REVIEWS

Engineering Fluid Mechanics, by C. JAEGER. (Translated from the German by P. O. Wolf.) London: Blackie, 1956. 529 pp. 60*s*.

In English-speaking countries the term hydraulics has long been under a cloud. The disparagement from which it still suffers arose out of the difficulties of the subject that until relatively recently permitted investigators to give only their observations of depth, pressure and discharge. No analysis of the details of the motion or effective comparison with previous papers was possible, and all too often the records of their painstaking work terminated with nothing more than 'the author's formula', applicable only to the exact conditions of the experiment. It is presumably for this reason that a misleading title heads this revised and enlarged translation of Dr Jaeger's *Technische Hydraulik*, of which a French version has already appeared under the title *Hydraulique Technique*. The book is concerned wholly with the motion of water. After a preliminary account of the physical basis of hydraulics and the fundamental equations the author turns to his three principal topics, steady and unsteady flow in open channels, unsteady flow in pipes due to surge and water hammer, and seepage, which between them occupy nearly three quarters of the book.

For several reasons the practical problem of steady flow in a uniform open channel of uniform slope is far more extensive than that of steady flow in a circular pipe, and our knowledge of it is relatively scanty. The channel may be of rectangular, trapezoidal, circular or egg-shaped cross-section with almost unlimited variation in the proportions of the cross-section, and the free surface destroys any possible symmetry in the velocity distribution over the cross-section. Two types of flow can occur according as the velocity in the main stream is greater or less than that of a long wave moving under gravity on the surface. They may be given the descriptions 'superundal' and 'subundal', which seem clearer than the adjectives 'shooting' and 'streaming' which are more commonly used. They correspond to Froude numbers greater and less than unity, and an analogy exists with the flow of a gas which likewise is of two types according as the Mach number is greater or less than unity. In practice, friction effects are of vital importance because they determine the discharge through a channel of given shape and slope, but for a large canal the slope is so minute that it cannot easily be measured in existing works or correctly constructed in new works. Further complications ensue if the slope or cross-section of the channel is not uniform or if blockages, such as weirs are inserted. Unsteady flow may be due to the passage upstream of 'jumps' of various kinds (such as may be seen in nature as bores in esturaries) or to the passage downstream of disturbances caused by floods or by the removal of obstructions.

Unsteady flow in pipe-lines is of two kinds, dependent on the rapidity with which the control valve is moved. If the valve is shut suddenly, a loud noise (water hammer) is heard which is familiar to many householders, and a pressure wave passes upstream, the intensity of which in pounds per square inch is roughly 60 times the original water velocity measured in feet per second. Now the velocity of sound in water in an almost rigid pipe is about 4500 ft/sec., and the original water velocity cannot be more than a very small fraction of this. Hence the aerodynamicist would describe the shock wave as weak; not so the hydraulic engineer as he surveys his shattered pipe and damaged power station. But normally the valve admitting water from the pipe-line to the turbine is moved relatively slowly by the governor, which can also open a bypass for a short time. The mass of water in the pipe-line is, however, so great that, to smooth out the resulting disturbances without excessive waste through the bypass, a surge tank is usually connected to the pipe-line. This is an open vertical pipe, much larger in cross-section than the pipeline and placed as close to the power station as circumstances permit. Under steady conditions the water level in the surge tank stands lower than that in the reservoir by an amount equal to the friction loss of head in the intervening pipe-line. The installation can be regarded as a gigantic U-tube; one limb (the reservoir) is virtually of infinite cross-section, and from the base of the other (the surge tank) water is drawn off to the turbine. Any change in this demand leads to damped oscillations of level in the surge tank which are governed by non-linear differential equations. If the demand increases, the surge tank serves as a source close at hand, and initially the level in it falls; if the demand decreases, part of the flow from the reservoir passes into the surge tank, the level in which begins to rise.

Dr Jaeger deals with these subjects in great detail, and almost every possible case and sub-case is fully examined. The treatment is entirely analytical supplemented, when the working grows too complex, by graphical methods. The standard of mathematics that is employed is not high, but the algebra is often long and tedious. The author evidently believes that there is no satisfactory means of escape from these laborious calculations, for alternative methods are cursorily dismissed. Thus in the description of surge tanks six lines and five references suffice for an account of the importance and use of models and electrical analogues, as " there is not, however, sufficient space to include a description of these techniques here ". (Additional references on the first of these matters have strayed into the chapter on water hammer.)

