OPENING SESSION

The opening session of the First Annual Inspection of the Ames Aeronautical Laboratory started in the Auditorium at 10 a.m. on July 18, 1946, and included an address by Dr. William F. Durand, dedicating the Ames 12-Foot Low Turbulence Pressure Wind Tunnel.

The following are excerpts from the speeches given in the opening session.

Smith J. DeFrance

It is a pleasure to welcome the representatives of the Army, the Navy, and the aircraft industry to the First Annual Inspection of the Ames Aeronautical Laboratory. This Laboratory was placed in operation shortly before the hostilities started in 1941; consequently, the results of the investigations conducted in this Laboratory have been on the restricted list, and we have not been able to discuss them until today. The restrictions have been released on some of the work, and today we will present some of the results that have been obtained during the investigations at the Laboratory. I hope that you will enjoy your visit here, and I want to assure you that the entire staff of the Laboratory are at your service to make your visit a pleasant one.

I would like at this time to introduce to you the Executive Secretary of the National Advisory Committee for Aeronautics, Mr. John F. Victory--

John F. Victory

The Chairman of the NACA, Dr. J. C. Hunsaker, is in Europe visiting some aeronautical activities, and he asked me to express to you in his name his welcome for coming here today.

This Laboratory is located on the Naval Air Station known as Moffett Field, California. I think it would be appropriate to just say a word about that fact. It is named in honor of Rear Admiral William A. Moffett, who I believe is the "father" of the Bureau of Aeronautics of the Navy. At least he was in charge of the aviation activities under the office of Chief of Naval Operations when he pushed legislation through the department and through Congress to establish a bureau in order to centralize the Navy control of aeronautics in one bureau. Admiral Moffett was a man of great vision, courage, patriotism, and skill, and I firmly believe that the Navy would do well to honor him even more than it has in the past because, in my humble opinion, he is responsible for the efficiency of the modern Navy. Largely because of his efforts during his three terms as Chief of the Bureau, he induced or forced the Navy to put aircraft on every type of vessel that could carry aircraft, and he championed the development of the aircraft carrier.

The NACA operates on this Naval Station known as Moffett Field in splendid accord and harmony and cooperation with the Navy as we have for so many years at Langley Field in cooperation with the Army. Our Laboratory here was brought into existence as a result of a Military Navy Committee appointed by the NACA in 1937, when in anticipation of the oncoming events in Europe, a special committee was formed on the relation of the NACA to national defense in time of war. The late General Westover, then Chief of the Army Air Forces, was the Chairman of that committee. This committee recognized the need for a new laboratory for the NACA on the west coast. At that time 60 percent or more of the airplanes being manufactured in America were being made by the west-coast industry. Any necessary contacts between those elements

of industry on the west coast and the NACA on the east coast were hampered by 3,000 miles that separated them and retarded the development of the aircraft industry. So, just 2 or 3 weeks before Hitler invaded Poland, a second major research station was approved and established here in California where we could be close to the aircraft industry on the west coast midway between the north and south and not play any favorites and at the same time where we could have good flying weather to conduct flight research the year round and plenty of power whereby we could operate tunnels better than at Langley Field, where there is very little power available.

This Laboratory was named in honor of Dr. Joseph S. Ames, one of the original members of the NACA, appointed by President Wilson in 1915. At that time he was professor of physics at Johns Hopkins University. Later he became president of the University, and in 1919 he became active scientific head of the NACA and remained so about 20 years in the capacity of Chairman of the Executive Committee and later as Chairman of the whole Committee. During these 20 years, he left an indelible imprint of his character upon our organization. Many of you knew him, and many of you never heard of him. He was an unusual man who really had a passion for anonymity. He did not attach his name to any statements or reports or he didn't make speeches or didn't bother public officials. Of course the NACA was very happy to name this Laboratory in his honor after he had resigned as Chairman. Because of his failing health, he knew he couldn't carry on in view of the greater responsibilities we would have to face in aircraft research. There is in the lobby of this building a memorial for Dr. Ames, signed by all the members of the Committee at that time. If any of you are interested, I suggest that you read it in the lobby.

