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CONTENTS

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THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

I

THE eighth annual meeting was held December 27 to 29, 1906, at Columbia University, New York. About sixty-five members attended and thirty-two papers were presented.

President Pickering, on taking the chair, discussed three lines of work which he believed the society should pursue. First, by cooperation to carry out some great routine investigation too extensive to be undertaken by a single observatory. The best example of this was the accurate determination of the positions of the northern stars, by European and American observatories, under the direction of the Astronomische Gesellschaft. Second, to bring together socially astronomers from all parts of the country, especially the older and younger men. The latter may think the work of the older men out of date, but they may find the experience of the older men and their personal acquaintance with the eminent men of still earlier date of great assistance. The older men have much to learn regarding new methods, and the extensive appliances at their command may often be employed to much greater advantage if they keep themselves personally in touch with the most recent developments of astronomical research. Third, the presentation of papers. While hitherto this has been the principal function of this and other societies it is not necessarily the most valuable. General discussions are more interesting and instructive than long technical papers. It may, therefore, be wise to follow the example of some of the engineering societies, and print abstracts of papers for distribution some days before the meeting. A brief statement is made by the author of each paper, and the greater portion of the time is devoted to discussion. The ideal conditions for meetings of the society would seem to be—a large hotel where all would eat and sleep under the same roof, and where the meetings could be held in the same building.

On the afternoon of December 28, a general discussion took place regarding neglected fields of work in astronomy, in which a large number of members took part, and the views expressed were varied and interesting. The president, in opening the discussion, cited a number of examples of fields of work, which seemed to him important but neglected. For example, in the astronomy of position, the formation of a standard catalogue of stars uniformly distributed, having similar spectra, and of nearly the same magnitude. Many troublesome sources of error, like those due to magnitude and color, would thus be eliminated. The variation in latitude should be studied at a series of southern stations like those now in operation in the northern hemisphere. The systematic search for double stars of the ninth magnitude and brighter, undertaken at the Lick Observatory, should be extended to the south pole. Photometric measures of faint stars, of comparison stars for faint variables, of the components of clusters, and of nebulæ are much needed. It is not known whether the spectra of nine tenths of the nebulæ are gaseous or continuous. A wide field is opened in the study of the spectra of bright variables when faint, and of faint variables when bright, of the distribution of faint spectra and of the components of clusters.

The election resulted as follows:

President—Edward C. Pickering.
First Vice-president—George E. Hale.
Second Vice-president—William W. Campbell.
Secretary—George C. Comstock.
Treasurer—C. L. Doolittle.
Councilors for 1907–9—Ormond Stone and W. S. Eichelberger.

The council designated Harold Jacoby to act as editor for 1907–8.

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

Distribution of Double Stars in the Zone $+56°$ *to* $+90°$: R. G. Aitken.

The survey of the sky undertaken at the Lick Observatory to secure data for a statistical study of the number and distribution of double stars is well advanced, but the only large zone completely examined is the one from $+56°$ declination to the north pole. This region was divided into eight smaller zones, four of which were examined by Professor Hussey and four by the present writer. By counts of the stars on the charts, it appears that 12,299 stars 9.0 or brighter were examined in the region $+60°$ to $+90°$. Of these, 294 were known double stars and 259 more were found to be double, a total of 553 pairs, all under $5''$ except seven bright stars, giving a ratio of one double star to every $22\frac{1}{4}$ stars to 9.0 magnitude.

Tabulated by hours of right ascension and by zones 4° wide, it is found that the distribution curve of these pairs closely resembles that of the stars to 9.0 magnitude in the same area, but that the double stars are *relatively more numerous in the richer sky areas.*

When only the pairs under 2″, or those under 1″, or the very close pairs, or the brighter pairs, are considered, the same relation is found; as may be seen from the following table which groups the results by quadrants:

