

one-one-hundredth of an hour increase over the preceding column and .15 of a degree of arc, so that the approximate increase in the table would be in the proportion of 100 to 60.

The table would still be 60 lines to the page, divided so that each one-hundredth of a degree would be noted on the margin with three intervening logarithmic values, showing a quarter difference and being equivalent to a haversine table divided to 9 seconds of arc instead of to 15 as at present. In hours, every sixth logarithm would be marked on the margin for .001 of an hour, equal to 3.6 seconds, and therefore the logarithms would read without interpolation to .6 of a second of time, instead of to 1 second as at present.

The table would occupy approximately 180 pages as against 106. The time intervals between .001, .002, etc., in the haversine table would read .001, .00116, .00133, .00150, .00166, and .00183. The volume thus proposed would be a little larger than H. O. 200.

It is safe to say that the decimal system being once in operation we will be fortunate if our successors do not regard the old system as an absurd survival which our mental indolence had too long tolerated. If they make the effort to turn time into arc and arc into time by our present system, their astonishment will be doubtless increased that such a clumsy arrangement had not been consigned to the scrap heap long ago.

New York, Aug. 20, 1919.

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## REPORT ON MARS, NO. 22.

By **WILLIAM H. PICKERING.**

### GENERAL INSTRUCTIONS.

This report has been somewhat delayed, not for lack of material, which is abundant, but because of pressure of work on other matters. It is hoped to deal with the many interesting observations made at the last apparition in subsequent papers. In the mean time both astronomers and amateurs, whether members of the Associated Observers of Mars or not, are invited to make their drawings of the planet, and forward them as heretofore, together with the required data, to the writer, not later than July 1. When drawings by different observers are to be compared, and canals and lakes identified upon them, as in this case, it is very desirable that the drawings should be forwarded promptly. Those arriving after the first of August will be given due

attention and consideration, and will be published if possible, but it is hoped that unnecessary delays will not occur.

It is proposed to maintain the Miscellaneous column established in Report No. 21. In it will be published the drawings of those unable to send complete sets, and also drawings by those whose sets we are not able to publish in full. It may be pointed out in this connection that longitude  $120^\circ$  shows less detail than any other in the series. Because it shows but little, observers should not be discouraged from drawing it, nor from sending in their drawings. As pointed out in Report No. 21, it may be well for those fairly familiar with the planet to study this region with extremely low powers, such as 150 to 200, as well as with the higher ones of 400 to 600 customarily employed. By thus bringing out all the contrast obtainable between the large featureless areas exhibited by this region it is possible that some explanation can be found of the diverse results secured by different observers in 1918, and possibly a better agreement may in future be obtained.

Specifications for the six drawings required to make a set, will be found in Reports Nos. 11, 15, and 18. New observers are cautioned that under no circumstances should they take a map of the planet with them to the telescope, to help them find the canals and lakes. That is not the proper way to observe. See Statistics of the Canals, in Report No. 21. They are also cautioned against trying to see too many canals and other details. A good rule is not to enter anything on the drawings that is not surely seen. Omit everything that is merely occasionally glimpsed. We should always compute the time at which the required meridians are central before beginning to observe, so that we may know at what time to begin the drawing (See Report No. 15). This requirement is most essential.

#### DATA OF THE APPARITION.

Opposition occurs this year April 20, but on account of the great eccentricity of the orbit of Mars, the planet will not be nearest the Earth until a week later. Its diameter will then be  $16''.1$ . In 1918 it was only  $14''.1$ . It is suggested that the six drawings should all be made between March 20 and June 1. On these dates the diameter of the planet will be  $13''.0$  and  $13''.8$  respectively. As heretofore, however, drawings of earlier, and of later date, if better, may be sent in. The declination will range from  $12^\circ.3$  to  $8^\circ.4$  south. The summer solstice of the planet occurs on February 8 of our calendar, and March 20 corresponds to the Martian Date July 9. Similarly June 1 with us corresponds to August 26 with them. Our drawings will therefore be made this year in the height of their summer season. We shall consequently see the maximum number of fine canals in their northern hemisphere, and the number of lakes should also be very large. We can also perhaps watch them as they are beginning to fade and dry up. After March 10 we shall see the planet to better advantage, that is

to say it will be nearer us, than it has been for many years at that season of the Martian year.

#### ALTERATIONS IN THE EPHEMERIS.

Observers of Mars throughout the world will notice with gratification, that in the case of the published diameters of the planet, the authorities have now gone back to the value determined by Hartwig, 4".68 for the semi-diameter, at unit distance, corresponding to a linear diameter of 4215 miles. This is the value used for many years by the British Nautical Almanac, and only changed by them for the last two or three apparitions. It will not be necessary therefore in future for observers to correct the diameters given in the Ephemeris in order to reduce them to this value.

American observers will also be particularly pleased to notice two other changes in their Almanac. In the first place the ephemeris is computed for Greenwich Mean Midnight, instead of Noon, that is to say for 7 p. m. E. S. T. This is much nearer the hour at which the majority of observations are made, and if we adopt the constant  $14^{\circ}.62$  for the hourly rotation of Mars throughout the apparition, which for most purposes is very convenient, then all of our interpolations will be more accurate than they would have been if the ephemeris were still computed for Greenwich Noon. Observers working on Mars in 1919 will notice that these two changes are made on the date of January 1, 1920.

