VI.—CRITICAL NOTICES.

The Analysis of Matter. By BERTRAND RUSSELL. Kegan Paul, 1927. Pp. viii, 408. 21s.

THIS book constitutes the complete work from which Mr. Russell's *Tarner Lectures*, delivered at Cambridge in 1926, were a selection. The introductory chapter states and subdivides the problem to be discussed. The rest of the book falls into three parts, *viz.*, (1) *The Logical Analysis of Physics*, (2) *Physics and Perception*, and (3) *The Structure of the Physical World*. In these three parts Mr. Russell raises, and tries to answer, three distinct but closely connected questions, *viz.*, (1) What is the logical structure of theoretical physics, considered simply as a hypothetical-deductive system like pure geometry? (2) How are the terms and laws of physics connected with the data of sense-perception, which are admittedly our ultimate evidence for the truth of theoretical physics? and (3) What is the most plausible view of the contents and structure of nature which will be consistent with the logical conclusions of Part I and with the epistemological conclusions of Part II?

Part I is a very lucid account of the present position of theoretical physics by an extremely competent onlooker who is able to see more of the game as a whole than the players themselves and who accompanies it with a running critical commentary. Reading it may be compared to attending a Rugby football match under the guidance of Mr. W. W. Wakefield. It should be extremely useful to those who already have some knowledge of current mathematical physics; but I doubt whether others will make much of it. This is not Mr. Russell's fault, but is inevitable from the nature of the subject.

We are first told about the pre-relativity physics; then about the fairly simple and common-sense view of the atom as consisting of planetary electrons revolving about a central positively charged nucleus. Then we are introduced to the theory of quanta, and so to Bohr's theory of the atom and its development by Sommerfeld and others. This leads on to the atomic theories of Heisenberg and Schrödinger, in which the picture of substantial electrons and nuclei fades away into mere mathematical functions requiring a special algebra of their own. Next we learn about the special and the general theories of relativity. This leads on to a discussion of the method of tensors, and to an explanation of the notions of geodesics and invariants. We are then ready to be introduced to Weyl's

theory, which bases the laws of electromagnetics on considerations of the relativity of measurement in different regions. This raises the general question of measurement, and introduces the principle that the fundamental laws of geometry and of physics must be expressible in differential equations. These subjects are discussed with special reference to Prof. Eddington's views. Then comes a chapter on matter and space, in which it is pointed out that the old sharp distinction between the two has vanished. In this chapter Mr. Russell also explains how quantum phenomena and the facts dealt with by ordinary optics and electromagnetics seem respectively to require different and inconsistent views of the nature of physical processes. Part I ends with a chapter on the abstractness of physics, in which Mr. Russell emphasises the extreme remoteness of the concepts of modern theoretical physics from anything that we can either perceive or picture in imagination. This naturally leads on to the epistemological problem of Part II.

The following points in Part I seem to be of special logical interest. (i) Mr. Russell remarks that there is a certain peculiarity in the method of tensors which suggests that it can hardly be ultimate. The object of the method is to state *intrinsic* natural laws, *i.e.*, laws which contain nothing that depends on the special system of co-ordinates used for placing and dating events. Yet, to secure this end, it has to start by assuming some set of co-ordinates or other. One cannot help thinking that there must be some less roundabout way of stating the intrinsic laws of nature. (ii) Mr. Russell points out that physicists have hardly recognised the full implications of the principle that the ultimate laws of nature are differential. Since there are no actual differentials, such laws must express the limits to which certain relations between *finitely* separated events approach as the separation between them is made smaller and smaller. He works this out in an interesting way in his treatment of measurement and its presuppositions. (iii) We are told that, apart from the facts which led to the general theory of relativity, there was no real objection to the Newtonian doctrine of absolute space, time, and rotation; but that the general theory of relativity has definitely answered the question in favour of the relational view. I do not think the matter is quite so simple as this. Of course the terms of the question are changed almost beyond recognition when we substitute space-time for space and time, and when the distinction between "empty" and "occupied" regions of space-time is made to consist in differences of "geochronometry". But I understand from a short paper by Prof. Eddington in the volume published in connexion with the Newton celebrations that the question about absolute rotation still has a meaning, and that, when interpreted in terms of tensor-theory, it has to be answered in the affirmative. (iv) Mr. Russell holds that the relativistic theory of gravitation can be stated either in terms of a homaloidal space-time with a contingent filling, or in terms of a non-homaloidal space-time with contingent variations in its

"geochronometry" from one region to another. He disagrees with Whitehead, who thinks that the former interpretation alone is right, and with Eddington, who thinks that the latter alone is right. Here, if I may venture to express an opinion, it seems to me that Mr. Russell is plainly correct; since each of these distinguished relativists has refuted the other by doing what, in his opponent's view, should be impossible.

