ress essentially through the subordination of individual struggle and development to species-maintaining ends."

All these changes and others, in fact the most important of floral variations, the big lifts distinctive for the evolution of orders, are thus seen no longer as indefinite, and hence dependent on external selection for their guidance; but, on the contrary, as parallel and definite, since determined through the continued checking of the vegetative process by the reproductive, and thus pressed along parallel and definite grooves of progressive change. But if this be so, the importance we have been taught by Darwin to assign to natural selection becomes greatly changed—from selecting accumulating supposed indefinite variations, to that mainly of retarding definite ones, after their maximum utility has been independently reached!

Despite, or perhaps because of, the clarifying definitions of vitalism given us by Professors Lovejoy, Ritter and others, I am now come to a point where I do not know at all what vitalism means. I once had at least a personal meaning for the word. But as I note the references to Driesch and Bergson in this book of Professors Geddes and Thomson and then read their chapter—Geddes and Thomson's chapter—on "The Evolution Process Once More Reinterpreted," and see that natural selection is for them the work "of Siva, not of Brahma," I am going hereafter to think of them as vitalists! To such a misunderstanding of vitalism and vitalists can one come through persistent reading about things and persons thus catalogued!

But let no one avoid this excellent little book about evolution because of fear of taint from vitalism. Probably no one else will find any vitalism in it; the authors perhaps least of all! V. L. K.

STANFORD UNIVERSITY, CAL.

British and Foreign Building Stones. A Descriptive Catalogue of the Specimens in the Sedgwick Museum, Cambridge. By JOHN WATSON.

Under the above caption Mr. John Watson has published a compact little volume of 483 pages descriptive of a collection of building stones prepared by him and installed in the Sedgwick Museum of Cambridge, England. The collection comprises upwards of eleven hundred specimens prepared in the form of 4½ inch cubes "the sides of which are dressed in the usual style adopted for the purposes for which the stone is generally used in the region from which the specimen comes." Each specimen is accompanied by a label giving the commercial name of the stone, its stratigraphical position, name and locality of the quarry and name and address of the owner. The individual labels state the color, average chemical composition, weight per cubic foot, and crushing strength so far as data are available.

Two hundred and forty-four pages of the catalogue are, however, given up to descriptive matter in which the stones are taken up according to their geological distribution, and it is this portion which will be of greatest value to those not having immediate access to the collection.

The collection is arranged according to the geological horizons, with the exception of the igneous rocks, which are divided into plutonic and volcanic. The portion of the work relating to the rocks of Great Britain contains much interesting historical matter and observations relative to the weathering of the rocks.

No illustrations are attempted, but there is a very full index and it is evident that a great deal of discrimination has been made in getting together the collection as well as in compiling the book which deserves the name of "handbook" rather than simply "descriptive catalogue."

GEORGE P. MERRILL

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

THE twelfth annual meeting of the Astronomical and Astrophysical Society of America was held in the Dominion Observatory, Ottawa, Canada, on August 23, 24 and 25, 1911. In opening the first session, President E. C. Pickering called attention to the fact that this was the first meeting of the society held outside of the United States. Welcome to Ottawa was extended to the society by Dr. W.

F. King, director of the Dominion Observatory, whose remarks were prefaced by the reading of an official welcome in behalf of the Canadian government, communicated by the Deputy Minister of the Interior, W. W. Cory, C.M.G.

Five sessions of the society were devoted to the reading and discussion of papers, to the reports of committees and to routine business. In addition the society's program was amplified by an opportunity extended the visiting members to examine the work and the equipment of the Dominion Observatory. Following this inspection a resolution was unanimously adopted as follows:

Resolved, That the Astronomical and Astrophysical Society of America, assembled at the Dominion Observatory for its twelfth annual meeting, has examined in detail the work of the observatory, and expresses its very favorable opinion of the character of the investigations carried on in all of its departments. This is particularly the case with the determinations of radial velocity, from which unusually valuable results have been obtained by means of a telescope of comparatively small size. In view of the pressing need for such data, the society hopes that a more powerful telescope may soon be provided, and one in keeping with the standing now attained by the national observatory of Canada.

Aside from the purely astronomical program of the meeting several most enjoyable social features were arranged for the members and friends present, whose appreciation was expressed in an unanimous resolution of thanks to Dr. King and his staff.

The list of members in attendance is as follows: Miss Bigelow, Miss Cannon, Miss Furness, Miss Palmer, Miss Swartz, Miss Whiting, Messrs. Apple, Bailey, Chant, Curtiss, C. L. Doolittle, Douglass, Eichelberger, Frisby, Harper, Jordan, W. F. King, Littell, Manson, Marsh, McDiarmid, J. A. Miller, Motherwell, Peters, Plaskett, Russell, Schlesinger, Slocum, Stebbins, R. M. Stewart, Tatlock, Tucker and A. B. Turner. In addition several friends of the society were in attendance.

The following eighteen persons were elected to membership: Mr. C. A. Bigger, Dominion Observatory, Ottawa, Canada; Mr. Leon Campbell, Harvard Surcursal, Arequipa, Peru; Dr. E. A. Fath, Mount Wilson Solar Observatory, Pasadena, Cal.; Mr. Alexander Sarkis Galajikian, Cornell University, Ithaca, N. Y.; Mr. Curvin H. Gingrich, Goodsell Observatory, Northfield, Minnesota; Mr. William Pratt Graham, 1205 Harrison St., Syracuse, N. Y.; Professor Thomas F. Holgate, Northwestern University, Evanston, Ill.; Mr. Louis Allen Hopkins, Ann Arbor, Mich.; Dr. Otto Klotz, 437 Alberta St., Ottawa, Canada; Mr. Carl Otto Lampland, Lowell Observatory, Flagstaff, Arizona; Rev. D. B. Marsh, Springville, Ontario, Canada; Mr. Richard John McDiarmid, Dominion Observatory, Ottawa, Canada; Mr. R. M. Motherwell, Dominion Observatory, Ottawa, Canada; Miss Margaretta Palmer, Yale Observatory, New Haven, Conn.; Mr. Harry B. Rumrill, Berwyn, Pa.; Mr. R. M. Stewart, Dominion Observatory, Ottawa, Canada; Miss Psyche Rebecca Sutton, 813 Market Street, Logansport, Indiana; Mr. Warren J. Vinton, The Wellington, Detroit, Mich.

A committee on cooperation in the teaching of astronomy was appointed with membership as follows: Professors C. L. Doolittle (chairman), Sarah F. Whiting, C. A. Chant and J. A. Miller.

The following officers were selected during the meeting:

President, E. C. Pickering; *First Vice-president,* E. B. Frost; *Second Vice-president,* W. W. Campbell; *Secretary* (for three years), W. J. Hussey; *Treasurer,* C. L. Doolittle; *Councilors* (for two years), W. S. Eichelberger, J. S. Plaskett; *Editor for the meeting,* R. H. Curtiss. The terms of office of W. J. Humphreys and F. Schlesinger as councilors did not expire at this meeting.

The next annual meeting of the society will be held at the Allegheny Observatory, Pittsburgh, in August, 1912. The society will also meet at Washington in December, 1911, in connection with Section A of the American Association for the Advancement of Science.

Papers (thirty in number) and reports read at the various sessions of the Ottawa meeting are given below in abstract.

Photographic Determination of the First Point in Aries: E. C. PICKERING. (Read in connection with the symposium on Photographic Astrometry.)

Absolute positions of the stars can probably be obtained by photography, with errors no greater than those of visual determinations, if a telescope can be made to remain in a fixed position during twenty-four hours. The most favorable conditions would probably be attained by mounting the telescope underground, pointing south at an altitude nearly equal to that of the sun. Azimuth observations with meridian circles indicate, in some cases, that an entire hill has a progressive motion. This is obviously improbable in a level plain. Great pains must be taken to connect the objective rigidly with a metal plate nearly in the focal plane and that this combination shall remain fixed. Rigidity is not required in any other parts of the apparatus. The plate has two holes illuminated by incandescent lamps which when lighted form minute points on the photograph. A circle about two centimeters in diameter is silvered in the center of the objective, whose aperture is reduced to this amount. Several exposures on the sun are made at noon automatically by the clock, moving the plate in declination after each exposure by an amount equal to the diameter of the sun. At the same time a current passes through the lamps which thus impress two reference points upon the photograph. At night the same or another plate is exposed for a second or so to the stars, using the full aperture, and the position of the trails with regard to the reference points, compared with that of the sun, gives the relative positions.

