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# Abstracts of Papers Published Externally





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# Abstracts of Papers Published Externally

*Reports and Memoranda No. 2916*

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*Note.*—All papers discussed by the Aeronautical Research Council and recommended by them for external publication after 1st April, 1932, have been published in abstract only in the Reports and Memoranda Series.

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# Measurement of Downwash at a Mach Number of 1.45 Behind Two Wings of Finite Span

*By*

W. F. Hilton, Ph.D., A.F.R.Ae.S.

This paper was published in full in the *Journal of the Royal Aeronautical Society*, January, 1951

Measurements were made of the downwash effects behind two finite wings $3\cdot1$ per cent thick, having square and 20 deg raked tips respectively. The tests were conducted at a Mach number of $1\cdot45$ and a Reynolds number of $1\cdot2$ millions by traversing a yawmeter $1\cdot62$ chords behind the trailing edge of the finite wings.

In general, a maximum downwash of the order of $\frac{1}{2}$ deg per degree of wing incidence was observed in that portion of the tip Mach cone behind the wing, and a maximum upwash of similar magnitude was observed in that part of the tip Mach cone situated outboard of the wing.

Thus it is apparent that these effects are large enough to affect the lift on any surface situated in the tip Mach cone behind a finite wing. In particular, placing the rear surface in the downwash region behind a finite wing, will tend to reduce the overall lift while placing it in the upwash region will tend to magnify the variations of lift initiated by the finite wing.

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# On the Conditions under which Energy can be Extracted from an Air Stream by an Oscillating Aerofoil

*By*

N. C. Lambourne, B.Sc.
(of the Aerodynamics Division, N.P.L.)

Published in full in the *Aeronautical Quarterly*, Vol. IV, pp. 54–68, August, 1952

A simple system is considered in which a two-dimensional aerofoil in an air stream performs a coupled oscillation in pitching and vertical translation. An expression for the energy transferred from stream to aerofoil is derived as a function of the frequency parameter, amplitude ratio and phase difference, and the conditions under which positive energy can be extracted from the stream are investigated. The connection between the case of zero energy transfer, and the critical flutter state is noted.

Attention is confined to the incompressible case and diagrams show the results obtained when the air loads are obtained from (i) vortex-sheet theory and (ii) the classical set of constant derivatives.

Vortex-sheet theory leads to the conclusion that, provided the amplitude ratio and phase difference satisfy certain conditions, energy can be extracted from the stream for all values of the frequency parameter. On the other hand, the use of a set of constant derivatives places an upper limit on the values of the frequency parameter for the extraction of energy.

# Note on the Distortion Characteristics of Swept and Cranked Wings in Relation to Flutter and other Aero-elastic Phenomena

*By*

D. WILLIAMS, D.Sc., M.I.Mech.E., A.F.R.Ae.S.

This paper was published in full in the *Journal of the Royal Aeronautical Society,* February, 1951

The calculation of the flutter speeds of new aeroplane types has in the past been simplified considerably by assuming the wings to have a straight flexural axis, which then forms the spanwise co-ordinate axis. Implicit in this assumption is that the bending displacement of such an axis, and the torsional displacement about it, are elastically uncoupled modes of wing displacement. The advent of unorthodox wing plan forms, such as those of swept-back 'cranked' and 'delta' wings, makes the concept of a straight flexural axis somewhat unreal and invites the conclusion that in such cases the notion of a flexural axis has outlived its usefulness.

In considering whether this is a proper conclusion it is necessary to clarify certain points concerning the data at the disposal of the flutter-speed computor. If the wings to be investigated belong to an aeroplane that has already been built, the normal modes can be found from a resonance test, after which two of these modes—usually the fundamental, consisting largely of wing bending, and the first higher mode of a predominantly torsional character—can then be taken as the two degrees of freedom for elastic deformation. The subsequent flutter calculation, which may well take in, as extra degrees of freedom, one or more of the rigid body motions of the aeroplane, requires no further data on the elastic behaviour of the structure, all the necessary elastic coefficients being derived simply from the shapes and frequencies of the two modes, and from the mass distribution over the aeroplane structure.

It is thus seen that, no matter how irregular the plan form of the wings may be, once the resonance modes are known, there is no further real difficulty in incorporating the elastic characteristics of the structure (*i.e.*, wings plus the rest of the aeroplane) in the flutter equations of motion, and it is not necessary to know whether the wings have, or have not, a flexural axis.