During the war, as Mr. DeFrance said, our activities were related to those problems which the Army and Navy desired us to work on in order to help us win that war. We did not conduct fundamental research as we ordinarily did because the results would be applicable for some other war, perhaps. It is inevitable that scientific organizations, as any other activities in our land, do more in like manner and help win the war we are in. This means that scientific research, long-range fundamental research, is of necessity set aside in favor of the specific improvement of the tools with which we are to fight the war. Now, you might think the NACA should stick to fundamental research. It is our purpose and it is the policy of the NACA to stick to fundamental research during times of peace and we hope that we will have to do nothing else and, if that is true, we will stick to fundamental research. Now, with aeronautics standing on the threshold of a new era due to the advent of new forms of propulsion, many new problems associated with supersonic speeds confront us and, as we think of supersonic speeds, we must keep in mind that there are many new problems associated with supersonic aircraft trying to fly with stability, control, and adequate lift at the subsonic speeds and at low speeds with lift necessary to safe landing and take-off; so a whole new world of problems is opened in the subsonic fields.

It will be our effort today to show you what the NACA is doing at this Laboratory in approaching those problems. The NACA has now in operation six supersonic wind tunnels, not all at this Laboratory. We have in the course of construction five additional supersonic tunnels, and there are plans now under consideration by a special committee for the establishment of larger and higher-powered, higher-speed supersonic facilities. Where they will be, I don't know yet.

It is a very happy privilege that I have this morning in the name of the NACA to extend the official welcome of the entire organization to you. I trust that you will enjoy the visit around our activities today and that you will return some other time and be with us again. Thank you.

Smith J. DeFrance

Mr. Victory has told you of the excellent cooperation we have had from our neighbors, the Navy. Many of the investigations that we have conducted during the war would not have been expeditiously completed if it were not for the assistance we have received from the Navy. At this time I would like to present the Commanding Officer of the Moffett Field Air Station, Captain George Watson.

Captain George Watson

Mr. DeFrance, Mr. Victory, distinguished guests - It is my privilege to welcome you from the United States Navy. Our relation with the Ames Laboratory is that of a close neighbor and a very good friend. We feel privileged to be associated with the Laboratory. We are very proud that we can participate in a small way in the events today.

Smith J. DeFrance

During your tour of the Laboratory today, there are two terms that you are going to hear quite frequently. One is Reynolds number and the other is Mach number. Before we start on the tour, I would like to have a little discussion on the meaning of these

two terms, and at this time I would like to present Mr. Arthur Jones, who will discuss Reynolds number. Mr. Jones---

Arthur L. Jones

Today you will hear many references to two terms commonly used in aeronautical research: Reynolds number and Mach number. In order that those of you who are not working with these technical terms may more readily grasp the presentations throughout the day, it will be our effort to give you at the outset at least a popular concept of them. I shall discuss Reynolds number, leaving the discussion of Mach number to the next speaker.

The wind-tunnel testing of models has played a prominent role in aeronautical research because it is safer, more economical, and more expedient than flight-testing. We must be cautious, however, about using data from model tests in the design of an airplane, because a model does not always react to the air stream in the manner that an airplane reacts. The flow of air around the airplane controls its actions, and although we may build a model that is a faithful reproduction of the airplane, the flow about the model is not usually similar to the flow over the full-size airplane. This dissimilarity in flow is generally referred to as "scale effect." To study this scale effect and to overcome its disadvantages, we make use of an index called Reynolds number, which effectively defines the air-flow pattern about an object. Match the Reynolds numbers about the model and the airplane and you've matched the flow patterns. Reynolds

number in its simplest form is the product of the object's size and the air's speed and density divided by the viscosity of the air. The latter factor is so nearly constant that for the purpose of this discussion, it can be disregarded.

By virtue of its size, an airplane has a larger Reynolds number than its smaller scale model for equal air speeds and densities. Now, the definition of Reynolds number reveals that there are two ways in which we may directly overcome the disadvantages due to the scale effect of the model. We can either test the model in a variable-density wind tunnel, increasing the density of the air over its usual density by as many times as the model is smaller than the airplane, or we can test the airplane in our full-scale wind tunnel. Such tests provide data at values of Reynolds number approximately as large as the Reynolds number at which the airplane flies.

Thus you can see that the use of this convenient index known as Reynolds number, in conjunction with modern methods of model testing and analysis, enables us to determine in advance desirable features or necessary modifications for an airplane design. We thereby attempt to eliminate the delay and cost of modifying the airplane after it has been constructed.

Smith J. DeFrance

Mr. Rose will now discuss Mach number. Mr. Rose---

Leonard M. Rose

Mach number is something you will be hearing about at every turn today; so, I will attempt to give you an idea of its significance.

As you all know, an airplane supports itself in flight by causing the air around it to move downward. Of course, the airplane doesn't actually touch directly all of the air molecules which are influenced by its passage. Instead, it makes use of a messenger system to persuade all the air molecules in the neighborhood to move out of the way and downward. This messenger service is provided by nature, and the messengers are dispatched in all directions. We call these messengers "pressure impulses."