Photographs were exhibited showing images of the sun and stars upon the same plate.

The Spectra of 762 Double Stars: Annie J. Cannon.

A list was prepared of all stars in the "General Catalogue of Double Stars" by Burnham, and the "Reference Catalogue of Southern Double Stars" by Innes, in which the components are of magnitude 7.5, or brighter. A special examination of the Harvard photographs was made to determine the spectra of these stars.

Classification of some Stellar Spectra Photographed with the Slit Spectroscope at the Allegheny, Lick and Yerkes Observatories, Compared with those taken at Harvard with the Objective Prism: Annie J. Cannon.

The Draper classification of stellar spectra depends wholly on photographs taken with the objective prism. In view of the fact that a large number of photographs is being made with the slit spectroscope at various other observatories, it appears to be a matter of great importance to make a comparative study of these spectra, and to determine whether the same system of classification will apply to spectra obtained by these two widely different methods. Accordingly, a preliminary study has been made of 131 spectrograms, including spectra from Class Od to Class Md.

The Spectra and Colors of Red Stars of Harvard Classes N and R: J. A. Parkhurst. (Read by Dr. Slocum.)

In June, 1911, Professor E. C. Pickering sent the writer a list of "Fourth Type Stars not Red" (Class R). This list was extended to include an assortment of ordinary red stars (Class N). An investigation of the spectra of these stars was made from plates taken with the objective prism on the 6-inch Zeiss camera and with the Brashear spectrograph on the 40-inch Yerkes refractor. The "Color-Index" was found by comparing the photographic magnitude with the so-called "visual" magnitude obtained with color-sensitive plates and the "visual luminosity" filter, on plates taken with the Zeiss camera and the 2-foot reflector.

The paper, which will be published in full in *Astrophysical Journal*, gives results for 17 stars, for which the "color-indices" range from 1.11 to 5.60 magnitudes. The principal conclusions are:

1. Excepting the first star, which apparently has a composite spectrum, all are as red or redder than *α Tauri*, and therefore seem to deserve the name of "red" stars.

2. No sharp line can be drawn between the Classes N and R.

The Orbits of the Spectroscopic Components of d Bootis: W. E. Harper.

Fifty-three spectrograms of this F-type star, photographic magnitude 5.3, form the basis of the determination of the elements of the orbit. The plates were obtained mostly with the single-prism instrument, but for considerably over half the period of 9.60 days the spectra were separated and measures were made on each component. Elements were determined for each by the method of least-squares, after preliminary elements had been obtained graphically. These were in substantial agreement with each other; but a more rigid determination was effected by combining the observation equations of the two components into *one* set of normal equations, thereby deriving uniform values for the elements.

Studies of Bright Variable Stars: Joel Stebbins.

Observations with the selenium photometer have been continued during the past year, and the paper contains results for three stars, *α Orionis*, *δ Orionis* and *β Aurigæ*. *α Orionis* is a well-known irregular variable, and the results for 1910–11 indicate a range of 0.2 mag. *δ Orionis* has long been suspected of variability, but it is now shown to be an eclipsing variable with two minima, the range being about 0.10 mag. The third star, *β Aurigæ*, has also been found to be an eclipsing variable with a range of less than 0.10 mag. A combination of the photometric and spectroscopic results gives the actual dimensions of this binary system, and the complete work will soon appear in the *Astrophysical Journal.*

The Variability of Polaris: EDWARD S. KING. (Read by Professor Stebbins.)

The variability of Polaris having been announced by Professor E. Hertzsprung, I examined the results obtained by photographing stars out of focus, contained in Nos. 4, 5 and 6 of H. A. 59, to discover what evidences of such changes might be afforded.

The corrections given for the individual plates were used to show changes in Polaris for the different nights. The spectroscopic period, 3.9683 days, was accepted. A separate grouping according to phase was made for each of the three investigations. The light curves derived from these three independent series of observations are all of practically the same form and amplitude as Hertzsprung's, and confirm his discovery. The curve derived from Nos. 5 and 6 of H. A. 59 suggested a sine curve. And such a curve was found to represent the ten points given by the grouping. A sine curve having an amplitude of 0.108 mag. is a very close approximation. The residuals, expressed in thousandths of a magnitude, for the ten points are + 6, + 2, — 9, + 6, + 8, — 4, — 6, + 5, — 7 and + 3. The average deviation is ± 0.0056.

The effect of the variability of Polaris on the magnitudes already determined by the out-of-focus method was practically eliminated by the nature of the reduction employed in the original work. Corrections were made which included any variation in the light of Polaris, or any change in the conditions occurring between photographing Polaris and the stars observed. The effect was the same as if Polaris had been known to be variable.

No special plates or measures have been made to obtain the above results. All the material has been derived from matter already in type.

A Study of Visual Binary Stars: HENRY NORRIS RUSSELL.

1. The masses of visual binary systems computed from their observed parallaxes vary through a wide range, as Aitken has recently shown. But if "hypothetical" parallaxes are computed on the assumption that the mass of each of these systems is 2.4 times that of the sun (the average for the twelve best determined systems) only five out of 26 observed parallaxes differ from these hypothetical values by quantities greater than might be expected in view of the probable errors of the former. The average difference between the observed and hypothetical parallaxes in the twelve best determined cases, corresponds to a probable error of only one fifth of the latter (including all errors of observation). It is evident that the binary stars are much alike in mass, and that the assumption of equal masses gives very good approximations to the true distances, etc., of these systems.

2. It is well known that a relation between the density P and the surface brightness J of a binary star can be obtained independent of its parallax. Let M and L be the actual mass and luminosity (the sun being standard), r the radius, π the parallax and l the apparent brightness (in suitable units). Then (assuming a single mass)

$$L = Jr^2 = \frac{l}{\pi^2}; \quad M = \rho r^3 = \frac{a^3}{\pi^3 t^2};$$

whence

$$\rho J^{-\frac{3}{2}} = ML^{-\frac{3}{2}} = \frac{a^3}{t^2 l^{\frac{3}{2}}}.$$

The values of $\rho J^{-3/2}$ for the individual components may be found when the ratios of their masses and luminosities are known, and (as experience shows) estimated with sufficient accuracy for the brighter component from the observed difference in magnitude.

Applying this to 83 binaries (the spectra of 29 of which, determined by Mrs. Fleming and Miss Cannon, were very kindly furnished the writer by Professor Pickering) it is found that the whiter stars are very much brighter for equal masses than the redder ones, while the stars of any one spectral type are much more similar in brightness.

The average masses of 73 of these binaries were determined by means of their parallactic motions on the assumptions (1) that the stars of a given spectral type are of equal mass; (2) that they are of equal luminosity. The two sets of values agreed closely, showing both methods to be equally legitimate.

3. For most "physical pairs," shown to be so by common proper motion, only the apparent distance and the rate and direction of the apparent relative motion are at present known. The masses, and related quantities, for the average of groups of ten or more such stars, can be found by a statistical process. Let r be the true distance, and V the true relative velocity in space; a the major axis of the orbit; s the observed distance, and w the observed relative velocity, as projected on the celestial sphere; i_1 and i_2 the angles between r and v and the line of sight; M the mass and π the parallax of the system.

Then $s = r\pi \sin i$, $w = v\pi \sin i_2$, and by gravitational theory

$$v^2 r = K^2 M \left(2 - \frac{r}{a}\right),$$

where the constant K^2 is 39.7 of the sun's mass; the astronomical unit and year are taken as units. Hence

$$\frac{sw}{\pi^3} = 39.7 M \sin i \sin^2 i_2 \left(2 - \frac{r}{a}\right).$$

The last three factors are unknown, but their average values can be predicted on principles of probability. This gives the formula

$$M = \frac{sw^2}{18\pi^3}. \qquad (1)$$

The average of the values given by (1) for a large number of stars will be practically correct. The percentage of individual cases in which the error of this formula may be expected to lie between given limits has been calculated, showing that the mean derived from ten cases will probably be within 10 per cent. of the truth.

4. This method has been applied to all available physical systems brighter than the sixth magnitude, 276 in all, raising the whole number of stars discussed to 349. All the principal spectral types are well represented.

For about half these stars, the relations between mass and surface brightness are very similar to those already found among stars for which orbits have been computed. The other half (including all the stars of type B and some of every other type) are *very much brighter in proportion to their mass* than those previously studied. These stars are probably similar to the stars of great luminosity to which Hertzsprung has called attention under the name of "giant stars." The others may be called "dwarf stars." In type A the two kinds run together, but among the redder stars they are more and more widely separated, though a few intermediate cases exist.