TABLE

Zone + 60° to + 90°

Double Stars	0 h. to 6 h. No. Ratio	6 h. to 12 h. No. Ratio	12 h. to 18 h. No. Ratio	18 h. to 24 h. No. Ratio
Under 5″	173 1:19.4	87 1:28.6	86 1:30.2	207 1:18.7
Under 2	113 1:30	56 1:44	66 1:39	132 1:29
Under 1	76 1:44	37 1:67	40 1:65	80 1:48
Under $\frac{1}{3}$	15 1:224	9 1:276	11 1:236	24 1:161
7.5 Mag. or brighter	49 1:68	23 1:108	18 1:144	63 1:61

Zone + 56° to + 60°

Under 5″	98 1:14.4	35 1:20.4	30 1:22.4	81 1:18.0

The zones north of 60° were examined with the 12-inch telescope, but for fully one half of the zone + 56° to + 60° the 36-inch was used. In this zone 4,257 stars 9.0 magnitude or brighter were examined and 130 new double stars were added to the 114 previously known pairs, giving a ratio of one double star to 17.4 stars to 9.0 magnitude. The table shows that the relations established in the area north of 60° hold true here also, though the ratio in the fourth quadrant is affected by the fact that in this quadrant the work was all done with the 12-inch telescope. It is, therefore, safe to state that in this entire sky area the double stars are relatively as well as absolutely most numerous in the region richest in stars to 9.0 magnitude, that is, in the region of the Milky Way. The study of the local irregularities in the distribution, of which the charts give evidence, is reserved for a later paper.

The Variable RS Persei: IDA WHITESIDE.

Three minima of this star observed this fall indicated a period of a little over thirty-one days, through about two thirds of which the star remained constant or very nearly so. This period also agreed very well with some scattered observations published in the *Astronomische Nachrichten,* and with others made at the Vassar College observatory. At the time predicted for the fourth minimum the star failed to respond, going down very little if at all. It is probably irregular, but more observations are needed to confirm this statement. The range is only about a magnitude, from 8.2 to 9.2.

A Systematic Error in Distance Measures of Close Double Stars: W. H. PICKERING.

In 1900 a series of measures was made of the wide double star μ Draconis. Its components are nearly equal, and their distance is 2″.3. The observations were executed with a 5-inch telescope whose aperture could be reduced by a series of diaphragms to 0.5 inch. A magnification of 300 was usually employed. It was found when the aperture was so small that the disks of the two components were in contact, or nearly so, that the distance between their centers was materially reduced. With an aperture of 0.6-inch the two centers coincided. Had they remained at their true distance apart, their combined image would have been appreciably elongated, instead of which it was perfectly circular.

It occurred to the writer to determine if the same effect was produced in the case of close double stars where large apertures were employed. A selection of suitable cases was made from Lewis's recent publication of measures of the Struve stars. It was found that the apertures employed by the various observers could be divided into three classes, those of about 8 inches, those of 15 inches and those of about 30 inches.

When the separation was so slight that the star disks would have appeared in contact, or nearly so, with the smaller telescopes, it was found that the measures made with them were uniformly about ten per cent. too small. When the images were well separated the large and small telescopes gave identical results.

The early measures made on μ Draconis with the very small apertures indicate that the deviation is a real rather than a subjective one, and that the star images actually approach one another owing to some diffraction phenomenon. It would appear, therefore, that future catalogues of close double stars should always give the reader an opportunity of knowing the aperture employed with every observation. A more detailed account of this investigation will shortly appear in the *Harvard Annals,* Vol. 61.

The Tenth Satellite of Saturn: W. H. Pickering.

The elements of the orbit of the tenth satellite of Saturn, recently published (*Harvard Annals,* Vol. 53), were based on negatives taken at Arequipa in 1904. An examination of another set of negatives taken in 1900 has just been completed. The satellite was found upon them also, but some of the elements of its orbit differ materially from those found in 1904. This is particularly true of the eccentricity and the inclination. The orbit of 1904 was extremely eccentric, and it was noted in the publication above mentioned that in one part the satellite would pass extremely near to Titan. It was further suggested that the peculiarities of the orbit might be due to such a recent encounter.

The orbit of 1900 was found to be nearly circular, at times passing near Hyperion, however. It was not possible to tell from the negatives just when or how the elements had been transformed from those of one orbit to those of the other, if such a transformation had indeed taken place, but it seemed at least as probable as that two satellites should exist with practically the same period. The orbit is still under investigation, and later results will be published in the *Harvard Annals,* Vol. 61.