If the aeroplane is only in the design stage and has wings of unorthodox plan form, a good estimate cannot easily be made of the frequencies and shapes of the main bending and torsion modes, as can be done for a straight wing with a straight flexural axis: it is likely indeed that every natural mode of the irregular wing will consist of bending and torsion inextricably mixed. The only course open under these conditions is either to calculate the normal modes or obtain them from a resonance test on a scale model of the complete aeroplane. An essential preliminary step before either of these methods can be applied is to represent the actual complex structure by a simplified structure that retains the essential characteristics of the actual structure. It will be understood that a closer approximation to the actual structure is possible when using the model technique, than when purely analytical methods are used.

The process of simplification will usually consist of dividing the structure into a number of box-beams, the characteristics of each of which can be defined in terms of its own individual bending and torsional stiffness and its own shear centre.

Once the important normal modes have been found by either of these methods, the process of deriving the coefficients of the equations of motion follows in much the same way as if they had been directly obtained from a resonance test on the completed aeroplane.

In the light of the foregoing remarks the conclusion tentatively put forward in the first paragraph appears to be justified, in so far, at all events, as convention identifies the flexural axis with the longitudinal co-ordinate axis. It can still be used for defining separately the elastic characteristics of contiguous longitudinal parts of the wing that together make up the span. To that extent, therefore, the notion may usefully be retained.

The paper is concerned with the implications of the foregoing conclusions as they affect unorthdox wing types, particular attention being given to the problem of shear deflections and the parallel, but distinct problem of shear-lag.

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## Manoeuvre Point Properties of the Aero-isoclinic Wing. A Comparative Study of the Manoeuvring Stability of Aircraft with Aero-isoclinic and Conventional Wings

*By*

A. S. Taylor

Published in full in *Aircraft Engineering*, Vol. XXIV, No. 283, pp. 257–262, September, 1952

As part of the Royal Aircraft Establishment's critical study of the aero-isoclinic principle of wing design, a detailed examination was made of high-speed aero-elastic effects on manoeuvre point, with special reference to the effect of rearward movement of local aerodynamic centres at super-critical Mach numbers.

From the results of calculations, using the method of R.A.E. Report No. Aero. 2320, it is concluded that as regards possible shifts of manoeuvre point, the aero-isoclinic wing is generally superior to the conventional wing.

For tailless aircraft, application of the aero-isoclinic principle makes it possible to employ wings of an aspect ratio much larger than is considered practicable with conventional design.

Structural design of a flutter-free aero-isoclinic wing entails radical departures from orthodox procedure, and with tailed aircraft it is therefore probably preferable to adapt the design of the tail plane and its attachment, to cope with the de-stabilizing deformability effects of a conventional wing, than to eradicate such effects at the source by aero-isoclinic design of the wing.

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## A Survey of External and Suppressed Aircraft Aerials for Use in the High Frequency Band

*By*

R. H. J. Cary

Published in full in the *Journal of the Institution of Electrical Engineers*, 25th May, 1951

External wire aerials, which are usually employed at frequencies below 20 Mc/s for radio aids on aircraft, are not preferred on high-speed aircraft because of their drag and general mechanical unsuitability. It becomes necessary to include the aerials within the aircraft skin, when they are usually referred to as suppressed aerials.

In the paper, information on well-known external wire aerials, such as fixed inclined wires (long and short), inverted-L wires, trailing wires and shunt-wire-fed wings, is compared with that obtained with various suppressed aerials. Some of the suppressed aerials have performances which compare favourably with the external wire types and in certain respects have apparently better electrical characteristics. In particular, aerials which are folded or near-end fed, or those which involve an insulated stabilizer unit, have a wide bandwidth and are reasonably efficient. The impedance characteristics of some of the suppressed aerials are such as to make their use suitable where it is required to cover frequencies lower than the h.f. band.

For h.f. suppressed aerials, where the wave-length is comparable to the aircraft dimension, the view is held that an efficient suppressed aerial will require the excitation of either the whole aircraft or a large part of it. Various methods of excitation are discussed and experimental evidence is given. Since the stabilizer is usually the only vertical component, its use is contemplated for vertical polarization: similarly, the wings and horizontal units of the aircraft are considered for horizontal polarization.

Measurements of the electrical characteristics of aircraft aerials present considerable difficulties. They are not often satisfactory on a grounded aircraft, and flights are very uneconomical for preliminary experiments. In order to overcome these difficulties, the method of scaling aerials on scale-model aircraft is widely used to determine the performance of both external and suppressed aerials. Some of the suppressed types of aerial which have shown satisfactory characteristics obtained with the scale models have been installed in aircraft, and successful long-range flights using these aerials in the 2–20 Mc/s communication band have been made.