The second change in the American Ephemeris consists in the introduction of a second column giving the "Central Meridian for the Intermediate date." As this is the most important, and most used quantity in the whole table, it will be a distinct convenience to have it given for every day of the apparition.

It is occasionally desirable to determine quickly the distance of Mars on any given date. This may readily be done by multiplying the Light Time given in the Ephemeris by 11,250,000, the velocity of light in miles per minute. To obtain the distance in kilometers multiply by 18,000,000.

#### DISCORDANT RESULTS IN 1918.

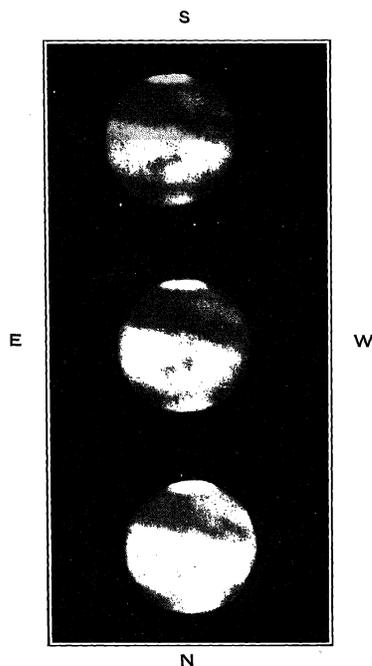
In comparing the work of the different observers in Report No. 21, one of the most striking differences is found to lie in the size of certain central figures in the regions **E** and **F**. The extreme cases occur in the second and third columns of Plates VI and VII, though in no two cases do the different observers agree very well. Such differences should not be, and it is hoped will not occur at the coming apparition. At first sight it might appear rather difficult to determine which drawings are correct. Although, as compared to eye observations, photographs give very inferior results, yet here is a case where photography may well be called in to settle a disputed point. The best photographs

of the planet hitherto taken have been at the Lowell, at the Mt. Wilson, and at the Yerkes Observatories. The writer is fortunate in possessing examples of the best work done at each of these stations. The longitudes of Aryn and of the Syrtis Major seem to have been favorites with the photographers, but fortunately a very successful series was taken by Mr. E. C. Slipher in Chile, of the surface about Elysium, shown in region **E** with the Amherst 18-inch equatorial. An enlargement of this photograph is shown in Plate VI. The date is July 13, 1907, and the canals bounding Elysium present the well known pentagonal form characteristic of the earlier apparitions of the present century. This form is still shown according to some of the observers, while to others it now appears nearly circular. Its diameter in the photograph, measured west from the center of Charontis to Hyblaeus, as well as we can measure it is 4.0 mm; the diameter of the planet is 18.0 mm, ratio 0.222. In the drawing the ratio ranges from 0.228 in Figure 18, to 0.326 in Figure 19. The ratio in Figure 17, the next to the smallest, is 0.256.

The writer may give here a brief description of his method of getting the proper proportions. The polar cap is first located, and carefully drawn of the correct size. Then any other points on the limb or terminator, especially any nearly opposite to the polar cap, are inserted. We next locate any point near the center, such for instance as the rim of Elysium, and then draw the northern and southern boundaries of the southern maria. After checking these fundamental points and lines carefully, the filling in of the other detail can be done with little error. The size of any circle-shaped area, such as Elysium, is always estimated in terms of the radius or diameter of the disk, and then the breadth of the surrounding area is estimated in terms of the diameter of Elysium, which thus serves as a check. Points are always sought out which form an equilateral or isosceles triangle. Regions along the eastern limb or terminator are preferably drawn first, since detail disappears upon that side. Some observers make a slight allowance in their proportions for the motion of the planet, during the time they expect to require to locate their fundamental points. The writer seldom finds that necessary, since the fundamental points and lines can usually be located quickly, while the final detail can always be put in at one's leisure.

On comparing the drawings and photographs of the lunar canals in my paper on Eratosthenes I (*POPULAR ASTRONOMY* 1919, **27**, 579), while the photographs are on a somewhat larger scale, yet after allowing for that fact, we see that the canals are on the whole drawn rather too narrow. The measured and corrected ratio between them is as two to one, but it is likely that the photographs represent the canals as rather too wide, so that the proper correction to the drawings may perhaps be fifty per cent. This fact may have a bearing on the drawing of the canals of Mars as represented by other observers.

## PLATE VI



PHOTOGRAPHS OF MARS.

The engravers have failed to bring out much of the detail which is shown in the enlarged negative from which they worked. The reader may see the pentagonal outline of the region Elysium, to which Professor Pickering refers, by holding the printed picture, either too far from the eye or too near the eye to be in good focus, so that the granular structure of the image is lost. Elysium is a white region just below the center of each picture, seen best perhaps in the middle one, where it is bounded on the upper edge by two black spots, on the lower edge by the dark streak just above the polar cap and on the three sides by very faint streaks. The two black spots are the Trivium Charontis and the Lucrinus Lacus. Editors.

POPULAR ASTRONOMY, No. 272.

## THE LIMITATIONS OF THE FILAR MICROMETER.

The filar micrometer is so valuable an instrument for double star work that it seems at first almost heresy to say that it is of little use for planetary measurements of position and survey. Where the threads can actually be set on two near objects, like two stars, and held on them, as can be done with the modern giant refractors, the result is eminently satisfactory. But where a smaller instrument is employed, such as is better adapted to studying planetary detail, and the threads are constantly swinging back and forth through an arc of one or more seconds, as is the case with smaller and inferior mountings, one of two different methods of measurement must be adopted: (*a*) A thread is made to coincide approximately with each of the objects to be measured, and when the threads swing to the ends of their path we must see that the two objects are equally remote from them, or (*b*) the threads must be placed to one side of the two objects, and the distance between the threads made equal to that between the objects themselves. With the latter method for small distances, smaller accidental errors are usually obtained, and there is no necessity of waiting until the threads swing to the end of their course.

