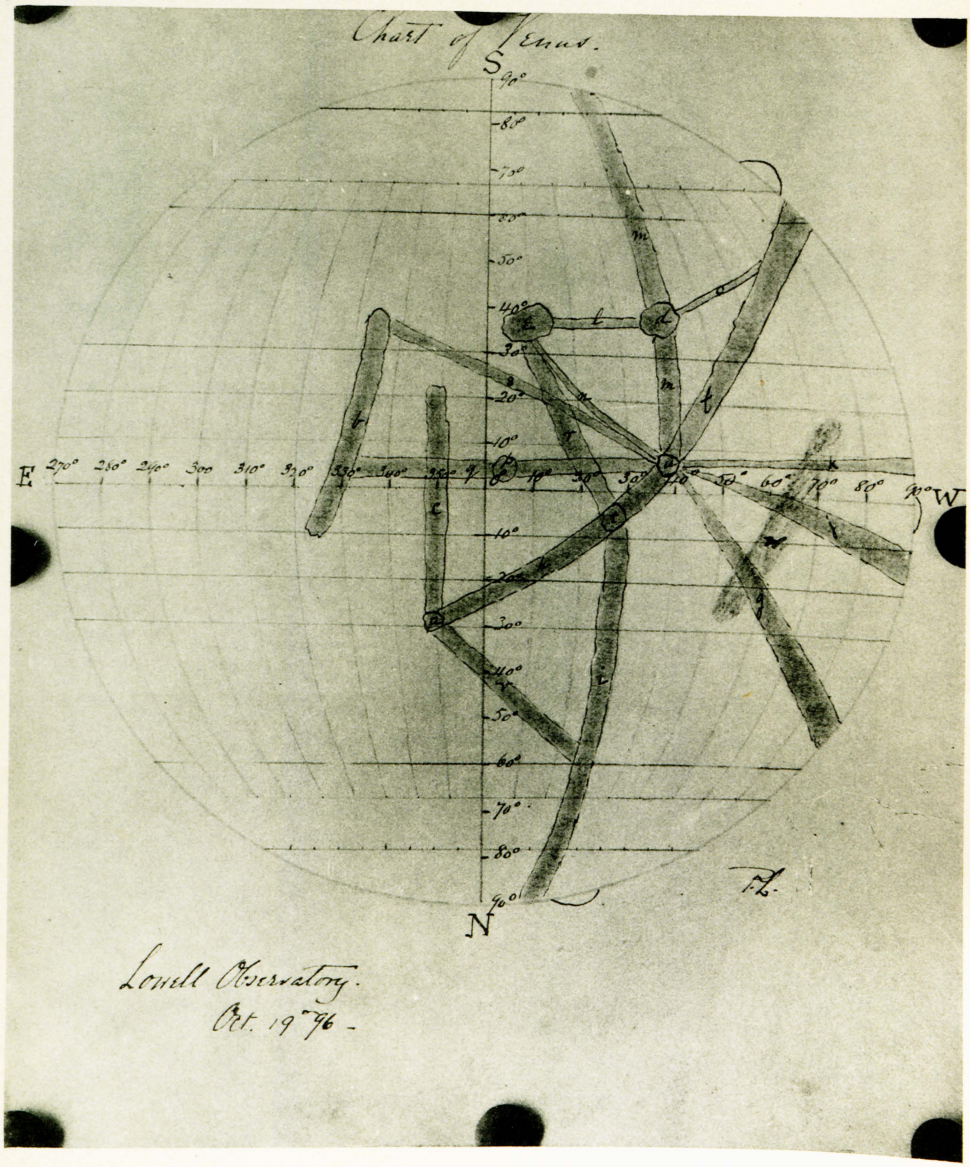
Compliments of the Author.

DETECTION OF VENUS' ROTATION PERIOD AND OF THE FUNDAMENTAL PHYSICAL FEATURES OF THE PLANET'S SURFACE,

PERCIVAL LOWELL.

Reprint from POPULAR ASTRONOMY.

PLATE XXIII.



INDEX TO MAP OF VENUS.

a	Eros	*i*	Aeneas regio	*q*	Somnus regio
b	Psyche regio	*j*	Anteros regio	*r*	Cytherea regio
c	Hermione regio	*k*	Adonis regio	*s*	Cypria regio
d	Astoreth	*l*	Dione regio	*t*	Pothos
e	Ashera	*m*	Paris regio	*u*	Bilit
f	Anchises regio	*n*	Hymenæus regio	*v*	Astarte regio
g	Hero regio	*o*	Hyphæstos regio	*w*	Libentina regio
h	Aphrodite regio	*p*	Istar		

DETECTION OF VENUS' ROTATION PERIOD AND OF THE FUNDAMENTAL PHYSICAL FEATURES OF THE PLANET'S SURFACE.

