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CONTENTS

(98578) A

Repeated Loading and Fatigue Tests on a D.H. 104 (Dove) Wing and Fin

By

W. A. P. FISHER

This paper was published in full in *Aircraft Engineering*, Vol 22, No. 256, p. 166, June, 1950.

Repeated loading tests on a D.H.104 wing and fin were made by the de Havilland Aircraft Co.

The wing sustained repeated applications of different loadings from zero up to values ranging between $1 \cdot 5g$ and $4 \cdot 37g$.

It afterwards sustained 3 million cycles under $0 \cdot 25g$ alternating load with a mean load of $1g$. Adhesion of the Redux joints was satisfactory.

The fin sustained 60,000 cycles of 33 per cent of the fully factored load and 30 cycles in reversal of $66 \cdot 7$ per cent. Under an alternating load of 10 per cent fully factored load the fin failed after $2 \cdot 3$ million cycles by fracture of a root fitting.

Structures Dept., R.A.E.

19*th January*, 1951.

ARC

Shock-wave and Boundary-layer Phenomena near a Flat Surface

By

A. FAGE, F.R.S. and R. F. SARGENT

This paper was published in full in the *Proceedings of the Royal Society*, A, Volume 190, 1947

Shock-wave and turbulent boundary-layer phenomena near the smooth flat metal floor of a specially designed supersonic tunnel are studied from traverses made with pitot, static pressure and surface tubes and from direct shadow and Topler striation photographs. Near-normal and oblique shock-wave systems, with or without a bifurcated foot, are considered.

A near-normal shock wave and the Mach shock wave of an oblique incident and reflected wave system bifurcate when the strength χ, of the wave above the point of bifurcation attains a definite value. The height of the bifurcated foot and the angle between the two limbs at first increase rapidly with an increase in χ above this value and afterwards much more slowly. The surface pressure rises steeply immediately behind the front limb of a bifurcated foot, whilst the back limb eases the distortion of flow behind. The boundary later thickens rapidly and the surface friction falls steeply to zero in the space between the two limbs. The loss of stagnation pressure, and so the drag, is smaller than that associated with the flow through the main wave. The rise in surface pressure and the thickening of the boundary layer are less severe, and the surface friction does not fall to zero, behind the foot of a wave which is not bifurcated.

A comparison of the properties of a bifurcated shock wave in an infinite inviscid stream with those measured in the tunnel shows that the boundary layer increases the angles ξ_1, ξ_2, (*see* Fig. 3) which the front and back limbs make with the undisturbed stream direction and also the angle of refraction ε_i at the front limb. The increase in ξ_1 and ε_i are associated with the thickening of the boundary layer behind the front limb; whilst the angle $(\xi_2 - \xi_1)$ between the limbs, which is also increased, is dependent on the manner in which the surface layer thickens.

(98578)

Jet Flow and its Effects on Aircraft

By

H. B. Squire, M.A.

This paper was published in full in *Aircraft Engineering*, Vol. XXII, No. 253, March, 1950

The data on round jets in still air and in a general stream are analysed to determine the spread of the jet and the decay of the axial velocity distribution. The temperature distributions for heated jets are treated in the same way. Methods of model test technique for jets and jet aircraft are discussed; it is shown that the jet momentum is the most important quality in the representation of hot jets. Illustrations of the effect of jets on neighbouring surfaces, including the Coanda effect, are given, and finally an examination of the effect of jets on aircraft stability is made.

A Shielded Hot-wire Anemometer for Low Speeds

By

L. F. G. SIMMONS, M.A.

This paper was published in full in the *Journal of Scientific Instruments*, Vol. 26, December, 1949

A low-speed anemometer suitable for speeds within the range 0 to 5 ft/sec is described. The instrument comprises a twin-bore silica tube having an electrically heated wire in one bore and the hot junction of the thermocouple in the other. In an air current the temperature change caused by the loss of heat is registered by the thermocouple and, with the instrument suitably calibrated, the e.m.f. developed serves as a measure of the speed of flow. A portable arrangement of the instrument includes a sensitive galvanometer for indicating the e.m.f.; for measurements requiring greater precision a potentiometer is needed.

ARC 11720

The Economic Value of Increase of Modulus of Elasticity in Aluminium Alloys

By

H. L. Cox, M.A. and Mrs. M. J. Windle, B.Sc.

This paper was published in full in *Aircraft Engineering*, Vol. XXI, No. 250, December, 1949

A comparison is made between normal aluminium alloys and alloys with increased values of the modulus of elasticity for covering the upper surfaces of wings of moderately thick sections, particularly of the smooth wing type. This comparison is intended to form the basis for the design of test panels for experimental verification of the theoretical conclusions.

