published by the International Latitude Service since 1908. Periods of one-fortieth of a year (9·125 days) were taken, and the values for x and y analysed independently, special attention being paid to the possible demonstration of a yearly period.

The resulting maxima show no trace of an annual period, but there is a weak maximum at thirteen months. A very strongly marked period, of 419·750 days for the x, and 410·625 days for the y, coordinate, was found, and agrees fairly well with the period (428 days) found by Chandler. Another less marked period of 438·0 days also results from M. Krassowski's investigation, and agrees with that found by Mr. Kimura.

THE PLANET VENUS.—In a very interesting lecture, now published in the December number of the *Popular Science Monthly* (vol. lxxv., No. 6, p. 521), Prof. Lowell describes the observations which have been made of the planet Venus, at present so prominent an object in our evening skies. Not only are the observations described, but the results accruing from them are discussed in popular language. Thus the spectroscopic and visual observations are held to have proved that the rotation and revolution of Venus are synchronous, the period being 225 days. A number of drawings accompanying the paper show the permanent markings recorded, and illustrate the unanimity of the observers working under good conditions. The main feature is a number of dark markings which, leaving the limb at different points, converge to the centre, thus giving the planet's disc a cart-wheel appearance.

SUGGESTED OBSERVATIONS OF HALLEY'S COMET.

THE Astronomical and Astrophysical Society of America, through its comet committee, is soliciting cooperation in the observation of Halley's comet at the present return, and has prepared a circular letter of advice that has been widely distributed among observatories with regard to such observations. A copy of this circular will be sent to any astronomer who may desire to use it upon request being made to the chairman of the committee, Prof. G. C. Comstock, Washburn Observatory, Madison, Wisconsin. As many astronomers and other observers of Halley's comet will be interested in the suggestion made by the committee, the circular is here reprinted in a slightly abridged form.

It is desirable that the position of the comet be well observed during the entire period of its visibility, and it seems probable that extra-meridian observations will be secured in sufficient number without especial solicitation. In view, however, of possible large perturbations arising from the close approach of the comet to Venus on May 1, and to the earth on May 18, meridian observations are especially desired during the period in which the comet is sufficiently bright for that purpose. An examination of the amount and character of these comet perturbations and their adaptability to a determination of the mass of the planets producing them has been undertaken by Profs. Leuschner and Crawford, and in case the conditions prove favourable, the meridian determinations may well be supplemented by heliometer observations of the positions of the inner planets with the view of a possible determination of the mass of the comet itself.

The close approach of the comet to the earth promises unusual opportunity for a study of the physical conditions that obtain in such a body, and, as an indispensable basis for such study, the committee recommends a photographic campaign as long and as nearly continuous as possible. The comet's close proximity to the sun's direction at the time of maximum brilliance imposes serious limitations upon this programme, and widely extended cooperation will be required throughout the whole circuit of the earth if this ideal of a continuous photographic record is to be even remotely realised.

About one-third of the earth's circumference in longitude is covered by the Pacific Ocean, within which there is known to exist no observatory with proper facilities for celestial photography. To fill this gap, at least partially, the committee, aided by a grant from the National Academy of Sciences, proposes to send to the Hawaiian Islands an expedition to photograph the comet during the period of its greatest brilliance.

The ends to be served by these photographs, and others obtained elsewhere, are as follows:—

To give a permanent record, as continuous as possible, of the phenomena and changes (1) in the tail of the comet, with special reference to outgoing masses; (2) in the head and nucleus of the comet, particularly as to the formation of envelopes and jets.

The following suggestions as to procedure and precaution in making the photographs have been formulated by Prof. Barnard.

Photography of Comets.