But whether attached to large or to small telescopes, either for small disks, or for planetary detail, the micrometer is of little use. The cause of the trouble is the systematic error. In measuring the diameters of small illuminated artificial disks of about 1" in diameter, with the 15-inch equatorial at Cambridge, it was found that by method (*a*) the result averaged 0".20 too large, and by method (*b*) 0".33 too small, and that the poorer the seeing the smaller the result. Consequently if we use method (*a*) with extremely poor seeing, the systematic error becomes very small indeed. The measurement of the location of detail on illuminated disks also gave large systematic errors, and since these errors varied with the seeing, and also with the proximity of the detail to the limb, it became evident that they were very uncertain quantities, and could never be satisfactorily corrected (H. A. 32, 133). It must be remembered also that even a spider's web appears very coarse as compared to the finer details on Mars, or the Moon, and bears about the same relation to the finer canals as a walking stick does to a wire. Moreover the detail is often very faint, and as a result, when the spider's web is introduced into the field of view, the detail utterly vanishes.

Nevertheless there are two uses to which the filar micrometer may be put in connection with planetary astronomy. One is to the measurement of the diameters of large planetary disks, and the other to the measurement of the polar cap of Mars. It is true that we cannot decide by this means what the real size of the cap may be, with any great accuracy. The systematic correction would have to be determined by drawings, or otherwise, and would vary with the diameter of

the cap. But we can measure the *variations* of size from night to night, or from hour to hour, with the micrometer, with much greater accuracy than we can obtain them by any other method. In the case of drawings the accidental errors are large, but the systematic errors small; with the micrometer the reverse is the case, the accidental errors being small, and the systematic errors large. In the study of Martian storms, we don't care what the real size of the polar cap may be, we want to study its variations only. The real size may be determined by a comparison of a sufficient number of drawings by different observers. Several of the Associated Observers have already sent me measures of their drawings made at the last apparition, and it was hoped to have reduced and compared them before this. It is expected to do so in the near future. In the mean time, besides drawings, it is recommended that micrometric measurements of the cap be secured whenever possible, both in Europe and America.

#### THE POLAR REGIONS.

On March 20, the date selected for beginning the drawings of Mars, the central latitude of the disk is only  $+16^{\circ}.0$ , but it increases gradually, so that by June 1, when the last drawing is to be completed, the latitude will have reached  $+22^{\circ}.9$ . This is very nearly its maximum possible value, so that since the polar canals appear to develop rather late in the season, we should have a still better view of them this year than we had at the last apparition. The summer solstice occurs at the Martian Date June 27, and in 1918 the border of the polar cap reached its highest latitude, about  $85^{\circ}$ , some two weeks later. This will occur with us this year on February 22, which would lead us to expect that throughout our observations the polar cap will be increasing in size, and the whole of it will be visible except when later crossed by the terminator. The increase at first slow, later becomes rapid, and we should have an excellent opportunity to study the form and extent of the successive precipitations, and probably to determine whether they were generally associated with clouds or with clear weather.

The melting of the polar caps is always readily observed, because this occurs when they are turned towards the Sun, and consequently towards the Earth at opposition. The formation of the caps on the other hand occurs during their winters, and consequently can never be well seen. Every advantage should therefore be taken of whatever opportunities are presented to us. Moreover, since the successive increments in their size are probably due to snowstorms rather than to frost, the increasing size of the caps is of far more interest than their diminution. Photographic observations made in 1888 and 1890 lead us to associate the increasing size of the caps with clouds, and at that time there were indications that successive increments of cloudiness at the two poles tended to occur simultaneously (H. A. 53, 155). Should this prove to be generally the case for Mars, it would be of in-

terest to see if a similar rule applied to the Earth. Visual observations this year should yield more conclusive results.

We have assumed so far that the phenomena of the northern polar cap was always the same year after year. This does not however appear to be the case. Thus, while in 1899 and 1901 its diameter at the time of the solstice was  $25^\circ$  and  $24^\circ$ , in 1903 it was but  $18^\circ$ , and in 1918 only  $12^\circ$ , or according to Mr. Phillips  $7^\circ$ . In 1903 the cap remained clear of cloud for at least 120 days after the solstice, when its diameter was steadily and continuously reduced to  $8^\circ$ . In 1918 its minimum size,  $10^\circ$ , was, as we have already seen, reached two weeks after the solstice, and the cap remained clear until at least 157 days later, when its diameter had increased to  $25^\circ$ . In 1905, on the other hand, the cap proper was not seen at all, the polar regions having become completely clouded over at 80 days after the solstice (Mem. B. A. A. 1903, 1905). As already noted, the solstice occurs this year upon February 8. European observations combined with those made in America, by permitting the observation of the duration of the storms to be continued through a considerable interval of time, may yield very interesting information and advance our knowledge of the meteorology of the planet considerably. As indicating what we may expect to record, a brief account may be given of an increase of the polar cap observed in 1918. See also Report No. 20, Snow Storms.

