RENÉ DESCARTES (1596-1650)

By Prof. HERBERT DINGLE

ON February 11, 1650, René Descartes died in Stockholm in his fifty-fourth year. Galileo had been dead for eight years and Newton was a child of seven. It is customary now to think of Galileo and Newton as the founders of modern science and of Descartes as 'the father of modern philosophy', and in retrospect the titles are justified. The principles of the former thinkers are implicit in all subsequent science and the text of the latter has been explicitly anatomized by all later students of philosophy. Reciprocally, of course, philosophers have regretted the gaucheries of Galileo and Newton, while men of science have forgotten Descartes. There is reason, therefore, in the classification that has been made, but it would have seemed strange in the seventeenth century. At that time all three were placed in the same genus, and, if fertility of crossing is a valid criterion, they were as thinkers of the same species also. The divergence that followed was inevitable, but none the less unfortunate. Let us, three hundred years after his death, try to estimate the scientific significance of Descartes.

His greatest contribution to the fundamentals of all thinking, whether it be called scientific or philosophic, seems to me to lie in his first principle—that the basis of one's system should be that which one cannot doubt. As a rough generalization we may say that earlier philosophers had started with what one ought not to doubt, and later ones with what it is convenient not to doubt. Descartes almost alone took the *impossibility* of doubt as the only valid token and honestly tried to discover what bore it. His solution—the famous *Cogito ergo sum* and its consequences—was perhaps scarcely worthy of the discernment that led to it, but had he done nothing more than sow this one seed of truth and left it to germinate in its own time, he would still have earned his title of the father of philosophy.

At the present time, it is true, its germination seems remote. To change the metaphor, in an age when building material is plentiful, a simple plan available, and workers eager and numerous, the question of the stability of the foundations is apt to be regarded as a tiresome hindrance to progress, and therefore one to be evaded or given whatever answer will most effectively prevent it from obtruding itself. For example, Sir Arthur Eddington, wishing to establish a philosophy on the impregnable rock of pure reason, found the existence of other people neither obvious nor deducible; he therefore *assumed* it. "For reasons which are generally admitted, though I should not like to have to prove that they are conclusive," he wrote¹, "I grant your consciousness equal status with my own." This would not have satisfied Descartes. Again, in a wider sphere, the mathematical form of modern physical relations is equivalent to that of the mathematical theory of probability. Accordingly, a physical picture is drawn to represent those relations which includes entities having a choice of states, with each of which an '*a priori*' probability' is associated; and the phrase '*a priori*' is accepted as an exemption from the task of looking deeper. Instead, a 'logic of probability' is sought, which means that instead of starting with what we cannot doubt, we seek to start with what we cannot help doubting—even with doubt itself:

uncertainty is made not only a principle but the fundamental principle.

Another tendency in the same direction arises from the axiomatic method of modern logic. Whereas ancient logic was merely an instrument for discovering mistakes—or rather for giving names to mistakes that were obvious—modern logic is creative: it seeks to build as large a calculus as possible from the fewest arbitrary axioms or postulates. This is excellent, and potentially of the greatest value to science, but it is not without serious dangers. When we find that to a certain department of observation a calculus of this type is applicable, the temptation to regard its axioms as 'fundamental truths' sometimes proves irresistible, and principles which it is not only possible to doubt but scarcely possible to credit become enthroned as intuitive principles of philosophy, and the observations on which they have been foisted are thought to have been deduced from them by pure reason alone. It is not difficult to imagine what Descartes would have thought of this.

It is the misfortune of Descartes that his influence was weakest where it was most needed, and where it was overwhelmingly strong our most urgent need now is to remove it. Science absorbed two things from Descartes—co-ordinate geometry and the fundamental division of existence into thought and extension—and, paradoxically, while these were essential to its progress they were alien to its nature. As a mathematical discovery, revealing the correspondence of algebra and geometry, and as a tool for the solution of problems in either, it would be impossible to over-rate the importance of co-ordinate systems. Take them away, and much of the science of the last three hundred years becomes impossible. But it is equally true to say, let them remain and much of the science of the future becomes impossible. What was not at first realized was that the arbitrariness of the co-ordinate system introduced a large element of arbitrariness into the results that were achieved by its use, and to-day, side by side with the technique of using co-ordinate systems, the mathematician has to learn the technique of finding invariants and tensors by which their influence can be eliminated. There is a sense in which Einstein's law of gravitation can be defined as what remains in the ordering of space and time measurements when the effect of co-ordinate systems has been removed. One cannot see how it could have been reached without the use of co-ordinates or without their disuse.

Much the same, though in a slightly different sense, can be said of the *res cogitans* and *res extensa*—thinking things and extended things—into which Descartes divided the realm of existence. To him the material world was something completely independent of the mind that perceived it. It had one fundamental characteristic—extension. Its other apparent qualities—colours, temperatures, sounds and so on—were merely a confused kind of knowing, ultimately mental in character, which could all be thought away from it, and he accordingly gave little attention to them. His physics was thus deprived of most of the data on which a successful physics could thrive, and the best he could do with the extended world was to fill its apparently empty spaces with an inapprehensible

'primary matter' in which vortical movements carried the heavenly bodies around in their courses. With thinking things he made no progress at all.

