* * * * *

This next article was originally published in *Popular Aviation* in September 1936.

The Behemoth of Wind-Tunnels

A detailed description, given at the request of many readers, of the mammoth wind-tunnel employed for testing the aerodynamic properties of full-size planes.

by M. E. JOSEPH

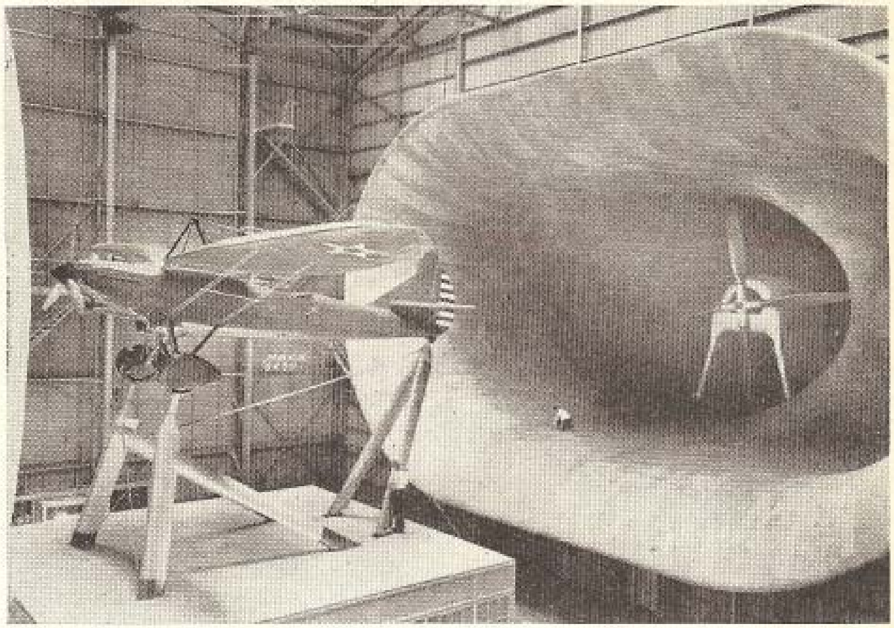
THE world's largest horizontal wind-tunnel might not convey anything of a definite size to a casual reader; but when one reads further and notes that the throat of this tunnel is large enough to serve as a dining-room for 300 men, even the least imaginative of persons can grasp something of the immensity of this creation of the N.A.C.A.

The 300 men dined in such novel style were some of the country's foremost aeronautical engineers who attended an Annual Engineering Conference of the National Advisory Committee for Aeronautics, the organization responsible for the huge tunnel.

The primary purpose of the tunnel is to make it possible to test full-sized airplanes. Although it is true that in the past scale-models have been satisfactorily used, and no doubt will continue to serve in certain capacities, such as in conducting fundamental research on airfoil sections and streamline bodies, nevertheless this new tunnel will offer distinct advantages.

It will be particularly helpful when the aerodynamic characteristics of a complete airplane are desired, especially if the effect of the slip-stream is to be considered. Heretofore such investigations have been conducted only in flight, and because of variation in atmospheric conditions numerous check-flights have been necessary to average out the discrepancies.

Furthermore, in flight-testing the scope of experiments is limited by the fact that changes in design must of a necessity be limited so they will produce no great degree of difference in the weight or air-worthiness of the plane. It is herein, no doubt, that the full-scale wind-tunnel will be of the most service—making it possible for alterations to be made in design without serious limitations. Naturally, too, it will reduce the element of hazard in first flight-tests.



A close-up view of the mountings of the test airplane which, in this case, is a YO-31-A full size plane.

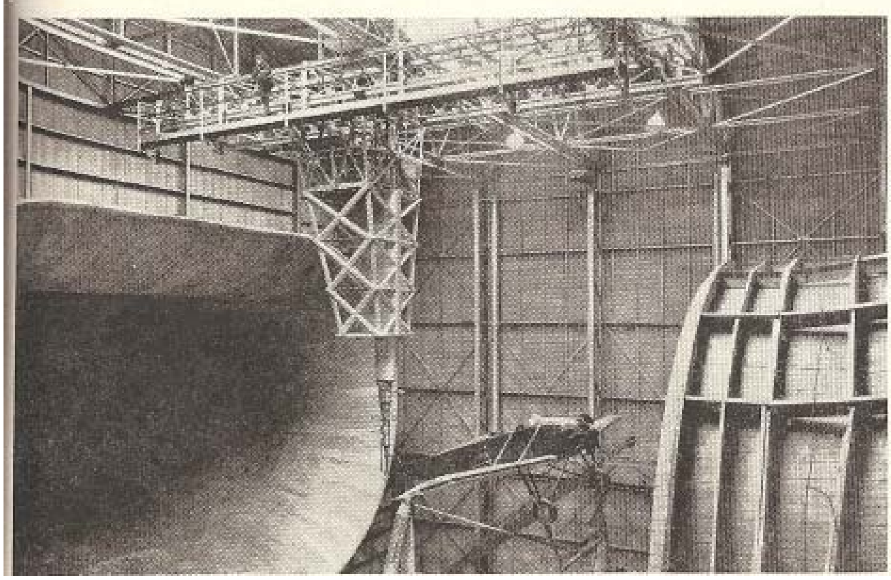
By means of this full-scale tunnel, studies may be made of body interferences and of control and stability characteristics, both with and without the slip-stream; lift and drag characteristics of a complete airplane may be determined. Additional equipment has been installed for ascertaining the direction and velocity of the flow at any point about an airplane. Cowling problems and aircraft engine cooling also may be examined under conditions comparable to those in flight.