February 12, solar longitude  $\odot 72^\circ.9$ , M. D. May 45, longitude of central meridian  $\lambda 32^\circ$ , latitude of center of disk  $\beta + 21^\circ.6$ , diameter  $12''.0$ , diameter of snow cap  $17^\circ.4$ . The brightness of the snow was only 8 on a scale of 10, but its color was white, not yellow.

February 16,  $\lambda 303^\circ$ , the diameter of the cap was reduced to  $11^\circ.4$ , but a light cloud near the terminator in longitude  $210^\circ$  extended  $14^\circ.2$  south of the cap. A bright area was observed in this location in 1903 and called Olympia by Antoniadi. It was seen at intervals as late as June 11,  $\odot 126^\circ.7$ , M. D. July 49.

February 17,  $\lambda 328^\circ$ , the diameter of the cap had increased to  $13^\circ.8$ , but the extent of the cloud was reduced to  $8^\circ.4$ . In a second drawing,  $\lambda 347^\circ$ , the cloud had disappeared.

February 18,  $\lambda 293^\circ$ , diameter of the cap  $13^\circ.6$ , but it was now completely surrounded by a fainter bright ring, diameter  $23^\circ.2$ . The brightness of the cap had increased to 9, that of the outer ring was 8.

February 19,  $\lambda 279^\circ$ , the brightness of the cap was now uniform throughout, 9 to 10, and its diameter  $21^\circ.0$ . Its outline however was hazy, as if surrounded by a narrow ring of cloud, or by snow only partly covering the ground. Its size had not appreciably diminished on February 27,  $20^\circ.0$ .

A bright cloud appeared near the southern pole on February 18, was visible on February 19, and on February 27 covered a large portion of the southern hemisphere, thus corroborating the earlier photographic conclusions. A series of micrometric observations by Mr. Phillips in

1918 gave for the diameter of the cap on February 6,  $11^{\circ}.9$ , for February 18,  $22^{\circ}.9$ , and for February 27,  $10^{\circ}.2$ . The divergence between our results for the last date is marked, and difficult to explain (Journ. B. A. A. 1919, **29**, 219). It is clear that a combination of micrometric measures made in Europe and America would have yielded interesting results. It is also certain that a series of position angles for the snow and for the temporary cloud would have been valuable. These are not difficult to obtain if we set the threads parallel to the snow, and between it and the center of the disk, and compare with the trail of the planet when the clock is stopped. The observed angle as compared with the ephemeris would then give the deviation from the Martian Pole.

By means of a careful series of micrometric measurements, we may hope to make the best use possible of this unusually favorable apparition for a study of the Martian storms. A knowledge of these storms will doubtless add to our knowledge of the meteorology of other portions of the planet, where the precipitation cannot be observed through our telescopes. Since the southern polar cap is quite eccentric, its position when small lying some  $6^{\circ}$  distant from the Pole, in longitude  $50^{\circ}$ , according to Lowell ("Mars" page 84), it is quite possible that towards the end of our observations, unless heavily clouded, it may make itself visible also, in this longitude. At all events the southern polar clouds, and the changes in their dimensions should be a distinctive feature of this apparition.

#### SHIFTING SURFACE DETAIL.

With regard to the determination of latitudes and longitudes on Mars, for the latitudes we must depend on large scale drawings some two inches in diameter, and for the longitudes on the time of transit across the central meridian, as fully described in Reports Nos. 13 and 18. In the former, the use of the micrometer is recommended for latitudes, but unless the point observed is near the centre of the disk, it is now believed that better results can be secured by means of careful drawings made as described in the latter, under the subtitle "Shifting of the Canals". In addition to the vertical diameter there mentioned, a horizontal one will be found of considerable assistance. The former is turned parallel to the Planet's Axis, and on it is indicated by a short cross line the position of the point under observation. From two such drawings carefully made, one before and one after the transit, the latitude can be determined far more accurately than from an ordinary drawing of the whole disk.

These methods of measurement are readily applicable after the northern polar cap becomes visible, at the time of the vernal equinox, and while it is diminishing in size, or between solar longitudes  $0^{\circ}$  and  $120^{\circ}$ . The later increases in size, due to precipitation, are believed to occur irregularly in different longitudes, thereby making the cap temporarily eccentric about the pole. Position angles of the cap should

therefore be taken as above described, to determine this eccentricity. The south polar cap, as already mentioned, is always eccentric, and its eccentricity probably varies with the season, so excepting for objects transiting near the centre of the disk, corrections for eccentricity are always necessary after  $\odot 120^\circ$ . This longitude is reached this year on April 14, but the corrections are not expected to be large before May. It is suggested that it may be possible to use the centre of the planet's disk in place of the snow cap without a serious loss of accuracy. That is, after setting the thread in the eyepiece parallel to the planet's axis by means of the ephemeris, we should note when the centre of the disk and the point under observation are equally distant from the thread. It is probable that the shading on the side of the terminator would affect the determinations of longitude, even allowing for the defect of illumination  $q$ , when this latter quantity exceeds 0.04 of the diameter of the disk. Determinations of positions should therefore be confined if possible within the interval between March 20 and May 20.

