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CONTENTS.

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA.

THE seventh annual meeting was held December 28 to 30, 1905, at Columbia University, New York. Some sixty members were in attendance and forty papers were on the program.

As usual, a number of pleasant social gatherings occurred during the meeting. On December 29 all lunched together in the department of astronomy, and in the evening were received by Mrs. Henry Draper at her house on Madison Avenue; many members also attended a dinner of the Mathematical Society and the Physical Society on the same evening.

The election resulted as follows:

President—E. C. Pickering.
First Vice-president—George E. Hale.
Second Vice-president—W. W. Campbell.
Secretary—George C. Comstock.
Treasurer—C. L. Doolittle.
Councilors for 1906–8—E. B. Frost and Harold Jacoby.

The council designated Harold Jacoby to act as editor for 1906.

We give below a list of papers presented at the society's sessions, together with brief abstracts furnished by the authors. Some of these have been slightly condensed by the editor.

PAPERS PRESENTED.

DAVID TODD: 'Saturn as seen with the Eighteen-inch Clark Refractor of the Amherst College Observatory.'

S. I. BAILEY: 'Some Variable Star Problems.'

ANNIE J. CANNON: 'Maxima and Minima of Variable Stars of Long Period.'

E. C. PICKERING: 'A Systematic Study of Faint Stars.'

G. C. COMSTOCK: 'Distribution of the Stars.'

F. H. SEARES: 'Photometric Investigations.'

MRS. W. P. FLEMING: 'Some Peculiar Spectra.'

E. B. FROST: 'Burnham's Forthcoming General Catalogue of Double Stars.'

C. L. POOR: 'The Figure of the Sun.'

J. A. PARKHURST and F. C. JORDAN: 'Photographic Photometry of Rapidly Changing Variable Stars.'

S. A. MITCHELL: 'Spectrograms taken at Daroca, Spain, August 30, 1905.'

E. B. FROST: 'Observations of Radial Velocities of Stars.'

G. H. PETERS: 'The Solar Corona, as observed by the U. S. Naval Observatory Eclipse Expedition, August 30, 1905, at Porta Coeli, Spain.'

N. E. GILBERT: 'Polarized Light in the Corona, Eclipse of 1905.'

C. C. TROWBRIDGE: 'Resemblances between Persistent Meteor Trains and the Afterglow from Electrodeless Discharges.'

E. E. BARNARD: 'Vacant Regions of the Sky.'

G. C. COMSTOCK: 'A Proposed Method for the Wholesale Determination of Velocities in the Line of Sight.' (To appear in the *Astrophysical Journal.*)

E. C. PICKERING: 'Determination of Absolute Positions of Stars by Photography.'

D. P. TODD and R. H. BAKER: 'Local Predictions for the Total Eclipse of 1907 in Turkestan and Mongolia.'

J. A. BRASHEAR: 'On Some Evidences of Permanent Set in Optical Surfaces.'

F. H. SEARES: 'The Polaris Vertical Circle Method of Determining Time and Azimuth.'

ERIC DOOLITTLE: 'Determination of Adjustment Errors for the Polar Axis of an Equatorial.'

ERIC DOOLITTLE: 'The Hough Double Stars.'

DAVID TODD: 'On the Practical Requisites for Securing Perfect Definition in Eclipse Photography.'

E. B. FROST: 'The Observations of Sun-spots by the late C. H. F. Peters.'

D. P. TODD and R. H. BAKER: 'Computed Tracks and Totality-durations of Total Solar Eclipses in the Twentieth Century.'

A. O. LEUSCHNER: 'An Analytical Method of Determining the Orbits of New Satellites.'

W. H. PICKERING: 'Planetary Inversion.'

C. G. ABBOT: 'A Standard Pyrheliometer and its Use on Mt. Wilson, California.' (Abstract in SCIENCE, XXIII., p. 203.)

B. L. NEWKIRK: 'Tables for the Reduction of Photographic Measures.'

R. T. CRAWFORD: 'A Contribution on Astronomical Refractions.'

SARAH F. WHITING: 'A Solar Planisphere.'

B. L. NEWKIRK: 'Investigation of the Repsold Measuring Apparatus of the Students' Observatory, Berkeley, Cal.'

W. W. DINWIDDIE: 'The 40-foot Camera of the U. S. Naval Observatory Eclipse Station at Guelma, Africa.'

C. D. PERRINE: 'Polarized Coronal Light, August 30, 1905.'

F. SCHLESINGER and G. B. BLAIR: 'Anomalous Refraction.'

HENRIETTA S. LEAVITT: 'New Variable Stars in the Small Magellanic Cloud.'

R. S. DUGAN: 'Magnitudes and Mean Positions of 359 Pleiades Stars.'

DAVID TODD: 'Results of Amherst Eclipse Expedition to Tripoli, 1905.'

M. B. SNYDER: 'The Philadelphia Observatory and the Disastrous Fire of March 9, 1905.'

R. T. CRAWFORD and A. J. CHAMPREUX: 'Orbit of the Seventh Satellite of Jupiter.'

Saturn as seen with the Eighteen-inch Clark Refractor of Amherst College Observatory: DAVID TODD.

This new telescope, which has especially fine definition and a very dark field, was used the past autumn on the Saturnian system. Pending completion of the micrometer, to be employed on the satellites, attention was given particularly to the rings and ball. Differences of illumination in the detail of different zones of the rings were carefully observed and embodied in a drawing. The shadings of the belts on the ball were also set down in estimated positions, and a watch was kept for spots by which to determine anew the rotation time.

Totality-predictions for the Solar Eclipse of 1907, January 13–14, in Turkestan and Mongolia: DAVID TODD and ROBERT H. BAKER.

Attention is called to the importance of this eclipse in advancing our knowledge of the corona. Of eclipses in the immediate future, although a total one occurs every year from 1907 to 1912, that of 1907 is likely to be the most important because the paths of its successors are for the most part inaccessible. The best region for the 1907 eclipse is available by means of railways recently constructed in Russian territory. Also, about 600 miles northwest of Peking, the eclipse track is rather difficult of access in Mongolia. The writer has computed, among other things, the positions of ten possible stations, exact local times of the four phases, durations of totality, position angle of first contact, and sun's altitude and azimuth at middle of eclipse. (To be published in *The American Journal of Science.*)

Some Variable Star Problems: S. I. BAILEY.

About ten years ago more than five hundred variables were found in globular clusters; and further discoveries of this kind are possible with instruments of large size among the faintest stars in the clusters already examined, and in clusters which have not yet been searched.

The variables in the clusters Omega Centauri, Messier 3 and Messier 5 have now been studied. There are in these clusters 348 variables; for 273 of these periods have been determined, averaging about half a day. Changes in brightness are very rapid, and in many cases the regularity of the periods is so great that these stars would serve as good celestial time-keepers.

We have observed the clusters from five to twelve years, obtaining from five to ten thousand returns of maxima, so that periods are obtained which are correct within a few tenths of a second. For seventy-five of the variables periods have not been determined. Of these, sixty-five are too difficult, on account of nearness of other stars, smallness of the range of variation, or both. The remaining ten variables present peculiarities not yet understood.

While our observations for most of these variables are satisfied by a simple, uniform period, there are a number of cases in which it has been necessary to introduce a second term, implying a secular variation in the period. Several have been found which are best explained by the supposition that they are doubles, both components varying with the same period but with alternate maxima.

