those in low-speed flow. At high speeds, but not at low speeds, significant temperature and density fluctuations occur, and at first sight it would appear that they must completely alter the nature of the flow. However, it can be argued that the velocity fluctuations are to some extent independent of the thermal effects, and many of the overall characteristics of supersonic turbulent boundary layers are sufficiently similar to the corresponding ones in low-speed flow to encourage the view that there is a fundamental similarity in the underlying processes of energy exchange between the mean motion and the turbulent eddies, at least up to moderate supersonic speeds. The energy radiated to the free stream, discussed above, may not play a very big part in the overall energy balance.

A disturbing feature that has been noticed in tests of supposedly two-dimensional turbulent boundary layers is the presence of three-dimensional effects. Such characteristics as the boundary-layer thickness have been found to be non-uniform for the boundary layer on a flat plate along lines across the plate perpendicular to the flow. These effects are not to be traced to any small imperfections in the leading edge of the plate, but they seem to depend on the condition fo the screens in the settling chamber of the tunnel. It has been shown that characteristics such as the frictional drag, as calculated from the rate of growth of the boundary layer, are considerably affected by taking into account the spanwise variations.

Spanwise variations of a somewhat similar kind have been observed in regions where a laminar boundary layer re-attaches itself to a surface downstream of a region of separation. Liquid which, after being smeared on to the surface, evaporates most rapidly from regions where the skin friction is highest, reveals a streaky pattern with streaks parallel to the flow. This is suggestive of a number of parallel vortices in the boundary layer, with their axes in the direction of the stream. Such vortices are formed when a fluid flows over a concave surface, as has been known for a long time. The laminar boundary layer on such a surface is unstable because if a relatively fast-moving particle of fluid gets displaced nearer to the surface, where the general speed of the fluid is less, it comes into a region where its centrifugal force exceeds the restoring force exerted by the local pressure field, which is such as to balance the local, smaller, centrifugal forces. Thus the motion is unstable, and pairs of counter-rotating vortices result. It would seem at first sight reasonable to expect a similar instability in a re-attachment region, where the streamlines tend to be concave even when the solid surface is flat. However, it was found that the streaky pattern persisted even when the surface on which the re-attachment occurred was made convex. This would presumably damp out any instability of the concave-surface type, so the cause of the streaky patterns remains at present a mystery.

Many other topics were considered at the meeting, but there is no space to describe them here. It will already be evident, however, how abundantly fruitful has proved the concept of the boundary layer, first thought of by Prandtl more than fifty years ago, in 1904. In the decade following that year scientific papers on boundary layers appeared at the rate of about one a year. The current rate has been estimated to be about 160 a year, and this rate is still increasing. Despite all this effort, we are still a long way from understanding many boundary-layer phenomena. The attempt to solve these problems is one of the most interesting tasks of present-day aerodynamics, a task which is likely to take at least another fifty years to complete.

G. E. Gadd

THE BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

The British Leather Manufacturers' Research Association held its fortieth annual open days during May 3–5 at Milton Park, Egham, the Surrey mansion where the laboratories of the Association have been established for the past ten years. More than four hundred visitors attended, mostly from the industry, but including representatives of university departments, research associations, government departments and other bodies.

The Association, which was one of the earliest to be established under the Department of Scientific and Industrial Research scheme for co-operative research in industry, has an income of £65,000 p.a., and applies its effort in roughly equal proportions to background research, technological investigations and member services. Studies of the composition of skin have been maintained since Dr. Joane H. Bowes, the Association's chief biochemist, worked out the overall amino-acid composition of collagen some fifteen years ago; in this year's exhibition the decrease with increasing age of the animal in the proportions of serum and other non-collagenous proteins in the skin was shown. The Biochemistry Department is making a fundamental investigation (sponsored by the U.S. Department of Agriculture) on the mechanisms of the deterioration of leather by various agencies such as heat, moisture and perspiration. A survey of the rates of deterioration of different kinds of leather was shown, together with an exhibit of the more fundamental aspects of the work, which involve the use of continuous paper electrophoresis and liquid-phase chromatography, to identify the breakdown products of the protein fibres and the tanning agents, and the use of isotopic labelling, to follow the movement of tanning agents out of the protein phase.

In the Physics Department, under Dr. R. G. Mitton, work on waterproofing of leather was shown. While the intrinsic water-resistance of leather is adequate for many purposes, there are increasing demands for special leathers with improved performance. Results obtained with a variety of treatments designed to improve water-resistance without reducing the porosity of leather were shown. An important objective of the work of the Physics Department is to devise laboratory tests for assessing the complex physical properties of leather in its many uses; a number of test machines constructed

in the Association's laboratories were exhibited. Performance trials under controlled conditions also prove valuable. Studies of the mechanical properties of collagen and leather fibres were also displayed. The properties of leather depend on those of its constituent fibres and on their mode of interweaving. An electrobalance for weighing very small fibres and an extensiometer for determining their stress/strain relation in different controlled atmospheres have been constructed at Milton Park for this work.