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## Recent Development in Methods of Strength Testing Pressurized Fuselages

*By*

A. W. HOTSON

This paper was published in full in the *Journal of the Royal Aeronautical Society,* Vol. 55, No. 491, p. 724, November, 1951

The dangers and disadvantages of using air pressure in the strength testing of pressurized fuselages are reviewed. A technique in which water is used instead of air is described, and its advantages considered.

References are made to future test methods, and particularly to the need for the application of pressure combined with aerodynamic and inertia loads.

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## The Round Laminar Jet

*By*

H. B. SQUIRE, M.A., F.R.Ae.S.
of the Aerodynamics Division, N.P.L.

This paper was published in full in the *Quarterly Journal Mech. and Applied Math.,* Vol. 4, part 3, pp. 321–329, 1951

An exact solution of the equations of viscous fluid flow for axi-symmetric motion is derived. It is shown that this corresponds to the round laminar jet, or, alternatively, to the flow produced by the application of a force at a point in a viscous fluid. Some examples of the calculated streamlines are given. The effect of a source of heat at the point of application of the force is also considered.

## A Simplified Method of Measuring Take-off Distances using an F.47 Take-off Camera

*By*

G. C. Abel

This paper was published in full in *Aircraft Engineering*, Vol. XXIV, No. 279, p. 132, May, 1952

The standard method of analysing F.47 take-off camera films, is very laborious. It was developed for use when take-offs were not normally made from runways. Now that most measured take-offs are made from a runway a simpler method of analysis has been introduced. This requires a fixed camera position at a known distance from the centre line of the runway from which the aircraft is taking off. The essential distances for the take-off can then be determined from the azimuth angle on the camera record without measuring the image of the aircraft on the film.

## Pre-tensioning for Preventing Fatigue Failure in Bolts

*By*

W. A. P. Fisher, R. H. Cross and G. M. Norris

Published in full in *Aircraft Engineering*, Vol. XXIV, No. 280, p. 160, June, 1952

The prevention of fatigue failure in bolts by controlled pre-tensioning is investigated theoretically. It is shown that the effect of pre-tension is to reduce the alternating load in the bolt, and that the stiffness of the fitting plays an important part in this reduction. Fatigue tests on $\frac{3}{4}$ in. B.S.F. bolts with various amounts of pre-tension confirm that this reduction in alternating load does prevent fatigue failure. The bolt tension was found by measuring the overall extension of the bolt.

A warning is given against relying on the benefits of pre-tensioning without ensuring that pre-tension is maintained in service.

## Variation in Strength of Nominally Similar Light Alloy Tailplanes

*By*

K. D. Raithby, B.Sc., A.F.R.Ae.S.

Published in full in *Aircraft Engineering*, Vol. XXIV, No. 282, pp. 223–225, August, 1952

The results of destruction tests on several batches of tailplanes of different types are recorded and a brief analysis is given. Owing to limited numbers of test specimens and to the fact that the results are not directly applicable to wing and fuselage structures, general conclusions cannot be drawn. The test results do, however, give an indication of the variation in strength among certain types of nominally similar light alloy structures. The results showed that coefficients of variation ranging from 2 per cent to 6 per cent can be expected. The scatter appears to be rather less for tailplanes whose primary structure is built up from a large number of components than for those whose primary structure is built up from comparatively few components. Failure did not always occur in the same place on a particular structure under given loading conditions.

# A Simple Method of Comparing Manometers

By

J. H. Preston, M.A., Ph.D., A.F.R.Ae.S.
of The Cambridge University Aeronautics Laboratory

This paper was published in full in *Engineering*, pp. 645–646, 23rd November, 1951

It is shown that the simple device of a water-sealed reservoir enables a constant pressure difference to be applied to the manometers under comparison. Effects due to temperature changes in the reservoir and the interaction of the adjustment of one manometer on the indication of the other are negligible compared with the observed effect when a completely closed reservoir is used. Thus the readings of two manometers can be compared to an accuracy which is limited only by the sensitivity of the manometers and the amount of zero creep due to room temperature changes.

A theoretical explanation is given and in particular it is shown that the change of pressure $p$ due to a change in temperature $t$ is given by:—

$$\frac{p}{P_0} = \frac{t}{T_0} \frac{1}{P_0/H_0 g\rho}$$

where $P_0$, $T_0$, $H_0$ are the original pressure, temperature and height of air-space in the reservoir; $g$ is the acceleration due to gravity and $\rho$ is the density of the liquid forming the seal.

