REVIEWS

Bores, Breakers, Waves and Wakes. By R. A. R. TRICKER. Mills and Boon, 1964. 250 pp. 35*s*.

Eddington (*The Nature of the Physical World.* Cambridge University Press, 1928) tells us that:

> One day I happened to be occupied with the subject of 'Generation of Waves by Wind'. I took down the standard treatise on hydrodynamics, and under that heading I read [there follows an extensive quotation from an early edition of Lamb, with conclusions that would not now find very wide acceptance]....On another occasion the same subject...was in my mind; but this time another book was more appropriate, and I read
>
> There are waters blown by changing winds to laughter
> And lit by the rich skies, all day. And after,
> Frost, with a gesture, stays the waves that dance
> And wandering loveliness. He leaves a white
> Unbroken glory, a gathered radiance,
> A width, a shining peace, under the night.
>
> The magic words bring back the scene.... We do not look back on them and say, 'It was disgraceful for a man with six sober senses and a scientific understanding to let himself be deluded in that way. I will take Lamb's *Hydrodynamics* with me next time.'

I have sometimes thought, on recalling these passages, that I would have taken Cornish (*Ocean Waves.* Cambridge University Press, 1934). Now Dr Tricker offers us something in between, with the expressed aim of 'bring[ing] an added interest and delight to times spent by river, loch or sea...[on the premise that] an understanding of the processes which go on and of their consequences can add very materially to the enjoyment to be had from the contact all of us have from time to time with waves'. Most of us will accept the premise as an article of faith; it therefore remains for me to consider how well the author has achieved his aim, especially *vis-à-vis* his predecessor.

Cornish, a dedicated amateur ('My time was my own, and I decided to investigate these various wave phenomena') was concerned primarily with observations ('I have compensations in the memory of many wonderful sights in storms at sea; of snow-waves moving in ghostly procession across the Canadian prairie; of sand-waves, rank behind rank, driven by the desert wind; of the onset of the tidal bore in the Severn and the Trent, and of Leaping Waves in the Rapids of Niagara'); he gave a minimum of detailed physical explanation and left mathematical derivations to Jeffreys (in an Appendix). Tricker has attempted much more, including a wider range of subjects, elementary physical explanations, simplified mathematical derivations, and suggested demonstration experiments. His coverage is indicated by the twenty chapter headings: The Tides, The Moon's Motion, The Tides as Observed, Tidal Bores, An Elementary Theory of Tidal Bores, The Theory of Gravity Waves in Shallow Water, Waves as Seen from the Shore, Bernoulli's Theorem, The Recording of Waves, Wave Spectra, Waves in Deep Water, The Generation and Properties of Ocean Waves, Microseisms, Trochoidal Waves, Eddies, Interference, Diffraction and Group Velocity, Ships' Wakes, Surface Tension, Ripples, Reflections in Rippled Water; there are also six Appendices. The coverage is there, but the excitement is not. One looks in vain for such as the following (in which Cornish sets the scene for his observations of wave heights in the Bay of Biscay):

> During the night the wind changed direction and blew from west-north-west, rapidly increasing in strength until in the small hours of the morning of December 21st its force was beyond the common experience of North Atlantic gales. Several ships sank with all hands in the Bay, and our liner was for a time in peril, until brought round with great difficulty so as to face the waves which had struck her abeam. With just enough steam to hold the bows head-on to the sea, the ship was kept hove-to until one o'clock in the afternoon of this memorable day. The opportunity for which I had longed for years had arrived, and at last I had a stationary post of observation amidst the great waves of the ocean. Moreover, by a fortunate and rare coincidence, the tremendous wind had come on to blow exactly in the direction of the heavy swell already running, and so there was no confused turmoil, but one magnificent procession of storm-waves sweeping across the sea from horizon to horizon. The sky cleared, and between the chasing clouds the sun shone down in strength, for we were still no further north than the latitude of La Rochelle.

These magic words do, indeed, bring back the scene.

Tricker has been generous with his pictorial illustration, giving us sixty-three black and white plates, twenty colour plates, and 158 figures. The colour plates can fairly be called beautiful, but, with the exception of three splendid views of the Masceret on the Seine at Candebec-en-Caux, I find them lacking both the force and the immediacy of Cornish's twenty-six sepia plates.

These comparisons would be unfair if Tricker had succeeded in giving us simple and accurate explanations of the physical processes. Unfortunately, he has not. Take his derivation of the speed of a tidal bore. Telling us that 'the basic mechanics which is needed is very slight', he erroneously assumes conservation of energy and, after neglecting the square of the particle velocity, arrives at the inconsistent approximation $c = \sqrt{g(H+h)}$, where H is the depth of the water into which the bore advances and h is the height of the bore. It is true that this result 'will hold for bores of small amplitude' (for which $c = \sqrt{gH}$ is a more rational approximation), but to ignore the crucial role of momentum in a bore is scarcely to have increased our 'understanding of he processes which go on'.

