true state of knowledge can be obtained. Besides, the knowledge of having discovered facts and relations which will enter into the structure of a growing science is the greatest source of pleasure that the student can obtain.

G. A. MILLER.

CORNELL UNIVERSITY,

THE MECHANICS OF SLOW MOTIONS.

THE slow continuous motion of a plastic solid (such as clay, wet sand, wax, tallow, lead, etc.), is a phenomenon of considerable interest to elasticians not only because of the natural interest attaching to this remarkable class of solids, but primarily because it is only during the very slow motions of these solids that it is possible to sharply distinguish them from the class of ultra-viscous liquids. It is possible to conceive of a 'perfectly plastic solid,' which, as an ideal body, is altogether free from viscosity, just as we may conceive of a theoretical elastic solid or of an ideal perfect fluid. It is not so easy, however, to secure experimental data upon which one may base his theoretical investigation of the motions of plastic solids and by which his conclusions may be tested.

It occurred to me a few years ago that the kinetoscope offered a ready means of securing almost any desired magnification of the rate of these slow motions and thus presented to us a method of securing the lines of flow and rates of motion for any desired case. The method that I selected for that purpose was as follows: Let the moving body be photographed upon kinetoscope film at stated intervals—every few minutes, or every few hours, as the case may require. After a sufficient number of these photographs have been obtained, the film may be run through an ordinary projecting kinetoscope at the usual rate. In this way the motion that has required several weeks for its production may be reproduced upon the screen within the limits of a few minutes or seconds. I have magnified in this way the rate of motion about 500,000 fold, but of course there is no major limit to the possible rate of magnification. I made the first application of this method of magnifying slow motions to the motion of growing seedlings. Several peas and beans were placed in a glass root cage containing wet sand. The photographs were taken by artificial light at fixed intervals day and night for about three weeks. When the film is run through the kinetoscope the entire growth for the period of three weeks is reproduced in a few seconds. I found the motions of two peas, which were placed upon the top of the soil, especially interesting. These peas found it almost impossible to get their roots into the soil. In one case the root came out of the top of the pea and made directly for the moist soil. It found this too hard to penetrate, but the root continued to grow, the result being that the pea was rolled about the root cage in a very grotesque manner, the root curving and writhing much like an angle worm struggling to get into the soil.

The kinetoscope also shows very clearly the different speeds at which the various parts of the plant grow, and the different speeds at which the same part grows at different times. The greatest variety in the rate of growth exists, as I suppose is well known, and of course the kinetoscope brings out the relative rates of growth in a very truthful and graphic manner. I regret that my first film does not show any considerable part of the growth of the stems of the plant, as after growing a few centimeters the stems opened the lid of the root cage and passed out of range of the camera.

The rather startling results of this method as applied to growing plants has caused me to give some further attention to the matter. At the present time I am preparing some

additional films taken from growing seeds. Of course there is no reason why the photographing should not be continued until the plants have bloomed and fruited, if any fact important to mechanics or botany is likely to result from the trouble. Perhaps botanists know of matters in plant growth and plant development that it may pay them to investigate by the same method. I anticipate that some interesting facts concerning the mechanics of the root's motion into and through the soil will result from such studies.

I have taken up the work now being done upon living organisms as merely preliminary to the general problem that I have set before me. It must be several months before enough material can be accumulated for a proper discussion of observed and theoretical results in the motions of plastic solids. The actual results may prove disappointing, but this fact cannot be determined in advance.

Chas. S. Slichter.

---

*MARYLAND'S HIGHWAY REPORT.**

There is a growing realization in this country that the problems which have to be met and solved in the construction of better highways are, in large measure, geological problems. The most satisfactory outcome of this tendency which has yet appeared in this country is the report on highway improvement in Maryland, which has been recently issued by the Maryland Geological Survey; and the Survey, through these investigations and this report, has rendered the cause of good roads in the country at large an important service.

The work resulting in this report was authorized by the General Assembly of Maryland, in an Act passed early in April, 1898, which provided an appropriation of $10,000 per annum for the investigation of questions of road construction in that State, and for the preparation of reports thereon. Under this act a highway division was at once established under the supervision of the State Geologist, Professor W. B. Clark, and Dr. H. F. Reid was appointed chief of this division; Mr. A. N. Johnson, Mr. St. George Lioussat and Mr. F. H. Schloer, special assistants. It was also arranged that other assistants connected with the different branches of the Survey should cooperate in examining the character and distribution in the State of the road-building materials.

Of the volume before us, which contains the results of these investigations, and which it is hoped may serve as a model for similar work in many other States, it is difficult to give any thing like an adequate synopsis in the brief space allotted for an ordinary book review. In a short introductory chapter, Professor Clark has given a copy of the law under which the work was provided for; and a brief statement as to the purpose and character of the enquiries and investigations carried on during 1898 and 1899. This is followed by a more elaborate chapter by Professor Clark on 'the Relations of Maryland Topography, Climate and Geology to Highway Construction'; a subject which must be thoroughly understood by the highway engineer before he can intelligently plan, locate or construct in any section of country, either a system of highways or an individual road. This chapter includes a brief description of the topographical features of the State and its different geographical subdivisions (coastal plain, Piedmont plateau and the Appalachian region), and the influence these have had and should have hereafter on the location of the roads. The question of temperature is not so important a feature in Maryland as in some of the more northern States, for the reason

* Maryland Geological Survey, Vol. III., 1899, pp. 461. Highway Improvement. Baltimore, Md., W. B. Clark, State Geologist.