Comparisons are made between two materials, one having a modulus of 10×10^6 lb/in.^{2} and a $0 \cdot 2$ per cent proof stress of 55,000 lb/in.^{2}, and the other a modulus of 12×10^6 lb/in.^{2} and a $0 \cdot 2$ per cent proof stress of 54,500 lb/in.^{2}, but the material with the higher modulus has a lower proportional limit, and its modulus limit falls below that of the old material at a stress slightly greater than 40,000 lb/in.^{2}. Wing coverings $0 \cdot 080$, $0 \cdot 064$ and $0 \cdot 048$ in. thick, and panel loadings of 4,000 and 6,000 lb/in. are considered for a panel width of 40 in.

At a panel loading of 4,000 lb/in., in comparison with aluminium alloy [having a modulus of 10×10^6 lb/in.^{2}, the aluminium alloy] with a modulus of 12×10^6 lb/in.^{2} should result in a saving of weight of an upper surface wing cover of about 5 per cent. On the other hand, at a panel loading of 6,000 lb/in., the aluminium alloy with a modulus of 12×10^6 lb/in.^{2} results in a weight about 1 per cent greater than the weight with the ordinary material. These results are for a sheet thickness of $0 \cdot 080$ in. for the material of modulus 10×10^6 lb/in.^{2}, and a sheet thickness of $0 \cdot 064$ in. for the new material, so that the shear stiffnesses of the two designs are roughly equal.

It is emphasised that the comparisons made relate to cases where the design is limited by the liability of the structure to buckle under compression. In cases where stiffness itself may be the chief criterion of design, the advantage conferred by increase of modulus is of course much greater.

ARC 10774.

Notes on the Opening Behaviour and the Opening Forces of Parachutes

By

F. O'HARA

This paper was published in full in the *Journal of the Royal Aeronautical Society*, Vol. 53, No. 467, November, 1949

An approximate theory of parachute opening is suggested. A formula is derived from the critical opening speed (the highest speed at which the canopy develops fully) which indicates variation of the critical speed with fabric porosity, rigging line length and so forth, of the order observed in wind tunnel tests. Assuming a simple form for the air flow about the parachute, a formula is obtained also for the rate of opening of a canopy. This enables an analysis to be made of the motion of a store-parachute system during canopy development. The theory confirms the possibility, found experimentally, of a large increase with altitude in the maximum parachute force on the store.

The Application of Mellin Transforms to the Summation of Slowly Convergent Series

By

G. G. MACFARLANE

This paper was published in full in the *Philisophical Magazine*, Ser. 7, Vol. XI, p. 188, February, 1949

The author discusses a method which is particularly useful for the summing of series of the form

$$\sum_{0}^{\infty} f\left[(n + a)^{\nu}\right].$$

It depends on properties of the Mellin transform pair.

(1) $$F(s) = \int_{0}^{\infty} f(x)\, x^{S-1}\, dx,$$

(2) $$f(x) = (2\pi i)^{-1} \int_{\sigma - i\infty}^{\sigma + i\infty} F(s)\, x^{-S} ds,\ \sigma_1 < \sigma < \sigma_2 .$$

If $f(x)$ is sufficiently well behaved for (1) and (2) to hold and the following interchange of sum and integral is permissible, x can be replaced by $n + a$, in (2), where n is an integer, to give

$$f(n + a) = (2\pi i)^{-1} \int_{\sigma - i\infty}^{\sigma + i\infty} F(s)\, (n + a)^{-S} ds$$

and hence

$$\sum_{0}^{\infty} f(n + a) = (2\pi i)^{-1} \int_{\sigma - i\infty}^{\sigma + i\infty} F(s) S(s, a)\, ds, \quad (\sigma_1 < \sigma < \sigma_2) ,$$

where

$$\xi\,(s, a) = \sum_{0}^{\infty} (n + a)^{-S},\ Res > 1 ,$$

is the generalized Riemann zeta function.

It is often possible to evaluate the integral in equation (3) to get a new expression for the sum.

The author considers three examples of this procedure; first the well-known sum

$$\sum_{n=1}^{\infty} \cos (ns)/n^2$$

is treated.