Photographic Color Photometry of Short Period Variable Stars: J. A. Parkhurst and F. C. Jordan.

The broad problem of astronomical color photometry finds an interesting application in the determination of color changes in short period variables of the δ *Cephei* type. Various observers, by indirect methods, have found that these variables show stronger color at minimum than at maximum. As the spectroscope shows these stars to be binaries, a proof of color change coincident with light-variation would be of the highest importance. A direct determination of such changes is made possible by a suitable combination of color-filter, orthochromatic plate and reflecting telescope. An exposure on an ordinary plate (Seed 27) was followed immediately by one with a filter and Cramer 'Trichromatic' plate, which give visual magnitudes (as described by R. J. Wallace in the *Astrophysical Journal* for November, 1906). The two principal advantages of the method are: (1) the simultaneous determination of visual and photographic magnitudes; (2) elimination of personal equation with its physiological complications, from the visual magnitudes of the colored stars, and the substitution of the peculiarities of the instrumental outfit, which can be definitely stated and exactly reproduced.

Briefly stated, the results confirm the color-changes in the short period variables under observation, the photographic range being greater than the visual; in other words, the color-factor (photographic *minus* visual magnitude) is greater at minimum than at maximum. Three stars will illustrate the results obtained.

X Cygni

	Visual	Photographic	Color Factor
	M	M	M
Max.	6.28	7.25	0.97
Min.	7.15	8.75	1.60
Range	0.87	1.50	0.63
T Vulpeculæ			
Max.	5.50	6.05	0.55
Min.	6.10	6.90	0.80
Range	0.60	0.85	0.25
S Sagittæ			
Max.	5.33	5.85	0.52
Min.	5.95	6.93	0.98
Range	0.62	1.08	0.46

We have then the following results:

1. Binary systems, showing orbital revolution.

2. Colored stars, pointing to atmospheric absorption.

3. A regular variation in that color (*i. e.*, that absorption).

Standard Photographic Magnitudes: Edward C. Pickering. (By title.)

On the Probable Distance of Orion: Henry Norris Russell.

Almost all the bright stars in Orion are similar in spectrum and proper motion, and are probably at roughly equal distances from us. Their very small proper motions indicate that their parallax is too small to be directly measured, and Gill's observations of β Orionis confirm this view.

But many of these stars are double, and some appear to be physical systems, showing more or less motion—always very slow. It is possible to derive a relation between the parallax and mass of such systems and the observed distance and rate of motion, which, though not exact in any one case, give good mean values when applied to several stars. Tests of this relation on forty well-known binaries show that its probable error for a single case is about 20 per cent. Applying it to nineteen pairs which appear to belong to the Orion group, and to be physical systems, we find for their mean parallax $\pi = 0''.011/\sqrt[3]{m}$, where m is their average mass, and π is subject to considerable uncertainty owing to errors of observation.

There are many spectroscopic binaries in Orion, but orbits have been published for only two. These indicate that the average mass of these stars is about ten times that of the sun (subject to revision when more data are available). This leads to a mean parallax of $0''.005$ or a distance of 600 light years.

For reasons already mentioned, this should be regarded only as an indication of the order of magnitude of the true distance. Errors of observation, and also errors of judgment in including as physical systems pairs which may ultimately turn out to be optical, would both tend to make the calculated parallax too great.

The Number and Distribution of Stellar Clusters and Nebulæ: S. I. Bailey.

The visible universe beyond our solar system is made up of two classes of objects, stars and nebulæ. All star-clusters may be divided into two classes, irregular and globular; the Pleiades serve to represent the former, the cluster in Hercules, the latter. The term nebula may be applied to any nebulous object, whatever its real nature, which can not be resolved into stars. All nebulæ may be divided conveniently into two classes, gaseous and white, the former giving a spectrum of bright lines, the latter an apparently continuous spectrum. The best known example of the former is the great nebula in Orion, of the latter, the great spiral in Andromeda.

