TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 757

THE AACHEN WIND-TUNNEL BALANCE

By C. Wieselsberger

Abhandlungen aus dem Aerodynamischen Institut
an der Technischen Hochschule Aachen
No. 14, 1934

Washington
November 1934

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Incidental to the remodeling of the experiment chamber of its wind tunnel in 1932, the Aerodynamic Institute of the Technical High School, Aachen, has obtained a new wind-tunnel balance which in its design and recording features should be of some interest.**

The guiding principles in the design of the balance were:

1. Rapidity and convenience of measurement.
2. Wide range of adaptation.
3. Yaw measurements.

As concerns the first requirement, the usual method of recording the lift on many of the conventional balances is to measure two components of the lift rather than measure the total lift direct. The measurement of the two lift components and of the drag defines the resultant aerodynamic force in magnitude, direction, and position if the attitude of the wing is symmetrical to the direction of the wind. With known magnitude of aerodynamic force, its position can equally be expressed with the moment about a stated axis, such as the leading edge of the wing. However, there is a certain necessity for being able to obtain the total lift with one measurement because

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*"Die aerodynamische Waage des Aachener Windkanales." Abhandlungen aus dem Aerodynamischen Institut an der Technischen Hochschule Aachen, No. 14, 1934, pp. 24-26.

**This balance was first designed by the writer for the wind tunnel of the Aichi Tokei Denki airplane factory at Nagoya and built in the shops of the firm. It has been in service there since 1929. Through the whole-hearted support of the said firm it was possible for us to obtain a balance of the same type under favorable conditions for our own wind tunnel.

the moment itself is of secondary importance in many cases. Now, if the design of the balance is such as to afford the total lift in one measurement, the polar curve is perfectly defined with two measurements, i.e., of total lift and drag and consequently results in a not inconsiderable saving of time.

The design and mode of operating the balance may be seen in figure 1. Temporarily arranged as three-component scale, it may, however, be readily adapted for six-component measurements. To assure measurements in yaw the balance is arranged over the air stream and in such a manner that the frame G, on which the balance is mounted, can be rotated on a cast-iron ring R by means of four wheels. The mounting of the wing relative to the frame is such as to bring the center of the leading edge on the axis A - A of the ring, as a result of which this point does not change its location while the balance rotates. The airfoil is so suspended that the relative position of the wires remains the same during a rotation of the balance. To this end the attachment point B of the upward sloping drag wire at the left is rigidly fastened to the frame and moves with the balance. This motion is obtained by fitting an appropriate slot in the entrance cone. The drag balance W_1 itself manifests no novel features in design or mounting. The total-lift measurement is based upon the principle of the weighbridge. The suspension wires of the model are joined at the upper lever T of the weighbridge; the leverage is such as to assure a 3:1 reduction ratio of the aerodynamic forces, i.e., the weights needed for weighing are only 1/3 of the actual air loads.

Thus the total lift can be measured direct with the balance W_2. As the top beam T of a weighbridge executes a parallel motion when weighing, so the airfoil also moves parallel in vertical direction. This is an advantage over the usual methods whereby the airfoil turns about the leading edge and then about an axis through the rear suspension wire, because the turning of the airfoil produces changes in air loads which increase or decrease the stability of the balance according to whether in the particular angle-of-attack range the lift increases or decreases with increasing angle. This phenomenon which makes itself felt disagreeably in the measurements is, of course, eliminated as soon as the airfoil moves strictly parallel as in this particular design. The balance W_3 serves to measure the moment about the leading edge of the wing. It can be moved vertically by means of a spindle S, and thereby accord a change in angle of attack. On the other hand, as the distance K F must be kept constant when the angle of attack is changed and must consistently equal the distance H J, the spindle S is mounted on a balance C, which slides on rollers provided on beam T as the balance W_3 rises or drops. The distance K F is held constant with rod D, the points K and F being designed as pivots. The angle of attack is read on a graduated scale E. With a base length of 300 mm (11.81 in.) (see further on) an angle-of-attack range of from -30° to $+30^\circ$ is possible. Another advantage of this type of balance is its suitability for a multitude of different kinds of models. Thus it is forthwith possible to change the "base length" l, that is, the distance between front and rear suspension points of the model. The connecting bar D passes at K through a sleeve, so that it may be held at any point by means of a set screw. In this manner the distance l may be changed from 240 to 700 mm (9.45 to 27.56 in.). The short base lengths are chiefly used for airfoil measurements, while longer base lengths assure a better and more substantial fixation for long models such as fuselages and airships. Even for complete airplane models it is of great advantage to have free choice in the point of application of the rear suspension wire.

The pivots of the levers shown as small circles in figure 1 are all knife edges, thus assuring ready response. The balance W_1 and W_3 record an additional weight of 1 g (0.0022 lb.), while balance W_2 still records a load of 3 g (0.0066 lb.) without pointer deflection.

It should be noted further that with this method of model suspension, changes in angle of attack involve no zero-point changes on balance W_1 and W_2. This reduces the time of recording as well as of evaluation. Normally the balance W_3 reveals zero-point changes caused by the center of gravity of the model being outside rather than on the connecting line H J. The result is then a slight change in the amount of the dead weight when the angle of attack changes, which is apportioned to the suspension wires. But for the W_2 balance this shifting of the weight quota is of no influence as it simply records a change in total weight.

