of astronomy. Its style is clear and attractive and the illustrations, some excellent, are in the main adequate although many of the diagrams are disagreeably crude. A familiar literary device, that of prefixing a brief metrical introduction to each chapter, has here been so felicitously applied as to deserve especial mention. An excellent table of contents and index greatly facilitate the use of the work as a book of reference. GEORGE C. COMSTOCK.

EARTH-CURRENT OBSERVATIONS IN THE GERMAN TELEGRAPH SYSTEM.*

The origin of these important observations dates back to 1881, when a committee was called together by Werner Siemens, to study the phenomena of earth-currents. Through their efforts, two underground cables were provided by the Imperial Telegraph System, one running in an easterly direction from Berlin to Thorn, 262 km., the other nearly due south from Berlin to Dresden, 120 km. The present work deals chiefly with the continuous observations of earth-currents from these two lines, from 1884 to 1888. The Prussian Academy of Sciences assisted, in part, in the maintenance of the observations.

The assumption is made at the start that the observed currents are due to potential differences between the ends of the lines; that is, they are derived from currents that flow in closed circuits within the earth, parallel to its surface. Of course *vertical* differences of potential have to be left out of consideration.

The attempt to express the intensities in the two lines by trigonometrical formulæ according to Gauss, using the latitude and longitude as variables, leads to equations whose constants are too difficult to be determined. Assuming the validity of Ohm's law, however, the intensity of the earth-current components in the two directions may be given by the equations

$$J = A\frac{W}{L}i, \quad J' = A\frac{W'}{L'}i',$$

where A is a constant and W, W' are the resistances, L, L' the lengths and i, i' the observed current strengths in the two lines respectively.

We thus obtain for the total earth-current,

$$E = A\sqrt{\frac{W^2}{L^2}i^2 + \frac{W'^2}{L'^2}i'^2}.$$

The value of the constants was computed for each of the two lines. The results are only relative, however, as no reductions to absolute units were made.

The most characteristic feature of earth-current variations is their dependence upon the position and condition of the Sun. The diurnal and annual variations are especially marked. In view of this, the attempt is made to modify the trigonometrical representation in such a way as to use, instead of the latitude, the angle with the Sun's declination, and for the longitude, the local time or the right ascension of the Sun. The results indicate, however, as was to be expected, that this is not sufficient, but that other factors have to be considered. In general there can be distinguished a constant component of the current, due to terrestrial and local conditions, and a variable component, depending chiefly upon the Sun. The four years of observations were not enough to make the derivation of accurate formulæ possible. As approximations, however, expressions for the components in the two directions were derived, as functions of the local time and its multiples, from which the diurnal variation is made evident.

The self-recording instruments were of two different types. In the Berlin-Dresden line a Siemens 'Russschreiber' was used, in the other line a mirror-galvanometer reflected a beam of light on to photographic paper. The sensitiveness of both instruments was frequently determined, and though the results were not reduced to absolute measure, still it is always possible to get accurate relative values between the two lines.

The magnetic records, which, as the title indicates, formed an essential part of the work, were obtained chiefly from the observatories at Wilhelmshaven and Vienna, but to a lesser extent also from the observations during the

* Die Erdströme im deutschen Reichstelegraphengebiet und ihr Zusammenhang mit den erdmagnetischen Erscheinungen, bearbeitet und herausgegeben von Dr. B. Weinstein. Braunschweig, Friedrich Vieweg & Sohn, 1900.

international polar year 1882–3 made at Kingua-Fjord, South Georgia and Fort Rae.

The discussion of the earth-currents is based upon the tabulated hourly ordinates from the curves. Instead of measuring a single ordinate for each hour, a planimeter was employed, covering a region on each side of the ordinate sought. A further reduction, by means of trigonometric series, was carried out, in order to get a still closer approximation to the true hourly values.

The diurnal variation of the earth-currents was well marked, showing two principal maxima, and two secondary. An examination of the equations for the mean diurnal variation for the different years shows a slight systematic change from year to year. The mean variation for each year is prettily shown in the excellent vector diagrams, which are a feature of the work. All of the curves show a motion in the direction of the hands of a watch, and in the details of configuration the agreement is also good. A number of interesting deductions are drawn, indicating the dependence of the phenomena upon the Sun's position.