Somewhat less than 700 resolvable star

clusters are known in the whole sky. Less than 600 of these are irregular; nearly all are in or near the Milky Way, of which they form an intimate part, as has long been known. More than 100 resolvable globular clusters are known, the distribution of which bears no relation whatever to the Milky Way, although a rich group of such clusters is found in the Milky Way. This appears to be an accident, however, since they do not seek the lines of greatest luminosity. This peculiar distribution of the globular clusters does not seem to have been pointed out before. Discovery of irregular clusters has been practically exhausted by small telescopes, since powerful photographic instruments reveal few new ones. It is probable, however, that the number of known globular clusters will be considerably increased among the so-called nebulous stars.

About 12,000 nebulæ are now known. The whole number in the sky, however, is several times, perhaps many times, greater. The white nebulæ are distributed in cloud-like groups over the sky, avoiding, in general, the Milky Way. The gaseous nebulæ occur probably over the whole sky, perhaps in greater numbers in the Milky Way where the most striking objects of this class are found. The gaseous nebulæ are probably few in number compared with the white nebulæ.

The majority of all nebulæ are spiral, but there are large numbers of nebulous stars, many of which may be faint globular clusters. The relation between spiral nebulæ and globular clusters may prove to be more intimate than is now apparent.

The Nebulous Regions of the Milky Way: E. E. BARNARD.

This paper deals with some peculiarities of the nebulosities in the Milky Way. Though in some cases there seems to be every evidence that the stars and nebulosities are freely mixed together, still peculiarities of distribution, etc., show that with few exceptions (such as ρ *Ophiuchi*) the nebulosity does not indicate any tendency to condense about the stars. This is especially striking in the case of the great North America Nebula (so named by Dr. Max Wolf), where to all appearances the stars seem to exist in a vast bed of nebulous matter with no condensation about them individually. In this particular case the identity of the details of the nebula and the groupings of the stars seem to be conclusive proof that the nebula and the stars, apparently in it, really occupy the same part of space. Even in the case of that remarkable combination of nebulosity and stars, *M 8*, the stars seem freely mixed with the nebulosity, but in no case to be centers of condensation. Contrary to this condition, the great nebula of ρ *Ophiuchi* has condensation about the principal stars in that region, including σ *Scorpii.*

A photograph shows the singular nebulosities about γ *Cygni,* where a profusion of curved sheets and wreaths of nebulous matter cover a large part of the sky about the star and extend as far south as χ *Cygni.* A photograph of the nebula about ν *Scorpii* seems to show quite distinctly an obscuration of the light of the stars in that region. Where this remarkable object veils the sky, the stars seem to have decreased in magnitude. It gives the impression that the brighter stars in this region are dimmed and the fainter ones blotted out, as if produced by a thin obscuring veil of nebulosity this side of the small stars. This peculiarity is very strikingly brought out by the photograph.

In *A. N.* No. 3,111, Bd. 130, the writer has given an account, with a sketch, of a group of small nebulous stars

$$(1860\quad \alpha = 18^{h}2^{m} \pm \quad \delta = 23°52' \pm),$$

which lies about $1\frac{1}{2}°$ following *M 8.* When these nebulous stars were examined with the 12-inch of the Lick Observatory in 1892, no connecting nebulosity could be seen. It was noticed, however, in a photograph made with the Willard lens that a nebulous wisp ran toward the group from *M 8*. The photographs made by the writer with the ten-inch Bruce telescope of the Yerkes Observatory at Mt. Wilson in the summer of 1905 show that in this group the nebulous stars are simply condensations in a large irregular mass of nebulosity which extends to and connects with *M 8*.

Apex of the Solar Motion: GEORGE C. COMSTOCK.

