RESEARCH AT HIGHER SUPERSONIC SPEEDS

by

SUPERSONIC FREE-FLIGHT WIND TUNNEL

In the last few years, interest in supersonic aerodynamics at speeds well beyond the speed of sound has grown tremendously. This growth has been stimulated by the large-scale effort to develop missiles for military use. The supersonic free-flight wind tunnel which you see on your right is one outgrowth of this interest in very high-speed aerodynamics. It is a new piece of research equipment developed to allow experimentation at and beyond the highest speeds considered practical at the present time.

Tests have been made in this tunnel at eight times the speed of sound, that is, a Mach number of 8. At an altitude of 20 miles this corresponds to a speed of 5,500 miles per hour. The equipment is believed to be capable of testing models at a Mach number of 15, but the major research effort is being focused on important problems in the Mach number range from 3 to 8 rather than on achieving the maximum test speed. An important feature of the tunnel is its ability to test at any speed below the maximum, and tests have been made at less than the speed of sound.

Missile designers must know the magnitude, direction, and point of application of the forces exerted on bodies in supersonic flight. The purpose of this wind tunnel is to permit measurement of these forces. Specifically, some of the measurements needed are: The drag force, which is the air resistance to forward motion of a body; the lift force, which is the aerodynamic force available for supporting the body against gravity and for executing turns; and the point of application of the lift force, which determines the stability of a missile in flight. These forces, and several others, are being studied in this wind tunnel, and some of the results of the tests will be shown by the next speaker.

The distinctive feature of this wind tunnel is the manner in which the high Mach number is obtained, and can be explained with the aid of this model of the wind tunnel. First, a supersonic air flow at Mach number 2 is established in the test section, with the air moving from left to right at 1600 ft./sec. Then, the model is shot at high speed from a gun, and moves from right to left, upstream through the air flow. The velocity of the model through the air is the sum of the air velocity and the model velocity. The high Mach number is due partly to this high velocity, and partly to the fact that the speed of sound in the test section is reduced due to cooling of the air in expanding through the nozzle. Because the speed of sound in the test section is reduced from 1120 to 830 ft./sec., the Mach number is increased by 1/3.

The test Mach number is varied by controlling the velocity of the model, through selection of proper powder charges. Mach numbers below 4 can be obtained by firing with no air flow in the tunnel, the Mach number being altogether due to the speed of the model.

The test models used, in common with full-scale missiles and projectiles, must be stable in flight. That is, they must not tumble, but must move through the test section nose forward and with only moderate angles of attack. Some models are naturally stable and tend to line up with the wind. Models with fins are in this class. Others are naturally unstable and must be stabilized gyroscopically by spinning, as is done in conventional rifles.

Most of the models used in this wind tunnel are fired in plastic carriers called sabots. These sabots provide support for the model while in the gun and make possible the use of models with fins. Since the sabot must break away from the model just after it leaves the gun, it is constructed in such a manner that the aerodynamic forces acting on the fingers cause them to break off and fall away.

There, the model and sabot are shown close to the gun, as yet unseparated. Here, the sabot fingers may be seen in the process of falling away.

The methods used to obtain aerodynamic data in this tunnel will now be explained by Mr.____________.

The fact that the model is in motion during the test requires the use of new techniques to obtain the desired aerodynamic data. In general, the forces are computed from the observed behavior of the model in flight, as is done in ballistic ranges. For example: The drag force decelerates the model and if the deceleration is known the drag force can be calculated.

The deceleration can be computed if the times required to cover successive distance intervals are known. Therefore, instruments are used to record accurately the length of three consecutive distance intervals and the times required by the model to cover these intervals. The manner in which this is done is illustrated in the model of the wind tunnel, in which some of the important elements of the instrumentation are represented. All of the elements shown below the wind tunnel here, are actually located in an 8-foot pit beneath the real wind tunnel.

As the model moves through the wind-tunnel test section, four shadowgraph pictures of it are made, at stations which are 5 feet apart. As the model approaches each station it partially interrupts a light beam which falls on a phototube. This interruption causes a spark to be fired when the model is in the center of the shadowgraph station. Light from the spark is made parallel by reflection from a spherical mirror, and then passes through optical windows in the tunnel walls and past the model to expose a glass photographic plate just above the tunnel.

An invar scale, which serves as the basis for distance measurement, extends through all four stations. It is mounted above the tunnel a few inches below the photographic plates and is not represented on the schematic model. The image of the scale may be seen at the top of this typical shadowgraph of a fin stabilized model in flight. The model position, and details of the air flow and shock wave system are permanently recorded as shown. Distance intervals, accurate to a few thousandths of an inch, can be measured with this system.

The standard used for measurement of time is a piezo electric crystal, which controls the flashing of a mercury arc lamp. Light pulses are produced by the lamp at precisely uniform time intervals. Several hundred light pulses are produced while the projectile moves from station 1 to station 4. These pulses are directed by an optical system of lenses and mirrors to a strip of 35 mm film placed at the circumference of a 5-foot-diameter film drum. At the center of this drum is a mirror, which reflects the vertical incident light over to the film. In operation, the mirror is rotated at high speed such that it makes one revolution as the projectile moves from station 1 to station 4, spacing the light pulses uniformly along the film. This is a small section of a chronograph film and in this case the time interval between pips is 1/50,000 of a second.

When a spark fires in a shadowgraph station, a part of the light is allowed to escape from the side of the gap. This light is directed along the same path used by the mercury lamp pulses, and a spot image of the spark light is formed on the 35 mm film. Thus, the complete time record consists of a 15-foot length of film with several hundred uniformly spaced mercury lamp pips, and four station pips, located at the approximate quarter points of the length. The time elapsed between any two spark firings can be determined by counting whole intervals and interpolating the intervals where the station pip occurs. Times measured using this apparatus are believed to be correct within one ten millionth of a second. A physical feeling for the amount of time represented by one ten millionth of a second can be acquired when it is realized that light, traveling at 186,000 miles per second, travels only 100 feet in this time. This extreme accuracy in time and distance measurement is necessary for accurate measurement of drag in this wind tunnel.