Part II starts by considering the development of the common-sense view of the world out of more primitive experiences, and the development of the modern physical view out of that of common-sense. To the plain man the world consists of more or less permanent things, each of which has many different qualities and is the subject of varying states. And these things are believed to exist and interact in a common space and time. Now, as Mr. Russell points out, it is quite certain that this view is not primitive. We can see infants painfully acquiring it by practice before they can speak or reason. It would, of course, be a grave mistake to call the common-sense view an "inference," if this means a conclusion reached by deliberate argument, inductive or deductive, from other beliefs. But "all our intellectual processes have pre-intellectual analogues". The acquirement of conditioned reflexes is the physiological analogue of inductive argument, and this plays an essential part in forming the common-sense notion of persistent things with varying states interacting in a common spatio-temporal system. When "inference" is taken in this wide sense it is difficult to point to anything that is a pure datum unmodified by inference. But this is unimportant; for we can certainly arrange our judgments in a hierarchy in this respect, and can see that the judgment "This is a sensibly red occurrence" involves much less inference than the judgment "This is a red material object".

The only plausible criticism which might be made on this part of Mr. Russell's doctrine is the following. Everyone would admit that, unless we had had certain reflexes and the power of forming associations, and unless there had been certain sequences and repetitions in our sensations, we should not have distinguished one thing from other things or identified each thing throughout a period of time and change. But, granted that these conditions are necessary, are they sufficient? Do they suffice to generate the belief in permanent things in a three-dimensional space, or do they merely fill in the details of a general scheme of interpretation of sensible experience which is innate? I suppose, *e.g.*, that Prof. Stout would accept all the positive part of Mr. Russell's contentions here, but would hold that the beliefs of common sense cannot be completely accounted for except on the assumption of certain innate categories in terms of which the mind interprets the sensible experiences which it gets and the associations which it acquires.

In Chapter XVII on *What is an Empirical Science?* Mr. Russell asserts that distinctions of modality apply properly to propositional functions and not to propositions. To say that $\phi(x)$ is necessary,

possible, or impossible means respectively that it is true for all, for some but not all, or for no, values of x. This doctrine has been confronted with very serious objections by Prof. Moore and others; and, until they have been answered, it must be regarded as a mere *obiter dictum* of Mr. Russell's. Mr. Russell defines an "analytic proposition" in this chapter as one which can be deduced from Logic alone. He then accepts Wittgenstein's view that all propositions which can be deduced from Logic alone are tautologies, *i.e.*, statements that two different sets of symbols symbolise the same thing. If this be so, it seems strange that Mr. Russell should say on p. 174 that "we may learn from experience that $2 + 2 = 4$, though we afterwards realise that the experience was not logically indispensable". It is difficult to see how experiments with beads or counters could tell us whether two different symbols do or do not symbolise the same thing. Mr. Russell regards the adjective *a priori* as essentially epistemic; we may talk of *a priori* knowledge or belief, but not of *a priori* facts or propositions. He thinks it doubtful whether there is any synthetic *a priori* knowledge, and certain that there is none about the subject-matter of physics. There are *a priori* beliefs, and some of them are true; but their *a priority* does not guarantee their truth.

We may now consider the passage from the common-sense view of perception to that of physics. The essential change is that we abandon naïve realism in favour of a causal theory. This theory has a negative and a positive side. The negative side is that what each of us is acquainted with in sense-perception is private to himself; the positive side is that correlated percepts in ourselves and others are due to remote causes, and that some of the properties of these causes can be inferred from the qualities and relations of the correlated percepts. The arguments for the negative side are hackneyed, and Mr. Russell does not waste much time over them. The important question is whether we are justified in accepting the positive side.

Mr. Russell holds that the positive contention of the causal theory cannot be demonstrated; but, if we accept the validity of induction and inverse hypothetical reasoning, it can be made highly probable. There is, I think, a slight danger of unwittingly getting into a logical circle here. Mr. Russell does not profess in this book to deal with Induction. He feels certain that it can be justified somehow, and refers us to Mr. Keynes for details, without committing himself to complete agreement with Mr. Keynes. Now, on Mr. Keynes's view, induction can be justified only on certain assumptions about nature. In particular Mr. Keynes finds it necessary to assume a limited number of generating properties which generate the rest of the properties of objects. Now the danger which I wish to indicate is that it seems possible that something like the causal theory of perception is one of the fundamental assumptions of induction. In that case it would be circular to support the causal theory by inductive arguments. I do not say that this

is so; but, until Mr. Russell has decided what are the fundamental presuppositions of induction, he cannot be sure that his arguments for the causal theory may not be circular.

