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics. The new wind tunnel's range is roughly equivalent to sea level airspeeds of 2000 to 5000 miles per hour.

The 10- by 14-inch wind tunnel (so designated because that is the size of its test section) was developed for use in the intensified study of air-flow problems encountered at high supersonic (hypersonic) speeds, and incorporates the latest developments in nozzle design and instrumentation. Its operation was explained yesterday at the opening day of the Laboratory's 1950 Inspection at Moffett Field.

Inspection visitors were told that recent spectacular advances in actual and potential flight speeds have made necessary the creation of new research apparatus which will supply basic information needed for the design of future missiles and aircraft. Much of this needed data involves air-flow changes occurring around a body traveling from transonic and low supersonic to hypersonic speeds (Mach number 5 and upwards). Development of such special equipment has been in progress at the Ames, Langley, and Lewis Laboratories of the NACA, as well as at other research centers. Newest of the wind tunnels in this category is the Ames 10 by 14 inch. Another is the supersonic free-flight wind tunnel at Ames, in which very high Mach numbers are accomplished by firing models from guns into the face of a moving air stream.

Among the obstacles in the development of hypersonic research apparatus were the difficulties encountered in providing the high compression ratios required for generation of high Mach numbers, and in providing instrumentation to cover the broad range of temperature, pressures, density, etc., encountered in hypersonic flow.

In the 10- by 14-inch supersonic wind tunnel, it was found that the compression ratio problems could be overcome by employing an unconventional type of diffuser which first contracts and then expands, smoothly reducing the air-flow velocity after it leaves the test section. Further efficiency was achieved by locating boundary-layer scoops just downstream of the diffuser throat to stabilize the flow out of the diffuser.

With this design, the compression ratios required for flow at Mach number 7 are only about 30 to 1, compared to an estimated 200 to 1 for a tunnel incorporating a conventional diffuser.

At a Mach number of 7, the test section pressure in the new wind tunnel falls to one-thousandth of an atmosphere, equivalent to that found at an altitude of 160,000 feet. Eighty special low-pressure gages are used to measure these pressures. A highly-sensitive optical apparatus is employed to visualize air-flow changes around the model in the test section. The model support and force measuring equipment are similar to those in other supersonic wind tunnels. The models are supported from the rear on a "sting," which in turn is supported by a strut passing through the sidewalls. The forces and moments acting on the model are measured by a conventional strain-gage balance system.

(7/10/50)

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

AMES AERONAUTICAL LABORATORY

MOFFETT FIELD, CALIFORNIA

A-14617

The upper and lower nozzle blocks of the new 10- by 14-inch supersonic wind tunnel at the Ames Aeronautical Laboratory of the NACA. One side plate has been removed to show (from left to right) the supersonic nozzle, the test section where models are mounted, and the converging and diverging passages of the diffuser, as well as the boundary-layer scoops which help stabilize the flow of air out of the diffuser. The jacks are used to change the shape of the nozzle and diffuser openings. The air flow is from left to right.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY
MOFFETT FIELD, CALIF.

For Release
on Receipt

RESEARCH ON NEW SUPERSONIC PROPELLER FOR
700 MPH FLIGHT SPEEDS REPORTED BY NACA

Research leading to the design of a new propeller which gives promise of improved efficiency and greater range at flight speeds of from 500 to 700 miles per hour was reported today at the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics.

Prior to actual flight, further aerodynamic research and industry development must find solutions to problems involving vibration and flutter. Such studies are being pressed at the Ames Laboratory and the NACA Langley Aeronautical Laboratory in Virginia, as well as by other research groups, the military services and propeller manufacturers.

Armed forces, industrial and scientific leaders attending the Ames Laboratory's 1950 inspection at Moffett Field were told that research results have created a resurgence of interest in propellers for flight faster than 500 miles per hour, and that there is reason to believe that further raising of the practicable upper speed limits for airplanes powered by turbo-props may be accomplished.

This new prospect for propellers is the result of abandonment of efforts to keep subsonic the speed of propeller blades through the air, the Laboratory reported. As a result, the new propeller is termed "supersonic," in that all parts may travel at speeds above the speed of sound (about 760 mph at sea level temperatures) even though the airplane is flying at subsonic speed.

It was pointed out that as early as the 1920's, loss of propeller efficiency from compressibility effects at the blade tips was observed. To reduce these losses, engines were geared to rotate the propellers more slowly. This in turn required larger propellers, and the increased diameter necessitated even greater reduction in the rotational speed of the propeller.

In addition, blade angles became so large that too much power was wasted pushing the air around with the propeller instead of propelling the airplane forward by pushing back on the air. These limitations were such that propellers could not compete with turbo-jet engines at flight speeds much above eight-tenths of the speed of sound.

The new supersonic design uses smaller blade angles and very thin blade sections compared to the older type. Also, because of its higher rotational speed, the supersonic propeller need have only half the diameter of a subsonic propeller for the same power, and this permits important savings in the weight of the propeller and drive gearing. It also permits a shorter and lighter landing gear for the airplane.

On the other hand, the extreme thinness of the new propeller blades has intensified the problems of vibration and flutter, which were limiting factors even with the thicker subsonic blades. But laboratory research has shown that proper selection of blade width can help prevent flutter, and advances are reported in methods of calculating blade vibration cycles. From such work, it is hoped to provide better tools for the engineer's use in analyzing his propeller designs to avoid flutter and vibration.

(7-10-50)