In order that a connected picture of the function of the various parts may be obtained, the model of the wind tunnel will now be operated.

(1) The projectile, on leaving the gun, moves through the wind-tunnel diffuser. During this phase, separation of the sabot takes place.

(2) As the model enters station 1 photobeam, the phototube signal opens a quick-acting shutter called the optical gate and the mercury arc lamp pulses begin to expose the film. After the proper time delay, spark No. 1 fires, producing shadowgraph No. 1 and a station pip on the time film.

(3) Light pulses from the mercury lamp and the spark gaps can be seen reaching the chronograph film.

(4) The firing of the spark in station 4 automatically turns off the mercury lamp.

(5) The model proceeds through the nozzle into the model catcher, ending the test. The elapsed time since the model left the gun is only a few hundredths of a second.

Testing in the real wind tunnel will now be demonstrated. The model used will be a commercial bullet, fired in a

220 Swift rifle at a muzzle velocity of 4100 ft/sec. In order to avoid the terrific noise developed by air flow in the wind tunnel, this test will be made without air flow. Even so, the Mach number will be 3.7. A shadowgraph picture will be made in station 1. The film holder tab is now being pulled to uncover the film. Three electronic instruments are grouped together beside the wind tunnel. The Potter counter will indicate the elapsed time between spark firings in stations 1 and 4. The error of measurement with this instrument is six times that of the tunnel chronograph, but is still exceedingly small. Neon indicating lights will blink in order as sparks 1, 2, 3, and 4 fire. The entire process takes place so fast that the four lights will appear to blink simultaneously.

The firing sequence is now under way. The pulsing mercury lamp must be preheated to suitable light intensity before the round is fired. The intensity of the light pulses is indicated by the height of the peaks on this oscilloscope. When the intensity reaches the necessary level, the round will automatically fire. There will be a moderately loud explosion. Remember, at the instant of firing to watch either the Potter chronograph or the spark indicator lights. (Round is fired.)

The Potter chronograph shows 3,750 microsecond. This corresponds to a velocity of about 4,000 ft./sec.

Some of the shadowgraphs which have been made during these demonstrations are on display at the table on the right.

Now, Mr.___________will discuss some of the measurements that have been made in this wind tunnel.

The range of altitudes and missile sizes which can be represented by tests in the supersonic free-flight wind tunnel is shown on this chart. Altitude is plotted on this axis, and the missile length on this one. Although the models used in this wind tunnel are relatively small, the results can be directly applied to full-scale missiles of these lengths flying at the altitudes represented in the shaded area of the chart. This border of the chart does not represent the limit of the test range. The chart can be extended in the direction of longer missiles at slightly higher altitudes if desired.

The importance of the drag force on missiles is demonstrated in the next chart, which shows, for a 3-foot-diameter missile, the variation of drag force with altitude at Mach numbers of 2, 4.5, and 7. Forces in the order of 50,000 pounds can easily be developed. The decrease in drag at high altitude is very striking, and substantial benefits result from high-altitude flight. Referring back to the previous chart, it is seen that the altitudes represented by wind-tunnel models, in general between 13 and 27 miles, are very practical altitudes.

Another point demonstrated in this chart is that the drag can be a limiting factor in missile design. It determines the size of engine required and the range of the missile, and thus, it is very important to pare it to the minimum consistent with other requirements.

Results will now be presented of some drag measurements that have been made in this wind tunnel. Results are presented in coefficient form. The drag force varies directly with the drag coefficient, the Mach number squared, the size of the body, and the pressure of the surrounding air. The advantage of using this coefficient is that it makes the results more general, over a range of altitudes and missile sizes, within the limits of the scale effect.

In this chart, test results are presented for a conical-nosed body, the included angle of the cone being 60°. The drag coefficient is plotted against Mach number. The circles represent data points. The average scatter of these points off the fared curve is about 0.8 percent. The drag coefficient decreases as the Mach number increases. However, it will be remembered that the drag force is increasing rapidly with Mach number due to the fact that the coefficient must be multiplied by the Mach number squared.

The drag of a simple body of this type may be considered as made up of three contributing parts: The head drag, which is due to high pressures acting on the nose; the base drag, which is due to low pressures behind the body; and the skin friction, which is the frictional effect of the air on the body surface.

The red curve represents the head drag for this cone cylinder, and is computed from theory. To this, the base drag and the skin friction must be added to get the total drag. It is seen that head drag is the biggest part of the total drag and that it largely determines the shape of the total drag curve.

This result is not general. It is true only for very blunt-nosed bodies. In this case, the head drag is such a large part of the total that it would be expected that major reduction of the drag coefficient could be brought about by changing head shape. This is borne out experimentally as shown on the next chart, where drag coefficient is plotted against cone angle. It is seen that a radical reduction in drag coefficient results from changing the cone angle. For example, at Mach number 3.7, the 30° cone has less than one-fourth the drag of the 90° cone.

The base drag is a very important part of the drag of most missile bodies, particularly at Mach numbers between 1 and 4. The skin friction is also important in the case of long slender bodies, because of the large amount of surface area over which the friction acts. In the case of the 60° cone cylinder the base drag and skin friction are small parts of the total drag but this is largely due to the fact that the 60° conical nose is very inefficient and overshadows the other drag components. The base drag and skin friction of this model can best be examined on the next chart, where the difference between total drag and head drag is plotted in coefficient form against Mach number. Within the limits of errors in theory and experiment, this curve represents the sum of the base drag and skin friction. The red curve is a plot of the maximum possible value of base drag, computed for zero pressure at the base. The actual value of base drag must be less than this, and must, in fact fall below both curves. Estimates of the base drag of this model, obtained by two different methods, are shown as points.

