ESSAY REVIEWS

CHANGING VIEWS OF MATTER

The Concept of Matter. Edited by ERNAN MCMULLIN (University of Notre Dame Press, 1963). Pp. xi + 624. $9.95.

Attempts to confront the history of scientific ideas with the philosophical analysis of scientific concepts are scarce and greatly to be welcomed. This book arises out of such a confrontation on a grand scale. It is the record of a conference of thirty philosophers, historians of science, and physicists, held at the University of Notre Dame in 1961, and consists of revised versions of the papers contributed, together with some of the comments upon them prepared in advance, and some excerpts of the discussions. Two of the papers and one comment were added subsequently. According to the Editor's Introduction, the concern of the Colloquium "was not so much with the history of ideas as with substantive questions of present philosophic and scientific concern" (p. 1), approached, however, through case-studies of historical examples.

The first two Parts of the book deal with matter in Greek and medieval philosophy, the first Part being mainly expository and the second analytic. In the classical doctrines 'prime matter' has three main roles, namely as the ultimate substratum which persists in substantial change, as the ultimate subject of predication, and as that which allows the forms to subsist in a multiplicity of individuals, that is, as the principle of individuality. In a particularly illuminating paper, Father Joseph Owens discusses the paradoxes involved in holding matter to be the ultimate subject of predication. According to Aristotle, the predication of matter by forms is like that of substance by its accidental qualities, for example 'this house' can be predicated of its materials in a way similar to the predication of 'this house' by, say, 'tall'. In addition, prime matter must also be predicated *essentially* as ingenerable, indestructable, etc., since it is a necessary property of the substratum of change that it does not itself change. But both these types of predication are different from the predication of substance by accidents, and hence they raise metaphysical problems that break through the Aristotelian logic of science. Such a concept as prime matter has to be introduced by *analogy* at the end of scientific reasoning, and according to Owens its introduction is wholly irrelevant to discussions of matter in natural science.

These themes and their attendant problems turn up again and again in the papers. Prime matter is a metaphysical principle, an unobservable, which can be known only by rational reflection on observed change. But it is in some sense indeterminate, bare, qualityless, so how is it to be known at all? And even if it can be known, is it a useful or necessary concept? Are the 'matters' arrived at in the contexts of change, of

predication, and of individuation necessarily the same matter? The interest of the historian of science will be focussed not so much upon the philosophic controversies engendered by these problems, as upon their interaction, if any, with the progress of science. On this point two reflections are suggested by the claim of Owens and other contributors that the metaphysical discussion is wholly irrelevant to science. First, neither Owens nor the other symposiasts succeed in clarifying the nature of the 'analogical' procedure by which matter and other metaphysical principles are supposed to be introduced. There seem to be three possibilities here. Either (1) the principles are introduced *via* examples of change, predication, etc., in ordinary discourse and in science, in which case the structure of the language and the science in terms of which they are introduced would seem highly relevant to their understanding; or (2) the metaphysical principles can somehow be cut loose from the chain of reasoning by which they are arrived at; or else (3) the notion of a metaphysical principle remains essentially unintelligible, and it must be possible to show that change, etc., can be adequately explicated without it. The explicit claim in the more traditional papers presented here seems to be (2), although the logical and linguistic difficulties involved are hardly clarified for those outside the scholastic tradition, and in practice, and especially in the discussions, the expository method is (1), and it is never clearly shown that (1) can be dispensed with. Two contributions from a more modern philosophical view-point adopt (3). In a brilliant analytic paper, "Primary matter and unqualified change", Milton Fisk argues that the problem of the existence of prime matter must be approached by means of three kinds of questions: Does the concept lead to contradiction, in which case the entity referred to by the concept does not exist? Does analysis of some process (*e.g.*, change) demand the postulation of new existing entities (*e.g.*, matter and form)? Does a given structure of thought in fact presuppose some such entities? Fisk concludes, in a discussion of great cogency, that prime matter does not exist in any of these senses. Wilfred Sellars, in "Raw materials, subjects and substrata", arrives by a different route at a similar conclusion, namely that there is no qualityless substratum in either predication or change. The first two Parts of the book would have been stronger if the philosophers in the classic tradition had attempted to meet the powerful arguments of these two papers on their own ground. As it is, too many of the traditionalists still appear to be talking to each other in their own language, and some indeed to be talking to no one but themselves. This makes the forced confrontation in the excerpts from the discussions especially valuable, but even here only Sellars appears to be able to move happily and intelligibly in both camps, and again and again he lights up the traditional terminology with apt examples drawn from live philosophical and scientific problems.

