

161/2 INDETERMINISM IN PHYSICS

Natural Philosophy of Cause and Chance

Being the Waynflete Lectures delivered in the College of St. Mary Magdalen, Oxford, in Hilary Term 1948. By Max Born. Pp. viii+216. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 17s. 6d. net.

READERS of *Nature* may recall a vigorous controversy conducted in its correspondence columns in 1944 and 1945, on the question whether present atomic ideas demand the abandonment of determinism. In the book which is the subject of the present review, Prof. Born comes down definitely on the side of the indeterminists. His book is not, however, in the main concerned with philosophical ideas. Rather it is an account of the historical development of parts of theoretical physics, explaining where strict determinism has been replaced by statistical concepts.

The subjects briefly treated include Newtonian mechanics, thermodynamics, kinetic theory, statistical mechanics and atomic theory. Naturally, no full historical treatment of all these can be given in the space of a single slender volume; Born has to select a few main points to illustrate his argument. He is especially interesting when describing ideas of men of science whom he has known personally—when describing, for example, how statistical ideas helped Planck to derive his radiation law, and Einstein to develop the theory that radiation was composed of quanta. His accounts of recent work are the more valuable because of his personal share in it; the last work described is that recently done by Born, with H. S. Green, on the kinetic theory of liquids.

Mathematical formulæ appear in the text; but, as in Born's "Atomic Physics", most of the detailed mathematical proofs are relegated to a series of appendixes, which take up some eighty pages of the book. These proofs cover an extraordinary variety of subjects. The Maxwell-Boltzmann distribution function is derived in three distinct ways; an explanation is given of the method of Darwin and Fowler in statistical mechanics; the properties of the density matrix are considered; and other mathematical sections treat Newton's law of gravitation, Brownian motion, irreversibility, the multiple distribution function in liquids, and gas degeneracy. Dealing with such a wide variety of separate subjects, the appendixes inevitably cannot provide an introduction to the mathematical theory for a reader unacquainted with the general ideas. On the other hand, the reader already knowing something, and desiring to systematize his knowledge, will find them invaluable, because of their clarity, compactness and mathematical elegance.

One detail only am I inclined to criticize in the historical account. Imbued with something of a missionary zeal, Born introduces Caratheodory's powerful and elegant method in considering the second law of thermodynamics. His account of the method is not altogether easy to follow; because of his compactness, it is not always immediately clear when he is considering reversible processes and when irreversible; moreover, the example of non-integrable planes on p. 40 is wrongly quoted. It would be a pity if trifles like these were to obscure the true worth of Caratheodory's method.

I feel less happy about the more philosophical aspects of the book. This is in part because Born,

busy with the details of the historical development, only occasionally straightens his back to survey the whole landscape; in part, too, because he does not state his ideas in full, but leaves the reader to piece together his point of view from hints. But I also feel that his arguments are not always logically unobjectionable. This last statement is prompted by no disagreement with his final conclusion, that indeterminism has come to stay, because the whole structure of quantum theory is bound up with it. That conclusion I accept; but some of the subsidiary points of the argument seem not well reasoned.

For example, Born takes, as one of the minor attributes of physical causation, antecedence—the cause precedes the effect. He states that causation in Newtonian mechanics violates antecedence—the equations are unaltered if the time direction is reversed, and so provide no means of deciding whether the cause precedes or follows the effect. He accordingly turns to thermodynamics, the irreversibility of which provides an objective test distinguishing the positive and negative time directions. One might object that classical mechanics, through friction and similar forces, has plenty of irreversible processes of its own; but actually the particular test used to fix the positive time direction is irrelevant in deciding whether one event precedes another.

Again, Born seems to imply that the acceptance of indeterminism makes it easier to reconcile the reversibility of dynamics with the irreversibility of thermodynamics. I question this; indeterminist quantum mechanics still leaves it possible that the molecules of a quantity of gas should, by a remarkable succession of accidents, sort themselves out in such a way that half the gas becomes hotter than the other half. One obtains irreversibility in kinetic theory, not by abandoning determinism, but because of approximations necessarily made in introducing statistical ideas.

I could give other examples, but it would scarcely be appropriate for me to do so. After all, they refer only to details; and when a master like Born writes a book on the subject of which he is a master, it is only fair to expect those interested to read it, and find out for themselves whether they disagree with his arguments. And this I recommend them to do; whether they agree or not they cannot fail to be stimulated.

T. G. COWLING

EFFLUVIA

Odors

Physiology and Control. By Carey P. McCord and William N. Witheridge. Pp. x+405. (New York and London: McGraw-Hill Book Co., Inc., 1949.) 39s.

The Chemistry of Perfumery Materials

By R. W. Moncrieff. Pp. vii+344. (London: United Trade Press, Ltd., 1949.) 30s. net.

SINCE "Odors: Physiology and Control" is probably the first book of its kind to be written, there are no standards for direct comparison; of the many volumes which have been written on the subject of odour this constitutes the first systematic survey of how to deal with those odours which we do not enjoy. From a purely factual point of view it is possible to divide the book into three distinct sections—the first thirty pages being devoted to the physiology of odour; thence to page 100 chemistry