PERCIVAL LOWELL.

For Popular Astronomy.

Owing hitherto to the impossibility of making out any certain markings upon the disk of the planet, the rotation period of Venus, together with the determination of all its dependent phenomena, has up to the present time been a matter of doubt. The history of the subject was thus summed up by Stanley Williams in the last edition of Webb, published in 1893.

"The question of the duration of the rotation of Venus is still a disputed one, and several very elaborate though contradictory investigations upon the subject have been published within the last few years. In 1890 Schiaparelli came to the conclusion after a very exhaustive discussion of all the existing material, including some observations of his own, that the rotation of Venus is very slow; and that whilst being very probably equal to the time taken by the planet in making one revolution round the Sun (225 days), it is certainly not less than 6 months or greater than nine months. Perrotin confirms this slow rotation from observations of the markings on the disc made by him at Nice in 1890, and fixes it at from 195 to 225 days. In the same year Terby published a number of observations made by him in 1887-89, which appeared to him to still further confirm the slow duration of the rotation. But in 1891 appeared an important memoir by Niesten, giving the results of many observations made by himself and Stuyvaert at Brussels between 1881 and 1890. These observers, instead of supporting the slow rotation, strongly confirm the short rotation period of De-Vico. They also found the markings so evident and apparently permanent, that they were able to construct a map of them. This map, however, does not bear the slightest resemblance to that of Bianchini on p. 58. More recently still Trouvelot has discussed the subject, and decides that the rotation is performed in about 24 hours. His observations of a large dark spot are referred to on p. 61. With results so contradictory, and obtained too by some of our very best ob-

servers, it is difficult to come to a satisfactory conclusion upon the subject. The balance of the evidence appears at present, however, to be in favor of a rotation in about 24 hours."

Since this Leo Brenner has published several papers affirming strongly the rotation period of about 24 hours.

Such was the state of our knowledge when in August I began systematic observations upon the planet with the 24 inch refractor. I had no sooner begun observing than it was apparent that there were markings upon the disk and before long it was furthermore apparent that the markings bore no resemblance to the indefinite patches commonly depicted. So distinct and definite did the markings prove that they have resulted in the detection of the planet's rotation and of the fundamental physical characteristics of the planet's surface. I shall give in this paper a first summary of what they have disclosed, together with reproductions of some of my drawings and those of my assistant Mr. Drew.

To begin with, then, the markings are both distinct and well defined; their contours standing out sharply against the lighter parts of the disk. In shape they are of two kinds: long, relatively narrow, and, generally speaking, straight markings; and spots. They are all of them permanent and permanently visible, our own air alone ever obscuring them. Indeed the seeing must be distinctly bad to have the more prominent among them not discernible. Such phenomena show that they belong to the actual surface of the planet itself.

As the rotation period is of primary importance both to the planet's past and present history we may take up its determination first.

The markings disclose the rotation period unmistakably. This period proves to be identical with the planet's orbital period. Such will be evident on comparing the several drawings with one another. In the first place the markings show at once that any rotation period of about 24 hours is impossible. The five drawings of October 15th furnish the most forthright evidence of this. For they cover between them a period of about five hours and during all this time the markings show no change. But in an interval of five hours the planet would, on the supposition of a rotation period of about 24 hours, have rotated through 75 degrees which would have caused the central markings to travel about five-eighths of their apparent journey across the disk.

So much for the negativing any short rotation period. The ac-

PLATE XXIV.