Among the giant stars the relation of mass and brightness is much the same for all spectral types, the values of $\rho J^{-3/2}$ ranging from 0.004 to 0.002 (the sun being the standard). Among the dwarf stars the brightness falls off very rapidly with increasing redness. $\rho J^{-3/2}$ being 0.03 for type A, 0.30 for F, 1.2 for G, 4.8 for K, and rising to over 2,000 for certain faint stars of large parallax whose spectra appear to be of types K_5 or M (with the exception of one aberrant star of type A).

5. The average masses of the giant and dwarf stars of each spectral type have been determined from the parallactic motions (assuming constant luminosity for the stars of each group 25 to 60 in number).

All the giant stars appear to be similar in mass—a system of this sort having about 10 times the mass of the sun. The average masses of the dwarf stars decrease with increasing redness—that of a system of type F being some three times the sun's mass, and of one of type K rather less than the sun's.

The average light emission of a pair of giant stars is from 150 to 250 times that of the sun (the latter for type B). That of the dwarf stars diminishes from 30 for type A to 4.5 for F, 1.3 for G, 0.3 for K and 0.01 for the faint stars already spoken of. It appears therefore that the more massive stars are by far the brightest.

6. The average densities of stars of types B, A and F can be found with the aid of Algol-variables of these types, and the surface brightness may then be deduced from the values of $\rho J^{-3/2}$ already found.

Allowing for the fact that in the average Algol-variable the brighter star is decidedly the smaller of the two, the following values are found—those for type F being uncertain, and the sun being throughout the standard.

	Giant Stars			Dwarf Stars	
	F	*A*	*B*	*A*	*F*
Density	0.04?	0.09	0.13	0.45	0.6?
Surface brightness	4.5?	7.2	15.0	6.1	1.7?

The very faint stars of spectra K_5 and M, even if of ten times the sun's density, can not exceed 1/30 of its surface brightness.

These values agree closely with those derived from the work of Wilsing and Scheiner on stellar temperatures (based on the distribution of energy in the spectrum).

They afford an independent confirmation of the hypothesis that the effective surface temperature of a star is the principal factor which determines its spectral type.

7. Assuming that the surface brightness of giant and dwarf stars of the same spectral type is the same (and interpolating values for spectrum K with the aid of Wilsing and Scheiner's results) it is found that the mean density of the giant stars increases steadily with *decreasing* redness from less than 1/10,000 that of the sun for type M, and 1/1,000 for type K, to 1/8 for type B. That of the dwarf stars increases with *increasing*

redness, the average density for types G and K being about that of the sun.

8. It may be added that all these facts (except the existence of one very faint star of type A) are in harmony with the scheme of stellar evolution sketched by the writer last year.

The 6-inch Transit Circle of the U. S. Naval Observatory: F. B. LITTELL.

Work has been begun with this instrument on a list containing the old or historical fundamental stars, and the new fundamental stars as proposed by the International Committee of the Photographic Chart of the Sky. The instrument is fairly satisfactory as to its errors, which are either quite constant, or are readily determined for any instant by interpolation between values observed at suitable intervals. The pivots have been measured with great accuracy by the axial microscope method. Their irregularities are very small. The division errors of the degree lines of circle A have been determined, also the periodic errors of the two-minute lines within the ten-minute spaces. The periodic and progressive errors of the telescope micrometers and of the microscope micrometers have been measured.

The zenith distance micrometer is used for declination work. Readings are made on two circle divisions under each of the four microscopes, using and reflected (D.R.), clamp east and west (E.W.), and with objective and eye-end interchanged (I., II.). Circle A was used in fixed position, and circle B was shifted each night. The level errors were determined from nadir observations.

Right Ascension.—By a discussion of the differences E.–W. and R.–D. the following flexures were wound:

Lateral flexure varying as cos $2z$

$$+0^s.005 \pm 0^s.001 \text{ (DEI)}$$

Axis flexure varying as cos $2z$

$$-0^s.025 \pm 0^s.002 \text{ (DEI)}$$

The following tables show the quantities indicated before and after the application of the corrections due to the above flexures.

	Azimuth of Marks			
	North Mark		South Mark	
	Observed	Corrected	Observed	Corrected
	s	s	s	s
Clamp E. I.	—0.055	—0.018	+1.040	+1.077
" W. I.	+ .010	— .027	+1.132	+1.095
" E. II.	— .067	— .030	+1.049	+1.086
" W. II.	+ .022	— .015	+1.132	+1.095

In the next table each quantity is the mean for 3 stars and each has been multiplied by cos δ.

	Right Ascension Uncorrected for Flexure											
	½ (D–R)				½ (W–E)				½ (II–I)			
2 DS	E, 1	W, 1	E, 11	W, 11	D, 1	R, 1	D, 11	R, 11	E, D	E, R	W, D	W, R
	s	s	s	s	s	s	s	s	s	s	s	s
+55°	+.006	+.012	—.005	+.001	—.001	—.007	+.004	—.002	—.010	+.001	—.007	+.007
49	— 1	+ 17	— 12	+ 15	+ 6	— 12	+ 20	— 7	— 9	+ 2	+ 4	+ 7
44	— 4	+ 4	0	+ 8	0	+ 3	+ 2	— 6	0	— 5	+ 3	— 2
27	+ 3	— 4	+ 4	— 1	— 5	+ 2	— 4	+ 1	+ 4	+ 3	+ 5	+ 3
+12	— 4	— 9	+ 2	— 13	+ 7	+ 12	+ 8	+ 22	+ 2	— 4	+ 3	+ 6
—11	+ 3	+ 3	+ 3	— 5	+ 8	+ 8	+ 8	+ 15	+ 5	+ 5	+ 4	+ 12
20	— 3	+ 6	— 8	+ 2	+ 2	— 7	+ 16	+ 6	— 1	+ 5	+ 15	+ 17
32	— 11	+ 4	— 12	— 2	+ 13	— 2	+ 25	+ 16	0	0	+ 12	+ 17
46	— 17	+ 24	— 11	+ 19	+ 26	— 16	+ 33	+ 2	+ 6	0	+ 14	+ 17
—58	— 22	+ 32	— 25	+ 30	+ 32	— 22	+ 39	— 15	0	+ 4	+ 8	+ 8

two pairs of threads in each, distant 2.5 revolutions of the micrometer screw from each other. A hand-driven self-registering right ascension micrometer is used. A reversing prism is used, by means of which each observation is taken half with image direct and half with image reversed. The instrument is reversed from clamp east to west and *vice versa* at short intervals.

In order to test the performance of the instrument a list of 30 stars was observed 4 times in each of 8 positions of the instrument; *i. e.*, direct

By the application of the flexure corrections the probable error of a single observation in right ascension is reduced from 0.0266 sec. δ to 0.0204 sec. δ. For direct observations it is reduced to 0.0190 sec. δ.

The above error is entirely eliminated from the mean of an equal number of clamp east and clamp west observations.

The following table gives the comparison with the right ascensions of Newcomb (N), and those of Boss (B), tabulated as above.

Declination.—From measures on the collimators and from a discussion of the observed declinations in different positions of the instrument the following corrections were determined. Some confirmatory results from short series of direct and reflected observation taken in 1909 are also tabulated.

Dn is a constant correction to reduce direct observations of north stars to the mean of direct and reflected, and *Ds* is a similar correction for south stars.

Coefficients of		Circle A. 1910	Circle B. 1910	Circle A. 1909
sin z, I.	From colls.	+ 0".33 ± 0".03	+ 0".27 ± .03	
sin z, I.	" star obs.	+ .45 ± .05	+ .51 ± .05	+ 0.36
sin z, II.	" colls.	— .13 ± .03	.00 ± .03	
sin z, II.	" star obs.	+ .31 ± .05	+ .44 ± .05	
cos z, II.	" " "	+ .07 ± .02	+ .13 ± .02	+ .01
cos z, II.	" " "	+ .17 ± .02	+ .09 ± .02	
cos $2z$	" " "	+ .18 ± .02	+ .09 ± .02	+ .10
Dn		— .21 ± .03	— .23 ± .03	— .24
Ds		— .28 ± .03	— .16 ± .03	— .11

By the application of the corrections due to the flexures, etc., as determined from the observations, the following improvements are made in the mean differences taken without regard to sign:

	Circle A			Circle B		
	D-R	W-E	II.-I.	D-R	W-E	II.-I.
Uncorr'd for flexure	0".60	0".34	0".30	0".54	0".43	0".40
Corr'd for flexure...	0.22	0.23	0.26	0.30	0.37	0.38

The probable error of a single observation is reduced from 0".62 to 0".34 for circle A and from 0".58 to 0".44 for circle B.