This dependence is no less clearly shown by the annual change in the diurnal variation. A principal maximum of current intensity occurs at the time of the vernal equinox, a secondary one at the summer solstice. The principal minimum is at the winter solstice. The east-west and south-north components for the diurnal variation are very similar throughout the year. As the Sun moves north, the principal waves in the diurnal variation become more pronounced, the secondary waves less so. In winter the reverse is the case, making the winter curves the more complicated. Similar fluctuations are shown in the coefficients of the trigonometrical representation, as well as by a series of vector diagrams for the months and the seasons. The latter are particularly interesting, showing that the mean current in winter is only about half as strong as in summer. Changes of a few days' duration in the character of the curves also occur frequently, which the author attributes to the varying relative position of nonhomogeneous portions of the Sun, with reference to the earth.

A patient study was made of the diurnal variation, bringing to light the existence of 36 secondary waves in the course of a day. These occurred about 11 minutes later in the north and south than in the east and west line. The exact number of wavelets may be open to doubt, for the personal equation carries great weight in such investigations; but at least the existence of a system of regularly occurring secondary waves seems established.

The second part of the work is devoted to a discussion of the magnetic records from the stations already mentioned, and the connection between them and the earth-currents. The method of treatment is essentially the same as with the earth-currents, the three rectilinear components of the total intensity being considered. A study of the diurnal variation by means of vector diagrams reveals a more or less definite connection with the Sun's motion. In discussing the direction of the variation, two systems of coordinates are used: First, the 'geopolar,' given by the hour-angle and latitude of the point where the direction at any hour cuts the Earth's surface; and second, the 'heliopolar,' in terms of the angle with the Sun's direction (heliopolar distance), and the angle which the plane through the direction at any hour and the Sun makes with the equator. The track of the diurnal variation upon the Earth's surface is described in detail, and shows interesting similarities between the different stations. The vector diagram of the total variation is also resolved into components in the directions of the planes of the equator, the meridian, and a plane perpendicular to both; in each case the dependence upon the Sun's position is well marked. The vector diagram in heliopolar coordinates takes the form of a conical surface around the Sun. The variation vector sometimes makes an angle as great as 90° with the direction of the Sun, but never points directly toward it, from which the conclusion is drawn, that if the Sun is the cause of the variation, the influence can not be exerted along a straight line from the Sun to the Earth. We must pass over the many interest-

ing details in the results from the different stations, merely noting that the vectors for the diurnal variation at Fort Rae move in a direction opposite to that at all other stations.

The study of the course of the magnetic variation throughout the year makes it appear that all phenomena occurring in any one season in the southern hemisphere do not, as was formerly supposed, correspond to those of the opposite season in the northern; on the contrary, certain features in the yearly variation seem to indicate the presence of influences outside the Earth, affecting the Earth as a whole. The dependence of the variation upon the latitude of the station is brought out with great clearness.

The above results have an important bearing upon Schuster's theory of the diurnal variation. This theory, as von Bezold has pointed out, requires an *invariable* system of forces, in whose field the Earth rotates. Weinstein's deductions show that excessive deformations of the system would be needed to account for some of his observed phenomena, so excessive, in fact, as to lend strong evidence in favor of local influences. We must therefore assume at least two systems of forces, one external, possibly subject to variations, the other of local character.

This part of the work concludes with a discussion of secondary magnetic waves, of which, for Wilhelmshafen in 1884, a mean of 36 were detected in the course of a day, in the case both of declination and of horizontal intensity. The connection between waves in the two elements could not however be established with certainty. It is at least significant that the number of secondary waves here is the same as in the case of the earth-currents.

