electrode as the cathode, for it is to this electrode that the cations, the copper ions, are migrating. No mention has yet been made of positive and negative electrodes. Actually, an electrode is negative only because it is more negative than the other electrode in the system.

Using the second definition, it is immediately apparent that the terms now indicate the chemical processes occurring in the vicinity of the electrodes—namely, oxidation in the vicinity of the anode and reduction in the vicinity of the cathode. It would seem better from the chemical point of view to label the electrodes with respect to the chemical processes occurring than by any other terms. Oxidation processes will always occur in the vicinity of the anode and reduction processes will always occur in the vicinity of the cathode if this definition is followed in the labeling of both electrolytic and galvanic cells. There can be no mistaking the processes of oxidation and reduction, since they can be defined in terms of electron loss and electron gain, respectively.

Affixing the terms positive and negative to the electrodes would be a very simple matter. In the electrolytic cell, that electrode to which electrons are being admitted is termed the negative electrode (cathode), for it is more negative than the other electrode in the cell. In the galvanic cell, that electrode at which electrons are being liberated is termed the negative electrode (anode), for it is more negative than the other electrode in the cell. The chemical processes occurring at the negative and positive electrodes in the electrolytic and galvanic cells will be different, but the processes occurring at the anode and the cathode will be the same. The diagram shown of the electrolytic and galvanic cells make clear the notation and charge of each electrode.

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Corrections

In the paper "Preliminary Observations on the Biological Effects of Radiation on the Life Cycle of *Trichinella spiralis*" by Alicata and Burr (*Science*, 1949, **109**, 595) the reports of earlier observations by E. E. Tyzzer and J. A. Honeij (*J. Parasitol.*, 1916, 3, 43), B. Schwartz (*J. Agric. Res.*, 1921, **20**, 845), and others, on the deleterious effects of radiation on the reproductive tissue of *T. spiralis* were inadvertently omitted from the list of references.

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A typographical error in Table 1 of my paper "The Validity of the Use of Tracers to Follow Chemical Reactions" (*Science*, 1949, **110**, 14), under the entries for chlorine makes the estimated maximum ratios for the tracers Cl^{36} and Cl^{38} somewhat ambiguous. The stable isotopes should be written as Cl (natural abundance). The ratios were calculated for reactions with the tracers Cl^{36} and Cl^{38} in systems containing chlorine of natural isotopic abundance. Due attention has been given to the fact that the Cl^{35} and Cl^{37} will react at different rates.

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Book Reviews

Kinematic relativity: a sequel to relativity, gravitation and world structure. E. A. Milne. New York: Oxford Univ. Press; Oxford, Engl.: Clarendon Press, 1948. Pp. vi + 238. $6.50.

This book is a presentation of the author's theory of cosmology and physics. It is a sequel to his study *Relativity, gravitation and world structure* (1935), but can well be read independently from the earlier volume. It is a fascinating treatise, centered around a brilliant idea, excellently presented and showing unusual skill in the elaboration of some of the details. Even though the reviewer could not agree with all parts of the book, his admiration never slackened for the scope of the work and the wealth of results obtained by the author with the help of only a handful of collaborators.

The central idea of Milne's theory is a restatement of Mach's principle (cf. p. 3) that the laws of nature are a consequence of the contents of the universe. Our expanding universe is, however, an ordered structure, consisting of galaxies moving as if they had originated at a certain time at a common point (the "origin of the world") and moved away from each other henceforth. There is, therefore, it can be claimed, no purpose in establishing laws of motion which would be valid in an arbitrary type of universe or in setting up laws of invariance which disregard the structure of our universe. In our universe, a definition of absolute rest, at every point of space time, can be obtained by considering the motion of the galaxies at that point. The coordinate systems in which matter, on the average, is at rest along the time axis are, according to Milne, preferred over other coordinate systems, but are mutually equivalent. The equivalent coordinate systems form a sixparametric manifold: three parameters are necessary to give the "average material point" whose world line coincides with the time axis of the coordinate system, and three parameters give the orientation of the space axes. The equivalent coordinate systems thus form a much smaller manifold than in Einstein's special theory of relativity, in which ten parameters are necessary to describe an inertial coordinate system. In Milne's theory, coordinate systems which have a common origin ($x=y=z=t=0$), but are in motion with respect to each other, are not equivalent any more unless the common origin is the origin of the world. If this is not the case, the coordinate system which is at rest with respect to the average motion of matter at its origin is preferred. Mathematically, the group of Milne's equivalent coordinate systems is the homogenous Lorentz group (with the origins at the origin of the world); for Einstein's equivalent coordinate systems it is the inhomogeneous Lorentz group. This restriction of the equivalent coordinate systems to a smaller manifold than in Einstein's special theory is the basic postulate of Milne's theory.

