

praise. The pure geomagnetician will find additional satisfaction in the fact that Professor Hellmann appears to have abandoned his original intention of publishing the earliest meteorological and magnetic charts in one and the same volume. This differentiation of purely meteorological and magnetic matter cannot be too highly commended.

As announced in the title, the purpose of this number is to reproduce in facsimile the earliest geomagnetic charts. The amount of careful and painstaking research, as evinced by the many copious notes following the text, necessary for the completion of this task can only be thoroughly appreciated by those who have made similar attempts.

Plate I, gives Halley's famous lines of equal variation or magnetic declination for the epoch 1700.

Plate II, the earliest (1721) lines of equal magnetic inclination by W. Whiston for southern England and the Channel.

Plate III, the earliest general chart of the lines of equal inclination by J. C. Wilcke, published in 1768.

Plate IV, Humboldt's attempt at a representation of the distribution of the intensity of the earth's magnetism on both sides of the equator passing through Peru.

Plate V, the earliest delineation of the lines of equal magnetic force by Hansteen, published in 1825 and 1826.

A limited number of copies of the above can be obtained from the reviewer at the price named.

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Thermal Conductivity of Copper. By R. W. QUICK, C. D. CHILD and B. S. LANPHEAR.

In a former paper (Phys. Rev., Vol. II., No. 6) the writers have given an account

of experiments made to determine the conductivity of copper at temperatures ranging from 70° to 170°. The present article is devoted to experiments upon the same copper bar at temperatures below 0°, the results being, so far as the writer is aware, the first that have been obtained for this range of temperatures. Several modifications in the method employed were made necessary by the new conditions. As a cooling bath, in which one end of the test bar was immersed, a mixture of solid CO₂ and ether was used. The temperature obtained by this means was about -70°. The formation of frost on the surface of the cold bar was a source of some annoyance, but was finally prevented by placing the bar in a large box filled with dry air. The temperature of the bar was measured, as in the previous experiments, by the resistance of a coil of fine copper wire, whose temperature coefficient was determined by reference to the melting points of ice and mercury.

The results show a variation in conductivity from 0.921 at -54° to 1.059 at 13°. It is to be observed that the increase of conductivity with rise of temperature corresponds with the behavior of the bar at high temperatures. The increase is, however, more rapid for temperatures below 0°. On the other hand, the average value of the conductivity for the range -54° to -13° is found to be slightly greater than the average value between 70° and 170°. Either, therefore, the results have been affected by some undiscovered source of error, or else the curve of conductivity must possess a maximum at some temperature between -14° and +70°. Determinations of conductivity for temperatures lying between this range are to be desired.

On Ternary Mixtures. I. By W. D. BANCROFT.

The attention which in recent years has been devoted to the subject of dissociation,

and to the development of the analogy between a dissolved substance and a gas, has heretofore prevented a systematic consideration of the more complex cases in which the solubility of one substance is influenced by the presence of a second. In the paper before us, which is the first of a series of articles on Ternary Mixtures, the experimental investigation of one of the simplest of such cases is begun: viz., the case of three liquids, two of which are non-miscible, while the third is miscible with each of the others in all proportions. Experiments were made with chloroform and water, and benzol and water, as non-miscible liquids, while ethylalcohol, methylalcohol and acetone were used as solvents. The quantity of solvent being kept constant, the amounts of the other two components necessary to produce saturation were determined. The results are found to be closely in agreement with the 'mass law': i. e., if x and y denote the amounts of the non-miscible liquids the condition for saturation is $x^a y^\beta = C$ where a , β , and C are constants. When the curve showing the relation between x and y is plotted it is in general found, however, that a single curve is not sufficient to represent the experimental results. There appear to be two sets of conditions leading to equilibrium. A mixture of chloroform, water and alcohol may, for example, be saturated with respect to chloroform; in which case a precipitate of the latter liquid will be formed on the addition of either chloroform or water. A mixture of the same liquids may also be made which is saturated with respect to water. The proportions of water and chloroform are, of course, different in the two cases. The paper contains a discussion of several such cases, as well as numerous tables of experimental data.