The presence of large numbers of variables in some clusters, and few, or none, in others, calls for an explanation. It may be that the axes of revolution of all members of such stellar systems are parallel. Variability, if associated with revolution, might then depend on the direction from which the system is seen. Stars which vary for us may be unvarying when seen from some other point in space. Again, variability doubtless marks an epoch in the development of stars. This epoch may be in the past for some, present for others, and future for still others.

The typical form of light-curve for variables in clusters is difficult to explain on the theory of axial revolution. But Dr. Curtis has shown recently that a relation exists between motion in the line of sight and variations in brightness in the case of W Sagittarii. Much may be learned by an extension of this research to other variable stars.

Maxima and Minima of Variable Stars of Long Period: ANNIE J. CANNON.

The original form of the bibliography of variable stars undertaken several years ago at Harvard College Observatory and for which all the material has been collected, was recently modified owing to duplication of much of the work by the Gesellschaft Committee in their proposed complete

'Catalogue of Variable Stars.' Tables of observed maxima and minima for class II., or long period stars, are now being printed. Proof sheets of such tables for stars between 0 and 6 hours right ascension are now submitted to the society. These tables give in successive columns, calendar date of the observed phase, Julian date, magnitude, name of observer, reference, epoch and residual from a period computed by a formula following the name of the star. Residuals have been calculated without the use of a second term in the formula: by plotting residual curves the form of correction to the period may often be found. Residual curves of *T Andromedæ*, *o* (omicron) *Ceti* and *S Ursæ Majoris* were shown to the society. The residual curve of *S Ursæ Majoris*, drawn from observations extending from 1843 to 1905, shows the need of a sine term in the formula. The residual curve of *T Andromedæ* is interesting in connection with the discussion concerning the period of this star soon after its discovery. Observations of *o Ceti* have extended over a longer time than those of any other long period variable. The residual curve, computed from observations since 1596, shows many irregularities and explains the difficulty of deducing a formula to represent the phases of this star.

It is hoped that these tables, by bringing together so much material in a convenient form, may prove of some use in investigating the variables of long period.

Systematic Study of Faint Stars: E. C. Pickering.

This paper described work that has been in progress at Harvard College Observatory, during the past five years, in studying the faint stars. The sky was divided into 48 exactly equal parts, as explained in detail in *Harvard Annals*, XIV., 477, and used in various publications of the observatory during the last twenty years. Portions of the sky, one degree square, in the centers of these regions, have been chosen for detailed study. The epoch employed is 1900. A sequence of fifteen stars of magnitudes 7.5 to 12.5 has been selected and measured with the twelve-inch meridian photometer, in each of these regions. Photographs have been taken with two hours' exposure, using the twenty-four-inch Bruce telescope, showing stars of magnitude 16, and brighter, and these have been enlarged to a scale of $20'' = 1$ mm. Photographs of the spectra with small dispersion, showing stars to magnitude 11, have been taken, and charts in and out of focus have been obtained. Photographs of these regions have also been made at the altitude of the pole, and for comparison the pole itself was photographed with the same exposure upon the same plate. The photographic magnitudes of all stars in the sequences mentioned above can thus be determined on the same scale. The measurement of photometric magnitudes from isochromatic plates is now in progress.

Nearly all photographs of the thirty-six regions north of declination $-30°$, and many of the others, have been completed; the entire work would probably have been finished, had the appropriation of 1902 been continued.

Distribution of the Stars: Geo. C. Comstock.

This paper deals with the extent of the visible universe and with the arrangement of the stars composing it. The data available and utilized for the discussion are of two kinds, (*a*) the number of stars per square degree of the sky as shown by the enumerations and gauges of Pickering, Argelander-Seeliger, Celoria and the Herschels, extending from the brightest stars down to the faintest visible in the Herschel telescope, about the fourteenth magnitude;

and (*b*) the average distances of the stars of each individual magnitude. These distances are obtained from a combination of the velocity with which the solar system moves through space and the resulting apparent displacement of the stars in the sky, the solar motion being determined spectroscopically and the displacement of the stars by means of the meridian circle. Kapteyn has obtained in this way the mean distances of stars from the third to the ninth magnitude; the present paper supplements this by a new determination of distances for stars between the ninth and eleventh magnitudes.

Based upon a part only of the above material, current astronomical doctrine affirms that the visible universe is a stellar system of limited extent whose boundaries, at least in some directions, lie within reach of our present telescopes. This view is opposed in the present paper, where it is pointed out that the evidence in favor of limited extent is obtained by ignoring two important factors of the problem; when these factors are taken into account the supposed evidence vanishes.

The first, and more important, of these factors relates to the intrinsic brightness of the stars. It has been commonly assumed that the fainter stars appear faint because of their greater distance from the earth and that there is no reason to suppose them to be intrinsically less luminous than the bright ones. The first part of this statement is unquestionably correct as far as it goes; the second part is wholly wrong. The faint stars, according to the writer, are less luminous than the bright ones, and stars of any given magnitude emit, on the average, only ninety per cent. as much light as do stars a magnitude brighter.

The second factor omitted in previous discussions is not here ignored, but rejected as useless. The known existence of dark matter or cosmic dust scattered through space leads naturally to the supposition that it may in some manner affect the transparency of interstellar spaces and cause an appreciable diminution in the light of fainter stars. Although this view has been rejected from current theories, it is evident from mathematical discussion of the data here considered that there is such an absorption and that approximately five per cent. of light is lost in transmission over a distance equal to a million times the diameter of the earth's orbit.

In abandoning the concept of a stellar system of limited and measurable extent the writer considers, provisionally, the consequences that result from the hypothesis of a system indefinitely extended on every side, with substantial uniformity in the direction of the Milky Way but thinning out on either side of the Milky Way, because the stars are here less numerous, or less brilliant, or because a denser cosmic dust more effectually quenches their light. It is impossible, now, to decide between these alternatives, but something of the kind is operative, and any one of the alternatives or a combination of all suffices to explain every feature of the stellar system for which the current theory accounts. The new hypothesis also brings out features hitherto unrecognized or unexplained.

The stars are not all of one kind, but differ among themselves in physical condition and properties which the spectroscope is able to detect and analyze. By far the larger part of the stars fall into one of two classes which the spectroscopists designate as type I. and type II., and which they regard as different stages of development of the individual, a star of type I. passing over with increasing age into type II. Now Pickering has shown recently that these stellar types are not scattered indiscriminately throughout the sky, but that the younger stars, type I., show a more pronounced tendency to cluster along the milky way than do the mature ones, and this tendency grows more and more pronounced with diminishing brightness of the stars. It is difficult to see why this should be so; why one part of the universe should lag behind the rest in development, but the new hypothesis indicates at once that such is not the case. The distribution found by Professor Pickering is only an apparent one depending upon the known fact that the type I. stars are intrinsically brighter than their companions of type II. This fact alone in a system such as is here supposed would produce an increasing accumulation of faint, and therefore distant, stars of this type in the region adjoining the milky way, although, in fact, the two types may be everywhere distributed with a uniform ratio of frequency.