The derivation of the transformation between Milne's preferred coordinate systems (i.e., the derivation of the Lorentz transformation) is carried out in part I of the book, without making use of the usual devices of rigid rods and perfect clocks, by a brilliant piece of reasoning. The assumption is introduced that it is possible to regraduate the time scales of all preferred coordinate systems in such a way that if the light signal from A's clock at time t reaches B's clock at time t' (by B's clock) then the signal from B's clock at time t also reaches A at time t' (by A's clock). A set of clocks satisfying the above condition and each moving with the average motion of matter at its position is called an equivalence. The existence of equivalences essentially makes space "flat" in the sense of Reimann-Einstein—an assumption which has been criticized a great deal, but which is certainly at least a permissible assumption.

The postulate of the existence of equivalences does not fix the time scales of all observers uniquely. On the contrary, it is shown that one of the observers can renormalize his clock by introducing a new time measure $T=f(t)$, if the other observers do likewise. Milne considers in particular two time measures: the t-measure corresponds most closely to the time scale of conventional physics and has been used in the above qualitative discussion, while the τ scale is obtained by setting $\tau=t_0 ln t/t_0$ with an arbitrary t_0. In t-measure the transformation between coordinate systems is by Lorentz's formulae, with the origin of the world corresponding to $t=0$. In τ-measure the origin of the world was at $\tau=-\infty$ and it is shown that actually the τ-measure coordinate systems can be considered to be at rest with respect to each other.

Milne's use of equivalences instead of rigid measuring instruments for the definition of his coordinate systems, as well as his emphasis on an elastic time scale, are, in the opinion of this reviewer, distinct advances in the epistemological sense. However, a study of his arguments fails to support the author's claim (p. 32) that he has not used the results of the experiments which conventionally go into the establishment of Lorentz's formulae. Similarly, the reviewer found it disturbing that the possibility of the renormalization of the clocks of all observers so that the equivalence axiom is satisfied for any pair of them has not been introduced more explicitly as an assumption.

This discussion of part I of Milne's book may indicate the stimulating and thought-provoking character of all four parts. Part II deals with the dynamics of a free particle. In the conventional special theory of relativity, Newton's first law is an immediate consequence of the equivalence of all coordinate systems which are in uniform motion with respect to each other. This is not the case in the present theory and the analogue of Newton's first law actually does not follow from the axioms introduced in part I. The most important result of part II is that Newton's first law in its original form is valid only in the coordinate systems which use τ-measure. The author attempts to give a derivation of this result, but his proof appears to be not much more than a plausibility argument. The apparent accelerations in t-measure are interpreted as the gravitational effect of the substratum, by assuming that the gravitational constant increases linearly with t.

The most interesting section of part II deals with the dynamics of light. The observed magnitude of the red shift of receding nebulae, which causes difficulties with the conventional theory, appears as a natural consequence of the author's concepts. The reviewer would have liked to see at this point a discussion of the basic experiments which have led to the special theory of relativity, such as the Michelson-Morley and the Trouton-Noble experiments, on the basis of the theory here presented. It would have been particularly important to discuss these experiments from the point of view of an observer who is in motion with respect to Milne's preferred coordinate systems, i.e. an observer who uses a coordinate system which is a preferred one in Einstein's theory of relativity but not in Milne's. The reviewer must also admit that he completely failed to understand section 133, dealing with the frequency of atomic transitions. It seems to him to follow from the argument presented on page 120 that light emitted by one galaxy and reflected back by a distant one cannot be absorbed at all by the original galaxy; as a result of the two kinds of Planck's constants, atoms which have the right resonant frequency do not possess the proper energy differences between their stationary states and conversely. This certainly could not have been the author's meaning.

The most interesting sections of part III deal with the structure of spiral nebulae. Again, the claim can be made that Milne's theory accounts better for the observations than does the conventional picture. Finally, in part IV, dealing with electrodynamics, the author ventures rather far into the field of speculation.

This summary should suffice to give an idea of the scope and significance of Milne's book. It is a book of many ingenious ideas, the concept of the change of the fundamental constants with time being only one of the author's original contributions. The reviewer suspects that most readers will disagree with some details of the book, just as he did. He hopes, however, that they also will find it highly interesting and stimulating, if somewhat too mathematical reading.

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