Next the very slowly converge series

$$\sum_{n=0}^{\infty} (-)^2 (2n+1)^{-1} J_1 [(2n+1)y].$$

is shown to be equal to the series

$$-\sum_{n=0}^{\infty} \frac{(-)^2}{2} \frac{B_{2n+1}(\frac{1}{4})(2y)^{2n+1}}{(2n+1)\,\Gamma(n+1)\,\Gamma(n+2)},$$

which is rapidly convergent for $y < 1$.

The final example is

$$\sum_{m=1}^{M} (1 - xm^{2/3})^{1/2}/m^{2/3},$$

where M is the largest integer such that $xM^{2/3} < 1$. In this case we get an asymptotic series for small x, that is M large.

The paper ends with a table of 72 Mellin transforms.

11860

A Note on the Time required to make a Level Speed Measurement with a Turbine-Jet Aircraft

By

K. J. Lush, B.Sc., D.I.C.

This paper was published in full in the *Journal of the Royal Aeronautical Society*, No. 478, Vol. 54, October, 1950

It was desired to confirm quantitatively pilots' impressions that on turbine-jet aircraft in the region of 40,000 ft the level speed stabilised very slowly.

The time required to make a conventional level speed measurement has been examined, for a representative turbine-jet aircraft, over a wide range of air speed and height. The results are compared with those for a typical piston-engined aircraft and their implications discussed.

It is concluded that the time required to make a conventional speed measurement increases rapidly with height, in the absence of compressibility effects on drag, and is about five times as great at 40,000 ft as at sea level. It is inconveniently large at high altitude and level speed measurements there will require very long runs, unless it is arranged that each run is started at an air speed near the steady level speed.

This increase will be present in most level speed tests, expecially those in the region of the best speed for range. In maximum level speed measurements, however, compressibility effects may be present and the air speed may then be expected to settle down quickly.

The need for long runs at high altitude is not peculiar to jet aircraft, but has come into prominence concurrently with them.

12269

A Note on Repeated Loading Tests on Components and Complete Structures

By

H. L. Cox and E. P. Coleman

This paper was published in full in the *Journal of the Royal Aeronautical Society,* Vol. 54, p. 1, January, 1950

The paper describes a method for carrying out repeated loading tests and illustrates several applications of the method. A slipping clutch between the driver and the driven member is used to permit the driver to run up to the resonant speed of the unit under test. At or near resonance clutch slip ceases, when the amplitude of oscillation of the driven member at the point of drive is maintained constant and equal to the amplitude determined by the mechanical drive unit. Within a range of speed determined by the tightness of the clutch setting variation of input to the driver has no effect on amplitude of the driven member, because that can vary only when the clutch slips.

The new method proves particularly applicable to the repeated loading of complete structures and components because it is readily adaptable to parts of awkward shapes loaded in special ways. Moreover, application of the method is not seriously restricted by large strains of the component under test nor by moderately heavy absorption of energy by the component. Four applications of the method to structures are instanced, and the development of fatigue testing machines working on the same principle is adumbrated.

11726

Longitudinal Stability, Speed and Height

An Examination of Dynamic Longitudinal Stability in Level Flight, Including the Effects of Compressibility and Changes in Atmospheric Phenomena with Height

By

S. NEUMARK, TECHN. SC.D., A.F.R.AE.S., A.F.I.AE.S.

This paper was published in full in *Aircraft Engineering*, Vol. XXII, No. 261, pp. 323–334, November, 1950

In high-speed level flight in the compressibility region an entirely new factor makes its appearance, viz., small variations of atmospheric density and speed of sound with height. This factor affects dynamic stability due to continuous changes of height during longitudinal disturbances; there is no effect in lateral disturbances. The effects are very small in low-speed flight but they increase steadily with Mach number. The short-period oscillations are not affected but the corrections to phugoid motion become appreciable in high subcritical flight, larger in supercritical (transonic) range, and very important in supersonic flight. The effects of compressibility are of paramount significance but they should be considered in conjunction with varying height effects. Another result of the investigation is the appearance of a new mode of disturbance, due to the stability quartic being converted into a quintic. The fifth (real) root is often small, it may vary in sign according to aerodynamic properties of the aircraft and characteristics of the power unit. The new mode is a subsidence or a divergence, and it determines height stability or instability, hence it may show to what extent an aircraft is able to keep constant altitude over long stretches of time.

