stood that advisory messages and hurricane warnings will be disseminated and hurricane signals displayed in Haiti the same as in the other West Indian Islands, beginning July 1, 1900. This information as to hurricanes will be available at the offices of the United States consuls, vice consuls, or consular agents, whenever such officials are available.

THE LAWS OF ATMOSPHERIC CIRCULATION.

A year ago, Prof. V. Bjerknes read before the German Association of Scientists, at Munich, a memoir on dynamics as applied to the circulation of the atmosphere, in which certain principles are developed that undoubtedly apply to many atmospheric movements although probably not to all of them. This memoir is the third that Professor Bjerknes has published on this subject, and one of his pupils, Mr. Sandstrom, has further developed the subject and applied this new method to a discussion of the American storm of September 21–24, 1898. The Editor is preparing to publish a complete translation of both these papers in order to make them available to American students. Meantime the following notice of the work of Professor Bjerknes is copied from Nature June 28, 1900, vol. 62, p. 200, and will give the reader a general idea of the considerations introduced into this latest effort to investigate the motions of the atmosphere in the light of rigorous mechanical laws:

The dynamical principle of atmospheric circulation is treated by Prof. V. Bjerknes in the Meteorologische Zeitschrift, March and April, 1900. Starting with the property that the circulation theorems of abstract hydrodynamics (according to which the circulation in any circuit formed by the same particles is constant) only hold good when the pressure is a function of the density alone, Professor Bjerknes points out that in the atmosphere this condition is not satisfied, owing to local differences both in the temperature and in the degree of moisture present in the air. Of these two causes the first seems to be the most important. The conception of "solenoids" is then introduced, a solenoid being an elementary unit tube bounded by pairs of consecutive surfaces of equal volume and equal pressure, respectively. The fundamental proposition in connection with circulation asserts that the rate of change of the circulation in any circuit is proportional to the number of solenoids inclosed by that circuit. A number of diagrams are given representing the cases of land and sea breezes, trade winds, local upward currents, hill and valley winds, cyclones, and anticyclones. The omission to take account of the extra complications arising from viscosity and terrestrial rotation probably prevents these investigations from being utilized for calculations in connection with weather prediction; and for this reason Professor Bjerknes' theory must be rather regarded in the same light as other dynamical theories of physical phenomena, in which certain simplifications not occurring in nature are made in order to bring the calculations within the range of mathematical analysis. But it is only by the aid of such simplifications that order can be evolved out of the chaos of statistics furnished by the experimentalist.

Prof. V. Bjerknes, of Stockholm, is the son of Prof. C. A. Bjerknes, of Upsala, and has lately published the first volume of the collected memoirs of his father. [1] These memoirs bear especially on very important theorems in the motion of fluids and have been by him applied especially to the movements of spheres in liquids whence resulted an apparent explanation of the force of gravity, the attractions of molecules, and many correlated phenomena. In order that our readers may have some knowledge of the general character of the work of Prof. C. A. Bjerknes, we append the following review of this first volume of lectures, as published by Prof. Carl Barus, at page 395 of the Journal of Physical Chemistry for May, 1900:

Among the attempts to explain the nature of force in terms of the medium through which it acts, those based on the hydrodynamics of an incompressible frictionless fluid seem most at hand, inasmuch as the inevitable ether is given as such a fluid at the outset. The irrotationally moving fluid surrounding a vortex has been used as a field of this kind by Kelvin; and J. J. Thomson has shown at length that whereas stable groups of aggregated vortices are possible up to eight in number, beyond this all grouping becomes unstable, thus suggesting close relations to atomicity. The technical difficulties in the way of the vortex hypothesis have barred its progress. On the other hand, the vibratory and pulsating theory, which had an independent origin throughout and need not be incompatible with the former, has now many achievements in its favor. That force can be derived from the impact of a wave train in evidence by the radiometer, but the mechanism of this apparatus is too complex to be suitable. Kelvin showed that waves lash the boundary of the medium with a pressure per square centimeter equal to the product of half the density of the medium and the square of the wave velocity. Mayer's famous experiment, with pivoted resonators rotating in the acoustic field of their own notes, was shortly after its discovery explained by Raleigh, proving that the internal pressure in a resonator exceeds atmospheric pressure, so that a force exists at the mouth directed normally inward.

