born Observatory—a fine instrument constructed by the celebrated REPSOLDS, of Hamburg, and which must have few equals in this country. It must be the occasion of serious regret that such a splendid piece of mechanism is put only to the task of the mere determination of time, when it is adequate to the determination of the exactest sort of fundamental star-positions. We may be permitted the hope that the creation of a new fund by the citizens of Chicago may ere long contribute to the very possible result of placing the Dearborn Observatory on a permanent footing as one of the first institutions of the kind in this country.

The Royal Danish Academy of Sciences has recently offered a prize of 320 crowns for the best discussion of the theory of the accidental errors of a clock. These errors may be divided into two classes, those arising from errors in the time observations and those depending upon the quality of the clock. These latter in turn may be divided into those depending upon the irregularities of the rate of the clock and those which are independent of the rate. The discussion must include a practical method of determining the value of each of these kinds of probable errors independent of the others.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1880.

(Continuation of papers read.)

ON PATENT LAWS AS A MEANS FOR THE ADVANCEMENT OF SCIENCE.

BY PROF. B. S. HEDRICK, of Washington, D. C.

THE proper aim of science was defined to be the making of discoveries. The discoverer of a new mineral, a new plant, a new law of nature, or a new world, has no proprietory right in his discovery. The honor and distinction he obtains is his reward. The discovery, then, cannot be the subject of a patent. The laws of nature, the properties of matter, the physical forces, the laws of their generation and government, are like the earth, the air, the water, the common property of all. Property in the former, as in the latter, is created by enactment. But in civilized communities the reason for the law is that something has been added to what was given by nature. The land has been fenced, ploughed, planted, or buildings placed upon it. That gives the foundation for proprietory right, and public policy requires that this be recognized, and civil, municipal and common law does this in the case of the land, the air, and the water. The patent laws do the same when discoveries, the properties of matter, the forces, the laws which govern them, are made to take the shape of useful inventions. The invention which the inventor created is secured to him as his property for a period at least. But note the laws themselves. It is the reflex action of the inventor that acts to advance science. Illustrations were given by referring to Watts' steam engine in advancing our knowledge of the laws of heat; the telegraph in giving an immense development to the source of magnetism and electricity; and now the telephone and other kindred inventions serve to push our knowledge into the farthest and outermost borders. The probation given by the patent laws enable the great host of investigators to carry on their researches, and instead of becoming a tax or burden to the commuity, they help themselves and bear a full share of the ordinary burdens of society. Reference was made to Wheatstone, Bessemer, Perkin, Graibe, Sir William Thompson, and others in Europe, and to Morse, Page, Henry, Gale, Bell, Edison, and many other members of our association, men who have greatly advanced science, and have received of the rewards which flow from the operation of patent laws.

THE MEAN RATIO OF OXYGEN TO NITROGEN IN THE ATMOSPHERE.

BY PROFESSOR E. W. MORLEY.

In the afternoon Prof. E. W. Morley presented the following remarkable conclusions from experiments: When the air at a given place is cold and the barometer high, there may sometimes be a vertical descent of cold air. Samples collected at such times are more likely to approach the composition of the upper atmosphere than those collected at other times. If there be any cause which tends to produce an excess of nitrogen in the upper atmosphere, the average per cent. of oxygen in many samples collected as mentioned, will be lower than that of other samples. Therefore, to determine whether there be any difference in the composition of the lower and upper atmosphere, Professor Morley collected samples of air during each time of unusual cold and high barometer from September, 1878 to April, 1879. In 1878 the average amount of oxygen in these was 0.16 per cent. below that of other samples. In 1879 the average was 0.12 per cent. lower. Careful revision fails to detect any source of error. Professor Morley was led, therefore, to presume that the upper atmosphere, is acted on by a cause tending to remove part of the oxygen, and to pursue the inquiry by means of a series of daily analyses in duplicate of air for six months, and a comparison of the results of analysis with the thrice daily maps of the United States Signal Service. He finds a deficiency of oxygen at times, and only at the times, when a vertical descent of air at or near the place of collection may be inferred with a fair degree of probability from these maps, and sometimes a deficiency when a vertical descent may be regarded as reasonably certain.