The air loads are measured in the known manner with flat weights (200 g = 0.441 lb., the lowest) and sliding weights. Figure 2 is a photograph of the balance mounted above the air stream.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

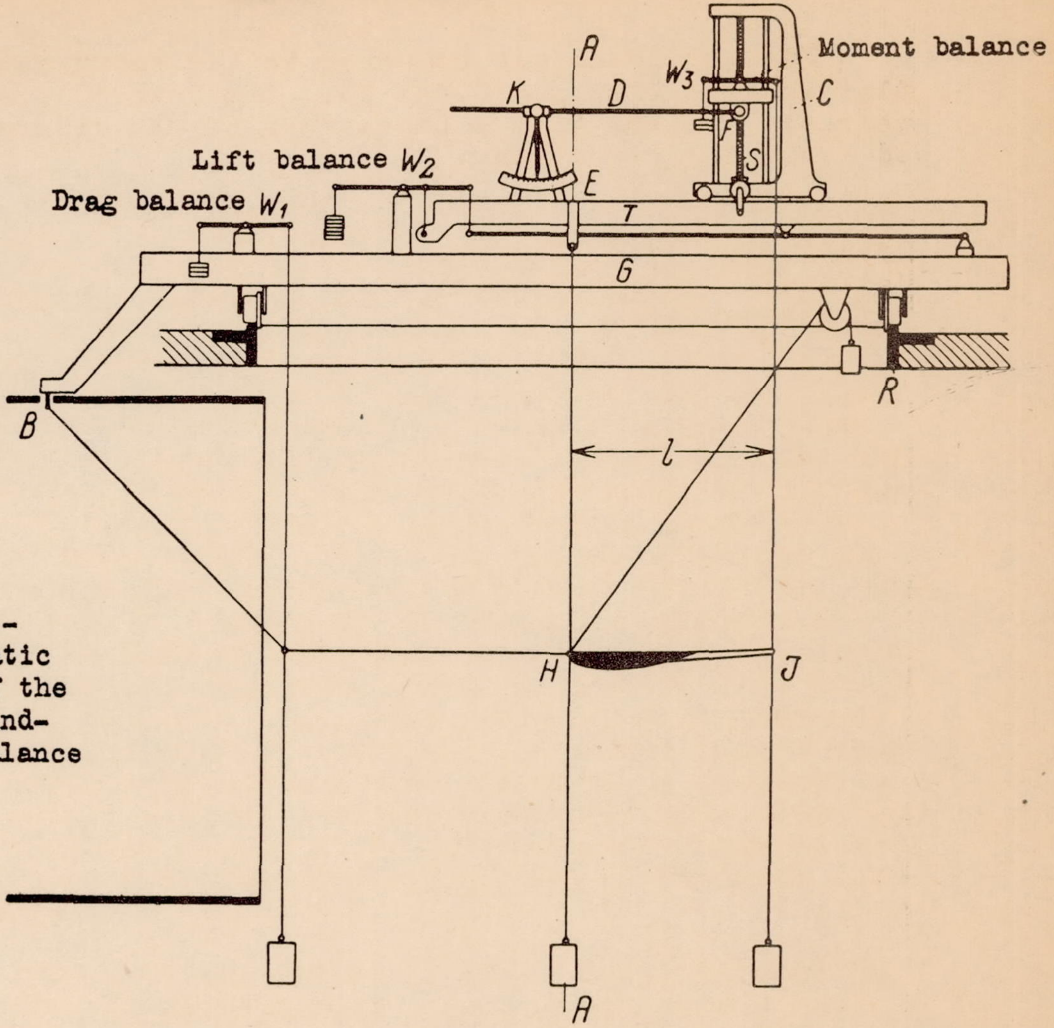

Figure 1.- Diagrammatic sketch of the Aachen wind-tunnel balance

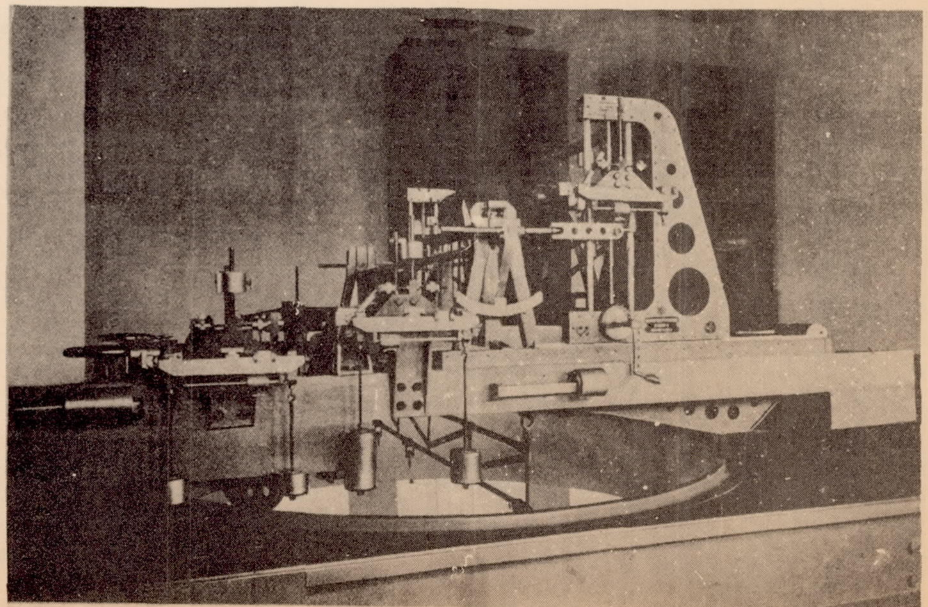

Figure 2.- View of the balance in the wind tunnel