A shadowgraph picture of a 60° cone cylinder moving at a Mach number of 7 is included on this chart. The model image is somewhat distorted by the strong density gradients in the air stream. The system of waves associated with the model, and the wake of the model can be seen.

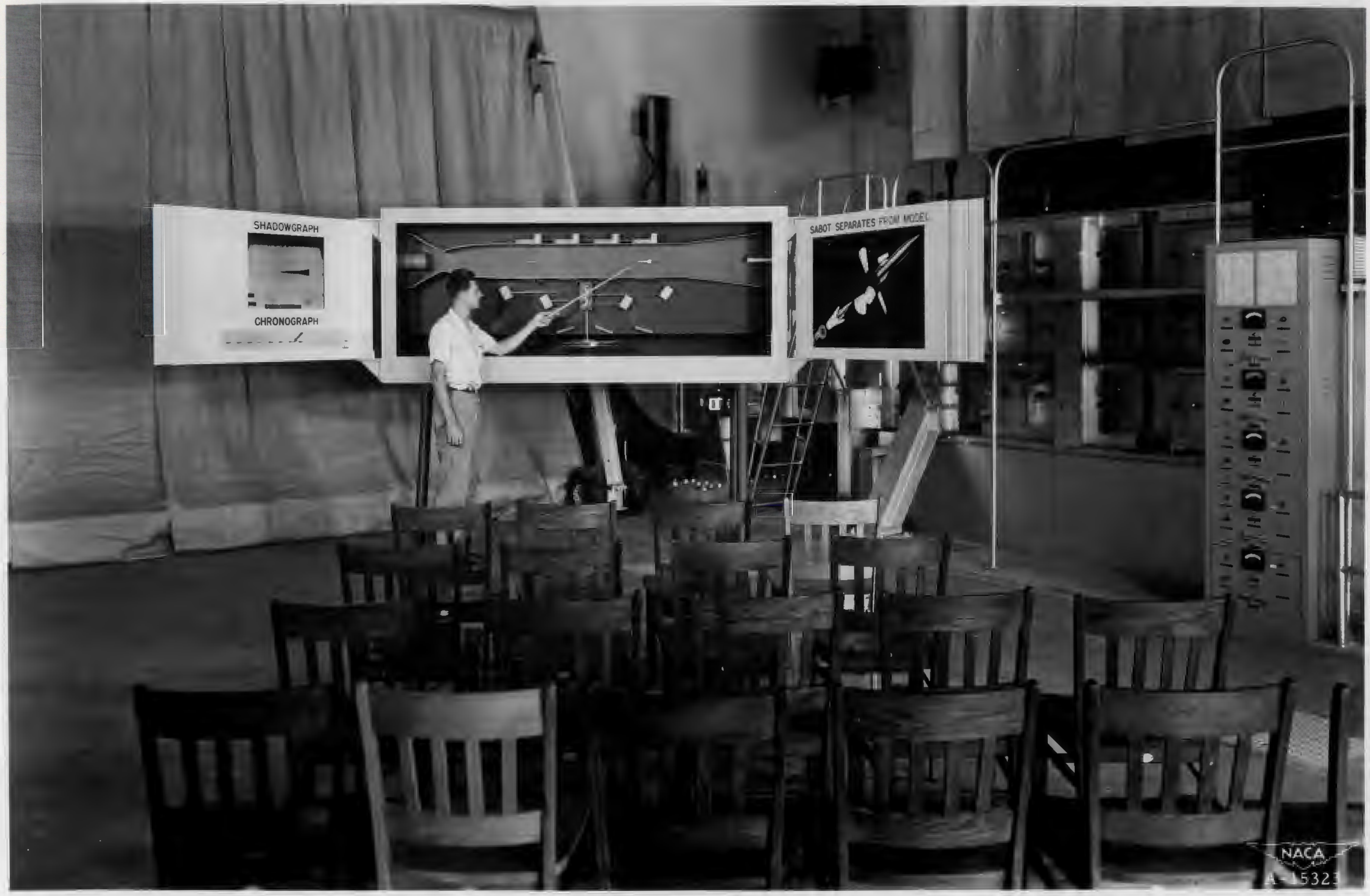
The next chart shows drag results for a slender, fin-stabilized body. Again, drag coefficient is plotted against Mach number. This curve, in which drag coefficient decreases strongly with rising Mach number, is typical of bodies with efficient noses, and represents a case where the base drag is a controlling factor.

In summary, the supersonic free-flight wind tunnel is a new piece of research equipment, capable of testing at Mach numbers from 1 to 15, at good scale.

Drag measurements have been presented on cone cylindrical bodies and on a slender, fin-stabilized body, and an effort has been made to break down the drag into its component parts.

This concludes our demonstration.

As you go to the bus, there may be a very loud noise due to a demonstration of the 1 by 3 blowdown tunnel which is next to the free-flight tunnel. Although this noise is very alarming, there is no actual danger.



