SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

AN ACCOUNT

OF THE

TOTAL ECLIPSE OF THE SUN

ON

SEPTEMBER 7, 1858, AS OBSERVED NEAR OLMOS, PERU.

BY

LIEUT. J. M. GILLISS.

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COMMISSION

TO WHICH THIS MEMOIR HAS BEEN REFERRED.

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THE JOURNEY TO OLMOS.

An announcement having been made that observers would leave England, and probably France also, for the purpose of observing, in Brazil, the total eclipse of the sun, which would take place on the 7th September, 1858, as no one was mentioned who contemplated visiting the rainless region on the west coast of South America, for that object, on the 8th June last I addressed a letter to Professor Joseph Henry, Secretary of the Smithsonian Institution, offering to undertake the journey, if no astronomer more competent to the task to be accomplished should volunteer his services.

Through the zeal for the advancement of science which has marked the administration of the affairs of this Institution under that eminent physicist, the proposition was promptly accepted, and arrangements for departure from the U. States were speedily made.

Prof. A. D. Bache, Superintendent of the U. S. Coast Survey, very liberally contributed the necessary instruments for accurate determination of the geographical position and time at the station which might be selected, and a tent for our shelter at night; Commander M. F. Maury, Superintendent of the U. S. Naval Observatory, furnished two excellent pocket chronometers; and Mr. Henry Fitz, of New York, who had made the object-glass for the equatorial of the U. S. Naval Astronomical Expedition, with great liberality specially completed and loaned a 4¼ inches achromatic telescope, mounted on an equatorial stand, suitable for all latitudes.

Accompanied by a young friend from New York—Mr. C. H. Raymond—I left that city on the 5th of August for Payta, in Peru; and traversing the isthmus of Panama on the 14th, we reached Payta on the morning of the 21st of the same month.

On landing at the latter place, most unfavorable accounts were given me of the condition of the atmosphere near the coast, about the hour of sunrise; and the contradictory opinions concerning that of the interior at the same period of the day—more especially at that season of the year—were very discouraging. All were agreed, however, that a land journey from Payta to a point on or near the Andes, which would be traversed by the central line of the moon's shadow, must be attended by many privations and great exposure and fatigue. On the other hand, the commander of the steamer on which I had come to Payta, warned me of the risks of landing with instruments through the heavy surf at Lambayeque,[1] and of the possibility that he might be obliged to leave me on board of one of the trading vessels anchored in the roadstead, where many days might be passed before a safe opportunity would occur for disembarking. Weighing all the circumstances, I concluded to remain at Payta, and be governed by the information and experience which a brief residence there would enable me to obtain.

On the same day, through Capt. d'Aignan, of the steamer of war Mégère, I received a message from the admiral of the French fleet in the Pacific, most courteously offering to convey me in the Mégère to any point on the coast, or to facilitate, in any other manner in his power the observations which were the object of my journey. His interest for the advancement of astronomical science was also shown in 1850, when he detailed M. Kutczycki for observation of the total eclipse which took place on the 7th August of that year, and his considerate offer on this occasion was gratefully appreciated. As it was most desirable to increase the number of stations and observers, Capt. d'Aignan received instructions to remain at Payta, and carry out the arrangements which might subsequently appear to promise the best results.

During the following eight days there was only one when the sky was clear to the eastward at sunrise. Cirrus clouds formed before daylight, and continued to obscure nearly the whole heavens until between 9 and 10 o'clock A. M. About these hours the southerly wind usually commenced, and this, together with the increasing heat, apparently dissipated the clouds. Towards 3 or 4 o'clock P. M. they formed again and continued until dark, often assuming a cirro-cumulo or cumulo form. From that time, also, the strength of the wind gradually decreased, and there were variable airs from the sea throughout the night, which was usually clear and the stars brilliant. It is to be presumed that clear nights preponderate, for the populace have a distich—

"La luna de Payta,
Y el sol de Colan"
(The moon of Payta,
And the sun of Colan) ;[2]

and the inference is legitimate, that the two places are respectively favored by the brilliancy of the celestial bodies named.

