The modification of mechanical behaviour by ordering of the atomic distribution in a solid solution has proved to be unexpectedly subtle; the design of superalloys for use in the hot components of gas turbines has depended on the presence of a coherent ordered precipitate γ′, the properties of which depend on the precise mismatch between the lattice parameters of matrix and precipitate. All this was discussed in detail at Bolton Landing, and so were current ideas about the nature of the forces that cause solid solutions to become ordered.

P. C. Clapp (Kennecott Copper Corp.) examined theoretically the validity of the "quasi-chemical" approach to ordering theory: since the classical paper by Bragg and Williams, the formation of order in alloys has been analysed in terms of interaction energies between nearest neighbours. This approach is still useful but will not cover all situations: elastic strains resulting from atomic size disparities, and collective electron energy calculations resulting from changes in shape of Brillouin zones on ordering must also be taken into account.

Several contributions were concerned with the atomic movements involved in the ordering process. Beeler presented the results of some interesting computer simulation experiments, which showed, *inter alia*, that a vacancy migrates in a peculiar pattern; it stays in one locality—effectively a microdomain—principally in a tight cluster, then streaks off to a new ordered nucleus. This study linked with a useful survey by Gupta and Lieberman of the diffusional behaviour of orderly alloys above and below their critical temperatures. U. S. Arunachalam (National Aeronautical Laboratory, Bangalore) and R. W. Cahn (University of Sussex) reported a study of the influence of small stresses applied during anneal on the distribution of domain orientations in an alloy, CuAu, which forms a non-cubic superlattice. An excellent Russian paper from Sverdlovsk, presented (as so often) *in absentia*, also reported on the ordering mechanism in CuAu studied by electron microscopy.

The rest of the conference was devoted to mechanical properties of alloys with superlattices; several papers had a pronounced practical bias. P. R. Strutt (University of Connecticut) and R. A. Dodd (University of Wisconsin) and N. S. Stoloff (Rensselaer Polytechnic Institute) and I. L. Dillamore (BISRA, Sheffield) surveyed the influence of atomic ordering respectively on creep and on fracture strength and ductility (substantial in some alloys). Whereas the influence of order on creep is not substantial in a homogeneous alloy, the situation can be very different in a two-phase material. Several papers dealt with the structure and behaviour of "superalloys", which usually consist of a disordered face-centred cubic γ matrix coherent with and strained by a slightly misfitting ordered γ′ phase. R. G. Davies and T. L. Johnston (Ford Scientific Laboratory) described the design of a superalloy to meet a specific performance criterion. This involved careful control of the magnitude of the lattice misfit by appropriate ternary alloying. Davies and Johnston were candid about the problems involved in compromising mutually conflicting requirements: thus lowering chromium content to improve creep resistance sharply impaired corrosion stability. Hamm reported a quantitative theory of the creep resistance of γ/γ′ alloys which satisfied Davies and Johnston's preferred criterion, that is, "no parameter mismatch of the two phases". H. Gleiter (Harvard University) presented an ingenious experimental measurement of the variation of antiphase domain boundary energy for small ordered particles as their size is decreased, and H. Warlimont (Max Planck Institute, Stuttgart) and others presented a controversial model for certain alloys in the Fe/Al, Cu/Al and Cu/Zn systems which appear to consist of a stable dispersion of micro-ordered domains in a disordered matrix.

MATERIALS

Products for Play

from a Correspondent

THE requirements of the sports industry for high-performance high-quality products present a unique challenge to the materials scientist. This was doubtless in the minds of members of the Materials Science Club meeting at Worcester on September 19 and 20. The topic of the meeting was materials in leisure and sport.

R. C. Haines (International Sports Co. Ltd) explained that the design of golf clubs has changed very little from the gradually evolved form, although the hickory shaft and laminated maple head have been replaced, in one case, by an all plastic club with glass fibre shaft and injection moulded head. In principle this has been achieved with no scientifically measurable change in performance, although the expert can sense significant variations through the subtlety of the wrist.

Carbon fibre reinforced materials offer certain advantages, particularly now that there is every indication that they will become less expensive. D. G. Pearce (AERE, Harwell) described how they can be used in skis and boat masts. Carefully designed experiments to measure torsional stiffness at various sections in existing skis have made it possible to calculate permitted stresses and deflexion characteristics so that the design can be achieved with a considerable saving in weight. Such skis would presumably require less effort to manoeuvre and should therefore allow for better personal performance. Within the strictly controlled classes of sailing boats, one way of achieving better performance is by improving the aerodynamics of the mast. This can be achieved by making the mast more slender, but because the load is great, the mast needs to be reinforced. From the load patterns obtained in two sets of conditions, namely, close hauled and 15 m.p.h. boat speed in a 40 m.p.h. gale, data for the design of an aluminium carbon fibre reinforced mast can be obtained, with a 20 per cent weight saving. Such a mast is significantly more slender than the conventional aluminium type, and aerodynamically more suitable.

A starting point for the selection of material for sails is the shape of the stress–strain diagram. On this basis, 'Terylene' can be shown to be superior to nylon, rayon and cotton, and M. R. Dixon (ICI, Harrogate) discussed those factors in textile production that are important if this property is to be exploited. Consolidation of 'Terylene' cloth by a hot rolling technique gives a superior material for sails by modification of extensions in both warp and weft. And photogrammetric studies of sail extension during loading make possible new designs based on changes in the geometry of the panelling.