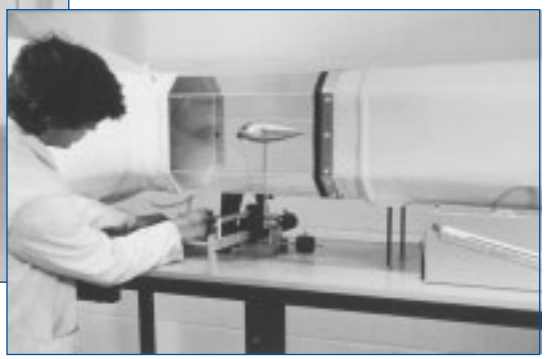
armfield

SUBSONIC WIND TUNNEL

C2
issue 13



The Armfield Wind Tunnel provides a comprehensive facility for the study of subsonic aerodynamics. The performance of the tunnel and its instrumentation also make it suitable for simple research projects.

DEMONSTRATION AND MEASUREMENT CAPABILITIES

A wide range of measurements and demonstrations is possible with the equipment. A selection using the models and instrumentation provided are:

- *investigation of the development of the Boundary Layer on a flat plate by measurement of the total head distribution*
- *flow visualisation studies around an aerofoil*
- *measurement of pressure distribution around an aerofoil at various angles of attack*
- *measurement of pressure distribution around a cylinder*
- *measurement of lift and drag on an aerofoil with leading edge slot and trailing edge flap*
- *velocity and pressure distribution measurements using a Pitot static tube and yaw probe*
- *measurement of drag for a selection of models of different shapes but common equatorial diameter*
- *demonstration of flutter of an aerofoil*
- *calibration of the Wind Tunnel velocity indicator using a Pitot static tube and inclined manometer*
- *investigation of the wake behind a cylinder or aerofoil using a wake survey rake*

Applied Fluid Mechanics

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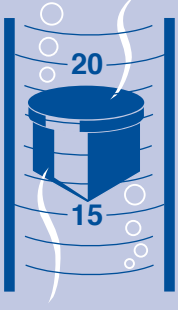


C2-10: Subsonic Wind Tunnel

The Armfield Wind Tunnel is simple and safe in operation. It is supplied as a complete self-contained facility mounted on castors for ease of movement. Main equipment comprises the tunnel with a two-component balance system and an air speed indicator.

Air enters the test section through a carefully designed contraction followed by an aluminium honeycomb flow straightener designed to ensure that the flow is steady in both magnitude and direction and has a flat transverse velocity profile. A low angle diffuser at the outlet end contributes to flow stability in the test section. A five bladed fan is located at the outlet of the diffuser section. The fan is driven by an AC motor supplied from an inverter speed control unit, allowing smooth control of air speed.

The parallel octagonal test section is manufactured from clear acrylic and may be retracted on rails to permit unobstructed access to the models.

The two-component balance consists of a pair of balances supported on knife edges on mutually perpendicular axes parallel to and normal to the axial centre of the tunnel. Lift and drag components of force exerted on the models under test are balanced by sliding weights along the arms of the balance until a state of null deflection is reached. Graduations in units of force allow lift and drag to be read directly. The complete assembly is linked to a simple oil filled damping pot.

Models are mounted on the balance within the working section and a protractor with cursor allows angles of incidence to be changed quickly and accurately while the tunnel is running.

The accuracy of the tunnel and its instrumentation make it suitable for undergraduate and simple research work.

A comprehensive range of accessories is available for use with the tunnel:-

C2-12: Flat Plate and Probe

The flat plate consists of an aerodynamically smooth surface 200mm wide and 302mm long with the leading edge carefully profiled to prevent separation of the boundary layer along the length of the upper test surface. The plate is mounted horizontally in the tunnel across its full width. Traverses of the total head distribution at five separate positions along the length of the plate are made with a capillary bore, stainless steel probe which is mounted on an adjustable micrometer head. The development of the boundary layer may then be reconstructed graphically from total head profiles in a vertical plane at each of the five positions. These measurements of total head are made by connecting plastic tubing from the probe to either the Armfield multi tube manometer, C2-13 or a similar manometer.

C2-13: Multi Tube Manometer

This is an inclinable manometer board equipped with 20 tubes, acrylic manifold and a reservoir mounted on a vertical rod such that the position of the datum manometer tube levels may be adjusted to convenient heights before commencing experiments.