	Right Ascension, Corrected for Flexure							
	½ (D-R)				½ (W-E)			
Z. D.	E, I	W, I	E, II	W, II	D, I	R, I	D, II	R, II
	s	s	s	s	s	s	s	s
+55°	+.011	+.007	.000	—.004	—.003	+.001	+.002	+.006
49	+ 3	+ 13	— 8	+ 11	+ 4	— 5	+ 18	0
44	— 1	+ 1	+ 3	+ 5	— 2	+ 7	0	— 2
27	+ 1	— 2	+ 2	+ 1	— 4	— 1	— 3	— 2
+12	— 11	— 2	— 5	— 6	+ 10	+ 2	+ 11	+ 12
—11	+ 1	+ 5	+ 1	— 3	+ 4	+ 1	+ 4	+ 8
20	+ 1	+ 2	— 4	— 2	— 7	— 8	+ 7	+ 5
32	+ 3	— 10	+ 2	— 16	— 6	+ 7	+ 6	+ 25
46	+ 5	+ 2	+ 11	— 3	0	+ 2	+ 7	+ 20
—58	+ 4	+ 6	+ 1	+ 4	+ 2	+ 1	+ 9	+ 8

Z. D.	Right Ascension	
	OBS.—N	OBS.—B
	s	s
+ 55°	+ 0.020	— 0.008
49	+ .030	+ .015
44	+ .009	+ .008
27	— .005	.000
+ 12	+ .004	— .006
— 11	— .001	— .004
20	+ .000	— .005
32	— .010	— .011
46	+ .009	+ .009
—58	+ .003	+ .004

All of the cosine flexures considered above are completely eliminated from the mean of an equal number of clamp east and clamp west observations. The following table gives comparisons with the declinations of Boss, and the reduction from Boss to Newcomb. The direct observations were re-

Z. D.	Circle A—Boss		Circle B—Boss		Boss—N
	All Obs.	Direct Obs.	All Obs.	Direct Only	
+ 55°	+ 0".30	+ 0".74	+ 0".27	+ 0".67	— 0".35
49	+ .16	+ .71	+ .05	+ .48	— .33
44	+ .31	+ .96	+ .23	+ .66	— .21
27	+ .37	+ .75	+ .39	+ .77	— .36
+12	+ .48	+ .76	+ .35	+ .55	— .24
— 11	+ .17	+ .32	+ .31	+ .48	— .19
20	+ .40	+ .50	+ .34	+ .49	+ .02
32	+ .39	+ .44	+ .35	+ .40	+ .13
45	+ .13	+ .11	+ .17	+ .07	— .09
— 58	+ .04	+ .05	+ .05	+ .08	+ .05

duced with the sine flexure determined from the collimators. The corrections $\Delta\phi = +0''.2_0$ for circle A and $+0''.14$ for circle B, based on direct observations of circumpolars observed at both culminations have been applied.

The Alt-azimuth Instrument of the U. S. Naval Observatory: F. B. LITTELL.

The telescope of this instrument is of 5 inches aperture and 50 inches focal length. The graduated circle is 23 inches in diameter, read by 4 microscopes magnifying 30 times. Two levels are used on the alidade. For stars at more than 10° zenith distance, the Pulkova vertical circle method has been used in observing the declinations of stars. For stars at less than 10° zenith distance, the instrument has been used in the meridian, and a double observation has been secured by bisecting with the micrometer at a side thread before and after reversal about the vertical axis.

The essential differences between the use of this instrument for declinations and that of a meridian circle are: (1) that the double zenith distance of the object is measured; (2) that each observation is complete in itself and does not depend on the stability of the instrument except for the short interval, 5 or 6 minutes, covered by the observation; (3) that cosine flexures are immediately eliminated; (4) that spirit levels are substituted for the mercury horizon in determining the reference point of the circle, and (5) that in the Pulkova method a time observation is substituted for a micrometer observation. This latter method, however, may be adapted to meridian circle work by slightly inclining the zenith distance thread, and it has been thus used by some observers.

In general the differences seem to be favorable to the use of the vertical circle and it is probably the best type of instrument yet devised for obtaining fundamental declinations. The use of the micrometer to obtain additional bisections may lead to the securing of greater accuracy.

About 5,000 observations made by the writer from December, 1903, to July, 1907, have been reduced. One of the levels used in the early part of the work did not give satisfactory results, but for the last 3 years of the work, the levels performed in a fairly satisfactory manner. During that period the element of probable error due to levels (mean of two) in a declination resulting from a single observation was $0''.035$.

The division errors were not measured, but their effect was reduced by reading on two divisions under each microscope and by shifting the circle. The probable error of a single observed declination due to division error is $0''.15$

The sine flexure was measured in 1910 after the installation of horizontal collimators. From 14 sets of measures the value $+0''.79 \pm 0''.063$ has been adopted.

The variation of latitude as given by the International Geodetic Commission has been applied.

From 1,190 observations on 134 circumpolar stars at both culminations, the following correction to the latitude, $\Delta\phi$, and correction to the refraction constant, ΔR, were obtained:

$$\Delta\phi = +0''.50 \pm 0''.090,$$
$$\Delta R = -0''.22 \pm 0''.056.$$

As the separation of $\Delta\phi$ and ΔR was not well determined, it was assumed that $\Delta R = 0$ and the resulting value $\Delta\phi = +0''.15 \pm 0''.017$ was adopted.

The accidental error of a single observation, not including division error, is shown in the following table:

Z. D.	No. O B S.	Probable Error
0°–10°	766	±0′.284
10 –30	1496	.243
30 –50	1340	.276
50 –70	1220	.335
70 –75	328	.465

On account of the construction of the instrument, it is difficult to observe stars near the zenith and this probably accounts for the larger probable error of stars from 0° to 10° as compared with those from 10° to 50° zenith distance.

Z. D.	No Stars	Obs. N	Obs. B
285°–290°	42	−0″.03	+0″.03
290–300	54	− .08	− .06
300–310	22	− .12	− .20
310–320	27	− .17	− .10
320–330	60	+ .35	+ .31
330–340	68	+ .02	+ .07
340–350	69	− .20	+ .11
350– 0	102	+ .05	+ .32
0– 10	96	+ .22	+ .58
10– 20	114	+ .31	+ .56
20– 30	113	+ .30	+ .53
30– 40	115	− .01	+ .34
40– 50	100	+ .23	+ .57
50– 60	89	+ .41	+ .72
60– 70	71	+ .32	+ .47
70– 75	15	+ .42	+ .52

The comparisons of the observed declinations with those of Newcomb (N) and those of Boss (B) after the application of the corrections for sine flexure and $\Delta\phi$ are as follows. The signs have been changed for sub-polars.

In addition to the above observations there are about 2,500 made by Mr. Geo. A. Hill and Mr. H. B. Evans from 1898 to 1903, which are nearly reduced. A preliminary survey indicates the following relative personal equations for declinations of the south stars:

$$\text{H–L} = -0''.2,$$
$$\text{E–L} = -0''.4.$$

Some experimental work to clear up this matter will be undertaken before combining these observations into a catalogue.

The Earth's Radiation Zones: W. J. Humphreys. (Read by Professor Eichelberger.)

Since heat may be transferred from one object to another only by conduction, convection or radiation, therefore by measuring the temperature of the isothermal region of the atmosphere, in which both conduction and convection are small, it is possible to determine the radiation intensity of the earth at as many places as one may wish.

The effective radiating level, as determined by Abbot and Fowle, has an average elevation of about 4 kilometers, consequently the lower clouds are within the radiating surface while the cirri are above it. Hence the latter, and they alone, can strongly affect the intensity of the outgoing radiation.

An extensive exploration of the upper atmosphere with sounding balloons has shown that, probably because of the unequal distribution of cirri, the intensity of the earth's escaping radiation within the tropics is to that of latitudes 35° to 60° approximately as 3 to 4. In fact, as a radiator the earth has an inefficient equatorial zone, efficient zones of middle latitudes, and finally, for which there is some evidence, inefficient polar caps.