Display for Presentation of "Research at Higher Supersonic Speeds"
by Supersonic Free-Flight Tunnel

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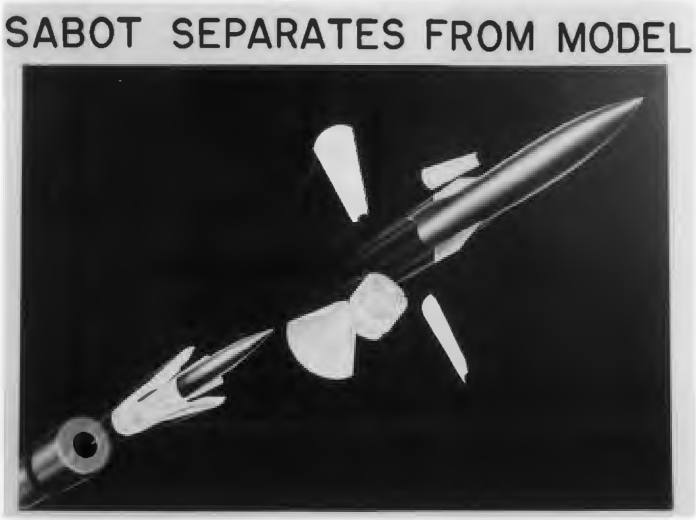

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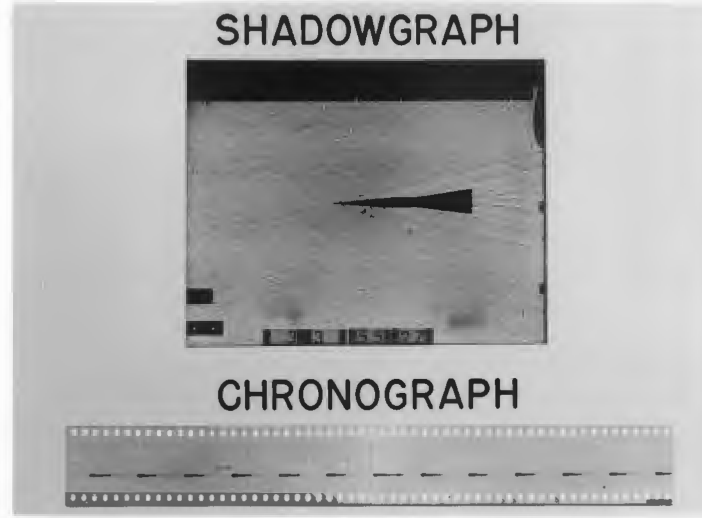

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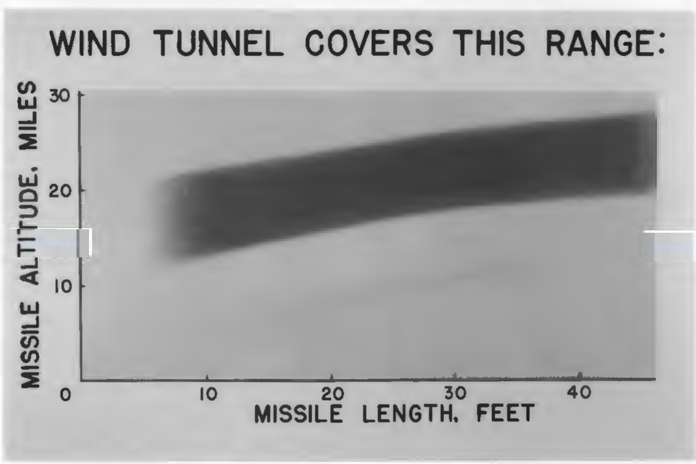

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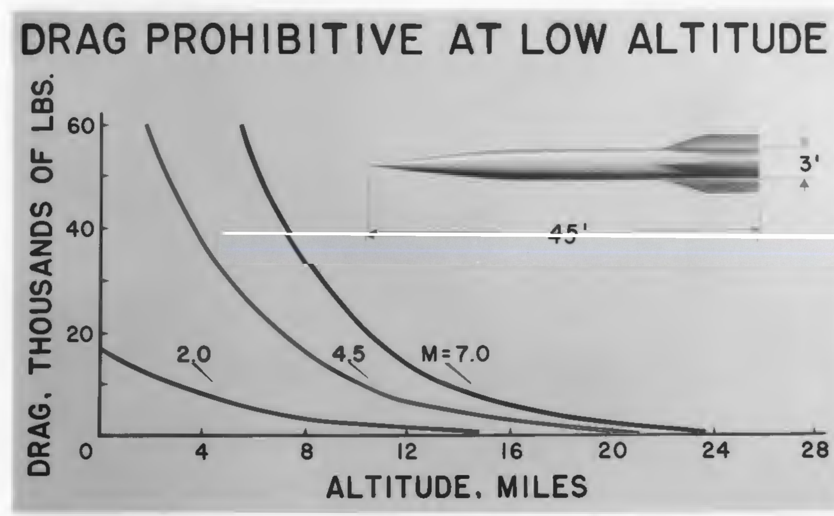

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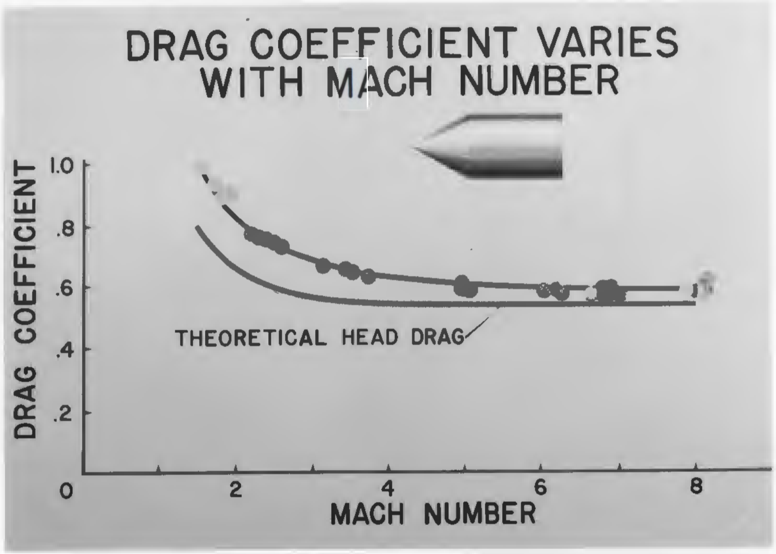