Other matters can be touched upon here in a summary way only. It is an immediate consequence of the present hypothesis that any considerable group of stars in a part of the sky remote from the milky way must on the average be nearer to us than a group of similar stars in the milky way. Although this relation has not been recognized hitherto, the writer finds from his own observations of faint stars between the ninth and twelfth magnitudes that such is the fact, the stars in the milky way being twenty-eight per cent. more distant than the mean of all other stars. It is commonly stated that the brightest stars emit an amount of light enormously greater than that given by the sun, 1,000 or 10,000 times as much, but from the measured magnitudes and distances of the stars it appears that while the large majority are brighter than the sun, few if any are more than two hundred times as bright.

Much of the investigation contained in this paper is summed up in a series of formulas, one of which shows the number of stars in the sky that are brighter than a given magnitude, *e. g.*, the tenth. Another shows the average distance of the stars of any assigned magnitude. A partial proof of the substantial accuracy of the numerical work contained in the paper is found in the fact that this last formula, although based solely upon distances of the fainter stars, derived by an indirect process, is in excellent agreement with the directly measured distances of the brightest stars.

Photometric Investigations: F. H. Seares.

This paper is a summary of results in an investigation of the wedges belonging to a Pickering equalizing stellar photometer. Two wedges were examined; one of photographic film, the other of shade glass. Absorption curves were determined by means of a disc photometer. The magnitude scales underlying these curves were then compared with that of the Müller and Kempf catalogue of Pleiades stars. Magnitude differences of twenty-one pairs of stars were measured and the results compared with the catalogue. The stars observed range from 7.24 to 10.76 magnitudes; the magnitude differences, from 0.80 to 3.52 magnitudes, with an average of 1.8 magnitude.

Eight observations were made with the shade glass wedge upon each pair. With three exceptions, each pair was measured upon at least four different nights. The results for this wedge are: P.E. of a single observation of four comparisons, $\pm$ 0.066 mag.; average deviation of mean magnitude difference from the catalogue difference, 0.07 mag.; deviation of wedge magnitude scale from the scale of Müller and Kempf, for the range 8.2–10.0 magnitudes, $+$ 0.028 mag. The scale agreement is to be considered satisfactory, since the deviation is not greater than may arise from personality alone.

Results for the photographic wedge were derived from five observations upon each pair, measured on three nights. The results are: P.E. of a single observation of four comparisons, ± 0.078 mag.; average deviation from the Müller and Kempf magnitude difference, 0.12 mag.; scale difference, — 0.073 mag. The two scales can be brought into agreement by multiplying the ordinates of the absorption curve of the photographic wedge by the factor 0.961.

The photographic wedge has been discarded in favor of that of shade glass.

Details of the investigation are to be found in Laws Observatory Bulletin No. 7.

Some Peculiar Spectra: Mrs. W. P. FLEMING.

The examination of stellar spectrum photographs at Harvard College Observatory, forming part of the work of the Henry Draper Memorial, has enabled us to follow new stars until they became gaseous nebulæ, too faint for observation. Since we can pass from gaseous nebulæ to stars of class O, or type V., in which characteristic bright lines extend from wave-length 4600 to 4800, thence to stars having several hydrogen lines bright with dark lines of helium also present, and from the latter through classes B, A, F, G, K and M, we may assume that we have a key to the formation of the stellar universe.

In putting together results from an examination of variable stars whose spectra are of class Md it was found that a few stars were assigned to several subdivisions extending from Md 1 to Md 10, the most marked case being *S Carinae.* Further examination showed actual changes in the spectrum, which probably (as in the case of *β Lyræ*) follow closely the variations in light. *R Scuti* also shows changes, and quite recently *R Cygni,* another long period variable, has been added to this list.

The spectrum of the star (now known to be a gaseous nebula) — 12° 1172, mag. 9.2, when found on Harvard photographs, has always led to an examination of the list of novæ before that of nebulæ, since in this spectrum the bright nebular lines at wave-lengths 5003 and 5007 are quite faint, the hydrogen lines, Hξ, Hε, Hδ, Hγ, and Hβ are bright and of normal intensity, while the most marked feature is the broad bright line at wave-length 3724. This is not generally well defined in photographic spectra of gaseous nebulæ, in which the strong line in the violet end is 3868, of slightly shorter wave-length than Hξ.

The star *Z.C.* 18^h 1935, mag. 9, shows a peculiar form of spectrum not yet assigned to its class. The continuous spectrum contains strong, dark bands of which the most marked extend from 4650 to 4710. This agrees closely with the strong characteristic bright line in spectra of the fifth type. A few other stars with similar spectra have been announced in Harvard Circulars. The variable star—*Crucis,* R.A. = $12^h\,50^m.7$, Dec. = — 57° 21′ (1900), has a spectrum similar to that of *Z.C.* 18^h 1935, but in it the hydrogen lines $H\gamma$ and $H\beta$ are bright, as in variables of the earlier subdivisions of class Md.

No other spectrum has yet been found on these photographs like that of *π′ Gruis,* but that of *R Cygni,* as photographed on December 2, 1890, bears a closer resemblance to it than any other spectrum yet photographed here.

Burnham's Forthcoming General Catalogue of Double Stars: EDWIN B. FROST.

With Professor Burnham's permission a brief statement is made here regarding this important undertaking, the basis for which has existed in manuscript for many years. A grant from the Carnegie Institution in 1903 made publication possible, and rather more than four fifths of the work has now been set up and electrotyped.

It includes about 13,000 double stars north of 31° south declination.

Part I. consists of a tabular catalogue, in quarto form, giving in order of right ascension the position, first measures, observer and other data, in eleven columns.

Part II. contains notes on the stars, selected measures (up to date of printing), showing motion or otherwise, present relation of the components, and references to all published measures.

This part will include some 10,000 unpublished observations made at the Yerkes Observatory in the last five years, and about as many more furnished principally by Messrs. Aitkin and Hussey of the Lick Observatory and Eric Doolittle of the Flower Observatory.

It is hoped that the work may be published during the year 1906.

Photographic Photometry of Rapidly Changing Variable Stars: J. A. Parkhurst and F. C. Jordan.

The light-curves of certain rapidly changing variables were determined from a series of short exposures on a single plate, taken with the twenty-four-inch Yerkes reflecting telescope. In order to utilize fully the advantages of the method: (1) the exposures were made short, so as not to smooth out the light-curve; (2) a number of comparison stars were used; (3) diameters of the focal images were measured to 0.001 mm. under the microscope.

The variable stars investigated by this method were:

Star.	Number of Plates.	Number of Exposures.
U Cephei,	1	20
W Ursæ Majoris,	3	35
RW Tauri,	7	55
14. 1904 Cygni,	8	53
32 Cassiopeiæ,	4	72

Results.—(1) *U Cephei.* The well-known curve was reproduced, with average residuals of ± 0.04 magnitude. (2) *W Ursæ Majoris.* The curve is similar to that drawn by Müller and Kempf; with corrections to their ephemeris for epoch 1777, $+2^m$; epoch 1945, $+13^m$. (3) *RW Tauri.* The range is 3¼ magnitudes, the most rapid change at the rate of three magnitudes per hour; the correction to Pickering's ephemeris at epoch 2598 is $+38^m$; epoch 2602, $+37^m$. (4) *14. 1904 Cygni.* The range is 0.7 magnitude, the period is $3^h\ 1^m\ 26^s.4$; the curve resembles the 'cluster type.' (5) *32 Cassiopeiæ* (suspected variable). No variation was found beyond accidental errors of measurement, the mean residuals for the four plates, each covering the greater part of the suspected period, being ± 0.05, ± 0.05, ± 0.06 and ± 0.04 magnitudes.