On the Secular Motion of a Free Magnetic Needle. II. By L. A. BAUER.

The accumulation and discussion of the observational data used by Dr. Bauer have been described in the first half of this paper (Phys. Rev., Vol. II., No. 6), and have already been noticed in SCIENCE. Practically all available sources of such data have been thoroughly searched, and the results collected constitute in themselves a valuable contribution to the literature of geomagnetism. By a combination and comparison of these data the author derives in the present paper certain important general laws regarding secular magnetic changes, which can perhaps best be stated in the language of the paper:

1. "In consequence of the secular variation of geomagnetism, the north end of a freely suspended magnetic needle, viewed from the center of suspension of the needle, moves on the whole earth in the direction of the hands of a watch."
2. "The secular variation curves appear to develop themselves more and more as we go around the earth eastwardly; or, in other words, the secular wave appears to travel in the main, roughly speaking, westward."
3. "The north end of a free magnetic needle, viewed from the center of suspension of the needle, moves clockwise in making an instantaneous easterly circuit of the earth along a parallel of latitude."
4. "The secular variation and the prevailing distribution of geomagnetism appear to be closely related."

Plates showing secular curves at different stations, as well as 'instantaneous curves' for several latitudes, accompany the paper. The author promises a mathematical discussion of the subject in the near future. Apart from the interest and value of the results obtained by Dr. Bauer, the directness and thoroughly scientific character of the work done form a pleasant contrast to the speculative and superficial methods by which the complex problem of geomagnetism are so often attacked.

A Galvanometer for Photographing Alternating Current Curves. By H. J. HOTCHKISS and F. E. MILLIS.

For the investigation of many important

alternating current problems the determination of the wave form by the ordinary method of instantaneous contacts is subject to many disadvantages. This method gives at most only a mean wave curve, corresponding to *steady* conditions. Some continuously recording instrument has long been needed, especially in the case of problems dealing with sudden changes in the conditions. But although numerous forms of apparatus have been suggested and tried, none of the methods proposed appears to be entirely satisfactory. The apparatus described in this article was construed by Messrs. Hotchkiss and Millis for use in the study of sudden changes in an alternating current; such, for example, as the change brought about by a sudden change in load of a synchronous motor. The apparatus consists essentially of a very light needle, which is merely a mirror mounted on a piece of soft iron, suspended in a rather strong magnetic field. Surrounding the needle is a coil which carries the alternating current to be studied, the axis of the coil being perpendicular to the lines of force of the field. The needle is held in its zero position partly by the magnetic effect, and partly by the torsion of the short fiber, the latter being attached both above and below the needle. Being deflected by the action of the current it indicates current strength by its deflection, and constitutes a true galvanometer. A photographic registering device enables a continuous record of the variable current to be obtained.

The essential requirement for accuracy in such an instrument, viz., a short period of vibration, seems to have been filled. The frequency in the case of the five needles used varied from 2850 to 3950 complete vibrations per second. Curves taken from various types of alternating generation are shown, in which no trace of the natural vibration of the needle can be seen. Several 'make' and 'break' curves are shown also,

both for alternating and direct currents, which are of considerable interest.

The authors call attention to the fact that the apparatus can be used for other purposes besides the study of alternating currents. One interesting example of its application is a curve showing the temperature variation in the interior of a steam-engine cylinder during a single stroke, the temperature measurement depending on the change in the resistance of a fine iron wire.

Experiments with a New Polarizing Photo-Chronograph as Applied to the Measurement of the Velocity of Projectiles. By A. C. CREHORE and G. O. SQUIER.

