

established by Professor O. M. Mitchell, professor of astronomy in the old Cincinnati College. Through the generosity of Nicholas Longworth a site for the observatory was secured and telescopes were mounted in 1845. In 1873 the observatory was made the astronomical department of the University of Cincinnati, and the present site on Mt. Lookout was donated by John Kilgour. Professor Mitchell was an innovator, publishing the first American magazine devoted to popular astronomy, and applying the principles now embodied in the chronograph to the recording of time. The scientific achievements of the observatory are well known, among them being the detection of double stars, orbits of comets, prediction of the weather and the study of nebulae. For years the problem worked on by Dr. Porter and his assistants has been the proper motions of the stars. The few thousands of stars which show sufficient motion to be perceptible, in the interval during which astronomers have had them under observation, have been reobserved at Cincinnati and their motions carefully investigated.

UNIVERSITY AND EDUCATIONAL NEWS

STONYHURST COLLEGE, Blackburn, England, has planned to raise £20,000 as a war memorial to be devoted chiefly to the erection of new science laboratories.

COLUMBIA UNIVERSITY, at the request of the War Department, is starting an emergency course in engineering for students entering from high schools. This emergency course, embracing civil, electrical, mechanical, metallurgical and chemical engineering, will extend over two years of four quarters each. The first four quarters of the course will be devoted largely to fundamental scientific training in mathematics, physics and chemistry. The strictly engineering subjects will come in the second year. The War Department does not guarantee that any man entering on this course can remain to finish it, but those who do well will be continued in it as long as the needs of the army permit.

LIEUTENANT COLONEL CHARLES F. CRAIG, who until recently has been stationed at Fort Leavenworth, Kans., has been placed in charge of the Yale Army Laboratory School, the new school for bacteriologists and chemists which is to be conducted at Yale University during the period of the war.

DR. R. M. STRONG, professor of anatomy at Vanderbilt University, has been appointed professor and head of the department of anatomy at the Chicago College of Medicine and Surgery.

DR. JOSEPH C. BOCK, Chem. Eng. (Vienna), Ph.D. (Cornell), for five years instructor at Cornell University Medical School, has been appointed professor of physiological chemistry in the school of medicine of Marquette University at Milwaukee.

E. J. QUINN, who for the past four years has been a research chemist on the chemistry staff of the Montana Experiment Station has accepted an appointment as assistant professor in the department of chemistry of the State College of Agriculture and Mechanic Arts of the University of Montana. He will have charge of the courses in analytical and agricultural chemistry.

MR. S. H. STROUD, formerly demonstrator in chemistry in the School of Pharmacy, Bloomsbury Square, has been appointed lecturer in pharmacy and chemistry in the University of Sydney, N. S. W.

DISCUSSION AND CORRESPONDENCE

THE FOUNDATIONS OF MECHANICS

IN SCIENCE of August 2, Messrs. Franklin and MacNutt attempt to make it "clearly evident that Professor Huntington's statement (that variation in acceleration from body to body for a given force is logically derivable from the variation from force to force for a given body) is not true." "Logically derivable" is scarcely a clear phrase in this connection. The *quid* of the matter is found, of course, in the fact that in the table of Messrs. Franklin and McNutt, these authors

have chosen to use three "identifiable" forces. According to their logic, they must mean that their forces are identifiable but not measurable, and further that you can not measure force until you bring in the idea of mass. The distinction between "identifiable" and measurable" seems to me to be valueless. Moreover, mass is in no way *necessary* either for the identification or measurement of forces. As Perin¹ observes, if a stretched spring A balances two stretched springs $M + N$, then force $A = \text{force } M + N$. Messrs. Franklin and McNutt emphasize the fact that mass is independent of time and place and exists independent of any gravitational field. So does the science of mechanics. Messrs. Franklin and McNutt's own logic should, then, force them to the conclusion that for all bodies, where F is measured independently of mass

$$f/a = \text{constant} = m \quad (1)$$

and the constant is defined as mass.

A much deeper source of confusion is found, however, in not making the distinction between mechanics as a "doctrinal function" to borrow Bertrand Russell's term and as an experimental science. If we put

$$x = y/z \quad (2)$$

we have asserted nothing, since no interpretation has been placed on x , y and z . So, in fact, we might go ahead and develop the whole of (mathematical) mechanics without interpreting the symbols at all, or specifying merely that they might be anything consistent with the fundamental equations or postulates and of course with the theorems deduced. Such a body of doctrine is Veblen's² system of axioms for geometry. The system has no necessary connection with space or geometry at all; but when for the one undefined element, we put "point" the doctrinal function becomes applicable to space. But we could substitute something else—and that non spatial—and get an equally good application. So if we let

¹ Perrin, "Traité de Chimie physique," Paris, 1903.