Spectrograms taken at Daroca, Spain, August 30, 1905 (U. S. Eclipse Expedition): S. A. Mitchell.

Five spectrographs were employed; three gratings and the other two alike having a dispersion of one weak prism. Weather conditions were perfect. Results with the two larger instruments are as follows:

1. *Parabolic grating,* diameter four inches, with 14,438 lines to the inch and a focal length of five feet. The dispersion of this instrument is about the same as the Bruce three-prism spectrograph of the Yerkes Observatory and the Mills spectrograph of the Lick Observatory. The distance from D_3 to H is almost exactly seven inches, the total length of the photographed spectrum being 9.5 inches. The definition is excellent throughout the whole length of the flash, which extends from D_3 to $\lambda 3300$, and shows a very great number of lines.

The spectrum taken near mid-totality shows some interesting coronal rings. The green 'coronium' ring appears very plainly and two rings in the extreme ultra-violet are just as prominent on the photograph as the green ring. As the plate used has a photographic action which is just as intense in the ultra violet as in the green, it would seem that the corona is very rich in ultra-violet rays. The following coronal lines are seen at approximately, λλ3381, 3388, 3455, 3643, 3984, 4228, 4565, 4618 and the 'coronium' line at λ5303.

2. *Flat Grating,* with 15,000 lines to the inch, and a ruled surface 3½ x 6 inches. The lens is a Clark five-inch visual with a focal length of about six feet. On the photographs the distance from D_3 to H is eight inches. In the flash spectrum lines can be seen beyond D toward the red almost to C. This is the end of the spectrum most desired, and the focus is excellent from F to the extreme of the red. The green (coronium) ring also appears on the plates taken near mid-totality.

Observations of Radial Velocities: EDWIN B. FROST.

The four principal programs of observations with the Bruce spectrograph of the Yerkes Observatory are: (1) standard velocity stars; (2) stars of *Orion* type; (3) visual binaries; (4) miscellaneous variable stars. About 500 plates of over 100 stars of program (2) have been measured (many in duplicate); three or more satisfactory plates have been obtained of 135 stars of the *Orion* type, and one or two plates of forty more.

It is important to secure at this epoch good determinations of the sight-line velocity component for visual binaries of program (3). With Burnham's assistance an observing list was compiled containing 120 stars known to be binary, and bright enough to be observable with the Bruce spectrograph, at least with one prism. Preference was given to pairs differing in magnitude sufficiently to prevent confusion of spectra, and for which the brighter component would have fairly sharp lines.

The writer's measurements of *P Cygni* show that the strong and broad *bright* components of the hydrogen and helium lines have only a very small displacement, corresponding to a radial velocity of about 12 km. per second of approach; while the *dark* components, sharply defined at each margin, and comparatively narrow, yield very large displacements toward the violet, differing for hydrogen and helium. If interpreted by Doppler's principle, the velocities (approach) would be about 190 km. for hydrogen and 150 km. for helium; the three blue silicon lines seem to have no bright components, and from these a consistent value of about 80 km. (approach) is derived. An attempt to account for these differences as a result of overlapping of the dark and bright lines has not yet been successful. A comparison with Belopolsky's observations of this star made in 1899 indicates that the displacements are not variable. Physical causes may be responsible for this remarkable spectrum.

Spectrograms of the variable star *R T Cygni,* obtained in conjunction with Parkhurst, when the star was of magnitude 7.5, showed bright $H\gamma$ and $H\delta$ with an exposure as short as 45 minutes. These bright lines were very strongly displaced toward the violet, corresponding to an approaching radial velocity of 100 km. per second. It now seems probable that this did not vary during the first half of December, 1905, which period included the five plates obtained.

It is possible that variations occur in the bright lines of *Pleione,* which were very weak, if present, on three plates recently obtained, although they were shown on spectrograms taken by the writer at Potsdam in 1891, and on Harvard plates. The spectrum of *α Columbæ* is peculiar, and *μ Orionis* has been found to be a spectroscopic binary.

The Solar Corona, as observed by the U. S. Naval Observatory Eclipse Expedition, August 30, 1905, at Porta Cœli, Spain: G. H. Peters.

The observing station was near the eastern coast of Spain, north of Valencia. It was located about ten miles north of the southern limit of the shadow path, for the purpose of studying especially the regions about the southern pole of the sun.

The corona at this eclipse, occurring near the sun-spot maximum, had a structure entirely different from those of 1900 and 1901. The polar rays were nearly obliterated by numerous streamers and wings, which were nearly equally prominent throughout the whole circumference. The entire corona exhibited a mass of fine details, considerably striated, and to a great extent intermingled.

Vacant Regions of the Sky: E. E. Barnard.

There are two distinct classes of these vacancies. The commonest form has all the appearance of real openings in the bedwork of stars—through which there is an uninterrupted view of space. The other class, mainly found in *Ophiuchus* and *Scorpio,* suggest the presence of a nebulous substratum among the stars. The appearance of these latter regions is widely different from ordinary vacancies, their marked features being areas devoid of stars, yet apparently filled with some other substance in which blacker holes occur, as if there were a nebulous veiling pierced with holes and rifts.

The most remarkable of these regions are those about θ and ρ *Ophiuchi,* the latter being connected with the great nebula of ρ *Ophiuchi.* From this latter region a straggling vacant lane runs easterly for a distance of some 15° and connects with a great chasm just east of θ *Ophiuchi.* Some vacancies near this latter star are very small and very curious, all showing more or less the appearance of vacancies within vacancies.

Attention is called to the probable relative smallness of stars forming the bedwork of the Milky Way near Antares. The small stars here seem to be intimately related to the great nebula of ρ *Ophiuchi.* But the nebula certainly involves such naked eye stars as ρ *Ophiuchi* and σ *Scorpii,* and appears to involve even *Antares.* Reasoning from this that the nebula, the small stars of the Milky Way, and the brighter stars here, are at relatively the same distance from us, the natural conclusion is that the apparently great difference in size between the above-named stars and the groundwork of small stars of the Milky Way at this point is not so much due to a greater distance of the smaller stars as to their being actually very much smaller.

Determination of Absolute Star Positions by Photography: E. C. Pickering.

It is proposed to determine the absolute positions of a zone of equatorial stars by means of photography. A telescope of long focus is pointed to the intersection of the equator and meridian, and motion is given to the photographic plate equal to that of the stars. Reference points are furnished by holes through which a small incandescent light shines on the plates. Current is sent from a standard clock, which should be kept underground at a uniform temperature and pressure. As observations would extend over one year at least, errors depending on the sun's position should be eliminated. The only parts of the apparatus that need be rigid are the objective and the plate carrying the reference holes. So long as the images, which have an exposure of about a minute, are sensibly circular, or uniformly elongated, slight motions of the photographic plate are unimportant. The principal advantage of this method is that stars as faint as the tenth or eleventh magnitude may be recorded, and a large part of the entire region may be photographed in a single night. It might be better to photograph a zone a little north of the equator in mid-winter, at a station so far north that observations could be made continuously during twenty-four hours. Many forms of small systematic error would thus be eliminated.

The Polaris Vertical Circle Method of Determining Time and Azimuth: F. H. SEARES.