The second reflection is more directly connected with the history of science. It is clear both in Owens's paper and in that by Allan B. Wolter on "The Ockhamist critique", that the existence of prime matter is connected with the existence of substantial change, and that that itself is connected with what we should now call the problem of reduction. Ockham, perhaps unexpectedly, does not use his razor on the concept of prime matter, because he finds it a necessity of thought in considering such changes as transformations of the elements and organic birth and death. Change such as rarefaction and condensation, however, is explicable in terms of local motion without recourse to prime matter. In the atomic tradition, on the other hand, there is no substantial change, and hence no prime matter, because all change is explicable in terms of motions and configurations of atoms, and the atoms are not qualityless substrata. It is not difficult to see in a thoroughgoing modern reductionist a successor of the atomists in this respect, and hence the question of prime matter seems highly relevant to a central question in the philosophy of science: even if we grant that physics is now not concerned with substantial change (and this itself is controversial), can the same be said of biology, or even chemistry, that is, are these sciences similar to or reducible to physics? The philosophical relevance of this question is indeed admitted by the Editor (Introduction, p. 9), and it is perhaps a pity that no contribution towards it was sought from a philosopher of biology.

Part III, "From matter to mass", begins with an excellent paper by Father James A. Weisheipl on "The concept of matter in fourteenth century science", which shows the scientific conceptions of mass and conservation struggling to be born from the matrix of Aristotelian philosophy. Aristotelian prime matter is conserved only in the sense that it is not determined quantitatively or in any other way, and hence while it cannot be said to change, it cannot be said to be quantitatively conserved either. Therefore for the scholastic philosophers the conception of 'same quantity of matter' preserved through change had to be referred to *second matter*, that is, to the substratum of accidental as opposed to substantial change. The idea of conservation thus shifts from the *identity* of prime matter in change, to the *equality* of quantity of second matter. If it is thus shifted, however, what grounds remain for asserting its quantitative conservation? Weisheipl is not explicit on this point, but it seems to be related to observable changes such as condensation and rarefaction where something other than prime matter appears even to superficial observation to be conserved. In the Aristotelian tradition condensation and rarefaction were generally regarded as changes of quality rather than quantity of matter in a given place, since the notion 'quantity of matter in a given place' could not arise if *prime* matter were meant. Swineshead, however, takes advantage of the

introduction of second matter as the subject of conservation to re-interpret condensation and rarefaction as changes of *position* of what he calls *massa elementaris*, rather than as changes of quality, thus returning to the atomists' interpretation of the dense and rare. For Swineshead the 'latitude' of rarity is the proportion of volume to *massa elementaris*, and since 'mass' as such is unknown, it has to be derived from spatial magnitude and density conjointly. This, Weisheipl argues, is the conception of 'quantity of matter' which lies behind Newton's famous definition. From Weisheipl's account of the opinions of the Oxford and Paris schools it appears that 'density' was regarded as an independent observable, so that the definition of mass is not subject to the objection of circularity often brought against Newton's formulation, and on the other hand it is independent both of weight and of the conception of 'number of atoms in a given volume'. Weisheipl does not, however, make quite clear what the fourteenth-century conception of 'density' is. If it is a perceptible quality, it is not after all closely associated with weight? And if so, Newton's claim to have demonstrated the purely empirical proportion of mass and weight by means of pendulum experiments still seems involved in definitional circularity.

The remaining two papers in this Part are also of a historical character. One is on "Action at a distance" by the present reviewer, and was contributed after the Colloquium had been held. The other is on "Matter in seventeenth century science", by Marie Boas Hall, and consists of a masterly survey of the concept of matter-in-motion in the natural philosophies of Bacon, Descartes, Boyle, Newton, and other pioneers of the mechanical science. Dr Hall argues that this conception was not much indebted to ancient atomism, which was sterile in the face of new scientific problems, but her thesis is controverted by Weisheipl, who maintains in his Comment that the mechanical philosophers all rejected the typical constituents of an Aristotelian philosophy, namely real becoming, substantial change, and teleological explanation, and hence that they were essentially returning to the atomist viewpoint. One would have liked to see more discussion of this, and of the assertion with which Dr Hall begins her paper, namely that with all their variety, the seventeenth-century philosophers agreed in rejecting the Aristotelian view of matter as "philosophically false and scientifically sterile". Many of them did this on philosophical as well as scientific grounds, and the Colloquium unfortunately lacks a philosophical paper to balance Dr Hall's historical account of the crucial century of scientific revolution.