It is well known that different astronomers have reached discordant results in seeking to determine the direction of the sun's motion through space. It is the purpose of this paper to present graphically (lantern projection) these several results classified with respect to the average brightness of the stars employed in the determination. When thus classified all determinations indicate a solar motion toward the north edge of the Milky Way, and the discordances in galactic latitude are not great. In galactic longitude, however, there is a well-marked dependence of the position of the apex upon the mean magnitude of the stars with reference to which it is determined. Stars of the tenth magnitude place this apex some 40° farther east than do stars of the third and fourth magnitudes, while intermediate magnitudes furnish intermediate positions. This variation is attributed to a small drift of the nearer stars in the plane of the galaxy and toward the constellation Cassiopeia. This is shared by most of the sun's stellar neighbors and affects the bright stars in larger measure than the faint ones because a larger percentage of the bright stars are included in this drift.

A Comparison Study of Bright Clusters and Nebulæ: S. I. BAILEY.

Field Experience with Transit Micrometers: JOHN F. HAYFORD.

Spectrographic Observations of Stars: EDWIN B. FROST.

Nine spectroscopic binaries were recently discovered with the Bruce spectrograph of the Yerkes Observatory, viz., *RZ Cassiopeiæ*, *X Cygni*, 13 *Ceti*, ω *Leonis*, 85 *Pegasi*, τ^5 *Eridani*, τ^8 *Eridani*, τ *Orionis*, ξ^1 *Canis Majoris*. (To be published in the *Astrophysical Journal*.)

The Central Eclipse of 1912, April 13: DAVID TODD and R. H. BAKER.

Although the land-totality of this eclipse will be visible for a few seconds only, it is desirable to prepare for observation. The central line extends from Oporto, Portugal, to Oviedo, Spain, the line of subsequent annularity passing close to Paris. These points are given by a definitive calculation of the track, made possible by the courtesy of Professor W. S. Harshman, U. S. Navy, Director of the Nautical Almanac, who forwarded in advance the necessary solar and lunar data which will be embodied in the 'American Ephemeris' of 1912. The change from total phase to annular takes place in the Bay of Biscay, according to the accepted diameters of sun and moon; and it will be well to repeat the computation with slightly varying values. The application of photographic apparatus, operated automatically, may make it possible to obtain a useful and permanent record of this brief totality.

Relation between Stellar Spectral Types and the Intensities of Certain Lines in the Spectra: SEBASTIAN ALBRECHT.

In connection with the measurement of spectrograms obtained at the Mills Observatory in Chili by Professor Wright, an investigation of the individual spectrum lines was begun, with a view to determining whether there is a shift of any lines which is progressive from spectral type to type. Several lines were found to undergo such a progressive change, as is indicated by the radial velocities obtained from them. An examination of Rowland's tables shows that in most cases, lines apparently single are in reality blends of two or more close components. The nature of the variations is such as to indicate varying intensities of the same components rather than the presence or absence of different components in the different types. The investigation was limited to types *F* to *Mb* inclusive on the Harvard classification. In this classification the sun is of type *G*.

A comparison with Adams's list of sun-spot lines gives strong indications that the physical conditions in the stars as we pass from the *F* to the *Mb* type vary in the same direction as from the sun to the sun-spots.

It was thought possible that for variable stars of large light changes, traces of velocity variations for some of the lines might be found, corresponding to small changes in spectral type as the stars varied from maxima to minima—and *vice versa.* In the case of *o Ceti* actual changes in the character of the spectrum are well established, though up to the present no appreciable changes in the wave-lengths of any of its spectrum lines have been observed—leaving out of account the large displacements of the bright hydrogen lines. A comparison of the available measures of *η Aquilæ,* a variable star of the fourth class with a range of only 0.8 of a magnitude in light variations, showed evidences of variations in the positions of some lines from light maximum to minimum similar to the variations that were found from type to type. A further study of this variable star is desirable to establish definitely the exact character and amount of these variations.

These variations in the wave-lengths of some of the lines depending on spectral type, will make necessary the exercise of great care in the selection of lines in radial velocity determinations, and a proper allowance for the type.

A Device of eliminating Guiding Error from Photographic Determinations of Stellar Parallax: FRANK SCHLESINGER.