The experience of eight days showing that the probabilities of a favorable morning near the coast were against us, on the 28th I resolved to leave instruments with Capt. d'Aignan and proceed to the interior, selecting there such station as from the information to be acquired, might seem to promise the best results. And at an

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[1] Lambayeque is 22 Peruvian leagues from Olmos, and the road between them is through a cultivated valley offering resources the whole way. Dr. Moesta was prevented from landing there (by surf) until 5th September ; and could only reach Motupe, a village 5 leagues south of Olmos, and where he had a cloudy morning on the 7th.

[2] The name of an Indian village also near the sea, but a few leagues north of Payta.

interview that day with this officer it was arranged that he should proceed with the Mégère to Punta de la Aguja, at the southern side of Sechura Bay, and some 60 miles south from Payta, where the central line of the shadow would first touch the continent. M. de la Pinelais, one of the officers of the Mégère, was selected by his commander to make the physical observations, and the zenith telescope and a chronometer lent by Professor Bache were furnished him, after having fully explained the mode of using the former during the eclipse.

Dispatching the Fitz telescope, with the essential smaller instruments, our tent, and provisions on the same afternoon, in company with Mr. Raymond I left Payta before daylight of the 29th, taking with me the barometers and pocket chronometers. We reached Piura, a town of some 10,000 inhabitants, and 45 miles distant from Payta, about 5 P. M. The country between the two places is a desert of sand, which is so drifted by the strong daily winds that the mule paths are obliterated almost as soon as made, and the traveller finds his way by the tall stakes that have been planted and the skeletons of animals that have died on the road from heat and thirst.

Letters of introduction to residents of Piura, most likely to afford reliable information, had been kindly furnished to me, and expectations had been formed that an officer of the Peruvian navy, thoroughly acquainted with the climate of the Andes, and himself an amateur astronomer, would most cheerfully accompany us. He was, unfortunately, absent, and the information derived from others, like that imparted at Payta, was of so contradictory a character as only to have the effect of discouraging.

Ascertaining from a recently published map that Olmos, a town within the outer Andes range, would certainly be included by the limits of the moon's shadow, and, possibly, be very near to its central line, preparations were made for a journey thither, and we departed from Piura before daylight on the morning of September 1st. Our train comprised myself, Mr. Raymond, two muleteers, one of whom was guide, and eight animals, two of which carried provisions for their subsistence.

In order that a supply of water might be obtained for the animals at the end of each day's journey, we took the direction of Vicuz, a cattle estate 50 miles E. N. E. from Piura, and lying on both banks of the river of the latter name. At that time the water of the river had ceased to flow 10 miles above the estate, though supplies were still obtained by digging shallow cavities in the dry bed. That for our own use—strongly impregnated with both nitre and lime—was carried by the muleteers in calabashes.

The second day's journey was more fatiguing than that from Payta to Piura. The country is all deep and loose sand on an undulating surface, and though there are occasional isolated trees, as the wind is cut off in the hollows, the heat there is most oppressive. We encamped after night, in a grove of majestic Algarrobos, near the dry bed of the Piura.

Before daylight of 2d September we were in the saddle again. The distance before reaching water was nearly 60 miles in a S. S. E. direction, the character of the country very similar to that between Piura and Vicuz, though with an increasing number of dwarf trees as we gradually approached the foot of the Andes. Before nightfall we were travelling south, and quite near to the base of one of the outer ranges. Here we found, both then and on the journey back, that the direction of the wind was parallel with the mountains, and its force less than half what we experienced in crossing the plateau between Payta and Vicuz. Although it drives clouds of a fine and almost impalpable sand along with it, and their volume depends upon its velocity, at any diminution of the last the traveller instantly suffers from a great apparent increase of temperature. On this day our guide lost the track, and we were detained some hours whilst he was searching for it.