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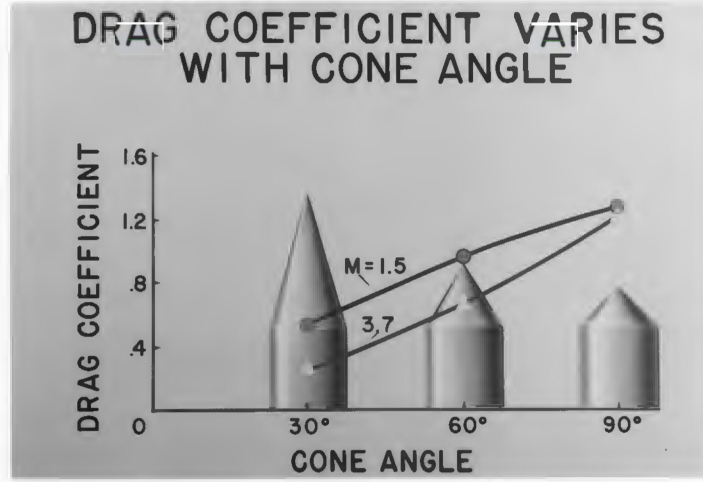

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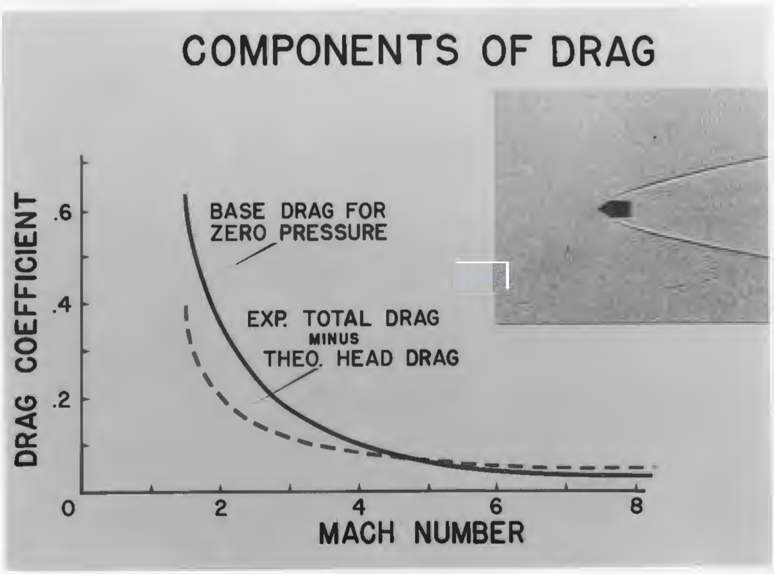

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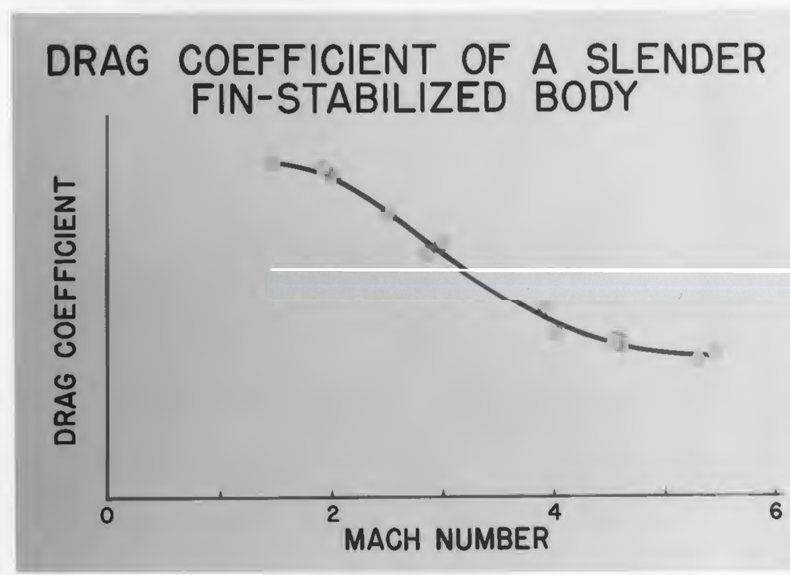

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We will now illustrate this reduction in shock intensity with a water channel which has a shape similar to this type of nozzle.

The waves on the surface of the water are analogous to the shock waves that occur in flow with supersonic velocity. These waves that now occur at the test-section velocity correspond to the terminal shock waves in a supersonic wind tunnel. As the channel is adjusted to allow these waves to pass downstream of the second throat the strength of the waves decreases.

The power required to operate a wind tunnel with this type of diffuser is much less than that required when a straight diverging diffuser is employed. To illustrate, for a wind tunnel designed to operate at seven times the speed of sound, the power required is cut in half.

This is the same type of diffuser and nozzle configuration as employed in the 10- by 14-inch supersonic wind tunnel. Mr.__________ will now discuss the operation of this wind tunnel.

B. Description of the 10- by 14-inch Supersonic Wind Tunnel

The need for equipment to conduct research at high supersonic airspeeds has been emphasized by the recent development of rocket-propelled missiles capable of flying at these speeds. The German V-2 is a familiar missile of this type. As was pointed out in the previous talk, many new problems are encountered at high supersonic speeds. The wind tunnel is the most efficient means of solving these problems experimentally. For this reason, the Ames Laboratory has recently placed in operation two wind tunnels - one is the supersonic free-flight tunnel, and the other is the 10- by 14-inch supersonic wind tunnel. I would now like to describe the latter tunnel to you.