One of the greatest difficulties in photographing the average bright comet is its proximity to the horizon, and consequent projection on a more or less dawn or twilight sky. The effect of this illuminated background with any considerable exposure is to fog the plate to such an extent as either to ruin it or to prevent a proper development of the image of the comet. A difference of three or four minutes in the duration of exposure when the sky is brightest may make a success or a failure of the picture. It is impossible to establish fixed rules as to when the exposure should stop or begin; so much will depend upon the condition of the sky, the position of the comet, the kind of lens, the rapidity of the plates, &c. The best rule is that of the judgment of the observer at the time, and this can only be derived from actual experience in the work.

The plates should be backed with the following to prevent halation. Cook two pounds of white sugar in a saucepan without water until nearly in the caramel stage, then add one pound of burnt sienna. Cook a little more (but not to the candy stage), stirring well. Finally, add about one-half an ounce of alcohol to each pint of backing as a dryer. This backing will keep indefinitely. When it is too hard, moisten it with a little water. This is to be applied to the back of the plate as a stiff paste with a broad camel's-hair brush, and should be applied just before using. A piece of old newspaper pressed upon this will prevent its being rubbed. The face of the plate should be very carefully dusted with a broad camel's-hair brush after it has been placed in the plate-holder. The camera tube should also be frequently wiped out with a damp cloth to avoid dust. Before developing, remove the backing with moist absorbent cotton. If a little remains on the plate it will not injure the developer. In removing the backing be careful to shield the plate from the dark-room light. Do not wet the surface of the plate before pouring on the developer, as it may cause air bubbles on the film; swab it carefully with absorbent cotton at the beginning of development. Develop until the plate is almost opaque to the ordinary developing light. Fix for twenty minutes or more in the ordinary fixing bath (frequently made new), to which has been added a teaspoonful of sodium bisulphite to prevent discoloration.

Lumière Sigma dry plates are recommended, because of their rapidity. Seed 27 Gilt Edge and Cramer Crown are both beautiful plates, but are not now so rapid as the Sigma.

Hydrochinon developer gives a good strong negative, and for astronomical work is excellent. Rodinal in a weakened form, say 1/60 or 1/70 of water, with a longer development, will give a soft and more transparent negative, especially suited for showing the details of the head of the comet on large-scale photographs.

The doublet, or portrait lens, such as is made in America by the Brashear Optical Company and the Alvan Clark Corporation, on account of its wide field, is the best form of instrument for showing the general features of the comet and its tail, and especially for following any outgoing masses that may appear in the tail. One of about 6 inches (15 cm.) aperture will be the most generally used, because of the expense of such instruments. It should be supplemented by several smaller lenses. A "lantern" lens of 1½ inches (4 cm.) aperture and about 6 inches (15 cm.) focus, made by McAllister, of New York, is recommended for showing the extent of the tail. The cost of one of these lantern lenses is seven dollars. It gives a good field of twenty to thirty degrees, especially when diaphragmed

down to 1 inch. It is extremely quick for comet work. Its focus should be carefully determined by star trails.

In comet work it is important in all these lenses that the camera should be so adjusted on the mounting with respect to the guiding telescope that the head of the comet can be displaced to one side of the field to secure a greater extension of the tail. Two of the small lenses may be so arranged by a mutual adjustment as to cover the full length of the tail, even though it should be fifty degrees long or more. Although it would thus be in two sections—the head and part of the tail on one plate, and the rest of the tail on the other—there would be no serious objection if the whole tail could thus be secured. The large reflectors will be of the utmost importance in dealing with the detail and structure of the head and envelopes, as has been recently shown at Greenwich.

Until something further is known of the spectrum of the comet, it would be unwise to attempt to give any specific directions as to the duration of exposure required with any telescope. Daniel's comet of 1907, and Morehouse's of 1908, were very different in respect to their photographic activity. The latter was relatively many times more actinic in its light, and hence required much shorter exposures to show the same strength of tail. This information must come from actual experience with the comet. It would seem, however, that the circumstances of the comet's visibility when brightest will make short exposures necessary.

The committee will be pleased to receive from every astronomer who may cooperate in the matter copies (glass positives) of his negatives of Halley's comet, and it will undertake the comparison and discussion of the material thus collected.