The vertical circle method of observing for time and azimuth has been known for a century or more, is capable of affording very precise results, but has never found general acceptance on account of a lack of satisfactory methods of reduction. The most important methods have been devised by Döllen and Harzer. The formulæ of Döllen are not sufficiently accurate for many purposes; moreover, the Ephemerides necessary for the use of his formulæ are no longer published. The method of reduction proposed by Harzer lacks nothing in precision, but the calculations are unnecessarily long. Laws Observatory Bulletin No. 5 contains a method which affords the desired precision, and permits of a saving of three tenths in the labor of calculation as compared with the process of Harzer. The present paper separates the features which are essential for the practical application of the method from certain purely theoretical considerations contained in Bulletin No. 5, and is intended to exhibit more clearly the simplicity and brevity of the operations involved in the employment of the writer's formulæ.

Although it is not contended that the vertical circle method can profitably replace the older methods in all cases, the following advantages are claimed:

1. A saving in labor when it is necessary to determine both time and azimuth.

2. A gain in precision and a saving in labor in the determination of time with unstable instruments, especially when it is desirable to secure all possible accuracy.

3. A frequent saving in time and labor, irrespective of whether the instrument be stable or unstable, when it is necessary to work through clouds.

4. When applied to the engineer's transit, it affords a very simple and precise method of determining time in the field, and frees the observer from any necessity of waiting for an elongation of Polaris in order to secure observations for azimuth.

Determination of Adjustment Errors for the Polar Axis of an Equatorial: ERIC DOOLITTLE.

The method consists in measuring the position angle of a pair of stars close to the pole. Each measure gives an equation for determining the position angle, supposed unknown, and the instrumental errors. From several measures at different hour angles the latter can be determined with a degree of accuracy probably higher than by any method in which the circles of the instrument are used. The ordinary formulæ must, however, be considerably modified for this purpose.

Two determinations of the error of adjustment for the 18-inch equatorial belonging to the Flower Observatory were made, the results agreeing within 1 second, and the probable error of each result being less than 1.5 seconds.

The advantages of the method are that observations are very easily made, that there is no moving of the dome or observing chair, and that the time need only be known very roughly. The setting circles are not read, and hence their errors of graduation do not affect the result. The disadvantage is that the subsequent labor of reducing positions of polar stars to apparent place is so great as to preclude the method becoming of much practical value.

The Hough Double Stars: ERIC DOOLITTLE.

Work on the 622 double stars discovered by Hough has been carried on, only about 50 of them now remaining unmeasured. It is hoped that these may be finished during the present year.

The Observations of Sun-spots by the Late C. H. F. Peters: EDWIN B. FROST.

It has been for many years a matter of regret to students of the sun that the solar observations by this careful observer have remained inaccessible. In 1904 the Carnegie Institution decided to publish them, and the writer was requested to edit them.

The observations cover the decade from May, 1860, to May, 1870, with some interruptions, and more than 13,000 heliographic positions of spots were accurately determined on over 1,100 days. The first year's observations overlap the last year of Carrington's series, and Spoerer's observations at Anclam extend from 1861 to 1871. While it is thus decidedly unfortunate that Peters's results could not have been published thirty-five years ago, their value for comparative purposes is still great, and they were obtained with better instrumental equipment than the other two contemporary series.

The manuscript was supposed to have been left by Dr. Peters in a condition for printing, but some abridgment of the tabular data has now seemed desirable. No manuscript has been found describing the method of observation or procedure used in obtaining the constants of reduction, which constants in fact have to be inferred. The galley proofs of the tabular part have now been read, and it is hoped that the volume can be issued during 1906.

Computed Tracks and Totality-durations of Total Solar Eclipses in the Twentieth Century: DAVID TODD and ROBERT H. BAKER.

Their tracks of visibility have been calculated and charted as accurately as possible. This has been done from Oppolzer's tables (*Canon der Finsternisse*), the most reliable at present in existence, and Oppolzer's own charts corrected. The longest eclipses of the next half-century are:

1911, April 28,	duration 5½	minutes.
1919, May 29,	duration 7	minutes.
1922, September 21,	duration 6½	minutes.
1923, September 10,	duration 4	minutes.
1926, January 14,	duration 4½	minutes.
1929, May 9,	duration 5½	minutes.
1937, June 8,	duration 7½	minutes.
1940, October 1,	duration 6	minutes.
1944, January 25,	duration 4½	minutes.
1947, May 20,	duration 5½	minutes.
1955, June 20,	duration 7½	minutes.

An Analytical Method of Determining Orbits of New Satellites: A. O. LEUSCHNER.

This paper contains formulæ for the computation of osculating elements of a material point moving under the attraction of more than one mass, from three or more geocentric observations. It is applicable to satellites, comets or asteroids which are greatly disturbed during the time over which the observations available for the computation of an orbit extend. The resulting osculating elements are the elements that would result from a solution irrespective of the perturbations if the observed right ascensions and declinations of the material point could be corrected in advance for the perturbations, starting with an arbitrary epoch of osculation within the range of the observations. As in the short method proposed by the writer for deriving orbits of comets and asteroids, the right ascension (α) and declination (δ), their velocities (α', δ'), and accelerations (α'', δ''), are determined empirically for the date of an observation near the middle of the available data. Being accurately determined from the disturbed geocentric coordinates, these six quantities correspond to the osculating elements.

In the case of a distant satellite of Jupiter disturbed by the sun, let be:

ρ, a, δ, $\sigma = \rho \cos \delta$, ξ, η, ζ = geocentric coordinates of the satellite.

r, a, b, $s = r \cos b$, x, y, z = Jovicentric coordinates of the satellite.

$[r]$, $[a]$, $[b]$, $[s] = [r] \cos [b]$, $[x]$, $[y]$, $[z]$ = heliocentric coordinates of the satellite.

(ρ), (a), (δ), $(\sigma) = (\rho) \cos (\delta)$, (ξ), (η), (ζ) = geocentric coordinates of Jupiter.

(r), (a), (b), $(s) = (r) \cos (b)$, (x), (y), (z) = heliocentric coordinates of Jupiter.

R, A, D, $S = R \cos D$, X, Y, Z = geocentric coordinates of the sun.

$(k)^2 = mk^2$, where m = mass of Jupiter.

Then from the equation of motion of the satellite referred to Jupiter's center as origin:

$$\frac{d^2x}{dt^2} + (k)^2 \frac{x}{r^3} = -k^2 \left\{ \frac{[x]}{[r]^3} - \frac{(x)}{(r)^3} \right\},$$

and the corresponding equations in y and z, three equations are deduced which give ρ, ρ', ρ'', in terms of known coordinates, velocities and accelerations, and in terms of the unknowns (r) and $[r]$. The complete expression for ρ is

$$\rho = \frac{A}{r^3} + \frac{B}{[r]^3} + C,$$

A, B and C being expressed, as indicated above, in terms of known quantities. The solution of this equation together with the equations

$$[r]^2 = R^2 + \rho^2 - 2R\rho \cos [\psi]$$
$$r^2 = (\rho)^2 + \rho^2 - 2(\rho)\rho \cos (\psi)$$

gives all the values of ρ corresponding to the various possible solutions. In practise, the solution of these equations is very simple. From ρ the value of ρ' is derived. The remaining steps leading to the osculating elements are similar to those of the short method. The short method, itself, is a special case of that under discussion, terms depending upon the mass of Jupiter dropping out and the motion being referred to the center of the sun.