Efforts have been made by the writer to secure latitude and longitude observations by other observers at both of the last apparitions. In 1918 he was partially successful, and a preliminary comparison of their results, corroborating his own, leaves little question in his mind but that some of the points observed have shifted. Thus in 1879 Schiaparelli found the longitude of Aryn to be  $356^\circ.1$  on the ephemeris now in use. In 1890 Wislicenus made it  $3^\circ.7$ . In 1892 the writer found it  $1^\circ.4$ . In 1894 Lowell made it  $0^\circ.3$ . In 1918 Phillips found it  $357^\circ.0$  and Douglass  $355^\circ.0$ . It seems unlikely that anyone should make an error much greater than  $1^\circ$ , yet the difference between Wislicenus and Douglass is  $8^\circ.7$ , corresponding to a time interval of 36 minutes. The construction curve, based on these and other observations, which best accords with the facts is a sinusoid, having a period of 16 years, an amplitude of  $6^\circ$ , and a minimum longitude of  $356^\circ$  occurring in 1916. That is to say Aryn is farthest to the east in the Martian April and May. This curve is merely provisional, but longitudes not far from  $359^\circ$  should be found this year, unless the shift in longitude is very irregular, or the accepted period of rotation of the planet, as suggested by Lowell, is quite erroneous. In the latter case longitudes of about  $356^\circ$  should be found. It is consequently most desirable that these observations should be repeated this year. A somewhat similar sinusoid applies to Syrtis Major, save that it was farthest east in 1914, or in Martian March and April.

The first measurements of Edom were made by the writer in 1892, who secured eight determinations of its longitude and nine of its latitude. It was measured by Lowell in 1894, by G. Fournier in 1912, and again by the writer in 1914. These are all the measurements known. The results of these four series are given below. The contrast between the accordance of the results and the variability of the

measures of Aryn is striking. The writer's investigations hitherto lead him to believe, unless future observations indicate a variation, that the longitude of this point is as well, or better known, than that of any other on the planet. The mean of the first two results as compared with that of the last two indicates that after an interval of twenty years, there is no evidence of error in the accepted rate of rotation of the planet.

TABLE I.

## LONGITUDE OF EDOM.

Year.	Observer.	Long.	Dev.
1892	Pickering	352°9	-0°1
1894	Lowell	353.1	+0.1
1912	G. Fournier	352.0	-1.0
1914	Pickering	354.2	+1.2
Mean		353°0	±0°6

It is hoped that observations of both longitudes and latitudes will be secured by a number of observers this year. The positions of as many of the following points as possible should be determined. Following each point is given its longitude and latitude according to our standard map (Report No. 15), and then a brief description of its characteristics.

1. Aryn;  $0^{\circ}$ ,  $-4^{\circ}$ . This point is very a poor one for purposes of observation, since it is subject to great changes in appearance. It has however been selected as the origin of longitudes on Mars, and has been observed many times by different observers. It is included in this list for these reasons. It usually appears as a dark rhomboid, projecting from the mare towards the north. This is the case on dates preceding the summer Solstice. On dates following it, a light covered wedge with its apex towards to south, Aryn proper, bisects the dark area. The appearance of the point observed should be carefully described.

2. Edom Promontory;  $356^{\circ}$ ,  $-8^{\circ}$ . Very sharply defined, with strong contrast, and undoubtedly the best point for longitude determinations upon the planet. It presents the same appearance, and is fairly conspicuous, at nearly all seasons of the year. For latitude we should select the boundary where it extends farthest to the south, near longitude  $350^{\circ}$ .

3. Ismenius Lacus;  $335^{\circ}$ ,  $+39^{\circ}$ . A fairly conspicuous, and therefore rather large lake, but a good point to measure.

4. Portus Sigeus;  $334^{\circ}$ ,  $-7^{\circ}$ . Sometimes well seen, and perhaps as stable as any point on the list.

5. Syrtis Major;  $283^{\circ}$ ,  $+20^{\circ}$ . The northern point should be measured. The most conspicuous marking on Mars, and probably subject to considerable changes of position. In 1916 its longitude according to Barnard was  $258^{\circ}.0$ , according to the writer  $284^{\circ}.2$ . In

1918 Phillips made it  $289^{\circ}.4$  (Journ. B. A. A. 1918, **29**, 52). This year it is expected to approach  $293^{\circ}$ , a higher longitude than has ever hitherto been recorded for it. The canal Nilosyrtris swings back and forth with it.

6. Triton Lacus;  $262^{\circ}, +12^{\circ}$ . In case the lake itself is not visible, the canal Thoth leading due south from it should be observed for longitude, the location being selected as near the lake as possible.

7. Boundary between Hephaestus and Elysium;  $235^{\circ}, +20^{\circ}$ . A sharply defined line.

8. Boundary between Elysium and Charontis;  $200^{\circ}, +17^{\circ}$ . A sharply defined line, and with its predecessor well adapted to determine the longitudinal width of Elysium.

9. Laestrigon Sinus;  $200^{\circ}, -25^{\circ}$ . This bay has of late been more marked than as shown on the map. While very far to the south, it is an important point.

10. Titanum Sinus;  $170^{\circ}, -20^{\circ}$ . A marked and very important point. Rather difficult on account of its southern latitude. It should be measured early in the season. Has been suspected of a considerable shift.

11. Castorius;  $155^{\circ}, +52^{\circ}$ . It may appear as a lake or as the southern end of a bay. On account of its latitude it will be difficult to measure after this apparition.

12. Phoenicis Lacus;  $106^{\circ}, -16^{\circ}$ . A very important point, and probably very conspicuous in a few years, but of late it has been rarely recorded.

13. Messeis Lacus;  $80^{\circ}, -5^{\circ}$ . Best identified as the spot where the canal Kedron branches off to the north. A small local map showing this lake and canal is given in Report No. 17.

