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VOL. VIII.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

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SATURN AND HIS SATELLITES.

EDWARD S. HOLDEN.

For THE MESSENGER.

Mr. Marth was good enough to call my attention to an interesting conjunction of Japetus on Nov. 8, at 17.8 P. S. T., which was observed here as follows:

At 15*h* 34*m* P. S. T. the double distance of Japetus east of the center of Saturn, measured in the direction of the major axis, was 8″.22 (6), or the distance was 4″.11. At 15*h* 49*m* the position angle of Japetus from the center of Saturn was 7°.0 (5).

At 15*h* 10*m* Mimas was the only satellite not visible; Enceladus being plainly seen just *n. f.* the following and north limb of the planet and almost half as bright as Japetus. At the same time Tethys was more than twice as bright as Japetus. At 15.7*h* Enceladus was no longer visible, being about 7.4*h* past elongation. Under the best circumstances I think this satellite can even now be followed completely round its orbit.

Since October 22 Saturn has been viewed here on every suitable night (about fifteen nights), usually by Professor Schaeberle and myself. The following notes of observation may have some interest, although subsequent observations may modify them:

The Ball.—At the south pole there is an extremely narrow brighter polar cap. Its dimensions parallel to the equator are about 5″, and perpendicular to this about the width of the Cassini division at the ansæ. It has been seen by Mr. Schaeberle on several occasions, but I have been sure of it only once, namely, on the very perfect night of November 10, when the seeing was strictly first-class, and when the estimates of its size, just given, were made. It is bordered on the north by a very narrow belt, which is notably darker than the dark olive-green hue of the southern hemisphere. On the southern hemisphere there is one narrow, bright belt south of the equatorial belt from which it is separated by a narrow dark band, not uniform in color, but broken into whitish clouds over a rosy background as in M. Trouvelot's Harvard College drawing of 1874. There are also two brighter narrow bands south of this. Next north of the bright equatorial belt is the dusky ring, the ring system (B and A), and finally the northern hemisphere, wh[illegible] materially brighter than any part of Ring A. There also seems to be a faint dusky belt just south of the dusky ring, and it is curious to note that the ends of this belt, where they meet the two limbs of the ball, are spread out (parallel to the minor axis) apparently more than perspective requires.

Shadow of Ball on Ring.—In good seeing this is always *concave* to the center of the ball and of a uniform curvature. Nothing whatever can be seen inside of this shadow.

Shadow of Rings on Ball.—This has always appeared, both to Mr. Schaeberle and myself, even in the best conditions, slightly wider north and south, at the preceding than at the following end.

Ring B.—This is shaded as in M. Trouvelot's well-known drawing, except that it appears to the eye perfectly flat, whereas the drawing gives a slight curvature to the surface. In front of the ball the shading is also seen, and here it gives the appearance of a rounded surface. The lines of division between the various shaded zones are fairly sharp. The line of division between B and C is perfectly definite and sharp, more so than in any recent drawing that we have seen, except one by Mr Keeler with this telescope.

Ring A.—This ring is notably less bright than B, and is gray in color. The Encke "division" has not yet appeared to Mr. Schaeberle or to me as a true *division*, but rather as a shading better defined on its outer edge than at its inner. This shading is now seen about two-fifths of the width of Ring A from the outer edge. We have so far seen no sign of the division in Ring A, shown in the drawing by Mr. Keeler in THE SIDEREAL MESSENGER, February, 1888, page 81. This division cut off a narrow zone from the outer part of Ring A, about one-fifth of the width of this ring, and this zone was represented as much brighter than the rest of Ring

A. Under the best circumstances of vision (only) I have seen such a zone, with less contrast of brightness, however, than as figured in the drawing referred to.

The Cassini division appears to be perfectly black and bounded by smooth curves.

I have been forcibly struck by the analogy between Ring A and Ring B. Both appear to have brighter exterior zones and to be shaded in similar ways. I think observers may aid their conceptions of the appearances on Ring A if they will consider whether Ring B would not present similar ones were it materially reduced in brightness.

Dusky Ring (*C*).—So far this ring has always appeared uniform in texture, and essentially so in color. The edge towards Ring B is sharply terminated, and the inner edge has always appeared to me to be uniform. I have so far seen no dark patches, etc., etc., on this ring with certainty. The color is a reddish brown, or a grayish red. At Washington with the 26-inch equatorial it has always appeared to me more vivid and sparkling in tone, and more violet in hue.

This difference in color I attribute to the difference in color corrections of the two telescopes. The secondary spectrum is less obnoxious here, and there is no diffused ghost from the object glass.

Satellites.—Titan has a reddish yellow disc, and shines with a mild light quite different from that of a star of the same magnitude. Enceladus, Tethys, Dione and Rhea are bluer and more stellar in appearance. On Nov. 9 Japetus was slightly fainter than Dione and Tethys, on Nov. 10 a little fainter than Rhea, and on Nov. 11 nearly twice as bright as the latter satellite.

THE NEW MERIDIAN CIRCLE AT CINCINNATI OBSERVATORY

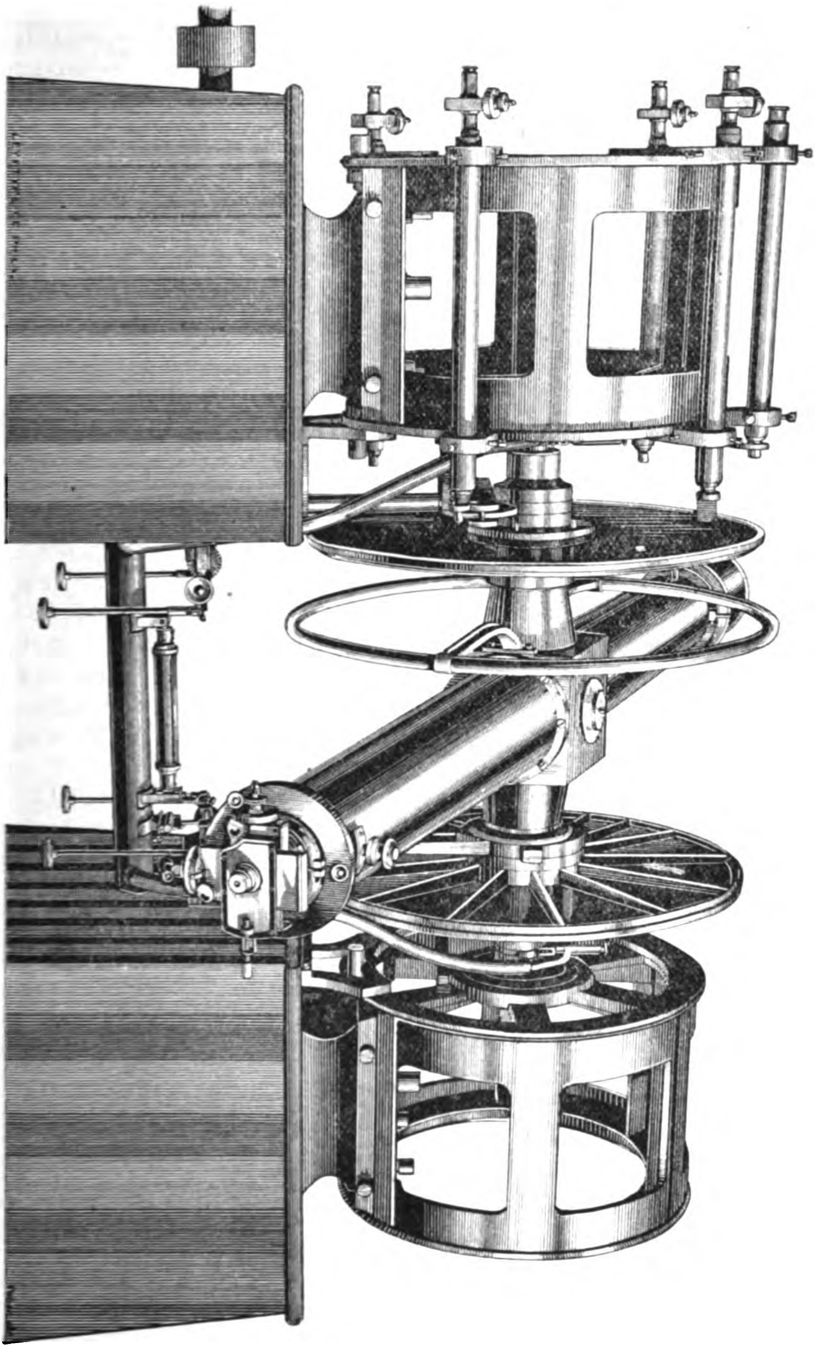
J. G. PORTER, DIRECTOR.

For THE MESSENGER.

The new Meridian Circle, constructed for the Cincinnati Observatory by Fauth & Co. of Washington, was placed in position on the first of September. As this instrument embodies several of the latest improvements in construction, and is in all respects a first-class piece of workmanship, a brief description of it may interest the readers of THE SIDEREAL MESSENGER.

The clear aperture of the object glass is five and one-eighth inches, and the focal length seventy inches. The instrument rests on two iron piers which are placed directly on the large masonry pier built even with the floor of the observing room. These iron piers are bricked up solid inside to within one foot of the top, leaving room only for the counterpoise weights, and the whole is then completely encased with wood. In point of stability stone piers may be preferable; but the counterpoises must be placed above the axis, where they are both unsightly and much more in the way when the instrument is reversed. In the description of Washburn Meridian Circle, which is slightly smaller than ours, Professor Holden states that five minutes is about the shortest time in which two persons can safely reverse it. One person can easily and safely reverse the Cincinnati instrument in about three minutes. To the top of the piers two iron plates are bolted. Into each of these three glass-hard steel plugs are inserted upon which the three leveling screws of the microscope holders rest. By suitable opposing screws the microscope holders can also be shifted east and west or north and south. The counterpoise levers are carried by arms which project from the microscope holders downward through openings in the top plates inside the piers.

The telescope itself does not differ materially from the Repsold type. The pivots are of steel, glass-hard. The object-glass and micrometer can be interchanged. The cell of the objective is steel, and the lens is supported at three points, one of the chucks being movable and pressed inward by a spring in such a way that changes of temperature will affect the collimation only and not the nadir point. The micrometer is fitted with a glass reticule. The horizontal lines are about 10″ apart. In observation the star is brought midway between them. The right ascension micrometer carries the glass reticule, so that the collimation can always be set at zero. A declination micrometer is also provided carrying a single spider line. The neat method of indicating whole turns by a separate dial is applied to both micrometers. For focusing a key with milled head is used, fitting into an opening in the side of the telescope. When the focus is satisfactory the key is removed and the aperture



NEW MERIDIAN CIRCLE FOR CINCINNATI OBSERVATORY, BY MESSRS. FAUTH & CO., WASHINGTON, D. C.

covered with a cap. The whole micrometer can also be turned around the optical axis to correct for inclination of the lines. The movement of the eye-piece across the field of view is effected by a screw of steep pitch with a small octagonal head which turns very easily between the fingers. Motion in either right ascension or declination can be given by simply turning the plate which carries the eye-piece ninety degrees.

The telescope carries two circles of twenty-four inches diameter. One is divided very coarsely to half degrees only; the other has two sets of graduation upon a silver band, both of them to five minutes of arc. The inner one is somewhat heavier than the other, and does not pretend to great accuracy. It is numbered to every degree, and is used merely for setting. The outer graduation alone is visible in the reading microscopes. Several sets of observations have been made for testing the accuracy of the graduation. The method employed was to compare the mean of the reading of two opposite microscopes with the mean of the reading of the other two. This difference should, of course, be constant were there no other source of error than eccentricity. Each of the sets disclosed a periodic error which can be represented under the form $1''.5 \, sin\,(2z-z_0)$, z being the reading of the initial microscope, and z_0 a fixed angle. This term disappears when the mean of the four microscopes is taken. The residual errors, after the application of this term, are very small, one second of arc being about the limit. For a twenty-four-inch circle this is certainly fine work. Professor Hall, of the Naval Observatory, has suggested that, since the ten degree marks were put in first and the dividing engine run from one of these marks to the next and then adjusted if necessary, the errors would naturally show most by comparing the divisions at 9° and 11°, 19° and 21°, etc. I have accordingly commenced an examination of this kind, but as yet no errors have been found which much exceed the limit already stated.

The circles are clamped to the axis after the Repsold fashion, and can be moved into any position. They are solid, with strengthening spokes upon the back. With circles of this size the flexure should be insignificant. Fastened by means of two arms directly to the cube of the telescope is a nickel-plated ring a little larger than the circles. Standing at the setting microscope one can readily reach the ring and revolve the telescope. As the field of this microscope is large, and at least one whole degree division is always in view, the setting can be done with great rapidity and ease.

The illumination of the circle is by means of small electric lamps, and is practically perfect. These lamps are placed at the end of each microscope and can be lighted in succession by turning a switch. The illumination of the field is also effected by an electric lamp, and a small hand lamp which can be lighted by pressing a spring is used for reading the micrometers. Thus no oil lamps at all are needed, though the instrument is so arranged that oil illumination can be used if desired. The intensity of the field illumination is controlled by turning a milled head near the eye end. Many stars of the ninth magnitude have already been observed, and it will probably be possible to get those of half a magnitude fainter. Of course, for very faint objects a spider line reticule is to be preferred.

With the instrument the makers furnish a reversing carriage, an observing chair of neat pattern and a hanging level. This latter is quite heavy, but it has a device which prevents the V's resting on the pivots with the full weight.

On the whole, the points about the instrument to be criticised are few and unimportant. Such slight changes as the writer might suggest would possibly not suit others as well as the present arrangements. It is certainly pleasant for Americans to feel that even in such matters as instrument making and observatory equipment they are scarcely behind the most renowned firms of the old world.

MR. BRASHEAR'S EUROPEAN VISIT.*

For The Messenger.

I had not the good fortune to spend an evening in any of the Swiss observatories though I paid an early morning visit to the prettily situated observatory at Geneva. While at Chamounix we had several days of beautiful weather, and I longed to make some observations in that far-off land. I found a very excellent 4-inch telescope by Secretan in the

* Continued from page 391, No. 69.

village and leased it at a pretty high figure for a few hours' work. Observations were made on Jupiter and some double stars, but as the telescope was only provided with a low power, the observations were not of much value; but I noted that there was very considerable disturbance in the atmosphere, probably due to the rapid change of temperature common to the summer nights in the Alpine mountains and valleys.

Hastening on to Munich, the home of Frauenhofer, of Merz and Mahler, of Ertel, of Steinheil and many others who have done so much for astronomical science, we found a hearty welcome in that city of art and science. This being the Bavarian jubilee year, and there being a great exposition at Munich it was a good time to be there, and I had the pleasure of meeting an old artist friend who knew Munich so well from several years' residence that our stay was doubly pleasant and profitable.

The Bavarians have not forgotten Frauenhofer, he being among the honored ones of the great jubilee. I had been there but a day when my friend suggested we visit a house which the Bavarians hold as almost sacred. It was found in a very narrow alley near the center of the city. The surroundings were very old fashioned and certainly, from an artistic point of view, not very inviting. At a distance of perhaps six feet from the pavement were these words inscribed on a tablet imbedded in the cement of the walls:

"Bei einsturz dieses
Hauses im 1801 wurde
der Glaser Lehrling und
Später so beruhinte
Mechanicker und Optiker
Frauenhofer verschüttet
und wunderbar gerettet."

which being translated would read about this way: Upon the falling of these houses in 1801 the honored glazier's apprentice, and afterwards the celebrated mechanic and optician, Frauenhofer was miraculously saved. It was an interesting spot to me, not made so by its architectural beauty or its surroundings, but because it was the early home of one whose labors in after life advanced in so marked a degree our knowledge of optical science. I didn't bring many relics home with me, but I could not resist the temptation to dig a few pebbles from the walls of the old house, once the home of Frauenhofer. The works of Steinheil and Sohn were visited, but at the time of my call they were not working, though I was shown around their place from which so much good work has come. The old firm of Ertel & Son were engaged principally on transit work, and I had much pleasure in examining their dividing engine. Mr. Ertel showed me an engine that he had experimented on for many years for making gratings, but it never came up to his expectations. He made a remark to me that was very pleasant to hear, which was that he would rather do work for American astronomers than for any other in the world, and then gave me the reasons, which summed up in brief were that the American astronomer *knew what he wanted, ordered it, and paid for it when he got it.* Reinfelder and Hertel do some very fine work in oculars, prisms, spectroscopes, etc., and at the time of my visit were making a nine-inch objective, and, to be certain of producing a first-class instrument, they were working too. That would seem a queer proceeding in this country.

They make a fine wide field negative eye-piece giving a beautifully clear and flat field; but the lowest powers show "ghosts" when a bright object is being observed which, of course, can be eliminated in the "mind's eye." From Munich we went to Leipzig, where a delightful day was spent with Dr. Victor Schumann who is doing, perhaps, the finest work of the kind in Europe. He is working principally in photographing the spectrum of the gases, and his work has been mostly in the ultra violet. I have never seen a more thoroughly equipped private laboratory; and the neatness and perfect system in every department was most delightful to witness. The Doctor has a battery of eighteen quartz prisms for work in the ultra violet as well as two fine diffraction gratings. I could fill many pages descriptive of Dr. Schumann's apparatus, but I will only say that he has taken perhaps 2,000 spectrum photographs, all of which are arranged for quick reference, and some of which are most remarkable. I will refer to but one, namely, a photograph in the ultra violet of the spectrum of nitrogen, in which I counted a symmetrical series of triplets, twelve in number, the individual lines of which were clear and sharply defined in the negative. I am sorry I have forgotten the wave lengths, but these symmetrical or harmonic series are characteristic of the spectrum of nitrogen as may be seen in Dr. Hasselburg's beautiful maps of this gas, particularly at wave lengths 442 *et seq.*, 45 *et seq.*, and 473 *et seq.*

But I must not dwell longer in this charming laboratory, much as I enjoy it. Dr. Schumann is doing a splendid work, and none know it better than his German co-workers.

The Astrophysical Observatory of Potsdam was our next objective point, and hither we went the day after leaving Leipzig. Drs. Vogel and Lohse were off on their vacation but we were offered every facility to study the many interesting instruments of this great Observatoy. A magnificent spectrometer has just been completed by Bomberg, of Berlin, for the Observatory, that has many new features. I might mention that the objectives of 2½ inches aperture are of the new "Abbe" glass made in Jena, and they are certainly beautiful specimens of the optician's art; the corrections are fine, and if the physical properties of the glass turn out equal to the optical characteristics, we will have great hopes for the future of it. Another feature of the instrument is that the circle has its graduations on the *under* side and are read by "broken" microscopes with great ease. When the observing telescope arm comes around, it would strike the upward projection of the microscopes if they remained *in situ*; but an ingenious device drops whichever one comes in its way, and immediately resets it when it has passed over it.

The solar photographic instrument of this Observatory is constructed upon the plan of Sir Howard Grubb's "siderostatic" telescope, *i. e.* the tube is the polar axis of the instrument, the objective being at the bottom of the tube. Below the objective is a flat mirror, which may readily be adjusted to throw the solar image in the axial line of the objective. Only the mirror need be exposed, and for solar photographic work I should think this instrument would be very effective. As much of the work in this grand institution is in the nature of laboratory work, the roofs of the buildings are covered with soil and a beautiful growth of lawn grass covered it at the time of my visit. One lingers in such a place, unwilling to leave it, with its pleasant people and grand work, but we *had* to go, willing or not. Hamburg we had long wished to visit. The name of Repsold has had an enchantment to us for years. Housed up in a city for nearly all our life time where we could see nothing of that higher class work that was always our ideal, it was a grand day for me when I set foot in old Hamburg. The very first day I met at dinner Dr. Neumayer, of the Hamburg "Seewarte," who introduced me to Dr. Mach, of Prague, Dr. Rumker, of the Astronomical Observatory, and here I also met Dr. Luther, so you see I found many genial spirits, and, what was more, they could talk English, which was a great boon to me.

The Hamburg Seewarte is perhaps the most complete institution of the kind in the world, and the courteous director, Dr. Neumayer, is known among all nationalities. There were thirty-five assistants in the different departments, and every department, such as the meteorological, was most thoroughly equipped with the most perfect instrumental means. In the center of the great building is erected the great whirling table for the study of the anemometer constants, and which was used not long since for a study of "aeroplanes" by a member of the French Aeronautical Society. Every device for deep sea soundings, in fact almost every nautical appliance, fills the interesting museum of the Observatory. They have their own corps of lithographers and draughtsmen, and the records thus kept and preserved for reference fill many hundred quarto volumes. These are always available to captains of vessels from any part of the world. Dr. Neumayer is the originator of the south polar expedition for the benefit of meteorological science. He is a grand fellow, and did everything in his power to make my stay in Hamburg pleasant. Dr. Rumker of the Astronomical Observatory has not been well, and Dr. Luther has been assisting him during the past summer. There are some fine meridian instruments in this Observatory, one of them the work of the grandfather of the present Repsolds, and of course it goes without saying that the grade of the instrument is very high.

A pleasant ride out into the suburbs brought me to an unostentatious building, on the doorway of which was a brass name plate about the size of a page of the MESSENGER, with the modest inscription "A. Repsold and Sohn," engraved upon it. I found both of the gentlemen "at home" and they gave me several hours of their valuable time, and much as I felt I was inposing on good nature in staying so long as I did, I could not but feel that I was welcome. Fortunately for me they had just finished one of their beautiful heliometers, a description of which was accorded me, and it may interest you to say a word about the driving clock. The form of clock now used by the Repsolds, they claim *does not need any electric control from the sidereal clock for photographic or any other accurate work.* I saw one attached to the photographic telescope at the Astrophysical Observatory at Potsdam, and was informed that its work was perfectly satisfactory to them. Briefly stated the principle is this; a rod of steel, say 15 inches long, ⅜ inches in diameter at the lower end, tapering to ⅛ of an inch at the top, is fastened securely at its base; *i. e.* not pivoted in any way. Near the top of this steel rod a weight of perhaps five pounds is secured at the proper point, but is adjustable up and down. A slotted crank extends horizontally from a vertical rapid movement axis of the driving clock, the upper end of the rod just spoken of extending up into the slot of the crank. As this crank is not slotted to the centre, it is evident that when it is set in rapid motion, the centrifugal energy of the rotating weight tends to throw it out to a certain distance, due partly to the position of the weight on the rod; but when this position is fixed at any one point the *elasticity* of the rod, which constantly tends to bring it to a vertical position, regulates the speed to a high degree of accuracy.

It may at once be seen that this is not a friction-controlled clock, and as it is so simple in its workings, so easily constructed, I am sanguine that it will rank high as a regulator for driving clocks. While the invention was original with the Messrs. Repsold, they laughingly informed me that they learned that a Yankee had applied it to regulating a Morse telegraph machine *twenty years ago.* I had the rare pleasure of an examination of the world-renowned dividing engine of Messrs. Repsold, as well as the smaller one which is largely used for the smaller work. It would occupy too much of your time to even run over the salient features of the dividing engine. It has come through three generations and stands to-day unrivaled in the excellence of its work. Of course it is known that the engine is not automatic, but every individual line is set with a high-power microscope, or several of them, as the accurcy of the work demands.

It may also be interesting to know that Messrs. Repsold make all their drawings to full size. Even the largest telescope has every part made full size. No tracings or blueprints are made, and, what may seem remarkable, no figures are marked on the drawings. The workmen must take all the measurements from the full sized drawings, and I was told that few errors are made. But the brothers Repsold have a personal superintendence over everything, and I need not speak of the results. Every astronomer knows that what they do is well done.

There was such a genuine spirit of unselfishness with these people that I came away a thousand times repaid for my visit, and, as was the case in Paris, I left Hamburg with feelings of deep regret, hoping to have the privilege of going again before my humble share of the world's work is done. I know I have exceeded the limits of propriety in this letter, so I must leave my visit to Hilger, Sir W. Thompson's laboratory, and the works of Sir Howard Grubb until I write again.

MARS AND HIS CANALS.*

H. C. WILSON, PH. D.†

When we examine the disk of the planet Mars with a telescope of sufficient power, we find it to be diversified by dark and light markings, of definite form and permanent character, which we have been accustomed to interpret as evidence of land and water, continents and oceans, similar to those which exist upon the surface of the earth. In this respect Mars differs from all the other planets. Mercury and Venus show no permanent markings whatever. They appear to be completely enveloped in perpetual clouds. Jupiter and Saturn, it is true, have their dark-colored belts, which are more or less permanent, but the arrangement of these par-

* A paper read before the Cosmos Club of Northfield, Minn., Nov. 23, 1888.

† Assistant Professor of Astronomy at Carleton College Observatory.

allel to the equators of the planets indicates that they are due to currents which are produced in the dense vaporous envelopes by the swift rotation of the planets. Uranus and Neptune are too distant to admit of accurate delineation of their surfaces, but what little has been done with two or three of the most powerful telescopes in existence indicates that they are, like Jupiter and Saturn, enveloped in clouds with colored belts parallel to their equators. It seems singular, as the late Mr. Proctor said eighteen years ago, in "Other Worlds Than Ours," that "among all the orbs which circle around the sun, one only, and that almost the least of the primary planets, should exhibit clearly and unmistakably the signs which mark a planet as the abode of life."

Mars alone presents appearances which we may, with any degree of certainty, ascribe to the presence of continents and oceans, islands and seas, like those upon our own planet. Upon Mars alone do we see indications of changes of seasons, winter and summer, rain and snow, like those which we experience. These facts lend a special interest to this planet which attaches to none of the others, and lead us to speculate as to the kind of inhabitants there may be upon that far-away world, and what they are doing; whether they are like ourselves. Are they devoted to science? Are they constructing immense telescopes and gazing at us, making maps of the Atlantic and Pacific Oceans and the eastern and western continents? Do they know whether, at the north pole of the earth, there is an open sea, or whether there is an undiscovered continent near the south pole? Are they a race of great engineers, and do they construct public works on a gigantic scale? This last question is suggested by my subject, "The Canals of Mars," which have added so much of interest to the planet during the last few years.

I place before you a chart* of the planet Mars, a copy of one constructed by Mr. Proctor from a large number of drawings made by that keen-sighted English astronomer, Dawes, in September, 1864 and 1865. This chart is on the stereographic projection and is inverted,—the south polar regions, that is, are at the top,—because the telescopes com-

* This chart may be found in Proctor's "Other Worlds than Ours" and in some of the later text books on elementary astronomy.

monly used by observers exhibit inverted views of the celestial objects. It is not accurate in its details, but shows very faithfully the outlines of the most prominent features, and gives the general appearance of what can be ordinarily seen with a telescope of moderate power. The darker parts are a dusky green or blue color and are supposed to be seas. The reddish tracts are supposed to be land. Both the dark and the reddish tracts are frequently seen to be covered with areas of white, either clouds or snow. I notice that Professor Holden, in his report of observations made this summer with the great Lick telescope, speaks of some parts of the continents as bright yellow. I presume that we may attribute both the red and yellow colors to different conditions of the Martial vegetation.

At the top of the map we see the region of ice and snow, which lies at the southern pole. Around that is a sea which is unnamed in the map. Then comes the south temperate zone with several tracts of land named after Cassini, Lockyer and other astronomers. In later and more accurate maps these are represented as islands. The coast line beyond them is not often distinctly seen. Below this zone the features are more distinct and easily recognized. First there is an almost continuous belt of water, Maraldi Sea, Hooke Sea, Dawes Ocean, Arago and Herschel Straits surrounding Phillips Island and connecting Dawes Ocean with Delarue Sea. Next the equatorial belt of four great continents, Herschel, Dawes, Mädler, and Secchi, separated only by straits and seas. Kaiser Sea, between the first two continents, is the darkest and most easily recognized marking on the disc of Mars. Below these continents is a narrow belt of water completely encircling the planet, then a narrow strip of land, La Place Land, then a narrow sea surrounds the north polar ice cap. These two polar caps are always brilliantly white, and sometimes appear, because of irradiation of light, to project beyond the edge of the disc.

The more prominent of these features of Mars' surface were noticed over two hundred years ago. Cassini, with one of those outrageously long telescopes which were used before the invention of achromatic refractors, was the first to discover that they were of a permanent character, but Hooke, an English astronomer, obtained better views of the planet as early as 1666. Since then a host of eminent astronomers, among them the Herschels, Arago, Secchi, Beer and Mädler, Nasmyth and Jacob, Delarue and Phillips, Lockyer and Dawes, have thought the study of Mars' surface worthy of a considerable portion of their time. Within the past few years this work has been prosecuted by a number of enthusiastic and careful observers, among them Burton and Boeddicker in Ireland, Knobel, Denning, Green and Maunder in England, Terby and Trouvelot in France, Perrotin and Schiaparelli in Italy, and we have for part of the past opposition and for the future to add the names of the observers who are permitted to use the great Lick telescope in America—Holden, Keeler and others.

Up to 1877 the observers appear to have confined themselves chiefly to delineating the outlines and variation of tint of the dark areas which immediately strike the eye when one examines the disc of Mars with a telescope of sufficient power, and to have neglected to examine carefully and persistently the bright reddish areas. During the opposition of 1877, which was exceptionally favorable, Mars being at its nearest approach to the sun and to the earth at the same time, M. Schiaparelli, the director of the Observatory at Milan, had the happy inspiration to concentrate his attention upon the great brilliant areas of the continents, in order to study their minutest details. He was rewarded by a brilliant discovery, of details so numerous and surprising in character that many astronomers are still, after the lapse of twelve years, incredulous of their reality. It was no less than a perfect network of very narrow dark lines, mostly straight, running across the continents in all directions, connecting the seas. To these Professor Schiaparelli gave the name of "canals," because, I suppose, of their straightness and from the fact of their connecting the seas. In 1879 he again saw the canals of 1877 and several new ones. No one else was able to see them, although many observers were provided with more powerful telescopes. Two or three saw some narrow markings on the planet, but it was not certain that these were the same that Schiaparelli had seen. During the opposition of 1881-82 Schiaparelli, following up his wonderful discoveries, struck a last blow to the confidence of the astronomers who hesitated to follow him; this time the canals appeared almost all to be double. A new canal appeared beside the old one, rigorously parallel in most cases, and starting, not from the same point of origin as if the old canal were simply divided into two component canals, but from a different point, as if a new canal had really been formed parallel to the first.

I have prepared a copy of a chart of Mars constructed by Professor Schiaparelli, from his observations made in 1882 and 1886, upon which you can see the network of fine lines, the canals, crossing the continents from sea to sea in all directions. They are somewhat exaggerated in distinctness in the drawing, so that you may see them with ease. This chart (Fig. 1) is upon what is called Mercator's projection, the regions near the poles being distorted out of all proportion, but the equatorial regions represented accurately.

Will you compare the lines of the chart with Schiaparelli's own words of description:

"These lines [the so-called canals] run from one to another of the dark spots of Mars, usually called *seas*, and form a very well-marked network over the bright part of the surface. Their arrangement seems constant and permanent (at least so far as can be judged by the observations of four and one-half years); but their appearance and the degree of their visibility is not always the same, depending on circumstances which we cannot at present discuss with full certainty. In 1879 many appeared which had not been seen in 1877 and in 1881–1882 all those which had been seen the first time were re-discovered, and other new lines as well. Their number could not be estimated as less than 60. Sometimes these lines or canals show themselves under the form of diffused and indistinct shading; at other times they appear as very definite and precise markings of uniform tone, as if they had been drawn with a pen. In most instances their curvature differs very little from a great circle, if indeed it does differ; some others however are much curved. The breadth of the finest can hardly be estimated at less than 2° [70 miles] of a great circle but in some cases it reaches to about 4°. As to the length, that of the shortest is certainly less than 10°, others extend to 70° and 80°. The color is sometimes as dark as in the seas of Mars, but often it is brighter. Each canal terminates at its two extremities either in a sea or in another canal. I know of no instance where one end remains isolated in the midst of one of the bright areas of the surface without resting on lines and dark spaces.

"Now in many of these lines it has fallen to me to observe the curious and unexpected circumstance of a doubling or reduplication; this happens in the following manner: To the right or left of a pre-existing line, which suffers no change from its previous direction or position, another line appears, nearly equal to the first and parallel to it; in some instances a slight difference of appearance being visible and sometimes also a slight divergence of direction. The distances between the pairs of lines formed in this manner varies from 6° to 12° of a great circle; there were also other lines which I suspected to be doubled, but the distance being less than 5° or 6° the telescope did not succeed in resolving them, and showed in that place a large, broad, and somewhat confused stripe. Sometimes a line is divided by another which intersects it into two districts or sections of unequal darkness and extent; in this case the companion line is divided into two sections in the very same way, with one exception no sensible irregularity of direction or of shape could be ascertained with the power used in these observations, which was always one of 417. Some of the pairs show so great a regularity that one would say that they were systems of parallel lines drawn by rule and compass. Perhaps however this regularity will not resist the use of a high magnifying power. In various instances, pairs are so connected the one with the other as to form a polygon of double lines with very pronounced angles, and such a series then occupies a great space. Two pairs sometimes cut each other without being interrupted; meeting then three by three they form at the points of triple intersection a network of which our telescope could only give an exact and complete resolution in one or two cases.

"Excluding those cases not well ascertained through the inability of the instrument to resolve objects so minute, the number of reduplications I observed in the last opposition is 20, of which 17 had been established in the course of one month, from January 19 to February 19, the mean date corresponding very nearly to the end of the second month after the vernal equinox of the planet. The phenomenon seems to be confined to a definite epoch, and it appears as if it took place simultaneously over the whole planet's surface occupied by the bright areas. No trace could be ascertained in 1877 during the weeks which preceded or immediately followed the southern solstice of the planet. Only one isolated case presented itself in 1879, between December 24 and 26, and this was exactly reproduced under similar circumstances between January 11 and 12, 1882; it took place in the two lines named Nile I and Nile II on my chart of 1879. Both of these two epochs being close to the vernal equinox of Mars there is ground for believing that the phenomena of reduplication may be periodical, and perhaps connected with the position of the sun with respect to the axis of rotation of the planet."*

When Schiaparelli's chart for 1882 was published it was received with incredulity and almost ridicule, by many. This was due in part no doubt to a fault in the engraving of the chart, which made the lines of the canals and the outlines of all the markings of the planet hard and unnatural, quite unlike the actual appearance in the telescope. But if you will compare the two charts you will see how difficult it is to reconcile the features of the one with those of the other. The different method of projection and the addition of so many new features, all exaggerated in distinctness,

* *The Observatory*, Vol. V, pp. 221-224.

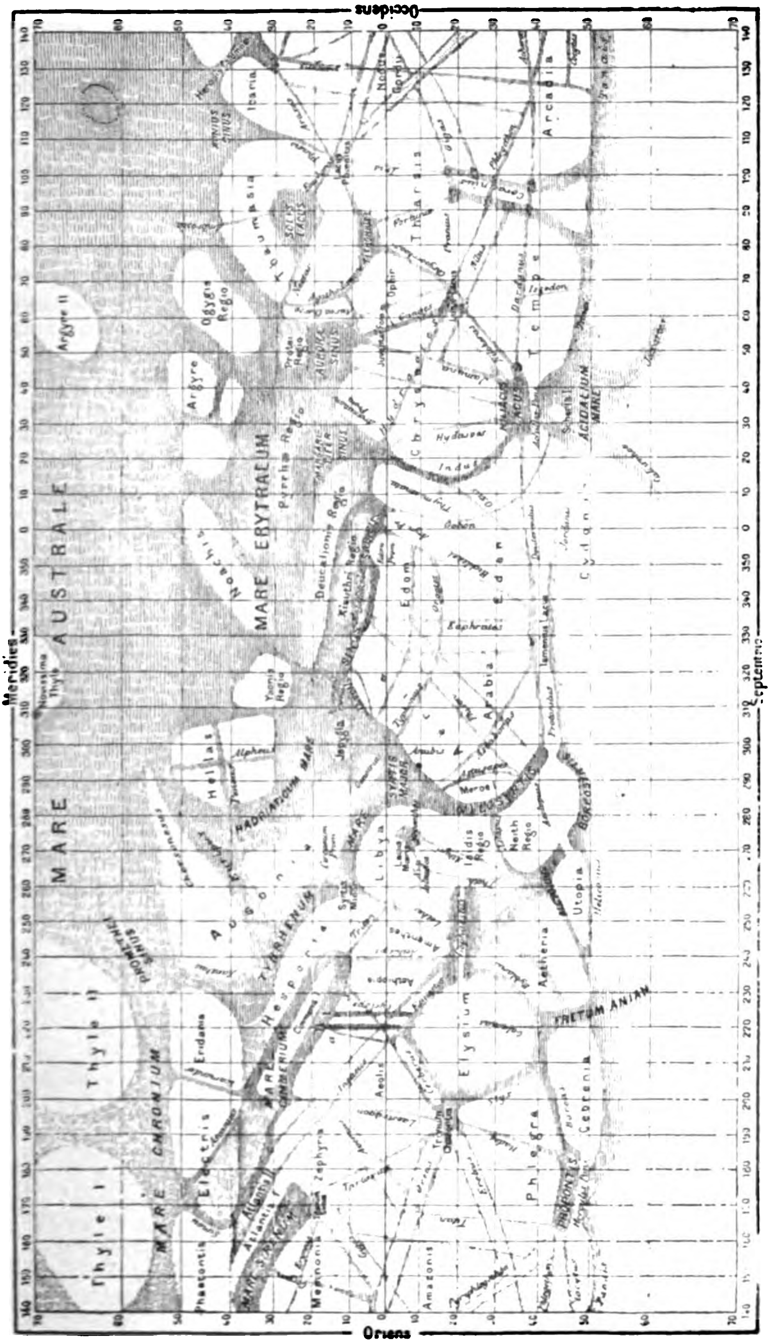


FIG. 1.—SCHIAPARELLI'S CHART OF MARS FROM OBSERVATIONS IN 1882 AND 1886, Copied from *L'Astronomie.*

renders the whole aspect unfamiliar. Yet if one will start with a prominent marking as, for instance, Kaiser Sea (Syrtis Major), and follow the coast lines, he will find nearly every feature of the Proctor chart upon that of Schiaparelli and in its proper place. Perhaps the greatest differences apply to the long narrow inlets of Nasmyth, Bessel and Huggins. These are replaced on Schiaparelli's chart by narrow canals or pairs of canals (Protonibus, Ceraunus, Iris and Gigas). In fact if we examine the original drawings of Dawes we find that the appearance of these features corresponds very much more closely with the chart of Schiaparelli than with that of Proctor.

Up to 1886 no certain confirmation of the duplication of the canals or of their existence was obtained by any other astronomer, but in that year Professor Perrotin of the Observatory of Nice, succeeded with a 15-inch telescope in detecting fifteen of them, and witnessed also the duplication of several. It will give one an idea of the difficulty of seeing these objects, to know that Professor Perrotin, armed with so powerful an instrument, at first gave up the attempt after several days' fruitless effort; having renewed his trials still without success, he was about to give them up finally, when he succeeded in seeing the canal Phison which crosses Dawes continent.

During the present year both Perrotin and Schiaparelli were provided with still more powerful instruments, the latter with an 18-inch and the former with a 30-inch refractor, and the results obtained from the study of Mars' surface go to completely confirm Schiaparelli's discoveries. Several drawings of the planet by these two gentlemen have been published in recent periodicals and I have copied two of them for your benefit. The lower on the left hand (Fig. 2) is by Schiaparelli, from sketches made on June 2, 4 and 6. The most prominent marking near the center is easily recognized as Kaiser Sea (Syrtis Major and Nilosyrtis) of the chart. On the right is the curious forked bay of Dawes. The canals of the equatorial regions are drawn very much as they appear in the chart. Some old ones are omitted while several new appear. This (Astaboras) is straight and double instead of curved and single as in the chart. It is not really a separation of the old canal into two, but a new canal is seen start-

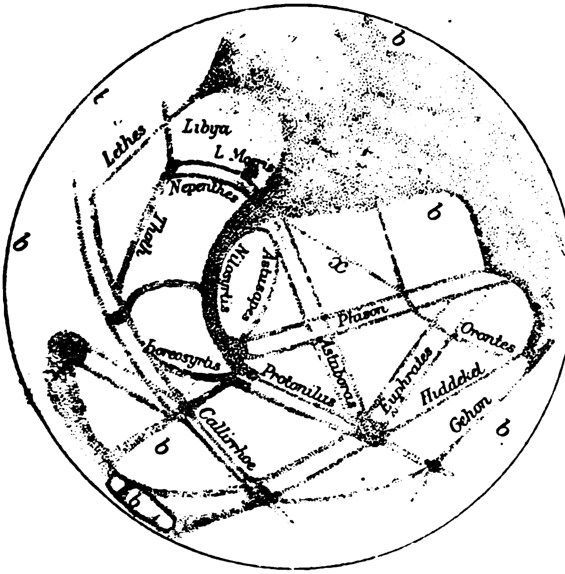


FIG. 2.—MARS, from drawings by Schiaparelli, with the 18-inch refractor at Milan, June 2, 4 and 6, 1888. From *Ciel et Terre*, Aug. 1, 1888.

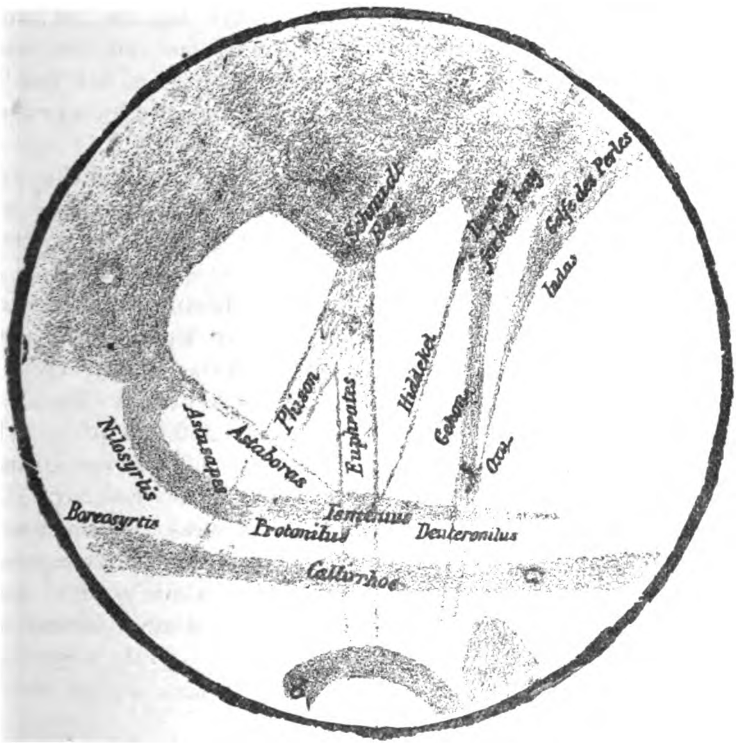


FIG. 3.—MARS, from drawings by Perrotin, with the 30-inch refractor at Nice, June 4, 1888. From *Ciel et Terre*, Aug. 16, 1888.

ing from a different point of Kaiser Sea, and running parallel to the old one to a different point of the lake (Ismenius). The greatest difference is in the regions around the north pole. The system of canals is extended right up to the polar cap, and we notice across the ice cap itself two dusky streaks. This opposition was very favorable for the examination of the north polar regions, that pole being inclined considerably toward the earth, and the opposition occurring after the midsummer of the northern hemisphere of Mars, so that the polar snows were largely melted and the ice cap reduced to a minimum. It seems quite reasonable to suppose that these dark streaks may be open channels in the frozen polar sea.

The drawing on the right (Fig. 3) was made by Perrotin at Nice on the evening of June 4, at about three hours later than Schiaparelli's, you will notice. The aspect of the planet seems quite different at first sight, and yet one may recognize several of the same features. The rotation of the planet has carried Kaiser Sea toward the left edge of the disk. Dawes Forked Bay has come toward the center and the large continent of Mädler has come into view on the right. Several of the same canals may be seen, and four of them extend across the sea on the north up to the polar cap. They agree well with those of the other drawing, considering the changed aspect of the planet due to rotation. At the left end of the polar cap is a notch which corresponds with the position of the dusky streak on Schiaparelli's drawing. Perrotin saw a dusky shading between the parallel canals. Whether that is due to the more perfect or less perfect defining power of his telescope I am unable to say. The upper drawings* are produced from sketches by myself with the 11-inch telescope at the Cincinnati Observatory. The one was drawn April 3, 1884, 8:30 to 9:00 P. M., some time after the opposition, so that the phase was quite gibbous. No canals were seen, but the colors of the different portions of the disk were carefully noted and I have attempted to reproduce them without, however, perfect success. The other sketch was drawn March 6, 1886, at midnight, the best observing night I have ever seen, and when

* One of these drawings was reproduced in the November number of the MESSENGER, p. 401. The other, showing no canals, is not reproduced.

the planet was almost exactly at opposition. Two of the canals, Indus and Hydaspes, are distinctly shown and the place of others indicated by a faint shading, although at that time I knew nothing about the canals and did not identify them until a few days ago.

Considerable curiosity has been felt as to the performance of the great Lick telescope and its testimony as to the existence and nature of the enigmatic canals, and, although it was late in the season, two months after the planet's opposition, that the monster eye at Mt. Hamilton was turned upon Mars, its testimony has been neither uncertain nor disappointing. A series of twenty-one drawings made by Messrs. Holden and Keeler during the months of July and August have recently been published. In these many of the canals are shown, closely agreeing with Schiaparelli's chart.

What then are these strange markings, and why have they not been seen before? are questions which naturally arise. The discoveries of Schiaparelli were made with a telescope of only eight inches aperture. Why is it that so many observers armed with more powerful instruments have utterly failed to see them? Partly, perhaps, because their skies were not so transparent as that of Italy; partly because their eyes were not so keen as those of the Italian observer; partly also because the phenomena of the canals are periodic; but more because of lack of persistent, long-continued scrutiny of the planet's disc. Again Mars can be seen well only when near opposition, that is, about two months in the year and his distance at opposition varies from 34,000,000 to 64,000,000 miles because of the ellipticity of his orbit, so that a really favorable opportunity to observe minute details occurs only once in about fifteen years. Also, it is necessary for such observations that the sky of Mars be free from clouds over immense areas, whole continents in fact, and we can judge from terrestrial analogy that such a condition would be rare.

Several ingenious theories have been suggested to account for the canals. We can hardly admit that they are artificial canals constructed by the inhabitants. Their great width of seventy miles or more would prohibit that hypothesis, although we may suppose, with Proctor, those inhabitants to be of gigantic stature. Mr. Proctor suggested (*M. N.*

xlviii, p. 307), that they might be rivers, the duplication being a diffraction effect, when mists hang over the river bed, but in doing so seemed to ignore their most characteristic features, their straightness, their frequent intersections, and the fact that they connect the seas, running from one to the other, and that the duplication is not the separation of the old canal, but the formation of a new one on one or the other side of the first.

M. Fizeau, the eminent physicist of Paris, explains them by the analogy of rifts in glaciers and considers the whole planet involved in a glacial epoch. He is led to this hypothesis by the presence of the dark canal in the north polar cap. Dr. Terby, of the observatory of Louvain, thinks this would necessitate a greater movement in the system of canals than has been observed. He finds no evidence of any change since they were discovered. Dr. Penard, a physicist of Geneva, suggests that the canals are immense fissures in the crust of Mars through which the waters flow from ocean to ocean. The mass of Mars, being about one-eighth that of the earth, has cooled off more rapidly, producing great fissures in the crust extending to a very great depth. Another writer suggests for the very same reason that the canals are ridges or wrinkles in the crust, or, in other words, mountain ranges. There are serious objections to each of these and we are still far from a satisfactory explanation. I am rather inclined to the view that these markings are in part, at least, rivers and chains of lakes, that the continents are low and flat and subject to extensive inundations at certain seasons of the Martial year. It seems possible in this way to account for the variations noticed in many of the markings and there appears to be no inconsistency in supposing evaporation and precipitation to be more rapid and abundant on Mars than upon the earth, because of the smaller force of gravity.

In May last Professor Perrotin announced that a whole continent on Mars, as large as France, had disappeared, being inundated by the neighboring sea. This continent, Libya, is well situated to be subject to floods, being surrounded on three sides by seas and a gulf, and on the other side by canals and a lake. Later the land partially reappeared, but was surrounded by much wider dark bands. Notice on the drawing by Schiaparelli the darker tint of this land as if the water had not yet all receded.

The next two oppositions of Mars in 1890 and 1892 will be very favorable for observation, and it is to be hoped that the giant telescopes as well as the little ones, will then be applied systematically to the solution of the enigma of Mars.

PHOTOGRAPHS OF NEBULÆ.

A. A. COMMON.

It is not many years since the idea of photographing such objects as nebulæ would have been considered impossible, more particularly by those who know most about the subject. Sir John Herschel, in the correspondence which took place about the making of a large telescope for the Southern Hemisphere, which resulted in the 4-foot reflector at Melbourne, expressed his opinion that photography might be used for getting the positions of stars near nebulæ, in order to assist their delineation by hand; but even he, whose knowledge of the nebulæ and of the powers of photography was so great, does not seem to have indulged in the hope that they would ever be photographed directly, possibly because he knew the great difficulties involved; indeed many years before, one who knew less about nebulæ or photography (at that time quite a new art) had, with the confidence of half-knowledge, expressed quite a different opinion. This man was Dr. Dick (whose charming works are not held in such repute as they deserve, or, at any rate, do not seem to be read as they ought to be), who said, as early as 1845, just after the advent of daguerreotype: "Nor is it impossible that the planets Mars, Venus, Jupiter, and Saturn may be delineated in this way, and objects discovered which cannot be discerned by means of the telescope. It might be perhaps considered as beyond the bounds of probability to expect that even distant nebulæ might thus be fixed and a delineation of their objects produced, which shall be capable of being magnified by microscope. But we ought to consider that the art is yet only in its infancy—that plates of a more delicate nature than those hitherto used may yet be prepared, and that other properties of light may yet be discovered which shall facilitate such designs. For we ought now to see no boundaries to the discoveries of science, and to the practical applications of scientific discovery which genius and art may accomplish." This was a long look ahead at the time; but all that Dr. Dick imagined as possible has since been done.

What may be done, or, rather, what will be done as better processes come to the front it is impossible to say, nor do I wish to discuss this aspect of the question in this short note, but rather to deal with what has been shown to be quite possible, and to make some remarks on what has been recently done, particularly by the MM. Henry and Herr von Gothard; and my excuse for doing so is that so little seems to be known as to what can and what cannot be done of a useful character in this department of astronomical photography, that discussion of the subject seems to be necessary. The photographing of nebulæ is remarkable as being almost the only actually modern achievement of photography; all else we can do now could be done in some form or other soon after the first application of photography to astronomy. It is true that the pictures of stars could not be taken as quickly then as they can now; but stars could be be taken; while all attempts to photograph comets or nebulæ failed or were not persevered in through the apparently hopeless nature of the attempt. We are now enabled to get pictures of the nebulæ that are certainly far superior to any drawings, and, what is of immense importance, with instruments of ordinary or moderate size.

In the practical work of photographing the nebulæ, whose light, as a rule, is so very feeble, the aim has been to collect, as much as possible on the plate; and in order to do this the telescope with the smallest ratio of focal length to aperture has been used, as giving the greatest amount of light on the least surface; and if the image produced on the sensitive film were made up of particles so small as not to affect the shape of the image, it would matter little what the size of that aperture was. But, as it is well known, the particles of silver that gather together to form the image have a sensible size, and by an appearance similar to stippling or mezzotint produce a picture. When this picture is small compared to the particles of silver that form it, detail is lost; and thus the absolute scale of the picture is a matter of importance.

How far processes will be improved in the direction of reducing the size of the silver particles and giving a perfection to the image that at present it has not, it is not possible to say, though there is a promise of improvement in this direction without loss of sensitiveness.

Pending such a solution of the difficulty, it is of interest to consider at the present time what size of image can be utilized—in other words, what is the least aperture that can be usefully employed in taking photographs of the nebulæ. As in all such discussions one ounce of practice is worth a great weight of theory, it is most satisfactory to appeal at once to fact and experience.

Dr. H. C. Vogel, of Potsdam, gives, in No. 2854 of the 'Astronomische Nachrichten,' a very important note on the recent work of Herr von Gothard in photographing nebulæ with a 10-in. reflector, with some drawings that show in a most unmistakable manner with what effect telescopes of this aperture can be used.

In this paper Dr. Vogel expresses an opinion that the photographs of Her von Gothard taken with his comparatively small instrument show results which far surpass any obtained by eye observation with the largest telescope. He mentions the fact that Herr von Gothard some few years ago discovered by photography a small star within the ring-nebula in Lyra, only a few uncertain observations of this star having been previously made, and describes its continued appearance on the photographic plate though invisible in the largest refractors; although I think that there is some slight mistake here, as the star has always been visible with sufficient optical power, still the fact of getting this star so plainly pictured is not less important. We are not, however, concerned with this, but with the work illustrated and described by Dr. Vogel. Six well-known nebulæ are illustrated on a larger scale by drawings made from the photographs, and these can, in most cases, be compared with existing drawings, and the value of those photographic pictures properly estimated. As it happens I can speak, with some degree of confidence, as to one of these.

This, the spiral nebula in Canes Venatici (G. Catalogue

3572), is a nebula that is most peculiarly fitted to deceive the eye by the shape of the outlying parts; hence the great difference in the various published drawings.

In the course of 1883 I took, with about thirty minutes exposure, a photograph of this nebula with a 3-foot aperture, and got a picture somewhat similar to that obtained by Herr von Gothard, *but with less detail;* I made at the time an examination of most of the drawings mentioned by Dr. Vogel, and can quite bear him out in all he says as to the different ways in which they show this nebula. A point of great interest comes out on examining these photographs mentioned by Dr. Vogel—that is, the peculiar aspect of the knotted parts of the nebula, that look almost like stars, but have quite a different character; but a description of a photograph is almost impossible, and to compare the drawings with it is the only proper way to get a correct idea of the respective values.

During the past year MM. Henry at Paris have taken a picture of the Pleiades that brings some most important features to light, showing that this group of stars is in a mass of nebula. This has been suspected by many observers from time to time, but no one had been able to localize any of the brighter parts that have since been shown by photography, except perhaps an observation made with a 3-foot in 1880, that showed two or three of the brighter portions that have since been shown so beautifully on the photographs of the Brothers Henry; on these latter plates not only were these and other masses more or less intense practically discovered, but the positions of exceedingly small stars are given in a way that cannot be attempted by observation or measurement in the ordinary methods—stars that are far too faint to be visible except in the largest telescopes, and even with these not susceptible of accurate measurement. In this particular case I had some years ago observed several exceedingly faint stars near Alcyone that were just visible with a 3-foot reflector, and all of these, with one exception, are shown on the photograph referred to, taken with a photographic telescope of 13 inches aperture.

Similar photographs of the Pleiades have also been taken by Mr. Roberts, near Liverpool, that show almost as much as the photographs of the MM. Henry; but if one can judge by a comparison of the beautiful engraving of the photographs taken at Paris, with the paper tints of those taken by Mr. Roberts, with less distinctness, particularly as to the peculiar line of light, or rather lines of light so well marked in the Paris photographs. The work of Mr. Roberts was done with an 18-inch silvered glass reflector, and with a shorter exposure than in the other cases.

In the case of the photographs of Herr von Gothard, the exposure was necessarily extended to over two hours, and in the case of the Henrys' photograph to four hours; but length of exposure is of minor importance when we know that once the photograph is secured it is an actual representation that can be afterwards dealt with at leisure and measured, giving then all the results that can be obtained by eye with an instrument far more powerful than that employed. The use of large telescopes will always be in such work of great value, no matter how processes may be improved upon, as the advantage will still be with them, when minute details of structure possibly hitherto unsuspected will be brought out; but even at the present time we can see from the work that has already been done that we need not look to these large telescopes alone; and as the number of known nebulæ is already so great, there is an amount of work to be done that will occupy any possible number of observers for many years if only in getting impressions on such a scale as those obtained by Herr von Gothard: improvement may come afterwards; but improvement can only follow actual work done.

The work of Herr von Gothard is a solid contribution to our practical knowledge of nebular photography, and goes a long way towards settling the capabilities of a certain aperture. Many other questions remain, and it is to be hoped that observers, encouraged by the remarkable success of Herr von Gothard, will do what they can by actual experiment with the means at their disposal, whatever those means are, to throw more light on this most interesting subject.

How far the great expense of large instruments and the increased difficulty of working them are compensated by the larger scale on which the photographs will be obtained; how far it will be advisable to increase the focal length of moderate apertures to get a larger scale at the expense of longer exposure; to what extent it is advisable to go in the other direction and increase the aperture beyond what is usual even now; how much will be gained by the use of orthochromatic plates or of special plates for special nebulæ; what is the best kind of clock to employ and the best means of giving intermittent exposures,—all these and many other questions will come up for discussion next year when those interested will meet for that purpose. A good deal is becoming known, it is true; but many no doubt thought that 10 inches was much too small an aperture to attempt serious work, and in the same way there may be wrong ideas as to the insufficiency of their means preventing men joining in this work. With Herr von Gothard's example before them they should accept nothing till it is put to the proof of experiment, and by this mean we should soon have a fair knowledge not only of what can be done, but of (what is almost equally important if it has been proved) what cannot be done.—*Observatory.*

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury may be seen in the southwest, about an hour after sunset, for about ten days in the latter part of January and first of February. He will be at greatest elongation east from the sun, 18°22′, Jan. 30, at a greater brilliancy the next day; in perihelion Feb. 2, in conjunction with the moon, 4°14′ north, Feb. 1, 10:38 A. M., and at inferior conjunction with the sun, 3°29′ north, Feb. 14, 6:58 P. M.

Venus will cross the First Meridian and the equator on Feb. 1, passing through the constellation of Pisces. No one can fail to recognize her in the early evening, as the most conspicuous object in the whole sky, excepting the moon. Her disc is slightly gibbous, the illuminated part of the equatorial diameter being 0.661 on Jan. 16 and 0.530 on Feb. 15. The declination and consequently the altitude of the planet when near the meridian is rapidly increasing, while at the same time the distance from the earth is decreasing, so that the next two months will afford excellent opportunities for study of any markings which may be visible on the planet's surface.

Mars although receding from the earth still keeps at nearly the same apparent distance from the sun so that he sets at nearly the same time every night, a little after 8 P. M. He may be found easily among the faint stars of Aquarius, about half way between the southern edge of the Square of Pegasus and the first magnitude star Fomalhaut, and from five to fifteen degrees west of Venus.

Jupiter rises from two to three hours earlier than the sun, but at such a low declination that it is hardly worth the while for northern observers to attempt any observations of his surface or satellites.

Saturn will be at opposition to the sun Feb. 4 so that the two months of January and February will be the best, so far as position is concerned, for observations of that planet. To find Saturn in January at 8 P. M. look toward the east and a little to the north; the brightest star near the horizon is Saturn. Above him, half way or more to the zenith one will recognize the two stars of The Twins, Castor and Pollux; to the right from them another pair, one star brighter than the other, Procyon and his comrade in the Little Dog; still farther to the right another similar pair, one of which is the magnificent Sirius the brightest of all the starry host; and to the right and north of these, that most splendid of all constellations, Orion. A little later the Sickle of the constellation of Leo will be seen above the eastern horizon and Saturn may be recognized as the yellow star just above th eSickle about equidistant from its extremities.

Uranus may be found after midnight in the constellation of Virgo about 3° north of Spica almost on a line between Spica and ζ Virginis.

Neptune is about 5° south and a little east of the Pleiades which are on the meridian at half past eight P. M. Jan. 15. There are but two or three stars as bright as Neptune within a radius degree or more, so that the task of identifying the planet, with a telescope of 4 or more inches aperture, provided with only rough circles, will not be very great.

MERCURY.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Jan. 25	21 43.6	−14°26′	8 18 A. M.	1 22.6 P. M.	6 28 P. M.
30	22 06.0	−11 19	8 07 "	1 25.1 "	6 43 "
Feb. 4	22 16.0	− 8 55	7 47 "	1 15.4 "	6 44 "
22	22 10.1	− 8 06	7 19 "	0 50.0 "	6 21 "
14	27 51.4	− 9 03	6 44 "	0 11 6 "	5 39 "

VENUS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	23 28.8	− 3 50	9 19 A. M.	3 07.3 P. M.	8 55 P. M.
Feb. 4	0 08.2	+ 1 18	8 59 "	3 07.3 "	9 16 "
14	0 45.6	+ 6 21	8 37 "	3 05.3 "	9 34 "

MARS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	22 57.0	− 7 36	9 02 A. M.	2 36.0 P. M.	8 09 P. M.
Feb. 4	23 25.6	− 4 29	8 40 "	2 25.2 "	8 11 "
14	23 53.7	− 1 20	8 15 "	2 13.7 "	8 12 "

JUPITER.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	17 50.5	−23 05	5 05 A. M.	9 29.8 A. M.	1 55 P. M.
Feb. 4	17 59.0	−23 06	4 34 "	8 59.0 "	1 24 "
14	18 06.9	−23 06	4 02 "	8 27.6 "	12 56 "

SATURN.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	9 22.2	+16 36	5 48 P. M.	12 59.1 A. M.	8 11 A. M.
Feb. 4	9 19.0	+16 52	5 04 "	12 16.6 "	7 29 "
14	9 15.8	+17 07	4 20 "	11 34.1 "	6 48 "

URANUS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	13 22.3	− 7 59	11 27 P. M.	4 58.5 A. M.	10 30 A. M.
Feb. 4	13 22.0	− 7 57	10 47 "	4 19.0 "	9 51 "
14	13 21.5	− 7 54	10 07 "	3 39.1 "	9 11 "

NEPTUNE.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	3 50.9	+18 25	12 09 P. M.	7 28.7 P. M.	2 48 A. M.
Feb. 4	3 50.8	+18 25	11 28 "	6 48.2 "	2 08 "
14	3 50.8	+18 26	10 50 "	6 09.9 "	1 30 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 20	20 12.7	−19 57	7 30 A. M.	12 11.5 A. M.	4 53 P. M.
25	20 33.7	−18 46	7 26 "	12 12.7 "	5 00 "
30	20 54.3	−17 26	7 20 "	12 13.6 "	5 07 "
Feb. 4	21 14.6	−16 00	7 15 "	12 14.2 "	5 14 "
9	21 34.6	−14 25	7 08 "	12 14.5 "	5 21 "
14	21 54.2	−12 45	7 01 "	12 14.4 "	5 28 "

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T. h m	Angle f'm N. P't. °	Wash. Mean T. h m	Angle f'm N. P't. °	Duration. h m
Feb. 8	δ^1 Tauri	4	13 20	42	14 03	304	0 43
8	δ^2 Tauri	5½	13 45	76	14 39	271	0 54
11	*d* Geminorum	6	11 07	69	12 20	303	1 13
14	83 Cancri	5½	4 38	6	Star 0.7′ N. of moon's limb.		
14	8 Leonis	5½	14 53	73	15 46	333	0 52
15	37 Leonis	5½	6 52	131	7 49	256	0 56

Phases of the Moon.

	Central Time. d h m
Full Moon	Jan. 16 11 37 P. M.
Last Quarter	" 24 9 57 P. M.
New Moon	" 31 3 10 A. M.
First Quarter	Feb. 7 2 58 P. M.
Full Moon	" 15 4 17 P. M.

Elongations and Conjunctions of Saturn's Satellites.

[*Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.*]

JAPETUS.

d		d	
Jan. 29,	I	Feb. 17,	W

TITAN.

d h		d h		d h	
Jan. 17, 8 A. M.	I	Jan. 29, 6 A. M.	E	Feb. 10, 4 A. M.	S
21, 7 A. M.	W	Feb. 2, 5 A. M.	I	14, 3 A. M.	E
25, 6 A. M.	S	6, 4 A. M.	W		

RHEA.

d h		d h		d h	
Jan. 16, 10.2 A. M.	E	Jan. 29, 11.0 P. M.	E	Feb. 12, 11.8 A. M.	E
20, 10.5 P. M.	E	Feb. 4, 11.3 A. M.	E		
25, 10.8 A. M.	E	7, 11.7 P. M.	E		

DIONE.

d h		d h		d h	
Jan. 16, 5.4 A. M.	E	Jan. 27, 3.9 A. M.	E	Feb. 7, 2.4 A. M.	E
18, 11.0 P. M.	E	29, 9.5 P. M.	E	9, 8.0 P. M.	E
21, 4.6 P. M.	E	Feb. 1, 3.1 P. M.	E	12, 1.6 P. M.	E
24, 10.2 A. M.	E	4, 8.7 A. M.	E	15, 7.2 A. M.	E

TETHYS.

d h		d h		d h	
Jan. 16, 9.2 A. M.	E	Jan. 27, 4.9 P. M.	E	Feb. 8, 12.5 A. M.	E
18, 6.5 A. M.	E	29, 2.1 P. M.	E	9, 9.8 P. M.	E
20, 3.8 A. M.	E	31, 11.4 A. M.	E	11, 7.1 P. M.	E
22, 1.1 A. M.	E	Feb. 2, 8.7 A. M.	E	13, 4.3 P. M.	E
23, 10.3 P. M.	E	4, 6.0 A. M.	E	15, 1.6 P. M.	E
25, 7.6 P. M.	E	6, 3.2 A. M.	E		

A Partial Eclipse of the Moon will occur on Jan. 16, 1889. It will be visible in the United States and generally in Europe, Africa, North and South America, and the Atlantic and Pacific Oceans. The following are the times of the phases:

	Washington Mean Time. d h m	Central Time. d h m
Moon enters penumbra	Jan. 16, 9 29.3	Jan. 16, 8 37.5 P. M.
Moon enters shadow	10 50.0	9 58.2 P. M.
Middle of eclipse	12 21.5	11 29.7 P. M.
Moon leaves shadow	13 53.0	17, 1 01.2 A. M.
Moon leaves penumbra	15 13.5	2 21.7 A. M.

The magnitude of the eclipse, or the portion of the disc covered, will be 0.702. First contact of the shadow with the edge of the moon will occur at a point 133.3° east from the north point of the disc and last contact at a point 122.0° west from the north point of the moon's disc.

Instructions for the January Eclipse. Professor David P. Todd, Director of the Amherst College Observatory, also prepared a pamphlet of instructions for those intending to observe the total eclipse of January 1. The proof sheets have been received. The details of these instructions have been carefully worked out, and will prove helpful to persons availing themselves of them.

Ephemeris of Comet e 1888 (Barnard). The following ephemeris is taken from *A. N.*, No. 2867:

1889	α app.	δ app.	log. r	log. Δ	L.
	h m	° ′			
Jan. 1	17 40	−7 16.4			
" 2	15 48	7 13.2			
" 3	14 2	7 9.9			
" 4	12 20	7 6.5	0.2664	0.2633	5.0
" 5	10 42	7 3.0			
" 6	9 9	6 59.3			
" 7	7 40	6 55.6			
" 8	6 14	6 51.8	0.2644	0.2850	4.6
" 9	4 52	6 47.9			
" 10	3 33	6 43.9			
" 11	2 18	6 39.8			
" 12	1 6	−6 35.8	0.2626	0.3053	4.2

Ephemeris of Faye's Comet 1888 IV. The following ephemeris is also found in *A. N.*, No. 2867, and for the month of January, computed by E. Lamp:

1889	α app.	δ app.	log. r	log. Δ	L.
	h m s	° ′			
Jan. 1	8 1 5	+0 10.2			
" 3	7 59 28	0 10.9	0.3330	0.0896	1.67
" 7	56 6	0 15.8	0.3372	0.0927	1.62
" 11	52 40	0 25.0	0.3414	0.0970	1.56
" 15	49 16	0 38.2	0.3455	0.1026	1.49
" 19	45 59	0 55.3	0.3497	0.1095	1.42
" 23	42 52	1 15.6	0.3538	0.1176	1.34
" 27	39 59	1 38.8	0.3580	0.1267	1.26
" 31	37 25	+2 4.1	0.3621	0.1367	1.18

Comt f 1888 (Barnard). We have not received the ephem-emeris of Comet *f* for January, 1889, and hence can only give the last ten days of December, as follows:

1888.	α app.	δ app.	log. r	log. Δ	L.
	h m s	° ′			
Dec. 22	10 26 54	−1 35.3	0.3100	0.1634	0.92
" 23	26 53	1 10.0			
" 24	26 50	0 44.2			
" 25	26 45	−0 18.0			
" 26	26 36	+0 8 7	0.3176	0.1577	0.91
" 27	26 26	0 35.7			
" 28	26 14	1 3.2			
" 29	26 0	1 31.1			
" 30	25 43	1 59.6	0.3251	0.1527	0.90
" 31	10 25 24	+2 28.6			

The Discovery of the Planet Uranus. [The Philosophical Transactions for 1781 contains a letter from Sir William Herschel announcing the discovery of a comet [*Uranus*], and as that volume is not within reach of hundreds of the readers of The Sidereal Messenger, I have thought that extracts from Herschel's letter would be interesting to those readers.] H. P. T.

ACCOUNT OF A COMET BY MR. HERSCHEL, F. R. S., READ APRIL 26, 1781.

"On Tuesday, the 13th of March, between ten and eleven in the evening, while I was examining the small stars in the neighborhood of H Geminorum, I perceived one that appeared visibly larger than the rest; being struck with its uncommon magnitude, I compared it to H Geminorum and the small star in the quartile between Auriga and Gemini, and finding it so much larger than either of them, suspected it to be a comet.

"I was then engaged in a series of observations on the parallax of the fixed stars which I hope soon to have the honour of laying before the Royal Society; and those observations requiring very high powers, I had at hand the several magnifyers of 227, 460, 932, 1536, 2010, etc., all of which I have successfully used upon that occasion. The power I had on when I first saw the comet was 227. From experience I knew that the diameters of the fixed stars are not propotionally magnified with the high powers as the planets are; therefore I put on the powers of 460 and 932, and found the diameter of the comet increased in proportion to the power, as it ought to be, on the supposition of its not being a fixed star, while the diameters of the stars to which I compared it were not increased in the same ratio. Moreover, the comet being magnified much beyond what its light would admit of, appeared hazy and ill defined with these great powers, while the stars preserved that luster and distinctness which from many thousand observations I knew they would retain. The sequel has shown that my surmises were well founded, this proving to be the comet we have lately observed.

"I have reduced all my observations upon this comet to the following tables: The first contains the measures of the gradual increase of the comet's diameter. The micrometers I used, when every circumstance is favorable, will measure extremely small angles, such as do not exceed a few seconds, true to 6, 8, or 10 thirds at most; and in the worst situations true to 20 or 30 thirds; I have therefore given the measures of the comet's diameter to seconds and thirds. And the parts of my micrometer being thus reduced, I have also given all the rest of the measures in the same manner; though in large distances, such as one, two, or three minutes, so great an exactness, for several reasons, is not pretended to." * * * [Then follow Herschel's measurements of the "comet's" diameter and remarks on the physical appearance of the "comet."]

"*March 19.* The comet's motion is at present 2¼ seconds *per* hour. It moves according to the order of the signs, and its orbit declines but little from the ecliptic.

"*March 25.* The apparent motion of the comet is accelerating, and its apparent diameter seems to be increasing.

"*March 28.* The diameter is certainly increased, from which we may conclude that the comet approaches to us.

* * * * * * * * * *

"*April 6.* With a magnifying power of 278 times the comet appeared perfectly sharp upon the edges, and extremely well defined, without the least appearance of beard or tail." * * * [Here follow a page of "remarks on the path of the comet," and several pages of diagrams of stars in the vicinity of the "comet." About this time Dr. Maskelyne, astronomer royal, began observations of the "comet" and Herschel appears to have dropped the matter until the following October. In the mean time the French astronomer had determined the true nature of the mysterious body.]

Queries and Answers. 12. It is difficult to say why text-books on Astronomy do not more generally notice the fact, that there is precession in the *declination* of the stars, as well as in *right ascension*, which is commonly spoken of. In some instances we presume that the writers leave that fact to be inferred from statements like the following: Since the position of ecliptic among the stars is well-nigh invariable the latitude of the stars does not change, but the declination, right ascension and longitude do change.

J. A. B. thanks the MESSENGER and Mr. Brennan and in return gives an answer to question 14 in November number, "How is the oft repeated statement made by astronomers explained, that the sun attracts a comet, and at the same time repels it to form its tail? How can the sun simultaneously attract and repel?

Miss Clerke in "Astronomy in the Nineteenth Century," page 385, says:

"It is perfectly well ascertained that the energy of the push or pull produced by electricity depends (other things being the same) upon the *surface* of the body acted on; that of gravity upon the *mass*. The efficacy of solar electrical repulsion relatively to solar gravitational attraction grows, consequently, as the size of the particle diminishes. Make this small enough, and it will virtually cease to gravitate, and will unconditionally obey the impulse to recession.

"This principle Tolluer was the first to realize in its application to comets. It gives the key to their constitution. Admitting (as we seem bound to do) that the sun and they are similarly electrified, their more substantially aggregated parts will still follow the solicitation of his gravity, while the finely divided particles escaping from them will simply, by reason of their minuteness, fall under the sway of his repellant electric power. They will, in other words, form "tails." Nor is any extravagant assumption called for as to the intensity of the electrical charge concerned in producing there effects. Tolluer, in fact, showed that it need not be higher than that attributed by the best authorities to the terrestrial surface."

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15. If a ball be fired from a zenith pointing gun to a great height, in falling it will strike the earth to the *west* of the point of projection. If the same ball be dropped from rest, from the same height, it will fall *eastward* of the vertical at the point of starting. In the former case the ball will reach the earth twelve times as far to the *west*, as, in the latter case, it does to the *east*. The following equations show this:

$$\eta = 8s\sqrt{\frac{2s}{g}}\, n \cos\varphi.$$
$$\eta = -\tfrac{2}{3}s\sqrt{\frac{2s}{g}}\, n \cos\varphi.$$

In which η means *westerly* direction of deviation, the minus meaning east, g, force gravity, s, greatest height, n, angular velocity of rotation and φ, the latitude of the place. The formulæ are perfectly general and show that the deviation of bodies falling from great heights, or projected upward and falling, would not deviate at all from the vertical at the poles of the earth.

Comet Faye. We learned by Science Code telegram that Faye's comet was observed at Nice, Dec. 3.7119 in

R. A. 8*h* 12*m* 31.3*s*.

Decl. + 2° 21′ 02″.

This comet has been regularly observed at Lick Observatory.

EDITORIAL NOTES.

This number is closed a few days earlier than usual, in order to give the editor an opportunity to visit California, and observe the total eclipse of the sun, which occurs Jan. 1, 1889.

It is believed that it will be possible to give a pretty full account of the observations of the total eclipse in our next issue, though it will be too early for best information or final results of some important work that may be done.

In our class in College Astronomy during the last three months, we have used the proof sheets of Professor C. A. Young's new General Astronomy with great satisfaction. This book contains 550 pages with 250 illustrations, and will be ready for the purchaser in complete form Jan. 1. All teachers of astronomy will certainlv be interested in examining this new book. Its introduction price is $1.80.

Professor Holden's pamplet of suggestions for observing the total eclipse of the sun Jan. 1, is a very useful and timely document. He deserves the thanks of the multitude of visitors, home and foreign, who will be on the mountains and the Pacific slope to observe Luna's dark compliments for the New Year's Day of 1889.

New Nebulæ by Photography. At Harvard College Observatory, new nebulæ have recently been detected by photography. The objective of the instrument employed is called a photographic doublet instead of an ordinary photographic objective. The advantages of the doublet are increase of field and of angular aperture, and these give about double the light energy for the sensitive plate over that of the ordinary photographic objective. The time of exposure is therefore correspondingly diminished. This is a great advantage in photographing objects in moonlight, or faint objects like many of the nebulæ. The results of work done in this way are determined by comparing the photographic plates with catalogues of nebulæ and so ascertaining what objects are new.

Each plate is laid on a frame inclined at an angle of 45°, and the light of the sky reflected through it by means of a horizontal mirror. Each portion of the plate is then studied with a magnifying glass, and the co-ordinates of every object resembling a nebula are measured. The approximate right ascensions and declinations of these objects are next determined from the configuration of the adjacent stars on the charts of the Durchmusterung, which are on the same scale of two centimeters to a degree. A comparison is next made of all the objects detected on any of the plates. The results of these comparisons are tabulated and new objects are easily known. The Batche telescope has an objective of 8 inches aperture and 44 inches focal length, and is a doublet as before described. Its photographic field of good definition is seven degrees in diameter, though each plate covers a region of ten degrees square. Trial of this method was made of the region of the sky with the great nebula of Orion as a center, and twelve nebulæ were found that were probably new. This is most encouraging progress in photography. It looks as if some of our American workers were rivaling the noble skill of von Gothard and the Henry brothers.

Comet e 1888. O. C. Wendell, of Harvard College Observatory, kindly sent the ephemeris of comet *e* (Barnard) for December, to the MESSENGER, rightly addressed and in time, but the letter visited one or more of the other numerous Northfields in the United States, so that it did not finally reach us in time. We have elsewhere given the last nine days of December because we mail so much earlier than usual.

We take great pleasure in presenting to our readers a cut and description of the new Meridian Circle, recently made by Messrs. Fauth & Co. of Washington, D.C., for Cincinnati Observatory. As far as is now known it is the finest instrument of the kind of American make in this country. We shall not be surprised if it prove equal to the best that even distinguished foreigners can produce. Messrs. Fauth & Co. are to be congratulated in this forward and difficult step of undertaking to make large, fine meridian instruments.

The Canals of Mars. In a late report of work going on at the Lick Observatory, Professor Holden says: "The season for making observations of the canals of Mars was in April and May of this year (1888). Owing to the delays in completing the Lick Observatory no observations could be made here until July.

"From that time until the latter part of August the planet was diligently followed, over forty careful drawings having been made. These drawings show at least twenty of the principal "canals," but no one of them was seen doubled. The submerged "continent" had reappeared also and was seen by us here, essentially as it had always appeared since 1877. It was most unfortunate that the Lick telescope could not be used for this purpose until so late a date; but it has shown its great power in such work by following the fine details on the surface two months later than other instruments, and it has conclusively proved that whatever may have been the condition of the "continent" previous to July, it was certainly in its normal condition from that time onward "

Seven Eclipses in one Year. In one of the text books of astronomy I read some time ago that the greatest number of eclipses that could possibly occur in one year is seven, and the least number is two; and that neither happens oftener than twice in a century.

This is greatly erroneous as regards the least number; two eclipses in a calendar year are of frequent occurrence; it happens three or four times in every 18-year period; but seven eclipses *in one calendar year* are of very rare occurrence. I have a pretty full list of eclipses for the past one hundred years, and I greatly doubt if there has been a year with seven eclipses in all that period.

Perhaps some of your readers may feel like investigating and letting us know *when* there were seven eclipses in one year, and when this will occur again. But seven eclipses *in a year's time* are not unfrequent. In Loomis's Astronomy are given examples illustrating the principle in connection with the 18-year period, beginning with eclipses in 1768–69, and running until 1894–96. There were seven eclipses from Feb. 12, 1877 to Feb. 1, 1878. In 1894, 1895 and 1896 occur the following:

Date.	Eclipsed.	Date.	Eclipsed.
Sept. 15, 1894	Moon.	Aug. 20, 1895	Sun.
Sept. 29, 1894	Sun.	Sept. 4, 1895	Moon.
Feb. 24, 1895	Sun.	Sept. 18, 1895	Sun.
Mar. 11, 1895	Moon.	Feb. 13, 1896	Sun.
Mar. 26, 1895	Sun.	Feb. 28, 1896	Moon.

Which gives us the following remarkable clusters of eclipses:

Date.	Ecl.	Date.	Ecl.
Sept. 15, 1894, to Sept. 4, 1895...	7	Feb. 24, 1895, to Feb. 13, 1896....	7
Sept. 29, 1894, to Sept. 18, 1869...	7	Mar. 11, 1895, to Feb. 28, 1896....	7

But it is of more interest, possibly, to remark that seven eclipses in a year's time are now in progress, viz.:

Date.	Eclipse.	Date.	Eclipse.
June 28, 1888..................	Moon.	Aug. 7, 1888......................	Sun.
Feb. 11, 1888......................	Sun.	Jan. 1, 1889......................	Sun.
July 9, 1888......................	Sun.	Jan. 16, 1889.................	Moon.
July 22, 1888...........	Moon.		

St. Louis, Nov. 17, 1888. . F. H. BURGESS.

Mr. J. E. Gore, Vice President of the Liverpool Astronomical society, has computed the orbits of two binary stars with following results:

Struve, 2120:

$$\rho^2 = 4.9729 + 0.0225\,(t - 1850.4)^2$$
$$\text{Sec}\,(317^\circ.20 - \theta) = 0.4484\,\rho.$$

45 Geminorum, $O\Sigma$ 165:

$$\rho^2 = 8.352 + 0.0093\,(t - 1873.55)^2$$
$$\text{Sec}\,(87^\circ.90 - \theta) = 0.346\,\rho.$$

The computed and observed places for the first for more than 100 years compare well. Those of the second extend over a period of 40 years.

J. E. Gore's Revised Catalogue of Variable Stars. May 12, 1884, Mr. Gore read a paper before the Royal Irish Academy under the title of "A Catalogue of suspected variable stars," which contained 736 such stars, and 114 pages of notes and observations. A neat two page map of the heavens also accompanied that paper showing the distribution of the known and the suspected variables. The known stars were printed red, the suspected, black, the right ascension and declination of each being read easily at sight.

We have now before us a revised catalogue of variable stars by the same author, it being a paper read before the Irish Academy Dec. 12, 1887. It is thought to contain all stars now certainly known to vary in light, including recent discoveries with positions brought down to 1890.0. The former catalogue contained the number, name, place for 1880, change of magnitude and authority. This one adds maximum and minimum of magnitude with dates for each, mean period in days, color and spectrum. We were not before aware of the existence of this important paper. We commend it to our readers.

Wolsingham Observatory. Communications intended for Wolsingham Observatory should hereafter be addressed Towlaw, Darlington, England. The site of the new Observatory is three miles northeast of the old one, and stands 1,000 feet above the sea. T. E. Espin is in charge.

Asteroid 281. The following circular elements of Asteroid 281 have been computed from the very simple formulæ given by Oppolzer in his *Lehrbuch*, vol. i (2d ed.) p. 447–452, using the discovery position of Oct. 31 and a Washington observation of Nov. 3:

Epoch: 1888, Oct. 31.5165 Gr. M. T.

$$\left.\begin{aligned} u &= 3^\circ 24'.1 \\ \Omega &= 32\ 15\ .8 \\ i &= 10\ 18\ .8 \end{aligned}\right\} \text{True equinox of epoch.}$$

$$\mu = 926''.9$$

$$\log.\ a = 0.38864$$

An ephemeris derived from these elements represents the position of the asteroid on Nov. 13 within 16s in right ascension and 0′.2 in declination. W. C. W.

In query No. 17 E. W. A. asks, "What is a dialytic telescope?" The ordinary meaning of that phrase is: "An achromatic telescope in which the colored dispersion produced by a single object lens of crown glass is corrected by a smaller concave lens, or combination of lenses, of high dispersive power, placed at a distance in the narrower part of the converging cone of rays, usually near the middle of the tube." A practical article entitled "Astronomical Telescopes, Their Object Glasses and Reflectors," by G. D. Hiscox, is to be found in Nos. 581, 582 and 583 of the *Scientific American Supplement.* These can be had at any time from the publishers of that paper. No. 582 treats upon the dialyte, and gives much information as to their construction and the principles involved. ⁂

Our readers certainly ought to enjoy with us some of the racy, off-hand good things of one of our royal correspondents from the other side of the water. The other day we had reason to believe that we had wrongly addressed a letter to our genial friend, C. Piazzi Smyth, or had, inadvertently, done some other equally bad thing, and so we asked him about it. From a prompt private letter we take part of his answer as follows: "But we are strangely in the dark as to addresses. You ask me in your postscript touchingly 'Will you not kindly give me your present address.' I reply, most certainly I will. 'Clova,' as above, is the name of the little house which my wife and I inhabit and own. 'Ripon' is the name of the little town, 1,000 years old as a municipality, but only numbering as yet 7,000 inhabitants, within five minutes walk of whose central market place the above little house of Clova is situated, and is yet a country-house in a garden and green field. Within all Great Britain there is not another town of the same name; so that for all home letters 'Clova, Ripon,' is quite enough post office address. But for those, as yourself, beyond the seas it is necessary that you should add thereto "*England*." So you see I have left Scotland as well as retired from the Astronomer Royalship thereof. You, or your part, do *not* give me the address of your nearest British money-order-paying office. Partly, perhaps, because you seem over generously to imply, that because it turns out that I had paid subscriptions for the Royal Observatory Edinburgh, to the SIDEREAL MESSENGER for two former years, you would let the present year go free. But that I cannot allow; I have therefore just walked into Ripon and obtained a money order for eight shillings British ($2 American, I suppose), payable to you by name, but at no nearer post office than St. Paul, Ramsey County, Minnesota. This I accordingly enclose and I hope you will be able to negotiate it without much trouble. Your last number I have sent to the Royal Observatory, Edinburgh, and if you will kindly send the next one there also, you will have accomplished your whole duty. I may then wait to see if my successor is as fully aware, as I have been, of the great advantage of being "in touch" with the rising American Astronomers.

I am more bent at present in trying to complete a great work on spectroscopy than any thing else, if health and life also hold out; but that will be as God planned from the beginning. I remain still admiring your excelsior struggles."

Queries. 18. When does the next century begin? Wrongly answered in the *Scientific American* recently.

19. Why does the full moon run high in winter and low in summer?

20. There is daily increase in the right ascension and the declination of the stars. It is irregular in both; is it periodical in one or both? A. B. C.

21. What are the properties of the new glass that make it superior to the old? G. H. P.

22. Is not the statement in the text books on astronomy that sunlight is 800,000 times greater than full moon-light manifestly wrong? Common observation would say that number is 1,000 times greater than it should be? I. C.

23. As a result of a long series of experiments conducted with the utmost skill and care, Professor Langley estimates that if the atmosphere were removed from the earth the temperature of the soil in the tropics, under a vertical sun would be reduced far below zero, probably down to —328 Fahr. On page 123, Professor Loomis' College Astronomy states that the extremes of temperature on the moon must be very violent. During the period of the sun's shining the surface must become intensely heated; and during the next fortnight the cold must be equally severe. Which is right? F. H.

Where the Eclipse Parties Observe. By referring to our map of the path of totality of the eclipse, published in the last MESSENGER those interested may learn the location of each of the observing parties, so far as we know them at present.

Dr. Lewis Swift, near Chico, California. He will observe for intra-Mercurial planets.

Charles S. Rockwell, of Tarrytown, New York, will observe at some point in California.

The Lick Observatory will send a party to a station in Lake County in charge of Mr. Keeler. Mr. Keeler will use the 6-inch equatorial of the observatory and a spectroscope (kindly lent for the occasion from the apparatus of the Chabot Observatory by Hon. Fred M. Campbell) for the purpose of testing the theory proposed by Professor Hastings of Yale College to account for the phenomena of the solar corona—namely, that it is chiefly due to the diffraction of the solar rays at the edge of the moon. Mr. Barnard of the Observatory, will have entire charge of the photographic observations of the corona. Mr. Hill of the Observatory, will observe the contacts and assist Mr. Keeler. Mr. Leuschner, student of astronomy, will probably make photometric observations to determine the relative light of the corona and the full moon. At the Lick Observatory the eclipse will be partial, not total. The contacts will be observed by Professor Holden, Mr. Burnham and Mr. Schaeberle, and a series of photographs of the various phase swill be made with the photoheliograph.

Under the enthusiastic direction of Mr. Burckhalter of the Chabot Observatory a great number of members of the Pacific Coast Association of Amateur Photographers intend to photograph the corona. If the day is fair it is almost certain that the plans adopted by these gentlemen will produce extremely valuable results.

A party from Harvard College Observatory will take station at Willows. The party is to consist of Professor W. H. Pickering, chief; A. L. Rotch, the meteorologist; Mr. Bailey, Mr. King and Mr. Black. The work of the party is the photography and photometry of the corona.

It is understood that Professor Lewis Swift, Director of the Warner Observatory of Rochester, N. Y., will search for intra-mercurial planets at some station in the Sacramento Valley.

Professor J. P. D. John, Director of the De Pauw Observatory of Greencastle, Ind., with his assistant, Dr. W. V. Brown, will probably occupy a station somewhere in Butte or Plumas counties. The equipment of this party consists of two 5-inch telescopes, an almucanter, etc.

Professor H. S. Pritchett, Director of the Observatory of Washington University of St. Louis, Mo., proposes to observe the eclipse by photography at a station not yet chosen.

Mr. Blinn will take some of the instruments of his private observatory in East Oakland to a station at or near Winnemucca, Nev.

In Nevada, also, United States Surveyor General Irish, who is practiced in astronomy, intends to make observations of the eclipse.

Professor W. Upton of Brown University, Providence, R. I., with observers from Blue Hill will seek a position in Western California for observation.

A party of observers from Carleton College, Northfield, Minn., cosisting of Professors Payne, Pearson and Wilson will probably observe the eclipse either in western Nevada or at Chico, California. Their instruments are a 6-inch reflector for photography, a 4-inch refractor, a zenith telescope and other lesser apparatus.

Lorenzo Kropp, of Paysandú, Uruguay, South America, in a recent private letter, gives useful information concerning the irregularity of the mails between the United States and parts, at least, of South America; but he says the European mails are always received with great regularity. This is the second instance that subscribers to the MESSENGER in South America have suggested that their copies should be mailed *via* England.

We are pleased to know that Mr. Kropp has a 5-inch Refractor by Reinfielder and Hertel, of Munich ,and that we are soon to hear of its quality and work.

E. F. Swayer of Cambridgeport, Mass., has given an important series of observations on suspected variable stars in the *Astronomical Journal*, No. 184. There are 33 such stars to which attention is called.

BOOK NOTICES.

An Elementary Treatise on Ayromechanics, with Numerous Examples, by Edward A. Bowser, LL. D., Professor of Mathematics and Engineering in Rutgers College. Second Edition. New York: D. Van Nostrand, publisher, 23 Murray and 27 Warren Street; 1886.

This book was written three years ago, and designed to follow the author's work in Analytic Mechanics noticed in this magazine a few months ago. Like the Analytic Mechanics, its proofs are by the aid of Analytic Geometry and the Calculus, whichever seems to the author best to use in any given case under consideration.

The work consists of two parts; Hydrostatics and Hydrokinetics. The first contains three chapters and the second four. The first chapter deals with equilibrium and pressure of fluids. In the study of normal pressure successive integration is used, bringing out very neatly the *nature* of fluid pressures, and showing what is often difficult for beginners to understand that the action of a fluid does not depend upon its *quantity*, but on the *position* and *arrangement* of its continuous portions.

The second chapter treats of the equilibrium of floating bodies and specific gravity; and the third of gases and elastic fluid.

The author devotes 162 pages to Hydrokinetics and discusses the resistance and work of liquids, the motion of water in pipes and open canals, the motion of elastic fiuids and hydrostatic and hydraulic machines.

The pratical bearing of this work, and the aim of it, to lead the student to an intellegent use of his mathematical knowledge in useful application, are points of commendation. It is a valuable book for the teacher's table if its scope is beyond his class-room work.

Plan and Spherical Trigonometry, by Alfred H. Welsh, A. M., of Ohio State University. Chicago: Messrs. C. Buckbee & Co., Publishers, 1888; pp. 196.

We always like to get a book from a Chicago printer, because we want to know how those young ambitious people succeed in printing books. It may, probably will, surprise our Eastern friends that Chicago is printing books on the higher mathematics, though we well remember that this is not the first one.

This book begins with a chapter on logarithms to which eighteen pages are devoted. Under each theme or theorem is a table of exercises designed to test the pupil's practical knowledge of the principles enunciated above. In this the author recognizes the need of the class-room, especially for the ordinary pupil before undertaking the operations of trigonometry.

Though there is good authority for defining trigonometric functions as ratios, in practice, we have always found that direct definitions upon the lines themselves, were preferable. The second chapter consisting of 54 pages, treats of the plane triangle in which the use of natural functions in the solution of examples is universally extended. The student, in this part of his work, has only to do with acute angles in the exercises given and this arrangement is designed by the author for the sake of developing the branch properly and obtaining from the student, as he believes, more definite results.

The second step in this book is called Gonometry which is that branch that treats of trigonometric functions in general. Under this head appear a study of the signs of the angles, and lines representing the functions, the general relation between the functions, and the common formulæ for the sum and difference of triangles and other similar ones usually given in such works. The exercises under each head are very good, we could only wish there were more of them. Here are two as specimens:

Given sin $(x+y)=\cos(x-y)$ to find x and y.

Adapt to logarithmic computation:

$$\frac{\text{Sin } 68^\circ - \text{Sin } 35^\circ}{\text{Sin } (68^\circ - 35^\circ)}$$

The spherical Trigonometry appears to be equal to that found in the latest and best books, presenting even some for the formulæ for the general spherical triangle. The numerial examples under this head might be increased with profit to the student. The logarithmic table for numbers is 4 places and extends to 200. The table for logarithmic functions is to 10′ and 4 places. The natural table is to 10′ and 5 places. They are in neat form and good type for its s'ze. This book is certainly a credit to the printing house from which it comes.

Numbers Symbolized, an Elementary Algebra, by David M. Seusenig, M. S., Professor of Mathematics. State Normal School, West Chester, Pa. Messrs. D. Appleton & Co., Publishers. New York, Boston, and Chicago, 1888; pp. 315.

This elementary book in the Appleton Mathematical Series has been prepared evidently by a teacher of experience of the best kind. We are pleased to see so much care in stating definitions and elementary principles. We expect that teachers in the best normal schools will know how to put things accurately and well, and usually they do not fail to meet expectations in this regard.

In the earlier pages the graded sequence of development is easy and natural for the beginning pupil, though he be young in years, for evidently such pupils were in the mind of the writer as well as others. After the fundamental operation the simple equation, with one, two and three unknown quantities, is briefly treated, but the burden of exercise for the pupil is in the study of the exponent, the fraction, the radical and the imaginary. This is right; for if a pupil is well grounded in these, from the beginning, he will always study algebra with pleasure and profit. We are sorry to see fractions written, as ⅔, for example.

Should a teacher ever allow a pupil to write a fraction that way? That is a commercial fraud. In method it is both inaccurate and inelegant. But this is a little blemish only on an otherwise excellent book.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE EFFECTS OF ROTATION UPON THE FLUID ENVELOPE OF A REVOLVING SPHERE*.

SEVERINUS J. CORRIGAN.

For THE MESSENGER.

As stated on the first page of this paper, I think that we are warranted by the concordance of theory and observation, in regarding the oceanic circulation as, primarily, an effect of rotation, but this bare statement needs a qualification; rotation is not the only factor that operates to produce the phenomenon as we know it; the configuration of the coasts is also an essential element. I purpose to demonstrate that it is to the combined influence of both that the main currents of the ocean are principally due.

It is well known that the tangential component of the centrifugal force generated by the earth's rotation is a pressure exerted equatorward, and that it is this pressure that sustains the waters of the ocean, in the equatorial regions, above the level proper to them if the earth had no axial rotation. It was by the operation of this component force, when the matter of the earth was in a fluid state, that the excess of matter near the equator was produced and sustained. If this upholding force were to be destroyed at any point, or along any line, it is evident that any fluid matter, the waters of the ocean, for instance, would seek to return to the normal level at that point or along that line. This tendency is exemplified by the action of the tides. It is well known that the "tide wave" is, in the open ocean, simply an elevation of the waters to an apex, this elevation being due to the diminution of terrestrial gravity at a given point by the moon's gravitative force, and to the consequent lateral pressure exerted by the aqueous particles tending to flow toward the point where the force of gravity is de-

* Continued from Vol. VII, p. 429.

creased, this pressure sustaining the waters above the normal level. When, by the diurnal rotation of the earth, the solid matter of the latter, or the coasts, approaches the fixed elevation of waters, or the "tide wave," the latter is deprived of the support on one or more sides. It is true that the pressure is exerted upon the rigid land, as well as upon the movable waters, but the former cannot move up to the support of the "tide wave," which, therefore, is precipitated upon the shore, and rushes inward through the indentations of the coast, producing that well known phenomenon, the tide. In an analogous manner the waters of the oceans near the equator, elevated as they are by the pressure due to the tangential component of the centrifugal force, must flow toward the north and the south seeking their normal level, where the trend of the coast lines is such that the supporting pressure is removed.

The force of the tangential component cannot, of course, be annihilated; it must act upon the rigid land as well as upon the movable waters, but by the interposition of the former, a practical destruction of the force, so far as it operates to sustain the waters above the normal level, will be effected; there will be a strain upon the land but the latter cannot move up to the support of the elevated waters; the latter must therefore flow down along the coasts northward and southward, as it were "under the lee of the land." If the trend of the coast were east and west, and the tangential pressure or upholding force at a right angle to it, this pressure might be likened to that of a mighty wind blowing equatorward and forcing the waters in that direction or "off shore." Under the condition of equilibrium in the fluid matter of the earth the "tangential component" is exerted directly toward the equator from both sides of the latter, and is at a maximum in latitude 45°. If we now regard this fluid matter as not in a state of perfect equilibrium or, in other words, if we admit the tendency to eastward pressure due to the disturbance of equilibrium by neighboring bodies, and the existence of which I have endeavored to demonstrate on preceding pages, the resultant pressure must be, generally, southeastward in the northern hemisphere, and northeastward on the other side of the equator. If the earth were completely covered by water the result of this pressure would be an excess of eastward motion in the aqueous particles near the equator, a condition which probably exists in the fluid envelope of the sun; but the rigid land is interposed amid the waters, preventing such action and giving rise to a motion of the aqueous particles in a direction differing from the above. I claim that the *modus operandi* is such as to produce the ocean currents as we know them.

To comprehend the matter clearly, the reader need only take a map showing the whole Atlantic basin, observe the trend of the coast lines on both sides thereof, and represent the forces brought into action by the rotation of the earth by arrows pointing southeastward in the northern hemisphere, and northeastward in the other; strictly speaking these arrows should point more directly east near the equator, for on that circle the tangential component is 0.

It will be seen, that the forces so represented will tend to cause the waters of the Atlantic not only to be raised near the equator above the level which they would occupy if the earth had no rotation, but also to press toward, or to converge to a point or region on the west coast of Africa, about the Gulf of Guinea; the waters there will thus be elevated to an apex above the level in the same latitudes on the opposite or American coast. Let the reader now turn his attention to the coast lines of North and South America. He will see that the arrows representing the forces will be directed off these coasts, in fact the direction will be almost at a right angle to the trend of the North American coast, but somewhat less to that of South America, particularly in the more southern parts.

This pressure away from the coasts, which may be likened to a mighty wind blowing "off shore," must tend to leave, as it were, a valley or trough near the coasts, down which trough the piled-up waters near the equator will, by the action of gravity, flow toward the north and the south, passing, as it were, "under the lee of the land." The north-flowing waters will form the well known Gulf Stream, while the southerly flow constitutes the Brazil current.

This out draught from the equatorial waters along the western coasts must set up a westward flow along or parallel to the equator from the apex on the African coast.

This westward moving stream is the equatorial current which thus flows, as it were, down hill from the apex in the Gulf of Guinea to the points of outflow on the American coast or the starting point of the Gulf Stream and the Brazil current. It is worthy of note that the former current, whose course is northeast along the coast of the United States, has its northerly movement stayed and its course deflected sharply eastward in latitude 45°, in which latitude the "tangential component," pressing southward, is at a maximum, and also where the trend of the coast changes so as to allow the southerly pressure to be exerted in full force; in other words where the stream forces out from the protection of the land.

The southern flow, or the Brazil current, is also deflected eastward, but about latitude 35° south. The comparative inferiority of the latter current, both in strength and in length of course, is probably due, at least in part, to the fact that the trend of the South American coast is such that the portion of the upholding force rendered inoperative by the interposition of the land is not so great as in the case of the Gulf Stream, the latter flowing along a coast whose trend is, up to latitude 45° north, nearly at a right angle to the "off shore" pressure. As is well known both of these currents turn at first sharply to the east in about the latitudes named above.

The principal part of the Gulf Stream, crossing the Atlantic, becomes merged into the North African current, which flows along the African coast toward the equator, while the Brazil current swerves first eastward across the South Atlantic, and eventually joins what is called the South African current, which flows northward toward the equator along the African coast.

These currents may be regarded as representing respectively the southeastward and the northeastward pressures arrested by the African coast, and deflected equatorward to the region of the Gulf of Guinea, where the waters are piled up to an apex, as has been shown above. From this point or apex they again flow westward as the equatorial current and make the same circuit as that above described, the process being repeated unceasingly, or so long as the forces brought into play by rotation and gravity, and the present trend of the coast lines exist. Similar action may be seen in the Pacific Ocean; the Japan current represents the Gulf Stream, and the Peruvian current northward along the west coast of South America is analogous to the South African current, while the flow southward along the west coast of North America may be regarded as the counterpart of the North African current. These principal streams naturally give rise to minor or derivative movements of the waters, but of these it is unnecessary to speak. The acceptance of this hypothesis does not necessitate the complete rejection of the generally received notion which regards prevailing winds and the differences of temperature in the waters of the oceans as causes of the phenomenon; these doubtless have a marked effect, but they only act as auxiliaries; the main or primary cause must be found, I think, in the action of the forces above mentioned. Unless well established laws of "mechanics," and, in particular, the law of "gravitation," be abrogated or suspended, the waters of the oceans must flow as they do, even were the atmosphere perfectly quiescent, and the temperature of the waters uniform. The fact that the currents follow the coast lines so closely is, I think, very significant, and corroborates the hypothesis which I have advanced.

I have thus endeavored to demonstrate that the four phenomena, viz.; sun spots and their perodicity, terrestrial storms, the seismic forces, and the oceanic circulation are primarily effects of rotation and gravitation. Of the absolute nature and cause of the force called "gravity" we have, at present, no knowledge; we know it only through its effects, but the determination of the probable proximate origin or cause of rotation is not a very difficult task.

On preceding pages I have shown the form and dimensions of the orbit in which a material particle on the equatorial circumference of the earth would move under the influence of the centripetal attractive force of the earth's mass and the linear velocity due to the axial rotation of our globe, that is, if said particle were free to move around the center of the earth and if the whole mass of the latter were concentrated at that point. The linear velocity of rotation has thus been regarded as a factor in the formation of the orbit, or as a cause, but I think that the axial rotation itself may be regarded as an effect due to an original orbital revolution of independent particles of cosmic matter. We may be aided in our search for the origin or cause of the axial rotation by a consideration of the much discussed but ever interesting "nebular hypothesis." We can conceive of the existence of a vast irregular mass of nebulous matter of indefinite extent moving through space, and of whose origin or destination it is not essential to our purpose that we should have any definite knowledge. As no valid physical objection stands in the way, we may regard it, if we will, as called into existence directly by the fiat of the omnipotent Creator, but whence it comes or whither it goes is immaterial in this connection. It suffices to assume this matter and motion to exist, and to the legitimacy of this assumption modern astronomical observations furnish abundant attestation. It is also most reasonable to assume that some portions of this irregular nebulous mass will be more dense than others; *i. e.*, that there will be a greater aggregation of matter at some point or points than at others. By the operation of the "law of gravitation" the surrounding matter must be drawn toward each point of greater density, or center of condensation. Considering any one such center or nucleus, it is evident that the surrounding particles must be drawn directly toward it if they are at rest relative to the nucleus, but it is practically impossible that in a vast irregular mass like the one under consideration such a condition should obtain; the mutual attraction of the particles must induce motion, therefore the surrounding matter will have a velocity relative to the nucleus, and this, in conjunction with the force of gravity resident in the nucleus, must cause the particles to describe orbits around the latter, under the operation of well known laws of mechanics.

The orbit of any one particle, unimpeded by others, may have any position relative to a fixed plane through the centre of gravity of the nucleus, but it is obvious that in the congeries of nebulous matter described above, the individual particles cannot have perfect freedom of motion; in proportion to the density of the mass, impact among the particles must occur, and some will have their orbital velocity accelerated thereby, while others will be retarded in their courses; the latter must therefore fall more directly toward the centre of attraction, or the nucleus. As the condensation increases the orbital motion of the separate particles will, by impact, tend to set up a rotation of the whole mass around a fixed axis, and a spheroid will be developed from the primitive irregular mass.

The fixed, or polar axis of this spheroid will have its position determined by the position of the majority of particles having the greatest freedom of motion, and the rotational velocity will depend upon the amount of orbital velocity possessed by these particles. Thus the fixed axis will be located in the matter having the least orbital motion, or among those particles which fall most directly toward the nucleus.

In a rotating spheroid derived from an irregular nebulous mass, minor or secondary centers of condensation may be developed at any point or number of points, in the same manner as that in which the primary center or nucleus was formed, and in like manner will surrounding particles gravitate toward these secondary centers and revolve, or tend to revolve, in orbits around them, the orbital revolution being finally transformed into axial rotation. From these secondary formations tertiary ones may be developed in an analogous manner. It is thus that, in all probability, our sun and the stars, which are only distant suns, have had their origin.

These secondary formations must, by reason of the rotation of the mass in which they are developed, revolve in orbits around the primary nucleus. In a dense nebulous mass the revolving particles must have their motions more or less affected by friction and impact among themselves; the motion of some being retarded or destroyed, they will tend to fall directly toward the primary center; while the smaller particles thus fall, the larger secondary formations must, by reason of the "living force" due to their mass and velocity, be enabled to overcome the resistance referred to, and retain nearly their original motion derived from the rotation of the parent mass; *i. e.* they will move in nearly circular orbits around the primary nucleus; the other and smaller aggregations of matter, less able to overcome the resistance, must move in orbits of very great eccentricity, in fact almost in straight lines. This matter thus falling down toward the center of attraction, will leave the larger bodies revolving in clear space in nearly circular orbits. In any primitive irregular mass such as that just considered, there may be one or more than one center of condensation; if only one, a body like our sun will be developed therefrom, while if there be two or more such centers or nuclei, the result will be the formation of binary and multiple stellar systems.

I think that we can consider the solar system as a perfect exponent of the processes above described. The sun can be regarded as the result of the condensation of an indefinitely extended nebulous mass into a rotating spheroid; it is obvious that a congeries of matter formed from the slowly moving particles near the outermost limits of the primitive irregular nebula would, by the operation of gravity, move in orbits of very great eccentricity; we know that the comets and meteors move in just such orbits. It is a well established fact that nearly all the cometary and meteoric orbits which have been determined approximate very closely the parabolic form, but that portion of the orbit of any one of these bodies through which it can be traced even by the aid of powerful telescopes is comparatively so small that it is impossible, in most cases, to tell whether it is part of a parabolic curve, or an ellipse of very great eccentricity, although in many cases the ellipticity is determinable. In view of the above facts it may be regarded as very probable that most, if not all, comets and meteors have their origin in the solar system. It is true that in a very few cases hyperbolic elements have been found, but the nature of the data from which they were derived is such that more or less doubt attaches to them; but circumstances may be such that a body may come into our system from the outside and one formed in that system be expelled therefrom; such cases must, however, be very rare.

The major axis of the orbits of these bodies are almost invariably of enormous length, a fact which can be accounted for by this hypothesis which regards comets and meteors as being formed near the outer limits of the primitive indefinitely extended nebula which has condensed into what we call the sun. By reason of their formation in these outermost regions, where the motion of the primitive nebulous matter was not confined to any definite direction, the cometary and meteoric orbits can have, and we know they do have, any inclination between 0° and 180°; but in the case of bodies formed in the interior portions of the nebula, where the condensation has become so great that the original orbital revolution of the individual particles has been transformed into a rotation of the whole mass, the motion will be confined to a definite direction, viz, that of the motion of rotation; the inclinations will therefore be confined between the limits 0° and 90°.

The planets may be regarded as bodies formed around the minor, or secondary centers of condensation; they have by reason of their "living force" retained the motion imparted to them by the rotation of the original mass in which they were formed, while the smaller particles have fallen toward the primary nucleus, thus forming the sun as we know it, and leaving the larger masses, or the planets, revolving around the latter body. As eminent physicists have shown, it is to this falling or condensing matter that the sun's heat and light are due through the principle of the "conservation of energy." The moon and the satellites of the other planets may be regarded as the tertiary formations above alluded to, these formations having been developed from the secondary masses, or the planets, by the same process by which the latter have been formed from the primary mass.

This conception of the origin of the members of the solar system differs from the "nebular hypothesis," as usually stated, in that these bodies are here considered as developed, not from rings thrown off by "centrifugal force" from the rotating mass, but from the matter gathering around the minor centers of condensation or nuclei by the action of the "force of gravity" resident in these nuclei, the mode of formation being analogous to that through which the primary nucleus, or the sun, has been derived from the primitive nebula.

It is customary to style the "nebular hypothesis" a very beautiful and plausible conception, yet *only* a speculation. But is it not more than this? We have ocular evidence of the existence of irregular indefinitely extended masses of nebulous matter; the "force of gravity" is an established fact, and the law of its operation is accurately known. We also know from the principles of "mechanics" that this force acting upon this matter must produce results such as I have described above. Therefore I think that we are warranted in regarding the origin of the "solar system" ascribed by the nebular hypothesis as the true one.

From what has been shown, we can plainly see that the motion of rotation is simply the derivative of orbital motion; therefore, since the latter is the result of the action of the force called "gravity," it follows that the effects of rotation, viz., sun spots, terrestrial storms, seismic phenomena and ocean currents, are primiarly due, as I have claimed at the beginning of this paper, to one cause, viz., "gravitation."

The rotational velocity of any cosmic body depends, as stated above, upon the original orbital revolution of the particles composing it, and the orbital velocity depends upon the degree of freedom of the particles to move. This freedom depends upon the density of the matter; therefore the velocity of rotation may be regarded as a function of the density; the greater the latter the less will be the freedom, and consequently the less will be the rotational velocity, and *vice versa*. In this connection, the following numerical facts tabulated below will, I think, be found remarkable:

PLANET.	1	2	3	4	5	6
Mercury	$\frac{1}{338}$	0°10′	1.12	1.00	1.06	−0.06
Venus	$\frac{1}{291}$	0 12	1.03	0.98	1.02	−0.04
Earth	$\frac{1}{296}$	0 12	1.00	1.00	1.00	0.00
Mars	$\frac{1}{202}$	0 17	0.95	1.03	0.97	+0.06
Jupiter	$\frac{1}{16}$	3 35	0.24	0.41	0.49	−0.08
Saturn	$\frac{1}{12}$	4 47	0.13	0.44	0.36	+0.08
Uranus	$\frac{1}{14}$	4 06	0.17	0.40	0.41	−0.01
Neptune	...	......	0.16	......	0.40	......

Column 1 contains the values of the "compression" computed by the method I have given. Column 2 contains the angles by which gravity would deviate from the normal to the surface at the equator, if the planets had not attained a figure of fluid equilibrium; it is the angle of which the "compression" is the sine, or $a = \frac{p}{r}$. Column 3 shows the value of the density of each planet, the earth's density being taken as the unit. Column 4 shows the rotational periods, that of the earth, the sidereal day, being taken as the unit. Column 5 contains the square root of the densities in column 3, and column 6 shows the differences between the observed rotational periods and the square root of the densities, taken in the sense, observatian—computation, or column 4—column 5; the differences are expressed in terms of the sidereal day. We thus see that the square root of the densities is nearly the same as the rotational period corresponding, a fact which, I think, corroborates my claim that these periods are functions of the densities.

The reader cannot fail to notice the distinct line of demarcation between the first four planets and the last four, a line which is also distinctly marked by the zone of the asteroids. Although we do not know from observation the rotational period of Neptune, yet, as its density is known, and since the rotational period is a function of the density, we can safely assume that it is nearly the same as the period of Uranus. This will give us compression for Neptune $= \frac{1}{10}$ and the corresponding angle 5°32′.

The action generated by rotation in the fluid particles of a sphere is probably to a certain extent cumulative: Considering the equation $p = \frac{V^2 r^2}{k^2}$, in which the first number represents, as has been shown, the radial or uplifting force, and also the equal force exerted at a right angle to the former, which latter force tends to produce motion in the direction of rotation, we can plainly see that for a constant velocity in the case of any given body, the forces represented by p will depend upon k; were there no axial rotation these forces would be *nil*, but if a rotary velocity be impressed, they will come into existence, and for a uniform motion they will be constant, and equilibrium will exist as long as k is not changed in value. The proximity of another cosmic body will effect a change in the value of k, and therefore of the forces; but if the perturbing body remain at a constant distance, equilibrium will again be established. It is only by the *variation* of the distance of the neighboring body that changes in the value of the forces can be caused and equilibrium be rendered impossible. Look at the case of Jupiter and the sun; the great planet is not at a constant distance from the latter, but moves from aphelion to perihelion and back again in nearly twelve years, with all the regularity of a pendulum vibration; the value of k for the sun, and therefore the forces represented by p, must vary with the same regularity within certain limits. When the planet is in perihelion k will have its minimum value; then will the uplifting force and the pressure at a right angle to it, and tending to produce motion in the direction of the rotation be the greatest; on the other hand, when Jupiter is in aphelion, k will be greatest, and the forces will have their minimum values. In the first case the tendency will be to cause the appearance of a maximum number of spots upon the sun, and in the last a minimum. The general effect of this action must be alternate expansion and contraction of the solar globe, within narrow limits, and this vibratory or undulatory motion must have a period corresponding to that of the disturbing body. Furthermore, this effect must be cumulative; the action generated during one swing of the planet from aphelion to perihelion and return may be very small, but that from many may be considerable. The other planets must also exert a similar influence, but in a less degree. When the planet is in aphelion the value of k is greatest, and that of the forces least; in other words, the sun's force of gravity is at a maximum; the solar matter must therefore undergo condensation toward the center, during the progress of the planet from perihelion to aphelion, and expansion while the perturbing body is moving in the opposite direction. Since, according to the principle of the "conservation of energy," this condensation must generate heat, it follows that there should be a slightly greater emission of heat from the sun when the spots are at a minimum than when they appear in greatest numbers. The same is probably true of electric and magnetic action. Thus meteorological effects dependent upon this solar action might be expected to occur upon the earth. Observation seems to indicate that they do.