This messenger service is, however, limited as to the speed of its messengers, or pressure impulses, which travel at the speed of sound. The speed of sound varies with the temperature of the air. Normally, it is about 760 miles per hour, but it may be almost 800 miles per hour on a hot summer day or as low as 720 miles per hour on a very cold day.

It is not hard to see how the speed at which this messenger service operates is an important item in high-speed flight. As the airplane travels faster and faster, the molecules of air ahead of it have less and less warning of its arrival; and when the airplane is traveling at or above the speed of sound, it arrives at the same time as, or before, the messengers. The resultant confusion of the air molecules is the root of all the troubles encountered in high-speed flight. Naturally under these conditions, the air can't react in the same way as it would with the proper advance notice; so, all of the rules about the behavior of air under the influence of an airplane we have formed from our past experiences no longer apply.

Because the speed of sound has such an important bearing on the character of the air flow around an airplane, it has become customary to express speed of flight as a fraction of the speed of sound rather than

in terms of miles per hour. This fraction is known as the Mach number in honor of one of the pioneer students in the field of high-speed flow. For example, if we say an airplane is flying at a Mach number of one-half, we mean that the airplane is traveling one-half as fast as the pressure impulses travel through the surrounding air. A Mach number of 1 means a speed equal to that of the pressure impulses, and a Mach number of 3 means a speed three times that of the pressure impulses.

This doesn't mean, however, that the airplane must be traveling at the speed of sound before difficulties occur - which brings us to **critical Mach number**, something else you will be hearing a lot about today. As you know, even though the airplane is traveling well below the speed of sound, the air traveling past some of the more highly curved parts of the airplane is speeded up and then slowed down as the curvature changes - for example, the airplane may be moving at a speed of 550 miles per hour and the air traveling over part of the upper surface of the wing at a speed considerably greater, say 750 miles per hour. You can see then that even though the whole airplane is traveling at a Mach number considerably less than one, the flow over some portion of it may be traveling at the velocity of sound. The airplane speed, expressed as a fraction of the speed of sound, at which the air flow over some portion of the airplane first reaches the velocity of sound is known as the critical Mach number.

When the airplane exceeds this critical Mach number, the air flowing over a portion of it is traveling at a speed greater than the speed of sound. The point on the surface of the airplane at which the flow returns to the speed of sound forms a barrier, forward of which the messengers, or pressure impulses, cannot go. These pressure impulses pile up at this

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point and cause a sudden change in pressure known as a shock wave.

After the airplane has exceeded the critical Mach number and shock waves begin to form, the airplane is in what is known as the transonic speed range. This transonic range continues to exist until a new type of flow, known as supersonic flow, is established over the entire airplane. This supersonic flow is usually not completely established until the airplane has exceeded the speed of sound by a substantial amount. Because of this changing air flow, the behavior of the air in this transonic range is especially difficult to predict.

Today you will hear considerably more about Mach number, critical Mach number, and the transonic speed range, and you will be able to see images of shock waves reproduced by various optical processes.

Smith J. DeFrance

I consider it a privilege and an honor to present to you the next speaker, the dean of the American engineering profession, Dr. William Frederick Durand, who will deliver the address of dedication for the 12-Foot Low-Turbulence Pressure Wind Tunnel, which is being placed in operation today. Dr. Durand---

Dr. William F. Durand

Members of the NACA and guests - This occasion turns back my own memory through some 28 years when at the very modest offices of the Committee in Washington, D. C., we were occupied in laying out the design of the first NACA wind tunnel, the start of a long and illustrious succession of wind tunnels, culminating in the structure which we dedicate on this occasion.

The first wind tunnel had a throat diameter of 60 inches and an airspeed of about 80 miles per hour. The cost of the tunnel and building was $38,275.00. The cost of the 12-foot low-turbulence pressure tunnel, to which our attention is directed today, was $3,300,000.00 with speeds up to 750 miles per hour. You'll each be provided with a little booklet fully descriptive of the wind tunnel; so, I need not go into full detail at this time. Since, however, you have not seen this booklet, I feel that I may be permitted to describe some of the main features of the wind tunnel.