14. Lunae Lacus;  $65^{\circ}, +19^{\circ}$ . A large hazy region, but occasionally small and defined.

15. Junction of Ophir with Aurorae Sinus;  $63^{\circ}, -7^{\circ}$ . Interesting because subject to marked change.

16. Juventae Fons;  $61^{\circ}, 0^{\circ}$ . Small and difficult, but suspected of marked change in longitude.

17. Niliacus;  $30^{\circ}, +28^{\circ}$ . The southern point at the junction with Hydaspes. Conspicuous and changeable.

18. Oxia Lacus;  $20^{\circ}, +13^{\circ}$ . In case the lake is not visible the northern part of Magaritifera should be measured. Suspected of considerable shift.

19. Thymiamata Promontory;  $20^{\circ}, -3^{\circ}$ . Like Edom its southern limit should be measured for latitude, in case the end of the promontory is not well defined. There is evidence of marked change in latitude.

20. Siloe Lacus;  $5^{\circ}, +34^{\circ}$ . Sometimes well defined.

Of these 20 points Aryn, Edom, Syrtis, Ophir, Oxia, and Thymiamata are perhaps the most important, and Ismenius, Hephaestus,

Charontis, Titanum, Phoenicis, and Niliacus are next. Some are interesting as being especially stable, and others as especially liable to shift. Measurements of the same point made on preferably three different nights are very desirable.

#### COLORS EXHIBITED BY THE PLANET.

It was found in 1918 that the deserts of the planet were red, matching No. 12 of the Color Scale until  $\odot 62^\circ$ , that they were yellow matching No. 11 at  $\odot 80^\circ$ , and again red later on. This is equivalent to saying that on the Martian Date of May 21 the deserts were red. By June 6 they had turned yellow, and were again red later on in August. This would appear to indicate that during the summer season the deserts are so only in name. The beginning and end of the crop (not necessarily by any means artificial) has now been well located, but its color in late May and early June has not at this writing been determined satisfactorily. Its duration is about thirty weeks. Observations made in 1915 (Report No. 11) indicate that the crop is a semi-annual one. Color measurements are now being made at regular intervals, and a description of them will appear in a subsequent report. A possible, but less probable explanation of the yellow color observed at this season, is that it is due to low lying fog or mist covering the deserts. The source of light, and colored medium employed in these measurements are described in Report No. 18. For the Color Scale see *POPULAR ASTRONOMY* 1917, 25, 419, and for the Color Wedge, Report No. 20. The latter was made with colored crayons, which are easier to control than water colors.

The southern maria which were experiencing their early winter weather were generally gray when well seen in 1918, with sometimes a slight greenish tint, like that of our remote pine clad hills. Towards the end of the present apparition they are expected to assume a fresher and more brilliant hue. The northern maria on the other hand which were in the midst of their June appeared brownish, and were markedly different in color from the southern ones. This fact, not so noticeable at recent apparitions, clearly implies vegetation. Some doubt has been expressed by one observer as to whether the bright blue color sometimes noted in the Syrtis might not be due to chromatic aberration of the objective. If this were so, it should always be seen, which is by no means the case. The color appears only shortly after the beginning of a flood. In the case of Acidalium, it only shows when the melting of the polar cap is at its height. Mr. Phillips states that colors are better seen with his 12 and 18-inch reflectors than with his 8-inch refractor. This is natural, since the reflectors give more light. He notes especially the very "beautiful greenish blue" color of the Syrtis on March 23, 1918; noticed also as unusual by several other observers at about this time. Mr. Ellison, using an 18-inch mirror, speaks of the "full sky blue" color of the Syrtis on March 21. The

writer recorded it with his 11-inch refractor in a color sketch on March 24. The tint as represented about matches No. 5 of the Color Scale, but is more heavily shaded. On March 28 he describes it as "very blue" and as rather more so than as shown in the color sketch.

#### MISCELLANEOUS OBSERVATIONS.

We are now approaching the season when small clouds may be seen surrounding the polar cap. Lowell describes a number observed shortly after the passage of the summer Solstice (*Annals Lowell Observatory* **3**, 1911). The eastern or preceding portion of Elysium frequently bears a cloud. Well defined clouds forming or disappearing near the limb or terminator should be carefully sketched at intervals of a few minutes. Clouds projecting beyond the terminator have been seen at this season. Canals surrounding the polar cap darken towards noon with the melting snow, and fade in the afternoon as they evaporate, or freeze with the coming of night. Equatorial Canals on the other hand fade towards noon as they evaporate, and probably darken again later. Nodus Gordii near longitude  $120^\circ$  is especially liable to rapid changes in darkness and location. It should be drawn at short intervals when conspicuous. In Report No. 20, under "Hourly Changes in Brightness," is given a detailed account of the variations detected in the region on both sides of Thoth. Two tropical frosts were recorded at the last apparition, when Mars was nearly at its greatest distance from the Sun. If detected this year, they should be observed, and their outlines drawn with care at frequent intervals. Notes on the color of the broader canals as seen with large apertures may be of value. A search for hourly changes in the finer canals should be made. This should include their curvature, duration, possible shifting of position, longitudinal development, and the formation or disappearance of any lakes in connection with them. Long continued observations on the same night if change is suspected, are desirable. The quality of the seeing should be noted frequently during the observation. In case any changes are noted. These changes would have a bearing on the interpretation of the canals, whether as marshes or as vegetation, and would therefore be of considerable importance.