This chart is a schematic diagram of the 10- by 14-inch supersonic wind-tunnel building. You are now located in this area facing toward the control panel. At the top is seen a cutaway view of the wind tunnel. This tunnel is of the closed throat, continuous-flow type. It can be operated at all speeds from three to seven times the speed of sound. Centrifugal compressors, located in the building at your left, supply air to the tunnel through this pipe line. After passing through the tunnel the air exhausts into either the boundary-layer scoops or the main diffuser. The boundary-layer-scoop air passes through these pipes and is drawn off by the rotary vacuum pumps shown here. It is then discharged to the atmosphere. The air in the main diffuser exhausts directly to the atmosphere through this pipe at low test speeds. At high test speeds, the air is directed through these centrifugal evacuators and then discharged to the atmosphere. You can see the main diffuser and boundary-layer-scoop piping at your right. The maximum total power required to operate the tunnel is 5700 horsepower.

From the control panel the tunnel operator has control of all components of the tunnel and auxiliary equipment. Models located in the test section are supported from the rear. Forces and moments acting on them are measured with a conventional strain-gage balance system. A sensitive optical system is used to observe and photograph flow patterns about the models. The mirrors in this system are shown here along with the path the light beam follows. The image of the model and the flow about it are observed on this screen.

This chart is a photograph of the 10- by 14-inch wind tunnel. One side wall has been removed in order that the pertinent features of the tunnel may be pointed out. The 10-inch dimension refers to the width of the tunnel, which is constant; and the 14-inch dimension refers to the nominal depth of the test section. The tunnel is composed of a nozzle, a test section, and a converging-diverging diffuser. You will remember from the previous discussion of channel flows that this type of diffuser was the more efficient for high supersonic speeds. The upper and lower movable sections, referred to as nozzle blocks, are identical and of rigid construction. The stationary side walls are flat and parallel. The position of each block is controlled by means of two independent sets of motor-driven jacks, one set located at the first throat and the other at the second throat. The jacks are rigidly attached to the side walls and pin-connected to the blocks. Each set is driven by a single motor through identical drives to ensure symmetry of the blocks at all times. By this means the blocks may be either translated or rotated with respect to each other. With this mechanism, the speed in the test section may be varied by changing the ratio of first throat area to test area. As previously mentioned, each block has a boundary-layer scoop at the second throat. The purpose of these scoops is to stabilize the flow in the main diffuser by removing the low-energy boundary-layer air. This improves the main diffuser efficiency. The scoops are independently driven by small motors attached to the blocks to allow for adjustments necessary with changes in tunnel speed.

Each nozzle block, including the scoop, is sealed from the atmosphere by inflated seals adjacent to the air passage.

It may be of interest to mention the change in the first throat and test-section heights over the range of tunnel operation. At the minimum test speed the first throat height is 4 inches and at the maximum speed it is 1/20 of an inch. The corresponding test-section heights are 15 inches and 10 inches.

Instrumentation of the wind tunnel is, in general, of conventional design. However, due to the high supersonic speeds attained in the test section, very low pressures are encountered. For example, the pressure drops to as low as 1/1000 of an atmosphere. Conventional pressure measuring devices are inadequate for measuring pressures of this magnitude. A special low-pressure gage called the McLeod gage, was adopted for this reason.

The air passing through the tunnel test section is also at a very low density. Special X-ray equipment is being investigated for the purpose of determining this property of the air stream.

The next chart compares the operating range of the 10- by 14-inch wind tunnel with the conditions encountered by a V-2 rocket in flight. In the lower figure, the vertical scale is altitude in miles. The horizontal scale is distance traveled by the V-2, in miles. The solid line is the combat trajectory of the V-2 from take-off to landing. The test conditions in the wind tunnel are represented by the shaded area. In the darkly shaded area the wind tunnel accurately duplicates the aerodynamic conditions to which this rocket is subjected. In the lightly shaded area the wind tunnel duplicates these conditions sufficiently well for most practical purposes since the corresponding speeds are the same.

In the upper figure, you will notice that the horizontal scale is unchanged. The vertical scale is now speed in miles per hour. The solid line here shows the speeds attained by the V-2 from take-off to landing. The speed range of the wind tunnel, which is independent of distance, is shown by the rectangular shaded area. You can see that except for a short distance just after take-off, the flight of the V-2 takes place in the lower speed range of the wind tunnel.

In conclusion, it may be pointed out that the definite advantage of this wind tunnel is its ability to operate at all speeds ranging from intermediate to high supersonic speeds. This feature, coupled with the fact that conditions at typical altitudes can be duplicated, makes the tunnel particularly suited as an instrument for basic research - that is, research on wings and bodies. It should also be pointed out, however, that due to the small size of the tunnel, and, consequently, the small size of the models that can be tested, this tunnel is somewhat unsuited for development work.

Our program will conclude with a short motion picture showing the changes with speed that occur in the flow field about a typical model mounted in the 10- by 14-inch wind tunnel.

This next chart, which is a picture of the flow about this model at three times the speed of sound or a Mach number of 3, will show you some of the points to be followed in the motion picture. The speed of the wind tunnel at any instant can be determined by noting where the bow shock wave crosses the superimposed scales. You will notice that the lower scale is the equivalent sea-level airspeed in miles per hour. The upper scale denotes the Mach number. Other points of interest will be covered while the movie is in progress.

Movie.

This concludes the program of the 10- by 14-inch supersonic wind tunnel. Thank you for your interest and attention.