We can obtain a very simple yet clear exemplification of the action of the forces above referred to in producing sunspots, etc., by means of the following experiment: If we take a vessel of water, and place in the latter small particles of any buoyant substance, these particles to act as indices of the motion of the water, and then pour or force an additional quantity of water so that it will produce a rapid current eastward across the vessel, vortices will be seen to form on each side of the current; those on the north will rotate in a direction opposite to that of the hands of a watch, while a contrary movement will be observed on the south side; along the current no vortices will be formed. It is a significant fact that the sun-spots are not found upon the equator, but at some distance on either side of it, just as the vortices in the above experiment. The reason may be found in the hypothesis which I have advanced above, viz., that there is at times a greater *angular* velocity near the solar equator than toward the poles, or a current, in the direction of the rotation, along or parallel to the equator. Furthermore the terrestrial storms or cyclones have a rotary motion in the directions shown by the experiment.

If we examine the elliptic orbit which a particle of matter on the equatorial circumference of the earth would describe if free to move, which orbit I have shown at the beginning of this article, we will see that the major axis of this ellipse is equal to the mean radius of the earth, and that the angle 11′47″.5 which gravity, on the equator, would make with the normal to the surface, if the original fluid matter of the earth had not attained a figure of equilibrium, is the same as the angle of the vertical in latitude 45° or the maximum angle; it is 16″.9 greater than the value generally used, because that is computed from Bessel's value of the compression or $\frac{1}{299.98}$, while the former is derived from the compression form by the method I have given or $\frac{1}{295.52}$ which is nearly the same as Clarke's value derived from arcs of meridian. It is the angle of which the compression is the sine, or it can be derived by combining the resultant of the forces represented by p, with the whole force of gravity; it will, then, be the angle which this second resultant makes with the whole force.

A study of the orbit will disclose other interesting relations which connect this simple process for finding the "figure of the earth," with the more elaborate analytical methods employed by Clairaut and other eminent geometers, for the same purpose. In closing I would say that while to many the claim set forth at the beginning of this paper, viz., that the diverse phenomena mentioned were due to one and the same determinable cause may have seemed preposterous, those readers who have possessed sufficient interest in the subject, and patience to follow closely and understandingly the development of my theme, must, I think, have arrived at a different conclusion.

Complexity in the appearance, but simplicity in the reality seems to be a characteristic of the workings of Nature, from the operations of whose law of "universal gravitation," these effects flow as inevitably and naturally as, by virtue of the same great law, the raindrop falls from the cloud, and the river flows to the sea.

THE AVERAGE PARALLAX OF STARS.

BY W. H. S. MONCK.

For The Messenger.

Dr. Elkin's computation of the average parallax of stars of the first magnitude must have interested most of the readers of The Sidereal Messenger, but the considerable differences between some of his results and those of previous observers seem to render it desirable, if possible, to solve the same problem by a different method. I think, moreover, that the average parallax of stars of the second magnitude would be a more soluble problem than the average parallax of stars of the first magnitude. For photometric researches have shown that stars ordinarily classed as of the first magnitude, may differ from each other by two to three magnitudes and even taking Dr. Elkin's list the extremes probably differ by nearly a magnitude and a half. This occurs with stars of the first magnitude only. Stars of the second magnitude moreover being more numerous, an average is more reliable. My present object, however, is only to suggest a different mode of computing such averages.

The principle of this method is as follows: The sun is a comparatively insignificant member of the stellar system, and situated at a great distance from its nearest neighbors. Therefore the stars on an average have no greater tendency to approach or recede from the sun than to move at right angles to the joining line; and on a general average the motion in the line of sight will be equal to the motion at right angles to it. The former of these motions can be measured in miles per second by the spectroscope; the latter is known as the proper motion of the star and is usually measured by the number of seconds or fractions of a second described annually. If we know the average motions in these two directions for the stars of any magnitude we can obtain the average parallax by equating them. Of course this method may be wide of the truth in the case of any individual star because the true direction of that star's motion may be nearly in the line of sight or nearly at right angles to it, but errors of this kind will balance each other in the average result. Further, I know of no reason for thinking that the average velocities of stars of the first magnitude are either greater or less than those of stars of any other magnitude, and this *a priori* anticipation is, I think, confirmed by the results of spectroscopic measurements as far as they have gone. If so, we can arrive at an average velocity in the line of sight for all stars, and then determine the average parallax of the stars of any given magnitude from the average proper motion of the stars of that magnitude.

Considering the difficulty of making accurate spectroscopic measurements, and the conflicting results often arrived at in the case of the same star, it is much to be wished that we had more of them. I have not, however, in making a first rough calculation, used all the measures that are available, but confined myself to the Greenwich results as published in the last three volumes of the *Monthly Notices* of the Royal Astronomical Society. In 1885 there was an average motion of 30.2 miles per second for 47 stars; in 1886 an average of 22.6 for 45 stars, and in 1887 an average of 28.0 for 43 stars. A large proportion of the stars observed each year were identical, and the differences must have arisen in part from errors of observation. Until, however, we have better results deduced from measurements of a larger number of stars, I think the average velocity of a star in the line of sight may be taken at 26 to 27 miles per second; and I believe a separate examination of the stars of the first magnitude would not have led to a materially different result as regards them. Equating this velocity with the proper motion, we obtain for the average parallax of a star of any given magnitude (in seconds) approximately 0.11 *a*, where *a* is the average proper motion (in seconds) for a star of that magnitude. The average proper motion of Dr. Elkin's ten stars is 0″.609, which gives an average parallax of 0″.067, a figure somewhat lower than has hitherto been assigned, but the general result of recent investigation has been to reduce our estimates of parallax.

I do not know of any table of the proper motions of the stars of the second (or of any higher) magnitude from which their average parallax could be deduced in this manner. According to the usual photometric scale, a difference of one magnitude indicates that the distance is increased by the multiplier 1.585, and the proper motion will naturally be diminished in the same ratio. On this assumption, taking the average parallax of a star of the first magnitude at 0″.067, we shall have for the second magnitude 0″.042, and for the third 0″.026, provided that no light is lost in transmission. If light is lost in transmission, however, the average distances will be less, and the average parallaxes and proper motions greater. Numerous and careful observations both of proper motion and of spectroscopic velocity are much to be desired.

TOTAL SOLAR ECLIPSE, JAN. 1, 1889.

THE EDITOR.

It is yet too soon to give more than a brief outline of the work undertaken during the total eclipse of Jan. 1, 1889. The long distance that many parties traveled, the time necessary to develope photographic plates and to prepare illustrations, make it impossible to give, in this number, the full report which was suggested last month.

It may, however, interest our readers to have an introductory statement, at least, of facts in hand concerning the location of various observing parties, the work undertaken and the probable results reached.

The following statement concerning observers, instruments, places of observation and work attempted was gathered in California from various sources, and from correspondence since our return home.

Willows. The Harvard College Observatory party were stationed at Willows in the Sacramento Valley, on the west side of the river. The party consisted of Wm. H. Pickering, chief, S. I. Bailey, Robert Black, E. S. King, from Harvard, and twenty-nine local assistants. Fourteen telescopes and cameras were employed, and eight spectroscopes. The first contact was lost by clouds. The duration of totality was reported to be one minute and eighteen seconds (which is evidently an error in transmitting the report). Eight photographs were secured with the thirteen-inch telescope, giving images two inches in diameter before enlargement. Nine were taken with the eight-inch camera. Twenty-five negatives were taken to measure the brightness of the corona and surroundings; five negatives to search for intra-Mercurial planets, and twenty to study the spectrum of the corona and determine its composition. These photographs are expected to reach from the yellow rays to the ultra violet. For the latter purpose the spectroscope with lenses and prisms composed exclusively of quartz were employed.

Seven observations were made with the photometer to measure the general illumination during totality. It was found lighter than during the eclipses of 1878 and 1886. The corona was similar to those of 1868 and 1878, but showed much more detail than the latter. It was an exceptionally fine corona, extending usually on one side to two solar diameters. Its striking characteristic was two forked wings of light. The polar rays were well defined and considerably shorter.

Professor W. Upton of Brown University, and A. L. Rotch of Blue Hill Observatory gave attention to meteorological observations at a little distance from the Harvard party. Results not learned.

Cloverdale was the point chosen by the Pacific Coast Amateur Photographers' Association under the direction of Mr. Burckhalter who himself used a 10½-inch Newtonian reflector with camera attached for photographic purposes. The party consisting of about forty persons succeeded in making one hundred and sixty-seven negatives with cameras of various sizes. As we went to press a full description of the work of this enthusiastic party came to hand accompanied by a dozen photographs of the corona as taken by diferent persons of the party.

The Lick Observatory party were located at Bartlett Springs. At the time of first contact the sky was perfectly clear, and both Mr. Hill and Mr. Barnard observed it. Mr. Hill observed the remaining three contacts, Mr. Keeler saw remarkable changes in the length of the coronal lines. Mr. Barnard obtained nine photographs with three different cameras. Mr. Leuschener made seven measures of light during totality. Drawings and paintings of the corona were also made. At the Lick Observatory thirteen photographs were taken of partial phases.

Norman. A party of 300 excursionists by special train from San Francisco, Sacramento and other points sought to reach a point within the path of the total shadow, but the train being late failed to see the total phase of the eclipse.

Healdsburg. A person by the name of Professor G. E. Hall reported that twenty-two negatives were taken at Healdsburg. Streamers were seen at this place ten or twelve degrees long as reported in the *Examiner* of San Francisco.

It was also said that "the corona presented the color of deep red near the moon, then rose vermillion, shading into orange violet." Solar prominences and portions of the chromosphere were doubtless meant. The length of the streamers was greatly exaggerated in this report, probably five times their true length.

Nelson was the point chosen by Professor Lewis Swift, of Warner Observatory, Rochester, N. Y. His purpose was to search again for intra-Mercurial planets, but clouds and haze made this work impossible.

All four contacts were well observed, a chronometer watch previously set to the Lick Observatory time being used by N. B. Scott. Five very small colorless protuberances were seen, all having pointed apexes. Near the point of one was another detached from the sun. Bailey's beads were seen at the second and third contacts, but entirely unlike those seen at Denver in 1878. No chromosphere was visible, though looked for.

Mercury, Venus, Vega and Alpha Cygni were seen; the corona could not be drawn, but as seen through the telescope was not very extensive.

The first contact was at 12*h* 24*m* 36*s*; the second contact was at 1*h* 48*m* 29*s*; the third contact was at 1*h* 50*m* 25*s*; the fourth contact was at 3*h* 8*m* 14*s*. The duration of totality was one minute and fifty-six seconds.

Chico. The Carleton College party observed at this point. Professors Pearson and Wilson made twenty-one exposures, nine of which belonged to the total phase. Some of these photographs have been developed and turn out well, others show a disturbed telescope, and over exposure. Professor Payne examined the corona with a two inch telescope, and noticed the north polar rays curiously curved, saw two colored prominences on the western limb and a portion of the chromosphere in all its usual strong color. Drawings were made and all contacts were observed.

The beginning of totality was observed at 1*h* 42*m* 7*s*, and its end came at 1*h* 50*m* 2*s*, giving a duration of 1*m* 53*s*, four seconds less than the time computed for this point by the Lick Observatory.

Free hand sketches of the corona were drawn by several persons connected with our party. Some of these will be published later.

The corona as seen through the telescope was full of interesting details. We had time to examine only a part of it.

Winnemucca (Nev.) The weather was perfectly clear during the entire day. Professor H. A. Howe, of Denver University, with five assistants, observed the contacts, made drawings of the corona and did some photographic work.

Professor Elkin of the Yale Observatory also chose this point. He did not discover two comets as was erroneously reported at the time.

J. A. Brashear made drawings of the corona especially in the region of the south pole of the sun.

No appreciable change of temperature was noticed during the eclipse. Shadow bands were observed here. The corona was similar to that of 1878. The streamers extended from 3 to 4 diameters of the sun and red protuberances were strongly marked.

Chas. W. Irish, Surveyor General of Nevada, chose a point on 120th meridian north of Reno. He made drawings of the corona, observed contacts, and secured several good photographs during totality. His results are important and will find place in the March MESSENGER.

Professor C. W. Pritchett, of Washington University, St. Louis, and his party were also very successful in their observations. Professor D. P. John, of DePauw University, Ind., was also somewhere in the path of totality. The results of his work we have not yet learned. There are many other observers whose work deserves mention, but want of space compels us to defer it at present.

NOTE ON THE ECLIPSE OF JAN. 1, 1889.

PROFESSOR DAVID P. TODD.*

For THE MESSENGER.

The clear skies everywhere prevalent along the belt of total eclipse on the afternoon of January 1st afforded a most favorable opportunity for the co-operation of volunteer observers who had received copies of the instructions for observing the eclipse prepared by myself under the direction of the Bache Trustees of the National Academy of Sciences. Several hundred pamphlets were distributed to the best addresses that could be secured, of persons within the path of the shadow from the Pacific Coast through California, Nevada, Idaho, Wyoming, Montana, Dakota and Manitoba. The returns from this expenditure already received are most gratifying. Only about one per cent of the observers remark any interference whatever from clouds. Practically the whole eclipse region was free from atmospheric obstructions, and even in Manitoba, near the point where the shadow left the earth and the sun was thus only a few minutes above the horizon, the reports I have received show that the observers had excellent conditions for this work.

It seemed best to confine the instructions to a very few points of scientific interest. So I selected five, (1) drawings of the entire corona, (2) drawings (telescopic) of the filaments about the solar poles, (3) sketches of the outlying streamers along the ecliptic (using an occulting disk), (4) ob-

* Director of Amherst College Observatory.

servations of the simple duration of totality along both edges of the shadow-track, (5) photographs of a standard object illuminated by the direct light of the corona.

These last which I regarded as of least importance, have apparently been least attractive to the amateur photographers. The plates I have received are not developed, and thus nothing is yet known as to the results.

Under (4), the observations appear to show no great error in the predicted position of the lunar shadow, though they cannot of course be definitely discussed until the exact longitude and latitude of the numerous observation points have been determined—a large work.

The drawings of class (1) are perhaps as diverse as those similarly obtained in the eclipses of 1869, 1878, and 1887; but the scores of sketches already received indicate a corona of unusual proportions and irregularity of figure. I shall discuss them uniformly with the Japan series of 1887 now in my hands, and the results seem likely to be of value, even as supplemental to whatever photographs have been secured. Certainly it will be determined whether, in future eclipses passing over inhabited regions, it will be worth the while to trouble the intelligent residents with coronal sketch-making. Should this note reach any person who has made a sketch of the corona at the late eclipse, and who has not forwarded it, he is invited to do so as early as practicable, and will receive in return a copy of the published report on all the observations which have been made in response to my instructions.

The drawings of class (2) are perhaps the most important of all, as even small telescopes and concentrated attention will bring out details of the complex polar filaments such as the photographs of previous eclipses have mostly failed to show. I should, perhaps, except the Krasnoiarsk negatives of 1887 from this statement; while the results of the best exposures of the present eclipse are, of course, unknown as yet. The case, however, seems to be so far quite as clearly in favor of the optical observer, as is the pictorial representation of the detail of sun-spots, where the photographic plate operates at a disadvantage which it is hard to see the way to overcome at present. It seems to me a matter for regret that more telescopes should not have been used in this way. Most of the polar sketches already received are excellent, but there are not so many of them as I had hoped for.

With reference to the zodiacal streamers (3) the returns are very satisfactory, when one considers the extra trouble the intending observer must take to set up the occulting disk, adjust a mark for the position of the eye—not to mention the requirement that he should keep his eyes in entire darkness for ten or fifteen minutes before totality, and thus sacrifice all chance of seeing a part of the phenomenon of very great popular interest. I have already a goodly number of such sketches, and they show that many of the observers traced the streamers quite as far from the sun as Langley and Newcomb saw them at the discovery in 1878. The persistence of those puzzling objects at or near the epoch of minimum spots must be taken, I think, as strong evidence in support of the theory of a ring of meteoric or other matter surrounding the sun approximately equatorially; and the probable absence of which, during the time of maximum spots, has, in some not yet fully understood manner, something to do with the occurrence of this maximum. This last eclipse was so short that I shall not be surprised if the optical sketches of the streamers are found to show them farther out than even the best of the photographs do.

ASTRONOMY IN THE UNITED STATES.*†

T. H. SAFFORD, PH. D.

Half a century ago, then, American astronomy in a practical form was beginning to show itself. About Boston there were three or four amateur observers of a good deal of skill. One of the best was the chronometer maker, Willam Cranch Bond, who had a little private observatory in Dorchester; Paine and Bowditch were others. Peirce and Lovering were young professors at Harvard. Bowditch had published his translation of the Mècanique Cèleste, copies of which he generously gave to libraries and to mathematical students. At

* A discourse read June 25, 1888, to commemorate the fiftieth anniversary of the dedication of the Hopkins Observatory at Williams College, Williamstown, Mass.

† Continued from Vol. VII, p. 437.

New Haven there was much interest, and some effort to make valuable observations; and the college was graduating more young mathematicians than it had usually done.

In the government service were skilled observers, who had at their command fairly good instruments of moderate dimensions; but there was no permanent observatory at Washington, or elsewhere in the country. About this time Captain Wilkes's exploring expedition sailed on its long voyage around the world. Wilkes will be remembered by his seizure of the Trent, rather than by his earlier reputation as a scientific explorer. In these voyages it was intended to determine the longitude of many places by observations of the moon, and it became necessary to make similar observations on land at known places. A young naval officer, Lieutenant Gilliss, was instructed to make such observations. His transit instrument, of very modest dimensions, was set up on Capitol Hill at Washington, under a temporary shed; and a fine clock was placed along with it. There Gilliss observed very regularly from 1838 to 1842.

Similar observations were made at Dorchester by W. C. Bond, under contract with the Government. But these beginnings of astronomical works, which led later to the establishment of observatories, were themselves subsequent to the building of the Williams College Observatory by Albert Hopkins. Almost from its foundation our College has had instructors who were lovers of natural phenomena, and science has in a modest way been long encouraged here. Chester Dewey, an early professor in this College, was the first scientific lecturer I had the pleasure of hearing. He was teaching physics and chemistry in a little medical school in Vermont, and I well remember how I was interested in a lecture on heat which I was allowed to attend. In the very early time, years before, of his professorship here, he taught all the sciences of the ocurse, or nearly all; his specialty, later, was a branch of botany. Eaton and Emmons will also be remembered among our professors, as men of original views; but I think we are indebted to Albert Hopkins for much of the impulse toward the direct study of nature which has long prevailed here.

When Mark Hopkins was made President in 1836, his brother Albert had been some years an instructor in the

College. In 1834 he had gone abroad to procure philosophical apparatus, and learn something of the European methods of investigation and teaching. At that time the impulse to scientific study which was contemporaneous with the French Revolution, and which had continued through the Napoleonic wars, had spread over nearly all Europe. Even England had submitted to the continental ways of studying mathematics,—not quite completely, but still far enough to give a good deal of community of spirit between the English and foreign astronomers. In Germany and the Baltic provinces of Russia there were astronomers—Bessel, Struve, Gauss, Argelander, Encke,—who taught practical astronomy as a university discipline, and employed their observatories as practical means of impressing their theoretical lessons on the pupils. In England and, I think France, it was not so; theoretical mathematics was studied to the completion of the course in it, and was followed by the more abstract parts ofastronomy.

The pupils of the astronomers before mentioned were not very many, but yet enough to keep the subject alive, and gradually diffuse a knowledge of it through the higher schools. At Cambridge, in England, the mathematical instruction had little by little taken the form of training men to pass examinations in the mathematics, and the senior wranglership, or first place in mathematics, was the goal of the ambition of the ablest men in the university. Our American courses were in part copied from the English studies of the last century, and were, little by little, modified to suit our circumstances. But their adaptation was not perfect, partly because no definite idea was dominant.

At Dr. Mark Hopkins's entrance upon the presidency of Williams, in 1836, a new spirit soon manifested itself. His scheme of studies was well thought out, and the leading idea, that of making man himself the subject of study for the Senior year, tended to give the course a certain roundness and distinctness to the mind. He taught physiology as an introduction to philosophy; a natural thing for a trained physician to do, and it was a very advanced idea at the time. This new impulse seems to have led to the building of the Observatory; both brothers probably thought it would make, as it has done, the study more vivid and interesting.

I need hardly enlarge here upon the character of Albert Hopkins. All Williams men know how strong in all respects he was; what an admirable helper to his more widely celebrated brother; how high and pure his aims, how great a factor he was, especially in the religious life of the College, for so many years. But even as a young man he was deeply imbued with the love of nature. There was no one who did more to interest his students in all the Creator's wonderful works. To his initiative is due the first scientific expedition sent from this College; for many years he was the leader in the exploration of these hills, which has been so fruitful both of health and knowledge to the generation now middle-aged.

I presume that in 1834 he had arranged for the purchase or construction of the transit instrument and clock, the latter still in active employment as a time keeper for ordinary as well as as for scientific purposes.

During his visit to Europe, too, he undoubtedly learned much of the interest in the return of Halley's comet, expected to occur within a year; and on his coming back he soon began the construction of an observatory. He built this chiefly at his own expense, and partly with his own hands; he even worked in the stone-quarry, getting out its materials.

It is a quaint little structure, but well planned and built for its purpose. The ground plan is that of a central portion surmounted by a dome, with two wings; very much like many observatories then and now. It is still used for gazing at the heavenly bodies, and is useful for the students in a variety of ways. Its replacement for scientific purposes by an observatory upon a new site is due to the situation, now partly surrounded by trees; so that if the attempt had been made to mount in it the beautiful meridian instrument which Mr. Field gave the College in 1881, it would have been necessary to sacrifice many of the ornaments of the campus. The authorities were naturally unwilling to do this, and preferred to provide more room in a retired spot, and Mr. Field's great kindness was again manifested in providing the building,—the "Field Memorial Observatory." In 1869 he had founded the Professorship, and so gave Professor Hopkins release from other duties in his declining years.

The Hopkins Observatory was, as I have implied, the first in this country of a permanent character. Every such building previously erected or arranged for the purpose, was temporary in its very nature; there is no one of these now standing. Of course Rittenhouse, and that admirable observer, the elder Bond, and other astronomers, had their private observatories in connection with their houses; but our Professor was the first actually to erect an observatory for public purposes. It was chiefly built in 1837, and dedicated on June 12, 1838; it is the fiftieth year from this which we now commemorate.

I do not think that in so generously devoting his savings to the College for this purpose, Professor Hopkins intended making regular courses of observation. For this his duties were too multifarious; his teaching included at first all the mathematics and natural philosophy of the course; and practical astronomy is a profession by itself, usually requiring for its highest perfection the devotion of a life-time. There are those, it is true, who have become distinguished astronomers while engaged in other professions,—the musician, William Herschel, the physician, Olbers, the shipmaster and man of business, Bowditch. But Professor Hopkins felt his true mission to consist in moulding character by the influence, direct and indirect, of the religious life; he was ever an active missionary.

His idea was rather that of using the Observatory to make tangible his teaching of the science; to give the instruction emphasis and force by actual sight where the abstractions were too deep for the pupils' minds; and also to interest one or the other bright student to use the instruments for himself, and thus awaken slumbering talent.

In the history of American astronomy this first establishment of a permanent Observatory is a striking landmark. Up to that time all efforts to establish one had failed. People were too materially inclined, it would seem, to encourage such an ideal science. What was known of astronomy seemed far distant. Even the practical every-day uses of the science were overlooked or despised; I have read a surveyor's petition to Congress, begging to be released from the requirements to run due north and south lines; he lost too much time in watching for the Polar Star on foggy evenings; he thought lines run in any direction would do as well, provided they were tolerably straight. Time-pieces were kept roughly correct by "noon-marks" and other rude contrivances, and few felt the need of more accurate subdivision.

Congress had sternly set its face against the establishment of an Observatory. The Coast Survey received its money on condition that none of it should be spent for any such purpose. The Survey had, it is true, collected transit instruments and telescopes, with which observations could be made; and the army engineers had also their little plant of similar apparatus.

Lieutenant Gilliss, as I have before mentioned, made astronomical observations from 1838 to 1842, in a cabin on Capitol Hill, and was enabled to show more or less of his work to visiting Congressmen, and to dispel in some degree their prejudices. In 1838, also, an Observatory was begun at Hudson, Ohio, under Elias Loomis, who observed pretty regularly for several years. A year or two later Sears C. Walker and E. O. Kendall built the Central High School Observatory of Philadelphia, and began observations and computations.

At West Point the need of an Observatory was strongly felt, and Professor Bartlett went abroad in 1840 to order instruments and visit observatories. On his return, rooms were provided for the instruments in the new library building of the school; in this we see the effect of the prejudice which would not allow a separate Observatory to be paid for out of public money.

Finally, in 1842, Congress authorized the building of a "Depot of Charts and Instruments;" the present Naval Observatory at Washington under a disguised name. It is one of the faults of our system of government, that appropriations are often made without a very distinct knowledge on the legislators' part of the use for which the money is intended. The astronomers of the Observatory were at first to be naval officers; partly of the line, lieutenants and passed midshipmen, partly the so-called professors of mathemathics. These were a small corps of educated men, whose duties had been to go to sea and teach the midshipmen navigation; their number became needlessly large when the

Naval Academy was founded, and the midshipmen concentrated at Annapolis; so that several of the "professors" were ordered to the Observatory. The corps is still kept up, and has contained many distinguished astronomers.

The next large Observatory founded was at Cambridge. In 1843 appeared a remarkable comet; probably a fragment of a much larger body which at some past time has been broken up by its near approach to the sun. It went within 100,000 miles of the sun's surface, and was subject to enomous heat and powerful attraction. It was visible in full daylight, as was the comet of 1882, which some of you may remember; probably not the same as the comet of 1843, but another broken piece of the same original body. In the study of the comet of 1843, Professor Benjamin Peirce was much interested, and he used his great eloquence to impress on the Boston men of wealth the need of a large Observatory.

Some time before this Mr. W. C. Bond had been invited to remove to Cambridge with his instruments, and a house belonging to Harvard College had been fitted up for him, so that there might be an Observatory at Cambridge, and, nominally at least, under college authority. Peirce's appeal was ably seconded by J. Ingersoll Bowditch, son of Nathaniel, and himself an astronomer of no mean attainments, but better known as an active business man in his father's footsteps. He has always shown a lively interest in the Observatory and all scientific enterprises about Boston; and by the efforts of Professor Peirce and Mr. Bowditch the money was raised for a great telescope.

The order was given in Europe for a refractor fifteen inches in diameter, equal to the largest then existing. It is still a comparatively large telescope; but our own opticians, as we shall see, have gone far beyond its dimensions. The Harvard College Observatory was built in the years before 1846 and the great telescope came in 1847. A few years later the indefatigable Peirce was laying the scientific foundations of the American Nautical Almanac; while his increasing reputation attracted about him a few mathematical students of high ability from various parts of the country, in addition to his college pupils.

Lieutenant (afterwards Admiral) C. H. Davis, a family connection of Peirce, was the one who succeeded in persuading Congress to pay for the calculation of an American almanac for the sailors, and release us from a dependence upon foreign nations, which might be troublesome in case of war. The office of the Nautical Almanac was established—at first in Cambridge—under Davis's business management and Peirce's scientific control.

Meanwhile the Coast Survey had gone steadily on; after Hassler's death it was placed under the superintendency of Professor Bache, of Philadelphia, a great-grandson of Franklin, and a distinguished graduate of West Point. From Franklin he seemed to have inherited both scientific ability and executive and diplomatic capacity to a high degree.

(TO BE CONTINUED.)

PROPER MOTION OF SOME DOUBLE STARS.

F. P. LEAVENWORTH.*

For The Messenger.

From recent observations made at this Observatory I find a number of Burnham's doubles appear to be in motion, while several, supposed to be in motion, appear fixed. Of these without doubt β 80 and β 83 are moving; the remainder are more uncertain and some, which are not included here on account of greater uncertainty, are possibly in motion.

I am much indebted to K. J. Tarrant, H. C. Wilson, N. M. Parrish, S. W. Burnham and J. G. Porter for copies of unpublished measures and for proper motion of principal stars.

The names of observers have been abbreviated as follows:

B	denotes	Burnham.	Mc	denotes	McCormick Observers.
Cin	"	Cincinnati Observers.	Mor	"	Morrison Observers.
De	"	Dembowski.	T	"	K. J. Tarrant.
Hl	"	Asaph Hall.	W	"	H. C. Wilson.
L	"	F. P. Leavenworth.			

β 395. 0*h* 31*m* —25° 26′.

yr.	°		″		No. of Obs.		yr.	°	″	No. of Obs.	
76	135	±	0.5	±	—	B	86	104.7	0.65	2	Mc
79.72	336.6		0.31		—	Cin	88.87	107.2	0.66	2	L

* Director of the Haverford College Observatory.

The Cincinnati measure does not seem to have been published in the Cincinnati Publications. The double is no doubt a binary, as otherwise, proper motion would in the interval 1886-88 change the distance some 2.8″.

β 4. 1*h* 17*m* +10° 58′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.6	68			De	86.71	74.2	0.43		Mc
79.66	119.1	0.52	1	Cin	88.83	61.0	0.41	3	L
80.06	77.2	0.53	4	B					

The motion of this difficult pair is doubtful. With the 10-inch glass of this Observatory and the highest power 400, it is barely elongated. Its distance can hardly be greater than 0.4″. With the 26-inch at the McCormick Observatory and a high power, it is an easy object on a good night. The observation of 86.71 is, no doubt, much more accurate than that of 88.83.

β 8. 2*h* 15*m* +8° 20′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.30	200.5	0.96	4	De	88.88	207.8	1.06	2	L
80.92	204.3	0.90	1	B					

β 83. 2*h* 40*m* −5° 28′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
76.02	121.3	1.40	4	De	86	115.8	0.98	6	Mc
77.91	122.2	1.00	3	Cin	88.87	109.2	1.00	2	L

β 89. 5*h* 31*m* −1° 30′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.68	344.2	0.55?	3	De	79.61	2.0	0.73	5	B
78.40	356.1	0.81	3	Cin	88.47	0.7	0.89	2	L

The first measure is very poor, the individual observations differing as much as 12°. If this were rejected the remaining measures would agree fairly well. However, it is possible that Dembowski's measure is approximately correct, and that the distance was smaller when measured by him than it now is.

β 916. 11*h* 8*m* −14° 47′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
80.33	8.1		1	Mor	86.31	357.4	0.80	1	W
83.26	7.0	0.5	1	W	88.16	357.4	0.65	1	L

β 929. 12*h* 58*m* −3° 1′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
79.40	229.4	0.48	3	B	88.32	221.6	0.62	2	L
88.25	219.1	0.54	5	T					

The Cape Catalogue gives a proper motion $\Delta\alpha - 0.004s$, $\Delta\delta - 0.03''$, which does not explain the change in position angle.

β 106. 14*h* 43*m* —13° 39′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.60	335.0	1.38	5	De	86.39	337.2	1.52	4	T
78.47	334.9	1.86	5	Cin	88.35	339.9	1.63	3	L
85.28	337.0	1.56	1	W					

Position angle seems to be increasing at the rate of 0.4° per year.

β 239. 14*h* 52*m* —27° 10′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
74.50	123.7	0.8	5	B	80.90	131.9	0.99	6	B
80.05	128.3	0.90	6	Cin	88.43	128.3	0.95	1	L

The earlier observations give indication of motion but the last one makes it doubtful.

β 119. 14*h* 59*m* — 6° 33′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.90	313.0	1.51	4	De	87.89	307.4	1.58	7	T
78.60	311.1	1.41	5	Cin	88.45	306.2	1.60	2	L

There seems to be a retrograde motion in position angle of 0.5° per year.

β 120. A B 16*h* 5*m* —19° 9′.

yr.	°	″	No of Obs.		yr.	°	″	No. of Obs.	
74.40	357.7		6	B	80.58	6.0	0.73	15	B
76.35	0.0	0.73	13	De	84.40	3.4	0.5	1	W
78.70	2.0	0.80	11	Cin	86.	7.2	0.65		Mc
79.59	5.3	0.74	1	Hl	87.63	5.4	1.00	5	T
80.54	0.9	0.54	6	Mor	88.39	4.6	0.80	3	L

Probably a slight increase in position angle. The differences may be due to accidental errors of observation. This is more likely as the errors are large; no doubt on account of the closeness, brightness, and southern declination of the star.

β 631. 17*h* 34*m* —0° 35′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
79.55	253.0	0.39	4	B	88.51	238.8	0.40	3	L

Other observations are needed to confirm this change.

β 142. 19*h* 22*m* — 12° 23′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
74.08	317.7	1.38	5	De	86.	327.6	1.68	1	Mc
78.89	319.6	1.37	6	Cin	88.53	328.0	1.59	3	L
82.53	324.4	1.68	2	W	88.70	326.3	1.47	3	T

Motion very probable.

β 80. 23h 13m +4° 45′.

yr.	°	″	No. of Obs.		yr.	°	″	No. of Obs.	
75.80	300.4	1.07	4	De	86.	316.1	0.48	1	Mc
77.79	306.1	1.24	2	B	88.76	319.6	0.84	3	L
81.69	312.2	0.91	3	B					

Position angle changing at the rate of 1.5° per year. The distances are very discordant. There can be little doubt of its binary nature, as the proper motion, according to Argelander, is 0.56″. Mr. Burnham in Washburn Publications first called attention to the motion of this double star.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury during the latter part of February and the first part of March will rise about an hour before sunrise, in this latitude, but will not reach a sufficient altitude in that time for good observations. He will be at greatest elongation, 27° 53′ west, from the sun March 13. There will be no bright stars in the vicinity of Mercury so that there can be no mistake in identifying the planet, if it be seen at all, in the morning twilight near the southeast horizon.

Venus will be at greatest elongation east from the sun, 46° 36′, February 18, setting then over four hours later than the sun. The phase then will be slightly gibbous, 0.514 of the disk being illuminated. This month and the next will be the most favorable for examining the surface of Venus, and every effort should be made to discover any permanent markings and determine the rotation period of the planet. The diameter of the disk will be 24.6″, Feb. 15 and 34.6″ March 15.

Mars is still visible in the evening twilight but is so far from the earth that nothing of detail can be seen on his surface. Some excellent maps of this planet by Schiaparelli have been published in the last number of *L'Astronomie* (January, 1889.)

Jupiter may be seen in the southeast in the morning, rising three hours before the sun. He is in the constellation of Sagittarius and is brighter than any of the surrounding stars.

Saturn may now be observed during the whole night, the best hours being from 8 o'clock to midnight. To find Saturn at 8 o'clock look toward the east about half way from the horizon to the zenith; the brightest object is Saturn, whose steady, yellow light is easily recognized. Below Saturn is the well known group, the Sickle, a part of the constellation Leo. The elevation of the plane of Saturn's rings above the earth is increasing slightly at present, being now 15°, so that the rings are coming into better position for observation. The outer major axis of the rings is a little over 45″. Saturn will be in conjunction with the moon, 1° south, at midnight March 13.

Uranus may be found in the east after 10 o'clock P. M. in the constellation of Virgo about 3° north of Spica.

Neptune is past the best point for observation this year, but may still be seen with a telescope of sufficient power until nearly midnight.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
			MERCURY.		
Feb. 24	21 19.5	−12 54	5 49 A.M	11 00.5 A.M.	4 12 P.M.
Mar. 1	21 19.5	−14 05	5 34 "	10 40.8 "	3 47 "
5	21 26.5	−14 27	5 27 "	10 32.0 "	3 37 "
10	21 41.6	−14 14	5 21 "	10 27.4 "	3 33 "
15	22 01.7	−13 19	5 18 "	10 27.8 "	3 38 "
			VENUS.		
Feb. 24	1 21.2	+11 08	8 13 A.M.	3 01.5 P.M.	9 50 P.M.
Mar. 5	1 51.1	+15 02	7 51 "	2 55.8 "	10 00 "
15	2 20.5	+18 46	7 24 "	2 45.8 "	10 08 "
			MARS.		
Feb. 24	0 21.7	+ 1 51	7 52 A.M.	2 02.2 P.M.	8 13 P.M.
Mar. 5	0 46.7	+ 4 38	7 30 "	1 51.6 "	8 13 "
15	1 14.3	+ 7 37	7 06 "	1 39.9 "	8 14 "
			JUPITER.		
Feb. 24	18 13.9	−23 05	3 30 A.M.	7 55.3 A.M.	12 20 P.M.
Mar. 5	18 19.8	−23 03	3 00 "	7 25.6 "	11 51 A.M.
15	18 25.3	−23 01	2 23 "	6 48.7 "	11 14 "
			SATURN.		
Feb. 24	9 12.8	+17 21	3 37 P.M.	10 51.8 P.M.	6 07 A.M.
Mar. 5	9 10.3	+17 32	2 58 "	10 13.9 "	5 30 "
15	9 08.0	+17 42	2 16 "	9 32.3 "	4 49 "
			URANUS.		
Feb. 24	13 20.7	− 7 49	9 26 P.M.	2 59.0 A.M.	8 32 A.M.
Mar. 5	13 19.7	− 7 43	8 50 "	2 22.7 "	7 55 "
15	13 18.4	− 7 35	8 09 "	1 42.0 "	7 15 "
			NEPTUNE.		
Feb. 24	3 51.0	+18 27	10 11 A.M.	5 30.9 P.M.	12 51 A.M.
Mar. 5	3 51.5	+18 29	9 36 "	4 56.0 "	12 16 "
15	3 52.2	+18 32	8 57 "	4 17.4 "	11 38 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m		h m	h m	h m
Feb. 24	22 32.5	— 9 11	6 46 A.M.	12 13.3 P.M.	5 40 P.M.
Mar. 1	22 51.4	— 7 18	6 38 "	12 12.4 "	5 47 "
5	23 06.2	— 5 45	6 31 "	12 11.5 "	5 52 "
10	23 24.7	— 3 48	6 22 "	12 10.3 "	5 59 "
15	23 43.0	— 1 50	6 09 "	12 08.9 "	6 09 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
Feb. 23	58 Ophiuchi	5½	15 01	90	16 00	302	1 00
Mar. 8	B. A. C. 1468	6½	8 32	125	9 30	219	0 57
8	*i* Tauri	5½	11 28	130	12 10	221	0 42
11	63 Geminorum*	5½	12 50	89	13 47	293	0 57

Phases of the Moon.

	Central Time. d h m
Last Quarter	Feb. 22 5 55 P.M.
New Moon	Mar. 1 4 01 P.M.
First Quarter	" 9 11 59 A.M.

Elongations and Conjunctions of Saturn's Satellites.

[*Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.*]

JAPETUS.

Feb. 17, W March 8, S

TITAN.

d h		d h		d h	
Feb. 18, 2 A. M.	I	Mar. 1, MIDN.	E	Mar. 13, 10 P. M.	S
22, 1 A. M.	W	5, 11 P. M.	I		
25, MIDN.	S	9, 10 P. M.	W		

RHEA.

d h		d h		d h	
Feb. 17, 12.1 A. M.	E	Feb. 26, 12.6 A. M.	E	Mar. 7, 1.2 A. M.	E
21, 12.4 P. M.	E	Mar. 2, 12.9 P. M.	E	11, 1.5 P. M.	E

DIONE.

d h		d h		d h	
Feb. 18, 12.9 A. M.	E	Feb. 28, 11.5 P. M.	E	Mar. 9, 4.4 A. M.	E
20, 6.5 P. M.	E	Mar. 3, 5.1 P. M.	E	11, 10.1 P. M.	E
23, 12.2 P. M.	E	6, 10.8 A. M.	E	14, 3.7 P. M.	E
26, 5.8 A. M.	E				

TETHYS.

d h		d h		d h	
Feb. 17, 10.9 A. M.	E	Feb. 26, 9.4 P. M.	E	Mar. 8, 7.8 A. M.	E
19, 8.2 A. M.	E	28, 6.6 P. M.	E	10, 5.1 A. M.	E
21, 5.5 A. M.	E	Mar. 2, 3.9 P. M.	E	12, 2.4 A. M.	E
23, 2.8 A. M.	E	4, 1.2 P. M.	E	13, 11.7 P. M.	E
25, 12.1 A. M.	E	6, 10.5 A. M.	E	15, 8.9 P. M.	E

Ephemeris of Comet e 1888 (*Barnard Sept. 2.*) From the second series of Elements of Berberich as given in A. N. 2862, I have computed the following ephemeris:

* A multiple star.

		R. A.	Decl.	log. r	log. Δ
		h m s	° ′		
1889 Jan.	1.5	0 17 6	−7 17.1	0.2676	0.2463
	3.5	13 29	−7 10.6	0.2664	0.2578
	5.5	10 10	−7 3.6	0.2653	0.2690
	7.5	7 8	−6 56.2	0.2643	0.2798
	9.5	4 20	−6 48.5	0.2633	0.2903
	11.5	0 1 47	−6 40.5	0.2625	0.3005
	13.5	23 59 27	−6 32.2	0.2617	0.3103
	15.5	57 19	−6 23.7	0.2610	0.3197
	17.5	55 22	−6 15.1	0.2604	0.3288
	19.5	53 34	−6 6.3	0.2598	0.3375
	21.5	51 56	−5 57.4	0.2594	0.3459
	23.5	50 26	−5 48.3	0.2590	0.3540
	25.5	49 4	−5 39.1	0.2587	0.3617
	27.5	47 50	−5 29.8	0.2585	0.3691
	29.5	46 41	−5 20.5	0.2584	0.3762
	31.4	45 39	−5 11 2	0.2584	0.3289
Feb.	1.5	23 45 10	−5 6.5	0.2584	0.3862
	3.5	44 16	−4 57.0	0.2585	0.3925
	5.5	43 27	−4 47.5	0.2587	0.3985
	7.5	42 43	−4 38.0	0.2590	0.4042
	9.5	42 2	−4 28.4	0.2593	0.4096
	11.5	41 25	−4 18.8	0.2598	0.4147
	13.5	40 52	−4 9.3	0.2603	0.4195
	15.5	40 22	−3 59.7	0.2609	0.4241
	17.5	39 54	−3 50.1	0.2616	0.4284
	19.5	39 29	−3 40.5	0.2624	0.4324
	21.5	39 6	−3 30.9	0.2633	0.4361
	23.5	38 45	−3 21.3	0.2642	0.4396
	25.5	38 27	−3 11.7	0.2652	0.4428
	27.5	38 9	−3 2.1	0.2663	0.4458

The light of the comet is diminishing so slowly that it will be visible for a long time to come. O. C. WENDELL.

Harvard College Observatory, 1889, Jan. 12.

Note on the 279th Asteroid. The circular of the Berlin Astronomical Year Book, No. 332, has just brought me the elements of this recently discovered member of the planetary cluster between Mars and Jupiter.* These results, calculated by H. Lange from the observations of Oct. 25, Nov. 9 and Nov. 27, have the following points of interest:

1. The orbital plane is nearly coincident with that of the ecliptic; the inclination being only 2°24′.

2. The eccentricity is 0.1762.

3. Its mean distance, 4.268, is twice that of No. 149, the innermost of the group; its aphelion distance, 5.02, is nearly the same as the present perihelion of Jupiter.

4. This asteroid is exterior to the space in which the period of a planet would be to that of Jupiter in the ratio of 2 to 3; a ratio of the first order.

* I am at present without access to astronomical works.

5. The breadth of the zone, from the innermost perihelion to the aphelion of No. 279, is equal to the entire interval between the orbits of Mars and Jupiter.

6. The period is 3220 days = 8.817 years.

7. As the 279th asteroid may approach indefinitely near to Jupiter, the question of its perturbation is one of great interest. Is its motion stable, or are the form and dimensions of its orbit liable to great variations?

DANIEL KIRKWOOD.

Riverside, California, Jan. 1, 1889.

Discovery of Comet Brooks—a of 1889. While sweeping the eastern heavens this morning as near as possible to the sun, I discovered a new comet, in Right Ascension 18*h* 4*m*; declination south 21° 20′. It is a faintish, nearly round nebulosity, with slight central condensation. I caught it in the short interval between the disappearing moon and the coming dawn. I had but a few minutes to do my work, but fortunately the comet was in a well marked field of stars so that its motion, which I found to be rather rapid westerly, was detected in a few minutes of intent gazing, as the day dawn extinguished the light of the comet.

WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., Jan. 15, 1889.

Comet 1888 V (*f*, Barnard, Oct. 30). I have computed the following ephemeris from elements published in the *Astronomical Journal*, No. 187, upon observations of November 1, 11, 21, December 1, 13.

The equatorial heliocentric co-ordinates referred to 1889.0 are:

$$x = [0.102603] \sin^2 \tfrac{1}{2}v \sin(174^\circ\ 3'\ 35''.2 + v)$$
$$y = [0.157478] \sin^2 \tfrac{1}{2}v \sin(\ 69\ \ 41\ \ 51\ .2 + v)$$
$$z = [0.002992] \sin^2 \tfrac{1}{2}v \sin(314\ \ 57\ \ \ 2\ .6 + v)$$

Ephemeris for Greenwich mean midnight:

1889	h m s	° ′	log. *r*	log. Δ	L.
Jan. 9	10 23 13	+ 7 22.4	0.3435	0.1452	0 92
11	21 58	8 28.1			
13	20 36	9 34.6	.3506	.1440	.90
15	19 7	10 41.9			
17	17 30	11 49.6	.3577	.1444	.87
19	15 48	12 57.6			
21	13 59	14 5.7	.3647	.1466	.83
23	12 5	15 13.6			

1889	h m s	° ″	log. r	log. Δ	L.
Jan. 25	10 10 5	16 21.1	.3717	.1506	.79
27	8 1	17 27.9			
29	5 54	18 33.8	.3785	.1564	.75
31	3 45	19 38.6			
Feb. 2	10 1 30	20 42.2	.3854	.1640	.70
4	9 59 15	21 44.2			
6	56 59	22 44 5	.3921	.1734	.65
8	54 43	23 43.0			
10	52 27	24 39.5	.3988	.1844	.60
12	50 12	25 33.9			
14	47 59	26 26.1	.4054	.1968	.55
16	45 48	27 16.0			
18	43 40	28 3.7	.4120	.2104	.50
20	41 35	28 49.1			
22	39 35	29 32.1	.4184	.2250	.45
24	37 40	30 12.8			
26	35 49	30 51.2	0.4248	0.2404	0.41
28	9 34 4	+31 27.3			

Light on Nov. 1 = 1

W. C. W.

Seven Eclipses in One Calendar Year. As a result of an investigation suggested by Mr. F. H. Burgess' communication in the SIDEREAL MESSENGER for January, I find two calendar years of this century within which there were seven eclipses: 1805 and 1823.

The series for 1805 is as follows:

DATE.	ECLIPSE.	DATE.	ECLIPSE.
Jan. 1	Sun.	July 11	Moon.
Jan. 15	Moon.	July 26	Sun.
Jan. 30	Sun.	Dec. 20–1	Sun.
June 26–7	Sun		

It is well known that eclipses repeat themselves in a period of eighteen years and ten or eleven days, known as the Saros. Accordingly, if we carry forward the above set of eclipses one period by adding eighteen years and eleven days, we obtain a repetition of them:

DATE.	ECLIPSE.	DATE.	ECLIPSE.
1823 Jan. 12	Sun.	1823 July 23	Moon.
" Jan. 26	Moon.	" Aug. 6	Sun.
" Feb. 11	Sun.	1824 Jan. 1	Sun.
" July 8	Sun.		

Examining more closely the time of the last eclipse, it will be seen that its beginning occurred at 53 minutes past 5 o'clock (Greenwich mean time) on the morning of Jan. 1, 1824. If the day begins at 180° from Greenwich, at all places between 88° 15′ (= 5*h* 53*m*) and 180° longitude west from Greenwich, the eclipse began before midnight (local time) of Dec. 31st; *i.e.* at these places seven eclipses occurred within the calendar year. It may appear ungracious to note that there will be no eclipse on Feb. 24, 1895, as stated by Mr. Burgess; more particularly so, as by using that date as a starting point and carrying back his series five periods (90 years and 54 days), I was able to obtain the above information. The Saros does not admit of an exact application without the necessary calculations. I cannot speak positively, but am lead to believe that there will be an eclipse of the sun July 18, 1917. If so seven eclipses in one calendar year will next occur in 1917.

We came within an ace of having seven eclipses in 1852; but to explain would trespass still more on your valuable space. R. W. PRENTISS.

Washington, D. C., Jan. 10, 1889.

Answer to Query 19. The full moon runs high in winter and low in summer for two reasons. First, because we are in the earth's northern hemisphere. This causes the moon to run high when north of the celestial equator, and low when its declination is south. Secondly, the sun and moon both move nearly in the ecliptic, and a full moon can only occur when that body is in the opposite part of the heavens from the sun. Consequently in winter, when the sun is south of the equator, the full moon must appear to "run high." In summer the positions of the two bodies are reversed, the sun being in north and the full moon in south declination; therefore the latter "runs low." This applies only to the northern hemisphere of the earth, as in southern latitudes the conditions are contrary. There the full moon "runs high" in summer and low in winter. ⁂

Query 20. Are the satellites of Mars of meteoric origin, or will the Nebular Hypothesis account for them? L. F. C.

21. What is the cause of the polar filaments, so called, in the corona of the sun as seen in the January eclipse? P. W.

22. The papers say that some observers at the late total solar eclipse saw what they call shadow bands in motion during totality. What are they, and what caused them?

23. What are the relative merits of reflecting and refracting telescopes of the same aperture? A. B. D.

EDITORIAL NOTES.

The all absorbing topic of the last month has been the eclipse of Jan. 1, and judging from the letters and reports already in hand opportunities for study of it were exceptionally good and the results obtained very encouraging.

January 28, this later report was received from Professor H. S. Pritchett, Observatory of Washington University, St. Louis. He says: "I took with me, as you perhaps know, one of the 6-inch equatorial cameras belonging to the government. Professor Engler and Professor Nipher of Washington University accompanied me and also Professor Charroppin of the St. Louis University as photographer. We secured excellent observations of all the contacts except the first, and six fine negatives of the corona. The negatives show a great deal of detail. The polar filaments are very strongly marked. Observing the coronal streamers with the aid of a disc sixty feet away Senor Valle, who also joined my party, was able to trace them three degrees from the sun. Hope to send you a complete report later."

The Eclipse of the Moon on the night of January 16 was observed at Carleton College Observatory. The night was cold and windy, and thin clouds were continually passing. Nothing of peculiar interest was noticed in the aspect of the lunar surface during eclipse. Four photographs were taken, two at the maximum phase, and two near the end of the eclipse.

Brilliant Venus. Some friend, having the initials P. B. S., claims to have seen Venus with the naked eye Jan. 1 and 14, at the hours respectively of half past one and half past twelve in the afternoon. This may be possible, but it is also certainly true that our friend has unusual powers of vision. As Venus nears the earth, this month will afford excellent opportunity for observation.

Professor Brooks, director of the Smith Observatory, Geneva, N. Y., secured the first contact of the eclipse of Jan. 1, 1889, at 4*h* 31*m* 5s, standard Eastern time. The sun's disc was conspicuously notched as it sank below the horizon.

Professor John G. Hagen, S. J., formerly of the Observatory of the College of the Sacred Heart, Prairie du Chien, Wis., has been recently called to the directorship of the Observatory of Georgetown College, Washington, D. C. His great interest in practical astronomy has been evinced by his work in connection with the Washburn Observatory, his independent observations, and, not least, by his thoughtful communications to the MESSENGER. We wish him abundant success in his new position, as he richly deserves.

H. P. Tuttle, of Washington, D. C., has been giving some attention to the observation of comets recently, with the 9.6-inch equatorial of the Naval Observatory. Comet *f* 1888 he could easily see in a 2.6-inch field, but finds it difficult to observe with bright wires.

On the day of the total solar eclipse, the first contact was well observed, but at the same time a bank of clouds was seen in the west that started our fears. The clouds soon covered the sun, and it seemed, more and more, as if the whole period of totality would be lost. However, a few minutes before the 113 seconds of totality began, to the joyful surprise of the Carleton party, the dense cloud broke away very suddenly, and the total phase was seen in a fairly good sky. We then remembered the kind words said to us before by the Chico friends: "We have been praying for you to-day." Others may, but we do not doubt the help of prayer in the success we enjoyed. This is one of the ways in which the Almighty works.

John Tatlock, Jr., care of North River Safe Deposit Co., 187 Greenwich Street, New York, U. S. A., requests that those astronomers who secured observations of the occultations of α Tauri by the moon between the dates of Sept. 10, 1884, and March 18, 1888, inclusive, will kindly send to him copies of the records of such observations together with full particulars essential to the reduction thereof.

Reflectors vs. Refractors. An interested young observer has raised the question of the comparative merit in defining power between a reflecting and a refracting telescope. We give below a portion of his letter for the help it may secure him from others in similar work. "I have a reflector of 9½ inches aperture and 6 feet 9-inch focal length, which I have been using for the past year . . . As test objects, I have observed γ^2 Andromedæ in steady air, and it was distinctly divided, so that a friend and myself each made independent drawings which corresponded with the one sent me by Professor C. A. Young of Princeton. The small star 5½ min. following Procyon was easily divided. The globular cluster in Hercules (M. 13) was resolved beautifully, looking exactly like the drawing in Chambers' astronomy. . . . .

"If any of your numerous readers who have refractors of 9½-inch aperture and of the best make, will kindly send me some test object either on the moon, planets, or some close double, I will try and prove how close the comparison can be made between the two instruments.

"Hoping I have not trespassed too long on your valuable time, I am, A. B. DEPUY.

216 North Sixth Street, Camden, N. J.

Mr. Stark's Observatory. We have only recently learned of Mr. H. P. Stark's private Observatory at Syracuse, N. Y. His telescope has a Spencer objective of $5\frac{5}{16}$ inches aperture, and equatorial mounting. His observatory is provided with a revolving dome twelve feet in diameter, and is conveniently and favorably located for observation.

The Iowa College Observatory at Grinnell, Ia., is soon to have, if not already in possession, one of the Fauth transit instruments of 3 inches clear aperture with modern improvements. Professor S. J. Buck, who is now in charge of the new Observatory, has been working industriously to obtain a good working outfit and he has been very successful according to late advices. He has secured a Fauth chronograph, has recently finished a new brick transit house and has a sidereal clock in place and running. His mean time clock has already been ordered. Both are by the Seth Thomas Clock Company. From what he says we know Professor Buck is very happy in the prospect of using these fine instruments. We hope he will use the grand illustrations of practical and observational astronomy to enforce spiritual truth that, as a minister of the Gospel, he loves to proclaim on Sunday. No field of science is so full of fresh and unused material as this.

The Leander McCormick Observatory. A very readable article in the *Scientific American* (Jan. 26), from the pen of H. C. Hovey, gives a full account of the Leander McCormick Observatory, at the University of Virginia, Professor Ormond Stone Director. A fine engraving of the Observatory building accompanies the article. We also notice the following paragraphs which give items of history of the Observatory new to us:

"The McCormick family, inventors of the well known reaper, originated in Rockbridge county, Va. Leander, the youngest of the three brothers bearing that name, residing in the city of Chicago, desired to do something to prove his affection for his native state; therefore contracted with Alvan Clark & Sons, of Cambridge, Mass., for a mate to the splendid telescope they were then making for the National Observatory at Washington, D. C., with certain noted improvements, and offered, on specified conditions, to present it to the Washington and Lee University, at Lexington, in the county where he had been born. As those conditions were not met, he next offered it to the University of Virginia, through Col. Venable, the Professor of Mathematics in the latter institution, who immediately took steps toward raising the necessary endowment. In answer to an appeal to the State Legislature, that body passed resolutions recognizing the generosity of the donor and the importance of securing such a telescope, but did not deem it wise, in the condition of the state finances at that time (1878), to make the appropriation asked for.

"Gen. Johnston, now of the South Carolina Military Academy, at Charleston, then visited the alumni of the University, pursuant to an appeal made by the executive committee, and raised over $50,000 to secure the $3,000 salary of the astronomer in charge. Mr. William H. Vanderbilt of New York added $25,000 as the beginning of a working fund. The University gave the ample grounds on the summit of Mount Jefferson, and also built the astronomer's residence, at a cost of $8,000. Mr. McCormick then gave the telescope, costing $46,000, and the building in which it is housed, costing $18,000; thus making a sum total, including the smaller buildings, etc., of $150,000. The Observatory was completed in 1884."

Stonyhurst College Observatory. The Rev. S. J. Perry, in charge of Stonyhurst Observatory, favors us with a copy of his results of meteorological and magnetical observations for the year 1887. In this report, we notice that solar drawings of spots and faculæ were made on 259 different days, and that complete measurements of the height of the chromosphere were secured on 123 occasions. The inclination of the filaments of the chromosphere and of the lesser prominences was also observed when the definition was good enough for such work.

Death of Robert D. Schimpff. During our absence on the Pacific Coast a telegram was received at the office, announcing the death of Robert D. Schimpff, Scranton, Pa., after a brief illness of typhoid fever. This sad event was so sudden that his physician was not apprehensive of danger until the day preceding the last. With like surprise did this unwelcome news come to us. Though we had no personal acquaintance with Mr. Schimpff, yet we had corresponded with him, invited and heartily welcomed his scientific articles for publication, and in such ways had learned to esteem him very highly for his scholarly and his manly qualities. Though a comparatively young man we do not wonder that he had so won the choice regard of the best in his home city, and that he had been called of their partiality to occupy places of trust and responsibility. It was only a fitting testimonial to modest merit that always rules, to some extent, in the consciences of men. Mr. Schimpff was an eager student of science. He was greatly interested in astronomy and physics, especially spectrum analysis. His observations with instruments were sought by the best periodicals on astronomy, and his skill in celestial photography has already been shown to our readers by engravings in this magazine which were copies of fine photographs wholly his own work. Professor Young spoke well of him when he said to a friend a little while ago: "He was so bright and quick in his thinking, so interested in everything new in science, and so enthusiastic in regard to its progress and prosecution that an interview with him was an inspiration."

We do not wonder, I say, that those who knew him best should vie with one another to do his name and memory honor, as he steps off the shores of time to those of his other Home. The account of the memorial services which we had the pleasure of reading was indeed the fitting close of a life of beauty and power.

Captain R. S. Floyd has recently added a fine 5-inch telescope by Alvan Clark & Sons to the outfit of his private Observatory at Kono Tayee, Clear Lake. By reversing the crown glass lens, which is fitted into a separate cell, the objective is converted into a photographic combination, the lenses being then separated by a distance of 1.7 inches and the focal length being 65.6 inches. With the visual arrangement the lenses are nearly in contact, and the focal length is 77 inches.

The telescope is mounted equatorially on a long polar axis, according to the English plan. It has an enlarging apparatus, with instantaneous shutter for solar photography. Two negatives of the corona were obtained by Captain Floyd during the total eclipse of Jan. 1st, the instrument having been roughly mounted for the purpose in the open air.

Astronomische Mittheilungen. We deem ourselves fortunate to obtain Dr. Rudolf Wolf's publication, *Astronomische Mittheilungen*, for the last eleven years, for place in our astronomical library. Dr. Wolf is professor of astronomy in Zeurich, Switzerland.

Mr. Tebbutt's Observatory. A neat pamphlet of 74 pages is before us, which gives the history and description of Mr. Tebbut's Observatory, Windsor, New South Wales.

Harvard College Observatory. The 43rd annual report of Professor E. C. Pickering of the Harvard College Observatory contains points of interest. The income of the Observatory has increased so much during the last three years that the astronomical work of the Observatory is materially advanced and enlarged. The Observatory can now invite coöperation of other smaller observatories, in certain lines of work. It is undertaking mountain astronomical observations at various points, at the present time, and it has assumed the control of the meteorological work of the New England society. This is in addition to the regular work going on at Cambridge which is a continuation of that formerly reported. We notice with pleasure the work that is being done at this Observatory in the new field of variable stars. The report says:

Messrs. Parkhurst, Eadie, and Hagen have continued their co-operation with this Observatory in collecting fresh material for the study of the variable stars. Mr. Parkhurst's preliminary series of observations on the variations of the asteroids, mentioned last year, has been published as No. III. in the collection of separate memoirs which will constitute Volume XVIII. of the Annals of the Observatory. Communications which will aid in the construction of the Index to Observations of Variable Stars, undertaken last year, have been received from the following foreign observers: Mr. T. W. Backhouse, of Sunderland, England; Messrs. Joseph Baxendell and Joseph Baxendell, Jr., of Southport, England; Rev. T. E. Espin, of Wolsingham, England; Mr. J. E. Gore, of Ballysodare, Ireland; Mr. George Knott, of Cuckfield, England; Major E. E. Markwick, of Queenstown, Ireland; Mr. C. E. Peek, of Lyme Regis, England; Mr. J. Plassman, of Warendorf, Germany: Professor Safarik, of Prague, Austria. Two large series of earlier unpublished observations have also been obtained, and it has been thought best to delay the publication of the Index above mentioned until these series could be received and utilized. The first series consists of observations by the late Professor E. Heis, of Munster, Germany. The records of these observations were transmitted by the family of Professor Heis to the Rev. J. G. Hagen, S. J., who has kindly communicated them to this Observatory. The second series contains the observations of the late Dr. J. F. J. Schmidt, preserved in manuscript at Potsdam. Professor H. C. Vogel, Director of the Potsdam Observatory, has kindly directed the preparation of a copy of these observations for use in the proposed Index. The printing of the Index has been begun, and it is hoped that the work may soon be distributed.

Stellar Parallax. In the *Monthly Notices* of the R. A. S. for Nov. 1888, Professor Pritchard gives some results of the work done at the University Observatory, Oxford, during the past year, in determining the parallax of stars by means of photography. The work has been confined to stars of the second magnitude, as the parallaxes of those of the first magnitude have already been derived by various astronomers and very recently have been the subject of investigation by Dr. Elkin, with the Yale College heliometer. The following table gives the final results obtained for *μ Cassiopeiæ* and *Polaris* and provisional results for *α*, *β* and *γ Cassiopeiæ*. The necessary photographic plates have been secured for completing the investigation of the parallaxes of *α Cephei*, *γ* and *ε Cygni*, *γ Coronæ*, *α* and *β Andromedæ*. Professor Pritchard thinks that to determine the parallaxes of twelve stars annually by this method is about the limit of work to be anticipated from the exertions of a single observer with a single instrument in the climate of England.

Table Showing the Parallaxes of Stars Recently Determined at the University Observatory, Oxford, England,

Stars of Comparison.	Magnitude of Comparison Stars.	Differential Parallax.	Probable error of Result.	Parallax from other Authorities.	
		μ CASSIOPEIÆ.			
°		″	″		″
D M 54 No. 225	7.7	0.0211	0.023	Bessel	−0.120
" 54 " 217	9.2	0.0501	0.027	Struve	+0.342
		POLARIS.			
D M 88 No. 4	6.7	0.0429	0.015	Lindenau	0.144
" 88 " 2	8.3	0.0758	0.014	Struve & Peters	0.172
" 88 " 9	8.4	0.0623	0.016	C. A. F. Peters	0.067
" 88 " 10	9.6	0.0992	0.013		
		α CASSIOPEIÆ.			
D M 55 No. 142	8.7	0.0748	0.024		
" 55 " 128	9.5	0.0678	0.055		
		β CASSIOPEIÆ.			
D M 58 No. 8	8.6	0.1759	0.047		
" 58 " 2700	8.8	0.1484	0.056		
		γ CASSIOPEIÆ.			
D M 59 No. 137	8.8	−0.014	0.047		
" 59 " 150	8.9	+0.007	0.042		

Speaking of the differences between the results obtained by different observers, Professor Pritchard says: "Guided by the suggestions of recent experience, I now think that such differences of 'parallax' might very reasonably have been anticipated, and may properly be accepted as matters of fact, without in any degree impugning the accuracy of the observations. For in the process of this work on parallax, and also from the general history of such inquiries, it has been made abundantly evident that no necessary connection exists between the brightness of a star and its position in space or distance from the sun. Nevertheless it is this very difference of brightness mainly which guides us in the selection of comparison stars. The 'Parallax' is, in fact, and is becoming more and more generally recognized to be a differential quantity, fainter stars being in very many instances much nearer to us than others possessing incomparably greater brightness." He calls attention, however, to the fact that the parallax of *Polaris*, as determined with reference to the four comparison stars, varies somewhat in proportion to the difference in brightness of Polaris and these stars.

U. S. Naval Observatory. By kindness of Lieut. Winterhatler we have received a copy of the report of the superintendent of the U. S. Naval Observatory for the year 1888. From it we learn that the contract for the erection of nine buildings comprising the new Observatory has been awarded to Messrs. P. H. McLaughlin & Co., Washington, D. C., and that work on the same has begun. The amount already appropriated by Congress is not sufficient to complete the new Observatory, but doubtless the deficiency will be made up in time. During the removal from the old to the new Observatory the use of Washburn Observatory has been tendered by the regents of the University of Wisconsin for such aid in astronomical work as might be desired on the part of the Naval Observatory. Coördination work between the two observatories has been invited and cordially accepted. Professor N. Hall is consulting director of Washburn Observatory, and Professor S. J. Brown is on duty there also.

We were also interested in the letter of Lieut. Winterhatler to the superintendent of the Naval Observatory concerning his European visit to observatories and scientific institutions under orders from the Department. His full report will be looked for with interest after publication.

Visit at the Lick Observatory. One of the treats of our late western trip was the half day spent with Professors Holden and Schæberle at the Lick Observatory. On the morning of Jan. 3 we left San José by stage, to go to the top of Mt. Hamilton, a distance by road of twenty-six miles; and in a straight line only thirteen miles. A zigzag course for this fine driveway was chosen that an easy grade might be secured for the entire distance. The maximum in any part of it, we believe, does not exceed 343 feet to the mile. It was a beautiful day, and the drive for six hours in the midst of such a variety of scenery, was most delightful.

At two o'clock in the afternoon our party had the pleasure of meeting Professor Holden in his famous Observatory and mountain home, and we were welcomed right royally. We looked at instruments from the mammoth equatorial down to the end of the list (and it was a long and interest ing one), we saw the library, the rooms and work of individual astronomers and something of the plans for future work.

The single regret was, that the evening should be cloudy so as to prevent a use of the 36-inch equatorial on some celestial objects to understand its marvelous power to penetrate the star depths, or to show details of the planets' surfaces.

Sir George B. Airy. It is an interesting and very impressive fact that the distinguished Sir George B. Airy at his present advanced age (88 years old) is still working on one of the most difficult problems known to astronomy, "The numerical lunar theory," as he titles it. He recently says that through failing strength and advanced years he can scarcely hope to complete the work he has undertaken, but that he still keeps his attention to the general subject, and that he believes the method he has chosen, if properly used, would have led to a comparatively easy process but for a serious mistake previously pointed out.

Books Received.

Star Atlas containing Maps of all the Stars from 1 to 6.5 magnitude between the North Pole and 34° South Declination, and of all Nebulæ and Star Clusters in the same region which are visible in telescopes of moderate powers. Explanatory text by Dr. Herman J. Klein. Translated and adapted to English readers by Edmund McClure, M. A., M. R. I. A. Eighteen maps. London: Published by the Society for Promoting Christian Knowledge. Also, New York: Messrs. E. & J. B. Young & Co.

An Elementary Treatise on Analytic Geometry, embracing Plane Geometry and an introduction to Geometry of three dimensions. By Edward L. Bowser, LL. D., Professor of Mathematics and Engineering in Rutgers College. New York: Published by D. Van Nostrand, 23 Murray Street, 1888, pp. 287.

Tornadoes, What They Are, and How to Escape Them. By John P. Finley, Lieutenant Signal Corps, U. S. Army. Washington: J. H. Soule, Publisher, 1888. Price 25 cents, pp. 90.

Publishers and others sending books to the MESSENGER for notice will confer a favor by stating, with each book, the retail price, so that the same may be incorporated in the notice of the book for publication.

THE SIDEREAL MESSENGER,

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DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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OBSERVATIONS AT CLOVERDALE, CALIFORNIA.

CHARLES BURCKHALTER.

For THE MESSENGER.

It was three months ago that I first suggested to leading members of the Pacific Coast Amateur Photographic Association that good work could be done by the members at the total eclipse on the first day of the present year, and it was exceedingly gratifying to me to observe the disinterested enthusiasm with which the proposition was entertained. By the word "amateur" I do not mean home-made apparatus and mere dabblers in the art of photography, for the Association has within its ranks men who probably have no superiors in the photographic art, and their outfits are as elaborate as wealth can buy.

Out of this association, composed as it is of men engaged in active business pursuits, many of whom could ill afford either the time or expense required, thirty cameras were pointed at the sun at our station (Cloverdale, Sonorra County, California), on the morning of the eclipse. Among this formidable battery were a few amateurs and two professionals who were not members of the Association, but all who were willing to devote their results to science were welcome to take advantage of our arrangements.

The Association had made me an honorary member and placed me in full charge of the expedition. On December 29th, accompanied by Messrs Harry T. Compton, Marston Campbell, Alpheus Bull, Jr., and C. P. Grimwood, I arrived at Cloverdale and at once selected our station and we began observations for latitude and longitude. Our station was in the midst of the little village, on a block of land kindly given us by Mr. M. Minnehan. It was surrounded by a neat fence, the only other improvement being a small cottage, a room of which was kindly given us by the owner in which we could keep our instruments, thus saving much labor in carrying them to and from the hotel.

Mr. Compton, assisted by Mr. Campbell, established the latitude of our station by a large number of observations with a sextant and artificial horizon, while I observed for time, with a small astronomical transit kindly loaned me by Mr. Edward Dillon, of Dillon & Co., San Francisco. I am desirous of thanking this gentleman also for the use of a mean time chronometer and, while under this head, I wish to thank the management of the San Francisco & North Pacific Railroad Co., for free and careful transportation of our instruments; the Western Union Telegraph Co., and Mr. Jones and Mr. Vandenberg for sending us the clock signals of the Lick Observatory for three days preceding the eclipse.

As the mean of Mr. Compton's sextant observations on the sun and Polaris and my own time observations and chronometer comparisons with the Lick clock, we found our position to be:

Latitude = 38° 47′ 40″ N.
Longitude = 122° 57′ 25″ W.

On the evenings of the 29th and 30th of December the sky was perfectly clear; but on the night of the 31st, when the members of the Association joined me, clouds had gathered, and there were evident signs of rain. However this did not dampen the ardor of the gentlemen, and we all assembled in the dining room of the hotel, where I was put through a sort of astronomical catechism by eager searchers after detail. We finally went through several drills in the matter of counting, etc., so that they would all have a complete understanding of what they were to do. It was agreed to meet at nine o'clock next morning at the station selected, and there drill again when all the cameras and other instruments were in position.

On the morning of the 1st, though the sun rose clear, there were banks of cloud on the horizon, and overhead masses had gathered which were slowly moving away. As the sun gathered strength the clouds became more fleecy and began to dissipate, the improvement in the weather continuing as the day advanced.

Carpenters had previously made trestles and inclined boards to be used instead of tripods for most of the cameras. The thirty cameras were then set up in two long rows, a place in the center being reserved for the telescopes, chronometer, etc. By 10 A. M. all the instruments were in position and drilling commenced. The drilling, which was done a number of times, corresponded to the programme afterwards carried out in the matter of counting and recording time. The system was as follows:

In order that there should be uniformity with regard to time, and each should know exactly the period at which the different plates were exposed and the time of exposure, a battery and telegraphic sounder were connected with a break-circuit sidereal chronometer so that the beats of the seconds were sounded. About one minute before totality, Mr. Alpheus Bull, Jr., began counting aloud, so all could hear distinctly, he taking the time from the sounder. This preliminary counting was done to determine how long before totality any observer could notice the corona, and each one noted on a prepared card when he saw it.

Meanwhile Mr. Compton with a sextant and Mr. Wm. M. Pierson with a 3½-inch refractor observed for time of second contact. As totality commenced Mr. Compton and Mr. Pierson simultaneously called "time" and immediately Mr. George H. Strong commenced counting aloud, taking the sounder as his guide. The work of the photographers then began and continued until the last instant of totality was called, when Mr. Strong ceased counting, and Mr. Bull again commenced counting till he had counted fifty-five.

The counting after totality was so that the length of time the corona could be noticed might be recorded. The object of having two men to call was that voices of different tones could be recognized as marking the periods before and after totality and during total phase. Each photographer had an assistant and each assistant had a card devised by W. H. Lowden, on which was printed a row of figures from 1 up to 200. His instructions were to indicate on this card the exact second of totality, at which the lens of the camera was uncapped and again when replaced, and repeat this as many times as there were plates exposed. This card then furnished a record not only of the time of exposure of each plate, but the period during totality the exposure was made. The assistant had but to listen to the voice of Mr.

Strong, who was calling, and mark on the card the number being called, as the lens was uncapped and capped. This arrangement proved perfect, as in every case the time and period of exposure of every plate is known, and all were working on the same time by chronometer.

The first and fourth contacts were not observed for, as we only cared to know when to begin our photographic work, and to know just the exact second of the time of totality each plate was exposed. The following times are probably right within half a second:

Second contact = 1*h* 46*m* 43.50*s*,
Third contact = 1*h* 48*m* 27.50*s*,

the duration being only 1*m* 44*s* by sidereal chronometer.

The predicted times at Cloverdale, in the pamphlet issued by the director of the Lick Observatory (and which were believed to be only approximate), were:

Time of second contact = 1*h* 46*m* 44*s* P. S. T.
Time of third contact = 1*h* 48*m* 32*s* "
Duration of totality = 1*m* 48*s* "

The time of contacts played but a small part in our work, as those who observed and recorded them had little or no experience in exact observations.

A card with a central black disk to represent the moon had been prepared for each one, and upon this each was to draw the corona as it appeared to him, and then turn it over to the President of the Association without correction or comparison with other drawings. These drawings have all been handed in and, with the original negatives and all of our work, will be sent to the Lick Observatory.

When Mr. Bull counted forty-two (ten seconds before totality), several members saw the corona very distinctly. Two members, Mr. W. C. Gibbs and Mr. George A. Story, claim to have seen it forty-three seconds before totality. After totality the corona was carefully watched and was lost generally from forty to fifty-five seconds after, with the exception of Messrs. A. J. Treat and George H. Strong, who state that they followed it sixty-nine and seventy seconds respectively.

The ladies of the party were skillful colorists and were instructed to protect their eyes preceding the total phase, so that the eyes would be color-sensitive. They describe the color of the sky before totality as being a leaden blue. It became brighter and more luminous during totality as it extended up to the corona. The light near the disk of the moon was an intense luminous silver, with a bluish tinge similar to the light of an electric arc. The outer corona was similar in color, though fainter, fading away into the surrounding sky. The disk of the moon appeared of a gaseous aspect and of a dark, hazy, purple color. At no time did it appear black. The streamers, which extended in an oblique direction, were of the same color as the outer corona. Warm colored or red rays were not observed by those who had made their eyes sensitive by protection previous to totality.

One of the best drawings was that made by C. Mason Kinne of the San Francisco Microscopical Society. He used a low objective and saw the color of the inner corona as a cold, steely blue, fading into purple red and slight yellow. He also observed a slight protuberance on the northwest periphery.

Captain C. L. Hooper, of the United States revenue cutter Corwin, had a 2½-inch telescope, but noticed no color at all in the corona. It was a swallow-tail shape and expanded about one degree on each side, as nearly as he could judge, in the direction of the ecliptic. No signs of protuberances or flames were noticed. The light appeared like that from a shaded electric light.

I was disappointed at the almost utter absence of sun-flames, a few very small ones appearing in the best photographs.

There were about seventy-five members of the party. Thirty of these were photographers and thirty recorders the rest performing other duties with the telescopes, sextant, meteorological instruments, etc. There were in all one hundred and sixty-seven negatives made. The shortest exposure was one-fiftieth of a second on a quick plate; the longest was forty-one seconds on a slow plate, the rest varying between these extremes. The photographing was systematically done. To each photographer were allotted certain times of exposure for his plates, taking into consideration such elements as character of lens and plate, length of focus, etc.

The results with the camera vary mainly in degree of extent of corona and size of image. Owing to the variety of quickness of the plates, difference of length of exposure and methods of development of negatives, a number of facts have been established which will serve as a valuable guide to future work of this character. Nearly all of the negatives made have been developed.

It is found as a result of the work accomplished thus far that there was no necessity for very long exposures of the plates, the light of the corona being better from a photographic point of view than was, perhaps, expected. The best general results have been obtained with an exposure of three seconds on a quick plate with an aperture not less than one-tenth the focal length of the lens. The negative made on a slow plate in forty-one seconds shows Mercury plainly, but so also does another which was only exposed ten seconds, and perhaps close inspection will reveal this planet on other negatives, though nothing under ten seems to show it.

The inner corona was satisfactorily photographed in one second, and exposures of only a twentieth of a second show it also very well. The outer portion required a longer time. Probably the five-second exposures on a rapid plate give about as great an extent as it is possible to photograph. The greatest extent was that shown in the forty-one second negative, where it is pictured as extending on two sides, about two diameters of the moon; but probably fifteen or twenty seconds exposure would have answered as well. The forty-one-second plate would seem to prove that the visual light of the extreme outer corona is greater than its photographic strength for the reason that in this case the rays merge into the diffused light of the sky at a less distance from the moon than the drawings made by observers appear to indicate. In developing this negative the sky was also developed, showing that it was impossible to obtain on a photographic plate any greater extent of corona than is shown thereon.

The photographers of our party think that hereafter exposures should be made separately for different parts of the corona. Short exposures, say of not over one second, should be given to obtain details of the inner corona; others of two or three seconds for details of the outlying portions; and others of five seconds and over to obtain the extreme limits of light given by it. These plates should, of course, be developed understandingly to get the best results from each. In the second and third class of exposures the inner corona would have to be entirely sacrificed in the development of the negative, while in the first, care should be taken to preserve all the detail possible.

It would seem from the results that the actinic strength of the light of the inner corona has been underrated, as the exposure of one-fiftieth of a second on it gave a good image. The light as shown on the negatives, especially the larger ones, is represented as long fine rays or wisps extending apparently from the edge of the moon's disk. Professor Langley thought at a previous eclipse that these wisps or rays were themselves formed of bunches of rays or wisps, and has been anxious for proof of his theory. The negatives made show that he was right; the broom-like rays are themselves formed of small bunches of rays like the separate bunches in a broom which go to form the whole. These show clearly on the negatives, but not so plainly on the prints.

Dr. Passavant took with him a Warnercke sensitometer for the purpose of testing the actinic strength of the light of the corona. He reports that an exposure was made by his assistant, Thomas Andrews, on an „H. L." plate, which registers 15 on the sensitometer by the ordinary tests. This exposure lasted fifteen seconds, commencing at forty-one seconds after totality and ending at fifty-six.

This photographic plate, of known value, was cut into four pieces. At the time of the next full moon another piece of this same plate will be exposed in the same sensitometer to the moonlight for a like period. Proper meteorological observations will be made and recorded at the same time. Still another portion of the plate will be exposed under the sensitometer to the standard light used by all photographic plate-makers. These plates will all be developed at the same time and with the same chemicals. They are expected to show: First, the standard value of the plate; second, the exact relation of the photographic strength of the diffused light of the corona as compared with that of the full moon.

This will enable photographers in the future to determine more accurately the proper exposure to be given the corona, even though the advances in photography should place the plates of to-day, so far as rapidity is concerned, very much behind the plates of the future.

The results of the above experiment will be forwarded in time for the next MESSENGER.

The party consisted of the following:

Members of the Photographic Association—A. J. Treat, S. C. Passavant, O. V. Lange, Charles G. Yale, P. Carleton, C. F. Montealegre, J. W. Stanford, J. V. A. Rey, Eugene Frost, Samuel C. Partridge, W. C. Gibbs, George W. Dornin, William Letts Oliver, J. H. Johnson, E. W. Runyon, A. P. Redington, W. H. Chapman, W. H. Lowden, E. L. Woods, George Tasheira, F. H. McConnell, George W. Reed, C. L. Goddard, W. S. Davis.

Assistants—Alpheus Bull, Jr., Harry T. Compton, Marston Campbell, C. P. Grinwood, George H. Strong, William F. Booth, W. B. Ewer, Lew Tasheira.

Recorders—H. W. Schwerin, William N. McCarthy, W. C. Edes, Alfred K. Gibbs, M. P. Donnelly, F. C. de Long, George A. Story, J. A. Bauer, E. S. Gray, E. B. Moore, George B. Baer, Walter Henry, M. Seligson, E. P. Livingston, F. S. Wright, C. W. Wilkinson, Harry Phelan, Moses Callan, Thomas Andrews, Mrs. C. L. Goddard, Miss Hermione Rey, Mrs. E. S. Gray, Mrs. George Tasheira.

Sketchers—Mrs. George Roe, Miss Silvia Rey, Miss Truesdell, Miss Treat, Col. C. Mason Kinne, Capt. W. B. Hooper.

The following professional and amateur photographers not connected with the Association were also present: I. W. Taber, A. C. Burnham, W. B. Tyler, Louis de F. Bartlett, Bert Remmel.

It may be here mentioned, as all were working under directions and allotments as to time of exposure of plates, some had to be "sacrificed" so as to get variety in results. For instance, Mr. Lowden to whom was assigned the forty-one-second plate expected to get nothing from so long an exposure.

My own instrument was the largest one in our party, my telescope is a 10½-inch Newtonian reflector, made by Brashear, and this I converted for the time being into a telescopic camera. It was mounted in a wooden tube 12 inches square and 8 feet 6 inches long. A special diagonal whose minor axis was 3¼ inches was specially made so that the field would be large enough to include the sun and any

From a photograph by Mr. Burkchalter; exposure 2 seconds.

possible extent of its corona. Two slow-motion attachments were provided to follow the sun in altitude and azimuth. This was all mounted on a working platform, so

From a photograph by Mr. Burckhalter; exposure 3 seconds on slow plate.

it could be pointed at the corona at the proper moment without loss of time. Mr. Charles G. Yale had charge of this mechanism. The tube was carefully blacked inside and everything done to prevent fogging the plate, but this was known to be an impossibility in an open tube. It was only a question whether the plate would be fogged beyond all value or not.

The manner of exposing the plate was by cutting an opening in the top side of the tube and adjusting the back portion of the camera that holds the plate holder over this opening. A small telescope with a large field was placed on the tube as a finder. The image was thrown to one side of the center just before totality, and no attempt made to follow the moon during the time of totality.

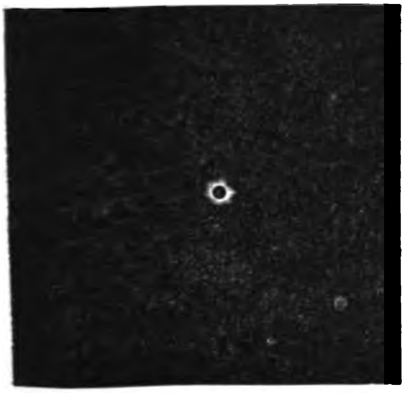
From a photograph by Mr. Burckhalter; exposure 1 second on slow plate.

The focal length of this camera was 84 inches, the longest in the field. The diameter of the image is thirteen-sixteenths of an inch, the largest made by any except that of the 13-inch instrument of the Harvard Observatory party. In this camera ten plates were exposed, varying from half a second to ten seconds. The plates used were Passavant, "C. I. P.' and "H. L.," with a sensitometer register of 22 and 15 respectively. Wm. F. Booth recorded, and Marston Campbell uncapped and capped the lens, I exposing the plates myself.

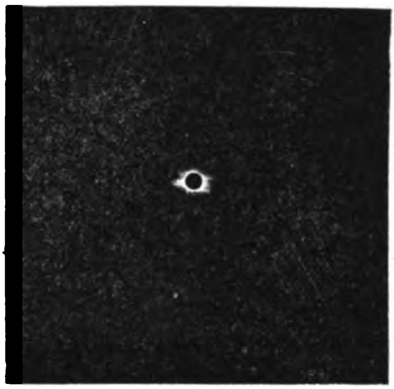
W. H. Lowden made special preparations with a view to obtain a long exposure on the corona. For this purpose he used an 11 x 14 camera mounted in such manner that during exposure he could follow the moon and keep it in the cen-

From a photograph by Geo. W. Dornin; exposure 10 sec.; from 53d to to 63d sec. of totality; focus, 17-inch; plates. Seed 25s.

From a photograph by A. J. Treat; exposure 6 sec.; Passavant plate 15 sensitometer; Darlot No. 3 lens, 12 inches back focus.



From a photograph by V. J. Rey, Miss H. Rey, assistant; lens, double combination No. 1; euryscope; focus 8½ inches; plate, Seed 26; exposure between 47th and 49th seconds of totality.



From a photograph by B. W. Runyon assisted by A. P. Redington; Steinheil antiplanatic double lens; stop, largest size; focal length, 10⅞ in.; H. L. plate, Passavant special; exposure 4 sec., 65th to 68th.

From a photograph by W. C. Gibbs; Lancaster single-view lens, 22-inch focus; exposure 1 sec. from 31st to 32d; C. I. P. plate, sensitometer 22.

From a photograph by C. F. Montealegre; exposure, 3 sec., 18th to 21st; Morrison sencoscope, 3 in. aperture; Eastman's American film plate trans-[illegible]d to and left on the glass, (hence [illegible]ersal of the poles).

ter of the plate. A Beck lens of twenty-two-inch focus with a three-inch aperture was used, and on top of the camera he mounted a two-inch telescope. Two exposures were obtained, one of forty-one seconds and one of twenty-eight, the latter embracing the last second of totality. These were made on extremely slow plates prepared by Dr. Passavant, which, being very rich in silver, were expected to show the detail of the extreme outer corona. The plates have been developed and are regarded as very successful. The corona is shown to a distance of nearly two diameters on each side of the moon, while the movement of the image is not perceptible, showing that the apparatus was well adapted to the difficult experiment, and carefully handled. Mercury is distinctly shown on both plates. Mr. Lowden made the mounting for this box himself, and it worked in a very satisfactory manner.

Mr. Yale took up with him a set of meteorological instruments furnished by Melville Attwood, John Roach and the Chabot Observatory. Mr. W. B. Ewer kept the records. The wind was so light that the anemometer scarcely recorded it. The black-bulb thermometer exposed to the sun recorded 69½ at 12:35, 62 at 1 P. M., 61 at 1:15, 52 at 1:35, 46 at 1:45 and 42 during totality. The dry-bulb thermometer registered 55¼ at 12:35, 54 at 12:50, 55½ at 1:07, 54 at 1:25, 57 at 1:40 and 51 during the total phase. The wet-bulb thermometer ran down from 51½ to 49, the latter figure during totality. The barometer dropped 5-100 during the total phase, quickly returning to normal, 39.093, on its conclusion.

I feel that I cannot close this already long article without mentioning our very narrow escape from our total failure. A light cloud covered the face of the moon and was photographed by Mr. Oliver only one and one-half minutes before second contact, and drifted off only thirty seconds before, and another light cloud again covered the moon only two minutes after the end of totality. I wish also to record the fact that the general light—visually speaking—was fully four if not five times brighter than bright moonlight and our lanterns were not needed.

AUTOBIOGRAPHY OF ALVAN CLARK.*

Some years ago, when residing in Cambridge, I became acquainted with the late Mr. Alvan Clark, the distinguished astronomical instrument maker, and after coming to Washington I had some correspondence with him. Among his letters is one containing his autobiography, written at my request ten years ago last October. If you think it would be of interest to the readers of the *Register* you may publish it there:

Cambridgeport, Oct..................1878.

MY DEAR SIR:

The account of my career you have desired I can write in pencil more conveniently than with ink. I have written but little in my life, and less of late than ever; so it is hard and slow work for me.

My father's name was Abram, and he was born in Harwich, Mass.; and my mother was Mary Bassett, born in Dennis, Mass. They removed to Ashfield, Franklin County, Mass., in 1794, where I was born, March 8, 1804. I was the fifth son of ten children, seven sons and three daughters; five of us are living at this date.

Our farm of 100 acres was one of the roughest and most rocky in that rough and rock town, and over the greater part of it, when I was a lad, the stumps of the primitive forest trees, mostly hemlock, and some very large, were standing. Two splendid trout brooks joined near the lower or eastern border of the farm, upon the larger of which is a grand waterfall near the middleof the farm, but being three and a half miles from the center of Ashfield, and about the same distance from Conway and Goshen centres, it has attracted little attention. The year I was born my father built a sawmill just below the confluence of these streams, and close upon the line between Conway and Ashfield. It was a fourth of a mile from the house in plain sight and of course a prominent object in my childish thoughts. It was washed away after standing seven years, but rebuilt when I was eight. I concluded then I should be a mill-wright, being

* Communicated to the *New England Historical and Genealogical Register* by Hon. William L. Richardson, LL. D., Chief Justice of the Court of Claims, Washington, D. C.

wonder-struck by the achievements of Capt. Gates, the chief in this work of rebuilding.

The first school-house in the district was located on our farm, and built when I was seven years old. At times forty scholars have attended there where now they can scarcely muster ten, and I sometimes might be inclined to fear that in forsaking a home abounding in inviting influences, my example had been pernicious, were it not that I see with regret the same depopulation going on almost all over the rural portions of New England.

An old grist mill located by the waterfall, built before I was born, was purchased by my father when I was about twelve. The school, the farm and these mills busied me until about seventeen, when I began to think that perhaps I might be better fitted for some other calling, and I went into a wagon-maker's shop and worked about a year with an older brother, but returned to the paternal mansion and put myself at work in good earnest to learn alone engraving and drawing, though I had first visited Hartford, and seen something of such works which were cheerfully explained to me, green as I was, by strangers well skilled, of which there were a number at that time in the place. I visited Boston in the autumn of 1824, carrying with me specimens to show my proficiency, which though not great, was sufficient to secure me a living employment for the time.

Supplying myself with some of the most needed art materials I returned to Ashfield the next May, and spent the summer as studiously as possible, with no settled plans further than the acquisition of skill. In neighboring towns I offered my services in making small portraits, some in India ink and some in water colors, and with a pretty satisfactory measure of success.

Here I must give you one little incident which tends to show what small matters can change the course of a human life. Wanting some fine sable hair brushes, I sent for them by a man in the habit of visiting Boston. Upon looking over a piece of newspaper in which they were wrapped when received, my eye fell upon an advertisement of recent date, headed, "Engravers Wanted." I was not long in making up my mind to apply for the situation. On reaching Boston I found the engravers were wanted at the engraving shop of the Merrimac Works in East Chelmsford for calico printing. The agent informed me that they had just contracted with Messrs. Mason and Baldwin of Philadelphia to do their engraving, and that one of the firm would soon be in East Chelmsford and very likely would employ me as an assistant.

Mason at once on his arrival offered me eight dollars per week for one year and nine dollars per week for three succeeding years, with opportunity for learning the art in which they were engaged. I was to work nine hours in winter and ten in summer per day, which terms I accepted. Such pay would now be considered small for a beginner in housekeeping, but I was able to supplement it a little by painting and cutting stamps out of the shop.

I have always felt that I incurred a very serious risk in marrying as I did. My wife, Maria, was the daughter of Asher Pease, and was born in Enfield, Conn., Nov. 30, 1808. The family removed to Conway and settled on a farm within half a mile of my own father's residence in 1811, where she resided with her parents until our marriage, except for a short time she boarded in the family of Dr. Edward Hitchcock, while he was settled preacher in Conway, previous to his taking the Presidency of Amherst College,—this for the purpose of attending a select school. After remaining about six months in E. Chelmsford, I invited my father to accompany this young woman to the place, which he did, and we were married, as the record shows, on the 25th of March, 1826.* My employer, Mr. Mason, was very kind, and procured credit for me, that we could arrange for housekeeping in an unpretentious way, where I felt that we were established for three years and six months at least.

But a disagreement sprang up between Mason & Baldwin and their employees, resulting in Mr. Masons' returning to Philadelphia; but previous to leaving he offered to cancel our engagement, or take me with him to Philadelphia to serve it out, or he would open a branch shop in Providence R. I., and give me charge of it, with pay of $10 per week and one-fourth the profits. I accepted the last proposition,

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* This was the first marriage in the *town of Lowell*. That part of Chelmsford called East Chelmsford was incorporated as Lowell, March 1, 1826. The first town meeting was held at Colburn's Tavern, March 25, 1826, and Mr. Clark was married on that very day, by the late Rev. Theodore Edson.—W. A. R.

as there was no chance that I could remain in the Lowell shop with comfort, for they had imported English engravers who had no notion of allowing the secrets of their art to slip into the hands of Americans. Our tarry in Providence was of only about one year's duration, when this branch of Mason & Baldwin's Works was removed to New York, where I continued on the same terms with them, until the spring of 1832, at which date I received an offer from Andrew Robeson for my services at his print-works in Fall River, such that I was induced to relinquish my connection with Mason & Baldwin. We had but just settled in Fall River when the cholera broke out in New York. Before passing I would say, the partner of Mason was M. W. Baldwin, afterwards the famous builder of locomotives. While residing in New York I had excellent opportunities for studying painting, and practiced all I could, and never gave it up even after removing to Fall River.

In 1835, Lucius Mantrus Sargent was invited by temperance people to give a lecture in each of the churches in the place, and as he was to be several days there, I sought a seasonable opportunity for inviting him to give me sittings for an ivory miniature. During these sittings I questioned him as to my chance of success as a miniature painter in Boston. He asked what practice, or experience, or opportunities for instruction I had thus far enjoyed in the art? After receiving my replies and preceiving that my heart was in it, without committing himself by advice he wished to know the highest price I had ever received for a picture, and when I stated $20 he said he wished to take this home with him and also to pay me $40 for it. This was an expression of liberality to which I had been quite unused, and caused me to throw up engraving and quit Fall River for Boston. The sympathy and friendship thus opened I was permitted to enjoy through the remainder of Mr. Sargent's life, which was of great advantage to me. I bought the house in Prospect Street, Cambridgeport, in 1836, where I resided until 1860; supporting my family by painting portraits and miniatures in Boston.

In 1844 my son George Bassett Clark, born in Lowell Feb. 14, 1827, had been for a time in the academy at Andover as a student, with the view of qualifying for a civil engineer.

In the course of his scientific reading this youth happened to fall in with some account of casting and grinding reflectors for telescopes, and before mentioning it to me had procured his metal and made a casting for a small mirror. I watched his progress in grinding and polishing with much interest, and perceiving a growing interest on his part I was at some pains to acquaint myself with what had been done, and how done, in this curious art, that my son could have the benefit of my maturer judgment in giving effect to his experiments. We spent much time on reflectors, and found for ourselves that the difficulties which have led to such an extensive abandonment of this form of telescope were really irremediable. The sacrifice here was pretty serious for us with then very limited means. I finally proposed to the youth to try a refractor, but he did not believe we could succeed with it, for the books described it as a very difficult thing.

About this time the great telescope at Harvard College Observatory was put to use, and greatly did I wish to see it and look through it, but Professor Bond informed me that I must come with an order from President Everett before this could be allowed. This order was speedily obtained. I was far enough advanced in knowledge of such matters to perceive and locate the errors of figure in their 15-inch glass at first sight, yet those errors were very small, just enough to leave me in full possession of all the hope and courage needed to give me a start, especially when informed that this object glass alone cost twelve thousand dollars.

I began by reworking some old and poor object glasses of small instruments, there being no material in our market of suitable quality, and after gaining confidence and tact, sufficient, as I thought, to warrant the outlay, I imported one pair of disks of 5¼ inches, and found others in New York of larger size even up to eight inches, of very good quality.

We made some instruments to order and sold some, worked on our own account; but the encouragement was small, until I reported my doings to Rev. W. R. Dawes, the famous double-star observer in England, in 1851. I gave him the places of two new double stars I had discovered the next year with a glass 4¾ inches diameter. One of the stars was in Sextans.

In 1853 I had finished a glass of 7½ inches aperture, with which the companion of 95 Ceti was discovered. Upon reporting this to Mr. Dawes, he expressed a wish to possess the glass, but to test its qualities further sent me a list of Struve's difficult double stars, wishing me to examine them, which I did and furnished him such a description of them as satisfied him that they were well seen. I sold him this glass, and afterward four others, one of which, an eight inch in the hands of Huggins has become well known. Knott, an English astronomer, has one of them 7¼ inches, which he greatly prizes.

Previous to 1859 my correspondence with Dawes had become more extensive than with any other fellow mortal in all my life. I visited him that season, carrying with me one equatorial mounting, and two object glasses, one of 8, the other 8¼ inches. All were admitted without duty at Liverpool, though I paid 30% on the rough glass in Boston; nor was that all, the glass was warranted first quality, and when I informed the deputy collector that a large portion of the amount in invoice was in consideration of the warranty and asked him if any allowance would be made in case it turned out worthless, he said, "No, not a cent, if you buy the devil you may sell him again." The crown *did* turn out defective, and I had to import another and pay 30% again. But we were then under a Democratic administration.

I spent between five and six weeks with Mr. Dawes, visited London with him, and we attended together the visitation at Greenwich Observatory and a meeting of the Royal Astronomical Society, seeing and conversing with many notable personages, among them Sir John Herschel and Lord Rosse. Before taking leave of Dawes, I told him he had paid me more money than I had ever received from one individual in all my dealings with my fellow-men, and it was most gratifying to me that he cordially allowed that I deserved it.

The reports concerning the performance of these glasses, published by Mr. Dawes from time to time, in the Monthly Notices of the Royal Astronomical Society, was of great service to me in procuring orders, without which, situated as I was, the proficiency which comes from long practice could never have been reached. In 1860 Dr. F. A. P. Barnard, now President of Columbia College, New York, then Chief of the University of Mississippi, ordered from us a telescope to be larger than any refractor ever before put to use. I say we, for my two sons G. B. and Alvan G. Clark were well skilled men, on whom my efforts in training had not been thrown away, and who were now ready to embark in an undertaking, the importance of which they were qualified to appreciate.

It now became necessary for us to secure more commodious quarters than had served our purposes thus far, and after visiting various sites, we finally settled where we now are purchasing nearly an acre and one half of land, and erecting our buildings in the summer of 1860. The glass for the Mississippi telescope in the rough was received from the makers, Messrs. Chance Bros. & Co., of Birmingham, England about the beginning of 1862, and within one year from that time Alvan G. Clark discovered with it the companion of Sirius, which after a few days in a fine night Professor George P. Bond was able to see and measure with the 15-inch telescope at Cambridge Observatory. Our glass was 18½ inches, and for the production of such a lens, coupled with this discovery, the Imperial Academy of Paris awarded my son the Lalande prize for 1862.

The war coming on and cutting off all communication with Mississippi, this telescope was sold to parties in Chicago, and is now in charge of S. W. Burnham, who has gained great celebrity by double star discoveries; though much of his work has been done with a glass of only six inches aperture.

We have made many instruments of smaller size, but one of 12¼ inches for the Pritchett School Institute of Glasgow, Missouri; one of 12¼ inches for Dr. Henry Draper, of New York, one of 11⅞ inches for the Austrian Observatory at Vienna, and one of 11 inches for the Observatory at Lisbon, Portugal. Also one of 12 inches for the Wesleyan University of Middleton, Conn., and have now in hand one of 15½ inches for the University of Wisconsin, at Madison.

But the most important work we have ever attempted was making two telescopes of 26 inches clear aperture, one for our government, and one for L. J. McCormick, of Chicago. The orders for them were received in the summer of

1871. The government telescope was delivered in the autumn of 1872, and it was with this instrument that Professor Asaph Hall discovered the two satellites of Mars at the time of its last opposition. The government paid us for this work $46,000. The McCormick telescope is not yet entirely finished, but will be very quickly when provisions are made for it, in the way of a suitable site and buildings, and the support of a competent astronomer.

Now I must give a narrative in response to another query.

Dr. Jacob Bigelow returned from a visit to Europe soon after the great telescope at Cambridge was placed in the Observatory. Knowing that he had been in Munich where it was made, I asked him one day in the street if he saw the establishment where it was made? He answered in the negative. When I informed him that I was interested in such matters and was then at work upon object glasses, he remarked, that if I wished to learn to make telescopes I must go where they make them, and passed along. Some years later the Rumford Committee sought information as to what original means or methods I employed. My reply was that I knew so little of the doings of others that I could not say, but if they would meet at our shop, I would explain to them as well as I could the steps by which I had been in the habit of bringing object glasses into figure.

The result was the Rumford prize was awarded me for a method of local correction. Upon the occasion of its presentation, the Academy meeting was attended by Dr. Bigelow. The president, Professor Asa Gray, stated the grounds on which the award was made, and I replied as well as I could. Charles G. Loring and Dr. Bigelow were seated near, and I heard one say to the other, "that was well done." After the adjournment I reminded Dr. Bigelow of his saying that if I wished to learn to make telescopes I must go where they make them, and added that I had been. "Have you, where?" Cambridgeport was my reply.

I met Dr. Hare at the August meeting of scientists at Albany in 1856. Finding him soon after in Boston, I invited him to sit for a portrait, which I finally sold to Dr. Henry for $100.*

So you will perceive that the three periods of my life of

* This was Professor Joseph Henry, Secretary or Director of the Smithsonian Institution at Washington, where the portrait is still preserved.—W. A. R.

which you write, have been considerably blended. Lives thus changeful are frequently troubled in their finances, but I have been fortunate enough to meet my money promises all along, and have a fair reserve for a rainy day.

I have received the degree of A. M. from Amherst, Chicago, Princeton and Harvard. I have read much popular astronomy, but in its mathematics I am lamentably deficient. You will see by the printed papers I shall send with this that I have made some use of telescopes. I have lived to see the companion of μ *Herculis* therein mentioned go through considerably more than half a revolution.

This is the most of an autobiography I have ever prepared, and my condition is such that I shall probably never make another attempt, so I would like you to preserve this after selecting your points, for some of the Ashfield people may be pleased to see it. Let me know at once if it is safely received, and when you puplish send me a copy of your production.

I will add further what may be of interest. I have always voted with the Republicans when voting at all since they came into power, but have never attended caucuses or held an office. I have never been a church member, nor had either of my parents, but my faith in the universality of God's providence is entire and unswerving. My grandfathers died one at 87, and the other 88. I knew them well, and they were good men. Both had been engaged in killing whales.—I have never heard of one of my progenitors —Thomas Clark* of the Mayflower was one—as being a bankrupt, or grossly intemperate.—I was never but once sued, and in that case employed Joel Giles as counsel, who made a compromise without going to trial. I never sued but one man, and that was Collector Austin, and I gained my case. I never studied music or attended an opera in my life, and know nothing of chess or card playing.—I never learned to dance, but was a good swimmer, though lacking generally in the points which go to make an expert gymnast.—I have long been a member of the American Academy of Arts and Sciences, and my son G. B. enjoys the same honor more recently conferred.

I hope the above will serve your purpose.

Yours with great esteem,

ALVAN CLARK.

* From whom Clark's Island, near Plymouth, takes its name.

TOTAL SOLAR ECLIPSE, JAN. 1, 1889.

PROFESSOR WINSLOW UPTON.*

For THE MESSENGER.

The following account of the observations made at Willows, California, by Mr. A. L. Rotch, proprietor of the Blue Hill Observatory, and myself may be of interest.

We located at Willows, California, about 2,700 feet W. N. W. of the station occupied by the Harvard Observatory party. Our selection of Willows was by invitation of the Harvard party, and our observations supplement those made by Mr. Pickering and his assistants. We were obliged to go to a different part of the town, however, to secure proper exposure of the wind instrument. The observations planned were chiefly to detect the atmospheric fluctuations caused by the withdrawal of the sun's heat, and to observe the shadow bands.

The instrumental equipment consisted of three sensitive aneroid barometers and one self-registering barograph, wet and dry-bulb thermometers, self-registering maximum and mimimum thermometers of special sensitiveness, a pair of black and bright bulb thermometers in vacuo to determine the solar radiation, a self-registering Violle actinometer, a self-registering anemometer of the Robinson pattern and a sensitive self-registering wind vane. Besides these meteorological instruments were a field chronograph, a three-inch telescope and a small camera. The wind and radiation instruments were mounted upon the railing of a tower about forty feet above the ground, and the suitable exposure of all the instruments was carefully secured.

The observations consisted of five minute readings of all the meteorological instruments except those which were self-registering. During totality a 60-second exposure was made, the camera pointed upon a newspaper fifteen feet from it, in order to determine the brightness of the sky during the eclipse, as requested by Professor Todd. Special attention was given to the shadow bands, both observers and two others joining in this part of the work. Part of the plan was an attempt to photograph them for which purpose

* Professor of Astronomy in Brown University, Providence, R. I.

two large white screens were erected, one vertical, the other inclined 45°, 27 feet from the camera. The contacts were observed and sketches of the corona made.

The results of work may be stated summarily as follows: The temperature fell 5° and reached its lowest point ten minutes after the total phase; the humidity rose thirty per cent; the dew fall was not appreciable on the ground, but papers were perceptibly dampened; the barometric pressure fell and rose but nearly in the usual diurnal curve; the wind died down nearly calm, and increased after totality; its direction, which was north, suffered a slight deflection towards the west near the time of the total phase. All of these effects can be ascribed to the eclipse. The shadow band observations were not as successful as had been hoped. Besides the white screens mentioned above, white sheets were spread upon the ground, and all four observers watched for them carefully both before and after the total phase, while one observer watched for them also during totality. The writer was the only one of the observers who saw them at all, and his view was a mere glimpse thirty-four seconds before the beginning of totality. They were about an inch wide and 3 to 4 inches apart, apparently stationary, and were seen upon the vertical screen towards which the camera was pointed. An exposure of one-fifth second was made. The plate on development showed no sign of the bands, but the fact that the screens are well defined and also the shadow of a tree upon them shows that the photographic power of the light, even so near totality, is remarkably strong. The plates used were Seed plates, very sensitive.

The shadow band observations were made in accordance with a plan by which records of the same kind were to be secured at a number of stations, as explained in a circular which had been widely distributed. Fourteen reports have been received. It is shown by them that the bands in this eclipse were faint and narrow. The estimates of velocity are various but all the reports agree in assigning the direction in which they lay before the total phase as N.E. to S.W. Other interesting facts will be brought out when the records are discussed.

The first contact was lost from clouds; the others were carefully observed and the comparison with the times calculated from the date in the American Ephemeris is as follows:

	CALCULATED. h m s	OBSERVED. m s
Second contact..................	1 47 46	47 48.5
Third contact.....................	1 49 42	49 47.0
Fourth contact..................	3 7 46	7 43.5

During totality it was perfectly easy to read the seconds dial of a white watch face, and the brightness was about that 20 minutes after sunset on the same evening. The sky was perfeetly clear in the region occupied by the sun during the time of totality and the corona observed under specially favorable conditions.

TOTAL SOLAR ECILPSE REPORT.

J. A. BRASHEAR.

For the MESSENGER.

I am not certain that my work on the eclipse is of any great value. I decided to go at such a late date, that I had little time to prepare for it; in fact, four days before starting I had no telescope; in that brief period I had a 4⅛-inch refractor ready for shipment. It is perhaps as fine a glass as we have ever turned out, and Mr. Burckhalter would not let me bring it away from San Francisco, but kept it "right there" as he enthusiastically said. At the request of Professor Very, of the Allegheny Observatory, I made as nearly as I could, a sketch of the south polar corona, confining my work to that alone, though I was tempted by the beauty of the scene to drop pencil and look. I believe it was of Professor Peters that the story is told, that he was asked what instruments he would take to the next eclipse and he replied "a pillow," and so I felt. Our station was at Winnemucca, and Professor Howe with Col. Maxson had made arrangements with Dr. Elkin, of Yale University Observatory and Mr. Henry Phipps of Allegheny. Col. Maxson's camp was about 1½ miles from the town where two tents were put up, and the instruments set. It is not necessary to give the names of the party for they have been published already.

The day dawn was exquisite. I had walked about four miles from the town before sunrise to see the glorious orb of day come up from the eastern mountain range. I was not disappointed. I saw a sight never before witnessed. The color display around the sun was glorious; but all at once a column of the loveliest hues stood up before me with its apex in line with the sun, and its base, like that of the rainbow, resting in a "pot of gold" not far off yet ever receding as I advanced. I found it was caused by ice crystals that were being driven to the westward by a gentle breeze, and the dark background of the mountain bringing it out in glorious relief. But this is not the eclipse of the sun, is it? Well, everything was ready by the time the moon was to put in an appearance. In order to help Professor Howe I took first and last contact, rating my watch from his chronometer, which was corrected from signals from Lick Observatory. My first contact was a little slow, perhaps two seconds, as I was carefully watching to see if I could not catch the moon's limb projected on the solar corona. The point of first contact being a little high in the field I did not see the limb of the moon until contact, although I do think it should have been seen in that exquisite atmosphere. I had an excellent polarizing helioscope with me, and as the moon's limb advanced on the sun's disc the projection of the lunar mountains, presumed to be the Doerful Mts., was clear cut and well defined as I ever saw them, and the granular surface of the sun came out beautifully. Professor Howe and Mr. Davidson coincided with me in this, after observing it with the four-inch telescope, using the polarizing eye-piece.

As totality approached, my sketching arrangements were made ready and consisted of a piece of plate glass half of which was finely ground and the other half left plain, the line between the two being a curve representing the limb of the moon. This made a splendid sketching plate when it was feebly illuminated by a lamp behind it and it could be used as a photographic negative reproducing in white the black pencil lines. I had practiced sketching frost crystals rapidly and when totality brought out the delicate structure of the polar corona I did my best to sketch the finer detail of the south polar corona, at the same time outlining the two beautiful protuberances that were at either edge of the field, one of which was very interesting from the fact that a tongue of flame had become detatched from that part resting on the sun's limb.

The chromosphere was observed in all its gorgeousness and simply outlined, as I stuck to my task of sketching a few degrees of the south polar corona.

After the appearance of the sun I shifted the telescope so as to observe how long I could see the coronal fringe. I was certain I saw it well for half a minute, and the hazy light could be seen for some seconds afterwards. The last contact agreed with Professor Howe's observation within half a second.

Finally I must say that the good people of Winnemucca were very kind, and Col. Maxson did all he could to make the work of the party a success, and the eclipse of Jan. 1, 1889 will long be remembered. Professor Howe is an enthusiastic man, and he will succeed. Dr. Elkin was not well, so he observed at the hotel.

WASHINGTON UNIVERSITY ECLIPSE PARTY.

PROFESSOR C. M. CHARROPIN.*

The party from St. Louis was composed of Professor Pritchett, in charge of the Washington University party, and Professors Nipher and Engler of that University and myself. We had been provided with all necessary instruments for making the observations, some of which had been kindly placed at our disposal by the government, and all these had been sent on before, and we went with the determination of making the most of the splendid opportunity that was open to us, providing there should be no clouds or hazy atmosphere to interfere with the observations. Professor Pritchett had determined to make Norman as our observing station, this being considered the most favorable spot in the Sacramento valley. We had sent our instruments to Willows, but we were unwilling to settle at that point, the station being already occupied by Professor Pickering and party of Harvard College.

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At Willows we were kindly received by Professor Pickering, who invited us to his station. We found him well equipped, with two 13-inch telescopes equatorially mounted, spectroscopes, cameras, etc.

Early next morning we were at the railroad station, but to our great disappointment we were informed that the freight train was six hours behind time. Professor Engler, who had an eye to business, perceived a locomotive and he at once telegraphed to the superintendent at Sacramento for the use of the locomotive to pull our freight car to Norman. A quarter of an hour later a message from Sacramento announced that our request had been granted. Through the kindness of the superintendent we were landed safely at Norman about 9 o'clock A. M., and here I must acknowledge the great kindness of the railroad men all along the line.

The remainder of the day was spent in building sheds and placing our telescopes in position. We were all delighted with our station; a beautiful little cottage with roses in bloom in front of the house, good-hearted and jovial companions; our location on the very center of totality; no one to disturb us we formed a happy little family. Professor Valle of the University of Tacubaya, just outside the City of Mexico, had joined our party, and his services were valuable to us. Five days of preparation were left us, and not a minute of time was lost. Professor Pritchett had assigned to each astronomer his special task. Our astronomical clock at first refused to do its duty, but under the control of Professor Nipher it soon learned to obey. Many photographs were taken to test the power of the government lenses, and we obtained very fair negatives of the crescent moon, of the sun, of Venus and other celestial objects, and terrestrial scenes were also photographed. The camera I had brought along did not remain idle. We obtained good negatives of the station, of the instruments, the surrounding mountains, etc. Even an instantaneous shot at a flock of wild geese left its impression on the sensitive plate. Finally the great day came. Our preparations were complete and our exact latitude and longitude had been determined by many observations. But a cloudy sky seemed to cast a gloom on the faces of the observers; one alone appeared to be confident of success.

The supreme moment approached. Each astronomer was at his post; a solemn silence prevailed. The sun peeped through the clouds, but soon was veiled again.

"Time!" called the observer at the chronometer. The first contact was lost.

The look of anxiety depicted on the contenance of every observer would have been a fit subject for the camera, but the camera was idle. Few words were exchanged, but our silence spoke volumes.

A special train then arrived from San Francisco. Mr. Rideout and family, Senator Boggs and many friends were present. A sumptuous lunch had been prepared, but the astronomers had no appetite. Clouds on clouds swept over the sun, the darkness now became apparent; nature assumed an unearthly appearance; a greenish, awe-inspiring light shone on the tips of the neighboring mountains. Suddenly the clouds opened, the sun and moon appeared in a clear blue sky. A shout of joy and admiration burst forth from every pair of lungs. The last lingering ray of the sun disappeared; the corona burst forth in all its glory and majesty; four planets and many stars shone brightly. A perfect silence followed, disturbed only by our astronomical clock beating the half seconds.

Our observations were very successful, Bailey's beads were distinctly seen. We have six excellent negatives of the corona, showing all the details of the streamers of the outer corona Six protuberances are distinctly marked. These red flames of hydrogen, being nonactinic, were supposed to be beyond the reach of a gelatine plate during a short exposure, but, thanks to Mr. Seed, who had made a special emulsion for the eclipse party and furnished us with excellent plates, our success was beyond all expectation.