Table II gives the data of those drawings made in Jamaica after March 16, 1918. Report No. 20 gives the data for the previous drawings of the apparition. Following the table is given a list of the canals and lakes identified on each drawing. The main object of these lists, which have been continued since our first Report, published in 1914, is to record under uniform and favorable conditions, as the Martian seasons progress, the dates of appearance, disappearance, and continued visibility of every canal and lake that it has been possible to identify on the surface of the planet.

TABLE II.

## DATA OF THE DRAWINGS.

No.	1918	☉	M. D.	Long.	Lat.	Sun	Diam.	Seeing.
54	Mar. 21	89.0	June 25	334°	+ 21.7	+ 24.0	14".1	7
55	" 22	89.5	" 26	335	21.8	"	"	9
56	" "	"	" "	358	"	"	"	8
57	Apr. 3	94.8	" 38	301	22.0	23.9	13.6	7, 6
58	" 4	95.2	" "	219	"	"	13.5	10
59	" "	"	" "	243	"	"	"	9
60	" "	"	" "	271	"	"	"	8
61	" 5	95.7	" 39	217	"	23.8	13.4	7
62	" 8	97.1	" 42	181	22.1	"	13.2	9
63	" 20	102.5	" 54	94	22.5	23.4	12.1	7
64	" "	"	" "	115	"	"	"	7
65	Apr. 21	103.0	June 55	57	22.4	23.3	12.1	9
66	" 28	106.1	July 6	343	22.8	23.0	11.6	10
67	" "	"	" "	1	"	"	"	11
68	" "	"	" "	27	"	"	"	11
69	May 2	107.9	" 10	301	23.0	22.7	11.1	7, 6
70	" 5	109.3	" 13	273	23.1	22.6	10.9	9, 8
71	" 9	111.1	" 16	248	23.3	22.3	10.6	9
72	" 14	113.5	" 21	214	23.6	21.9	10.1	10
73	" 28	120.0	" 35	97	24.3	20.6	9.0	8
74	" 30	121.0	" 37	59	24.4	20.4	8.9	8
75	June 1	122.0	" 39	34	24.5	20.2	8.8	7
76	" 2	122.3	" 40	31	"	20.0	"	8
77	" 3	122.9	" 41	4	"	"	8.7	8, 9
78	" 4	123.4	" 42	2	"	19.9	"	10
79	" "	"	" "	17	"	"	"	10
80	" 9	125.8	" 47	337	24.7	19.2	8.3	10
81	" 10	126.3	" 48	323	24.8	19.1	"	9
82	" 11	126.7	" 49	302	"	19.0	"	8
83	" 24	133.1	Aug. 5	177	25.0	17.3	7.5	6
84	" 25	133.6	" 6	148	"	17.1	7.4	10
85	" 28	135.0	" 9	121	"	16.7	"	7
86	July 4	138.0	" 15	64	24.9	15.8	7.2	7
87	" 5	138.5	" 16	56	"	15.6	7.1	8
88	" 9	140.6	" 20	26	24.7	15.0	7.0	7
89	" 10	141.1	" 21	2	"	19.8	6.9	7
90	" 16	144.1	" 27	301	24.5	13.8	6.8	7
91	" 18	145.1	" 29	302	24.3	13.4	6.7	7
92	" 20	146.1	" 31	277	24.2	13.1	"	6
93	" 22	147.2	" 33	248	24.0	12.7	6.6	7
94	Aug. 1	152.4	" 42	149	23.2	10.9	6.3	7
95	" 8	156.0	" 49	81	22.4	9.5	6.1	9
96	" 11	157.7	" 52	53	22.0	8.9	6.0	6
97	" 13	158.7	" 54	32	21.6	8.5	"	7
98	" 14	159.2	" 55	21	"	8.3	5.6	6
99	" 16	160.3	Sept. 1	357	21.3	7.9	"	8
100	" 22	163.6	" 7	303	20.3	6.6	5.8	8
101	" 28	166.8	" 13	238	19.3	5.3	5.7	6, 7

## CANALS AND LAKES IDENTIFIED ON THE DRAWINGS.

Mar. 21, **BC** Pandora, Gehon, Oxus, Indus Deuteronilus, Protonilus, Callirrhoe, Pierius, Nilosyrtris, Asclepius, Pyramus, Iaxartes, and Caloe, Ismenius.

Mar. 22, **FA** Pandora, Typhonius, Asopus, Nilosyrtris, Astusapes, Protonilus, Deuteronilus, Gehon, Oxus, Indus, Pierius, Callirrhoe,

Iaxartes, and Sirbonis, Ismenius, Arethusa, Oxia.

Mar. 22, **A** Pandora, Gehon, Oxus, Protonilus, Deuteronilus, Pierius, Callirrhoe, Anonymous (c), and Ismenius, Arethusa, Oxia.

Apr. 3, **F** Thoth, Casius, Nilosyrtris, Astusapes, Astaboras, Protonilus, Pierius, Cadmus, and Caloe, Ismenius.

Apr. 4, **DE** Cyclops, Hephaestus, Nepenthes, Triton, Thoth, Casius, Nilosyrtris, Anian, Eunostos, Hyblaeus, Chaos, Boreas, Rhyndacus, Styx, Cerberus, Erebus, Pyriphlegethon.

Apr. 4, **E** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Cyclops, Hephaestus, Anian, Nepenthes, Thoth, Casius, Nilosyrtris.