Display for Presentation of "Research at High Supersonic Speeds"
by the 10- by 14-Inch Supersonic Tunnel

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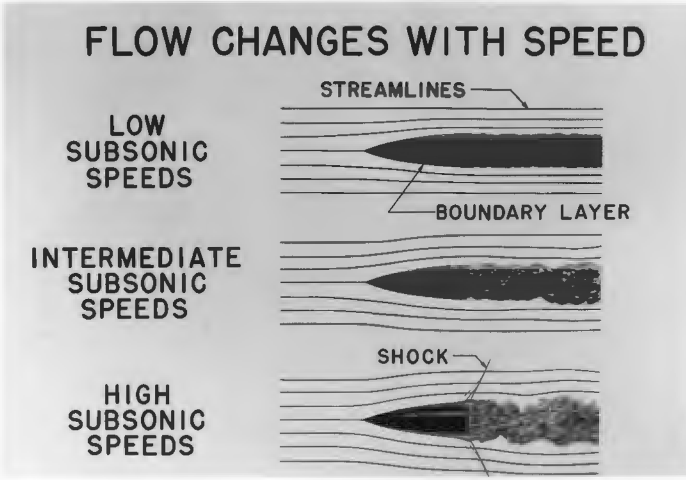

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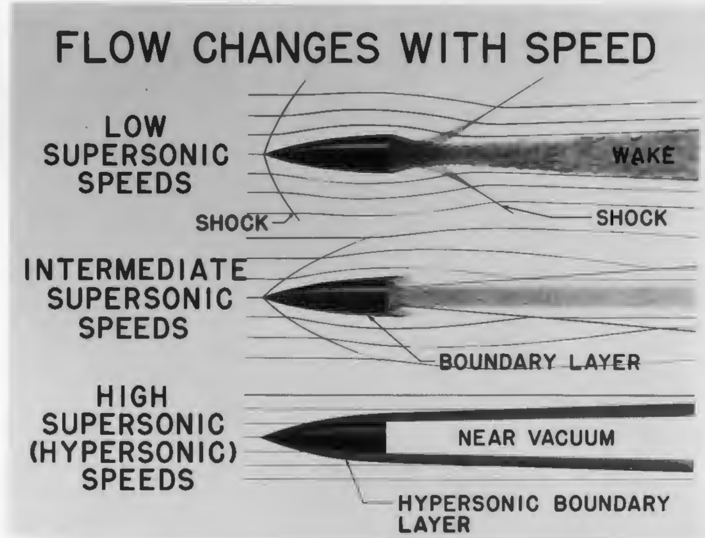

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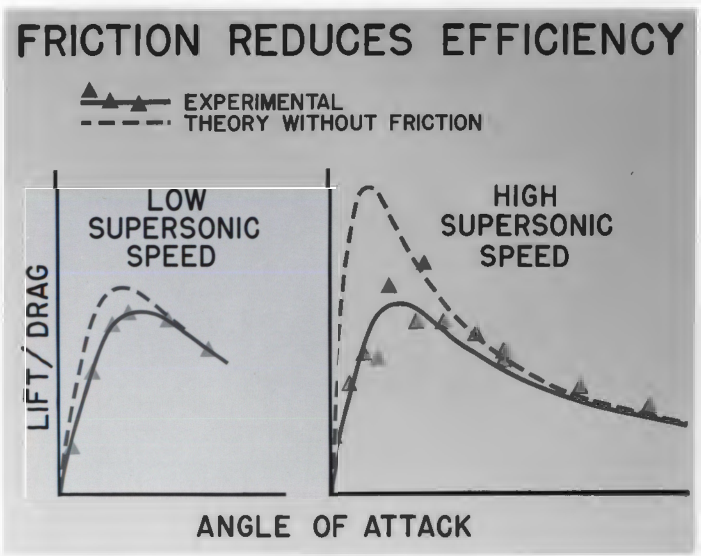

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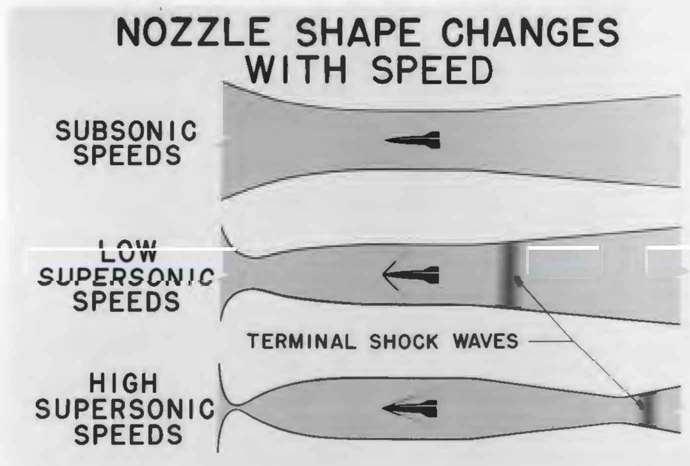

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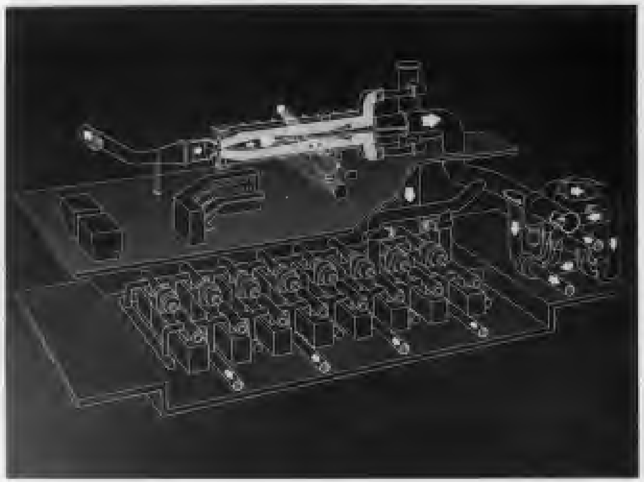

