

magnet, which in this new form is vertical and provided with unusually massive cheeks. One detail of construction is, however, singular, though it seems to have escaped the notice of electricians. Beneath the longitudinal strands of covered wire the central core of the armature, which is of wood, is overspun with a few layers of iron wire wound transversely. This layer of iron resembles in a kind of way the iron ring in the armature of the Gramme machine, and though no conducting wires traverse the interior of it, it clearly may serve one of the important functions of the iron ring in the Gramme machine in concentrating the lines of force in the field. In support of the allegation that this machine gives out in electricity 90 per cent. of the energy it receives from the driving engine, Mr. Edison caused certain calculations by Mr. Upton to be published in the *Scientific American*. We have examined these calculations and find that they are based on the supposition that the electromotive force of the generator is a constant quantity when the speed of revolution is constant, and independent of the resistances of the circuit and of the quantity of current generated. This can only be true if the field magnets are excited by a separate current and generator. Now, in the numerical calculations which have thus been put forth *in proof* of the above assertion, there is no statement made as to the power necessary to supply this auxiliary current, nor indeed are any statistics whatever given of the actual power (in foot pounds or any other measure) delivered by the driving engine to the generator; only a cut-and-dry calculation to show that if the external resistance be greater than the internal the machine will theoretically work more economically when not generating the maximum current! In the *Scribner* article it is explicitly stated that a second Faradic machine is used to render active the magnets of the machine which supplies the light, and in two admirable pictures, one of which is a view of the battery of Faradic machines set up in a "central station," the nature of the arrangements is shown.

We need not refer in detail to the enthusiastic inconsistencies in the *Times* correspondent's accounts. Upon Edison's own data, electricity, instead of costing one-fortieth of the price of gas, costs at least seven-eighths as much, or about thirty-five times as dear as the *Times* correspondent declares. As to the cost of the lamp itself, with its carefully incinerated horseshoe of paper, its glass globe exhausted to one-millionth of an atmosphere, and its platinum-connecting wires, we confess we do not know where the work could be done for anything like the cost of a shilling. "The current can be transmitted on wire as small as No. 36," says the *Times* reporter, who, probably being unaware that the resistance of a yard of such wire is at least half an ohm, avoids saying what length of such wire may be used. With a generating machine "in a central station, perhaps a half-mile away," the introduction of 400 ohms' resistance would be serious—to the light.

But apart from the mild absurdities of newspaper correspondents, the more we study the detailed accounts of the new inventions the more we regret that Mr. Edison does not devote some time to learn what has been already done in this field. An inventor who ignores what has been done ought not to be mortified to find himself occasionally forestalled by others in some discovery which he prides

himself is his own. Possibly this may explain the inability sometimes shown by an inventor to credit the good faith of a rival who has priority. The worst feature of such a course of thought lies in its absolute incompatibility with a truly scientific spirit. Here the scientific man and the inventor part company; since the habits of accurate thinking and the necessary candour of the scientific method preclude the truly scientific man from ignoring, even for the sake of scientific discovery, that which is already a part of scientific truth. We are doing no injustice to Mr. Edison's splendid genius when we say that it is to the character of the inventor, not to that of the scientific thinker, that he aspires.

What shall we say, finally, to the whole system of these reckless newspaper announcements—for which, as we have said, we ought not to hold Mr. Edison responsible—by which the public mind is periodically fluttered?

The remedy to these things is obvious enough. Let scientific men once and for all repudiate these false and unwholesome displays of ignorance. Let public opinion insist that the inventor shall be allowed to pursue his way unhampered by the officious interference of the unprincipled speculators whom his soul abhors, or by the irrepressible unscientific reporter who is only one degree less reprehensible for the part he plays. Whether the latest forms of the invention are doomed to the fate of their predecessors or not, the man who can struggle against failures and discouragements as indomitably as Edison has done deserves to succeed, however erratic his methods. But if he succeeds ultimately, it will be in spite of the vampires of the Stock Exchange and the hangers-on of the New York press, who dog his steps for their own selfish ends.