Apr. 4, **EF** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Cyclops, Anian, Triton, Nepenthes, Thoth, Casius, Nilosyrtris, Astusapes, Protonilus, Pierius, Argeus.

Apr. 5, **DE** Erigone, Phlegethon, Propontis, Hades, Cephissus, Boreas, Styx, Cerberus, Eunostos, Hyblaeus, Chaos, Thoth, Casius, and Charontis, Propontis.

Apr. 8, **D** Marne(P), Titan, Avernus, Laestrigon, Axon(L), Elison(J), Tantalus, Pallene(J), Hebrus, Hades, Pyriphlegethon, Boreas, Styx, Cerberus, Eunostos, Hyblaeus, Chaos, Cephissus, Aesacus, Adonis, and Biblis, Castorius, Propontis, Arsenius.

Apr. 20, **BC** Nectar, Ophir, Daemon, Fortuna, Araxes, Iris, Uranius, Nilokeras, Gigas, Issedon, Tantalus, Tanais, Acheron, and Solis, Tithonius.

Apr. 20, **C** Araxes, Gigas, Ceraunius, Tanais, Acheron.

Apr. 21, **B** Oxus, Indus, Deuteronilus, Callirrhoe, Jamuna, Nectar, Ophir, Daemon(L), Kedron(P), Eumenides, Iris, Nilus, Phlegethon, Chryssorrhoeas, Nilokeras, Tanais, and Oxia, Solis, Ascraeus, Hyperboreas.

Apr. 28, **FA** Thoth, Nilosyrtris, Protonilus, Astaboras, Phison, Asopus, Pierius, Arnon, Euphrates, Typhonius, Orontes, Gehon, Deuteronilus, Callirrhoe, and Sirbonis, Hipponitis(J), Caloe, Ismenius, Arethusa.

Apr. 28, **A** Nilosyrtris, Asopus, Orontes, Euphrates, Siticus, Gehon, Indus, Anonymous(a), Astaboras, Phison, Protonilus, Deuteronilus, Pierius, Callirrhoe, Iaxartes, Tanais, and Caloe, Ismenius, Oxia.

Apr. 28, **AB** Protonilus, Deuteronilus, Gehon, Indus, Callirrhoe, Iaxartes, Tanais, and Ismenius, Oxia, Niliacus.

May 2, **F** Thoth, Casius, Pyramus, Nilosyrtris, Astaboras, Astusapes, Protonilus, Deuteronilus, Pierius, Callirrhoe, and Ismenius.

May 5, **EF** Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Hephaestus, Thoth, Casius, Nepenthes, Nilosyrtris, Astusapes, Astaboras, Protonilus, Pierius.

May 9, **E** Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Aesacus, Anian, Hephaestus, Nepenthes, Thoth, Casius, Nilosyrtris.

May 14, **DE** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Aesacus, Choaspes, Gyndes, Heliconius, Alcyonius, Thoth, Nepenthes.

May 28, **BC** Indus, Jamuna, Nilokeras, Ophir, Fortuna, Iris, Issedon,

Uranus, and Niliacus, Lunae.

June 2, **AB** Siticus, Deuteronilus, Aron, Callirrhoe, Nilokeras.

June 3, **A** Typhonius, Orontes, Protonilus, Deuteronilus, Pierius, Callirrhoe, Gehon, Oxus, and Caloe, Ismenius.

June 4, **AB** Protonilus, Deuteronilus, Callirrhoe, Gehon, and Ismenius.

June 9, **FA** Nilosyrteis, Asopus, Orontes, Astaboras, Protonilus, Deuteronilus, Gehon, Arnon, Pierius, Callirrhoe, and Hippontis, Ismenius, Arethusa.

June 10, **FA** Nasamon, Nilosyrteis, Aspus, Astaboras, Phison, Protonilus, Deuteronilus, Arnon, Pierius, Callirrhoe, and Ismenius, Arethusa.

June 11, **F** Nepenthes, Thoth, Casius, Nilosyrteis, Astusapes, Protonilus, Deuteronilus.

July 4, **B** Nilokeras.

July 5, **B** Nilokeras, Ganges.

July 9, **AB** Indus, Jamuna.

July 10, **A** Protonilus, Deuteronilus, Pierius, Callirrhoe.

July 16, **F** Casius, Nilosyrteis.

July 22, **E** Cerberus, Styx, Casius.

Aug. 14, **AB** Deuteronilus, and Ismenius.

Aug. 16, **A** Protonilus, Deuteronilus, Gehon.

Aug. 22, **F** Nilosyrteis.

Mandeville, Jamaica, B. W. I., January 1, 1920.

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### YERKES OBSERVATORY 1919.

By **EDWIN B. FROST.**

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*Personnel.* Mr. Edison Pettit had received his discharge from the Army at the end of December 1918 and continued his duty here as assistant for solar physics through the year. Until June 30 he also assisted in securing the plates for stellar parallaxes with the 40-inch telescope.

Mrs. Hannah Steele Pettit continued her work as assistant for stellar parallax until June 30. She took her examination for the Doctor's degree at the observatory on July 12 and received the degree at the University at the end of the summer quarter.

Mr. Van Biesbroeck left the observatory, with his family, on May 31 for a trip to Belgium. He attended the meetings of the International Astronomical Union at Brussels. He returned with his family and mother and sister on Aug. 23.

Professor Paul Biefeld of Denison University worked as volunteer