The book does not contain examples to be worked out, and it is clearly meant, not for the general student, but for the designer and the advanced specialist. The designer will not, however, find here all that he wants. For many of the problems alternative methods of solution are provided, but he is given little help in choosing which is the best; the treatment is comprehensive rather than critical. Moreover, he is made aware that the theories are inevitably based on a variety of assumptions, yet they are left unsupported by experimental evidence. Thus a doubt may arise in his mind whether the lengthy computations are worth while—a doubt that will not be lessened by the author's remark that "it is not within the province of this book to investigate the usefulness and practical results of the methods of analysis developed in" the chapters on surges and water hammer. It is to be hoped that Dr Jaeger will soon provide this much wanted assessment. He remarks with great truth that observations of surge and water hammer are, regrettably, too rarely published, but in his list of references there is sufficient information for at least some comparison to be made. This shortage of experimental evidence, which is seriously delaying the advance and spread of knowledge, seems to arise from financial pressure. A costly pipe-line must be put into commercial service the moment it has passed the simple tests required by the contract, and even a single day devoted to experiments would involve a serious loss of revenue. No lead in this matter has been given in the highest quarters, for in the course of a discussion on a paper on surge tanks read in 1933 before the Institution of Civil Engineers, a distinguished speaker expressed his hope of publishing surge observations on the Lochaber installation. This hope is long deferred, for these readings have not yet been communicated to the institution.

The book ends with appendices on empirical coefficients, flow over a movable bed, and density currents. A very valuable feature of the entire work is the enormous number of references extending up to 1955, which are presented in the form of footnotes. These are accompanied by brief biographical notices of the more eminent authors.

In his two prefaces Dr Jaeger describes his work as a handbook as well as a summary of his lectures at Zürich, and in a very large handbook of this sort it is inevitable that the author's chief interests are shown up by unevenness in the standard of treatment of the various topics. Thus, in the chapter on the basic equations when he is dealing with the loss of energy at a sudden expansion in a pipe, he is content to reproduce the usual dubious analysis that survives in text books seemingly because it leads to a tidy result. It depends on the assumption that the pressure on the annular surface at the enlargement is the same as that in the smaller pipe. This assumption, he writes, "is supported by experimental evidence", but the references provided are scarcely convincing. Taylor's name might have been included in Chapter II amongst those who have gone deeply into that intractable subject, the theory of turbulence; and much more experimental confirmation of boundary-layer theory exists than can be found in Escande's 1938 book on dams, which is the only reference provided on this point. Little use is made of Froude number to simplify the analysis of flow in open channels, and Chapter IV on steady flow in channels ends in confusion as the calculation of the critical depth for various shapes of cross-section is apparently extended to include free and aerated jets. The detailed treatment of critical flow theory, which includes an interesting history of the problem, would have been improved by an account of the simple ideas introduced long ago by Hugoniot. The wretched weir formula involving a dimensional coefficient of discharge, which engineers are accustomed to use, is stated without protest; and the opportunity is missed of explaining the advantage of comparing the actual discharge with that over the theoretical broad-crested weir having the same width and head. Lemoine's sinusoidal theory of undular jumps is noticed, but not its demolition by Benjamin and Lighthill. The important advance made by Southwell and Vaisey in their application of relaxation methods to free-surface problems is mentioned only in a footnote to a remark on a problem which they did not treat.

There is much to be said for the widely held view that the days are past when an author could produce a lengthy and balanced book covering the latest advances in many fields. It can no longer be expected that one man, no matter how scholarly and industrious he may be, can have everything at his fingers' ends at the same time. Of recent years the stream of original papers has greatly increased in width, depth and velocity, and the only way of control is by division of the flood. Two methods have been tried with success. The first is the large book covering a number of topics, each with a chapter to itself written by a different yet expert hand. Conspicuous examples are *Engineering Hydraulics* and *Modern Developments in Fluid Dynamics* under the respective editorship of Hunter Rouse and Goldstein, both of which have served as powerful springboards for further advances. A drawback of this method is the long delay that a big book encounters at the printer's hands. Moreover, the editor, if conscientious, must expect to be brought by his labours almost to the grave. The second method is the monograph of limited scope compiled and seen through the press by one man. The final stages are relatively brief, and the book need not be seriously out of date as soon as it is published. There is nothing to prevent a gifted author from producing a succession of monographs. In both methods it is unnecessary for the size of the book and therefore its price to be inflated by the inclusion of preliminary matter than can readily be found elsewhere.

A. M. BINNIE

CORRIGENDUM

Equation (41) of my paper, "The influence of radiative transfer on cellular convection" (*J. Fluid Mech.* **1**, 1956, 424), should read as

$$R' = \frac{\int_{-\frac{1}{2}}^{+\frac{1}{2}} w' Q(w')\, d\zeta}{\int_{-\frac{1}{2}}^{+\frac{1}{2}} w'^2 (\beta/\bar{\beta})\, d\zeta}. \tag{41}$$

R. M. GOODY