Spectroscopic Observations.

For spectroscopic observations of the comet the committee makes the following suggestions, formulated by Prof. Frost. While it may be possible to make visual observations of the comet's spectrum with ocular spectroscopes attached to large telescopes, it is likely that most of the photographic records of the spectrum will be obtained by the objective prism or the slit spectrograph, and reference will be made in what follows to the use of these two types of instrument.

These methods of observation are mutually complementary; for the accurate measurement of wave-length, effect of motion in the line of sight, and analysis of structure of lines or bands (if sufficiently sharp), the slit spectrograph has all the advantages, but for study of distribution of elements in different parts of the comet, and for reaching faint details, the prismatic camera, or objective prism, with its much greater light-power, is essential. The prismatic camera may be employed, with a fair possibility of success, when the comet's brightness is equivalent to that of a ninth- or tenth-magnitude star; the slit spectrograph cannot be hopefully applied before the comet is two or three magnitudes brighter. The size and kind of telescope employed, of course, make such statements relative rather than absolute, and uncertain at best. Too much here depends upon the comet; if its light is chiefly reflected rather than intrinsic, and the continuous spectrum is predominant, then the comet will have to be much brighter for satisfactory spectroscopic analysis than if the light is largely intrinsic and concentrated at half a dozen points in the spectrum. Comets showing sudden and marked fluctuation in size or brightness are likely to exhibit changes in the bright band spectrum.

(1) Prismatic camera or objective prism.

The camera should be a doublet of large angular aperture, 1/4 or 1/5. Useful observations could be secured if the linear aperture is as small as 4 or 5 inches (10 or 12 cm.). The objective prism should be of small angle, perhaps 10° or 15°; if an additional prism is available for the period of the comet's greatest brightness, its angle should be about three times that of the smaller prism. If the doublet is of comparatively short focus, as is likely to be the case, it will be found to be quite sensitive to focus, and separate exposures will be needed for the blue-violet region and the yellow-green region. Optical parts transparent to ultra-violet would be useful, as there may be some important bands of shorter wave-length than λ 3883.

It is very desirable to photograph the spectrum of a star before or after the comet, placing the star at such a point on the reticle of the guiding telescope that the stellar lines may serve for comparison.

Prof. Pickering suggests that an interesting observation would be to photograph the spectrum of a star when seen through the bright portion of the tail, to see if dark absorption lines could be detected.

(2) Slit spectrograph.

A small spectrograph will be a very useful attachment to a photographic doublet as described above. It need not be complicated, and its dispersion may be small. Apparatus for producing a comparison spectrum is not essential, for a neighbouring star of the first type may be brought upon the slit, and its spectrum impressed above and below that of the comet. With one thread of the guiding telescope, or finder, movable, the star can be placed so that its spectrum will fall on the slit as desired. The identity of the cometary band can be thus established better than with the objective prism. After spectrograms of the comet have thus been obtained, it will also be desirable to obtain plates with the slit as narrow as feasible, in order to detect duplicity or complexity of the lines or bands.

Observations with powerful stellar spectrographs of the types in use for determining radial velocities will doubtless be made as soon as the comet's brightness permits, but this is likely to be disappointingly late on account of the heavy loss of light in such instruments. The fixed equipment of these instruments will determine their operation by their regular observers.

Photometric and Polariscopic Observations.

Photometric and polariscopic observations of the comet should certainly be made, although they will doubtless occupy a position of subordinate importance. The suggestions of the committee in this respect are formulated by Prof. Pickering, as follows:—

A great variety of methods may be employed for measuring the light or amount of polarisation of the comet. It is suggested that astronomers undertaking this problem should correspond with the chairman of the committee, in order that uniform methods may be employed throughout by different observers. The plans proposed below may require modification, according to the instruments available.

A direct estimate, by Argelander's method, of the entire light of the comet, as seen by the naked eye, or in the smallest telescope with which it is visible, may have a certain value to observers in the future, although large systematic errors are to be expected in such estimates.

