VORTEX RINGS.

A treatise on the motion of vortex rings. An essay to which the Adams prize was adjudged in 1882, in the University of Cambridge. By J. J. THOMSON, Trinity college, Cambridge. London, 1883. 19 + 124 p. 8°.

THOSE cases of fluid motion in which no rotational motion is present, are, as is well known, readily amenable to analysis. Helmholtz[1] first called attention to the nature of the analysis by which rotational motion must be treated. This memoir was followed by Sir William Thomson's suggestive paper on vortex atoms,[2] and finally by his important mathematical memoir on vortex motion.[3] The very great mathematical difficulties of the theory have operated to prevent almost entirely farther progress in the investigation of this otherwise alluring subject. To the best of our remembrance this essay is the first systematic attempt, since 1869, to enlarge our knowledge of the theory of vortex rings. How great the difficulties to be vanquished are, may be imagined from the appearance of the pages of the essay before us, which bristle with periodic series and complicated expansions.

The scope of the essay may perhaps be best apprehended from its opening paragraphs, which we quote: —

"The theory that the properties of matter may be explained by supposing matter to be collections of vortex lines in a perfect fluid filling the universe has made the subject of vortex motion at present the most interesting and important branch of hydrodynamics. This theory, which was first started by Sir William Thomson as a consequence of the results obtained by Helmholtz in his epoch-making paper, *Ueber integrale der hydrodynamischen gleichnungen welche den wirbelbewegungen entsprechen*, has *à priori* very strong recommendations in its favor; for the vortex ring obviously possesses many of the qualities essential to a molecule that has to be the basis of a dynamical theory of gases. It is indestructible and indivisible; the strength of the vortex ring, and the volume of liquid composing it, remain forever unaltered; and if any vortex ring be knotted, or if two vortex rings be linked together in any way, they will retain forever the same kind of be-knottedness or linking. These properties seem to furnish us with good materials for explaining the permanent properties of the molecule. Again: the vortex ring, when free from the influence of other vortices, moves rapidly forward in a straight line. It can possess, in virtue of its motion of translation, kinetic energy; it can also vibrate about its circular form, and in this way possess internal energy: and thus it affords us promising materials for explaining the phenomena of heat and radiation.

"This theory cannot be said to explain what matter is, since it postulates the existence of a fluid possessing inertia; but it proposes to explain, by means of the laws of hydrodynamics, all the properties of bodies as consequences of the motion of this fluid. It is thus, evidently, of a very much more fundamental character than any theory hitherto started: it does not, for example, like the ordinary kinetic theory of gases, assume that the atoms attract each other with a force which varies as that power of the distance which is most convenient; nor can it hope to explain any property of bodies by giving the same property to the atom. Since this theory is the only one that attempts to give any account of the mechanism of the intermolecular forces, it enables us to form much the clearest mental representation of what goes on when one atom influences another. Though the theory is not sufficiently developed for us to say whether or not it succeeds in explaining all the properties of bodies, yet, since it gives to vortex motion the greater part of the interest it possesses, I shall not scruple to examine the consequences, according to this theory, of any results I may obtain.

"The present essay is divided into four parts: the first part, which is a necessary preliminary to the others, treats of some general propositions in vortex motion, and considers at some length the theory of the single vortex ring; the second part treats of the mutual action of two vortex rings which never approach closer than a large multiple of the diameter of either; it also treats of the effect of a solid body immersed in the fluid on a vortex ring passing near it; the third part treats of knotted and linked vortices; and the fourth part contains a sketch of a vortex theory of chemical combination, and the application of the results obtained in the preceding parts to the vortex-ring theory of gases.

"It will be seen that the work is almost entirely kinematical: we start with the fact that the vortex ring always consists of the same particles of fluid (the proof of which, however, requires dynamical considerations), and we find that the rest of the work is kinematical. This is further evidence that the vortex theory of matter is of a much more fundamental character than the ordinary solid particle theory; since the mutual action of two vortex rings can be found by kinematical principles, whilst the 'clash of atoms' in the ordinary theory introduces to forces which themselves demand a theory to explain them."

The great difficulty which inheres in the vortex theory of chemical combination is to sufficiently account for what takes place at the instant of chemical union by showing that vortex atoms can, without supposing other forces than those due to their motion, have any such attractions as are known to exist, and especially to account for the enormous quantities of heat liberated in many cases of chemical decomposition.

The author, however, postpones all extended application of the vortex theory of atoms to the dynamical theory of gases for consideration in a future paper, but, among other important conclusions, states that the phenomena attending the diffusion of gases through a porous diaphragm which separates portions of gas at different temperatures will probably furnish a crucial experimental test between the vortex atom theory and the ordinary kinetic theory.

[1] *Crelle's journ.*, 1858, and translated by Tait, *Phil. mag.*, 1867.

[2] *Phil. mag.*, 1867.

[3] *Edin. trans.*, 1869.