Our destination was Tortolitas—a name given to two or three scattered ranchos near a small spring of very brackish water. A headache, unquenchable thirst, and fever experienced during the last five hours of the journey thither, were attributed to the exposure and fatigues of the day, nor was I undeceived until two days afterward. On arriving, we learned that as there was scarcely water to supply the people and their limited number of goats and pigs, none could be afforded for our mules. But the hospitality of their humble shelter was readily granted, and scanty as was their supply and late as was the hour, the best of their food was freely prepared for us.

On the morning of the 3d the mules were suffering for want of water. We therefore started earlier than usual, intending to make a halt at Ñaupe, another collection of scattered ranchos, 5 leagues from Tortolitas, and near which there is a better supply of water. At seven miles from Ñaupe we crossed a low pass in the outer broken range of the Andes, and descended on the S. E. side to the level of the plain just left. The summit was reached about sunrise, and we once more had the pleasure to witness the solar rays unobstructed by clouds, at that hour. At the same time, however, all the lower elevations, as well as the plain to the westward, were obscured under a veil so impenetrable that there was not one illuminated point visible in that direction.

Owing to the distance of the spring from the rancho where we halted, and the slowness with which the water flowed, we were detained until 2 P. M., making it necessary to ride until quite a late hour. So long as the track could be distinguished, and there was no danger of going astray, as we escaped both heat and dust, this was the most pleasant period for travelling; but as we had twice been lost in broad daylight, and more than one had been known to perish of thirst on that desolate level, we necessarily moved with caution. This night was remarkably clear—surpassing the transparency of atmosphere witnessed in Chile so frequently—indeed, the planet Venus cast a well-defined shadow as late as 8 P. M. At 11 o'clock we camped on the sand for the night, having travelled about 25 miles over a country similar to that already mentioned.

Starting before sunrise on the morning of the 4th, we reached Olmos at 11 A. M. The last four or five miles of the journey is near the dry bed of a water-course, whose banks are covered with majestic trees of various descriptions. Here too there are a great many patches of cultivated ground. As the region is, in fact, within the Andean ranges, and the population reasonably expect one shower of rain during the year, they prepare the ground and put in the seed. If the rain fails, they dig in the dry bed of the water-course and obtain water enough for irrigating their small fields once, or at most twice. This is sufficient for the growth and maturity of their crop.

Ascertaining that there was no house of public entertainment, and being unwilling to follow the custom of the country by asking hospitality at the residence whose appearance was most inviting, as the schoolhouse was then unused we succeeded in obtaining permission to occupy it, and proceeded there with the equipment, until I could make inquiries respecting the road across the Andes and the climate on the summit.

Curiosity had induced several of the citizens to follow us, and our mules were scarcely unloaded before others arrived, instigated by the same feeling, but all of them ready to impart any information or to give us any required aid.

By noon I was shaking with an ague, whose violence increased through more than two hours, and which did not cease until nearly sunset, when I was greatly exhausted. The fever continued nearly all night. This rendered the journey to an elevated point of the Andes impracticable, if not hazardous; and, after obtaining time sights for the chronometers on the morning of the 5th, as soon as I found myself strong enough, I decided to seek the best of the neighboring hills, from whence the observations might be made, without the risk of a crowd from the town, yet near enough to it for succor in case of continued illness. Such an one was found one mile S. E. from Olmos, and we encamped upon it on the afternoon of the same day.

Meantime, in accordance with experience gained of the disease in the U. States, remedies had been taken for it, and there was no return of the ague on the 6th of September. Instead of it, there was such excessive fever, accompanied by violent pain in the head and vertebræ during the entire day, that it was impossible to sit up until late at night. But to be prepared for a favorable change in case the following morning should prove clear, whilst lying upon the ground, I instructed my young friend as to each portion of the telescope until it was satisfactorily mounted. A little later, though weak from fasting three days, and the effects of the medicines, I was strong enough to make sextant observations for latitude on α *Lyræ*, α *Cygni*, and α *Gruis*, and to adjust the telescope approximately to the meridian and elevation of the pole by the same stars. I must acknowledge, however, that when I again laid down, it was with a hope that the morning would prove cloudy, for a return of the illness was apprehended, and an overcast sky would have been far more satisfactory to me than compulsory inactivity. Before daylight, however, I was up and quite able to work.