Aug. 24.5^h 40^m
$\lambda = 18°$

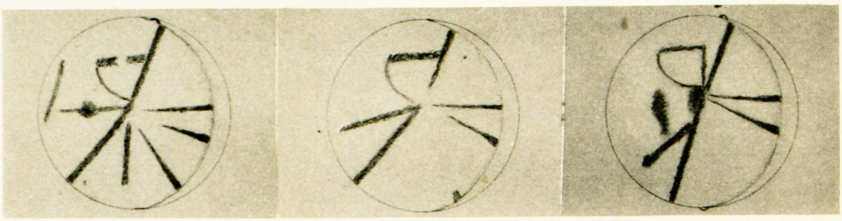
Aug. 31 2^h 48^m 52^s
$\lambda = 21°$

Aug. 31 5^h 35^m
$\lambda = 21°$

Sept. 29 3^h 30^m
$\lambda = 31°$

Sept. 29 5^h 12^m
$\lambda = 31°$

Oct. 4 4^h 5^m
$\lambda = 32°$



Oct. 9 1^h 19^m — 2^h 28^m
$\lambda = 35°$

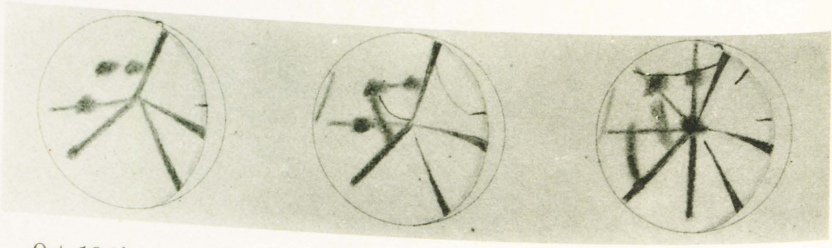
Oct. 9 2^h 48^m — 56^m
$\lambda = 35°$

Oct. 9 5^h 3^m — 8^m
$\lambda = 35°$

VENUS.

Drawn by Percival Lowell, Lowell Observatory.

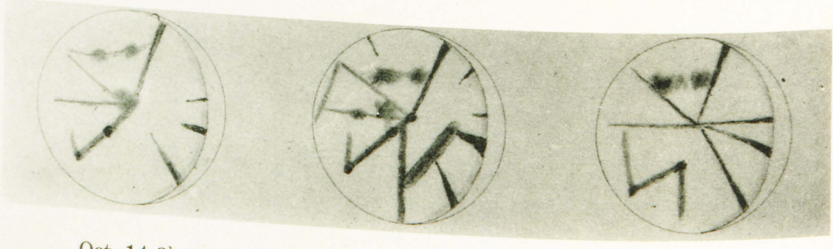
PLATE XXV.



Oct. 13 $2^h\ 55^m - 3^h\ 4^m$
$\lambda = 37°$

Oct. 14 $1^h\ 59^m - 2^h\ 12^m$
$\lambda = 37°$

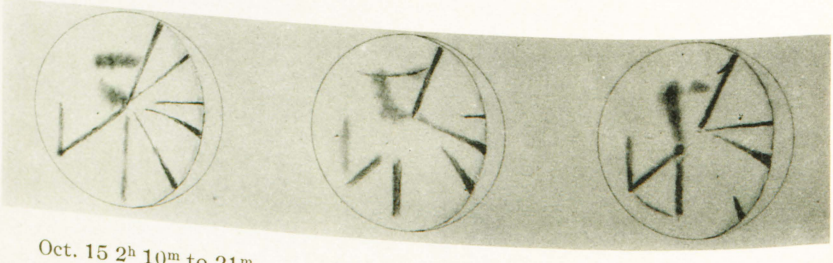
Oct. 14 $3^h\ 13^m$ to 18^m
$\lambda = 37°$



Oct. 14 $3^h\ 50^m$
$\lambda = 37°$

Oct. 15 $0^h\ 5^m$ to 14^m
$\lambda = 37°$

Oct. 15 1^h
$\lambda = 37°$



Oct. 15 $2^h\ 10^m$ to 21^m
$\lambda = 37°$

Oct. 15 $3^h\ 48^m$ to 55^m
$\lambda = 37°$

Oct. 15 $4^h\ 57^m$
$\lambda = 37°$

VENUS.

Drawn by Percival Lowell, Lowell Observatory, Oct. 16, 1896.

tual rotation period is disclosed by a certain detail of their presentation of an instantly tell-tale character. This feature is the fact that the markings always hold the same position with regard to the terminator. For such a relation to the terminator shows that the rotation period and the orbital one coincide and that the axis of rotation is perpendicular to the plane of the orbit. This will at once be evident on considering what must occur in the case of a body travelling in an orbit practically circular, and rotating about such an axis once in the course of its circuit of the Sun: its illuminated side must remain forever the same. In whatever position, therefore, the body be presented to the view of an outsider, the boundary of the light and shade must occupy perpetually the same points upon the body's surface. In an orbit non-circular, in consequence of the eccentricity of that orbit, there would take place a certain libration in longitude and in consequence of any tilt in the axis there would occur one in latitude. But the orbit of Venus is practically circular, its eccentricity being only .00684 and the consequent libration from apse to apse amounts, therefore, at most to 47′, a quantity smaller than the inevitable errors of observation.