Again, in discussing the flow over weirs and under floodgates, he tells us that 'Bernoulli's theorem can be applied only in cases where viscosity can be neglected...[but that] the viscosity of many common liquids is small enough for this to be done as a first approximation in many cases, including many of fundamental importance.' Turbulence is not mentioned in this context.

Errors and omissions such as these spoil what otherwise would have been a commendable attempt. To be sure, many of the topics are handled more competently than the last two examples would suggest. The explanation of the tides is simple and clear, even though I do not find that it stands comparison with G. H. Darwin's Lowell lectures of 1897 (*The Tides*. W. H. Freeman, New York, 1962); and the explanation of ships' wakes is exemplary. The illustrative sketches are excellent, and the suggested demonstrative experiments are clever. Still, taking all together, and imposing appropriately heavy penalties for errors of fact, I conclude that Dr Tricker has failed to achieve his stated aim.

And so my resolve remains unchanged: I will take Cornish with me next time, and I recommend the same to my friends and colleagues.

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Magnetohydrodynamics with Hydrodynamics, Vol. 1. By P. C. KENDALL and C. PLUMPTON. Pergamon, 1964. 181 pp. 17*s*. 6*d*.

This is the first of two volumes "designed to introduce the student to the subject in a simple way". The note on the inside cover suggests that the level of the book is that of "an advanced undergraduate course or an elementary post-graduate course in hydrodynamics with magnetohydrodynamics". There are five chapters, of which the last three are on m.h.d.

Chapter I on 'Techniques' consists of a catalogue of results and methods in applied mathematics that are frequently used in m.h.d. Dimensional analysis, vector analysis, the theory of normal modes for a continuous system, variational methods for stability analyses, and tensor manipulation are discussed. In such a short space (38 pages), these topics cannot be treated in any depth, and the results are stated merely to provide a mathematical background for the rest of the book (and for volume 2). If a student has previously mastered these topics, then this chapter may be helpful in reminding him of some of the more important techniques.

Chapter II ('Fundamental ideas in hydrostatics and hydrodynamics') is again something of a catalogue. The emphasis is on classical inviscid hydrodynamics, with sections devoted to the Euler equations, Bernoulli's integral, vorticity, complex variable methods, sound waves, shock waves and surface waves. Turbulence and boundary layers are summarized in two paragraphs. It will be evident that if Chapter I was brief, Chapter II (45 pages) breaks all records in the range of topics surveyed. The chapter may again be useful for students who have already had a good grounding in fluid mechanics, and wish to be reminded of some key results. But one begins to wonder what purpose this book will serve if it is going to be intelligible only to those readers who already thoroughly understand the topics described. If they don't thoroughly understand them, Chapter II is not going to provide much enlightenment. For example, Bernoulli's integral for steady, inviscid flow is stated as applying to flow "through narrow tubes"—which of course is true. But there is no mention of the fact that the integral exists in a wider sense for any steady rotational flow. This may not be serious; it is merely an omission of what appears to me to be an important generalisation. But consider the next example. On p. 51, the equation $\nabla^2\mathbf{A} = -\boldsymbol{\zeta}$ is derived, where $\boldsymbol{\zeta} = \text{curl } \mathbf{v}$, and $\mathbf{v} = \text{curl } \mathbf{A}$ with $\text{div } \mathbf{A} = 0$. The Poisson integral of this equation is then stated. The following "corollary" is *deduced*:

"If the vorticity vanishes everywhere in the liquid, $\mathbf{A} \equiv 0$, and only irrotational motion is possible. We note that for uniform flow the vorticity is non-zero at infinity". The connexion between these two sentences is obscure, the first states an absurd half-truth, and (unless there is a misprint) the second is blatantly false.

Lest I be accused of carping at a few unfortunate "turns of phrase", let me give a third example, this time of a paragraph which I believe would be incomprehensible to the most intelligent of students, were he unfortunate enough to be meeting the subject here for the first time. The topic is 'Unidirectional flow of a viscous compressible fluid', and I quote from p. 72. "Consider non-uniform flow parallel to the x-axis with speed v.... Consider the case in which the fluid velocity varies continuously from $v = u_1$ at $x = 0$ to $v = u_2$ at $x = d$, being uniform for $x < 0$ (with $v = u_1$) and for $x > d$ (with $v = u_2$). Suppose that the pressure and density are p_1, ρ_1 at $x = 0$ and p_2, ρ_2 at $x = d$. This problem is known to be soluble. If μ is the coefficient of viscosity, it is found that $d \to 0$ as $\mu \to 0$." Now we're lucky, because we've all been through shock wave analysis at some stage, and we know from the last sentence that the authors must be thinking about steady flow, and not about the unsteady steepening of simple waves; but they don't mention the word 'steady' (the last time it was mentioned, as far as I can locate, was p. 65, and we have considered turbulence and sound waves since then); and how is the hypothetical student to know what they are talking about?