Some Developments of Expansion Methods for Solving the Flutter Equations

By

J. WILLIAMS, M.Sc.

This paper was published in full in the *Aeronautical Quarterly*, Vol. II, November, 1950, pp. 209–225

In a theoretical flutter analysis, the real zeros $x < 0$, $y > 0$, of a stability determinant $\Delta(\sqrt{x}, y)$ which is a polynomial in y are required, and can readily be evaluated once the polynomial expansions are known for assigned values of x. When the air loads are estimated on the basis of classical derivative theory, Δ becomes a bivariate polynomial in $\sqrt{x}$ and y of a special type. Direct expansion of the stability determinant becomes too involved when the number of degrees of freedom is large and indirect methods of expansion are needed.

A method of bivariate expansion which uses a framework of lines subject to certain restrictions is examined in Part I, and is applied to a quaternary wing-flutter problem. The analysis shows that frameworks previously proposed, having all intersections outside the flutter quadrant ($x < 0$, $y > 0$), demand very high computational accuracy. A new framework is suggested having all intersections inside the flutter quadrant. The improvement in computational accuracy is considerable.

In Part II, methods for the univariate expansion of Δ with x assigned are briefly discussed, and some methods of bivariate expansion are given which provide useful alternatives to the framework method.

The Reheat Factor in Turbines and Turbo-compressors

By

J. Kestin, Ph.D., D.I.C., A.M.I.Mech.E.,
Polish University College, London

This paper was published in full in *Aircraft Engineering*, Vol. XXII, No. 262, December, 1950 pp. 361–367

The paper contains an analysis of the factors which influence the value of the reheat factor in gas turbines and turbocompressors. The first part deals with the known methods of calculating reheat factors for turbines with an infinite number of stages of equal efficiency. The differential equation obtained from first principles is integrated explicitly under the assumption of constant specific heats and numerically for variable specific heats. In the latter case curves are given for air, and it is shown that for comparatively rich combustion gases the deviation from the air standard cycle in the value of the reheat factor is small. The working fluid is assumed to be a perfect gas, hence only the dependence of the specific heats on temperature is taken into account. Values for the various thermodynamic functions were taken from the "Gas Tables" by J. H. Keenan and J. Kaye.

The second part repeats the calculations for the case of a turbo-compressor under identical assumptions. It is shown that the assumption of constant specific heats adequately covers the range of calculations encountered in practice.

In the third part formulae are derived for a turbine and turbocompressor having a finite number of stages, with the working fluid treated as a perfect gas with constant specific heats and for equal isentropic stage efficiencies and equal pressure ratios across all stages. A rigorous formula is derived and compared with the approximate formula quoted by Kearton. A similar rigorous and approximate formula is given for a turbocompressor.

Results of calculations are presented in the form of graphs and it is shown that values of the heat recovery factors in the case of turbines depend almost linearly on the stage efficiency, whereas the heat loss factor for compressors is linearly dependent on the reciprocal of stage efficiency.

For turbine calculations with variable specific heats it is suggested to use the curves for an infinite number of stages and to correct them for a finite number of stages in the same way as deduced earlier for the case of constant specific heats.

The Steady Circulatory Flow about a Circular Cylinder with Uniformly Distributed Suction at the Surface

By

J. H. PRESTON, M.A., Ph.D., A.F.R.AE.S.
(AERONAUTICS LABORATORY, CAMBRIDGE UNIVERSITY.)

This paper was published in the *Aeronautical Quarterly,* Vol. I, February, 1950

Exact solutions for the steady circulatory flow about a circular cylinder with suction applied at its surface have been obtained for the following cases :—

(a) The cylinder at rest and a circulation at infinity.

(b) The cylinder rotating and zero circulation at infinity.

(c) The cylinder rotating in either direction with a circulation at infinity.

Provided that, in general, the suction velocity is greater than a certain limiting value.

An exact solution can still be obtained when any of the above circulatory motions is combined with a uniform stream parallel to the cylinder axis.

The analysis throughout is simple and expressions are obtained for the velocity distribution, the stresses, the vorticity and the torque, and so on.

For high rates of suction flow, the flows exhibit the characteristics of boundary layer flows, in that the vorticity is confined to a narrow annulus enveloping the cylinder and the velocity distribution near the wall tends to the well-known asymptotic distribution of Griffith and Meredith.

Case (a) represents a type of flow obtainable by withdrawing a Thwaites flap and reducing the forward speed of the cylinder to zero. It is concluded that a wing employing this device should retain its lift indefinitely, when the flap is withdrawn.

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