Scale length is 370mm accommodating measurement of pressure up to 290mm water gauge.

This general purpose kerosene manometer is suitable for use with many Armfield model accessories requiring pressure measurement (kerosene supplied).

C2-14: Pressure Wing, Cylinder, Wake Survey, Rake & Flow Visualisation Kit

The wing profile is based on the NACA 0015 aerofoil section with chord length of 100mm. Eleven pressure tappings, all perfectly flush with the wing surface are distributed around the profile and fitted with flexible tube designed to be connected to the multi tube manometer C2-13. All the tubes are housed inside the wing to avoid interference with the air flow.

The wing position can be adjusted and one of the two end plates is graduated so that the angle of attack can be read directly. The wing is also fitted with an acrylic visualisation plate on which a graphite/kerosene mixture can be used to show the lines of flow. A supply of this mixture and other accessories are also provided. An eighteen tube wake survey rake is provided together with a 25mm diameter cylinder so that its wake may be compared with that of the aerofoil.

C2-15: Aerofoil with Slot & Flap

The aerofoil, accurately machined to NACA 0015 profile, is equipped with an adjustable leading edge slot and trailing edge flap.

It has a 63mm chord and a 250mm span. The flap is adjustable in angular deflection and in clearance from the aerofoil.

Experimental results such as lift curve slope (corrected for aspect ratio), maximum lift and maximum drag may be checked against NACA data (NACA details not supplied).

C2-16: Pitot Static Tube

This item is of 4mm diameter stainless steel tube with a collet type mounting chuck to facilitate full traverse across the working section. It is of Prandtl design and may be used with negligible correction up to angles of yaw of at least five degrees. As with the yaw probe, C2-17, this instrument is designed to be used in conjunction with other models where velocity and pressure distributions are of interest. The multi tube manometer C2-13 is used to monitor the pressure readings.

C2-17: Yaw Probe

This item is of 4mm diameter stainless steel tube with a collet type mounting chuck to facilitate full traverse across the working section. It is of the three hole type with centre hole for total pressure determination. It is provided with an aligning block with set screw to permit calibration in the wind tunnel. The multi tube manometer C2-13 is used to monitor the pressure readings.

C2-18: Drag Models

Five models, designed to be mounted in the lift and drag balance and all of the same equatorial diameter, are provided:

- *sphere*
- *hemisphere, convex to airflow direction*
- *hemisphere, concave to airflow direction*
- *circular disk*
- *streamlined shape*

A spare support rod is provided for drag calibration purposes.

C2-19: Pressure Cylinder

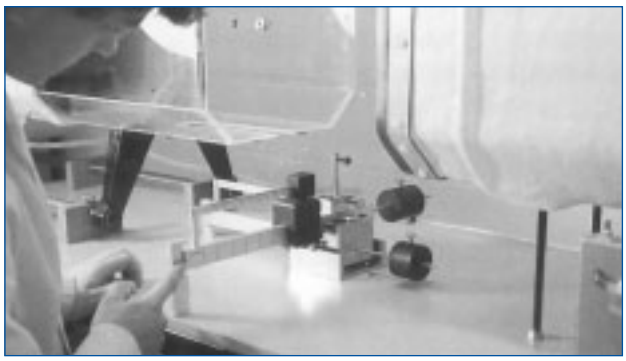
The polished cylinder of 50mm diameter is provided with 19 equi-spaced tapping points around half of the circumference, i.e. at ten degree intervals between 0° and 180° inclusive. The model is designed to be mounted vertically and pressure tapping points taken through the cylinder are connected to a series of flexible tubes suitable for the multi tube manometer (C12-13). The cylinder can be rotated through 180^{0} if it is required to plot the pressure distribution over the whole circumference.