The Amount and Vertical Distribution of Water Vapor on Clear Days: W. J. Humphreys. (Read by Professor Eichelberger.)

It is important to any one using a bolometer, or a pyrheliometer, to know the approximate amount of water vapor through which the radiation reaching his instrument has passed. In attempting to determine this amount the records have been brought together of 74 balloon flights, made on cloudless days, or such as were adapted to the ordinary use of the bolometer.

According to these data the amount of water vapor per unit volume decreases with elevation on *cloudless* days in an approximate geometric ratio, and the thickness of the water layer that would result from a condensation of all the water vapor in the atmosphere on such days above any given level may be approximately expressed by the equation

$$d = 2e,$$

in which d is the depth of the water layer in millimeters, and e the partial pressure of the water vapor, at the place of observation, in millimeters of mercury. This value is about 13 per cent. less than that given by Hann for all sorts of days, and heretofore commonly used in bolometric work.

Daytime Laboratory Work in Astronomy: Sarah F. Whiting.

The list of members of this society includes those responsible for the teaching of astronomy in more than fifty colleges and universities. It seems therefore in order that the society should take cognizance not only of the research work by which knowledge is increased, but also of the teaching by which it is diffused.

From not very detailed information it seems probable that the methods of teaching generally used in elementary classes are not those of the other sciences.

Daytime laboratory work in astronomy by the students themselves requires a teaching force, an equipment of instruments and photographs, and a place for the work, which has not yet been demanded by the departments of astronomy nor provided by the institutions. No less research work should be done by the observatories, but the teaching should not be allowed to suffer. Useful apparatus and photographs which are the material for daytime work will never be provided by dealers in apparatus till a sufficient number of institutions adopt modern methods of teaching to make a demand for such material. Also larger numbers of students should take an elementary course in astronomy to lessen the deplorable ignorance which exists.

Other learned scientific societies have lent valuable aid to the advancement of elementary teaching. May it not be for the advancement of astronomy for this society to consider the teaching of those beginning classes from which the professional astronomers and the patrons of the observatories must come?

On Scales of Intensity for the Lines of the Solar Spectrum: Frank W. Very. (Read by Mr. De Lury.)

A spectral line not appreciably broader than an image of the slit, and perfectly black, may be rated as 10 on an absolute scale of intensity, and the strength of any line in absolute units is the product of its width by the intensity of its absorption, multiplied by a constant. The constant may be chosen so that unity coincides with Rowland's unity, and it is found that in this case the above definition is very closely fulfilled, although Rowland's numbers diverge considerably in other parts of the scale.

From a smooth curve which represents the true photometric intensities of ultra-violet lines on negatives by Higgs, the significance of Rowland's symbols has been found to be as follows:

$R_{0.1} = 0000 = .05$	$R_1 = 1.05$	$R_6 = 10.60$	$R_{11} = 21.40$
$R_{0.2} = 000 = .15$	$R_2 = 2.57$	$R_7 = 12.80$	$R_{12} = 23.55$
$R_{0.3} = 00 = .25$	$R_3 = 4.30$	$R_8 = 14.95$	$R_{13} = 25.70$
$R_{0.4} = 0 = .35$	$R_4 = 6.30$	$R_9 = 17.05$	$R_{14} = 27.85$
	$R_5 = 8.40$	$R_{10} = 19.20$	$R_{15} = 30.00$

These values have been confirmed by measures in the green.

It is shown that, in general, the relation between the width and the intensity of the photographic images of spectral lines is not as simple as has been assumed. It is also shown that differences of width of spectral lines have been exaggerated in Thollon's Atlas, doubtless in order to convey a more realistic impression of the intensities.

Periods of Variable Stars in the Small Magellanic Cloud: HENRIETTA S. LEAVITT.

(Read by Professor Russell.)

The periods of 25 of the variable stars in the Small Magellanic Cloud have been determined, and have been found to vary in length from 1.25336 days to 127.0 days, while the light curves are of the cluster, sometimes called the ''antalgol'' type. The brightness and the length of the period are so closely related that if one is known, the approximate value of the other may be inferred. For an increase of one magnitude in brightness at maximum or minimum, the logarithm of the period increases by about 0.48. It seems possible that all these variables are of similar mass, those whose periods are long having slight densities, and *vice versa.* On account of their faintness, it is impracticable to obtain their spectra, with our present facilities. A number of brighter variables having similar light curves, as UY Cygni, are in isolated positions, and should repay careful study not only of their spectra, but, if possible, of their parallaxes. Among other questions suggested are the following:

1. Are there definite limits to the mass of variable stars of the cluster type?

2. Does the spectra of such variables having long periods differ from those of variables whose periods are short, and how?

The Radial Velocities of 96 Herculis: S. A. MITCHELL.

Preliminary results from the measures of twenty-five spectrograms of 96 Herculis taken with the one-prism Bruce spectrograph of the Yerkes Observatory show the presence of four components and a period of 50.2 days. On account of the large velocities, which range on the plates measured from — 98 kilometers per second to + 74 kilometers per second, it was possible to measure three separate components on half the plates, and four components on a few of them. The components all belong to the B-type.

This interesting system will be followed closely, and more definite results will be given when more plates are obtained.

The San Luis Observatory of the Carnegie Institution: R. H. TUCKER.

The first part of the expedition sailed from New York in August, 1908.

Ground was broken for the observatory, on land set aside by the national government, a month later.

The piers were built of reinforced concrete, and the observatory and dwelling of brick, with wooden roofs covered with rubberoid. The shutters for the meridian circle building were constructed at Albany, before starting, and were taken out by freight along with the rails for the floor, instruments for preliminary adjustment, chronometer and one of the astronomical clocks.

Five months later the dwelling was ready for the staff of ten men, and the observatory was completed for the installation of the Pistor and Martins instrument of the Dudley Observatory.

Observing on the regular list was begun in April, fundamental and miscellaneous observing being taken up. The full list contained 15,000 stars. About 1,600 of these were fundamentals, of varying degrees of precision; from 4 to 32 observations were taken of each; usually the observations have been in excess of the requirements. The first year 61,000 observations were made, though, from the time observations were in full swing, 62,000 were made in one year. About 300 nights were available for observations, of which 200 were clear throughout, in the first year. At the close of the work, in January, 1911, there had been made 87,000.

These were taken in 650 series, of which a full night would include two.

Above 300 fundamental series had been made, each including the observations for groups of primary clock stars twelve hours apart, and those for the combination of successive upper and lower culminations of one or more circumpolar stars.

For the study of the refraction 3,000 observations of stars at large zenith distances were made.

For the corrections to the instrument, collimation had been regularly observed; flexure at the beginning and end of the work; pivot error and division error were measured with sufficient detail to confirm the more elaborate investigations at Albany; and 400 reflection observations were obtained, an average of 40 for each ten degrees employed.

For the personal corrections of the observers, over 2,000 determinations of the magnitude equation were made, by the five telescope observers.

Special determinations of the value of the screen employed accompany this correction. For the bisection error and transit error (N.-S.) 1,750 observations were made. The difference of eye and ear minus chronograph was determined for the observers.

The instrument was dismembered in February of this year, and was returned to the Dudley Observatory, where the reductions will be completed.

Short Formula for Computation of Circum-meridian Azimuths: C. C. SMITH. (Introduced by Dr. W. F. King.)

A short formula for the computation of azimuths observed near the meridian is here given. The ordinary formula for azimuth requires the use of a subtraction logarithm. In the short formula $1 + \cot\delta \tan\phi \cos t$ is expanded in a series and after rearrangement and reduction gives a formula for azimuth which requires the looking up only of the natural logarithm of the declination, after which the multiplications may be quickly carried out on the arithmometer. The formula is much shorter and gives less chance for error than the ordinary formula, especially where a considerable number of observations have been taken at each station.

Changes in Collimation and Level of the Ottawa Meridian Circle: R. M. STEWART.

This paper deals with the observations made at Ottawa from March to December, 1910. Measurements of collimation and level were made usually twice in the course of an evening's work; the changes during the interval (four hours on the average) are here investigated. The average change of collimation was $+ 0''.03$ for Clamp East and $- 0''.20$ for Clamp West; these changes run with great regularity, changing invariably with the reversal of the instrument, and appear to be entirely independent of seasonal and temperature changes or of the interval between the observations. The changes of level were not sensibly affected by reversal of the instrument, but there is some evidence of a small seasonal effect.