After shakings of hands and mutual congratulations, we packed carefully our instruments and left for San Francisco on the following day. There Professor Prichett gave to his party, at the Palace Hotel, a grand eclipse dinner. The same evening the party left for Mount Hamilton. Sickness detained me two days at Santa Clara College. From the college I could see the Lick Observatory over-towering the clouds. It was painful to an astronomer to see at a distance the land of promise and not be able to enter it. My party could not wait for me. They started with a heavy rain, spent two days at Mount Hamilton well impressed with the grandeur of the monster telescope, but the seeing was poor on account of the bad weather. Returning, they met me climbing up the slope with a team of two fine horses. In a bee-line the Lick Observatory is 13 miles from San José, our starting point. But the road, which is like "a wounded snake dragging its slow length along," is 27 miles. After a ride of six hours I arrived at the Observatory. The scenery is gorgeous. The deep canyon; the brilliant effects of a rising sun on distant mountains; the snow-capped Sierra Nevadas 200 miles away; the deep valleys covered with a carpet of green grass, are descriptions which belong to the poet and should be left untouched by the astronomer.

Professor Holden, who is not only a great astronomer, but a scholar and a perfect gentleman, received me with the greatest cordiality. He gave me the use of the great telescope for two hours. From 12 midnight to 2 o'clock in the morning I feasted my eyes on celestial objects.

The night was clear and beautiful, Saturn was a beautiful object. It appeared much larger in the telescope than the moon appears to the naked eye. The markings on the sphere of the planet were well defined and extended almost to the poles. Seven moons shone brightly, but coy Mimas was hidden behind the old god. The nebula in Orion was another object of great interest, but it baffles all description. The six stars of the Trapezium were separated, and the "Nova," Alvan Clark's star was barely visible. Nebulous matter extended far beyond the field of the telescope. I next observed double stars and nebulæ, objects familiar to me, but how differently they now appeared. How insignificant to me is my small telescope which but lately I prized so much. The large telescope weighs 10 tons, and yet it is so well balanced that I could move it with one hand. At 2 o'clock A. M. Professor Schæberle brought me to my room. After a good rest and a hearty breakfast Professor Holden brought me to his sanctum. He showed me excellent photographs of the moon, the work of Professors Burnham and Barnard, who are excellent artists as well as good astronomers. I had a long talk with Professor Holden, whose conversation is both interesting and instructive. The next part of the program was to climb up the hill. We formed a party of three, Professor Swift of Rochester, N. Y., Professor Barnard, the discoverer of twelve comets, and myself. We visited Mount Copernicus, Mount Galileo and Mount Keppler. From the last named we had a sight of the Pacific Ocean, fifty miles distant. Professor Barnard was our leader. He climbed up the steep cliffs like a deer, encouraging us to follow him by both word and example. A more genial companion than Professor Barnard I never met before. It is difficult to say what is to be admired more in him —the efficient astronomer, the refined gentleman or the genial companion who seems to forget himself in order to make his guests happy. The remembrance of Mount Hamilton shall not soon fade from my memory.

AMATEUR ASTRONOMY.

The friendly relations which were established between the professional astronomers at Mount Hamilton and the amateur photographers and amateur astronomers of San José and coast on the occasion of the recent eclipse of the sun have almost spontaneously resulted in the formation of an astronomical association. Just prior to the eclipse a pamphlet of information relative to it was issued from the Lick Observatory, and was widely read and followed by the many photographers and amateur astronomers, and the community of interests led to friendly relations and intercourse. During the first week of last month these culminated in the initiatory steps being taken toward the formation of the Astronomical Society of the Pacific Coast, as first suggested in the field on January 1st. The meeting was immediately followed by a discussion of the constitution and by-laws of the new association referred to.

The following temporary officers were elected to hold office until the the annual election of officers, which will be held on the last Saturday in next month: Edward S. Holden, president; J. M. Schæberle, vice-president; C. Burckhalter, secretary; E. J. Molera, treasurer. The newly elected officers at once agreed to issue a circular inviting all who take a genuine interest in astronomy to join the society. The circular which was adopted sets forth that meetings shall be held part of the year in San José and the remaining portion at Mount Hamilton Observatory; and that a journal devoted to the astronomical interests of the coast and the diffusion of general knowledge on astronomy should be established. The names of thirty-four private individuals were set down as members, and copies of the circular will be at once forwarded to the members of the Academy of Sciences, the Technical Society, the Microscopical Society, the Geographical Society, the Historical Society of San Diego and other similiar bodies, as well as the various colleges and universities of the coast.

The constitution and by-laws were then discussed and adopted. The object of the society is therein set forth simply as the advancement of the science of astronomy. The headquarters of the society are to be in San José, and until suitable quarters have been obtained the annual meetings will be held on the last Saturday in March in the rooms of the Amateur Photographers' Association. Eleven directors will have control of the business of the society and special officers will be appointed and paid as such are required. An astronomical library is to be formed under the care of a librarian. The meetings will be held every two months, those in May, July and September in the library of the Lick Observatory, those in January, March and November in San José, all meetings being held on the last Saturday of each of the months named.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury may be seen in the morning during the first half of March, rising in the southeast about an hour before the sun. During the latter part of this month and the whole of April he will be too near the rays of the sun and too far from the earth to be well seen. No doubt many of our readers noticed how conspicuous this planet was in the southwest after sunset during the first few days of February.

Venus will be at her greatest brilliancy March 25. No doubt many have noticed during the past month the perceptible shadows which are cast by objects in the light of this planet. The writer was considerably surprised a few evenings since, on opening the dome towards Venus, to notice the intensity of the shadows of the equatorial thrown upon the opposite wall of the dome. Several very fair telescopic views have been obtained but none when the seeing could be called perfect or even excellent. No markings could be detected on the illuminated half of the disk but the gradual shading off at the terminator, indicating twilight in the atmosphere of the planet, was very perceptible. Although the phase was only slightly gibbous, considerably more than half the disk was illuminated. Venus is easily visible in full sunlight during the afternoon. Several persons have written concerning their own observations, and the writer has several times, while walking across the college grounds, detected the planet by a single glance at that portion of the sky where it was known to be. The phase of Venus is diminishing rapidly, the illuminated portion of the disk being 0.356 March 15, 0.276 March 25, the time of greatest brilliancy, and 0.084 April 15, while the apparent diameter of the disk will increase from 33.2″ March 15 to 53.4″ April 15.

Mars, though still visible in the early evening a little west of Venus, is so distant from the earth that its apparent diameter is only 4.3″, so that no detail can be made out upon its surface.

Jupiter is coming in good position for observations in the morning and we give again the phenomena of the satellites which may be observed and the approximate times of transit of the great red spot across the center of the disk. An interesting report on the observations of Jupiter in 1887 and 1888, is given by Mr. W. F. Denning in the December, last, number of the Journal of the Liverpool Astronomical Society. Few observers have paid much attention to the red spot, but a long series of observations by Mr. A. Stanley Williams at Brighton gives for the rotation period of this spot 9*h* 55*m* 39.6*s* or 1*s* less than the period adopted in Mr. Marth's ephemeris. Eighteen observations of an equatorial white spot give for its period of rotation 9*h* 50*m* 28*s* or 5*m* 12*s* less than that of the red spot. Mr. Williams says: "A gradual change took place in the whole aspect of the planet in the course of the opposition of 1888. Last year nearly all the equatorial spots both white and dark, were ranged along the south equatorial belt. In the latter part of the previous opposition corresponding white spots had formed by the north equatorial belt, opposite to nearly all the white equatorial spots by the south belt, the two opposed spots being generally connected by a white streak. Most of the dark equatorial spots south of the equator also had corresponding dark spots opposite to them, connected in many cases by dark streaks. The equatorial region then had a curious uniformity of appearance. A number of little dark spots also appeared in the equatorial belts, frequently connected by a faint dusky shade between the spots on the several belts. These were somewhat delicate features sometimes. When several sets of spots with their connecting shades were visible at once, the aspect was rather curious; the streaks on either side being, of course, curved, and appearing to radiate from the pole. The spots on these belts all had rotation periods approximating to that of the red spot." An occultation of Jupiter by the moon will occur on the morning of March 24, visible throughout the United States. The Washington times of beginning and end are given in the tables of occultations. Although this occultation will occur in sunlight or strong twilight at most points where it is visible, it may be observed without great difficulty with a telescope of moderate power. At Carleton College Observatory the duration will be 49 minutes for the center of the planet beginning at 5:14 and ending at 6:03 A. M., Central time.

Saturn will also come very near being occulted by the moon March 13 at midnight, his distance from the center of the moon as seen from the earth's center being only 60′ south. In northern latitudes the parallax of the moon will bring its southern edge very near to if not over the planet. Saturn is in excellent position for observation so that splendid views of the rings and the surface of the planet may be obtained on any clear night. In the *Monthly Notices* of the Royal Astronomical Society there is an interesting paper on "*Retrogradation of the Plane of Saturn's Rings,*" in which the author gives a table of the times of disappearance and reappearance of Saturn's rings for the four epochs 1848-49, 1861-62, 1878 and 1891 and the recorded observations during the first three epochs. In 1891 there will be but one disappearance from September 23d 15.9*h* to November 2d 16.9*h*, Berlin mean time. The disappearance cannot be observed as the planet will be within a half hour from the sun, but there may be some chance for the reappearance, Nov. 2, when the planet will rise over two hours before the sun.

Uranus will be at opposition to the sun April 9, and therefore in good position for observation. It is to be hoped that the observers with the Lick telescope may be able to detect some marking upon this planet which will enable them to determine its period of rotation, about which we know nothing. Uranus may be found in the east, after 8 o'clock P. M., in Virgo about 3° north of Spica.

Neptune may still be seen in the early evening about 5° directly south of the Pleiades.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
MERCURY.					
Mar. 20	22 25.2	−11 47	5 15 A.M	10 31.6 A.M.	3 48 P.M.
25	22 51.1	− 9 40	5 13 "	10 37.8 "	4 03 "
30	23 18.9	− 7 01	5 10 "	10 46.0 "	4 22 "
April 5	23 54.6	− 3 11	5 07 "	10 57.8 "	4 49 "
10	0 26.4	+ 0 30	5 04 "	11 09.9 "	5 15 "
15	1 02.3	+ 4 35	5 03 "	11 24.0 "	5 42 "
VENUS.					
Mar. 25	2 43.7	+21 41	6 54 A.M.	2 29.9 P.M.	10 06 P.M.
April 5	2 57.8	+23 34	6 15 "	2 00.6 "	9 46 "
15	2 55.8	+23 38	5 34 "	1 19.3 "	9 05 "
MARS.					
Mar. 25	1 41.9	+10 28	6 43 A.M.	1 28.3 P.M.	8 14 P.M.
April 5	2 13.0	+13 23	6 18 "	1 15.8 "	8 13 "
15	2 41.3	+15 48	5 57 "	1 04.8 "	8 13 "
JUPITER.					
Mar. 25	18 29.9	−22 58	1 52 A.M.	6 18.1 A.M.	10 44 A.M.
April 5	18 33.6	−22 56	1 08 "	5 33.8 "	9 59 "
15	18 35.5	−22 55	12 30 "	4 56.3 "	9 22 "
SATURN.					
Mar. 25	9 06.4	+17 50	1 34 P.M.	8 51.3 P.M.	4 09 A.M.
April 5	9 05.2	+17 54	12 49 "	8 07.0 "	3 25 "
15	9 05.0	+17 55	12 10 "	7 27.4 "	2 45 "
URANUS.					
Mar. 25	13 17.0	− 7 26	7 27 P.M.	1 01.3 A.M.	6 35 A.M.
April 5	13 15.2	− 7 15	6 42 "	12 16.3 "	5 51 "
15	13 13.6	− 7 06	6 00 "	11 35.4 P.M.	5 11 "
NEPTUNE.					
Mar. 25	3 53.0	+18 35	8 18 A.M	3 38.7 P.M.	10 59 P.M.
April 5	3 54.2	+18 39	7 36 "	2 56.7 "	10 18 "
15	3 55.5	+18 43	6 57 "	2 18.6 "	9 40 "

THE SUN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Mar. 20	0 01.3	+ 0 08	6 03 A.M.	12 07.4 P.M.	6 12 P.M.
25	0 19.4	+ 2 06	5 53 "	12 05.9 "	6 19 "
30	0 37.6	+ 4 03	5 44 "	12 04.4 "	6 25 "
April 5	0 59.5	+ 6 21	5 33 "	12 02.6 "	6 32 "
10	1 17.8	+ 8 13	5 24 "	12 01.2 "	6 38 "
15	1 36.2	+10 02	5 15 "	11 59.9 A.M.	6 44 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Mar. 18	80 Virginis	6	13 03	157	14 07	268	1 04
23	Jupiter		18 34	46	19 35	314	1 01
April 4	θ^3 Tauri	5	6 21	121	7 20	219	0 58

Phases of the Moon.

	Central Time. d h m
Full Moon	March 17 5 47.2 A.M.
Last Quarter	" 24 12 54.4 A.M.
New Moon	" 31 5 37.4 A.M.
First Quarter	April 8 7 4.70 A.M.
Full Moon	" 15 4 18.6 P.M.

Phenomena of Jupiter's Satellites.

Central Time. d	h m		Central Time. d	h m	
March 18	2 44 A.M.	III Ec. Re.	April 2	3 03 A.M.	I Ec. Dis.
	3 16 "	I Tr. In.	3	1 31 "	I Tr. In.
	4 15 "	I Sh. Eg.		2 29 "	I Sh. Eg.
	5 16 "	III Oc. Dis.		3 37 "	II Tr. In.
	5 32 "	I Tr. Eg.		3 43 "	II Sh. Eg.
19	2 46 "	I Oc. Re.		3 47 "	I Tr. Eg.
25	3 53 "	I Sh. In.	5	3 03 "	III Tr. In.
	3 54 "	II Ec. Dis.	9	4 56 "	I Ec. Dis.
	4 14 "	III Ec. Dis.	10	2 07 "	I Sh. In.
	5 00 "	I Tr. In.		3 23 "	I Tr. In.
26	4 40 "	I Oc. Re.		3 42 "	II Sh. In.
27	1 54 "	I Tr. Eg.		4 23 "	I Sh. Eg.
	3 39 "	II Tr. Eg.	11	2 54 "	I Oc. Re.
29	1 53 "	III Tr. Eg.	12	1 53 "	III Sh. In.
				3 20 "	II Oc. Re.

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

Central Time. d h m		Central Time. d h m		Central Time. h d m	
March 16	4 18 A.M.	March 27	8 21 A.M.	April 7	2 29 A.M.
17	12 09 "	28	4 13 "	8	8 16 "
18	5 56 "	29	12 04 "	9	4 07 "
19	1 48 "	30	5 51 "	10	9 54 "
20	7 35 "	31	1 42 "	11	5 45 "
21	3 26 "	April 1	7 30 A.M.	12	1 37 "
22	9 13 "	2	3 21 "	13	7 24 "
23	5 05 "	3	9 08 "	14	3 15 "
24	12 56 "	4	4 59 "	15	9 02 "
25	6 43 "	5	12 50 "		
26	2 34 "	6	6 38 "		

Elongations and Conjunctions of Saturn's Satellites.

[Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.]

JAPETUS.

March 27, E April 16, I

TITAN.

	d	h			d	h			d	h	
March	17,	9	E	March	29,	7	S	April	10,	6	W
	21,	8	I	April	2,	6	E		14,	6	S
	25,	7	W		6,	6	I				

RHEA.

March	16,	1.9 A. M.	E	March	29,	2.8 P. M.	E	April	12,	4.0 A. M.	E
	20,	2.2 P. M.	E	April	3,	3.2 A. M.	E		16,	4.4 P. M.	E
	25,	2.5 A. M.	E		7,	3.6 P. M.	E				

DIONE.

March	17,	9.4 A. M.	E	March	28,	8.0 A. M.	E	April	8,	6.6 A. M.	E
	20,	3.4 A. M.	E		31,	1.6 A. M.	E		11,	12.3 A. M.	E
	22,	8.7 P. M.	E	April	2,	7.3 P. M.	E		13,	6.0 P. M.	E
	25,	2.3 P. M.	E		5,	12.9 P. M.	E				

TETHYS.

March	15,	8.9 P. M.	E	March	27,	4.7 A. M.	E	April	7,	12.5 P. M.	E
	17,	6.2 P. M.	E		29,	2.0 A. M.	E		9,	9.8 A. M.	E
	19,	3.5 P. M.	E		30,	11.3 P. M.	E		11,	7.1 A. M.	E
	21,	12.8 P. M.	E	April	1,	8.6 P. M.	E		13,	4.4 A. M.	E
	23,	10.1 A. M.	E		3,	5.9 P. M.	E		14,	1.8 A. M.	E
	25,	7.4 A. M.	E		5,	3.2 P. M.	E				

Ephemeris of Comet e 1888 (Barnard Sept. 2). From the second series of elements of Berberich as given in *A. N.* 2862, I have computed the following ephemeris for March:

Gr. M. T.	R. A.	Dec.	Log. *r*	Log. Δ
	h m s	° ′		
Mar. 1.5	23 37 54	−2 53.1	0.2675	0.4486
3.5	37 39	−2 43.3	0.2687	0.4510
5.5	37 25	−2 33.5	0.2700	0.4532
7.5	37 12	−2 24.0	0.2714	0.4552
9.5	37 1	−2 14.8	0.2729	0.4570
11.5	36 48	−2 5.6	0.2744	0.4585
13.5	36 36	−1 55.9	0.2760	0.4598
15.5	36 24	−1 46.4	0.2776	0.4608
17.5	36 12	−1 37.0	0.2794	0.4617
19.5	36 0	−1 27.8	0.2811	0.4623
21.5	35 48	−1 18.5	0.2830	0.4627
23.5	35 35	−1 9.4	0.2849	0.4628
25.5	35 21	−1 0.3	0.2868	0.4628
27.5	35 6	−0 51.2	0.2888	0.4625
29.5	34 50	−0 42.2	0.2909	0.4620
31.5	34 33	−0 33.3	0.2930	0.4613

The comet will be unfavorable for observation during most of the month, being so near the sun, but may possibly be seen near the beginning and end. On March 1 it will set about an hour later than the sun, being still an evening comet, but on March 31, it will rise about an hour earlier, having then become a morning comet.

It is worthy of remark that its apparent motion for the whole month is only between three and four minutes of time in R.A., and a little over two degrees in Declination, while its change in distance from the earth is only eight million miles and from the Sun, ten million miles.

Its distance from the earth increases, but with greater slowness, until March 23, when it begins to diminish.

O. C. WENDELL.

Harvard College Observatory, Feb. 16, 1889.

Ephemeris of Tempel's Comet 1873 (II.)

		R. A.		Dec.		Log.Δ
		h.	m.	°	′	
1889 Feb.	2	20	49	−18	28.5	0.3667
	6	21	4	17	53.5	0.3667
	10	21	18	17	14.7	0.3669
	14	21	32	16	32.4	0.3673
	18	21	46	15	46.9	0.3680
	22	22	0	14	58.6	0.3689
	26	22	14	14	7.7	0.3700
Mar.	2	22	27	13	14.7	0.3712
	6	22	41	12	19.9	0.3727
	10	22	54	11	23.7	0.3743
	14	23	7	10	26.4	0.3760
	18	23	19	9	28.3	0.3779
	22	23	32	8	29.8	0.3799
	26	23	44	7	31.1	0.3819
	30	23	56	6	32.6	0.3841
April	3	0	7	5	34.5	0.3863
	7	0	19	4	37.0	0.3885
	11	0	30	3	40.4	0.3907
	15	0	41	2	44.8	0.3929
	19	0	52	1	50.5	0.3951
	23	1	3	0	57.0	0.3972
	27	1	13	−0	6.1	0.3993

Mr. George A. Hill of Washington, D. C., kindly furnished the above ephemeris of this expected comet. He says in an accompanying note, "After looking over the ephemeris, I am lead to believe that the comet will not be found until some time in March or April, as it is moving almost in the same right ascension as the sun. Yet the ephemeris will be of value to comet-seekers who do not have the use of foreign publications and receive the MESSENGER." Speaking of the late eclipse Mr. Hill says. "I caught the first contact at 4*h* 28*m* 32.3*s* Washington mean time, using my 3-inch refractor; the sun's limb was very unsteady and I may have been one or two seconds slow."

We also notice with interest that Mr. Hill and Mr. Tuttle have been searching carefully for the Brooks' comet discovered Jan. 15. The observing was not favorable in January until the last day but one. On the morning of that day Mr. Hill made a very thorough search, by the aid of his 6¼-inch reflector, covering a space of 25° in declination, near its supposed place, but was unsuccessful in finding it. He thinks the comet can not be in the region of his search, or is too faint for his telescope.

Minor Planets. A minor planet of the 13th magnitude, or fainter was discovered at Nice Jan. 28.5337, in R. A. 9*h* 40*m* 11.3*s*, Decl. +11°46′33″; daily motion, minus 54*s*; north 10′.

Another new minor planet of the 12th magnitude was discovered at Nice Feb. 8.3942, in R. A. 9*h* 40*m* 52.7*s*; Decl. +10°19″23″; daily motion in R. A. doubtful; in Decl. 2*m* north.

EDITORIAL NOTES.

Large space is given in this number to reports of the late total solar eclipse by various parties. Mr. Burckhalter's account is an instructive one, and the prints of the negatives taken during totality which we have seen, were very good. The illustrations accompanying his article are inferior to the prints, and the prints must be inferior to the original negatives, for any one acquainted with the process of making prints knows that the fine details of the negative cannot be perfectly transferred. Our engraver ought to have done better work from the copy, but it is our misfortune that such work must be done without personal oversight.

The six cuts given on one page in Mr. Burckhalter's report are to show what good, small cameras will do. All of those prints with small image are good, some excellent, and this ought to encourage the amateurs to pursue this branch of study perseveringly.

The report of Carleton College party is defered till next month because of the failure of the engraver to finish the cuts in time.

C. W. Irish, Surveyor General of Nevada has furnished the MESSENGER an important report of his observations of the eclipse, accompanying the same with drawings and photographs taken during the eclipse. This report will also appear next month.

It will be a source of gratification to the friends of this journal to know that before the second month of 1889 had ended, the number of subscribers to the MESSENGER was forty per cent greater than on any previous year in its history.

Speaking of the brightness of the planet Venus, last month, we inadvertently ventured the opinion that a person must have pretty good vision to see that gem of the sky with the naked eye at one o'clock in the afternoon. We were suddenly and rightly called to account for such a statement by observers in Canada and in the United States. The truth is we had not noticed that Venus passed the perihelion of her orbit and greatest eastern elongation at nearly the same time. Of course the planet ought to be seen, then, near mid-day, if ever, north declination being favorable.

Satellites of Uranus. In a recent letter Mr. S. S. Chevers of Bridgeport, N. J., says: "While in Utah, at an elevation of 5,500 feet, I had some superb observations with my 3-inch telescope bought of Mr. Knipe, of Jas. W. Queen & Co., Philadelphia recently. Here in New Jersey I have caught a glimpse of the satellites of Uranus more than once. The glass is of French make and has proved most excellent in definition and power.

The Seven Eclipse Question. I am greatly obliged to Mr. Prentiss for his reply to my question concerning "Seven Eclipses in one year," and I might concede that the question is fairly answered. But he obtains seven eclipses in 1823 by a mere "scratch," since it depends on the longitude of a place whether his last eclipse of that year occurred in 1823 or 1824. And I would call attention to the remarkable coincidence that his seven eclipses in 1805 depend on a similar chance at the beginning of the year. American almanacs had only six eclipses in 1805, but announced a solar eclipse on December 31st, 1804, at about 8 P. M. at Boston which to European countries would bring the eclipse on January 1st, 1805, giving them the seven eclipses in that year; and I find, on referring to my catalogue of eclipses that I had already noted this curious circumstance.

I should hardly say that we have found a fair answer to the question; it is a very strange thing that the only two instances in this century of "seven eclipses in one year" should both depend on so close an accident as above noted.

Evidently one will have to go back a good ways further than 1805 to find seven eclipses undoubtedly in any one year! *Query:*—How far back? And who can verify Mr. Prentiss' suggestion that the next "Seven Eclipse year" is 1917?

This is not a matter of great importance, but I mentioned it as of considerable interest, especially to the amateur and the untechnical reader. F. H. BURGESS.

The Next Total Solar Eclipse. Of a similar character is the question always asked, when a total eclipse passes, when will the next one take place? Some one has lately asked the *Scientific American* when there will be a total eclipse of the sun visible in the vicinity of New York. Probably the eclipse of May 28, 1900 fills the conditions fairly well. This eclipse begins in the Pacific Ocean, covers Mexico, enters the United States in Southern Texas, is total at New Orleans, the path of totality passes over Alabama, Georgia, the Carolinas, leaving the land near Albemarle Sound in longitude 76°4′ west from Greenwich, latitude 36°45′ north. The duration of totality will be 1 minute and 39 seconds. Its course will continue some distance northeasterly over the ocean, then turn southeasterly entering Portugal near Ovar, crossing Spain and the Mediterranean Sea and leave the earth in Africa. The track of totality is on the sea when nearest New York, being 200 or 300 miles distant. At New Orleans totality occurs at 7 o'clock A. M. and lasts 39 seconds.

I suspect it will be many years before New York City will have a larger eclipse than this. F. H. BURGESS.

St. Louis, Feb. 19th, 1889.

Methods of Tracing Constellations. An important illustrated article, titled, Methods of Tracing Constellations, is in hand from the pen of Professor William A. Rogers of Colby University, Waterville, Me. It will appear next month.

Astronomical Bibliography. William C. Winlock of the United States Naval Observatory kindly calls our attention to the fact that some work in the line of a current account of astronomical bibliography might prove an interesting and useful feature for the MESSENGER. Of course we say, yes, to that most heartily, and accordingly have urgently solicited Mr. Winlock to furnish the matter, knowing as we do that he has given careful attention to this kind of work for years past, and that few other American astronomers, if any, are ready to do it so well. This new feature will begin in the May or June number, or as soon as Mr. Winlock is through with the Smithsonian Review of Astronomy for 1887 and 1888 on which he is now engaged.

Error in Klein's New Star Atlas, Nebula 4415. Our attention is called by a friend to an error in Dr. Klein's new Star Atlas, on page 58, *Nebula in Draco*, 4415; Dr. Dreyer's C. G. 6643. In Klein's Atlas it is stated "According to Tuttle *it is variable in brilliancy.*" Also in the last part of the note, it is said that "Tuttle's nebula was so brilliant and remarkable in the finder, that he was convinced that it had increased in brilliance since *J. Herschel and his father observed it.*" The italic portions of the two quotations are erroneous. By referring to Dr. Dreyer's catalogue, it will be seen, that the first sentence ought to read: "6643, Discovered by Tuttle Sept. 8, 1863, and it would appear to be variable for M. d'Arrest says (in a letter May 8, 1863)," etc. The second error cited above is a wrong translation of d'Arrest's letter to John Herschel which is given in French, in Dreyer's catalogue. It should read: "Tuttle's nebula was so brilliant and remarkable in the finder that he was convinced that it had increased in brilliance since the time of Messior, and your father's and your own observations."

Partial Eclipse of the Moon Jan. 16, 1889. This eclipse was observed with the 12-inch equatorial. The first contact with the shadow was recorded as also were the bisections of prominent craters by the edge of the shadow. The recorded times are Standard Pacific Time and are eight hours slow of Greenwich. *7h* 58.7*m* the limb begins rather suddenly to darken as if entering a dense shadow;

8*h* 59.7*m* the limb is decidedly in the shadow; 8*h* 10*m*, pale red at the obscured limb; 8*h* 15*m*, the limb and the disc for about 2′ of a pale reddish yellow color. 8*h* 21*m* 12*s*, bisection of Tycho by shadow. At this time the yellowish color of the immersed part of the disc is decidedly unsymmetrical with reference to the edge of shadow—the coloring extending more to the s. p. 8*h* 29*m*, the light yellow coloring extends as far as Tycho. 8*h* 31*m* 17*s*, Kepler bisected by the shadow. 8*h* 43*m* 32*s*, Copernicus bisected by the shadow. 8*h* 48*m* 27*s* Aristarchus bisected. 9*h* 5*m*, about one half of the obscured portion of a dullish red; from this to the edge of shadow it is a beautiful steel blue. 9*h* 27*m* 27*s*, Aristarchus bisected, shadow leaving. 9*h* 32*m*, the red color is unsymmetrical with reference to the edge of shadow; it is now deeper red to the s. f. 9*h* 56*m* 42*s*, Copernicus bisected by the receding shadow. At this time the Mare Crisium was also bisected by the shadow. The obscured portion of the moon was conspicuous to the naked eye throughout nearly all the eclipse, and appeared of a lightish red color. Nothing specially noteworthy was seen. The color being probably about as decided as at the same stages in the eclipse of July 22, 1888. The edge of the shadow was moderately well defined. The prominent objects were easily seen within the shadow. E. E. BARNARD.

Lick Observatory, Mt. Hamilton, Cal.

The Peters-Borst Star Catalogue. On the last day of January, the case of Dr. C. H. F. Peters, Director of the Litchfield Observatory of Hamilton College, Clinton, N. Y., against Mr. Charles A. Borst, Fellow at Johns Hopkins University, to obtain possession of the manuscript containing the places of over 30,000 stars, arranged for a star catalogue, came up for hearing before Judge Williams, in the Supreme Court at Utica, New York. This manuscript was made by Mr. Borst, aided by his sisters, during his connection with Litchfield Observatory, apparently in the capacity of assistant to Dr. Peters, beginning it in the year 1884, three years after he entered the Observatory in this capacity. As reported by a correspondent to the New York *Evening Post*, the manuscript in dispute contains the position of 35,608 stars reduced to the epochs of 1850 or 1875, and arranged in the order of their right ascensions. These positions have been gathered from various sources of information covering a period of the last fifty years, and every place chosen has been verified. The amonnt of work involved in such an undertaking is simply enormous, and no one can appreciate it who has not been similarly employed.

A general idea of it may be conveyed by a brief numerical statement taken from the same source as cited above. The manuscript of the catalogue numbers 3,572 pages, 900 of which are nearly double folio size, and bear on their face upwards of 7,000,000 figures. More than half of the computations, it is claimed, was made by Miss Emma Borst, and that all the annual precessions were computed by her. Nearly 1,000 pages of the catalogue is in the hand writing of Miss Lucy Borst.

Dr. Peters claims that Mr. Borst did the work of compilation and computation while he was working at the Litchfield Observatory, on a salary paid by himself, and that therefore the property belongs to him.

On the other hand Mr. Borst claims, that he did the work on the catalogue outside of his labors at the Observatory, and that most of the computations were made by persons at his request, without Dr. Peters having anything to do with them.

The importance of this case in the minds of the parties is seen in the reputation of the witnesses called, two of which were Professor L. Boss, Director of Dudley Observatory, Albany, N. Y., and Professor Asaph Hall, U. S. Naval Observatory, Washington, D. C..

Their evidence was secured to aid in determining the point of ownership and the cost of such work. In the testimony of those distinguished astronomers the cost of this work was claimed to be $15,000, certainly not less than $12,000. The cost of publication of it and the limited sale that such a catalogue would have, in the general market, would make the work one undertaken chiefly in the interest of science and for the reputation of those doing it. We have not, at this writing, learned whether the case has yet been decided or not.

A Large Meteor is said to have fallen in Orange county, New York. The report claims that it was very brilliant, yellow tinged with green, and that "*bursting showered gravel stones over an acre of ground!* We would like to buy that acre of ground.

Rowland's Photographic Maps of the Solar Spectrum. A new and improved edition of Rowland's Photographic Maps of the solar spectrum from the extreme ultra violet down to, and including B, to wave length 6950 is now ready. This new series of maps was made from new gratings ruled by a new engine. It is claimed that the new gratings give definition much superior to any before made at the laboratory of Johns Hopkins University, although some of this better definition is lost in the photographic process of enlargement, which difficulty the photographic art does not yet know how to overcome. The original negatives show E, and even finer lines like that at wave lengths 5276.1 and 5914.3, plainly double, but there is little hope of showing this in the map. These maps, in general, are the same in form and mounting as the old ones, but are to be sold at a somewhat higher price, on account of the necessary increase of cost in making them.

New Astronomer Royal for Scotland. The January *Journal* of the Liverpool Astronomical Society says: "The Queen has been pleased, on the recommendation of the Secretary of Scotland, to appoint Mr. Ralph Copeland, Ph. Doc., F.R.A.S. to be Astronomer Royal of Scotland, and Professor of Practical Astronomy in the University of Edinburgh, in the room of Professor Piazzi Smyth, resigned." For the last fifteen years Dr. Copeland has been at the Dun Echt Observatory, and his work during this time has been well known and esteemed of high order. Dr. Copeland is now between fifty and sixty years of age.

Annuaire de l' Obsevatoire Royal of Brussels for 1889 is at hand by the kindness of Director F. Folie. In general appearance it is a companion of previous volumes, but also presents interesting records peculiar to the year 1887. The illustrations of sun spots observed in June, July and August of that year are skillfully represented. Other solar studies are also interesting.

Editor of Knowledge. We notice with pleasure that A. Cowper Ranyard, M. A., F. R. A. S., takes the position of Editor of *Knowledge* since Mr. Proctor's decease. Its sustained vigor and excellent contents do its new management honor, and will doubtless bring to it deservingly increased success.

Annals of the Cape Observatory. Part 2, Vol. II, of the Annals of the Cape Observatory contains a thorough study of the variations of the instrumental adjustments of the Cape Transit Circle by W. H. Finlay, M. A., chief assistant. There is so much of value in this paper that another occasion must be taken to speak of the salient points.

Haynaldo Observatorium. A report for the year 1888 is on our table. The greater part of the report is given to records of the chromosphere of the sun, and observations of the protuberances for the year 1886.

Foreign periodicals mention the interesting fact that Mr. Isaac Roberts of Dunsink Observatory has presented his reflecting telescope of fifteen inches aperture to that Observatory. This instrument is to be used in the study of stellar parallax by the photographic method.

The Roberts' Photograph of the Great Nebula of Andromeda. Mr Isaac Roberts, of Dunsink Observatory, photographed the great Nebula of Andromeda, Dec. 29, 1888, with an exposure of four hours. As he himself truly says: "It is now seen for the first time in an intelligible form." The best drawings of this object previously known to astronomy were by Bond and Trouvelot. These observers pictured it as a long, irregular mass, with two nearly straight rifts and a prominent nucleus.

Roberts' fine photograph brings out clearly its grand oval form with condensed center and other nuclei and the two dark spaces gently curved and concentrically placed, giving to the nebula a beauty and symmetry of form undreamed of before. The MESSENGER congratulates Mr. Roberts on this noble victory by the photographic art.

Mr. Croll's Theory of Climate. After the appearance of my note in the MESSENGER on this subject, Mr. C., in answer to the inquiry why he had not replied to Woeikoff's objections, wrote that the gentleman had evidently not "grasped the question at all." Similarly, one who thinks that *time* is not an element of the problem, has yet to advance a long way before coming up to Woeikoff's position, at least such is my opinion. R. W. MCFARLAND.

Oxford, O., Feb. 1889.

BOOK NOTICES.

Star Atlas Containing Maps of All the Stars from 1 to 6.5 Magnitude between the North Pole and 34° South Declination, and of all Nebulæ and Star Clusters in the Same Region which are Visible in Telescopes with Moderate Powers. By Dr. Herman J. Klein. Translated and adapted for English readers by Edmund McClure, M. A., M. R. I. A. With eighteen maps. New York: Messrs. E. & J. B. Young & Co., Publishers. 1888.

This new star atlas is a pleasant surprise to us. We did not before know that Heis had any such rival for real merit in existence. We desire to call special attention to a few points which seem meritorious after a somewhat careful examination. The printed page is 10 inches by 5¾ inches, with a good margin, the covers being 9 by 11¾ inches. The table of contents fills six of these large pages. In it the constellations are arranged in alphabetical order, the name of each being printed in a heavy-faced letter, and after it all the prominent objects of the constellation with reference to the page in the subsequent part of the atlas where a detailed description of the object will be found. As an illustration, under the constellation *Lyra*, α Lyræ is the first object named, with reference to page 59, where we read: "This splendid star, 1 mag., has near it several faint stars, but their connection with it is merely optical. One of them which was used by Struve and Brünnow as a comparison star for cataloguing the parallax of Vega, is of 9.5 mag. d = 48″, p = 156°, another of 9 mag., d = 150″, p = 40°. Winnecke and Burnham have also measured a very faint star (13 mag.), d = 52″, p = 292°." This illustration is about the average of others in length, and, as to quality, speaks plainly for itself.

After the index follows the introduction, covering ten pages, in which are given, first, tables for converting sidereal time into degrees and *vice versa*; a table showing the sidereal time of mean noon for every day in the year, and then follows brief articles on the constellations, magnitudes of the stars, number of the fixed stars, double stars, star clusters, nebulæ, explanation of the maps, and general description of the catalogue of interesting celestial objects that follows and fills 61 pages.

This catalogue is one of the excellent features of the atlas. On the left hand side of each page are two vertical columns, each about one inch in width, which give the right ascension and declination of every object on the page for the epoch of 1880. The entire catalogue is arranged in the order of the right ascensions of the objects it contains, each page giving on the average about ten objects, or more than six hundred in all. The references in this catalogue come down as late as August of last year, as shown by notes relating to Professor A. Hall's paper entitled, The Extension of the Law of Gravitation to Stellar Systems, and the theoretical difficulties arising therefrom in the case of stars like Groombridge 1830, and also in the table of star distances given in light-years, so called.

But the most important feature of the atlas is, of course, its star maps. These are nearly the same in size as those of Heis. Klein's maps are about 12½ inches by 9¼ inches while those of Heis are about 13 inches by 8½, the former being a trifle the larger. Heis' circum-polar map places the North Pole 10° from the center of the map and 0° of right ascension at the upper left hand corner, and shows 40° of polar distance in the direction of 18*h* right ascension, and 20° in the direction of 6*h*. Klein puts the pole in the center of his map and gives 35° of north polar distance on every hour circle, has 0*h* of right ascension at the bottom of the map, and draws parallels to the equator at every 5° of declination. In the eleven maps that follow, Heis projects both meridians and parallels as arcs of circles and shows the celestial sphere to 30° south declination. Klein proceeds differently. From the second to the fifth map inclusive, he draws the meridians as straight lines, and the parallels as arcs or circles, showing 5*h* of right ascension from center to center, except in the fifth map, which should give only $4h$. The last six maps present the equatorial regions of the sphere to $-32°$ and $+26°$ in declination. The middle of the first map is $2h$ in right ascension, the second $6h$, the third $10h$, etc. The projections of hour circles and parallels in these maps are both in straight lines, which is often spoken of as the cylindrical method. Though it would be interesting to consider the relative merits of the different methods of making maps chosen by these two authors, yet it is not necessary here, since the scale of each is small, and their differences of error a quantity of still lower order.

In Heis' maps the Milky Way is beautifully figured; in Klein it is omitted altogether. Heis gives the old constellation figures, the outlines, star designations, the names of the constellations in red; Klein uses the same color, omits the pictures of animals and things, gives the outlines of the constellations, designates many more objects with catalogue numbers, so that the map, at first sight looks a little crowded; but every feature is clean and distinct, and we have not yet noticed an object or point in any way ambiguous.

Following the star maps are several double page lithograph plates representing favorite celestial objects. The first is the star cluster of the Pleiades reproduced from a photograph by the Brothers Henry of Paris. Then follow Bond's Great Nebula in Orion, Trouvelot's representation of Nebula G. C. 4355, Vogel's star clusters G. C. 4440 and 1361; Trouvelot's star cluster G. C. 4294; heliographical reproduction of part of the constellation Cygnus from a photograph by Brothers Henry, Paris; Holden's Ring Nebula in Lyra, G.C. 4447, and seventeen other fine illustrations by the same and other equally competent artists.

The publishers have done their part very neatly and well, and wonder is that the book can be sold for the low price of $2.50 per copy.

Books Received.

A Treatise on Trigonometry by Professors Oliver, Wait and Jones, of Cornell University. Third Edition. Ithaca, N. Y., Dudley F. Finch, Publisher, 1889.

Logarithmic Tables, by Professor George Williams Jones, of Cornell University. Publisher, Dudley F. Finch, 1889.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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METHODS OF TRACING CONSTELLATIONS.

PROFESSOR W. A. ROGERS.*

For THE MESSENGER.

It has always seemed to the writer that the student in astronomy ought to be able to locate the positions of the principal stars visible in the heavens at any assumed time, and to give their names, by some method in which memory plays a less prominent part than in the ordinary way of locating constellations by a knowledge of the configuration of the brighter stars. Even if the student has a star map, he finds it a difficult matter to use it on account of the ever changing form of these configurations with respect, for example, to the horizon. If the student were able to construct his own chart easily and with little loss of time, the problem of tracing constellations would be reduced from bewildering guess-work to certainty.

After a trial of the method proposed in this paper with college classes for two years, sufficient experience has been gained to warrant the conclusion that this method of presenting the subject awakens enthusiasm and gives to the average student a far better knowledge of all the problems which relate to the celestial sphere than the usual method is likely to give.

It is proper to say at the outset that this paper is not written for astronomers. It is written for the benefit of the ordinary academic and collegiate student who is pursuing the study of astronomy for the first time. It will be seen at once that there is nothing new about the method proposed except its adaptation to the needs of the average student.

We start with the statement that the position of a star upon the celestial sphere is to be determined in precisely the

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same way that we locate a point upon the surface of the earth, viz.: by means of its longitude and its latitude. We first assume a primary circle, viz.: the equator. From the pole of the primary circle, or the extremity of the earth's axis, we draw a secondary circle through some point which we assume as the zero of longitude, *e. g.*, Washington, and extend it until it intersects the equator. This point will be the zero of the co-ordinates from which all longitudes are to be reckoned. We next draw another secondary circle through any selected point on the earth's surface, and extend it till it intersects the equator. Then the distance from this point of intersection to the zero of co-ordinates measured *on the primary circle* will be the longitude of the place, and the distance from this intersection measured *on the secondary circle* to the point will be its latitude. The longitude and the latitude taken together form a *system of co-ordinates.* In the determination of the position of a point upon the celestial sphere, four systems of co-ordinates are in common use. As will be seen presently each system has certain advantages peculiar to itself. Since each system has its own primary circle, its own secondary circle and its own zero of co-ordinates, it is necessary to define these circles of reference and these points of reference.

The great circles of the celestial sphere which are employed as reference circles, may be defined as the circles described upon the celestial sphere by the extension of the planes of the great circles of the terrestrial sphere until they cut the celestial sphere. The three primary circles which are employed in the location of a point upon the celestial sphere are the equator, the ecliptic and the horizon. The poles of these circles are, of course, the points on the great circle passing through the zenith of the observer and the pole of the heavens which are 90° from their respective primary circles. If we designate the pole of the equator by P, the pole of the ecliptic by P' and the pole of the horizon by Z, we can conveniently designate all great circles which pass through these points as P-circles, P′-circles and Z-circles respectively.

The points which are assumed as the origin of co-ordinates are as follows:

For the equator. 1. The intersection of the ecliptic with the equator or the vernal equinox.

2. The intersection of the equator with the meridian passing through the zenith of the observer.

For the ecliptic. The vernal equinox.

For the horizon. The intersection of the meridian passing through the zenith of the observer and the horizon at the south point.

We may define the several systems of co-ordinates by the aid of Fig. 1. This figure is the photograph of a wire globe with a hemispherical cap which has a black-board surface.

In taking the original negative, the pole of the cap was inclined towards the camera in order to show all the elements involved.

FIG. 1.

$V \alpha V'$ represents a section of the celestial equator.

$V \lambda V''$ (V'' not shown in the figure) represents a section of the ecliptic.

VAS (S = south point of the horizon, not shown in the figure) represents a section of the horizon.

Having selected a point O upon the celestial sphere, we proceed as follows:

SYSTEM I.

Primary Circle = the equator.

Pass a *P*-circle through the point O and extend it till it intersects the equator at α.

Then: $V\alpha =$ the right ascension of the point $O = \alpha$
$\alpha O =$ the declination of the point $O = \delta$.

SYSTEM II.

Primary Circle = the ecliptic.

Pass a *P′*-circle through the point O and extend it till it intersects the ecliptic.

Then: $V\lambda =$ the celestial longitude of $O = \lambda$
$\lambda O =$ the celestial latitude of $O = \beta$.

SYSTEM III.

Primary Circle = the horizon.

Pass a *Z*-circle through O and extend it to the horizon.

Then: the azimuth of $O = A$
the altitude of $O = h$.*

SYSTEM IV.

Primary Circle = the equator.

Pass a *P*-circle through O.

Then: $V'\alpha =$ the hour angle of $O = ZPO = \tau$
$\alpha O =$ the declination of $O = \delta$.

For convenience of reference, these elements are given in the following tabular form:

System.	Primary Circles.	Secondary Circles.	Origin of Co-ordinates.	Co-ordinates.
I.	The equator.	P-Circles.	Vernal equinox.	Right Ascen. $= \alpha$ Declination $= \delta$
II.	The ecliptic.	P′-Circles.	Vernal equinox.	Longitude $= \lambda$ Latitude $= \beta$
III.	The horizon.	Z-Circles.	South point of the horizon.	Azimuth $=$ A Altitude $= h$
IV.	The equator.	P-Circles.	Intersection of the circle through P and Z with the equator.	Hour angle $= \tau$ Declintaion $= \delta$

The first system is employed in the catalogues of stars and in the location of the positions of planets, because the origin of the co-ordinates, the vernal equinox, occupies the same

* Not given in figure.

position from year to year with the exception of a slight motion annually in precession.

The second system is mainly used in connection with planetary reductions, on account of the simplicity introduced by referring the position of a planet or a comet to the plane of the orbit of the earth.

The third system has the practical advantage of enabling the observer to locate the position of an object upon the celestial sphere by eye-estimates of the altitude and azimuth, since he always has the horizon before him and the zenith is a well defined point in the heavens. Since, however, every point in the heavens has a motion from east to west through the diurnal motion of the earth upon its axis from west to east, we can only determine these co-ordinates for a particular instant of time.

The fourth system enables us to obtain from the elements given under System I the data required to fix the position of the zenith at a given instant.

From Fig. I we have:

$$V'\alpha = V'V - V\alpha$$

Or

$$\tau = V'V - \alpha$$

But $V'V$ is equal to the right ascension of the vernal equinox, since it is the distance of the vernal equinox from the meridian, or rather of the meridian from the vernal equinox. How shall we measure the arc? Let us suppose that there is a bright star exactly at the intersection of the equator with the ecliptic which can be easily recognized. Let us suppose also that before this star reaches the meridian on March 22nd of any year the hands of a clock which will run with a uniform rate have been set at 0*h* 0*m* 0*s*. The moment the star crosses the meridian, the clock is started. If at the end of 24 hours, the hands of the clock point to 0*h* 0*m* 0*s* at the instant when the star again crosses the meridian, it is evident that the face of the clock will indicate the arc of revolution passed over by the star at any time selected during the 24 hours. Such a clock is called a sidereal clock. It indicates the sidereal time of the vernal equinox which we designate by S. T.

We have, therefore: $\tau = \text{S. T.} - \alpha$ (1)

When τ is given and α required: $\alpha = \text{S. T.} - \tau$ (2)

When α and τ are given: $\text{S. T.} = \alpha + \tau$ (3)

We must now connect the sidereal time with the mean time, since the value of S. T. will be required for some instant of mean time. Let us suppose that the sun and the star cross the meridian at the same instant on March 22nd. Since the sun moves eastwardly with a mean motion of 360° in one year, or of 236.555*s* in one day and of 9.8565*s* in one hour, it is clear that the star will gain on the sun in its westward motion.

Hence, to find the sidereal time corresponding to any given mean time, we must add to the assumed mean time 236.555*s* for each day and 9.8565*s* for each hour after the beginning of any day for which the sidereal time of mean noon is given. The sidereal time of mean noon is given in the Nautical Almanac for each day of the year. It will be advisable, however, for the student to make the computations for himself from two dates as a check upon the work. For the purpose in hand, it will be quite sufficient to use the sidereal time of Washington mean noon.

In order to reduce the size of the factor of 236.555 it will be convenient to take from the Almanac the sidereal time of mean noon for the first day of each month. The student can then select the value which is nearest the date required. The following values are taken from the Nautical Almanac for 1889-90:

	h m s		h m s		h m s
Jan. 1,	18 46 9.15	April 1,	0 40 59.05	Aug. 1,	8 41 58.89
Feb. 1,	20 48 22.41	May 1,	2 39 15.66	Sept. 1,	10 44 12.08
Mar. 1,	22 38 45.92	June 1,	4 41 28.90	Oct. 1,	12 42 28.66
Mar. 22,	0 1 33.52	July 1,	6 39 45.62	Nov. 1,	14 44 41.82
				Dec. 1,	16 42 58.50

As an example we require the sidereal time corresponding to April 6, 1889, at 9*h* 12*m* P. M., Washington mean time.

h m s	From March 22.	h m s	From April 1.
0 1 33.52	= S. T. W. M. N.	0 40 59.05	= S. T. W. M. N.
0 59 08.32	= 15 × 236.555	0 19 42.78	
9 12 0.00		9 12·00.00	
0 1 30.68	= 9.2 × 9.8565	0 1 30.68	
10 14 12.52	= S. T.	10 14 12.51	= S. T.

Having found the value of S. T. for any assumed time and having at hand a catalogue from which the values of α can be taken, the computation of the hour angle τ by equation (1) becomes a very simple matter.

LOCATION OF STARS BY MEANS OF THE "STAR-FINDER."

Even when the values of α and δ are given, the student will find it exceedingly difficult to locate by eye-estimates the position of a star on account of the difficulty of keeping in mind the position of the celestial equator. With the aid of a very simple piece of apparatus which I have called a "star-finder," the location becomes very easy. It is shown in Fig. 2. The hour circle, attached to the end of the polar axis is graduated to hours and tenths of hours. A circle graduated to degrees is attached permanently to the polar axis

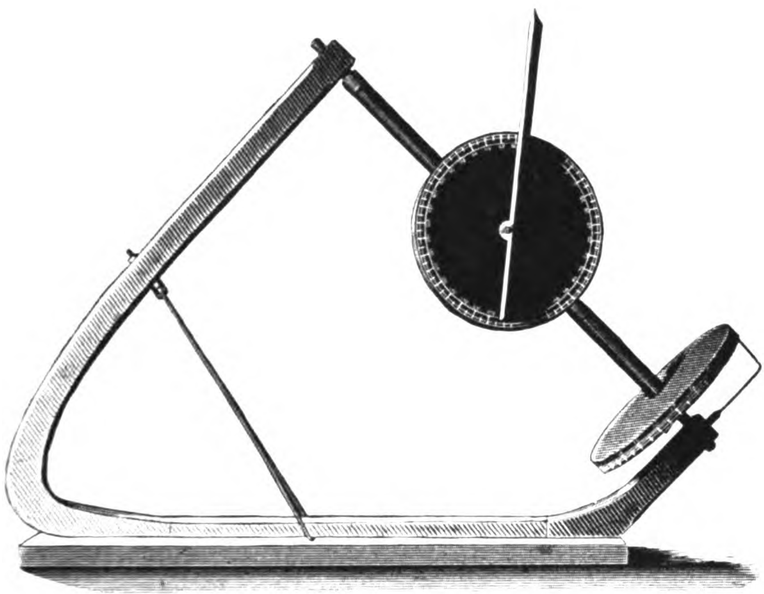

FIG. 2.

near the middle point. An arm of wood works about a pivot fastened at the center of this circle. A piece of tin, painted black except at the upper edge, is attached to this arm in a vertical position. This constitutes the declination-pointer. When the edge of the arm is set at 0° on the circle, the pointer is directed towards the celestial equator. When set at any given declination, it describes the diurnal circle corresponding to this declination when the polar axis is revolved. In order to prepare the instrument for use, place it in the meridian of the observer and set the base approximately in the horizontal plane by means of a spirit level. If the sidereal time is given, we have only to set the declination pointer for a known declination and revolve the polar axis till the pointer of the hour circle indicates the given hour angle. By sighting along the edge of the tin, the object sought will be readily seen. If the real sidereal time is not known, as may often happen from not knowing the exact local mean time, it can be determined from equation (3) by selecting two bright stars whose co-ordinates are known, one east and the other west of the meridian. Direct the pointer to these stars, read off the hour angle from the hour circle in each case, and find the values of S. T. from equation (3). The mean of these two values will give the value of the sidereal time nearly free from an erroneous adjustment in the meridian and with sufficient precision for the work of the evening.

The computation of the hour angles should be made in advance according to the following scheme:

Example: Locate the position of the following stars for April 6, at 9.2*h* P. M.

S. T. for April 6 at $9.2h = 10.24h$,

Star.	Magnitude.	δ	α	S. T. $- \alpha = \tau$
		°	h	h
α Andromedæ	2.0	+ 28.5	+ 0.04	10.20
α Persei	2.0	+ 49.5	3.29	6.95
β Eridani	3.0	− 5.2	5.04	5.20
α Aquarii	3.0	− 0.9	22.00	12.24
α Pegasi	2.0	+ 14.6	22.99	11.25

It is the experience of the writer that the student can locate from thirty to forty stars during an hour if the values of τ have been computed in advance. Allowance can be made for an extension of the time beyond that for which the value of S. T. has been computed by adding the excess to the computed values of τ.

LOCATION OF STARS BY MEANS OF THE CO-ORDINATES, ALTITUDE AND AZIMUTH.

A little practice will enable the student to estimate altitudes and azimuths with considerable precision, but the following simple and inexpensive apparatus will be found to offer many advantages:

A wooden frame, *A*, is suspended freely from the point *C*. This frame has an altitude pointer, *P*, and an azimuth pointer, *P'*, which swings freely with the frame a little above the top of a table upon the surface of which a circle *B* is graduated. The only adjustments required are, the shifting of the point of contact at (*a*) till the edges of the frame are vertical and setting the table so that the line of the circle *B* from 0° to 180° shall be in the meridian of the observer.

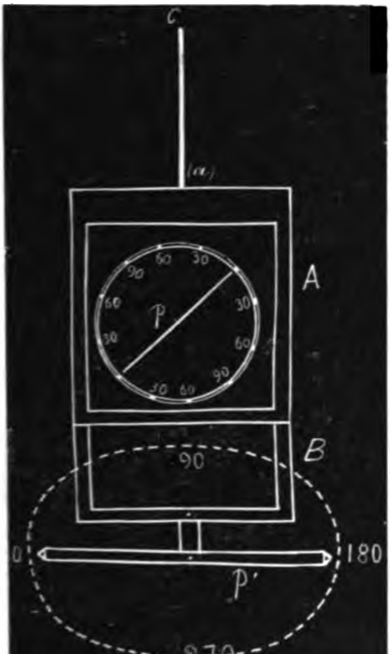

FIG. 3.

It has been assumed thus far that the co-ordinates, altitude and azimuth, are known. It is now required to find some method of obtaining these quantities quickly and by means within the reach of the student. Three methods are available:

First, By means of the hemispherical globe. After tabular values of the hour angle have been prepared for the stars whose locations are sought, we proceed as follows to obtain the corresponding altitudes and azimuths. The zero of a quadrantal circle, which is a secondary P-circle, is placed at the pole of the equator, *P*. It is extended a little beyond the equator. The arc is then swung about the point *P* until the point which intersects the equator marks the given hour angle. The declination is then read off on the secondary P-circle and the point is marked upon the sphere. The zero of the quadrantal arc is then placed at the zenith, and with this point as a pole it is passed through the point just found and extended to the horizion. The azimuth is then read off on the horizon and the altitude on the vertical circle. In Fig. 1 the quadrantal arc intersects the equator at *V'* and the point *O* is laid off on the secondary circle *PO*. Then the quadrantal arc is made to pass from Z through O till it intersects the horizon at A. $S\ A$ will then be the azimuth and $A\ O$ will be the altitude.

Second, By means of the terrestrial globe.

First measure off the hour angle from the intersection of the equator with the ecliptic. Pass a quadrantal arc from this intersection through the point P. In order to fix the point given by the declination upon the globe without defacement, take from a tumbler of water triangular bits of paper and while wet place the sharpest vertex at the point obtained. Revolve the globe until the vernal equinox makes an angle with the metal arc which surrounds the globe equal to the hour angle. Hold the globe in this position by means of a wedge of wood between the globe and the frame work which represents the horizon. Pass a Z-circle through this point, extend it to the horizon, and read off the co-ordinates required.

Third, By means of an orthographic projection of the diurnal circles described by the stars.

The two methods described above, while they are simple and expeditious, involve the difficulty presented by the limitation that only one or two students can work with the apparatus at one time, and since an unlimited supply of globes is not likely to be available, these methods are hardly adapted to the needs of an instructor who has a large class of students.

We now proceed to describe a method by which the student can construct for himself, a system of right projection of points upon the celestial sphere, upon the plane of the horizon from which he can obtain the altitude and azimuth corresponding to a given hour angle and declination, with a degree of precision considerably greater than can ordinarly be obtained by the use of a globe. The problem may be stated as follows:

Given the position of the point O upon the celestial sphere, by means of its hour angle and declination, it is required to find the azimuth and altitude of the point O' where a perpendicular let fall from O pierces the plane of the horizon.

In Fig. 4, O' is the projection of a point O, which is situated upon the surface of the celestial sphere, upon the plane of the horizon of WNE. ZA is the projection of the Z-circle passing through O.

ZO' is therefore the cosine of the altitude h. But the numerical value of h can be found from the spherical triangle POZ, Fig. 1, in which $PO = 90° - \delta$, $ZO = 90° - h$ and $PZ = 90° - \varphi$. (Since the altitude of the pole P above the north horizon is equal to the latitude of the place of observation.) The hour angle $\tau = ZPO$.

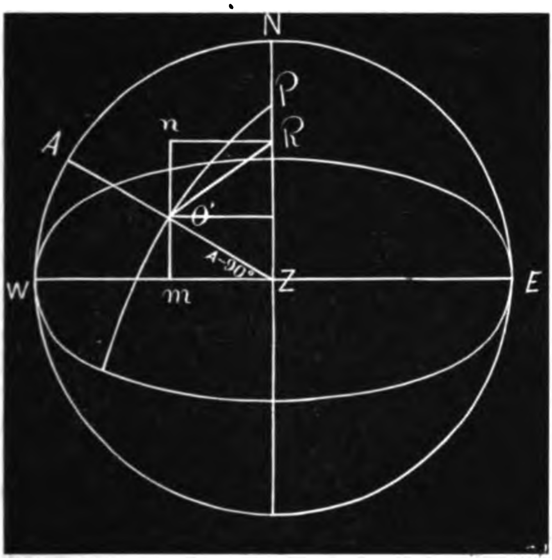

FIG. 4.

We have given in this triangle the parts τ and δ to find h. From spherical trigonometry we have the general relation

$$\cos a = \cos b \cos c + \sin b \sin c \cos A.$$

In order to adapt the triangle to this formula place A at the given angle ZPO and B at the angle PZO.

Then, $\cos (90° - h) = \cos (90° - \delta) \cos (90° - \varphi) +$
$\sin (90° - \delta) \sin (90° - \varphi) \cos \tau.$

or $\sin h = \sin \delta \sin \varphi + \cos \delta \cos \varphi \cos \tau.$

in which all the terms of the second member of the equation are given. Having found the natural cosine of h the line ZO' becomes known.

The direction of the line ZA will be determined by the right angled triangle MZO', in which we have one side given. In order to find the side MZ, proceed as follows: Let fall from the point O upon the surface of the sphere, a perpendicular to the diameter from the center of the sphere through

P. Let R represent this point. From R draw a perpendicular to the same radius in the plane of the great circle passing through the points E, P, W. Also let fall from O a perpendicular until it intersects the last line at the point N. Then $NR = ZM$ since these lines are included between two parallel planes which are perpendicular to the same line.

But $RO' = \sin(90° - \delta) = \cos\delta$; and

the angle $NRO' = 90° - \tau$.

Hence in the right angled triangle $O'NR$ we have

$$NR = \sin\tau\cos\delta = MZ.$$

We have now two sides of the triangle $MO'Z$ from which

$$\cos(A - 90°) = \sin A = \frac{MZ}{ZO} = \frac{\sin\tau\cos\delta}{\cos h}$$

Collecting the formulæ we have:

$$\sin h = \sin\delta\sin\varphi + \cos\delta\cos\varphi\cos\tau \quad (4)$$

$$ZO' = R\cos h \quad (5)$$

$$\sin A = \frac{\sin\tau\cos\delta}{\cos h} \quad (6)$$

For a given hour angle and declination, the corresponding azimuth is obtained by laying off on the horizon the computed value of A. The point O' is then determined by drawing a straight line from Z to the point A and laying off on this line the computed distance ZO'.

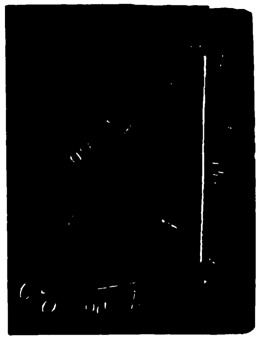

FIG 5.

If the positions of point O are determined for a given value of δ and for successive values of τ; equal, *e. g.*, to 10°, it is obvious that we shall have the projections of a series of points which lie in the diurnal circle described by a star whose declination is equal to the value employed in the computation.

If similar positions of O' are found for diurnal arcs which are, *e.g.*, 5° apart in declination, we shall have a series of points in the ellipses which are the projections of these circles and by drawing P-circles through the points computed with the same value of τ we shall have the projections of the P-circles.

The labor involved in the location of all these points is considerable but in my own case, by assigning to each member of the class a single diurnal circle, the time required for the work was only the time required for the preparation for two recitations. Having arranged the values of A and

ZO' in tabular form, the location of O' was obtained by noting the point on the horizontal circle corresponding to the tabular value of A, and then measuring the distance ZO' on the line ZA.

The full projections of the diurnal circles and the P-circles are then made by drawing smooth free-hand curves through these points.

But the projections both of the diurnal circles and of the P-circles can be made by the mechanical construction of the ellipses which are the projections of these circles.

PROJECTIONS OF DIURNAL CIRCLES.

Let $x =$ the projection upon the horizontal plane of the meridian altitude of any diurnal circle.

Let $x' =$ the corresponding point at the lower culmination. The minor axis of the ellipse will then be equal to the distance between x and x' and the major axis will pass through a point half way between x and x'. We have then the numerical value of the minor axis and the position of the major axis but not its length.

It will be easily seen that the foci of all the ellipses fall in a circle described about the zenith with the radius, PZ, Fig. 5. For any given case, the foci will be determined by the intersections of the major axis with this circle.

PROJECTIONS OF P-CIRCLES.

In this case we have the major axis equal in every case to the diameter of the horizontal circle. The direction of the axis for a given value of τ is however not given.

The point at which the major axis intersects the south horizon can be found from equations (4) and (6). Since for this case the altitude is zero, equation 4) becomes

$$0 = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\tau,$$

$$\text{and } \cos\tau = \tan g\,\delta \tan g\,\varphi. \qquad (7)$$

Substituting in equation (6) the value of τ found from equation (7) we have the azimuth of the end of the major axis from which the position of the axis becomes known.

It will be easily seen that the foci of the ellipse described upon this axis will fall in an ellipse whose foci are the points P and the intersection of the equator with the meridian of the observer, being determined by the intersection of the major axis with this ellipse. The dots in the ellipse, Fig. 6, represent the positions of the foci with which the projections of the P-circles were described.

METHOD OF USING A PROJECTION-CHART CONSTRUCTED FOR A GIVEN LATITUDE AS SHOWN IN FIGURE 6.

When a chart has been made similar to the one shown in Fig. 6, the positions of the stars of a selected list can be laid off upon it directly with the known values of δ and τ, by es-

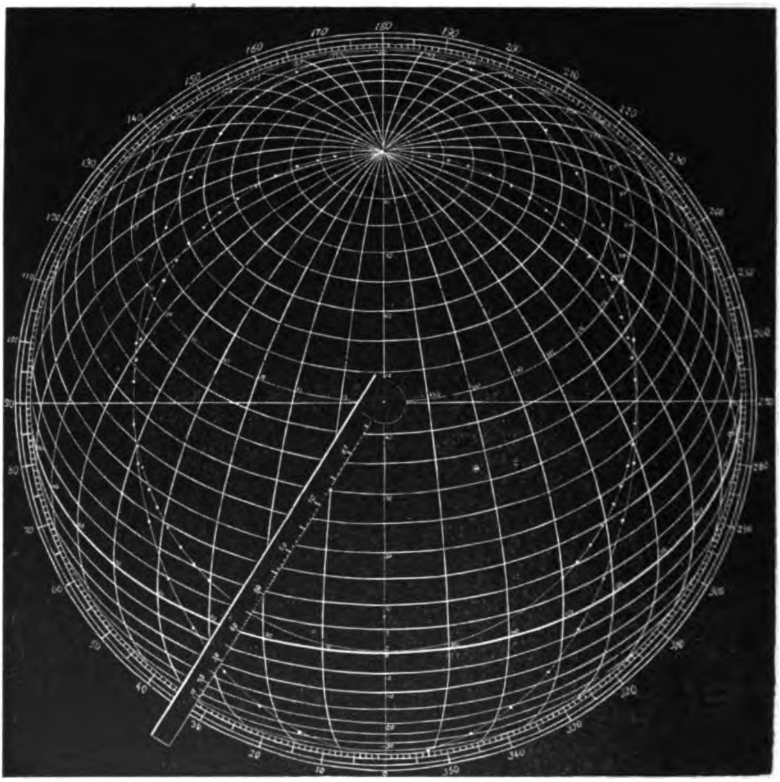

FIG. 6.

timating the position corresponding to the declination upon the line *NS*, then, noting its distance from the nearest ellipse follow the ellipse from east to west till the given hour angle is reached. In the present case the P-circles are separated by intervals of 10°. If a more exact interpolation is desired the intervals must be reduced to 5°.

Since, however, the space upon the chart is largely pre-occupied, it will be found advisable to use this chart only for the purpose of reading off the co-ordinates in altitude and azimuth, which correspond to the given values of δ and τ. For this purpose a graduated radius is made to revolve about the point Z as a center, as shown in Fig. 6. The distances from the center have been multiplied by the cosine of the altitudes corresponding to the given declinations; hence the altitudes can be read off directly from this radius. Having located by estimation the point corresponding to a given value of δ and of τ, the radius is revolved until the edge falls upon this point. The intersection of the edge with the horizon will give the azimuth, and the graduated radius will give the altitude.

METHOD OF CONSTRUCTING A STAR CHART.

In the method of projection employed there will be no fore-shortening in azimuth, and the fore-shortening in altitude will increase rapidly as we approach the horizon. It will hardly be noticeable at an altitude of 30°. For the purpose of identification it will be sufficient to use a radius subdivided into 90 equal parts instead of the projections of the equal subdivisions of the circular radius. With such a radius and a graduated circle representing the horizon, the positions of a selected list of stars are obtained by using the azimuths and altitudes drawn from the projection-chart as shown in Fig. 6.

The application of this method will be shown in the following example:

Required the azimuths and altitudes of the stars in the "Dipper" for May 11, 1889, at 10*h* P. M.

From April 1.		From May 1.	
h m s		h m s	
0 40 59.05	= S. T. W. M. N.	2 39 15.66	= S. T. W. M. N.
2 37 42.20	= 40 × 236.555*s*	1 5 25.55	
10 00 0.00		10 00 00.00	
1 38.56	= 10 × 9.8565*s*	1 38.56	
13 19 19.81		13 19 19.77	

Hence S. T. = 13.32*h*.

Name of Star.	Magnitude.	δ	α h	τ in time. h	τ in arc. °	A °	h °
β	2.0	+ 57.1	10.92	2.40	36.0	131.8	64.7
α	2.0	+ 62.4	10.94	2.38	35.7	143.5	63.1
γ	2.3	+ 54.3	11.80	1.52	22.8	130.0	72.2
δ	3.0	+ 54.7	12.17	1.15	17.2	137.0	75.1
ϵ	3.0	+ 48.5	12.82	0.50	7.5	127.5	83.8
ζ	3.0	+ 55.6	13.33	23.99	359.9	180.5	79.6
η	2.0	+ 49.9	13.72	23.60	354.0	217.3	83.5

The values of *A* and *h* were taken from a projection-chart having a radius of 34 cms. Accuracy sufficient for the present purpose will be obtained if the circle representing the horizon has a radius of 12 cms.

The exact values of *A* and *h* will now be derived from formulæ (4), (5) and (6).

For $\varphi = 45°$.

Log sin δ = 9.84948. Log cos δ = 9.84948.

Star.	β	α	γ	δ	ε	ζ	η
	°	′		°	′	°	°
δ	57.1	62.4	54.3	54.7	48.5	55.6	49.9
τ	36.0	35.7	22.8	17.2	7.5	− 0.1	− 6.0
Log sin δ	9.92408	9.94753	9.90960	9.91176	9.87446	9.91651	9.88362
Log sin δ sin φ	9.77356	9.79701	9.75908	9.76124	9.72394	9.76599	9.73310
Log cos δ	9.73494	9.66586	9.76607	9.76182	9.82126	9.75202	9.80897
Log cos τ	9.90796	9.90960	9.96467	9.98013	9.99627	10.00000	9.99761
L'g cos δ cos φ cos τ	9.49238	9.42494	9.58022	9.59145	9.66701	9.60150	9.65606
cos δ cos φ cos τ	.3107	.2660	.3804	.3903	.4645	.3995	.4530
sin δ sin φ	.5937	.6266	.5742	.5771	.5296	.5834	.5409
sum	.9044	.8926	.9546	.9674	.9941	.9829	.9939
Log sin *h*	9.95636	9.95066	9.97982	9.98561	9.99743	9.99251	9.99734
h	64° 44′	63° 12′	72° 40′	75° 20′	83° 46′	79° 23′	83° 40′
Log comp cos *h*	0.36971	0.34594	0.52589	0.59654	0.96426	0.73462	0.95738
Log sin τ	9.76922	9.76607	9.58829	9.47086	9.11570	7.24188	9.01923
Log cos δ	9.73494	9.66586	9.76607	9.76182	9.82126	9.75202	9.80897
Log sin *A*	9.87387	9.77787	9.88025	9.82922	9.90122	7.72852	9.78558
A	131°35′	143°9′	130°37′	137°23′	127°12′	180°18′	217° 37′

When sin δ sin φ is greater than cos δ cos φ cos τ the angle *A* is to be subtracted from 180°.

ERRORS IN ASTRONOMICAL TEXT BOOKS.

LEWIS SWIFT.*

For The Messenger.

Errors of one kind or another are sure to insinuate themselves into scientific books, regardless of the painstaking care to exclude them exercised by writers and proof-readers. A faultless work on any branch of science, especially on astronomy, has probably never been published, and the most exacting critic, doubtless, does not expect to meet with a perfect volume; yet there are errors extant too obvious to be quietly passed over, to which it seems advisable to call attention. The following are a few I have noticed:

In that most excellent work of Professor Newcomb, "Popular Astronomy," in which are found fewer inaccuracies

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than in almost any other, there occurs, on page 395, this statement: "In the same year (1819) Dr. C. H. F. Peters, at Naples, discovered a comet of quite short period," etc. Now at that time, as Dr. Peters was but six years old, he was quite unlikely to be searching for comets. Two comets, supposed to be of short period, were found in that year, one by Pons, the other by Blainpain, but the comet discovered by Dr. Peters, in Italy, was Comet VI, 1846. He also discovered Comet IV, 1857, at the Dudley Observatory, Albany, N.Y. On page 403, same work, in speaking of one of the assumed five values for the revolution of the meteoroids causing the November meteoric shower, it says: "The greatest of these values, and the one it seems most natural to select, is that of the mean interval between the showers, or 33¼ years." It is true that the meteoroids complete a revolution in 33¼ years, but whether in half or in ten times that period cannot possibly affect the interval between the showers, as that is governed by the earth's period, or a year. Owing, however, to the motion of the node, each return of the great shower occurs one day later, or once in 33 years and one day. In 1799 it occurred on Nov. 12th; in 1833, on Nov. 13th; in 1866, on the 14th, and it will again repeat itself on Nov. 15th, 1899. Were the text true, the shower of 1866, Nov. 14, would have fallen on the middle of February. Dr. Ball, in his work on astronomy, fell into the same error, but has corrected it in his latest writings. Because of the high authority of these two astronomers, this mistake has been copied in nearly all modern text-books.

The April issue of *The Observatory*, page 206, alluding to the resignation of the Directorship of the Vassar College Observatory, by Miss Maria Mitchell, and her discovery of a comet in 1847, says: "She has the credit of discovering seven other comets." Again the author of "Progress of Astronomy during 1888" (see English Mechanic of Jan. 14th, 1889), referring to her resignation, says: "She is chiefly known in this country as a discoverer of comets." While we would not be ungenerous to this most worthy lady and astronomer, yet, as we seek for truth and not error, we are compelled to assert that but one comet, that of 1847 for which she was awarded the gold medal offered by the king of Denmark, was ever discovered by her.

Lardner's Natural Philosophy, article "Astronomy," third course, page 649, says of former and future pole-stars, that 4,000 years ago Gamma Draconis was the pole-star. In *Astronomy Simplified* by F. A. S. Rollwin, page 208, is found the same statement. This recalls to mind that, on the occasion of a lecture on astronomy which the writer once gave and in which he stated that 4,200 years ago Alpha Draconis occupied the position of pole-star, a gentleman in the audience rose to correct his statement declaring that from the books Gamma was then the pole-star. The lecturer, by drawing the precessional circle round the pole of the ecliptic, convinced him of his error.

On page 409, Lardner says, "The greatest possible duration of a total solar eclipse is the time necessary for the moon to gain upon the sun 122″; it follows that the duration of a total solar eclipse can never exceed four minutes." Truth is, totality may continue nearly twice that length of time.

Astronomy Simplified, page 20, declares that "according to Struve (?) the star Castor (Alpha Geminorum) is one of a ternary system consisting of three suns. . . . This star has completed an entire revolution in its orbit since 1790." The fact is, the two stars, nearly equal in magnitude, have, during the last one hundred years, moved so little that astronomers are in doubt whether the motion is orbital or not. On page 196 is the astonishing statement that "Every time it (Mercury) completes a revolution in its orbit, it makes a transit of the sun."

Chambers' Astronomy, page 346, gives the number of apparitions of Halley's, Encke's, Biela's and Faye's comets correctly, but quite erroneously adds, "and two each of the following," giving dates, fifteen of them, but not one of these has been proved by a second return to be an elliptic comet.

Again on page 39, first edition, the maximum distances of Mars, Jupiter, Saturn and Uranus are placed in the minimum column, and *vice-versa*, while the distances of Mercury, Venus and Neptune are properly recorded.

Lockyer in the first edition of his astronomy, gives, in two places, the equatorial diameter of the earth as 7901 miles, and, on page 65, makes the polar diameter greater than the equatorial. On page 100, writing of solar eclipses, he says curiously enough, "As the moon, which throws the shadow, revolves from west to east in a month, while the earth's surface on which it falls rotates from west to east in a day, the shadow travels more slowly than the surface and so appears to sweep across it from east to west with great rapidity." It is difficult to conceive how this distinguished author could have made so inaccurate a statement. Another erroneous declaration, and one which appears in several text-books, is found on page 206, article 446, as follows: "As it is, however, the line joining the aphelion and perihelion points, termed the line of the apsides, slowly changes its direction at such a rate that in a period of 21,000 years it makes a complete revolution." As the annual amount of the motion equals only 11.″29, and as there are 1,296,000″ around the sky we find, by the simple division required, the period to be 115,000 years. The 21,000 years of our author has reference to the motion of the apsides coupled with that of precession, which two are in opposite directions. The two phenomena are utterly unlike and produce entirely different effects.

From a long list of misstatements found in Bishop Warren's charming work, *Recreations in Astronomy*, now adopted by the Chautauqua circles as a text-book, I select the following: [Page 24] "We see the light reflected from the new moon to the earth; reflected back from the housetops, fields, and waters of earth to the moon again, and from the moon to us once more" . . . "and thus we see the old moon in the arms of the new." It is not moonlight but sunlight that causes the dark part of the moon to be faintly illuminated After the sun has set, say, in London, it is shining over the entire American continent and it is this sunlight reflected from the earth to the moon and, from the moon back again that causes the phenomenon observed. On page 196 it says: "So that the famous star, 61 Cygni, is the 111th star in brightness in that one constellation." The fact is, it is called 61 Cygni because it is the sixty-first star in the order of Right Ascension in that constellation. Pages 26 and 214 contain assertions often found in astronomical books, viz.: that sunlight coming to us through fog or a cloud is red, whereas it is, in truth, as white as burnished silver, though, reaching us through smoky haze (dry fog) it always appears red, especially when near the horizon. I question whether the cause of this be exactly known. It is not enough to declare as is often done that the red ray has greater momentum and can force its way through obstructions while the others are absorbed. Were this true, then sunlight through a block of glass or of ice ought to be red, while it is in fact green. In a recent visit to Mt. Hamilton, Cal., the writer saw many red sunsets almost as brilliant as those of three or four years ago. In his opinion, only for the presence of dust of some kind in the atmosphere, the sun would always set white.

This list of errors in our works on astronomy might be greatly extended, but I forbear.

NOTE ON THE PROPER MOTION OF BRADLEY'S STARS.

BY TRUMAN HENRY SAFFORD.*

For THE MESSENGER.

Bradley's catalogue by Professor Auwers has not yet been published, or, at least, sent to America, so far as I can find out; we here have Vol. II of the work, which contains Bradley's own positions in detail, but not the catalogue, which contains the proper motions.

I have consequently extracted from the "Positions Moyennes de 3542 Étoiles (the Pulcova catalogue for 1855), the proper motions of the stars there given, mostly below the 4th magnitude, and from "Publication 14 der Astronomischen Gesellschaft," those of the brighter ones; the two catalogues are complementary to each other in this respect.

As the boundary of the Pulcova catalogue of 1855 is —15° of south declination, I have extended the list of proper motions taken from Publication 14 to this parallel,by extracting from Publication 17 the few stars between —10° and —15° which are of the 4th magnitude or brighter.

The few stars of the magnitudes 1–4 which are not in Bradley have been included, as their proper motions have been calculated.

The number of stars and of proper motions greater than 0″.1 of a great circle annually are given in the following little table:

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* Williams College Observatory, March 7, 1889.

	Magnitude.	No. Stars.	P. M. 70″.10	Per Cent.
Fundamental stars..................	1.0 to 4.0	328	149	45
Other stars..............................	4.9 or brighter.	249	73	29
Stars..	5.0 to 5.9	823	202	25
"	6.0 to 6.9	1117	215	19
"	7.0 or fainter.	280	48	17

That is, of the 328 fundamental stars, 149 or 45 per cent have proper motions greater than 0″.10 annually; and so on.

From this it will be seen that the percentage of sensible proper motions of the fainter stars is not very small; I adopted 0″.10 yearly as my lower limit, thinking that very few stars indeed could be erroneously assigned proper motions of this amount, even supposing Bradley to have a single observation only; or that the proper motion in one co-ordinate depends on Piazzi or Groombridge.

The logarithms of the percentages are roughly represented by the formula

$$h = -0.06 - 0.1m$$

which of course gives an absurd result for $m = 1$, but elsewhere is not far from the truth. For the magnitudes 7.0, 8.0 and 9.0 the percentages of proper motion greater than 0″.10 annually would be: 7th magnitude, 17th per cent; 8th magnitude, 14 per cent; 9th magnitude, 11 per cent. That is to say, the 110,000 stars not in Bradley's catalogue which have been observed in the zones of the Astronomischen Gesellschaft may be expected to furnish at least 12,000 proper motions greater than 0″.10 yearly, so soon as a value of that amount can be distinctly recognized.

If the older observations to be had in any case are Lalande and Bessel's or Argelander's zones only, the probable error of an annual proper motion (including both co-ordinates) will be somewhere between 0″.02 and 0″.03; Piazzi or Groombridge would most likely reduce this amount to 0″.015 or 0.″02; while all the authorities of 1790–1810 should not have a greater uncertainty than 0″.01 to 0″.015, provided the star is found in all three catalogues, or is twice or more observed by Lalande, and is in one other. In these rough estimates I have supposed the modern authority to have a probable error of 0″.5, or of 0s.024 read in right ascension, and 0″.35 in declination—which is probably an average value for the two or three observations of the zones after

Astronomischen Gesellschaft—and have taken the mean epoch as 1875.0.

An equally accurate repetition of these zones in 35 years would give the probable error ± 0″.02 for the annual proper motions of stars not observed before the present zones were begun in 1868, so that it will be hardly time to undertake it for this purpose.

The non-fundamental work for first rate meridian instruments which seems to me most important at the present time is the re-observation of stars of the 7th and 8th magnitudes, especially such as are either contained in Piazzi or Groombridge, or give in other ways indications of sensible proper motion. The proper motions averaging 0″.10 annually have now a very great importance in the problem of the solar motion and its relation to the stellar distances.

I am just publishing a catalogue of polar right ascensions which will furnish in one way a basis for these observations.

TOTAL ECLIPSE OF THE SUN, JAN. 1, 1889.

HON. C. W. IRISH.*

For The Messenger.

Liegan is a new town situated on Section 13, in Township 27, N. R. 16 E. Mt. Diablo Meridian, and is 6½ miles west from the 120th meridian. In time it is approximately 8*h* 00*m* 29.4*s* W. of Greenwich; in latitude approximately 40°9¾′ N.; altitude 4,050 feet above the sea. The altitude was given me by L. F. Warner, Esq., chief engineer of the N. C. and O. Ry., and is determined with accuracy by engineers' levels.

The weather for several days before the 1st was very cloudy, so much so that only an approximate meridian could be obtained, and no observations of precision could be made for obtaining local time, until noon of the 1st. Clouds attended us then and until time of first contact, but did not materially interfere with us after that. The upper regions of the atmosphere were much disturbed by a warm S. E. current, coming in contact with a cold one from the west. This gave the air in the vicinity of the eclipse much tremu-

* United States Surveyor General of Nevada, and Director of the Nevada State Observation Party; Observing Station was at Liegan, California, at the present terminus of the California and Oregon Railway.

lous motion at about the time of first contact, but during totality and on to the end of the eclipse, it was hardly noticed.

After the fourth contact clouds again gathered, and at sundown shut the sky entirely from view.

I was assisted by Professor C. W. Friend, of Carson, Nev., who took the contacts, assisted by Hon. Trenmore Coffin. I myself took the contacts, assisted by Mrs. C. W. Irish.

I put the photographic work into the hands of Professor E. P. Butler, of Reno, Nev., and Mr. James W. Moffat, C. E., of Silver Peak, Nev. Professor Butler was assisted by Mr. Sidney Pinniger, who changed the plate holders for him, and Mr. Moffat by Professor Wm. McN. Miller of the Nevada State University, who preformed the same service for Mr. Moffat. Professor Miller joined the party for the purpose of making meteorological observations of his own, and, as I was short a man for the photographic work, he kindly volunteered for the purpose. Mr. J. S. Hawkins of Carson, Nev., by means of a sighting tube and tangent screw attached to the platform upon which the photographic cameras were fixed, kept these instruments pointed upon the sun, and Mr. L. P. Warner called the times the exposures began, from the face of the chronometer and recorded them.

As I was watching for first contact I had the good fortune to catch a view of the moon as it closely approached the sun.

I could not see the entire body of the moon, but only a crescent-formed part of it. An arc of about 45° in extent was plainly seen; it was of a silvery gray tint, very sharp and well defined on edge next to the sun and fading away to invisibility, and was lost at about 20° each way from the point nearest to the sun.

It was in breadth about one-third the diameter towards the center of the moon from the advancing edge.

Thus I was able to call time of exact contact, and half a second later saw the black edge of the moon's disk overlap the brilliant limb of the sun.

The photographic party now began their work, taking several drop-shutter views of the partial phases.

As the total phases approached closely, I could plainly perceive that yellow rays predominated in the waning sunlight; all things illuminated by it wore the ghastly livid look as if illuminated by a salted flame.

The landscape partook of this deathly pallor. A few seconds before second contact, diffraction bands began to appear, their lengths disposed north and south, and their motion towards the east. I saw them at first faintly depicted upon the canvas of my tent, and as they brightened they were seen creeping along the ground surface. Their motion I judged was about from 6 to 10 feet per second eastward.

When the instant of the second contact came, the sun's light seemed to leap out of that point of the moon's limb where contact took place, and springing around the circle of the moon in opposite directions, clasped it as if in a pair of loving arms. At the same time the corona, which before was faintly seen, flashed out upon the ashy purple sky. At the end of this article I give four sketches made by members of the party, second and third are duplicates. The corona had two double pointed rays, one of them about tangent to the sun's upper limb, the other tangent to the lower limb. The outer edges of these rays were straight lines, or nearly so; they appeared to me to be exactly parallel, and if they deviated in their lengths from a straight line, it was where they came in contact with the sun's limb, where they seemed to curve outward around it. The rays had a direction in space, upward, from a line through the sun's center parallel with the horizon, of about 27°, rising towards the east. The westward point of the upper ray reached out towards the west about 1½ diameters of the sun from its center, and the eastward point towards east 1¼, the westward point of the lower ray 2, and its eastward point 1½ such diameters. The inner edges of these rays curved inward towards each other, and meeting, formed a fringe of pure white light to the sun's limb about ½ diameter broad. The two western rays, together with the included fringe, were by far the brightest part of the corona, while the two eastern were, with their included fringe, the faintest.

The upper eastern ray was much the weakest of all. The corona in density, brightness and species of its light, reminded me strongly of the great nebula of Orion when I view the latter with my 4-inch telescope with a power of 20

I saw several stars in vicinity of the eclipse twinkling brightly; and, on looking overhead eastward and northward, saw many more, but I was too much occupied in sketching the corona to take any note of them. The sun's polar rays flashed out in a broad fan from both poles; and extending, as I judged, ¾ of a diameter, they blended with the corona's light and gave to that its southward curved appearance. I paid but little attention to the sun's inner corona, as I had not the time to do so. The red prominences were quite evident to the unaided eye, principally on the western limb of the moon.

A short view of them with my telescope showed the two which were noted by the observers by naked eye observations, to be enormous in proportions. The one in the axis of the upper western ray was sharply spear-shaped, and, doubtless, of quite recent formation. Its shape and appearance reminded me strongly of a view I had, some years since, of the formation of just such a figure on the sun's surface in pure white.* The other prominence, which appeared in the axis of the lower western ray, was cone-shaped, the apex bent upward somewhat, and from it there floated off three beautiful roseate clouds, in the direction to which the bended apex pointed. These clouds were cumulus in form.

A number of small and very red prominences appeared in the axis of the lower eastward coronal ray; they seemed to be just forming. In the base of the upper ray near to its outer edge appeared a cone-shaped prominence, having a hue of ashes of roses. It was evidently dying away, for it seemed to be settling down to the surface of the sun. The red points of other prominences could be seen peeping up from behind the black limb of the moon, but I took no further note of them. The photosphere, to my eye, had the appearance of a rose-colored spherical shell, enclosing the sun at a distance of one-twentieth of his diameter from him, and to be lighted up by roseate fires, which were hidden from my view by the dark body of the moon. After third contact I watched the parts of the beautiful scene as they one by one faded from my view.

The chromosphere parted at the point of third contact and withdrew each way from it to disappear at the opposite

* The SIDEREAL MESSENGER Vol. III, page 186.

side of the moon. It disappeared altogether in about 3 seconds. But the beautiful corona lingered, its eastern rays dissolving in about 15 to 18 seconds, and its brighter western rays in about 20 seconds after third contact.

The diffraction bands and the retreating shadow now claimed my attention. The bands seemed brighter than before totality, and danced along like the reflected sunlight from faint ripples of a broad water surface. Their peculiar motions caused me to remark that their origin might be discovered in the wave-like tremulous motion of the air, described at the beginning of the eclipse. The shadow was seen creeping away eastward, over the plain and along the mountain side, its motion not as swift as I had expected it to appear. I had no trouble in following the limb of the moon to exact fourth contact, and continued to see the slaty silver gray crescent for about three seconds after that.

Again the photographic party took photographs, at convenient intervals of time, of the now declining eclipse, and observers completed their sketches before the figures faded from memory. This was faithfully done, no comment or communication with each other until it was done.

At noon of the 2nd we secured two reliable observations for time over our approximate meridian, and having in the forenoon pulled down our camp and packed our instruments, we left on the N. C. and O. train for Reno.

My observed times of the four contacts, referred to the chronometer, and corrected for its rate, and difference between noon of the 1st and second by our approximate meridian, were as follows: 1st, 0*h* 29*m* 04.6*s* P. M., Jan. 1st, 1889; 2nd, 1*h* 51*m* 15.0*s*; 3rd, 1*h* 53*m* 00.6*s*; 4th, 3*h* 09*m* 55.5*s*.

Professor Friend and Hon. Trenmore Coffin jointly report as follows: "Diffraction bands were not noticed at the beginning of totality. The corona on each side of the sun somewhat resembled an elongated tail fin of a fish, with the outer edge fairly well defined, and with the inner edge shadowing off into invisibility. The four points seemed to extend out into long, single, hair-like rays of indefinite length, losing themselves in the brighter outer sky. Point *d* (Fig. 2) was discernible for at least two diameters of the sun. The relative lengths of the four points were in the order *d*, *b*, *c*, *a*. The rifts in the corona between the points *a*, *c* and *b*, *d* were deeper, or extended nearer to the sun's limb towards the line *ab*, than on the side of the line *cd*. I made no attempt to observe anything except the form and appearance of the corona, and to look for the diffraction bands before and after totality. The sketch, No. 3, was made in camp at Liegan on the morning of Jan. 2d. It would be difficult if not impossible to represent the corona as it really appeared. In color it was a very light soft yellow, with a greenish tint. The points of the corona, especially the lower right hand point, seemed to extend out into long, luminous hairs, which appeared to float in space. There was a gradual decrease of light from the limb of the sun to outer limits of the corona. Referring to sketch (No 2), there was no sharply defined outline, except a part of line *ab*. Lines *ab* and *cd* should be a little nearer or quite parallel, by widening the space between *a* and *c* and narrowing the space between *b* and *d*. The lines across diagram and about the eclipse are intended to represent very light cirro-stratus clouds, nearly all other parts of the sky being clear. The approach and recession of shadow was not clear cut or well defined. The light faded gradually into dull twilight and *vice versa*. Diffraction bands were not noticed before totality, but were sharply defined for four or five seconds after third contact. They were without perceptible onward motion. They appeared like the quivering light cast upon a wall by innumerable wavelets upon nearly still water in sunlight.

"No candle was necessary for the reading of my watch or to make the drawing during totality. Two small red prominences were seen by the unaided eye. The corona was not visible before second, nor after third contact. Times of observation by Professor Friend;—1st, 0*h* 29*m* 05.4*s* Jan. 1st, 1889; 2nd, 1*h* 51*m* 16.3*s*; 3rd, 1*h* 53*m* 00.3*s*; 4th, 3*h* 09*m* 38.4*s*. Professor Friend concurs in the foregoing which I have written. Very respectfully, TRENMORE COFFIN."

RENO, NEV., Jan. 25, 1889.

Gen. C. W. Irish, Director of Eclipse Observation Party:

SIR: I have the honor to report to you the result of my part in the observation of the total eclipse of the sun on the 1st inst., at Liegan, Cal. I, by your direction, took charge of the Darlot single-view lens and camera. The glass was eighteen inches back focus, and was about three inches in diameter, with a maximum stop opening one inch in diameter. It was provided with two stops of smaller diameters, but all the work upon the total phase was done with the full opening of one inch. I was assisted in the work at the camera by Professor McN. Miller, who changed plates for me and managed all that part of the work, while I made the exposures and counted the times of the same by the second hand of my watch. Attached is a tabular statement giving the history of each plate. It is as follows:

Photographed by Engineer James W. Moffat.
No. 12, exposure 5s. (The upper figure an enlargement of the lower.)

Photographic Plates Exposed by J. W. Moffat, C. E., and Professor Wm. McN. Miller with the Darlot Lens.

Plate No.	Chron. Time Exposure Began. h m s	Time Exposed.	Remarks.
7	1 12 01	Inst.	View of observation of grounds.
8	1 16 46	"	Partial phase covered by clouds.
9	1 21 02	"	Partial phase, good definitive.
10	1 47 46	"	Shows fan-shaped light.
11	1 51 15	4 sec.	Totality.
12	1 51 28	5 "	Totality.
13	1 52 02	7 "	Totality.
14	1 53 58	5 "	Totality; jarred during exposure.
15	....	....	Not exposed.
16	1 53 01	5 "	Caught by sun at end of totality and jarred.
19	1 58 01	Inst.	Same as No. 10.
20	2 22 47	"	Sun covered by very thin clouds.
21	2 50 48	"	

All the plates used during the observation of the eclipse were "Seed's, sensitometer No. 26," and were developed by myself and Professor Butler, who will give description of the developer used. It is a weaker one than is generally used upon these plates.

I would draw your attention to the peculiar fan-shaped light shown by Nos. 10 and 19, each of which were exposed within four and five minutes of totality, No. 10 before and No. 19 after that event. Respectfully yours,

JAS. W. MOFFAT, C. E.

Gen. C. W. Irish, Director of Nevada Eclipse Observation Party:

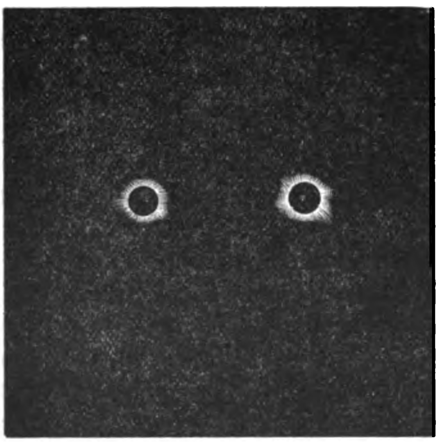
SIR: I take much pleasure in reporting to you, in conjunction with Mr. Moffat, the results of our photographic work on the recent eclipse, Jan. 1st, 1889.

The following table shows a history of the plates which I exposed at the time of total observation, using a Suter lens, Swiss make, No. 3 of the doublet form, 3-inch full opening of the front combination, and 16 inches back focus. It was supplied with three stops, but I used the full opening of 3 inches during the work upon totality. I made the exposures and timed them by counting (mentally) the seconds.

It was a happy conception of yours to experiment with the cameras and lenses by making exposures of some plates sighted upon Mount Rose fifteen miles away after sunset, and the stars had shown themselves in the evening twilight; upon development of these trial plates, the mountain ridge and slopes, together with the figures of the pine trees, came out clear cut, and this with an exposure of only five seconds, with full aperture of the lenses. The developer used upon the trial and eclipse plates, was that of Professor Newton, "standard dry pyro," as follows: One ounce carbonate soda, dry, one ounce carbonate potash, dry, one ounce sulphite soda, dry, ten ounces of water, six grains of pyro, dry, put into four ounces of water and dissolved, to which add two drams of the alkali solution. The mixture makes sufficient developer for a 5 × 8 plate.

I think, General, that we may congratulate ourselves upon having attained such perfect results, photographically, of all the phases of the eclipse, while using the rude and hastily improvised stand and appliances, fashioned from materials found upon a desert waste. In conclusion, I have to say that all the plates, whether shutter or cap exposures, show images which come out quite vigorously during development. The cap exposures made during totality with open lenses, though so variously timed, obeyed the requirements of development easily, and without any forcing or prolongation of time or patience.

Photographed by Professor E. P. Butler. No. 36, exposure 5s; enlargement 7:23.



Photographed by Professor E. P. Butler.
No. 37, exposure 3s. (Right hand figure.)
No. 38, exposure 2s. (Left hand figure.)

The axis of the platform on which was fastened the cameras in use was so arranged that the Darlot lens, being placed over the pivot about which the whole apparatus revolved, showed less movement and disturbance, from the jarring incident to removing and replacing the plate holders in the cameras, than did the Suter lens, which was farther away from said pivot. I would infer from this, that every camera in such use should have its own separate support.

The following is a tabulated statement of the plates exposed by me. I took no photographs of partial phases, having no drop shutter to my lens.

No. of Plate.	Chron. Time. h m s	Time Exposed.	Remarks.
33	1 51 15	3 sec.	Excellent, good definition.
34	1 51 41	4 "	Shows signs of jar during exposure.
35	1 52 08	1 "	Badly jarred.

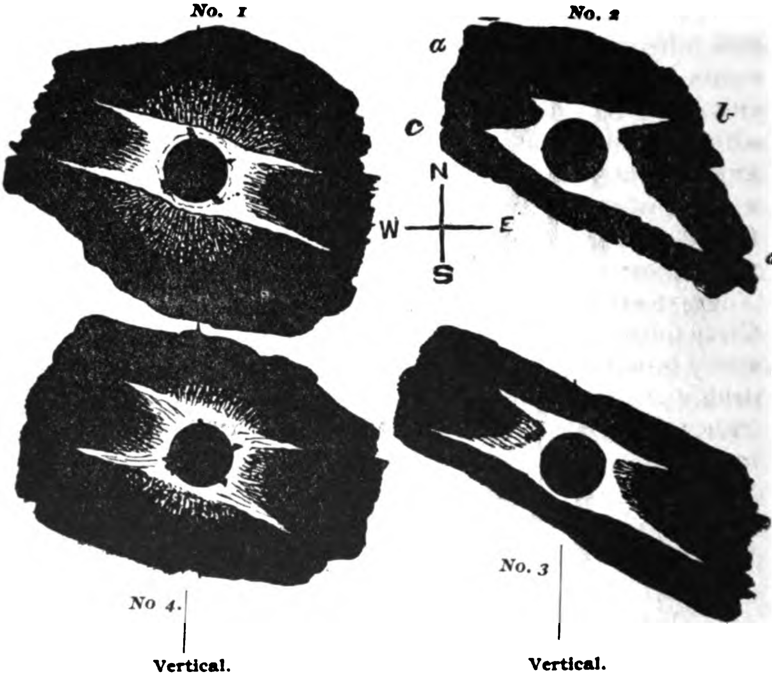
No. of Plate.	Chron. Time. h m s	Time Exposed.	Remarks.
36	1 52 22	5 sec.	
37	1 52 44	3 "	
38	1 53 01	2 "	Caught by end of totality, excellent definition.

Sincerely yours,
PROFESSOR E. P. BUTLER.

In preparing for photographic work upon the eclipse I was ably seconded by Professor Butler, whose long experience in the lights and shadows of the mountains of California and Nevada was a training much needed for such work. He cheerfully consented to assist, and together we made experiments with the two lenses selected for our work, by exposures of "*Seed's plates*" after sunset at times selected by myself, at which the darkness of receding twilight was first a little brighter than I had, in former experience with total eclipses, observed the light on such occasions to be; and, second, when the still fading twilight was surely a shade or two darker. To this end I selected the pine-covered slopes of the Sierra Nevadas, distant about fifteen miles. The newly fallen snow caused the black pine trees to stand out boldly in relief on the sides of the mountain known as Rose Peak.

We focused the cameras carefully upon the clouds which hovered over the mountains in bright sunlight, and marked the position of the plate carriers, and then on the evenings of December 27th and 28th preceding the eclipse, we pointed the cameras upon the mountain selected, and at twenty-five minutes after sundown, at a time when the unaided eye could clearly make out the pine trees on the mountain sides, made exposures with the medium stops of five seconds; at thirty-three minutes after sunset, exposures of ten seconds, at a time when I judged by the eye that the darkness was about as we might expect it during the eclipse; and again at forty minutes when the pine trees had lost their forms to the eye, and only the bulk of the mountain could be outlined upon the sky, and clouds as a background. At this time we made exposures of from five to ten seconds, with full opening of lenses, getting negatives which not only gave an outline of the clouds and mountains, but also of the pine trees on the darkly shadowed slopes. The figures of the pines are clear cut, showing that our cameras could catch forms in a light so weak that the eye altogether failed in the attempt to make them out. I found by comparison, on the day of the eclipse, that the darkness was just about equivalent to the forty minutes after sundown experiment.

I here give the four field sketches made at the time of the eclipse, and a photograph from negatives made by each of the lenses used; A by the Darlot and B by the Suter. The figure of the moon in photograph A shows the same cres-



Field Sketches of the Sun's Corona, Jan. 1, 1889, by the Nevada State Observation Party. No. 1 by Gen. C. W. Irish. No. 2 by Hon. T. Coffin. No. 3, by Hon. T. Coffin, is a revision of No. 2. No. 4 by Mrs. Gen. C. W. Irish.

centic reflection as I saw it to have in the telescope, which enabled me to see the moon before the second contact and after the third. Not one of the negatives by this lens shows more than a suspicion of the presence of the red prominences, while in every one by the Suter they strongly appear. We were very kindly treated by the people of Liegan, and owe a debt of gratitude to E. Gest, Esq., Manager, and J. M. Fulton, Superintendent, and to Mr. L. F. Warner, Chief Engineer of the N. C. & O. Ry. Co., for transportation and other help furnished the expedition, without which we could not have succeeded.

THE CARLETON COLLEGE ECLIPSE PARTY.

A brief report of the work of the Carleton College observing party made Jan. 1, 1889, may be given at this time. The party consisted of Professors Payne, Pearson and Wilson. The instruments taken were, a six-inch reflecting telescope, kindly loaned to the party by Mr. C. E. Crane, of Owatonna, Minn., a zenith telescope of 2½ inches aperture, also loaned to Carleton College by John Bidwell, chief engineer of the Department of Dakota, Fort Snelling, Minn., a chronometer, an aneroid barometer of sensitive pattern for measuring altitudes, fine thermometers and a variety of photographic apparatus.

The route of the party to the Pacific Coast was over the Chicago, St. Paul and Kansas City Railway, and the Atchison, Topeka and Santa Fè Railway. We were surprised and delighted to find the new Kansas City line so complete in all its appointments, for the comfort and pleasure of those who travel by it, although its main line is not yet completed to Kansas City. This new route has quickly come to the front and is one of the best equipped for passenger service in the West.

From St. Joseph, Mo., to San Francisco, California, we were on the Santa Fè cars without change. In this justly famous route we found many things to admire; chiefly the attention and politeness of the employès, and the excellent eating houses for the whole length of the line, furnished by the company, under one management, which is the finest arrangement of the kind we ever saw. The sight-seeing afforded by this route was a continual round of pleasure not soon to be forgotten. The idea that an ordinary traveler, not choosing a Pullman car, may step into a railway coach and not necessarily leave it again until he set foot on the pier at Oakland, California, is one of the marvels of modern trans-continental travel which it is difficult to realize until one has experienced it.

In this connection it is a great pleasure to mention the thoughtful interest and the liberal courtesies in the way of free transportation in the interest of science furnished by President Wm. B. Strong, of the Atchison, Topeka and Santa Fê Railway Company, President Stickney and General Manager Egan, of the Chicago, St. Paul and Kansas City Company, and also the generous offers of like favors by President J. J. Hill and General Manager A. Manvel of the St. Paul, Minneapolis and Manitoba Company. We further delight to speak of the great personal kindness of Mr. Chas. S. Hulbert, of Minneapolis, a member of the Board of Trustees of Carleton College, who generously paid the bills of the party, thereby not only making so expensive and delightful a trip possible to us, but also giving us an opportunity to observe for the first time a total solar eclipse, the grandest celestial phenomenon within the reach of mortal eyes.

The place chosen by our party for observation was Chico, California. This is a city of seven thousand inhabitants, in the Sacramento valley, east of the river bearing the same name, about eighty miles north of the city of Sacramento. The particular point selected for mounting the instruments was on the famous ranch of the Hon. John Bidwell, 32.47 chains, with bearing S. 32° 45′ W. from corner of sections 22, 23, 27 and 36, and on N. E. ¼ of section 27, T. 22, N. R. 1 E. Mt. D. M., variation of needle being 17° east. The survey was made by Engineer M. T. Brown, of Chico.

The telescopes were mounted Dec. 28 and 29, and were ready for observation on the evening of the 29th, but clouds so continually interfered that but a single opportunity was found for taking time and obtaining the approximate latitude of our place. As thus roughly obtained our position was:

Latitude = 39° 43′ 56″ N.

Longitude = $8h$ $7m$ $27.5s$ West of Greenwich.

We were greatly favored by the kindness of the general officers of the Western Union Telegraph Company resident at San Francisco and Sacramento in the free use of the Lick Observatory time signals for five days preceding and including January 1. By this means it was possible to know the error of our chronometer very closely. The morning of Jan. 1 was not altogether favorable, yet there were hopefu signs, though at 10 o'clock a heavy bank of clouds in the west caused our party to feel more doubtful. The last comparison of the chronometer with the noon Lick time signal was made and we hurried to our instruments to be ready for the first contact. The four contact observations, in Pacific standard time, were as follows:

Contacts observed by W. W. Payne.

Zenith Telescope 2½ inches aperture, power 106.

	h m s		h m s
First contact..........	12 24 31	Third contact...............	Not observed
Second "	1 48 20	Fourth "	3 7 57

Times of contact observed by H. C. Wilson.

	h m s	Instrument.
First contact..............................	12 24 30.5	6-inch reflector.
Second "	1 48 20	1⅝-inch finder.
Third "	1 50 15	1⅝-inch finder.
Fourth "	3 08 02	6-inch reflector.

The eye-piece employed with the 6-inch reflector gave a magnifying power of 45, that with the finder about 15.

The chronometer used was by Bond, and numbered 374. It was placed at a convenient distance from the observers, that the counting of time might be distinctly heard by all. Mr. H. H. Camper of Chico did this service for the party in a clear voice, for the entire period of totality.

As before said, late in the forenoon of the day there was some promise of a fair opportunity for observing the eclipse, and at fifteen minutes after one o'clock we felt sure of first contact. A few minutes later a vigorous call of "time" from the observers at both telescopes, at an interval of one-half second apart, was the beginning of the important record. In five minutes more the sun was covered by a large, dense cloud, that had a very depressing influence on our party, for it did not seem possible that such a thick, slow-moving mass could pass by the sun in the short space of twenty minutes, the computed time for the beginning of totality. The moments following were long and painful, and the growing disappointment pictured in every countenance was plainly visible. However, at 1:45 there was a sudden breaking away of the clouds in the immediate vicinity of the sun that was very surprising to the thoughtful observer. If this uncovering of the face of the sun, at the time, had been known to be miraculous, it could not have been more joyfully surprising to the writer. Two minutes more and the thin crescent of the sun's eastern limb hung on the black moon like a silver thread, its southern cusp broken into two parts which tremblingly linger for an instant and then disappear. The sight in the telescope was beautiful beyond all anticipation.

In searching for the phenomena attending the third contact, its time was not noted. The sudden disappearance of the sunlight, the bursting forth of the corona with its four long and distinct streamers, the effort necessary to sketch an outline of the same, and view its interior structure in the telescope, were the thoughts occupying our minds in the 113

No. 7 of totality. Exposure 1 sec. Plate, Seed No. 26. Instrument, Camera, 2½-inch Darlot lens.

precious seconds of time allotted for these things. The photographic work of the party was given to Professors Pearson and Wilson, and illustrations of part of the same are given herewith with explanation by Professor Pearson as follows:

"The instruments used in the photographic observations were a 6-inch reflecting telescope, a 2½-inch projecting lens of about 7 inches focus, and a couple of Rochester cameras carrying a one inch rapid-working Darlot lens and a Rochester lens, and supplied with 5×8 Seed plates, No. 26. To the upper part of the reflector was fitted a wooden support, one arm of which carried the plate holder for the telescope while the other arm bore the projecting lens fitted into a box which was arranged for receiving 4 × 5 plate holders. The axis of the projecting lens coincided with that of the reflector, so that when the image was upon the crossed wires of the finder of the large telescope it was in the axis of each instrument.

No. 2 of totality. Exposure, 5 sec. Plate, Seed No. 26. Instrument, 6-inch reflector.

"The reflector was furnished with an equatorial mounting so that the proper motion could be given by a turn of the hand. The plate holder of the reflector consisted of an outer square case, within which rotated a hexagonal box, each of whose faces was furnished with a 4×5 plate. Before and after totality this holder gave way to a holder fitted for instantaneous exposures.

No. 5 of totality. Exposure, 10 sec. Plate, Seed 22. Instrument, 6-inch reflector.

"A 5 × 8 Seed plate No. 26, given a short exposure with the Darlot lens at the time of first contact shows the sun and the neighboring sky covered with light clouds whose general drift was to the east and south-east. Occasional instantaneous exposures were made upon Seed plates Nos. 22 and 26, with the large telescope up to the time of second contact as rifts in the clouds afforded opportunity. The images upon the most of these negatives, while showing well the advance of the moon, were more or less obscured by clouds. The uncertainty concerning the intensity of the coronal light of course rendered necessary as wide a range as possible of exposures during totality. To the image of the reflector received through the side of the tube, exposures of five and six seconds were first made upon Seed plates No. 26, then of seven seconds upon a Seed plate No. 22, then successively of eight seconds upon a Seed 26, of ten seconds upon a Seed 22, and of twelve seconds upon a Seed 26. It was found that the effort to maintain the motion of the instrument would jar the plates, so that attention was confined to bringing the image of the moon to the axis of the telescope in the intervals between exposures. This of course resulted in a decided drift of the image upon the plates during the longer exposures.

"The intensity of the coronal light was underestimated, which appears to have been the case quite generally, and of course the shorter exposures and the slow plates gave the best results. The most satisfactory picture, so far as detail in the corona is concerned, was obtained from the projecting lens by an exposure of one second through the unstopped lens upon a Seed plate No. 26.

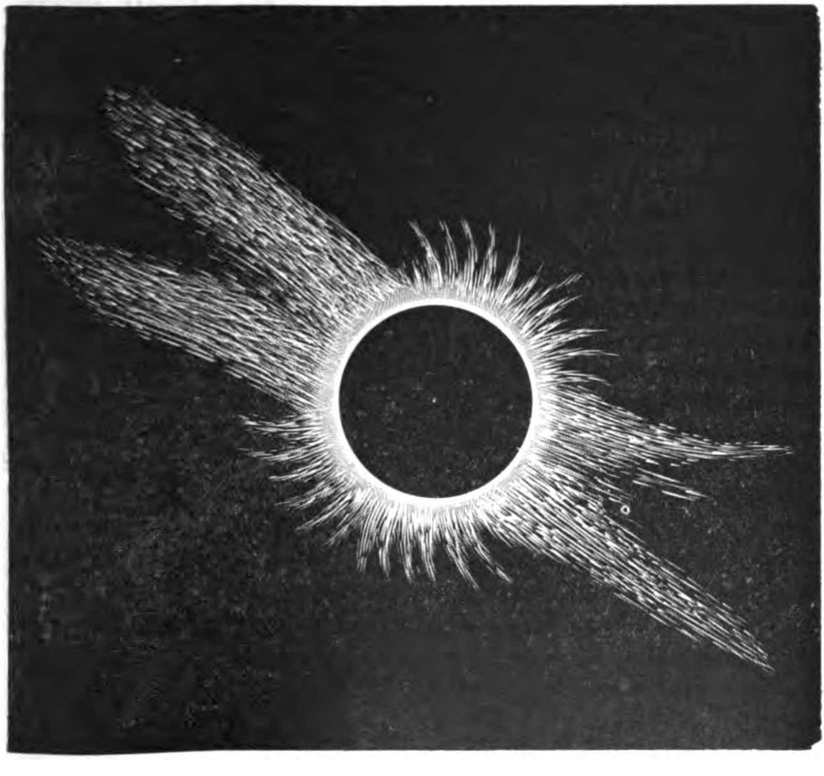
"Exposures of 50 and 60 seconds upon Seed plates No. 22, in the 5×8 cameras of course show over exposure at every point of the drifting image.

"The clearing of the sky a few minutes before totality afforded a fine opportunity for photographic as well as observational work. And the continuance of this condition after totality resulted in a satisfactory set of views of the remaining phases of the eclipse."

Free-hand sketches of the corona were made by Messrs. Coster, Brown and McGann, of Chico, who kindly consented to assist our party in this particular, and whose work was very creditable, and will be embodied in the fuller report of the party that will be published some time during the summer.

The following sketch is by Dr. H. C. Wilson, and the explanation of it is given in his own words, as follows:

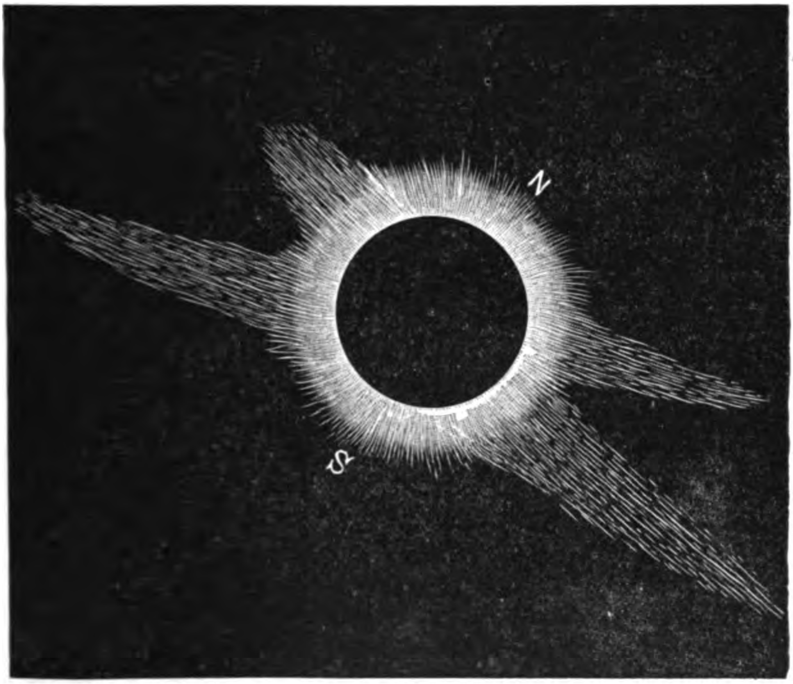
"My sketch of the corona was drawn from memory immediately after totality. As I was occupied with the photographic apparatus, guiding the 6-inch reflector, I could spend very little time in looking at the corona with the naked eye. The impression, however, which I received in the few seconds snatched at intervals between exposures, was a very vivid one. My first thought at the moment was that the corona was very like the Trouvelot drawing of 1878, but differing es-



pecially in the polar rays which were curved and pointed, instead of straight and spreading as in the Trouvelot drawing. These polar rays impressed me so forcibly that I have doubtless made them too conspicuous in my drawing. I had no time to count them, so that the number sketched is a mere estimate. The broad bands extending to the east and west were each divided at a short distance from the moon's edge into two faint streamers which reached out to a distance of two or more diameters of the moon. I may have been confused as to the direction of the two broader ones of these streamers from the fact that I was looking most of the time through the finder, which inverted the image. The upper streamer to the right, as seen with the naked eye, was, I am certain, decidedly curved upward near its extremity. Three rose-colored prominences were visible in the finder during the greater part of totality. I saw the inner corona through the finder several seconds before the beginning and after the end of totality, although a thin neutral tint shade was used. I looked carefully to see the projection of the moon upon the corona before the beginning and after the end of the eclipse, but was unable to see it, as the sky was slightly hazy."