An even more persistent thread of error and misleading statement runs through Chapters III–V on magnetohydrodynamics. Here are a few examples, all, in my opinion, relating to points of fundamental importance:

1. At the top of page 96: "Let **E** denote the electric field at any field point arising from sources other than motion of the fluid element at that point.... Ohm's law becomes

$$\mathbf{j} = \sigma(\mathbf{E} + \mu \mathbf{v} \wedge \mathbf{H})."$$

Presumably by 'sources other than the motion', they mean externally applied e.m.f.'s. But suppose there are no 'applied' electric fields. Does this mean $\mathbf{E} = 0$? Certainly not, since $\nabla . \mathbf{j} = 0$ implies $\nabla . \mathbf{E} = -\mu \nabla . (\mathbf{v} \wedge \mathbf{H})$, in general non-zero. The field cannot be dissociated from the fluid motion; and its value within a fluid element is directly affected by the motion of the element.

2. Top of page 104: "The tangential components of the electric field are continuous" (across a surface of discontinuity). This is not necessarily true (i) across a moving current sheet, (ii) across the surface separating a perfectly conducting liquid from a perfectly conducting solid which is thinly coated with insulating material. These are not artificial examples devised merely to exhibit the inadequacy of the statement. The situations, particularly (i), have been recognized frequently in the literature of m.h.d. (e.g. Kruskal & Schwarzchild, *Proc. Roy. Soc.* A, **223**, 348, 1954, in discussing the stability of the sharp linear pinch).

3. On p. 151: "A force-free magnetic field is one which exerts no force upon its own electric currents, that is, curl $\mathbf{H} = \alpha \mathbf{H}$ where α is any function of position." (There is no mention here of the immediate requirement that α must be constant on lines of force; this is not serious since only the case α = constant

(everywhere) is given further consideration.) Four pages later, we learn again, though with a subtle change of wording, "A magnetic field which satisfies curl $\mathbf{H} = \alpha\mathbf{H}$ is known as a force-free magnetic field, since the Lorentz force (curl $\mathbf{H}) \wedge \mathbf{H}/4\pi$ vanishes". In the same section, it is shown that if $\mathbf{A}$ is the vector potential of a field $\mathbf{H}$ in a region τ surrounded by a closed surface S, then $I = \int_\tau \mathbf{A}.\mathbf{H}\, d\tau$ is constant provided $(\mathbf{A} \wedge \partial\mathbf{A}/\partial t).\mathbf{n} = 0$ on S. But the physical conditions under which this boundary condition is satisfied are not examined. The only possibility in fact seems to be that S is a perfect conductor, the fields $\mathbf{E}$ and $\mathbf{H}$ vanishing outside S. Such a strong restriction surely deserves mention.

4. The discussion of magneto-acoustic waves on p. 129 is very misleading. It is suggested that of the two compressible modes (usually, though not here, called the 'fast' wave and the 'slow' wave), one "corresponds to the acoustic mode, and the other to the Alfven mode". This is perhaps simply a matter of terminology, but I think, to avoid confusion, the term 'Alfven mode' should be reserved for the incompressible transverse mode which exists quite independently of the two magneto-acoustic modes.

5. The problem of channel flow between walls $z = \pm b$ in a transverse magnetic field $(0, 0, H_0)$ is considered in § 5.7 (the last section of this volume). The only slight subtlety that this problem presents is the question of how the current circuit is completed; if the distant side walls ($y = \pm\infty$) and the walls $z = \pm b$ are insulating, then an electric field E_y is established, so that the net current $J = \int_{-b}^{b} j_y\, dz$ is zero. If they are perfectly conducting on the other hand, and no potential differences are externally applied, then $\mathbf{E} = 0$ and then $J \neq 0$. Or, again, the the field $\mathbf{E}$ may be externally applied. There is no discussion of these possible alternatives in this section; the first possibility is arrived at almost by accident by imposing the condition that the induced magnetic field must vanish at $z = \pm b$, implying that $J = 0$; and it is suggested that there is no other possibility satisfying all the "appropriate physical conditions"—just what is meant by 'appropriate' is not apparent. This last example shows up the dangers of thinking solely in terms of the velocity and magnetic fields. The currents are, after all, the ultimate source of the magnetic field, and deserve at least equal consideration. Likewise the role of the electric field is all too often sadly forgotten.

It may be inferred from the above comments that I cannot enthusiastically recommend this book as a first introduction to m.h.d. The subject is rich with paradoxes and subtleties, which demand the greatest care in statement and analysis. I fear that this type of book may encourage students to slide into a careless and facile mode of thought, anathema to the spirit of inquiry.

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