Preliminary Measures of the Solar Rotation: J. S. PLASKETT.

This paper is a first contribution towards the scheme of cooperation in determining the solar rotation by the Doppler displacement of the spectral lines, which was organized at the meeting of the Solar Union at Mt. Wilson last September. A large amount of preliminary work which is briefly described has been performed for the purpose of ascertaining the most suitable apparatus and methods for accurate work. The mean of 23 rotation plates, obtained in June and July of the present year, gives, at the equator, a velocity of 2.034 ± 0.004 kms., the probable error of a single plate from the mean of the plates being ± 0.017 km. The average probable error of a single line is ± 0.021 km., varying from ± 0.010 to ± 0.030 km. in the different plates.

The measures of upwards of 50 spectra, in the region allotted to this observatory λ 5,500 to λ 5,700 give no definite indication that the velocity due to any particular lines or elements differs from that of the general reversing layer. Tabulating the residuals from the lines on these plates, it is found that the mean residual, taking account of the signs, is in only one case, and that a faint and diffuse line, equal to as much as one half the average numerical residual. Furthermore, the measures of twelve plates of the spectrum of the sun's limb, which had impressed upon them an arbitrary displacement of the same magnitude and character as the rotation plates, differing from the latter only in the displacement being the same for each line, show small varying displacements of different lines of the same order as those obtained for the rotation plates. It is probable, therefore, that in the region under consideration there is no systematic difference in the velocities of rotation obtained for different lines or elements, the very small differences observed being probably due to the character of the lines for measurement.

Preliminary Report on the Photographs of Halley's Comet taken at Honolulu, H. I., by Ferdinand Ellerman in 1910: E. E. BARNARD. (Read by Dr. Slocum.)

The expedition for the observation of Halley's comet, sent in 1910 to the Hawaiian Islands by the Astronomical and Astrophysical Society of America in the sole charge of Mr. Ferdinand Ellerman, established itself on the south slope of Diamond Head about five miles southeast of Honolulu, Oahu Island, and at an elevation of about one hundred and fifty feet above sea-level.

The instrumental equipment consisted of a Warner and Swasey mounting with a six-inch Clark lens, loaned by the Lick Observatory; a metal camera with a Brashear six-inch portrait lens of thirty-two inches focal length, loaned by Brashear; and a wooden camera with a two-and-one-fourth-inch Bausch and Lomb Optical Company-Zeiss Tessar lens of nine and seven eighths inches focus, loaned by the Bausch and Lomb Optical Company. The cameras were carried on the telescope tube.

Mr. Ellerman secured an excellent series of photographs of the comet and made very important though negative observations at the time of the comet's transit across the sun on May 18. On this date, though small spots could be distinctly seen on the sun's surface, no trace of the comet or its nucleus was evident.

Visual observations of the extent of the tail of the comet on the mornings of May 15, 16 and 17 accord with observations made elsewhere. In the record of May 24 occurs the following note: "Nucleus of comet appeared double or dumbbell-shaped. Separation estimated about 20″ of arc."

Mr. Ellerman secured sixty photographs of the comet with the six-inch Brashear camera and thirteen with the Tessar. Many of these photographs are exceedingly interesting, but in the main they agree with other photographs in showing that very little of the abnormal occurred in the phenomena of the comet's tail. One thing apparent in the phenomena of Halley's comet which was first shown in Daniel's comet was the fact that on several occasions two slender streams, which doubtless had their original intersections in the nucleus, receded from the head still connected as if the source of supply were going out with them.

The length and breadth of the tail of Comet Halley as shown on Mr. Ellerman's Tessar plates are here tabulated.

Near its extremity the tail was always very faint on these photographs. On the plate of May 14 at least twelve degrees of the forty-nine recorded was very faint.

Date, 1910	Length of Tail	Width	At Distance from Head
May 4	28°	2°.7	18°
5	31	4.0	19
6	21	2.6	16
7	27	3.1	18
8	24	3.1	18
9	30	3.7	18
11	32	4.3	27
12	43	2.3	27
14	49	4.3	38
28	32	6.6	23
June 1	15	1.8	12

The Solar Prominence of October 10, 1910: FREDERICK SLOCUM.

This paper is based upon a series of photographs taken in the light of calcium with the Rumford spectroheliograph of the Yerkes Observatory, and upon some hydrogen photographs, nearly simultaneous, taken by Mr. Ellerman at the Solar Observatory, on Mount Wilson.

The prominence extended from latitude — 24° to latitude — 40° in the east limb, and reached a height of 105,000 km. In connection with the spectroheliograms are discussed the relations of hydrogen and calcium images, absorption effects due to dark masses projected against bright prominences and gravitational effects upon prominence particles.

Direct photographs of the H and K region of the spectrum between λ 3,910 and λ 3,980, were made with the slit across different parts of the prominence. These show the H_3 and K_3 lines following sinuous courses throughout the whole lengths of the H_2 and K_2 lines. The local relative displacements of the emission and absorption lines amount to $\pm$ 0.20 A, corresponding to velocities of about 15 km. per second if the displacements are manifestations of the Doppler effect.

Vapor-density Effects on the Calcium Lines H, K and g: OLIVER J. LEE. (Read by Dr. Slocum.)

The experiment discussed in this paper was undertaken because of the writer's interest in the anomalies shown by these lines of calcium in radial velocity work, and limits itself to determining the relative vapor-densities at which self-reversal occurs.

The high temperature, about 2,500° C., required to vaporize and incandesce calcium makes the usual apparatus for experiments on vapor-density quite useless. The rate of volatilization of the element under standard conditions was assumed to be constant and was made the basis of the experiment. The apparatus devised consists of a carbon rod, mounted in a spindle and made to rotate between the poles of a right-angled arc fed by a 20-ampere direct current at 40 volts. The end of the rod is bored to receive charges of the metal up to .5 gram. The inside of the bore is projected by a lens upon the slit of a concave grating spectrograph.

The calcium was introduced into series of tubes in two different ways: (1) The tubes were filled with a supersaturated solution of calcium chloride diluted in multiples of two; (2) uniform slivers of metallic calcium each of weight about 2 mgr. were weighed out into charges of from 5 to 100 mgr. and placed in the heating tubes. Each tube was charged only once, and two to five exposures of 20^s each were made with it. About 800 photographs were taken with 225 tubes. The temperature of the bore was determined from a curve constructed with currents and melting points of refractory metals as arguments. The approximate effect of the calcium impurities in the carbon tube and the air was obtained and allowed for.

Conclusion: The lines g, λ 4,227, and H, λ 3,968, require for reversal vapor-densities that are about 1/7 and 3/2 as great, respectively, as that necessary for a reversal of K, λ 3,933, when the vapor is observed at a temperature of 2500° C. and at atmospheric pressure.

(To be published in the *Astrophysical Journal.*)

Radial Velocity of Halley's Comet as Derived from a Spectrogram: EDWIN B. FROST. (Read by Dr. Slocum.)

The radial velocity of Halley's comet on May 24, 1910, as determined by the writer from the displacements of the Fraunhofer lines, was + 55 km. per second. The velocity calculated from the ephemeris of the comet agreed with this value within a kilometer.

Note on the Magnitudes of the Stars in the Cluster, Messier 3: S. I. BAILEY.

Certain globular clusters appear to be composed of two groups of relatively bright and faint stars, with few stars of intermediate magnitudes. This appearance has been noted by Pickering, Palmer, Fath and the writer.

A recent plate taken by Ritchey on Mount Wilson with the 60-inch reflector, having an exposure of four hours, shows extremely faint stars. An enlargement of this plate, loaned for this purpose by the acting director of the Solar Observatory, was used for the present discussion. The faintest stars shown appear to be of magnitude 21.5. The number of stars is probably not less than 30,000. An enlargement was made with a réseau dividing the photograph into 1,280 squares. The magnitudes of all the stars in 160 of the squares were determined by comparison with the sequence selected for the study of the variables in the cluster. The number of stars thus measured was 2,542. The scale of magnitudes as extended to the fainter stars may be somewhat in error.

Grouped by magnitudes, the number of stars of each magnitude from 13.5 to 21.5 is as follows: 2, 6, 16, 31, 43, 221, 576, 1,071 and 573; the total light derived from the groups in percentages are: 11, 20, 15, 11, 6, 12, 13, 10 and 2. The light of stars fainter than magnitude 21.5, if such exist, is probably negligible. The stars of the four groups, 13.5 to 16.5, give 57 per cent. of the light of all the stars measured, and those of the four groups, 18.5 to 21.5, 37 per cent. The group at 17.5 may be regarded as intermediate, and here the light is a minimum. The total light of the 2,542 stars whose magnitude was determined is approximately equal to that of a star of magnitude 10.4.