As the next point: the successive positions of the markings show that the axis of rotation is practically perpendicular to the plane of the orbit. This is disclosed by the fact that the markings in the course of their apparent journey in company with the terminator traverse the disc in straight lines. As yet no deviation from this course has been revealed by the drawings down to the last yet made, those of November 9; any apparent slight variations which may appear in any single drawing being shown by a comparison of all to be within the errors of observation.

Besides giving the period of the rotation and the position of the axis of that rotation, the markings establish certain physical characteristics with regard to the surface condition of the planet of which the chief are the following:

First, the invariable visibility of the markings shows that they are not obscured at any time by clouds. In other words there are no clouds upon the planet.

Next: the intense lustre of the disk is shared by all the markings. It is as if a bright veil of some sort were drawn over the whole disk, making the bright parts brighter and the dark less dark. Compared with Mercury and his markings the effect is striking. The bright parts of Mercury are very much fainter than are those of Venus, while his dark markings are very much darker than hers. This veil is unquestionably atmosphere.

The presence of atmosphere is further corroborated by the relative measures I have made of the planet's polar and equatorial diameters as compared with those of Mercury. The Venusian appears to reveal a twilight arc as the Martian ones do—while the Mercurial do not.

Third: there appears to be no sign of water or of vegetation upon the planet. This is shown by the absence of color in any part of the disk. The disk is simply a design in black and white over which is drawn a brilliant straw-color veil. Compared with the pronounced and beautiful tints of Mars, the white, blue-green and reddish-yellow, Venus is a very drab-like thing.

Such appearance is what the probable meteorologic conditions prevailing on the sun-lit side of the planet would lead us to infer a priori. Being exposed in perpetuity to the full blaze of the Venusian sun, it would seem that a funnel-like indraught of air from the dark side to the bright and then an umbrella-like return of it, would necessarily result and that the eventual outcome of this would be the depositing of almost all the water upon the unilluminated side where in the form of ice it would substantially remain.

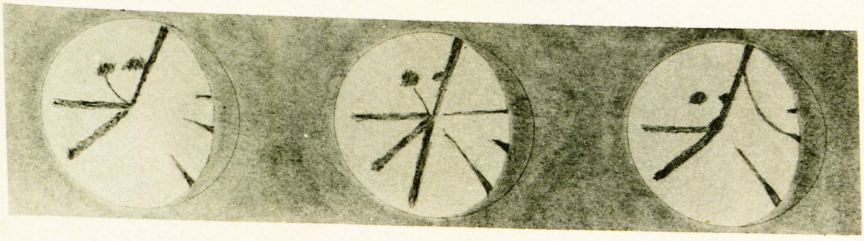
Furthermore there is no evidence of any polar-caps. At one time I thought to see something of the kind but it had nothing of the unmistakableness of the Martian polar caps and the effect has not been repeated. It was undoubtedly of simple irradiation origin.

The absence of polar caps tallies with the above meteorological view since on that supposition there should be, not polar caps, but a polar hemisphere which the absence of sensible libration would forever hide from our view. Mr. Godfrey Sykes suggests that such an ice-clad hemisphere may account for the phosphorescence seen upon the dark side.

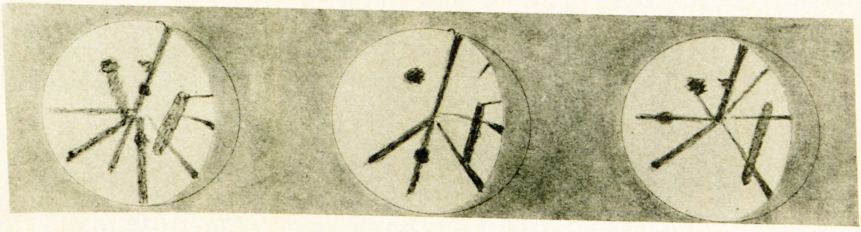
We may now consider the markings in detail. So permanently visible are they that I have been able to construct the accompanying map of the only hemisphere Venus can ever show us. The relative absence of markings on the left side of the map simply means that during the observations that side was not favorably presented, the extreme edge not having heen presented at all, as the observations began when the phase angle was 17°.

The most instantly curious phenomenon about the markings is that a great many of them are of the general nature of broadish lines radiating from a certain point in longitude 37° and north latitude 8°. Curious as this character and distribution appears to be, the look of the whole is natural. There is nothing about

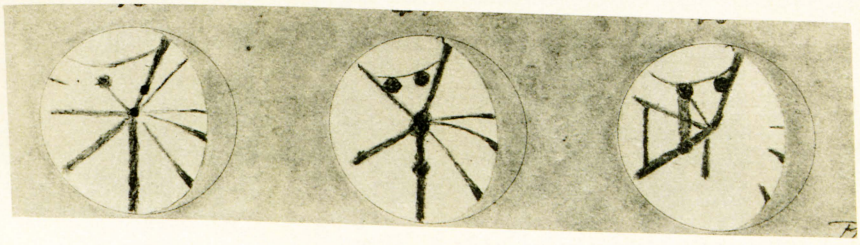
PLATE XXVI.



