Williams, Messrs. A. E. Bibbins, F. P. King, E. P. Kohler, P. R. Moale, R. M. Parks, Jun., D. H. Roberts, M. J. Vea, and D. B. Pope, of the Johns Hopkins University; President Henry E. Alvord of the Maryland Agricultural College; Messrs. W. H. Holmes, N. H. Darton, C. D. White, and G. D. Harris, of the United States Geological Survey; Dr. E. Lewis Sturtevant, late director of the New Yerk Agricultural Experiment Station; Professor Frank D. Adams of McGill College, Montreal; and Mr. G. L. Collie of Harvard University; while President D. C. Gilman and Dr. H. M. Hurd, as guests of the expedition, accompanied the party the first day as far as Annapolis The expedition started from Baltimore at noon of April 23, and reached Washington, where the party was disbanded, at noon of April 30. Four lines of investigation were proposed, namely: (1) study of the oyster; (2) study of the geological formations; (3) study of the soils; (4) study of the Indian remains. By reason of the illness of Mr. A. E. Bibbins, which necessitated his return to Baltimore, work upon the oyster, of which he had charge, had unfortunately to be abandoned, although indications of good results were shown during the day or two he was with the party. The geological work, under the direction of Mr. Clark, assisted by Mr. N. H. Darton, was participated in by the larger number present; the agricultural investigations were conducted by Professor Milton Whitney; and Professor W. H. Holmes of the Smithsonian Institution examined the area for evidence of Indian occupation.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

Eddies in the Atmosphere.

DURING last December there was published a paper by Professor Bezold "On the Theory of Cyclones" (*Sitzungsberichte der königlich preussischen Academy der Wissenschaften zu Berlin*). This exhaustive setting forth of theories by the director of the German meteorological bureau is of the highest interest, and demands notice from this side of the ocean. Professor Bezold says: "If one has attentively followed meteorologic literature for late years, so can he not fail to note that in the fundamental principles of air motions, little by little, a powerful revolution has taken place." Our author then gives a summary of the views that have arisen from time to time, especially regarding the relations between the general atmospheric circulation between the equator and poles, and the occurrence of storms or eddies in this circulation. He then gives a theoretic discussion of a particular cyclonic circulation, stationary, and having the wind directions parallel to the isobars. In this he finds that the whirl which occurs at the earth's surface extends only a short distance vertically, though he does not intimate whether this height should be 2,000, 10,000, or 20,000 feet. He also finds that if this whirl is exceedingly rapid, as one approaches the axis, a centrifugal effect is induced, and there results an "air-thinning" at the centre; moreover, there would be no tendency for air to rush to the centre, and hence there would be no uprush of air there. This is certainly a most startling conclusion, and agrees almost word for word with the view already advanced in this country ("The Tornado," pp. 57, 58, and others). Our author would account for the condensation and precipitation at the centre from the partial vacuum produced there by centrifugal action.

The origin of the tornado funnel is sought in the upper air current because there there is less friction, but no idea is given of even the approximate height of this formation. If the velocity of the gyration becomes sufficiently great, and other conditions favor, the funnel may reach the earth. This conclusion is also drawn: "In wide extended cyclones is it somewhat different; here is it very well thinkable, that, through the origin, or especially through the stronger unfolding of the same, in the middle atmospheric layers, which arise as well through the general circulation, as also in consequence of local drawing-in of the air, even as well is the air sucked into this whirl or eddy in the middle atmosphere, from above as from below." This is a most extraordinary result of this study. It is a little to be regretted that no idea whatever is given of the approximate height of this middle region, whether 5,000 or 10,000 feet. Our author finally concludes that there may be a reconciliation between the anomalous results of temperature conditions in storms and high areas, as found by Dr. Hann, and his own studies here given, as well as between the older convection theory and the eddy theory of M. Faye, more recently adopted by Siemens and Hann.

Professor Bezold's whole paper, of twenty-three royal-octavo pages, is very interesting reading, and should be perused by every one interested in the subject. It seems as though, in his attempts to reconcile two theories which are diametrically opposed to each other in almost every particular, he has indulged in some remarkable flights of imagination, but that question I leave for discussion to the advocates of each theory. Faye's view, that our storms are eddies in the upper atmosphere, seems to be gaining ground, and has already been accepted by Siemens and Hann. In *Science* for March 13, p. 151, I have suggested that "these views are entirely at variance with the facts observed in this country, and cannot possibly be accepted as an explanation of the phenomena in question." I desire to advance a few facts which show how untenable such an hypothesis as this eddy theory is.