The outline of the figure given below was made by the writer during totality and immediately after it. The time given to observing it was divided nearly equally between views by the naked eye and by the zenith telescope, mainly upon the inner corona. The naked eye view was first in order. Immediately after third contact the corona was examined and the three longer streamers of the figure were distinctly in view, and the fourth was seen, though faint in comparison with the others. At first sight the southern limits of the two lower streamers seemed to make one straight line outside of the corona proper; but the northern limits of the northern pair were not well defined. At the middle of totality the streamers seemed to be wider at their bases, more extended and slightly curved, and the whole corona larger and more symmetrical in the polar regions. The writer thinks that a considerable portion of these changes may not have been real, but rather due to compelling the eye to grasp the view as definitely as possible, which could be done better after a few seconds of steady observation, as his eye is not very sensitive to faint details such as these.

After a few seconds of attention to the sketch, the telescope was turned upon the inner corona of the western limb of the sun to search for Bailey's Beads, and to note the structure of the corona in the few seconds of totality that remained. Beginning in the base of the upper western streamer, and sweeping to the south, we noted the photosphere in full view for 90° to the south, from which arose two large and beautiful prominences; but, knowing that we had less than ten seconds of time left, we took a hasty look at the corona about the south pole, and the view which met our eyes there was beautiful beyond the power of delineation or expression. The view as a whole reminded us of the observations and drawings of Professor Lewis Boss, made at West Las Animas, Colo., July 29, 1878, and published in



the U. S. Naval Observatory Report for 1880, so far as the filaments about the south pole are concerned. With a better means of illustration than we now have at hand we hope in the near future to represent more fully and faithfully what we saw.

We had no means of determining the light of totality, and can only say that it was necessary to use artificial light to carry on our sketching, and that the young men before named were also aided in the same way. Another physical fact of interest was noticed during the progress of the eclipse. At 12:45 the barometer stood at 30.13, at 1:50 it read 30.03, and at 3:45 the reading was 30.13 again.

The members of our party remember with great pleasure the kindness and helpful attention given them by the Hon. John Bidwell, the owner of that magnificent ranch where our observing position was, and the interest manifested in the success of our observations by Editor Chalmers, of the Chico *Enterprise*, Rev. E. Graham, of the Presbyterian church, and Messrs. Burroughs and Goodyear and many other friends whose names would make a list too long for our space if given here.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
			MERCURY.		
April 20	1 36.8	+ 8 56	5 02 A.M.	11 40.8 A.M.	6 20 P.M.
25	2 16.0	+13 22	5 03 "	12 00.3 P.M.	6 58 "
30	2 57.4	+17 32	5 06 "	12 21.9 "	7 38 "
May 5	3 39.4	+21 01	5 12 "	12 44.1 "	8 17 "
10	4 19.3	+23 32	5 19 "	1 04.2 "	8 49 "
15	4 55.1	+25 00	5 27 "	1 20.2 "	9 13 "
			VENUS.		
April 25	2 39.2	+21 37	4 48 A.M.	12 23.5 P.M.	7 59 P.M.
May 5	2 17.3	+17 53	4 05 "	11 22.2 A.M.	6 40 "
15	2 03.2	+14 10	3 28 "	10 28.7 "	5 30 "
			MARS.		
April 25	2 55.6	+16 54	5 46 A.M.	12 59.4 P.M.	8 12 P.M.
May 5	3 38.9	+19 47	5 17 "	12 43.7 "	8 10 "
15	4 08.2	+21 21	5 00 "	12 33.6 "	8 08 "
			JUPITER.		
April 25	18 35.9	−22 55	11 52 P.M.	4 17.4 A.M.	8 42 A.M.
May 5	18 35.0	−22 57	11 11 "	3 37.2 "	8 03 "
15	18 32.9	−23 00	10 30 "	2 55.8 "	7 21 "
			SATURN.		
April 25	9 05.5	+17 53	11 31 A.M.	6 48.5 P.M.	2 06 A.M.
May 5	9 06.6	+17 47	10 53 "	6 10.4 "	1 27 "
15	9 08.5	+17 39	10 16 "	5 32.9 "	12 49 "
			URANUS.		
April 25	13 12.1	− 6 56	5 18 P.M.	10 54.5 P.M.	4 30 A.M.
May 5	13 10.6	− 6 48	4 37 "	10 13.8 "	3 50 "
15	13 09.4	− 6 40	3 56 "	9 33.2 "	3 10 "
			NEPTUNE.		
April 25	3 56.8	+18 49	6 19 A.M	1 40.9 P.M.	9 02 P.M.
May 5	3 58.3	+18 52	5 41 "	1 03.1 "	8 25 "
15	3 59.8	+18 57	5 03 "	12 25.3 "	7 48 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
April 20	1 54.8	+11 46	5 08 A.M.	11 58.7 A.M.	6 49 P.M.
25	2 13.5	+13 25	5 00 "	11 57.8 "	6 56 "
30	2 32.5	+15 00	4 52 "	11 57.0 "	7 02 "
May 5	2 51.7	+16 28	4 45 "	11 56.5 "	7 08 "
10	3 11.1	+17 49	4 39 "	11 56.2 "	7 13 "
15	3 30.8	+19 02	4 33 "	11 56.2 "	7 19 "

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T.	Angle f'm N. P't.	Wash. Mean T.	Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
May 6	35 Cancri	6½	12 33	175	12 50	213	0 17
7	83 Cancri	5½	8 52	186	9 15	220	0 23
8	37 Leonis	5½	12 30	137	13 21	268	0 52

Phenomena of Jupiter's Satellites.

	Central Time. d h m			Central Time. d h m	
April	18 1 19 A. M.	I Ec. Dis.	May	3 3 19 A. M.	I Tr. In.
	4 46 "	I Oc. Re.		4 30 "	I Sh. Eg.
	19 12 50 "	II Ec. Dis.		11 35 P. M.	I Ec. Dis.
	1 57 "	I Tr. Eg.		4 2 52 A. M.	I Oc. Re.
	21 12 35 "	II Tr. Eg.		5 12 02 "	I Tr. Eg.
	23 12 43 "	III Oc. Dis.		12 48 "	II Sh. In.
	3 34 "	III Oc. Re.		2 51 "	II Tr. In.
	25 3 12 "	I Ec. Dis.		3 26 "	II Sh. Eg.
	26 12 22 "	I Sh. In.		6 11 49 P. M.	II Oc. Re.
	1 30 "	I Tr. In.		7 4 01 A. M.	III Ec. Dis.
	2 37 "	I Sh. Eg.		11 12 27 "	III Tr. Eg.
	3 23 "	II Ec. Dis.		1 28 "	I Ec. Dis.
	3 46 "	I Tr. Eg.		4 40 "	I Oc. Re.
	27 1 03 "	I Oc. Re.		10 36 P. M.	I Sh. In.
	28 12 25 "	II Tr. In.		11 33 "	I Tr. In.
	12 50 "	II Sh. Eg.		12 12 52 A. M.	I Sh. Eg.
	3 04 "	II Tr. Eg.		1 48 "	I Tr. Eg.
	30 12 02 "	III Ec. Dis.		3 24 "	II Sh. In.
	2 38 "	III Ec. Re.		11 07 P. M.	I Oc. Re.
	4 23 "	III Oc. Dis.		14 2 11 A. M.	II Oc. Re.
May	3 2 14 "	I Sh. In.			

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

	Central Time. d h m		Central Time. d h m		Central Time. h d m
April	16 4 53 A. M.	April	26 11 00 P. M.	May	8 3 02 A. M.
	17 12 44 "		28 4 47 A. M.		8 10 53 P. M.
	18 6 31 "		29 12 38 "		10 4 40 A. M.
	19 2 23 "		30 6 25 "		11 12 31 "
	19 10 14 P. M.	May	1 2 16 "		12 6 18 "
	21 4 01 A. M.		1 10 07 P. M.		13 2 09 "
	21 11 52 P. M.		3 3 54 A. M.		13 10 01 P. M.
	23 5 39 A. M.		3 11 45 P. M.		15 3 47 A. M.
	24 1 30 "		5 5 32 A. M.		
	24 9 22 P. M.		6 1 23 "		
	26 3 08 A. M.		6 9 15 P. M.		

Elongations and Conjunctions of Saturn's Satellites.

[Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.]

JAPETUS.

April 16, I   May 6, W

TITAN.

d	h		d	h		d	h	
April 18,	6 P. M.	E	April 30,	5 P. M.	S	May 12,	4 P. M.	W
22,	5 P. M.	I	May 4,	5 P. M.	E			
26,	5 P. M.	W	8,	5 P. M.	I			

RHEA.

April 16,	4.4 P. M.	E	April 30,	5.7 A. M.	E	May 13,	7.1 P. M.	E
21,	4.8 A. M.	E	May 4,	6.1 P. M.	E			
25,	5.2 P. M.	E	9,	6.6 A. M.	E			

DIONE.

April 16,	11.7 A. M.	E	April 27,	10.5 A. M.	E	May 8,	9.3 A. M.	E
19,	5.4 A. M.	E	30,	4.2 A. M.	E	11,	3.0 A. M.	E
21,	11.1 P. M.	E	May 2,	9.9 P. M.	E	13,	8.7 P. M.	E
24,	4.8 P. M.	E	5,	3.6 P. M.	E			

TETHYS.

April 16,	11.1 P. M.	E	April 28,	6.8 A. M.	E	May 9,	2.8 P. M.	E
18,	8.4 P. M.	E	30,	4.2 A. M.	E	11,	12.1 P. M.	E
20,	5.7 P. M.	E	May 2,	1.5 A. M.	E	13,	9.4 A. M.	E
22,	2.9 P. M.	E	3,	10.8 P. M.	E	15,	6.8 A. M.	E
24,	12.2 P. M.	E	5,	8.1 P. M.	E			
26,	9.5 A. M.	E	7,	5.5 P. M.	E			

Phases of the Moon.

		Central Time. d	h	m
Full Moon	April	15	4	18.6 P. M.
Last Quarter	"	22	7	55.8 A. M.
New Moon	"	29	8	04.9 P. M.
First Quarter	May	8	12	42.4 A. M.
Full Moon	"	15	12	42.2 A. M.

Note on Observations of Saturn. A few minutes after receiving Krueger's telegram in reference to a white spot on the rings of Saturn, I had a 6½-inch reflecting telescope in use to look up the phenomenon. I had been observing the planet the night before and had not noticed anything peculiar save that the *shadow* of the globe on the ring was very clear and its edge sharply defined. The definition was not nearly so good on the night of the 13th, but at times was good enough to notice a whitish "tint" on the rings bordering the shadow, which I should say was certainly the effect of contrast. I could not use a higher power than 200, and as the definition became worse rather than better I gave it up for the evening. Saturday evening, the 16th, looking fine, I went to the Allegheny Observatory near by, and with Professor Very made quite an extended observation on the planet with the 13-inch equatorial. Various powers were used up to 900, the atmosphere being quite steady. As Professor Very had no knowledge of the phenomenon, he asked me to say nothing, so as to leave him unbiased in his search for any peculiarity. After using powers up to about 600 he concluded he saw nothing peculiar. I then told him where to look and what to look for, when he concluded he could see an apparent whitening on the border of the shadow, but like myself thought it was due to contrast with the black shadow of the planet. I certainly could see it with all powers above one hundred, though I am not certain that I should not, in an ordinary observation, have set it down at once as the *effect of contrast*. But the question comes in, why has this feature not before been delineated? According to Webb, Grover has seen a penumbra to the shadow, but here we have just the opposite. It cannot be of a like character with the white spot which formed and spread out over the globe of the planet in 1876, and from which Professor Hall determined the time of revolution of the planet, because it could only be seen next the shadow at every revolution of the rings. If it is not the effect of contrast it might be explained upon the basis of a rapid cooling of a vaporous atmosphere from the cold upon that part of the ring in shadow; but even this is not satisfactory on account of the rapidity with which the rings move. At any rate observations of a critical character on such phenomena are always of value and interesting, and in such work the earnest amateur may make himself useful in the domain of the "New Astronomy."

The belts on the planet were exquisitely brought out on the night of the 16th, reminding me of the glorious view I had of it two months since in the 36-inch at the Lick Observatory, only that what we saw here in the 13-inch *dimly*, yonder we saw, as it were, "face to face." Never shall I forget that sight which has been seen by few mortal eyes as we saw it at Mt. Hamilton. J. A. BRASHEAR.

Allegheny, March 20, 1889.

The White Spot on Saturn's Ring, recently announced by Terby of Belgium, was observed at this Observatory on the evening of March 14th both by Professor Brooks (who was my guest on that night) and myself. In consequence, however, of its faintness, and of the bright moonlight in which it was viewed, it was a difficult object; but as we both saw it in the same position and of the same size and shape, there could be no doubt in the mind of either of us that we had seen the "spot," which appeared as a narrow band extending across both outer rings, its western boundary being in contact with the black notch termed the shadow of the ball on the ring.

As we found the spot in the same place as at discovery, it cannot belong to the ring itself, as the latter revolves, and, so doing, would cause the spot to be seen on all parts of the ring. We are led, therefore, to believe that the phenomenon must be produced by reflected sunlight from the globe of the planet, though in just what manner produced we are not able to determine. LEWIS SWIFT.

Warner Observatory, Rochester, N. Y.,
March 16, 1889.

The "White Region" on Saturn's Ring, announced by Dr. Terby, has been well seen with the 10-inch equatorial of this observatory. My first view of it was through Dr. Swift's 16-inch, while on a brief visit in Rochester. Since my return home I have given it very careful study and it has, at intervals, been a comparatively conspicuous object. My young daughter, Anna, who often observes with me, sees it distinctly.

The brightness appears to me to be variable. Pulsations of the light of this "white region" have been noticed at irregular intervals, ranging from two to seven minutes. Its appearance at my last observation was that of two small nearly semicircular white "tufts," where the ring is cut by the shadow of the globe. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.,
March 19, 1889.

The Occultation of a Star, estimated at the 8½ magnitude, by the dark limb of the new moon was observed by me on the evening of March 6. Disappearance of the star was taken at 3*h* 11*m* 17*s* local sidereal time. The dark limb of the moon was very distinct and steady, but the star did not disappear at geometrical contact, but seemed to *sink into* the body of the moon fully three of the star's diameters, and disappearance did not occur until two seconds after geometrical contact. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.,
March 19, 1889.

EDITORIAL NOTES.

Our space is so largely given to eclipse reports this month that almost all matters of a miscellaneous kind, including the planet notes, must be deferred until the next issue.

We received too late for use in the article by Hon. C. W. Irish, some fine drawings of the corona as seen at Liegan, Cal., by his eclipse party, Jan. 1, 1889.

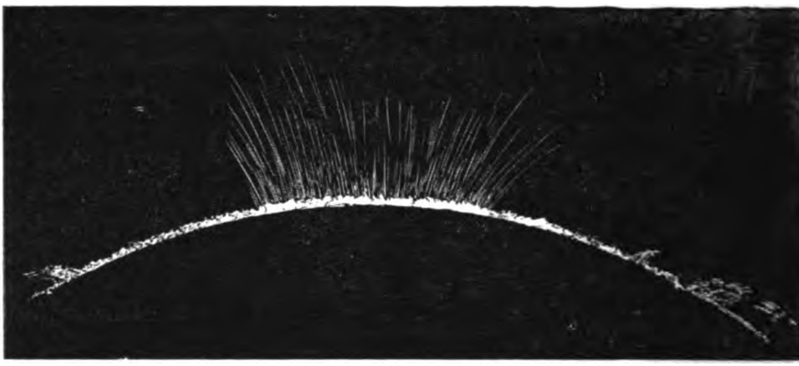
White Region on Saturn's Rings. Harvard College Observatory announced by telegraph, March 13, that Terby had seen a white region on Saturn's rings against the globe shadow.

Although the observers at Carleton Observatory have examined Saturn's rings with the Clarke eight-inch refractor, on four different evenings, in fairly good viewing, with care, nothing has been seen of unusual character. There is the appearance of a lighter color near the shadow of the planet on the rings, but only what might be expected from contrast. It may be that the phenomenon which was first reported by Terby, and later seen in America, by Swift, Brooks and McLeod, is too faint for our aperture. We, however, used powers 200, 400, and 800 with ordinary results.

International Polar Expedition. We are in receipt of Vol. II. of the report by Gen. A. W. Greeley, on the Proceedings of the United States Expedition to Lady Franklin Bay, Grinnell Land. This volume is companion to the one published last year, and completes one of the most important reports in the interest of science and discovery known to American history. Though that heroic party of explorers suffered great privations and the loss of the lives of several of its members, a record has been made that is truly international in character.

Fauth & Company's Small Telescopes. We have recently learned that Messrs. Fauth & Company, Washington, D.C., have made arrangements with the Clarks of Cambridge to supply them with objectives for telescopes ordered of them in the future. We also notice that this company are to give special attention to the mounting of small telescopes well adapted to the wants of students and amateurs. The 4-inch clear aperture, with finder, clockwork, clamp and tangent movements in right ascension and declination, mounted on tripod or iron pillar, as preferred, makes a very useful and comparatively inexpensive telescope. Should an astronomical clock, chronograph, spectroscope, or even a wooden observatory for small instruments be wanted, these well known and reliable makers of precision instruments will certainly not disappoint any one entrusting work to them.

South Polar Rays of the Corona, by Mr. Brashear. After sending his brief report of the observations of the January eclipse made at Winnemucca, Mr. Brashear had the kindness to send us his drawing of the south polar rays of the corona which is given below:



Concerning this astonishing phenomenon, it will be remembered that he said in his last report, that his sketching arrangements consisted of a piece of plate glass, half of which was finely ground and the other half left plain, the line between the two being a curve representing the moon. This made a splendid sketching plate when it was feebly illuminated by a lamp behind it, and it could be used as a photographic negative reproducing in white the black final lines. The figure shows something of the detail of the polar rays and two beautiful solar protuberances.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 8, NO. 5. MAY, 1889. WHOLE NO. 75.

THE ASTRONOMICAL THEORY OF THE ICE AGE.

W. H. S. MONCK, DUBLIN, IRELAND.

For THE MESSENGER.

This subject has perhaps sufficient interest for astronomers to warrant the insertion in THE SIDEREAL MESSENGER of the following remarks partly suggested by Professor McFarland's note in the March number. At the outset I wish to say that I do not think the phrase, "Astronomical Theory," should be limited to that of Dr. Croll. Besides including the counter-theory of Mr. J. J. Murphy, that phrase is also wide enough to include the theory which makes the sun a variable star of long period. This period I suspect will prove to be much less than 200,000 years. The Ice Age may not improbably have occurred not more than 20,000 years ago, in which case, of course, both Croll and Murphy would be put out of court. The best test of this is the amount of post-glacial erosion, of which the Americans have a magnificent example in the falls of Niagara.

I think, however, that neither Dr. Croll nor Mr. Murphy have ever stated the problem in its general form — much less attempted to solve it. It is admitted that during the period when the earth's orbit was most eccentric the total heat received from the sun in each year was not diminished, but in fact slightly increased. And (subject to the qualification to be made hereafter) the same remark is true of every locality on the earth's surface. The problem therefore is: Supposing the total heat to be constant, what distribution of it is most favorable to the formation of a permanent snow cap or ice cap? Without stating the problem generally, Dr. Croll virtually replies: The best arrangement is that which gives an under-supply of heat for the longest time and an over-supply for the shortest; while Mr. Murphy replies: The best arrangement is that which gives the longest duration to the over-supply, and the shortest to the under-supply. (The words "over-supply" and "under-supply" refer to a supply in excess or defect of the mean.) It is essential to both theories that time should enter as a factor into the problem; and in one sense it is obvious that it does so. What I intended to convey by my former remarks in THE SIDEREAL MESSENGER (and I think I expressed my intention with sufficient clearness), was that time is not an *independent* factor in cases where the total annual heat is constant. If q be the amount of heat received in the unit of time and Q the amount received in the year, then $q_1t_1 = \frac{1}{2} Q$, and $q_2t_2 = \frac{1}{2} Q$ where q_1, q_2 are the mean heat of summer and winter respectively, and t_1, t_2, the lengths of the summer and winter respectively; and the quantities Q and $t_1 + t_2$ are both constant according to Croll. Time is thus a factor which is invariably associated with another factor that varies inversely as the time, and the element that we have really to consider is the product of the two factors, which is constant. If Professor McFarland places a block of ice at the temperature of 32° *F*, on a surface whose temperature is kept constant at 33° *F*, he will find that the amount of ice melted at the end of an hour is exactly equal to what would be melted in a minute if the surface temperature was kept constant at 92° *F*.

The problem of the formation or melting of a snow cap or ice cap is not statical but dynamical, and the quantity of heat, not the temperature, is primarily to be looked to. If we desired that a given quantity of heat should melt the maximum amount of ice, we would endeavor as far as possible to keep it from raising the temperature of the air or other surrounding objects. But Dr. Croll and his followers seem to me to forget the equivalence of heat and work, owing to which heat must always be employed either in raising the temperature, in melting ice, or in doing both; the same quantity of heat always performing the same amount of work. Dr. Croll, for instance, insists on Tyndall's statement that a joint of meat could be roasted while the surrounding air was as cold as ice; but did Tyndall ever say that a joint of meat could be roasted where a block of ice could not be melted? Or that rays powerful enough to melt pitch would fail to produce any effect upon ice? Croll is no doubt right in saying that if India was covered with an ice cap the summers would be cold. But why? Simply because most of the summer heat would be employed in melting the snow and ice. The low temperature would be due to the rapidity of the melting. When it is once admitted that the total quantity of heat received from the sun in each year at the period of greatest eccentricity is as great (or rather a little greater) than at present the question arises: How is it possible that this equal quantity of heat proves insufficient either to melt the winter accumulation of snow or to raise the summer temperature above the present level? —for Dr. Croll and his followers will not allow it to have either effect. The total effect in the two departments must be the same as before, on the principle of the conservation of energy, but Dr. Croll apparently ascribes to it a diminished effect in each department. Many of Dr. Croll's arguments on this point may be retorted. Is the air clear and dry? The result is favorable to the theory, according to Croll, because the temperature of the air is not raised. Is the air moist and foggy? The result is equally favorable, in his opinion, because the incident heat is absorbed by the air and does not reach the snow and ice. But in the former case it might be replied that the incident heat produces its maximum effect in melting because none of it is exhausted in raising the temperature of the air; and in the latter case, that since the absorbed heat raises the temperature of the air, the cold will not be as great as Dr. Croll supposes. But any view which takes in only one-half of the subject is misleading, whether it is Dr. Croll's half or the other half.

I do not deny that there may be special cases in which Dr. Croll is correct, as also special cases in which Mr. Murphy is so. What I deny is that either of them has stated or solved the problem in its general form. If we take a locality well supplied with moisture, in which the annual heat, if uniformly distributed, would keep the temperature constant at 28° or 30° *F*, an uniform distribution of this heat would be favorable to a permanent snow cap. The snow could never be melted though it might be slowly evaporated, and snow usually falls in the greatest profusion when the temperature is not much below freezing point. An unequal distribution of heat would be necessary to clear off the snow cap during any portion of the year, however short, and I think there can be little doubt that a sufficiently unequal distribution would enable the ground to be cleared of snow for a few days or weeks in summer. Indeed, if the winter was very short but intensely cold, such a summer clearance would be almost certain. On the other hand if the supply of heat was sufficient to produce an uniform temperature of 34° *F*, I doubt whether a permanent snow cap could be produced; but without an unequal distribution of temperature there could not be even a temporary one.

There are, I think, but two of Dr. Croll's arguments which are worthy of consideration by scientific men, for his talk about long cold winters and short hot summers is evidently intended for ordinary readers only, who are likely to overlook the principle of compensation by which length is always attended with feebleness, and shortness with intensity. These arguments are: 1. Snow and ice are good reflectors of heat, and, therefore, when a snow cap is once formed the incident heat is practically reduced, inasmuch as a large proportion of it is reflected back into space without doing any terrestrial work. 2. The northern and southern regions at present receive large quantities of heat from the equatorial regions by means of ocean currents and air currents (Croll seems to regard the latter as unimportant); but when northern or southern ice caps were formed these currents would be diverted, and the glaciated regions would thus be deprived of a considerable part of the heat which they now receive.

To commence with the latter argument, it presupposes the validity of some of the others; for the cause of the diversion of the ocean currents, according to Croll, is the increasing coldness of the region from which they are diverted. Thus suppose the northern region to be the colder one, the ocean currents would be diverted towards the south, and thus intensify the northern cold by diminishing the supply of heat from the equator. It is evident that this reasoning would not hold good if the main agent in producing ocean currents is the difference of temperature between their extremities. The cause of ocean currents is still under debate, but for the present purpose I will assume it to be what Dr. Croll supposes. The winter being coldest when the eccentricity is greatest, and the earth is at aphelion in winter there will therefore at this period be a southern diversion of the ocean currents during the winter. But what of the ensuing summer? If it is likewise hotter (as it ought to be from the greater quantity of heat received in the same time), there will be a counter diversion of the ocean currents to the north which might not impossibly break up snow caps and ice caps that remained undisturbed so long as the ocean currents oscillated within narrower limits. At all events the summer heat will be as much increased by the northern diversion as the winter cold by the southern diversion, and the prospects of a permanent snow cap increasing from year to year are in no way improved by the change.

Assuming the quantity of heat received in the year to be unaltered, the mean temperature of the year will not be affected by the formation of snow and ice so long as the summer heat suffices to melt the winter accumulation. The fall of temperature is as much checked by the formation as the rise is checked by the melting. But in order that the accumulation of snow and ice should increase, the mean temperature of the year must be raised; for the fall of temperature is more checked by the formation than the subsequent rise is checked by the melting. And if the accumulation of snow and ice diminishes during the year, the temperature must be below the mean; for the rise of temperature is more checked by the melting than the fall is checked by the formation. Consequently if it is the mean temperature of the year that fixes the mean position of the ocean currents, this mean temperature will be above the average when the snow and ice are increasing, and the mean position of the currents will be farther north than before. I do not, of course, affirm that this was actually the case when the snow caps and ice caps were forming. I only say that it is what must have occurred if Dr. Croll is right in maintaining that there was no decrease in the total heat received in each year during the formation. If so, the mean temperature must have increased during the formation of the ice caps and diminished during their dissipation. Dr. Croll will perhaps find a confirmation of this view in the fact that (according to Mr. Ferrel) the mean temperature of the Antarctic regions, where there is at present a winter aphelion and a partial glaciation, is higher than that of the Arctic regions at equal latitudes—a result which Dr. Croll accepts.

It only remains to consider the loss of heat by reflection from the surface of snow and ice. I doubt whether this is considerably greater than the reflection from the same surfaces when free from snow and ice. Observations and statistics on this subject are highly desirable, and in fact they seem to me to be the only way in which Dr. Croll's theory can be proved. The differences between the reflecting powers of different substances diminish as the angle of incidence increases, and we are dealing with regions where the angle of incidence is always large. The surfaces of snow and ice, too, often become covered with impurities which seriously diminish their reflecting power. The question, however, is one which I leave experimentalists to deal with, merely calling attention to it as the turning point of the theory. On other points it may be said that Dr. Croll's theory would work admirably if more heat was absorbed in melting snow and ice than is given out in forming them; but the equivalence of these two quantities, together with the constancy of the total annual heat, seems to me fatal to it. For those who desire to pursue the subject I desire to refer to Dr. Haughton's researches on radiant heat recently published by the Royal Irish Academy. Dr. Haughton's results, though not arrived at with any controversial object, appear to me to be very unfavorable to the views of Dr. Croll.

ASTRONOMY IN THE UNITED STATES.*†

T. H. SAFFORD, PH. D.

In the quarter century which elapsed between the first beginning (1836) of our Observatory and the outbreak of the civil war, American astronomy had made great progress. The work of an astronomer involves certain professional habits of care and accuracy, whether he be chiefly an observer or a calculator; and an abstract mathematician does not always make the best practical astronomer, for the latter must attend to certain every-day matters which the former some-

* A discourse read June 25, 1888, to commemorate the fiftieth anniversary of the dedication of the Hopkins Observatory at Williams College, Williamstown, Mass.

† Continued from No. 72, p. 77.

times neglects. The best cure for absent-mindedness and day-dreaming which I know, is to observe star-transits; for the stars are extremely punctual; if the observer wanders off into regions of abstract thought, the star will not wait for him, it is always in its proper place at the exact second.

Then, there are mechanical operations to be performed which sometimes involve a good deal of manual labor; and the man who has to do this must be skilled in the science; even the subordinates in an Observatory need education; they must have a good deal of mathematics at their finger's ends.

One great advance in mathematics during the present century is the theory of the errors of observation which we owe to Gauss, and which shows us how to distinguish between good observations and bad, and even between blunders and the necessary imperfections of our senses.

By 1861 this country had acquired what I may call a school of astronomers. That is, there were many observatories,—public and private,—with far too little money for their maintenance in regular activity, it is true, but with here and there an observer or calculator who knew how to use the instruments and the results of observation. Any young man who, like Rittenhouse or Bowditch, felt himself impelled to study astronomy, could find instructors, and after sufficient training could usually get remunerative employment. He could also gain the ear of a public interested in such things; by the better newspapers, if what he had to say was of a popular character; or by the scientific journals of America or Europe, if he had something new and original for the specialists. There was also an astronomical journal of much merit, published by the zeal and munificence of its editor, Dr. Gould.

Some of the early achievements of our astronomers have been of permanent use to the science. Of these the most important are the two connected inventions,—the chronograph, and the telegraphic method of determining longitude.

The chronograph is the instrument used in the "American Method" of observing transits. It is practically a telegraphic ink-writer, or other register; connected with a clock, it marks the seconds on a sheet or tape of paper; and the observer, who has to find the exact time of any astronomical phenomenon has simply to press a telegraph key near his instrument, and the time is recorded. Similar instruments have since been used to measure the speed of thought and compare one man with another as to quickness of apprehension, or willing; so that astronomical methods have thus been introduced into psychology. In the old way of taking transits, the observer, while looking through the telescope, was obliged to count his time, second by second; to do this without mistake, and write down the small fractions of a second, is much more difficult than to observe by the American method.

Very soon after Morse's inventions, and the establishment of a few telegraph lines, Walker, Loomis, and other American astronomers, used them to send time from one Observatory to another. We can readily see that by the earth's steady motion on its axis, difference of time is equivalent to difference of longitude; twenty-four hours correspond to the whole circuit of the earth, and every hour to fifteen degrees. All our railways are now run by Greenwich time, with a change in the whole hours only; thus seven o'clock of railway time here is simply twelve o'clock at Greenwich; and our trains are run on the time of the seventy-fifth meridian.

Before this system could be inaugurated, our astronomers must find out how their Observatories were situated with respect to the Greenwich meridian; or at any rate to *some* meridian. The telegraph was, as I have said, first employed in America for this purpose, after many trials of other methods had been made, with partial success. Before the ocean cable was laid, the position of Harvard Observatory from Greenwich had been determined with great care by the Bonds; their method of exchanging times was to send a great many ships' chronometers backwards and forwards between England and America.

Our astronomical progress had been most considerable in those branches which are of practical importance; but yet there were those who gladly took hold of more ideal problems. The American mind is peculiar; partly from heredity, partly, I suppose, as influenced by the greater command of circumstances possible in a free country. The American is ambitious in intellectual things, if once his interest is aroused; and he frequently cannot reconcile himself to take a second place.

A striking example of this quality is seen in the life of Alvan Clark, the great optician, who has lately gone from us at a ripe old age. In my boyhood I met him, then a modest portrait painter of middle age, who had begun to interest himself in the making of object glasses, and to hope that he could by-and-by compete with the German opticians in telescopes of moderate dimensions.

One of his early object glasses, of half the diameter of the Cambridge telescope, is that belonging to the equatorial of the Williams College Observatory, given by that constant friend of the college, Amos Lawrence. Mr. Clark did not then construct the machinery of entire telescopes, and the mounting is by an inferior mechanic, and not very good.

It was not long before Mr. Clark's reputation increased, and he received some orders from England. His acquaintance with the English amateur astronomer Dawes gave him opportunity to learn what a very sharp-sighted, careful observer desired in his object glass,—for Mr. Dawes was extremely critical,—and he was finally able to surpass even the German makers in the precision of the images seen in his telescopes. At this point he was assisted by liberal capitalists to set up a larger establishment, and, with his sons, to enter upon telescope-making on a greater scale.

His first great telescope, belonging to the Chicago Observatory, was completed in 1865; the object glass, larger than any then existing, had been made several years before. From that date until his death in 1887, he was actively at work, though already an old man; and my last visit to him, two years ago, was made in his workshop, where he was busy on the greatest object glass now existing, one of more than twice the diameter of the Harvard telescopes. This glass, that of the Lick Observatory, in California, was preceded by one which gave him great triumph. He had displaced his competitors' instruments in America, wherever increased dimensions were called for; but the great Imperial Observatory of Russia, at Pulcova, near St. Petersburg, was in the market for such an instrument.

The Struves, father, sons and grandsons, have long been known as among the most careful observers. But the present head of the family became convinced that in his own special line of work he needed a more powerful telescope;

and what he learned of the performance of the Clarks' glasses led him to give them the order for the optical part of the instrument. The mechanical portion was made in Hamburg, by the Repsolds, who are the greatest mechanicians of the world, the makers of our fine meridian circle.

The last twenty-five years have brought much material advancement to the science in this country. It is hardly possible to go deeply into it; in many respects it is a repetition of the earlier history. Observatories have been founded in new places, sometimes with means for their maintainance, at other times without. Some of the older ones have received large accessions of invested funds, and have thus been enabled to do more; this is notably the case at the Harvard Observatory, which has been given the handsome fortunes of Robert Treat Paine, the amateur observer of the earlier time, and of Uriah Boyden, an inventor of turbine wheels, who had been greatly aided by Benjamin Peirce's knowledge of the higher mathematics. Boyden's bequest requires the establishment of a mountain Observatory; his trustees have placed it under the Harvard management, so that the mountain observations will be calculated at Cambridge. The ability and success of our younger astronomers in handling deep and difficult problems have been proved entirely adequate; I think we have never lacked the men, but it is only lately that they have found education and encouragement.

Many able astronomers, too, have come to us from foreign countries, among whom is our Nestor, Dr. Peters, who is with us on this occasion. I dare not attempt to say how many small planets he has discovered within the last quarter of a century, but his other work has been enough by itself to give his Observatory a high reputation both at home and abroad.

It is pretty plain that the public mind has changed its attitude towards astronomy. We now find more general intelligence on the subject; more disposition to believe in astronomers; more encouragement to those of them who are still struggling with difficult problems; more pride in their achievements; European scientists now come occasionally to see what is doing here; the profession of an astronomer is a recognized career.

What then shall be the future of our science in this country?

Two things are plain: first, that the great benefactions to colleges help all sciences; and second, that original investigation is much more prominent as a feature of college work than ever before.

We have giant telescopes enough in this country; Alvan Clark's sons will doubtless keep up the supply of large instruments; but we need to look at the science a little more deeply on the intellectual side. I would remind you that our college studies are largely traditional; that astronomy, along with geometry and music, was one of the studies of the old Quadrivium, and that perhaps a recasting of our courses may be possible and beneficial.

I am a believer, as are other college instructors of some eminence, in the disciplinary value of astronomy as an independent study. The mathematics have their value, and a very high one it is; but the lower mathematics, especially arithmetic, have been overdone in a certain direction; I mean that of riddles, puzzles,—brain-spinning, as the Germans call it. While our boys and girls are given problems to solve which quite exceed their thinking powers—I don't suppose I could ever have gone successfully through Greenleaf's National Arithmetic till I had graduated from college—their minds are quite undeveloped in the power of observation, and they are often imperfectly trained in the four ground rules, especially in decimal fractions. So far as my own experience goes, the best mathematical training is that which deals with tangible objects; the abstractions should have a sensible basis.

I would then have the observation of the common phenomena of nature accompany the study of arithmetic and geometry in the common schools. The pupils should learn to watch the barometer and the thermometer, sunrise and sunset, the phases of the moon, the motions of clouds; they should know the pole-star, Ursa Major, Orion, the Pleiades, Leo, the Scorpion; should learn to distinguish between the stars and the planets, to watch for the aurora borealis, to note the colors of the rainbow. The high school, or college preparatory school, should always have its telescope, and some simple means of accurately keeping time; a few notions of scientific astronomy should not fail to be inculcated.

In college, the professor of astronomy should have time and opportunity to interest even the Freshmen in his study; I do not mean that he should give them formal teaching, this may well be reserved for later years. But he should have a variety of instruments, some of the inexpensive kind made now-a-days, for gazing purposes; or old telescopes, out of fashion for observation, so that one or another of the students could watch the heavens for himself. Informal instruction may always well precede the more formal; and occasional observatory evenings with interesting objects could be arranged, so that a good part of our classes might enter on the regular study of the science with some distinct notions.

To introduce the work I have described into our common schools will take a long time, perhaps a generation. But it seems a waste, when we open any mathematical school-book and find in it so much that refers to a merely imaginary world; and then to hear from business men and college professors that all this training leads to nothing definite; and, when the young men are nearly through their college course, to find them unable to tell the points of the compass in a strange place, or even in their own college town; or not aware that when the moon is full it rises very nearly at sunset.

The colleges have begun to do their part in teaching the teachers. Courses in practical astronomy are now given in many institutions; the instruments can be used, and the results of observation calculated, by the few who elect this subject.

It is more difficult than it ought to be to go very far in these studies, because the habit of applying the earlier mathematics to tangible objects is unformed. The young man is at first confused when you tell him that he must measure the sides or angles of his spherical triangle. He has always thought a spherical triangle to be an abstraction. Moreover, he cannot always handle even his arithmetic with facility; and certainly, again and again I have found mistakes in difficult calculations, which the student himself could not detect, to lie in carrying wrongly in addition or subtraction.

A return to nature in our whole method of education—even in the elementary teaching of Greek, that bugbear to some so-called educators—is now actually going on; the next generation will reap the benefit. Could I have learned Greek and Latin as my colleagues are now teaching them, I should have had many more interested hours; and other subjects, history, biology, physics, are now taught by better methods.

The college Observatory of the future, in this country should contain a good many moderate instruments; none very gigantic, but some of that handy size which is best adapted to advance the science. A giant instrument renders the observer helpless, if he has not a file of soldiers, or other servants, to help him move the machinery; one which he can just conveniently handle leaves him free to work, and always shows him objects enough to observe. If he have a trained eye, that in itself is equivalent to an increase in the size of his instrument.

I hold that in a strong college, independent work, to advance the science, should be going on; the student will be benefited by the closer contact with realities which is thus gained. Moreover the teachers themselves can better be kept from rusting, or falling into a treadmill round; they can be in the current of scientific thinking, even if their problems be modest. But along with the best instruments to show the refinements possible, there should be samples of simpler and cheaper ones, partly for the independent work of the pupils, partly for the exploration of the heavens to gain immediate communion with nature in its grander aspects, partly to show the future teachers what their schools can afford. The general framework of mathematical training will gain largely, the more it is connected with modern scientific applications, and thus the more closely it is conjoined with nature.

I may be permitted here some quotations from a modest but deep thinker, whose little work Emerson recommended Carlyle to read, the late Sampson Reed, of Boston. The book is called "Observations on the Growth of the Mind."

Mr. Reed says: "If it were desired to make an individual acquainted with one of the abstract sciences, this might best be effected by leading him gradually to whatever conduced to the growth of those powers on which a knowledge of these sciences depends; by cultivating a principle of dependence on the Divine Being, a purity and chastity of the affections, which will produce a tranquil condition, of all things the most favorable to clear perceptions; by leading him to an habitual observation of the relation of things, and to such continued exertion of the understanding, as, calling into use its full powers without inducing fatigue, may impart the strength of the laborer without the degradation of the slave; in a word, by forming a penetrating mathematical mind rather than by communicating mathematical information. The whole character and complexion of the mind will thus be gradually changed, till at last it will become (chemically speaking) in its very nature an active solvent of these subjects." This return to nature, in our teaching, was thus eloquently recommended in 1826; it is gradually becoming accomplished in the scientific studies of our better colleges.

Astronomy deals with immensity of space; who can conceive the enormous distances at which the stars are from us? The nearest one is forty millions of millions of miles from us, or nearly that; the light is six or seven years in coming from it. The little star which was seen to blaze out in 1866 may really have burst into flame before the discovery of America by Columbus; the dim cloudy spots which we see in so many places, and are tempted to call world-stuff (nebulous matter is the usual name), are so far that no human mind can do more than guess their distance.

It will be well, I think, if we can interest our pupils—and I do not mean college students alone—in the contemplation of the heavens as well as in the scientific study of their motions and phenomena; if the telescope can become an indispensable piece of apparatus in the highest school of any locality, even a village. This study should go hand in hand with the ordinary common observations of the nearer things around us.

But looking back over the last half century of scientific progress in America, we have every reason to be hopeful for the future. America is the great republic; every man is born equal to every other; if the bricklayer's son exhibits the genius of the century in mathematics he needs no petty Grand Duke's favor, but will be recognized and helped by his fellow citizens and the organizations for study which have grown up during our few centuries; while the experience of the past fifty years has shown that these organizations will have an unexampled growth in the next fifty years so far as predictions in any human affairs are possible. American astronomers and American instrument makers—few indeed half a century ago—are now known by reputation and respected in the whole civilized world.

The first permanent American Observatory is still standing, to show by its modest dimensions how great a growth has been possible in half a century.

THE DOUBLE STAR, ε HYDRAE.

S. W. BURNHAM.

FOR THE MESSENGER.

In measuring this pair (Σ 1273) at Pulkowa in 1860, OΣ suspected an elongation in the principal star in a vertical direction; and again in 1864, by an entirely independent observation, noted an apparent elongation in the direction of 190°. With this in mind I examined it in 1877–8 with the Chicago 18½-inch on several occasions, and always found the larger star round. It was also observed by Holden and Hall with the Washington 26-inch in 1875, and a new companion of the 14th magnitude discovered at a distance of 20″ from A. The Struve companion was measured by Hall in 1878, 1880 and 1883; and while it does not appear that the Washington observer specially looked for the suspected star, doubtless any irregularity in the figure of the bright star would have been noticed. In April, 1888, Schiaparelli, with the 18-inch refractor at Milan, found it plainly elongated, and measured it with that instrument on six nights. Last fall I turned the 36-inch on it, and at once saw the close pair, and measured it with a power (about 3300) which fairly separated the components. Subsequently it was observed again with the same instrument. The two sets of measures are as follows:

1888.28	P = 142°.0	D = 0″.21	4 . . 5.5	Sp	6n
1889.04	154 .4	0 .26	4 . . 6	β	2n

It is quite certain that this will prove to be a physical system, and perhaps one in rapid motion. It must be at all times a difficult object, and will require a large aperture to properly measure it. The physical relation of the Struve component has long been established, although the movement is comparatively slow. The change from 1825 to 1889 amounts to about 33°.

The observations do not cover a sufficient period to show whether or not the distant companion is a member of this system. The following are all the measures:

1878.33	P = 193°.9	D = 19″.78	. . 14	Hl 1n
1878.60	192 .0	20 .05	. . 12–13	β 2n
1889.15	193 .5	19 .71	. . 13	β 1n

Altogether this must be considered as one of the most interesting star systems, and worthy of the attention of observers having telescopes of sufficient power to satisfactorily show the new stars.

Lick Observatory, March 14, 1889.

METEOR COMETS.

W. H. S. MONCK, DUBLIN, IRELAND.

For The Messenger.

That comets connected with any well sustained meteor shower must be periodical, seems pretty evident, and that there have been previous visits may be regarded as certain if the shower can be traced in the past. Only four comets have hitherto been connected with meteor showers with any degree of certainty. Of these four the history of Biela's comet need not be recapitulated. The period of the Leonid comet has been fixed with reasonable certainty at between thirty-three and thirty-four years, and it has been shown to be highly probable that the comet of 1366 was a previous appearance of this comet. The shower no doubt existed before 1366 and earlier comets have been identified with this meteor comet on probable grounds.

The question therefore whether any earlier appearances of the Perseid or Lyraid comets can be traced, and consequently their periods and those of the corresponding meteor showers fixed, is therefore of considerable interest. Both comets were fairly bright on the occasion of their last visits and are not therefore likely to have escaped observation on all previous occasions. The earlier comets, however, have been but roughly observed, and we cannot hope to discover anything like exact accordance between the elements of the meteor comets in question and their predecessors. Considerable differences exist between the elements of Halley's comet and those computed for earlier comets which were almost certainly identical with Halley's; and differences also exist between the elements of the Leonid comet of 1866 and those of the comet of 1366 with which it is supposed to be identical. A general resemblance in the elements and near coincidence of period is all that can be looked for..

The period of the Perseid comet (Comet III of 1862) has been computed at 123 or 124 years. Adopting this period I do not find any preceding comet which resembles it, but by increasing the assumed period to 131.3 years or thereabouts there is a fair general resemblance between the following three comets:

	π	☊	i	q	μ
	° ′	° ′	° ′		
1337	· 2 20	93 1	40 28	0.828	—
1468	356 3	61 5	44 19	0.853	—
1862 III	344 41	137 26	66 25	0.963	—

Alternative orbits have been computed for the first and second of these comets which in some respects agree better with the third than those which I have selected. The times assigned for the respective perihelion passages are June 1337, October 1468, and August 1862, so that the interval between the second and third is almost exactly three times that between the first and second; but on the assumption of identity I find no trace of the returns of the comet in 1600 and 1731. Four more periods of this comet (if my conjecture is correct) would lead back to the year A. D. 813, when a comet appeared which seems to have exhibited considerable traces of disruption during its visit. Possibly this disruption may have been the origin of the Perseid meteors.

The Lyraid comet (Comet I 1861) was computed to have a period of about 415 years. The meteors (as might be expected from the length of the period) do not appear to be distributed over the entire orbit, and have already thinned out to a large extent. A great display of meteors is recorded on the 4th of April, A. D. 1095, which (allowing for precession) were very probably Lyraids. The comet must, in this case, have returned in or about the year 1095, and the orbit computed for the comet of A. D. 1097 is in many respects similar, save that Burckhardt makes the *descending* node of this comet nearly coincide with the *ascending* node of the Lyraid comet. I would, therefore, suggest that this comet has very probably a period of 382 or 383 years instead of 415 as computed, and it appears from the *Chronica Bossiana* that a great comet appeared in September 1478, which may possibly have been an intervening return.

I may perhaps note that the perihelion distances of all four known meteor comets lie between 0.9 and 1.0. Making allowance for the roughness of early observations the comets of 1097, 1337 and 1468 agree fairly in this respect.

THE RELATIVE TIME OF ROTATION OF ANY COSMIC BODY A FUNCTION OF ITS RELATIVE DENSITY.

SEVERINUS J. CORRIGAN.

For The Messenger.

In that portion of my paper on the "Effects of Rotation," published in No. 72 of The Sidereal Messenger, I advanced the hypothesis that the axial rotation of any member of the solar system is due to an original orbital motion of the individual particles of which the body is composed, around a common "center of gravity," or nucleus, and that the angular velocity of rotation must depend upon both the original orbital velocity, and the degree of freedom possessed by each particle, whereby it can move among the surrounding matter. It is obvious that the degree of freedom must depend upon the number of resisting particles encountered by the moving element in its passage through any given space, and since the number depends upon the density, it is plain that the "time of rotation" must be some function of the latter. As evidence tending to establish the truth of this hypothesis, there was tabulated on page 58 of the above named number, among other quantities, the rotation period of each one of the eight principal planets, in terms of that of the earth, and also the square root of the density of each planet relative to that of our globe.

For the sake of convenience these quantities are again set forth in the following tabulation:

Planet.	1	2	3	Planet.	1	2	3
Mercury............	1.00	1.06	—0.06	Jupiter..............	0.41	0.49	—0.08
Venus................	0.98	1.02	—0.04	Saturn..............	0.44	0.36	+0.08
Earth................	1.00	1.00	0.00	Uranus.............	0.40	0.41	—0.01
Mars..................	1.03	0.97	+0.06	Neptune......	Unknown.	0.40	......

In the above table, column 1 contains the relative rotation periods, column 2 the square roots of the relative densities, and column three the differences between the two taken in the sense $1-2$. While the relation between the quantities above set forth is remarkable, yet since the agreement between the rotation periods and the square roots of the densities is, in any case, only approximate, it furnishes only *presumptive* evidence in favor of the hypothesis. To render this relation conclusive proof, it must be shown by a rigorous demonstration that it is not a mere coincidence, as many readers may infer, but the result of an indubitable law of "celestial mechanics." I shall now endeavor to prove the existence of such a law. The proposition to be demonstrated may be stated as follows:

The relative "time of rotation" of any cosmic body formed by the congregation of particles originally independent, moving around a common "centre of gravity," and subject to only the force of gravity directed toward that centre, must be equal to the square root of the relative density of the body.

If we regard any cosmic body as an aggregation of particles endowed with orbital motion, and the axial rotation as a derivative of this motion, the demonstration can be effected most readily by considering the circumstances of motion of any element at the equatorial circumference of the body. Let A represent the angular velocity of rotation of this element, T its "time of rotation," and v its orbital velocity; furthermore, let M denote the mass, D the density, and k the unit of attraction due to the mass, of the body to which the element belongs.

It is to be *distinctly* understood that all of the above named quantities are to be regarded as only *relative*, the corresponding quantities pertaining to the earth being taken as the respective units.

Now, it is evident that if the particle were to meet with no resistance, its angular velocity would be equal to the orbital velocity, and that this relation would be expressed by the equation,

$$A = v; \quad (1)$$

but, since there must be a resistance due to the impeding or retarding action of surrounding matter, which indefinite resistance will here be denoted by R, the angular velocity will also be *inversely* porportional to R, and we will have the equation $A = \frac{v}{R}$, or, since the "time of rotation" is the reciprocal of the angular velocity,

$$T = \frac{R}{v}. \quad (2)$$

But, as shown above, the resistance is equal to the density D, hence results the equation,

$$T = \frac{D}{v}. \quad (3)$$

From the principles of "analytical mechanics" we know that the relative mean motion n of any body, great or small, moving around a "center of attraction," in obedience to the "law of gravitation," is expressed by the equation,

$$n = \sqrt{\frac{k}{a^3}}, \quad (4)$$

in which a represents the mean distance of the body. Since the above equation holds good for any value of a, we may regard the body or the particle as moving in a *circular* orbit whose mean distance, a, is equal to r, or the radius of the spherical mass to which the particle belongs; and as k is equal to the mass M, equation (4) may be written $n = \sqrt{\frac{M}{r^3}}$ or, since in a circular orbit $n = v$, we may write the following: $v = \sqrt{\frac{M}{r^3}}$, substituting this value of v in equation (3) the following results,

$$T = \frac{D}{\sqrt{\frac{M}{r^3}}}. \quad (5)$$

Since the density of any spherical body is proportional *directly* to the mass, and *inversely* to the cube of the radius of the sphere, the *relative* density will be given by the equation, $D = \frac{M}{r^3}$. From this we see that the denominator in the second member of equation (5) is equal to $\sqrt{D}$; therefore that equation becomes,

$$T = \frac{D}{\sqrt{D}} = \sqrt{D}, \quad (6)$$

i. e., the "relative time of rotation" is equal to the square root of the "relative density," which was to be proven.

The existence of the law having been thus demonstrated, there arises the question, to what cause or causes can the discrepancies noted in column 3, be justly attributed?

Four possible causes can be enumerated:

First, possible error in the determination of the "time of rotation" and of the mass and radius of the body, the two last, of course, involving the density.

Second, the retarding action of an accumulation of fluid matter analogous to a "tide wave," raised upon the body by the attractive influence of neighboring bodies.

Third, the non-coincidence of the centre of gravity and that of figure.

All of these causes may operate in the case of any cosmic body, so that the discrepancies shown in the above tabulation can exist without casting any doubt whatever upon the legitimacy of the hypothesis above advanced.

Since the rotation periods, the masses, and the radii of the principal members of the "solar system" are known quite accurately, the first named cause can be properly charged with only a very small part of the discrepancies. To one or both of the second and third causes the latter are, therefore, mainly due. An example of the operation of the second cause can be found in the case of the moon; the density of our satellite is approximately 0.61 that of the earth; therefore, according to my hypothesis, the *relative* time of the lunar rotation should be equal to the square root of this relative density, or to 0.78; but it is known from observation that the time of the moon's axial rotation is nearly the same as that of the orbital revolution, or nearly twenty-seven days, instead of about three-fourths of a day, the determination from the density. A part, or even the whole of this difference can be attributed to the operation of a "tide wave" generated in the originally fluid matter of the moon by the attractive force of the earth, this wave acting as a *break* opposing the rotational movement and reducing the "time of rotation" to nearly equality with that of the orbital revolution of our satellite. It is evident that this retarding influence must depend upon the mass and the distance of the neighboring body, and upon its time of revolution relative to the rotation period of the retarded body, and it is also obvious that the maximum effect from the second cause will have been produced when the time of rotation has been made thereby equal to the time of orbital revolution. As the earth has acted against the lunar rotation, so must the moon have affected the earth through the originally fluid mass of the latter. Even now the friction of the oceanic "tide wave" is recognized as a cause operating to retard the "diurnal motion." The effect of the action of the moon upon the earth must, of course, have been very much less than that produced by the action of the earth upon its satellite, because of the relative smallness of the lunar mass. Planets having satellites are particularly subject to this retarding influence, but all are more or less affected by the action of the sun and of other members of the system. The third cause may be effective in the case of any planet or satellite, and may operate even against the sun's rotation.

There is a fourth and very important cause which may act to modify the relation between the density and the "time of rotation," but it is one that operates, probably, only in the case of the sun. The sun's relative density is known to be 0.25, the square root of which, or 0.5, should, according to the hypothesis, represent the relative solar rotation period; but it is well known that the sun rotates upon its axis once in 25.3 days, instead of once in twelve hours; in other words, its actual "time of rotation" is nearly fifty-one times as great as that determined theoretically from the density. It may seem that this great discrepancy between the fact and the theory would render the latter untenable, but, in reality, such is not the case; the hypothesis as stated above is founded upon the condition that the only force in action is the centripetal force of gravity due to the mass of the body under consideration.

From preceding equations the following are easily deducible:

$$T = \frac{D}{\sqrt{\frac{k}{r^3}}} = \frac{D}{\sqrt{\frac{M}{r^3}}} = \sqrt{D}.$$

Now it is obvious that since the values of M, r, and therefore of D, are quite accurately known, the only quantity whose value is in doubt is k, or the attractive force. It is true that when gravity is unopposed, k is equal to M, and the relations expressed by the above equation hold good; but if there be in action in the solar matter a force directly opposed to gravitation, but whose influence does not extend to the bodies of the "solar system" from whose movements the value of M is determined, k will not be equal to M, and although the values of the mass and of the radius, and, consequently, of the density, be accurately known, they will not give the true relative "time of rotation" through equation (4). The difference between the value of T determined from the density, and that derived from observation, will be a measure of the force acting against solar gravity.

If we consider the equation,

$$T = \frac{D}{\sqrt{\frac{k}{r^3}}}$$

we can readily see that if we should use that value of k which is equal to M, and which is determined from the motion of the earth, the resulting value of T would be 0.5, or one-half a day; but, as above stated, observation shows that its real value is 25.3 days, or 50.6 times as great as the theoretical determination. To reduce them to equality it is necessary that the value of k should become only the $\frac{1}{2560}$ of its value due to the mass. Of course this determination of the value of k may be too large because T may be affected by one or all of the three causes already mentioned, but as the influence of these is probably comparatively small, it may be permissible for the purposes of illustration, to assume that the whole difference between the "time of rotation" determined theoretically from the density, and that revealed by observation, is due to a force operating in the solar matter directly against gravity and reducing the latter to the $\frac{1}{2560}$ part of the value that it would otherwise have.

This hypothetical antagonistic force may be either the expansive action due to the tremendous thermic energy of the sun, or a repulsion resulting from the action of the correlated force, electricity, or, as is very probable, the result may be brought about by the operation of both of these possible causes. I think that observation furnishes evidence of the existence of such a force. It is known that "terrestrial attraction" is a force that will cause a body near the surface of the earth to fall towards the centre, and to attain a velocity of about thirty-two feet per second, this velocity which is, in the case of the earth, denoted by g, being equal to k; if the body be not free to fall, the restraint will give rise to the pressure called weight, and in the case of the sun, the value of k or M, determined from the motion of the earth, is such as to make the surface gravitation about twenty-seven times as great as "terrestial gravity," *i.e.*, it is a force that will cause a body, in falling, to attain a velocity of 872 feet per second, and to weigh twenty-seven times what it would upon the surface of our globe. A volume of matter that would weigh one pound here, would, on the sun, weigh twenty-seven pounds; but if the attractive force, represented by k, be reduced by the operation of the antagonistic force to the $\frac{1}{2560}$ part of the value due to the mass, it follows that the above mentioned volume of matter would, if on the sun and free to fall, attain a velocity of only 0.34 feet per second, and would weigh only $\frac{27}{2560}$ of a pound, instead of twenty-seven pounds. As before stated, this value of the opposing influence may be too great, and it is used simply for the purpose of illustration; but it is evident that the existence of any *considerable* force, so acting, would remove a great difficulty in the way of a conception of certain phenomena transpiring upon the sun's surface, and which are, otherwise, very puzzling. I refer to the astonishingly great degree of mobility with which the surface matter of the sun seems to be endowed, and which is evinced by the opening and the closing of spots or cavities covering millions of square miles of the sun's surface, and the upheaval of vast quantities of solar matter, to the height of several hundred thousand miles, in a space of time so short that a force capable of producing the observed effects is, judging from terrestrial analogy, almost inconceivable.

Such action upon the sun suggests the possibility of the existence of a force acting against gravity among the particles of the earth's atmosphere. Living, as we do, at the bottom of the atmospheric ocean, it is impossible that we should have much *definite* knowledge of the condition and properties of the upper portion of the gaseous envelope which surrounds the earth, for the greatest elevation ever attained or attainable by man, and even the highest stratum capable of sustaining a cloud, lie far below the upper limit; yet we know that the atmosphere is a mechanical mixture of gases, and that a distinctive property of a gas is *expansive* force. Such a force operating in the surface matter of the sun or in the earth's atmosphere, would render both more sensitive to the disturbing action of neighboring bodies than they would otherwise be, and thus the possibility of the agency of these bodies in the production of sun spots and atmospheric disturbances, as claimed in my paper on "The Effects of Rotation," published in Nos. 69, 70 and 72 of the SIDEREAL MESSENGER," is the more easily conceivable.

The relation between the density and rotation is intimately connected with the conditions of equilibrium, and in a fluid envelope such as the atmosphere, whose density decreases with the height, these conditions may be such that the influence of outside bodies may produce a very considerable disturbance. Finally, the existence of the relation between density and rotation just discussed, furnishes, I think, strong proof in favor of the truth of the "nebular hypothesis," which regards the members of the "solar system" as formed from originally independent particles of matter falling toward and moving around a common centre in obedience to the law of gravitation; for it is only by regarding them as so formed that the equation connecting the "relative time of rotation" with the "relative density" can be deduced.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury sets later than the sun during the whole of May, and will be in very favorable position for observation in the evening from the 15th to the 30th. It will be at greatest elongation, east 22°49′ from the sun, May 24; in conjunction with the moon, 1°53′ north, May 31, 10 A. M.; stationary in right ascension June 6.

Venus has just passed inferior conjunction with the sun, 4° north of the latter, April 30, and cannot therefore be seen without telescopic aid. At the end of the month the planet will again be visible in the east before sunrise. During the past two months we have had many exquisite views of the "evening star," and have obtained several very good photographs, but have been unable to detect any markings upon its surface with the eight-inch equatorial. Venus will be stationary in right ascension May 19, and at greatest brilliancy June 5.

Mars is beyond the sun and sets at nearly the same time as the latter, so that no observations of it can be made.

Jupiter may be observed after midnight and will soon be in position for evening observation. He is in the constellation of Sagittarius in a bright portion of the Milky Way. Jupiter will be in conjunction with the moon May 17 at 9 P. M. Central time; to observers in Africa the planet will be occulted by the moon, but in our northern latitude it will pass near the northern edge of the moon. June 14 at 3 A. M. the planet will again suffer occultation by the moon, visible between the equator and about 40° of north latitude. Several observers have reported successful observations of the occultation of March 24.

Saturn will be visible in the west in the early evening, but at so low an altitude that observations of the satellites will be unsatisfactory. We therefore omit the ephemeris of the satellites. In March Dr. Terby of Louvain, France, announced the appearance of a white region upon the rings of Saturn next to the shadow of the planet. Many observers have examined the planet under favorable circumstances since that time and while some have reported the white region as distinctly seen and always in the same position, most have seen nothing more than a slight brightening of the rings, where they seem to be cut off by the shadow, and which appeared to be simply the effect of *contrast* with the intense blackness of the shadow. The *Astronomical Journal*, No. 191, contains a report by Professor Holden of the observations made at the Lick Observatory with both the 36-inch and the 12-inch refractors. On the best nights the observers were able to detect nothing abnormal, but when the definition was poor an ill-defined, yellowish "lump" could be seen "extending across rings A and B about half as wide as the shadow, and close to it." "A similar appearance was seen across both A and B where they met the ball of the planet on the s. p. side." On March 21, at the suggestion of Mr. Schaeberle, the experiment was tried of placing an occulting bar in the eyepiece and bringing it over different parts of the planet. Wherever the bar was placed a brighter confused lump seemed to rise and to border the bar. If the the bar was over the ball, this brighter border extended all across the disc. If it was placed on the ring the appearance was just that of the lump bordering the true shadow of the ball on rings. The observers, therefore, concluded that there was nothing abnormal upon the rings, but that the appearances seen were due to bad atmospheric conditions alone. A perusal of Dr. Terby's letter to the editor of the *Astronomische Nachrichten* (A. N. No. 2887 p. 109) will probably lead one to the same conclusion with regard to his observations.

Uranus is in very favorable position for evening observation. He may be easily found with an ordinary telescope, being in field of a finder with θ Virginis, the nearest naked eye star northwest of Spica. No reports of observations of this planet this year have reached us as yet.

Neptune is too nearly in line with the sun to be seen.

MERCURY.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 20	5 25.2	+25 30	5 35 A.M.	1 30.6 P.M.	9 26 P.M.
25	5 48.6	+25 17	5 38 "	1 34.2 "	9 29 "
30	6 04.4	+24 31	5 40 "	1 30.4 "	9 20 "
June 5	6 12.6	+23 07	5 32 "	1 15.0 "	8 58 "
10	6 10.3	+21 45	5 17 "	12 53.1 "	8 29 "
15	6 01.5	+20 25	4 55 "	12 24.5 "	7 54 "

VENUS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	2 03.3	+12 00	2 58 A.M.	9 49.7 A.M.	4 41 P.M.
June 5	2 18.3	+11 38	2 31 "	9 21.4 "	4 12 "
15	2 41.7	+12 38	2 11 "	9 05.3 "	4 00 "

MARS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	4 37.6	+22 36	4 43 A.M.	12 23.6 P.M.	8 04 P.M.
June 5	5 10.1	+23 34	4 27 "	12 12.8 "	7 58 "
15	5 39.8	+24 03	4 15 "	12 03.1 "	7 51 "

JUPITER.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	18 29.5	−23 07	9 48 P.M.	2 13.2 A.M.	6 38 A.M.
June 5	18 24.6	−23 08	9 00 "	1 25.0 "	5 50 "
15	18 19.4	−23 12	8 16 "	12 40.5 "	5 05 "

SATURN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	9 10.9	+17 28	9 41 A.M.	4 56.1 P.M.	12 12 A.M.
June 5	9 14.2	+17 12	9 02 "	4 16.2 "	11 31 P.M.
15	9 17.8	+16 56	8 27 "	3 40.3 "	10 54 "

URANUS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	13 08.3	− 6 34	3 15 P.M.	8 52.8 P.M.	2 30 A.M.
June 5	13 07.5	− 6 29	2 31 "	8 08.7 "	1 46 "
15	13 07.0	− 6 27	1 51 "	7 28.9 "	1 07 "

NEPTUNE.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
May 25	4 01.4	+19 01	4 32 A.M.	11 54.8 A.M.	7 18 P.M.
June 5	4 03.1	+19 06	3 43 "	11 05.9 "	6 29 "
15	4 04.6	+19 10	3 04 "	10 27.9 "	5 52 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
May 20	3 50.6	+20 08	4 27 A.M.	11 56.3 A.M.	7 25 P.M.
25	4 10.8	+21 04	4 23 "	11 56.7 "	7 30 "
30	4 31.1	+21 53	4 20 "	11 57.3 "	7 35 "
June 5	4 55.7	+22 38	4 17 "	11 58.3 "	7 40 "
10	5 16.4	+23 04	4 15 "	11 59.3 "	7 43 "
15	5 37.1	+23 21	4 15 "	12 00.3 P.M.	7 46 "

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T.	Angle f'm N. P't.	Wash. Mean T.	Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
May 30	ζ Tauri.	3½	7 10	97	8 06	263	0 56
31	μ Geminorum.	3	4 23	16	4 42	350	0 19
June 1	δ Geminorum.*	3½	7 20	132	8 13	250	0 54
13	Jupiter.		16 59	356	Jupiter 0.2′ N of moon's limb.		

Phases of the Moon.

		Central Time.
		d h m
Last Quarter	May	21 3 53 P.M.
New Moon	May	29 11 20 A.M.
First Quarter	June	6 2 02 P.M.
Full Moon	June	13 7 58 A.M.

Phenomena of Jupiter's Satellites.

Central Time. d h m		Central Time. d h m	
May 17 9 43 P. M.	III Sh. In.	May 29 9 54 P. M.	II Sh. In.
18 12 31 A. M.	III Sh. Eg.	11 07 "	II Tr. In.
1 04 "	III Tr. In.	30 12 33 A. M.	II Sh. Eg.
3 22 "	I Ec. Dis.	30 1 46 "	II Tr. Eg.
3 57 "	III Tr. Eg.	June 3 1 39 "	I Ec. Dis.
19 12 29 "	I Sh. In.	10 45 P. M.	I Sh. In.
1 19 "	I Tr. In.	11 15 "	I Tr. In.
2 45 "	I Sh. Eg.	4 1 02 A. M.	I Sh. Eg.
3 35 "	I Tr. Eg.	1 31 "	I Tr. Eg.
9 50 P. M.	I Ec. Dis.	10 50 P. M.	I Oc. Re.
20 12 53 A. M.	I Oc. Re.	5 12 36 A. M.	III Oc. Re.
10 02 P. M.	I Tr. Eg.	6 12 30 "	II Sh. In.
21 12 21 A. M.	II Ec. Dis.	1 24 "	II Tr. In.
22 9 57 P. M.	II Sh. Eg.	7 10 11 P. M.	II Oc. Re.
22 11 26 "	II Tr. Eg.	11 12 39 A. M.	I Sh. In.
25 1 41 A. M.	III Sh. In.	12 59 "	I Tr. In.
4 30 "	III Sh. Eg.	10 01 P. M.	I Ec. Dis.
4 30 "	III Tr. In.	11 52 "	III Ec. Dis.
26 2 23 "	I Sh. In.	12 12 34 A. M.	I Oc. Re.
3 04 "	I Tr. In.	3 54 "	III Oc. Re.
11 45 P. M.	I Ec. Dis.	9 03 P .M	IV Ec. Dis.
27 2 39 A. M.	I Oc. Re.	9 24 "	I Sh. Eg.
9 30 P. M.	I Tr. In.	9 36 "	IV Ec. Re.
11 08 "	I Sh. Eg.	9 41 "	I Tr. Eg.
11 47 "	I Tr. Eg.	14 9 21 "	II Ec. Dis.
28 2 55 A. M.	II Ec. Dis.	15 12 25 A. M.	II Oc. Re.

* A Multiple Star.

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

	Central Time.				Central Time.				Central Time.		
	d	h	m		d	h	m		h	d	m
May	15	11	38 P. M.	May	27	3	39 A. M.	June	6	1	53 A. M.
	17	5	25 A. M.		27	11	30 P. M.		6	9	44 P. M.
	18	1	16 "		29	5	17 A. M.		8	3	31 A. M.
	18	9	07 P. M.		30	1	08 "		8	11	22 P. M.
	20	2	54 A. M.		30	8	59 P. M.		10	5	09 A. M.
	20	10	45 P. M.	June	1	2	46 A. M.		11	1	00 "
	22	4	32 A. M.		1	10	37 P. M.		11	8	51 P. M.
	23	12	23 "		3	4	24 A. M.		13	2	38 A. M.
	23	8	14 P. M.		4	12	15 "		13	10	29 P. M.
	25	2	01 A. M.		4	8	06 P. M.		15	4	16 A. M.
	25	9	52 P. M.								

Occultations of the Planet Jupiter as Observed at the Lick Observatory March 23, 1889.

[*Communicated by Edward S. Holden.*]

I beg to forward with this the observations of the occultation of Jupiter made at the Lick Observatory March 23. The altitude of the planet was too small to allow the great equatorial to be used. Mr. Keeler observed with the 6½-inch Clark equatorial. Mr. Barnard observed with the 12-inch Clark equatorial. Mr. Hill observed with the 4-inch Clark comet-seeker. He also computed the times of immersion and emersion. Mr. Leuschner, Cand. Phil., observed with a portable Clark telescope of 3 inches aperture.

Their results follow:

OBSERVATIONS BY MR. KEELER.

My observations were made with a low power on the 6½-inch equatorial. At immersion Jupiter was very low, and the definition was so bad that no detail could be seen on the surface of the planet. No attempt was made to note the time of any occurrence.

The limb of the moon at the point of contact was much brighter than Jupiter. I estimated the point of equality of brightness to be about 5 diameters of the planet, or 3′ from the limb.

At emersion the definition was better, but still so bad that the belts on Jupiter could only occasionally be seen. The only curious appearances noticed were those due to irradiation. The satellites, which were large and brilliant, appeared suddenly, leaving a feeling of surprise that such (apparently) large discs could be so quickly uncovered by the motion of the moon. The disk of the planet when it emerged appeared to be notched into the dark limb of the moon, which was easily visible. The observation of other phenomena than these was prevented by the bad seeing.

J. E. KEELER.

OBSERVATIONS BY MR. BARNARD.

The immersion of the planet and satellites was observed under very unfavorable conditions, the planet being low and the air excessively disturbed. The satellites were very faint at contact, the unsteadiness of the moon's limb preventing any accurate observation of their disappearance. I think the observations of disappearance will scarcely be out over one second, however.

Recorded Times of Disappearance.

		h	m	s	
Satellite	III	14	3	45.1	disappeared in undulations—very faint.
"	II	14	6	46.6	" " " " "
"	I	14	9	37.2	probably 1s early; disappeared as above.
Jupiter	I	14	11	31.9	images very unsteady; Contact I will be more
"	II	14	12	41.7	accurate, the disturbance being greater at II.

Satellite IV, though pretty distinct before reaching the limb, was completely blotted out some four seconds before contact by an undulation of the limb that did not cease for ten seconds after the satellite had disappeared.

At reappearance the seeing was somewhat slightly improved, though still unusually bad.

The approximate times and angles of reappearance having been projected by Mr. Hill, the reappearances were caught sharply. The satellites were bright and very large in coming out—seeing = 1 or 2 on a scale of 5. They shot out rather rapidly, though a sensible interval was required —from 0.2s to 0.3s. As near as could be judged, the times of the reappearances of the centers of the satellites were recorded.

The reappearance of Limb I of Jupiter was that of a very ill-defined mass of boiling-light, which grew rapidly, without any special form; as it progressed the limb of the moon was seen cutting the disc, but so badly distorted that nothing could be made of it. At last contact the planet had scarcely any definite form, and the belts were hardly recognizable.

Recorded Times of Reappearance.

		h	m	s			h	m	s
Satellite	III	15	11	53.6	Jupiter	I	15	19	58.8
"	II	15	14	47.8	"	II	15	21	21.2
"	I	15	18	40.8	Satellite	IV	15	35	27.5

From the bad definition, nothing worthy of note was seen. The observations were made with full aperture of the 12-inch equatorial, a power of 150 being used. The times are Mt. Hamilton mean time. E. E. BARNARD.

OBSERVATIONS BY MR. HILL.

The observations were made with the 4-inch broken tube comet-seeker, on the roof of the main building; times noted on M. T. chronometer Negus 1719. The prism of this instrument gives poor images of bright stars and planets, and the moon was very low in the heavens at each phase of the phenomenon. In addition, the atmospheric disturbance was greater than I have before seen it at this Observatory. For these reasons the only records marked "good," at time, were those of "first glimpse" of planet and satellites, at the emersion. It was entirely impossible to make any notes of physical appearances, etc.

Immersion observed with power of about 25 diameters, not sufficient to distinguish between light of planet and that of moon. Made two guesses at contact and disappearance, as below; chronometer correction being applied, to reduce to Mt. Hamilton M. T.:

	h	m	s	
Contact I =	14	11	36.2	:
" II =	14	12	26.7	::

Emersion: For this used a somewhat higher power from the 6-inch equatorial, giving with this instrument, about 60 diameters.

			h	m	s	
Reappearance	Satellite	III =	15	11	54.0	Good.
"	"	II =	15	14	48.1	"
"	"	I =	15	18	41.2	"
"	Jupiter	(III) =	15	19	58.9	"
"	"	(IV) =	15	21	18.8	Poor.
"	Satellite	IV =	15	35	29.6	Good.

Could with difficulty distinguish dark limb of moon at this observation. CHAS. B. HILL.

OBSERVATIONS OF MR. LEUSCHNER.

The occultations were observed with a portable telescope of 3¼-inch aperture and a terrestrial eyepiece magnifying about 40 diameters. The times were taken from sidereal chronometer No. 1720. The satellites preceding Jupiter were fairly well seen until about 3–5*s* before disappearance when they were lost in the glare. The moon's limb was very unsteady and seeing exceedingly poor. Jupiter touched the moon's limb several times before making a complete contact and the time was not recorded for this reason. The second contact occurred at 14*h* 12*m* 42.9*s* L. O. M. T. The disappearance of the last satellite could not be observed, as it was lost about 4*s* before disappearance. Mr. Keeler, however, observed it near by in the 6-inch equatorial and called time, which I recorded.

Disappearance of 4th Satellite, 14*h* 25*m* 52.2*s* L. O. M. T. M. Keeler estimates that this time may be 2*s* out. The reappearances were all observed except the third contact of Jupiter. The times are as follows:

		h	m	s			h	m	s
Satellite	I	15	11	53.8	Jupiter	IV	15	21	14.8
"	II		14	48.3	Satellite	IV		35	28.5
"	III		18	42.2					

The Polar Rays of the Corona. In speaking of this point, in a recent private letter, Professor W. H. Pickering remarked that the difference in the character of the rays at the two poles of the sun, noticed in 1886, was well marked at the last eclipse. Some of the long jets, seen by the naked eye in 1886, were carefully searched for at the last eclipse and not found. These did appear on the photographic plates of this year.

The outline of the moon was followed for nearly four minutes after totality by the aid of a 4½-inch glass. Numerous photographs of the corona were taken by the Harvard party after the third contact.

Speaking of the spectroscopic observations Professor Pickering also remarked that the spectrum was much simpler than in the eclipse of 1882, showing perhaps a half dozen lines besides the hydrogen. In the spectra of the protuberances the H and K lines were strongly marked. The hydrogen rings which did not come out with the prismatic camera in 1886, were moderately well shown. During totality forty-seven negatives in all were secured, and about twenty within a few seconds afterwards which can be used with advantage.

Ephemeris of Comet e 1888 (*Barnard, Sept. 7*). The following is a continuation of my ephemeris of Barnard's comet from Berberich's elements, for the month of April:

G. M. T.	R. A. h	m	s	Decl. °	′	Log r	Log Δ
April 1.5	23	34	23	—0	28.8	0.2941	0.4608
3.5		34	4	—0	20.0	0.2962	0.4598
5.5		33	43	—0	11.3	0.2984	0.4586
7.5		33	19	—0	2.7	0.3007	0.4572
9.5		32	54	+0	5.9	0.3030	0.4555
11.5		32	26	+0	14.3	0.3053	0.4536
13.5		31	56	+0	22.6	0.3077	0.4516
15.5		31	23	+0	30.9	0.3101	0.4493
17.5		30	46	+0	39.0	0.3126	0.4468
19.5		30	7	+0	46.9	0.3150	0.4442
21.5		29	24	+0	54.7	0.3176	0.4413
23.5		28	38	+1	2.4	0.3201	0.4382
25.5		27	48	+1	10.0	0.3226	0.4349
27.5		26	54	+1	17.3	0.3252	0.4314
29.5		25	55	+1	24.4	0.3278	0.4278

O. C. WENDELL.

Harvard College Observatory, March 22, 1889.

[The above ephemeris was received too late for last month's MESSENGER, but is published by request of certain astronomers, who desire to compare their observations with the places given in the same.—ED.]

The Orbit of Sappho (*80*). Robert Bryant, F. R. A. S., has done astronomy great service in a recent thorough and apparently complete discussion of the orbit of the minor planet Sappho (80). The particular object in the mind of the author in doing this laborious work at the present time is that the orbit of this planet may be well known, so that it may be observed at opposition, with the heliometer, for the study of the sun's parallax. Dr. Gill thinks that minor planets Victoria, Sappho and Ariadne are the best situated of any for this kind of work.

Photographing the Great Nebula of Orion. In the March number of the *Monthly Notices* Isaac Roberts gives a brief paper on what he terms photographic analyses of the Great Nebula of Orion, M 42 and M 43 and *h* 1180 in Orion. This was done by exposing negatives between 5 seconds of time and 205 minutes, and studying the gradations of the nebulosity obtained, in order "to compare the relative actinic power of the light in different parts of the nebula." The first exposure of 5 seconds showed the four stars of the trapezium. The second exposure of 30 seconds increased the diameter and density of those stars, and a third exposure of 1 minute intensified the same effect and showed the beginning of nebulosity around *θ*. The fifth exposure of 6 minutes made the star images one with irregular outline, and brought out the nebulosity more fully, giving points for comparison with the well known drawings of Rosse. When the exposures were continued for 15 minutes or more these resemblances more or less disappeared on account of the increasing density of the nebulosity. The interesting question whether this nebula is in a state of change is, at least, presumptively answered in the affirmative by Mr. Roberts' series of photographs. On this point he says: "It is obvious, if we compare the positions of the stars within the nebula, as they are shown on the charts by Lord Rosse and by Bond, that changes in the relative position of some of them have taken place since the year 1866, and I shall here just refer to one as an illustration. In the Trapezium the two stars numbered 65 and 69 on Lord Rosse's chart are shown much closer to each other than the stars numbered 67 and 73, and Bond's chart agrees with Lord Rosse's, whereas in the photographs these pairs are nearly equidistant."

Within the last few months Mr. Roberts has made exposures on this nebula varying from 30 minutes to 205 minutes. Those made during 30 and 81 minutes show great extensions of the nebula, and M 43 and M 42 are joined, "*h* 1180 is well developed with characteristic dark cross streams." An exposure of 205 minutes, Feb. 4, 1889, gave evidence that all three of these objects belong to one and the same gigantic nebula. The inferences which Mr. Roberts seems to draw fairly from his work up to the present time are intensely interesting, indeed, almost startling. We give his concluding words:

"The evidence and confirmation place it beyond reasonable doubt that the links shown between these objects are realities, and though they supply us with vastly extended knowledge of the dimensions and form and details of this nebula, yet leave us with unsatisfied desire to see more, and probably to find that the nebula will be shown to have a symmetrical form in external outline, but is in a state of strong internal commotion. Next year we ought to be able to supply the missing links, and see it as a finished picture. In the mean time we ought, with all gratitude, to admire the patient, long-suffering endurance of those martyrs to science who, during the freezing nights of many successive winters, plotted, with pencil in benumbed fingers, the crude outlines which have been handed down to us as correct drawings of this wonderful nebula, which we can now depict during four hours of clear sky with far greater accuracy than is possible by the best hand-work in a lifetime."

EDITORIAL NOTES.

A new comet was discovered by E. E. Barnard, astronomer at Lick Observatory, March 31.7215 G. M. T. in apparent right ascension $5h\ 20m\ 49.3s$, in apparent polar distance 73°53′, having daily motion in right ascension, — 13′ of arc; in polar distance, — 2′. The comet at time of discovery was on the southern border of the constellation Taurus, about 12° east of Aldebaran; its motion during last month was slowly to the south-east. April 4, observations of the comet were made by E. Lamp, Weiss, and C. F. Pechüle. It was then very faint—too faint for the use of the micrometer by the first named observer.

J. M. Schaeberle, astronomer at Lick Observatory has computed the following

ELEMENTS:

$$T = 1889 \text{ May } 26.44 \text{ G. M. T.}$$

$$\left.\begin{array}{l} \pi = 286^\circ\ 3' \\ \Omega = 297\ \ 26 \\ i = \ \ 90\ \ \ 0 \end{array}\right\} \text{Mean Eq. } 1889.0$$

$\log q = 8.6064 = 0.0404$ for q, which appears to be very small for the perihelion distance. The following places for April are by Dr. H. Oppenheim, as given in A. N. No. 2889.

	R. A. h m	Decl. ° ′	L.
April 4	5 17.9	+15 39	1.10
8	15.1	50	
12	12.7	41	
16	5 10.8	+15 32	1.62

By the above table it is apparent that the light of the comet is increasing, but its position for observation is not very favorable, as it is only 2½ hours east of the sun.

Photographic Study of Stellar Spectra at Harvard College Observatory. The third annual report from the Harvard College Observatory, on work which constitutes the Henry Draper Memorial, under the direction of Professor E. C. Pickering, is received. The plan of previous years has been continued during the last. The five special lines of research are: 1. Catalogue of spectra of bright stars. Instrument, 8-inch Batche telescope, a photographic doublet, as an objective. Work: photographs cover the entire sky north of —25° declination, exposures from 5 to 10 minutes. About 28,000 spectra of 10,800 stars of 7th magnitude and brighter have been examined. Copy of catalogue is nearly ready for the printer, as far as 14*h* in right ascension, the positions being brought forward to the epoch of 1900. 2. Catalogue of spectra of faint stars. Instrument used is the 13-inch photographic telescope. Work of taking photographs required to cover the sky north of the equator was nearly finished in November, 1888. Since that time the instrument has been in use in the Western and Southern expeditions.

3. Detailed study of the spectra of bright stars. The instrument for this work is the 11-inch refractor with one, two or four large prisms over its objective. With this instrument 686 photographs have been taken, most of them with an exposure of two hours. Photographic plates now in use are sensitive enough to get 570 stars north of —30° declination with one prism, 170 with two prisms and 87 with four prisms. It is expected that this work will be completed during the next year.

4. Faint stellar spectra by the aid of the 28-inch reflecting telescope by Dr. Draper has not been continued.

5. Catalogue of spectra of bright southern stars is now in progress by the 8-inch Batche telescope in Peru. The sky from—25° to the south pole will be covered, and the resulting photographs sent to Cambridge and reduced as in the case of the northern stars. The work will probably require two years.

6. The catalogue of spectra of faint southern stars will be extended to the south pole simultaneously with the observations just referred to above, which are being made in Peru. These memorial funds are being put to excellent service in the interest of astronomy, as is plainly seen from this important report.

Occultation of Jupiter. The occultation of Jupiter by the moon March 24, 1889, took place here at sunrise. The sky was very clear but there was so much light that the disappearance of the satellites could be seen with difficulty, and at reappearance they had faded entirely out of sight. The disappearance of satellite III was noted at March 23d 17*h* 45*m* 0.5*s* but with some uncertainty as to the exact instant.

The times of disappearance and reappearance of the planet were noted at the following instants, Ann Arbor mean time:

			h	m	s
Dis.	First contact		17	55	18.2
"	Last	"	17	57	39.9
Reap.	First	"	18	47	14.7
	Last	"	18	48	55.4

The disappearance was on the bright edge, 30° to 40° from the north point. The reappearance of the planet's edge outside the moon's limb was not seen at the instant it occurred. The time given is several seconds late.

The 6-inch equatorial was used with an eye-piece magnifying about 200 diameters, careful watch was kept for the remarkable contact phenomena which have been sometimes described for occultations of planets, but nothing noteworthy was observed. There was some tremulousness and flickering at contact, but nothing else. M. W. HARRINGTON.

Ann Arbor, Mich.

Comet 1882 II. We have received the first part of an "Investigation of the Comet System 1843 I, 1880 I and 1882 II,"* by Dr. Heinrich Kreutz, which is indeed a model work of its kind. It was published in 1888 as a Publication of the Observatory in Kiel, Germany. The author gives first a short but complete review of the apparition of Comet 1882 II (the great September comet), followed by an ephemeris depending upon Dr. Stechert's elements of the orbit. He then discusses briefly the passage of the comet over the disc of the sun, showing that it entered upon the western edge of the disc Sept. 17, 4*h* 30.6*m* Berlin mean time, passed off the eastern edge at 5*h* 47*m*, reached perihelion at 6*h* 24*m* at a distance of less than half the radius of the sun from his

* Untersuchungen uber das cometensystem 1843 I, 1880 I and 1882 II. I Theil Der grosse September comet 1882 II. Von Dr. Heinrich Kreutz, zweitem Observator der konigl. Stenwarte. Kiel, 1888.

east limb, passed behind the east edge of the sun at 7*h* 59*m*, and out from behind the west edge at 9*h* 58*m*. The first of these times was observed by Finlay and Elkin at the Cape of Good Hope, the comet totally disappearing as it passed upon the solar disc, so that the observers thought that it had gone behind the sun. The comet was on the east side of the sun for 2*h* 11*m*, during which time it should have been visible in America, but appears to have been nowhere noticed.

The author then gives a list of the comparison stars, with all the observed places of each, and a complete collection of all the published observations of the comet. A discussion of the observations of the nucleus is given next. Considerable difficulty was found in identifying the parts of the nucleus which the different observers took as the points of measurement. At the time of discovery of the comet, Sept. 8, the nucleus was round, 10″-15″ in diameter, and it retained the circular form as it approached the sun. Sept. 17, half an hour before it entered upon the disk of the sun the nucleus had a diameter of only about 4″; the next day it was the same, as observed on the meridian at the Cape of Good Hope. Sept. 21.0 the nucleus was first noticed to be oval; Sept. 22.2, according to Schaeberle's measures, the major axis was 11.9″, the minor axis 4.8″. Toward the end of the month the elongation was generally noticed; Sept. 30.7 Finlay first discovered two balls of light in the head of the comet. Later other separate points of light were seen, so that the nucleus appeared to be divided into 3, 4 or 5 parts. Still later these became enveloped in a dense haze so that only one or two could be distinguished, and it is somewhat uncertain which points were the brightest toward the last. Dr. Kreutz thinks, however, that he has succeeded in nearly all cases in identifying the point which was taken for measurement and has deduced the necessary corrections to reduce each to the point which he has assumed as the center of gravity of the comet. From all the observations he has derived nineteen normal places of the comet, and after correcting these for the perturbations by Jupiter and Saturn, has formed nineteen normal equations from which are deduced the corrections to the assumed elements. The final elements thus derived are as follows:

Epoch of occultation 1882, Sept. 20.5 Berlin mean time.

$T = 1882$ Sept. 17.2612428 ± 0.0000319

$$\left.\begin{aligned} \omega &= 69^\circ 35' 20.80'' \pm 7.57'' \\ \Omega &= 346\ 00\ 42.70 \pm 7.31 \\ i &= 141\ 59\ 44.63 \pm 1.79 \end{aligned}\right\} \text{Mean equinox 1882.0}$$

$\log q = 7.8893666 \pm 0.0000364$

$\log \varepsilon = 9.9999600 \pm 0.0000001$

$\varepsilon = 0.9999078 \pm 0.0000002$

$\log a = 1.9551 \qquad a = 84.16 \pm 0.22$

Period $= 772.0 \pm 2.9$ years.

The nineteen normal places are represented within the errors of observation.

Dr. Kreutz discusses the possible identity of this comet with that of 1106, which was recorded as a very brilliant one, seen in daylight close to the sun. He reaches a negative conclusion from the fact that the comet of 1106 was seen north of the equator in February, which could not be true of one moving in the orbit of the 1882 comet.

The Satellites of Uranus. In the last number of your valuable journal appears my reference to a glimpse of the satellites of Uranus with a 3-inch telescope. As the statement will undoubtedly be questioned, since they are said to be "beyond the range of glasses as large as 8 or 10 inches in aperture," permit me to call attention to "Webb's Celestial Objects," fourth edition, revised, 1881. Page 186, he says: "Ward has glimpsed the two outer ones, Oberon and Titania, with a $4\frac{3}{10}$-inch Wray achromatic."

In June of last year Uranus was in splendid position for observation, and for three or four evenings in the early part of the month the seeing was very fine. At that time with Uranus in the field, I glimpsed those extremely faint little moons of the planet with my 3-inch glass. S. S. CHEVERS.

Brighton, N. J., March 19, 1889.

The above in substance is what appeared in the March MESSENGER, and attracted considerable attention, as might have been expected in view of the small aperture employed. As Mr. George A. Hill of Washington says, the satellites of Uranus are difficult objects for glasses of 8 or 10 inches aperture. "Herschel pronounced these objects the most difficult of all in the solar heavens, and gives as an example of their faintness a double star between β^1 and β^2 Capricorni.

The object glass, he says, that is not capable of splitting this double, which is about 3″ apart would not have a ghost of a chance in seeing the satellites of Uranus." Speaking of these satellites Newcomb remarks (Popular Astronomy, p. 365): "They may fairly be regarded as the most difficult known objects in the planetary system; indeed, it is only with a few of the most powerful telescopes in existence that they have been certainly seen." Professor Newcomb doubtless had in mind all four of the satellites of Uranus when the above statement was written. Lamont of Munich saw the second and fourth satellites in 1837 with a 10½-inch refractor. Professor Young says (General Astronomy, p. 368): "Titania, the largest and brightest of the satellites of Uranus, has a distance of 280,000 miles, with a period of 8*d* 17*h*. Under favorable circumstances this satellite can just be seen with a telescope of 8 or 9 inches aperture." These views are cited to show the prevailing idea of skillful observers relative to the difficulty experienced in observing these minute satellites. It is not the purpose of this note to throw doubt on the observation of Mr. Chevers. Nobody knows as well as he, probably, what he saw, especially if he observed carefully, and was certain of what he saw. On the other hand it is true, if he saw those satellites with a 3-inch telescope, that his is the finest record of observing in this particular known to modern astronomy, so far as our knowledge goes. We may fairly say that a good eye, a fine glass and exquisite seeing in Utah air at high altitude were doubtless favoring circumstances in this observational problem. Mr. Chevers will doubtless try his glass on the double star between β^1 and β^2 Capricorni that further tests of its defining power may be known; and yet, in fairness it should be added that if his glass fails to divide that double, it would not prove that he did not see what he claims to have seen.

Errors in Elementary Astronomical Text-Books. In the last number of THE SIDEREAL MESSENGER, Dr. Lewis Swift, of Warner Observatory, Rochester, N. Y., in an article on "Errors in Astronomical Text Books," gives one or two from Lockyer's Astronomy. There is one not mentioned by Dr. Swift which gave the writer of this communication a good deal of trouble at one time, and it is therefore desirable to notice it.

In speaking of the stationary appearance of the superior planets, Mr. Lockyer says (Art. 374, p. 208): "The planet, as seen from the earth, will appear at rest, as we are advancing for a short time straight to it." As the earth is always moving in the direction of a tangent to the point of its orbit then occupied by the earth, and the tangent makes a right angle with the radius, or line between earth and sun, a stationary planet ought, if Lockyer's explanation is correct, to be 90° from the sun on the celestial sphere. In the case of the planet Mars, it is plain, without any measurement at all that Mars, when stationary, is more than 90° from the sun. The true explanation of the stationary phenomenon, given by Herschel and other astronomers, is that all lines drawn through the centers of the earth and a planet during its stationary periods are parallels, and parallels extending from any point on the earth's orbit towards the celestial sphere seem to converge to a point upon that sphere. Since a stationary planet is on such parallels it is always seen against the point to which they seem to converge, and therefore seems to us to be motionless.

It is a strong illustration of the way in which elementary astronomy is divorced from observation that Lockyer's book has been taught for nearly twenty years, but no teacher has discovered this error, which is apparent as soon as observation is used.

The same correction applies, with slight changes to the subject of inferior planets as treated by Lockyer. B. A.

White Region on Saturn's Ring. This phenomenon is still visible, and has been distinctly seen on every occasion that the planet has been observed. It is visible with all powers from 80 to 450 on the 10⅛-inch equatorial. With a magnifying power of 150 it is most conspicuous. To me "the region" has appeared somewhat smaller of late, as if the shadow of the ball was encroaching upon the white spot.

I do not think the contrast theory will explain this white spot, for an observation made a few nights ago through large thin clouds proved that the white region was *intrinsically brighter* than the rest of the ring. I regard the observation as a fortunate and valuable one. These large drifting clouds acted like a graduated photometric wedge of colored glass, gradually obscuring the planet and as gradually allowing it to reappear. In every case the white spot was the last to disappear at the planet's obscuration, and the first to reappear as the planet became visible.

WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.,
April 19, 1889.

The Harvard Party Photographs of January Eclipse. We have had the pleasure of seeing two of the photographs of the Harvard College Eclipse party who observed at Norman, California, Jan. 1, 1889. These pictures were sent us not long ago by Professor W. H. Pickering, from Los Angeles. The smaller picture was taken with a telescope of 5 inches aperture and 91 inches focus, and shows the black disk of moon seven-eights of an inch in diameter. The polar filaments are distinctly seen and the four lateral streamers are fairly well marked.

The larger picture was received later and is the finest photograph of the solar corona we ever saw. This picture was obtained by the aid of the 13-inch photographic telescope, and shows the diameter of the moon's disk to be 1⅞ inches, with streamers traceable to a distance somewhat more than the moon's diameter. The plate used was a Carbutt A, grade of sensitiveness 12, and was exposed 10 seconds, between the 38th and 48th seconds after second contact. Those beautiful polar rays must stand out on the original negative with charming delicacy, because they are so well shown in this picture. We congratulate Professor Pickering on the success of his photographic work of the late eclipse.

Observatory at Iowa College, Grinnell. A recent letter from Professor Buck, by whose earnest labors an Observatory has been recently equipped for Iowa College, informs us that a time service for the city of Grinnell is already in operation. He has contrived an ingenious device by which the steam whistles in the city may be blown daily that the Observatory time may be known. This is now done by a push-button in Professor Buck's study.

Occultation of Jupiter. The occultation of Jupiter by the moon March 23, was observed here with the 10⅛-inch equatorial. The sky was very clear, and the images fairly steady, considering the low altitude of the objects. The first contact was noted by me at 18*h* 45*m* 47*s* local sidereal time (corrected for clock error). The last contact at emersion was recorded at 19*h* 37*m* 31*s*.

My young daughter, Anna Caroline (now eleven years of age, and whom I trust I may be allowed to say manifests a promising ability for precise observation), observed the phenomena with the 3-inch finder of the large instrument, and independently recorded the first contact one second earlier than above. After geometrical contact at immersion the moon's limb *seemed* to me to become indented, to give way, so to speak, before the planet, so that the limb of Jupiter appeared visible nearly three seconds after true geometrical contact. Although observed in bright sunshine, Jupiter appeared very distinct and the belts were plainly visible. Magnifying powers used were 80 diameters by myself on the 10⅛-inch; and 30 by Anna on the 3-inch finder.

WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.
March 25, 1889.

Astronomical Society Proposed. The *Globe-Democrat* of St. Louis recently contained the following item from Mr. F. H. Burgess:

Your suggestion in a recent issue, that wealthy St. Louisans should endow an astronomical Observatory here, deserved more attention than it seems to have received. The excellent work done by the St. Louis party in the eclipse expedition shows that we have astronomical ability here of the highest order, only it needs encouragement. I suggest first the formation of an Astronomical Society to awaken an interest in the subject, and I should be glad to receive the addresses of any who, like myself, are students of the "sublime science," and would like to come together and see what can be done in the line of your excellent suggestion.

The Great Telescope for Los Angeles, Cal. The following note was taken from the *Alta California* of Feb. 28, 1889:

The great telescope which it is proposed to put upon Wilson's Peak, near Los Angeles, will perhaps not be built. Alvan Clark, who was invited there by the trustees of the University of Southern California to look over the ground and consider the practicability of the scheme, made a favorable report and named a price of less than $200,000 to erect a 40-inch lens instrument and necessary accessories. But that offer was not accepted. There is not much more than $200,000 available to spend upon the entire Observatory, and the purchase of the telescope is not more than half the expense. Mr. Clark left Los Angeles without an order, and the scheme will probably never be carried out.

The Chamberlin Observatory. The building for this Observatory will be begun in a few weeks; it is to be situated six miles from the heart of Denver, on a plat of ground containing two blocks. It will be constructed of lava stone; the length is 65 feet, and the extreme depth 45 feet. A steel dome, 37 feet in external diameter, and having its summit 45 feet above the ground, will surmount it. The chief rooms are the library, computing room, director's office, instrument room, transit room, clock room, dome room with the observer's room adjoining it, photographic dark room and janitor's room.

The disks for the 20-inch object-glass are almost ready in the optical works of Mantois. The Clarks will grind the lens. Fauth & Co. of Washington have the contract for the large equatorial mounting, and have begun its construction. It will be the first new instrument to be equipped with Saegmuller's finding circles, at the eye-end. This firm will also furnish the Observatory with a six-inch equatorial mounting (glass by Brashear), a three-inch meridian circle, two standard clocks, a chronograph, two micrometers, and several other subsidiary instruments.

The crown lens of the large object glass will be reversible, for photography. The Observatory will be a department of the University of Denver, to which Mr. H. B. Chamberlin, its founder, will present it.

The White Spot on Saturn. On the evening of March 26, Professor H. L. Smith, of Hobart College, Geneva, N. Y., examined the white spot on Saturn with his Spencer telescope of 4¾ inches aperture, 35½ inches focal length, with powers from 100 to 350. His report is that he cannot make up his mind that the phenomenon is anything more than the effect of contrast of the shadow and the ring, yet it seems a little too conspicuous to be explained in that way only.

March 24th another very skillful observer tried the white spot on Saturn and was unable to see anything unusual. By the aid of the spectroscope this observer could see G. F. b E. D. and C? (a strong line in the red) with perfect certainty, and with glimpses of a multitude of lines more in the yellow, green and blue, but could not find any traces of bright lines.

Notch in the Terminator of Venus. William Edward Wood of U. S. Architect's office, Washington, D. C., while observing Venus March 13, with 3½-inch refractor, with various eye-pieces, including a Steinheil achromatic, believes he saw a notch in the terminator about one-fifth of the way from the north horn inward toward the south horn. Special care seems to have been given to the observation to assure its faithfulness and the distinctness of the notch remained. Subsequent observations of the terminator by several astronomers with good instruments fail to show the notch described; but this might happen on account of the change of the terminator. The observation is mentioned that astronomers generally may consult their note books for further information at or near the date March 13.

Astronomical Clock Record. Frequently from time to time, we have requests for information concerning the performance of good astronomical clocks, by persons with and without experience in accurate time-keeping. As an example of good work in this direction we append the record of an astronomical clock owned by Mr. Chas. H. Rockwell, Tarrytown, N. Y., for a brief period during last year. The clock is the Pond Motor, Gerry escapement, with a Rockwell pendulum.

1888.		Correction.	Daily rate.	1888.		Correction.	Daily rate.
		s	s			s	s
August	24	−2.289		Setpember	21	2.573	+0.012
	26	2.353	+0.032		24	2.603	0.011
	30	2.497	0.036	October.	4	2.033	−0.057
September	5	2.700	0.034		8	2.178	+0.036
	13	2.471	−0.029	(Obliged to stop the clock.)			

Persons desiring further information will find Mr. Rockwell always an interested and helpful correspondent.

Double Star Observations by S. W. Burnham, of Lick Observatory. A paper containing the observations of double stars, new and old, made by S. W. Burnham, astronomer at Lick Observatory, during August, September and October of 1888 has been received. The new double stars were discovered and measured by the 12-inch or 36-inch equatorial belonging to the Observatory. The paper is entirely devoted to objects of special interest in this branch of astronomy.

New Instruments for the Chamberlin Observatory. In connection with our note on the late work of Messrs. Fauth & Co., Washington, D. C., in last month's issue, we inadvertently omitted to mention that the company had been awarded the contract for furnishing a large part of the instruments of the new Chamberlin Observatory of the University of Denver, Colorado. Messrs. Fauth & Co. are to make the mounting for the 20-inch equatorial, to furnish a 3-inch transit circle, chronograph, sextant with artificial horizon, mean time clock, mounting for 6-inch equatorial, a solar transit level and a spherometer. These instruments will be finished in the best style of workmanship and some of them will have improvements recently devised by the company that are new, convenient and apparently very useful.

Death of William Tempel. We were pained to learn, some days ago, by kindness of Charles W. Dunn of Florence, Italy, of the death of Professor William Tempel, Director of the Arcetri Observatory. This sad event took place on the 16th of February, after a long and painful illness. A brief sketch of the life and work of Professor Tempel will be given in a later number of this journal.

BOOK NOTICES.

A Treatise on Trigonometry, by Professors Oliver, Wait and Jones of Cornell University. Ithaca, N. Y.: Dudley F. Finch, Publisher, 1889.

The first edition of this book was published in 1881. Its plan was first outlined by Professor Jones, and submitted to the other professors of the University whose names are given above. After full discussion of its plan, the first edition was published as the joint production of all. During the last eight years this text has been used in Cornell University, going through one revision in the meantime. We have now before us a second revision which bears the date of 1889 on its title page. From a comparison of this with the first edition, we find so many and so important changes that it may be fairly said to be wholly rewritten, and that virtually the book is a new one. In the earlier part of it, the matter is made more simple and direct, and vastly improved in our judgment for use in the class-room. Further on, we find new matter in the way of applications of trigonometry to surveying, astronomy and navigation, which will serve a good purpose for those students who have the time to follow up the branch in this way, and to learn something of the vast range of mathematical physics herein suggested. The discussion of the general triangle, plane and spherical, is an interesting feature in this book, and one that the college student ought to know something of, before he passes on to other branches of mathematics in regular course, if he shall at all have right notions of trigonometry as a science, or realize its uses as an instrument of mathematical investigation. The attention of teachers of mathematics is called to this text-book on trigonometry.

Logarithmic Tables, by Professor George William Jones of Cornell University. Published by Dudley F. Finch, Ithaca, N. Y., 1889. Flexible covers, pp. 72.

This appears to be an excellent book of tables. Its arrangement is certainly first rate. The table of logarithms of numbers is six place, and for four figure numbers, with right hand column on each page for differences. The page is open, and the figures, with variety of face, are easy for the eye. The table of constants in natural and logarithmic numbers is unusually full, and gives latest values, so far as we know. The arrangement of the trigonometric tables so as to place natural and logarithmic numbers side by side, is unusual, but these tables present this so neatly and well as to give convenience without confusion. To promote the detection of errors in these tables Professor Jones offers one dollar for the first notice of each error.

The Student's Atlas in twelve Circular Maps. On a Uniform Projection and one scale. With two Index Maps, intended as a *Vade-Mecum* for the Student of History, Travel, Geography, Geology, and Political Economy. By Richard A. Proctor. Publishers, Messrs. Longmans, Green & Co., London. Also New York, 15 East 16th Street. 1889.

This atlas was prepared by Mr. Proctor, in the course of his studies, to meet his own wants as a student, in the desire to form exact ideas of the relations of different parts of the earth's surface to each other. The one scale in all the maps is a new feature and deserves attention because not in general use by those who have been esteemed the best makers of atlases for geography. The way Mr. Proctor came to adopt the one scale for all his terrestrial maps was partly accidental. In preparing projections of the earth for his "Seasons Illustrated" the "Old and New Astronomy" and "Studies of the Transits of Venus," he found the one-scale plan much more convenient and satisfactory than that in use in ordinary atlases, and so it was adopted, and the terrestrial maps needed for his numerous publications were so made. The maps of this atlas are reductions from those prepared for earlier works. They are circular and have a diameter of nearly seven inches, are printed in colors, show prominent physical features, names of prominent places in clear type, and have on the back of each map its contents as a convenient reference title. The index maps are also an interesting feature, showing at a glance how the six maps belonging respectively to the northern and southern hemispheres are related to one another. As a whole we do not know of an atlas so convenient and handy in form as this, and therefore commend it to the attention of students generally.

Lessons in Elementary Mechanics by W. H. Grieve, P. S. A. Publishers, Messrs. Longmans, Green & Co., London. Also, New York, 15 East 16th Street.

We have before us two small books which were prepared by Professor Grieve to meet the need of the separate stages of instruction in mechanics or elementary natural philosophy, as defined by what is known as the schedule of the New Code in use in the various schools under the school board of the city of London.

The book designed for the third stage has for its subject matter the simple mechanical powers, liquid pressure, the hydrostatic press, liquids under the action of gravity, the parallelogram of forces and velocities, with numerous examples under each topic. The language is simple and direct, and the illustrations and cuts well chosen.

The second book for the second stage is more difficult and deals with matter in motion, the weight of a body, its inertia and momentum, measures of force, work and energy, energy may be transformed, but can not be destroyed, and heat as a form of energy.

The methods employed in tracing these themes are essentially the same as in the other book. No mathematics above the common arithmetic is needed to perform the examples. The review questions at the close of each chapter are an excellent feature of this stage, not only on account of points raised in them, but also others which are easily suggested by them.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE WAVE LENGTH OF LIGHT AS A PRACTICABLE AND A FEASIBLE STANDARD OF LENGTH.

PROFESSORS A. A. MICHAELSON AND E. W. MORLEY.

For THE MESSENGER.

Our experiments have now shown that our method of making the wave length of light of some definite refrangibility a practical standard of length is perfectly feasible. Several steps are involved.

I. We prepare a metallic bar carrying two parallel plane mirrors, whose distance is as great as that at which we can get well defined interference between two pencils of light. We have found that this distance is certainly as much as an eighth of a metre and may be a quarter of a metre.

II. The distance between the two planes is determined in terms of the yard or metre. Our apparatus for this comparison may be called the Interferential Comparer. We have not yet used it for the final comparisons required in our method, but we have had it in daily use for subsidiary comparisons, and have just confidence in the feasibility of making determinations of great accuracy.

III. The whole number of wave lengths, say of sodium light, contained in the distance between the two planes of our intermediate standard (I) is determined. On a standard called E, we have repeated this determination by entirely different steps, and by different observers; the results were 26502, 26502, 26502. The method by which we make this determination by measurements of fractions, with no enumeration of whole numbers may be briefly described. We prepare a set of intermediate standards whose lengths are nearly as the numbers 1, 2, 4, 8, 16, etc. We compare (16) with the metre, (8) with (16), (4) with (8), etc. It is easy to get the length of each within one-fifth of a wave length. For instance, (1) $= 0.4891mm \pm 0.0001mm$. Now the determinations by other methods of the wave.length of D, show that in double this length, the number of waves is 1659.1 ± .2 ($\lambda = 5896.08$). We measured this fraction directly, in the refractometer previously described by us: it was .01 instead of .10; the corrected number is therefore 1659.01. With this corrected value, we found double (2) to contain 3314.22 wave-lengths; and correcting the fraction, 3314.27. In this way we have gone in triplicate, with five different kinds of light, to numbers ranging (for these different kinds of light, but for the same intermediate standard between 23270 and 35815; and in duplicate to numbers four times as large for four kinds of light.

IV. The measurement of fractions mentioned above may be made in various ways. We have often made it consist in measuring the diameter of circular interference fringes by means of the filar micrometer. In this way it is not difficult to make determinations trustworthy to $\frac{1}{50}\lambda$, as far as *optical* errors are concerned. Sometimes we make it consist in shortening the effective path of one of the interfering rays by a minute of angular motion of a certain part of the apparatus, and measuring this motion by the torsional couple required to produce it. This method we find capable of almost incredible precision.

V. As a somewhat tangible evidence of the feasibility of our method, we may use our data for the inverse problem of determining wave lengths. The results of two entirely independent series of determinations by one of us, and of one by the other, are as follows:

	Na.	Li.	Hg_y	Hg_g	Hg_v
I	5896.08	6707.98	5790.70	5460.85	4358.42
II	5896.08	6708.00	5790.67	5460.85	4358.42
III	5896.09	6708.00	5790.68	5460.85	4358.41
Mean	5896.083	6707.993	5790.683	5460.850	4358.417

VI. We feel a reasonable confidence that the number of wave lengths in (16) is known to one part in a million as a result of our early experience with apparatus devised in a tentative way. We feel a reasonable confidence that this distance may be made eight-fold or sixteen-fold longer, with a proportionate increase in precision. We think we have the right to hope that, with better apparatus, and with the benefit of the experience already gained, the work of establishing a material standard a metre in length whose length in wave lengths is known to a millionth or even a ten-millionth may be effected with ease and certainty.

In regard to the relative motion of the earth and the luminiferous ether, I have only to say that the observations of July were repeated in November and December, with the result that if any relative motion between the earth and the luminiferous ether can be detected by such experiments, its amount is less than one-sixth of the absolute motion of the earth.

Cleveland, May 13, 1889.

A NOTE ON DOUBLE-STARS.

W. H. S. MONCK, DUBLIN, IRELAND.

For The Messenger.

That the great majority of double-stars are physically connected, although their motions may be so slow as to have escaped detection up to the present, seems certain. Not only are these stars as a rule closer together than the doctrine of chances will account for, but they exhibit peculiarities which, in the case of casual connection, would be wholly inexplicable. Thus it has been noticed that no blue or green star of decided tint has been found save in immediate connection with a brighter star of a different color; while even when the colors of the component pair are identical another peculiarity is observable, viz., that they are almost equally bright, the brightness being usually very different when the colors are so. Why physical connection leads to these peculiarities is indeed unknown, but that they should have been produced by mere casual arrangement appears incredible. Common proper motion also frequently reveals the existence of physical connection. A few chance coincidences in direction between stars situated at very different distances from us no doubt occur, but if we ascribe one-tenth of the known double-stars to chance coincidence, we shall probably have made a very liberal allowance, while the total number of double-stars now known probably exceeds 10,000. How many more of the known stars are really double is a matter for further conjecture. The motions of Procyon are strongly suggestive of a companion not yet discovered, as those of Sirius were before the satellite was detected. The class of variable stars known as the Algol-type probably possess satellites which intercept a considerable part of their light at each transit. It would be difficult to name a star with a decided measurable parallax which is known to be single; and as any double-star would appear single if removed to a sufficient distance, the apparent singleness of a very distant star affords no argument against its duplicity. It is, at all events, possible that double-stars may prove to be the rule and single stars the exception.

It is somewhat singular that neither the brightness nor the elements of a double-star afford any direct indication of its distance from us. For let us replace any pair by another pair situated precisely in the same direction at $\frac{1}{n}$ of the distance from us, with masses equal to $\frac{1}{n^3}$ of those of the stars which they replace. The angular distance being the same as before, the true distance of this pair will be $\frac{1}{n}$ of that of the former, and the periodic time will be unaltered. Moreover, assuming the new stars to be of the same density as the old ones, and the surfaces to be equally bright, each star will have the same magnitude as before, the illuminated surface being $\frac{1}{n^2}$ of the former, while the light of each unit of surface will be multiplied by n^2, owing to the nearer distance. The ordinary mode of measuring the distances and angles would fail to afford any distinction between the old and new binary systems, and we may in fact replace any given binary system by an equivalent system at any distance, so long as no attempt is made to determine the parallax (assuming also that no light is lost in transmission.)

It is owing to this property of binary systems that we can compare what I may term the intrinsic brilliancy of any two systems whose orbits are known. Suppose, for instance, that we desire to compare the intrinsic brilliancy of Sirius (and satellite) with that of γ Leonis. According to the *Harvard Photometry* the difference in magnitude is 3.61 (the Oxford measurements make it less), whence it readily appears that the light of Sirius is 27.68 times as intense as that of γ Leonis. Replace γ Leonis by an equivalent pair at the distance of Sirius. Now, according to Mr. Mann (SIDEREAL MESSENGER for January, 1888, the semi-axis major of the Sirian ellipse is 21″.8, and the period 51.22 years, while Doberck gives for the semi-axis major of the Leonid ellipse 1″.98, and for the period 407.4 years. The relative masses of Sirius and the pair equivalent to γ Leonis are therefore as $\frac{(21.8)^3}{(51.22)^2}$ to $\frac{(1.98)^3}{(407.4)^2}$, or about 84436 to 1. The excess of mass is thus 3000 times as great as that of light, and assuming the density to be equal, the extent of illuminated surface will be proportional to the masses raised to the power ⅔, or, in this case, 1925 to 1. The unit of surface is therefore, on this supposition, 66 times as bright for γ Leonis as for Sirius. The only way of avoiding this conclusion appears to be to assume that γ Leonis is composed of much lighter materials than Sirius. Sirius, however (as might be expected from its color), stands by no means lowest in the scale of brightness, though γ Leonis apparently stands highest. I wished to indicate the general mode of comparison, and also to give an estimate for these two remarkable binaries on the latest available data. The brilliancy of Sirius is, of course, lessened in this mode of comparison by the faintness of its satellite, whose surface is perhaps half as large as that of the primary; but neglecting the light of the satellite altogether, γ Leonis appears to be brighter (for each unit of surface) than Sirius in the ratio of 44 to 1. (I confess, however, that I think Mr. Mann's value of the semi-axis major of the Sirian orbit is too large.)