Theory suggests and experiment confirms that the best shape of reservoir is one in which the height of air-space is small, but the volume of which is large. The area of the tank forming the water seal should be large compared with the cross section area of the reservoir.

# The Use of a Potential Flow Tank for Testing Axi-symmetric Contraction Shapes suitable for Wind Tunnels

By

A. W. Babister, M.A., W. S. D. Marshall, D.Ae. (Hull), G. M. Lilley, M.Sc.,
E. C. Sills and S. R. Deards

This paper was published in full in the College of Aeronautics Report No. 46, April, 1951

The tests described were in connection with the design of an axi-symmetrical contraction shape for an 8 ft × 6 ft wind tunnel and for a water tunnel, the contraction ratios being approximately 7 : 1.

The tank consisted of a heavy wooden frame (72 in. × 36 in.) with a slate bottom. The inside of the tank was lined with glass, the joints being made watertight with 'Bostik'. The whole assembly was supported on an angle iron cradle which permitted the tank to be tilted through ±7 deg.

To represent axi-symmetric flow the bottom of the potential flow tank was tilted through 5 deg. The depth of electrolyte at any point is then proportional to the distance from the shore line (representing the axis of symmetry), and the distribution of electric potential is the same as that of the velocity potential in the air flow.

The electronic equipment consisted of a bridge and a suitable null indicator. The potential at any point in the tank was determined by comparing it with the known potential difference between the electrodes at the low and high speed ends.

The potential in the electrolyte was found by means of a platinum probe. Two different probes were used, the first attached to a trolley spanning the tank (for exploring the mid-stream potential), the second attached to a metal block for determining the variation of potential along the wall of the contraction.

In setting up the model for testing, a plywood template representing the contraction shape was first mounted in the tank on wooden packing pieces (approx. 2 in. high). The contraction shape was then cast in wax to the template shape. With the high contraction ratios the electrolyte at the high-speed end of the contraction was relatively shallow and special care had to be exercised to minimise experimental errors. It was essential to ensure (i) that both end electrodes were normal to the wall of the contraction and (ii) that there was no leakage or evaporation of the electrolyte.

For the wind-tunnel contraction, the first tests were made on a theoretical infinite axi-symmetric contraction giving a monotonic velocity distribution.

Good agreement was obtained. Small modifications were made to both the high-speed and low-speed ends of the contraction to give a contraction of finite length. For such a contraction the velocity distribution along the wall was no longer monotonic, having a small adverse pressure gradient at the high-speed end (near the working-section).

No modification was made in the shape of the water-tunnel contraction.

The repeatability of any one reading is approximately $\pm$ one per cent. Small errors could arise due to (i) the cutting of the template, (ii) any curvature of the bottom of the tank, and (iii) misalignment of the trolley span. To minimise the error in probe setting the wall probe was adopted. This could be set to $\pm 0 \cdot 02$ in.

The electronic apparatus gave the potential correct to $\pm 0 \cdot 5$ per cent.

The probable error due to all these causes was about $\pm 2$ per cent; suggestions are given for increasing this accuracy.

---

## The Flow past Elliptic-nosed Cylinders and Bodies of Revolution in Supersonic Air-Streams

*By*

D. W. Holder and A. Chinneck
of the Aerodynamics Division, N.P.L.

Published in full in the *Aeronautical Quarterly*, September, 1953

In addition to its practical importance, the study of the motion near the front of a blunt-nosed body held in a supersonic flow is of fundamental interest because it is an example of mixed subsonic and supersonic flow in which the interaction between a shock-wave and a boundary layer is not involved. The present experiments were designed to provide systematic information about this problem for two-dimensional cylinders and bodies with axial symmetry. The nose shapes used were of elliptic cross-section with axis ratios varying from zero (*i.e.*, a square nose) to $8 \cdot 0$; the free-stream Mach numbers of the experiments lay between $1 \cdot 42$ and $1 \cdot 82$. The observations included schlieren photography and measurements of the pressure distribution at the surface.

The measured pressure distributions and positions of the detached bow-waves are found to be in fair agreement with values calculated by a number of methods. The drag coefficients of the slender two-dimensional elliptic noses are considerably higher than those calculated for wedges of the same axis ratio with attached shock-waves, but the drags become almost equal when the axis ratio approaches the value for subsonic flow behind the bow-wave of the wedge. For most axis ratios the drag coefficients of the elliptic-nosed bodies of revolution are lower than those for cones of the same axis ratio.