To avoid the errors due to inertia, which are present in all ordinary types of chronograph, the present form of instrument is made to depend upon the rotation of the plane of polarization by a current. In the path of a beam of light, which is converged upon a moving photographic plate by a lens, are placed crossed nicols, and between them a tube filled with carbon bisulphide. If current flows in a coil surrounding this tube, light is restored, while if the current is broken, the light reaching the plate is *immediately* suppressed. The apparatus is especially suited to the measurement of small time intervals. In addition to a description of the instrument, the article contains an account of experiments made with it to determine the velocity of projectiles.

Experimental Demonstration of a Law of Fluid Pressure. W. J. HUMPHREY.

A description of a simple apparatus for showing that the pressure of a fluid is the same in all directions.

Books Reviewed.—Hertz. *Die Principien der Mechanik.* S. P. Thompson. *Elementary Lessons in Electricity and Magnetism.* Yeo. *Steam and the Marine Steam Engine.*

THE AMERICAN GEOLOGIST, AUGUST.

Joseph Granville Norwood, M. D., LL. D. By G. C. BROADHEAD.

Dr. Norwood's geological work was done between the years 1845 and 1855. He was associated with Dr. D. D. Owen in the Geological Survey of Wisconsin, Iowa and Minnesota, and was later State Geologist of Illinois. From 1860 to the time of his death (May 6, 1895) Dr. Norwood held a professorship in the University of Missouri, but on account of ill health his active work with that institution ceased in 1880. The paper is accompanied by a portrait and a list of publications.

The Keweenawan According to the Wisconsin Geologists. By N. H. WINCHELL.

This is the sixth in a series of papers entitled 'Crucial Points in the Geology of the Lake Superior Region.' With the conclusions of the Wisconsin Geological Survey concerning the Laurentian and Huronian the author does not essentially disagree, but he criticises the conclusions regarding the Keweenawan and the Upper Cambrian sandstones. It is stated that the Keweenawan was introduced by a period of subsidence and the deposition of conglomerates and sandstones, and that the great igneous activity of this age was later than these basal clastic rocks; the opposite view was held by the Wisconsin geologists. The author also brings forward evidence to show that there was not necessarily a long erosion interval (and a consequent unconformity) between the Keweenawan and the Upper Cambrian sandstones, as was held by the Wisconsin Geological Survey.

Superior Mississippian in Western Missouri and Arkansas. By CHARLES ROLLIN KEYES.

Recent work has shown that the upper Mississippian rocks in western Missouri, which have been regarded as not presenting a series easily parallelized with the typical rocks of this age in the Mississippi valley, are present in both their superior and inferior portions. The Burlington limestone is practically the same as at the typical

locality, and a typical Kaskaskia fauna is present in the uppermost member of the Mississippian.

Glacial Notes From the Planet Mars. By E. W. CLAYPOLE.

A summary of knowledge concerning the polar caps of Mars, which are believed to be composed of snow and ice, is presented. It is shown that Mars affords no evidence in support of the eccentricity theory of glacial cold, though his conditions are at present such as to favor a state of intense glaciation in his southern hemisphere.

Correlations of Stages of the Ice Age in North America and Europe. By WARREN UPHAM.

The series of stages of fluctuating growth and decline of the ice sheets on both sides of the North Atlantic are shown to be nearly alike and probably contemporaneous, so that the names proposed by Chamberlin for the principal American stages are applied also to the European, these names being here given on maps of the glacial drift of each continent. The marginal moraines of each are referred to the Champlain epoch, which was the short closing part of the Glacial period.

Besides the foregoing articles, this number contains departments of editorial comment, reviews of recent geological literature, lists of recent publications in geology, and personal and scientific news.

NEW BOOKS.

The Principles of Physics. ALFRED P. GAGE. Boston and London, Ginn & Co. 1895. Pp. ix + 634.

An Introduction to Chemical Crystallography. ANDREAS FOCK. Translated and edited by WILLIAM J. POPE. Oxford, The Clarendon Press. 1895.

Petrology for Students. ALFRED HARKER. Cambridge, University Press. 1895. Pp. viii + 306. \$2.00.