There is good reason, I think, for believing that the parallaxes of the great majority of double-stars are very small. In a larger proportion of cases there is scarcely any perceptible difference, either in the position or the distance, for a considerable number of years, notwithstanding which the distance (in angular measure) is not very great. A first approximation may be made in such cases by supposing the orbit to be circular. Most probably it is not so, but if the period is less than that computed on the assumption of a circular orbit the mean distance will also be less, and if the period is greater the mean distance will be greater. As regards mass and parallax therefore the necessary connections (which will no doubt be made hereafter) tend to neutralize each other, while the substitution of the true for the apparent orbit will in all cases increase the distance and thus reduce the mass and parallax computed on the assumption of a circular orbit whose plane is at right angles to the line of sight. I take a few examples to illustrate the consequences of this assumption. The first is the star 6 Cygni, for which Sir Robert Ball found a parallax of 0″.482, while Professor Asaph Hall obtained a negative parallax with the same comparison star. According to the measures in Crossley, Gledhill and Wilson's *Handbook of Double-Stars* the angular distance has remained nearly constant at about 10″ for over forty years. During this period the angle described is 4°.3, which a critical examination seems more likely to reduce than to increase (I have no recent measurements of this interesting pair at hand). A period of 3,600 years with a mean angular distance of 10″ is thus indicated. The equivalent parallax (as I termed it in my former article, or hypothetical parallax, if the phrase be preferred) for such an orbit is 0″.042. If Sir Robert Ball's parallax is correct the mass of this binary pair probably does not exceed that of Jupiter. It is possible, however, that while Ball's parallax is too large Hall's is too small. With a parallax of 0″.042 the proper motion of the star in declination alone exceeds 15 radii of the earth's orbit in the year. It may be worth while before leaving this star to compare its brilliancy with that of γ Leonis. An equivalent pair to γ Leonis, placed at the distance of 6 Cygni, would contain only about ⅔ of the mass (on the above assumption as to the orbit of 6 Cygni) of the latter star; but the difference in magnitude being about 3.8, γ Leonis gives at least 33 times as much light. The contrast is almost as striking as in the case of Sirius.

I have referred to 6 Cygni chiefly as an interesting star, for there are comparatively few double-stars situated at a distance of 10″ whose angular motion can be detected at all. As a type of another class in which angular motion can be detected I take the first star in the *Handbook*, Σ 3063. Observation indicates a period of at least 1,400 years with a mean distance of 1″.8 (which has hardly altered for half a century). The equivalent (or hypothetical) parallax here is only 0″.015. In 69 Andromedæ the distance is only about 5″, and yet 40 years have produced no perceptible change in the angle. If we allow a motion of 1° in 40 years (and it may be much less than this), we should obtain a period of over 14,000 years for revolution in a circular orbit and an equivalent parallax of less than the hundredth part of a second. But in Σ 59 the angular motion appears to be equally slow, while the angular distance is little more than 2″, thus suggesting a still smaller parallax. One of the best known double-stars is Mizar, in the Great Bear. It is doubtful whether any angular motion has been observed since its duplicity was first detected, much more than a century since. The distance of the components is indeed considerable, but still the equivalent parallax must be very small. On the assumption of circular orbits, the equivalent parallaxes for the pair ϵ_1 ϵ_2 Lyræ are about 0″.020 and 0″.026 respectively. As their distances from us are probably nearly equal it may be conjectured that the mass of ϵ_1 is somewhat greater than that of ϵ_2. For the Pole star the measures are uncertain, but on the assumption of a circular orbit the equivalent parallax seems to agree fairly with the most recent determinations of its actual parallax. In these latter instances, however, the binary stars are probably nearer to us than the average of the class to which they belong. 69 Andromedæ and Σ 59 are more typical cases. Of the binary stars whose orbits are still undetermined, it seems likely that not one in ten has a parallax of 0″.01. Accurate results, however, cannot be expected for some time to come.

THE STUDY OF VARIABLE STARS.

During the last four years Harvard College Observatory has given particular attention to the study of variable stars, and from time to time several articles have been published by different astronomers connected with the Observatory, giving information as to methods for the proper study of such stars, observations of old and new variable stars, and, to some extent, setting forth what other astronomers were doing in this comparatively new branch of astronomical observation.

Very recently Professor E. C. Pickering, the Director of the Observatory, has published another important and most useful paper on this theme, under the title of "Index to Observations of Variable Stars." This publication is intended to be a systematic arrangement of observations of variable stars, as far as known, covering the entire period from 1840 to the end of 1887. These observations have been reported to Harvard College Observatory chiefly by the astronomers who made them, and are mostly new. Three large series of unpublished observations by Argelander, Heis, and Schmidt, however, are given in the account of the separate series, and they are important because of their early date and the reputation of the observers.

This publication also contains a notice of some others, especially of those found in the three most familiar published series of observations of variable stars: Argelander's comparisons in Vol. VII of the Bonn observations, those of Schönfeld, and those of Oudemans.

A deservedly prominent place in this account is given to the work of Mr. S. C. Chandler, who is author of a catalogue of variable stars which was published in Nos. 179 and 180 of the *Astronomical Journal.*

The following statement taken from this paper will be of interest to those who would care to know the names of observers, the instruments, and something of the method of observations:

The observations of Argelander, in the second part of Vol. VII of the Bonn observations, and also many yet unpublished, a copy of which has been made with the kind permission of Professor Schönfeld were chiefly made with the naked eye or with an opera-glass; telescopes were employed only in special cases. The method of numerical comparison, by means of grades or steps, between the amounts of light received from different stars, which was introduced by Argelander, has been extensively employed by subsequent observers.

Mr. T. W. Backhouse, of Sunderland, England. A refracting telescope by Cooke, aperture 4¼ inches, magnifying powers 38 and 75, was often used; other observations were made with the finder, power 9, and the rest with a field-glass and similar instruments of low power, or with the naked eye. The methods of comparison were chiefly three, —that of Argelander; that in which the relative brightness of the star observed is indicated by a fraction of the apparent difference between two comparison stars; and that of verbal description, in which, however, the words employed are regarded as having numerical values.

Mr. Joseph Baxendell, of Birkdale, Southport, England. The telescope used in the observations was an achromatic refractor by Cooke, aperture 6 inches; the magnitudes of the variables were determined by comparisons with neighboring stars whose magnitudes had been determined by the method of limiting apertures.

Mr. Joseph Baxendell, Jr. The place, instrument, and method of observation were the same as described above.

National Observatory at Cordoba, in the Argentine Republic, the Director of which, Professor John M. Thome, has kindly communicated the facts here given. The observers at Cordoba were Messrs. F. H. Bigelow, W. M. Davis, J. T. Hedrick, Miles Rock, and J. M. Thome.

Mr. S. C. Chandler made observations in 1883 and 1884 at this Observatory with a telescope by Clacey, aperture 6¼ inches, magnifying power generally 45, sometimes 125 or 200. The method of observation was that of Argelander.

Dr. N. C. Dunér, of the Observatory of Lund, Sweden. The observations were made by the method of Argelander.

Mr. John H. Eadie; observations were made at Bayonne or at Madison, both in New Jersey, by the method of Argelander. The telescope employed was made by John Byrne; its aperture was 3¼ inches, and the lowest magnifying power was about 50. Mr. Eadie acted in co-operation with Mr. Parkhurst in a manner explained below. This system of co-operation appears to be highly efficient and economical. It deserves extension and general introduction among observers not too far separated for ready communication with one another.

Rev. T. E. Espin, of Wolsingham, Darlington, England. The instruments employed were a binocular glass and reflecting telescopes of 9 and 17¼ inches in aperture, the last by Calver. Mr. Espin's Observatory has recently been removed to Tow Law, near Darlington.

Large equatorial telescope of Harvard College Observatory. The aperture and focal length of the instrument are respectively 15 and 279 inches. The magnifying power employed was ordinarily 103. The observers were Messrs. Arthur Searle and O. C. Wendell. The observations to which reference is made were mainly photometric determinations, made with the wedge photometer, of the brightness of the comparison stars known to have been employed by previous observers; but when the variable stars themselves were visible, they were incidentally compared with others by estimate, according to the method of Argelander, and were also observed with the wedge. This work is to be continued; and it is desired to make it include as many as possible of the comparison stars which have been employed by any observer. The list now in use is chiefly derived from the published work of Argelander, Schönfeld, and Oudemans. Observers are requested to send lists of the comparison stars not included in these publications, which they have themselves employed, or which have been employed to their knowledge by others. It is very desirable that not only the places of these stars, but also their designations in the Durchmusterung, when they occur in that Catalogue, should be entered in the lists thus sent.

Mr. J. E. Gore, of Ballysodare, Ireland. The instrument was a binocular field-glass having object-glasses of 2 inches aperture, and a magnifying power of about 6 diameters. The method of Argelander was employed.

Dr. E. Hartwig, whose observations were made at Dorpat, Russia.

Rev. J. G. Hagen, S. J., of the College of the Sacred Heart, Prairie du Chien, Wisconsin, now of Washington, D. C. The instrument was a telescope by Merz, aperture 3 inches. The observations were made by the division into tenths of the interval between two comparison stars, and subsequently by the method of Argelander. Messrs. Zwack and Zaiser took part in the work as assistants.

Dr. E. Heis, of Münster, Germany. Father Hagen, having received from the family of Dr. Heis a series of note-books containing records of his observations, has kindly forwarded them to this Observatory for examination. It has thus become practicable to include in the present publication an enumeration of the observations of variable stars made by Dr. Heis.

Mr. George Knott, of Knowles Lodge, Cuckfield, Hayward's Heath, England. The telescope was by Clark, aperture 7⅛ inches, with a finder, aperture 2 inches. The variable was compared with stars differing little from it in brightness; the magnitude of the comparison stars, and sometimes the magnitude of the variable, were determined by the method of limiting apertures.

Mr. H. A. Lawrance, whose observations will be mentioned below in connection with those by Professor W. Upton.

Major E. E. Markwick, of Haulbowline, Queenstown, Ireland.

The meridian photometer of Harvard College Observatory. The observers using this instrument were Messrs. E. C. Pickering and O. C. Wendell. The magnitudes of the stars observed with it were referred to a series of one hundred circumpolar stars, the brightness of which was determined by observations described in Vol. XIV of the Annals of the Observatory.

Mr. C. E. Peek, of the Rousdon Observatory, Devon, England.

Mr. J. Plassmann, of Warendorf, Germany, who has kindly furnished some observations recently made by him with small instruments.

Mr. Henry M. Parkhurst, of Brooklyn, N. Y. The instrument was a telescope by Fitz, aperture 9 inches, and magnifying powers 56, 90, and 150. Many of the observations were made by the method of Argelander, others by photometric apparatus devised by Mr. Parkhurst, and described in his account of observations of asteroids. The system of co-operation between him and Mr. Eadie has already been mentioned. Mr. Eadie undertook the observation of certain stars while they were sufficiently bright to be well seen in his telescope; and when they became too faint for further observation he notified Mr. Parkhurst to begin observing them. When they were again sufficiently bright to be observed by Mr. Eadie, he was informed of the fact by Mr. Parkhurst. This system permitted each observer to employ his time to the best advantage. It is hoped that some astronomer having a large telescope at command will undertake similar observations in co-operation with other observers having smaller telescopes.

Professor Safarik, Prague, Austria. The instrument used previous to March, 1885, was a Newtonian reflector 6½ inches in aperture, with a mirror of silvered glass. The ordinary magnifying power was 32. The finder had an aperture of 3 inches, and a magnifying power of 12. Subsequent observations were made with a refractor by Schröder, with an aperture of 4.5 inches, a magnifying power of 23, and a field of 1° 30′. The obervations were made by the method of Argelander, and on all suitable occasions the colors of the stars were observed upon Schmidt's scale.

Mr. T. S. H. Shearmen, of Brantford, Canada. The instruments employed were an opera-glass and a two-inch refractor. Each variable was compared with stars differing little from it in brightness. Many suspected variables have been photographed.

Mr. E. F. Sawyer, of Cambridgeport, Mass. The observations were made according to the method of Argelander, by means of an opera-glass for the brighter stars, and of a field-glass for the others.

Professor J. F. J. Schmidt, of the Athens Observatory, whose extensive observations of variable stars are preserved in manuscript at the Potsdam Observatory. Professor Vogel, the Director of that Observatory, has kindly facilitated the copying of these observations, and the copy has been transmitted to this Observatory.

Professor Winslow Upton, of Brown University, Providence, Rhode Island. The observations here mentioned were made by Professor Upton during an expedition to observe the total eclipse of the sun which occurred on May 6, 1883. The place of observation was generally on board the U. S. S. Hartford, but occasionally on Caroline Island, in the Pacific Ocean. No instruments except a field-glass were employed in the comparisons, which were made by the division into tenths of the interval between two comparison stars. Most of the observations were independently repeated by Mr. H. A. Lawrance. The stars observed were all south of — 30° declination.

Rev. T. W. Webb, of England. The observations mentioned under this heading were found by Mr. Espin in some of Mr. Webb's manuscripts, and were kindly transmitted to this Observatory.

Dr. F. Wilsing, of the Potsdam Observatory. The wedge photometer was employed in part of the comparisons, but in such cases estimates in grades of the difference in brightness between the stars compared were almost always added.

An examination of the tables of this paper gives many useful facts, prominent among which are the following:

Table I shows the observations of each star in separate years grouped together, with date, number of observations, and the name of the observer.

Table II is a summary of the detailed information furnished by Table I, and contains also a statement of the position and character of each star as derived from the catalogue of Mr. Chandler, before referred to; also from the ephemerides for 1889 of Professor Schönfeld in *Astronomische Gesellschaft*, and from M. Loewy (Companion to the Observatory, 1889). Dunér's catalogue of spectra, the revised catalogue of variable stars of J. E. Gore (Proceedings of the Royal Irish Academy), and peculiar spectra observed at Harvard College Observatory chiefly, furnish the data for classification in this table. The first column gives the numbers proposed by Mr. Chandler for future designation of variable stars, each number being one-tenth of the number of seconds of time in the right ascension of the corresponding star for the epoch of 1900. Other columns give magnitudes at maximum and minimum, period, date of discovery, day of maximum for 1889, number of observations of each for particular years, and whole number of observations.

Table III shows the observations for the year 1888, and Table IV gives the distributions of observations with annual results.

It would be interesting also to compare the results of this paper with those found in other catalogues before referred to, but want of space forbids. It must suffice now to say that although a vast amount of work has been done in the last few years in studying variable stars, but little has been learned, and that future work should be conducted with greater care and in reference to some definite system if much advancement is to be gained in this new and important branch of astronomy.

ERRORS IN ASTRONOMICAL TEXT-BOOKS.*

LEWIS SWIFT.

For THE MESSENGER.

These strictures are not designed to cast reflections upon the character of any book noticed, nor to indicate the want of ability in any author, and no errors will be noted which are purely typographical in given values in figures, as, perhaps, the omission of a cipher, such as that on page 243 of Professor Young's admirable work, "The Sun," and four different places on page 341 of Professor Mitchel's "Popular Astronomy," where the eminent author was, evidently, not the proof-reader. No doubt, many of the mistakes shown in my former, as well as in this, article have been corrected in subsequent editions of the authors criticised, but for the sake of those who have and read the first publications, I point out errata for correction.

Professor Mitchel, "Popular Astronomy," page 77, says: "4089 years before the Christian era, the perihelion of the earth's orbit coincided with the vernal equinox," and that, "In A. D. 1250, it passed the summer solstice and will meet the autumnal equinox about the year 6483." This will read correctly by changing "vernal" to autumnal, "summer" to winter, and "autumnal" to summer. On page 87, he calls the moon's apogee the least distance from the earth. On page 296 he says: "Encke was the discoverer of Encke's comet." On page 326, near bottom, for "opposition" read superior conjunction.

Brocklesby's Astronomy, page 213, says, writing of double nebulæ, they belong to the class of planetary nebulæ. Though I have observed nearly all the planetary nebulæ visible from this latitude, yet I have never seen a double, and I doubt if the heavens afford a single example.

In Mitchel-Burritt's Astronomy, page 249, regarding the moon's changes, we find the following: "As her enlightened surface comes more and more into view until she arrives at her first quarter and comes to the meridian at sunset, she has then finished her course from the new to the *full*, and half her enlightened hemisphere is turned towards the earth."

* Continued from No. 74, page 194.

Page 158, speaking of a cluster in Sagittarius, says of it: "It is midway between Beta Ophiuchi and Beta Lyræ." Page 163 shows three or four errors. Zeta Herculis is called Delta, and, near the bottom, is named Chi. Also the given right ascension of the cluster is an hour too little. "Heavens Above," by Rolfe & Gillett, page 301, bottom, declares the average number of shooting-stars visible to the naked eye at any one place to be estimated at about one thousand per hour, while at the top of the page the number is correctly given as three or four. Page 221 asserts that there are more lunar than solar eclipses. And on page 148 we find this: "The sun's distance is such that his parallax is about eighty-eight seconds." This error, 88 for 8″.8, cannot be regarded as typographical, since the value is given in words and not in numerals.

"Astronomy Simplified," page 254, says: "Ceres was discovered on the *second* New-year's-day of the present century, Jan. 1, 1801." The author must advocate the erroneous idea—quite a current one—that the first day of this century was Jan. 1, 1800. Had he called to mind that there was no year 0 and that Christ was born in A. D. 1, and that the previous year was B. C. 1, he must have perceived that the 1st of Jan., A. D. 1, was the first day of the first century, and, therefore, that Jan. 1, 1801, was the first day of the nineteenth century.

Lockyer's Astronomy, American edition, page 66, avers the presence of hydrogen in the sun to be doubtful, yet in the frontispiece of the book the positions of two of the five or more hydrogen lines in the sun are shown, and on page 268 it says: "One of the hydrogen lines in the sun is found in the planetary nebula in Draco. Page 35, 1st edition, says of 79 Messier, that it is a nebulous star in Ursa Major, while on page 52, last edition, it is called 79 Ursa Majoris, which is the star Eta, the end star in the handle of the Dipper. Seventy-nine Messier is a resolvable cluster, 24° south of the equator, in Lepus. Mr. Lockyer probably refers to 97 M. which is in Ursa Major though, even then, his statement is erroneous, as it is not a nebulous star but a very remarkable planetary nebula, the largest known.

Under the same head he writes that Epsilon Orionis and 8 Canum Venaticorum are nebulous stars. No modern telescope shows nebulosity surrounding either. I have frequently examined them with the 16-inch refractor of this Observatory, and have never been able to detect the slightest nebulosity. It is quite strange that these doubtful bodies should have been chosen when the sky furnishes so many striking examples, some of which are visible through small telescopes. Other errors there are, but they are mostly typographic and will be readily detected by an intelligent teacher. Because this work is so excellent, and because of its extensive use in the United States as a text-book, it has given me great pleasure to call attention to its minor faults.

Page 539, Newcomb's Astronomy, (table of periodic comets) "Tempel's I" should read Tempel's II and *vice versa*.

On page 90, Mattison-Burritt's Astronomy (telescopic objects) for Alpha, Beta and Gamma Lupi, read Alpha, Beta and Gamma Leporis. The nebula is also in Lepus.

All text-books on astronomy which have come to my notice convey this misleading statement regarding star-showers, viz.: that they (the falling stars) seem to emanate from one place called the radiant. Now were this assertion made to an audience who had never witnessed a star-shower, a wrong impression would be made. I saw on Nov. 13, 1833, the great shower of that year, and the American side of its return in 1867, and not one in ten thousand in the shower of 1833 *seemed* to radiate from the Sickle in Leo, though their paths, *had they been traced backwards* would have met in the Sickle; a different statement from the other, and one which could not deceive a child. In 1867 a large number were seen low down in the north-west and also many at a rather low altitude in the south-east. Now, it certainly would not be strictly correct to say that they all appeared to start from the radiant, as some of the luminous paths in the north-west were not over a degree in length, but, as we have already seen, their visible tracks traced backwards would converge to the radiant like the radii of a circle to its center.

"Herschel's Outlines of Astronomy," page 521, and Chambers' Astronomy, page 766, give the radiant of the Aug. 9-11 star-shower as B. Camelopardalis. I have, for more than 30 years, been an observer of this shower, and have always regarded an elliptical region (not, as it is often called, a point about 6° by 12° in Perseus as its radiant. From the radiant being in this constellation, its meteors are called Perseids, as those of the Nov. 14 shower, being in Leo, are called Leonids.

"Herschel's Outlines," page 531: "The Solar Cycle consists of 28 Julian years, after the lapse of which, the same days of the week would always return to the same days of each month throughout the year." It would seem, according to the above rule, that, say, the Fourth of July, would fall on Sunday only once in 28 years, whereas I, myself, have seen ten such instances. July 4th has occurred on Sunday thirteen times during this century, and in 1897 we shall again have a Sunday Fourth. And it is certainly a fact that between the extremes of the Cycle there are three recurrences at irregular intervals of the phenomenon which appear not to appertain to the solar cycle proper. These intervals for them all are 11-6-5-6; 11-6-5-6; 11-6-5-6, etc. Cannot an explanation without ambiguity be given by some one concerning the Solar Cycle?

My own criticism, in a previous article, of Chambers' list of fifteen comets which have twice appeared, is itself erroneous, so far as the last three were concerned, they being the well-known comets of Winnecke, Brorsen and D'Arrest, respectively.

Warner Observatory, May 12th, 1889.

WILLIAM TEMPEL.*

G. V. SCHIAPARELLI.

William Ernest Tempel, astronomer at the Observatory of Arcetri, died on March 16th, after a long and painful illness. His life was a notable example of a strong calling, drawing man with overwhelming force to a fixed object, and surpassing the greatest obstacles.

Born of a poor family, Dec. 4, 1821, at Nieder-Cunersdorf, in upper Lusatia, he early learned the art of lithography, which he followed at first in many cities of Germany, and attained in it great ability united with delicate artistic feeling.

* (From *La Nazione* (Italian) April 5, 1889.) Translated for the MESSENGER by F. W. Fiske, of St. Paul.

Endowed by nature with an imaginative and restless temperament, after a time he left his fatherland to seek his fortune in foreign countries. He lived three years in Denmark, then came to Italy; and in 1859 we find him living in Venice. At this time began his interest in astronomical matters. He purchased with his savings a telescope from Steinheil, not a very large one to be sure, but very good, and he was soon recompensed by his first discovery, the comet of 1859. In the same year he began to make a map of the well-known group of the Pleiades in which in a short time were included six large stars and many hundreds of smaller ones.

How many telescopes since Galileo had been turned to that part of the heavens! Yet aided by the excellence of his instrument and by uncommonly keen vision, Tempel there found that which in 250 years, with telescopes of every size, none had been able to see. He discovered the famous nebula of the Pleiades, whose existence is even now doubtful to many, and he was harshly disputed by those who in astronomy—as is often the case in other departments of knowledge—claim to be the highest critics.

Lately, however, celestial photography has come to confirm the observations of Tempel, and not only removes every doubt of the existence of that nebula, but shows that what Tempel saw is the brightest and thickest part of a nebulous mass extremely complicated and extensive, which extends through nearly all the space occupied by the group of the Pleiades and forms one mass with it. He thus showed in a convincing way the close connection existing between the nebulæ and the stars, and utterly destroyed the belief, still held by Humboldt in his Cosmos, that the nebulæ are collections of stars of a high order, in extent and formation like the Milky-Way, and situated at a much greater distance than ordinary stars.

In 1860 Tempel went to live in Marseilles, and in 1861 served a while as assistant in the Observatory there under the direction of Benjamin Valz. In that position he remained only six months. Loving above everything his own independence, he continued to follow his profession as engraver in that city until 1870, alternating these labors with astronomical investigations. In Marseilles he discovered six small planets, Angelina (64), Maximiliana (65), Galatea

(74), Eurynome (79), first discovered a little before by Watson in America, Terpsichore (81) and Clotho (97); at that time those discoveries had greater fame and greater importance than would be given to them at present. It was then indeed reasonably supposed that the number of the smaller planets between Mars and Jupiter was limited; this does not seem likely to the present astronomers already embarrassed by the mighty army of "*atomi planetarii*," now increased to about 300, and of which no one can see an end. Most important to astronomy were, and always will be, his discoveries of comets, in which he was especially assisted by a very keen eye, the perfect climate of the Provence and the Steinheil telescope of excellent clearness. These are the comets discovered by Tempel in Marseilles: 1860 IV, 1862 I, 1863 IV, 1864 II, 1866 I, 1867 I (with Stephan), 1867 II, 1869 II, 1869 III, and 1870 II (with Winnecke); these gained for Tempel several prizes from the Imperial Academy of Vienna. Of these the most important, from the result to which it led, was 1866 I; which, rather than a comet, should be called a remnant or the ruins of a comet. In the course of the destruction of that body came the thick swarm of bright meteors of November, which at periodic intervals of 33 years meet and surround the earth, producing bright showers of falling stars. We have finally learned the cause of such a phenomenon, which, from the year 902 of the common era even until to-day, has occurred so many times and always been seen with new wonder; and to this progress not a little has been contributed by Tempel's discovery of that burning comet in a very favorable time, just in time to explain the last return of meteors, which was in the night between the 14th and 15th of November, 1866.

The stay in Marseilles marked a very calm and very fruitful period in the life of Tempel, to which, unfortunately, the political whirlwind of 1870 put too early an end.

Expelled from France for no other offence than that of being a German, in the beginning of 1871 he went to Milan where he was established as assistant in the Royal Observatory of Brera. Then giving up the art of lithography he gave himself wholly to science, and in his new field of work engaged in useful labors. In the four years that he stayed in Milan (1871-1874) he discovered four more comets, 1871 II, 1871 V, 1871 VI, 1873 II. Besides these, he observed and drew several other comets, particularly the splendid one of Coggia that appeared in 1874, whose appearance he represented in a way that has not yet been excelled.

Though so tireless a hunter of comets, Tempel in the number of his discoveries did not rival Pons, to whose life his own presents many analogies. Yet it may be said that no astronomer has made discoveries in this line more important and more useful.

I have already shown how timely and how fruitful in its results was his discovery of the comet 1866 I; to this I should add that, of the ten comets of short periods yet known, three are due to Tempel. The story of these comets belongs to the most interesting part of astronomy. The changes through which, by the powerful attraction of the larger planets (for the most part of Jupiter), they were drawn in periods sometimes not very distant, to become lasting members of the planetary system; the exact forces whose application has caused these disturbances through the planetary bodies; the notions that some of them have given and can still give in the future about a supposed resisting ether filling all the heavenly space; and, finally, the destruction that one of them, Biela's, and perhaps also Vico's, has suddenly undergone, as if before our eyes separating into small fragments; all these questions give to these bodies of feeble light and modest appearance a degree of importance not inferior to the largest and brightest comets.

His age and the state of his health made his labors very severe, continuing nightly observations in the trying climate of Milan; and in the beginning of 1875 he was led to accept the position of astronomer in the new Observatory founded by Donati a few years before in Arcetri, where he lived and worked alone, expecting a definite arrangement at that fine Observatory. There at first he continued his assiduous investigations of comets; his last discovery in this field was the comet 1877 V. Finding himself entirely his own master and having two large telescopes by Amici that were distinguished for the clearness of their images, he gave himself, with the zeal that he put in every act, to the study of the nebulæ, whose forms and details he represented in a large number of drawings, which are the finest and the most accurate yet made in this line.

For this labor he was thought, in 1880, worthy of the Royal prize which the Royal Academy gives every six years to astronomical work. So perfect are these drawings that Tempel in vain sought an artist capable of reproducing them satisfactorily to him; and they are among his unpublished works; but their existence and their value are not unrecognized in the astronomical world, and already a movement has been made in Germany to acquire and publish them.

The reason for so great an interest in them is not hard to find, for besides an eye skilled in astronomy Tempel had a practised artist's hand; two qualities that are rarely both found to so high a degree in the same person. The drawings of the nebulæ that he left are, in the opinion of all who have seen them and compared them with the heavens, a faithful representation of the appearance presented by the nebulæ to a telescope of the present time. Therefore they can give to astronomers in the future a means of judging upon the question of the possibility of change in these bodies; which perhaps we could now do, had there been a Tempel provided with a telescope upon the Nile with the builders of the pyramids, or in an Observatory upon the roofs of the temples of Babylon. It is then of great importance not to allow to perish or become forgotten a work whose value will always increase with the ages.

One might think that photography applied to representing the heavenly bodies would now render useless drawings made by the aid of the telescope. But let me say that is an error; for those rays or vibrations of light by which the heavenly bodies are made visible to the human eye are generally different from those ðth rays by means of which these bodies are figured upon photographic plates. So it can happen that a star in which at first sight prevail rays of great intensity appears very bright to our eyes and yet acts with feeble impression on the plate of the camera. On the other hand another heavenly body, whose light abounds in chemical rays, can act with strong effect upon the photographic plate and yet be hardly visible to the human eye, or entirely invisible. There are such essential differences existing in the character of the light emitted by different stars, and also by different nebulæ; and they can exist in different parts of the same nebula, which will appear of different aspect whether seen by the eye or photographed. A remarkable instance is seen in the case of the nebula of the Pleiades, which in a photograph shows an appearance quite different from that seen through the telescope. Not only therefore will the drawings of the nebulæ made by the eye in the usual way never be useless, but when they are compared with the photographic impressions there will rise very instructive ideas about the different characters of the nebulæ.

In the last years of his life Tempel was obliged to give up entirely night observation as too fatiguing to his declining health. The impossibility of completing these tasks, which would bring him the greatest fame and happiness, contributed not a little to increase his illness. After a year's sickness a sudden crisis ended his sufferings on the 16th of March, 1889.

Although Tempel had not received a regular education he was not wholly without culture; he had a strong love of nature and art, and poetry made a strong impression upon him. In mathematics he had, without the aid of teachers, and by himself, mastered the first steps, and was never troubled in making the needed calculations.

His honesty of character made him worthy of high esteem; but his mind was very sensitive and ill fitted to bear the inevitable disagreements caused by daily contact with his fellows; nor had he learned the necessary art of bearing them philosophically. He often kept himself brooding over injuries, and sometimes without any real cause; and this produced the impression in those who did not know him that he was a distrustful and unaffable man. Only a long acquaintance with his character could correct this judgment and give a just estimate of his faults, which injured no one but himself and were fully compensated by the strength of his noble qualities.

His friends cannot forget his pure and disinterested love which made of a humble workman a wise astronomer, gaining for his memory a name that will last as long as the study of the heavenly bodies is held in honor by men.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury comes into inferior conjunction with the sun on the morning of June 19. The planet will then be about four degrees south of the sun, and so not visible. From July 5 to 20 Mercury will be visible in the morning an hour before sunrise, a little to the right and above the sunrise point. He will be visible at greatest elongation west from the sun, 20°47′, on the morning of July 12.

Venus rises from two to three hours earlier than the sun, so that she is in favorable position for morning observations. She will be in conjunction with the moon, 1° 01′ north, June 23 at midnight; in aphelion June 25; at greatest elongation west from the sun, 45°44′, July 10; in conjunction with Neptune, July 10 at 10 P. M., the latter being then 1°48′ north of the former.

Mars sets a few minutes later than the sun, and so cannot be seen.

Jupiter is now in best position for observation this year, coming into opposition to the sun June 24, and visible during the whole night. *The Observatory* for May, 1889, contains a review of some observations of this planet made in the years 1881-86 at Birr Castle Observatory, Parsontown, Ireland, and published in Vol. IV of the "Scientific Transactions of the Royal Dublin Society." Eighty complete drawings and four sketches of Jupiter were made with a reflector of three feet aperture by Dr. Otto Boeddicker. The drawings were executed in pencil, the average time devoted to each being not more than ten minutes, and are reproduced, without retouching or correction in any way, by a photo-mechanical process, so that errors of lithography are thus avoided.

Saturn sets too early in the evening to be well seen. He will be in conjunction with the moon, south 2°, July 1 at 1 P. M. Reports still come in of observations of the white region upon the rings of Saturn seen in March. Several astronomers seem unwilling to admit that the appearance seen was due to the effect of contrast or bad atmospheric conditions; yet after reading carefully all the accounts at hand, we are inclined to believe that nothing has been seen but what would, in the absence of Dr. Terby's announcement, have been set down as the result of one or both of those causes.

Uranus will be in quadrature, *i. e.* 90° east from the sun, July 9. He crosses the meridian early in the evening, and may be found near θ Virginis, the nearest naked-eye star northwest of Spica.

Neptune may be seen again in the morning, 5° south of the Pleiades, rising from two to three hours before the sun. The conjunction of Neptune with Venus has been mentioned above. He will be directly north of the moon, about 1°46′, on the morning of June 24.

MERCURY.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 20	5 49.7	+19 20	4 29 A.M.	11 53.1 A.M.	7 18 P.M.
25	5 39.5	+18 45	4 02 "	11 23.3 "	6 45 "
30	5 35.1	+18 48	3 38 "	10 59.3 "	6 21 "
July 5	5 38.8	+19 25	3 19 "	10 43.3 "	6 08 "
10	5 51.5	+20 25	3 07 "	10 36.5 "	6 06 "
15	6 13.3	+21 30	3 04 "	10 38.4 "	6 13 "

VENUS.

June 25	3 11.8	+14 23	1 54 A.M.	8 56.0 A.M.	3 58 P.M.
July 5	3 46.8	+16 24	1 41 "	8 51.7 "	4 02 "
15	4 25.9	+18 23	1 31 "	8 51.2 "	4 11 "

MARS.

June 25	6 08.3	+24 11	4 04 A.M.	11 53.0 A.M.	7 42 P.M.
July 5	6 38.5	+24 01	3 55 "	11 42.9 "	7 31 "
15	7 07.2	+23 31	3 74 "	11 32.2 "	7 17 "

JUPITER.

June 25	18 14.0	−23 15	7 32 P.M.	11 55.7 P.M.	4 20 A.M.
July 5	18 08.5	−23 18	6 47 "	11 10.9 "	3 35 "
15	18 03.4	−23 20	6 03 "	10 26.6 "	2 50 "

SATURN.

June 25	9 21.7	+16 38	7 52 A.M.	3 05.1 P.M.	10 18 P.M.
July 5	9 26.0	+16 18	7 20 "	2 30.0 "	9 40
15	9 30.5	+15 57	6 46 "	1 55.2 "	9 04 "

URANUS.

June 25	13 06.9	− 6 26	1 11 P.M.	6 49.4 P.M.	12 27 A.M.
July 5	13 07.0	− 6 28	12 32 "	6 10.4 "	11 48 P.M.
15	13 07.5	− 6 31	11 54 A.M.	5 31.6 "	11 09 "

NEPTUNE.

June 25	4 05.9	+19 14	2 26 A.M.	9 50.2 A.M.	5 14 P.M.
July 5	4 07.4	+19 17	1 48 "	9 12.3 "	4 36 "
15	4 08.5	+19 20	1 10 "	8 34.1 "	3 58 "

THE SUN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 20...........	5 57.9	+23 27	4 15 A.M.	12 01.4 P.M.	7 48 P.M.
25...........	6 18.7	+23 23	4 16 "	12 02.4 "	7 49 "
30...........	6 39.4	+23 09	4 18 "	12 03.5 "	7 49 "
July 5...........	7 00.1	+22 44	4 21 "	12 04.4 "	7 47 "
10...........	7 20.5	+22 10	4 25 "	12 05.1 "	7 45 "
15...........	7 40.8	+21 26	4 29 "	12 05.7 "	7 42 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
June 17	56 Aquarii	6½	13 40	49	14 53	269	1 13
19	B. A. C. 17	6	12 31	80	13 24	281	0 53
July 6	88 Virginis	6½	10 02	190	10 22	204	0 20

Phases of the Moon.

	Central Time. d h m
Last Quarter.......................................June	20 1 35 A.M.
New Moon..June	28 2 54 A.M.
First Quarter.......................................July	5 11 59 P.M.
Full Moon..July	12 3 02 P.M.

Phenomena of Jupiter's Satellites.

Central Time. d	h	m		
June 18	2	33	A. M.	I Sh. In.
	2	43	"	I Tr. In.
	11	56	P. M.	I Ec. Dis.
19	2	18	A. M.	I Oc. Re.
	3	50	"	III Ec. Dis.
	9	01	P. M.	I Sh. In.
	9	09	"	I Tr. In.
	11	18	"	I Sh. Eg.
	11	25	"	I Tr. Eg.
20	8	44	"	I Oc. Re.
21	11	56	"	II Ec. Dis.
22	2	39	A. M.	II Oc. Re.
	8	30	P. M.	III Sh. Eg.
	8	39	"	III Tr. Eg.
23	9	39	"	II Sh. Eg.
	9	41	"	II Tr. Eg.
26	1	46	A. M.	I Oc. Dis.
	4	02	"	I Ec. Re.
	10	52	P. M.	I Tr. In.
	10	56	"	I Sh. In.
27	1	09	A. M.	I Tr. Eg.
	1	12	"	I Sh. Eg.
	8	12	P. M.	I Oc. Dis.
	10	31	"	I Ec. Re.
28	7	41	"	I Sh. Eg.
29	2	15	A. M.	II Oc. Dis.
	9	03	P. M.	III Tr. In.
	9	34	"	III Sh. In.
	11	56	"	III Tr. Eg.
30	12	29	A. M.	III Sh. Eg.
	9	17	P. M.	II Tr. In.
	9	36	"	II Sh. In.

Central Time. d	h	m		
June	11	56	P. M.	II Tr. Eg.
July 1	12	15	A. M.	II Sh. Eg.
4	12	36	"	I Tr. In.
	12	50	"	I Sh. In.
	2	53	"	I Tr. Eg.
	3	06	"	I Sh. Eg.
	9	56	P. M.	I Oc. Dis.
5	12	25	A. M.	I Ec. Re.
	7	02	P. M.	I Tr. In.
	7	19	"	I Sh. In.
	9	19	"	I Tr. Eg.
	9	35	"	I Sh. Eg.
7	12	20	A. M.	III Tr. In.
	1	33	"	III Sh. In.
	3	13	"	III Tr. Eg.
	8	52	P. M.	IV Tr. In.
	9	38	"	IV Tr. Eg.
	11	32	"	II Tr. In.
	11	36	"	IV Sh. In.
8	12	12	A. M.	II Sh. In.
	12	55	"	IV Sh. Eg.
	2	11	"	II Tr. Eg.
	2	52	"	II Sh. Eg.
9	8	59	P. M.	II Ec. Re.
11	11	40	"	I Oc. Dis.
12	2	20	A. M.	I Ec. Re.
	8	47	P. M.	I Tr. In.
	9	13	"	I Sh. In.
	11	03	"	I Tr. Eg.
	11	30	"	I Sh. Eg.
13	8	49	"	I Ec. Re.

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

	Central Time. d	h	m		Central Time. d	h	m		Central Time. h	d	m
June	16	12	07 A. M.	June	26	6	12 P. M.	July	7	2	22 A. M.
	16	7	58 P. M.		27	11	59 "		7	10	14 P. M.
	18	1	45 A. M.		28	7	50 "		8	6	05 "
	18	9	36 P. M.		30	1	37 A. M.		9	11	52 "
	20	3	23 A. M.		30	9	28 P. M.		10	7	43 "
	20	11	14 P. M.	July	2	3	15 A. M.		12	1	30 A. M.
	21	7	05 "		2	11	06 P. M.		12	9	21 P. M.
	23	12	52 A. M.		3	6	58 "		14	3	08 A. M.
	23	8	43 P. M.		5	12	44 A. M.		14	10	59 P. M.
	25	2	30 A. M.		5	8	36 P. M.		15	6	50 P. M.
	25	10	21 P. M.								

Ephemeris of Variables of the Algol-Type.

Approximate Greenwich M. T. 1889.

From the Astronomical Journal, No. 193.

	June. d	h		June. d	h		June. d	h
U Cor. Bor.	1	9	U Ophiuchi	11	12	U Ophiuchi	19	21
U Ophiuchi	1	11	U Cor. Bor.	11	18	U Ophiuchi	20	18
Y Cygni	1	18	Y Cygni	12	6	Y Cygni	21	6
Y Cygni	3	6	δ Libræ	12	18	U Ophiuchi	21	14
δ Libræ	3	10	Y Cygni	13	18	Y Cygni	22	18
U Cephei	4	12	U Cephei	14	11	Y Cygni	24	6
Y Cygni	4	18	U Ophiuchi	14	21	δ Libræ	24	9
U Ophiuchi	4	19	Y Cygni	15	6	U Cephei	24	10
U Cor. Bor.	4	20	U Ophiuchi	15	17	U Cor. Bor.	25	13
U Oqhiuchi	5	15	U Ophiuchi	16	13	Y Cygni	25	18
Y Cygni	6	6	Algol	16	17	U Ophiuchi	25	19
U Ophiuchi	6	11	Y Cygni	16	18	U Ophiuchi	26	14
Y Cygni	7	18	δ Libræ	17	9	δ Libræ	26	17
Y Cygni	9	6	Y Cygni	18	6	Y Cygni	27	6
U Cephei	9	11	U Cor. Bor.	18	15	U Ophiuchi	27	11
U Ophiuchi	9	20	U Cephei	19	11	Y Cygni	28	18
δ Libræ	10	10	Algol	19	14	U Cephei	29	10
U Ophiuchi	10	16	δ Libræ	19	17	Y Cygni	30	6
Y Cygni	10	18	Y Cygni	19	18	U Ophiuchi	30	19

Ephemeris of Comet B 1889 (*Barnard Mar. 31.*) From the elements of Dr. Krueger as given in A. N. 2893, I have computed the following ephemeris of Barnard's Comet:

	Gr. M. T.	R. A. h m s	Dec. ° ′	Log r.	Log Δ.
June	1.5	5 7 21	+14 4.2	0.3529	0.5111
	7.5	7 22	+13 47.5	0.3524	0.5109
	13.5	7 24	+13 30.9	0.3520	0.5107
	19.5	8 12	+13 10.9	0.3524	0.5067
	25.5	9 1	+12 50.9	0.3529	0.5028
July	1.5	9 19	+12 28.2	0.3539	0.4967

O. C. WENDELL.

Harvard College Observatory, May 13, 1889.

An Annular Eclipse of the Sun will occur June 28, beginning at 6*h* 06*m* A. M. and ending at 11*h* 54*m* A. M., Greenwich mean time. It will be visible in southern Africa and the South Atlantic and Indian Oceans, the northern limit of the eclipse reaching to Arabia, Hindostan and the East India Islands. The moon will be at apogee June 27 and the earth at aphelion July 1. The sun's diameter at the time of the eclipse will be 2′ 02″ greater than that of the moon.

A Partial Eclipse of the Moon, invisible in the United States, but visible generally in Europe, Asia, Africa, Australia and the Atlantic Ocean and the easterly portion of South America, will take place July 12, beginning at 6*h* 33*m* P. M. and ending at 11*h* 15*m* P. M., Greenwich mean time. Magnitude of eclipse 0.486 diameters of the moon.

The Extent of the Corona of The Sun, as seen in the eclipse of Jan. 1, 1889, is well stated in the following paragraph by Professor Holden:

"So far as I know, no photograph of the corona has traced these wings further from the center than fifty minutes of arc. Out to that distance they seem to be convergent and to indicate that they quickly come to an end. Mr. Barnard's photographs, however, show faint extensions as far out as seventy-five minutes of arc, and it is evident that the outer corona, instead of quickly terminating, must extend far into space. The pictures show this divergent outer extension in a form like that of a fan, or like the open mouth of a trumpet. This, of course, indicates that the outer corona is in the shape of a huge disk, surrounding the whole sun, with its outer rim much deeper than its inner one. In fact, if the sun were surrounded by a ring of meteorites, the appearance would be much the same as in the photographs."

Solar Activity in 1888. From a late number of *The Journal of the Liverpool Astronomical Society* some interesting facts are taken pertaining to solar activity. In that article it is claimed that the behavior of the various orders of solar phenomena, spots, faculæ, and prominences, during the year 1888, show conclusively that the minimum must be near at hand. The evidence of this from the sun-spots is that they are few in number, small in size and low in latitude, with considerable intervals in which no spots at all are seen. These statements are supported by comparative tables taken from the observations by Tacchini in the *Comptes rendus.* It is interesting to notice that, while the faculæ have not varied simultaneously with the spots, their diminution since 1886 and 1887 has been slight, while that of the hydrogen prominences has been more pronounced. The magnetic variation has shown a decline parallel to that of the sun-spots.

Burnham on the Trapezium of Orion. At the April meeting of the Royal Astronomical Society, a paper titled the "Trapezium of Orion," written by Astronomer Burnham of Lick Observatory, was read and discussed. The points made in the paper, as reported by the *Observatory* were, that perhaps no object in the heavens had received so much attention as this, and that no equal area had furnished room for so many purely imaginary stars; that most of these so-called discoveries had been made with small telescopes and by inexperienced observers, but that the largest and most perfect refractors, in the hands of skilled observers, had utterly failed to show a single one of these supposed new stars; that an observer with a 12-inch mirror believed he saw nine or ten stars in the Trapezium which Mr. Burnham, with the Chicago 18½-inch telescope, and Professor Hall, with the Washington 26-inch could not see. When the 36-inch equatorial of Lick Observatory was mounted Alvan G. Clark found a small star in the Trapezium (see February MESSENGER, 1888) which Mr. Burnham has since repeatedly seen and measured, though extremly faint and difficult, as it seemed to be near the limit of visibility by the 36-inch; that Mr. Barnard last October found another new star just preceding the Trapezium, this star being double, and afterwards measured by Mr. Burnham; that Mr. Barnard had also discovered a second star within the Trapezium which was much fainter than the others, and which Mr. Burnham had not succeeded in observing for want of favorable conditions.

In the discussion of the paper Capt. Noble disagreed with the views of Mr. Burnham on one point, claiming that the fifth and sixth stars of the Trapezium were certainly variable and gave strong proofs of his position. This view was also held by Professor Chambers and others of the Royal Society.

Brilliant Meteor. On the evening of May 15, while walking on Broadway, Oakland, a street brilliantly lighted by electric arcs, and in the light of the full moon just risen, at $8h\ 40m$ Pacific Meridian, I saw a very large and brilliant meteor or fire-ball which came, as nearly as I could estimate, from a point midway between the stars Gamma and Alpha Leonis. It pursued a southerly course along an arc drawn through those stars and seemed to disappear at a point about half way between Regulus and α Hydræ. Then instantly it reappeared just a very little farther on, became quickly as bright as ever, *wabbled* from east to west as it flew on and down, turned in a hooked path toward the west and almost instantly disappeared about six degrees directly north of α Hydræ.

Its motion was very rapid, the total interval of time from appearance to final extinction being, by my estimate, not more than one second. Its trail at no time was very long, and died out quickly, but was the broadest that I have ever seen, and was uneven or *humpy* at different parts of its length seen at the same instant. The *wabbling* motion or vibration before mentioned was very marked and there was an evident tendency to drift toward the west. The hooked path at the time of extinction was short and faint, the last direction being about at right angles to the long path, but was a well marked deflection from it.

The head and trail of the fire-ball had the same color; namely, a yellow as seen through a green mist or vapor.

The intensity of the light was about that of Saturn, but the apparent size of the fire-ball was that of Venus at time of greatest brilliancy. FRANK SOULE.

Students' Observatory,
Berkeley, Cal., May 16, 1889.

The Trisection of the Arc. We have received a pamphlet from Michael H. Brennen of Devil's Lake, Dakota, entitled "The Trisection of the Arc." Most of our readers probably know that the problem of trisecting an arc is very old, and that the ancient geometers were unable to solve it by the ordinary methods of geometry as then known. It was only by the aid of the higher plane curves that the solution was found, and in this, Diocles, the inventor of the "Cissoid," and Nicomedes, the author of the "Conchoid," were the leaders. The latter lived in the second century of the Christian era, and the former in the sixth. That which led to the discovery of these two different and interesting curves was the persistent endeavor of these scholars to find a method of trisecting an angle, and for constructing two geometrical means between two straight lines and ultimately to construct a cube double a given cube.

The Cissoid of Diocles referred to rectangular coördinates gives an equation of the third degree, while the Conchoid of Nicomedes is a locus of the fourth, and yet both solve the problem of duplicating the cube, or trisecting the angle, because they are essentially one problem. Later Sir Isaac Newton gave an elegant mechanical method of producing the Cissoid by continuous motion, which is found in Lardner's Algebraic Geometry. This curve has also been shown to be the locus of the vertex of a common parabola rolling in an equal parabola. With these leading points pertaining to the history of this problem let us turn to Mr. Brennen's work and see what has been added in the way of method or principle to that which is already known.

Starting with the eqation $x^3 - 3x + m = 0$ (1), in which x has one real value, suppose $x = y$; then $x - y = 0$. Depress the former equation by dividing by the latter and the result is $x^2 - xy + y^2 - 3 = 0$ (2). Equation (2) represents an ellipse with the semi-axis inclined 45° to rectangular axis of reference in the negative direction. The semi-axes of the ellipse are respectively the $\sqrt{6}$ and the $\sqrt{2}$, and the curve cuts the axes of reference at $\pm\sqrt{3}$ for both, and the foci are each 2 from the center.

The next step taken by the author is to show that this equation of an ellipse is the locus of the intersection of a plane with the convex surface of a right cylinder. The triangle formed by the oblique plane of the ellipse, the base of the cylinder and a perpendicular from the upper vertex of the ellipse is right angled, with sides respectively $\sqrt{3}$, 1, $\sqrt{2}$, and is called "the mystic triangle." This triangle is the key to the solution of the problem under consideration, by the author's method. Chiefly by the use of this, the connection between the chord of the given arc, as shown on a perpendicular transverse section of the cylinder and the point on the ellipse whose ordinate represents the value of the chord of one-third of the arc is determined.

In doing this some very interesting relations appear in the author's work. Referring to the cubic equation again, it apears that the three roots under consideration are all real, and that their sum is equal to zero, although Cordan's process of solving the equation shows that x is apparently imaginary. Now, if a curve is produced by the intersection of what is called a trisecting radius with the chord of a whole arc, or such chord produced, the locus closely resembles the Lemniscate of Bernoulli. But the Lemniscate is the locus of the intersection of a perpendicular from the origin on the tangent to the equilateral hyperbola, and it is well known that the square of the ordinate of a hyperbola is to the rectangle of the distances from its foot to the vertices, as the square of the semi-conjugate axis is to the square of the semi-transverse axis. Now, if $A = \frac{1}{3}\sqrt{3m}$ and a point T on the ellipse is conicidently in the axis of the cone and hyperbola, the distance from such point to the vertex is also A. Then this proportion will follow:

$$m^2 : \tfrac{1}{3}\sqrt{3}\,m \,.\, \sqrt{3}\,m :: B^2 : \tfrac{1}{3}m^2$$
$$\tfrac{1}{3}\sqrt{3}\,m = A,\ e = \sqrt{2},\ P = A.$$

We have not given this interesting paper the full attention it deserves. Its successive steps in development ought to have been illustrated by approximate figures. It seems to us that Mr. Brennen's work on this interesting old problem has in it points of originality that show a high order of analysis in dealing with conics.

Encourage Young Observers. Within the last few months we have received many letters from young observers, giving account of what they have seen with their own instruments. The observations have generally been on objects familiar to astronomers, and many of the things seen entirely commonplace and not important enough for public notice. But it has been our purpose constantly to answer all such letters with a word of encouragement, and a suggestion or two in the line of the student's thinking and work, so as to help him to persevere; because it is no easy task to start in observing on astronomical studies and depend on one's self largely for guidance. Where one will succeed ten will fail. The circumstances are not improved for such students if astronomers make light of their weak attempts, or answer occasional queries from them in such a way that there will be no desire to get help from that source any longer. A worthy young man has recently been so unkindly treated, in this particular, that the following sentence I know to be but a part of the sting keenly felt by him: "I am glad to receive some encouragement from such a reliable source; to tell the truth, I had almost resolved not to say anything more about my observations, but to keep them to myself in the future."

Not long ago, while attending a public meeting of scientists, one physicist of national reputation in the course of his paper, took occasion to berate the small Observatory whose telescope was used "to look at the moon with" in a very remarkable manner, claiming how much better it would be to turn all funds used for such purposes into one large institution of national character and for the aid of great achievements in pure science. His was a lofty period of irony, and no doubt its effect was to make the little scientists wish they had staid at home if any had been guilty of dabbling with small things at any time. Others might lose their patience and think (if they did not say) such rhetoric is nonsense and had better be omitted from the deliberations of scientific societies.

New Edition of Chambers' Descriptive Astronomy. From a private letter, dated April 15, by Professor G. H. Chambers, Northfield Grange Observatory, East Bourne, Sussex, England, we learn that a new edition of his Descriptive Astronomy is to appear very soon. His numerous American friends and correspondents may not all know that the first volume of this new fourth edition was expected to be published during the month of May. The high place that the third edition of his astronomy has held in the opinion of American scholars is ample guaranty that the new edition of this standard work will find ready and general sale in America.

The Pond Motor Astronomical Clock. We were so much interested in a recent account given us of the study of Observatory time-keeping by Mr. Chas. H. Rockwell, of Tarrytown, N. Y., that we append a full report of it for the benefit of our readers.

Five years ago, when he first received his almucantar, he commenced a series of experiments on clocks. The almucantar itself was then an experiment, but he found its use for time determination more satisfactory than the transit instrument. It is not worth while, here, to give a list of the batteries, motors, escapements and pendulums which he tried and discarded before coming to his present combination. All his experiments, however, have been with electric clocks in one form or another. He considers it a very great advantage to be able to avoid going frequently into the clock-room, and to free the movement from even the small disturbance of winding with a key. Certainly it is no disadvantage to the clock *to be let alone.*

In the present instance he locked up the clock-room on the 8th of November last, and the door was not re-opened until April 22d, when he found everything in good condition. The power is supplied by three Laclanche cells, conveyed to the motor by about fifty feet of No. 14 copper wire. The Pond motor winds the train *each hour*, using the spring more gently and more uniformly than if it were required to run for twenty-four times as long a period.

The escapement was invented by Mr. Jas. H. Gerry, who was for a number of years the foreman of the Howard Clock Co., Boston.

It is an improved form of the well-known gravity escapement, presenting, however, some peculiarities which commend it to him over any other form with which he is acquainted.

One of these is the opportunity to change the arc of vibration of the pendulum. The pendulum is now swinging 2° 20′ from the center.

Some day he hopes to be able to undertake a series of experiments in this line, to learn whether better results can be obtained with a large arc or a small arc.

The pendulum he is using was made from his own drawings, by Messrs. Warner & Swasey, of Cleveland. The jar is three inches in diameter by nine inches deep inside, and was bored out of a solid bar of steel.

He is using thirty-one and a half pounds of mercury. Taking an ordinary Frodsham pendulum as a standard, he has dispensed with the *thumb-hold*, also with the *jam-nut*, also with the *sleeve*, on which the regulating screw is cut; discarding especially the clumsy pointer which we sometimes see. The regulating screw is cut on the rod itself, which is three-eighths inches in diameter. This screw is received in the *nose* of the top of the jar, and the whole jar is turned up or down, as may be required. In looking at the memorandum of the running of the clock one will notice changes in the *sign* of the daily rate.

A week of warm weather, Aug. 30 to Sept. 5, gave a continuance of the small *gaining* rate. A few days of cool weather, Sept. 5 to Sept. 13, gave a small *losing* rate. This indicated too much mercury in the jar, so he took out thirty-seven grains.

He is now working at the problem to find the proper amount of mercury for temperature correction, to compensate the expansion and contraction of the pendulum-rod.

Camden Astronomical Society. From a recent private letter we are informed that, in Camden, N. J., an Astronomical Society has been formed, of which there are now eleven members. The society owns a complete Observatory with a 5½-inch equatorial, transit instrument, chronograph, sidereal clock, and the various accessories in the way of micrometers, solar eye-pieces, etc. They have also ordered a spectroscope which, when completed, will about finish their outfit. The society was incoporated in April of last year. The officers are E. E. Read, Jr., president; A. B. Depuy, secretary.

January Total Eclipse. In our report of C. W. Irish's observation of the total solar eclipse of Jan. 1, 1889, it was an oversight not to have given the size of the telescope used. It was a 4-inch objective, 42½ inches focal length. Powers 75 to 250. In observing first and fourth contacts, power 75 was used.

Lunar Study near Plato. Just under Plato is a square enclosure, sometimes called the "battlements." It is bounded on two sides by high ridges, on the other two by those which are very much lower, one of which is barely visible. Just in the shadow of the highest is the form of a cross, which is a very curious object. It is not more than about four miles each way but it is almost perfectly symmetrical. To me it looks as though it were very high in the centre and sloped towards the ends of the arms. It can be seen when the terminator is just beyond Copernicus, and well repays search. I looked a long time in vain to see it, but never at just the right time. When it is near the terminator I judge it is hidden in the shadow of the wall, and after the sun gets above it, it disappears completely from want of contrast with the small shadow it throws. Webb mentions it, but says he never succeeded in seeing it.

A. B. D.

Satellites of Uranus. While at the Observatory of a friend on the evening of June 6, 1888, I turned the 6¼-inch refractor, an admirable glass by Cook, upon Uranus, and saw near the planet, at first *one*, later in the evening, *two*, faint stars, "glimpse stars," so to speak. They were very unsteady, yet I presumed them to be the satellites, Oberon and Titania. The time of the observation was 8*h* 20*m* mean time, Elizabeth, N. J. Micrometric measurements gave their respective distances about 93″ and 149″, which were recorded. Several evenings later their distances had become greater, and soon one was invisible, but every measurement showed a widening distance. I therefore concluded that the objects could not belong to Uranus, but were stars over which the planet was moving. HENRY HARRISON.

South Bergen, May 16, 1889.

Wolsingham Observatory. The spectra of R Leonis and R Hydræ contain bright (hydrogen?) lines, first seen on Feb. 25th. Observation confirmed, through the kindness of Mr. Common, by Mr. Taylor, at Ealing, who sees two in R Leonis and one in R Hydræ. T. E. ESPIN.

April 2, 1889. Circular No. 23.

EDITORIAL NOTES.

Our readers will please remember that July and August, or September, are usually vacation months, and that the MESSENGER will not be published for two of these months. In making up annual files for binding, the consecutive numbers will always be found on the first page of the cover, and the first page of the reading matter of each issue.

It is also asked that our friends in the list of foreign subscribers will please remember to draw all post-office orders for remittances on either the offices at Faribault, Minn., or St. Paul, Minn., and not on the office at Northfield, New York, or any other, for the first is not a foreign money-order office, and collections from others are inconvenient.

We have greatly desired for a long time to add some new features to the MESSENGER which seem to us desirable, to increase its usefulness and general interest in it. We refer now particularly to the feature of biographical sketches and suitable engravings of the great astronomers of the world and possibly other noted men in kindred scholarly pursuits, especially those who have contributed largely to the past or present growth of astronomical science, although their chosen life work may have been in some other profession. We feel special interest in this feature, not only for the variety of contents that it may give to each volume of the MESSENGER, but also because that if such work be well and systematically done it will be a contribution to the history of our science that is now lamentably neglected. In order to present as many as ten fine engravings each year and to secure the best biographical sketches possible, considerable expense will be involved, yet it is believed that our subscribers will not object to a slight increase of subscription price if so valuable a feature as this and some others should be added in way of compensation.

During the last two months the attention given to eclipse reports and other current topics has so filled our space as practically to crowd out the long list of queries on astronomical themes that have come to our table from various sources, including the professional astronomer, as well as the amateur. This phase of current thought will be resumed again in our next publication.

The Parallax of 61 Cygni. Under date of May 1, 1889, in *Astronomische Nachrichten*, No. 2895, we notice that W. T. Lynn has rightly called attention to the omission of Professor Asaph Hall's determinations of the parallax of 61 Cygni in the list of such determinations given by Mr. Belopolsky. Professor Hall's measures were made in two series, one in 1885–6 and the other in 1880–1, and published in the Washington Observations for 1883 in the year 1887.

Mr. Lynn also says that Mr. Belopolsky has inserted a value by Dr. Gill of 0″.50, but that value is not the result of a determination, as readers might suppose, but is apparently taken from an article by Dr. Gill on parallax in the Encyclopedia Britannica, in which he mentions that as probably the best result from all the determinations. But Professor Hall's investigation, which gave a result of 0″.27 ± 0″.01, makes it probable that the true value is smaller. Some time ago we called attention to the important work of Professor Hall in the study of the parallax of this star.

Chandler on Variable Star Phenomena. In speaking of the work on variable stars at Harvard College Observatory (in another place in this issue) during the last four years, we had not then seen the article by Mr. Chandler in the *Astronomical Journal*, No. 193, entitled, "On the general relations of variable star phenomena." From that interesting article we gather the following points of general interest: That a comparison of the phenomena of the variable stars naturally begins with a knowledge of that set of relations that spring from periodicity, such as the coördination of the lengths of the periods with the number of variables, with their color, with their range of fluctuation, with the forms of their light-curves and the irregularities of their period and of the light-variations. The number of known variable stars is yet small for thorough or exhaustive comparison in all these particulars, and hence some conclusions will be uncertain, but there are others that are established beyond doubt.

1. It was known long ago that variable stars differ

widely in the length of their periods of light-variation. This is not a chance relation, but doubtless exists in the nature of the bodies themselves. This inference is drawn from a table showing three classifications, "the first by Schönfeld in 1863, with 71 periods known; the second in 1875, with 101 known periods" by the same astronomer, and the last with 160 periods by Mr. Chandler in 1888. From this table the excess of short periods is apparent, even after we exclude the nine stars of the Algol-type. The maximum of the long period variables lies at about 320 days.

2. The fact that a large proportion of variables are more or less red also attracted early notice, and led to the belief that some connection existed between color and variability. Mr. Chandler thinks that present knowledge of this relation may be stated as follows: "That those stars whose chemical constitution manifests itself to us by redness of their light are especially inclined to change in brightness." We may go one step further and say, "that the redness of the variable stars is, in general, a function of the lengths of their period of light-variation. The redder the tint the longer the period." If this shall prove true as discoveries go on, a long step will have been taken in finding the causes of stellar variation.

3. The range of variation and the length of the period. This relation is less certain than either of the preceding ones, and the only feature of interest that appears from study so far is that there is a dissimilarity between the variables of short period and those of long period in this particular.

The last point is the length of period compared with irregularities of their periods and of their light-variations. The discussion of this is only begun in this paper. Its full consideration is reserved for awhile, and until certain work now in hand can be completed.

Table of Standard Wave Lengths. The Johns Hopkins University Circular for May, No. 73, is devoted to notes from the physical laboratory. It contains a table of standard wave lengths by Professor Rowland and an interesting article on "The Concave Grating in Theory and Practice," by Joseph S. Ames, with one full page plate. The mathematical part of the article shows the general theory of the grating, and also the theory of errors in adjustment. In the descriptive part will be found a full reference to the accompanying plate, information concerning proper adjustments, how to use the grating and something of the methods of work with this delicate piece of apparatus. Particular mention is made of the contents of this circular, because not a few of our readers will find in it answers to some of the queries, at least, that have suggested themselves whenever the subject of gratings is under consideration. Few will be able to read the mathematics, most will be profited by the descriptive part, and some may be helped who are trying to use the gratings.

The Williams College Catalogue of North Polar Stars, Right Ascension for 1885.0. This catalogue is the work of Henry Truman Safford, Ph. D., Professor of astronomy at Williams College, Mass. It was made partly for the practical use it might serve, to other astronomers as well as himself, and partly as a beginning of a more extensive list whose observation is in progress. Professor Safford has also desired to strengthen the weak points of all our standard catalogues, viz., the right ascensions of polar stars. To observe these stars well is one of the most difficult tasks in the range of meridian circle work, and which has been neglected chiefly because few modern observers in the possession of precision instruments care to undertake it.

The instrument used is this work is a fine Repsold meridian circle like those at Madison, West Point and Northfield. The aperture of the object-glass is 4½ inches French, the ratio of aperture to focal distance 1:12, and the diameter of the circle 20 inches French, with four micrometers on either side reading to seconds directly.

The mode of making this catalogue has been mainly differential, but in the case of polars, observations were made above and below the pole, because this process eliminates a certain portion of the personality of the standard observers whose catalogues were Professor Safford's guide, and substitutes his own in their stead. If Professor Safford had used zero stars above the pole, for observations above the pole, and observed below the pole in a similar manner, his right ascensions would have been purely differential and the standard that of Pulcova. This he claims he did not do partly because the close circumpolars were too few, and partly because the proper motions since 1865 are themselves effected with unknown personalities.

The standard catalogue at first adopted was that of Publication 14 of the *Astronomische Gesellschaft*. The errors that were found in this catalogue were due to a lack of knowledge of true proper motion. A list of eleven stars was chosen from this catalogue, all within ten degrees of the pole, for instrumental correction. In the plan of observation, Professor Safford says he avoided the use of Pond's method, which is employed at Greenwich for time stars only, and not for declinations, although Pond at first himself so used it. He thinks that method is now antiquated and that we need, at the present time, to discriminate between known or standard stars and those which are unknown and to be determined. He then points out the errors of the Pond method and says, "I am pretty well convinced that the strict use of a standard catalogue for clock corrections and instrumental zeros, and a careful study of these latter results, will produce more accurate secondary places than any other."

The stars used for clock correction were commonly those of the Berlin Jahrbuch. If the stars were taken from the American ephemeris they were reduced to the Jahrbuch standard by a correction of – 0.016s suggested by Professor Auwers. The collimation was at first obtained by the level and the mercurial horizon, afterwards by the collimators. No star was considered as determined on any evening which had been required on the same evening for instrumental corrections.

The observations began in the summer of 1882 and the instrument has not been reversed at all, but Professor Safford proposes to do so soon. He thinks the reversal of the instrument will not much affect the results already obtained because the range of declination is small. The object-glass and eye-piece have been once interchanged, and the more important stars have been observed in both positions. This will diminish pivot errors upon the mean.

Then follows the detailed study of the catalogue which will prove of special interest to those engaged in meridian circle work.

The catalogue proper embraces six tables, the first a list of right ascensions for 1883.0; the second a list of right ascensions for 1884.0; third, mean right ascensions reduced to 1885.0; four and five, observations respectively of 1886 and 1887; and six is the catalogue of 261 stars arranged in the order of right ascension. The first column gives the current number; second, the star's name; third, mean epoch; fourth and fifth, number of observations; sixth, mean right ascension for 1884.0; seventh, precession; eighth, secular variation; ninth, declination for 1885.0; tenth, annual variation in declination.

This catalogue appears to be a piece of very careful and thorough work, as well might be expected from the reputation of its distinguished author.

Death of Dr. Warren De la Rue. We regret to find in the May number of the *Observatory* the following sad notice:

The scientific world has sustained a great loss in the death of Dr. Warren De la Rue, F. R. S., whose energy was only equalled by his generosity. His friends had noticed with regret for some time past that his health was rapidly failing; but he made great efforts to attend the meetings of the Royal Astronomical Society, and at the last Annual General Meeting spoke a few pertinent words on his own subject, photography. He died on Good Friday last, at the age of 74.

South Bergen Observatory. The private Observatory of Henry Harrison is at South Bergen, N. J. Many of our readers will remember the artistic work of Mr. Harrison, named the telescopic picture of the moon, of which we have spoken many times favorably. In a recent private letter he says: "After selling my 4¼-inch telescope of short focus, I mounted one 5¼ inches in aperture of 74 inches focus, with circles respectively 8 and 12 inches in diameter. I have sidereal and mean time clocks, micrometer and spectroscope. My astronomical work is limited, being confined to drawing mainly. I am now at work on a picture of the nebula of Orion." Mr. Harrison speaks of his unfinished work of the series of telescopic moon pictures, the first of which only was published. Some scientific friends have been in conference to ascertain what it would cost to complete the series. It is to be hoped that the lithographic plates will not be found so expensive as to long delay the completion of this unique, accurate and very useful representation of the moon's surface.

The Jena Glass for Telescopes. From time to time queries have been made concerning the Jena glass, its advantages over common glass and the prospects of its use for telescopes in the future. Until recently little could be said in answer to these queries because the glass was new, having been tested only in a small way by physicists or opticians, so far as we have known. In a paper published by Professor C. S. Hastings, in the June number of the *American Journal of Science and Arts*, entitled "Secondary Chromatic Aberration for a Double Telescope Objective," a description of a telescope sensibly free from this defect is given and the glass used is of the new kind. As to its advantages and the probability that it may be used for telescope objectives something of interest is learned from the paper above referred to, as follows:

"The largest objective which could be made of the pieces in my possession was of 2¾ inches clear aperture. This, though smaller than desired, was sufficient to give a fairly satisfactory answer to the questions. Accordingly the glasses were worked accurately to the curvatures and thicknesses corresponding to the computations and mounted for use. The astonishing beauty of the images in the new telescope was its most surprising feature at first. The familiar purple was wholly wanting, or at least, could only be recognized with the closest attention, with magnifying powers greater than forty to the inch aperture, and on objects most suitable to its exhibiton. But the moment that the instrument was applied to astronomical use it was also evident that its defining power was remarkable. The companions to Polaris and Rigel, instead of being objects which require somewhat careful looking, as is the case with my eye and an ordinary achromatic of the same aperture, were strikingly plain. More difficult, but certainly seen, was the fifth star in θ Orionis. The binary star, η Orionis, was so well elongated that its position angle was estimated to within 5° of its true value; on the other hand, ξ Ursa Major, which I suppose to have at present a separation of 1″.7, was divided only with difficulty on a fairly good evening though it was supposed that it would be easy. Saturn showed all that I have seen with an admirable telescope of considerably greater aperture, including more than half of Ball's division, the ring C, a single belt and five satellites, though Tethys and Dione have not been seen unless they had an elongation equal or greater than that of the end of the ring. Rhea has been seen in conjunction. By reference to the records of many observations which have been made with various telescopes the power of the new telescope was estimated as equivalent to a 3½ inch objective of the ordinary construction. The powers used varied from 53 to 265 diameters, with 194 as the most satisfactory for Saturn and for double-stars.

The Trees along the Canals of Mars. A reader of the MESSENGER asks if we will explain for the benefit of novices the following paragraph clipped from the *Chicago Tribune* of date May 22: "Wiggins says his discovery of the recession of the earth from the sun is the greatest discovery of the age. The recession, he says, is proved by what is known as the precession of the equinoxes, which causes the tropical year to be shorter than the sidereal, the latter being the real measure of the earth's increasing orbit. The time, he declares, will come when it will be necessary to carve up the continent by canals such as we see on Mars, and the same is no doubt true of the planets Saturn and Jupiter. Trees will be planted along the canals to produce moisture as they appear to be along the canals of Mars."

Friend Colbert, what is the matter with the *Tribune* editorial staff? They ought every one to be indicted for astronomical heresy. If you do not see to it the reporters of the *Tribune* will next be asking astronomers what kinds of trees Wiggins has planted by the canals of Mars. The worst of it is we imagine how Professor McLeod of Montreal, next town to Wiggins' place, will smile when he sees that Chicago has the news first hand.

Colby's New Physical Laboratory. In a letter bearing the date May 19, from Professor W. A. Rogers, we were delighted to learn that Col. R. C. Shannon, a graduate of Colby University, has contributed the sum of $15,000 for the erection of an Observatory and physical laboratory for the department of physics, which is Professor Rogers' department of work in the University. Professor Rogers says the laboratory will be fully equipped for metrological work, and that soon he will order $3,000 worth of apparatus for this special line of work.

Photographic Chart of the Sky. The third number of the Bulletin of the Permanent International Committee on the photographic chart of the sky has just been received. It contains an introductory note by the president of the committee, Admiral Mouchez, referring to the coming reunion of the committee at Paris, Sept. 15, 1889; a Description of an Instrument and Explanation of a Method of measuring the positions and magnitudes of stars photographed and of engraving them upon metallic plates, by Mr. Isaac Roberts; Measures of Plates according to the method of rectangular coördinates, by H. G. van de Sande Bakhuyzen; communications relative to the dimensions of the reticules to be used for the measurement of plates, by Drs. H. C. Vogel and D. Gill, and the correspondence between several members of the committee. The paper by Mr. Roberts appeared in the November number of the *Monthly Notices* of the R. A. S. and is illustrated by actual specimens of measurement and engraving, which appear to be very satisfactory.

Professor van de Sande Bakhuyzen also gives the results of actual measurement of a photographic plate taken by the Henrys, Aug. 5, 1887, and a comparison of these results with the Leyden meridian circle observations of the same region of sky. The portion of the plate exposed was about 6 in. or 2° in diameter and contained 341 measurable stars. The comparison with the meridian observations shows that the relative positions obtained by photography are at least equal in accuracy to those obtained with the best meridian circles.

In the correspondence Mr. Gill suggests the following as the most important points to be decided upon by the Congress in 1889:

1. Assignment of region of sky to be photographed at different observatories.

2. What time shall be allowed each observatory in which to complete the work? In case any observatory fails to perform the amount of work assigned to it shall the Bureau confide this work to another more active observatory?

3. Annual reports will be required of each observatory. These reports will be addressed to the president and published in the Bulletin.

4. What kind of plates shall be adopted? Shall the

plates be furnished by the same laboratory and verified by the same person, appointed by the Bureau?

5. What are the best methods by which to photograph, as far as possible, all the stars to the 14th and 11th magnitudes on the two series of plates? How shall we decide that the plates contain quite all the stars in question?

Professor C. Piazzi Smyth of Clova, Ripon, England, has again favored us with one of those genial letters which occasionally it is our good fortune to receive. In the midst of unfavoring circumstances, so far as externals are concerned, we can still read between the lines the fervor of a hope in usefulness that nothing mortal can quench or disarm. What matters it though the years be three-score and ten, the light of a soul true and good burns on, and the glorious stars keep their courses, and will, till the better hope be ushered in.

Dr. Copeland has removed to Edinburgh. His address will be Royal Observatory, or 15 Royal Terrace, Edinburgh, Scotland. We are informed that the Dun-Echt circulars will be continued from Lord Crawford's Observatory as heretofore.

Latitude of Detroit Observatory. We have received a paper by Ludoic Estes, Ph. D., formerly of the University of Michigan, now at the University of North Dakota, Grand Forks, which contains a full discussion of the latitude of the Detroit Observatory, Ann Arbor, Michigan. The instrument used was a 3-inch transit instrument, made by Messrs. Fauth & Co. of Washington, D. C., of which a particular description is given. After finding the value of a revolution of the micrometer screw, the value of one division of the zenith level, and a table of needed star places, the observations and reductions of 138 pairs of stars are given in tabular form for the determination of the latitude sought. The discussion of the results appears in full and shows a good degree of precision in detail. The final result obtained for the latitude of the Observatory at Ann Arbor is 42° 16′ 47″.87. That which has been in use by the American Ephemeris is 42° 16′48″.00, a difference of 0.13″ of a second of arc. Mr. Estes' work is published in neat form.

Errata. In the April issue, page 168, 12th line from top, the word "light" should be "chromosphere." On page 169, 7th line from top, the word "southward" should be "outward." On the same page, 9th line from bottom, the word "photosphere" should be "chromosphere." Page 184, last line, for "photosphere," read "chromosphere."

In the May issue, page 228, 10th line from bottom, "Batche" should read "Bache." Page 231, first line, "occultation" should read "osculation." On the same page, 9th line from bottom, "Brighton" should be "Bridgeton."

BOOK NOTICES.

Elements of Geometry. A New System of Presentation; by C. F. R. Bellows, M. A., C. E., Professor of Mathematics, Michigan State Normal School, and Author of Several Text-Books on Mathematics. Philadelphia: Messrs. John E. Potter and Company, Publishers, 29 to 35 North Tenth Street; pp. 374.

The author of this new book calls the attention of the teacher, in the outset, to geometry as an educational instrument, adapted

1. To train the hand and the eye;
2. To train the attention and concentrate the mind;
3. Te develop the imagination and conceptive power;
4. To cultivate the language, and
5. To develop and train the logical powers.

These are evidently the ideas of a teacher of large experience and mature judgment in the available uses of geometry as a means of cultivating and strengthening the mental powers, and of one who believes that "it is what a student does for himself, not what is done for him, that *educates* him." With these principles in mind, particular attention will be given to the choice and arrangement of the subject matter of the text-book to be used. In this geometry the classification of its themes finds logical sequence in the order of the properties, relations and measurement of geometrical figures. The old method of dividing the work into books, instead of into chapters and sections, is followed, contrary to the practice of the best late writers. While not a serious defect, this plan seems to us to disturb the unity and the continuity of the theme, which is so well modernized in other essential particulars.

The books are ten in number, treating respectively of the following topics: 1, lines, angles, polygons; 2, proportion, similarity; 3, the circle; 4, rectangles on lines; 5, supplementary subjects; 6, points, lines and planes; 7, polyedral angles; 8, polyedrons; 9, the three round bodies; 10, spherical angles and polygons.

In the details of the plan careful attention is given to definitions and illustration, so that the student is early made acquainted with, and is exercised in, the easy and exact language of geometry, which is the first essential in strong argument. The book differs from others in the mode of its proofs of theorems. Instead of giving a demonstration complete as is ordinarily done, the proposition is stated, mode of constructing the figure and of making the special enunciation are shown, and then something of an outline of the proof given, leaving the student something to do to complete the demonstration and draw the proper conclusion. This exercises the reasoning powers constantly and necessarily without making the work of proofs an effort of mem ory on the part of the student, which is too often the case when the full demonstrations are given. Then, to be sure that the student understands what he is doing, questions, unsolved examples and bare theorems are freely used throughout the work in keeping with its general plan as before suggested. By the aid of such a book on geometry as this a student ought to be able to get an excellent knowledge of the subject in the time usually allotted to its study. The publishers have put this book in a very neat dress, indeed quite as novel as the work of its author inside.

Algebraic Analysis, Solutions and Exercises Illustrating the Fundamental Theorems, and the Most Important Processes of Pure Algebra; by G. A. Wentworth, A. M., Professor of Mathematics in Phillips Exeter Academy, J. A. McLellan, LL. D., Inspector of Normal Schools, and Conductor of Teachers' Institutes, Ontario, Canada, and J. C. Glashan, Inspector of Public Schools, Ottawa, Canada. Part 1. Boston, U. S. A.: Messrs. Ginn & Company, Publishers, 1889; pp. 418.

This is a book intended for teachers or students in algebra who wish to supplement the ordinary text-books for fuller knowledge of, or as specialists in, this interesting branch of mathematics. In the first part the following themes appear: Substitution, principle of symmetry, factoring, measures and multiples, linear equations of one unknown quantity, simultaneous linear equations, quadratic equations, indices and surds, cubic and quartic equations and determinants. The method of treating a topic is to give a large number of solutions typical in character, then a great number of exercises to bring out methods and principles that are new as well as those known to elementary algebra; in this way the work serves as a guide-book, or a work of reference. As an illustration, let us take the theme of factoring and briefly indicate how the authors have treated it. The first point is the direct application of the fundamental formulæ:

$$(x \pm y)^2 = x^2 \pm 2xy + y^2.$$

Following this is the statement, in ordinary language, of the meaning of the above formulæ. Four typical examples solved, show their application to algebraic expressions of quite varied form of which the third is a fair example:

$$(a-b)^2 + (b-c)^2 + 2\,(a-b)\,(b-c) =$$
$$(a-b+b-c)\,(a-b+b-c) = (a'-c)\,(a-c)$$

Remarks pointing out the facts pertaining to the signs of the monomial terms of the expressions are next given, followed by nearly a page of exercises involving numerical and literal exponents. The formula for the difference of the squares of two quantities is next treated in a way entirely similar to those just given. The method of resolving a trinomial with one perfect square term into two binomial factors is fully treated and covers eight consecutive pages. Then follow twelve pages devoted to an extended application of these general formulæ, consisting of groups of exercises, amounting in all to nearly one hundred separate examples to factor, in the application of principles and suggestions accompanying the exercises. Factoring by parts and the application of the theory of divisors are the last points under this general head of factoring, and their development covers thirty pages of well selected matter, giving the themes a fullness and generality of treatment that is unusually exhaustive.

We were also interested in reading the topics entitled cubic and quartic equations and that of determinants. It would seem to us, after years of experience in teaching, that those who intend to teach or study algebra in an exact and comprehensive way would do well to give this important work a careful examination. It is especially commended to all who are fond of algebraic analysis.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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NOTE ON RECENT PAPERS OF DR. HUGGINS.

PROFESSOR C. A. YOUNG.

For THE MESSENGER.

Dr. Huggins has recently published two important notes which bear heavily upon certain details of Mr. Lockyer's "Meteoric Hypothesis." One of the notes relates to the position of the principal line in the spectrum of the Aurora Borealis; and the other to the photographic spectrum of nebulæ.

Mr. Lockyer has taken the wave-length of the aurora line as 558 (millionths of a millimetre), which he identifies with the *bright edge* of one of the "flutings" in the low temperature spectrum of *manganese*. Apart from all questions of wave-length, the identification of a sharp, definite line like that of the aurora spectrum with the edge of a fluting struck many spectroscopists from the first as highly improbable. To this may be added that an agreement of *three* figures in the observed wave-lengths of two lines would be entirely insufficient to establish more than a faint presumption of their identity; at least *four* figures, and often *five*, would be necessary. But Mr. Huggins shows that the wave-length of the auroral line cannot vary more than one or two *ten* millionths of a millimetre from 5571, instead of being 5580. The writer can add that a number of unpublished observations of his own quite confirm this (they were never published because they simply confirmed the results already obtained by others).

A word here as to the presence of this auroral line in the spectrum of the zodiacal light, which Mr. Lockyer assumes on the strength of a statement by Angström that he had observed it. But Angström himself does not consider that it belonged in the spectrum of the zodiacal light, for at that time the auroral line could be seen "anywhere in the sky." It was when auroræ were prevalent almost continuously. There is no satisfactory evidence that the zodiacal light spectrum contains a single bright line or band.

As regards the nebulæ Mr. Huggins gives a list of no less than 16 lines as belonging undoubtedly to the spectrum of the nebula of Orion (6 of which are observable visually), and 20 more which lie in three groups, and seem to belong *both* to the spectrum of the trapezium stars and of the portion of the nebula immediately adjacent. Dr. Huggins has made a careful investigation by direct visual comparison between the spectrum of magnesium and that of the nebula, with reference to Mr. Lockyer's identification of certain of the most conspicuous lines of the nebula spectrum with the edges of certain flutings in the low temperature spectrum of that element. He finds that the brightest nebula line has a wave-length of 5004.8 (probable error about ± 0.3), and that it is about *two* Angström units *more* refrangible than the first line in the mg. band at "500," to use Mr. Lockyer's "three-figure" notation; its true position is 5006.4 according to Lieving and Dewar. Under proper arrangements Dr. Huggins was able to observe the two lines (of the nebula and of mg.) simultaneously forming a rather close *double* line, the lower component of which vanished when even the mg. flame was screened off.

As to the other lines in the nebula spectrum upon which Mr. Locker relies as confirming the presence of mg. in these bodies Dr. Huggins shows that while indeed the line at 3724 nearly agrees with one of three lines in a mg. triplet, the other two lines of the triplet do not appear in the nebula spectrum, though in the mg. spectrum they are fully as bright as the one at 3724. He considers it perfectly certain that mg. holds no such place in the nebula spectrum as Mr. Lockyer imagines.

As to further conclusions that may hereafter perhaps be deduced from the photographs, Dr. Huggins is disposed to be non-committal. A most interesting relation, however, seems to be indicated between the stars of the trapezium and the surrounding nebula; the short, bright lines which cross the star spectrum and extend out into the nebula spectrum almost *prove* what has long been believed, that the stars are only condensed masses of the nebula.

As regards the meteoric hypothesis in general, there is no question that as a "working hypothesis" it has considerable value; but we should be on our guard against the confidence with which Mr. Lockyer expresses himself in respect to identifications of spectrum lines based on "three-figure wave-lengths," and the off-hand way in which he often says "we *know*," in cases where we really are entitled to nothing more than an opinion more or less probable: as, for instance, where in a recent paper he says (Proc. Royal Soc., Vol. xlv., p. 389) of the spectrum of the sun, that it "must lie on the descending side of the curve, as we *know* it to be cooling." I am not aware of any evidence that is decisive on this point, though, as things stand at present, it seems *probable* that it has passed its maximum temperature.

PRINCETON, May 25, 1889.

ON THE OBSERVATION OF SUDDEN PHENOMENA.*

S. P. LANGLEY.

By a sudden phenomenon is here meant one of that large class where the occurrence is awaited without the observer's previous knowledge of its exact instant, and of which familiar examples may be found in the bursting of a rocket, the appearance of a meteor, or the emergence of a star from behind the moon. A great part of all the phenomena of daily life, as well as of scientific observation, are of this kind, though the importance of a special instance of another class (I refer to the gradual and foreseen approach of a star to a wire) has drawn to this latter such particular attention that we are apt to think only of it when "personal error" is in question.

When, in an Observatory, we study the means taken to record the precise time of the transit of a star, we find that the precision of modern apparatus has reduced the error which we may expect in almost any part of the mechanism to an extremely minute amount, which may be calculated to the fractional part of the one hundredth of a second. I say "almost," for, as we are all aware, there is one notable ex-

* Read before the Philosophical Society, Washington, D. C., March 2, 1889.

ception, at least until photography can be made to intervene. The human brain and nerves, and behind these the inscrutable processes of the will, themselves form an inevitable link in the chain of apparatus of observation, and here an error may and does arise enormously greater than that of all the rest put together.

We all know that this error varies with the individual and the occasion. It is most constant in the experienced observer, but even in his case it varies with the daily accidents of the human organism, and even with him it is presumably constant only for the particular observation to which the experience applies. There is not even a presumption, I think, that the personal equation belonging to an experienced transit observer would apply to the same person's notation of the occultation or emergence of a star, and still less, if possible, to any phenomenon outside his ordinary professional experience; for we must, of course, recognize that we carry this fallibility with us in every act of life, and that it is just as present when we attempt to determine the instant at which a race-horse passes the winning post as when we seek to note the particular hundredth of a second at which a star passes the wire.

The very words "personal equation" imply that the errors due to this fallibility can be ascertained and allowed for, and may lead us to think (if we think carelessly) that there is a personal equation always ascertainable; whereas, as we in fact know, it is only possible to apply the correction where long habit has settled the amount of error to be expected with regard to some one special phenomenon.

The number of devices for obtaining and correcting the personal equation, even in the special case of meridian observation, is, as those who have studied the subject know, surprisingly great. I think I have myself examined more than fifty such, and with hardly an exception they all exhibit variations on one idea—the idea, that is, that the error must have been committed *first;* the committing of the error being assumed to be an inevitable necessity, for which subsequent correction has to be made.

I have thought, then, that it might be interesting if I were to ask you to consider with me what may seem at first the somewhat paradoxical suggestion, that means may be found by which any individual, skilled or ignorant, may make, not only meridian observations, but an observation of any sudden visible event of whatever nature so accurately that we need apply no correction, because the precision may be, if not absolute, at least such that no correction will in ordinary practice be needed. I may deceive myself in thinking that what I have to suggest involves a novel idea, but I am led to suppose so from the fact that I have met no application of it in a somewhat extended reading on this point.

Let me first remark that while such error as that in question doubtless belongs to all the senses in some degree, we are at this moment considering it in connection with the sense of sight only.

When we see anything in motion (let us suppose for instance a passing train on the railroad) we have the well-known facts that—

First. An instantaneous photograph is made by the optic lens upon the retina, there being a picture formed there which is perfectly distinct, but which fades out upon the retinal plate in from one-tenth to one-quarter of a second, while the perception of this image is under ordinary circumstances* sensibly instantaneous; (but)—

Second. Nerves convey the distinct impression of every part of this picture to the brain, and it is here, if we have to act on this impression, that a certain time is lost, not only in the carrying of the message along one set of nerves and the bringing back the answer on the other, but in the decision that is being made by that unknown and inner self, which appears to us to exert here a more or less conscious act of will.

In the case of a sudden and startling event, the time elapsed may be almost indefinitely great; and in some cases, probably several entire seconds may pass without the consciousness of the observer. A very imperfectly appreciated interval must occur in all cases, for what we have just said applies to every event of our daily lives, and the professional observation is only a particular instance of it.

* The writer's observations (Am. Jour. Sc., Nov., 1888) show that appreciable time is required for perception of the retinal impression, with certain excessively faint lights; but these are not here in question.

Now, I ask your attention to the practical instantaneity of the *formation* of this visual picture, which is known to be obtained where the duration of the phenomenon to be observed is much less than the one thousand-millionth of a second, and where we have every reason to believe that the actual formation of the image on the retina under known ordinary conditions requires a time of like order.

We may say, then, that the casting of a picture on the retina is instantaneous. It is its fading out that requires time, and it is while this fading out takes place, and even long after it, that the work of perception, decision and action is going on behind the retinal curtain in the chambers of the brain. Notice, then, that while to determine *when* a phenomenon occurs may require, under some circumstances, several seconds, and under all ordinary circumstances a notable fraction of a second, to determine *where* it occurs requires (sensibly) no time at all, for one single impression remains on the retina long enough to obtain full recognition and to be reproduced by processes of memory.

I can make my meaning clearer, perhaps, by using the same specific instance as before. Let us suppose that an accident to a passenger on the passing train is the phenomenon, the time of whose occurrence is to be noted, and that this accident is seen from a room in which there are two windows looking on the track. We must have seen the accident, if it be instantaneous, either through the first window or the second. If we had been led to anticipate that we should be called upon to say through which window we saw it, I think we may all admit that there would be no discrepancy on this point between different observers, for in this case we are considering only the element of position, and the element of time does not directly enter at all, so that observers in the same position who had been bidden to note through which window they saw it would all agree on this point.

Now a connection can here obviously be established between the place and the time, from which we infer the latter, if we are granted the knowledge of two facts: the time at which the carriage could have first come into view from the first window, and the time at which it must have passed out of view behind the second; for if we suppose the speed of the train to have been uniform, we have the means of deciding the fraction of the time when we know the fraction of space. Here, then, as in the case of a common clock or chronograph, or any device where time and space are proportional, we can infer the former from the latter; only let it be observed that we here need no recording apparatus. What we use is the memory of where the event occurred; in other words, we recall the impression on the retinal screen and have no need to bring into use what we may call the time-perception apparatus of the brain which lies behind it; *nor do we in fact need that the object of our observation shall be really in motion, but only that it shall be made to appear to be so.*

This last point is all important, and what I ask your attention to is an experiment heretofore, I think, untried, and which is perhaps a novel application of the fundamental horological idea that time and space must be made proportional, for it seems to me it must be theoretically possible, not only in the case of the clock or the chronograph, but always, to so connect the former with the latter that the essential task of the observer is to say where any visible event apparently occurred, and then let some mechanism outside of himself say when.

That at least is the idea, and if it has, as I hope, been clearly apprehended by you, I will now ask your attention to a working plan for carrying it out. Numerous different devices have been under my consideration. I will take one which is primarily designed for the observation of any celestial phenomenon, though it could very well be adapted to terrestrial ones; and in order to fix our ideas I will suppose that we have an event which we know the approximate time of, but which may burst upon us at some fraction of a second which we want to determine. I will assume (merely to fix our thoughts) that we wish to note the time at which a star emerges from behind the dark body of the moon with an accuracy which ensures us that we have not made an error so great as one-twentieth of a second.

You see I hold in my hand a peculiar eye-piece, which has been made to observe this or any other terrestrial or celestial phenomenon of sudden occurrence. It can also be used for meridian observation, but its special field seems to lie in noting an event where no correction for personal equation is applicable. This event may be anything celestial or terrestrial, from the entrance of Venus on the disc of the sun to the explosion of a mine; but for the purpose of illustration merely, let us take it to be the sudden appearance of a star.

On looking into the telescope we see, in the first place, two prominent wires crossing each other at right angles, dividing the field of view into four quadrants. Now, by a simple mechanism, which I shall shortly explain, any object that our telescope is directed on—any fixed star, for example—seems to be revolving in the field, passing successively through the first, second, third and fourth quadrants. If the star is hidden the mechanism is working just the same, and when the star appears it must evidently first be seen in some particular one of those four quadrants, and experience shows that we shall have no difficulty in telling in which one. The mechanism itself has recorded for us by an electric contact the limiting instant between which it is possible to see the beginning and the end of the cycle during which revolution may be supposed to be made. It is not necessary that this cycle should last just one second; but, supposing it (still for illustration only) to be a second, if it was seen in the first quadrant it was seen in the first quarter of the second; if it was in the second quadrant, sometime in the second quarter of the second; in the third, in the third quarter; in the fourth, in the final quarter. All that we have to do in this case is to know in which second it occurred; for the quarter of a second we may say is noted for us by the purely automatic action of the optic lens and retina, since the first image on the retina must be that of the star as seen in some particular one of the four quadrants.

Going a little farther, we will now suppose each of the four quadrants, which in turn correspond to quarter seconds, to be divided into five parts, so that the whole circle is divided into twenty. All the observer has to say is in which quadrant and in which subdivision of the quadrant the star appears, to say in which twentieth of the second (or other brief cycle) it emerged.

The reticule I have just described is fixed in the focus of the eye-piece and does not revolve. What does revolve is a minute double prism of total reflection just before the reticule, the middle of whose reflecting face lies in the optical axis, and by whose means the optical axis is twice broken at a right angle, so that when the telescope is directed at a star the image of the star is not seen at the center of the field, but on one side of it. If the prism is revolved, the star must appear to revolve in a circle whose radius is nearly that of the side of the prism.

The little prism is turned by a small piece of watch-work, but it is not at all necessary that this should be exact, since all we demand is that the rate shall be constant during a second or so—a condition easily secured with the most ordinary mechanism.

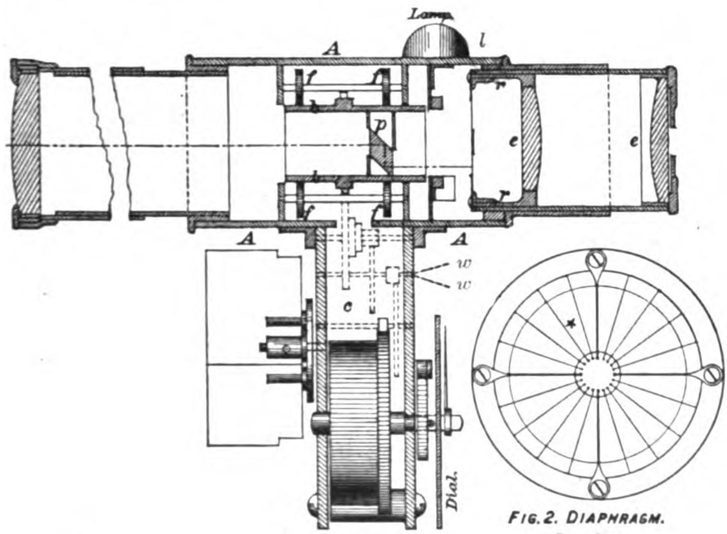


FIG. 1. SECTION. ½ FULL SIZE

FIG. 2. DIAPHRAGM. FULL SIZE.

S. P. LANGLEY. INVT

The sketch and the apparatus exhibited sufficiently indicate, I think, the simple means by which this is brought about.

Figure 1 is a section one-half full size. A A A is the outer tube, which can be fitted, if desired, into the eye end of a telescope. *b b* is the inner tube, resting on friction-wheels *ff*, revolved by the clock-work *c* about once a second, and recording the time at which a key in the observer's hand may be pressed to indicate the particular second. This record may be made electrically by the wires *w w* on a chronograph, or more simply and directly on a little attached dial like that of a recording stop-watch.

p is the prism of double total reflection. *r r* is the position of the fixed reticule (shown independently as it appears to the observer and of full size in figure 2.)

e e are the lenses of a positive eye-piece. *l* is a lamp for giving wire illumination, if desired, when a telescope is employed.

Field illumination is readily obtained by making the diaphragm in which the prism *p* is set of translucent material.

Finally it should be remarked that on removing the eyepiece, events may be observed without using any telescope. In this, its simplest form, the chronograph may also be dispensed with, and the record of the second made on an attached stop-watch dial, and the instrument may thus carry its own complete recording apparatus and be more portable than an ordinary opera-glass.

I have not found time to use this apparatus on the moon or occultations, but I have, what is possibly more to the purpose now, tried it on an artificial star, the instant of whose appearance and disappearance was independently recorded on a chronograph by an electrical contact. Different observers, entirely unskilled and ignorant in the use of the instrument, were invited to look into it and to determine the quadrant and section in which the star appeared and disappeared.

I have momentarily mislaid my notes containing in full detail the results of four observers, but I can summarize them approximately in saying that after being simply told what to note, the average probable error—(that is, for any single observation)—was rather less than one-twentieth of a second. As far as I can judge from the limited number of instances, the younger the observer the better the observation. The worst of the observers (the oldest), however, had a probable error considerably less than one-tenth of a second; the youngest, a probable error of something like one-fortieth of a second, which implies, as you will observe, that he not only readily noted the quadrant and the subdivisions of the quadrant, but also, as a rule, even the part of subdivision in which the star was first seen. None of these observers had so much as one hour's practice.

The plan in question is easily adapted to meridian observations, but for these we have numerous plans for correcting personal equation, and the writer may also direct attention to the fact of the existence of a distinct device (Am. Journal of Science, July, 1877) which practically eliminates the personal error in the very act of a transit observation. It is more elaborate than the present one, which is so simple that it may be useful even in longitude work with the transit, though its proper field seems to be the observation of sudden events; but, to whatever purpose it is applied, I beg leave to present it to your attention less for any interest that attaches to the particular mechanism exhibited than as an illustration of a principle which seems to me to have not been employed before in this way, and which I trust may have useful applications.

HEIGHTS OF METEORS.

W. F. DENNING.

For The Messenger.

Three conspicuous meteors have recently been observed in this country with sufficient fullness and accuracy to enable their real paths to be determined with unusual precision.

On April 20, 1889, 10*h* 16*m* G. M. T., Professor A. S. Herschel at Croydon, Surrey, recorded a meteor with a path from 32° + 53½° to 42° + 50° in Perseus. At the same time Mr. T. W. Backhouse, at Darlington, saw a meteor as bright as Sirius passing from 189½° — 7° to 179° — 14°. A comparison of the two observed paths shows the radiant point to have been at 301° + 36°, in altitude 13° above the N. E. horizon. The meteor passed over Derby shire at heights from 50½ to 45½ miles. Its visible length of path was 22 miles, which it traversed in one second. Parabolic velocity would be about 20 miles per second; the accordance in the two values leaves little doubt as to the form of orbit this body was pursuing.

On April 21, 1889, 10*h* 16*m* G. M. T. Professor Herschel noticed another conspicuous meteor, with a flight extending from 112° + 27° to 98° + 26° in Gemini. The same object was seen at Bristol by the writer, who registered its path as from 163½° + 55° to 119½° + 61¼° in the western region of Ursa Major. This meteor belonged to a radiant at 218° — 5°, in altitude 25½° above the S. E. horizon. When first seen the body was 72 miles high, and it was but slightly S. W. of the zenith at Bristol. At disappearance the height was 54 miles, and the meteor was then over Crickhowell, in Wales. Its real length of path was 42 miles, which it traversed in 1½ seconds, so that its speed was 28 miles per second, which is slightly greater than parabolic velocity.

On May 22, 1889, 10*h* 8*m* G. M. T. a fine meteor equal to Jupit was recorded by Mr. G. T. Davis at Reading. It moved with remarkable slowness from 216° + 31° to 239° — 24°. Duration 15 seconds. It left a yellowish train 15° long. The same object was observed by the writer at Bristol, and its path was noted from 287° + 39° to 254½° — 15°. It moved very, very slowly, the duration being estimated as 16 seconds. A thick yellow train, 7° or 8° long, followed the nucleus as it leisurely sailed across the sky. Another observer at Bristol estimated the duration as 18 or 20 seconds. Projecting the observations it is found the radiant was at 63° + 35° on the N.N.W. horizon. The meteor appears to have been seen earlier in its flight at Bristol than at Reading, but at the latter place its end-path was better observed. At first appearance its height was 50 miles above a point six miles east of Oxford, and its disappearance occurred at a height of 58 miles above a place ten miles west of Orleans in France. The real length of its course was 292 miles, and the velocity from a mean of the observations 14¼ miles per seeond. This is less than a parabolic orbit would give, and, if correct, the meteor must have been traveling in a nearly circular orbit. The earlier portion of the flight was nearly parallel with the earth's surface at a height of about 50 miles, but the extraordinarily long course it pursued augmented the effects of the earth's curvature in such degree that towards the end of its course the body was *ascending* in the atmosphere and its height was several miles greater than at the period of its first appearance. The meteor was quite an exceptional one, for it diverged from a radiant close to the sun's place, and traveled with extreme slowness through a great range of path.

BRISTOL, ENGLAND, June 10, 1889.

THE WATERS UPON THE EARTH.

B. J. BROOKINGS.

For The Messenger.

Among the many discussions relative to the formation of systems and worlds, it seems to me few have touched directly upon the question of the conditions which have made the two elements composing water such a factor as we see them in our solar system, and, at least, especially upon our own planet.

As to our earth, may we inquire how came they here, and what part did they take in its early formation, and how did they finally become so important and permanent a portion?

When we consider that three-fourths of the visible portion of the globe consists of water, and that the remaining fourth invariably shows the effects of intense heat, we cannot but wonder how the two opposites were originally conditioned, how they acted and reacted toward or upon each other, and how and when the former became the more imposing mass as regards the earth's surface.

Without going into the depths of theory regarding the formation of systems and worlds, it would appear that, in the composition of such matter, the elements of water were a portion, and that in its concentration and rotary motion, it became more and more heated, and this heat was intensified finally to a maximum as the mass attained a certain centralization. What would result? Evidently the elements composing water would be vaporized and ascend to the intensely rarified atmosphere in part produced by their own conditions.

Evidently the greatest intensity of heat showed the least amount of vapor or water, because these had ascended to and become a part of the earth's atmosphere, surrounding it with a cloudy envelope which extended as far as the extremely heated and rarified atmospheric conditions would allow.

This envelope of vapor no doubt continued in vastness until the earth began to cool, when gradually it descended as rain, a portion remaining, as conditions allowed, in the nature of water, until finally the greater portion had found its place upon our globe as we now see it.

The reasonableness of this assumption is apparent, as we find that, naturally or chemically, this action is always produced. Furthermore, if we look to the other planets, especially exterior to Mars, we can observe precisely such conditions existing, and such changes taking place,—*i. e.*, the masses of the planets concentrating and therefore enveloped in clouds of vapors which have not cooled in sufficient quantities to form lakes and rivers upon their surfaces; in fact seeming, in some instances, like orbs of vaporous matter.

Sufficient earth-heat and sun-heat still prevail in and around our planet as yet to prevent the entire descent and absorption of atmospheric vapor; but supposing that the earth, in course of time, has entirely cooled, like its satellite, the moon, and its vapors thereby have descended and become water, and these waters, by intenser cooling, have penetrated our globe's exterior, what would prevent the same lifeless condition which we now see upon its satellite?

Has not this physical change taken place there?

Is not the change taking place here, although cycles of centuries may pass before it will be completely effected?

WASHINGTON, D. C.

LIMIT OF VISION.

H P. TUTTLE.

FOR THE MESSENGER.

In Vol. XVIII. of the Monthly Notices of the Royal Astronomical Society Mr. Norman R. Pogson has given a formula for computing the magnitudes of the faintest stars visible in an achromatic telescope of a given aperture, and as that volume may not be within reach of many of the readers of THE SIDEREAL MESSENGER I herewith transcribe Mr. Pogson's remarks and append a table which I have computed from his formula. The table will be found to include about all the objectives now in use, and many not yet constructed. The magnitudes are given to the nearest tenth.

Mr. Pogson says: "The limit of vision or faintest magnitude on the scale here employed which is discernible in a good telescope on a fine moonless night may be found by the following formula:

Limit of vision = 9.2 + 5 log. aperture in inches."

Diameter of Objective. Inches.	Limit of Mag.	Lt. Gathering Surface. □ inches.
1.1	9.4	
1.2	9.6	
1.3	9.8	
1.4	9.9	
1.5	10.1	
1.6	10.2	
1.7	10.4	
1.8	10.5	
1.9	10.6	
2.0	10.7	3.1
2.1	10.8	
2.2	10.9	
2.3	11.0	
2.4	11.1	
2.5	11.2	
2.6	11.3	
2.7	11.4	
2.8	11.4	
2.9	11.5	
3.0	11.6	7.1
3.1	11.7	
3.2	11.7	
3.3	11.8	
3.4	11.9	
3.5	11.9	
3.6	12.0	
3.7	12.0	
3.8	12.1	
3.9	12.2	
4.0	12.2	12.6
4.1	12.3	
4.2	12.3	
4.3	12.4	
4.4	12.4	
4.5	12.5	
4.6	12.5	
4.7	12.6	
4.8	12.6	
4.9	12.7	
5.0	12.7	19.7
5.1	12.7	
5.2	12.8	
5.3	12.8	
5.4	12.9	
5.5	12.9	
5.6	12.9	
5.7	13.0	
5.8	13.0	
5.9	13.1	
6.0	13.1	28.3
6.1	13.1	
6.2	13.2	
6.3	13.2	
6.4	13.2	
6.5	13.3	
6.6	13.3	
6.7	13.3	
6.8	13.4	
6.9	13.4	
7.0	13.4	38.5
7.1	13.5	
7.2	13.5	
7.3	13.5	
7.4	13.5	
7.5	13.6	
7.6	13 6	
7.7	13.6	
7.8	13.7	
7.9	13.7	
8.00	13.7	50.3
8.25	13.8	
8.50	13.8	
8.75	13.8	
9.00	13.9	63.6
9.25	14.0	
9.50	14.1	
9.75	14.1	
10.00	14.2	78.5
10.25	14.3	
10.50	14.3	
10.75	14.4	
11.00	14.4	95.0
11.25	14.5	
11.50	14.5	
11.75	14.6	
12.00	14.6	113.1
12.25	14.6	
12.50	14.7	
12.75	14.7	
13.00	14.8	132.7
13.25	14.8	
13.50	14.9	
13.75	14.9	
14.00	14.9	153.9
14.25	15.0	
14.50	15.0	
14.75	15.0	
15.00	15.1	176.6
15.50	15.2	
16.00	15.2	201.0
16.50	15.3	
17 00	15.3	226.9
17.50	15.4	
18.00	15.5	254.3
18.50	15.5	
19.00	15.6	282.4
19.50	15.7	
20.00	15.7	314.0
21.00	15.8	346.2
22.00	15.9	379.9
23.00	16.0	415.3
24.00	16.1	452.2
25.00	16.2	490.6
26.00	16.3	530.7
27.00	16.4	572.3
28.00	16.4	615.4
29.00	16.5	660.2
30.00	16.6	706.9

Diameter of Objective. Inches.	Limit of Mag.	Lt. Gathering Surface. □ inches.	Diameter of Objective. Inches.	Limit of Mag.	Lt. Gathering Surface. □ inches.
31.00	16.7	754.8	44.00	17.4	1520.6
32.00	16.7	804.2	45.00	17.5	1590.4
33.00	16.8	855.3	46.00	17.6	1661.9
34.00	16.9	907.9	47.00	17.6	1734.9
35.00	16.9	962.1	48.00	17.6	1809.6
36.00	17.0	1017.9	49.00	17.7	1885.7
37.00	17.0	1075.2	50.00	17.7	1963.5
38.00	17.1	1134.1	60.00	18.1	2827.4
39.00	17.2	1194.6	70.00	18.4	3848.5
40.00	17.2	1256.6	80.00	18.7	5026.6
41.00	17.3	1320.2	90.00	19.0	6361.7
42.00	17.3	1385.4	100.00	19.2	7854.0
43.00	17.4	1452.2			

If we concede the above formula to be approximately correct for small lenses it will certainly not be so for very large ones, owing to the great amount of light lost by the increased thickness of the objectives.

WASHINGTON, June, 1889.

THE BRUCE PHOTOGRAPHIC TELESCOPE.

EDWARD C. PICKERING.

The astronomical Observatory of Harvard College has received from Miss C. W. Bruce, of New York, a gift of $50,000, to be applied "to the construction of a photographic telescope having an objective of about twenty-four inches aperture with a focal length of about eleven feet, and of the character described by the Director of the Observatory in his Circular of November last; also to secure its use under favorable climatic conditions in such a way as in his judgment will best advance astronomical science."

This instrument will differ from other large telescopes in the construction of its object-glass, which will be a compound lens of the form used by photographers and known as the portrait lens. The focal length of such a lens is very small compared with its diameter, and much fainter stars can be photographed in consequence. The advantage is even greater in photographing nebulæ or other faint surfaces. Moreover this form of lens will enable each photographic plate to cover an area several times as great as that which is covered by an instrument of the usual form. The time required to photograph the entire sky is reduced in the same proportion. A telescope of the proposed form, having an aperture of eight inches, has been in constant use in Cambridge for the last four years, and is now in Peru photographing the southern stars. It has proved useful for a great variety of researches. Stars have been photographed with it too faint to be visible in the fifteen-inch refractor of the Observatory. Its short focal length enables it to photograph as faint stars as any which can be taken with an excellent photographic telescope having an aperture of thirteen inches. The eight-inch telescope will photograph stars about two magnitudes fainter than can be taken with a similar instrument having an aperture of four inches. A corresponding advantage is anticipated from the increase of the aperture to twenty-four inches. Each photograph will be thirteen inches on a side, and will cover a portion of the sky five degrees square, on a scale of one minute to a millimetre. The dimensions will be the same as those of the standard charts of Chacornac and Peters. The entire sky would be depicted upon about two thousand such charts.

It is very important that the best possible location should be found for such an instrument. In Europe and in the eastern portions of the United States, where nine-tenths of the principal observatories of the world are situated, it is cloudy for a large portion of the year. Great advantages are expected from a location where clouds and haze are seldom seen.

This generous gift offers an opportunity for useful work such as seldom occurs. It is expected that the Bruce Photographic Telescope will exert an important influence upon astronomical science by the large amount of material that it will furnish.

CAMBRIDGE, U. S., June 26, 1889.

ON THE INCLINATION OF THE ASTEROIDS.*

PROFESSOR DANIEL KIRKWOOD.

The forty-ninth page of my little volume on the Asteroids contains a brief statement respecting the orbital positions

* Read before the American Philosophical Society, May 17, 1889.

of these bodies, and the supposed connection between great eccentricity and high inclination. If the phenomena referred to have any bearing on the theory of asteroid formation—in other words, if facts hitherto regarded as isolated prove mutually dependent—may not their discussion point out new and unexpected relations? A more exact examination, at least, of these planetary statistics will not be without interest.

The first column of the following table gives the asteroids in groups of ten, in the order of distances; the second, the limits of the respective groups; and the third, the average inclination of the several clusters.

INCLINATIONS OF THE MINOR PLANETS.

Groups.	Distances.	Av. Inclination of Groups.
1 to 10	2.13 — 2.28	3° 37′ 32.8″
11 — 20	2.28 — 2.36	7 0 22.1
21 — 30	2.36 — 2.38	11 0 13.9
31 — 40	2.38 — 2.40	12 20 15.2
41 — 50	2.40 — 2.43	6 44 48.1
51 — 60	2.43 — 2.45	5 25 7.4
61 — 70	2.45 — 2.56	7 20 51.5
71 — 80	2.56 — 2.58	10 19 23.2
81 — 90	2.58 — 2.616	9 27 49.3
91 — 100	2.616 — 2.647	8 10 43.1
101 — 110	2.647 — 2.667	7 2 53.5
111 — 120	2.667 — 2.685	8 4 11.0
121 — 130	2.685 — 2.712	9 25 17.1
131 — 140	2.712 — 2.737	8 2 6.1
141 — 150	2.737 — 2.745	10 10 30.0
151 — 160	2.745 — 2.762	8 36 12.7
161 — 170	2.762 — 2.771	11 23 0.2
171 — 180	2.771 — 2.799	10 36 6.2
181 — 190	2.799 — 2.870	8 16 7.1
191 — 200	2.870 — 2.921	8 10 4.8
201 — 210	2.921 — 3.012	7 23 35.3
211 — 220	3.012 — 3.06	7 48 19.0
221 — 230	3.06 — 3.11	5 54 43.0
231 — 240	3.11 — 3.126	8 48 52.6
241 — 250	3.126 — 3.14	7 0 36.9
251 — 260	3.14 — 3.185	10 46 51.3
261 — 270	3.185 — 3.42	8 39 16.8
271 — 280	3.42 — 4.24	6 28 26.3

1. The average inclination of the first hundred (in the order of distance) is........ 8° 8′ 42.66″
   Of the second hundred.......................... 8 58 38.87
   Of the last eighty................ .... 7 51 20.15
   And that of the whole two hundred and eighty.. 8 21 34.87
2. The inclinations in the edges of the ring are less than the average.

3. Other *minima* are found about the distances 2.44 and 3.09. The *maximum* between 2.36 and 2.40 is distinctly marked.

4. As in the case of other planets, the inclinations vary, though with extreme slowness. It has not been shown, however, that the *average* will change to any great extent.

5. This average compares thus with certain other inclinations:

Mercury's orbit	7°	00′
Plane of the Sun's equator	7	15
Average inclination of asteroidal comets	16	40

6. The *maximum* inclinations of Mercury and Mars are 10° 36′ and 7° 28′* respectively. The table indicates that *the mean inclination* of the asteroids has not differed greatly from the mean inclination of Mercury.

VELOCITY OF SOUND—THE WHOLE GIST OF THE MATTER.

SMITH GOOODENOW, A. M.

For The Messenger.

1. THE FACTS AGREED UPON.

In a long open tube a frictionless piston moves distance u in a second; the air before it is pushed and compressed as far as some point z at the end of the second; and what was air V now occupies $V-u$ space.

The normal pressure of the air at first, and so remaining at and beyond z, is P; its pressure from z back to the piston has increased to P'; so that the increase of the pressure in air V is $P'-P$.

Now if $V=1000u$, so that the u reduction (of space V to $V-u$) is a reduction of .001th part in the volume of air V, then the increase of pressure $(P'-P)$ is $.001P$, or about .001th part of the normal pressure (saying nothing about heat). And this increase of pressure $(.001P)$ within the air-wave or pulse, must have required that much pressure applied to the piston to make, to meet, and to overcome it.