1. The direction of the upper current does not coincide with that of the storm, but is very often at right angles to it.

2. The velocity of each stratum increases as we rise in the atmosphere to about 15,000 feet or a little less, and then diminishes; and in only a very limited stratum, perhaps at about 5,000 feet or less, is it the same as that of the storm. It is easy to see that no eddy could possibly be maintained more than a few minutes under such conditions.

3. The existence of the high area is practically ignored in this theory, though it must be very evident to every student of meteorology in this country that the high area is almost as important as the storm, and is built up under somewhat similar conditions, though with an opposite sign. To be sure M. Faye regards the high area as a static phenomenon, being led thereto by the stationary character exhibited by it in Europe, but in this country it is almost as much a dynamic phenomenon as the storm itself.

4. There are no obstructions, or counter currents at the same level, which can be invoked in calling such eddies into existence.

5. Even if it be granted that such an eddy can originate in the upper atmosphere, it is plain that its gyrations could not be transmitted to the earth through a frictionless medium. It has been computed that about twenty years would be needed for the communication of such conditions, through friction, in an air thickness of only three hundred feet.

6. If such an eddy should begin in the upper atmosphere, it is perfectly certain that absolutely no precipitation could result from it, for its downward propulsion, if it could occur, would serve to thoroughly dry the air.

7. High-level observations in this country show that a good share of the variation in pressure in our high areas and storms is far above the highest mountains, and very far from where any appreciable eddy could be formed.

8. There is absolutely no whirl in the air above 4,000 feet or less. This is fatal to this eddy hypothesis.

In *Science* for June 5 is an abstract or short statement of a paper, by Rev. W. H. Dines, read before the Royal Meteorological Society, in which were discussed these theories of storms: (1) The convection theory, or Espy's; (2) the eddy theory, or Faye's. To these I wish to add two more: (3) the wave theory, first proposed by Archibald, so far as I know, in these words: "Many facts, such as the observed direction of the upper clouds over and surrounding a cyclone, the velocities at the surface in different quadrants, the retardation of the barometric minima at mountain stations, and the frequently small elevation reached by the entire disturbance (not more than 6,500 feet, according to Loomis), tally more with a species of wave-motion by which the conditions are continually reproduced in a certain direction, than with the drift theory, and in any case require other and additional causes for their complete elucidation" (*Nature*, June 14, 1888, p. 151). This same theory has been independently advanced by Mr. John Eliot of India (*Science*, May 29, 1891). This theory is undoubtedly a great advance on the others, but is not entirely satisfactory. It

is much to be hoped that when fully carried out it will not only annihilate the others but will lead up to the true theory. (4) The electric field theory.

The final theory must include the following points: (*a*) Storms and high areas are largely dependent upon each other, and are somewhat alike except with opposite signs.

(*b*) The velocity of the current varies at every level as one rises in the atmosphere.

(*c*) In this country at least, storms and high areas follow each other and have practically the same velocity.

(*d* The conditions producing our storms and high areas seem to extend far above our highest mountains, and may extend to the limits of the atmosphere.

(*e*) There is no motion or carrying of air or moisture particles in a horizontal or up-and-down direction, by pure air currents, to form storms or high areas.

(*f*) There is an enormous increase of moisture in the fore-front of storms, entirely independent of precipitation, wind, heat, evaporation, and every other ordinary element.

(*g*) There is a corresponding dryness in the fore-front of our high areas, which may be due in part to the descent by gravity of the cooler, denser, and drier air above.

(*h*) The precipitation, in the case of general storms, is, in this country at least, far (at times four hundred miles) in advance of the central point of the isobars, and very often none at all falls at the centre.

(*i*) In what may be called normal storms, the velocity may rise to forty or even more miles per hour, especially in the winter season.

(*k*) The temperature in normal storms most emphatically shows no reversal as we ascend in the atmosphere, but, if any thing, shows a greater relative rise at the upper station than occurs at the earth's surface.

(*l*) The temperature in normal high areas has, if any thing, a greater relative diminution at a high mountain station than at the earth's surface.

While the last two propositions are most abundantly borne out on Mount Washington, it should be noted that a study of the conditions at the highest regular station in Europe (Sonnblick, 10,000 feet) has shown no reversal. While there is a difference in the results at the two mountains, yet this is only in degree. Excepting a few anomalous cases, the conditions are practically the same at both stations (*Science*, Sept. 5, 1890).

The time for formulating a consistent theory of storm generation and motion is still a long way off. It seems to me that the most promising sign of recent discussions is the marked tendency on all hands to lay aside pure theoretic considerations and to demand rather the facts and causes which underlie all atmospheric disturbances.

H. A. HAZEN.

Washington, D.C., June 15.