It is doubtful if photometric measures of the nucleus of the comet will have much value, as the results will probably be greatly affected by the coma, and will differ with different photometers and telescopes. If the nucleus be distinctly stellar it may be compared directly with an adjacent star, by means of a double-image photometer. The effect of background would thus be eliminated. Direct measures with a Zöllner photometer, or similar instrument, would probably have but little value, owing to the effect of the coma. Any series by the same observer with the same instrument would be valuable by itself, and the observations by different persons and different instruments might be subsequently adjusted for systematic differences.

The measures described in Harvard Circular 68 showed that the absorption of light by the tail of comet 1902*b* was certainly less than a tenth of a magnitude. Similar measures should be made of Halley's comet. A double-image photometer is indispensable for these measures also, to eliminate the effect of background.

The light of different portions of the tail of the comet may best be measured by the following method. Take two photographs at the same time with similar instruments, using the same kind of plate and developer, and giving equal exposures, taking one in focus and the other out of focus, so that the images of the stars shall appear as circles two or three millimetres in diameter. Make similar enlargements of the two plates, interposing screens of perforated brass. Measures of the opacity of the resulting circular images of different portions of the comet on one plate may be compared with the images of stars the magnitudes of which are known as photographed on the

other plate. The effect of the light of the sky or of twilight may thus be eliminated, and the light of the comet compared with that of a star of known magnitude spread over a standard area. The two photographs may also be compared directly with a suitable photometer.

Messrs. Barnard and Frost, having also the benefit of Mr. Parkhurst's opinion, suggest as an alternative and possibly better method the extra focal use of a single camera. The intensity of the extra-focal cometary image could be reduced to the focal plane as accurately as for the star images. The relative values on different nights would always be correct.

Useful suggestions for the photometric observations of the comet may be derived from a paper by Dr. Rosenberg upon photometric observations of the Morehouse comet, contained in the *Astrophysical Journal* for November.

The polarisation, if any, of the comet's tail may best be studied by photographs taken with a camera having a double-image prism placed over the lens. The prism should be turned so that the two images are perpendicular to the direction of the sun. The two images of an unpolarised object should be alike if the correction for colour is the same for both, otherwise it will be necessary to take a second photograph, turning the prism 180°. If the light is polarised, one image may be fainter than the other, as in similar photographs of the solar corona. Measures may be made as described in the preceding paragraph.

Bands will doubtless be seen if the comet is examined by means of a Savart's polariscope or similar instrument, but it is, in that case, difficult to distinguish between slight polarisation of the comet and the strong polarisation of faint sky-light.

Minor Notes.

The following titles may be specified as minor matters not included above, but which may in some circumstances become of importance, viz. :—

The head of the comet should be carefully examined for traces of phase. Possible disturbances may be found in the comet, due to its close approach to Venus on May 1 and to the earth on May 18. A transit of the earth through the comet's tail is possible at or near the latter date, and, if such should occur, a meteoric shower should be looked for and observed with reference to a determination of the meteoritic particles, their frequence, size, &c. Resultant disturbances of the electric potential of the earth's atmosphere are possible, and the cooperation of meteorological observers, and especially of national weather bureaus, is earnestly desired in this connection.

Although the amount of refraction experienced by light in transit through a comet is known to be very small, it seems desirable to make investigation of the matter photographically with long-focus telescopes. The position of a sufficiently bright star near the nucleus, or in the brightest part of the edge of the tail, should be referred to a group of more distant ones, and the resulting position of the star compared with that resulting from another plate exposed after the comet has left the star.

THE HEADMASTERS' CONFERENCE.