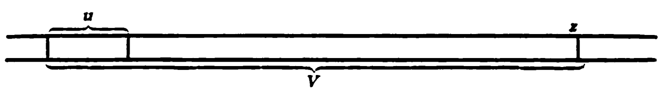
This extra pressure has been accompanied by a certain amount of *work* done or *motion* of air against *resistance*, as follows: air u has been removed from space u, and all air V has been moved along to correspond; which, if the air be

* Stockwell's Mem. on the Sec. Var. of the El. of the Eight Princ. Planets, Smith Contrib. to Knowl., 232, p. 116.

taken as if solid and unresisted, makes in all a motion of air V through a distance u (equivalent to a motion of air u through a distance V).

But, more exactly, since the air is not solid, but yields with resistance, air u is moved an *average* of $\frac{u}{2}$ distance (in leaving space u), and the whole air V is moved the same *average* of $\frac{u}{2}$ distance (varying from distance u for the particle next the piston down to distance o for the particle at z. But by either reckoning the whole work of making the air-wave to z is $\frac{V}{u}$ times as much or 1000-fold greater than is the piston work of simply removing the air from space u.

This 1000-fold greater work spent in carrying air V through distance u (or $\frac{u}{2}$) is equivalent to carrying the air u (or $\frac{u}{2}$) through the whole distance V, or diffusing through V the resistance P, which would be met in shoving air u into the next space u (with the air there); by which diffusion the resistance against the piston is reduced from that P down to the .001 P of the whole air-wave.



2. THE POINT OF THE CONTROVERSY.

Now, the question is, what *force produces* this whole work or motion of the air-wave?

The pulse-heat theory of sound answers, that the whole air-wave work, viz., air V carried distance u (or air u carried distance V), is produced without aid by the extra pressure P′—P or .001 P, put upon the piston by the air-wave, and of course exerted by or through the piston in securing it; because the whole $u \times V$ motion is *known to result from* the piston pressure, and *would be produced by* it if without resistance in a vacuum (as seen in the fall of a body, by proportion "A.")

On the contrary, I answer (with Newton), that the piston-pressure (P′—P or .001 P) produces by its motion *against resistance* only the work of moving air u from space u; while *another force* 1,000 times greater, viz., the elastic force of the air, or P, diffuses the resistance through the air-wave, and so lengthens the motion all the way through V.*

* It takes as much piston force (.001 P) to meet the resistance (.001 P) in simply moving u, as would without resistance move the whole V.

3. MY PROOF IN A NUTSHELL.

The .001 P pressure of the piston has only to overcome the .001 P resistance met by the piston in making its motion *u*;* but meanwhile, a like .001 P resistance has to be met by each *u*-length of air in making its motion *u*; and as there are 1,000 of these *u*-lengths of air moved in the whole *V*, it takes 1,000 times .001 P, viz., the force P (or whole elastic force of the air), to lengthen the piston-motion (*u* distance) into the air-motion (*V* distance). Therefore, the whole air-wave motion *V* is made by the air's whole elastic force P, which is only incited thereto by the initial or unit motion *u* of the piston force .001 P.

Consequently, the piston motion *u* may be *more or less* than .001th part of *V*, without changing the air-wave distance *V*, or velocity of sound; which is just what the facts require. And moreover, if anything increases the pressure within the air-wave, (say extra heat, as alleged), this will equally enlarge the resistance at each step, to the *decrease* of the wave motion, (rather than its increase, as alleged by the pulse-heat theory). And still further, the absurd result of the pulse-heat theory is escaped, which requires a tiny locust by its own unaided strength to shake the whole atmosphere for a mile in every direction, say 500 times forward and backward every second.

THE RESULT.

When the sound-propagating force is treated as being only the elastic variation P′—P, or .001 P, then its increase .00041 by heat engendered (as alleged), makes the force 1.41 greater than before; and this being regarded as enlarging in equal proportion both *u* and *V* (so as to keep their ratio 1,000), will give an increase of $\sqrt{1.41} = 1.19$ to *V*, the velocity of sound, raising it from the Newtonian 916 to 1,090 feet per second, as required. This then is the pulse-heat theory, for rectifying the Newtonian value, by alleged heat engendered.

On the contrary, when the sound propagating force is taken as elastic pressure P (or at most P′), instead of its variation P′—P, then the alleged heat effect .00041 P, said to

* The motion being uniform, is *not produced by the pressure at all*, but by a slight stroke in starting the pressure.

enlarge P′—P to .00141 P, makes the force but 1.00041 larger than P, (or P′ = 1.00141 P); and the slight increase of elastic or sound-propagating force cannot give over $\sqrt{1.00141} = 1.000705$ increased to the 916 feet velocity of sound *V*, viz. 0 .907 feet, or nine-tenths of a foot, instead of the 174 feet claimed. This my view leaves alleged heat as entirely inadequate to rectify the Newtonian value, making necessary some other rectification; and that is what I have undertaken to give.

THE STUDY OF ASTRONOMY.

We often receive letters from persons asking, for substance, what books they should read to gain a knowledge of results reached in the recent progress of astronomy. Most of those who thus inquire are persons unknown to us; yet, doubtless, they have an earnest desire to do something for themselves, and they want to know how to go about it. They seem to have the spirit of self-reliance and self-help, and they are anxious to put these excellent qualities of mental furnishing to the task of gaining useful scientific knowledge. We ought to expect that the queries of the inexperienced will often come in crude form, and sometimes be very large and indefinite, and take them for what they mean, and answer accordingly; and so attempt wisely to direct the energy of mind seeking worthy employment. In view of such facts as these, it has seemed to us that it might be worth the while to name a few precepts to guide in the study of astronomy, and then to mention some books which will be needed in making advancement in astronomical studies. As a precept of great importance we would say,—

1. *Know thoroughly and familiarly whatever ought to be mastered.* Knowledge has its degrees. As another has well said, "It is of all grades from the first dim and vague apprehensions of a fact or truth to the full and familiar and felt understanding of such fact or truth, in all its causes and connections, its philosophy and its power and beauty. We may know it so as to recognize it when another tells it; we may know it so as to recall it in fact and reflect upon it; we may know it so as to tell it in a general way to a friend; or,

we may know it so as fully to describe, demonstrate and illustrate it as a truth whose importance we feel, and whose grandeur or beauty inspires us." It is this last form of knowledge that the student of astronomy should covet earnestly. The reason is evident. It is impossible to use readily and well anything which is not thoroughly and familiarly our own. Truth is never revealed in its beauty or power to one who only partially knows it. Slight knowledge does not enlist the feelings, neither does it move the heart with ardent zeal. It was an earnest love of truth, grandly and vividly conceived, that caused Kepler to grow wild with delight in the glories of the stars; or the great Newton to say that he was but a child, picking up pebbles on the beach, with the great ocean of truth before him yet unexplored.

Thorough study only brings fresh conceptions of the truths sought; it only furnishes best modes of expression for idea or fact, and it only begets consciousness of strength in timely need.

2. *Solid attention and a habit of study.* It is not an easy thing for those who have the habit of study to hold the attention well at all times. The varying circumstances and moods of the student often exercise large control and weaken the power of mental effort. Attention is usually either compelled or attracted. The former is an act of the will, the latter is the result of a gratified sensibility; the former acts listlessly or unwillingly, the latter is eager in opportunity and scarcely knows fatigue. Attention also has its degrees. Some writers specify three: (1) physical attention, or that which employs eye and ear while the mind is inert and moves only as it is moved; (2) intellectual attention, or that mental state just enough active to follow and understand what is uttered, and (3) that higher form of attention in which the intellect and heart are enlisted, and all the powers of the soul are alert for conquest and victory. This latter kind is the attention the student should cultivate for rapid advancement in any department of study. It is true that the mind will be unable to work long, at first, under such tension of its powers, but enduring vigor will surely come with wise and habitual use in *this* way, and in this way only as a rule. It is not "how much, but how well"; it is not the number of hours a man studies that is to meas-

ure progress or true acquirement, but rather the *way* he works—the kind of attention he gives—that counts most in lasting results. Such attention in work or habitual study will surely bring a student to place and power rapidly.

3. *A faithful application of principles and methods to obtain definite results.* It is one thing to see and know, in a general way, how a given result is obtained, but it is quite another thing to do the work indicated to obtain the result. The student of astronomy may well heed the maxim, "Be not of those who say and do not," but rather be of those who do that they may *know* whereof they speak. Time spent in the study of a numerical example intended to illustrate a principle or a method, is the best possible use of it, not only to familiarize the case in hand, but also to bring out the laws of sequence which show the relation of a particular truth or principle to the whole body of the science of which it is a part. A noticeable defect in the scholarship of scientists too generally is, that they have failed to relate truth in science logically and effectively. Scientists are readers, but they are not always severe and logical thinkers. This is not certainly the fault of astronomy as a science, for what else it may not be, it is emphatically a science built by rigorous logic and exactitude elsewhere unparalleled. As a branch of study, astronomy therefore is one of the best that could be chosen for training the imagination and the reasoning powers.

With precepts like these in mind, we next inquire what books we shall read in beginning the study of astronomy. We may suppose the student has some knowledge of elementary astronomy, such as is found in text-books commonly used in the public schools, and that he has prepared somewhat thoroughly the branches of algebra, geometry, trigonometry and physics. He is then prepared to begin the study of astronomy in earnest, and the first book suggested is Young's General Astronomy. This is a book that should be mastered because of what it contains and the spirit in which it is written. In our judgment, its author has grouped the salient points of this science in this work more fully, faithfully and naturally than can be found elsewhere in any single book. Not only so, but the spirit of the text is admirable. These features are peculiarly strong and all important. It is of great moment that a student entertain right notions of astronomical truth in the outset in order to understand and apply its principles. He must depend largely on the mere statements of fact by others for forming his opinions of the truth in any given line of inquiry, and so determine for himself what is known, and distinguish sharply and continually from what is merely supposed. The person that loves science will always hold the truth in high esteem, and give it place in earnest thought; and if he be misled into cherishing that which is false, by errors in essential facts, harm is done and the best mental stimulus for work is lost. For such reasons as these there are comparatively few books that will pay the student to read with avidity and soul insight,—to mentally devour them in hard work,—because they are not worth it; but when such a book is found it is worth something to know it beforehand, and give it proper place in the plan of study contemplated.

How this valuable book may be studied to best advantage, and what should follow it, we will consider somewhat at length in following numbers of this journal.

TO BE CONTINUED.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

The planet tables are given for two months, because THE MESSENGER will not be published for the month of September.

Mercury was at greatest brilliancy July 30; will be in superior conjunction with the sun August 7; in greatest heliocentric latitude north same day; in conjunction with Saturn August 10, the planet being 38′ north of Saturn at 21*h*; in conjunction with the moon August 17; in descending node August 30; at aphelion of its orbit Sept. 10; in greatest elongation east September 20, 6*h*, being at that time 26° 19′ from the sun, and in south declination about 11°30′, so that its position is not quite as favorable for observation as it might otherwise be.

Venus is a morning star, and will be in conjunction with the moon August 22; passes to the ascending node Sept. 12, is again in conjunction with the moon Sept. 21, and in conjunction with Saturn Sept. 25, the former being 34′ south of the latter; and five days later, Sept. 30, it will be in conjunction with Mars, being only 22′ south.

Mars is also a morning star in northeastern Cancer. During August the planet will move southwesterly through Cancer, and Sept. 5 enter Leo, and Sept. 17 the planet will be very near Regulus. August 24 Mars will be in conjunction with the moon, 1° 28′ south; in conjunction with the planet Saturn Sept. 19 14*h* 52*m* Washington mean time, the distance between the planets at that time being only one minute of arc. In civil time this date would be Sept. 20 4*h* 52 *m* A. M., or about 4 o'clock in central time. This interesting phenomenon should be observed if possible. Those who have good eyes may try to separate the two planets when nearest without telescopic aid; and it will be interesting to those who have telescopes to measure their least distance and report the results obtained. Physicists say that when two bright objects are nearer than 1′ 12″ few eyes can distinguish them as two objects. This phenomenon will take place two hours before sunrise and about one hour after the planets rise.

Jupiter is in the constellation of Sagittarius approaching the small stars a few degrees southwest of the star μ; his motion is towards the southwest until Aug. 24 when the planet is stationary. Quadrature with the sun will be reached Sept. 21, and conjunction with the moon for the third time in two months on Sept. 30. The last distance is the least, being only 39′ south.

Interesting studies of the planet Jupiter have come to our notice recently in the form of observations and drawings of the planet made at Birr Castle Observatory, Parsonstown, Ireland, by Otto Boeddicker, Ph. D., covering a period from Sept. 2, 1881 to March 13, 1886.

These studies were made by the aid of a reflecting telescope of three feet aperture, and they consist of notes of observations and some eighty drawings of the surface markings of Jupiter which were made with pencil not more than ten minutes being devoted to each of them. In the publication before us the drawings are reproduced by a photo-mechanical process, in order to avoid the inaccuracies frequently caused by a transferring lithographer, and so probably well represent the original work.

We also notice that work of interest has been accomplished on the belts and markings of Jupiter, as appears in a Memoir to the Royal Astronomical Society found in Vol. xlix, 1889, notice of which appears in the July *Observatory*. The instruments used by Mr. Green were refractors of 4 and 5 inches aperture, and reflectors of 9, 13 and 18 inches, with observations from 1859 to 1887. "From 1860 to 1868 the equator was white with dark bands north and south of it, in 1869 it changed to a copper hue, and the bands moved towards the poles; from 1873 to 1879 the equator was white again, and the dark bands approached it, while after 1879 and the appearance of the great red spot the changes have been many and rapid." The prevailing features noticed in the brief account referred to, are the light and dark markings, their relative heights in the atmosphere of the planet, the probable meaning of the great red spot, the activity of the equatorial regions and the quiescence of the polar, and the effect of extensive trade winds and solar heat. . The 21 drawings accompanying the memoir are said to be beautiful, showing an immense amount of detail and delicate gradations of color.

Saturn will be near the sun during August, but in September it will be a morning star. The phenomena of most interest have already been noticed in connection with other planets.

Uranus, August 5 will be in the constellation of Virgo, 2° east and nearly 2° south of the star θ. During the months of August and September the apparent motion of the planet will be one degree south and about 2½° east. It will be in conjunction with the moon Aug. 29, and again Sept. 25.

Neptune is an evening star, in the constellation of Taurus a little north of the Hyades August 5. This planet will be in conjunction with the moon Aug. 18; in quadrature with the sun Aug. 27; stationary Sept. 6, and again in conjunction with the moon Sept. 14.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
MERCURY.					
Aug. 5	8 56.2	+19 02	4 35 A.M.	11 58.4 A.M.	7 21 P.M.
15	10 15.0	+12 35	5 43 "	12 37.5 P.M.	7 32 "
25	11 20.2	+ 5 05	6 40 "	1 03.1 "	7 26 "
Sept. 5	12 20.2	− 2 56	7 28 "	1 19.6 "	7 11 "
15	13 06.2	− 9 16	8 00 "	1 26.4 "	6 53 "
25	13 41.2	−13 57	8 14 "	1 21.9 "	6 30 "
Oct. 5	13 52.5	−15 17	7 52 "	12 53.9 "	5 55 "
VENUS.					
Aug. 5	5 58.1	+21 05	1 28 A.M.	9 00.6 A.M.	4 33 P.M.
15	6 45.9	+21 15	1 35 "	9 08.5 "	4 42 "
25	7 33.5	+20 33	1 47 "	9 17.3 "	4 47 "
Sept. 5	8 27.0	+18 42	2 06 "	9 27.3 "	4 49 "
15	9 15.2	+16 06	2 27 "	9 36.0 "	4 45 "
25	10 02.4	+12 44	2 49 "	9 43.9 "	4 39 "
Oct. 5	10 48.9	+ 8 44	3 13 "	9 50.8 "	4 29 "
MARS.					
Aug. 5	8 05.9	+21 21	3 34 A.M.	11 08.0 A.M.	6 42 P.M.
15	8 32.8	+19 56	3 28 "	10 55.5 "	6 23 "
25	8 59.0	+18 19	3 23 "	10 42.3 "	6 02 "
Sept. 5	9 27.0	+16 16	3 17 "	10 27.0 "	5 37 "
15	9 51.9	+14 16	3 11 "	10 12.4 "	5 14 "
25	10 16.1	+12 07	3 05 "	9 57.3 "	4 49 "
Oct. 5	10 39.8	+ 9 52	2 57 "	9 39.9 "	4 22 "
JUPITER.					
Aug. 5	17 55.6	−23 23	4 33 P.M.	8 56.2 P.M.	1 20 A.M.
15	17 53.7	−23 24	3 52 "	8 15.0 "	12 38 "
25	17 53.2	−23 26	3 12 "	7 35.1 "	11 58 P.M.
Sept. 5	17 54.1	−23 27	2 30 "	6 52.8 "	11 16 "
15	17 56.4	−23 28	1 53 "	6 15.7 "	10 39 "
25	17 59.9	−23 30	1 17 "	5 39.9 "	10 03 "
Oct. 5	18 04.5	−23 31	12 42 "	5 05.3 "	9 28 "
SATURN.					
Aug. 5	9 40.8	+15 07	5 38 A.M.	12 42.8 P.M.	7 48 P.M.
15	9 45.8	+14 43	5 05 "	12 08.4 "	7 12 "
25	9 50.7	+14 18	4 32 "	11 34.0 A.M.	6 36 "
Sept. 5	9 56.1	+13 51	3 57 "	10 56.2 "	5 56 "
15	10 00.9	+13 27	3 24 "	10 21.6 "	5 19 "
25	10 05.4	+13 04	2 51 "	9 46.7 "	4 43 "
Oct. 5	10 09.6	+12 42	2 17 "	9 11.7 "	4 06 "
URANUS.					
Aug. 5	13 09.6	− 6 44	10 34 A.M.	4 11.0 P.M.	9 48 P.M.
15	13 11.0	− 6 54	9 57 "	3 31.1 "	9 09 "
25	13 12.6	− 7 04	9 20 "	2 55.5 "	8 31 "
Sept. 5	13 14.7	− 7 16	8 40 "	2 14.3 "	7 49 "
15	13 16.7	− 7 30	8 03 "	1 37.0 "	7 11 "
25	13 18.9	− 7 43	7 27 "	12 59.9 "	6 33 "
Oct. 5	13 21.2	− 7 57	6 51 "	12 22.9 "	5 55 "
NEPTUNE.					
Aug. 5	4 10.5	+19 24	11 49 A.M.	7 13.4 A.M.	2 38 P.M.
15	4 11.1	+19 26	11 10 "	6 34.8 "	2 00 "
25	4 11.5	+19 26	10 31 "	5 56.0 "	1 21 "
Sept. 5	4 11.7	+19 26	9 46 "	5 12.8 "	12 38 "
15	4 11.6	+19 25	9 09 "	4 33.4 "	11 58 A.M.
25	4 11.4	+19 24	8 29 "	3 53.8 "	11 59 "
Oct. 5	4 10.8	+19 22	7 49 "	3 14.0 "	10 39 "

THE SUN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Aug. 5	9 03.7	+16 48	4 52 A.M.	12 05.7 P.M.	7 19 P.M.
15	9 41.5	+13 51	5 04 "	12 04.2 "	7 05 "
25	10 18.6	+10 32	5 15 "	12 01.8 "	6 48 "
Sept. 5	10 58.5	+ 6 34	5 28 "	11 58.4 A.M.	6 29 "
15	11 34.5	+ 2 46	5 40 "	11 54.9 "	6 10 "
25	12 10.4	− 1 07	5 51 "	11 51.5 "	5 52 "
Oct. 5	12 46.7	− 5 00	6 04 "	11 48.3 "	5 33 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Aug. 18	δ^1 Tauri	4	11 37	132	12 04	189	0 27
18	δ^3 Tauri	5	12 42	82	13 43	234	1 02
Sept. 3	Jupiter	0	9 43	135	10 31	224	0 49
3	Px vii 330	5½	11 06	66	12 04	289	0 58
9	30 Piscium	4½	13 41	133	14 30	161	0 49
14	B. A. C. 1272	6	12 38	54	13 53	254	1 15
Oct. 1	26 Sagittarii	6½	6 43	42	7 40	314	0 56
3	17 Capricorni	6	7 10	93	8 27	234	1 18

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

Central Time. d h m	Central Time. d h m	Central Time. d h m
Aug. 5 9 09 P. M.	Aug. 26 11 30 P. M.	Sept. 16 3 58 P. M.
6 5 00 "	27 7 21 "	17 9 45 "
7 10 47 "	28 3 13 "	18 5 37 "
8 6 39 "	29 9 00 "	19 11 24 "
10 12 26 A. M.	30 4 52 "	20 7 16 "
8 17 P. M.	31 10 39 "	21 3 07 "
11 4 08 "	Sept. 1 6 30 "	22 8 54 "
12 9 56 "	3 12 17 A. M.	23 4 46 "
13 5 47 "	8 09 P. M.	24 10 33 "
14 11 34 "	4 4 00 "	25 6 25 "
15 7 25 "	5 9 52 "	26 2 17 "
16 3 17 "	6 5 39 "	27 8 04 "
17 9 04 "	7 11 26 "	28 3 56 "
18 4 55 "	8 7 18 "	29 9 43 "
19 10 42 "	9 3 10 "	30 5 35 "
20 6 34 "	10 8 57 "	Oct. 1 11 22 "
22 12 21 A. M.	11 4 48 "	2 7 14 "
8 13 P. M.	12 10 36 "	3 3 05 "
23 4 04 "	13 6 27 "	4 8 57 "
24 9 51 "	14 2 19 "	5 4 44 "
25 5 43 "	15 8 06 "	

Phases of the Moon.

	Central Time. d h m
First Quarter	Aug. 4 7 27 A. M.
Full Moon	10 10 43 P. M.
Last Quarter	18 4 52 A. M.
New Moon	26 8 00 A. M.
First Quarter	Sept. 2 1 35 P. M.
Full Moon	9 7 53 A. M.
Last Quarter	16 10 49 P. M.
New Moon	24 8 42 P. M.
First Quarter	Oct. 1 7 33 P. M.

Phenomena of Jupiter's Satellites.

Central Time. d	h m			Central Time. d	h m		
Aug. 5	9 52	P. M.	I. Ec. Re.	Sept. 2	6 24	P.M.	II. Tr. In.
8	9 55	"	II. Tr. In.		8 57	"	II. Sh. In.
10	8 44	"	II. Ec. Re.		9 05	"	II. Tr. Eg.
11	8 21	"	III. Tr. Eg.	4	7 40	"	I. Oc. Dis.
	9 31	"	III. Sh. In.	5	6 34	"	III. Oc. Dis.
	10 20	"	I. Tr. In.		7 06	"	I. Tr. Eg.
	11 22	"	I. Sh. In.		8 22	"	I. Sh. Eg.
12	12 32	A. M.	I. Tr. Eg.		9 32	"	III. Oc. Re.
12	12 35	"	I. Sh. Eg.	9	8 55	"	II. Tr. In.
	7 40	P. M.	I. Oc. Dis.	11	8 33	"	II. Ec. Re.
	10 57	"	I. Ec. Re.		9 33	"	I. Oc. Dis.
13	8 08	"	I. Sh. Eg.	12	6 43	"	I. Tr. In.
18	8 31	"	IV. Ec. Dis.		8 01	"	I. Sh. In.
	9 03	"	III. Tr. In.		9 00	"	I. Tr. Eg.
	10 37	"	IV. Ec. Re.		10 18	"	I. Sh. Eg.
	11 59	"	III. Tr. Eg.		10 26	"	III. Oc. Dis.
19	9 29	"	I. Oc. Re.	13	7 34	"	I. Ec. Re.
20	6 38	"	I. Tr. In.	16	8 37	"	III. Sh. Eg.
	7 45	"	I. Sh. In.	19	8 38	"	I. Tr. In.
	8 55	"	I. Tr. Eg.	20	5 56	"	I. Oc. Dis.
	10 03	"	I. Sh. Eg.		6 08	"	II. Sh. Eg.
21	7 20	"	I. Ec. Re.		8 33	"	IV. Oc. Dis.
22	6 38	"	III. Ec. Re.	21	6 43	"	I. Sh. Eg.
24	8 56	"	II. Oc. Dis.	23	7 17	"	III. Tr. Eg.
26	6 36	"	II. Tr. Eg.	25	8 29	"	II. Oc. Dis.
	6 47	"	IV. Tr. In.	27	6 00	"	II. Sh. In.
	8 20	"	IV. Tr. Eg.		6 02	"	II. Tr. Eg.
	9 04	"	II. Sh. Eg.		7 51	"	I. Oc. Dis.
27	8 29	"	I. Tr. In.		8 44	"	II. Sh. Eg.
	9 40	"	I. Sh. In.	28	6 20	"	I. Sh. In.
	10 46	"	I. Tr. Eg.		7 20	"	I. Tr. Eg.
28	9 15	"	I. Ec. Re.		8 38	"	I. Sh. Eg.
29	6 27	"	I. Sh. Eg.	29	5 53	"	I. Ec. Re.
	7 44	"	III. Ec. Dis.		8 13	"	IV. Sh. Eg.
	10 39	"	III. Ec. Re.	30	8 20	"	III. Tr. In.

Note.—The meaning of Ec., is eclipse; Tr., transit; Oc., occultation; Dis., disappearance; In., ingress; Eg., egress; Re., reappearance; and Sh., transit of the shadow.

Annular Eclipse of the Sun June 27, 1889. We have not yet received any report of observations of the annular eclipse of the sun which took place June 27, 1889. Its path was principally through southern Africa and the Indian Ocean.

The Partial Eclipse of the Moon which occurred July 12, was visible only in Europe, Asia, Africa, Australia, the Atlantic Ocean and the easterly portion of South America.

Variable Star α Cephei. We have received Mr. J. E. Gore's paper on the variable star α Cephei which contains a series of observations from Sept. 1874 to Dec. 27, 1887, with interesting notes on the same and other information.

COMETS.

Comet e 1888 was observed in Bristol, England, on June 19 and 21; it was also observed by Professor Frisby, U. S. Naval Observatory, Washington, D. C., as late as June 23. This comet was discovered by Mr. Barnard of Lick Observatory, Sept. 2, 1888, and has been visible since that time. Its perihelion was passed in January of this year at the great distance of 169,000,000 of miles from the sun. Owing to this fact and the favorable position of its orbit, its period of visibility has been remarkably long. The comet is still in view, though exceedingly faint.

Ephemeris of Comet e 1888 by C. W. Crockett. From *A. J.* No. 195:

1889 G. M. T.	App. α	App. δ	log r	log Δ	Br.
	h m s	° ′ ″			
Aug. 1.5	19 52 37.8	− 3 35 58	0.45699	0.27621	1.9
2.5	49 23.9	3 46 34			
3.5	46 13.1	3 57 06	0.45963	0.28222	1.8
4.5	43 05.4	4 07 33			
5.5	40 01.1	4 17 55	0.46225	0.28870	1.7
6.5	37 00.3	4 28 11			
7.5	34 02.9	4 38 20	0.46486	0.29560	1.6
8.5	31 09.0	4 48 22			
9.5	28 18.7	4 58 18	0.46746	o.30288	1.6
10.5	25 32.1	5 08 07			
11.5	22 49.2	5 17 48	0.47006	0.31049	1.5
12.5	20 10.0	5 27 21			
13.5	17 34.6	5 36 46	0.47264	0.31838	1.4
14.5	15 03.0	5 46 02			
15.5	12 35.1	5 55 10	0.47521	0.32653	1.4
16.5	10 10.9	6 04 10			
17.5	07 50.5	6 13 01	0.47776	0.33488	1.3
18.5	05 33.8	6 21 44			
19.5	03 20.8	6 30 18	0.48031	0.34341	1.2
20.5	19 01 11.5	6 38 43			
21.5	18 59 05.9	6 47 00	0.48285	0.35207	1.2
22.5	57 04.0	6 55 08			
23.5	55 05.6	7 03 07	0.48538	0.36084	1.1
24.5	53 10.8	7 10 58			
25.5	51 19 5	7 18 40	0.48789	0.36969	1.1
26.5	49 31.6	7 26 14			
27.5	47 47.2	7 33 39	0.49039	0.37859	1.0
28.5	46 06.2	7 40 56			
29.5	44 28.4	7 48 05	0.49288	0.38751	0.9
30.5	42 53.9	7 55 06			
31.5	41 22.6	8 01 58	0.49536	0.39643	0.9

Elements and Ephemeris of Comet b 1889. The following are the corrected elements of comet *b* 1889, computed by Professor W. W. Campbell, of Detroit Observatory, Ann Arbor, Mich, as given in the *Astronomical Journal* No. 197:

ELEMENTS.

T = Gr. M. T. 1889 June 7.654619d
$\omega = 234° \; 55' \; 38''.1$
$\Omega = 310 \; 51 \; 41 .0$ } Ecliptic and Mean Equinox 1889.0
$i = 163 \; 53 \; 25 .2$
$\log q = 0.354458$
$q = 2.261817$

EPHEMERIS FOR GREENWICH MEAN TIME.

1889		α (h m s)	δ (° ′)	log r	log Δ	Br.
July	5.5	5 9 16	+ 12 11.8	0.3587	0.4948	0.88
	9.5	5 9 6	11 53.4	0.3600	0.4892	0.90
	13.5	5 8 46	11 33.5	0.3515	0.4830	0.92
	17.5	5 8 14	11 11.9	0.3631	0.4760	0.94
	21.5	5 7 30	10 48.5	0.3648	0.4682	0.97
	25.5	5 6 31	10 23.2	0.3698	0.4598	1.00
	29.5	5 5 15	9 55.7	0.3688	0.4506	1.03
Aug.	2.5	5 3 39	9 25.8	0.3710	0.4407	1.07
	6.5	5 1 41	8 53.2	0.3734	0.4300	1.11
Sept.	5.5	4 29 51	+ 2 54.7	0.3946	0.3319	1.59
Oct.	5.5	3 9 23	− 7 20.5	0.4208	0.2483	2.07
Nov.	5.5	1 15 17	− 15 58.3	0.4507	0.2973	1.44

[The brightness at date of discovery is taken as the unit.]

Comet c, 1889. Comet *c* 1889 was discovered by E. E. Barnard, astronomer at Lick Observatory, June 23.9499 G. M. T. in R. A. 1*h* 26*m* 54.4*s*; Decl. +48° 50′ 44″; daily motion +4*m* 24*s* in R. A.; −0° 34′ in Decl.

ELEMENTS.

T = 1889, June 20.115, Greenwich M. T.
$\omega = 59° \; 21'$
$\Omega = 271 \; 4$ } Mean Eq. 1889.0
$i = 31 \; 15$
$q = 1.1024$

EPHEMERIS.

Greenwich M. T.		R. A. (h. m. s.)	Decl. (° ′)	Light.
June	29.5	1 47 4	+41 51	0.92
July	3.5	2 5 48	43 40	
	7.5	2 24 20	45 11	
	11.5	2 42 30	+46 27	0.76

Light at discovery = 1.

Computed by Professor Leuschner, of Lick Observatory, from Lick Observations of June 23, 24 and 25.—*Sc. O. C.* No. 85.

Elements and Ephemeris of Comet *c* 1889 (Barnard). These elements and ephemeris were also computed by Professor W. W. Campbell of Ann Arbor.

ELEMENTS.

$T = 1889$ June 20.64221 Gr. M. T.

$= 60°$	54′′	57′.2	}	Ecliptic and Mean Equinox 1889.0
$\Omega = 271$	25	11 .2		
$i = 31$	21	23 .6		

$\log q = 0.049016$

$q = 1.119478$

Residuals (O−C) $\begin{cases} \cos \beta' \Delta\lambda' = +3''.5 \\ \Delta\beta' = +6''.0 \end{cases}$

EPHEMERIS FOR GREENWICH MEAN TIME.

1889	α	δ	log r	log Δ	Br.
	h m s	° ′			
July 27.5	3 50 29	+ 49 21.8	0.1027	0.1325	0.54
29.5	3 58 7	49 32.7	0.1078	0.1363	
31.5	4 5 33	49 41.7	0.1130	0.1401	0.50
Aug. 2.5	4 12 45	40 48.9	0.1184	0.1436	
4.5	4 19 44	49 54.4	0.1238	0.1471	0.46
6.5	4 26 29	49 58.3	0.1293	0.1503	
8.5	4 33 0	50 1.0	0.1349	0.1534	0.42
10.5	4 39 17	50 2.3	0.1405	0.1563	
12.5	4 45 20	20 2.6	0.1462	0.1591	0.38
14.5	4 51 9	50 1.9	0.1519	0.1616	
16.5	4 56 43	+ 50 0.2	0.1577	0.1641	0.36

—*Astronomical Journal.*

Comet d 1889. From a dispatch received July 7, it was announced that a new comet had been discovered by W. R. Brooks, of Geneva, N. Y. The date of discovery was July 6, 12*h* 30*m* Washington M. T.; its place R. A. = 23*h* 45*m*
Decl. = −9° 9′

The comet appeared to be one minute of arc in diameter, slightly elongated and as faint as an 11th magnitude as observed by Mr. Barnard July 8.

July 6, Professor Swift, of Rochester, N. Y., announced the discovery of a comet in R. A. = 22*h* 52*m* 28*s*
Decl. = +0° 49′

It is probable that the last observation is a re-discovery of comet *e* 1888.

Elements and Ephemeris of Comet d 1889, *by S. C. Chandler.* Just before going to press we received by telegraph, from Harvard College Observatory, the elements and ephemeris of comet *d*, computed by S. C. Chandler, of Cambridge, Mass.:

ELEMENTS.

Time of perihelion passage = Aug. 3.40 Greenwich M. T.

Dist. of perihelion from node	= 311° 24′	Mean Equinox 1889.0
Longitude of node	= 28 13	
Inclination of Orbit	= 5 56	

Perihelion distance = 0.3627

EPHEMERIS.

Date.	R. A. h. m. s.	Decl. ° ′	Light.
July 27.5	0 1 55	−7 19	1.25
July 31.5	0 4 13	−7 03	
Aug. 4.5	0 6 8	−6 48	
Aug. 8.5	0 8 40	−6 34	1.40

Light at the time of discovery taken as unity.

From the message we could not be quite sure of the dates of observations from which the above elements were computed. If we mistake not, they were July 8 for the first, and July 10 for the second and third.

Comet e 1889 (*Davidson*). July 25, a telegram was received from Harvard College Observatory announcing the discovery of a bright comet by Davidson of Queenstown, July 21. The position for July 22.9610 was R. A. 12*h* 46*m* 09*s*.0; Decl. south 32° 29′ 06″; daily motion east 11*m*; north 2° 48′. This rapid motion to the north and east will soon make its position favorable for observation in northern latitudes, if the direction of its path be rightly anticipated.

Sun-Spot Seen by Naked Eye. Saturday evening, June 22, while on an outing down the Potomac river, I noticed during a very red sunset a sun-spot of great magnitude distinctly visible to the naked eye. Its apparent magnitude was such that I could scarcely believe it a solar appendage. On Thursday following (the first clear day) I observed the spot with the telescope just as it was disappearing on the west limb of the sun. W. E. W.

Report of Astronomical Observatories for 1886. The usual reprort on Astronomical Observatories for the year 1886 has just come to hand. It was prepared for the Smithsonian Report for the same year by George H. Boehmer, and is in the usual form, covering 116 pages.

Minor Planet No. 284 was discovered May 29 by M. Charlois at the observatory of Nice.

Bright Meteor. I noticed in your June number a description of a brilliant meteor seen by Frank Soule at Students' Observatory, at Berkeley, Cal., May 15 of this year, which, as he says, pursued a southerly course along an arc drawn through the stars Gamma and Alpha Leonis and seemed to disappear at a point half-way between Regulus and Hydra. Then he says that it immediately reappeared pursuing a course irregurlarly from east to west disappearing to the north of Hydra, etc; that its brilliancy was that of Saturn, but its size was that of Venus at its greatest brilliancy. This at 8:40 P. M. Pacific meridian.

On the same evening (as I find by comparing notes) at about 10:30 P. M. meridian of Washington, I saw a very bright meteor pursuing a *southwesterly* course in the direction, I should judge, of the star Gamma, and disappearing very near the western horizon. It had almost precisely the glow of Saturn, but the size of Venus as shining at that time of the month. Its motion was very rapid, and had I not been looking in that immediate direction, it would probably have escaped my notice notwithstanding its brilliancy.

As the description corresponds very closely with that seen by Professor Soule, can it be identical, considering even the long distance across the continent? E. J. BROOKINGS,

Washington, D. C., June 10, 1889.

Queries with Brief Answers.. 19. When does the next century begin? A. B. C.

In astronomical time Dec. 31, 12 *h*, 1899; in civil time 12 hours earlier, if we call the 365th day of 1899 the 0 day of 1900.

20. There is daily change in the right ascension and the declination of the stars; is it irregular in both? Is it periodical in one or both?

It is irregular in both; it is periodical in both so far as luni-solar precession is concerned. Planetary precession affects the right ascension of the stars, not their declination. There are also conditions of secular change in the star coördinates. (See Chauvenet, Vol. 1, ch. xi.)

21. What are the properties of the Jena glass that make it superior to the old kinds? J. C.

We suppose it is meant to ask what are the advantages of the Jena glass for optical purposes over those kinds in common use.

The persistent and troublesome defect in the so-called achromatic lens is the secondary spectrum, due to the fact that the lens does not focus all refracted rays at the same point; hence images formed have traces of color arising from this cause. By using different kinds of glass opticians are able to bring together two widely differing rays of light, as the red of the line C of the spectrum and the blue of line G, but it by no means follows that the same two pieces of glass will bring together in a focus all other rays. On the contrary, owing to what is called the "irrationality of dispersion," the color correction has never been complete. Some opticians have tried to remove this color entirely by using three lenses of different media but with partial success only. In 1881 Professor Abbé and Dr. Schott undertook the study, chemically, of a wide range of substances from which a perfect glass for optical purposes could be made. In 1883 their work seemed to be narrowed to two problems: one of which was to make pairs of kinds of flint and crown glass, such that the dispersion in the various regions of the spectrum should be, for each pair, as nearly as possible proportional. The object of this was to diminish the secondary coloring effects inseparable from the irrationality of ordinary silicate flint and crown glasses. In this study these distinguished Jena physicists have been so successful, it is claimed, that color correction is practically reduced to zero in the new glass disks they make, and that the foci for visual and for photographic purposes are the same. The first point, we believe, is generally admitted in the case of small lenses; large ones have not yet been made of the new glass. The second point possibly needs confirmation.

22. Are the satellites of Mars of meteoric origin, or will the nebular hypothesis account for them? L. F. C.

The nebular hypothesis alone will not account for a period of revolution of satellites that is shorter than that of the primary planet. But it is claimed by some physicists that the tides are constantly lengthening the period of rotation of the primary planet and that in this way the time of revolution of the inner satellite of Mars has become shorter than the planet's day. Some European astronomers favor this view, but concurrence in it does not yet seem to be general. The supposition of a meteoric origin is less probable.

23. What is the cause of the polar filaments in the corona of the sun as seen in the January eclipse? P. W.

24. What is the cause of the shadow bands seen during the period of totality of the solar eclipse? P. W.

25. What are the relative merits of refracting and reflecting telescopes of the same aperture? A. B. D.

26. In Chambers' Astronomy (p. 6.) we find the statement that the solar heat is sufficient to raise the temperature of an ocean of fresh water 60 miles deep from freezing point to boiling in one year. Do later studies of solar heat verify that assertion? W. & M.

27. In No. 74 S. M., Professor Swift, speaking of the double star, Castor says, "the two stars, nearly equal in magnitude, have moved so little during the last hundred years that astronomers are in doubt whether the motion is orbital or not." Is not the orbital motion of this star absolutely certain? W. H. S. M.

28. Is not the statement in the text-books on astronomy that sunlight is 800,000 times greater than full moon-light manifestly wrong? Common observation would say that number is 1,000 times greater than it should be. I. C.

29. After studying Pierce's Analytical Mechanics, I think that if the pendulum of a clock were to swing in a vacum of uniform temperature the error of the clock would be a minimum. Have clocks been tried in this way? A. J.

30. In what constellation is star 1830 Groombridge? Can it be 'picked up' from its position in reference to other stars without use of an equatorial? S. W. F.

31. What causes Mercury and Venus to form the black drop in transit? F. D. B.

32. I have been trying to observe the red spot of Jupiter without success. What is its position, size and color?

L. F. C.

33. Can you refer me to any source from which I can get a record of sun-spots for the last maximum period? C. E. B.

EDITORIAL NOTES.

Contrary to expectation, we publish for August instead o September, because we have recently received some matter that ought to appear sooner than we had previously planned for our next issue. Hence our readers will please bear in mind that the next MESSENGER will be for October, and be mailed the last days of the preceding month as usual.

Mr. Lockyer's Meteoric Theory. We have been greatly interested in the researches of Mr. Lockyer, and the new theory which he is now working out in detail. The results foreshadowed are so new and revolutionary in kind that those in the well worn paths of science will hesitate to accept them until they have had opportunity to give the evidence on which they rest for support careful and severe scrutiny. This is right; the discoverer can afford to wait, and the scientist must know for himself before he can rationally accept radical doctrine that is new. The leading article in this number by Professor Young, setting forth late work by Dr. Huggins, is exactly in line of this thought, and if we mistake not, his positions against Mr. Lockyer's identifications are very strong, if not absolutely conclusive. It looks as if Dr. Huggins had picked out some weak points in the new theory that will trouble its author to answer. Spectroscopists will follow this discussion with deep interest.

Determination of the Magnifying Power of Eye-Pieces.— The following is a very simple and accurate method of finding the magnifying power of any eye-piece by measurement of the small circle of light seen in the eye-piece when the telescope is pointed at the sky.

Almost every mechanic now-a-days has one of those very accurate little micrometer calipers, or wire gauges, by Browne and Sharpe. When new the jaws of the instrument are finely polished, and if it be laid upon the eye-piece with the circle of light between the jaws, by moving the eye a little from side to side, three circles will be seen, the true one and a reflected image of it in either jaw. Now by moving the caliper and its screw, the true circle can be made tangent to both its reflected images at the same time. The reading of the screw will now be the true diameter of the circle, and it only remains to divide the aperture of the object glass (or mirror) by this reading to know the magnifying power of that particular eye-piece. The measurement can be made with great nicety, two successive readings rarely differing by more than 0.001 inch, and the result is as accurate as can be obtained by a much more expensive dynamometer. C. C. HUTCHINS.

Bowdoin College, May 31, 1889.

Mean Scottish Meteorology for the last thirty-two years is the title of a publication recently issued by C. Piazzi Smyth, late Astronomer Royal for Scotland. The first part of this volume has 31 chronological tables of mean Scottish meteorology, month by month, for the entire period of the thirty-two years, beginning with 1856 and ending with 1887. Following the tables are fourteen full page lithograph plates showing the results of observations projected in curves in various ways for ready comparison. The purely meteorological part of this volume is very instructive; but we were, naturally, more interested in the deductions that pertain to solar phenomena. Four points are briefly discussed which ought to be more fully reported than our space, now, will allow. They are, (1) supra-annual cycles of weather and solar phenomena, (2) temperature, barometric range and sun-spot, (3) details of sun-spot cycles, and (4) aurora, lightning and sun-spots. The curves representing solar waves for the three periods under special study are so interesting that we have ventured to ask Professsor Smyth to prepare an article covering those topics with appropriate graphic representations to assist the eye in their careful study.

The concluding article is upon eight years' observations of the new earth thermometers at the Royal Observatory, Edinburgh, 1879 to 1888, with tables and graphic illustrations as already described.

Electric Light for Observatory Instruments. Mr. F. G. Blinn, East Oakland, Cal., in a recent letter, says: "The use of the miniature, incandescent electric lamp is a delightful change from the greasy, uncertain bull's-eye lantern, for the purpose of illuminating the field of the transit instrument. One disadvantage, however, attending its use is the need of frequent renewal of battery material, and continued care of the cells when the lamps are less used, to be sure that light will be forthcoming when wanted. It would seem that a miniature dynamo driven by a sewing machine water motor would be a desirable acquisition to the Observatory, and if the attention of the manufacturers of electric light appliances could be directed to this subject, it might result in benefit to those who use astronomical and microscopical instruments.

There is probably a water supply under pressure within the reach of most Observatories, and as one horse-power will give out about 320 candle-power through sixteen lamps it would seem to be an easy matter to develop a sufficient current with this device. One-fourth or one-eighth candle-power is sufficient for the needs of an observer, and by a well arranged switch system it is an easy matter to use such a light."

Optical Plane Surfaces. The physicists who are wrestling, at the present time, with the problem of standards for measurement have so taxed the finest known optical apparatus in pushing researches for better results, that work had to be stopped, because, apparently, the optician could not meet the demands made on him for more perfect apparatus. We learn with great pleasure that Mr. J. A. Brashear, of Allegheny City has overcome the very difficult task of making plain optical surfaces that are so perfect that some of the best physicists in this country pronounce them superb and the best they have ever seen. Mr. Brashear's optical work is commanding wide and very favorable notice.

Measuring Lunar Radiation. We have received an interesting paper entitled "An Account of a New Thermograph, and of Some Measures in Lunar Radiation," by C. C. Hutchins, assisted by Daniel Edward Owen. Extracts from this paper, with a cut of the new instrument, will be given in our next issue.

Spectrum of Uranus. At the July meeting of the Royal Astronomical Society, Mr. Taylor read a paper on "Observations of the spectrum of Uranus." On May 16, 1889, with direct-vision spectroscope attached to the 5-foot reflector at Mr. Common's Observatory at Ealing, England, bright flutings were detected in the red, orange and green in the spectrum of Uranus, and also four dark bands in the orange, green, greenish blue and blue respectively. No trace of solar lines. The bright flutings would indicate that the planet to some extent is luminous. Dr. Huggins, however, has succeeded in solving the question of the existence of solar lines in the spectrum of Uranus by the aid of photography. On the 3rd of June, with an exposure of two hours, he got a fine spectrum extending from about F to N in the ultra violet, in which all the principal solar lines were distinctly seen. The observed and photographed spectra, though seemingly in conflict, are not necessarily so, as spectroscopists readily understand. Both give evidence of value concerning the physical constitution of the planet Uranus.

After the sketch of the life of the late Professor William Tempel, published in June, was in type, we received a translation of the same article by Mrs. C. W. Dunn, Florence, Italy, wife of the assistant to Mr. Tempel in the Observatory at Arcetri. This translation of Schiaparelli's article from the Italian was furnished in answer to our request to Mr. Dunn to give us some account of Professor Tempel's work for publication. Mrs. Dunn's rendering of the Italian was so much better than that which we used that we were sorry that it did not come to hand earlier. The MESSENGER gratefully acknowledges the kind courtesies of these friends and heartily joins them in revering the name of another of earth's honored and departed ones.

White Spot on the Ring of Saturn. We notice that Professor Hall, of the U. S. Naval Observatory, Washington, D. C., carefully observed the so-called white spot on the ring of Saturn between dates March 13 and 15. He says it looks to him like the effect of contrast between the shadow and the surface of the ring, such as has been noticed before. In high powers on the 26-inch equatorial the region becomes less distinct. For observers generally it is difficult to see when attention is called to its exact locality.

W. C. Winlock, formerly assistant Professor of Mathematics in the U. S. Naval Observatory, Washington, D. C., has recently been appointed Chief of the Bureau of International Exchanges, at the Smithsonian Institution, the position being made vacant by the death of Dr. Kidder. This will afford Mr. Winlock the best of opportunities for pursuing the bibliography of astronomy, one of his favorite lines of study. Our next issue will contain his first communication in line of such matter.

Mr. Albert Howard, general manager of the E. Howard Watch and Clock Co., Boston, Mass., in a recent very courteous letter seeks to set us right regarding an error in last month's issue in which reference was made to Mr. Gerry, a former employé of his company. On page 273, we said, "The escapement was invented by Mr. Jas. H. Gerry who was, for a number of years, the foreman of the Howard Clock Co., Boston," Mr. Howard says: "This statement relating to Mr. Gerry's foremanship of the Howard Clock Co., is entirely misleading. The clock and watch factories have always been two separate departments and under entirely different managements, with the exception of having the same general manager. Mr. Gerry's position while in the employ of E. Howard & Co. was that of superintendent of the watch department, and he was in no wise connected with the invention or construction of clocks or regulators."

Measures of Double-Stars and other observations made at Haverford College Observatory under the direction of F. P. Leavenworth is the title of a neat publication just received. The micrometrical measures of double-stars were mostly made during 1888 with a Clark 10-inch refractor, and the power of single eye-piece used was 375. The stars chosen for measure were those of Burnham and Struve in which motion has been detected.

L'Astronomie (French), by Camille Flammarion, for July, has for its leader a description of the Lick Observatory by Professor Holden, the Director. The article fills eight pages, and is handsomely illustrated by five large engravings.

Trees along the Canals of Mars. Our note last month on astronomical heresy in the Chicago *Tribune* causes our excellent friend, Professor Colbert, to send us the following, which was published in the *Tribune* May 25, and before our note appeared in THE MESSENGER:

A Canadian who has alternately posed as a propounder of alleged astronomical discoveries and a weather prophet is announced by telegraph as saying he has discovered the earth to be receding from the sun, and considers it the greatest astronomical event of the century. He quotes as proof two well-known facts—namely: the precession of the equinoxes and the moon's secular acceleration. He says the recession of the earth from the sun makes her less and less subject to solar attraction. For this reason our globe is expanding, its oceans are gradually becoming more shallow, and the time is coming when it will be necessary to carve up its continents by canals, as is already done by the inhabitants of the planet Mars, who have planted trees along their banks to produce (attract) moisture from the atmosphere. There is no occasion for alarm as a consequence of these dire forebodings. The mathematics of the solar system were investigated long ago, and the principal facts of motion by the earth in her orbit are known with precision and certainty, not only for the present, but for many millions of years. There is no appreciable widening out of the earth's mean distance from the sun, and one of the neatest pieces of work doné by the mathematical astronomers nearly a century ago was the demonstration that the disturbing influence of other bodies in the system, having once acted to increase the mean distance from the sun, could produce no further alteration in that respect. It is true the eccentricity of the earth's orbit is at present decreasing and will continue to do so for many thousands of years, this fact producing about half of the observed acceleration in the orbital motion of the moon. But it is easily shown that the disturbing force of the sun on the moon, and also that upon the waters on the earth's crust, could never be decreased by more than about one part in 3,400 of its present value. A more involved process of reasoning proves the decrease will change to an increase far inside the limit named. The precession of the equinoxes, being due to the disturbing forces exerted on the earth's equatorial protuberance by the sun and moon, will vary slightly as a consequence of this change, but has no more to do with causing or indicating a continuous widening out than the planets have to do with changes in our weather.

The Scientific American (July 20) favors its readers with a biographical sketch of the life and work of the late Maria Mitchell, so well and favorably known in scientific circles for nearly half a century. The honors done this distinguished lady while visiting abroad, and, in later years, at her home, are proofs of merit that Vassar College may well be proud of. Her place at the head of the Vassar Observatory is apparently a hard one to fill.

Orbital Motion of Sun and Stars. Concerning the theory that the sun is revolving as a planet around some star in obedience to the Newtonian law of gravity, it may be pointed out that a star at the distance of the nearest known fixed star, having a mass equal to the sun's, would, basing calculations upon certain masses and distances given in text-books of astronomy, attract the sun with a force equal to about $\frac{1}{2872}$ that of the sun's attraction for Neptune. At the average distance of stars of the first magnitude the controlling star would need to have a diameter equal to thirty-eight times that of the sun, assuming equal densities for both bodies, with a corresponding mass, to enable it to attract the sun with a force equal only to that necessary for the sun to exert to hold Neptune in its orbit. And if we go one step further and multiply this augmented mass by the number by which the sun exceeds Neptune in mass, a proceeding consistent with the theory in question, it would have a diameter approaching that of Jupiter's orbit.

If a spherical shell be conceived concentric with the supposed governing star and passing through the sun, it would probably inclose other stars, all of which together, possibly with some stars without the shell, must also be moving with the sun around the central star, otherwise there would be apparently an entangling of systems dangerous to many suns.

E. B. WHITMORE.

Rochester, N. Y.

We do not wonder that Mr. Whitmore finds difficulty in accepting the theory of orbits for the sun and stars which he seems to have thought upon carefully and well, and which is advanced in elementary text-books on astronomy. Late astronomy does not sustain that theory. There are no proofs that the motion of the sun or stars is orbital, when independently considered, except in the case of multiple stars, and, possibly, some clusters of stars. Every star attracts every other according to a well-known law, and hence individual stars must obey all these separate forces drawing one another with varying intensities at the same time in all possible directions. Hence the path of any star in space can not follow the law of any known curve, neither can it be an absolute straight line. The probabilities of the case are that their motions are irregular and widely dissimilar.

Refraction of Magnetic Radiation. *Knowledge* for July speaks of the study of Dr. Hertz, in relation to the "phenomena of reflection and interference of ether waves due to electro-magnetic radiation. By means of a prism of pitch he has more recently obtained an experimental proof of their obedience to the laws of refraction. Professor Oliver Lodge has gone a step further. In a paper read before the Physical Society he described a series of experiments he had carried out in conjunction with Dr. J. L. Howard, in which they had employed a pair of plano-convex hemi-cylindrical lenses, made of the best comercial pitch. With these lenses they performed such experiments as would be made with a beam of light and similar lenses of glass. The lenses were 85 centimeters high, 90 centimeters broad, and 21 centimeters thick, each weighing about 300 pounds. Dr. Lodge found that the results obtained with them were throughout in complete agreement with those of Professor Hertz."

Astronomy by Observation. We have received specimen pages of the book entitled "Astronomy by Observation" by Miss Eliza A. Bowen, Messrs. D. Appleton & Co., publishers. The first edition of this book was published in 1885, if we are rightly informed. It is now being revised and the specimen pages speak well for the new edition.

Himmel und Erde is the name of a comparatively new monthly publication by Dr. M. Wilhelm Meyer, of Berlin, which is devoted to astronomy and kindred sciences. We have as yet had the pleasure of seeing only the April number. It is in German, with the English letter, small quarto form, neatly illustrated, and has a scholarly appearance every way. Its leading article on the Norwegian North Sea Expedition is by Professor Dr. H. Mohn.

Mr. Ambrose Swasey of the firm of Warner & Swasey, makers of astronomical instruments, Cleveland, Ohio, is now traveling in Europe. He first visits Paris, then spends five or six weeks in a circuit through Italy, Switzerland and Germany. He has plans for visiting all the observatories he can find on the way, to make special studies of their latest improvements in instruments. He will return about October first.

Observatory at Kasan, Russia. By the courtesy of Professor D. Donbiago, the Director of the Observatory at Kasan, Russia, the Carleton College Observatory library has received Tomes I (1885) and II (1887) of the observations of stars *de la zone entre* 75°· *et* 80° *declinaison boreale.* The Director of Carleton Observatory extends cordial thanks.

Origin of the Binary Stars is the title of a thesis prepared by T. J. J. See of the Missouri University, Columbia, Mo. The gist of this paper is to show that the general theory of cosmic tides by Professor G. H. Darwin on the origin of the moon is sufficient to explain the origin of the binary stars. The plan of the paper is a good one.

Latitude of Ann Arbor Observatory. In giving the recently determined latitude of the Observatory at Ann Arbor, Michigan, in our last number (p. 285), we inadvertently wrote the position of the instrument with which the observations were made. To that should have been added the difference of latitude for the dome of the Observatory proper, making the deduced latitude 42° 16′ 48″.66. The value which Professor Watson used, we believe, was 42° 16′ 48″.3; but we notice the Nautical Almanac has 42° 16′ 48″.0. Mr. Schaeberle's opinion heretofore has been, as we are told, that 48″.0 was too small. Mr. Estes is not informed how the American Ephemeris came to have the last named value.

The June Century Magazine has an agreeable surprise for those interested in astronomical biography in an illustrated article entitled, "An American Amateur Astronomer," written by John Fraser. The subject of the sketch is S. W. Burnham, astronomer at Lick Observatory, and is a short account of some of the excellent work for astronomy done by Mr. Burnham, mainly at leisure moments, while regularly following a business vocation. The article is a good one; we wish it were longer, setting forth his varied studies more in detail.

Professor C. S. Hastings of the Sheffield Scientific School, New Haven, is now spending some time in France according to plans of last month.

Honor for E. E. Barnard. The degree of A. M. was conferred upon Mr. E. E. Barnard, of the Lick Observatory, by the University of the Pacific, on May 23, 1889, in recognition of his services to astronomy during the past year. It is an honor well deserved.

BOOK NOTICES.

A Text Book of General Astronomy for Colleges and Scientific Schools, by Charles A. Young, Ph. D., LL. D., Professor of Astronomy in the College of New Jersey, (Princeton). Boston: Messrs. Ginn & Company, Publishers, 1889. pp. 551.

We have already spoken briefly of this book, but by no means as fully as it deserves. We used the text in class, in the proof-sheet form, less than one year ago, and so have tested it somewhat in the place it was primarily designed to fill. From knowledge of its distinguished author, our expectation regarding the merit of the book was high, and as a teacher, and careful student of it, we have been disappointed by it in no important particular.

This book is now so well known in scientific and higher educational circles that extended notice for such readers is unnecessary. What we may say of it is intended more particularly for the general reader of the MESSENGER who may not have had his attention called to it before. To such we commend it as one of the few books in behalf of astronomical science that should have place in every library. We think so because it contains a complete setting forth of the whole field of modern astronomical science; because it distinguishes so sharply and well between what is known as fact on the one hand, and mere fancy or theory on the other; because the spirit of the book is that belonging to true science, and not dogmatism or irreverence, and because its language is usually so plain and direct that the reader is unhindered by the many technical terms that often needlessly encumber books of this kind. Ripe scholarship has little need of, or small use for, so much that is technical, so called, in giving general instruction. As is true of all that Professor Young writes, we find in this book no display of rhetoric, no attempt to finish sentences nicely, but simply and constantly a purpose to state facts and principles plainly, definitely, and in exact accordance with the truth as far as that is known.

In the new issue of this book, now just through the press, opportunity has been taken to correct a number of errors and misprints that were detected in the first impression, so that in detail, the work of this book is abmirably done, and it fully deserves the hearty reception that it is everywhere receiving. We are also pleased to say that the publishers have given the book a very neat and substantial dress, for which those who use it will be constantly grateful.

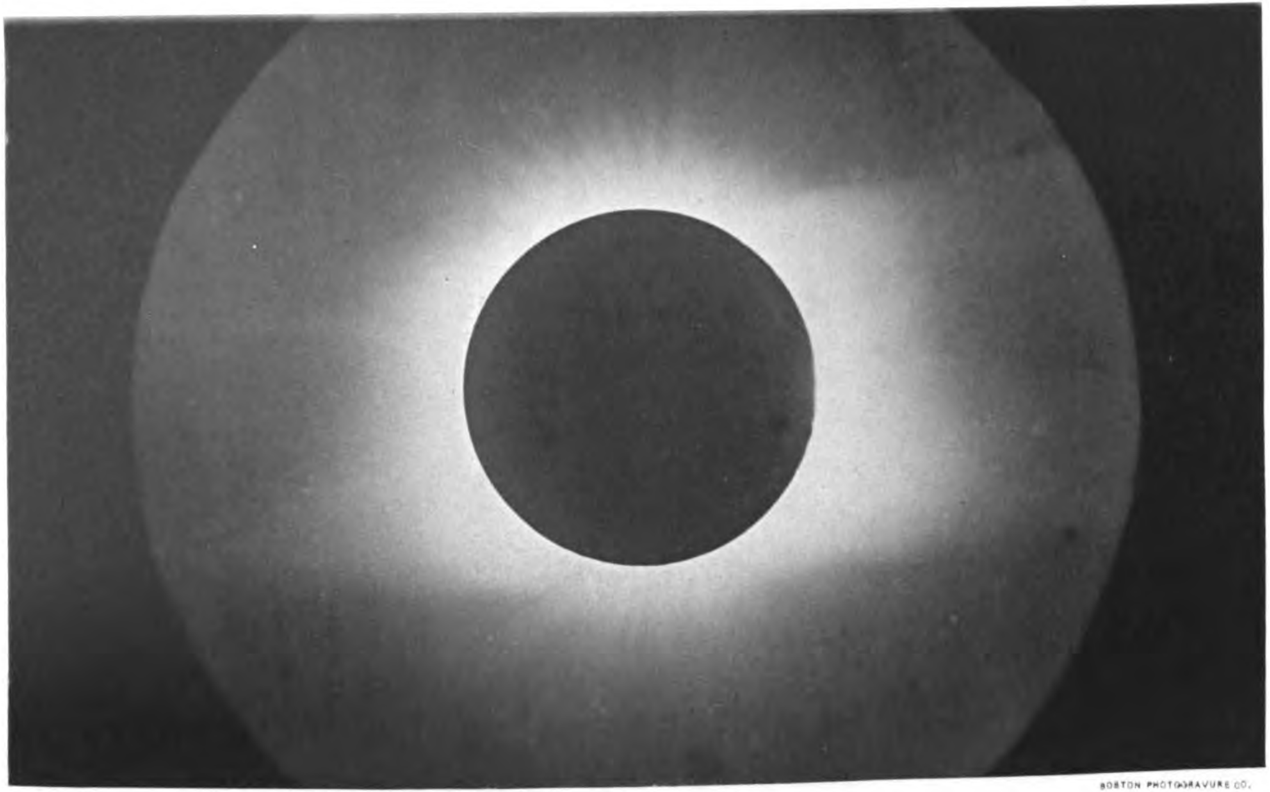
Astronomy with an Opera-Glass. A Popular Introduction to the study of the Starry Heavens with the simplest of Optical Instruments. With Maps and Directions to facilitate the recognition of the constellations and the Principal Stars visible to the naked eye, by Garrett P. Serviss. New York: Messrs. D. Appleton & Co., Publishers, 1888. pp. 154.

This book is the result of some faithful work to bring together, in useful way, a series of celestial objects for study by the aid of the opera-glass. It is intended for those who have not the advantage of more powerful optical instruments and yet who desire to continue observational study of the heavens. In giving attention to this way of studying astronomy Mr. Serviss has done real service to the science. It is helpful to the beginner to know how to select a good opera-glass and then to be told what he can do with such an instrument. He needs help just at this point, and we may be sure that the earnest student with such needed judicious direction will find his way onward rapidly.

This book contains five chapters titled respectively: The Stars of Spring, Summer, Autumn, Winter, and the last, the Moon, Planets and the Sun.

The text is a description of the constellations with appropriate maps presenting to the eye the place and relation of the prominent celestial objects to which attention is called. The outlines of the constellations are given in these maps, but not the figures of the earlier star charts.

One of the best things about this book is the fact that its author has made observations with the opera-glass of all the objects he describes, and so speaks definitely of what he himself has seen. In this day of large telescopes, humble workers are in danger of forgetting what immense strides in astronomy were early made, by the aid of the opera-glass, in the lands of Argelander, or, in the present decade, in the study of the variable stars, by the industrisous Chandler.



BOSTON PHOTOGRAVURE CO.

TOTAL SOLAR ECLIPSE. JANUARY 1, 1889.

THE SIDEREAL MESS...

CONDUCTED BY WM. W. ...

... OF CARLETON COLLEGE OBSER...

VOL. 8, NO. 8. OCTOBER ...

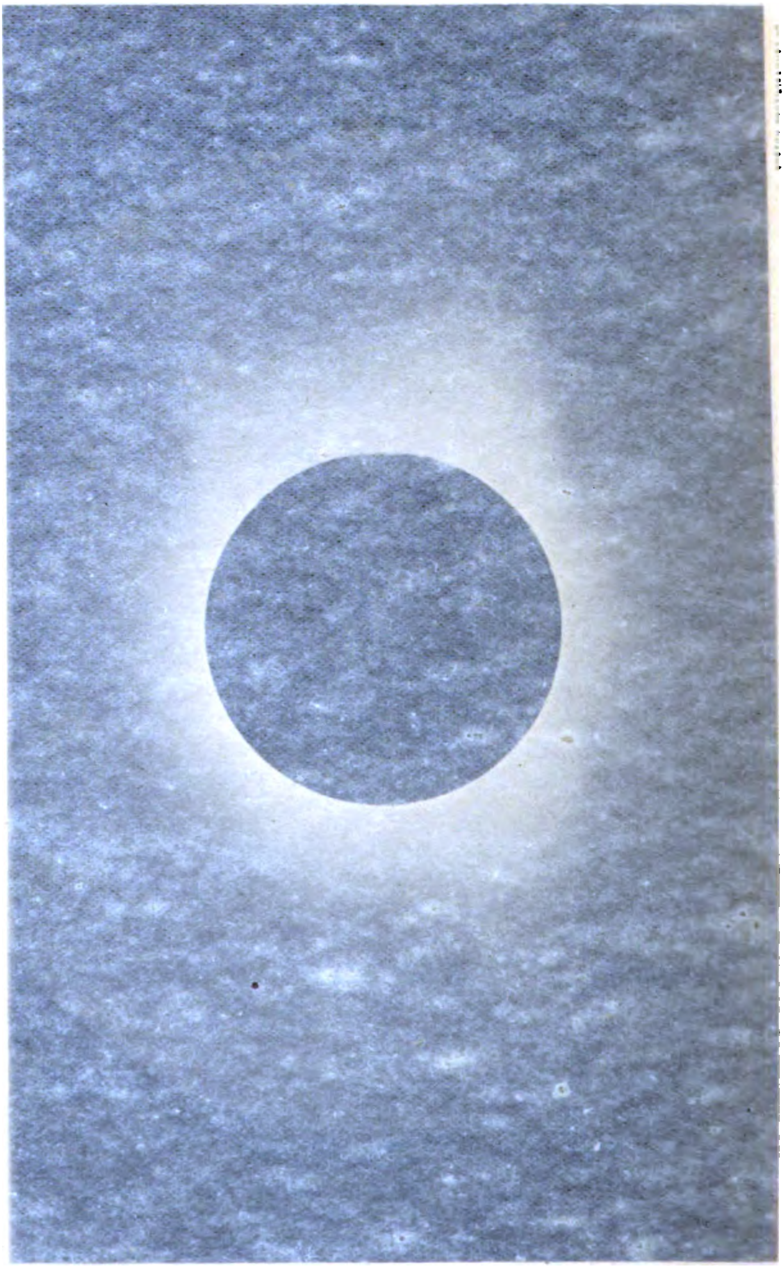
THE TOTAL SOLAR ... OF JANUARY

... PICKERING.

For THE MESS...

The frontispiece accompanying this numb... ative of the corona taken with the thirteen ... tographic telescope belonging to Harvard Co... tory. No e... ment is used in the repro... on the original scale of 42".4 to one mi... oriented that the north point of the coro... bottom of the picture, the middle circle of dec... nearly parallel to the edge of the plate. The neg... tive was taken on a Seed plate ... with an exposure of two seconds. It was taken ... treme end of totality, and the sun had already ... appear around the western limb of the moon. It is ... that the sun came out only a minute ... before the exposure was closed ... otherw... have been ... As it is, no ... on the negative, as shown by the ... e disc of the moon ... the other ... quite ... ill... the ... ring as a well defined ring ... corona ... at prese... disproval by means of photog... any considerable body ... sun.

It is also on account of this diffuse... no advantage to be gained by us... than those at present employed for the ... tography. If the inner co... t from the sun than we are at p... is perhaps doubtful, we shall ...



THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 8, NO. 8. OCTOBER, 1889. WHOLE NO. 78.

THE TOTAL SOLAR ECLIPSE OF JANUARY, 1889.

WILLIAM H. PICKERING.

For THE MESSENGER.

The frontispiece accompanying this number is from a negative of the corona taken with the thirteen-inch visual photographic telescope belonging to Harvard College Observatory. No enlargement is used in the reproduction which is on the original scale of 42″.4 to one millimeter. It is so oriented that the north point of the corona is towards the bottom of the picture, the middle circle of declination being nearly parallel to the edge of the plate. The original negative was taken on a Seed plate, sensitometer number 26, with an exposure of two seconds. It was taken at the extreme end of totality, and the sun had already begun to appear around the western limb of the moon. It is probable that the sun came out only a minute fraction of a second before the exposure was closed, as otherwise the plate would have been badly fogged. As it is, no trace of fog appears upon the negative, as is shown by the perfect transparency of the disc of the moon. On the other hand the sky around is quite brilliantly illuminated, the field of the telescope appearing as a well defined ring. It is this outer structureless corona which furnishes at present the chief impediment to the disproval by means of photography of the existence of any considerable body revolving between Mercury and the sun.

It is also on account of this diffuse illumination that there is no advantage to be gained by using more rapid plates than those at present employed for this class of coronal photography. If the inner corona really does extend further out from the sun than we are at present able to photograph, which is perhaps doubtful, we shall approach nearer its limits by using plates giving greater contrast, not greater sensitiveness. Most of my photographs with this instrument were taken on Carbutt H plates, which give much stronger contrasts than the Seed, and enable one to make a much better study of any given part of the corona; the short exposures being suitable for the inner portions, and the long exposures for the outer. But for a general view of the whole corona, one needs a plate giving less contrast, but greater range. A negative taken upon a Seed plate was therefore employed for the present purpose.

The prominent feature of this corona is the great ring of light lying nearly in the plane of the ecliptic, whose cross sections we see to the east and west of the sun. This has now for the third time been shown as characteristic of the sun during its quiescent state. On both sides this ring is seen to be distinctly cleft into two portions, a northern and a southern one, the dividing notches coinciding nearly with the sun's equator. On the original negative these sections are seen to be striped by curved lines and rays, whose general direction is radial. Some of the stronger of these are faintly shown in the reproduction. After the double ring the most prominent features of the corona are the two sets of polar rays, some of which in the northern group extend to the length of four hundred. thousand miles. These rays are frequently slightly curved, being convex to the pole, and seem to radiate from two points on the polar axis, situated about one hundred and fifty thousand miles below the surface. The rays furthest from the pole are in general the most curved. In the original negative one can see the chromosphere extending around the western limb of the sun through 140°, and rising three thousand two hundred miles above its surface. Unfortunately in the reproduction this could not be shown at the same time as the outer portions of the corona. Several protuberances are also visible upon the negative, including one completely detached from the limb.

Twenty-nine observers were occupied in manipulating the different instruments at the time of the eclipse, and the same plan of organization as that first tried at Grenada in 1886 was employed. One man furnished with a metronome was charged with counting seconds for the rest of the party, beginning the moment he received the signal of totality. The other observers were stationed at the different instruments, and each had his own particular piece of work to perform. Thus the plate-holders were inserted in the thirteen-inch telescope by Mr. E. T. King, the exposures were made by Mr. E. Lehorn, the seconds were counted by Mr. Dexter, and the times at which the lens was capped and uncapped were recorded by Messrs. Carter and Eilerman. Finally, the plates were developed by myself. In all between forty and fifty negatives were secured, which will furnish enough material for many months' computation and study.

THE LICK OBSERVATORY EXPEDITION TO OBSERVE THE SOLAR ECLIPSE OF DECEMBER 21, 1889.

EDWARD S. HOLDEN.

For The Messenger.

The Editor of The Sidereal Messenger has asked me to contribute a full statement of the plans which will be followed in the observations of the solar eclipse of next December, and I am very glad to accede to his polite request. The eclipse of last January was observed by a party from the Lick Observatory and the results there obtained seem to be both interesting and important. The report of this work has been in type for some time and will shortly be in the hands of those interested. Therefore I will content myself with a mere reference to this work.

A very important result of the eclipse observations of January, 1889, was the discovery of a remarkable extension to the outer corona. This is shown on the negatives of the Lick Observatory by Mr. Barnard, on those of several of the California amateurs (especially on the negatives of Messrs. Ireland and Lowden), and also on the beautiful negatives of P. Charroppin who was attached to Professor Pritchett's party. It is presumably shown on the admirable series of negatives obtained by Mr. Pickering in charge of the party of the Havard College Observatory, and very likely it is to be found on other negatives which I have not seen.

Its existence is beyond all doubt. Under these circumstances it seemed very desirable to attempt to secure photographs of the December eclipse with the principal object of tracing this new extension still further from the limb, but the Lick Observatory was not in a position to incur the considerable expense of sending a special expedition to South America, and so the plan was reluctantly given up. Fortunately our situation was made known to Hon. Charles F. Crocker, a regent of the University and a member of the Astronomical Society of the Pacific. Mr. Crocker at once volunteered to personally bear the expense attending such an expedition including the purchase of the necessary instruments, etc.

This generous offer has made it possible to undertake an expedition, thoroughly equipped for photographic operations. The regents of the University have authorized the use of any of the portable instruments of the Lick Observatory, and have also given a leave of absence to Messrs. Burnham and Schaeberle who will do the work. Capt. R. L. Phythian, U. S. N., Superintendent of the Naval Observatory, has kindly lent us one of the six-inch Dallmeyer cameras of the Washington Observatory, and Mr. Blinn, of Oakland, has also aided us materially by the loan of minor apparatus. Before obtaining the loan of the U. S. N. O. camera, we had purchased from the eclipse fund a six-inch Willard portrait lens, the same one which was so successfully used by Mr. Ireland in January last.

The objects of the expedition are, in the order of importance:

1st. To obtain negatives of the inner corona showing all the detail possible from the limb outwards. This work will be done by Mr. Burnham with our 6½ inch Clark telescope with its aperture reduced to 3 inches (chemical focus = 76.63 inches). The exposures will be 2, 5, 7, 10, 25 seconds on Seed 26 plates. Two of these plates will be standardized to permit of photometric measures. A long dew-cap will be used with each photographic instrument to exclude atmospheric glare.

2d. To secure photographs of the extension of the outer corona. Mr. Schaeberle will do this work with the six-inch U. S. N. O. camera. At least four Seed 26 plates will be exposed for 10, 15, 20, 25 seconds respectively. Two of these will be standardized.

3d. To secure a photograph with a small camera immediately after contact III on a standardized plate for use in measures of the brightness of the sky, etc. Mr. Burnham will expose this plate.

After the eclipse is over, the astronomers will remain at Cayenne for a short time. We all know what to expect if Mr. Burnham has a 6½ inch Clark telescope at his disposition for a month or two, in a field as uncultivated as the southern sky. Mr. Schaeberle will utilize this time to carry on an investigation (already begun here) on the photographic atmosphereic absorbtion from the zenith to 70° or 75° Z. D. He will also be able to determine the brightness of several of the more important southern stars in terms of that of Polaris.

The eclipse photographs will (probably) be developed shortly after they are made and by next Christmas Day, at latest, we may expect to hear of the success of the expedition. If the day is clear there can be no doubt as to the results.

THE NEW DEARBORN OBSERVATORY.

G. W. HOUGH, DIRECTOR.

FOR THE MESSENGER.

In the fall of 1887 the old site of the Dearborn Observatory in Chicago was abandoned, and the instruments transferred to the Northwestern University, at Evanston.

The new building is a gift of James B. Hobbs, Esq., of Chicago, and was erected at a cost of twenty-five thousand dollars. The new location is about sixteen miles north and three miles west of the old site in Chicago.

The site for the building is on the grounds of the Northwestern University three hundred feet from the shore of Lake Michigan, and the same distance from the street.

During the first year the Repsold Meridian Circle has been temporarily mounted near the lake shore. The usual nadir observations by observing the image of the wires of the Meridian Circle, when directed over a basin of mercury, were made a number of times each week, and it was found that such observations were possible at all times. During a heavy storm, however, the image was somewhat disturbed, but the tremors were not such as would interfere with ordinary observations. It is a well known fact that one of the most annoying troubles of the astronomer, the world over, is the inability to make nadir observations when most desired. At the old site of the Dearborn Observatory, as well as at Evanston, nadir observations are very easily made; the freedom from disturbance in this vicinity is undoubtedly due to the fact that the surface soil to a considerable depth is composed of sand and gravel, through which vibrations are not readily transmitted.

The plans for the new building were prepared by Cobb & Frost, architects, under the supervision of President Joseph Cummings, and, before being adopted, were submitted to the building committee, consisting of James B. Hobbs, Joseph Cummings, J. Y. Scammon, and Elias Colbert, and every detail was carefully considered. It was the aim of the committee to secure a building which should have architectural merit and at the same time be well adapted for scientific purposes.

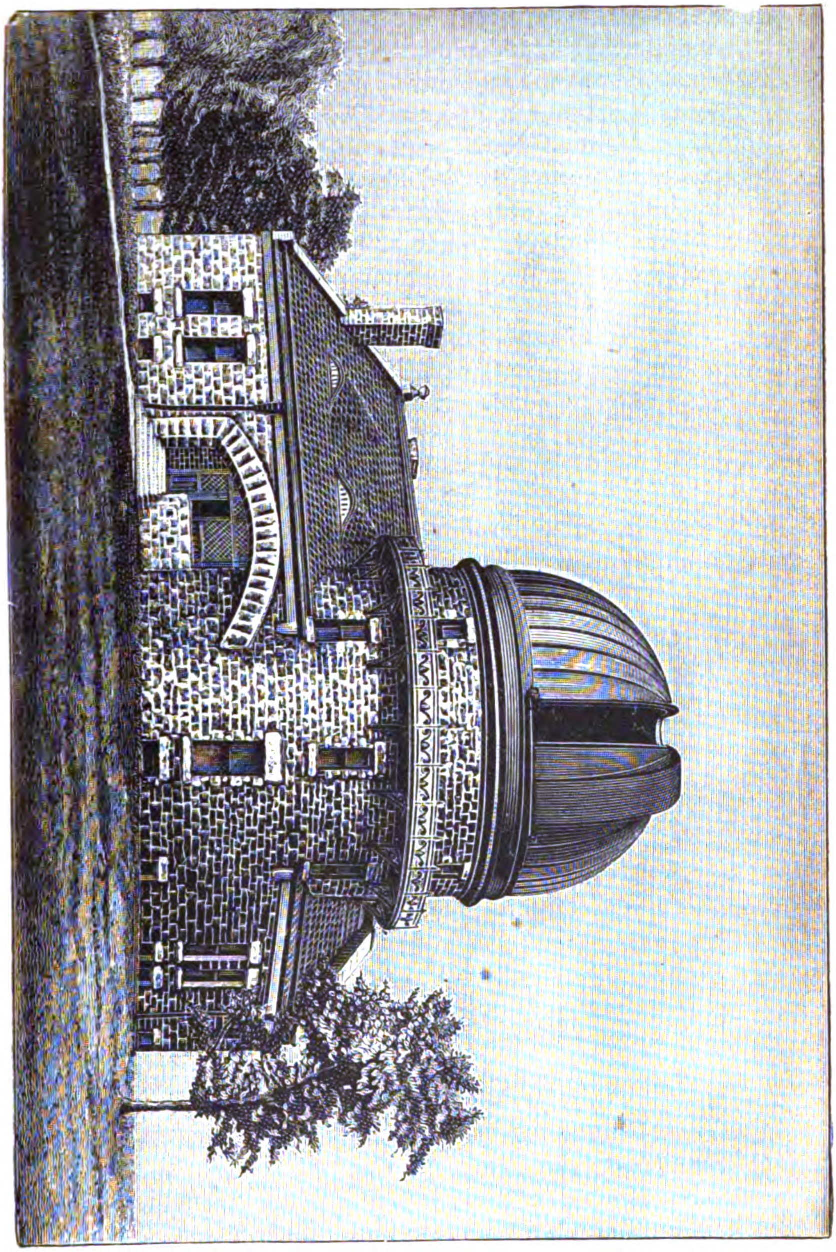
The erection of the building was in charge of Dr. Joseph Cummings, who, from the time of locating the site until its final completion, has given to it almost daily attention. The successful carrying out of the plans is largely due to his constant oversight.

The accompanying wood-cuts will show the style of architecture and the arrangement of the rooms. The exterior is of rubble limestone, level in the vertical joints and horizontal beds, and trimmed with tooled and carved Bedford stone. The cornices and gutters are of copper, while the entire roof, with the exception of the dome, is covered with Akron red tile.

The building is eighty-one feet in length from north to south, and its greatest breadth is seventy-one feet. There is a cellar extending under the entire building, which is used for the furnace, batteries, and other purposes.

The front entrance is on the west side, and communicates with a spacious hall-way extending through the building from west to east.

On the southeast side is the meridian-circle room, 26×35 feet in size, giving ample space for the telescope and acces-



THE NEW DEARBORN OBSERVATORY.

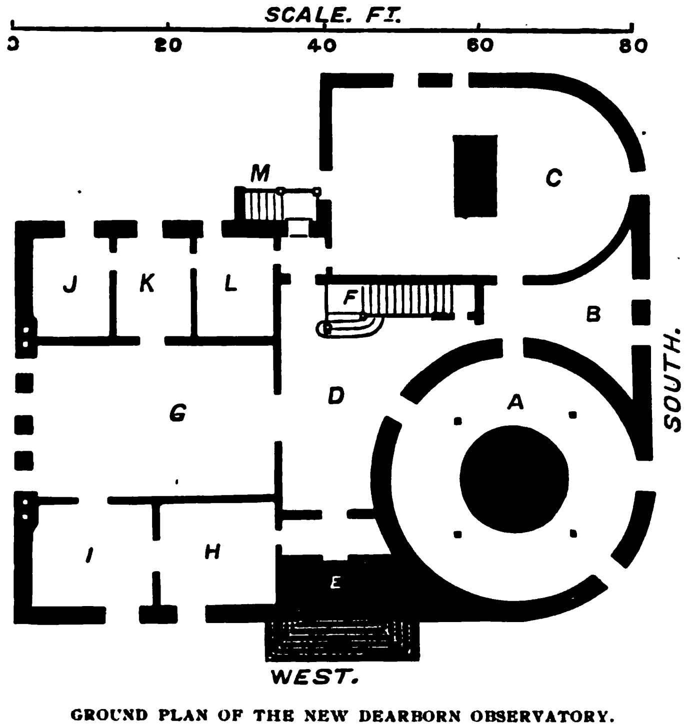
sory apparatus. The opening in the meridian for making observations is three feet in width and is covered by three shutters, which are counterpoised in every position so that they may be opened and closed with ease.

The counterpoise for the meridian shutters is secured in the following manner which, so far as I know, is a novel device as applied to observatories. The support for the shutters is elevated eighteen inches above the level of the roof and the rear of the shutter projects a like amount. On the under side of this projection a sufficient weight of flat iron bars is bolted to nearly balance the weight of the shutter. On the under side of the shutter, in the observing room, a single knee-joint is attached at the middle of the shutters and by means of a rope fastened to the knee-joint, and passing over a pulley the shutter may be elevated. When the shutter is raised, the arms of the knee-joint are nearly in a straight line, and hence there is no leverage for a downward pull. In order to secure the necessary leverage, a hinged arm is attached to the side wall of the opening, being held nearly vertical by a small weight when the shutter is open. A rope is connected to the shutter and arm, allowing about two feet of slack between the shutter and arm. Now a downward pull on the rope throws the hinged arm nearly at right angles to the slit opening before the pull is applied to the shutter to close it. The ropes for opening and closing are wound in an eight-inch drum which is turned by an iron hand-wheel two feet in diameter. The slack in one of the ropes, due to the motion of the lever arm as above mentioned, is taken up by a spiral spring pulling at right-angles to the motion of the rope.

The shutters are wide and quite heavy, each requiring about four hundred and fifty pounds of iron to counterpoise, yet it requires only a few pounds of force on the hand-wheel to open and close them.

On the northeast side there is a suite of three rooms for the clocks, chronographs, and minor apparatus. On the northwest side are two rooms, each 15 × 16 feet, to be used for offices or computing rooms. Between the east and west suite of rooms before mentioned there is a large room, 21 × 30 feet, lighted from the north side, and fitted up for the library.

The north half of the building only is heated, the hall-way serving as a barrier to the heat entering the observing rooms. The tower for the great equatorial is circular in form and is thirty-seven feet in diameter on the outside. The walls are of stone and are carried up far enough so that when the telescope is pointed horizontally no portion of the building will obstruct the view. The top of the wall is surmounted by a layer of cut stone, twenty inches in width and ten inches in thickness, all fastened together to form a substantial bed for the dome.



GROUND PLAN OF THE NEW DEARBORN OBSERVATORY.

The observing room in the tower is reached by means of two flights of stairs.

The revolving dome is 34 feet in diameter in the clear and is constructed wholly of iron and steel. As there are some novel features pertaining to this dome, a brief description may be of interest. In the mounting of domes, the universal method has been to rest the dome on balls or wheels, between tracks above and below; when wheels are used, they are usually set in a ring and two upper and two lower tracks, are employed. In recent years, however, Messrs Warner & Swasey, of Cleveland, have used one upper and two lower tracks, and the wheels are mounted in separate trucks, which are connected together. In our dome a single upper track is used, which rests on the tops of stationary wheels. There are sixteen of these wheels, sixteen inches in diameter, and the axles are supported on anti-friction cylindrical bearings, somewhat similar to a bicycle bearing. The method is very simple and also offers a number of advantages over any other method hitherto employed. The following are some of the principal advantages:

1. The lower double track is dispensed with.
2. The live ring is eliminated.
3. Each support and wheel are independent.
4. Any wheel may be removed for repairs or adjustment without disturbing the rest.
5. The dome may be leveled in a few minutes, should it become necessary from irregular settling of the wall.
6. Great stability of the dome.

The upper track is of cast iron, twelve inches wide and six inches deep, made in twenty sections. The surface in contact with the wheels is planed, as well as the inside, and the sections are bolted together to form a solid ring, the total weight of which is about three and one-half tons. There are no flanges on the wheels; the dome being kept in place laterally by inside anti-friction guide wheels, bolted to the wall. Each truck, for supporting the wheels, is held in place by two bolts inserted in the top of the wall, and the truck is also provided with four set screws for leveling up the wheel.

The superstructure is wholly of iron, the ribs are of wrought iron, and the covering is of numbers 20 and 22 galvanized iron-plate. The weight of the moving parts of the dome is about ten tons, and when in motion it requires a direct force of about twenty-five pounds to keep it going. It is rotated by a crank, with rack and pinion, the dome moving one-third the speed of the crank. The ease of rotation is all that could be desired, since the dome may be turned by one person through one revolution, or 115 feet, in one minute. When started at the ordinary speed one would naturally use, it will travel from 6 to 10 feet by its own momentum. Although 16 wheels are used under the dome, it will revolve equally well when every alternate wheel is disconnected by lowering the truck.

The opening for observations is four feet in width, all in one place, and extends from the horizon to two feet beyond the zenith. We consider this arrangement of the opening of the greatest importance. Any one who has had experience in the use of a large equatorial will appreciate the convenience of a continuous opening.

The principle involved in the construction of the shutter, so far as I know, was first applied on the new Greenwich dome, viz., extending the shutter over the whole hemisphere. In the construction of our shutter we have, however, materially modified the Greenwich construction. The shutter is entirely disconnected from the superstructure, being supported at the base of the dome on a pivot on one side and a track on the other. Immediately after its erection it was found that there was some lateral sway to the shutter, especially during a high wind, and to cure this defect a second pivot was added about six feet above the base of the dome. This method of construction is found to give sufficient lateral rigidity to the shutter without interfering with its freedom of motion. The shutter runs on anti-friction wheels, and may be completely opened or closed in less than ten seconds with a direct pull of about ten pounds.

The method for opening and closing the dome shutter is as follows: On the inside of the dome is mounted a short shaft which carries a small drum and a V pulley. Wire ropes are attached to the shutter, and after passing over guide pulleys are wound on the drum. An endless rope, having a loose pulley and half pound weight at the lower end, hangs over the V pulley in the inside within three feet of the floor. Another cord is fastened to the spring bolt and also hangs within reach. The spring bolt is first unlocked, when, by pulling on the endless rope the shutter may be opened. By this arrangement there are no ropes to be looked after when revolving the dome, except when the endless rope is passing the crank.

Considering the dome as a whole, and taking into account its ease of rotation, combined with the convenience of the shutter, we believe it will rank among the best domes hitherto constructed.

The foundation of the equatorial pier is a bed of cement resting on clay at the depth of 15 feet below the surface of the ground. The pier is circular and is 15 feet in diameter at the bottom and 10 feet at the top. It is built of brick, hollow, with cross walls at right angles through the center, and is entirely disconnected from the building. The top of the brick column is covered with three stone slabs, nine inches in thickness, on which is placed the stone pier to which the great telescope is attached.

In mounting a Meridian Circle, it is desirable, if possible, to secure unchanging stability in the instrument. Any instrument which is liable to change in level or azimuth a number of seconds of arc, during a night's work, or from one day to another, leaves a suspicion of uncertainty in the accuracy of some of the observations. At the old site in Chicago, the Meridian Circle was mounted on brick piers, covered with wood. It was found to be greatly affected by temperature; the change in level and azimuth, between summer and winter, amounting to more than twenty seconds of arc. In the construction of our new pier it was decided to use stone, and at the suggestion of Dr. Cummings a cement or artificial stone pier was constructed. The foundation of this pier is three feet below the floor of the cellar. The pier is rectangular, 8 feet 5 inches in length, 5 feet in width, and about 10 feet in total length. On account of its great mass it will not readily be affected by sudden changes in the temperature. On the top of this base is laid a stone slab 8 feet in length, 4 feet in width, and 9 inches in thickness, on which rest two sandstone piers, each weighing about two and a half tons on which the meridian circle is mounted.

On the second floor of the building, besides the room in the tower, there is a large room the same size as the library, and two side rooms, one of which has been fitted up for photographic work. The interior of the building is finished throughout in hardwood; it is probably one of the most convenient and best constructed Observatory buildings in the United States.

AN AUTOMATIC RIGHT ASCENSION CIRCLE.

LEWIS SWIFT.

For The Messenger.

The object of this device is to read, directly from the circle, the R. A. of an object already reduced to any desired epoch, regardless as to the month or year in which the observation was made, or of even the error of the sidereal clock, its *rate*, during the hours of observation only, entering as a function of discordance, all that is required of the clock being to make and break, once per second, the connection with a galvanic battery. Three kinds of clocks are employed, viz: the sidereal by Howard, standing in a niche in the north side of the pier in the dome-room, the driving-clock, and two which I shall name the vernier-clocks, one of which (see cut 1) is now both propelled and controlled in the usual manner; the other, cut (2), is *controlled* by a sounder connected electrically with the sidereal clock.

For several years I had used an arrangement constructed on similar principles as the one about to be described, attached to the north side of the pier just above the sidereal clock and on a level with the eye (an important consideration), but as it necessitated the use of a somewhat lengthy metallic cord braided of fine brass wires, connecting two equal sized pulleys, one on the polar axis of the telescope and its elasticity causing a slight error, it was abandoned as a measuring instrument a year since, though still employed for finding purposes. The present method was then substituted, and, for measuring, leaves nothing to be desired, though less convenient for finding as a short ladder has to be climbed.

The original has been more fully described and illustrated in "The History and Work of the Warner Observatory," Vol. I, a copy of which will be mailed to any reader desiring it, but as that is now devoted to finding purposes only, it becomes necessary to briefly explain its new use which an inspection of Fig. 1 will greatly assist.

On the east side of the pier, firmly screwed into its wooden casing, is a heavy bolt not seen in cut, projecting to such a distance that, when the brass head of the telescope tube touches it, the telescope is exactly in the meridian. This answers as a pretty accurate transit instrument. In fact, it serves to correct the rate of the sidereal clock whose running is so satisfactory that it is seldom more than one or two seconds in error. Suppose it be desired to point the telescope on, say, 13 Messièr (the cluster in Hercules), without

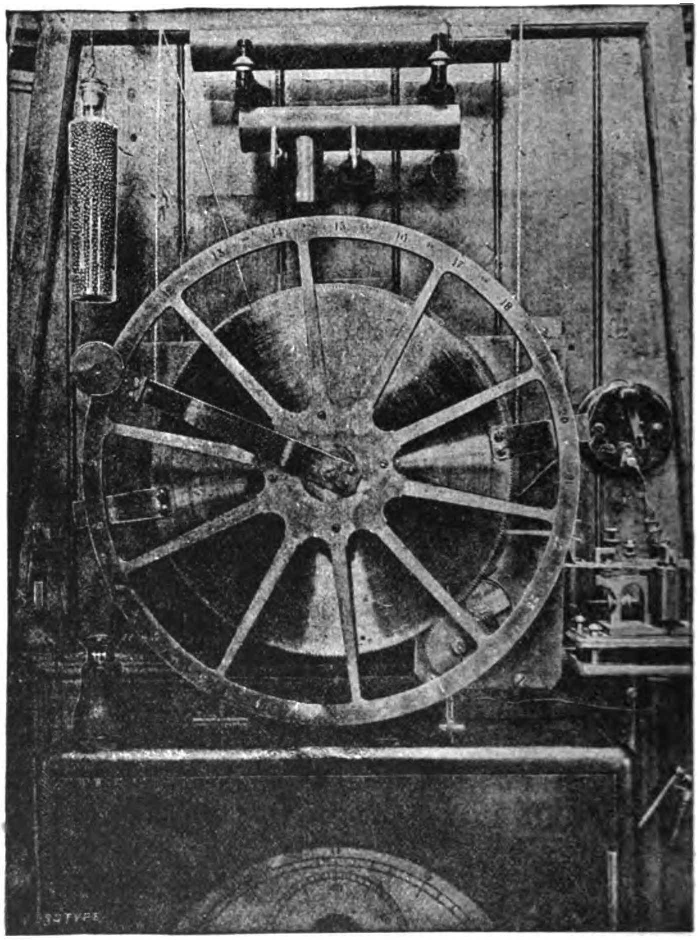


FIGURE 1.

the trouble of seeking a setting star, or of twice moving the dome, once for the star and again for the object to be observed. The telescope is brought into contact with the head of the bolt, the vernier set to the time as read from the clock face below which, if correct, is given, of course, the

R. A. of the meridian. Now the little clock is driving the vernier around the circle at the same rate that the stars are moving around the sky, and the hands around the dial face of the clock. For finding the object sought, it matters not what the R. A. of the meridian is; it is sufficient to know that the reading of the circle gives the R. A. of the place at which the telescope is pointing, technically called the line of collimation, which, if the vernier clock keeps running, it will do. The R. A. of the cluster being 16*h* 37*m* 42*s*, the eye-end of the telescope is pushed too far out, and, with eye at the vernier, the telescope cord is gently pulled till the vernier reads its proper R. A., and when the telescope is moved to its declination the cluster will be fonnd in the center of the field.

Figure 1 shows the circle (15 inches in diameter) graduated to minutes of time, the verniers, the toothed wheel on the hour arbor of the vernier-clock, the sounder which *controls* the rate of the verniers, the weight (a bottle of shot) which propels them, the switch and the upper portion of the sidereal clock. Since, however, this was discarded for measuring, a common clock has been substituted for the control sounder, thus dispensing with an extra set of batteries.

DESCRIPTION OF THE IMPROVEMENT.

What has previously been said will greatly assist in understanding what is to follow. The Mosstype shows, though not as clearly as desired, the invention attached to the polar axis of the telescope, thus doing away with one source of error, the yielding of the metallic cord before alluded to. The hours on the circle are numbered from *east to west* consecutively from 0*h* to 23*h*; and also the zero of the verniers had to be shifted to likewise read in the same direction. The circle, 20 inches in diameter, is graduated to minutes of time, and reads by verniers to single seconds. It is loose on the polar axis in order to be revolved for setting to the R. A. of the setting star, preferably when on or near the meridian, for the elimination of refraction in R. A., but is firmly held in place by friction. Between the hours 16 and 17 is seen a vernier, and, directly opposite the other, both attached to the large gear (4) having 480 teeth cut around its circumference, into which a pinion with twenty teeth on the hour arbor of the vernier-clock (2) engages, which causes the attached verniers to make a revolution in $480 \div 20 = 24$ sidereal hours. If, therefore, a meridional star be bisected by the meridional wire in the eye-piece, and the circle be revolved that one vernier shall read to the R. A. of the setting star for the selected epoch, the reading will constantly and accurately give the R. A. of the line of collimation, providing the vernier clock runs truly and the circle does not slip.

In front of the little clock is seen a sounder, to the vibrating bar of which is attached an arm connecting it with a pinwheel escapement of thirty pins to the vernier clock, one of which is released at each vibration of the armatue. A wooden wheel (5) is bolted to the vernier gear (4), around which a cord is wound, going over pulley (7) and others to a weight running down by the side of the driving clock weight. This is the propelling power of the verniers, the control being the electric sounder. The cord steadily pulling one way allows no play between the teeth. The little clock (called a double spring locomotive clock) is substantially built; the escapement, escapement wheel, and hair spring were removed, and the previously mentioned pinwheel substituted, and unless the sounder ceases to vibrate, will run as accurately as the sidereal clock itself with which it is electrically connected.

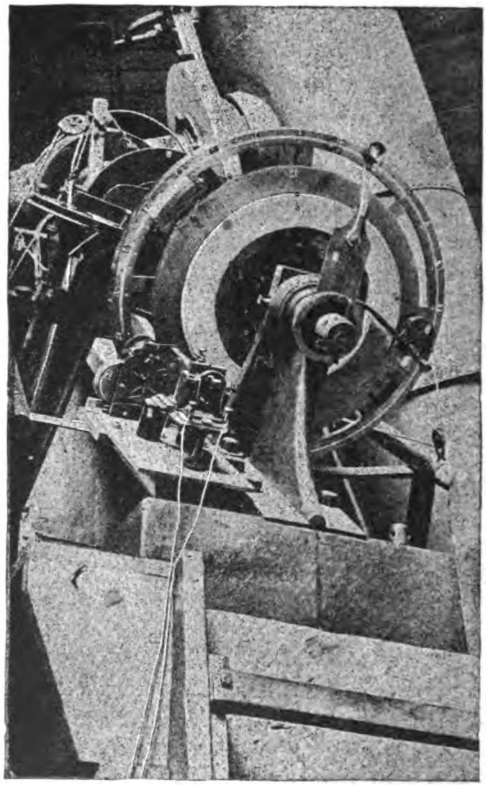


FIGURE 2.

To prepare for the night's work I proceed as follows: The driving is started, the telescope pointed to a mean time almanac star for 1890.0, say Arcturus (if I wish to work on a zone having a north declination of from 15° to 25°) whose R. A. for that epoch is 14*h* 10*m* 39*s*, and when it is accurately bisected by the meridional wire in the eye-piece, the circuit with the battery is closed by the switch, the ladder ascended and the circle revolved to read 14*h* 10*m* 39*s*, all of which requires but a moment.

The sounder is worked by a battery of three gravity cups. Formerly the break wheel in the sidereal clock had but 29 teeth, one of the 30 having been cut out to cause the circuit to be broken at the 58th second, which also necessitated the use of 29 pins in the escapement of the vernier clock, causing a slight error at the latter portion of each minute. This was corrected by replacing the cut-away tooth, and using an escapement of thirty pins.

I hope the above explanation and description will make the matter intelligible to the readers of THE SIDEREAL MESSENGER.

The celerity and accuracy with which the R. A. of a nebula can be obtained already reduced to any desired epoch, is surprising, saving a vast amount of valuable time which, in a cloudy country like this, cannot be overestimated.

WARNER OBSERVATORY, July 20, 1889.

THE SOLAR CYCLE.

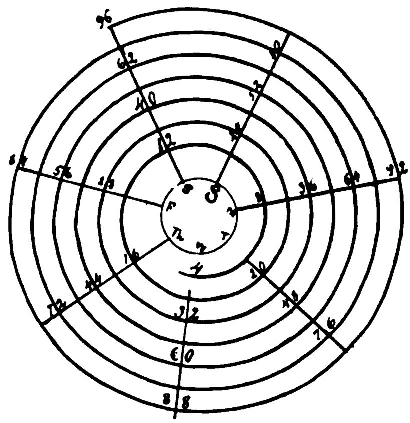
R. W. MCFARLAND.

For THE MESSENGER.

The meaning intended to be conveyed by Herschel, in the extract referred to by Professor Swift, June MESSENGER, I would express in the following terms: "After a lapse of twenty-eight years the order of the days of the week and the days of the month will be the same," or, "in twenty-eight years all possible changes in the days of the week, as applied to any month, will have occurred, and then the same order will be repeated." And any day of any month must therefore come at least once on Sunday, or Monday, etc., in twenty-eight years:—for example, the twenty-ninth of

February occurs on Sunday only once in twenty-eight years. It occurs also once on each of the remaining days of the week.

The solar Cycle is the product of four, the interval from one leap year to the next, and seven the number of days in a week; and was made by the chronologists many centuries ago for the ecclesiastical calendar. Were it not for the extra day in leap year all possible variations of the days of the week, as related to any given day of the month, would take place in seven years. Everybody knows that ordinarily the year begins and ends on the same day of the week. It follows, as a matter of course, that the next year begins one day later in the week, but the year following leap year begins two days later, and it is this extra day which requires four times the cycle of seven in which to make all possible variations.



FEB. 29 OF THE NINETEENTH CENTURY.
[62 in the figure should be 68.]

The law of the succession can be very prettily shown in the following way: make a circle of any convenient size, mark the circumference off into seven divisions, as in the diagram. Set *Sunday* at the top, and the other days of the week in order towards the right. Extend the radii through the several divisions. Knowing that the 29th of February occurred on Wednesday in 1804, set the number four on the radius passing through Wednesday. Then, since in four years the first day of January, or any day of any month, goes forward five days of the week, the 29th will go from Wednesday to Monday. It amounts to the same thing to say that it goes backward *two* days, *i. e.*, from Wednesday to Monday. Each successive period of four years will show the like result. Beginning at Wednesday draw a left-handed spiral; on the Monday radius set 8 for the year 1808; passing again 2 to the left and the year 1812 is marked 12 on the Saturday radius, and so on for the century. But as 1900 is not a leap year we stop at 96.

The following facts are apparent on inspection:

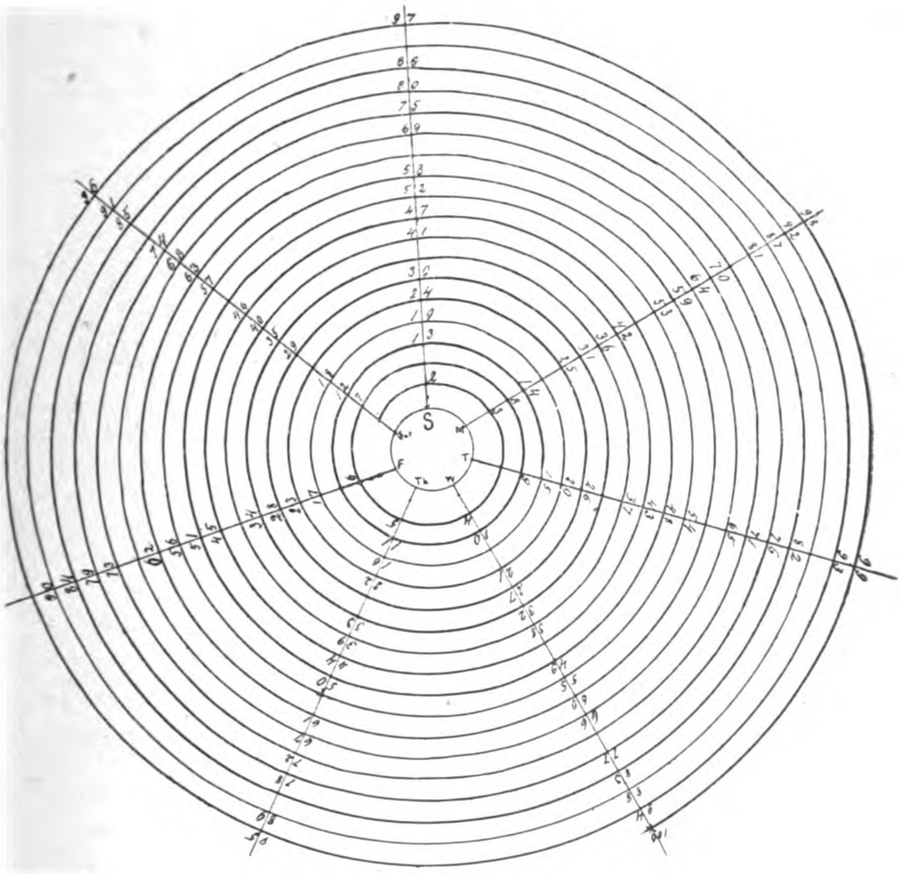


Diagram of the Fourth of July during the Century.

1st. That there is a lapse of twenty-eight years from the time the twenty-ninth falls on Sunday before it again falls on that day; and similarly for the other days.

2d. That the 29th of February falls 3 times on Sunday in this century, 4 times on Monday, 3 times on Tuesday, 4 times on Wednesday, 3 times on Thursday, 3 times on Friday, and 4 times on Saturday. The same thing will be repeated in the next century.

In like manner for any day of any year, say the 4th of July, make a circle and set in the days of the week as before; then as the 4th day of July was Saturday in 1801, mark 1* on the Saturday radius. In 1802 the 4th was on Sunday, place 2 on the Sunday radius; 3 on Monday, and 4 on Wednesday, because the 29th of February had pushed the day one further along in the week. I should have stated that the spiral should run in the same direction as the days of the week,—right-handed in this case. It will require 17 or 18 spires for the century. The cut on the preceding page shows the arrangement here suggested, and one notices that the 4th does not fall at intervals of 28 years strictly as does the 29th of February, but that at one time there is an interval of 11 years followed immediately by another of 6 years, then one of 5, then one of 6, the sum being 28, and then the 11 year period comes on again. The same rule holds for all the days of the common year of 365 days. Of course it is the mathematical relation existing between the natural numbers when arranged in spires of 7 spaces, and a skip is made once in 4. There is no mystery about it, and when the series of numbers is put down as here suggested, the whole order is patent on the simplest inspection.

It is further seen that 28 is the smallest number of years which will accomodate the 29th of February and the reason why 28 is the solar cycle is readily seen.

OXFORD, OHIO, Aug. 1889.

THE DOUBLE-STAR, 26 DRACONIS (β 962)

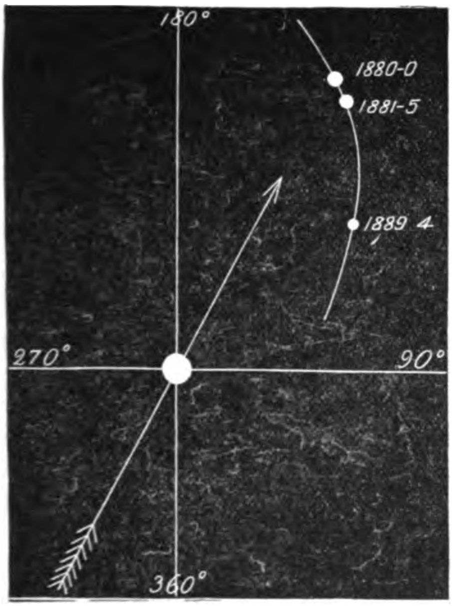
S. W. BURNHAM.

For THE MESSENGER.

This star was discovered to be double with the 18½-inch refractor of the Dearborn Observatory. It seemed quite certain that it would prove to be an interesting physical pair from the fact of the large proper motion of the principal star. This is given by Argelander as 0″.582 in the direction of 152°.2. It was obvious, if the new component was fixed in space, or did not share this movement, that at any time more than half a dozen years before its discovery

* Omitted in cut by mistake of the engraver.

the two stars would have formed an easy pair which could not have well escaped detection. In 1881 I made another set of measures with the 15½-inch at the Washburn Observatory and this showed conclusively that both stars had the same proper motion, and also that there was some orbital motion. A recent set of measures here with the 36-inch shows a decided change in both angle and distance. It is now much more difficult and is likely to be soon beyond the reach of all ordinary telescopes.



STAR 26 DRACONIS (Scale 1′ to 1.25 in.).

If the stars were of nearly the same magnitude, there would be no difficulty in following the companion much nearer the primary with a moderate aperture, but as the large star is about 5½ magnitude and the other only 10 or 11, it makes a difficult pair when the distance is much under 1″. Apparently in two or three years more, it will test the power of the great telescope.

With the exception of a single observation at Cincinnati in 1879, the following are all the measures down to this time:

1879.97	151°.8	1″.37	β	4*n*
1881.53	148 .1	1 .31	β	3*n*
1889.42	130 .1	0 .95	β	4*n*

These measures are carefully platted to scale on the accompanying diagram. The direction of the proper motion is indicated by the arrow. It is desirable that measures be made of this pair by observers having sufficient optical power.

MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

FOR THE MESSENGER.

The Astronomical Society of the Pacific met in the library of the Lick Observatory on July 27th, with a good attendance of members. It was announced that the report of the observations of the solar eclipse of last January, now being printed by order of the Regents of the State University, had reached page sixty, about one-third of the volume. It contains reports from more than 150 persons, distributed at twenty-five different observing stations. Hon. C. F. Crocker has offered to bear the expenses of an expedition from the Lick Observatory to Cayenne, South America, next December, and it is expected at that time to confirm and extend some of the discoveries made at the last eclipse. The announcement was also made that Hon. Joseph A. Donohoe of Menlo Park had founded a medal for the discovery of comets and had provided a permanent fund for the purpose. This gift was gratefully accepted by the Society.

There were too many papers presented to allow all of them to be read, and accordingly some were postponed till the next meeting. The papers read, either by title or in full, were: On the possibility of photographing the corona in full sunshine, by Mr. Keeler; on the orbit of the comet Barnard (June 23d), by Mr. Leuschner; on the occultations of Jupiter to be expected in 1889, by Mr. Hill; on a photograph of the Milky-Way near Jupiter, taken on the 24th inst., with one hour and forty-eight minutes exposure, by Mr. Barnard (this beautiful picture was exhibited to the meeting); on the real shape of the nebulæ in which we see a spiral, by Professor E. S. Holden. The latter paper was the longest one of the evening, and will be printed in the publications of the society in full. Its purpose is to show the real shape of the so called spiral nebulæ in the space of three dimensions as deduced from their apparent shape as projected in two dimensions on the background of the sky. This is a problem that has had no solution up to this time and it is one that has important bearings, not only on the question of the construction of the spiral nebulæ, but also upon the much larger question of the constitution of the solar system and of the universe as a whole.

The following persons were elected to active or life membership at the meeting: Ex-United States Senator James G. Fair, Robert D. Fry, Rudolph E. Voight, D. P. Belknap, Mrs. Wm. Alvord, Alexander Montgomery, Mrs. Alexander Montgomery, John Partridge, Dr. George C. Pardee, Miss Fidelia M. Jewett, Miss L. J. Martin, Lester L. Robinson, A. B. Forbes, John R. Spring, Judge John H. Boalt, Robert M. White, Horace L. Hill, Joseph G. Lavery, Dr. W. B. Leavitt, Dr. L. L. Dunbar, Charles Webb Howard, John Perry, Jr., Dr. M. J. Sullivan, Darius Ogden Mills, Captain Charles Goodall, Adam Grant, Joseph D. Grant, Arthur W. Foster, all of San Francisco, Cal.; Hon. Alfred L. Tubbs, J. McClymonds, Charles G. Yale, George N. Strong, ex-Governor George C. Perkins, J. C. Bullock, of Oakland, Cal.; Charles R. Tisdal, of Alameda, Cal.; Charles W. Friend, of Carson City, Nev.; C. H. Clement, of Livermore, Cal.; United States Senator John P. Jones, of Nevada; Henry B. Alvord, of San Jose, Cal.; and Senor Felipe Valle, Senor Manuel G. Prieta, Director Angel Anguino, Feodora Quintano, Camillo Gonzales, Francisco Rodrigues Rey, of the National Observatory at Tacubaya, Mexico.

After the adjournment of the society the members looked at the various objects of interest shown by the astronomers of the Observatory, and then a portion returned to the Smith Creek Hotel to sleep, while the rest, as many as possible, were entertained by the astronomers on the mountain. The affairs of the society are in a most prosperous condition owing to the great interest taken in its progress by the members. It is essentially a Society for amateurs, and desires to include in its membership every person in California who takes an interest in astronomy, whether he has made studies in this direction or not. Several ladies are already members. The dues are $5 per year, and there is no initiation fee. Life membership is $50. Its publications are sent to every member, and three of its six meetings are held in San Francisco. The scope of the society is defined so that it can have no possible rivalry with any other. Its sole object is to forward the study and the science of astronomy.

The medal offered by Hon. Joseph A. Donohoe of Menlo Park is to be given to the first discoverer of every unexpected comet and to the first person making a precise observation of a telescopic periodic comet at any one of its expected returns. This medal is intended solely as a recognition of merit and to commemorate the discovery, and is not designed in any sense as a reward. The astronomer's reward consists in the discovery itself. Mr. Donohoe also offered the gift of a fund sufficient to maintain such a medal in perpetuity from and after January 1, 1890. The Society will proceed to give practical effect to the offer by the establishment of the medal and by the fixing of the regulations for its bestowal. No application for the award of the medal is required. It will be given as a matter of course to the acknowledged discoverer of a new comet. It is, however, prescribed that a letter should be addressed to the director of the Lick Observatory, which communication must contain all the particulars of the first observation.

Such medals as this are given by various scientific societies and academies, both in America and abroad, and they serve as interesting and valued mementos to their possessors, as incentives to the younger generation of astronomers and a series of landmarks in the history of scientific progress. The full conditions on which the awards will be made will shortly be printed in the various scientific journals and the publications of the Astronomical Society of the Pacific, where they can be found by those interested.

LICK OBSERVATORY, July 28, 1889.

ON THE COMPANIONS TO COMET d 1889 (BROOKS).

E. E. BARNARD, ASTRONOMER.

Since the discovery of a group of companions to the great comet of 1882 [see *A. N.* 2489] I have been impressed with the idea that other comets may be attended by companions which, from their faintness, or from a failure to search for them, may escape discovery. I have therefore examined the immediate neighborhood of all comets since then in the hope of finding such companions.

The 12-inch telescope being out of order, it was not possible to observe Brook's comet with it after the July moon until the night of August 1, when I observed the comet for position. While examining the region about the head of the comet on this date, I detected two small nebulous bodies following the head, but preceding the comet in space. The nearest of these was suspected to be a companion; its distance and position-angle were therefore measured from the nucleus. The second morning showed that both objects were moving with the comet, and therefore were companions. These objects I have named *B* and *C*.