The course of the argument, on Mr. Russell's view, would be as follows: (1) Each percipient can supplement the percepts which he actually has by other correlated percepts which he would have had if he had followed up his actual percepts by certain series of sensations of movement. This is an induction from cases in which such series were actually experienced. (2) The next step is from my actual and possible percepts to the existence of foreign percepts. At this stage we can construct a common space of percipients. It will not be continuous, but we can eke it out by the notion of possible percipients. The argument here is supposed to be by analogy, and Mr. Russell thinks it a very strong one. (3) The last step is from the actual and possible percepts of myself and other percipients to events which take place where there are no actual percipients at the time. These may be qualitatively very unlike percepts. Mr. Russell holds that this third step presupposes the second and is more precarious. But he thinks that the sort of facts which physicists explain by ascribing a finite velocity to light and sound make it almost inevitable to take this step unless we are prepared to accept extremely odd and complicated causal laws. I have only two comments to make here. (*a*) When we argue to "foreign percepts," how much is to be understood by a percept? Does it mean an event which qualitatively resembles some percept of mine? If so, we shall be breaking Mr. Russell's rule that only structural characteristics can be inferred. Or does it mean an event which is related to a large number of other events in the way in which my percepts are related to each other? If so, we seem to be inferring a great deal; and one wonders whether the argument is so cogent as Mr. Russell thinks. (*b*) In so far as Mr. Russell's objection to pure Phenomenalism rests on the principle that the cause of an actual event must be actual and not merely possible, it seems open to the following query. The notions of cause and substance being so intimately connected, have we any right to assume that, when the traditional notion of substance has been so radically transformed, as it is by Mr. Russell, the traditional notion of causation will not need a parallel transformation? And can we be sure that, with the transformed notion of causation, the cause of an actual event must be actual?

The next question discussed by Mr. Russell is this. Granted that we can infer from percepts and their relations that there are actual events which are not anyone's percepts, how much can we know about the character of such events? Mr. Russell's general principle is that we can infer with high probability the structural characteristics of such events from the structural characteristics of percepts, but that we cannot infer their purely qualitative characteristics from those of percepts.

This brings us to Mr. Russell's doctrine that, from one point of

view, my percepts are inside my head, whilst, from another point of view they are outside my body. The second statement is fairly obvious. In my visual field at any moment my visual percept of so much of my body as I can see is central, and my visual percepts of other objects are arranged about this centre in various directions and at various distances. The first statement is more paradoxical. It depends on Mr. Russell's view that a percept actually *is* that event in the brain which would usually be regarded as its immediate necessary and sufficient condition. Suppose I am looking at a penny. I am aware of a brown and roughly round visual percept. Now the penny, on Mr. Russell's view, is a set of correlated percepts and other events which converge to or diverge from a certain region in physical space. This region is "the place where the penny is". Similarly "the place where my head is" is another region in physical space which is the centre of another set of correlated percepts and other events. And the event which is my percept of the penny is an event which takes place inside the latter region. Suppose you object: "If I were to open your head and look inside I should not see a brown roundish disc but a greyish mass". Mr. Russell would answer: "But what you are directly acquainted with then is an event in *your* head and not an event in *my* head". It does appear to me that most of the difficulties which strike one at first sight in Mr. Russell's view vanish when we clear up the confusions into which one almost inevitably falls.

If we now raise the question: "Are the events outside our bodies qualitatively like or unlike the correlated events in our brains?", Mr. Russell answers that the fundamental difference between the two is epistemic rather than constitutive. We know a good deal about the intrinsic qualities of certain events inside our own bodies, *viz.*, our percepts. We know comparatively little about their laws. We know a good deal about the laws and structure of external events, but nothing for certain about their intrinsic qualities. There is, however, no reason why external events should not resemble percepts in their intrinsic qualities, and no reason why they should. We are therefore free to ascribe, as an hypothesis, just as much and just as little qualitative resemblance as we find most convenient.

The remaining point of special interest in Part II is Mr. Russell's view of substance. He accepts the distinction between substantives and adjectives as irreducible, and admits the existence of substances, in the sense of existent substantives. But he thinks that there is no ground to believe that what are commonly counted as persistent substances, *e.g.*, tables or electrons, really are existent substantives. The only existent substantives that we have any good reason for accepting are short-lived events. What is ordinarily called a substance is a set of successive events connected by a purely immanent causal law, such that the positions and qualities of the later events could be inferred from those of the earlier events. The law may be such that the successive events of the set form a line in

space, or such that they form a series of concentric spheres. An electron would be an example of the first kind, and a light-wave of the second. It must be noted, however, that substances, so defined, are ideal limits rather than actual existents, since there is constant interaction in the world. The real position may be expressed roughly as follows. The actual characteristics of any event may be inferred by supposing that there were several substances, A, B, C . . ., in the sense defined; and that this event had belonged to all of them. Its actual characteristics will then be found by superposing on each other the characteristics which it would have had if this supposition had been true. Generally the characteristics of this event will be to a first approximation as they would have been if it had belonged to A, *e.g.*, alone; and B, C, etc., will need to be introduced only for modifications of detail. We then say that the event "occurs in" A, but is in part "determined by" B, C, etc.