² *Transactions of the American Mathematical Society*, Vol. 5, p. 343.

$x = m$, $y = f$ and $z = a$, we have equation (1), which we assert is true from experience or experiment.

There is of course no objection to having as many postulates as we please or as the case requires provided they are consistent. Elegance also requires that they be independent. For a start, let us put

$$m = f/a \quad (1)$$

$$f = k(m_1 m_2 / r^2) \quad (3)$$

where K is the constant of gravitation. These two postulates are obviously both consistent and independent. There is a double definition of mass,—i. e., mass as inertia, and mass as capacity to be attracted in a gravitational field. In the doctrinal function we *postulate* the m 's (whatever they represent, if anything) identical. By experiment we say mass by one definition equals mass by the other. Similarly, a chemical compound is something that (at least) fits into the equations of Gibbs' paper "On the Equilibrium of Heterogeneous Substances." It is intended, of course merely to indicate a line of thought, not to develop it.

Thus it is clear that the units we have in the Bureau of Standards need not be the same as the undefined elements in the doctrinal function. We do not need even to imagine that Bureau keeping standard springs, rubber bands, strong armed men, etc., and more than it would have to keep a standard point (!) instead of a standard meter, for Veblen's system of geometry. Any equation may be made use of to measure any quantity which it contains.

There remains the formal possibility that we might find by experiment that the mass of (1) is not the same as the mass of (3). A doctrinal function corresponding to mechanics would not be affected, but a new one would have to be made corresponding to the new experimental fact, provided we wished to define mass, in part, by making use of gravitational pull, that is, to retain a postulate comparable to (3) along with (1). But this last is not necessary, since $f/a = m$ is a sufficient definition of mass, and has nothing to do with

gravitation that we can explain further. It is the real definition of mass, and (3) is a useful additional postulate, or a useful experimental fact.

So far as ease of thinking is concerned, which is more or less irrelevant, force and acceleration are far more easily grasped than mass. That is to say, it appears so to the writer; but Frederic Soddy³ says: "the conception of force and its pseudo physical reality undoubtedly delayed for centuries the recognition of the law of the conservation of energy. Only what is conserved has the right to be considered a physical existence. In other branches of science, the conception is a stumbling block and a delusion." Perrin takes a radically different view. There seems to be a certain mysticism in Soddy's contention, for what do we care whether a force goes on "existing" when we finish with it? We find velocities and temperatures convenient, yet they go out of "existence" without any special regret. The main fact is we can give numbers to these forces, temperatures, etc., and make equations that correspond (somewhat) to experiments.

Mass, on the other hand, means (1) inertia. (2) capacity to be attracted by a gravitational field (3) capacity to create a gravitational field, and some other things. It appears to depend on velocity, though it is not intended to consider non-Newtonian mechanics. It is about as puzzling a thing as there is in physics—for who knows what gravitation is?

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NONSILVERABLE CONTAINERS FOR SILVERING MIRRORS

In the ordinary process of silvering glass mirrors by chemical decomposition (*e. g.*, Brashear's method) the metal is deposited upon the glass container. In this manner a great deal of silver which might have added to the thickness of the mirror is lost. This is an important item when silvering mirrors 25 cm. or more in diameter.

³ "Matter and Energy," New York, 1912, p. 108.

The object of this note is to call attention to the usefulness of ordinary, "granite ware," enamelled iron pans, which do not attract the silver and hence increase the supply of material available for deposition on the mirror. This was observed some years ago, but its importance was not very apparent. However, during the past year the writer has had frequent opportunities to verify this observation and to apply it in producing thick deposits of silver on glass.

WM. W. COBLENTZ

BUREAU OF STANDARDS,
September 9, 1918

QUOTATIONS

SCIENTIFIC WORK IN INDIA

THE Board of Scientific Advice for India has, like similar bodies elsewhere, felt the effect of war conditions. The board has been strengthened by the addition of a representative of the Indian Munitions Board, and power has been conferred upon the president to appoint subcommittees, membership of which need not be confined to members of the board, for the purpose of dealing with particular investigations. The board has found it necessary to modify the treatment of programs of work submitted by individual scientific departments, and to resolve that the annual report for 1916-17 be confined to a brief statement of work actually done during the year, also that the bibliography of publications bearing on particular subjects be consolidated. But the establishment of a Zoological Survey recorded for the year under notice, has not affected the composition of the Board of Scientific Advice, representation of this subject having been provided for already. That its organization should have been so slightly affected affords striking evidence of the soundness of the original constitution of the board.

The report of the board for 1916-17 is an interesting document, and much of its contents, especially where the applications of science are concerned, may repay perusal outside India. In agriculture the low values of