On Aug. 3, these were examined with the 36-inch equatorial, which showed the whole group very beautifully. Each of the companions had a very small nucleus and condensation in a very small head, and a short, faint tail, presenting a perfect miniature of the larger one, which was pretty bright and well developed, with small nucleus and slightly fan-shaped tail ¼° long. There was then absolutely no nebulous connection with the larger, nor has there been at any time since, either in the 12-inch or in the 36-inch telescope. Nothing whatever has been seen here of the nebulous envelope spoken of by the Vienna observers as apparently enclosing the whole group [A. N. 2914]. I have from the first carefully looked for a nebulous connection. Under unfavorable circumstances the tails of *B* and *C* might be imagined to be a connecting nebulosity, but the tail of *B* falls short of A and that of *C* does not nearly reach *B*. Each comet is in appearance absolutely independent of the other. The tails of all three have lain in the line of the nucleus of *A*, and therefore have not sensibly deviated from the position-angle 241.°

On August 4 two other companions were detected with the great telescope, one of which was measured, the other being too elusive to place the wires on. I have numbered these four companions *B*, *C*, *D*, *E*, in the order of increasing right ascension, *A* being the larger comet, *D* and *E* being the two last discovered. The position of *D* Aug. 4, referred to *C* was: distance, 78″.18; P.A., 23°.3. *D* has been seen several times since the moon withdrew, but has always been too faint to observe; it has not sensibly changed its position. *E* has only been seen once; its position-angle referred to *C* would be the same as that of *D*, and its distance twice as great. Four or five other nebulous bodies observed near the comet Aug. 2 have not since been seen, and were probably nebulous.

The results of the observations of the two brighter companions are extremely interesting. Measures of *B* have been made on eighteen and of *C* on seventeen nights. These two have almost exactly the same position-angles, which have been sensibly constant; their distances from the main body have, however, been increasing. At the last few observations *B* seems to be stationary, the distance from *A* remaining constant, while *C* continues to recede. The following from my measurements will give some idea of these changes.

From Aug. 1 to Aug. 5 *B* was separating from *A* at the mean rate 0″.93 per day, while from Aug. 16 to Aug. 24 this was reduced to 0″.20, or essentially zero.

From Aug. 2 to Aug. 5 *C* was receding 1″.72 per day, and from Aug. 16 to Aug. 24 this had increased to 2″.76.

From Aug. 1 to Aug. 5 the mean position-angle *AB* was 59°.92, and from Aug. 16 to 24 it was 61°.27.

Aug. 3 to Aug. 5 the mean position-angle *AC* was 61°.43; and from Aug. 16 to Aug. 24, 61°.68. At first the position-angle *AB* was sensibly less than *AC*. They now appear to be on the same line with the nucleus.

Following are the positions of the two companions with reference to the nucleus *A* on two of the dates of observation:

Aug.	3	*AB*	66″.48	59°.9	:	*AC*	263″.46	61°.4
"	28	*AB*	73 .22	63 .2	:	*AC*	328 .44	61 .6

I have measured these objects every night, except when the moon interfered, and have been struck with the rather sudden change in the appearance of *B*. At first very small with ill-defined nucleus, and a tail nearly 1′ long, it was comparatively an easy object to measure in the 12-inch. It has steadily become more difficult, even in the great telescope, and at the last few observations has become extremely difficult, ceasing to be visible in the 12-inch; the central condensation has disappeared almost entirely, and the nebulosity become much larger, fainter and more diffused, making it almost impossible to bisect it accurately. In the mean time *C* has become easier, perceptibly brightening, and the central condensation more marked.

Since August 2, the observations have been made with the 36-inch equatorial.

In hopes that it may be possible to determine the mass of this cometary system, I have made careful micrometric measures on every night possible, and these measures will be kept up as long as the companions can be seen.—*Astronomical Journal* No. 202.

MT. HAMILTON, Aug. 29, 1889.

COMET BROOKS (d 1889).

WILLIAM R. BROOKS.

For THE MESSENGER.

Clouds and moonlight prevented observations of the new comet discovered by me on July 6, from July 9th to July 21st, but on the latter date I set the 10-inch equatorial to the place I had computed the comet to be from its rate and direction of motion, and had it at once in the field. The approximate place was July 21, 13 hours; R.A. 23*h* 57*m* 50*s*; decl. south 7°48′. I found the comet considerably brighter than at discovery. The tail was more conspicuous, and at the extreme front of the head was a stellar nucleus.

July 23.—The apparent motion is exceedingly slow, the place of the comet this morning at 14 hours being R. A. 23*h* 59*m* 20*s*; decl. south 7° 38′.

The comet is brighter, and the tail broader and longer.

Aug. 7.—Good view of the comet this morning, the air being much clearer than for some time past. The nucleus is elongated in a line with the axis of tail. I see distinctly one of the fragments reported by Barnard, thrown off from the comet, just in front of the head. It has also a very faint tail. I also suspect another just below the first. But considerably larger and more distinct than the latter, I see another fragment which has evidently drifted backwards over the tail of the main comet, and is now near the end of the same as if immersed in it.

Aug. 28.—The comet at midnight is in R. A. 0*h* 6*m*; decl. south 5° 59′. How slow it moves! Nearly two months since the discovery, and yet it is only four wide fields distant from the place of discovery. The brightness is about the same as at last observation, and the comet does not appear to have lost anything by the companions it has thrown off.

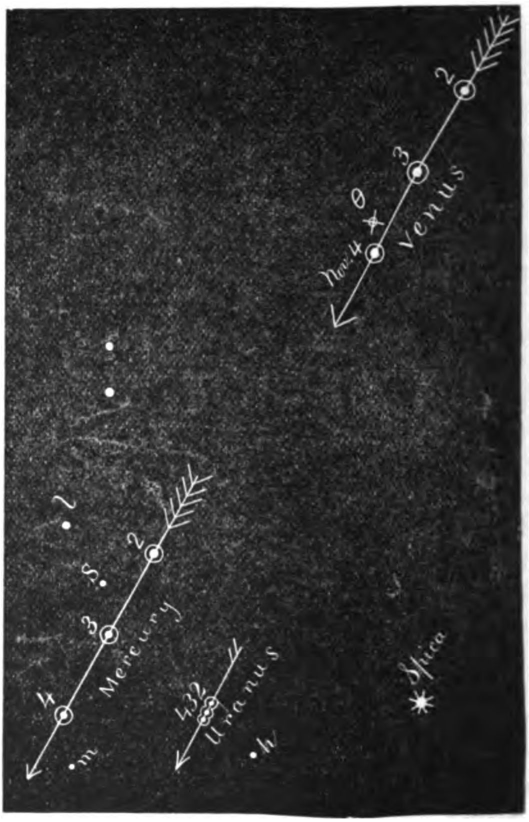
Dr. K. Zelbe in *Astro. Nach.* has computed elliptical elements with a period of 12⅛ years. Mr. Chandler in his first elements suggested its probable short-period character.

SMITH OBSERVATORY, Geneva, N. Y., Sept. 10, 1889.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at inferior conjunction with the sun Oct. 15, being then a degree and a half south of the sun, so that no transit will occur. During the greater part of the month he will be too near the sun for favorable observation. On the morning of Oct. 31 he will be at greatest elongation, 18° 43′ west from the sun, rising an hour and a half earlier than the latter. Three days later Mercury and Uranus will be in conjunction, the distance between them being 1°45′, coming within the diameter of field of an ordinary finder. Here will be a good opportunity to compare the colors and relative brightness of the two planets.



RELATIVE POSITIONS OF VENUS, MERCURY, URANUS AND SPICA (Scale 2°38′ to 1 in.

Venus, having passed the conjunction with Saturn and Mars in Leo near Regulus, proceeds eastward through Leo, entering Virgo Oct. 14, passing close to the stars β, η, γ, and δ of the latter constellation, and coming to conjunction with Uranus Nov. 9, at 1 P. M. On the mornings of Nov. 2, 3, and 4, the planets Venus, Mercury and Uranus will form an interesting group with the brilliant star Spica. About nine-tenths of the disc of Venus is illuminated, and its brilliancy is about one-third of that which it had in March of this year.

Mars follows Venus, but at a slower pace, from Leo into Virgo, and may easily be found in the morning a little higher up than Venus, almost on a line between Venus and Regulus. Recent numbers of *L'Astronomie* contain an extensive article by the editor, C. Flammarion, on "Changes Actually Observed on Mars." The author illustrates the article by a large number of well engraved and presumably accurate copies of drawings by various observers from Huyghens, 1659, to Schiaparelli, 1888. For this collection of drawings the article is an extremely valuable one, although we may doubt somewhat the accuracy of the drawings themselves, and so, in some particulars, the conclusions which the author draws from them. The conclusions are as follows:

1. "There are on the globe of Mars permanent spots which must represent seas, lakes, streams, marshes, etc.

2. "These spots are permanent; they are seen in our time in the same places where they were observed in the seventeenth and eighteenth centuries.

3. "However, while on the whole permanent, they are not invariable. They change in extent, form and hue, following the years and doubtless the seasons.

4. "There are some regions particularly variable, which appear to hold an intermediate position between continents and seas, like marshes alternately uncovered and submerged by a shallow sheet of water.

5. "The continents of Mars appear flat, and liable in almost all parts to encroachments of the water and inundations.

6. "The northern hemisphere is more elevated than the southern. The seas belong largely to the southern hemisphere; they do not appear to be deep.

7. "Evaporation is without doubt considerable and rapid. Millions of cubic meters of water pass easily from the vaporous to the liquid state, and thousands of square kilometers change from a continental to a maritime aspect.

8. "Not only water, perhaps, comes into play. There is an entirely different order of things from that which exists upon our planet."

The author commenting upon these says: "*We have only our terrestrial observations and ideas with which to explain things not terrestrial*, and the study of Mars is one of those which show us best that we are far from knowing all, that our planet is not the absolute type of the universe and that the other worlds differ from that which we inhabit. It is absolutely certain that this world is not inactive, sterile, dead, but, on the contrary, animated with life intense and prodigious, in comparison with which the normal aspect of the earth, seen from that distance, would seem lethargic tranquility."

Jupiter is getting too low in the southwest for good observations in the evening. Indeed its altitude has been so low when on the meridian that very few good observations have been obtained at Northfield this summer. The red spot has been distinctly visible only once; however, we must say that very little attention has been paid to the object here. Jupiter will be in conjunction with the moon Oct. 28 at 5 P. M. central time, and, as seen by observers in latitudes from 20° north to 30° south, will suffer occultation. The occultation on the night of Sept. 3 was observed at many places. At Carleton College Observatory the weather was cloudy, but a break in the clouds occurred just before the beginning of the occultation, and another at the end, which permitted the following observations to be made:

	Local Mean Time. d	h	m
First contact; Jupiter's limb perceptibly notched	8	00	00.3
Jupiter's disk half covered	8	00	48.8
Second contact; Jupiter's disk wholly covered	8	01	39.0
Satellite I disappeared	8	02	56.0
Jupiter's disk half uncovered	9	10	42.9
Fourth contact; very poor definition	9	11	46.1

The second of these times was difficult to note because of a large mountain on the moon's limb where it was projected upon the planet's disk, rendering the estimate of bisection of the latter doubtful.

At the reappearance the sky was in a still worse condition, a thick haze being behind the clouds. The satellites were invisible and the planet was not detected until nearly half the disk had emerged. The difference in brilliancy of the planet and the bright limb of the moon was very striking.

The observations were made by Dr. H. C. Wilson with the 8-inch refractor, magnifying power 95; times recorded upon chronograph.

Saturn is in good position for morning observation, and will soon be seen at midnight. He is in Leo, a little east of Regulus. Nothing of importance has recently come to hand concerning this planet.

Uranus is about 2° northeast of Spica, in Virgo. The conjunction with Mercury has already been spoken of.

Neptune is about one-third of the way from Aldebaran to the Pleiades, and may be seen during the whole of the night.

The Sun has not lately been as free from spots as it was during the first half of the year. During August spots were observed on sixteen days, four different groups being noted. On four days, Aug. 21 to 24, the disk was entirely free from spots. A large single spot, surrounded by many brilliant faculæ, was seen on the east limb Aug. 27, and was followed across the disk until Sept. 7. On that date two new spots of considerable size had been formed close to the old one. Sept. 9, 10, 12 and 16 no spots were visible.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
MERCURY.					
Oct. 15	13 23.5	−10 25	6 24 A.M.	11 45.7 A.M.	5 08 P.M.
25	13 02.1	− 5 01	5 01 "	10 45.0 "	4 29 "
Nov. 5	13 39.2	− 8 01	5 07 "	10 38.9 "	4 10 "
15	14 35.9	−13 51	5 48 "	10 56.1 "	4 04 "
VENUS.					
Oct. 15	11 34.6	+ 4 17	3 37 A.M.	9 57.0 A.M.	4 17 P.M.
25	12 20.0	+ 0 03	4 00 "	10 03.1 "	4 07 "
Nov. 5	13 10.4	− 5 41	4 29 "	10 10.2 "	3 51 "
15	13 57.1	−10 19	4 55 "	10 17.3 "	3 39 "
MARS.					
Oct. 15	11 02.7	+ 7 34	2 52 A.M.	9 25.4 A.M.	3 59 P.M.
25	11 25.5	+ 5 11	2 45 "	9 08.9 "	3 33 "
Nov. 5	11 50.3	+ 2 33	2 35 "	8 48.6 "	3 02 "
15	12 12.6	+ 0 10	2 29 "	8 33.2 "	2 37 "
JUPITER.					
Oct. 15	18 10.3	−23 30	12 08 P.M.	4 31.8 P.M.	8 56 P.M.
25	18 16.9	−23 29	11 35 A.M.	3 59.1 "	8 23 "
Nov. 5	18 25.4	−23 26	11 01 "	3 24.2 "	7 47 "
15	18 33.7	−23 21	10 29 "	2 53.1 "	7 17 "

SATURN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 15	10 13.4	+12 23	1 43 A.M.	8 36.3 A.M.	3 30 P.M.
25	10 16.9	+12 06	1 08 "	8 00.3 "	2 52 "
Nov. 5	10 20.1	+11 50	10 29 "	7 20.3 "	2 11 "
15	10 22.4	+11 39	11 53 P.M.	6 43.3 "	1 34 "

URANUS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 15	13 23.6	− 8 10	6 15 A.M.	11 45.9 A.M.	5 17 P.M.
25	13 26.0	− 8 25	5 39 "	11 08.9 "	4 39 "
Nov. 5	13 28.5	− 8 40	4 59 "	10 28.2 "	3 57 "
15	13 30.7	− 8 53	4 23 "	9 51.0 "	3 19 "

NEPTUNE.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 15	4 10.1	+19 20	7 09 P.M.	2 33.8 A.M.	9 58 A.M.
25	4 09.2	+19 18	6 29 "	1 53.6 "	9 18 "
Nov. 5	4 08.1	+19 14	5 45 "	1 09.2 "	8 39 "
15	4 07.0	+19 11	5 05 "	12 28.8 "	7 52 "

THE SUN.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 15	13 23.6	− 8 48	6 17 A.M.	11 45.7 A.M.	5 14 P.M.
25	14 01.4	−12 22	6 29 "	11 43.1 "	4 57 "
Nov. 5	14 44.4	−15 55	6 45 "	11 43.7 "	4 42 "
15	15 24.9	−18 42	6 59 "	11 44.8 "	4 31 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Oct. 14	η Geminorum	3½	9 06	54	9 55	284	0 49
14	μ Geminorum	3	13 25	168	Star 1.2′ S. of moon's limb		
16	7 Cancri	6½	12 16	358	Star 0.0′ N. of moon's limb		
16	μ^2 Cancri	5½	14 15	176	14 20	184	0 05
29	χ^3 Sagitarii	5½	4 47	61	6 03	286	1 16
Nov. 1	56 Aquarii	6½	10 06	57	11 15	244	1 09
3	33 Piscium	4½	4 46	34	5 47	274	1 01
3	B. A. C. 17	6	7 51	77	9 07	215	1 17
8	ϵ Tauri	3½	17 36	70	18 40	273	1 04
10	141 Tauri	6½	10 58	135	11 36	194	0 39
10	3 Geminorum	6½	16 40	32	17 24	329	0 45
10	6 Geminorum	6½	18 01	86	19 16	281	1 15
12	84 Geminorum	6½	15 59	150	16 59	228	1 00

Phases of the Moon.

	Central Time. d h m
Full Moon	Oct. 8 7 26 P. M.
Last Quarter	" 16 6 38 "
New Moon	" 24 8 26 A. M.
First Quarter	" 31 2 30 "
Full Moon	Nov. 7 10 05 "

Approximate Times of the Transit of the Great Red Spot Across the Middle of Jupiter's Disc.

	h m		h m		h m
Oct. 6	10 31 P. M.	Oct. 11	9 41 P. M.	Oct. 16	8 51 P. M.
" 7	6 23 "	" 12	5 33 "	" 17	4 43 "
" 9	8 02 "	" 14	7 12 "	" 19	6 22 "
" 10	3 54 "	" 15	3 04 "	" 21	8 01 "

Phenomena of Jupiter's Satellites.

Central Time d	h	m				Central Time d	h	m			
Oct. 6	5	46	P. M.	II	Ec. Re.	Oct. 22	5	47	P. M.	II	Sh. Eg.
6	7	48	"	I	Ec. Re.	22	6	07	"	I	Ec. Re.
11	5	40	"	III	Oc. Re.	29	5	32	"	III	Sh. In.
11	7	42	"	III	Ec. Dis.	29	5	37	"	II	Sh. In.
13	6	14	"	I	Ec. Dis.	29	6	06	"	II	Tr. Eg
14	7	59	"	I	Sh. Eg.	30	5	18	"	I	Sh. Eg.
18	6	50	"	III	Oc. Dis.	Nov. 5	5	28	"	III	Tr. In.
20	5	54	"	II	Oc. Dis.	5	6	07	"	II	Tr. In.
21	5	26	"	I	Tr. In.	5	6	40	"	I	Oc. Dis.
21	6	36	"	I	Sh. In.	6	6	13	"	I	Tr. Eg.

New Minor Planets, 285, 286 and 287. A planet of the 13th magnitude or fainter was discovered by Palisa, Aug. 3.4972 G. M. T. in R. A. 22*h* 13*m* 54.6*s*; decl. south 9°01′23″. Another was discovered by Charlois, at Nice, Aug. 3.4917 G. M. T., R. A. 21*h* 23*m* 24.5*s*; decl. south 13°04′22″. The third was discovered by Dr. Peters, at Clinton, N. Y., Aug. 25.5589, R. A. 22*h* 15*m* 17.5*s*; decl. south 14°03′00″.

The Occultation of Jupiter on Sept. 3.

Several have sent us very enthusiastic accounts of the occultation but giving only approximate times and no longitudes or latitudes of the places of observation, so that we cannot notice them here. Professor William Brooks, of Smith Observatory, Geneva, N. Y., writes as follows:

"The occultation of Jupiter on the evening of Sept. 3 was well observed here with the 10-inch equatorial and the 3-inch finder attached thereto. The latter was used after the photographic corrector and plate-holder had been attached to the larger telescope.

"The first contact with the moon's dark limb at immersion was noted at 20*h* 29*m* 21*s* local sidereal time; and the re-appearance of the planet from the moon's bright limb was recorded at 21*h* 25*m* 30*s*. The conditions were decidedly unfavorable for photographic work, the air being very smoky, which made the moon's color a deep orange. However I succeeded in obtaining several good negatives of Jupiter and the moon previous to occultation. Also one negative, and this I had set my heart upon, showing the planet when it was half covered by the dark limb of the moon. The motion of the moon in its gradual approach to the planet is shown in an interesting manner in the series of photographs. And the record is autographic and permanent."

Mr. George A. Hill, at Washington, D. C., observed the first contact at 9*h* 41*m* 39*s*, and the second contact at 9*h* 43*m* 30*s* Washington mean time. The first of these observations was made through thick clouds, but the second was good.

Mr. J. W. Thompson, at Salem, Ohio, observed all four contacts with a four-inch telescope.

	h	m	s	
First contact,	8	39	00	railroad central time.
Second "	8	40	30	" " "
Third "	9	37	25	" " "
Fourth "	9	38	48	" " "

Mr. H. S. Hulbert, at Lansing, Mich., says that the time of the passage of the moon's edge off the disk of Jupiter was 1*m* 12*s*, "which greatly surprised" him.

COMET NOTES.

Comet e 1888 (Barnard, Sept. 1, 1888) will be in very favorable position for observation in the evening during October, but its light is becoming so feeble as to make it a difficult object. The following ephemeris by C. W. Crockett is taken from *A. J.* No. 195:

1889 G. M. T.	App. α (h m s)	App. δ (° ′ ″)	log. *r*	log. Δ	Br.
Oct. 2.5	18 15 03.0	−10 43 28	0.53349	0.52800	0.4
6.5	14 02.8	10 57 14	0.53805	0.54216	0.4
10.5	13 23.9	11 09 51	0.54256	0.55574	0.3
14.5	13 04.2	11 21 22	0.54704	0.56873	0.3
18.5	13 01.8	11 31 53	0.55147	0.58115	0.3
22.5	13 14.9	11 41 25	0.55585	0.59298	0.3
26.5	13 42.2	11 49 59	0.56018	0.60424	0.3
30.5	18 14 22.1	−11 57 40	0.56448	0.61494	0.2

Comet b 1889 (Barnard, March 31) may be seen during the whole night. It is increasing in brightness, reaching the maximum about Oct. 8, but will not be visible to the naked eye. It is moving southwest through the constellation Eridanus, the River, toward the second star in β Ceti. Oct. 10 it will pass very close to the star η Eridani. We have no ephemeris at hand later than the following by W. W. Campbell (*A. J.* No. 201):

1889 G. M. T.	App. α	App. δ	log. r	log. Δ	Br.
	h m s	° ′			
Oct. 1.5	3 23 22	− 5 48.9	0.4171	0.2541	1.70
3.5	3 16 28	6 34.8			
5.5	3 09 23	7 20.5	0.4208	0.2483	1.70
7.5	3 02 07	8 05.9			
9.5	2 54 41	8 50.6	0.4245	0.2451	1.71
11.5	2 47 07	9 34.4			
13.5	2 39 28	10 17.0	0.4283	0.2449	1.68
15.5	2 31 45	10 58.1			
17.5	2 23 59	11 37.5	0.4321	0.2477	1.63
19.5	2 16 14	12 15.0			
21.5	2 08 32	−12 50.3	0.4360	0.2534	1.56

Comet c 1889 (Barnard, June 23) has passed beyond the reach of the most powerful telescopes. The latest reported observation was on Aug. 5.

Comet d 1889 (Brooks July 6) was found, by Barnard at Lick Observatory, Aug. 1, to be divided into three parts. This discovery was verified on subsequent nights and was communicated by telegraph to other observatories. Elsewhere will be found a communication from Mr. Barnard to the *Astronomical Journal*, and another from Mr. Brooks on the same subject.

Elliptic elements of this comet have been computed by Dr. K. Zelbr (*A. N.* 2918), Rev. George M. Searle and Mr. S. C. Chandler (*A. J.* 202), and Dr. O. Knopf (*A. N.* 2921), the first deriving a period of 12⅓ years, the second 8.34 years, the third 8.186 years, and the last 7⅓ years. The second and third results, while agreeing well, are not, however, independent, as the first and last observations used in the two computations were identical, July 8 and Aug. 19. The following elements and ephemeris are by Mr. Chandler:

$$T = 1889 \text{ Sept. } 15.3618 \text{ G. M. T.}$$

$$\left.\begin{aligned} \omega &= 335^\circ\ 50'\ 42'' \\ \Omega &= 19\ \ 15\ \ 08 \\ i &= 6\ \ 00\ \ 10 \end{aligned}\right\} 1889.0$$

$$\log q = 0.300652 \qquad q = 1.99826$$

$$\epsilon = 0.507112$$

$$\text{Period} = 8.186 \text{ years.}$$

1889 G. M. T.	App. α	App. δ	log r	log Δ	Br.
	h m s	° ′			
Oct. 2.5	23 47 49	−5 01.8			
4.5	46 50	4 56.0	0.3021	0.0122	2.15
6.5	45 54	4 49.6			
8.5	45 04	4 42.8	0.3028	0.0193	2.08
10.5	44 18	4 35.4			
12.5	43 38	4 27.5	0.3036	0.0276	1.99
14.5	43 04	4 19.2			
16.5	23 42 36	−4 10.2	0.3046	0.0371	1.90

Comet e 1889 (Davidson, July 21) was observed by Barnard on the evening of July 26 in R. A. 13*h* 30*m*, decl. south 22° 01′ in the constellation of Hydra. It has moved rapidly northeast, and may now be found in the middle of Hercules. Its brightness is however diminishing rapidly so that it will be a difficult object for small telescopes. The orbit is probably parabolic. The latest elements are by Professor T. H. Safford (*A. J.* 202) depending upon observations at Rome July 26 and Washington Aug. 7 and Aug. 16.

$$T = 1889 \text{ July } 19.3066 \text{ G. M. T.}$$
$$\left.\begin{aligned} \omega &= 345^\circ\ 53'\ 59.0'' \\ \Omega &= 286\ \ 08\ \ 21.3 \\ i &= \ \ 65\ \ 59\ \ 16.4 \end{aligned}\right\} 1889.0$$
$$\log q = 0.016959$$
$$q = 1.03982$$

The following ephemeris was computed by Mr. William Bellamy from elements quite similar to the above (*A.J.* 201):

1889 G. M. T.	App. α			App. δ		log *r*	log Δ	Br.
	h	m	s	°	′			
Oct. 2.5	17	19	56	+32	31	0.2033	0.1782	0.024
4.5		23	43	32	46	0.2095	0.1876	
6.5		27	31	33	01	0.2156	0.1967	.021
8.5		31	19	33	15	0.2216	0.2055	
10.5		35	09	33	29	0.2276	0.2141	.019
12.5		38	59	33	43	0.2335	0.2224	
14.5		42	50	33	56	0.2394	0.2305	.017
16.5		46	43	34	09	0.2452	0.2384	
18.5		50	36	34	22	0.2510	0.2460	.014
20.5		54	31	34	35	0.2567	0.2535	
22.5	17	58	27	34	47	0.2623	0.2608	.013
24.5	18	02	24	34	59	0.2679	0.2680	
26.5		06	23	35	12	0.2734	0.2750	.011
28.5		10	24	35	24	0.2789	0.2818	
30.5	18	14	26	+35	37	0.2843	0.2885	.010

Warner Prizes for Cometary Discoveries. We are sorry to learn from Mr. Denning's comet notes in the September number of *The Observatory* that the money prizes offered by Mr. H. H. Warner, founder of the Warner Observatory, Rochester, N. Y., expired on May 1st last, and will not be renewed during the present year. These prizes were first offered in 1881, and the amount was then fixed at $200 to be paid to each discoverer of an unexpected comet. This sum was reduced in 1886 to $100 for each new comet. The greater number of these prizes have been won by Messrs. Barnard and Brooks, the two American observers who have been most zealous in their search of the heavens, but there is chance for others, and we hope that the zeal of young amateurs will not be diminished because of the lack of a monetary consideration. It is gratifying to know that the prizes will probably be offered again next year. We take pleasure, also in this connection, in calling attention to the medals which are to be offered next year by the Astronomical Society of the Pacific (see page 360).

Brilliant Meteors. Tuesday, Aug. 27, a very brilliant meteor was seen in the eastern heavens. It started near the great nebula in Andromeda, pursuing a southerly course, and bursting near the center of the square of Pegasus. It was of an intense white color and somewhat more brilliant than an electric light. A few minutes later a second one started from the same constellation. It was about double the size of the first, and changed to an intense red, then to blue, finally bursting with a slight report. The pieces fell like sparks from a sky-rocket. It was a very beautiful sight, the finest I ever saw. W. S. HULBERT.

Lansing, Mich.

Queries with Brief Answers. The answer to query number 19, as given in the last MESSENGER, was carelessly wrong, and a number of our readers were prompt to set us right. It is a pleasure to acknowledge the mistake, and a delight to say the spirit of reproof by these friends, in every case but one, was admirable and generously kind. Now we hasten to give a better answer on the next page.

Query 11. The reason why almanac makers use the word *morn*, in case of the moon's rising or setting, is plain, on proper reflection. Let the proposer of the query look in some calendar for October, 1889. On the 18th he will find *morn*. The 17th gives 11*h* 42*m* for the rising. Opposite the 19th he will see 41*m*, which of course denotes so many minutes past 12; but the intervals between the risings is only one hour; and one day *plus* one hour from Thursday night 11*h* 42*m* throws the rising past midnight on Friday, and hence is counted as Saturday morning. So when two successive settings occur, one on each side of midnight, the like skipping of one day takes place. The moon does not rise at all on Friday, Oct. 18, 1889. R. W. M.

Query 19. The answer printed in the August number is incorrect. Evidently the inquirer asked the common time; and that is midnight of Dec. 31, 1900. This is so plain and simple a matter that it is cause for wonder that anyone could be in doubt on the subject. The year is always the *current*, not the *complete* year. The same is true of the day, —when we say the 31st day of the 12th month, the meaning is the *current* day and month—not 31 days and 12 months. The Christian era is now in its *eighteen hundred and eighty-ninth* year. The 1889 years will be completed at midnight Dec. 31. There was no year zero. The Christian era starts with the year 1, and when 1900 have passed we shall reach the 20th century, and not till then. R. W. M.

30. In reply to the question of S. W. F. in THE MESSENGER for August I enclose the position of 1830 Groombridge:

α 11*h* 47*m* 51*s* δ + 38*h* 34*m* 37*s*

The star is about 6.5 magnitude. I am of the opinion that S. W. F. will have some trouble in finding it unless he is furnished with an equatorial telescope. The star is in the lower part of the right leg of the Great Bear, and when δ Ursæ Majoris is on the meridian 1830 Groombridge will be about 19½° to the south and slightly west of the former star. It might be located from Cor Caroli. It is about 16° west and directly south of that star. It is also near a nebula of a pale white tint and quite bright. It should be in the field with the nebula in an eye-piece that covers 60′ or 70′. G. B. H.

Photographic Equatorial for Cordoba Observatory. Messrs Warner & Swasey, of Cleveland, have just completed the mounting of a 12-inch photographic equatorial for Professor Thome of the Cordoba Observatory, Argentine Republic, South America.

Spectrum of χ Cygni. Bright lines were seen in the spectrum of Chi Cygni on May 19, 21; D_3 very plain, confirmed by Mr. Taylor at Ealing, England. T. E. ESPIN.
Wolsingham Observatory.

A student interested in elementary algebra finds trouble in solving the following example:

$$x^2 + y = 7$$
$$x + y^2 = 11$$

Possibly some of our readers would like to try it.

EDITORIAL NOTES.

The beautiful frontispiece which we are able to present this month by courtesy of Professor W. H. Pickering, of Harvard College Observatory, we think will be studied with great interest in connection with the important article accompanying it.

Two excellent articles are already in hand for next month, one by Professor Piazzi Smyth, of England, and the other by W. H. S. Monck, of Dublin, Ireland.

The dome of the new Dearborn Observatory at Evanston is said to be one of the most perfect pieces of mechanism of its kind. It was planned by Professor G. W. Hough. It is to be duplicated for the new Observatory at Denver, Col.

The Bruce Photographic Telescope, a doublet of 24 inches aperture and 11 feet focal length, for Harvard College Observatory, will be completed in the near future. The terms offered by Mantois of Paris for the rough disks are satisfactory, and the contract has been signed with A. Clark & Sons of Cambridge, Mass., for the entire instrument.

Professor Howe's New Telescope. Professor H. A. Howe, Director of the Observatory of the University of Denver, Colorado, writes recently that the crown glass for his new 20-inch objective is on exhibition at the Paris Exposition. Mantois of Paris, the maker, says he is willing to have the jury decide his rank as a competitor by it alone if they choose. The flint glass is still in the pots.

Photograph of Jupiter. Professor W. H. Pickering has favored THE MESSENGER with a reversed positive of the planet Jupiter, mounted for a transparency. The negative was taken on Wilson's Peak, in Southern California, at an altitude of 6,250 feet, by the aid of the 13-inch Boyden photographic doublet, June 21 19*h* 15*m* G. M. T. The exposure was 14 seconds. The scale is 1 : 5,000,000,000. A surprising amount of detail is seen in the positive, the focal image being enlarged to show an equatorial diameter of 29 millimeters.

New Telescope for Carleton College Observatory.—A few weeks ago Dr. E. H. Williams, of Philadelphia, most generously donated to Carleton College $15,000 for the purpose of purchasing a new equatorial telescope, of 16-inches clear aperture, for the new Observatory. This noble gift is now in the College treasury, and steps are being taken for the construction of the telescope. There are so many new and interesting questions pretaining to the glasses and the mounting, that we shall not greatly hasten the work, but go only so fast as the best way opens after careful study. It will probably be two years before the large telescope will be in place and ready for work.

The friends of Carleton have reason to rejoice greatly in this another gift by Mr. Williams to this institution, and as the most thoughtful of them ponder it, they well know that whatever the scientific character of this college now is, or may be, its measure of success will be largely due to the generous, Christian spirit of this noble man. These grand memorials, which he has so wisely placed here, will fittingly bring Heaven and earth nearer in gracious power to touch the hearts of the young, with the matchless beauty of the star-depths painted there as the handiwork of God.

Recent Papers by Professor William Huggins. Two excellent papers have recently been published by Dr. William Huggins, of London, with titles as follows: "On the Wave-Length of the Principal Line in the Spectrum of the Aurora," and "On the Spectrum Visible and Photographic of the Great Nebula of Orion." To the last the name of Mrs. Huggins is added as author also. In our last issue appeared a brief article by Professor C. A. Young covering most of the important points; for details the papers themselves should be read.

Change in Crater Pliny. On Sept. 15 telegraphic notice came that an observer in Geneva had noticed a change in the central crater of Pliny. Bad weather at Carleton College Observatory has prevented observation. Attention is asked to this during the next moon. We also suggest that Gassendi be examined carefully, for *l'Astronomie* (France) reports a new crater on its northwest rampart observed July 8, 1888.

The Observatory Criticises Professor Pickering's Plans for Stellar Photography. The August *Observatory* (Greenwich, England), in a remarkable manner editorially criticises the plans for stellar photography proposed by Professor E. C. Pickering of Harvard College Observatory. The occasion of our worthy cotemporary's displeasure seems to arise in this way: In November last, Professor Pickering prepared a circular, for special and personal uses, setting forth the advantages of a photographic telescope of 24 inches clear aperture and eleven feet focal length, and briefly showing what such an instrument could do in the promising field of stellar photography. To this appeal Miss C. W. Bruce, of New York City, promptly responded with the munificent gift of $50,000 to procure such a telescope.

The *Observatory* now takes Professor Pickering to task severely for the following reasons: 1st. Because no mention was made of similar work proposed by the International Congress in 1887, in his appeal for funds it is said he has not "put his case before the public in a fair manner;" curiously suggesting also, that some evil-disposed person might charge Professor Pickering with deliberately excluding such mention from his appeal, as likely to be prejudicial to his chances of success in getting the desired money. 2d. That Professor Pickering is setting up a rival scheme to that of the International Congress and thereby opposing and discouraging its great work. 3d. In assuming that he can make a photographic chart of the whole sky in two or three years, with one large telescope, is to say that the united efforts of seventeen observatories to do the same work with smaller telescopes, is all wrong. 4th. That, by his course, Professor Pickering "has re-peopled the world with critics whose attention is distracted from the research by the manner in which it has been endowed."

As a whole, this is the most remarkable criticism by men of acknowledged ability that we ever saw. Surely it does not "mince matters." In a unique way it raises some very grave questions, that lead us to ask what obligation any man is under, in any business, to publish to the world what other men *propose* to do, before he can properly go at the same work in his own way, if he chooses? Or what right have English gentlemen to impugn the motives of any person and color them up to suit their fancy, and then turn round and politely ask the accused to say whether or not that is a true picture of himself? It is difficult to imagine what provocation would justify such conduct.

This so-called "rival scheme" seems to trouble the *Observatory*. Why is this? Is there real fear of one man against the seventeen—one Observatory against the seventeen, possibly of the best in all the world beside?

Another curious feature is the supposed fact that the manner of obtaining $50,000, in America, for endowing stellar photography should re-people the world with critics to harm the work in the eyes of our friends on the other side. We do not believe it will. The International Committee know that Harvard College Observatory has a fine 13-inch photographic telescope, and it is now ready, doubtless, to do its full share of work on the international plan. If that noble Observatory wants to do more, or try different plans for the same kind of work, we say, go ahead, and bid her God speed in it, especially when we know that Professor Pickering has already photographed stars with an 8-inch instrument whose magnitudes are as small as the limit of those contemplated by the International Congress.

Whether this large photographic telescope of 24 inches aperture can be made or not, as our friends seem to doubt, we do not know, but we do know, that the disks are already contracted for, and that the Clarks have agreed to make the lenses. Time will soon test all these interesting questions.

Total Solar Eclipse Expedition for Dec., 1890. An expedition to West Africa to observe the total eclipse of the sun which will occur Dec. 21-22, 1889, is now being organized in Washington, D. C., with headquarters at the Navy Department. Secretary Tracy has placed the entire management of this expedition in the hands of Professor D. P. Todd, Director of the Observatory of Amherst College, Mass. It is too early to speak of the personnel of the expedition, as but few are yet named. It is probable, if not certain, that Professor Bigelow, of the Nautical Office, Dr. Holland, Professor Agassiz, Mr. Orr, and Professor Loomis and Harvey Brown from the National Museum are among the persons already chosen.

Harvard College Observatory and the Massachusetts Institute of Technology are to loan some instruments for the service of the expedition. The plans, so far matured, seem to cover a wide range of work, as this will probably be the most favorable eclipse for observation (if the weather at the time is propitious) that will take place for a few years to come. Professor Todd is anxious, of course, to obtain all the observational data possible in this early opportunity, and we believe he will spare no pains to make the expedition successful in all ways.

The path of totality of this eclipse touches the west coast of Africa at 10° south latitude, and near the city of St. Paul Loanda, two or three hundred miles below the mouth of the Congo River. The expedition will land at this city and choose its point of observation probably at some distance beyond, near the central line of the shadow.

Astronomical Photography. The fourth part of the Bulletin of the Permanent International Committee on the Photographic Chart of the Sky is just at hand. It contains valuable papers by Dr. Scheiner, J. C. Kapteyn, Dr. H. C. Vogel, David Gill, and E. Renz, on subjects of investigation connected with the great project. The paper by Dr. Scheiner, of Potsdam on "The Application of Photography to the Determination of Stellar Magnitudes," giving results of measurements of plates exposed by E. von Gothard at Hereny, and by himself at Potsdam, is specially interesting. The paper also by Dr. Vogel, describing the new photographic refractor recently constructed for the Observatory at Potsdam by the Repsolds is of great interest and importance. This instrument has two objectives and eye-piece and plate-holder in the same tube, conforming to the resolutions of the congress in 1887, but the peculiarity is in the form of mounting, which is quite different from the English and German forms. The pillar which supports the polar axis is not upright, but L-shaped, the lower part being inclined nearly in the plane of the equator, the upper almost at right angles to this, extending toward the north pole and enclosing the polar axis. The support possesses very great stability, and its form permits an *uninterrupted motion of the telescope in all positions.* The

English form of mounting, which was adopted by the Henrys, does not permit the telescope to be directed toward the polar regions. The German form does not permit the telescope to pass the meridian near the zenith without reversal, the tube striking upon parts of the pillar. The Repsolds, in their new form of mounting, have avoided both of these difficulties.

The President of the Bureau, E. Mouchez, after calling attention to the reunion of the Permanent Committee to be held in Paris Sept. 15, and the new Astrographic Congress at Bruxelles the following week, gives a brief report of progress already made and a list of questions to be considered at the meeting. He says, "According to some reports received it seems that the results obtained with the photographic objectives constructed in other countries are not so satisfactory as ours, especially in regard to the extent of measurable field. If this be so there will be a troublesome cause of delay for several of the observatories which should take part in the construction of the chart of the sky and the catalogue.

"The seven instruments, the construction of which was given to Messrs. Henry and Gautier, are finished. The three destined for the French observatories of Bordeaux, Toulouse and Alger have been delivered, and the four for La Plata, Santiago du Chili, Rio de Janeiro an San Fernando are also finished and in course of shipment. These seven observatories, with that of Paris, will be ready to commence work in the first half of the coming year." H. C. W.

International National Congress on Celestial Photography. By courtesy of Mr. A. A. Common, vice president of the International Congress on Celestial Photography, we have a circular giving a programme of meeting appointed for Sept. 20. It is as follows:

PROGRAMME.

Sun.—The establishment of an understanding between Observatories with a view of obtaining an uninterrupted series of Solar Photographs of uniform plan, giving the condition of the Sun's surface several times a day.

A systematic Photographic Study of the Solar Spectrum.

Moon.—Systematic study by Photography of the surface of the Moon, in order to obtain a complete delineation of the whole visible surface of our Satellite.

Planets.—Photography of Planets and their Satellites, for physical features and measurement.

Meteorites and Shooting Stars.—Study by Photography.

Comets.—Photography of Comets during the whole course of their appearance.

Star Clusters.—Photography for purposes of description and measurement.

Stars.—Photometric study of Stars by Photography.

Special Study: Stellar Spectra, for classification and measurement.

Nebulæ.—Descriptive Photography and Photometry.

Searching for Nebulæ by Photography. Preparation of documents enabling the detection in the future of any modification of form which may arise.

GENERAL QUESTIONS.

Instruments to be employed in each case.

Suitable methods for obtaining an exact definition of the conditions under which the Celestial Photographs are obtained so as to allow of comparison in the future.

Reproduction of negatives and multiplication of copies.

Preservation of negatives and copies as photographs.

Measures to be taken in order to ensure the preservation of these documents in public collections.

Professor Loomis' Will Bequeaths over $300,000 to Yale University. By the Will of the late Professor Elias Loomis, Yale University is ultimately to come into the possession of over $300,000. After special bequests to relatives the following provisions of the Will relate to the University and the Astronomical Observatory:

An elegant picture of the deceased, painted by Mrs. H. A. Loop, of New York, is given to Yale to be kept in the Astronomical Observatory

All the professor's books and pamphlets which relate to mathematical and physical sciences go to the University Library.

After bequeathing certain books, manuscripts, etc., to a son, all the remainder of his property goes to Yale University in trust. One-third of the income from this trust fund in the care of Yale is to be given to Henry Bradford Loomis, another third to his other son, Francis E. Loomis, who is in Europe in very delicate health, and a third to the Yale Astronomical Observatory.

Upon the death of each son the one-third of the income from the trust fund they are entitled to while living goes to the Yale Observatory.

The income of said trust fund, which is to go to the use of the Observatory, as above provided, may be applied, at discretion of Yale University, in any year, to all, or one, or more of the following objects, namely: The payment of salaries of observers whose time is exclusively devoted to the making of observations for the promotion of the science of astronomy, or to the reduction of astronomical observations, and their discussion in papers prepared for publication, or to defraying the expenses of publishing these observations. If, in any year, the income of this trust fund, which he desires to be forever kept as a distinct fund by the name of the Loomis fund, available for the use of the Observatory, shall be more than sufficient to provide for the above named objects, the excess of income shall be added to the principal and shall thenceforth form an integral part of this fund.

Henry Bradford Loomis is named as executor. The treasurer of Yale college is executor ex-officio.

Provisions like these for the endowment of scientific research are eminently wise, and are gaining the attention of the public more and more in recent years.

The Velocity of Sound Mathematically Completed (*From Newton's Demonstration*) *and shown to be not seriously modified by Heat.* PROPOSITION I. Newton taught that the whole air-tension, from its averaged weight-height A ($\frac{P}{W}$) is the pulse-force producing the wave-length or velocity of sound in air.

PROPOSITION II. Newton was right in thus treating air-tension P (or weight A), and not its mere increase ($P' - P$) by condensing vibration, as the pulse-force producing velocity of sound, V.

PROPOSITION III. The fact that the whole air-tension A (or $\frac{P}{W}$) is the pulse-force producing its velocity, at once annihilates the pulse-heat theory, which regards the velocity of sound as greatly increased by vibrational heat.

PROPOSITION IV. Instead of any great addition of velocity from heat, the true filling out of the Newtonian value is the mere supply of a slight mathematical deficiency, one little item overlooked in Newton's demonstration. Namely, the fact that the work of pulse-force A (as an already acquired tension) is by instant *stroke*, instead of steady pressure (as reckoned,—whereby its efficacy in pulse motion or velocity of sound is increased $\sqrt[4]{2}$-fold, *i. e.*, to 1.19 of its Newtonian value, or from 916 to 1090 feet per second, as the facts of nature require.

A CHALLENGE.

After the most thorough, and long-continued, and oft repeated examination and demonstration of the case, I now call upon the scientific world to meet the issue here made, and either disprove the ground here taken or else accept it as the truth. Which of the four propositions above does anyone call in question? Each candid expert should answer, that we may know in what direction to spend our labor, and furnish our argument. I deem this a serious matter; and it is high time for our current science to be proved right, or set right, upon this important point. Correspondence is kindly solicited, SMITH B. GOODENOW.

Battle Creek, Iowa.

Stonyhurst College Observatory. The report for 1888, giving the results of meteorological, magnetical and solar observations, made at Stonyhurst College Observatory, by Rev. S. J. Perry, S. J., D. Sc., F. R. S., has been received. It is a neat pamphlet of 99 pages of the usual form of Father Perry's reports of this kind that have been issued for several years past. The work of this Observatory is known in both hemispheres.

Professor H. V. Egbert has recently been appointed to the position of Professor of Mathematics and Astronomy in Buchtel College, Akron, Ohio, in the place of Professor Chas. S. Howe who has resigned. Mr. Egbert is well and favorably known very generally in lines of his chosen pursuits and he comes to his new field amply qualified for it.

BOOK NOTICES.

ZENOGRAPHICAL FRAGMENTS. I. The Motions and Changes of the Markings of Jupiter in the Apparition of 1886–87, by A. Stanley Williams, F. R. A. S. London: Publishers, Messrs. Mitchell & Hughes, 140 Wardour Street W. 1889. pp. 118.

In the study of the surface markings of Jupiter Mr. Williams used a silver-on-glass reflector by Calver, 6½ inches in aperture and equatorially mounted, with magnifying power 170. The observations were principally designed to effect two objects. 1st, to fix the zenographical longitudes of the different spots; 2nd, to record the magnitude, intensity and appearance of the various markings diversifying the disk of Jupiter. In the first section is given the method of observation, delineation and reduction; in the second is shown how the construction of the chart of the markings is made; in the third the general arrangement of the Jovian belts and markings of 1886–87; fourth, observations of individual markings with remarks on their motions and changes; fifth, summary of rotation periods, mean motion of matter at different latitudes in 1887; sixth, relative attitudes of different Jovian markings, and seventh, on the repellent influence apparently exerted by the Red Spot.

By a mere glance at these topics, it will be seen at once that the author is dealing with themes on which the student of astronomy desires knowledge, and hence new and useful studies will be most welcome everywhere. The latitude of the different belts in the first plate are said to be not fully satisfactory because determined from a limited number of drawings of the entire disk of Jupiter, and that it should be remembered in comparing these drawings with others that the maps are reduced to some particular date and show the face of the planet as seen at that date. This is important if the reader remembers that the equatorial spots make a complete revolution on the surface of the planet, relatively to the Red Spot, in an interval of 45 days.

In the body of this book there is much of detail in relation to the north and south temperate and equatorial spots, the study of which give strong hints of physical characteristics of prominent surface markings, especially that of the Great Red Spot which has attracted so much attention everywhere since 1879. The accompanying lithographic plates are excellent features in the author's plan, and if accurate would be invaluable for future reference. The first plate is 12 inches by 5½ showing a zone of belts and spots to 50° north and south of the Jovian equator. The remaining seven full page plates show different phases of the more prominent markings observed during the period of their studies. Our readers will be interested to compare this work with that so well done by Professor Hough, of Dearborn Observatory, now located at Evanston, Ill.

This book is certainly a valuable contribution to the study of the Giant Planet that Americans will appreciate.

The *National Magazine* is the name of a new literary venture of Chicago, which begins with October number. It is published under the auspices of the new "National University," which opens October 1st, of which it is organ. The first number will contain articles on literary, educational and scientific subjects, and a prospectus of the University, which is said to be modelled after the London University and has extensive non-resident courses, teaching many subjects by mail. Published at 182 Clark Street.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 8, NO. 9. NOVEMBER, 1889. WHOLE NO. 79.

RECENT SCOTTISH METEOROLOGY COMPARED WITH SIMULTANEOUS SUN-SPOT CYCLES.

BY C. PIAZZI SMYTH.*

For THE MESSENGER.

When Professor Wm. W. Payne, in his able catering for the growing public of his "SIDEREAL MESSENGER," was pleased to honor me with a request for a compendious account of my rather over-long paper on the above subject, printed last year in the Transactions of the R. Society, Edinburgh; and to flatteringly assure me that the deductions which I brought out there would "interest readers in America, who have been giving some attention to phenomena of that kind," I felt it even a double duty, to endeavor to do what I could. For over and above all present claims and interests, I am old enough to remember the whirlwind of excitement with which, some fifty years ago, all the leading phisicists of Great Britain received *their* Colonel Reid's accounts of *your* Mr. Redfield's explanations of the West Indian hurricanes; and of the greater British storms as those huricanes' later dying efforts after traversing over nearly half the world in an orbital path of pre-ordained and regular kind. For out of such a combination of British, with American, observations, the generous sentiments of all the best of our scientist kind leaped at once in hope to the firm conclusion that meteorology so pursued had a grand future before it, and might become one of the highest, and even most cosmical, of the sciences.

Yet is it doomed to begin with local details even of the pettiest kind. And I,—having had officially such observations to the extent of many millions pass through my hands, for ordinary computation, and for furnishing out

* Late Astronomer Royal for Scotland.

government reports on the health of the people, every month, and every quarter, year after year and for upwards of thirty years,—considered it in honor incumbent upon me, before resigning in old age my national office, to put all those almost innumerable observations together on a general principle, and compare any symptoms of progress amongst them, with the course of physical phenomena in that great enlightening and necessarily ruling orb, the sun.

The only novelty here was in the particular mass of meteorological observations discussed; *viz.*, bi-diurnal notations of some twenty different instruments on phenomena at fifty-five different stations in Scotland, throughout all the years 1856 to 1887 inclusive. For the connection of *some* mundane meteorology, as well as magnetism, with the central and most visible, though still little understood eleven year spot-cycle of the sun, had begun long before in other countries; and many names of American, English, Irish, Swiss, German and other scientists have been rendered famous forever by their labors therein, though they themselves in too many cases have now passed away.

THE FIRST EDINBURGH SUN-SPOT ENQUIRY.

Indeed, even in Edinburgh, we had had some previous experience bearing on the same question; and as touching the disagreements, as well as agreements, of those earlier Scottish labors with those of other researches at the same times, a few words may well be expended now, before coming to the later observations and dates more particularly called for in these pages.

That earlier Edinburgh essay for comparing local weather at one little point only on the earth's surface with sun-spot cycles, ruling, if at all, the entire globe, had the limitation of depending almost entirely on temperature alone; but that in a first rate manner. For, from 1836 to 1876, there were weekly observations of four grand thermometers with their bulbs sunk into the rock of the Observatory hill, at the successive depths of 3, 6, 12, and 24 feet respectively. The results, too, thence derived, were found capable of so much solidity of proof that attempts were made to connect with them the temperature observations of the air by ordinary meteorological observers, for the still earlier dates of 1821 down to 1835, or from five years before the immortal sun-spot cycle observations and discoveries of M. M. Schwabe and Wolf, to the establishment of the rock thermometers on the Edinburgh Observatory hill by the late Professor James David Forbes.

Now the first result of bringing together the Edinburgh temperatures and the mighty sun-spot cycles for those fifty years in all was, I am afraid, a disappointment to the Observatories of Greenwich and Kew, to the British Association, and many of its then living, most able, members now alas, no more; as Warren de la Rue, J. Alan Brown, General Sabine, Professor Balfour Stewart and many others,—for there was no immediate and simultaneous likeness in the curves of our thermometers and the sun-spot numbers as furnished from various acknowledged sources. (See a plate three feet long in the Transations of R. Society, Edinburgh, Part II, Vol. xxix for 1879-1880; also the xiiith Vol. of the Edinburgh Observations published in 1871.)

But while the eleven-year cycle of sun-spots was repeated five times clearly in those fifty-six years and still more conspicuously three times in the last thirty-four of them;—it was precisely in this latter period that the Edinburgh rock thermometers also were most emphatic in showing a cycle of the same peculiar duration, but not coinciding even in its solitary maximum with the date of any one maximum, or minimum either, of any eleven year cycle of sun-spots; but appearing some two or three years after the beginning of each new cycle of spots.

The difference might indeed have admitted of simple explanation, had it stood by itself; but it was accompanied by the further feature, that though the seasonal variations of temperature had been eliminated by calculation, yet the course of super-annual temperature, in place of a nearly uniform rise from *minimum* to *maximum*, and then a similar fall from *maximum* to *minimum*, exhibited little but series of successive undulations of short period, say from 1.5 to 3 years; and it was these, sometimes running together which raised their maxima, as well as depressed their nearest minima, beyond the average; while at other times of half period they decreased both the one and the other. Yet never so perfectly as to exhibit the true course of aerial temperature (which the deep rock thermometers showed most incontestably had smote the earth from the outside, or from the heavens towards the inward terrestrial parts), as a dead level, but proved it a never ending, tumultuous motion of waves following waves.

With such varied and compound orders of interferences too, that besides four nearly eleven-year maxima, each of two or three years, duration at the central epochs of:

1834
1846
1857 and
1868

it was quite plain that the 1857 maximum of temperature rose far above the two preceding, as well as the one following maximum. Also that nothing so low as the grand minimum of the temperature curve in 1836 had been experienced in the whole fifty-six years under study. Whence all men are led anxiously to enquire, *when* is likely to take place the next equally low minimum to that of 1836, and the equally high and long continued heat period of 1857, or concurrence of temperature undulations of a more signal and rarer kind than each and every eleven-year cycle can show? Some vague surmises had imagined that sixty-one years might be the time of a restoration of the earthly temperature; and there *were* lately some remarkable coincidences between 1825 and 1886, 1826 and 1887, as well as 1827 and 1888. But a great depression chronicled in 1822–23 was not repeated in 1883 and 1884; nor is it likely from the very nature of wave effects, that the practical results should run long together. Alas that the science of the world has lost that born genius for undulation mathematics, your Professor Pliny Earle Chase, of Haverford College, Pa., who seemed more fitted and inclined for such calculations than almost any other scientist of his time! But it was not to be, and in the midst of the void which his departure occasioned, I attempted to report anew on the sun-spot bearings of the observations of the Meteorological Society of Scotland from 1850 to 1887 or those exactly which Professor Payne now inquires after.

THE SECOND EDINBURGH SUN-SPOT ENQUIRY.

The period therein concerned, it will be seen, was rather short; *viz.*, not quite three of the eleven-year cycles, and only half the possible sixty-one-year cycle. But the value as well as the peculiarity of the occasion chiefly resided in this, that the terrestrial portion of the observations, instead of being by a single observer on one hill top, were by fifty-five observers spread all over Scotland and the Isles thereof; and instead of being confined to temperature alone, were equally directed to a large variety of physical influences; while it was still to be proved by practical test, which of those several observable quantities might be more immediately in touch with sun-spot variations.

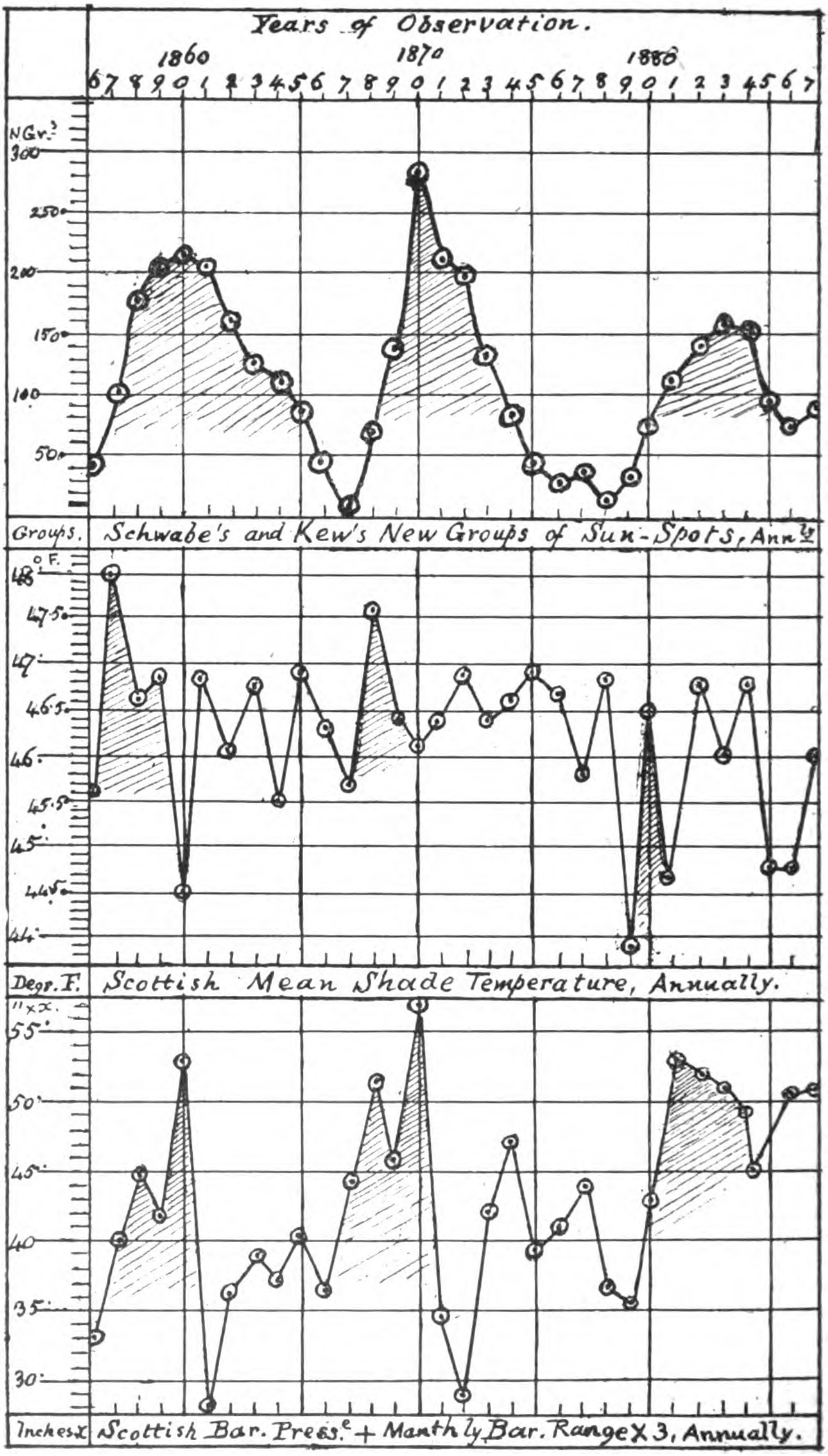
At the time, indeed, of beginning this second enquiry in Edinburgh, I was informed by high authority that the sun-spots had lost their influence, and that no one believed in them now as affecting the weather.

But the undulation idea given by the earlier enquiry, led me to take more note of the *difference* of one sun-spot cycle from another. Whence it immediately appeared that while the cycle from 1856 to 1867 had been a more than fairly ordinary one; that from 1867 to 1878 had been one of acute confluences; while that from 1878 to 1887 (probably to end in 1890) had been one of a miserably weak beginning; much disturbed too, as well as depressed, throughout. And an idea of the extent to which these differences were carried by nature, and established by observation, may be described thus,—

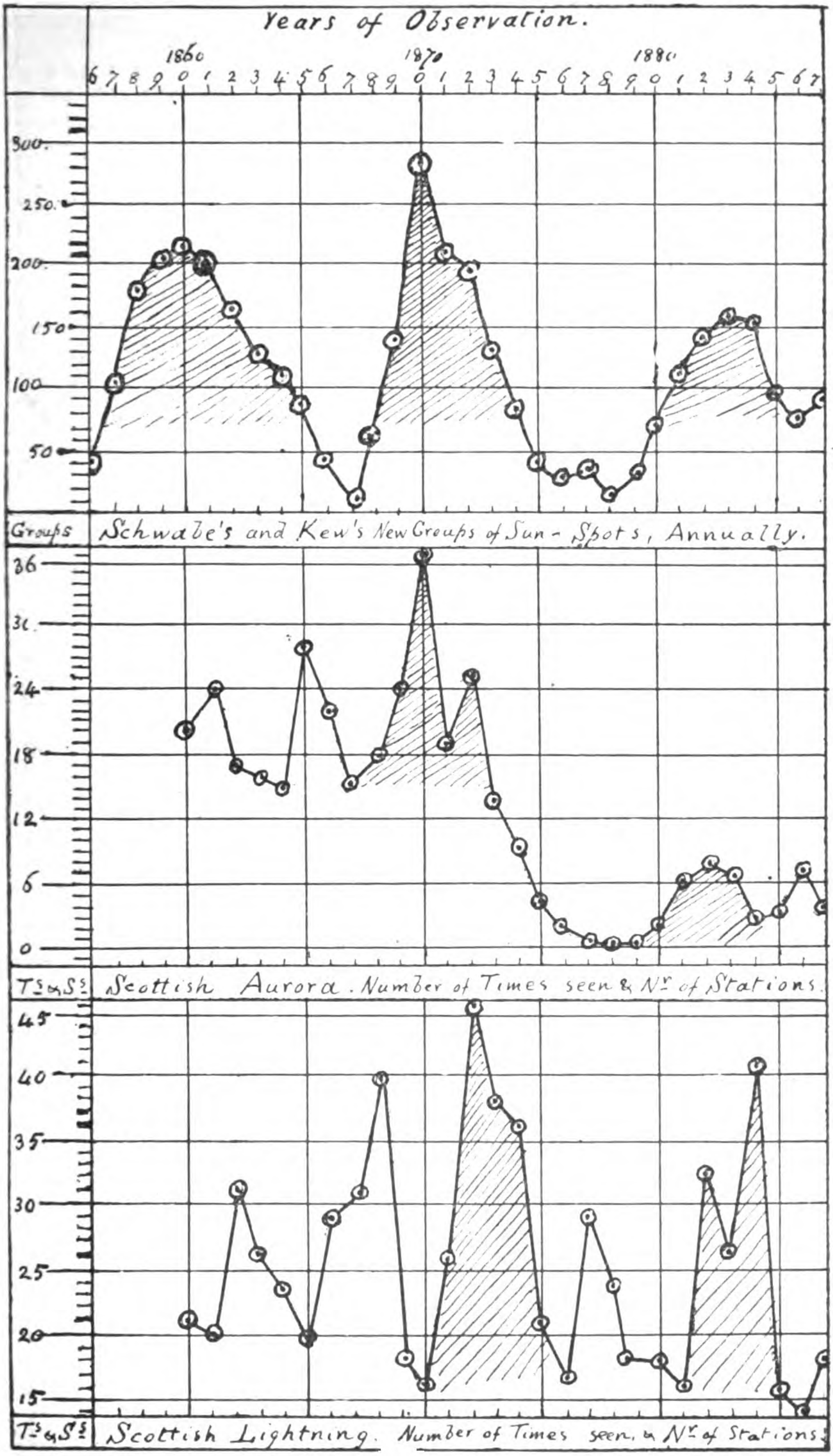
Every sun-spot cycle yet chronicled has the front of its undulation steeper than the rear; testifying to the greater energy of the solar radiations in that earlier part of the cycle; or when there is, *mirabile dictu*, more nearly a minimum than a maximum of visible sun-spot area.

And every cycle similarly recorded, testifies also to the occurrence of another, though smaller, outburst of energy in the course of the longer dying out of the principal wave; sometimes single as in our first, and probably in the third eleven-year wave; sometimes double as in the second.

But while the first of these three particular waves has nearly the normal steepness of front, viz.: 4 years of rise to 7 years of fall, and a maximum height of 220 new spot groups; the second of our three waves rushes up in the short period of only three years, and then to the unparalleled height of 280 groups, but takes 8 years to decline



Years of Observation.
1860
1870
1880
NGr.
300
250
200
150
100
50
Groups.
Schwabe's and Kew's New Groups of Sun-Spots, Ann^ly
°F.
48
47.5
47
46.5
46
45.5
45
44.5
44
Degr. F.
Scottish Mean Shade Temperature, Annually.
55
50
45
40
35
30
Inches
Scottish Bar. Press.e + Monthly Bar. Range X 3, Annually.



Years of Observation.
1860
1870
1880
300.
250.
200.
150
100
50
Groups
Schwabe's and Kew's New Groups of Sun-Spots, Annually.
36
30
24
18
12
6
0
Ts & Ss
Scottish Aurora. Number of Times seen & Nr of Stations.
45
40
35
30
25
20
15
Ts & Ss
Scottish Lightning. Number of Times seen, & Nr of Stations.

therefrom. While the third wave is feeble and sluggish beyond example, employing 5½ years to rise slowly to its maximum, and that a poor one of only 160 groups.

No distinct and equal recurrence, therefore, was to be expected in the weather of each of those three eleven-year periods; but there might be sufficient difference in the sun-spot elements to establish a dependent difference in the earthly simultaneous experiences.

To this end the sun-spot numbers, as collected at Kew Observatory since Mr. Schwabe's death, were projected on a uniform scale for each year concerned; while underneath, for the same years, were projected the mean annual results of 23 different kinds of meteorological observations, as thus,—

(1). Barometric pressure. (2). Monthly range of above. (3). Mean temperature in shade. (4). Daily range of shade temperature. (5). Black bulb thermometer by day. (6). Black bulb by night. (7). Humidity. (8). Elastic force of vapor. (9). Days of rain-fall. (10). Annual depth of rain. (11). Strength of wind. (12). Days of north wind. (13). Days of east wind. (14). Days of south wind. (15). Days of west wind. (16). Hours of sunshine. (17). Daily percentage of cloud. (18). Aurora, amouut and extent. (19). Lightning, amount and extent. (20). Mean maxima of shade temperature. (21). Mean minima of shade temperature. (22). Elevation above freezing point. (23). Depression below freezing point.

TEMPERATURE CONNECTIONS AGAIN.

On looking over all these plates it was easy enough to recognize the chief temperature characteristics of the earlier enquiry coming out again, though in degree, and more disturbed by rapid undulations than the older deep-sunk thermometers. Also that the chief manifestations of terrestrial air-temperature were by no means simultaneous with the greatest tabulated areas of sun-spots; but were, on the contrary, singularly coincident with something that rapidly took place in the sun, during the first or second year only, or near the very beginning of each new eleven-year cycle of spot-making and growing; and testifying to a violent variation of the solar radiating energy then taking place.

But this great *excess* of heat, which chiefly took place in 1857 and the times of our first cycle, did not prevent its being followed by an almost equally marked depression of temperature in 1860. And if the maximum temperature of the second cycle in 1868 was a small one, so was also the following minimum. While in the third cycle the maximum heat undulation, while still visible at the important epoch for starting a new set of undulations, viz., 1.5 years after the sun-spot maximum, was almost lost and swallowed up between two of the deepest temperature *depressions* on either side of it.

In short, all the earth-felt but sun-derived temperature—(and derived, not from accumulated "spotted area" of the sun's surface so carefully observed by certain astronomers, but from some invisible radiation at the time of almost minimum of spots, said spots themselves being further shown by spectroscopy to be a cooler region than the rest of the sun's photosphere)—was on a long-continued down-grade, extending and felt more or less through all the three eleven-year cycles, or whole period of thirty-two years. Not, however, bespeaking thereby, or proving a dying out of the sun's heat, sensible in so short a space of time; but merely indicating the approach of a minimum of long period, like that of 1836; and afterwards a rise like that of 1857. See our first Plate, its top horizontal compartment representing the three crucial sun-spot cycles between 1856 and 1887, and its second compartment representing the mean shade temperature of Scotland for the same years.

BAROMETRIC CONNECTIONS.

The next most remarkable dependence on a new sun-spot eleven-year cycle's beginning, but occuring rather later, or more nearly with the growth of spotted sun area, than the temperature shock,—say in the years 1860, 1870 and 1881, instead of 1857, 1868, 1880,—is found *first* in the projection of barometric pressure, and *then* and still more remarkably, in that of the monthly range of that same kind of pressure.

Now this is an important double result to have arrived at because the barometer is the most accurate, far-reaching and trustworthy instrument which meteorologists possess. It is one, too, with which it is almost impossible to make a bad observation for absolute height; while for variation, or range of height in the course of a month, no prejudice can well exist in the mind of the observer; and the numbers chronicled, refer to something in the air invisible to the eye impreceptible to the feelings and yet allowed by scientists to be at the base and root of all meteorology. But for testimony of the now proved concurrence of a certain kind between the barometric and the eleven-year cycle of sun-spots, please to look again at our first Plate, where the third and lowest compartment represents barometric pressure combined with three times its value of the monthly range thereof, and greatly varying with each of those three diverse and yet related cycles of solar appearances turned towards the earth.

In fact the variations *inter se* of three sun-spot cycles, which cover the duration of all the Scottish Meteorological Society's observations discussed at the R. Observatory, Edinburgh, are a most fortunate differential feature to assist in the present investigation; and we have not to go much furthur in our research before alighting on another meteorological curve which intensifies, while it exactly synchronizes with the excess and acuteness of the energy outburst displayed in the second sun-spot cycle's curve, extending from 1867 to 1878; and equally confirms the deplorable want of energy at the right time revealed in the third one.

AURORAL AND WIND CONNECTIONS.

This singuiarly confirming curve is that of aurora, its frequency and extent; or the number of times seen, and the number of stations reporting it each time. And if the first of the three sun-spot cycles is not very conspicuously marked with aurora, it is largely due to the want of a sufficient number of trained observers at that beginning of the Scottish Meteorological Society's activities, so that neither aurora nor lightning were observed during the beginning of the first cycle, say 1857 to 1860, though very steadily ever afterwards.

Further the "strength of the wind" curve, responds sensibly, though inversely to the auroral curve. So that during years of abundant auroral display, the winds were moderate in force or velocity, and chiefly from the west. But when Auroras left us in darkness on moonless nights, the winds became more violent, and verged to east and north, as testified by their curves for "Direction."

LIGHTNING'S CONNECTION WITH AURORA AND SUN-SPOTS IF TIME BE ALLOWED.

But there is a more accentuated connection still with Aurora, though by opposition, in the lightning curve, observed in the same manner as the aurora. For the very maximum demonstration of Aurora is exactly coincident in time, with the very minimum of lightning, and *vice versa;* but with the curious feature of the lightning's variation taking place *directly*, so nearly two years after the variations of the Aurora, that if the latter are combined with the lightning returns two years before they took place (or as if Aurora, once emitted into the terrestrial atmosphere, requires two years before it is changed into lightning), the original Aurora curve has all its chief features remarkably intensified; especially its acute rise in 1870, coincidently with the similar feature of the second sun-spot cycle.

For the pure and simple curves, however, of Aurora first, and then lightning, please to see our Plate 2, its horizontal sections two and three from the top. And if you should further ask why we have not of late been having any of those magnificent displays of Aurora which were so frequent in 1869, '70, '71 and the beginning of '72, the want of spot-forming energy in the present (or the third) sun-spot cycle is the nearest phenomenon to the real cause which can be quoted from crude observation.

CLOVA, RIPON, ENGLAND, August 15, 1889.

METEORS AND METEORITES.

W. H. S. MONCK.

FOR THE MESSENGER.

The promulgation of Mr. Norman Lockyer's theory of the origin of the stars has caused astronomers to devote more attention to the subject of meteors and meteorites. I do not propose to discuss this theory in the present article, but only to give a short summary of what is known on the subject.

By *meteorites* I mean solid bodies which have fallen to the earth, whatever their origin may be; by *meteors*, the shooting stars that flash for a few moments in our night sky and then vanish. To one or other of these heads what are termed ærolites, fire-balls, bolides, etc., may be referred. The term, fire-ball, for instance, is usually applied to a meteor of unusual magnitude and brilliancy. Mr. Lockyer's spectroscopic observations were made with *meteorites* as thus explained. Konkoly and a few others have endeavored to analyze the spectra of *meteors*, but the task is one of great difficulty. The first question to be considered is: Are meteorites merely meteors which from some cause have escaped dissipation in the atmosphere, or are they bodies of a different origin?

There is a good deal to be said on both sides of this question. On the one hand it is urged that meteors as a rule are dissipated at great heights in the atmosphere, having been intensely heated before dissipation; whereas meteorites were not only in the solid condition when they fell, but did not appear to be very highly heated—some apparently not being even red hot. As the heating is due to the resistance of the atmosphere which is greatest in the dense regions near the earth, this remarkable difference in the temperature of meteors and meteorites points to a difference of velocity so great as to suggest a different origin.

Again it is urged that no meteorite has been connected with any of the great meteor-showers recognized by observers,—especially with those in which the velocity of the moving meteors is known. Finally, meteorites exhibit traces of volcanic origin, and seldom, if ever, exhibit any chemical constituents which are not found on the earth; and if we suppose terrestrial volcanoes to have been more powerful in past ages (and considering the height to which the Krakatoa dust ascended, and the time which it remained suspended in the air the difference may not be very great), the stones shot from these volcanoes would revolve in orbits intersecting the earth's orbit, with velocities little different from that of the earth. On the other hand it may be said that some meteorites appear to have been highly heated when they fell; that some have been connected to a high degree of probability with well-known meteor-showers; that some meteors, especially fire-balls, have been dissipated at comparatively small heights; that the fall of meteorites has often been preceded by detonation, and detonations are quite common in the case of large meteors which approach pretty near the earth before dissipation, though their velocity is evidently considerable and their heat intense; with other similar reasons. One of the latest meteorites (known as the Mazapil meteorite) favors the latter theory. It was evidently very highly heated when it fell, and there are strong reasons for identifying it with the well-known meteor shower which follows in the track of Biela's comet. It is worth mentioning, however, that the Bielan meteors are about the slowest of known meteor-showers, while the Mazapil meteorite was one of the most highly heated of meteorites.

Should the late Mr. Proctor's theory of the ejection of comets and meteors, not only from the stars, but from the sun and planets (when in the sun-like state), be finally accepted, it will go far towards reconciling these conflicting views. Meteors and meteorites will then belong to the same class, but as earth-born or planet-born meteors are likely to be moving with less velocity than star-born meteors, they are more likely to fall to the earth in the solid form as meteorites. The chemical composition of a meteor will, according to this view, depend on the chemical composition of the body from which it was ejected, and there is some risk in drawing general conclusions from either the chemical composition or the spectra of meteorites unless we know from whence they came. The Mazapil meteorite would be an interesting one to experiment upon from our comparative certainty as to its origin; but even then the question remains whether Biela's comet was an original member of the solar system (ejected from Jupiter as Mr. Proctor thought), or a wanderer from space which Jupiter captured.

With respect to meteors it is well known that they appeared to come in showers emanating from particular radiant points, which, allowing for the effects of perspective, means that they come to us from the same direction, just as the clouds usually appear to diverge from one point on the horizon and converge to the opposite point. As to their motion being in right lines the very small portion of the path which we see them describe could hardly exhibit the curvature of the real orbit. If observers at two distant places observe the points where the meteor appears and disappears its height above the earth at appearance and disappearance can be computed (assuming the points to be the same). When it is vaporized or dissipated in the atmosphere the points of disappearance are almost certainly identical, but as to the point of first appearance there must always be some uncertainty. If the duration of the flight is also observed we can compute the velocity, but here again there are considerable chances of error. The radiant point of a shower is found by tracing the paths of the meteors on a globe or map and finding the points of intersection. But of course every point where the paths of two meteors meet is not a radiant. It is only when the paths of several meteors pass through a point that a radiant can be positively assigned. They seldom however pass exactly through a point and the radiants determined by different observers for the same shower often differ. Nevertheless the coincidence is sufficiently close to show that a large number of meteors frequently come to us very nearly in the same direction and thus belong to a common system.

Enormous velocities indicating strongly hyperbolic orbits were formerly assigned to some meteors or fire-balls, but since observations have been made with greater care such velocities have been rarely, if ever, observed. An important step was subsequently taken by observing that certain meteors followed in the track of certain comets and, in some instances, at least, exhibited the same periodicity as the comet itself. The best known instance is that of the November Leonid meteors which follow the track of the comet of 1866 and attain a maximum every thirty-three or thirty-four years, that being also the period of the comet. These meteors have a very high velocity in the air (not less than forty-four miles per second) because the motion of the comet is retrograde and the inclination of the orbit not being large, the earth and the meteor-shower are moving very nearly in opposite directions at the time of their encounter. Hence this grandest of meteor-showers has not been known to produce a single meteorite. There is, however, a second November meteor-shower more favorably situated for that purpose. It follows the track of Biela's comet whose motion is direct and inclination small, so tyat the velocity of the meteors is only about one-fourth of that of the Leonids. It is to this shower that the Mazapil meteorite probably belonged. Two other known meteor-showers have been in like manner connected with comets,—the Lyrids of April, and the Perseids of August. Any other identifications hitherto made must be regarded as very doubtful.

How are these meteors related to the corresponding comets? As yet we do not know. It is to be observed, moreover, that in speaking of them as following the tracks of comets we are not quite correct. If they followed the *exact* track of the comet they could never enter the atmosphere at all, for the nearest point of the comet's orbit lies at a considerable distance from the earth. What really occurs is that when the earth is making its nearest approach to the comet's orbit we see a number of meteors whose motion is nearly parallel to that of the comet when at the same part of its orbit. In some cases, too, these meteors exhibit a periodicity agreeing with that of the comet. But the August Perseids return every year with apparently but little change in the richness of the shower, so that the meteors must be scattered all along the path of the comet; while even when meteor-showers are periodic they usually appear in considerable numbers for two years in succession and in diminished numbers for some years before and after. Moreover, even when densest, they are at a considerable distance from the comet. The Perseids exhibit another peculiarity; they appear a considerable time before the earth reaches the node of the comet's orbit and continue for some time after the node has been passed. A possible explanation of this fact is afforded by the discovery of Dr. Hock that there are families of comets—comets having a similar origin and to a large extent similar orbits. The Perseid meteors are perhaps attached, not to the single comet with which they are usually associated, but to a family of comets of which it is a member.

It would be rash to conclude from what we know at present that comets consist of collections of meteors. The meteors rather appear, as a rule, to *follow* the comet; and, as has been seen, to follow it in a somewhat different path. As yet, however, no meteor-comet is known to have passed the node nearly at the same time that the earth did so; whenever this occurs we shall be in a better position to decide the question. It seems, however, equally probable that comet-meteors are formed by the condensation of comets' tails, a fact which would account for their divergence from the track of the comet to which we owe their visibility. The ascertained fact is simply that four known periodical comets are followed by meteor-showers in which the meteors are moving nearly (but not exactly) in the path of the comet.

It is remarkable that so few comets have hitherto been connected with showers of meteors. But it should be borne in mind that, in numerous instances, the comet is so distant from the earth at its nearest approach, that a meteor attached to it would be very unlikely to enter the atmosphere. A further difficulty in the comet theory is that a number of well known meteor-showers do not appear to be connected with any known comet. There is however reason to think that comets are liable to dissipation (a fate which seems to have overtaken Biela's comet) in which case the meteor train might continue after the corresponding comet had disappeared. Again, if Mr. Proctor's theory of the origin of comets in ejection should prove correct, it is evident that not only might meteors be ejected nearly in the path of a comet by a subsequent outburst of activity, but that meteors might be ejected in eruptions where the conditions for ejecting a comet were not realized. Our great terrestrial volcanoes eject clouds of steam (probably not unmixed with other gases or vapors) as well as stones. The comet may perhaps be assimilated to the vapor-ejection and the meteors to the stone-ejection; and under particular circumstances stones may be ejected with little or no vapor or *vice-versa*. It thus becomes doubtful whether we should go outside of the solar system for the origin of any of the meteor-showers which we have been considering. The Bielan meteors may have their origin in Jupiter, the Leonids in Uranus, and August Perseids in Neptune; but for the April Lyrids an ultra-Neptunean planet seems requisite. The existence of such a planet, however, is not improbable on other grounds.

It is therefore doubtful whether meteorites can give us any information (otherwise than by analogy) as to what goes on beyond the limits of the solar system. No doubt if we could be certain that a meteorite which had fallen to the earth was a visitor not only to us but to the solar system both its chemical analysis and experiments on its light would have very great interest. But unfortunately a body is not likely to reach the earth in the solid form if its velocity is considerably different from that of the earth, and where the difference in velocity is not great it is pretty certain that the falling body is now a member of the solar system whatever its origin may have been. To obtain certain information as to anything beyond the solar system from meteors, we should require to examine the spectra of some of those whose velocity proved that they were visitors from external space, and I doubt if even Konkoly has effected this. Reasoning from analogy it seems very unlikely that meteors exist nowhere except in the solar system, but it does not follow that meteors outside of our system possess all the same properties, or the same chemical composition as those within it.

One very important question in connection with this subject is raised by Mr. Denning's discovery (or theory) of meteors with fixed or stationary radiants. That Mr. Denning observed the meteors in question cannot, I think, be disputed; nor are his radiants open to much doubt. The real question is whether the meteors observed by him belonged to the same meteor-flight or not. Comparing the results of different observers it would seem that there is an uncertainty of probably some degrees in determining the radiant-point of a given meteor-shower; and therefore, if a shower on the 15th of April and another on the 15th of May were recorded as having the same radiant, the radiants might still be really different. If the shower continued during the whole of the intervening period the chances against such an explanation would be considerable, but if it was intermittent the probability of dealing with two really distinct showers would be increased. Everything depends on the number of meteors observed, the accuracy of the observations, and the question whether they appear to be spread evenly over the period of continuance or collected in clusters at particular points of time. Mr. Denning's observations, however, have been partially confirmed by others, while no one has arrived at a contrary result by observation; and when his well-known skill and practice are taken into consideration the chances are decidedly in favor of the existence of meteors with fixed or stationary radiant points, however they are to be accounted for. Their existence, or apparent existence, at all events deserves a high place among the unsolved problems of meteoric astronomy.

The late Mr. Proctor explained the existence of such meteors by supposing their velocity to be so great that the changes in the earth's motion produced very little effect on their apparent direction. Mr. Denning is decidedly of opinion that they do not move with this astonishing velocity, and, in fact, from the duration of visibility, etc., it is certain that they cannot do so unless the atmosphere extends to a much greater height than has hitherto been supposed. Mr. Denning, moreover, refers to some doubly observed meteors belonging to the stationary-radiant class whose height was by no means so great as Mr. Proctor supposed. I ventured to suggest that these meteors had already been so impressed by the motion of the air, when they first became visible, that they appeared to a terrestrial observer to be moving in their original direction—the actual displacement of the meteor by the air exactly balancing the apparent displacement, (supposing that it had pursued its original path) due to the spectator's motion. This explanation is not very satisfactory, but I know of no better, assuming that the meteors in question really belong to the same group or cluster; while if they do not, no rational explanation has hitherto been given of the apparent constancy of the radiant-point during a considerable period of time.

The question whether meteors belong to the solar system, or are visitors from external space, or whether each supplies its quota, is still, I think, unsolved. But if any of them originate within the solar system this is probably true of meteorites or bodies which fall to the earth in the solid form, their escape from dissipation in the air being due to the very moderate velocity of their motions relative to the earth. For this reason I think we are never likely to meet with a meteorite of which we can assert positively that it once existed outside the limits of the solar system. At all events we cannot affirm this of any known meteorite.

THE SOLAR ORIGIN OF THE AURORA.

M. A. VEEDER.

For The Messenger.

The identification of the precise solar condition upon which auroras and their attendant magnetic storms depend, requires that an account shall be made of all the facts known in regard to these phenomena, and that any conclusions adopted shall be consistent with these facts. The following article is a synopsis of the results of observations during a series of years bearing upon various phases of the subject, and justifying, it is thought, certain conclusions in regard to the origin of the aurora that are worthy of note.

It has long been known that auroras and magnetic storms increase and diminish in like ratio with each other, and also in proportion to the spottedness of the sun. When, however, an attempt is made to go further than this and study these phenomena in detail from day to day, instead of by a system of averaging through extended periods, serious difficulties are encountered. Very often for days together spots are numerous upon the sun, and yet there is no aurora and no extraordinary variation of magnetic declination. Likewise, on the other hand, fine auroras are not unfrequently seen when the sun is absolutely devoid of dark spots. The problem is to explain, if possible, this apparent anomaly.

It requires but little observation to show that something else upon the sun beside the dark spots is concerned in the production of magnetic phenomena, which often occur in the absence of such spots. We are compelled to extend our investigations further, and inquire as to the part performed by the eruptions of glowing vapors known as the faculæ. Here, as will appear in the course of the discussion, the results of such study are more satisfactory than in the case of the spots. Carrington's famous observation in 1859 in regard to an outbreak upon the sun, which was coincident with a magnetic storm and aurora, certainly had reference to a facular disturbance. Professor C. A. Young, in his treatise upon the sun, at page 157 describes another instance of similar character, the disturbance in that case also being facular, although followed by a spot appearing by rotation. Aside from these two instances nothing has been published having sufficient precision to be worthy of notice. In any event it is evident that the faculæ must be taken into the account. Inasmuch as the faculæ and spots vary in like ratio during any given period of sufficient extent, although not coincidently, the one group of phenomena following the other at an interval of days and sometimes weeks, a portion, at least, of our anomaly has been explained, namely, the occasional outbreak of auroras and magnetic storms at times when there are no dark spots upon the sun. Thus avoiding one difficulty we have, however, increased another. The sun is often free from dark spots, but is scarcely ever free from well defined groups of faculæ. Accordingly we might suppose that auroras ought to continue all the while.

We may relieve a portion of the difficulty at this point by studying the history at each return of disturbances that persist through successive revolutions. Through comparisons thus made it becomes apparent that all solar disturbances have not the power of originating magnetic phenomena in equal degree. Often those that are comparatively insignificant in appearance nevertheless are very active in this respect. But, even in the case of those that are most active and persistent, we find that auroras and magnetic storms do not continue throughout each transit which they make across the earthward side of the sun. On the contrary auroras and their associated magnetic perturbations are for the most part of comparatively limited duration.

At a single station in the United States, as a rule, the aurora is seen for but one night at a time, no matter how brilliant it may have been. Usually, however, at each manifestation it is reported from different stations for about four days. Magnetic storms also die out in about the same length of time. It must be the fact, therefore, that solar disturbances have the power of producing magnetic phenomena during a very limited portion only of their transit across the earthward side of the sun, and this, too, in spite of the fact that they may remain equally active from day to day, there being no evidence of any decided variation in the eruptive forces.

Another curious feature in connection with the behavior of the aurora that is inconsistent with the idea that its brevity of duration is due to sudden variations in the explosive forces, is its not infrequent regularity of recurrence at intervals closely approximating the time of the revolution of the sun. Thus the finest auroras of recent years have appeared in more or less extended series twenty-six or twenty-seven days apart. During the spring and summer of 1886 there was a succession of magnificent auroras at very nearly this interval from each other, the dates of maximum display being April 14, May 8-9, June 3-4, June 29-30, July 26 and August 23. During the winter and spring of 1887 there was a remarkable double series, the dates of maximum display of one portion being February 9, March 7, April 2-3, April 30, and May 27, the other half of the series following at regular intervals upon dates eight days later than those above given. The same periodicity is very common in connection with smaller displays and may be readily shown by counting the number of stations daily reporting auroras in the Monthly Weather Review of the Signal Service and constructing curves. It is inconceivable that such regularity of recurrence can be due to explosive forces alone. It looks very much as though the rotation of the sun on his axis must be concerned. This being the case we need only to identify the particular portion of each transit in which disturbances have the power of producing auroras.

Here, again, we may receive aid from studying the behavior of auroras. As a rule they burst forth suddenly, being most widely extended at the outset and becoming fainter, and being seen only at isolated stations subsequently. Such behavior is inconsistent with the idea that solar disturbances originate auroras as they approach the sun's meridian, in which case there would necessarily be a gradual instead of an abrupt increase. There can be but one point in the transit at which abruptness of beginning can be satisfactorily accounted for, and that is at the eastern limb.

Instituting observations and keeping a record in reference to this point it is found that there is a preponderating weight of evidence in favor of the conclusion that solar disturbances originate auroras, when at the sun's eastern edge appearing by rotation. At times it has seemed as though outbreaks located elsewhere upon the sun's disc had been concerned, but by comparing the record during successive revolutions it has become apparent in many such cases that some small dot of faculæ at the eastern edge was really responsible; this mere dot at other returns developing into a disturbed area of vast extent, and being attended at each appearance for months by an outbreak of magnetic phenomena. Pursuing this method, and judging as to the activity of disturbances by their history as well as their appearance, it has been found that there is a remarkable coincidence between the occurrence of auroras and the location of disturbances at the eastern limb.

During the three years from April, 1886, to April, 1889, there were one hundred and eighty-eight well defined outbreaks of the aurora in the United States. In connection with one hundred and sixty-two of these, observation of the sun was secured, and in every case a disturbance was found upon the sun's eastern edge, small, it is true, in some instances, but larger at other returns, so as to be unmistakable. There were also twenty-two other instances in which outbreaks appeared by rotation upon the sun, no aurora being reported within the borders of the United States. It is possible, however, that the aurora was visible at more northerly latitudes. A curious feature noted in these cases especially, as well as in some others, was a manifest increase in thunder-storms as though they had taken the place of the aurora.

From these considerations it follows that disturbances at certain points, upon the sun's surface for months together, have the power of originating magnetic phenomena when appearing by rotation at the sun's eastern edge. It certainly is very remarkable that these impulses should be conveyed along lines tangent to the sun's surface. It looks almost as though something had been whirled off into space from the sun, the earth remaining within range for a limited period only.

Finally it may be remarked that the magnetic storms associated with auroras have very similar characteristics as respects brevity, periodicity and abruptness of beginning. Evidence in respect to such storms is specially important in connection with these studies because the self recording instruments are not affected by the weather, the negligence of observers, and the like, as is the case in regard to auroras.

LYONS, N. Y., Oct. 7th, 1889.

THE STUDY OF ASTRONOMY.*

In the introductory part of this article we were speaking of Young's General Astronomy as a desirable book with which to begin the study of astronomy. We then promised that later something would be said of the manner of its use to obtain best results in laying a good foundation for education in astronomical science. We know how difficult it is to give direction, in writing, for detailed study in any science, and that some able scholars say that such a thing is wholly impracticable; yet it is believed that the essential points in any line of study may be stated, properly related and emphasized in such a way that the inexperienced student may receive help when and where most needed. With this thought in mind to guide, we open this new text-book and notice some of its prominent topics by way of illustration.

The "Doctrine of the Sphere" is properly first in order. An accurate and a complete idea of the celestial sphere is all-important. The author suggests two ways by which the mental picture of it may be made definite. Either seems equally good for the end in view, and will serve the purpose if pondered and sufficiently applied. In working out the general idea of the celestial sphere, the student needs a celestial globe or a wire sphere so constructed as to represent all its principal parts, for the sake of applying definitions and thereby testing the statements made by the author. This kind of exercise will tend to fix facts in mind and lead to an exercise of judgment that will prove, in time, very serviceable as a habit of thought and clear expression. The need of a globe or a wire sphere to connect the statements of an author with the imaginary lines and points in the sky, to which he ought constantly to refer, is also very essential. A powerful imagination will not be able to hold all the details of this great science in mind and properly relate them and make a lasting memory picture of them, without some judicious helps like these or others that might be named. The order then is to understand and memorize the definitions pertaining to the celestial sphere, illustrate the same by suitable apparatus of home contrivance, or better, if it

* Continued from p. 313.

can be afforded, and then transfer the knowledge thus gained to the sky, and familiarize the mind with it there, in place, so thoroughly that reference to it may always be ready, easy, and definite. The student who is self-guided in study will be likely to underestimate the value and need of all this work at the outset, and will probably soon become impatient and be tempted to slight the work here and there in seemingly unimportant particulars, because he does not wish to waste valuable time in acquiring details of so little apparent value. Right here let a word of warning be given. Such thoughts about the mastery of details in a chosen pursuit ought never to be entertained by the student for one moment. If they are yielded to it means later either damaging delay in possible progress, or utter defeat after a series of weak attempts that convince him that he never had any talent for astronomical studies whether that is really the fact or not. After considerable experience in guiding students in higher mathematical studies, it is our plain conviction that more persons of good natural powers fail of high attainment in such studies by lack of thorough mastery of elemental principles and facility in their application than from any other cause. If these words shall stimulate any to do better work in early study and to take the necessary time for it, their purpose will have been served.

After the idea of the celestial sphere as a whole is gained, its motions ought next to be clearly comprehended and all the terms used in describing them. In this the globe or sphere will be very serviceable, not only in showing what motions belong to important parts of the celestial sphere, but also to give ideas of their direction and their relative velocities.

"Astronomical Instruments" is the next general theme which this text-book offers for study, and a few of the more common and important ones are described.

The first question that may well be asked by a student about a telescope, for example, is concerning the principles on which it works. How does the telescope help the observer? Briefly, it is answered that the instrument (1) has light gathering power; (2) it magnifies objects, and (3) it has a measuring apparatus which will fully use all the gathered light in determining the places and dimensions of magnified celestial objects. How the working parts of the telescope unitedly accomplish these objects should be thoroughly understood. A small telescope should be in the hands of the student, if possible, that the parts may be examined and tried separately and unitedly. There is no picture or illustration that will at all take the place of the instrument itself. Better sacrifice a cheap spy-glass, if necessary, in order to understand the principles of the instrument, in order to gain this desirable personal knowledge. The theories of all the parts of all common telescopes are admirably set out in Young's Astronomy, and if the student will only apply the knowledge there given until he knows it for himself, opportunities to use such knowledge will rapidly multiply.

In regard to an elemental knowledge of all the instruments described in the second chapter of this book, three things may be learned definitely:

(1). What are the working parts of each instrument? (2). What work is done by each, and (3) exactly how is that work done? A plan in study of this kind presents finished steps of progress, to which the student may add as much as he pleases, without confusion if full or detailed study is later undertaken.

Chapter third offers another interesting step in our progress. It is now known what work astronomical instruments will do, but the results obtained need to be corrected before they can be related to other work properly. The dip of the horizon, parallax, semi-diameter and refraction give the apparent places, where generally the true places of celestial objects are wanted. Now the student will need to use his knowledge of geometry and algebra. The principles called for in these branches, for this work, are simple enough; but the danger is that the average student will fail to apply them independently and thoroughly enough to fix in mind either methods or essential facts. For example take the author's interesting statement concerning the dip of the horizon, that *the square root of the elevation of the eye* (in feet) *gives the dip in minutes*, and that this value is about one-twentieth too large, as compared with the exact formula. The student may well ask himself what is the use of giving this approximate formula when it is known to be inaccurate, and especially to make it prominent in the text by the side of the rigorous one. This important query ought not to be answered too briefly for the student needs to be instructed right here, and be put on his guard against falling into wrong notions regarding standards of accuracy in text-books and astronomical work in general. The author has covered this point nicely and well as he usually does those that are likely to perplex the accurate and the conscientious student. He has worked out the approximate formula by a very neat use of the principles of algebra and trigonometry, which show plainly what is meant by the use of the word "approximate," and wherein the real difference between the two formulæ lies. This is useful knowledge to the beginner, because he is always so unwilling to substitute approximate work or results for those which he has proved to be rigorously true. When he is asked to do this he often thinks that he has lost something of truth by so doing, if he does not believe the results uncertain or worthless because obtained by methods known to be defective. On the contrary he ought to see that he has actually lost nothing by his chosen method of work, but rather gained by it in every useful and important particular. Another valuable lesson is drawn from this illustration which we desire also to emphasize, and that is the care which the author has taken to show the student how to pass from the general units of measure in the exact formula, to those of various concrete kinds, as radians, minutes, etc., found in the working forms of the approximate formula. We have known good students in pure mathematics to stumble badly and frequently, and with reason, because they generally have so little exercise in the change of units in ordinary elementary study. Applying these thoughts to the formulæ for parallax, refraction, and height of the atmosphere, the student will certainly have new interest in the themes themselves as well as the mathematical instrument of investigation which he has been using to measure them.

In this connection and at the end of our space for this study at this time, we give a list of errors already noticed in second issue of this text-book, kindly furnished us for publication by Professor Young only a short time ago:

Errata in the Second Issue of Young's General Astronomy.

1. P. 133; line 8 from top; for γ *Draconis* read α *Draconis.*
2. P. 190; line 1 from top: for *southern* read *northern*; for *northern* read *southern*; also add to the sentence the words, *as seen by an observer on the earth.*
3. P. 232; lines 13 and 14 from top: for *12° 5′* read *12° 15′.*
4. P. 234; line 8 from top: for *1886* read *1884.*
5. P. 234; line 11 from top: for $\frac{1}{400000}$ read $\frac{1}{1400000}$
6. P. 234; line 21 from top: for *Moon's shadow* read *Earth's shadow.*
7. P. 311; article 520: substitute the following: "Since there are *five* in-"dependent co-efficients in the general equation (in space) of a conic "having a given focus (*viz.*, the sun), it is necessary to have five con-"ditions in order to determine them. Three are given by the obser-"vations themselves, *viz.*, the *directions* of the body as seen from the "earth at three given instants; a fourth is supplied by the 'law of "'equal areas,' since the sectors formed by the radii vectores must be "proportional to the elapsed times; and finally the fifth depends upon "the requirement that the changes in the speed of the body between "the observations must correspond to the variations in the length of "the radius vector according to the known intensity of the solar at-"traction."
8. P. 314; line 3 from bottom: for *of the periods of the major axes* read *of the periods and of the major axes.*
9. P. 318; line 12 from bottom: for *longer* read *shorter.*
10. P. 328; line 6 from top: for *four* read *seven.*
11. P. 332; line 4 from top; for *1¾°* read *about 4°.*
12. P. 337; line 10 from bottom: for *11h* read *5½ hours.*
13. P. 337; line 3 from bottom: for *at every revolution* read *at two full moons out of three.*
14. P. 337; line 2 from bottom: for *every new moon* read *with corresponding frequency.*
15. P. 394: line 3 from bottom: for *ten* read *five.*
16. P. 395; line 20 from top: for *discovery* read *perihelion passage.*
17. P. 395; line 22 from top: for *pass the perihelion* read *were discovered.*
18. P. 407; line 5 from top: for $\frac{1}{250000}$ read $\frac{1}{1000000}$
19. P. 407; line 6 from top: for *twenty-four* read *six.*
20. P. 415; line 3 from top: for *fixed* read *convex.*
21. P. 439; line 18 from top: for *Thomson* read *Thomsen.*
22. P. 475; line 14 from bottom; for $\frac{1}{27000}$ read $\frac{1}{37000}$
23. P. 482; line 6 from bottom: for *twelfth* read *ninth.*
24. P. 498; table: mass of α Geminorum should be 0.054.
25. P. 499; article 879. The relation deduced by Monck is true only on the assumption that the stars compared are of *equal density*: a most serious restriction.
26. P. 503; line 8 from bottom: for *10,000 or 11,000* read *8,000.*
27. P. 508; line 5 from bottom: for *1,000 and 2,000* read *2,000 and 3,000.*

28. P. 510; line 6 from top: for *37°* read *27°*.
29. P. 530; table of Saturn's satellites: the period of Titan is 15*d*, etc., instead of 13*d*, etc., as given.

There are a few other typographical errors, but, so far as I now know, none of any real importance.

TO BE CONTINUED.

MEETING OF THE PERMANENT COMMITTEE OF THE ASTRO-PHOTOGRAPHIC CONGRESS.

The following notes are not quite complete, but will doutbless be of interest.

Several members of the Committee asembled on Sept. 12 at the Paris Observatory, and after some preliminary business drew up the following programme for discussion:—

A. Execution of the Photographic Work.

1. Accuracy with which the center of the plate is to be pointed on the selected point of the heavens.
2. Exposing shutters.
3. Construction and mounting of plate-holders.
4. Dimensions of plates and réseaux, and maximum admissible deformation of stellar images.
5. Amount of overlapping of plates.
6. Construction of réseaux.
7. Distribution of work among Coöperating Observatories.
8. Plates; plate-glass or ordinary; chemical formula; manufacturer; testing.
9. Shall the sensitiveness of plates for Chart and for Catalogue be the same?
10. Method of impressing réseau on plates: shall a réseau be used for the Chart plates as well as for the Catalogue?
11. Times of exposure for the two series.
12. Development.
13. Fixing, varnishing, etc.
14. Test objects for the different Observatories.

B. Use of Plates when taken.

15. Nature of method of measurement (distance and position angle; rectangular axes; parallactic method).
16. Measures to be taken to lighten the labor of the measurements in closely-starred portions of the sky.
17. Shall there be a central bureau to measure the plates?

18. Shall there be a special committee to consider the reproduction of the plates and the publication of the Map of the Heavens?

These points were decided at the actual meeting of the committee somewhat as follows:

1. It was decided that the actual center of the plate should not be more than about 5″ distant from the point selected in the sky.

2. It was decided to use an exposing shutter, but the actual form was left to discretion.

3. MM. Christie, Gautier, and Paul Henry appointed as committee to consider this question.

4. Size of field unanimously adopted as 2° square. MM. Bakhuyzen and Henry reported that within this area on the Paris plates measurement showed the errors to be very small. The réseau to be 130 mm. square as proposed by Vogel, lines 5 mm. apart; and Christie's proposal that plates be 160 mm. square was adopted unanimously.

5. Overlapping of 5′, as suggested by Vogel, proposed by Kapteyn.

5. Vogel's offer to construct and verify the réseaux was accepted. The lines to be continuous and not mere crosses at the points of intersection.

7. Committee of Bœuf, Christie, Kruls, and Loewy proposed the following distribution, which was adopted:

Observatory.	Decl. °	°	Observatory.	Decl. °	°
Helsingfors	+ 90 to	+ 70	S. Fernando	0 to	− 6
Potsdam	+ 70	+ 58	Mexico	− 6	− 12
Oxford	+ 58	+ 48	Tacubaya	− 12	− 18
Greenwich	+ 48	+ 40	Rio	− 18	− 26
Paris	+ 40	+ 32	Santiago	− 26	− 34
Vienna	+ 32	+ 24	Sidney	− 34	− 42
Bordeaux	+ 24	+ 18	Cape	− 42	− 52
Toulouse	+ 18	+ 12	La Plata	− 52	− 70
Catania	+ 12	+ 6	Melbourne	− 70	− 90
Algiers	+ 6	0			

8. Plate-glass decided unanimously. Chemical formula left open.

9. Sensitiveness to be the same for both.

10. Vogel's method for impression of réseau adopted. Réseau to be used for both series.

11. The Paris Observatory will prepare a series of standard plates, giving stars to 14.0 and 11.0 magnitudes re-

spectively, for distribution to each of the Coöperating Observatories; the time of exposure to be adjusted so as to compare properly with these standards. For definition of magnitude 11.0 as limit for the Catalogue series, it was decided that as 7.0 and 9.0 are well-understood magnitudes, the photographic difference between them should be determined and carried on from magnitude 9.0 to get magnitude 11.0.

For the Catalogue plates there are to be two exposures on each plate; the first to give stars to magnitude 11·0, the second of one quarter the duration with a displacement of about 0·2 mm., as a check on the first.

12, 13. The plates to be tanned. Otherwise left open.

14. See 11.

15. Referred to a committee.

16, 17, 18. The question of a Catalogue was left open, and one or more bureaus to be established for such observatories as cannot measure their own plates. Photographic copies of all plates to be taken and preserved in selected places in case of accident to the negative.—*Observatory.*

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury may be seen in the morning a half hour before sunrise until abont Nov. 20, after which time it will be too close to the sun. It will come to superior conjunction with the sun Dec. 7, and will be at aphelion or greatest distance from the sun on the same day.

Venus is morning star, but is moving rapidly eastward and getting nearer the sun, so that it is not in so favorable a position for observation as in the past months. This planet will be visible in the morning, however, until the end of the year. Venus will be in conjunction with Uranus Nov. 9, 1 P. M., 1° 08′ north, and with the moon Nov. 21, 4 A. M., 3° south.

Mars will be at its greatest distance from the sun Nov. 11, and in conjunction with the moon, 4° 08′ south, Nov. 18, 5 P. M. Its course is through Virgo, passing 2′ north of the star η Nov. 16 at 2 A. M., 1° 20′ south of γ Nov. 26, and 20′ south of θ Dec. 8. The October number of *L'Astronomie* contains an interesting article by Philippe Gérigny on "The Tides on Mars." The writer has attempted to investigate the tides which would be produced upon Mars by the two satellites, with a view of explaining some of the changes which have been observed upon the face of the planet, and which have been suggestive of periodical inundations. The greatest difficulty in the way of such an investigation is our ignorance of the mass and density of the satellites. Assuming the diameters to be 12 km. for the inner and 10 km. for the outer, and the densities equal to that of the planet, the writer finds the tides to be insignificant. The bulging of an ocean of water due to the attraction of the first satellite would be only 1.79 mm. or less than one-tenth of an inch, and that produced by the second satellite still less. If, however, the diameters of the satellites be greater (which is probably true) than the above estimates, the resulting tides will be greater in proportion to the cubes of the diameters, and it may be possible to explain some of the changes observed on the planet as the result of high tides overflowing the lowlands and filling up the long narrow valleys or channels.

Jupiter will continue to be visible as evening star setting in the southwest about two hours after sunset. Its altitude is too low for good observations. We therefore cease to give the tables of the satellites and the red spot. Jupiter will be in conjunction with the moon Nov. 25 but will not suffer occultation in northern latitudes.

Saturn is in Leo a little east of Regulus, and may be observed after midnight. He will be in quadrature with the sun Nov. 25, in conjunction with the moon Dec. 13, 4 P. M., and stationary in the sky Dec. 15, 1 A. M. The inclination of the plane of the rings to the line of sight is now only eight degrees. This month we begin again to give the times of elongation of the five brighter satellites of Saturn. We omit the others as not likely to be seen by any observers who do not already possess a complete ephemeris.

Uranus is a morning star, and may be found about 2° northeast of Spica in Virgo. On the morning of Nov. 20 it will be about 4° south of the moon.

Neptune is in Taurus about one-third of the way from Aldebaran to the Pleiades, and may be observed during the whole of the night. He will be in opposition to the sun Nov. 24. Dec. 6 at *2h 34m* A. M. Neptune will be directly north of the Moon at a distance of about the moon's diameter.

Sun-spots were observed at Carleton College Observatory Sept. 24, 26, 27, 28, Oct. 9, 10, and 17. No spots were visible Sept. 18, 19, 20, 21, Oct. 3, 4, 7, 11, and 14.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
MERCURY.					
Nov. 25	15 38.3	−19 15	6 35 A.M.	11 19.0 A.M.	4 03 P.M.
Dec. 5	16 44.1	−23 11	7 21 "	11 45.2 "	4 10 "
15	17 52.8	−25 11	8 00 "	12 14.4 "	4 29 "
VENUS.					
Nov. 25	14 45.3	−14 33	5 22 A.M.	10 26.1 A.M.	3 31 P.M.
Dec. 5	15 35.4	−18 12	5 48 "	10 36.6 "	3 25 "
15	16 27.4	−21 01	6 13 "	10 49.2 "	3 26 "
MARS.					
Nov. 25	12 34.5	− 2 11	2 21 A.M.	8 15.8 A.M.	2 11 P.M.
Dec. 5	12 56.4	− 4 29	2 13 "	7 58.3 "	1 44 "
15	13 18.1	− 6 43	2 04 "	7 40.7 "	1 18 "
JUPITER.					
Nov. 25	18 42.4	−23 14	9 58 A.M.	2 22.5 P.M.	6 47 P.M.
Dec. 5	18 51.7	−23 04	9 27 "	1 52.5 "	6 18 "
15	19 01.3	−22 52	9 57 "	1 22.7 "	5 49 "
SATURN.					
Nov. 25	10 24.2	+11 31	11 12 P.M.	6 01.9 A.M.	12 51 P.M.
Dec. 5	10 25.2	+11 28	10 34 "	5 23.5 "	12 13 "
15	10 25.9	+11 29	9 55 "	4 44.5 "	11 34 "
URANUS.					
Nov. 25	13 32.8	− 9 05	3 46 A.M.	9 13.6 A.M.	2 41 P.M.
Dec. 5	13 34.7	− 9 15	3 10 "	8 36.5 "	2 03 "
15	13 36.3	− 9 25	2 33 "	7 58.7 "	1 25 "
NEPTUNE.					
Nov. 25	4 05.7	+19 08	4 21 P.M.	11 44.3 P.M.	7 08 A.M.
Dec. 5	4 04.6	+19 05	3 40 "	11 03.8 "	6 27 "
15	4 03.5	+19 02	3 00 "	10 23.4 "	5 46 "
THE SUN.					
Nov. 25	16 06.8	−20 54	7 11 A.M.	11 47.7 A.M.	4 25 P.M.
Dec. 5	16 50.0	−22 28	7 22 "	11 51.1 "	4 20 "
15	17 34.0	−23 19	7 30 "	11 55.6 "	4 20 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
Nov. 24	4 Sagittarii	5½	5 24	92	6 25	266	1 01
27	27 Capricorni	6½	4 23	44	5 36	276	1 13
30	30 Piscium	4½	10 47	100	11 38	202	0 50
Dec. 14	ν Virginis	4	18 53	137	20 12	291	1 20

Phases of the Moon.

		Central Time. d h m
Last Quarter	Nov.	15 2 36 P. M.
New Moon	"	22 7 44 "
First Quarter	"	29 11 29 A.M.
Full Moon	Dec.	7 3 52 "
Last Quarter	"	15 8 58 "

Elongations and Conjunctions of Saturn's Satellites.

[Central time: E = east elongation: W = west elongation: I = inferior conjunction (north of planet): S = superior conjunction (south of planet.)

JAPETUS.

Nov. 5 S. Nov. 25 E. Dec. 15 I.

TITAN.

Nov. 16	Midnight.	I.	Nov. 28	Midnight.	E.	Dec. 10	11 P. M.	S.
20	"	W.	Dec. 2	"	I.	Dec. 14	10 "	E.
24	"	S.	6	11 P. M.	W.			

RHEA.

Nov. 15	7.1 A. M.	E.	Nov. 28	8.5 P. M.	E.	Dec. 12	9.7 A. M.	E.
19	7.6 P. M.	E.	Dec. 3	9.0 A. M.	E.			
24	8.0 "	E.	7	9.4 P. M.	E.			

DIONE.

Nov. 16	3.4 A. M.	E.	Nov. 27	2.2 A. M.	E.	Dec. 8	1.0 A. M.	E.
18	9.1 P. M.	E.	29	7.9 P. M.	E.	10	6.7 P. M.	E.
21	2.8 P. M.	E.	Dec. 2	1.6 P. M.	E.	13	12.3 P. M.	E.
24	8.5 A. M.	E.	5	7.3 A. M.	E.			

TETHYS.

Nov. 16	9.6 A. M.	E.	Nov. 27	5.5 P. M.	E.	Dec. 7	4.0 A. M.	E.
18	6.9 A. M.	E.	29	2.8 P. M.	E.	9	1.3 A. M.	E.
20	4.3 A. M.	E.	Dec. 1	12.1 P. M.	E.	10	10.6 P. M.	E.
22	1.6 A. M.	E.	3	9.4 A. M.	E.	12	7.9 P. M.	E.
23	10.9 P. M.	E.	5	6.7 A. M.	E.	14	5.2 P. M.	E.
25	8.2 P. M.	E.						

Comet d 1889 (Brooks, July 6) is in the west end of constellation Pisces and moving slowly northeast. The similarity of the preliminary elements of this comet, especially the inclination, to those of comet 1884 II (Barnard) computed by H. V. Egbert, led Dr. K. Zelbr to test their identity. He finds that the observations of Brook's comet cannot be represented by the elements of comet 1884 II (*A. N.* 2926). He has computed a new set of elliptic elements, from observations made July 8, Aug. 5 and 19 which represent within small errors a later observation made Aug. 30:

$$T = 1889 \text{ Sept. } 19.2964 \text{ Berlin mean time.}$$

$$\left.\begin{array}{l} \omega = 337^\circ\ 52'\ 11.4'' \\ \Omega = \ \ 18\ \ 52\ \ 47.7 \\ i = \ \ \ 6\ \ 01\ \ 07.5 \end{array}\right\} \text{Mean equinox 1889.0}$$

$$\varphi = 29\ \ 41\ \ 50.6$$

$$\log \mu'' = 2.657852$$

$$\log a = 0.472470 \qquad a = 2.96804.$$

$$\text{Period} = 7.8 \text{ years}$$

The following ephemeris is by Dr. O. Knopf (*A. N.* 2926):

1889 Berlin Mean Time.	App. α h	m	s	App. δ °	′	log r	log Δ	Br.
Nov. 5.5	23	42	56	−2	03.6	0.2988	0.0745	1.7
7.5		43	44	1	48.6			
9.5		44	39	1	33.1	0.3001	0.0888	1.6
11.5		45	40	1	17.1			
13.5		46	49	1	00.8	0.3015	0.1025	1.5
15.5		48	04	0	44.1			
17.5		49	25	0	27.0	0.3030	0.1163	1.4
19.5		50	52	−0	09.5			
21.5		52	25	+0	08.4	0.3046	0.1303	1.3
23.5		54	04	0	26.7			
25.5		55	49	0	45.2	0.3063	0.1445	1.2
27.5		57	39	1	04.1			
29.5	23	59	34	1	23.3	0.3082	0.1587	1.1
Dec. 1.5	0	01	34	1	42.8			
3.5		03	39	2	02.6	0.3101	0.1728	1.0
5.5		05	48	2	22.6			
7.5	0	08	02	+2	42.9	0.3121	0.1868	0.9

Comet *b* 1889 (Barnard, March 31) is in the middle of the constellation Cetus, moving southwest. We have at hand no ephemeris extending beyond Nov. 5.

The Solar Corona. The volume containing the reports on the observations of the total eclipse of the sun, Jan. 1, 1889, published by the Lick observatory, has been received.

The introduction to this report, covering twenty-two pages, is written by Professor Holden. It is a detailed statement of great interest, setting out in a clear way, the advancement made by observation and study of the last total solar eclipse. His conclusions are given in full, and are as follows:

I. That the characteristic coronal forms seem to vary periodically as the sun-spots (and Auroras) vary in frequency, and that coronas of 1867, 1878, and 1889 are of the same strongly marked type, which corresponds, therefore, to an epoch of minimum of solar activity.