From the relation between the known magnitude of the whole cluster regarded as a single object, and that portion studied in the present paper, assuming that the distribution of the stars by magnitudes is the same throughout, the whole number of stars in the cluster may be derived. This number will be in error, if the scale of magnitudes employed is incorrect. By an independent determination of the number of stars by count, the error in the scale of magnitudes, if any, may be determined.

Tables of Effective Wave-lengths of Lines in Stellar Spectra: S. ALBRECHT. (Read by Mr. W. E. Harper.)

This paper is a report of progress in the work, begun in 1906, of determining the effective wavelengths of spectrum lines in stellar spectra. The writer has determined tables of wave-lengths for each of the main divisions of the Draper classification (as modified by Miss Cannon) from types B to M, both inclusive. The part of the spectrum covered is from λ 4,236 to λ 4,655. The work is based on measures made, while at the Lick Observatory, on spectrograms taken with (*a*) the Northern Mills three-prism spectrograph having λ 4,500 central with Ti-spark comparisons; (*b*) the Southern Mills three-prism spectrograph, λ 4,450 Central and Ti-spark comparisons; (*c*) the same Southern Mills spectrograph but with λ 4,340 Central and Fe-spark comparison spectra. These tables are preliminary to the more extensive investigation which has been made possible by the generous loan from observatories in different parts of the earth of suitable sets of spectrograms.

The relative accuracy attained, though naturally not quite equal to that of the International secondary and Kayser's tertiary standards, apparently approximates these in each set of measures separately for a large number of the lines which are best suited for accurate measurement. Differences of a systematic nature were encountered which might easily have escaped notice if the work had been based upon only one instead of three practically different sets of spectrograms.

A large number of lines has been found, in addition to those already published, whose wave-lengths vary progressively from type to type.

Inasmuch as the accuracy attainable in the relative wave-lengths of lines in stellar spectra, with a good modern three-prism spectrograph, is not much inferior to the accuracy of the available standards of wave-length, it is important for the future progress in this work that results show clearly on what line or group of lines any newly determined wave-lengths are based. Designations like "On the Rowland system" are not sufficient. Results should be published in such form as to be readily convertible to any standard system. This should be done with due regard to the increasingly necessary precaution to condense published results as much as possible without impairing their usefulness.

Wave-lengths of the Silicon Lines λ 4,552.7, λ 4,567.9 and λ 4,574.9 in Stellar Spectra and in Laboratory Spectra: S. ALBRECHT. (Read by R. J. McDiarmid.)

Among the lines whose wave-lengths were dedetermined as part of the extensive program referred to in my preceding note are the three silicon lines λ 4,552, λ 4,567 and λ 4,574, which were first identified with silicon, in stellar spectra, by Lunt. It is not within the scope of this paper to go into much detail. The principal object, besides giving the wave-lengths in stellar spectra, is to call attention to the need of more extensive study of these lines in the laboratory. This will be evident from the tables given below. In table I. are given the wave-lengths of these lines as determined from stellar spectra. For purposes of comparison with the wave-lengths obtained from the Lick spectrograms, I have computed the wave-lengths from the measures of Frost and Adams, published in the Publications of the Yerkes Observatory, Vol. 11. Table II. gives a summary of the determinations of the wave-lengths in stars and in the laboratory.

TABLE I

Based on	In Stars	Determined from		
		Types	No. of Spectrograms	No. of Stars
Lick spectrograms...	4552.752	B to B2	47	7
	.798	B3 to B5	8	4
Mean............	*4552.759*	B to B5	55	11
Yerkes spectrograms	4552.770	B to B3	42	10
	.717	B5 to A	5	3
Mean............	*4552.765*	B to A	47	13
Lick spectrograms...	*4567.970*	B to B5	49	9
Yerkes spectrograms	*4567.963*	B to A	44	12
Lick spectrograms...	*4574.916*	B to B3	41	6
Yerkes spectrograms	*4574.920*	B to A	22	9

TABLE II

Wave-length in Stars			Laboratory Values			
			With High Dispersion		With Low Dispersion	
Albrecht	Gill	McClean	Exner & Haschek	Frost & Brown	Lockyer	Lunt
4552.762	4552.79	4552.6	*4552.75*	*4552.64*	4552.8	4552.75
4567.967	4567.90	4567.5	*4567.95*	*4567.90*	4568.0	4567.82
4574.918	4574.68	4574.5	*4574.9*	*4574.79*	4574.9	4574.86

The values of the wave-lengths in stars, table I., as determined from the Lick spectrograms and from the Yerkes spectrograms are in very close agreement. The early determinations by Gill and by McClean, which are added in columns 2 and 3 for the sake of completeness, were, I believe, determined with low dispersion. The laboratory values, table II., by Exner and Haschek (*Aph. Jour.*, 12, 49, 1900) and by Frost and Brown (*Ibid.*, 22, 159, 1905) were both determined with high dispersion. The wave-lengths by Exner and Haschek are slightly smaller, 0.016 Å, on the average, while the values of Frost and Brown are 0.122 Å, 0.067 Å and 0.128 Å smaller, respectively, for the three lines than the wave-lengths in stars. The two laboratory determinations differ by 0.11 Å 0.05 Å and 0.11 Å, respectively, for the three lines, which is equal to an average systematic difference of 0.090 Å. Measures by Frost of another plate, taken by Mr. Fulcher, of the silicon spark in air gave the wave-length of λ 4,567 ". . . quite a little larger than on the plates taken with the observatory grating." This latter measure was not given, but it is in the direction of the value for the line by Exner and Haschek. Frost (*Aph. Jour.*, 1910) recognized the fact that the use of his laboratory determinations of the wave-lengths did not increase the accordance, in stellar spectra, of the velocities from the separate silicon lines.

The large systematic differences in the laboratory determinations would indicate that the effective wave-lengths of these lines may be influenced, in some way at present unknown, by the conditions of the experiment. As the lines are generally diffuse and are sensitive to the atmosphere surrounding the spark, it seems likely that differences in the electrical conditions of the spark or in the surrounding atmosphere produce an unsymmetrical widening of the lines.

Further laboratory investigation of these lines, under a variety of different conditions, is of great importance in the discussion of fundamental problems in astrophysics.

On Fundamental Systems of Wave-lengths in Stellar Spectra, and especially for the B Type Stars: S. ALBRECHT. (Read by Mr. Parker.)

The object of this note is to point out a clew to the elimination, in part at least, of systematic errors in the wave-lengths of the B type stars.

In the stellar spectral types A to M a considerable number of the spectrum lines in two or more neighboring main divisions of the spectral classification have a common origin. This makes possible a comparison of the wave-lengths in any one type with the wave-lengths or system of wave-lengths in any other type, from types A to M, both inclusive. In consecutive spectral types the systems of wave-lengths can be compared with comparative ease. In the B types, however, the lines are, with a few exceptions, of entirely different origin from the lines of even the A type, and it is only by means of the few lines which the B and A types have in common that the system of wave-lengths in the B type can be connected with the systems of wave-lengths in types A to M.

A connection with each other of the systems of wave-lengths in the different spectral types is highly desirable in the solution of several problems, the more important of which are perhaps: (*a*) the classification of stellar spectral types; (*b*) the elimination from the system of wave-lengths for each type of shifts, other than those due to radial velocity, which are systematic for the entire system of lines, or for groups of lines in each type, and which may be due to such effects as "pressure" or to other causes. The shifts which are shared by all lines are at present included in the radial velocities of the stars.

One of the best lines which is at present available for this purpose is H-gamma. The wave-length in the A type was found to be 4,340.655, and it diminishes progressively, slowly from types A to G and more rapidly from types K to M. If we make a plot with wave-lengths as ordinates and spectral types as abscissæ, a smooth curve can be drawn through the points in the plot from types A to M. If this curve were extended to the B type, it would indicate a wave-length for that type of 4,340.657. The wave-length actually found for the line in the B types is 4,340.627.

As pointed out above this difference for the B type, relatively to other spectral types, is at present to be taken as merely an indication of a method of approach for the solution of this problem. The final solution will have to be based upon a greater number of lines, extending over a longer portion of the spectrum. For a proper distribution to each spectral type, of relative differences which may be found in the different types, it will be absolutely essential to have an accurate knowledge of the behavior of spectrum lines under various different conditions.