Experience has shown that a fruitful source of error in photographic work is what has been aptly termed the 'guiding error.' This arises from the fact that when the guiding is imperfect, the image of each star wanders from its mean position and these excursions are registered upon the photographic film to a different extent for stars of different brightness. This error is particularly troublesome in parallax work where the star under examination is usually much brighter than the comparison stars. After considerable experimenting the writer adopted the following simple device that seems to overcome the difficulty in a very satisfactory way. A rotating disc was mounted a little below the center of the photographic plate and about ten millimeters in front of it; that is, on the side toward the objective. The disc was made in two halves moving on the same axis, so that the opening left between their edges could be adjusted to any desired angle. The image of the bright star having been brought to the center of the plate and the disc set into motion, a part of the star's light will be occulted in each rotation of the disc. The amount of light that reaches the plate depends only upon the angular opening between the two halves of the slit and neither upon the rate at which they are revolving nor the distance of the image from the center of rotation. The images obtained in this way were free from any trace of diffraction caused by the edges of the disc-opening and were otherwise indistinguishable from images of fainter stars taken without the occulter. In parallax work the opening of the disc should be so adjusted that the apparent magnitude of the star under examination is about equal to the mean of the magnitudes of the comparison stars. The effect of guiding error will, therefore, almost entirely disappear. Actual measures upon plates taken with this device fully confirm this last statement.

Photographic Observations of Giacobini's Comet: E. E. BARNARD.

These photographs show the almost sudden development of the tail between December 25 and 29, 1905, from a scant trace to a splendidly developed tail. A comparison with a photograph, made by Mr. Duncan at the Lowell Observatory on December 26, limited the time of development to less than three days. The tail underwent remarkable changes from day to day, but through interference from cloudy weather it was not possible with the one set of photographs to distinguish identical features on different dates, even though they existed, to determine the velocity of the tail-producing particles.

On the Distortions of Photographic Films: FRANK SCHLESINGER.

The question as to the amount of distortion that a photographic film suffers during development is not yet settled. The method employed in the present paper is free from some assumptions that have hitherto been made and gives the average amount of the distortions independent of other sources of error. A plate was exposed to the sky and developed and dried in the usual way. It was then measured independently by two observers. Let us call these measurements A' and B'. The plate was soaked in water and then dried. It was now inserted in the measuring engine in, as nearly as possible (within 0.01 mm.), the same position it had occupied and measured a second time by each observer. Instrumental errors were thus eliminated. Call these second measures A'' and B''. Then if e represents the *mean value* of the distortion (in a sense analogous to mean error) and if e_A and e_B are the mean errors of bisection for the two observers, then by appropriate subtractions we obtain

$$[(A'-A'')^2] = [e^2] - 2[e_A^2],$$
$$[(B'-B'')^2] = [e^2] - 2[e_B^2].$$

If we subtract each of the differences $(B'-B'')$ from the corresponding $(A'-A'')$ the result is free from the effect of distortion and we have

$$[\{(A'-A'') - (B'-B'')\}^2] = 2[e_A^2] - 2[e_B].$$

These three equations enable us to evaluate e as well as e_A and e_B. Three plates, each with about 60 star images, were treated in this way and gave $\pm$ .0008 mm., $\pm$ .0006 mm. and $\pm$ .0003 mm., respectively, for the mean value of the distortion of the film. The experiment was varied and improved by spattering an *undeveloped* film with ink and measuring the small and perfectly round dots that were thus obtained, before and after the plate had been cleared in hypo, and thoroughly washed and dried. Five plates treated in this way gave, respectively, $\pm$ .0006 mm., $\pm$ .0006 mm., $\pm$ .0014 mm., $\pm$ .0015 mm. and $\pm$ .0015 mm. These experiments indicate that the distortions of the film are considerably less than inevitable errors like those of bisection, guiding error, etc. If this conclusion should be confirmed by other observers it must have an important bearing on methods for measuring and reducing plates, since it would follow that elaborate precautions, such as have sometimes been employed for guarding against these distortions, are unnecessary.

Distortions of Photographic Films on Glass: Sebastian Albrecht.