The work reaches its culmination in Part III., where the relation between terrestrial magnetism and earth-currents is discussed. We regret that space does not permit a more extended review of this interesting chapter. To test first the hypothesis that the earth-currents are simply inductive currents caused by changes in the Earth's magnetism, the author compares the mean diurnal variation in vertical intensity for Vienna in 1884, with that of the earth-currents for the same year. Instead of maxima in increase of vertical intensity corresponding to maximal current, etc., we find almost the reverse to be the case. The author therefore confines himself to the question whether variations in magnetism are partly due to the earth-currents. If the *vertical* component of the current changes were known, the problem would be much simplified; in lieu of this, ingenious methods have to be resorted to in order to gain such circumstantial evidence as is possible. Even in a horizontal direction only the mean components for certain distances in two directions are known, while the true path of the current lies wholly in the dark. An increase in one or both of these components would not of necessity cause an increase in any one of the magnetic elements, since any such effect might be more than counterbalanced by changes in the direction of the earth-current.

A comparison of the mean absolute values of vertical magnetic intensity and earth-current intensity for the 24 hours tends to strengthen the theory. To explain certain peculiarities in the former, assumptions are made concerning the variation in direction of flow of the earth-currents, which in turn would require an increase in the magnetic horizontal intensity; and this increase is in fact found to take place. When the changes in azimuth of the horizontal components of earth-current and magnetic intensity are compared, the evidence is weaker, though still in the same direction. The comparison of changes from season to season is also favorable, certain minor variations agreeing remarkably well.

As concluding evidence, reference is made to the parallelism in the occurrence of sudden disturbances. By picking these out on the declination traces in Vienna and comparing them with corresponding disturbances on the Berlin earth-current records, the difference in longitude between the two cities could be quite accurately determined. A rigid comparison would of course be possible only if both direction and amount of the resultant disturbances were known, which is far from being the case in the present state of the science.

The author states his conviction that almost the whole of the variations observed by magnetometers are due to earth-currents which act upon the instruments as upon galvanometers. An immense amount of patience and skill has been devoted to the compilation of results, and it must be admitted that the evidence is favorable to this theory. As a working hypothesis it may be found of great value; but our knowledge of the phenomena, and particularly the mass of actual observations, must be vastly extended before we can finally accept the solution as a physical fact.

W. G. CADY.

U. S. COAST AND GEODETIC SURVEY,
MAGNETIC OBSERVATORY, CHELTENHAM, MD.,
December 21, 1901.

The Birds of North and Middle America: A Descriptive Catalogue of the Higher Groups, Genera, Species and Subspecies of Birds known to occur in North America, from the Arctic Lands to the Isthmus of Panama, the West Indies and other Islands of the Caribbean Sea, and the Galapagos Archipelago. By ROBERT RIDGWAY, Curator, Division of Birds, U. S. National Museum. Part I. Family Fringillidæ—The Finches. Washington, Government Printing Office. 1901. Bulletin of the United States National Museum, No. 50. 8vo. Pp. xxxii + 715, pls. 20.

The geographical scope and general character of this important work is well indicated by the above transcript of the title-page, which does not, however, give an adequate idea of the amount of labor involved in its preparation, which has largely engaged the author's attention for the last twenty years, and for the last six years has occupied the greater part of his time. The present volume is the first of the series of eight required to complete the work, averaging about 800 pages and some twenty plates to each volume. As much of the drudgery of collating references, and taking measurements, for the 3,000 species and subspecies comprised in the work, has been mostly completed, it is expected that the publication of the remaining volumes will proceed with little further delay.

The present volume treats only of the single family Fringillidæ, or Finches, which number 389 species and subspecies, of which about one-half occur in North America, the rest being exclusively birds of 'Middle' America. The introductory matter comprises an appropriate dedication to the late Professor Baird, followed by a preface of seven pages, stating the principles that have guided the author in his work, with other explanatory matter. The author has to regret the necessity of beginning his work with the highest instead of the lowest forms, owing to the lack of adequate facilities for arranging the collection of birds in the National Museum, the larger birds being inaccessible for study. This state of affairs has existed for some ten to fifteen years, greatly to the regret and inconvenience of many ornithologists besides the curator, and affords a striking commentary on the neglect by the government of our great but inadequately housed National Museum.

The first twenty-five pages of the main text are devoted to a critical consideration of the classification of the class Aves, with diagnoses and keys for all the higher groups, and for the families of the Oscines. His system is admittedly eclectic, but is on the whole a quite satisfactory compromise. The Fringillidæ, as defined by Mr. Ridgway, embrace several finch-like genera usually referred to the Tanagridæ, but which seem to fit better as members of the Fringillidæ; yet, with these transfers, there is still no hard and fast line of division between the two groups.