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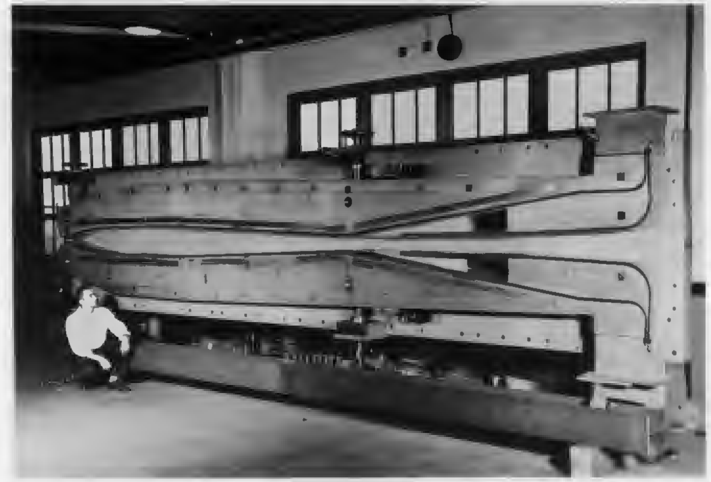

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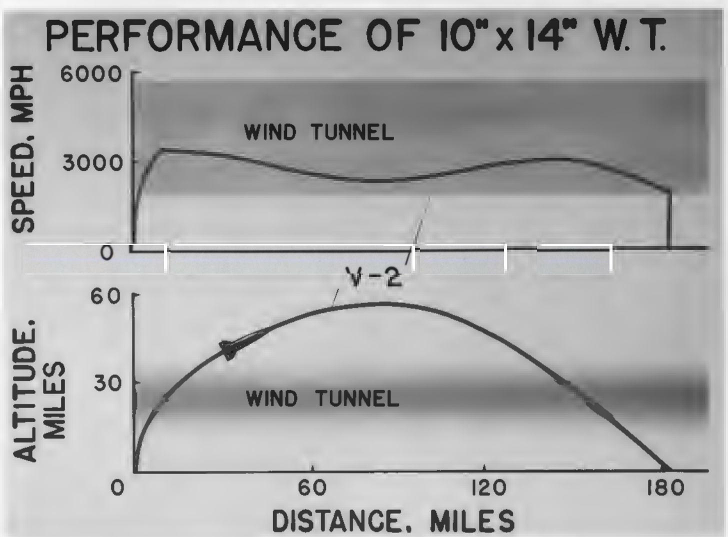

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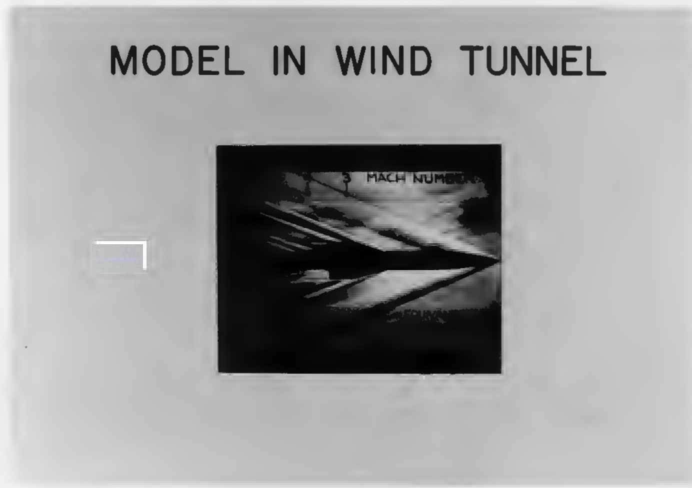

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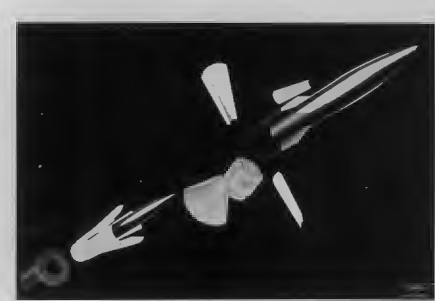

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Models launched from guns in the new supersonic free-flight wind tunnel at the Ames Aeronautical Laboratory of the NACA are protected in the gun barrel by plastic "sabots" which keep the models accurately aligned and act as pistons on firing. This 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.

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For Release
PM's, MONDAY
July 10, 1950

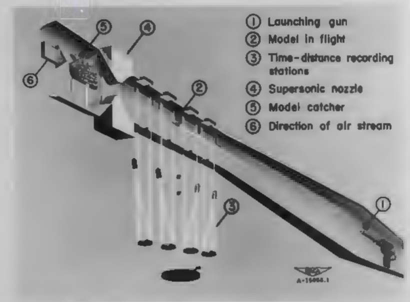
AIRCRAFT MODELS FIRED FROM GUNS IN NEW SUPERSONIC
WIND TUNNEL AT NACA AMES LABORATORY

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



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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.

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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,

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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.

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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,

PROGRAM

– N A C A –

1950 BIENNIAL INSPECTION
AMES AERONAUTICAL LABORATORY
Moffett Field, California
July 10 and 11

Pacific Daylight Time	
9:30 am to 9:55	Register and procure lunch ticket. Baggage may be checked in foyer of Auditorium. Don't check your hat if you will want it during the tour of the Laboratory.
10:00 to 10:23	Introductory Session in Auditorium.
10:30 to 10:40	Photograph of group north of 16-Foot High-Speed Wind Tunnel. Introduction of group leaders.
10:45 to 12:32 pm	Tour Laboratory for demonstrations and lectures in groups designated by colors. See schedule of tour inside.
12:40 to 1:55	Luncheon for all groups at Flight-Research Laboratory No. 2. Enter center west door.
[illegible]	Complete the tour.
4[illegible]	Social period [illegible] Moffett Field Officers' Club. Busses will leave Officers' Club as required for San Francisco and San Jose. All b[illegible] will stop at [illegible] Auditorium for guest[illegible] [illegible] from check room.

NACA
A-15310

Board, 36- by 40-inches, displayed in temporary press room on opening day (July 10) of 1950 Inspection.

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