Mr. Jervis's mechanical application made the state of the art so complete that his theory has been well-nigh forgotten.

The stremmatograph confirms the theory that on tracks of stiff rails and joints, locomotives when drawing their trains distribute their total load and effects of the expended tractive effort in accordance with a principle of mechanics. In the evolution of American locomotives this principle has received its greatest application, not only in more wheels in the wheel base of the engine, but in that of the tender.

The decided advantage of being able to distribute the total load of the locomotive through a number of wheel contacts, enables a heavy load to be carried without unwarranted injury to the track, by making the forward wheels check deflections under the following driving wheels. The drawbar-pull also becomes of assistance in the distribution of the loads on the driving wheels and effects of the expended tractive effort. In this way the combined stability between the locomotive and the superstructure of the permanent way is increased.

The rail is the most important member of the conservative system either of the superstructure of the track or of the permanent way. The bending of the rails is produced directly by the moving wheel loads, and the tension under one wheel contact can not take place without producing compression at some other point. Therefore, bending in either direction is resisted by the metal, which helps distribute the load to a longer portion of the track than is possible on lighter rails.

The combined stability, efficiency and capacity between the locomotive, rolling stock and the permanent way increase in a faster ratio than the direct stiffness between two sections of rails. This is shown by the great increase in the weight of the locomotives and cars in the last few years, running over the same road-beds which were formerly laid with light rails.

The stresses of the specific deflections of the different wheels of the locomotive running over a flexible track are of necessity quite irregular. The irregular application of steam also makes an irregular distribution of the stresses per revolution.

As the smoothness of the track has increased, the realized coefficient of adhesion of the system of the driving-wheel base of the locomotives has also increased.

P. H. Dudley.

SCIENTIFIC BOOKS.

Analytical Chemistry. By F. P. Treadwell. Translated from the second German edition by William T. Hall. Vol. I., 'Qualitative Analysis.' 8vo. Pp. xi + 466. New York, John Wiley & Sons. 1903.

There are so many books on qualitative analysis, and so many of them have little reason for existence, that it is a matter of satisfaction to examine one, like the work under consideration, which possesses many features of novelty and excellence.

The book begins with an introduction explaining general principles, including the law of mass action and the ion theory of Arrhenius. While the latter theory is apparently advocated, its influence is shown but little in the book as a whole. For instance, in the first part of the introduction it is stated that a precipitation always takes place when an insoluble substance is formed by means of a 'chemical decomposition,' and, although the part of the book which treats of acid radicals is headed 'Reactions of the Metalloids (Anions),' the substances dealt with are called 'acids.' This neglect of the modern theory will be approved by some, but it will be objected to by many.

The book seems to be particularly good in its clear and full descriptions of qualitative tests. Many new and improved methods are introduced, and the methods adopted are generally very satisfactory. However, the re-

tention of the calcium sulphate method for testing for barium and strontium, which has been abandoned by Fresenius and others, is open to criticism, and the failure to mention de Koninck's excellent potassium cobaltic nitrite test for potassium seems unfortunate in view of the increasing cost of platinum, and of the fact that the test is much more delicate than the one with hydrochloroplatinic acid. Those who have used Gooch's separations of lithium chloride from sodium and potassium chlorides, and of calcium nitrate from strontium nitrate, by means of amyl alcohol, will regret that they receive no mention here.

A striking and valuable feature of the book is the elaborate treatment of the equations of the reactions. In these equations the formulas are frequently rather elaborately developed according to the theory of valency, a practice which at times seems to involve an unnecessary waste of space, on account of the uncertainty of the positions of the atoms in the inorganic compounds.

The part on the acids is unusually full and extensive, including a number of acids that are not usually considered in the text-books. There is a supplement, also, which deals with the rarer metals.

Analytical tables, to which some teachers object, are freely used, but it is stated that in the author's experience these have given the best results.

The translation appears to have been very well done, but a number of errors, particularly in the equations, indicate some lack of care in proof-reading. H. L. W.

The Movements and Reactions of Fresh-water Planarians: A Study in Animal Behaviour. By RAYMOND PEARL, Ph.D. *The Quarterly Journal of Microscopical Science.* Vol. 46, 1903, pp. 509–714.

This paper from the zoological laboratory of the University of Michigan gives a detailed account of a very thorough and careful study of the behavior of planarians. Dr. Pearl states in his introduction that it is his purpose to give such a complete account of his observations that no desired information concerning the work shall be lacking. In America, especially among physiologists, the tendency is to limit papers to the bare statement of results; details of method and observation are omitted. This Dr. Pearl considers an unfortunate tendency; he, therefore, presents a minutely descriptive paper. But even two hundred pages on planarian behavior are not tiresome in this case, for the paper is written with a noteworthy clearness, accuracy and precision of statement. Everywhere it inspires confidence in the reliability of the observations and experiments. The author's painstaking care, resourcefulness and enthusiasm for research are unmistakable. Although Dr. Pearl is evidently responsible for the whole of this study, he gives generous thanks to Professor Herbert S. Jennings for suggestions, criticisms and general helpfulness. Professor Jennings is really the pioneer in the analytic study of animal behavior in this country, and his excellent work on the reactions of unicellular organisms is inspiring many to research along similar lines.

In the paper at hand we find the following chapters: (1) 'A Résumé of the Literature Bearing on the Subject,' (2) 'A Discussion of the Habits and Natural History of Planarians,' (3) 'A Description of the Normal Activities of the Animals,' and (4) 'A Consideration of Their Reactions to Stimuli.' In this chapter the author deals with: (*a*) reactions to mechanical stimuli, (*b*) reactions to food and other chemical stimuli, (*c*) thigmotactic and righting reactions, (*d*) reactions to an electric current, (*e*) reactions to desiccation, and (*f*) reactions to currents of water (rheotaxis).

Throughout the investigation Dr. Pearl's aim has been to analyze all the reactions into their reflex components and to describe the mechanism of each reaction. Briefly stated, the most important results of the investigation are as follows: (1) The normal locomotor movements of planarians are two: *gliding,* by the beating of the cilia on the ventral surface, and *crawling,* due to longitudinal waves of muscular contraction. (2) The animals fa-