Among other special cases of this analytical method is that obtained by omitting the terms depending upon the solar attraction in these formulæ. The resulting formulæ will then be those for the determination of the undisturbed motion of the satellite. The general method is applicable to material points moving under the attraction of any number of masses. The method presents the advantage that it is free from all arbitrary assumptions, whether introduced with the assistance of graphical construction or otherwise, and that it reveals all possible sets of osculating elements which will represent the disturbed geocentric positions given by observation.

Planetary Inversion: WILLIAM H. PICKERING.

This paper was illustrated with a gyroscope. The subject has already been treated theoretically in other places, and the present paper is therefore purely experimental. The gyroscope was arranged so that it could turn about an axis passing through the plane of the wheel, and also about a vertical shaft which supported it.

According to the nebular hypothesis, when the rings or spirals surrounding a central sun broke up into planets, each planet should, by Kepler's third law, have a retrograde rotation. The fact that nearly all planets rotate in the opposite direction has always been held a serious objection to the hypothesis, and several different suggestions have been offered to explain the discrepancy. None of these even attempted, however, to explain the rotation of Uranus, which lies in a plane practically at right angles to the orbit.

The gyroscope was set spinning in a

retrograde direction. The stand which supported it was then held by the speaker at arm's length, while he gave himself a slow direct rotation upon his feet, thus imitating the motion of a retrograde planet in its orbit. By applying friction to the vertical shaft, and thus introducing the effect of an annual tide upon a planet, it was shown that the gyroscope would slowly shift its plane of motion. Its equator first became inclined to the orbit, like that of Neptune, and later nearly at right angles to it like that of Uranus. The shifting of the plane of rotation continuing in the same direction, the rotation itself now became direct, and its plane gradually approached that of the orbit. The inclination was before long the same as that of Saturn, and later the same as that of Jupiter. The two planes now practically coincided, and the rotation and revolution were in the same direction.

When this became the case the plane of rotation had reached a position of stable equilibrium, unaffected further by tidal action. Reversing the direction of orbital motion again shifted the plane of rotation, which now also became retrograde, showing that the phenomenon exhibited was a real property of the gyroscope, as had indeed been proved theoretically, and was not an effect due to some faulty construction of this particular instrument.

Tables for the Reduction of Photographic Measures: BURT L. NEWKIRK.

These tables are intended to facilitate the transformation from standard rectangular coordinates to differences of right ascension and declination as well as the converse transformation, and the correction for refraction, including terms higher than the first order in the measured coordinates. Being intended primarily for use in the reduction of plates made with certain lenses belonging to the Berkeley Astronomical Department, which cover a field some ten degrees in diameter, they are applicable to stars whose right ascensions differ from that of the center of the plate by ten degrees or less and whose declinations differ from that of the center of the plate by five degrees or less, no matter what the declination of the center of the plate may be.

The tables for the transformation of standard rectangular coordinates into intervals of right ascension and declination and its converse are based upon Professor Turner's fundamental relations:

$$\eta = \tan (d - \delta_0)$$
$$\tan d = \tan \delta \sec (\alpha - \alpha_0)$$
$$\xi \sec d = \frac{\tan (\alpha - \alpha_0)}{\cos (d - \delta_0)}$$

Three tables have been constructed, giving quantities A, B, C, such that, given:

$$\alpha_0,\ \delta_0,\ \xi,\ \eta,$$
$$d - \delta_0 = k\eta - A,$$
$$\alpha - \alpha_0 = k\xi \sec \delta - C,$$
$$d - \delta = B,$$

giving:

$$\delta - \delta_0 = d - \delta_0 - (d - \delta),$$

or, given:

$$\alpha_0,\ \delta_0,\ \alpha,\ \delta,$$
$$d - \delta = B,$$
$$k\eta = d - \delta_0 + A,$$
$$k\xi \sec d = (\alpha - \alpha_0) + C.$$

In which

$\alpha_0, \delta_0 =$ coordinates of center of plate;
$\alpha, \delta =$ coordinates of star;
$\xi, \eta =$ standard coordinates of star;
$k =$ scale value factor.

The tables for the determination of the refraction correction are also based upon formulas of Professor Turner:

$$\Delta x = (X - x)\,t,$$
$$\Delta y = (Y - y)\,t,$$
$$t = \mu \frac{1 + x^2 + y^2}{1 + xX + yY}$$

In which

$\left. \begin{array}{l} X, Y \\ x, y \end{array} \right\} =$ true coordinates of zenith and star projected on plate;

$\left. \begin{array}{l} \Delta x \\ \Delta y \end{array} \right\} =$ projections on plate of *total* displacement of star due to refraction;

$\mu =$ refraction constant.

The tables are so constructed that the terms of Δx and Δy, which represent the displacement common to the star and the center of the plate, have been omitted. Those terms of Δx which are proportional to x and the terms of Δy which are proportional to y have also been omitted, these corrections being automatically applied in the determination of the plate constants.

A Contribution on Astronomical Refraction: RUSSELL TRACY CRAWFORD.

An investigation of the constant of refraction was made in the year 1899 which resulted in the discovery that this so-called constant is a function of the zenith distance. The observations were made with the Repsold meridian circle of the Lick Observatory and reduced by a method which is the converse of Talcott's method of determining latitude.

This method has both its advantages and disadvantages. Among the former, the most important are: first, total elimination of the latitude, and hence also of its variation; second, elimination of the nadir reading; third, there is no wait of twelve hours or six months in order to observe a star at both culminations; fourth, only one half of any error of observation or in the declinations used enters into the reductions; and, finally, the simplicity of the observations.

The greatest disadvantage lies in the fact that the declinations have to be considered known. But by taking fundamental stars, such as those of Professor Newcomb's new 'Fundamental Catalogue,' and by taking a large number of these stars, this difficulty will be nearly completely eliminated.

Two independent series of observations were made for this investigation. One was made during the summer months, giving

$$\Delta \log \mu = 0.000101 \; (56°.6 - z).$$

The other made during the winter months gives

$$\Delta \log \mu = 0.000117 \; (59°.3 - z).$$

Combining these into one solution, the two constants of the expression become

$$+ 0.000108 \pm 0.000010 \quad \text{and} \quad 58° \pm 8°,$$

so that the Pulkowa tables should be corrected by

$$\Delta \log \mu = 0.000108 \; (58° - z)$$

where z is the zenith distance in degrees.

The efficiency of tables constructed by applying this correction to the Pulkowa tables may be shown by comparing a series of observations reduced by the two. In his preliminary reductions of his observations of the Piazzi southern stars, Tucker has used the Pulkowa refractions. In his final reductions, he has corrected his declinations for errors in refraction which are given as a function of the zenith distance. Auwers has published further corrections to reduce Tucker's results to his fundamental system (*Abhdlg. z. d. A. N.*, No. 7). The differences between the corrections Auwers + Tucker and those resulting from this investigation are less than the probable errors of observations found by Tucker.

A Solar Planisphere: SARAH F. WHITING.

In connection with the students' laboratory work at Whitin Observatory, Wellesley College, a device for working problems in relation to the hours of day, night and twilight, at different latitudes at different times of year, has lately been worked out chiefly by E. Rebecca Ellis, assistant. We do not find this simple contrivance, which we call a solar planisphere, elsewhere described.