#### THE MOTION OF FLUIDS

*A Treatise on the Mathematical Theory of the Motion of Fluids.* By Horace Lamb, M.A., formerly Fellow and Assistant Tutor of Trinity College, Cambridge; Professor of Mathematics in the University of Adelaide. (Cambridge University Press, 1879.)

NOT the least part of the good that must be attributed to the publication of the first volume of Thomson's and Tait's "Natural Philosophy" is that, as in the cases of Maxwell's "Electricity" and Lord Rayleigh's "Sound," it has led and prepared the way for the complete revision and great advancement of several branches of mathematical physics at the hands of those who have made a special study of these branches. Lamb's "Theory of the Motion of Fluids" must be looked upon as another, and for the most part a worthy, offshoot of this wonderful volume. Although it would be too much to expect that one so young as Mr. Lamb should display the same masterly knowledge of his subject as has been displayed by the authors of the two previously-mentioned works, still the thoroughness with which the very difficult and somewhat extensive literature has been handled, and the appreciation of the mathematical points displayed by the author, together with a rare facility in abbreviating and expressing, render this in most respects about the best possible text-book of which the present state of the subject admits. Having said this, it will be seen that I do not make the following remarks with any view of disparaging the

book. These remarks, although directed to the matter in the book, do not, excepting one rather important case, refer unfavourably to anything for which the author is responsible.

Of all subjects on which to produce a satisfactory textbook, perhaps the theory of the motion of fluids, as actual fluids, presents the greatest difficulties. The phenomena of fluid motion, at once commonplace and very obscure, have excited so little interest and called forth such slight observation that at the present time a writer is unable to set before his readers any adequate description of the phenomena which it is his implied object to explain. And as regards the theory, he has to begin by apologising for his fundamental assumptions as being obviously contrary to facts, and after carrying his readers through most difficult and complex mathematics, he has again to apologise for his conclusions, which are in general contrary to experience. As applied to one class of phenomena—that of waves—it is true the theoretical results accord closely with facts; but the satisfaction to be derived from this is largely mitigated for want of a sufficient reason why the theoretical conclusions should be right in this case while they are entirely wrong in others, such as the flow of fluids and the resistance offered to the motion of solids. The usual explanation, that in the theory no account is taken of the friction or viscosity of actual fluids, is hardly satisfactory since no reason has been found why friction should play any other part than the altogether unimportant part which it plays in the case of waves.

It is, however, only in its application to actual fluids that the theory is unsatisfactory. If it be cut adrift from its origin, and be considered as a branch of abstract mathematics relating only to ideal matter having the properties assigned, it occupies the place of one of the most advanced as well as the most important branches of philosophy. It has been partially viewed in this light since the middle of the last century, when Euler and Lagrange founded the modern theory, and the tendency so to regard it has greatly increased of late with the development of the theory. The greatest success, indeed the only real success, has been obtained by the rigorous development of the theory of the motions in a perfect fluid, as it is called, regardless of whether or not these motions take place in actual fluids. Certain of the motions are then seen to agree with the actual motions, and wherever this is the case the theoretical motions have taught many things about the actual motions, as, for instance, the trochoidal motion of the fluid elements in a wave, for which we might, otherwise, have groped for ever without apprehending them. It is, however, the observed motions of actual fluids which suggest the problems; and of course the greater and truer the knowledge of actual phenomena the more chance there is of success in the study of the ideal fluids. But what tends to retard its development and greatly to confuse the subject, is the mixing up, with the rigorous reasoning, of surmises as to the behaviour of actual fluids, as, for example, that the non-divergence of a stream of water when flowing from a pipe into a large vessel is owing to an actual opening having been formed in the fluid; a surmise which is at once negated by the fact that the same phenomenon occurs in the case of air in which such discontinuity is impossible. The present work is in the

main free from such surmises, and such as there are, are not the work of the author, but even these he would have done well to have omitted.