---

## The Elasticity and Strength of Paper and other Fibrous Materials

*By*

H. L. Cox, M.A., F.R.Ae.S., A.M.I.Mech.E.,

Published in full in the *British Journal of Applied Physics*, Vol. 3, pp. 72–79, March, 1952

An analysis is made of the effect of orientation of the fibres on the stiffness and strength of paper and other fibrous materials. It is shown that these effects may be represented completely by the first few coefficients of the distribution function for the fibres in respect of orientation, the first three Fourier coefficients for a planar matrix and the first fifteen spherical harmonics for a solid medium. For the planar case it is shown that all possible types of elastic behaviour may be represented by composition of four sets of parallel fibres in appropriate ratios. The means of transfer of load from fibre to fibre are considered and it is concluded that the effect of short fibres may be represented merely by use of a reduced value for their modulus of elasticity. The results of the analysis are applied to certain samples of resin bonded fibrous filled materials and moderately good agreement with experimental results is found.

---

## Wave Motion in an Annular Tank

*By*

I. J. Campbell

Published in full in the *Philosophical Magazine*, Serial No. 7, Vol. 44, pp. 845–853, August, 1953

This paper reports a theoretical and experimental investigation of the formation of waves on the surface of water contained in an annular tank, with particular reference to the operation of a water whirling-arm. A water whirling-arm is similar to an air whirling-arm; a model can be suspended by means of a strut, which penetrates the surface of the water, from a rotating arm and can thus be towed in a submerged circular path through the water, which is contained in an annular tank. When this equipment is operated at certain speeds, large wave disturbances are observed to grow up: this is the phenomenon which the present investigation sought to elucidate.

It is demonstrated that the normal modes of wave motion of the water in an annular tank form a double infinite set, some member of which has any integral number of diametrical nodes in combination with any integral number of circumferential nodes. Superposition of a simple mode on itself, with certain appropriate phase changes, produces a travelling wave which presents the surface appearance of the corresponding simple nodal pattern travelling round the tank at a

certain predictable speed. Such a situation clearly offers the possibility of resonance to a strut and model travelling round the tank at this speed. A more elaborate theoretical analysis confirms this intuitive idea. It is thus possible to predict the operating speeds at which large wave disturbances can be expected to grow up and also to predict the surface appearance which these disturbances will present. Experimental observations confirm these predictions.

---

## Integration of the Equations of Transonic Flow in Two Dimensions

*By*

D. Meksyn

Published in full in the *Proceedings of the Royal Society*, A, Vol. 220, pp. 239–254, 10th November, 1953

The equation for the velocity potential $\phi$ of compressible flow is transformed to $\alpha,\beta$ co-ordinates, where $\alpha + i\beta$ is the corresponding complex potential of the incompressible flow; the equation is then integrated on the following assumptions:—

(1) Compressibility in the case of subsonic and transonic flows can be considered as a perturbation effect, and the equation for the velocity potential $\phi$ can be treated as a form of a non-linear Poisson equation.

(2) To a first approximation $\partial\phi/\partial\beta$ is disregarded; $\partial\phi/\partial\alpha$, which appears in the equation multiplied by a rapidly varying function, is taken to be constant in differentiation and integration; $\partial^2\phi/\partial\alpha^2$ and $\partial^2\phi/\partial\beta^2$ are, however, retained in the equation.

The differential equation for the velocity potential $\phi$ is, thus, reduced to Poisson's equation where the right-hand side contains mainly known functions, and it can be integrated by two simple quadratures.

The integration leads to an algebraic equation of the fifth degree in the unknown quantity $\partial\phi/\partial\alpha$, which can thus be evaluated at any given point of the fluid.

The condition for the occurrence of double roots in this equation determines the characteristic Mach number at which, it is assumed, a shock-wave first appears.

The method is applied to the motion past a circular cylinder, and the results are compared with Imai's solution based on Janzen-Rayleigh's method, and with Woods' calculations by the relaxation method.

The agreement is satisfactory in both cases. The Mach number first reaches its characteristic value due to conditions at the point $\theta = \pi/2, \tau = 1$, and is equal to $M_1 = 0 \cdot 414$; the characteristic velocity is $q = 2 \cdot 75$ (corresponding to $q = 2$ for incompressible flow) and the characteristic local Mach number is $M_e = 1 \cdot 29$.

The method is also applied to an aerofoil of thickness 1/10, which consists of two arcs with cusps at the leading and trailing edges; the results obtained are in close agreement with Kaplan's calculations. The characteristic Mach number is $M_1 = 0 \cdot 839$, the increase in the velocity over that of incompressible flow is 32 per cent, and the local characteristic Mach number is $M_e = 1 \cdot 44$.

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