Using a stiff card, the sphere is projected on the plane of the meridian. The horizon and twilight circles eighteen degrees below are also drawn. Upon another smaller circular card, pivoted to the first at its center, the six-o'clock hour-circles through the poles, the equator, and diurnal paths of the sun at the solstices are projected in straight lines. Harmonic projections of the hour-circles for every twenty minutes are marked on these.

By revolving the movable card the pole can be set to the proper elevation for any latitude, and the number of hours of darkness, twilight and daylight can be read. The time of sunrise and sunset and the meridian altitude of the sun at noon or midnight can also be measured.

These fundamental phenomena should be made clear even in preparatory schools, but from our observation of college students it is evident they are not. To put such a piece of apparatus into the hands of each student, with which he can solve a set of problems, would be another move in the direction of individual laboratory work in general astronomy which it seems so difficult to secure.

The model has been entrusted to the Arthur Hall Scientific Company, of Boston, for reproduction, in the hope that it may be of service.

The Repsold Measuring Apparatus of the Students' Observatory, Berkeley, Cal.: Burt L. Newkirk.

This paper contains an investigation of the instrument, with a determination of corrections which must be applied to measures made with it. The method employed in measuring division errors of the scales is essentially the one employed by Gill for the scales of the Cape heliometer and Repsold measuring apparatus. Corrections are determined for each line of the X scale and for seventy lines (from line 230 to line 300) of the Y scale. The corrections are given to ten-thousandths of a millimeter and are accurate to within a few units of the last place.

The irregularities of the X micrometer throughout three revolutions have been investigated and a table of the corresponding corrections determined by the method outlined in Brünnow's 'Spherical Astronomy,' p. 426, fourth German edition. Two independent determinations yield results differing by about .0003 mm. in the maximum.

The straightness of the cylinder which determines the Y axis and of the bar which determines the X axis was also tested, as well as the perpendicularity of the directions of these two parts of the apparatus. The cylinder and bar were found to be very satisfactory and their directions are made perpendicular by adjustment.

The measurement of the distance between two well-defined points on a plate, first as a difference of X coordinates and then as a difference of Y coordinates, yields results differing by slightly more than the error of measurement, indicating that the Y scale is not exactly parallel to the plate. The maladjustment in this particular would introduce an error into the measures that would in general be entirely negligible.

Tables are added for applying the necessary corrections to measured coordinates.

The Forty-foot Camera of the U. S. Naval Observatory Eclipse Station at Guelma, Africa: W. W. Dinwiddie.

This instrument was mounted horizontally and the light was led to it by the mirror of a Gaertner cœlostat. Three ventilating doors were made in the lower side of the forty-foot tube, which, operated in connection with the trap doors in the roof of the building at the plate end of the tube, gave perfect ventilation and kept the whole instrument cool.

The shutter used in making the exposures during totality was placed in a nearly horizontal position above the mirror, and not between the lens and mirror, as is customary. The sunshade over the building and tube, and the wall of the tube, which was on the opposite side from the sunshade, were all whitewashed with ordinary lime. The sunshade was of opaque black cloth, and all the inner surfaces were black.

At the time of the eclipse eight exposures were made as follows: 2^s, $5^s.2$, $13^s.2$, $1^m28^s.1$, $38^s.3$, $6^s.8$, 5^s and an exposure of one fourth second about ten seconds after third contact. All the negatives are sharp and clean. The unusual completeness of the series gives every part of the corona in fine detail on one or more of the plates. The first exposure shows a very large group of prominences. The short exposure made after the reappearance of the sun shows the entire ring of the corona. On this plate the prominences on the bright limb are shown in fine detail, and from it good measures may be made of the height of the chromosphere.

The first and fourth contacts were observed visually from the image on the face of the focal plane shutter, and recorded by a stop-watch. I think that this method of observing the outer contacts has advantages over the ordinary method of observing the limb with a small telescope. The times of the exposures were marked on the chronograph by a key operated by an assistant who looked after the cœlostat clock, set the mirror, etc.

The plates were thoroughly backed with water-color lampblack, which was carefully wiped off before development. Distilled water was used in developing and fixing, and after washing, the plates were rinsed in distilled water.

Polarized Coronal Light, August 30, 1905: C. D. PERRINE.

Observations of polarized light in the corona were made by the Lick Observatory-Crocker Eclipse expedition to Alhama, Spain. A double-image prism was used in connection with a camera of twenty and three fourths inches focal length, in continuation of the work at Sumatra in 1901.

More efficient apparatus was designed for the recent eclipse, and plane glass mirrors were used as analyzers. These cameras were of fifty inches focal length and yielded sharp images of good scale for photometric measurement. Strong radial polarization is shown on all the negatives.

Anomalous Refraction: FRANK SCHLESINGER and C. B. BLAIR.

Under ordinary circumstances the atmosphere is disposed in horizontal strata of uniform density; but these strata may be inclined occasionally to the earth's surface, giving rise to anomalous refraction.

In this case the usual expression for refraction should be replaced by a somewhat different one, deduced by the writer. The new formula has been applied to observations made in 1900 and 1901 at the six international latitude stations, with the object of discovering whether the effect of anomalous refraction is large enough to justify the frequent, but vague, appeals which have been made to this source of error in order to account for inconsistencies in meridian work. From this discussion it appears that observers have little to fear from this cause.

An important corollary to this conclusion relates to Kimura's recently discovered term in the latitude variation, independent of longitude. The present paper makes it highly probable that this phenomenon has a real existence and is not due, as has been suggested, to anomalous refraction.

New Variable Stars in the Small Magellanic Clouds: HENRIETTA S. LEAVITT.

At the meeting of the Astronomical and Astrophysical Society held in Philadelphia in December, 1904, a brief account was given by the writer of methods and results in a study of faint variable stars recently undertaken at Harvard College Observatory. The most remarkable regions as yet examined are the Nebula of Orion and the two Magellanic clouds. These were mentioned a year ago, when it was reported that the numbers of variables in the large and the small Magellanic clouds were one hundred and fifty-two and fifty-seven, respectively. In the autumn of 1904, a series of sixteen plates was taken at Arequipa, covering the region of the small Magellanic cloud. These arrived at Cambridge in February and were examined with great interest, as it was expected that the number of variables would be considerably increased. The result of the examination, however, exceeded all anticipations. So many were found that it was April before the preliminary study of the plates was completed and it could be announced that nine hundred new variables had been discovered. The number has since been increased to nine hundred and seventy, and new ones are still being discovered from time to time. Measurements of the positions of all these, selection and measurement of a large number of sequences of comparison stars, and the determination of a provisional light-scale, have necessarily consumed much time, so that it is only within a few weeks that it has become possible to begin actual observation of the brightness of the variables. Light-curves thus far deduced are of well-defined types. Periods of many of the variables appear to range from one and a quarter to four days. A number, mainly among the brighter ones, have periods of from one to two weeks, while very few appear to have long periods. A preliminary examination of recent photographs of the large Magellanic cloud shows that it resembles the region now under discussion and it is probable that a very large number of variables will be found to exist within its limits. Preparations for measuring the positions and brightness of these are already being made.

The question as to whether there are other regions containing such remarkable groups of variable stars, is of the greatest interest. Not less important is the general problem of the distribution of these fainter variables. An exploration of new regions, therefore, is being undertaken as time permits, and even negative results, though less immediately interesting, are valuable as a contribution toward an ultimate solution of the problem.