In conclusion I wish to refer briefly to the importance which the solution of this question has in connection with our conception of the structure of the sidereal universe. If the results found for H-gamma should be confirmed by a more extensive investigation, such systematic differences in the radial velocities of stars as a function of the spectral type, as were found, I believe, by Kapteyn, Frost and Campbell, may find a simple explanation.

Photographic Determination of the Position of the Moon: HENRY NORRIS RUSSELL. (Read in connection with the Symposium on Photographic Astrometry.)

The photographs discussed below were taken at Harvard by Mr. King, and, by the kindness of Professor Pickering, were sent to the writer for discussion. They were measured and reduced at Princeton by Professor A. H. Joy, of the Syrean Protestant College, Beirut, and the writer, according to plans prepared by the latter. An account of the results will soon appear in the *Harvard Annals*.

To secure comparable images, the exposures to the moon must be less than a thousandth of those on the neighboring stars; and, except during this short exposure the objective must be completely shielded from the moon's rays to avoid fogging by diffusely reflected light. This was accomplished by placing a disk, some distance in front of the telescope, which shades the objective from the moon, but is not so large as to cut off much of the light from the surrounding stars. This disk may be turned edgewise for a short exposure on the moon, the exact time of which is recorded chronographically.

The instrument employed was the Metcalf telescope of sixteen inches aperture and eighty-seven inches focal length, stopped down to $3\frac{1}{2}$ inches aperture, with a disk five inches in diameter carried on a pole nine feet long attached to the telescope tube. Exposures of ten minutes on the stars and of 0.2 to 0.4 second on the moon, gave very satisfactory plates.

A standard réseau, was photographed on each plate. The rectangular coordinates of the stars chosen for reference points were measured with respect to this system, and also those of ten or more points on the moon's illuminated limb (most of these being the intersections of the limb and réseau lines). After allowing for the slight distortion of the moon's apparent disk by refraction, the circle which passed as close as possible to the measured points on the limb was determined by least-squares, and its center assumed to coincide with that of the moon. The determination of the right ascension and declination corresponding to this point on the plate and the comparison with the tabular places of the American Ephemeris, were made in the usual way.

The probable error with which the coordinates of a star relative to its neighbors are determined from a single plate is $\pm 0''.25$. The absolute positions of the same stars, given in the catalogues consulted, appear to have probable errors of about $\pm 0''.4$ in each coordinate. The measures of the moon's limb are almost as accurate as those of the star-images; but the actual irregularities of the surface raise the probable error of position of one measured point (determined by means of its departure from the mean circle of the limb) to $\pm 0''.47$.

More dangerous than any of these errors is that arising from imperfect guiding. If the telescope is not directed towards exactly the same point in the heavens during the short exposure on the moon as, on the average, it is during the long exposure on the stars, errors will result which with a poor mounting might be very serious.

To investigate such errors, special plates were taken, on which bright stars were photographed in exactly the same way as the moon. These showed that the combined effects of errors of guiding and measurement is equivalent to a probable error of $\pm 0^s.031$ in R.A. and $\pm 0''.29$ in declination.

Combining all these results it appears that the known errors of observation will account for probable errors in the deduced places of the moon of $\pm 0^s.044$ in R.A. and $\pm 0''.40$ in declination.

Eleven plates have so far been discussed. The agreement of pairs taken on the same night is satisfactory. Comparison of the results of observations on different nights is complicated by the fact that the errors of the moon's tabular place are now large and variable. Through the courtesy of the Astronomer Royal, Professor Dyson, the results of the Greenwich meridian observations of the moon are available for comparison. The Greenwich and Harvard results agree excellently *inter se*, showing that in December, 1910 (during which month most of the plates now discussed were taken), the moon was ahead of her tabular position by an amount varying from $10''.7$ on December 9 to $4''.8$ on December 22, and at the same time $0''.6$, on the average, south of the tabular place. Representing this by an empirical curve, it is found that the outstanding probable errors of one observation at Greenwich are $\pm 0^s.048$ R.A. and $\pm 0''.57$ in declination, while those of the result of one plate are $\pm 0^s.043$ and $\pm 0''.55$.

The photographic method, therefore, appears to give results, on its first trial, somewhat superior in accuracy to those of meridian observations of the first class. It also appears, upon comparison of the observed and predicted probable errors of observation, that the greater part of the error of the photographic results arises from definitely known sources of error. There is little doubt that these can be considerably diminished by appropriate methods.

The photographic method has also the two great advantages that its errors are for the most part different in origin from those of meridian observations, and hence independent of them, and that it is available over a wide range of hour angles. It seems, therefore, likely to prove of great value in the attempt to improve our knowledge of the moon's motion.

Many more plates have already been taken at

Harvard, and it is hoped that arrangements for their regular measurement will soon be completed.

Note on the Ellicott Astronomical Instruments: A. E. Douglass.

These five instruments are now on permanent exhibition in the U. S. National Museum at Washington. They were partly made by Ellicott between 1780 and 1790 and were all used by him between that time and 1820. The zenith sector, six feet in focus, is suspended by its objective end. The eye end carries an arc, divided to degrees, which passes beneath a plumb line. The fractions of degrees are read by a micrometer. This is the type of instrument by which Bradley discovered aberration and nutation and with which the flattening of the earth's figure was first determined. This telescope itself was made by the Rittenhouse brothers in Philadelphia before 1784 and is a copy of the instrument used in locating Mason and Dixon's line. This instrument was used in locating the point where the boundary between the United States and Canada touches the St. Lawrence River. Bradley's original sector with its iron tube and mounting is now in the Royal Observatory, Greenwich. The small zenith sector, 20 inches in length, was used as a substitute for the larger in much boundary work.

The "transit and equal altitude" instrument was used in laying out the boundaries and avenues of the city of Washington, and many state boundaries. It is the type used in much surveying work in the eighteenth century. Instruments of this type may also be seen in the American Philosophical Society at Philadelphia, at Harvard University and in the Museum of the Buffalo Historical Society.

The quadrant is the oldest type of measuring telescope and is likely to be the oldest of this collection. A similar instrument of larger size is at Harvard University. There are many in the European Science Museums.

The four-foot telescope was made by W. and S. Jones, of London. It was used for longitude work by observations of Jupiter's satellites.

The metal work of these instruments is entirely of brass and, except for two of the smaller lenses, all are in excellent condition.

Report of the Committee on Photographic Astrometry: F. Schlesinger, chairman.

The report of this committee took the form of a symposium. The chairman outlined briefly what had been done previously on the determination of star places by photography. The experiments of Pickering, Hagen, Hirayama, Trümpler, Donner, Jacoby, Cookson, Ross and Pluvinel were briefly described. The chairman then presented the following resolutions, which were adopted at a meeting of the committee held in New York on April 23, 1911, when there were present Messrs. H. Jacoby, E. C. Pickering, H. N. Russell, F. Schlesinger, E. W. Brown and S. A. Mitchell, the last two by invitation:

RESOLUTIONS

The Committee on Photographic Astrometry of the Astronomical and Astrophysical Society of America is strongly of the opinion that photographic methods can be applied successfully to absolute as well as to differential determinations of star positions, thereby gaining the advantage of independent observations with instruments of entirely different characters. The committee recommends:

1. That the north and south polar points be determined by means of trails secured with a fixed telescope according to the method originally proposed by Pickering and developed by Jacoby.

2. That these polar points be connected with a number of regions on the equator and that the latter be connected among themselves by the methods proposed by Turner on pages 427 et seq., Vol. LXXI., *Monthly Notices of the Royal Astronomical Society.*

3. That the method proposed by Pickering (to be published soon in the *Harvard Circulars*) be used to determine the positions of stars to the twelfth magnitude in the immediate vicinity of the equator.

4. That the differential method proposed by Turner (page 422, Vol. LXXI., *Monthly Notices of the Royal Astronomical Society*) be employed to ascertain the positions of stars referred to the standard regions mentioned under 2.

The committee is further of the opinion that the degree of accuracy attainable by these methods can not be predicted with certainty, but can be found only by accurate trial.

The symposium then continued with the reading of papers (given above in abstract) by E. C. Pickering and H. N. Russell; and various aspects of the general problem were discussed by Messrs. C. L. Doolittle, Littell, Russell, Tucker, E. C. Pickering, Frisby and the chairman.

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