In the winter of 1904 an investigation of the distortions of photographic films on glass plates was undertaken by the writer at the suggestion of Director Campbell and Dr. Perrine. A preliminary investigation showed that if ordinary good care is taken in the treatment of the plate during development, fixing, hardening, washing and drying, there will be no general distortions, *i. e.,* no distortions extending over a large area of the film. Accordingly, the work was continued by a method which would more readily determine the character of local distortions. Photographs of spectra with numerous lines of different widths are very well suited for this purpose. These spectrograms showed that there were local distortions. These distortions were confined in each case to one or a few adjacent spectrum lines, and very rarely covered an area as much as 0.25 mm. square. The displacements of individual points in the distorted area occasionally amounted to 0.02 mm., which on the Crossley star photographs is equivalent to about one second of arc, and on the spectrograms taken with the one-prism spectrograph of the Lick Observatory to a radial velocity of about 80 km. per second (for the H_γ region). Such large displacements as these are, however, extremely rare.

The distortions seemed to be of two different kinds: one caused by an actual movement of portions of the film, and the other by a displacement of the image apparently due to local differences in the sensitiveness of the film. Some of the characteristic shapes of the distorted lines due to the first cause were: a sine-curve, a question mark, an irregular crinkle, an abrupt bend, a gradual bend which was sometimes shared by two and occasionally by three lines, while the lines immediately on either side of the distorted ones were perfectly straight.

The structure and chemical composition of the film are materially altered in the process of development and fixing, so that the strains produced in the subsequent drying need not be exactly the same everywhere in the film as they were before development. In fact, slight local readjustments might be expected, and it is remarkable that the resulting movements in the film should be so few in number, and be confined to such minute areas.

A Riefler Clock and a Self-registering Right Ascension Micrometer: W. S. Eichelberger.

In September, 1903, there was installed at the U. S. Naval Observatory one of Riefler's sidereal clocks, No. 70, with a nickel-steel pendulum and mounted in an air-tight glass case. At the same time the following scheme of observing was undertaken with the 9-inch transit circle; one astronomer would observe fundamental and miscellaneous stars for about two hours before sunrise, would observe the day planets and the sun, and would finish his tour of duty with another two hours' star observing just after sunset; a second observer would then commence and do star work for about six hours; and then a third man would observe a list of stars for about two hours before sunrise. Thus there were frequently three clock corrections determined during the same night by three different observers. Each night from September, 1903, to August, 1904, on which two or three men observed, has been utilized for determining the relative personal equations of the various observers. This interval was divided into five parts and an independent determination of the relative personal equation was obtained for each of these shorter intervals with the following results:

	E—L	E—R	E—B	E—M
1903	s	s	s	s
Sept. 5 to Oct. 5	+0.210	+0.051		
Oct. 12 to Nov. 13	+0.195	+0.048	+0.188	
1904				
Jan. 30 to Mar. 29		+0.056	+0.139	+0.062
Apr. 3 to May 13		+0.052	+0.119	+0.055
May 24 to Aug. 15			+0.112	+0.019
Weighted Mean	+0.205	+0.052	+0.133	+0.047

The average probable error of one of these individual determinations is $0^s.009$.

All the men except *M* had observed with a transit circle some years before the observations here discussed were begun, yet with one pair of experienced observers there is quite a decided change in the relative personal equation within a few months.

For the same periods and the same pairs of observers the following differences between the largest and smallest value for a single night were obtained.

	E—L	E—R	E—B	E—M
1903	s	s	s	s
Sept. 5 to Oct. 5	0.072	0.053		
Oct. 12 to Nov. 13	0.083	0.050	0.069	
1904				
Jan. 30 to Mar. 29		0.067	0.128	0.137
Apr. 3 to May 13		0.090	0.094	0.040
May 24 to Aug. 15			0.140	0.075

The general mean of all these numbers is $0^s.085$.

In attempting to adopt a mean clock correction for the entire night and to test the irregularity of the running of the clock from day to day, this number is certainly large enough to be annoying. If it is due to irregularities in the running of the clock during the night, a new clock is needed. If it is inherent in the old key method of observing transits, something should be done to improve the method.

To test the clock for periodic daily irregularity another Riefler clock, No. 82, was compared with it every morning and afternoon and frequently twice during the night from January 19 to February 2, 1906, and a second time from February 23 to March 9. Between these two periods Riefler No. 70 was dismounted, cleaned and set up again. The probability that any periodic irregularity that might exist in these two clocks would be in the same phase in both series of comparisons is not very large.