II. That so-called polar rays exist at all latitudes on the sun's surface, and are better seen at the poles, simply because they are there projected against the dark background of the sky, and not against the equatorial extensions of the outer corona. There appears to be also a second kind of rays or beams that are connected with the wing-like extensions.

These latter are parts of the "groups of synclinal structure" of Mr. Ranyard.

III. The outer corona of 1889 terminated in branching forms. These branching forms of the outer corona *suggest* the presence of streams of meteorites near the Sun, which by their reflected light, and by their native brilliancy, due to the collisions of their individual members, *may* account for the phenomena of the outer corona.

IV. The disposition of the extensions of the outer corona along and very near the plane of the ecliptic might seem to show that if the streams of meteorites above referred to really exist, they have long been integral parts of the solar system.

Note.—The conclusions III. and IV. appear to be contradictory to that expressed in I. The electrical theory announced by Dr. Huggins in the Bakerian lecture for 1885, seems to reconcile the conclusions I., III., IV.

V. The photographs of the corona which were taken just before Contact II. and just after Contact III., prove the corona to be a solar appendage, and are fatal to the theory that any large part of the coronal forms are produced by diffraction. (See the photographs of Mr. Woods and a discussion of them in the reports of Mr. Keeler.)

VI. The spectroscopic observations of Mr. Keeler show conclusively that the length of a coronal line is not always an indication of the depth of the gaseous coronal atmosphere of the sun at that point, and hence to indicate the important conclusion that the true atmosphere of the sun may be comparatively shallow.

VII. Mr. Keeler also draws the further conclusion in his report that the "polar" rays are due to beams of light from brighter areas of the sun illuminating the suspended particles of the sun's gaseous envelopes.

In order that this conclusion may stand, it is necessary to show that all these "polar" beams are composed of rectilinear rays.

It appears to me that the beams Nos. 62 and 64 of the Index-Diagram (among others) present serious difficulties of interpretation in this regard.

VIII. The conclusions respecting the photographic and photometric values of the corona and surrounding sky at time of totality are exhibited in the tables accompanying the reports of myself, Mr. Barnard, Mr. Leuschner, and Dr. Passavant. An important conclusion from these measures seems to be that it is impracticable to photograph the corona in full sunshine with our present plates, and that a photographic search for *Vulcan* is hopeless.

Queries. Query No. 23, which asked for the cause of the so-called polar filaments, has not yet been satisfactorily answered. It was hoped that more light would be gained by the observations and the photographs of the last total solar eclipse. The photographs by Professor Pickering and Mr. Barnard of Lick Observatory show this phenomenon well,—it is believed better than in any other way previously. In Professor Holden's study of the Lick photographs much that is interesting appears as to the location of these filaments on the solar surface: that they were found not only in the regions of the poles, but, as he thinks, scattered all over the surface of the sun, and that, if the bright background of the equatorial regions were removed, the general appearance would be quite the same for the class having the ordinary polar form. The "groups of synclinal structure" are still more puzzling, and seem to neutralize all that the polar form might suggest in the direction of magnetic force as a cause. The last eclipse gave considerable of detail which may bring out useful results in the light of the coming December eclipse observations which will be made in Africa and South America.

24. The shadow bands, as some observers call them, which are seen about the time of the third contact, in the total solar eclipse, are probably the diffraction effects of solar rays passing over the advancing limb of the moon near the beginning and end of totality. This is the reason why other observers call the phenomena diffraction bands. Exactly how the bands are formed does not yet clearly appear. As an illustration of how they sometimes appear we give a part of the report of one of the observers of the eclipse of July 27, 1878. He said: "Before totality I had observed the diffraction bands flying across the roof of the building, but failed to catch the moment of their beginning. They commenced immediately on the occurrence of the III contact and lasted 48 seconds moving from west to east. This observation was carefully made. They coursed after each

other very rapidly, seeming about three feet from center to center, the dark band being, say six inches wide, the interior being bright. In reality the dark and bright spaces must have been of equal width, but the appearances were as stated." These observations were confirmed by others at the same place. An attempt to count the number of these bands that passed a given point in a second of time failed, as might have been expected.

Professor Winslow Upton observed the same phenomena at the last total solar eclipse, Jan. 1, 1889.

Mr. Charles E. Myers has furnished two neat solutions of the example in elementary algebra given in our last issue. The example was to find x and y in the following:

$$x^2 + y = 7$$
$$x + y^2 = 11$$

One method is as follows:

Adding (1) and (2), $x^2 + x + y^2 + y = 18$

Adding ½ to both numbers, $x^2 + x + \frac{1}{4} + y^2 + y + \frac{1}{4} = 18\frac{1}{2}$ $= \frac{74}{4} = \frac{25}{4} + \frac{49}{4} \therefore x^2 + x + \frac{1}{4} = \frac{25}{4}$ and $y^2 + y + \frac{1}{4} = \frac{49}{4}$ whence $x = 2$; $y = 3$.

EDITORIAL NOTES.

On and after December 1, the annual subscription price of the MESSENGER will be $3 to American subscribers, and those of the Canadian provinces; to foreign subscribers, in countries included in the Postal Union $3.25, and to those of other countries $3 plus the cost of annual postage.

The chief reason for increasing the subscription price is to cover a portion of the expense to be incurred in contemplated improvements which will begin with the first number of 1890. We will briefly indicate two or three points of change which have been under consideration for some time.

One is, as already suggested, the addition regularly of a series of notes on the bibliography of astronomy, which we expect will be full enough to cover all important topics from all sources within reach. This very valuable matter will be furnished by Professor W. C. Winlock, Superintendent of the

Bureau of Exchanges at the Smithsonian Institution, Washington, D. C. THE MESSENGER is fortunate in securing the services of one, so ready in this kind of work and surrounded as he is, with rare facilities for gathering the information desired.

Another feature is, the purpose to make the current astronomical notes and news items fuller and more general. This probably will involve a new and better plan for this part of our work than we have previously used. A third point, and the last that we can now mention, pertains to articles of general scientific interest that should be accompanied by expensive engravings. An illustration of this feature may be found in the frontispiece of our last issue. It is earnestly hoped that our large list of subscribers will not feel this change of price a burden to them, but rather that they will continue their hearty support as in the past, and also aid us in securing many new subscribers.

Change of Latitude. At an international meeting of scientists in the interest of geodetic survey work, held at Rome in 1884, a proposition was made by Professor Fergola and adopted, that simultaneous determinations of latitude should be made at two places nearly in the same parallel of latitude, but at very considerable distances apart in longitude, in order, if possible, thereby to measure any changes in the earth's axis, in the body of our planet as detected in the variation of latitude at certain points of the earth's surface.

In order to carry on this delicate and very important piece of work, Dr. F. Porro, Director of the Astronomical Observatory of the Royal University of Turin, Italy, has recently, by letter very politely suggested that the Observatory of Carleton College and his own are well located for doing this work, and requests that we favorably consider the proposition. To this we have replied that our Observatory will very gladly join him in this, and assign one of our transit instruments to it, and that we will begin as soon as he is ready and his detailed plan of work is known.

Observations for best work of this kind are taken in the Prime Vertical, and our Observatory has excellent facilities for such observations, with a good transit instrument already mounted in the Prime Vertical.

The Orbit of Sirius by J. E. Gore is a short paper of interest. From it is learned the fact that the components of this wonderful binary are now approaching their minimum distance, which is becoming rapidly very difficult to measure even by the aid of the largest telescopes. The companion was discovered by Alvan Clark in 1862, and Mr. Gore has collected all the known measures since that time, and from them deduced the following elements:

$P = 58.5$ years	$\Omega = 49°59'$ (1880.0)
$\tau = 1896.47$	$\lambda = 216°18'$
$\epsilon = 0.4035$	$a = 8''.58$
$i = 55°23'$	$\mu = -6°.156.$

The method used was to plat all the observations (corrected for precession to 1880.0) and draw the interpolating curve, and the apparent ellipse in the usual way, and then compute by Professor Glasenapp's method the co-efficients of the general equation. These values were substituted in Kowalsky's equations, from which the geometrical elements of the orbit were found.

With Gyldén's parallax for Sirius the above values of *P* and *a* give

Sum of masses = 26.298 (sun's mass 1).

Mean distance 44.45 (earth's mean distance from sun = 1). According to the ephemeris the minimum distance of the components will occur in 1893 with a value of 3''.23, and a position angle of 310°.88.

Professor Charles S. Howe, formerly in the chair of Mathematics and Astronomy at Buchtel college, has been recently chosen to fill the Kerr Professorship of Mathematics in the Case School of Applied Science at Cleveland, Ohio. From all that we know of it Professor Howe will find his new position a most congenial one, with favoring prospects in the line of his chosen work.

Smith Observatory. Professor Chas. A. Bacon, Director of Smith Observatory, Beloit College, Wis., has a new Brashear helioscope which he is using with great satisfaction in daily study of the sun. He is also doing some work in celestial photography. We are to be favored with reports for publication soon.

Notices from Lick Observatory. By favor of Professor Holden we have the following notices prepared by members of the staff, at the Lick Observatory, from the publications of the Astronomical Society of the Pacific:

Photographing the Milky Way. The great success obtained by Mr. Barnard in his preliminary experiments with the Willard portrait lens ($a = 5.9$, $f = 30.7$) has led to the determination to employ it in making a systematic study of the Milky Way by photography. For this purpose it has been mounted at the object-glass end of the tube of the great telescope, and arrangements made by which the lens can be capped and uncapped from the eye end. The driving clock of the great telescope (with a control) will keep the camera directed at the star-group chosen during an exposure of two hours. An independent equatorial stand for this instrument is very desirable, but cannot be had at present. Plates 8 × 10 are used, which correspond to about 16° × 20°. The definition is good over the central 10° or 11°. E. S. H.

Occultation of Jupiter, 1889, September 3.

Initials of the Observer.......	J. E. K.	E. E. B.	C. B. H.	A. O. L.
Phenomenon Observed.	Lick Observatory Mean Time.			
	h m s	m s	m s	m s
First contact of Jupiter.........	5 25 39.1*	25 41.3	25 43.5†	25 41.6
Second contact of Jupiter.....	5 27 50.7	27 47.3·	27 47.8	27 43.9
Reappearance of Satellite II..	6 11 33+	....	....	....
Reappearadce of Satellite IV.	6 16 46.2	....	....	....
Third contact of Jupiter........	6 19 17.2	....	....	19 26.2
Fourth contact of Jupiter......	6 21 39+	21 38.3::	21 39.5::	21 32.2
Reappearance of Satellite I....	6 23 12.8	23 15.7::	23 16.0‡	....
Instrument employed..........	36-in. tel.	12-in. tel.	6½-in tel.	Comet seeker.

OBSERVERS' NOTES.—* 2 secs. late; † 3-5 secs. late; 2-3 seconds late.

Observers: Mr. Keeler = J. E. K.; Mr. Barnard = E. E. B.; Mr. Hill = C. B. H.; Mr. Leuschner = A. O. L.

Mr. Schaeberle obtained several photographs of the moon and Jupiter after fourth contact.

Examination of Stellar Photographs. If it is desired to obtain *all* the information which can be had from a given negative, it is necessary to make a positive copy of it on glass, and to examine both negative and positive independently. Each presents a different set of contrasts. The negative will show the empty spaces and lanes between stars; the positive will show the arrangement of the stars themselves. It is only by examining both that *all* the information can be had from a given exposure. This is certainly true for stellar photographs, and it is even more important in regard to photographs of surfaces,—as nebulæ, the corona, etc. It should also be remembered that no single negative can establish the existence of a new nebula. At least two are required.

Experiments by Mr. Barnard have shown that many features may be brought out by the simple device of copying the whole of an 8 × 10 plate on a plate of 3¼ × 4¼ inches. This process is analogous to the automatic one by which a person places a picture to be viewed at an appropriate distance for seeing the particular details he wishes to examine. Enlargements of negatives are also sometimes serviceable. These simple precautions are worth mentioning, as they help to emphasize a fundamental point, namely,—that it is far more important to extract all possible information from a few photographs, than to make large collections of negatives without sufficiently examining each of them. E. S. H.

Review of the Early Numbers of the Publications of the Astronomical Society of the Pacific. The *Vierteljahrsschrift* of the German Astronomical Society (Vol. 24, 1889, p. 210) has a very friendly review of Nos. 1 and 2 of our own *Publications*, written by Professor E. Schoenfeld, Director of the Observatory at Bonn. The last paragraph is:

"The reviewer has no right to speak in this place in the name of the *Astronomische Gesellschaft*; but, in his own name and in that of other members, he expresses a hearty greeting to the new Society which has been founded on the Coast of the Pacific Ocean and wishes for it all success and prosperity."

It will be gratifying to our members to know of this early and courteous recognition of our modest beginnings. E. S. H.

Note on the Corona of January 1, 1889. Professor Tacchini has a note in the *Atti della R. Accademia dei Lincei* 1889, page 472, on the corona as shown in a positive-copy on glass of one of Mr. Barnard's negatives. The corona extends, he says, from + 64° to — 68° on the west limb of the sun, and from + 53° to — 68° on the east limb. These are about the limits of the zone of the maximum frequency of protuberances defined by Professor Tacchini's own observations. Two of the protuberances of the photograph were observed at Rome and at Palermo. The other protuberances shown on the photograph were not seen by the spectroscope, and Professor Tacchini surmises that they belong to the class of *white* protuberances discovered by him at the eclipses of 1883 and 1886. This surmise is completely corroborated by the observations of Professor Swift (L. O. Eclipse Report, 1889, page 203). E. S. H.

The Gundlach Optical Co. of Rochester, N. Y., is making a low-power eye-piece with a large field—something like half a degree—for the use of visitors who come to see the moon. Such an eye-piece will show enough of the lunar surface to make a *picture* with a background of sky, which is what is really needed to convey the effect. The eye-pieces used in the regular astronomical observations have fields of view of hardly more than 10′ of arc, and, hence, only serve to show a limited portion of the Moon's surface—less than one tenth usually. As the image of the moon in the large telescope is 6.51 inches in diameter, it follows that the field lens of the new eye-piece must be of about the same dimensions. It will be useful in real work; also, for objects like nebulæ and comets where a large field and full contrast are required.

E. S. H.

Notes on Double-Stars. The Herschel companion to ψ^1 Aquarii is shown in the 36-inch telescope to be a very close double-star. From a single measure the distance appears to be less than 0″.15, and, of course, it is a different object, even in a large refractor. This companion has the same proper motion as the large star, and the relative change is practically nothing since the measures of Struve, in 1836, when the distance was 49″.63 in the position-angle of 312°.2.

Professor Hough found the neighboring star ψ^3 (95) Aquarii double, with the Chicago 18½-inch refractor, in 1884, the companion being eleventh magnitude, at a distance of a little more than 1″. Last year this was noted independently here with the 12-inch, and measured on three nights, the result being substantially the same as the single measure by Hough in 1884. In the course of the observations given above, this star was looked at with the 36-inch on two or three nights, but there was not the faintest trace of the companion. I am wholly unable to account for this failure, as there was apparently no change in the preceding four years. It should be carefully watched hereafter.

The sixth magnitude star, 44 Cassiopeiæ, has a minute attendant, hitherto unseen, at a distance of 1″.7 from the principal star.

Several new pairs have been found in the Pleiades, one of them following Alcyone 64s and about 4′ north. This is a difficult pair, as the distance is only 0″.3, and the components below the ninth magnitude. Another new pair, still more difficult, is 55s following Pleione (28 Tauri). The distance of this pair is about 0″.4, but the components are only 11½ magnitude.

Since the time of Herschel, 67 Ophiuchi has been known as a wide double-star (54″). The large telescope shows a very faint star at a distance of 6″.8.

The star D. M. 63°, 1618 has a very small companion at a distance of 4″.3. The principal star is brighter than sixth magnitude, but is strangely wanting in nearly all of the star catalogues covering this part of the heavens. It is not in the B. A. C., Radcliffe (1 and 2), Lalande, Argelander U. N., Heis, Piazzi, Bradley, Romberg, AOe, Grant, D'Agelet, Armagh, Yarnall, Bonn observations. In fact, it is found only in the D. M. and Rumker (No. 8289), the magnitudes being 5.9 and 5.6, respectively. In the Harvard Photometry the magnitude is 5.82. In observing it here as a double-star the magnitude was estimated 5.8. It does not appear to be variable, and is probably a rare example of star catalogue omissions. The attention of meridian observers is called to this object.*

The double star, Σ 2816, consists of a sixth magnitude primary, and two 7½ m. companions with distances from the larger star of about 12″ and 20″, respectively. These stars have remained relatively fixed since 1832. The large telescope shows a minute companion within 1″.5 of the large star.

*This star will be observed by Professor Schaeberle with the L. O. meridian circle. E. S. H.

The fifth magnitude star, 2 Andromedæ, is a very close and difficult pair, the distance being only 0″.8, and the components quite unequal. This was suspected with the 12-inch, and verified and measured with the 36-inch.

Herschel noted a ninth magnitude companion to α Cassiopeiæ at a distance of 63″. The large telescope shows a very faint star at a distance of 17″.5.

The distance of the close pair in γ Andromedæ (OΣ 38) is now less than 0″.1. It is very difficult, and the best conditions are necessary to see the elongation at all with the large telescope.

The binary star, 7 Tauri, has been rapidly changing. The distance now is 0″.30.

The large refractor fails to show any third star in the system of 70 Ophiuchi, and both components are single with all powers. At one time 72 Ophiuchi was thought to be double (OΣ 342), but no companion can be seen here. S. W. B.

Observations on the Near Approach of Mars and Saturn on September 19, 1889. The eastern sky was thick with haze when the two planets rose, and they were not visible until a considerable altitude was attained. At about 4 A. M. they could be seen dimly with the naked eye; *Mars*, small and insignificant, slightly east of *Saturn*. As soon as the images were at all measurable, I made a series of micrometrical observations of the two for position angle and distance, and for differences of right ascension and declination, using the 12-inch equatorial.

Following are the measures which are corrected for refraction in distance an in the $\Delta\delta$ and $\Delta\alpha$; the times being Mt. Hamilton mean time:

		d	h	m	s	
1889.	Sept.	19	16	16	39.	Position angle of Mars, 101°.0 (3).
"	"	19	16	24	24.	Dist. bet. outer limbs of Mars and Saturn, 356″.1 (3).
"	"	19	16	29	14.	" " nearer " " " " 342″.3 (3).
"	"	19	16	34	19.	" " center and center, 358″.8 (3).
"	"	19	16	39	49.	Position angle of Mars, 101°.8 (4).
"	"	19	17	36	29.*	$\Delta\delta$ Mars—Saturn —1′ 39″.2 (5) apparent.
"	"	19	17	45	49.*	$\Delta\alpha$ Mars—Saturn —0m 29.91s (11) apparent.

* These times are for the bisection of Mars.

The most striking feature was when the two planets were fading from the advent of daylight. At the approach of day Saturn assumed a pale, ashy hue, with a slight tinge of yellow, while Mars retained its luster in a surprising manner, being of a strong orange yellow in color; its north polar cap stood out strikingly towards the close of the observations, a dark marking being also visible near the middle of the disc. Saturn ceased to be visible in the telescope at 18*h* 6*m*, the last glimpse being had a few seconds earlier. At this time Mars was easily conspicuous, the sun being 5° or 6° high and the sky pretty thick. At 18*h* 10*m* Mars began to grow pale. At 18*h* 25*m* it was still visible but very pale and easily lost in the field, though it could have been followed for some time longer. By the time the planets were high enough to observe with the large telescope they had separated too far to be brought into the field of view of the largest eyepiece. E. E. B.

Mt. Hamilton, Sept. 20, 1889.

The Todd Eclipse Expedition. By the Philadelphia *Press* it is recently learned, that the United States expedition to Africa, to observe the total solar eclipse of Dec. 21 and 22 set sail from New York on the Pensacola the early part of last month. The party, including the astronomers, numbered about twenty-five in all. Those from Washington were E. J. Loomis, F. H. Bigelow, W. Harvey Brown, Cleveland Abbe, and G. D. Preston. A number of Professors from Eastern colleges also accompany the expedition.

A Telescope for Hanover College. Messrs. Warner and Swasey, Cleveland, O., have received an order for a 7½-inch equatorial telescope, with all the accessories to make the instrument complete, for Hanover college, Hanover, Indiana. The same firm are to furnish a dome and the architectural plans for a new Observatory.

Mr. Ambrose Swasey, of Warner and Swasey, has returned from four months of travel in Eurppe. While absent he visited many of the principal observatories and spent some time in the study of newer forms and improvements for astronomical instruments.

Spectrum of R. Andromedæ. T. E. Espin reports bright lines seen in the spectrum of R. Andromedæ on Sept. 25. The F. line was very bright. This was circular number 25 from Wolsingham Observatory.

Miss E. M. Bardwell, in charge of the Observatory at Mount Holyoke Seminary and college, South Hadley, Mass., took measures of the distance between Mars and Saturn at 4*h* 9*m* local sidereal time, and found the two planets 1′ 38″ apart. At 5h 19*m*, they, were distant 2′ 46″. Clouds interferred after this time.

Marshall D. Ewell, address 97 Clark street, Chicago, Ill., gives notice that he has revoked the agency for the sale of his micrometric rulings hitherto conferred upon *The Microscope,* because of the sale of that journal. Future orders and correspondence should be addressed to him as specified above.

Himmel and Erde for October is one of the finest members of this new magazine yet issued. It has a beautiful frontispiece, photogravure plate of the disc of the sun showing sun-spots, faculæ and general granulation of the solar surface. If this picture be a faithful copy of any photograph it is certainly one of high excellence.

Spectrum of Saturn and Uranus.—We notice in the last *Nachrichten* (No. 2927), just as we go to press, an interesting article on the spectrum of Saturn and Uranus, by James E. Keeler, of Lick Observatory. The last part of the article is accompanied by a fine lithographic plate of the spectrum of Uranus. Fuller notice of this will be given later.

Asaph Hall, Jr., has been appointed Assistant Astronomer in the Naval Observatory, Washington, D. C., in the position formerly held by W. C. Winlock.

Errata in First Article. Page 385, line 13 from top for *phisicists* read *physicists*; page 386, line 16 from bottom, read *researchers* for *researches*, page 387, line 11 from top read *Broun* for *Brown*; page 388, line 5 from bottom, for *1850* read *1856*; page 390, bottom line, for *manthly* read *monthly*; page 393, fourth line from top, for *maximum* read *minimum*; in eleventh line of page 394 insert *the* after *of.* Sorry that it was impossible to hold type for the authors corrected proof.

BOOK NOTICES.

Hand book of Descriptive and Practical Astronomy, by George F. Chambers, F. R. A. S., Oxford, England, at the Clarendon Press, 1889.

A copy of the first part of the fourth edition of Chambers Handbook of Descriptive and Practical Astronomy has reached our table. American readers of the MESSENGER who have not seen the first part of the new edition of this standard work on astronomy will doubtless be glad to know what changes have been made. The most important of these we will give as fully as space will allow. The fourth edition was a single volume of 928 pages, but there were undesirable omissions in its plan, and so the author went back to the original plan, of three volumes for the entire work as he had arranged the scheme twenty-nine years ago. The three divisions of the present work are as follows:

I. The Sun, Planets and Comets.
II. Instruments and Practical Astronomy.
III. The Starry Heavens.

The intention now is that each volume will be paged, indexed and sold separately.

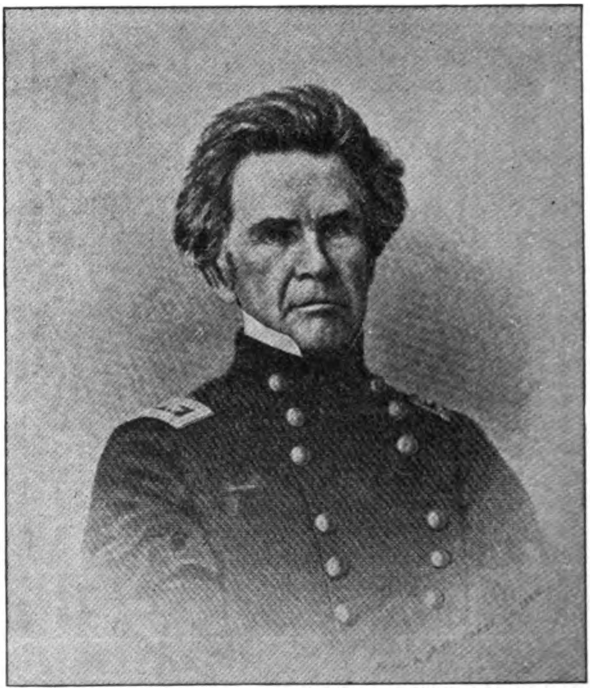
The most obvious changes in the matter pretaining to the themes of the first part of the fourth edition are the illustrations. In the previous work for the same subjects there were 133 cuts; in this volume we find 253. All data depending on the solar parallax have been re-computed using the value of 8″.80, and a number of verbal changes, omissions and additions are noticed in the text: for example the extension of the table showing the results of Wolf's sun-spot observations from 1874 to 1887 giving a continuous period of thirty-eight years, the addition of six new cuts showing the appearance of sun-spots observed in 1883 and 1886, and the new and fuller statement pertaining to the photosphere, chromosphere and corona, bringing the study of the sun within the range of most modern investigation.

The introductory chapter on the planets has six new pages of matter with four new cuts, one giving the apparent motions of Mercury and others, the apparent sizes of the planets. The chapter on Vulcan (?) in the new edition is increased by six pages, also much of the matter being in fine print and containing a fair account of the views and discussions of American astronomers relative to the supposed discovery of Valcan. The planet Mercury is given two new illustrations and a brief account of the recent studies of Denning and Schiaparelli, and mention is also made of Professor Newcomb's view that discordance between the observed and theoretical motions of the perihelion of Mercury's orbit, first pointed out by Le Verrier really exists and is indeed larger than he supposed.

Considerable variation and addition are found in the text for the planet Venus. Six illustrations of phases and spots seen by several observers furnish most of the new matter. Newcomb's mass of the planet, which agrees most nearly with that of Littrow, is given in this edition. The increase of matter in the chapter on the earth is five pages, with an illustration of Foucault's pendulum experiment to show the earth's axial rotation. The description of the experiment is a worthy edition to the former text. In a way quite similar to these particular citations the whole text of this revision is dealt with in regard to the remaining planets. Then follow eclipses and associated phenomena, to which large space is given, followed by chapters on transits of inferior planets, occultations, tides and tidal phenomena, and other general physical phenomena, closing with comets, meteors, and shooting stars. The tables, notes, and illustrations accompanying the last-named themes are varied and full, and close a volume of 676 pages of closely arranged and well ordered matter.

Professor Chambers has made an excellent beginning in the revision of this book, and we shall soon look for the second volume in the series, which is also promised for the autumn of 1889. The third is expected to be completed in 1890.

As a closing thought we can not do better than to take his own words from the preface of the last edition. Though not closely connected with the general idea of this review they plainly show how a leading English scholar and scientist looks at some of the broader and greater questions of the present time. He says: "Where are we now in the effort to discover first causes? The answer is: Very much where we were a quarter of a century ago. The theory of evolution may be true, or it may be false, but be it one or the other I agree with Professor Mivart (who believes it) when he says, 'There is no necessary antagonism between the Christian Revelation and Evolution.' Evolution is an at-attempt to guess at a process; it does not touch the Author of that process and never will."



O. M. MITCHEL.

THE SIDERI[illegible] [illegible]NGER,

CONDUCTED [illegible]

DIRECTOR OF CARLETON C[illegible]

[illegible] 9, No. 10. DECEMB[illegible] [illegible]0.

THE RESISTING MEDI[illegible]

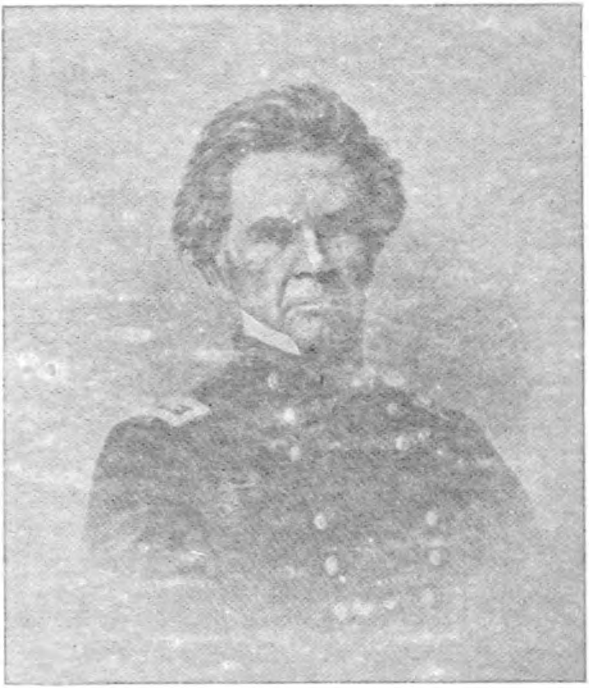
ASAPH HALL

[illegible] THE MESSENGER

To any one who looks at our s[illegible] way, and who observes the contin[illegible] light and heat from the sun to the pl[illegible] action of the gravitating force wh[illegible] the planets into ellipses [illegible] natural, perhaps, t[illegible] tered medium in the planet[illegible] these forces act thro[illegible] the sun from his at[illegible] Such a [illegible] the motion of [illegible] through it, and as unceasingly, its effect w[illegible] mulative, and arise an important quest[illegible] to be [illegible] the theory of celestial mech[illegible] gators soon gave their [illegible] more than a century ago [illegible] effect of a resisting medium [illegible] acceleration of the moon's [illegible] gation of the action of such [illegible] planet is given by Cousin [illegible] published in Paris, 1787; [illegible] gated this question in the [illegible] m[illegible] plete examination of [illegible] however, showed that the law [illegible] sufficient at that time to explain [illegible] heavenly bodi[illegible].

The results for a resisting medi[illegible] the law assumed for the resistance [illegible] tance as they are known fro[illegible] observ[illegible] general effects on the moti[illegible] of a pl[illegible]

* U. S. Naval Observatory [illegible]



O. M. MITCHEL.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 8, No. 10. DECEMBER, 1889. WHOLE No. 80.

THE RESISTING MEDIUM IN SPACE.

ASAPH HALL.*

For THE MESSENGER.

To any one who looks at our solar system in a simple way, and who observes the continual communication of light and heat from the sun to the planets, and the steady action of the gravitating force which bends the courses of the planets into ellipses round the central body, it would be natural, perhaps, to assume that there must be some material medium in the planetary spaces, by means of which these forces act through the great distances that separate the sun from his attendant planets. Such a medium may resist the motion of a planet through it, and as it would act unceasingly, its effect would be cumulative, and hence would arise an important question, necessary to be examined in the theory of celestial mechanics. In fact the early investigators soon gave their attention to this question, and more than a century ago the Abbe Bossut sought in the effect of a resisting medium an explanation of the secular acceleration of the moon's motion. An analytical investigation of the action of such a medium on the motion of a planet is given by Cousin in his Physical Astronomy, published in Paris, 1787; and afterwards La Place investigated this question in the *Mecanique Celeste*, Tome IV. A more complete examination of the theory of perturbations, however, showed that the law of gravitation alone was sufficient at that time to explain the motions of all the heavenly bodies.

The results for a resisting medium depend, of course, on the law assumed for the resistance. With the laws of resistance as they are known from observation on the earth the general effects on the motion of a planet are as follows:

* U. S. Naval Observatory, Washington, D. C.

(1). *The position of the plane of the orbit is not changed.*

(2). *The mean longitude of the planet and the longitude of the perihelion undergo only periodical changes.*

(3). *The mean distance of the planet and the excentricity of its orbit are continually diminished.*

The first result seems almost self-evident; but the important changes are those of the third kind. From these it follows that the motion of the planet is constantly accelerated and at the same time the orbit continually approaches a circular form. The final result therefore under these conditions is that the planet falls into the central body.

As simple a way perhaps as any of reaching these results by analysis is that given by Poisson in his *Mecanique*. The method employed is that of the variation of the four constants that belong to the plane of the ellipse described by the planet. However the formulæ take a somewhat neater form by using the excentric anomaly as the independent variable instead of the true anomaly as Poisson does. The law of density of the resisting medium generally assumed is that it varies inversely as the square of the radius vector of the body. There is an uncertainty in this assumption which it is difficult to avoid, since many laws may be assumed that will give nearly the same results. Having assumed the law of density the principal parts of the integrals can be obtained at once when the excentricity of the orbit is small, but when the excentricity is great, as in the orbits of comets, the perturbations can be expressed by means of elliptic integrals. The differential equations for the mean distance and the mean motion of the body can be written in a simple form, and so that they exhibit very plainly the resulting effect of the resisting medium on these elements. If a is the mean distance, μ the mean motion, and c the velocity of the body in the unit of time; r its radius vector, and U the disturbing force acting in the direction of the tangent, these equations are:

$$\frac{da}{dt} = \frac{2a - r}{r} \cdot \frac{2a}{c} \times U$$

$$\frac{d\mu}{dt} = -\frac{3(2a - r)}{r} \cdot \frac{\mu}{c} \times U$$

In these equations $2a-r$ is the distance of the body from the vacant focus of the ellipse, and all the factors that multiply U are positive in every part of the orbit. The integral effect, therefore, on a and μ will depend on the character of the disturbing force. In the case of a resisting medium U will be negative, so that the mean distance will be diminished, and the mean motion will be increased.

The plausibility of the existence of a resisting medium in the planetary spaces has been increased by the adoption of the wave theory of light, which assumes a luminiferous ether pervading the universe. The character of this ether has been described in various ways; generally, however, as a vast solid body, through which the dense planets move without hindrance but which may present some resistance to the motions of comets. Hence it is from the motions of these light and expanded bodies that we should expect to learn something about a resisting medium in space. But whatever may be the physical theories of light, and the theoretical qualities of the luminiferous ether, let us see what the observations of comets have shown.

The most famous of the periodical comets whose motions have been carefully investigated is the Encke comet, discovered by Mechain in 1786, and again by Pons in 1818, when its short period of about 1212 days was first detected. For a long time Encke persisted in calling it the Pons comet, but his own laborious investigations on the motion of this comet have justly given it the name of the *Encke Comet*. On account of the short period of this comet and its near approach to some of the planets, the work of computing the perturbations is very great. The persevering labor of Encke through so many years deserves the highest praise. Beginning with the earliest observations he reduced many of them anew, computed the perturbations produced by the six principal interior planets, formed normal places and equations of condition, and deduced the best elements of the orbit; also a correction to the mass of Mercury and the coefficient depending on the resisting medium. The work of Encke extends from 1786 to 1858, and altogether it is one of the most laborious computations ever performed by an astronomer. This comet passes inside the orbit of Mercury and in some cases approaches so near the planet that it is necessary to compute the coefficients of the perturbations for every second day. Under the assumption of a resisting medium, and because the observations are all made near perihelion, the mean motion of the comet will have the form,

$$\mu' = \mu + 2\alpha\,(t - T)$$

where μ is the pure elliptic mean motion, T the epoch, and α a constant coefficient to be found from observation.

The mean anomaly will be:

$$M = \mu\,(t - T) + \alpha\,(t - T)^2$$

The expression for the excentricity of the orbit will be:

$$e' = e - \beta\,(t - T)$$

In the case of the Encke comet the coefficient β is very small, and it may be neglected for several revolutions of the comet. Taking the epoch

$$T = 1829,\ \text{Jan. } 9.72 \text{ Paris M. T.}$$

the periodic time resulting from Encke's computations, extending over 72 years, is

$$1211^d.3259 - 0^d.117573\ .\ r$$

where r denotes a revolution of the comet. Each revolution, therefore, since the epoch is diminished by $2h\ 49.3m$; so that from 1818 until 1885 the periodic time would be shortened 2⅓ days. A careful examination of Encke's methods and work will convince anyone, I think, of the truth of his result that the period of this comet was diminishing by nearly this amount during the time 1786 to 1858.

After the death of Encke in 1865 the computations on this comet were undertaken by Dr. Von Asten and Dr. Becker, and after a short time the entire work passed into the hands of Dr. Von Asten. These calculations were pursued with great zeal and industry by him until his death in 1878. Von Asten recomputed the perturbations and made a complete investigation of the motion of the comet from 1819 to 1875. As a general result there was found to be a good agreement with the theory of Encke in respect to the resisting medium But an exception occurs for the interval from 1865 to 1871, when it was found that no resisting medium was required to satisfy the observations. This investigation is very elaborate, Von Asten's equations of condition containing eleven unknown quantities; the six elements of the orbit of the comet, the coefficient for the resisting medium, and corrections to the masses of Mercury, Venus, Earth and Jupiter.

After the death of Von Asten the computations on the Encke comet were undertaken by Mr. O. Backlund of the Pulkowa Observatory, now professor in St. Petersburg, in whose able hands they remain. Backlund found on revision that the result reached by Von Asten for the years 1865 to 1871, of the non-existence of a resisting medium, came from a small error in computing the perturbations during that time. He has deduced elements of the orbit of the comet from the observations made in the years 1865 to 1885, and his representation of the normal positions for these years is excellent. The corrections to the masses of the planets have been omitted in Backlund's discussion, except for Mercury. The final result is that the coefficient of the resisting medium has only one-half the value found by Encke and Von Asten from the earlier observations of the comet. The mass of Mercury comes out very great, but agreeing nearly with the value found by Encke from all the appearances of the comet from 1818 to 1848, and curiously enough, with the old value assumed by Lagrange from rather arbitrary analogies. In fact, a singular feature in the investigations of the motion of this comet is the variation in the resulting mass of Mercury. These values of the mass are as follows, the mass of the sun being the unit:

MASS.	OBSERVATIONS.	COMPUTER.
1 : 3271742	1818 to 1848.	Encke.
1 : 10252900	1828 to 1848.	Encke.
1 : 8234192	1828 to 1848.	Encke.*
1 : 7636440	1818 to 1868.	Von Asten.
1 : 2668700	1871 to 1885.	Backlund.

A decided change in the effect of the resisting medium appears to be clearly shown by the observations, so that after 1870 the coefficient is reduced to one-half the value found before that time.

Soon after Encke proposed his theory of a resisting medium in space the objection was brought forward that this theory is too general, since the motions of the planets and of other comets are not affected by such a medium. However a short time before his death Encke had the satisfaction of seeing the work of Professor Axel Möller on Faye's comet, which showed that a resisting medium was also necessary to account for the motion of this comet. Since the Encke

* Rejecting observations after passage of perihelion.

and Faye comets move in very different parts of the planetary spaces, the Faye comet having a period of seven and one-half years, this result was a striking confirmation of the existence of such a medium. But in later computations Professor Möller has removed this apparent confirmation, since he has found that the whole series of observations can be represented very well by means of the law of gravitation alone, so that there is no need of a resisting medium. The first and erroneous result appears to have been produced by the method of computing the perturbations in rectangular coördinates, which give the perturbations in such a form that one does not easily see how the elements are changed. This method was devised by Bond and Encke, and it is theoretically very simple, but though strongly recommended by Encke it does not work so well in practice as the old method of the variation of the elements.

Dr. E. von Haerdtl has recently published a very elaborate investigation of the orbit of the Winnecke comet, whose motion also was at first thought to be accelerated, and finds, after a complete discussion of the observations, no evidence of a resisting medium. This work is very complete, and the calculations appear to have been made with the utmost care. The situation of this comet is intermediate between those of the Encke and Faye comets. Its period is about five and one-half years, and the work of Dr. von Haerdtl extends from 1858 to 1886.

At the present time, therefore, the general result of all the investigations on the motions of comets is that the Encke comet alone shows evidence of a resisting medium; and in this case the coefficient of resistance has been diminished one-half for the observations made during the last five appearances, or from 1871 to 1885. Such a result must lead to the examination of what is peculiar about this comet, and its position in space. The perihelion distance is so small that the comet can approach very near to Mercury, within 0.04, and the discordant values of the mass of this planet found from the discussion of different series of observations have been referred to; but all these values require the existence of a resisting medium, or of some tangential force producing a similar effect, though varying in amount. It is one of the conditions that add to the probability of the theory of a resisting medium in space, that it furnishes a simple and sufficient cause for this tangential force. But the assumption of such a medium, and its identity with the luminiferous ether, when only the motion of a single body gives evidence of it, and this with a varying coefficient, seems much too general. Fifty years ago Bessel pointed out that there are many other causes which may produce the diminution of the period observed in the Encke comet, and he called special attention to the repulsive action of the sun on the matter of a comet when near its perihelion. In recent years we have seen several instances of a similar action, sometimes proceeding so far as to disintegrate the nucleus of the comet. It seems to me, therefore, that the views of Bessel deserve to be reconsidered, especially since the latest investigations on the motions of different comets have failed to confirm the theory of a resisting medium in the planetary spaces.

The following is an outline of Bessel's argument (*Astr. Nach.*, Bd. 13, p. 345): Let V be the velocity of a body in its orbit round the sun, r its radius vector, and a the semi-major axis of its orbit. If m be the mass of the sun plus the mass of the body, we have the well known equation,

$$V^2 = m\left(\frac{2}{r}-\frac{1}{a}\right).$$

Take the axis of coördinates in the plane of the orbit, and the major axis of the ellipse for the axis of x; if we put $m = 1$, we have

$$\frac{1}{2a}=\frac{1}{r}-\frac{dx^2+dy^2}{2dt^2}. \qquad (a.)$$

Suppose that the comet throws off in a unit of time a part of its mass, which is to the remaining part as $u : 1$; then in the time dt it will throw off udt. If the velocity of the part thrown off be g, the angle which the direction of the ejected part makes with the radius vector be α, and if the true anomoly of the comet be v, the velocities of the comet along the axes arising from this disturbance are

$$gu \cos (v-\alpha)\, dt, \qquad gu \sin (v-\alpha)\, dt.$$

The values of $\frac{dx}{dt}$ and $\frac{dy}{dt}$ for this instant become

$$\frac{dx}{dt} + gu \cos (v-\alpha)\, dt \ : \ \frac{dy}{dt} + gu \sin (v-\alpha)\, dt.$$

Since r is constant in differentiating for the perturbation, equation (a) gives,

$$d \cdot \frac{1}{2a} = -gu \left\{ \cos(v-\alpha)\frac{dx}{dt} + \sin(v-\alpha)\frac{dy}{dt} \right\} \cdot dt.$$

The polar equation of the ellipse is

$$r = \frac{p}{1 + e \cos v}$$

and we have

$$x = r \cos v : \qquad y = r \sin v.$$

Differentiating these values of x and y, and substituting the values of

$$\frac{dv}{dt} = \frac{\sqrt{p}}{r^2} \quad : \quad \frac{dr}{dt} = \frac{e \sin v}{\sqrt{p}}$$

we have

$$\frac{dx}{dt} = -\frac{\sin v}{\sqrt{p}} \quad : \quad \frac{dy}{dt} = \frac{\cos v + e}{\sqrt{p}}$$

and hence

$$d \cdot \frac{1}{2a} = \frac{gu}{\sqrt{p}} \cdot \{ \sin \alpha - e \sin(v - \alpha) \} \cdot dt,$$

p and e being the semi-parameter and and excentricity of the orbit. Now

$$dt = \frac{r^2}{\sqrt{p}} \cdot dv = \frac{\sqrt{p^3} \cdot dv}{(1 + e \cos v)^2}$$

so that

$$d \cdot \frac{1}{2a} = gup \cdot \left\{ \frac{\sin \alpha - e \sin(v-\alpha)}{(1 + e \cos v)^2} \right\} \cdot dv,$$

or we have finally

$$d \cdot \frac{1}{2a} = gup \cdot \left\{ \frac{\sin \alpha \, dv}{1 + e \cos v} - \frac{e \cos \alpha \sin v \, dv}{(1 + e \cos v)^2} \right\}. \qquad (b)$$

The integral of (b) between the limits v_2 and v_1 gives the variation of $\frac{1}{2a}$ in the corresponding interval. If ε be the excentric anomaly we have

$$\frac{d\varepsilon}{dt} = \frac{1}{r\sqrt{a}}$$

and hence

$$r \cdot dv = \sqrt{ap} \cdot d\varepsilon.$$

The differential (b) takes the form

$$d \cdot \frac{1}{2a} = gu \{ \sin \alpha \sqrt{ap} \cdot d\varepsilon - \cos \alpha \, dr \},$$

and the integral is

$$\Delta \cdot \frac{1}{2a} = gu \left\{ \sin \alpha \sqrt{ap} \cdot (\varepsilon_2 - \varepsilon_1) - \cos \alpha \, (r_2 - r_1) \right\}.$$

The corresponding change in the periodic time is

$$\Delta\tau = -3gua\,\tau \cdot \left\{ \sin \alpha \sqrt{ap} \cdot (\varepsilon_2 - \varepsilon_1) - \cos \alpha \, (r_2 - r_1) \right\}.$$

For a numerical example let $\alpha = 0$, or assume that the matter is thrown off towards the sun. Bessel found from his observations of Halley's comet in 1835 the value of

$$g = 0.03756,$$

the unit of time being

$$\frac{1}{k} = 58.13244 \text{ days},$$

where k is the Gaussian constant. Hence we have

$$\Delta\tau = +\,57185\,(r_2 - r_1)u, \text{ in days.}$$

For Oct. 2 and Oct. 25, $r_1 = 1.08386$; $r_2 = 0.75085$, so that

$$\Delta\tau = -\,19043\,.\,u.$$

Suppose that during this interval of 23 days the comet threw off daily $\frac{1}{1000}$ part of its mass towards the sun, an amount which Bessel thinks was indicated by observation; we have

$$u = \frac{0.001}{k} = 0.05813244$$

and the result in this case is

$$\Delta\tau = -1107 \text{ days}.$$

The Halley comet has a period of about 76⅓ years, or 27,900 days, and the major axis is 18.178. On account of the magnitude of these quantities the value of $\Delta\tau$ in this example comes out large, but the numbers are used simply to illustrate a possible case. In order to destroy the influence of $\Delta\tau$ on the periodic time there should be an equal ejection of cometary matter on the other side of the perihelion, but such an equality does not seem probable.

If now we compare the methods of Encke and Bessel we see that the assumption of a resisting medium filling space has the advantage and the attraction which belong to vast and indefinite theories; such, for example, as the nebular hypothesis, and it is not to be expected that such a theory will be given up because a few facts contradict it. There is always a hope that further investigation may reconcile the facts; but so far the progress of astronomy has weakened, I think, the position taken by Encke with such confidence thirty years ago, and at the present time the astronomical proof of a resisting medium is very slight. On the other hand Bessel has only called attention to a phenomenon which has been observed many times, that is the throwing off of envelopes from the nucleus of a comet, which is one where the velocities of the ejected particles have been measured and their orbits computed. The mechanical action of these masses on the nucleus of the comet is therefore a question that astronomers ought to consider, and one for which they should seek a rational explanation. The only quantity in Bessel's expression for the change in the periodic time that must be assumed is u, the ratio of the mass thrown off to the remaining part. In the example given above this ratio may be taken erroneously, but the distinction between the methods should not be overlooked on account of any numerical error. That a certain part of the comet is ejected is a matter of fact, and if it has a finite ratio to the remaining part the mass and velocity of the ejected part must exert a certain force.

Oct. 15, 1889.

ORMSBY MACKNIGHT MITCHEL.*

J. G. PORTER.†

FOR THE MESSENGER.

To have been the founder of a scientific institution which has now completed nearly half a century of activity and usefulness; to have secured for this institution through his own personal influence and efforts the largest telescope at the time in the western hemisphere, and one of the largest in the world; to have aroused by his eloquence such a widespread interest in the science of the stars that other observatories were organized, and the thoughts of multitudes were elevated above the sordid cares of money getting to the ennobling contemplation of celestial scenery; such are some of the achievements which should cause the name of Ormsby M. Mitchel to be held in lasting honor.

* See frontispiece in this number. † Director of the Cincinnati Observatory.

Born in Kentucky in 1809, when the whole of the west was little more than a wilderness, and losing his father soon afterward, he was early thrown upon his own resources. While he was still a boy the family removed to Ohio and settled in Lebanon, a village not far from Cincinnati, which was afterward the scene of his heroic struggles and brilliant success. Resolving to gain an education, he obtained an appointment to the military academy at West Point through an influential relative of his mother. When that gentleman said to him, "We have had many of our boys go to West Point, but few of them get through," Ormsby drew himself up, looked him in the eye, and replied. "I shall go through, sir!" He was as good as his word. Though one of the youngest of his class he graduated with honor, and was appointed assistant professor of mathematics in the Academy. Afterward he was stationed for a short time in Florida; but soon tiring of the inactivity of army life, he resigned his position and came to Cincinnati, where he commenced the practice of law. In 1834 he was elected professor of mathematics, philosophy and astronomy in the Cincinnati College then just established.

Astronomy was at that time in its infancy in this country. A few observatories, connected for the most part with institutions of learning, and very imperfectly equipped with small and inferior instruments, had already been built; but the energies of the nation were absorbed in developing the grand resources of a new and ever widening territory, and the cultivation of the liberal arts and sciences was mostly left to the established civilizations of the Old World. Still there was already wealth enough in the country, and even in the West to justify an increased attention to higher learning. What was specially needed was some one to interest the people and awake enthusiasm on such subjects. This is what Mitchel did for astronomy. Others have accomplished far more than he in the way of laborious scientific research; but none probably have wielded a more potent influence for the advancement of astronomy in this country than did Mitchel by his matchless eloquence, the echoes of which have not yet died away in the memories of those who heard him.

Becoming deeply interested himself and desiring to lead his students into still more intimate knowledge of the wonders of the sky, he conceived the idea of erecting an Observatory. It was an arduous undertaking for a man without fortune himself and with no wealthy patron to back his enterprise; and nothing short of indomitable energy and perseverance, coupled with no inconsiderable business tact, could have carried it through to successful completion. He opened his campaign by a brilliant series of lectures which he illustrated with a stereopticon, taking his hearers over the whole range of astronomic discovery, from the rude observations of the primitive gazer upon the Babylonian towers, on down the ever brightening track, till he ushered them into glories which stream upon the vision of him who views the heavens through the modern telescope. At the close of these lectures he laid before the audience his project for securing for Cincinnati an Observatory which should be worthy of the name. The fact was emphasized that in the Old World "monarchs lavished treasures on the temples of science," while here the people must build them; and accordingly his plan was to divide the amount needed into shares of twenty-five dollars each, and each subscriber was to have the privileges of the Observatory. When three hundred share holders had been obtained, the association thus formed sent Professor Mitchel to Europe to make the necessary arrangements for procuring a telescope. After a vain quest in London and Paris, he finally found in Munich in the cabinet of Merz and Mahler, successors of the famous Fraunhofer, the object of his desire, an objective nearly a foot in diameter. To mount this glass would require about ten thousand dollars, a larger amount than had yet been subscribed; but Mitchel believed that the money could be secured, and he ordered the instrument. Before returning to this country he spent some months with Professor Airy, Astronomer Royal of England, whose friendship greatly encouraged and assisted Mitchel in his laborious undertaking.

A commercial depression had come upon the business of the country during his absence in Europe, a fact which much increased the difficulty of raising the payments for the telescope. Moreover a building must be provided for its reception. Even his most enthusiastic friends were troubled by the gloomy state of affairs, and some of them felt too poor to do all that they had promised; but the unwavering faith and resolution of this heroic man achieved victory in the face of obstacles that would have discouraged a less exalted nature. The munificence of Nicholas Longworth supplied the society with a site for their building unsurpassed in natural advantages by any excepting those of our mountain observatories. Professor Mitchel compares the view with that from the castle opposite the city of Coblentz on the Rhine. The broad sweep of the Ohio around the foot of the eminence, and the city enclosed by the amphitheater of hills, present a prospect never to be forgotten. It is greatly to be regretted that in subsequent years the increasing dirt and smoke of the city rendered a change of location necessary.

The ninth of November, 1843, was a memorable day. John Quincy Adams, then nearly four score, had consented to deliver the oration at the laying of the corner stone; and amid the hush of the vast throng which had assembled on the hill top, he paid a worthy tribute to the "founders of the Observatory, to science, and then to the country he loved, the home of a free, enterprising and intelligent people." The following summer saw the work on the building resumed. During the winter and spring the remainder of the purchase price of the instrument had been raised and sent to Munich. The treasury was empty, but the indefatigable astronomer appeals to the intelligent mechanics of the city. Some of them take stock and pay for it in labor, others in materials; and thus the walls slowly rise, Mitchel himself much of the time working with his own hands. In the early part of 1845 the building was ready for the reception of the telescope which had arrived in February. We can more easily imagine than describe the anxiety and eagerness with which, after successfully completing the work of mounting and adjustment, he turned the immense tube upon the heavenly bodies. Its performance from the first seems to have been entirely satisfactory.

Of the scientific work accomplished by Mitchel there is not very much to be said. His title to fame does not rest upon this, although he seems to have made good use of the telescope during the time that circumstances permitted him to observe with it. Much attention had necessarily to be shown to the stockholders of the astronomical society and their friends. During the first year after the telescope was mounted five evenings out of the week were devoted to them, and in subsequent years half the evenings. Not long after the completion of the Observatory, moreover, the Cincinnati College burned down, and his salary as professor ceased. As he had agreed to superintend the observatory for ten years without salary, depending on that from the college, he was obliged to give part of his time to maintaining his family. In 1846 he commenced the publication of *The Sidereal Messenger*, the earliest magazine devoted to popular exposition of astronomy. This was successful for a couple of years, but for some reason was then discontinued. In the mean time Mitchel had begun his course of lectures in the great cities of the Union. He first visited Boston, where his success was so marked that he was at once recognized as one of the leading orators of the country. Says one who heard him, "In New York the Music Hall is thronged night after night to hear his impassioned eloquence poured in an unbroken flow of 'thoughts that breathe and words that burn' on the excited thousands. A sublimer spectacle in lecturing was never seen. The object, the theme, the orator, the intellectual audiences, the wrapt attention, the almost painful intensity of feeling, all crown him the prince of lecturers."

With all these interruptions to his strictly scientific work, it is not to be wondered at that he has left no long series of observations behind him. Yet in this department he was not idle. He early undertook, at the suggestion of Airy and Struve, the observation of the double stars in the southern sky. Some of his measures were published at the time in the scientific journals, and others may be found in the publications of the Cincinnati Observatory. The duplicity of Antares was discovered by him in 1846, though it seems that Grant in India had anticipated him by a year or two. Mitchel was one of the first to employ the principles now embodied in the chronograph to the recording of time, though he laid no claims to having originated the idea. In his Popular Astronomy he says:

"In the autumn of the year 1848, the late Professor S. C. Walker, then of the U. S. Coast Survey, was engaged with me at the Cincinnati Observatory in a series of observations for the determination of the difference of longitude between Philadelphia, and Cincinnati. In comparing our clocks with those of Philadelphia, an observer at Philadelphia listening to the clock beat touched the key of the telegraph at every beat, and we received at Cincinnati an audible tick every second of time, which was carefully noted, and thus our clocks were compared. There were two sources of error in this method of comparison, arising from an imperfect imitation of the clock-beat by the Philadelphia operator, also from our noting the arrival of that beat in Cincinnati. On the 26th of October, 1848, Professor Walker, while conversing on this subject, first presented to me the mechanical problem of causing the clock to send its own beats by telegraph from one station to the other, or what amounted to the same thing, the problem of converting time into space: for in case the clock could send its own beats by telegraph and these beats could be received on a uniformly flowing time scale, the star transit could be also sent by telegraph and received on the same scale, and thus a new method of transits would at once spring from the resolution of the first mechanical problem. I was informed by Professor Walker that the problem had already been presented to others, but so far as he knew, had never been solved. The full value of the idea was at once appreciated; and on the same evening a common brass clock, the only one then in the Observatory, was made to record its own beats by the use of the electro-magnet on a Morse fillet. The problem once solved, nothing more remained than to elaborate such machinery as would render it possible to apply this new invention to the delicate demands of astronomical observation."

In 1860 he was appointed to the directorship of the Dudley Observatory in Albany, but scarcely had he entered upon the position before the breaking out of the Civil War called him to higher duties. His early training at West Point made him feel it only right that he should give his services to the support of the government. How well and nobly he acted his part and gave up his life in the struggle for freedom, is a matter of history. To trace his military career is beyond the scope of this article. Had he no other claims to eminence he would be gratefully remembered as one of the heroic defenders of his country. His pastor in Albany, in a public address, thus refers to him:

"General Mitchel was distinguished in so many departments that I am unable to say whether he was most eminent as an astronomer, a soldier, or a Christian. He certainly presented in a most happy union, scientific culture, earnest patriotism, tender humanity, and devoted piety. His intellect moved among the stars and caught their brilliancy. His thoughts partook of their harmony and grandeur. His discoveries and contributions to astronomical science are alone sufficient to render his name distinguished in the annals of American literature. His popular lectures made him a favorite with all, and inspired the minds of the people with a love for the beauties and sublimities of astronomy and with adoration for the great Creator and His marvellous works. . . . In his death science lost a rare ornament, the army mourned a brave and skillful soldier, humanity wept for an earnest defender and advocate, and the church lost a true Christian and humble follower of our Lord Jesus Christ."

EARTH-TREMORS.

HERBERT A. HOWE.*

FOR THE MESSENGER.

During the month of October just passed, some experiments were made at University Park, a suburb of Denver, to determine the effect of vibrations of the earth caused by trains, teams and men, on images reflected from a mercurial horizon. The reflected images of objects on the roofs of houses were watched with the naked eye, and also through the telescope of an engineer's transit, made by Fauth & Co.; the magnifying power of the latter was about twenty diameters. The observing station was 1,500 feet away from the Denver, Texas and Gulf railroad and 500 feet from the Denver and Santa Fé [narrow gauge]. The soil is a loam several feet deep, and was very dry, the surface being quite hard.

Below is a summary of the results.

1. When a man weighing 135 pounds jumped up from the ground six inches, and came down on his heels, the reflected image quivered, if the man was not more than 125 feet from the mercurial horizon.

2. A team of small horses, attached to a light wagon, and driven at a slow trot, caused disturbances which vanished when the vehicle reached a distance of two hundred feet from the mercury.

3. A pebble half as large as one's thumb, dropped one-eighth of an inch at a distance of one foot, made the reflected image tremble perceptibly to the naked eye. When the pebble was dropped similarly and repeatedly on a little heap of loose earth, no vibration was detected until the earth became packed. The image seemed to leap *away* from the point where the pebble struck.

4. Denver and Santa Fé trains did not shake the image, probably because they ran slowly in approaching the depot.

5. Passenger trains on the Denver, Texas and Gulf made more marked tremors than freight trains of much greater weight. Though the amplitude of vibration of the image was not great, it was seen to increase as the trains approached, and to die away as they receded.

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* Director of the Chamberlin Observatary, University of Denver, Colorado.

6. The horizon was placed on the ground at the bottom of a rectangular excavation 6 feet deep, 16 feet long, and 2 feet 8 inches wide, which was surrounded by a 12-inch stone wall. The transit was above, its tripod resting on the natural surface, and the reflected image was that of the cornice of a house. Pebbles of various weights were dropped repeatedly a distance of 3 feet, striking on the natural surface near the instrument. The point of striking was 8½ feet from the mercury [six feet horizontally and the same distance vertically]. Some of the pebbles caused no tremor that could be seen, others a slight one, and the heavier ones a very marked quivering.

The horizon was then placed on the natural surface at a distance of 8½ feet from the point where the pebbles struck the ground. The same pebbles were again dropped from the same height, but *no shaking of the image could be perceived.* When, however, they were dropped at a distance of six feet from the horizon, the disturbance of the image was a trifle greater than when the horizon was at the bottom of the excavation.

7. The horizon was set on top of the stone wall surrounding the excavation, and the pebbles were dropped *on the wall* at a distance of six feet from the mercury. The tremors were much stronger than before.

8. Two pieces of iron, weighing respectively one and two pounds, were dropped from different heights at various distances from the mercury; the weights were dropped, in each case, at such distances that the vibrations caused were barely preceptible. A discussion of these revealed the following law:

The intensity of vibration varies directly as the potential energy of the suspended weight, and inversely as the square of the distance between the mercury and the point of striking of the weight.

These observations seem to show that greater gain is to be expected from placing the piers of instruments at a distance from disturbing influences, than from sinking their foundations deep in the earth. They are somewhat at variance with the first page of Loomis's Practical Astronomy.

NOTE ON THE PHOTOGRAPHIC SPECTRA OF URANUS AND SATURN.*

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S., AND MRS. HUGGINS.

Uranus.—In 1871 I had the honor to communicate to the Royal Society an account of the examination of the visible spectrum of Uranus.† The visible spectrum of this planet is remarkable, as it is seen to be crossed by several strong lines of absorption. Six of these dark bands are shown in a diagram which accompanies the paper,‡ and their approximate positions in the spectrum are given. The spaces between the dark bands appear bright by contrast, and might suggest at first sight bright bands. I was unable to use a slit sufficiently narrow to enable me to determine whether the bright parts of the spectrum contain the Fraunhofer lines, which would be the case if Uranus, like the other planets, shines by reflected solar light.

The spectrum of this planet was carefully examined in 1872 by Vogel,§ whose results are in accordance with my earlier ones. He observed some fainter lines or bands, in addition to those given in my paper. Vogel was unable to obtain evidence of the Fraunhofer lines. His observations agree with mine in placing a dark band at the position of F in the solar spectrum.‖

In consequence of the Fraunhofer lines not having been seen, a presumption has arisen that Uranus may shine, in part at least, by emitted light.

It appeared to me that this question might be answered by photography. With an exposure of two hours, I obtained on June 3 a photograph of the spectrum of the planet from a little above F to beyond N in the ultra-violet. A pair of sky spectra, one on each side of the planet's spectrum were taken on the same plate.

The spectrum of Uranus, though fainter, shows all the chief Fraunhofer lines seen in the comparison spectra, and is clearly solar. I have not been able to detect any indications

* Read before the Royal Astronomical Society.
† 'Roy. Soc. Proc.,' vol. 19, p. 488.
‡ To be published in next MESSENGER.
§ 'Untersuchungen uber die Spectra der Planeten,' Leipzig, 1874.
‖ Measures of some of the bands were made at Greenwich in 1882. See 'Greenwich Spectroscopic and Photographic Results,' 1882, p. 33.

of bright lines, nor of any strong bands or groups of absorption, such as those in its spectrum from F to C.

There can be no donbt that the spectrum of Uranus, at least, from a little above F to beyond N in the ultra-violet, is due to reflected solar light. I have not yet been able to re-examine the visible spectrum of the planet.

Saturn.—In 1864, I gave an account of an examination of the visible spectrum of this planet and its rings. In my paper on the "Photographic Spectra of Stars,"* I described the photographic spectra of Venus, Jupiter, and Mars. About a year later I took a photograph of the spectrum of Saturn and his rings, but as it did not present any new features, but was purely solar, I have not given any description of it.

The favorable position of Saturn this year for obtaining a photograph in which the spectra of the ansæ of the rings could be seen distinct from the spectrum of the ball and of the part of the ring crossing it, determined me to take some photographs of the planet and its rings.

I have adopted the plan described in 1880, in which the planet is photographed while the sky is sufficiently bright to give a faint daylight spectrum on the plate. Any additional lines or other modifications of solar light due to the planet's atmosphere can in this way be easily detected.

In the photographs taken this year the slit was so placed upon Saturn that the spectrum consists of three distinct parts, the middle part being formed by the light from the ball, and the part of the ring across it, and on both sides of this spectrum the spectra of the ansæ. The planet was kept upon the same part of the slit with sufficient exactness to keep these three spectra distinct, and from encroaching upon each other, and therefore if any difference existed between them it could be detected.

The exact correspondence of the Fraunhofer lines in the spectrum of the planet and its rings with those of the sky spectrum is clearly shown, but I am unable now, as I was in 1881, to detect any lines, dark or bright, other than those which are also present in the sky spectra. The spectrum on the plate extends from a little above F to beyond N in the ultra-violet.

* 'Phil. Trans.,' 1880, p. 669.

I am trying to obtain enlargements of the spectra of Saturn and Uranus to serve as illustrations to this note. If they can be done so as to admit of reproduction, I will do myself the honor to present them to the Royal Society.

[We have observed since, the visible spectrum of Uranus, but under unfavorable conditions, the planet being low and the sky not dark. These observations confirm me strongly in the opinion I formed in 1871 that the brighter parts of the spectrum appear so as an effect of contrast, and do not represent emitted light. In the moments of best vision the spectrum on both sides of brighter parts appeared to be darkened by groups of lines which give a heightened effect by contrast to the less obscured parts between them.

At moments, we were conscious of dark lines crossing the spectrum, but the unfavorable conditions under which the observations were made prevented us from ascertaining by measurement or otherwise, whether any of these lines were Fraunhofer lines.—July 5.]

OBSERVATORY LOCAL PATRONAGE THREATENED.

It is well known to all our readers that it has been the practice of astronomical Observatories, from the first, to give attention to the matter of keeping accurate time, and often to distribute it to local customers for whatever pay, in money, could be properly secured. These customers have usually been jewelers, hotels, banks, business houses, railroad companies and other forms of business depending more or less upon the use of accurate time. Outside of voluntary gifts by the few friends who might be interested, this local time service for the public has been the only means that Observatories have had by which to secure a little money to pay running expenses. The endowed Observatory is the exception and not the rule. The cost of erecting a good working Observatory is considerable, but the expense of maintaining one and prosecuting work therein for years is even more. Now, it has happened during this last year that this old and time-honored custom of having the benefit of this local time service from local patronage has been curiously invaded, and very persistent attempts have been made wholly to divert this local patronage from the local Observatory to the use and benefit of a merely commercial corporation, and that, too, one of the largest corporations of the kind in the United States. The general plan of work to accomplish this important commercial end was about as follows: By printed circulars the general officers of the various railroad companies were informed that Observatory time would be furnished for the use of railroad companies at much cheaper rates than were being paid to local Observatories. To this appeal little or no attention was paid by those it was intended to interest, and the next step was to buy, or get control of, certain clocks having self winding and synchronizing attachments, and then offer to rent these clocks at very low figures to all parties interested in using accurate time, and already using local Observatory time in various parts of the United States. The point in this step seemed to be to control all good patents, and then offer their use so low that Observatories having local time patronage would be unable to compete for it longer. To make this step a final one in this large commercial transaction, and give it character everywhere in the country, the general officers of this commercial company (which we will now name as the Western Union Telegraph Company), interviewed the Superintendent of the U. S. Naval Observatory, and sought and obtained of that officer, as they say, certain definite contract relations by which the telegraph company should have the privilege and right to use the time of the United States Naval Observatory for its own uses in commercial sale and barter. This is no secret on the part of the telegraph company, for the writer has heard a Vice President of the company very freely speak of the matter, and so have others. What arrangements the Superintendent of the United States Naval Observatory entered into with the telegraph company named, by which it was deemed wise to permit this kind of an attack to be made on the local financial support of the Observatories of the country, it is not apparently very easy to find out. So far as we know, all fair and courteous endeavor to get at the real gist and meaning of this rather extraordinary transaction between a government official and a private telegraph company, by which the rights and interests of educational institutions of the land are put in hardship with the prospect of financial loss, to increase the business of a private telegraph company in lines of business not naturally its own, seems to us certainly proper matter for public notice and public record. It is very hard to believe statements on good authority that have furnished some of this information; and we shall be more surprised than ever if it shall turn out that the professors of the United States Naval Observatory are in any way giving countenance to any such scheme as this.

In view of the palpable wrong in all this procedure, it is suggested that the Directors of Observatories and others interested take up this matter in earnest, and by judicious and general concert of action, seek promptly and thoroughly to right whatever of wrong may oppose the just advancement of our science by the encroachment of unworthy or mercenary projects. A convention in the interest of this movement, called at an early date to formulate a plan for general use, seems a feasible and natural step as a first one to take. General correspondence is solicited.

DOUBLE SHOOTING STARS.

DR. LEWIS SWIFT.

FOR THE MESSENGER.

The phenomenon of a double shooting-star seen passing through the field of a telescope must, I judge, be exceedingly rare, as, during the past thirty-two years, I have seen but four,—two several years since, with my 4½-inch telescope, and two more recently with my 16-inch. Of the former two, if I remember rightly (having mislaid the record), but a day or two elapsed between their appearances, and, very singularly, the second traveled not only over the same path (across Draco), but in the same direction, northeasterly, as the first. In neither case did one component precede the other, but passed through the field side by side, at a right angle to the direction of motion. Had they not done this the phenomenon might have been ascribed to an optical illusion caused by persistence of vision or something akin to it. Between the components of both of these was a strongly marked nebulous ligament, in form like a dumb-bell, connecting them together.

On the evening of September 18, 1889, one traversed the field of the 16-inch glass from east to west, crossing the square of Pegasus, presenting two small disks without ligamental band between, and resembling, as to distance apart, magnitude, and general appearance, the star Castor.

On the night of October 24 another was seen to pass across the neck of Pegasus with components tied together like those first described, and the distance between them was estimated to be about 15 seconds of arc. It suggested Gamma Delphini in appearance. Its motion was exceedingly rapid.

We have double stars, double clusters, double comets, and double nebulæ, and now the list of doubles must be extended to the meteors.

A few evenings ago I had the pleasure of seeing what I had never before witnessed, namely, a serpentine shooting star, which careered across the field from west to east. Two or three small curvilinear deviations were observed as it moved along, and, when it had spanned almost two-thirds of the diameter of the field, it gracefully turned to the south, curving like a sickle blade, and disappeared from view.

I have read of meteors of this sort having been occasionally observed, but has any other astronomer ever seen a double shooting-star?

WARNER OBSERVATORY, Rochester, N. Y.,
November 18, 1889.

DR. PETERS' STAR CATALOGUE.

In the March number of this journal, an account was given of the case of Dr. C. H. F. Peters, Director of the Astronomical Observatory of Hamilton College, Clinton, N. Y., against Mr. Charles A. Borst, Fellow at Johns Hopkins University, to obtain possession of the manuscripts containing over 30,000 stars arranged for a star catalogue, which came up for hearing before Justice Williams of the Supreme Court at Utica, N. Y., on the last day of January of the present year. It appears that the manuscripts were made by Mr. Borst, aided by his sisters, and that they contain the positions of 35,608 stars reduced to the epochs of 1850 or 1875, and arranged in the order of their right ascension. These manuscripts number 3,572 pages, 900 of which are double folio in size, and show upwards of 7,000,000 figures. Dr. Peters claimed that Mr. Borst did the work of compiling and computing while he was employed in the Observatory, on a salary paid by himself, and that therefore the property belongs to him.

On the other hand, Mr. Borst claims that he did the work on the catalogue outside of his labors at the Observatory, and that most of the computations were made by persons at his request without the direction of Dr. Peters.

The testimony in the case showed that the labor put on this catalogue would have cost at least $12,000. The progress of the trial developed large interest in scientific circles because of the new questions raised in a court of justice, and the prominence of some of the witnesses.

The decision of the case was rendered by Justice Williams November 8, in favor of Dr. Peters, and the principal points were substantially as follows:

1. The court held that the manuscripts and the work on them did not belong to Hamilton College nor to Litchfield Observatory, because the compensation paid to Dr. Peters since 1858 was deemed too small to cover the work of literary authorship in justice to him. This point was stated at length, and the legal authorities for the position were cited.

Dr. Peters is Professor in Hamilton College and Director of the Litchfield Observatory. On the relation of his official position to that of authorship the court held as follows:

In this case there seems to have been no agreement that any production of these parties as authors should be the property of the Observatory or the College. The plaintiff acted as professor and teacher in the College, and had the custody of the Observatory and the instruments and property connected therewith, and the defendant acted as his assistant, and while the Observatory and College might enjoy the benefits to be derived from having such men in their employ, men who might become eminent and distinguished by reason of the mental labor and results they achieved, it can hardly be claimed the Observatory or College would become the owners of the works they might, as authors, produce and publish to the world. The property in these works, so long at least as they remain unpublished, belonged to the authors and to them alone. So that the real question to be determined here, is not whether the Observatory or College was the owner of these chattels, the book and manuscripts, in question, but which one of these two parties was the owner thereof, and therefore entitled to their possession when this action was commenced.

In this view of this case, I think it must be said the book, exhibit 2, was the property of the plaintiff and he was entitled to its possession. It was his in 1884, before the preparation of the other exhibits in question was made, and it is not claimed he ever gave it to the defendant, or parted with its possession so as to prevent his demanding, and being entitled to its return at any time.

2. The second point related to the ownership of certain parts of this manuscript catalogue, whether they belonged to Dr. Peters as plaintiff or to Mr. Borst as defendant. After speaking of the various exhibits into which the manuscript was divided, and the evidence of ownership belonging to each, the court finally concludes as follows:

I am impressed in the examination of this case with the truthfulness of the plaintiff's claim—that he regarded this catalogue all along as his own work; that he never consented to surrender it to the defendant; that he intended to give defendant full credit for all he did upon or with reference to it; but that the defendant, as he became familiar with the work and learned how to manage its details, conceived the design of appropriating the whole work to himself, and depriving the plaintiff of all credit for or reputation growing out of it. That then it was that he threw into the work all his executive ability, and that of his sisters, with a view to overwhelming the plaintiff, and creating the impression and belief in the public mind that it was his own personal work, with which the plaintiff had practically nothing to do. In this view I must hold that the exhibits in question, including exhibits 4, 5 and 6, were, at the time of the commencement of this action, the property of the plaintiff, rather than the defendant, and that plaintiff is entitled to recover them in this action.

3. The third is also an interesting one, as indicating a ground in such a case for legal damages. On this point the court said:

In view of the evidence in the case, as to the value of the papers, I can not fix this value very definitely, but I should say exhibit 2 was worth $250; exhibits 4 and 5 each $500; exhibit 6, $1,000; and exhibit 8, $10, making in all, $2,260.

Damages for detention will be fixed at the amount of interest on above values, and from time of commencement of action.

The above citations from Judge Williams' decision in this now prominent case are taken from the *Utica Morning Herald* (Nov. 9) and are given somewhat at length, because it is the only case of the kind known to us in the annals of astronomical science. There may have been others like it, but, if so, we do not know of them. Those who may be interested in the legal or ethical parts of this case and its decision should read it entire.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury is in the descending node of his orbit, passes aphelion Dec. 7, and, at the same time, is in superior conjunction with the sun. On Dec. 26 he is in conjunction with Jupiter, and on the 27th he will be in greatest heliocentric latitude south. His position for the whole month is as unfavorable for observation as it well could be.

Venus is a morning planet during this month and will be in conjunction with the moon Dec. 21.

Mars will be a morning star for this month and next. He is in the constellation of Virgo, and during the first part of December he will pass a little north of the bright star Spica, thence to the south and east entering Libra first days of next month. His declination will then be eleven degrees south, and so less favorable for observation.

Jupiter's position is becoming unfavorable, because so low in the southwestern sky at early morning. The leading article for November in *l'Astronomie* (French), by editor Camille Flammarion, is about Jupiter. It is accompanied by six illustrations of telescopic views of the planet's disk, showing the prominent features of the surface markings. In A. N. 2928 is a brief article on the occultation of Jupiter by the moon, Aug. 7, 1889, by O. Tetens of the Observatory at Bothkamp, accompanied by a fine plate showing the planet Jupiter about one-third occulted. Two great belts on the planet's surface are seen, and another singular phenomenon which we do not remember to have noticed before. We refer to a kind of penumbral haze, about eight minutes in breadth, on the disk of the planet, extending beyond the limb of the moon, and concentric with it. The shade seems to be about one-half as dark as belts of the planet's disk.

Mr. Tetens' observation is given below in his own language as translated from the German:

"Although the occultation of Jupiter which took place the 7th inst., by the moon, could be followed only in part on account of unfavorable weather here in Bothkamp, nevertheless I communicate my observations in regard to it, on account of a peculiar appearance noticed by me during the reappearance of the disk of the planet, with the supposition that the phenomenon was also observed at other places.

What is most important in this unexpected observation consists in this, that upon the disk of Jupiter, which was quite dark in comparison with the moon, during the last two thirds of its emersion there showed itself a tolerably sharply defined shadow; which, fixing itself in a width of about one-fifth of the diameter of Jupiter from the southern to the northern limit of the planet on the edge of the moon, did not seem to change in the course of the appearance which lasted more than a minute. The light and dark zones of the planet could be seen with lessened intensity in the extent of the shadows, but with perfect distinctness. Within the limits of the shadow imposed on Jupiter, a parallelism, with the outlines of three mountains somewhat perpendicular near the edge which were projected on the disk, was not seen.

During the last seconds of the occultation I was obliged, in order not to lose the desired chronometrical observation of the four contacts, to turn my attention from the shadow. It was impossible to further locate the cause of this appearance as there was no other observer at hand, and during the short duration of the appearance the change of the lens or of the entire instrument did not seem practicable.

Nevertheless I believe that circumstance dare not be suppressed. The observation was made at the time of the following clock observations and the photographic impressions with an 11 inch refractor. A magnifying power of about 270 diameters was applied for the ocular observation, the photographic impressions were taken in the focus. The mechanism was adjusted during the whole time according to the movement of the moon. The time stated indicates star time. The added probable errors depend on estimations which were made at the time of the observation.

h m s s	
16 56 30	Jupiter is entirely visible through the clouds.
17 2 30 ± 2	Jupiter, of which a few seconds before a very narrow segment was visible through the clouds, disappears entirely.

h m s	s	
17 7 17		Small rift of the clouds; the second satellite seen two minutes before is now hidden.
17 7 30		It begins to rain; the roof is closed.
17 15 35		Through the door leading to the platform the fourth satellite can no more be seen with a previously arranged Fraunhofer 3-inch glass.
17 57 23	± 2½	was estimated as the time of emersion of the third satellite.
17 57 31		Its observed disappearance and its suddenness.
18 4 57	± 1	Emersion of Jupiter, exterior contact.
18 9 32	± 1½	Emersion of Jupiter, interior contact.
18 4 1	± 4	Half of Jupiter has reappeared.
18 4 57	± 1½	Emersion of the second satellite.
18 26 40 to 43		and
18 27 40 to 43		Two photographic impressions were received on the same plate. With the aid of a magnifier the first impression shows two dark equatorial bands to be clearly seen, and also the light band which borders on the south on the most southerly of those two; on the other hand no trace of the satellites is visible.

Saturn. The chief thing of interest in recent Study of Saturn comes from Lick Observatory, and is the work of astronomer Keeler by the aid of the spectroscope. It will be remembered that Mr. Lockyer in A. N. No. 2881 published a note on the spectrum of the rings of Saturn which was intended to strengthen his view of their origin as meteoric. The acknowledged meteoric constitution of the rings of Saturn made it important to obtain a photograph of their spectrum to learn, if possible, whether collisions were of sufficient intensity to produce incandescent vapors. A fine photograph of the spectrum of the rings was obtained by the Henry Brothers, Paris, which showed that the rings were not only more luminous than the planet (already visually known), but also that "this is truer for the blue light than for visual rays." There was evidence of bright lines in the photograph, and it was this point which Mr. Lockyer wished to emphasize and bring to the attention of astronomers generally. He did not claim to have established the fact.

In April and May last Mr. Keeler made a study of the rings with the different spectroscopes belonging to the Lick Observatory, but although careful search was made for the bright lines on every available opportunity they were not found, and he thinks the probability of their existence extremely small, as he reports in a very instructive article in A. N., No. 2727. A further objection is that if the rings were self luminous, and that this was the cause of the difference in brightness between the rings and the planet, then the rings ought to be seen in the shadow of the planet. That point is well made. Mr. Keeler is very careful to say that his observations, favorable or unfavorable, would not be conclusive evidence against the photographic process at all, because its long exposures can register the action of light too small to affect the eye.

Uranus is a morning star and is northeast of Spica in the constellation of Virgo, moving slowly to the southeast. He will be in conjunction with the moon Dec. 17, the planet then being 4° 41′ south.

The planet Uranus has also been a favorite object of late for the work of the spectroscope. Mr. Lockyer gave a note to A. N. No. 2904, in which he suggests that the apparent dark bands in the spectrum of this planet which have been mapped by Huggins and Vogel are in all probability not due to the absorption of any known substances, but require some other explanation. He suggests that it is really a radiation spectrum, the apparent dark bands simply indicating defect of radiation in the region where they occur, and that the bright flutings which appear in the spectrum may require a reconsideration of the prevailing ideas of the constitution of the planet. In reply to this Mr. Keeler says in A. N. 2927, that on examining the spectrum of Uranus April 26, 1889, with 36-inch equatorial of Lick Observatory, he found that the brightness of certain places in the yellow and green with a low power and small dispersion certainly gave the impression of self-luminosity, but that later study led him to change his mind. His reasons are as follows:

"1. The appearance of the spectrum with a moderate dispersion is more like that of a continuous spectrum crossed by absorption bands than of a fluted spectrum with dark spaces. The bright places do not border sharply on the dark bands, but are separated from them by less luminous portions into which they gradually merge on both sides. The light curve would therefore have rounded maxima at these points, and not fall off abruptly, as in a fluted spectrum. 2. The great band at $\lambda = 618$ is, according to my measures, as well as those of other observers, exactly coincident in position with the great band in the red in the spectrum of Jupiter and Saturn, this band showing a regular gradation in depth with increasing distance of the planet producing it from the sun, and in Jupiter and Saturn the band is undoubtedly due to a surrounding absorptive atmosphere. The same band probably appears in the spectrum of Neptune, and analogy points to an identity of origin. It is true, however, that the other great bands in the spectrum of Uranus have no counterpart in the spectra of the interior planets. The band at *F* in the spectrum of Uranus is also an undoubted absorption band. If then two of the prominent bands are due to absorption, it is natural to suppose that the others are also, and that the older views in regard to the nature of the spectrum are correct."

Neptune is in good position for observation for the entire night. He has just passed opposition to the sun, and is between the Pleiades, and Aldebaran in the constellation of Taurus. He will be in conjunction with the moon Dec. 5, the planet being almost one degree to the south of the moon.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
			MERCURY.		
Dec. 25	19 03.5	−24 50	8 29 A.M.	12 45.6 P.M.	5 02 P.M.
Jan. 5	20 18.0	−21 30	8 44 "	1 16.6 "	5 50 "
15	21 07.4	−16 38	8 31 "	1 26.7 "	6 22 "
			VENUS.		
Dec. 25	17 21.0	−22 49	6 37 A.M.	11 03.5 A.M.	3 30 P.M.
Jan. 5	18 21.3	−23 29	6 57 "	11 20.3 "	3 43 "
15	19 16.0	−22 49	7 09 "	11 35.4 "	4 02 "
			MARS.		
Dec. 25	13 39.7	− 8 49	1 54 A.M.	7 22.9 A.M.	12 51 P.M.
Jan. 5	14 03.3	−11 00	1 44 "	7 03.0 "	12 22 "
15	14 24.5	−12 51	1 31 "	6 43.0 "	11 55 A.M.
			JUPITER.		
Dec. 25	19 11.1	−22 38	8 26 A.M.	12 53.2 P.M.	5 21 P.M.
Jan. 5	19 22.1	−22 19	7 52 "	12 21.0 "	4 50 "
15	19 32.1	−21 59	7 21 "	11 51.6 A.M	4 22 "
			SATURN.		
Dec. 25	10 25.0	+11 34	9 15 P.M.	4 04.6 A.M.	10 55 A.M.
Jan. 5	10 23.8	+11 44	8 30 "	3 20.1 "	10 11 "
15	10 22.0	+11 57	7 48 "	2 39.0 "	9 30 "
			URANUS.		
Dec. 25	13 37.7	− 9 33	1 56 P.M.	7 20.8 A.M.	12 46 P.M.
Jan. 5	13 38.8	− 9 39	1 14 "	6 38.6 "	12 04 "
15	13 39.6	− 9 43	12 35 A.M.	6 00.1 "	11 25 A.M.
			NEPTUNE.		
Dec. 25	4 02.4	+18 59	2 19 P.M.	9 43.0 P.M.	5 07 A.M.
Jan. 5	4 01.5	+18 57	1 35 "	8 58.8 "	4 22 "
15	4 00.8	+18 55	12 55 "	8 18.8 "	3 42 "
			THE SUN.		
Dec. 25	18 18.4	−23 23	7 36 A.M.	12 00.6 P.M.	4 25 P.M.
Jan. 5	19 07.0	−22 34	7 37 "	12 05.8 "	4 34 "
15	19 50.4	−21 02	7 35 "	12 09.8 "	4 45 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	Immersion. Wash. Mean T. h m	Immersion. Angle f'm N. P't. °	Emersion. Wash. Mean T. h m	Emersion. Angle f'm N. P't. °	Duration. h m
Jan. 3	*o* Tauri	6	8 54	50	10 17	276	1 23
6	7 Cancri	6½	9 26	162	9 52	199	0 26

Phases of the Moon.

			Central Time. d	h	m	
Last Quarter	1889	Dec.	15	8	58	A. M.
New Moon	"	"	22	6	53	A. M.
First Quarter	"	"	28	11	16	P. M.
Full Moon	1890	Jan.	5	11	37	P. M.
Last Quarter	"	"	14	12	33	A. M.
Perigee	"	Dec.	22	7	4	P. M.
Apogee	"	Jan.	6	6	5	A. M.

Elongations and Conjunctions of Saturn's Satellites.

[Central time; E = east elongation; W = west elongation; I = inferior conjunction (north of planet); S = superior conjunction (south of planet.)]

JAPETUS.

Dec. 15, I. Jan. 3, W.

TITAN.

Dec. 18	10 P. M.	I.	Dec. 30	9 P.M.	E.	Jan. 11	6.2 P. M.	S.
22	10 P. M.	W.	Jan. 3	7.3 P.M.	I.	15	5.6 P. M.	E.
26	10 P. M.	S.	7	6.8 P.M.	W.			

RHEA.

Dec. 16	10.1 P.M.	E.	Dec. 30	11.2 A.M.	E.	Jan. 12	12.0 midn.	E.
21	10.4 A.M.	E.	Jan. 3	11.3 P.M.	E.			
25	10.8 P.M.	E.	8	11.7 A.M.	E.			

DIONE.

Dec. 16	6.1 A.M.	E.	Dec. 27	4.8 A.M.	E.	Jan. 7	3.2 A. M.	E.
18	11.8 P.M.	E.	29	10.4 P.M.	E.	9	8.8 P. M.	E.
21	5.5 P.M.	E.	Jan. 1	3.8 P.M.	E.	12	2.5 P. M.	E.
24	11.1 A.M.	E.	4	9.5 A.M.	E.	15	8.1 A. M.	E.

TETHYS.

Dec. 16	2.6 P.M.	E.	Dec. 27	10.4 P.M.	E.	Jan. 8	6.1 A.M.	E.
18	11.9 A.M.	E.	29	7.7 P.M.	E.	10	3.4 A.M.	E.
20	9.3 A.M.	E.	31	5.0 P.M.	E.	12	12.7 A.M.	E.
22	6.6 A.M.	E.	Jan. 2	2.2 P.M.	E.	13	10.0 P.M.	E.
24	3.9 A.M.	E.	4	11.5 A.M.	E.	15	7.3 P.M.	E.
26	1.2 A.M.	E.	6	8.8 A.M.	E.			

Still Another Comet.—At about 10 o'clock on Saturday evening last, while engaged in nebular work, I ran upon a nebulous object having a cometary appearance. As the seeing was poor, and the object so near the naked-eye star Xi Pegasi as to be difficult of observation, and to render impossible accurate bisection with the wires of the eye-piece, I made from the circles the following approximate position: Right Ascension, *22h* 40*m* 35*s*; Declination, north, 11° 35′;

and described it as "Pretty faint, large, little elongated, cometary, and preceding Xi Pegasi 40*s*, a little south." Inasmuch as Sir William Herschel had two nebulæ near, which I was unable to find, and as in 30*m* no motion was detected, I came, though not without misgiving, to the conclusion that this was, probably, one of his, presumably the brighter of the two. The place of my suspect did not, however, agree with his; but this is a not uncommon occurrence. Last evening, with the seeing moderately good, I again essayed an observation of the suspicious body, which was missing. A search revealed on the other side of the star a similar object distant 75*s*. The distance in R. A. in both cases was determined by counting the clicks of a sounder beating sidereal seconds. A bank of cloud low down in the southwest threatened interference, so as quickly as possible I determined its position from the circle reading, making it at 6*h* 45*m*, R. A. 22*h* 42*m* 25*s* + 11° 50′ 30″ allowing for refraction in Dec. Motion having been observed I hastened to the telegraph office and announced its discovery to Professor Pickering with injunction to "cable." Returning home I secured another hasty observation, but the sky suddenly clouded.

LEWIS SWIFT.

Warner Observatory, Rochester, N. Y.,
Nov. 18, 1889.

Ephmeris of the Brorsen's Comet.

1889 G. M. T.	App. α h	m	s	App. δ °	′	log. r	log. Δ	L.
Dec. 1	22	16	6	−42	33.4			
2		17	0	42	17.3	0.1854	0.1832	0.18
3		17	56	42	0.9			
4		18	54	41	44.4			
5		19	54	41	27.7			
6		20	57	41	10.8	0.1709	0.1799	0.20
7		22	1	40	53.6			
8		23	8	40	36.3			
9		24	16	40	8.7			
10		25	27	40	0.9	0.1557	0.1759	0.22
11		26	40	39	42.8			
12		27	55	39	24.6			
13		29	11	39	6.1			
14		30	30	38	47.4	0.1398	0.1710	0.24
15		31	50	38	28.5			
16		33	12	38	9.3			
17		34	36	37	49.8			
18		36	2	37	30.1	0.1230	0.1652	0.26
19		37	29	37	10.1			
20		38	58	36	49.8			
21		40	29	36	29.2			

1889 G. M. T.		App. α		App. δ		log. r	log. Δ	L.
	h	m	s	°	′			
22		42	1	36	8.4	0.1054	0.1584	0.29
23		43	35	35	47.2			
24		45	10	35	25.8			
25		46	47	35	4.1			
26		48	26	34	42.0	0.0869	0.1507	0.33
27		50	6	34	19.6			
28		51	48	33	56.8			
29		53	32	33	33.6			
30	22	55	17	−33	10.0	0.0675	0.1420	0.38

Elements and Ephemeris of Comet f 1889 (*Swift*). A telegram from Rochester, received November 18, announces the discovery of a comet by Prof. L. Swift, the position being the following: 1889, November 17*d* 6*h* 45*m* (probably Eastern Standard Time). R. A. 22*h* 42*m* 25*s*. Decl. N. 11° 51′.

The comet has been observed on November 18 and 22 at Harvard College Observatory by Mr. Wendell, and at Lick Observatory by Mr. Barnard.

The Lick position, communicated by telegraph, is as follows: 1889, Nov. 20.6704, Gr. M. T. R. A. 22*h* 49*m* 19.0*s*. Decl. + 12° 45′ 52″.

From the two Cambridge positions, kindly furnished by Professor E. C. Pickering, and that obtained at Lick, the Rev. George M. Searle, of St. Thomas College, Washington, D. C., has computed the following elements and ephemeris:

ELEMENTS.

T = 1889, December 1.6136, Greenwich M. T.

$$\left.\begin{aligned} \omega &= 74^\circ\ 17'.8 \\ \Omega &= 324\ \ 48\ .9 \\ i &= 10\ \ 58\ .2 \end{aligned}\right\} 1889.0$$

$q = 1.4294$

Middle Place (O—C), $\Delta\lambda \cos\beta = +\ 28''$ $\Delta\beta = -\ 3''$

EPHEMERIS.

Gr. Midnight 1889.	R. A.			Decl.		log Δ	Light.
	h.	m.	s.	°	′		
November 26	23	3	3	+14	28.4	0.8979	0.96
30		13	25	15	40.3	0.9041	0.94
December 4		24	28	16	51.9	0.9110	0.91
8	23	36	9	+18	3.4	0.9188	0.89

Light at discovery = 1 .

The small inclination gives considerable probability of periodicity; the sign of the discordance for the Middle Place also seems to point the same way.—*Science Observer.*

Ephemeris of Comet II 1889, (Barnard, March 31).

1889 G. M. T.	App. α h m s	App. δ ° ′	log. r	log. Δ	L.
Nov. 22	0 28 2	−17 25.4	0.4644	0.3679	0.83
23	26 3	17 25.7			
24	24 8	17 25.6			
25	22 17	17 25.2			
26	20 29	17 24.7	0.4684	0.3862	0.74
27	18 45	17 23.9			
28	17 5	17 22.8			
29	15 28	17 21.5			
Dec. 30	13 55	17 20.0	0.4725	0.4043	0.67
1	12 25	17 18.3			
2	10 58	17 16.3			
3	9 34	17 14.3			
4	8 13	17 12.0	0.4765	0.4221	0.61
5	6 56	17 9.7			
6	5 41	17 7.1			
7	4 29	17 4.4			
8	0 3 20	−17 5.1	0.4808	0.4395	0.55

E. Milosevich in A. N., No. 2931.

The equations, $x^2 + y = 7$; $x + y^2 = 11$, should never be classed with elementary quadratic equations. I beg leave to assure the student of elementary algebra that he is perfectly right in finding them difficult to solve, for the reason that they cannot be solved at all by a correct application of the principles of elementary algebra.

Eliminating y, the equation for x becomes $x^4 - 14x^2 + x + 38 = 0$; which being of the fourth degree will be satisfied by four different values of x (the numerical values of x being best found by a tedious process of trial;) and then to every value of x will correspond a particular value of y. In this manner the following approximate values were found.

	x	y	x^2	y^2
1	+ 2.0000	+ 3.0000	+ 4.0000	+ 9.0000
2	+ 3.1313	− 2.8051	+ 9.8051	+ 7.8687
3	− 3.2832	− 3.7793	+ 10.7793	+ 14.2832
4	− 1.8481	+ 3.5844	+ 3.4156	+ 12.8481

CLEVELAND KEITH.

Another Solution. Allow me to observe that Mr. Myers' solution in Number 79 of the MESSENGER is not quite satisfactory. From the equations $x^2 + y = 7$, $x + y^2 = 11$, he obtains virtually $(x + \frac{1}{2})^2 + (y + \frac{1}{2})^2 = (\frac{5}{2})^2 + (\frac{7}{2})^2$, and then *assumes* that $(x + \frac{1}{2})^2 = (\frac{5}{2})^2$, and $(y + \frac{1}{2})^2 = (\frac{7}{2})^2$.

Why should he not as well assume $(x + \frac{1}{2})^2 = (\frac{7}{2})^2$, and

$(y + \frac{1}{2})^2 = (\frac{5}{2})^2$? From these he could not find values of x and y that satisfy the given equations as they stand. Again, on Mr. M.'s assumption the results should be $x + \frac{1}{2} = \pm\frac{5}{2}$, $y + \frac{1}{2} = \pm\frac{7}{2}$; hence $x = 2$ or -3, $y = 3$ or -4. The values $x = -3$, $y = -4$ ought to satisfy the given equations, which they will not.

A correct solution of the equation is as follows: Eliminating y by substitution gives

$$x^4 - 14x^2 + x + 38 = 0. \qquad (1).$$

This equation has *four roots* or values of x, and from them *four* corresponding values of y may be found from the equation $y = 7 - x^2$. Equation (1) may be written

$$x^4 - 2x^3 + 2x^3 - 4x^2 - 10x^2 + 20x - 19x + 38 = 0,$$

$$\therefore x^3(x - 2) + 2x^2(x - 2) - 10x(x - 2) - 19(x - 2) = 0,$$

$$\therefore (x - 2)(x^3 + 2x^2 - 10x - 19) = 0$$

Hence, by the Theory of Equations,

$$x - 2 = 0, \text{ and } x^3 + 2x^2 - 10x - 19 = 0. \qquad (2).$$

$\therefore x = 2$, and $y = 7 - 2^2 = 3$.

The other three roots or values of x, are those of (2). By Sturm's Theorem, the roots of (2) are found to be *real*, but incommensurable with unity, and one of them lies between 3 and 4, a second root between -3 and -4, and the third between -1 and -2. By Horner's Method these roots are found to be approximately, $x = 3.1313125$, $x = -3.283186$, and $x = -1.84812652$. The corresponding values of y, from $y = 7 - x^2$, are $y = -2.8051181$, $y = -3.779310$, and $y = 3.58442837$. These, with the corresponding values of x, will satisfy the equation $x + y^2 = 11$ to at least six places of decimals. The writer at one time computed and verified the values of x and y, for a friend, to thirteen decimal places by the method here stated.

The associated values of x and y are:

$x = 2$	$x = 3.1313125$	$x = -3.283186$	$x = -1.84813652$
$y = 3$	$y = -2.8051181$	$y = -3.779310$	$y = 3.58442837$

The last three sets of values are, of course, only approximate.

GEORGE W. COAKLEY.

Hampstead, Long Island, N. Y.

EDITORIAL NOTES.

Volume VIII of the MESSENGER closes with this number. Patrons will please bear in mind that all subscriptions for the year 1889 also end with this issue. Those that wish the journal continued, who have not already done so, will confer a favor by notifying the publisher at once, that mailing lists for January may be correct.

It is very gratifying to receive so many words of commendation, during the last month, in regard to new features for this periodical for the year 1890. We wish to assure these many friends that their well chosen words give more encouragement and heart in this difficult, though useful work that we have undertaken, than they can realize unless they have had a like experience. The change of subscription price to $3 was the most trying part of it all for ourselves, but the need of it, for the better results in the future plan seemed clearly necessary and therefore the change was made after careful consideration.

Now, as a new start is to be taken, contributors are respectfully asked and kindly urged to make communications as brief *as possible*, consistent with a clear setting forth of the matter to be presented; and if manuscripts are plainly written and simply worded, the points made will certainly be more attractive and forceful for the general reader.

Drawings of the Milky Way. In November *Knowledge* attention is called to three large detailed drawings of Milky Way made, by Dr. Otto Boeddicker, assistant to the Earl of Rosse at Parsonstown. The space covered by these maps is a little more than the northern half of the Galaxy extending from 10° south of the celestial equator. One map gives the whole view, the other two show the same on a larger scale. Dr. Boeddicker was occupied five years in completing this work, and, in detail, the drawings are said to vary considerably from the work of Heis and Gould. It is suggested that the Galaxy offers an inviting field for those observers who are provided with photographic telescopes, for its detailed structure may be the key that we need, to lead to a better understanding of sidereal astronomy.

The Yarnall Catalogue of Stars Revised and Corrected. A copy of the Yarnall catalogue of stars, as revised and corrected by Professor Edgar Frisby, of the United States Naval Observatory has been received. The first edition of this catalogue was published in 1873 by Mr. Yarnall, and was in the same form as it now appears. In 1878 a second edition was published by Mr. Yarnall, which gave better places of some of the stars previously observed but once or twice. The object in publishing a third edition of this catalogue at the outset was to correct the errors generally known to exist in the previous ones. Professor Frisby had not gone far in this work before he learned that he had a greater task on hand than had been anticipated; for it seemed necessary that a more complete and systematic examination should be made than had been done before, including a re-examination of all anonymous stars, comparing the named stars with those of existing catalogues, re-numbering of all the stars, changing names wherever necessary, and supplying names that existed previous to the publication of the catalogue. In this he was greatly aided by the recent publication of the Southern Durchmusterung, Gould's Zones, and General Catalogue, in identifying many stars, and in correcting the records of others. One common mistake in the former editions was due to combining the right ascension of one star with the declination of another, a very easy mistake whenever the right ascension is observed by one instrument and the declination by another. The other sources of error are mainly such as notice here would not help any one to avoid like errors in similar work.

In giving names to stars the following principles have generally been adopted, taking care, however, not to change the existing names unless for some good and satisfactory reason:

1. The oldest name in any standard catalogue has been preferred unless there was some uncertainty or mistake in that catalogue, or unless the name already used was that of one of the recognized standard authorities, although not the oldest. 2. No catalogue issued since the publication of Yarnall's Catalogue has been used for that purpose. Most of the names in the British Association have been retained, although, in the case of double stars, or such stars that had

one authority given in that catalogue the original name has been retained.

Following this catalogue of 10,964 stars are 25 pages of notes referring to the mistakes in the second edition and the changes that have been made in the third. We give one illustration from these pages which is a fair example: "New numbers 593, 622; old number, 590, Right Ascension and Declination belong to different stars, the given Right Ascension also being 1*m* wrong for the former star." For those who have not seen the former editions of this catalogue it may be said that the arrangement is, first column, Catalogue number of star; 2d, star's name; 3d, magnitude; 4th, 5th, 6th and 7th (between heavy vertical lines), respectively, mean right ascension for 1860, mean year, number of observations, annual precession for 1860. The last four columns on the page are respectively, mean declination for 1860, mean year, number of observations, annual precession 1860.

Apparently this revision is a thorough piece of work, and one that has been much needed.

Washington Transit-Circle Observations of the Sun 1875-1883. The September number of the *Monthly Notices* contains a discussion of the observations of the Sun, made with the Washington Transit-Circle, during the years 1875-1883 inclusive, by A. M. W. Downing. This investigation was undertaken because of the comparatively large discordances in the position of the equinox, as found from the meridian observations of the principal Observatories. The observations of the sun so made ought, from time to time, to be discussed and a determination of the position of the equinox found, which will be supported by the weight of all. This is what Mr. Downing has tried to do with apparently great care, using 103 equations of condition in the final reduction.

The corrections to the principal systems of right ascensions resulting from this discussion of Washington observations of the sun are as follows:

Washington (1875-1883)	— American Ephemeris (Newcomb)	= — 0.016
	— Berliner Jahrbuch (Auwers)	= — 0.000
	— Greenwich (1880)	= + 0.026
	— Pulkowa (1845)	= + 0.003
	— Pulkowa (1865)	= + 0.052
	— Conn. des Temps. (1883)	= + 0.029

An improved Astronomical Mirror is the title of an illustrated article that appeared in the *Scientific American* (Sept. 7). The claim there made is that concave mirrors of long focus may be readily produced from plane-faced mirrors and that the process has been patented by Dennis O'Brien of Oswayo, Penna. This process is so novel, and the probability so great that it will be an astonishing improvement on the old form of parabolic mirror that we copy a single paragraph, as follows:

"The mirrors to be formed must be of a parabolic section, a true parabolic mirror 6 feet in diameter and 72 feet focus having a central depression of just ⅜ of an inch. To make such a mirror a pan is employed, preferably made of cast metal to be extremely rigid, and with flanged edges by which it may be bolted by three equidistant bolts to the flanged end of the tube. This pan is formed with a seat or shoulder, upon which there is placed a plane mirror, through the axis of which there is drilled a small hole adapted to receive a tube, with threaded ends to engage an upper and lower disk fitting on the upper and lower faces of the mirror. The bottom of the pan has a central aperture through which is passed a headed and threaded tube engaging the other tube; and the tube passing through the bottom is turned by means of a suitable wrench, to draw the center of the mirror down against its own rigidity, bending it into concave shape. It is estimated that the central disk need not be larger than half an inch in diameter for a six-foot mirror, and this bending of the mirror is preferably done while the mirror is set facing a test object."

Is there one chance in a million that such a mirror as that would be good for anything for astronomical purposes?

Law of Density of Planetary Bodies. Robert Hooke has published an article in *The American Journal of Science* (November) titled "Law of Density of Planetary Bodies." The hypothesis adopted is, "that the material which forms the principal part of the masses of the planets and their satellites would, when subjected to the same conditions of temperature and pressure, have the same density." By this hypothesis it follows, that all planetary bodies would have the same surface density as rapidly as they reach the same physical condition.

In seeking the relation of density to diameter in planetary bodies, it is obvious that the so-called older planets, Mercury, Venus, Mars, Earth and the satellites generally, which have reached a solid condition, are the only ones from which the physicist can determine a relation between the surface density and the mean density. This is Mr. Hooke's first step. But, in seeking this relation, he does not want the mean density of the planet as a whole, but only that part of it which is due to compression, if he is rightly to find the law of density to diameter. This value, Mr. Hooke claims, is the *difference* between the surface density and mean density as a whole.

This point in the discussion is an interesting one, and is claiming the attention of physicists at the present time.

From values of the surface and mean densities and diameters of the earth and moon, the following conclusion is reached, viz: *the increase of the difference between the mean and surface density is proportional to the increase of diameter.*

If equations are formed and applied to Mars, Venus and Mercury, we have the following numbers:

Mars	4211	4.22	4.17	$\frac{1}{3093500}$
Venus	7660	5.56	5.24 (?)	$\frac{1}{390000}$
Mercury	2992	3.74	4.56 (?)	$\frac{1}{7500000}$

The first column represents the diameters, the second the value computed from the law of density, the third, value computed from assigned values of masses and diameters, and last Mars, (sun = 1). The agreement of values in the case of Venus and Mercury is so bad that confidence is weakened in the principle as a general one. Further study, however, may remove this difficulty.

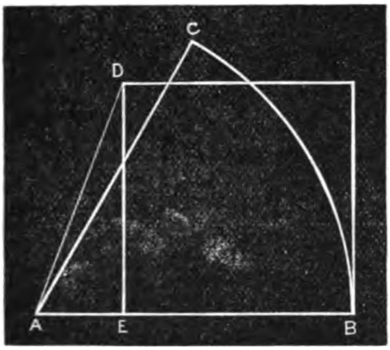
An interesting application of this relation of density, has been made by Mr. Hooke to determine, by computation, the diameters and densities of the sun and the outer planets when they shall have become solid like the earth and moon. The results are as follows:

	Diameters	Mean Diameters.
Sun	218,808 miles	87.69
Jupiter	37,183	17.04
Saturn	27,128	13.13
Uranus	16,552	9.00
Neptune	17,220	9.28

Several other points of equal interest are found in this suggestive article.

Mr. A. S. Flint of the U. S. Naval Observatory, Washington, D. C., has been appointed assistant at the Washburn Observatory, Madison, Wis.

Relative Distances of the Inner Planets from the Sun. Bode's law enables us to state roughly the relative distances of the major planets from the sun. The following device, concerning the inner group only, has the advantage of giving very close approximations, at the same time representing the results to the eye by means of geometrical figures.



Draw a sextant and a square equal to it in area; arrange them as in the figure, and draw AD.

Let the radius AB represent the earth's distance; then EB represents that of Venus; the perimeter of the sextant ABCA twice that of Mars; and AD twice that of Mercury.

The distances as thus determined are given in the first column and the true distances in the second:

Mercury, - - - - -	.3873	.3871
Venus, - - - - - -	.7236	.7233
Earth, - - - - -	1.0000	1.0000
Mars, - - - - -	1.5236	1.5237

A Bibliography of Geodesy. We have received a full and very important paper entitled "A Bibliography of Geodesy," prepared by J. Howard Gore, B. S., Ph. D., Professor of Mathematics, Columbian University, Washington, D. C. This paper was published as Appendix No. 16 to the Report of 1887, by the United States Coast and Geodetic Survey, F. H. Thorn being superintendent. A casual glance at this book of 300 closely printed and double-column pages, of large size, will give little idea of the immense labor involved in it. One only begins to realize something of the task when he knows that Professor Gore, in the outset visited in person thirty-four of the principal libraries of America and Europe, consulted many minor libraries by proxy, and undertook, in addition a searching inquiry by correspondence with all the geodesists or mathematicians of both continents. That interest was awakened in his work, abroad, is apparent, for Col. Herschel very courteously gave Professor Gore access to his manuscript contribution to Pendulum Bibliography, and the International Geodetic Association at Berlin offered to undertake the publication of his book. This was certainly a gratifying evidence of Professor Gore's fitness for the work as well as an indication of its anticipated value which an examination of the paper now fully sustains.

In the plan of this work one alphabet only is used for authors, abbreviations and subjects and that a neat heavy faced letter. The full names of authors are witten whenever possible at first, but when repeated, the last name with initials of the Christian name appears. The works of authors are arranged chronologically under their names and in many instances helpful notes are given which show leading subjects treated by the writer. This is a time saving arrangement in the canvass of authors on special themes. Scholars will regard this piece of work as one of the most important of its kind that has ever been published.

Longitude of Carleton College Observatory. During the last month Carleton College Observatory exchanged telegraphic time-signals with the Naval Observatory at Washington, D. C., for three nights, for the purpose of determining the longitude of the former Observatory more closely. Professor A. N. Skinner observed at Washington, and Dr. H. C. Wilson at Northfield. The reductions have not yet been completed. The telegraph line between Northfield and Washington had but one repeater for the whole distance, and service was excellent. This will be spoken of more fully later.

Errata. On page 424, occultation of Jupiter, column headed J. E. K., omit the note to the time of first contact of Jupiter; the time does not require any correction. In the same column the + signs should be ± indicating an approximate observation. The copy from which this matter was set was uncorrected page proof, hence the errors.

BOOK NOTICES.

Unto the Uttermost. By James M. Campbell. Messrs. Fords, Howard & Hulbert, publishers. New York, 1889. 254 pp. Vellum cloth; price, $1.25.

The author of this book is a preacher of the Congregational faith, one of that increasing class of earnest enquirers who are not afraid to say, "I do not know," while yet they demand a hearing for their well considered reasons for saying, "I believe;" but their faith is in God rather than in the wisdom of men. The line of his discussion in this thoughtful book is well suggested in the titles of its chapters which are as follows:

Unto the Uttermost; Castaway Reclaimed; Grace Conquering Nature; A Pessimistic View; The Limits of Evolution; Modern Miracles; The Higher Environment; The Universality of Divine Providence; Redemptive Effort a Necessity of the Divine Nature; The Sin that Shuts the Door of Mercy; The Chief Danger Point; Fluidity of Character; Judicial Blindness; A Common Spiritual Disease; Past Feeling; Bartering the Birthright; Death a Loss; The Finality of the Present.

We must confess that as we perused the earlier chapters we were a little afraid that the author was preparing to land us in the hazy regions of the Andover unpleasantness, willing or unwilling, possibly; for he certainly writes with point and tact on hard themes, and we relished unusually the fresh putting of the chosen trains of thought belonging to each topic.

But when we finished "The Sin that Shuts the Door of Mercy," "The Chief Danger Point," and "The Finality o the Present," we were ready to say, in the judgment of a layman, Mr. Campbell is 'sound'; he is orthodox after the good old western style of belief, although he tells it in a little different way than do some of his good brother ministers. It is evident that he does not believe in limiting God's mercy, but that he is concerned about, and calls very frequent attention to, limitations on man's capability and willingness to grasp, at possible cost, the essentials of life and faith as taught by Jesus Christ. The probationists will find much worth thinking about in the compact and weighty sentences of these chapters, and religious readers and thinkers will peruse the entire book, we think, with a feeling of conscious and added strength, where prevailing opinion is in need of more careful statement for its ready support against the attacks of recent dogmas that some reputed scholars are urging with unmistakable influence, and, as we believe, with harmful effect.

Elementary Mathematical Tables. By Alexander MacFarlane, D. Sc., LL. D., Professor of Physics in the University of Texas. Messrs. Ginn & Co., publishers, Boston, U. S. A., and London; 1887, pp. 105.

The purpose of this new book of tables is not only for ordinary computation and the uses in graphic methods in general, but also in the teaching of arithmetic, and in the illustrations of the theories of algebra. The table of common logarithms are four-place and first pages are for any sequence of three significant figures, with difference column on the right hand side of the page, and a small table at the bottom of the page for proportional parts of small numbers.

Later pages give the logarithms of any sequence of four places from 1,000 to 1,900, and a small table giving the logarithm of six places of numbers 1.000 to 1.100 which occur in the calculation of interest. Then follow in order tables respectively with these titles: Antilogarithms; Addition Logarithms; Subtraction Logarithms; Logarithmic Sines and Cosines; Logarithmic Tangents and Cotangents; Natural Sines; Cosines, Tangents and Cotangents; Secants and Cosecants and Radius Equivalent in Degrees. Tables also of reciprocals, squares, cubes, square roots, cube roots; multiples of 100—999; circumference of circles; area of circle; constant of sphere; hyperbolic logarithms; amount at the end of *n* years, present value of 1,000; amount of an annuity paid at the end of each year; present value of the same; amount of an annuity paid at the beginning of each year; sum to be paid at the end of each of *n* years to extinguish a debt of 1,000; least division; exponentials; and multiples from 1 to 100.

The reader will wonder at this extended list of tables to be found in one book containing only 105 pages, but he is assured they are all there in clear figures of heavy and light face type, sufficiently open and large for easy reading. The tables do not extend as far as those of the larger volumes with more places, and the plan on which they are made varies somewhat. A hint or two on the table of logarithmic sines and cosines will help the reader to form some idea of the construction. Pages fourteen and fifteen contain the sines and cosines of the *degrees* only from 1 to 89 in first and last vertical columns. Between these are 11 columns of four place functions headed at the top respectively .0, .1, .2, etc., to 1.0 of degrees. The reductions to minutes of arc would be done mentally when desired. From this arrangement the interpolation for odd minutes is of course very easy. It seems to us that this book of tables is a very handy and useful one for the table of the teacher or the general computer. We are not able to speak of its accuracy for the want of time to make the necessary comparisons for personal knowledge, but the names interested in its publication in England and at home, are doubtless a strong guaranty for this. It is rather a novel feature that a book of this kind should be published simultaneously in the two countries.

Celestial Motions is the title of a small, handy book of Astronomy by William T. Lynn, F. R. A. S., recently revised and enlarged. The first edition appeared in 1884, the latest revision belongs to the present year. This little work is meant only to be a concise digest of the most important facts pertaining to the motions of the celestial bodies, especially those of the solar system. Care has been exercised to give the latest reliable information which could be secured in plain language and without the use of technical terms to hinder the popular reader.

The author makes no attempt at fine essay writing, but presents the following topics, in such a way, as to convey the facts about them that an interested reader would like to know, viz., the earth, moon, sun, solar system, planets, comets, meteors, fixed stars, constellations, refraction, propagation, observation of light and a sketch of the history of astronomical discovery, a table of astronomical terms explained and index to subjects and names.

The best thing that can be said, further, about this little book is that a young man took it from our table, the other day, and became so interested in it that he did not stop until the greater part of it was read.

The book contains 144 pages and is published by Edward Stanford, 26 and 27 Cockspur street, Charing Cross, S. W. London, England, 1889. Price half a crown.

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