Amherst Eclipse Expedition to Tripoli, 1905: David Todd.

Instruments installed on the rigid roof-terrace of the British Consulate-General. Six departments of observation:

1. Observations of the geometric contacts.

2. Coronal photography with a twelve-inch Clacey lens of nine feet focus, photographically corrected. Eighteen exposures with semi-automatic movements. Baily's beads also photographed before second contact. My modified form of Burckhalter revolving occulter was employed on the corona. Corona photographed to 30′.

3. Duplex Clark lenses (photographic) of three inches aperture and eleven feet focal length, for long exposures on the circum-solar stars and the outer coronal streamers. No intra-mercurial planet revealed on 14 x 17 plates of the highest sensitiveness, stars to seventh and eighth magnitude.

4. A three-and-one-half-inch Goerz doublet of thirty-three and one half inches focus, attached to one of the automatic movements, used on my previous expeditions of 1896, 1900 and 1901, secured 63 fine pictures of the corona during the 186

seconds of totality. Some of these show the coronal streamers to exceptional length.

5. Sketches of the corona with usual results.

6. Observations of shadow bands begun at least ten minutes prior to totality: bands wavering and narrow, moving swifter than one could walk, at right angles to the wind, their length with it, and waxing and waning five times during the interval of observation preceding totality. These observations communicated in detail to Mr. Lawrence Rotch of the Blue Hill Observatory. Other results in the *Astrophysical Journal.*

The Philadelphia Observatory: MONROE B. SNYDER.

The Philadelphia Observatory, an outgrowth of the old Central High School Observatory (1837–1900), was planned by the writer for an astrophysical observatory to begin with the twentieth century. The plan included a city station, chiefly for solar work and necessary popular instruction, and a suburban station, not yet realized, where certain lines of celestial photography could be undertaken. Peculiar difficulties delayed completion of the building and equipment, and there was a marked absence of financial and other support for the scientific work, so that not until early in 1905 was the really superb equipment, designed for both stations, received, and, as far as possible, erected at the city station in the new building of the Philadelphia Central High School.

On March 9, 1905, a destructive fire (probably originating in a combination gas and electric-light fixture), and long feared by the director of the observatory and others on account of municipal neglect of the usual fire precautions, swept the tower and destroyed an equipment and astronomical library valued at approximately $55,000, and produced a loss in equipment and building of more than $100,000. The equipment destroyed represented in a number of respects the very best attainable in instruments of moderate size, and included: A fifteen-inch refractor with Warner and Swasey mounting, the finest for its size, and provided with both a visual objective and a photographic objective of excellent definition, by Brashear; a Wadsworth-Hale spectroheliograph designed to photograph the sun in three different wave-lengths simultaneously; a large Keeler spectroscope and spectrograph, attached to the telescope on the day of the fire for the purpose of rediscovering (during maximum solar activity) Hale's disturbance in the sun's spectrum; a Warner and Swasey filar micrometer; a four-inch portable transit instrument with the writer's electrical transiter attached; clocks and chronographs (partially destroyed); a five-inch Rowland concave grating finely mounted by Brashear; a goodly equipped mechanical shop and photographic laboratory; and many smaller but valuable physical appliances.

The loss of a carefully selected library of some four thousand volumes representing the chief periodicals and literature in astronomy and astrophysics almost completed the destruction of years of effort. An eight-inch refractor and an unmounted set of Brashear eight-inch curved plate star cameras were rescued.

The main purpose, under the conditions of work hitherto allotted, was not only that the equipment should as a whole express the best current science, but that certain instruments like the spectroheliograph and its method of operation, the transiter, the new form of Hough printing chronograph, and the large curved plate star cameras should represent distinct advances in observatory equipment.

The observatory is in process of reconstruction.

Orbit of the Seventh Satellite of Jupiter: R. T. CRAWFORD and A. J. CHAMPREUX.

This paper gives results of an application of Leuschner's 'Analytical Method of Determining the Orbits of New Satellites.' Three solutions were made which are designated in the tabulation given below by (Cr. & Ch.)$_1$, (Cr. & Ch.)$_2$ and (Cr. & Ch.)$_3$. The orbits are based on Perrine's positions of January 3, February 8 and March 6, 1905. The first set of elements was derived irrespective of any perturbations. The second represents the first approximation to elements osculating February 8 by taking immediate account of the attraction of the sun. The third set is the result of a close representation of the observations on the same basis. For comparison, the elements by Perrine (L. O. Bulletin No. 78) and by Ross (L. O. Bulletin No. 82) are also tabulated. The first set of elements does not represent an observation of August 9 any better than those by Ross. The third set, however, gives the residuals $(O - C)$:

$$\Delta p = + 2°.7$$
$$\Delta s = + 5'.2$$

the computed positions being derived directly from the third set of elements osculating for February 8 without applying the solar perturbations February 8 to August 9. The solar perturbations are being computed for all observations secured since the discovery observations, by an adaptation of Encke's method of special perturbations in rectangular coordinates. With these perturbations it is expected to represent recent observations closely. Outstanding differences will serve to correct the third set of elements. With each of the three sets, a second solution with retrograde motion was obtained.

HAROLD JACOBY.

ELEMENTS OF THE SEVENTH SATELLITE OF JUPITER (DIRECT MOTION) REFERRED TO THE EARTH'S EQUATOR.

Computer.	Ω	i	ω	e	Period.	a
(Cr. & Ch.)$_1$	279° 45′ 8″	26° 27′ 14″	006° 28′ 42″	0.12576	251^d.1415	49′ 48″
(Cr. & Ch.)$_2$	289 47 45	25 39 42	189 15 19	0.13195	255.5376	50 20
(Cr. & Ch.)$_3$	288 19 59	25 39 23	187 29 41	0.12152	258.9424	50 47
Perrine (prel.)	275 47	26 15	182 6	0.24	200	43 48
Ross (final)	281 7.8	26 12	331 16.8	0.0246	265.0	52.54

a (Cr. & Ch.) for log $(\rho) = 0.72124$; a (Ross) for log $(\rho) = 0.71624$.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. SECTION A—MATHEMATICS AND ASTRONOMY.

Vice-president—W. S. Eichelberger, United States Naval Observatory, Washington, D. C. In the absence of the vice-president, Professor Alexander Ziwet, the retiring vice-president, presided at the meetings of the section.

Secretary—Professor L. G. Weld, State University of Iowa, Iowa City, Iowa.

Member of the Council—President C. S. Howe, Case School of Applied Science, Cleveland, Ohio.

Sectional Committee—Dr. W. S. Eichelberger, vice-president, 1906; Professor Alexander Ziwet, vice-president, 1905; Professor L. G. Weld, secretary, 1904–1908; Professor J. R. Eastman, one year; Professor Ormond Stone, two years; Professor E. B. Frost, three years; Professor E. O. Lovett, four years; Professor Harris Hancock, five years.

Members of the General Committee—Professor G. B. Halsted.

Press Secretary—The secretary of the section.

Dr. Edward Kasner, of Columbia University, was elected vice-president for the year 1907.

The address of the retiring vice-president, Professor Ziwet, on 'The Relation of Mechanics to Physics,' was presented on the afternoon of December 29, in the general assembly room in Gibson Hall, Tulane