Part III is much more technically mathematical than the rest of the book, and it is hardly possible to give an intelligible brief account of its details. The object is to suggest hypotheses about the ultimate stuff and structure of nature which shall do justice both to the latest developments of theoretical physics and to the epistemological results of Part II. It is admitted by Mr. Russell that the conclusions here are tentative, for two reasons. Theoretical physics are still in a state of flux on fundamental questions; and, even if we took one particular view of quantum and relativity phenomena, many alternative hypotheses about the stuff and structure of nature might equally do justice to it and to the epistemological results of Part II.

The main points of Part III are the following: (1) Mr. Russell, whilst paying the highest tribute to Prof. Whitehead's absolutely fundamental work on the definition of points and instants in terms of volumes and durations, finds one defect in it. Whitehead assumes that every event contains within it events of smaller spatio-temporal dimensions; *i.e.*, that there are no minimum events. It would obviously be advantageous if this limitation could be removed, and points and instants could be defined by some method which would work equally well whether there were or were not minimum events. Mr. Russell outlines such a method, and there seems no reason to doubt that it is correct in essentials. (2) Proceeding on these lines, Mr. Russell shows how to construct a space-time which shall answer to the requirements of *Analysis Situs*. (3) To pass beyond this to metrical properties he considers that it is necessary to introduce causal considerations. Here he deals with the conception of Interval, and tries to give a physical meaning to it which shall account for the otherwise rather mysterious physical importance which it plainly possesses. (4) The other conception which is also of the utmost physical importance is the Quantum. Now this appears to be specially connected with periodic changes. Mr. Russell therefore gives an important and interesting account of the real meaning of periodicity. He suggests that, in view of relativity

considerations, on the one hand, and of the later theories of the atom, on the other, we cannot rest content with the notion of periodic *motion* as fundamental. Qualities, which have so long been banished from theoretical physics, must be re-introduced; and the fundamental fact of periodicity will be the rhythmic repetition of certain series of qualities. In this connexion Mr. Russell draws a distinction between "steady events," "rhythms," and "transactions". Transactions are connected with quantum changes, like radiation and absorption of energy. The distinction between rhythms and steady events may be compared to Prof. Whitehead's distinction between "non-uniform" and "uniform" objects.

In this review I have necessarily omitted many interesting points in Mr. Russell's book, for it is singularly full of what he will no longer permit us to call "matter". But I have perhaps succeeded in making clear to the reader that it is a most important contribution to the philosophy of modern physics by one of the very few writers who possess the peculiar combination of gifts and acquirements which are needed if one is to write intelligently and intelligibly on the subject.

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Duns Scotus. By C. R. S. HARRIS. Oxford: Clarendon Press, 1927. 2 vols. 8vo, of ix-380 and 401 pages. 42s.

THE object of Dr Harris' work is a twofold one: firstly, to give a general survey of the philosophy of Duns Scotus; secondly, to establish that the teaching of Duns Scotus represents more truly than Thomism the culminating point of Latin scholasticism: "It is in him," Dr. Harris says, "rather than in the Angelic Doctor, that the scholastic philosophy reaches the highest point of its development. Notwithstanding the fact that he never left behind him a finished and well-rounded system like that of Thomas, he shows a wider range of thought and a greater degree of consistency, and above all a far deeper appreciation of the philosophical needs of Catholic Christianity, than his more famous rival" (I, p. 267). In order to justify this last conclusion, Dr. Harris has tried to accumulate all possible sorts of evidence. Thomism, in his two volumes, is very easily disposed of and it would be difficult to discuss his assertions precisely, because they are nothing but assertions. Scotism, on the other hand, has been very carefully studied. Dr. Harris not only knows all the printed texts attributed to Duns Scotus, but he contributes himself two hitherto unpublished fragments of the Subtle Doctor (II, pp. 361-398), thus enriching our knowledge of his thought. It is therefore necessary to look attentively at the facts on which this new interpretation of Duns Scotus is grounded, in order to see whether or not they are firm enough to support his interesting conclusions.

Let us say at once that if the main thesis of his work cannot be