Mr. Schueller's talk for 10x10 Dedication Ceremony - May 22, 1956

The purpose of wind tunnels, whether they be supersonic or subsonic, is to simulate on the ground the conditions which an airplane or parts of an airplane experience in flight. This simulation may be better understood if you remember that when you put your hand out the window of an automobile traveling at moderate speeds, a lift force is produced which tends to blow your hand back. In this case your hand is being propelled through still air much as an airplane is in flight. If, on the other hand, you stand in front of a fan and incline your hand to the airstream, it will again be blown back as a result of the lift. But in this case, your hand is fixed and the air is moving past it in the same way as the air is blown past models in supersonic wind tunnels. Thus to obtain airplane flight characteristics, you may move the airplane through still air, as in flying, or hold the airplane and blow air past it as in wind tunnels. The latter technique is cheaper, faster and more accurate which makes the wind tunnel such a potent research tool.

This chart is a layout of the 10x10 foot supersonic wind tunnel and the airplane or component which is being studied is located in this area which we call the test section. Now out of this huge facility having a length of 450 feet and a width of 330 feet, only this section, 10 feet high by 10 feet wide and 40 feet long is used in the research and development investigations. It is in this area that the models are located and that air is blown past the model at conditions which correspond to those which would be encountered in flight.

To make this air flow past the model, we must connect the test section by means of piping to this compressor which sucks the air. After going through the compressor, the air is discharged out the exhaust muffler to the atmosphere. The exhaust muffler contains acoustical material to reduce the noise level of the discharged air. Since we are discharging the air to the atmosphere here, continuous flow in the test section can be attained only by introducing air from the atmosphere. In this facility the air is brought in through the air dryer building where the air is made to pass through a drying agent known as activated alumina. There are approximately 1900 tons of alumina in this building and as such, is capable of removing from the air that we are now breathing, approximately 7,000 gallons of water in one-half an hour. This moisture must be removed from the air to avoid variations in velocity and temperature which are experimentally unacceptable in the test section. After the air is dried, it can be directed through the #2 compressor for speeds greater than M = 2.5 or this valve is opened and the air is by-passed around No. 2 for speeds from M = 2.5 to 2.0.

This then represents the path of the airflow for the propulsion cycle and is used whenever the model being investigated in the test section includes an operating engine which introduces contaminants, such as water to the airstream. If contaminants are being introduced into the airstream, it is possible to close this 24 foot diameter, 25 ton valve to the position shown here. We now have an alternate airflow path which is called the aerodynamic cycle. In this case, the tunnel circuit is filled with dry air, and the same air is circulated around and around the tunnel circuit. Now when you compress air such as we are doing with #1 and #2 compressors, it gets hot. This you can remember from feeling the barrel of a recently used tire pump. So if no provisions are made to remove the heat of compression, the temperature of the air in the tunnel will continue to rise and the tunnel structure will become so weak that it will fail. Accordingly, two coolers, which use chilled water, have been introduced in the tunnel circuit to remove the heat resulting from compression of the air.

With the tunnel operating on the aerodynamic cycle, the altitude which is being simulated in the test section can be varied by means of the exhausters located here. These exhausters pump air out of the tunnel circuit on the aerodynamic cycle and thus reduce the pressures or increase the operating altitude of the test section. In this way the effect of altitude on the performance of an airplane component is determined.

The path of the air in the tunnel circuit has now been described for the propulsion cycle and the aerodynamic cycle, and before leaving this, we should answer the question of why two cycles. The answer is quite simple. Since the dryer contains a limited amount of drying agent, the tunnel can be operated on the propulsion cycle for a time which is dependent upon the relative humidity of the air passing through the dryer. This means that in the summer when the air temperatures and humidity are high, tunnel operation may be limited to 15 or 20 minutes due to the dryer. Therefore for investigations which do not include engine operation and thus do not contaminate the airstream, it is more efficient to operate on the aerodynamic cycle. Conversely, it is not practical to have only the aerodynamic cycle because engine investigations will so contaminate the tunnel flow that the experimentor cannot be sure of the conditions being simulated or of the results being obtained.

In discussing the path of the air through the tunnel circuit, it was pointed out that it is the function of compressor #1 to pull the air, and of compressor #2 to push the air. Compressor #1 is driven by 4 motors on a common shaft, having a total power of 150,000 h.p. The compressor consists of eight stages of fans 20 feet in diameter, similar to, but more efficient than our household fans. The #2 compressor is driven by 3 motors on a common shaft having an installed power of 100,000 h.p. Thus, to push more than a ton of air per second at supersonic speeds around a model located here in the test section, a total of 250,000 h.p. is required. Approximately 95 percent of this power is required to overcome the losses in pressure due to shocks which occur between the end of the test section and the first elbow in the tunnel. These shock losses which occur when air traveling at 1700 miles per hour is abruptly slowed down can be reduced by a device, called a second throat.

The second throat is located here and consists of movable sidewalls which squeeze the supersonic flow and thus slow it down before the shock, thus reducing the losses.