In his description of the methods by which the equations of motion are obtained the author has included (Art. 12) a very important method first given by Maxwell, which method is given at greater length in Note A at the end of the volume, otherwise he has followed previous writers as far back as Laplace. Considering its difficulty the fundamental reasoning is, on the whole, well put. But there is a considerable amount of vagueness attending the author's use of the term *particle*. Having rightly defined fluids as being such "that the properties of the smallest portions into which we can conceive them divided are the same as those of the substance in bulk," he proceeds to reason about a particle as though it were a discrete quantity, the position of which is defined by some point, thus ignoring the fact that, according to his definition, the same particle of fluid may at one time be a sphere, at another a filament of indefinite length, or a sheet of indefinite breadth. This vagueness appears to have led him into error in Art. 11.

Art. 8 on the equation of continuity seems to be unnecessarily bare of explanation. There used to be an impression that, as the name implied, the equation of continuity did in some mysterious way involve the condition that the fluid should be continuous in space. Thomson and Tait, however, have in Art. 191 of their volume effectually dispelled this notion. They say:—

"As there can be neither annihilation nor generation of matter in any natural motion or action, the whole quantity of matter within any space at any time must be equal to the quantity originally in that space, increased by the whole quantity that has entered it, and diminished by the whole quantity that has left it. This idea, when expressed in a perfectly comprehensive manner for every portion of a fluid in motion constitutes what is called the *equation of continuity*, a needlessly confusing expression."

The meaning of this can be nothing less than that the equation of continuity has nothing to do with continuity in space; for certainly there is no creation or annihilation of matter amongst the stars, probably fluids, and yet we should hardly consider them continuous in space. As this Art. 191 stands the last sentence is erroneous, and is certainly calculated to increase the confusion. To render it true, the term *fluid* must be understood *continuous fluid*. In deriving the equation, the constancy of mass is certainly taken as an axiom, but that is not all; when it is said that the mass in a certain volume  $V$  is  $\rho V$ ,  $\rho$  is understood to be the ratio of the mass to the volume in a space, so small that it may be neglected as compared with  $V$ , at any point within  $V$ . And hence the assumption, fundamental to the equation of continuity, that the mass within  $V$  is  $\rho V$  is equivalent to assuming that the matter is uniformly distributed through  $V$ , and therefore cannot be discontinuous. Nevertheless, it would have been better to have called the general equation the *equation of density*. But it is clear that this general equation was an afterthought, and that the name originated from consideration of water or an incompressible fluid, in the case of which the equation does not involve the density, and simply expresses space continuity within a substance of constant volume.

Another point of fundamental importance, on which a

remark is called for, is the proof of the permanence of the velocity potential. Mr. Lamb has offered a proof of this now historic theorem, which, if judged by the space it occupies, *should be much simpler* than the acknowledged Proceric of *auchy* and Stokes. As no authority is cited, it as it appear that this proof is here given for the first time. If so, the author has done himself great injustice in not examining or explaining his reasoning more closely. For, as it stands, it suggests the idea that he has ignored the fact that  $dx, dy, dz$  on the left of his equation, are integrals through a finite time, and hence, inasmuch as he has given no reason to the contrary, may be of a different order of magnitude from their initial values,  $da, db, dc$ , which appear on the right of his equation. If this is not so, it is a peculiarity of the motion of continuous fluid, and needs establishing, otherwise we might infer that two people who had once shaken hands could never after be so much as a mile apart. If this proof is found to be unsound, it is an unnecessary blemish in the book, for even if true, it would not replace the more elaborate, but much more physically instructive, proofs given by Stokes and Thomson, which the author has given further on in the book.

These remarks only carry us into the second chapter. The rest of the book, with the exception of the last chapter, is devoted to the account of what has been done in the way of integrating the equations of motion, and this may be taken as the purpose of the book.

