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 statement 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.

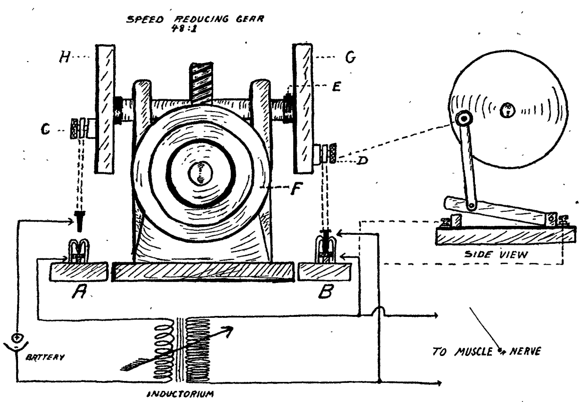
LEIGH PAGE

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 fatigue. In attempting this procedure by hand it was soon realized that the successful performance of the experiment necessitated considerable patience on the part of the operator, and such a degree of coordination of the hands, that not infrequently the investigator displayed signs of both muscular and nervous fatigue, while the isolated muscle was at its peak of activity. The desirability of some mechanical device for assisting in this phase of our experiment became apparent. A suitable apparatus for stimulating muscle and nerve preparations in the manner stated has been constructed from a speed-reducing gear, two single knife switches and an electric motor. Since the performance of this apparatus has been most satisfactory, both in the amount of time saved, and in its uniformity of action, its construction is presented here for any possible service it might render other investigators.

An essential part of the apparatus is a reducing gear with a speed ratio of 48:1. This is readily obtained from dealers in physical equipment at a nominal cost. An electric motor of fairly constant speed, usually 1750 r.p.m., is also required. The induction type A. C. motor is preferable. By the use of suitable pulleys the rotation speed of discs G and H (Diagram 1) is regulated to one revolution



per second. A and B are two single pole, single throw, knife switches, and are connected by metal strips of brass to eccentrically placed bearing surfaces C and D. The lengths of these bars are so adjusted, that when C and D are at their point of nearest approximation to switches A and B, the latter are fully closed. It is essential that one of these switches be completely insulated from the main body of the reducing gear. This is easily accomplished by means of a bushing of fiber or hard rubber contained in the disc at C or D, through which the brass bearing is inserted.

The knife switch A is connected in series with a battery, and the primary of an inductorium, in such a manner as to exclude the action of the vibrating interrupter. In other words, the primary is connected to produce single shocks. Switch B is a short-circuiting device, and is shunted across the secondary of the inductorium. The time relation of the opening and closing of switches A and B is regulated by the set screw E, which permits independent adjustment of the disc G with respect to H. For example, in stimulating by break induction shocks, set screw E is loosened, and by rotating disc G slightly forward, the position of D is advanced. The result is that B is opened, and is followed by the opening of A, and the production of a break induction shock.

This apparatus may be adapted to select the type of stimulus when employing either galvanic or faradic current, and leaves the operator's hands free to vary the intensity of stimulation.

W. R. BOND

DEPARTMENT OF PHYSIOLOGY,
MEDICAL COLLEGE OF VIRGINIA

CRYSTALLIZATION OF CERTAIN SALTS USED FOR THE DISINTEGRATION OF SHALES

ONE of the most difficult problems confronting everybody working on microfaunas is the breaking of shales containing microfossils and cleaning the latter of matrix. In several cases the writer used to get very satisfactory results soaking shales in hot saturated solution of sodium hyposulphite ("hypo," the common fixing salt of photographic practice). Since hypo is several times less soluble in cold water than in hot, crystallization begins at once as soon as the solution has been sufficiently cooled, accompanied by disintegration of shale. When disintegration was found incomplete, it was only necessary to warm the specimen, bring into solution hypo which had crystallized from cold water, and cool it again. The process can be repeated as many times as would be necessary to achieve the complete disintegration of shale or to realize that this particular shale could not be broken in this way. It was possible to attain complete and rather quick disintegration of a shale which had resisted boiling, even with alkalies. To a certain extent this process may be compared with freezing and thawing, used successfully by micropaleontologists in similar cases.[1] The whole operation can be carried on conveniently in the s. c. Kjeldahl flask of pyrex glass with long neck and round bottom. As has been shown by experience, they stand well without cracking repeated, and even quick, warming and cooling.

[1] G. D. Hanna and C. C. Church, "Freezing and Thawing to Disintegrate Shales," *Jour. of Paleontology,* ii, p. 131, 1928.