Oct. 16 0^h 15^m to 25^m | Oct. 16 5^h to 5^h 5^m | Oct. 17 3^h 30^m



Oct. 19 3^h 25^m to 34^m | Oct. 19 5^h 5^m | Oct. 20 1^h

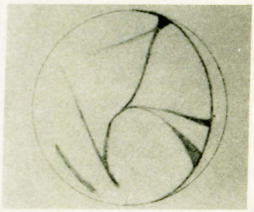


Oct. 23 23^h 36^m — 43^m | Oct. 25 3^h 45^m | Oct. 25 4^h 2^m — 11^m

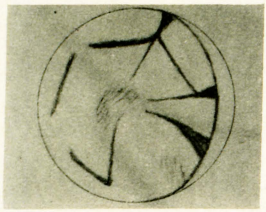
VENUS.

Drawn by Percival Lowell, Lowell Observatory, Oct., 1896.

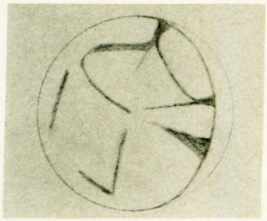
PLATE XXVII.



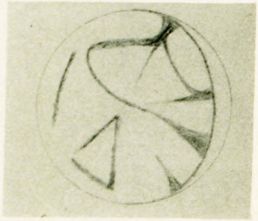
Sept. 29 $4^h\ 10^m$



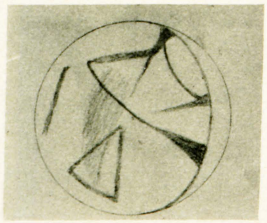
Oct. 7 $5^h\ 5^m$



Oct. 8 $3^h\ 15^m$



Oct. 8 5^h



Oct 9 $2^h\ 40^m$

VENUS.

Drawn by D. A. Drew, Lowell Observatory.

the system bearing resemblance to the noticeable artificiality of the markings of Mars.

The next most salient features are the spots. Chief among these are two *oculi* in longitudes 8° and 38° and latitudes 36° and 38° north.

Another feature worth mentioning is the permanent projection about 20° to the west of the southern cusp. This would seem to have been seen by Schröter. That from observations of the return of this projection he deduced a rotation period of 23 hours 21 minutes 19 seconds is worth quoting since the projection was never absent.

Lastly: the relative visibility of some of the markings changes with their position with regard to the observer. For instance Somnus regio, which was almost invisible when in the centre of the disk, has grown more conspicuous as it has approached the limb. Anteros regio and Adonis regio have similarly become less salient on nearing the central meridian. Other markings under like conditions of position and illumination have not done so, but have remained as evident in the one aspect as in the other or, as in Hermione regio, have become less conspicuous on nearing the limb. As of two markings occupying the same part of the disk, Hermione regio and Somnus regio for example, the one will change in one way, the other in the opposite manner, the change cannot be a matter of obscuration. Secondly as the position of the markings has not shifted with regard to the Sun, the change cannot be intrinsic. It is therefore probably due to a difference in the character of the rock or soil, greater or less roughness for example, in one region than in the other which causes them to appear differently under different angles of illumination. That in these markings we are looking down on a bare desert-like surface is what the observations imply.

INDEX TO MAP OF VENUS.

a	Eros	*l*	Dione regio
b	Psyche regio	*m*	Paris regio
c	Hermione regio	*n*	Hymenæus regio
d	Astoreth	*o*	Hyphæstos regio
e	Ashera	*p*	Istar
f	Anchises regio	*q*	Somnus regio
g	Hero regio	*r*	Cytherea regio
h	Aphrodite regio	*s*	Cypria regio
i	Aeneas regio	*t*	Pothos
j	Anteros regio	*u*	Bilit
k	Adonis regio	*v*	Astarte regio
		w	Libentina Regio

LOWELL OBSERVATORY, November, 1896.

Lowell, Percival
"Determination of the rotation period and surface character of the planet Venus. Monthly Notices of the RAS. v.57:#3 (L. O., Oct. 1896)

See

Lowell, Percival
"Mercury" Monthly Notices of the RAS...