Mr. Ridgway's work is strictly systematic and technical. Aside from the descriptions of the forms, the elaborate keys, and the statements of range, a special feature is the very full bibliographical citations, which constitute a large part of the text, and include all references of any value, thus forming an index to the literature of each species. The locality to which a citation relates is stated whenever possible, thus greatly facilitating the labors of future workers. In compiling the references extreme exactness has been attempted in all matters of orthography and nomenclatural combinations—a feature often neglected, but of the highest importance. As Mr. Ridgway

observes: "Anyone who has had occasion to verify citations must know that the amount of inaccuracy and misrepresentation in current synonymies, even the most authoritative and elaborate, is simply astounding. They abound with names which do not even exist in the works cited, with those which do not correspond with the originals in orthography, with others that have no use or meaning whatever, being evidently culled from indices without reference to what their status may be on the pages indicated."

In matters of nomenclature the author has followed the American Ornithologists' Union 'Code of Nomenclature,' which has 'been strictly adhered to in all respects.' He has, however, reached different conclusions, in a few cases, regarding the status of certain forms, from those of the A. O. U. Committee. Considering the large amount of time he has been able to give to such points, aided by access to all of the available material, the benefit of the doubt may be safely permitted to rest with Mr. Ridgway, till some equally competent expert, with superior resources, reverses his conclusions.

The 20 plates give outline figures of the bill, feet, tail and wings of each genus treated, and are thus a valuable aid to the student. The work in all its details shows the author's characteristic and well-known thoroughness of treatment, and ornithologists the world over will wish him health and strength to complete the enormous undertaking involved in the preparation of the 'Birds of North and Middle America.'

J. A. A.

SCIENTIFIC JOURNALS AND ARTICLES.

The American Naturalist for January begins with an article on 'Prehistoric Hafted Flint Knives,' by Charles C. Willoughby, describing various forms of these implements; Douglas H. Campbell discusses 'The Affinities of Certain Anomalous Dicotyledons' and J. H. Comstock and Chujiro Kochi present a long and careful study of 'The Skeleton of the Head of Insects,' using the known facts of embryology to give a clearer idea of the structure of the head, attention being mainly given to representatives of the more generalized orders of insects. The article is well illustrated and a long list of references is appended. R. W. Shufeldt contributes a paper 'On the Habits of the Kangaroo Rats in Captivity,' and under the title 'A Contribution to Museum Technique' S. E. Meek describes the method of mounting fishes for exhibition in flat jars, the specimens being hardened in alcohol, then painted with water-colors and then replaced in alcohol.

The Plant World for December, 1901, contains 'Farther Notes on Trees of Cuba,' by Valery Havard, with a fine plate of the silk cotton tree; 'Notes on the Pan-American Exposition,' by Pauline Kaufman, in which we are sorry to see an account of a 'petrified body'; 'The Flora of Snow Cañon, California,' by S. B. Parish, besides the customary Briefer Articles, Notes and Reviews. In the Supplement Charles L. Pollard continues the description of the families of the order Parietales.

The Museums Journal, of Great Britain, contains a brief biographical sketch of Dr. Henry Woodward, who has just retired from the keepership of the department of geology in the British Museum. J. G. Goodchild describes, under 'Astronomical Models in Museums,' a practical orrery on a rather large scale devised by him for the Edinburgh Museum of Science and Art, and D. P. H. discusses 'Hygiene as a Subject for Museum Illustration,' giving an outline of the method and objects of such an exhibit. There are a few short articles and numerous notes on Museums in various parts of the world.

The American Museum Journal for November–December continues L. P. Gratacap's paper on 'The Development of the American Museum of Natural History,' and deals with the department of vertebrate palæontology. Other articles deal with recent work of the Museum, and the number has a well-illustrated supplement on 'The Saginaw Valley Collection,' by Harlan I. Smith, which is to serve as a visitors' handbook.

Following the death of Dr. Charles Henry Brown, the former proprietor of the *Journal*