Because no other wind-tunnel has ever been constructed with an elliptic throat and with two propellers mounted side by side, a 1/15-scale model was built to study the flow problems. Flow conditions obtained in the model tunnel were satisfactory and this piece of equipment is now used for small-scale testing.

The overall length of the tunnel is 434 feet 6 inches, the width 222 feet, and the maximum height is 97 feet. It is of the double-return flow type with an open-throat measuring 60 feet in horizontal dimension and 30 feet in vertical dimension. A return passage 50 feet wide and anywhere from 46 to 72 feet high is on either side of the test chamber.

The outer walls of the return passages are formed by the outside walls of the structure, which houses the entire equipment. The frame work is of structural steel and the walls and roof are of $\frac{5}{16}$-inch corrugated-cement asbestos sheets. Galvanized sheet metal protects the entrance and exit cones, which are made of 2-inch wood planking, from fire.

The entrance cone is so shaped to give, as far as possible, a constant acceleration to the air-stream and to retain a 9-foot length of nozzle for directing the



changes from a rectangle 72 by 110 feet to a 30 by 60 foot elliptic section.

The working section of the jet is located in the test chamber, which is 80 by 122 feet. Seventy-one feet is the length of the jet, or the distance between the end of the entrance-cone an the smallest cross-section of the exit-cone collector. Airplanes enter through doors, size 20 by 40 feet, in the walls of the return passage on one side. Light for day-time operation is supplied by two sky-lights, size 30 by 40 feet, in the test chambers; at night eight 1,000-watt flood-lights provide illumination. The tracks for an electric crane, which lifts the airplanes onto the balance, are attached to the roof trusses.

The description of the exit cone is as follows: Located in the middle line of the tunnel and forward of the propellers is a smooth fairing, which transforms the somewhat elliptic section of the single passage into two circular ones at the propellers. From the propellers aft, the exit cone is separated into two passages and each transforms in the length of 132 feet from a 35-foot 6½-inch circular section to a 46-foot square. The included angle between the sides of each passage is 6 degrees.

Four cast-aluminum alloy blades, screwed into a cast-steel hub, make up the 35-foot 5-inch propellers (diameter), and they are located side by side, 48 feet aft of the throat of the exit-cone bell.

Since it was found that alternating current slip-ring induction motors, together with efficient control equipment, would cost about 30 per cent less than direct-current equipment if used in the full-scale wind-tunnel, this was substituted for the direct-current motor-generator set with Ward Leonard control system, which is commonly used as the power plant for operating a wind tunnel. For this reason, two 4,000-horsepower slip-ring induction motors, with 24 steps of speed ranging from 75 to 300 r p.m., were installed. To accomplish the speed range, one-pole change was provided and the other variations are obtained by use of resistance in the rotor circuit. A variation in air speed from 25 to 118 miles per hour is made possible by this control. In the test chamber is one drum-type controller and the two motors are connected to it through an automatic switchboard. Irrespective of how fast the controller handle is moved, the motors will increase in speed at regular intervals, since all the control equipment is interlocked and joined through time-limit relays.

Friction losses are reduced to a minimum by the ball and roller bearings provided for the motors. The thrust of the propellers is taken on a ball bearing at the rear end of each motor shaft and roller bearings of 8.5- and 11.8-inch bores are provided at the slip-ring and propeller ends, respectively. The motors are mounted with the rotor shafts centered in the exit-cone passages. Fairings enclose the motors and supporting structure so that they offer the least possible resistance to the air flow.

Guide vanes at the four corners of each

(Concluded on page 60)

HELP WANTED!

THE VAHS MARKER COMMITTEE NEEDS SUGGESTIONS FOR FUTURE HISTORICAL ROADSIDE MARKERS. TOPICS CAN BE LOCATIONS, EVENTS OR INDIVIDUALS. THE ONLY STIPULATION IS THAT THE EVENT MUST BE OLDER THAN 50 YEARS. IN THE CASE OF INDIVIDUALS, THEY MUST BE DECEASED.