MAXIMA AND MINIMA TIDE-PREDICTING MACHINE.

BY WILLIAM FERRILL.

This machine is merely prospective as yet, and is designed to indicate, by means of indices on its face, the times and heights of high and low water for any tide station. These have been determined heretofore by means of laborious computations. The mathematical principles upon which the proposed machine is based, and also the internal structure of the machine, are both very complex, and no idea of them can be conveniently given here. The face of the machine is to be 20 inches by 16 inches, and the depth of the case 6 or 8 inches. The face contains an hour circle 10 inches in diameter, and a lunar and solar index turning around the same centre with slightly different velocities, the one pointing out the lunar time and the other the solar time elapsed from the time of an assumed epoch, as the first of January. There is also an index moving vertically, indicating the heights of high and low water. The machine is designed to stand upon a desk, and the power is the left hand applied to a crank on the side, leaving the right hand free to record the result as read from the face of the machine. The crank is turned until the lunar index comes in conjunction with the upper or positive end of a needle, also in motion, when the solar index indicates the time of high water and the vertically moving index the height of high water. The same for low water when the lower index comes

in conjunction with the negative or lower end of the needle. This is continued from high to low and from low to high water and from day to day, the result being recorded as read off. The mechanical difficulties in the construction of the machine are very great, but not considered insuperable.

ON THE DEFICIENCIES OF METEOROLOGICAL WORK IN DATA OF VALUE TO AGRICULTURE, AND MEANS FOR SUPPLYING THEM.

By WILLIAM MCMURTRIE.

Meteorological records, as they are and have been and are being made, are deficient in many of those data which have the most important influence upon farm crops. Temperatures are recorded, but they are always observed in the shade. Rainfall is given, but often in such a way as to render its record of no value in the study of the development and condition of crops, because no indication is given as to the way in which it is distributed; light being of little importance to meteorologists generally, while it is one of the most potent factors in the development of vegetable and animal life, has been almost completely ignored. Late investigations have proven conclusively the importance of the tension of atmospheric electricity upon vegetation, and it should be regularly observed and recorded. In fact, meteorologists have principally confined themselves to the record and study of such conditions as enable them to predict the approach and occurrence of storms, thus looking more to the commercial than to the cultural side. Gasparin was the first to call attention to the importance of the relations of Meteorology to agriculture, and he has had at least two active followers—Quetelet in Belgium, and Marie Davy in France. Through the instrumentality of the latter there has been established, near Paris, an observatory of Agricultural Meteorology, where observation and record of all the conditions above named is made. The results already obtained have shown great practical value, and worthy of the means and labor required in securing them. In this country we have nothing similar to it. Our Signal Bureau, as nearly perfect as may be for the purposes for which it was designed, is devoted to the record and study of those observations as will render possible the prediction of future conditions which may affect human affairs, than such as may influence the development of crops. Besides this, the number of stations at which observations are made in this country is too limited, being not over 800, while for agricultural work 3,000 would not be excessive. Additional work should, therefore, be carried on, and observations at a larger number of stations made and recorded, to be discussed in connection with the records of observations made upon the condition of the crops. The nature of the work is such that it should be undertaken by the Department of Agriculture, and the organization of the latter with the 2,300 reporters it already employed would be well adapted to it. Fortunately, General Le Duc, the Commissioner of agriculture, is in favor of the establishment of such work in the Department, but will require congressional support to enable him to do so. The plan of work suggested by the author is as follows: 1. The establishment of a system of observation and record among the reporters of the Department of Agriculture, and others whose co-operation could be secured throughout the United States and Territories, with instructions to observers to keep careful records of the conditions of atmospheric pressure, temperature in its various relations, relative humidity, evaporation of moisture, winds, light, tension of atmospheric electricity, occurrence of dews, fogs and frosts, and report them at stated intervals of time to the Department for consideration and permanent record. I. The collection of meteorological records from every part of the world, from which to construct detailed tables showing the relations of all the conditions named above, and may influence the growth and health of vegetation. 3. The construction of maps showing the geographical distribution of crops, to be used in connection with the meteorological or climatic data to be collected.

