We had some little faith in the truth of the old saying that lightning never strikes twice in the same place, and as all signs of the storm had disappeared we now felt reasonably secure.

By noon, however, the weather again changed and we experienced almost an exact reproduction of the events of the day before.

This time the bolt of lightning struck earlier in the evening and caused somewhat greater damage. A small round hole was pierced through one of the two-inch rafters of the observatory roof. The theodolite was again struck, a second notch being melted in the rim of the sunshade. The molten metal was again spattered over the objective, and the pivots, the wyes and all bearing surfaces where two different pieces of metal came in contact were burned as before. This time the brick pier was completely shattered and an eight-inch furrow was ploughed through the rocky surface of the summit for about fifteen yards, when it disappeared beneath a snow bank. A little later upon the same evening a bolt struck the verticle circle, but did comparatively little damage to that instrument. A hole was burnt in the tent, the ridge pole was somewhat splintered, the wooden stand which supported the instrument was badly shattered, and a small furrow was ploughed through the ground. A small blister upon the circle showed the effect of the passage of the electric.

In my former experience I have found that all electric phenomena were more marked and the shocks more violent on sharp, isolated peaks. For some reason, Mount Elbert seems to be an exception, and I have come to the conclusion that there must have been something powerfully attractive in the rock composing the peak, perhaps a bed of magnetic ore.

P. A. WELKER.

## SCIENTIFIC LITERATURE.

*The Principles of Physics.* By ALFRED P. GAGE, Ph. D. Boston, Ginn & Co. 1895. Pp. 634, with 493 illustrations.

Thirteen years ago the author of this text-book, after many previous years of practical experience as a teacher in high school work, put forth a manual for high schools, the guiding principle of which was expressed in the words, 'Read Nature in the Language of Experiment.' He advocated the plan of putting the pupil from the outset in the position of an inductive inquirer, of placing in his hands the simplest apparatus that could be made available, and of causing the experiment, whenever possible, to precede the formulation of the truth to be apprehended.

There were already many others who believed in the extension of the objective method of instruction to all subjects in which it could be made applicable, but Dr. Gage's position was so radical as naturally to cause much healthy discussion in relation to the practical limits of the inductive method in schools. The opinion is now very generally held that, in the teaching of physics, laboratory practice should either accompany or closely follow the study of principles; but it can scarcely be said that there are very many successful teachers who now advocate the plan of trying to make original discoverers of all the students who are required to become acquainted with the elements of physics within the limited time usually alloted in a high school or college programme. The brighter pupils may indeed be so directed as to be led to the rediscovery of some long-known truths; but these are also the ones whose eagerness causes them to devour with avidity all the information they can glean from books. The prescribed experiment is performed and the corresponding deduction is correctly expressed; but the knowledge had been acquired beforehand, so that the experiment merely confirms what had already been apprehended, instead of opening out a new avenue to knowledge. Pupils whose ability is only medium, or less than average, may follow the instructions given, but are seldom able to formulate the corresponding law except under guidance. Original discovery is for them out of the question. No law of nature has ever been discovered, even by a mature investigator, as the outcome of a single experiment; and the most successful investigators are keenly alive to the difficulty of so isolating the conditions of experiment as to exclude what is confusing or misleading. No one is ready to make a discovery in physics without considerable preliminary knowledge of principles.

In the present volume Dr. Gage avoids insistence upon the doctrine to which he gave such emphatic expression in its predecessor. He states that it is simply a text-book, not a laboratory manual, but that its teachings should be supplemented by laboratory work and that "experiments are introduced chiefly for the purpose of illustrating principles and laws." With this clear statement of the object in view, he writes, not a revision of the older volume, but an independent expression of his riper experience in adapting the expression of truth to the capacity of those for whom the book is intended. These are in the main high school pupils, but a considerable amount of interesting material is introduced that is confessedly beyond the range of most of these pupils. The book is intended to include two courses, one for the high school and the other an advanced course suited for 'the requirements of the so-called classical courses in many colleges.' In such courses it is customary to avoid mathematical difficulties as far as possible; but it is safe to say that in many of them, certainly in our leading colleges, the course in general physics is so given as to include many applications of not only algebra and geometry, but also plane trigonometry and elementary analytical geometry. Indeed, the careful avoidance of equations, and the almost entire exclusion of trigonometry from the present volume, necessitates such fullness of verbal explanation as to amount to redundancy in some parts.

But, despite the objection just expressed, the explanations contained in this text-book are always clear, and the work has been admirably done. On every page are the marks of the skillful teacher, methodical, careful and accurate. To say that there are no mistakes would be, of course, inadmissible, but they are unusually few. The author has been alert in keeping up with the results of recent physical investigation, and many old definitions and technical terms have been so modified as to adapt them to modern demands. The book will undoubtedly be very useful, not only in the high school, but as a book for parallel reading by the college student, whose course in the class room is more mathematical, but who wants the 'plain English of it' where difficulties are encountered. To such it can be heartily commended, although he will perhaps find less than he wants on some special topics, such as elasticity, moment of inertia, and the physical pendulum. The presentation of the elementary principles underlying the dynamo, the motor, the transformer, and other familiar applications of electricity will be found particularly good.

A few words of adverse criticism may perhaps be applied to some points that are capable of easy modification and relatively of inferior importance.

The term 'centroid' is employed in many places where 'center of mass' is implied. The latter is explicit; the former is unnecessary. The two expressions are used about equally frequently. Centroid has not come into general use, whatever may be the objection to such generally used expressions as 'center of mass,' 'center of inertia,' or 'center of gravity.'

In saying (p. 223) that 'if two tones form a narrower interval than a minor third, the combined sound is harsh and grating on the ear,' the author forgets that this is not true for the higher parts of the musical scale. These facts were fully investigated by Mayer about twenty years ago.

The specific heat of water (p. 263) is represented to increase continually from 0° to 80° C. The figures given are those of Regnault (1850). More recent careful investigation by Rowland and others has shown that the specific heat of water decreases slightly from 0° to about 30° and then increases gradually to 100° C.

Absolute zero (p. 273) is said to be 'a point of absolute cold or absence of heat, beyond which no cooling is conceivable.' This statement is admissible only on the assumption that the laws of Boyle and Gay Lussac are applicable rigidly at even the lowest temperatures, an assumption which is now known to be not admissible.

It is stated (p. 417) that 'carbon bisulphide is exceptionally transparent to all forms of radiation.' This may be qualified by adding 'except the violet and ultra-violet.'

There are a few other points, the noting of which would unduly extend this criticism. There are few text-books in which the first edition is so free from serious errors.

W. LE CONTE STEVENS.