A general weakness in respect of post-Cartesian philosophy shows itself in Part IV: "The concept of matter in modern philosophy". This consists of a brief and somewhat esoteric account of "Matter and individuation in Leibniz"; a notable attempt by John E. Smith to bring

together the various concepts of matter in Kant, including those in his much neglected scientific work *Metaphysische Anfangsgründe der Naturwissenschaft*; articles on the Idealist and Marxist traditions; a critique of phenomenalism; and an attempt by Father Robert O. Johann to reconcile the concept of prime matter with genuine novelty in an evolutionary universe. This selection of topics and their treatment is such as to reinforce the thesis of the separation of science and philosophy in the understanding of matter in this period, and one would like to have seen some space given to other philosophical problems in which interaction certainly did take place, for example, the metaphysical foundations of Cartesian science, Leibniz's very considerable contributions to the mechanical theory of matter, the discussion of primary and secondary qualities in the empiricists, and the Kantian grounds of much nineteenth-century German natural philosophy within which 'energy' came to replace 'matter' as the scientific substratum.

The title of Part V, "Modern science: the 'dematerialization' of matter", makes explicit a pervasive assumption of the whole book, namely that, as the Editor's Introduction has it, the concept of matter "plays no *direct* part in the doing of science today" (p. 2), but only in *talking about* science. But which concept of matter? If the classic concept of prime matter is meant, then no doubt the assertion is correct, but it would be curiously parochial to conclude without further ado that no concept of matter of any philosophic interest whatever plays a part in modern science. The argument, however, both in the Introduction and in N. R. Hanson's "The dematerialization of matter", is more substantial than this, and is drawn from a particular, somewhat positivist, interpretation of modern scientific theory. Hanson argues that although Berkeley killed the *philosophic* distinction between primary and secondary qualities, he left scientists free to employ the distinction in theories of matter having only primary mechanical properties, but that modern physics no longer leaves them free to do this, since elementary particles can no longer be unambiguously described by properties previously thought essential to matter, such as precise space-time location and momentum, shape, size, solidity, contact, self-identity, and so on. In his Introduction Father McMullin lists several ways in which the dematerialisation of matter has taken place: the disappearance of mass as an operational quantity in relativity theory; the observer-dependence of primary qualities; the reduction of primary qualities of macroscopic objects to properties of yet more and more fundamental particles; the geometrisation of matter in field theories and apparent absence of any 'substratum'; and the assimilation of mass to non-reifiable energy. Several of these last points are illustrated by informative papers on recent quantum field theory by Cecil B. Mast, A. E. Woodruff, and Charles W. Misner.

The many issues raised in this section would take this review too far afield. But it may be suggested that before concluding too hastily from the contents of the book that the philosopher's 'concept of matter' is of no direct relevance to the scientist, and that 'matter' as such has disappeared from science, several further questions need examination. For example, the disappearance of matter understood in terms of certain mechanical qualities hardly seems a conclusive answer to the question whether some other kind of matter now replaces it, or even to the question whether something having the functions of classical prime matter is still presupposed in science. Various attempts to 'substantialise' energy and field need to be taken much more seriously in this context. Again, how far does a non-realist philosophy of the theoretical entities of science influence the conclusion of irrelevance? This view is tacit in many of the philosophical contributions here, and explicit in McMullin's paper "Matter as a principle", and it is also connected with his distinction between *doing* science and *talking about* the conceptual framework of science. If, on the other hand, we ought to view our fundamental scientific models of matter as attempts at real descriptions (as I argue briefly in my contribution "Action at a distance"), the traditional philosophic problems about matter may well not be irrelevant to these models, although they will no doubt be transposed into different terms. For example, is it even logically consistent to hold that the fundamental particles of matter have no permanence, no distinguishability and no individuality, as is held in quantum field theory? It is possible for there to be *no* substratum here, or do we have to look elsewhere for it, perhaps to the space-time manifold itself? Questions like these do become relevant to modern science whenever an attempt is made to formalise a theory, because it then has to be decided what in the theory are the 'individuals' (subjects, 'substances') and what the 'predicates' ('forms', relations). Discussion of such questions cannot be separated from the 'doing' of science, as the recent history of interpretations of quantum theory has shown.

If this book raises more questions than it answers, this is not an indication of failure, but rather the reverse. The University of Notre Dame is to be congratulated on bringing together such a diverse group of scholars and getting them to address each other relevantly for at least most of the time. In particular, Father McMullin has performed a Herculean task in editing the material and drawing together the threads into some kind of unity in his Introduction. If that unity turns out to be perhaps too sharp a dichotomy between philosophy and science, that may merely ensure that others are provoked to continue the conversation.

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