AIRCRAFT DYNAMICS

Scheme of Notation

from a Correspondent

THE basic equations of aircraft dynamics are those of classical mechanics, with the elaboration that the forces and moments of aerodynamic origin are themselves influenced by the motions which occur. Aeronautical engineers are greatly addicted to dimensionless expressions because, when used with discernment, they often render generalities more apparent, increase the clarity of the work and yield succinct results. The equations of motion of an aircraft, together with appropriate systems of symbols, have therefore been the subject of much dimensionless invention for more than half a century.

The most familiar system in the United Kingdom has been that of Bryant and Gates (Aeronautical Research Council Reports and Memoranda (R&M) No. 1801 ; 1937) which separately defined dimensionless aerodynamic derivatives and inertial parameters. In the United States, a somewhat different system with broadly the same intentions was adopted. There have also been sundry variations on these themes and—to borrow a felicitous phrase from the latest number in the R&M series—the "clash of symbols" has been considerable. Moreover, the pre-war systems were devised largely in the context of small perturbations from a simple undisturbed condition, using only first-order derivatives. The behaviour of modern aeroplanes and the increasing importance of cross-coupling effects, the demands of aeronautical engineers concerned with missiles and the use of computers has rendered such systems inadequate.

R&M 3562 (H. R. Hopkin, *A Scheme of Notation and Nomenclature for Aircraft Dynamics and Associated Aerodynamics,* Parts 1 to 5, HMSO, 1970, £6.75) proposes a unified system of notation and nomenclature for the study of aircraft dynamics which seeks to avoid the limitations of the earlier systems, to be more self-consistent and to be capable of further expansion. It is the product of some years of discussion at the Royal Aircraft Establishment in cooperation with the National Physical Laboratory and is a most comprehensive and closely argued work. In the course of explaining the basis of the new system, it presents a useful survey of the whole of the fundamental concepts and definitions used in the field. The geometry associated with aircraft attitude, incidence and axis systems is presented in detail, although the quality of the diagrams is no more than adequate—rather better ones are provided in the Engineering Sciences Data Unit (ESDU) Data Sheets published by the Royal Aeronautical Society. The basis of the system is, inevitably, somewhat similar to that of R&M 1801 save that it has been recognized that it is preferable, in defining "normalized" or non-dimensional quantities, to treat the aerodynamic data and the equations of motion in slightly different ways. The dynamic-normalized system is intended for investigations of the dynamic behaviour of an aircraft of certain mass acted on by aerodynamic and other forces when travelling at a certain speed. The aero-normalized system is convenient for expressing functions of the aerodynamic forces acting on an object of certain dimensions when it is in a stream of air moving at a certain speed. An important change, compared with the previous British system, is that the unit of force is now the datum dynamic head multiplied by an area, as opposed to twice this quantity. The characteristic lengths are now the mean aerodynamic chord for longitudinal quantities and the span for lateral quantities. The new aero-normalized derivatives are therefore similar to the "old" derivatives (and are denoted by similar symbols) but differ, in some cases, by factors which may involve powers of two and ratios such as the mean aerodynamic chord of the tail moment arm. "Concise" derivatives are introduced, obtained by dividing a derivative by the appropriate inertial quantity and incorporating a sign change so that most derivatives become positive (for example, $m_q = -M_q / I_y$). The system is then arranged so that the equations of motion have the same form whether they are dimensional or non-dimensional. The precise significance of a symbol can, if necessary, be made explicit by a suitable "dressing", but in most cases the context will be such that the dressings can be omitted, as has mostly been done in the ESDU Data Sheets. As Hopkin observes, however, "the undressing of symbols should be discreet". In the absence of dressings, the symbols will look very similar to those of the older system although their numerical values, signs and non-dimensionalizing factors will usually be different. Until the new system has gained general acceptance, authors should be careful to explain exactly how they are using it.

The Engineering Sciences Data Unit has already issued several Data Sheets on Aeronautical Dynamics using this system, and it seems that it will have the blessing of the International Organization for Standardization.

Understanding the Origin of Petroleum

FATTY acids have long been regarded as possible predecessors of n-paraffins in petroleum. Some years ago Jurg and Eisma (*Science*, **144**, 1451; 1966) heated behenic acid ($C_{21}H_{43}COOH$) with kaolinite and with kaolinite and water for varying lengths of time and produced small amounts of n-paraffins—principally $C_{21}H_{44}$—and unsaturated hydrocarbons and fatty acids. In next Monday's *Nature Physical Science* Shimoyama and Johns describe an experiment in which they heated the same fatty acid in the presence of Ca-montmorillonite.

The chief product was insoluble material deposited on the clay which they describe as kerogen-like. As in Jurg and Eisma's experiments the chief n-paraffin product was $C_{21}H_{44}$, formed by decarboxylation of the fatty acid. Smaller quantities of n-paraffins down to C_{16} were determined, and generally smaller amounts of n-paraffins in the C_{22} to C_{28} range. No fatty acids were detected in the products in contrast to Jurg and Eisma's findings and also to expectations based on their proposed reaction scheme. Failure to find new fatty acids may result from the use of Ca-montmorillonite instead of kaolinite or such acids, although formed, may have lost their identities by firm attachment to the kerogen-like product.

The production of $C_{21}H_{44}$ seems to have been halted by poisoning of the clay catalyst by the kerogen-like material. Shimoyama and Johns conclude that the C_{16} and C_{17} n-paraffins are produced by breakdown of the C_{21} paraffin, whereas C_{18}, C_{19} and C_{20} develop in the early stages directly from the fatty acid and later by disruption of $C_{21}H_{44}$. Composite plots of amounts of individual n-paraffins and behenic acid against time show the braided form suggested by Hobson (*Earth Sci. Rev.*, **2**, 257; 1966) for a breakdown sequence $A \rightarrow B \rightarrow C$ . . . . The dual origin of C_{18}, C_{19} and C_{20} yields hybrid curves.

With increasing age and maturity the larger n-paraffins in sedimentary rocks show a decrease in their carbon-preference indices, a measure of odd-carbon number dominance in the distribution of the molecules. Shimoyama and Johns's data for the C_{16} to C_{20} range show a comparable decrease with increase in time of heating and increase in temperature. But limited data on the C_{22} to C_{28} range show even-carbon number dominance, an unusual condition. Kvenvolden and Weiser (*Geochim. Cosmochim. Acta*, **31**, 1281; 1967) have noted a crude oil in which there is even-carbon number dominance in the C_{20} to C_{26} range and odd-carbon number dominance in the C_{27} to C_{33} range.

Tentative calculations based on the experimental data suggest the attainment of "mature" n-paraffin distributions under conditions approaching geological requirements of time and temperature.