THE headmasters of sixty of the leading public schools met at the Leys School, Cambridge, on December 22 and 23. On the first day the chief matter discussed was the work of the Public Schools' League for Imperial Land Settlement in the Overseas Dominions, which was strongly supported by the Rev. Dr. Gray (warden of Bradfield College). Under the auspices of the committee, approved boys are to be sent to a Canadian farm after completing their school career. A course at an agricultural college is to follow a year's practical training on the farm, and it is hoped that the public schools will assist the supply to the dominion of "men of character, intelligence, and energy, possessed of a little capital, who will settle down seriously and will assist in bringing under cultivation the immense areas of land at present untouched." The conference pledged its support to the establishment of a central office in London for the permanent work of the league. Later in the day the meeting asked for fuller recognition of English in the university examinations for admission. All the speakers emphasised the importance of the subject, which was no longer regarded as something for a spare hour; not a few were of opinion that to add English to the entrance examinations would be the worst service they could do to the cause. Fear was expressed lest a set period or figure in literature might be made compulsory, and the comments of some speakers upon the university examinations were decidedly caustic.

On the second day the meeting debated the report of the curriculum committee as to a scheme of studies for schoolboys from the age of nine to about sixteen. The conference passed, practically unanimously, the three following resolutions :—

That this conference approves the principle laid down in the curriculum report of the committee that a boy should not be allowed to begin Greek until the foundations of Latin and French have been securely laid and he has received systematic training in English.

That it is essential to give such a definite position to English and French in the entrance scholarship examinations that these subjects may not be sacrificed to a premature study of Greek; that this meeting be urged to take such steps as will ensure full consideration of the nature and results of the mathematical teaching of boys from nine to sixteen; and that it be referred to a subcommittee to consider and report to this meeting.

That a special meeting of those headmasters who are in favour of the recommendations of the committee be summoned in the early part of next year to take steps to give practical effect in their own schools to the proposals made by the committee, and with this object in view that the secretary be instructed to send a circular to the members of the conference in the third week of January asking whether they are generally in favour of the recommendations of the committee, and, if so, whether they will be prepared to meet in London on a certain date in February or March.

There were several points in the report which were not dealt with in the resolutions, *e.g.* the committee is convinced that German should be excluded from the preparatory school. At the present time the two languages must be Latin and French, in order to provide a basis of education preparatory to classical and modern sides. Dealing with mathematics, the committee reports that in some cases the attempt is made to cover too much ground for the average boy, yet in others there is a danger that mathematics may be sacrificed entirely.

Although reformers will wish that the headmasters had gone further, it is a matter for congratulation that this year's conference exhibited a progressive spirit alike in resolutions and in individual speeches. Not only did the meeting recognise the relation of the public schools to the Empire, but it deprecated early specialisation in Greek, encouraged the advance of English studies, and adopted the principle of differentiating curricula to suit varying capacity. Above all, the headmasters acknowledged the obligation to give practical effect to the opinions which they expressed in conference. Perhaps we may not have to wait many years before drawing, nature-study, music, and handwork are accorded the status of essential subjects in the preparatory curriculum. G. F. D.

WATER SUPPLY IN THE UNITED STATES.[1]

IT is an obvious truism that water is the commonest and most plentiful substance in nature. Oceans, seas, lakes, rivers, floods, and streams innumerable testify to its universality, and its indispensability is no less manifest. Whenever man penetrates into virgin territory, his first care is to find water; wherever civilisation sets up her ultimate standard of health and comfort, she establishes and secures an efficient water supply. Water is the embodi-

1 Water Supply Papers: No. 224. Some Desert Watering Places in South-eastern California and South-western Nevada. By Walter C. Mendenhall. Pp. 98.

No. 228. Water Supply Investigations in the Yukon-Tanana Region, Alaska, 1907 and 1908. By C. C. Covert and C. E. Ellsworth. Pp. 108.

No. 230. Surface Water Supply of Nebraska. By J. C. Stevens. Pp. 251.

No. 231. Geology and Water Resources of the Harvey Basin Region, Oregon. By Gerald A. Waring. Pp. 03.

No. 224. Papers on the Conservation of Water Resources. Pp. 96. (United States Geological Survey. Washington: Government Printing Office 1909.)