C2-20: Flutter Wing

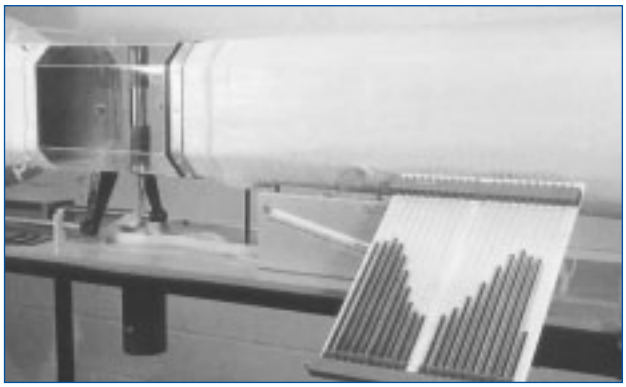
The flutter wing is constructed of solid balsa wood and is a two dimensional symmetrical aerofoil to NACA 0015 specification.

The aerofoil has aluminium end plates and is supported at each corner by two springs. These eight suspension springs simulate the flexural and torsional structural characteristics of a real three dimensional wing.

Angle of attack is adjustable. The flutter air speed may be determined experimentally and the value compared with a calculated one.



Detail of two-component balance system



C2-13 Inclined Multi Tube Manometer in use with C2-19 Pressure Cylinder

ORDERING SPECIFICATION

- *Self-contained wind tunnel for the study of subsonic aerodynamics, complete with two-component balance system and air speed indicator*
- *Special features:*
  - *Contraction and Diffuser: precision glass fibre mouldings*
  - *Test Section: clear acrylic, which retracts to permit access to the models.*
  - *Adjustment of models can be made with the tunnel in operation.*
  - *Fan: Variable speed motor driven unit downstream of the working section permitting stepless control of airspeed between 0 and 26ms^{-1}*
  - *Balance: Lift and drag*
    Lift - 7.0N, Drag - 2.5N, Sensitivity ±0.01N
  - *Air speed: Indicated on inclined manometer directly calibrated in m/s*
  - *Support structure: A strong steel frame including working surface and fitted with castors for easy movement*
- *Suitable for undergraduate and simple research work.*
- *Working section: 304mm wide x 304mm high x 457mm long (octagonal cross- section)*
- *Contraction area ratio: 3:1*
- *Motor rating: 1.5kW*
- *A user instruction manual is supplied*
- *Optional models and instrumentation allow:*
  - *Investigation of the development of the boundary layer on a flat plate by measurement of total head distribution*
  - *Flow visualisation studies around an aerofoil*
  - *Measurement of pressure distribution around an aerofoil at various angles of attack or around a cylinder*
  - *Measurement of lift and drag on an aerofoil with leading edge slot and trailing edge flap*
  - *Velocity and pressure distribution measurements using a pitot static tube and yaw probe*
  - *Measurement of drag for models of different shapes but common equatorial diameter*
  - *Demonstration of flutter of an aerofoil*
  - *Calibration of the wind tunnel velocity indicator using a pitot static tube*
  - *Investigation of the wake behind a cylinder or aerofoil using a wake survey rake*

SERVICES REQUIRED

Electrical Supply:

C2-10-A:	*220/240V/1ph/50Hz*
C2-10-B:	*120V/1ph/60Hz*
C2-10-G:	*220V/1ph/60Hz*

OPTIONAL ACCESSORIES

C2-12:	*Flat plate and probe*
C2-13:	*Multi tube manometer*
C2-14:	*Pressure wing, cylinder, wake survey, rake & flow visualisation kit*
C2-15:	*Aerofoil with slot and flap*
C2-16:	*Pitot static tube*
C2-17:	*Yaw probe*
C2-18:	*Drag models*
C2-19:	*Pressure cylinder*
C2-20:	*Flutter wing*
H14/2:	*Computer Compatible Manometer Bank*

COMPLEMENTARY PRODUCTS

C1:	*Compressible Flow Bench*
C3:	*Multi-pump Test Rig*
C4:	*Multi-purpose Teaching Flume*
C6:	*Fluid Friction Measurements*
C7:	*Pipe Surge and Water Hammer Apparatus*
C9:	*Flow Meter Demonstration Apparatus*
C10:	*Laminar Flow Table*
C11:	*Pipe Network Apparatus*
F6:	*Air Flow Studies*
F14:	*Hydrogen Bubble Flow Visualisation System*

OVERALL DIMENSIONS

Length:	*2.98m*
Width:	*0.8m*
Height:	*1.83m*

SHIPPING SPECIFICATION

Volume:	*4m^3*
Gross weight:	*430kg*

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