PRELIMINARY ACCOUNT OF A SPECULATIVE AND PRACTICAL SEARCH FOR A TRANS-NEPTUNIAN PLANET.

By D. P. TODD, M. A., Assistant in the Office of the American Ephemeris and Nautical Almanac.

So early as the year 1834, HANSEN was credited with expression of the opinion, in correspondence with the elder BOUVARD, that a single exterior planet would not account for the differences between the tabular and observed longitudes of the planet Uranus. Dr. GOULD, however, in his "Report on the History of the Discovery of Neptune," says: "I have the authority of that eminent astromener himself (HANSEN) for stating, that the assertion must have been founded on some misapprehension, as he is confident of never having expressed or entertained that belief."

Professor PEIRCE'S criticism of the investigations of LE VERRIER, to the effect that his predicted orbit of Neptune was so widely discordant from its observed orbit as to indicate that his computations did not pertain to the actual disturbing planet, elicited from him the reply that the perturbations of Uranus due to a possible planet exterior to Neptune might readily cause an uncertainty of 5″ to 7″ in the fundamental data of his research.

In 1866, the Smithsonian Institution published the general tables of Neptune, by Professor Newcomb. In the investigation of its orbit the author proposed: "3. To inquire whether those motions [of Neptune] indicate the action of an extra-Neptunian planet, or throw any light on the question of the existence of such a planet." He concludes (page 73) that it is "almost vain to hope for the detection of an extra-Neptunian planet from the motions of Neptune before the close of the present century."

In 1873, the Smithsonian Institution published the general tables of Uranus, by Professor Newcomb. His success in the treatment of the theory of Uranus was such that astronomers generally may be said to have been satisfied from the smallness of the longitude-residuals, that there existed no evidence of perturbative action upon Uranus other than that actually taken into account in the construction of the tables. It is well known, however, that since the publication of these tables the error of longitude has been increasing.

Sometime in the spring of 1874, the first preliminary outline of the very simple method which I have here employed in the treatment of planetary residuals with reference to exterior perturbation, suggested itself to me. For more than three years very little opportunity offered for consideration of the problem of a trans-Neptunian planet. In August, 1877, however, I began to devote the larger portion of my leisure time to the theoretic side of the question. It was soon evident that no certain hold upon any possible cause of exterior perturbation could be obtained from the residuals of Newcomb's tables. And I may remark here that I have consequently chosen the term *speculative* rather than *theoretic* as applying more fitly to the investigation which preceded the actual telescopic search.

It did not seem to me that the magnificent researches of Le Verrier and Adams on the perturbations of Uranus should be taken as models in the present investigations, for two reasons:

(1) The residuals of longitude which must form the basis of the investigation are not sufficiently well marked to justify the execution of so laborious a research, especially if it be found that a simple, rational treatment, unencumbered with the refinements of analysis, may be fairly interpreted as indicating the position of an exterior perturbing body with merely a rough approximation.

(2) Even in the case of Uranus, and the theoretic search for Neptune, where the residuals of longitude were very strongly marked, many of the elements pertaining to the disturbing planet, which Adams and Le Verrier sought to determine theoretically, turned out afterward, when their real values became known, to have been indicated with only meagre precision. Much less should we now expect these elements to be given with any certainty in the case of a planet exterior to Venus.

This provisional treatment of the residuals of Uranus was undertaken, then, as a preliminary to the proposed