The relative daily rate of the two clocks was in the first period

$$0^s.1426 + 0^s.00052\,t$$

and in the second period

$$0^s.0298 + 0^s.00032\,t.$$

The residuals arising from the comparison of the observed and computed differences between the two clocks were then grouped with respect to the tenth of the day at which the clock comparison was made with the following results:

JANUARY 19 TO FEBRUARY 2, 1906

Decimal of a Day	No. of Comp.	Mean Residual	
		s	s
.0	—	—	
.1	13	+0.004	+0.005 (.1–.2)
.2	2	+0.008	
.3	1	+0.011	—0.001 (.3–.6)
.4	7	0.000	
.5	2	—0.014	
.6	5	+0.001	
.7	—	—	—0.005 (.7–.9)
.8	1	+0.008	
.9	11	—0.006	

FEBRUARY 23 TO MARCH 9

Decimal of a Day	No. of Comp.	Mean Residual	
		s	s
.0	—	—	
.1	15	0.000	0.000
.2	—	—	
.3	6	+0.002	0.000 (.3–.6)
.4	7	0.000	
.5	—	—	
.6	4	—0.005	
.7	—	—	
.8	—	—	
.9	14	0.000	0.000

Of the 88 separate residuals three quarters are less than $0^s.01$ each, a quantity that I had supposed less than the uncertainty with which a clock comparison was read from the chronograph sheet.

At the end of October, 1906, the 6-inch transit circle was equipped with a self-registering right ascension micrometer of the Repsold type made by Warner and Swasey.

Previous to beginning the following series of observations, one of the observers had practised with the new micrometer on two nights and the other two on one night each. Two men worked on each of the eight nights, each observing ten time stars. Each man on half of the nights that he worked observed the first list of ten stars, and on the remaining nights the second list. The same twenty stars were used throughout the entire series.

A least-square solution gives for relative personal equation

$$E - F = + 0^s.001 \pm 0^s.012$$

and

$$E - L = - 0^s.001 \pm 0^s.015.$$

The relative personal equation $E - L$ by the key method of observing was $+ 0^s.20$.

The clock rates during these six weeks were also computed by least squares, first giving a weight unity to each rate and, second, a weight equal to the interval between the observations from which it was determined.

The resulting rates are

$$- 0^s.0436 + 0.000924 (T - \text{Nov. } 25.0)$$

and

$$- 0^s.0445 + 0.000997 (T - \text{Nov. } 25.0),$$

giving as residuals:

$O-C$	Wt.	$O-C$	Wt.
s		s	
—0.011	1	—0.009	8
+0.015	1	+0.017	5
+0.010	1	+0.012	1
—0.023	1	—0.022	2
+0.011	1	+0.012	4
—0.001	1	0.000	13
—0.003	1	—0.003	7
±0.011		±0.007	

A similar discussion of rates obtained by the key method of observing transits gave for thirteen weeks in the spring of 1904 a mean residual of $0^s.015$.

We thus see that by the use of the self-registering right ascension micrometer in this series of observations the mean residual of the daily clock corrections is decreased from 25 to 50 per cent. and relative personal equation has disappeared.

HAROLD JACOBY,
For the Council

(To be concluded)

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION I—SOCIAL AND ECONOMIC SCIENCE

FIFTEEN different papers and addresses were presented at the New York session. The attendance varied from thirty-five to over a hundred persons. One joint session with Section H was held. In the absence of Professor Irving Fisher, whose address has already appeared in SCIENCE, at the opening session, the incoming vice-president for the section, Charles A. Conant, presided, beginning the proceedings with an introductory discussion on banking reform, the substance of which was as follows:

Unless some sound legislation is in due time enacted, our prosperity will be arrested, our rapidly absorbed currency will prove entirely inadequate for business needs, and we must be put at a great disadvantage at home and in our competition with foreign nations in the open markets of the world.

The proposed banknote reform, it should be understood, is not a measure intended