This brings us to one of the contrary conditions which arise in handling airflow, namely, when air is traveling at supersonic speeds, squeezing it down decelerates the airflow; however, when air is traveling at subsonic speeds, squeezing the area down accelerates it. This then explains the technique used to accelerate the airstream from a velocity of say 30 miles an hour here in the bellmouth to 1700 miles per hour around the model. This is done in what is commonly referred to as a supersonic nozzle. The supersonic nozzle consists of a converging section shown here which accelerates the air to Mach number 1 by squeezing it down, that is, pushing the same amount of air through a smaller opening. Thereafter further increases in speed require that the area gradually increase. Actually a particular combination of test section area to throat area is required for each Mach number. Since the test section is fixed at 10 feet high and 10 feet wide, the throat opening varies from 60 inches wide at Mach 2.0 to only 18 inches at Mach number 3.5. Furthermore, a different wall contour is required between the throat and test section for each Mach number. In the case of this facility, flexible stainless steel side walls approximately 70 feet long and 1-3/8 inches thick are pushed and pulled to within .005" of the desired shape by 27 jacks on each wall. Even though loads of the order of a ton per square foot occur on the flexible wall during tunnel operation, these walls are moved automatically and remotely during tunnel operation. This excellent piece of engineering equipment provides the necessary variations in test section velocity. Thus the speed of the air around the model can be varied by increments of 0.1 Mach number from Mach number 2.0 to 3.5 in less than 20 minutes.

The question might now be asked, since you have all of this tremendous piping, 250,000 h.p., and the ability to blow air past the test model at supersonic speeds, what flight conditions can be simulated in such a facility? 1.5 This is shown in the next chart which indicates that speeds from Mach number 2 .5556 to 3.5 or velocities of 1200 to 1800 miles per hour at altitudes of from 48 to .29 155,000 feet can be simulated. We thus have a facility having both speed and altitude capabilities which are far in excess of current airplanes. Furthermore, over a period of years, many airplanes, each of which will cost much more than the 33 million dollars invested in this facility, can be studied and changes made in the design which will permit them to fly higher, faster and farther. For example, many of the century series fighters which you have been reading about recently such as the F-101, the F-102 and the F-104 were investigated here at Lewis as much as three years ago and as a result of these studies, significant changes in the airplane design were evolved which in some cases made the difference between a supersonic airplane and just another subsonic airplane.

Specifically, what types of investigations can be conducted in a facility such as this? First and foremost, full scale engines up to 5 feet in diameter can be studied under conditions corresponding to supersonic flight. A J-34 type turbojet engine is displayed here and as you can see, the exterior is quite rough so the first thing to do is either wrap a fairing around it which we call a nacelle or bury it inside the airplane fuselage. In either case, reduce the exterior drag. Since the engine is traveling at supersonic speeds but requires subsonic velocities entering the compressor, the air must be slowed down without incurring the tremendous losses in energy previously discussed in decelerating the tunnel flow from supersonic to subsonic velocities. This is accomplished by what we refer to an an inlet which to the layman appears to be a forward extension of the fairing around the engine such as shown here. We now have a powerplant installation. Since single engine supersonic airplanes represent powerplant installations in the 100,000 h.p. class (a Naval destroyer has 70,000 h.p.) the development of these powerplants and the proper installation in the airplane are obviously of major importance. This is one of the main functions of this facility, namely to investigate powerplants operating at supersonic speeds, and the engine that you see here was, as far as we know, the first turbojet engine ever operated at a supersonic speed of Mach number 2.

Since an air-breathing engine of the 100,000 h.p. class consumes hundreds of pounds of air per second, the supersonic inlet is of primary importance if engine power losses of the order of 20,000 h.p. are to be avoided. Fortunately it is possible to make certain inlet studies without the complications of the engine by using a flow control orifice at the diffuser exit to simulate the engine effects. The 19" model shown here is such a configuration. This also comprises an important part of the investigations which will be conducted in this facility. Another area of research which is difficult to study but absolutely necessary consists of adding all of the components together to make a complete airplane configuration such as the one shown here. Here we have added the inlet component, the engine component, the wings, fuselage, all the various pieces which make up the entire airplane and we will study all of them at the same time. Such studies are required to determine the effect of the inlet on the rest of the airplane or the effect of the engine installation on the rest of the airplane.

The final question which you might ask would be, how do projects get into such a facility? Actually for the good of the country, it has been decided that half of the operating time of the tunnel will be spent on basic research. By basic research is meant research which is not currently applicable to a particular airplane or component but may be five to seven years ahead of current design practice. However, it is practical information, which will be used in future designs. The remaining 50 percent of the tunnel running time will be required for development type projects. They are projects which the designer has today. In this case, models are made of a current airplane such as the century series fighters. As a result of the wind tunnel investigation, changes or modifications are developed to correct or improve these designs. All information, whether it be research or development, is then distributed to qualified people all over the country for use in their own designs.

FINAL

LEWIS UNITARY PLAN SUPERSONIC WIND TUNNEL

MAY 22 TUNNEL TOURS

TOUR PLAN