Galileo, on the other hand, with much less theorizing, instinctively adopted the practice which has been the hall-mark of science ever since. Instead of attributing observed motions to hypothetical motions conceived to be necessities of thought, he described them in terms of measurements made with rods and water clocks, and thus discovered the regularities that they exhibited. This was a procedure that could be developed. Newton could complete Galileo's work on motion and show the barrenness of the Cartesian vortices. Moreover, later workers could treat in the same way those very sensations that Descartes had despised. Hotness and coldness could be described in terms of measurements made with thermometers and radiometers and their regularities discovered; colours could be described in terms of measurements made with spectrometers and photometers and laws of colour formulated. Other sensations could be similarly studied, and the whole modern science of physics thus grew up as a rational correlation of sense experiences.

But while it was the Galilean practice that was followed, it was in the light of the Cartesian philosophy that it was seen. The men of science were correlating their observations, but thought they were discovering the nature of the independent, objective, extended world that Descartes had bequeathed to them. The philosophy of Descartes held the science of the eighteenth and nineteenth centuries in an iron grip, all the firmer because it was unrecognized. Berkeley had shown the hollowness of the extended things and Hume that of the thinking things, and they were unanswerable, but the mischief had been done. They might as well not have lived for all the effect they had on the ideas of the men who were making scientific history. Nor is this entirely to be deplored. It is very questionable whether the great advances of those two centuries would have been possible without the simple concrete picture of a passive extended universe of matter presented for study to independent minds. There was much to be done that could be effectively conceived in those terms, and the excesses of an over-confident materialism were perhaps not too high a price to pay for the discoveries and correlations that would otherwise have been achieved, if at all, only with much more difficulty, less general understanding, and far less speed.

It was, indeed, not until almost our own time that the Cartesian doctrine began to mislead. Experiments such as that of Michelson and Morley were the first that utterly refused to accommodate themselves to it. The facts compelled us to substitute the result of the actual process of measurement for the supposed objective extension of the arms of the apparatus, and that result was found to depend inescapably on the particular co-ordinate system in terms of which it was interpreted. The Cartesian world of extended things was seen, in fact, to be an illusion. What physics was concerned with, and always had been concerned with, were the results of its own specified operations, not a hypothetical world of dead being on which those operations were conceived to have been performed.

Such a long-standing prejudice, however, is not easy to abandon. Physics to-day is in a transition stage, in which many of its devotees, rather than abandon their Cartesian universe, are prepared to make it nonsensical by giving it contradictory

properties. Others accept the relativity requirement where they must, but maintain the incompatible traditional view where they still can. Such anomalies must be expected; they will be temporary. A more portentous aspect of the new freedom is the rise of scientific psychology. Such a thing is impossible under the Cartesian scheme: thinking things cannot be related with extended things. To-day emotions and hallucinations are being studied exactly as though they were sensations or cognitions of a material world. Here the Cartesian duality is not refuted: it is simply ignored—a far more fatal treatment.

It is perhaps a melancholy thought that we can best celebrate the death of Descartes by expediting the death of his system; but there are compensating reflexions. In a world of enlarging experience no philosophy can hope to live for ever, and we can only stand in respectful admiration before one which, born at the beginning of a great new era of thought, could direct the course of that thought for two hundred and fifty years. Its passing leaves a blank which, when it is fully realized, will be seen to demand a successor, and no successor can be acceptable that does not start where Descartes started, with that which cannot be questioned. As the first clear exponent of that principle at least he is immortal.

¹ "The Nature of the Physical World", p. 283 (Camb. Univ. Press, first edit.).

MECHANISM OF DETONATION

A DISCUSSION on "Detonation" was held by the Royal Society on November 10, in the Society's rooms, with the president in the chair. Some of the speakers described work which was done during the Second World War, while others described work which has recently been completed or is still in progress.

The discussion was opened by Dr. W. G. Penney, who described current ideas on the structure of the reaction zone. The leading edge of this zone is a strong shock front in which the pressure rises to its maximum value in a distance of order 10^{-6} cm., while at the same time the temperature rises high enough to start reactions at a very fast rate. The reaction energy may be regarded as heat supplied from an external source; and the result is to produce an expansion of the reacting material, with a fall in pressure but an increase in temperature. The width of the reaction zone is a few millimetres for most solid explosives, and the time of transit of any particle through the zone is approximately one microsecond. In most cases, the width of the reaction zone is small compared with the radius of curvature of the shock front, and the flow through the zone can therefore be regarded as one-dimensional. Conservation of momentum then leads to a linear relation between pressure P and specific volume V throughout the zone:

$$P - P_0 = D^2(V_0 - V)/V_0^2. \quad (1)$$

The detonation velocity is D , and zero suffixes refer to undisturbed material ahead of the wave.

Conservation of energy leads to the second Rankine-Hugoniot equation

$$E - E_0 = Q + \frac{1}{2}(P + P_0)(V_0 - V), \quad (2)$$

where E is the internal energy and Q the heat added from chemical reaction or from some other source.