NACA - Langley

1951 BIENNIAL INSPECTION

INTRODUCTION BY MR. F. L. THOMPSON

At this time we would like to take the opportunity to discuss briefly two subjects that we thought would be of general interest. The first of these concerns the problem of providing the tools for conducting research in the difficult speed range around Mach number 1.0; that is, the transonic range. We thought that a review of the current status of that problem would be of interest, and Mr. John Stack, Assistant Chief of Research of the Langley laboratory will discuss that subject.

The second subject that we would like to discuss briefly at this time concerns the problem of reducing the manual labor and time required to handle data reduction and the voluminous calculations required in a large research laboratory such as this. The capacity of the laboratory for making measurements is great. For example, a few days of operation of a single wind tunnel in an investigation of pressures on wings may yield hundreds of thousands of readings. This situation provides a fertile ground for reduction of manual labor by use of appropriate devices and machinery. Progress has been made in this problem and a display of equipment in current use has been arranged to be shown during the luncheon today. Mr. M. J. Stoller, Assistant Chief of the Instrument Research Division, will discuss this problem briefly at this time to provide you with a better understanding of the display to be shown at lunch time.

Talk presented by Mr. John Stack:-

As you may well know, wind tunnels have been inoperative through important parts of the transonic range. The phenomena is generally referred to as "choking". Viewed simply, the phenomena is related to the fact that the speed of sound is the speed at which small pressure impulses travel through any gas. Thus, for a wind tunnel without a model when the speed of sound is reached in the test section which, of course, is the throat or smallest section of the whole air circuit, any additional pressure field set up by the fan cannot travel upstream through the throat to cause more air to flow through the throat. If a model is put in the wind tunnel, it in effect makes the test section or throat area smaller by the space the model occupies and thus the amount of air that can flow through is lowered. Further, the velocity field around the model has local sonic or supersonic regions which add materially to the choking effect. Thus, fairly large regions of speed in the important region of the speed of sound are "blocked" so far as wind-tunnel operation, and so data for this region have been impossible to obtain in wind tunnels. The significance of the speed of sound is so great that we now have come to measure speed in terms of the speed of sound. I mean, of course, the Mach number, the actual speed divided by the speed of sound.

This "choking" limitation of the wind-tunnel technique has been a serious handicap and great efforts have been made to overcome the limitation or to devise other methods to do the necessary research.

You will recall that 2 years ago at the Langley Inspection, we reviewed the effort made to obtain aerodynamic data in the transonic range. At that time, we discussed the wind-tunnel choking limitations that prohibited or made impossible the obtaining of transonic aerodynamic data in wind tunnels. Some other methods had been devised all with more or less serious limitations. This slide was shown as a summary of the discussion to illustrate the position with respect to the methods of obtaining transonic data.

The bottom line shows the blocked out range of Mach number for conventional closed-throat wind tunnels using what was then, 2 years ago, conventional techniques. The line next above showed what was possible by improvement of technique and greatly reduced model size. The next three lines were the free-air methods developed and then in use to get results continuously through the transonic range. The upper line illustrated what we had been able to accomplish with what was then a new type of transonic tunnel - a very highly developed adaptation of the whirling arm concept. Such was the position then. The transonic tunnel of the whirling arm type and the "bump" or wing-flow techniques were the only Laboratory techniques capable of operation continuously through the transonic range and these methods had many serious disadvantages, limitations, or complications.

The effort then summarized was continued and, since then, by a special new development of a type of wind-tunnel throat, the "choke" limited speed range of wind tunnels can be eliminated. That is, true transonic wind tunnels have been developed. Security regulations prohibit complete disclosure of the means by which continuous transonic operation is achieved. This much can be said. The test section might be termed ventilated. There are many means by which the ventilation can be accomplished and by the same token, many of the means are unsatisfactory. We have developed a satisfactory system.

It must be pointed out that the idea of ventilated throats is not new except in its application transonically. Ventilated test sections to achieve nullification of wall corrections at subsonic speeds is a fairly old idea and the theory has been available and discussed in the literature. In fact, the arrangements we are now using in the transonic range were influenced to a very great extent by the older subsonic studies. The forms in which the ventilated throats or test sections have been applied here are designed as well to give zero wall correction for low speeds for many types of models.

As a practical construction matter, the new type throat is somewhat simpler to build - not requiring a high order of precision as to contour.

Aerodynamically, large models may be used. It is conservative to say models about three times the size that would choke at Mach number 0.9 in a conventional tunnel of the same size.

We now have two large transonic wind tunnels in operation - the Langley 8-foot and 16-foot wind tunnels. In addition, we have one smaller transonic wind tunnel approximately 2-foot throat operating as a blowdown tunnel, but capable of high Reynolds number because it can be operated to something above 5 atmospheres. Under construction is a fourth transonic tunnel of this new type having a test section cross-sectional area of approximately 50 square feet.

The next slide illustrates schematically the flow for the fore part of a body as investigated in the 8-foot transonic tunnel for a Mach number slightly over 1.0.

Describe setup

Note bow wave

The movie

We cannot yet claim that we are satisfied with the present state of development. Two problems require further work. One is the wave reflection problem after the Mach number passes 1.0. We have achieved a considerable weakening of the reflected wave but not yet complete cancellation of the reflected wave. By modification of the testing technique, we are able to reduce to relative unimportance the effects on the aerodynamic characteristics of the weakened reflected wave. Eventually, we expect to accomplish satisfactory wave cancellation. The other is the power required. The power to operate is considerably more than required for a closed throat of the same size. We have made a material reduction from the power required in the initial installations and we can further reduce the power. Even so, at present power levels, the much larger size model that can be used much more than offsets the present additional power requirement.

In your tour today, you will be conducted through the 16-foot high-speed tunnel which has recently been placed in operation having been repowered and fitted with this new throat. You will not be able to see the exact means by which the test section has been made transonic, but you will be able to see that most major components of the wind tunnel, that is, the drive, the cooling system, the diffuser, the structure, generally remain familiar.

brn