SUGGESTIONS CAN BE SENT TO W. SCHULTZ AT WSCHULTZ5@COX.NET OR BY PHONE AT 757-258-8875.

Request for Articles

Do you have an aviation story or a relative or friend with one? Why not share it with your fellow members of VAHS? I am always amazed that people who have had the most fascinating experiences will say "oh, that's nothing special; it's just something I did." And I'm sitting there wide-eyed and amazed at the bold adventure they had. Please share your memories with us! If you are uncomfortable with your writing, don't worry. I am more than happy to write it for you if you will just write your basic story and send it to me. I love to write and nothing pleases me more than the chance to tell your story. This is a wonderful time to ensure that your story is preserved for years and generations to come. Please contact me at lfburdette@verizon.net or by phone at (540) 899-9500.

Linda Burdette
Feature Articles Editor

Wind-Tunnel

(*Continued from page 32*)

return passage turn the air. The vanes are of the curved airfoil type, produced by two intersecting arcs with a rounded nose. Such arcs were selected so as to give an almost constant area through the vanes.

The vanes at the first two corners behind the propellers have chords of 7 feet and are spaced at 0.45 and 0.46 of a chord length, respectively. At the opposite end of the tunnel the vanes have chords of 3 feet 6 inches and are spaced at 0.41 of a chord length. A satisfactory distribution of velocity has been obtained by a correct adjustment of the angular setting of the vanes, and so no honeycomb has been needed.

The balance is of the 6-component type. At the top of each of the struts, ball and socket fittings hold the axles of the plane to be tested. The tail is fixed to a triangular frame. A turntable is attached to the floating frame and the struts are secured to this turntable. The floating frame rests on other struts, which transmit the lift forces to scales. The drag linkage is secured to the floating frame on the center line, and working against a known counterweight transmits the drag force to a scale. Attached to the floating frame on the front and rear sides at the center line, are the cross-wind force linkages. Working against known counterweights, these linkages transmit the crosswind force to scales. Thus the forces in three directions are measured, and by combining the forces and the proper lever arms, the pitching, rolling and yawing moments can be reckoned.

The dial-type scales are provided with solenoid-operated printing devices. No personal errors are possible, for when the proper test condition is obtained, a push-button switch is momentarily closed and the readings are registered simultaneously on all seven scales. The triangular frame can be telescoped by electrically-operated screws, which raise and lower the tail of the plane and thus vary the angle of attack. By a like arrangement, the turntable can be moved so as to yaw the airplane from 20 degrees left to 20 degrees right.

To protect the floating frame and scale assembly from air currents, it is enclosed in a room. All the supporting struts are shielded by streamlined fairings, which are fastened to the roof of the balance room and free from the balance. Since a small amount of the supporting structure is exposed to the air-stream, the tare-drag measurements are consequently lowered to a minimum.

This survey equipment is valuable for observing the downwash behind wings and the flow around the tail surfaces of the airplane. A 55-foot structural steel bridge is attached to the bottom chord of the roof trusses. This bridge can be rolled across the entire width of the test chamber, and mounted on the bridge is a car which can be rolled along the entire length.

By gearing with an electrical control on the car, a combined pitot, pitch, and yaw tube (suspended below the car) can be raised or lowered and pitched or yawed. This arrangement allows the alignment of the tube with the air-flow at any point around an airplane. The alignment of the tube is shown by null readings on the alcohol manometers connected to the pitch and yaw openings in the head and the angle of pitch or yaw is read from calibrated Veeder counters joined to the electric-working motors.

The same airplanes when tested in flight and in the tunnel have shown good agreement. The velocity distribution has been measured over a number of planes at right angles to the jet, but the plane representing approximately the location of the wings of any airplane during tests was completely studied.

An area that would be occupied during tests by an airplane with a wing span of 45 feet shows a dynamic pressure distribution within ± 1½ per cent of a mean value.

END.

CHICAGO AREA

Pal-Waukee's major claim to local prominence is its large number of private pilot-owners . . . compared to Curtiss-Reynolds. Pal-Waukee is a small airport . . . several innovations have been incorporated at Pal-Waukee, chief among them being the Chicago Aviation Country Club and the large permanent hangar used during the summer to house the Goodyear semi-rigid blimps (Puritan, Reliance, etc.) . . .

The Chicago Aviation Country Club originally was intended to be a duplicate of the fashionable and successful Long Island Aviation Country Club at Hicksville, New York . . . little activity, however, like the aerial vacation flights of the Long Island club or their week-end flight visits to members' homes or estates has been undertaken by the Chicago group. . . .

An emergency stop on the Chicago-Twin Cities airway, Pal-Waukee is managed by popular young Cliff Gandil. . . .

This field also was the official aviation operations base for A Century of Progress both in 1933 and 1934 . . . both the Goodyear blimps and the Sikorsky amphibians which carried a record number of sightseers at the World's Fair were based at Pal-Waukee. . . .