related to the velocity in the narrowest restriction between the tubes.

The designer will usually be concerned with obtaining the greatest possible heat transfer for a given pressure drop. For a given mass flow, the lower the velocity, the smaller the pressure drop, and the smaller also the heat transfer for any given surface. Hence a compromise is necessary between the limitations of pressure drop and of space.

Heat Transfer and Fluid Friction

Osborne Reynolds, in 1874, pointed out the analogy between the transfer of heat and the transfer of momentum through an eddying fluid. Recently, with the conception of a more or less stationary film of fluid in contact with the surface, it has been realized that Reynolds' theory must be modified to take account of the two successive stages of heat transfer, first through the stationary film by conduction, and then into the core of the fluid by turbulence.

Boiling Liquids

Three distinct stages are now recognized in the boiling of liquids. The first stage, in which there is no appreciable bubbling, corresponds to the heating-up process before the boiling point has been reached. In the second stage, chains of bubbles rise from the heating surface, their sweeping and stirring effect increasing with the violence of the boiling. As the temperature difference is increased, there comes the third stage, in which the vapour bubbles tend to merge, until they may ultimately form a continuous layer over the heating surface. In the first stage, the heat transfer can be calculated from the appropriate convection data. In the second, or bubbling, stage, the heat transfer is relatively very high, and increases with the temperature difference until the final, or 'film', stage is approached. A sharp decrease then occurs, owing to the blanketing effect of the vapour layer. Hence, there is an optimum temperature difference, which depends upon the nature and condition of the surface, and particularly upon whether or not it is wettable.

Experiments on boiling liquids are of exceptional difficulty for, if the load is high, there may be considerable temperature differences both through, and over the surface of, even metal heating surfaces. Moreover, surface conditions, which greatly influence the rate of heat transfer, may change with time. Thus it is not surprising that no altogether satisfactory correlation of the experimental data has yet been achieved, although many attempts have been made. Surface tension and viscosity, however, are known to be important factors.

Condensing Steam

Nowadays, in designing condensers and evaporators it is essential to know the heat transfer coefficients from condensing steam. The condition of the surface is a very important factor. On a rough surface, free from grease, the condensate spreads out in a continuous film ; but on a smooth, greasy surface it tends to form in separate droplets, giving five or ten times the heat transfer of a film. Consequently, much interest is being shown in finding effective 'promoters' of dropwise condensation.

Small proportions of air in steam, by introducing an additional thermal resistance, greatly reduce the heat transfer.

Conclusions

During recent years the engineer has looked more and more to fundamental science for help in his problems of design and working, and, on the other hand, the pure scientist has shown an increasing readiness to admit the importance of industrial applications. Although in full-scale plant, even when scientifically controlled, the conditions can never be specified with the accuracy possible in small-scale laboratory apparatus, key calculations can often give the designer a valuable pointer in deciding what changes are most likely to lead to improved results. There are still many gaps to be bridged, both in basic knowledge and in methods of using it, but much real progress has been made.

OBITUARIES

Prof. W. J. Young

PROF. W. J. YOUNG, whose death occurred recently in Australia, was best known for the work on the breakdown of carbohydrate by yeast which was carried out in conjunction with the late Sir Arthur Harden between the years 1904 and 1913.

The classical researches of Harden and Young on the fermentation of carbohydrate by yeast established the phosphorylation of carbohydrate as an essential stage in the conversion of sugar to alcohol and carbon dioxide, and finally Young successfully accomplished the isolation of a hexose diphosphate. A quantitative relation was demonstrated, the amount of carbon dioxide liberated being proportional to the amount of inorganic phosphate which disappeared from the solution. The process of phosphorylation thus established as essential for the breakdown of carbohydrate by yeast was later shown by Embden and his colleagues to be also a necessary stage in the transformation of carbohydrate to lactic acid carried out by the muscle cell of the animal organism, and by Robison to play an important part in the ossification of cartilage. Harden and Young had laid the foundations of carbohydrate biochemistry, when they showed that it is by the process of phosphorylation that the living organism changes the starch and sugar molecules into the simple substances which are their final products.

After nearly ten years of fruitful co-operation with Harden, Young accepted the post of biochemist to the Institute of Tropical Medicine at Townsville, Australia, and left the Lister Institute. Some years later he was appointed professor of biochemistry in the University of Melbourne. There he became greatly interested in the teaching of biochemistry and built up a very fine department, paying special attention to the needs of medical students. His published papers during this period were concerned chiefly with the natural products of Australia and with problems brought to him for investigation.

Young was a man of wide interests and nothing gave him more pleasure than a friendly argument with his colleagues on every variety of subject. He was keenly interested in politics; and whatever subject he followed he devoted himself to it with enthusiasm, whether it was carbohydrate chemistry or the game of golf.

He will be remembered with affection by his former colleagues at the Lister Institute. He leaves a widow and a daughter, Sylvia, now practising medicine.

I. SMEDLEY-MACLEAN.