BOOK-REVIEWS.

An Introduction to the Study of Metallurgy. By W. C. ROBERTS-AUSTEN. Philadelphia, Lippincott (London, Griffin). 292 p. 8°.

IN telling something about this book we cannot begin better than by quoting the first part of the preface, which runs as follows: "The literature of metallurgy is rich, but those who are beginning to study it need guidance to a knowledge of the principles on which the art is rightly practised. It depends, as is well known, on the application of chemistry, physics, and mechanics; but the methods of metallurgists vary greatly from those of chemists, who, however, frequently fail to appreciate the difference. Ten years' experience has convinced me that it is more important at the outset for the student to know what was the scope of mind of the early practisers of metallurgy, and to see what kind of aid the art may be expected to receive in future from the sciences, than to acquire familiarity with complicated details of processes and appliances."

In these few sentences the author has given not only the reason for the existence of his book but also an outline of what the student may expect to find in its pages. The first four chapters may be considered almost as a separate section, covering the subject generally as a whole, the other chapters going more into the details of the various processes employed in metallurgy.

The first chapter is devoted wholly to a consideration of the relation of metallurgy to chemistry. The second treats of the physical properties of metals,— molecular structure, density, fracture, malleability, ductility, tenacity, etc. The third chapter is the best brief treatise of the kind and for the purpose we know of in the literature of metallurgy, and might have been expanded into a separate volume without a suspicion of a resort to what is known as "padding." In its thirty-six pages the subject of alloys is presented, briefly, of necessity, but comprehensively and clearly; and the results of recent investigations and experiments are given, including those in which electricity plays a part. The fourth chapter deals with the thermal treatment of metals.

The remaining chapters are devoted respectively to fuel, materials and products of metallurgical processes, means of supplying air to furnaces, typical metallurgical processes, and economic considerations. The illustrations are as numerous as the purpose of the volume warrants; there is an abundance of diagrams and tables, and the table of contents and index are models of their kind.

AMONG THE PUBLISHERS.

THE first number of Vol. II. of the *Outing Weekly Tennis Record* for the season of 1891, was published on June 13. It is the official organ and bulletin of the United States National Lawn Tennis Association.

— G. P. Putnam's Son's have just ready a handsome volume entitled "Landscape Gardening," by Samuel Parsons, Jun., containing notes and suggestions on lawns and lawn planting, laying out and arrangement of country places, large and small parks, trees, shrubs, plants, rockwork, etc. They have also ready an American edition of Professor William Peck's "Popular Handbook and Atlas of Astronomy."

— J. G. Cupples of Boston will publish immediately "The Life-Romance of an Algebraist," by George Winslow Pierce, a distinguished pupil of the late Benjamin Peirce, the eminent professor of mathematics in Harvard University. This book opens with a discovery in algebra, addressed to students, and proceeds with the discussion of every subject of human interest, poetry, philosophy, constructive criticism, adventure, forms of truth, and mysteries of being, strung on the thread of a love story.

— The July number of *The Annals* of the American Academy of Policical and Social Science will contain a translation into English of the Constitution of Mexico, by Professor Bernard Moses of the University of California. Dr. G. Ritchie, instructor in Oxford University, has contributed to the same number an article on the teaching of political science in that institution. Professor J. W. Jenks of the University of Indiana discusses a reform of the system of land transfer, and advocates the adoption of a method which shall guarantee security to the purchaser, without the heavy expense and uncertainty which the existing system involves. "The Economic Basis of Prohibition," a paper read by Professor Simon N. Patten of the University of Pennsylvania at the May meeting of the American Academy of Political and Social Science, also appears in the same issue.

— Among its new and continued articles the *American Journal of Archæology* for the present year will contain the following: "A Series of Babylonian and Assyrian dated Cylinders," by Mr. T. G. Pinches of the British Museum; "Hittite Sculptures," and "Oriental Antiquities," by Dr. William Hayes Ward of New York; "Antiquities of Phrygia," by Professor William M. Ramsay of Aberdeen, Scotland; "Terracottas in American Collections," by Salomon Reinach of the Museum of Saint-Germain, France; "The Aphrodite of Melos," by Dr. A. Furtwangler of Berlin; "Three Heads of Zeus, Hades, and Poseidon, of the Hellenistic Period," by Professor Adolph Michaelis of Strassburg; "A New Fragment of the Edict of Diocletian, found at Plataia in 1890," by Professor Theodor Mommsen of Berlin; "The Mantineian Reliefs," by Dr. Charles Waldstein, director of the American School at Athens; "Terracottas from Southern Italy, now in Baltimore," by Professor Har-