This part of the theory, which is now very extensive, has almost all been developed within the last fifty years, and most of it within a much shorter period. It is the work of the very ablest mathematician, and is of the highest and most difficult kind, and in general incomplete. It was only to be found in isolated memoirs in various languages. The collecting, abbreviating, and arranging this into a systematic treatise has been no ordinary task, and the result shows that, in addition to his mathematical power, the author must possess the gift of compiling. One of the most striking features of the book, considering the variety of sources from which the matter was collected, is the uniformity of the notation. There is, however, one departure from this which is important, although evidently an oversight. The term *stream-lines*, carefully defined in Art. 28, as applicable only to steady motion, is freely used throughout the book in the sense of *lines of motion*, as applied to cases in which the motion is not steady.

The advance which has been made of late years has not been by the discovery of any general method of integrating the equations of motion, but by the discovery of certain general relations between the motion within certain regions of space, and the shape and motion of the boundaries to those regions. The steps in the discovery of these kinematical relations are principally due to Green, Stokes, and Helmholtz, but they have been generalised and elaborated by Thomson and Maxwell, and to these latter the present method of expression is due. An extremely lucid account of these relations is given in Chapter III., by which the author has cleared his ground for the treatment of such integrations as have been effected. These comprise many cases of steady flow, the method being that of the stream-line function first given by Stokes, but afterwards reduced to a geometrical

form by Maxwell, and largely applied by Rankine. They also comprise cases of vortex motion treated by Helmholtz's well-known method, and the theory of waves, as worked out principally by Stokes, Green, and Rankine. Only one chapter of the book is devoted to elastic fluids, and this, under the shadow of Lord Rayleigh's complete work, does not call for special comment.

The last chapter is on viscosity, and is taken from Prof. Stokes's paper on this part of the subject. Although this paper has been published thirty-three years, this is the first treatise in which any adequate account of its very important contents has appeared in a general treatise.

Throughout the book the various steps are carefully ascribed to their different authors, a very difficult task, and one in which the author appears to have been generally successful. There are, however, two instances of failure which call for notice. Equation 10, Art. 29, is known by modern French writers as Bernoulli's theorem ("Théorème de Daniel Bernoulli, Bresse," vol. ii. p. 25). Example 11, Art. 97—The fact that the contraction from a canal projecting inwards is  $\frac{1}{2}$  was proved long ago and the results verified by Borda.

In respect of diagrams Mr. Lamb's book might certainly have been improved. The great difficulty in the study of the subject is to obtain a conception of the lines of motion, and in this, diagrams such as those given by Rankine, Maxwell, and Sir William Thomson, are invaluable. The graphic method of obtaining the lines of motion developed by Maxwell and Rankine, has led to most important steps, but without diagrams it is as impossible to form a conception of this method, as of the lines of motion themselves.

The omission in this respect, as well as a tendency to reduce verbal explanations, would have shown without the examples at the end of the volume, that the author has been influenced by a desire to adapt the book to the requirements of the mathematical tripos, in which desire he has certainly succeeded. Whether it is well to introduce students to such a difficult, complex, and incomplete subject in such a concise, not to say cut and dry form, is a question which the author probably did not feel it necessary to consider. He has, however, by the numerous references throughout the work, and in the table of authorities at the end, done all in his power to put the students in the way of consulting the original works. This is aid of which students will do well to avail themselves, for nothing can equal work from the master's hand, and however carefully the general features may have been studied, the reading of such papers as those of Stokes, Rankine, and Helmholtz cannot fail to shed, what may be called, the light of life over the whole subject.

OSBORNE REYNOLDS

#### THE INTERIOR OF GREENLAND

*Meddelelser om Grønland, udgivne af Commissionen for Ledelsen af de geologiske og geographiske Undersøgelser i Grønland. Fors. Hefte. (Copenhagen, 1879.)*

SO large an amount of interest has been awakened during recent years concerning the nature of the interior of the vast island of Greenland, that the publication of this first instalment of the researches carried on under the auspices of the Danish Government will be