

as given by Dr. C. W. Stiles and described briefly several duplicating methods other than regular type which are of sufficient character to dignify the product as "a publication." In this discussion, he did not mention the process of photo-printing as such, although it is an important process, and some of his examples which he called "mimeographing" may have been reproduced by that method.

Photo-printing has for some time been developed commercially in connection with lithography and has been used in our factory for several years, particularly in the duplication of instruction sheets and pamphlets for scientific apparatus. In flexibility and appearance, it approaches type printing and for small runs from 100 to 800 or 1,000 is considerably cheaper than the latter, being comparable in cost to that of the mimeograph or multigraph. It is exceedingly satisfactory for scientific laboratory manuals, reading courses, synopses, reports, doctor or master theses and many other publications. The process is peculiarly adaptable to the reproduction of all black and white line material such as line drawings and diagrams as well as half-tones and photographs. Rare books or editions out of print may be reproduced for short runs at comparatively small expense, and whole articles or individual pages with their accompanying illustrations appearing in any publication may be duplicated in any specific size.

The process is briefly as follows: A typewritten sheet of any desired size is made, preferably on one of the typewriters with removable fonts of type which give almost as much variety of heading and body type as a regular type process. If there are illustrations, space is allowed for them on the sheet when typed and the page is made up as it is to appear. The complete manuscript for the article or publication is prepared in this way and photographed. Negative photographic films are developed and a final positive on sheet zinc is prepared, this latter being, of course, of the proper size to fit a rotary offset press. If the book is to be printed both sides, the make-up on the zinc sheet is laid out according to the usual book methods. If the book is a one-side printing, no such layout is necessary.

It will be seen from this brief description that the method is flexible and accommodating and can be used for a variety of purposes. It is also clear that the duplication is of such positive character, no one can say with justice that an article in this form is not "a publication." I am reporting it here with the thought that scientists and educational agencies of the country should know and appreciate the many advantages of this process.

GLENN M. HOBBS

W. M. WELCH MANUFACTURING COMPANY,
CHICAGO

SCIENTIFIC BOOKS

The Nature of Physical Theory. By VICTOR F. LENZEN, PH.D. John Wiley and Sons, New York, 1931, pp. 301.

THE author of this stimulating analysis of physical concepts and theories has had the advantage of a comprehensive training in both philosophy and physics. He divides the book into four parts: (I) "Special Classical Physical Theories," (II) "Unitary Systems of Physical Theory," (III) "The Quantum Theory" and (IV) "Methodological Principles," containing seven, five, two and two chapters, respectively. As the titles indicate, the text is informative as well as critical. In fact, the reader will find here a concise survey of the whole field of physical theory in a form demanding the minimum of familiarity with mathematical symbolism.

The author's program is to describe how the concepts of physical theory are derived from experience of aspects. Some discussion of the problem of subjectivism *versus* realism and the statement that the physicist, in the last analysis, employs a subjectivistic criterion of reality, indicates that the author is less convinced of the illusory character of this meta-

physical distinction than is the average physicist. However, he properly adopts an empiricistic point of view and emphasizes the fact that concepts are abstractions from experience which are reached by a process of successive approximation.

The discussion of scalars and vectors, of space, time and kinematics is lucid and penetrating, but the analysis of the concepts of dynamics does not carry the same conviction. After emphasizing the importance of the selection of the frame of reference to which dynamical laws are to be referred, the author proceeds to the definition of force. This is taken up from the statistical point of view at first, and the definition is based on the anthropomorphic concept arising from the primitive experience of exertion. After defining work in terms of force he concludes by stating that "the principle of virtual displacements defines the concept of force." This principle may be considered as defining absence of force, but surely it can not be considered to define force unless the concept of work is presupposed.

Passing on to Newtonian kinetics the author offers two alternative points of view. Proceeding from the anthropomorphic definition of force derived from

statics, he defines momentum as a function of velocity which satisfies the integral relation between increase of momentum and impulse, in effect, Newton's second law of motion. This method, however, fails to disclose the simple functional form of the momentum and conceals the real content of the second law. His second method is somewhat more satisfactory. Here he starts by defining equality of momentum from a consideration of two bodies moving in opposite directions which come to rest upon collision. This gives him a unit of momentum in terms of which the momentum of a third body can be measured. Mass is the ratio of momentum to speed. In some ways this procedure is not as pleasing as that which starts with the definition of mass, since mass is an invariant, whereas momentum is not, but it is certainly significant. Finally he defines force as time rate of change of momentum. The author's second method, therefore, is pretty much the inverse of his first method. However, it makes Newton's second law of motion merely a definition, entirely devoid of physical content.

Now a definition is the process of attaching a word-label to a measurable quantity. Logically no one can quarrel with Kirchhoff's definition of force as time rate of change of momentum. The question is one of convention rather than logic. In solving the problem of the projectile do we put the force (identical with time rate of change of momentum) equal to mg , or do we equate the time rate of change of momentum to the force (identical with mg)? Certainly the latter is the general custom. Force, then, is something conceptually different from time rate of change of momentum which is related to it by a physical equation. Newton's second law of motion, too, is more than a definition and contains physical content. Is not its content expressed in the statement that the time rate of change of momentum is always equal to a definitive function (*i.e.*, one containing no arbitrary constants) of the coordinates? More briefly put, that the differential equations of motion are of the second order? This definitive function of the coordinates is what we mean by the force.

Part I continues with a critical discussion of classical electrodynamics and thermodynamics. At the conclusion of the first the author, after obtaining the circuital equations for electromagnetic fields in a polarizable and permeable medium, makes the state-

ment that arguments may be adduced for the use of the vector B instead of H in these equations. Presumably he had in mind the equations in the form they take in empty space.

The second part of the book contains an illuminating account of the transition from the mechanical concept of nature to the electrodynamic concept and on to the geometrical concept. The discussion of both the special and the general relativity is especially to be commended to those who desire to obtain a clear understanding of the methods and objectives of the relativity theory without wading through a lengthy mathematical treatise. Although the author is concerned with unitary systems of physical theory, he does not mention the emission theory of electromagnetism in his two chapters on this subject.

The two chapters on quantum theory are too short to do justice to this rapidly growing subject, particularly as the first is devoted entirely to the Bohr-Sommerfeld theory. However, the fundamental features of the quantum mechanics are brought out, both from the point of view of the matrix representation of Born and Jordan and from that of the wave representation of Schrödinger. The author concludes this part by pointing out that science is now passing over to a symbolic conception of nature.

The last part of the work has to do with the methodology of science. Here the author brings out the fact that the important entities in nature are the invariants of physical theory. In every-day language, substance is that which is permanent. The book ends with a brief discussion of the concept of causality.

While the author has analyzed in considerable detail and with great penetration the concepts of theoretical physics, he pays too little attention to the objectives of theory. A satisfactory theory must account correctly for the facts observed: is this characteristic sufficient as well as necessary? Should a theory involve only quantities which are directly observable? If so, how is such a quantity to be distinguished?

Although written primarily for philosophers interested in science, the book should prove very valuable to physicists. For the concepts of science have their origin in philosophy, and some of the greatest advances in science have sprung from a critical examination of these concepts.

LEIGH PAGE

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MOTOR-DRIVEN MAKE-BREAK STIMULUS SELECTOR

DURING the course of some recent investigations on muscle fatigue it became desirable to stimulate an

isolated muscle preparation with maximal break induction shocks at one-second intervals, and simultaneously obtain a graphic record of all changes from the initial stimulus until the occurrence of complete