The primary purpose of this wind tunnel is to provide a flow of air at high velocity 12 feet in diameter in the working section, with a minimum of turbulence in the air flow. This particular purpose is realised by passing the air through eight fine-mesh screens located in a sphere some 60 feet in diameter, just ahead of the working section. This screen combs out most of the turbulence of the tunnel. The air is then subject to a contraction ratio of 25:1 at the working section, which squeezes out, as it were, most of the residual turbulence. The result is air with a low degree of turbulence closely approximating that encountered by airplanes in flight in free atmospheric air. The tunnel length is 336 feet. The tunnel shell is formed of electric arc-welded steel plate, which varies from 3/4 inch to 2-1/4 inches in thickness. The installation is provided with equipment for varying the internal pressure from 1/8 atmosphere to 6 atmospheres, a range of 36 fold. This wide variation in pressure, together with a wide range in speed, will provide conditions of operations for a wide range of Reynolds and Mach numbers, one of the main objectives for the design of the tunnel. The tunnel provides means for investigation

of the effects of Reynolds and Mach numbers, making the former up to some 11,000,000 per foot of chord and the latter up to unity. The main drive requires motors of 11,000 horsepower with a total power installation of some 15,000 horsepower. This combination of operating conditions therefore permits the study of aerodynamic phenomena with accurate control of the influence of variations of speed, turbulence, and density in a length of time not possible with less versatile facilities. It appears to be a fair claim that in this tunnel, full-size flight conditions may be more nearly approached than in any other wind tunnel in the world. Through the control of air density, a small-size model can be tested and data directly applicable to aircraft as large as an attack bomber or a medium-size transport airplane can be obtained.

This tunnel is the first ever built to combine the features of high-speed low-turbulence air flow to simulate full-scale conditions and large dimensions to accommodate complete models of large size. The special significance of low-turbulence air flow lies in the fact that there is no way of correcting the data to eliminate the influence of the turbulence in order to reduce the results to the values appropriate to aircraft moving in free atmospheric air.

I spoke a moment ago of the long series of tunnels showing our very modest beginning 29 years ago. The Committee has in the three laboratories, Langley Field, Cleveland, and Moffett Field, a total of some 34 wind tunnels, representing a total investment of $85,000,000.00. These tunnels range in size from 12-inch jets operating at supersonic speeds to the mammoth 40- by 80-foot tunnel, which was dedicated in 1944. It is a long and illustrious series going hand in hand as it has with a startling

development in the science of aerodynamics and aircraft construction. There is no need to enlarge on this topic before this audience. It has revolutionized the great service of transportation and war and all international relations, and the facilities which we dedicate on this occasion may be relied on to contribute largely to this development.

And now, therefore, by virtue of the authority herein vested in me by the Chairman, I now dedicate this 12-Foot Low-Turbulence Pressure Wind Tunnel for the further service of our country and for the advance of understanding of aeronautical phenomena.

Smith J. DeFrance

I am sorry to announce at this point that General Arnold is unable to be present. Mrs. Arnold unfortunately met with an accident last night and broke an ankle, and he is unable to attend.

Dr. Durand has just dedicated the tunnel. The guests will please leave by the back entrance and get in busses that are waiting on either side of the auditorium, and we will proceed to the 12-foot tunnel, where Dr. Durand will place the tunnel in operation. Will you please leave at this time. The busses are waiting.

(The following speeches are given in front of the 12-foot wind tunnel.)

Smith J. DeFrance

Dr. Durand has dedicated the wind tunnel, and now I would like to ask Dr. Durand to step forward and push the button and place the wind tunnel in operation. Dr. Durand---

Dr. William F. Durand

Members of the NACA and guests - A few minutes ago in the auditorium, with some degree of formality, I dedicated the 12-Foot Low-Turbulence

Pressure Wind Tunnel, but nothing happened! I now have the privilege of pressing a button, and I predict that something will happen! The tunnel will start. The air flow will begin and you may be able to hear something - here goes---

Smith J. DeFrance (after a few minutes)

We will now break up into groups.

I would like to introduce Mr. Allen, who will conduct all the members who have red tags on a tour of the Laboratory.

The group leader for the white group is Mr. Carlton Bioletti. Mr. Bioletti, will you form at your location.

For the blue group, Mr. Arthur Freeman.

For the green group, Mr. Harry Goett.

For the gold group, Mr. F. R. Nickle.

For the gray group, Mr. Donald H. Wood.

For the tan group, Mr. James A. White.

And for the rust group, Mr. Ralph Huntsberger.

Before we form in groups, I'll say that the official time is 10:53. If any of you would like to set your watch at this time, you may do so because we will adhere to a time schedule. Will you please at this time form at the color of the identification badge you are wearing for your prospective group. Please form at this time at your station.