The Biology Department, under Dr. Mary Dempsey, is pre-eminent in the study of the fibre structure of skin; one of the items on show was the album of photomicrographs ("Hides, Skins and Leather under the Microscope"), published by the Association, which has had a wide circulation among investigators in other fields concerned with the structure of animal skins. Other exhibits showed the influence of abnormal skin conditions such as mycotic dermatitis, hyperpigmentation and melanomia, on the resulting leather.

In the Chemistry Department, under Dr. D. E. Hathway, exhibits summarized the work done during the past five years, which has contributed substantially to the understanding of biogenesis and structure of the condensed and the hydrolysable groups of natural organic tannins; the aromatization of glucose yields gallic acid and other phenolics (including ellagic acid formed by oxidation of gallic); these by esterification with glucose form the hydrolysable tannins, which are converted to condensed tannins by oxidation in the plant. A variety of non-tannin extractives from trees were also shown, for example, taxifolin and dihydropiceatannol from barks of native conifers (supplied by the Forestry Commission) and hydroxystilbenes from the heartwood of *Eucalyptus redunca*. The Chemistry Department is also responsible for work on leather dyeing, and has developed the application to leather of the 'Procion' range of dyestuffs introduced a few years ago by Imperial Chemical Industries, Ltd. These dyes combine with the substrate by a covalent link giving improved fastness in comparison with other types of dye, which in general become attached by less-specific links. The use of a resist, of the same chemical type, to modify the fixation of 'Procion' dyes on leather, was also shown. This material, now manufactured by Imperial Chemical Industries, Ltd., under the designation 'Lissatan *PR*', was first prepared in the Association's laboratories.

Enzyme treatments have been used by the leather industry for many years for softening skins before tanning, and proteolytic enzymes have been used to a very limited extent for loosening hair in the pre-tanning treatments. Mr. K. G. E. Wyatt demonstrated current work by the Association on the proteolytic treatment which, if it can be made practicable for full-scale operation, will have several operational advantages over the customary treatment with milk of lime and sodium sulphide, for hair-loosening. In the Chemical Engineering Department, under Dr. F. E. Humphreys, investigations on drying leather were displayed. The best drying conditions (air temperature, humidity and flow-rate) for combining fuel-economy and satisfactory leather characteristics have been worked out for the more important types of leather, and a simple drying tunnel with air re-circulation, suitable for most kinds of leather, has been devised. In many of the processes of leather manufacture, accurate control of simple physico-chemical factors such as *p*H value, electrolyte concentration and temperature is desirable and the Department is studying methods for making the necessary measurements inside revolving drums; continuous determination of *p*H value of the liquid in a drum was demonstrated.

Following Procter's application of the Gibbs–Donnan theory of membrane equilibrium to the gelatin/acid system, much work has been done by the Association and in other laboratories on the swelling of collagen in water mostly by acid or alkali, but the addition of any electrolyte, one ion of which can be fixed or adsorbed in the collagen phase, will set up a membrane equilibrium or modify an existing one. An application of this was shown by Mr. E. F. Nattrass in the use of a polymeric phosphate, the anion of which combines with collagen, to control the swelling in acid pre-tanning treatment, so that the maximum practicable leather thickness is obtained; but the swelling is kept below the level at which practical difficulties, such as retarded absorption of tanning agent, would occur. K. W. PEPPER

REACTOR FUEL ELEMENT TECHNOLOGY

A COURSE of ten lectures in reactor fuel element technology was given in the Department of Chemical Engineering at the Imperial College of Science and Technology, London, during February and March. The lecture series, which formed part of the postgraduate diploma course in nuclear technology (chemical), was designed to lay emphasis on the industrial problems of reactor fuel element technology and to appeal to scientists and technologists interested in the metallurgical aspects of nuclear power development. All the lecturers, who were from the United Kingdom Atomic Energy Authority, were specialists in their subjects and spoke from personal experience about the problems inherent in fuel element manufacture.

The course was arranged by the reader in nuclear technology (Mr. G. R. Hall) in collaboration with Mr. L. Grainger, chief metallurgist at the Atomic Energy Research Establishment, Harwell.

Mr. Grainger gave the introductory and concluding lectures. He described various types of reactor fuel element, the qualitative requirements of a satisfactory fuel element, and future developments in fuel element design and fabrication. In Mr. Grainger's opinion, progress in fuel element performance was now the most vital factor in the economic utilization of nuclear power; experimental irradiations would determine the rate of advance for some years to come.

Dr. J. F. M. Bishop, deputy head of laboratories at Springfields, discussed the theoretical evaluation of a fuel element. He outlined the general methods of procedure, illustrated by examples, and described the effects of irradiation and other factors which require consideration. The first stage in the evaluation of a fuel element is to see if it will endure for the proposed charge life under the conditions of stress and temperature imposed. If so, the effects of