which have been deduced from their properties; and finally some three chapters to the well-known analogies between hydrodynamics and electromagnetism. One chapter is somewhat of a polemic on mechanical explanations of the phenomena of physics.

There are two fundamental difficulties which are always encountered in any attempt at mechanical or electrical explanations of gravitation. The first arises from the marvellous accuracy of the law: at the distance of the moon there can be no deviation from the well-known index 2 of the inverse square greater than one divided by a hundred million, and very probably the deviation is less than one tenth of this fraction. At one time Newcomb brought forward a larger deviation to explain the outstanding difference between theory and observation in the motion of the perihelion of Mercury, but abandoned it when the theory and observation of the moon showed that its adoption would require the explanation of a much larger error in the motion of the perigee of the moon. In fact, astronomers of the present day rarely invoke any such hypothesis to explain their difficulties.

The second difficulty arises from the apparently instantaneous propagation of gravitation. It has been computed that its velocity must be at least a million times that of light. In view of these facts one is tempted to wonder whether any of the ordinary mechanical explanations are possible, unless indeed it is a case where two effects counterbalance one another, as in the principle of relativity. It must be said in this connection that M. Combebiac emphasizes in his preface the fact that analogies and not explanations constitute the chief object he has in view. "Mais l'analogie," he says, "n'est elle pas l'un des plus efficaces moyens utilisés par l'esprit humain dans son effort d'adaptation au déterminisme naturel?" For this reason, the volume will be acceptable to all those who have puzzled their minds over this fascinating problem.

E. W. BROWN.

The Mechanics of the Earth's Atmosphere. A Collection of Translations (third). By CLEVELAND ABBE. Smithsonian Miscellaneous Collections, Vol. 51, No. 4.

THE plan adopted by Professor Abbe for forwarding the interests of meteorology by the republication of the more important memoirs has several advantages peculiar to this

subject. It is not one which is ordinarily taught in educational institutions except incidentally in connection with physiography or geology, and naturally it is rare for a student to go much further than to learn the principal phenomena and their causes. If, later, he wishes to obtain a more extended grasp of the subject by reading its literature, he is confronted with a mass of discussions, opinions, guesses, and facts of every variety of value from the worst to the best. The treatises which are available are not extended enough for the sifting of all this material. Hence when a worker with long experience gathers together the papers and memoirs which have real value, translates those in a foreign tongue and arranges them in a manner sufficient to show their connection, he performs a service which cannot fail to be highly appreciated by future if not by present generations of meteorologists.

The danger in this procedure—that of tending to make future investigations follow the same grooves as those of the past—is probably not very serious. The study of the motions of our atmosphere is only beginning to emerge from the condition of a pure theory to one which has some relation to the phenomena, and it is probably better for the present to follow lines of investigation already established than to start many new methods, lest neither the old nor the new be properly developed.

The theoretical difficulties arise mainly from the fact that, in the language of the mathematician, there is apparently no first approximation; at any rate, none generally applicable has yet been found. Forces which ordinarily might or would be neglected in a first approximation have a habit of causing effects as great or greater than those which arise from the forces which have been included. The motions of liquids are troublesome enough, but they can usually be reduced to symbols unless there is turbulence: the motions of the atmosphere which we desire chiefly to know are nearly always turbulent. There is much to be done too in reducing law and order in the mass of observations which has been collected during the last few decades. A thorough investigation into the best methods of treating this material seems to be almost as much needed as is theoretical research.

From the point of view of the mathematician a detailed review of Professor Abbe's third collection is not necessary. The great majority of these papers consist of applications of

theory to observation and they are therefore somewhat outside the province of a mathematical society. It is interesting to notice, however, that while most of the papers have been published since 1880, we have one by George Hadley dated 1735. Another by Poisson (1837) is on a subject which has received attention once again, namely, the motion of projectiles taking into account the rotation of the earth.

E. W. BROWN.

NOTES.

THE April number (volume 15, number 2) of the *Transactions of the American Mathematical Society* contains the following papers: "Sur la notion de différentielle d'une fonction de ligne," by M. FRÉCHET; "A type of primitive algebra," by J. H. M. WEDDERBURN; "Properties of surfaces whose asymptotic curves belong to linear complexes," by C. T. SULLIVAN; "Relatively uniform convergence of sequences of functions," by E. W. CHITTENDEN; "Note on Fermat's last theorem," by H. S. VANDIVER; "A set of axioms for line geometry," by E. R. HEDRICK and L. INGOLD; "The Cauchy problem for integro-differential equations," by G. C. EVANS.

THE March number (volume 15, number 3) of the *Annals of Mathematics* contains the following papers: "On continued fractions in non-commutative quantities," by J. H. M. WEDDERBURN; "A new type of solution of Maxwell's equations," by H. BATEMAN; "Relation between the zeros of a rational integral function and its derivate," by T. HAYASHI; "The invariants, seminvariants, and linear covariants of the binary quartic form modulo 2," by L. E. DICKSON; "Examples of normal domains of rationality belonging to elementary groups," by G. A. MILLER; "On Lebesgue's constants in the theory of Fourier series," by T. H. GRONWALL; "The linear difference equation of the first order," by K. P. WILLIAMS; "Geometric properties of the Jacobians of a certain system of functions," by A. EMCH; "On the irregular integrals of linear differential equations," by C. E. LOVE.

AT the meeting of the London mathematical society held