Long before all this, before Faraday had proclaimed his doctrine of lines of force, and before Maxwell had developed that doctrine, indeed, almost before Kelvin had published his method for the solution of hydrodynamic problems by Hamilton's principle, the elder Bjerknes had, independently, become dissatisfied with "action at a distance," and had tentatively suggested a remedy. As far back as 1868, (Maxwell's great treatise was completed in 1873) with the simplest of media (frictionless, incompressible fluid) and the geometrically simplest solid, (a sphere) Bjerknes had found that the force actuating the center of one of two spheres, and arising in a second moving sphere, has the same intensity and direction as if the former were absent, and is equal to the acceleration in question, multiplied by three-halves of the medium displaced by the first sphere, certainly a suggestive proposition, though it did not then predict Newton's third law. Meanwhile Kirchhoff had adopted Kelvin's hydrodynamic method, and had developed it for problems of precisely the present kind, with his usual ability. Bjerknes was then able to apply the Kelvin-Kirchhoff investigation to his own researches with such success as not only to deduce the law of action and reaction as a necessary property of his own mechanism, but to show that pulsating spheres act on each other through the medium by stressing it into a field of force, *mutatis mutandis*, identical in character with the action on each other of magnetic or electrical molecules.

These papers have been much sought after by physicists, in spite of their inaccessibility, and the fact that demonstrations were often withheld. It is therefore fortunate that the younger Bjerknes, an equally able investigator, has collected the work of his father in a systematic treatise, of which the first volume is now before us. As above indicated, the book treats at length of the motion (vibration, translation) of a system of spheres of variable (pulsating) volume submerged in the ideal fluid stated, preliminarily to deriving action at a distance from purely hydrodynamic phenomena. This book is, therefore, not without interest to the chemist, for the behavior of molecules imbedded in ether is precisely such as falls within the scope of Bjerknes' investigation.

It would be going too far to examine the work in detail, and such an examination, without mathematics, would be most unsatisfactory. Investigations like the present are usually made by deriving the particular equations of motion, and then so transforming them that they may be identical in character with those of the known phenomenon which it is aimed to explain. The remainder of the work is an interpretation of corresponding terms, parameters, and constants. Suffice it to add, therefore, that in 1878 Bjerknes investigated the condition of rotational stability of the axis of permanent oscillation of spheres in an oscillating medium, and found both a pulsating pair or a single oscillating sphere to be subject to torque, the final link in his argument.

A reexamination thus reveals that Newton's first, second, and third laws have all been deduced, inclusive, of course, of inertia. Hydrodynamic forces may be superposed, which is a predication of vector summation. They are independent of the velocity of the body actuated. The system admits of concealed motions (potential energy); it is subject to the law of the conservation of energy, and its potential is subject to Laplace's equation. In a general way hydrodynamic forces vary as the product of the volumes (ultimately masses) of mutually reacting spheres. Specifically, two identically pulsating spheres attract each other, two oppositely pulsating spheres repel each other, with a force varying as the density of the medium and the intensity of pulsation, and inversely as the square of their distance apart. Furthermore, action of magnetic character (attraction, repulsion, rotation) occurs between oscillating and pulsating systems. Finally, heavy spheres of opposed pulsations attract each other at long ranges and repel each other at short ranges, with a position of stable equilibrium for an intermediate range. The converse holds for spheres lighter than the medium.

It is hardly necessary to give further examples of the contents of this remarkable book. The author has been gracious in collecting the chief dynamic and hydrodynamic principles in the introduction, for the convenience of the reader, but a good working knowledge of applied mathematics is necessarily presupposed.

[1] Vorlesungen über hydrodynamische Fernkräfte, nach C. A. Bjerknes' Theorie. By V. Bjerknes. Band I. 17 by 26 cm., pp. xvi, 33 S. Leipzig: Johann Ambrosius Barth, 1900. Price: paper, 10 marks.