I hope these personal details will be pardoned. They have been thought necessary, because my expectation regarding one of the phenomena of total eclipses was not realized, and it does not become me to decide to what extent my physical condition may have had influence.

THE STATION.

Our camp was erected upon a small level spot, on the northern ridge of a spur from the Andes, the line of which from the main chain is a segment of a circle.

The best ascent to it was on the eastern side, both the northern and the western being too precipitous for loaded animals. Indeed, the ascent of the western slope is almost impracticable for even pedestrians. To the east, the Andes form a serrated but apparently unbroken chain, with lateral spurs at unequal distances extending to the westward. The greatest depression bore E. by N. from our camp, the crests there being estimated to form an angle of 8° with the horizon and 20 miles distant in a straight line, corresponding to an elevation of about 15,000 feet. From a mean of the barometrical observations made at various hours of three days, our elevation above the plain was 300 feet, and above the level of the sea 930 feet.

Between us and the spur next on the north, there is a narrow valley having a broad band of verdure on each side of the dry water-course, already mentioned. To the north the view extended over a nearly level plain as far as the mountain pass beyond Ñaupe. Northwest and west, there are lofty, isolated hills, mostly of bare and precipitous rock, and west of them again, perhaps ten miles distant, are the lower broken ranges of the coast mountains. To the south the view was interrupted at a short distance, partly by hills similar to the western ones and partly by the spur we were encamped upon.

From a mean of meridian and circum-meridian altitudes of *α Lyræ*, *α Cygni*, and *α Gruis*, made at camp on the nights of 5th and 6th September, with sextant and artificial horizon, its latitude was found to be S. 6° 0′ 2″. That of Olmos, from similar observations of the same stars on the night of the 8th September, S. 5° 59′ 20″. Applying to the latter the difference of latitude (42″), we have—accidentally—a result varying only 0″.1 from the former, whilst some of the individual determinations differ more than 40″. I adopt for the station

Latitute 6° 0′ 2″ south.

On the local map, previously referred to, and which purports to have been compiled from Humboldt, Fitzroy, and others, the longitude of Olmos west of Greenwich is 80° 22′ 20″. On the map of Arrowsmith (*London, May*, 1839), made up in part from Capt. Fitzroy's labors, and which accompanies his narrative, it is in 80° 4′ 30″. Neither Humboldt nor Fitzroy ever visited the interior of this portion of Peru, nor can I learn that its geographical position on the maps rests upon any better determinations than the estimations of native travellers between it and Lambayeque, not one of whom—most probably—possessed even a pocket compass. Unless the line of the Andes is placed on both maps very far out of the way, the longitude given by Arrowsmith is much the nearer to the truth. But, I shall proceed to show that this, as well as the whole coast of South America north of Valparaiso, is probably laid down by Capt. Fitzroy too far to the westward.

The longitude of Santiago de Chile, deduced from all the moon culminations and occultations observed by the U. S. Astronomical Expedition (vol. III. p. 1), during the years 1849—'52, is W. $4^h\ 42^m\ 33^s.81$ (70° 38′ 27″.1), and the difference of longitude between the observatory there and that of Mr. Mouatt, at Valparaiso, was found by exchanging 100 telegraphic signals—(50 in each direction)—to be $3^m\ 56^s.51$ (59′ 7″.65). Consequently, the longitude of Valparaiso would be 70° 37′ 35″.

Capt. Fitzroy, R. N., places Fort San Antonio at Valparaiso in 71° 41′ 15″, and as there is no important difference of meridians between his station there and Mouatt's observatory, if the result from the 235 corresponding moon culminations and occultations observed at Santiago is to be depended upon,[1] Capt. Fitzroy's longitude of Valparaiso is 3′ 40″ too great. His longitude of other points on the west coast of America, being derived from chronometric differences, if his chronometers had accumulated an unknown error of $14^s.67$[2] before arriving at Valparaiso, all his determinations of places north of that city will probably be affected to at least an equal amount.

Correcting the longitude of Olmos given on Arrowsmith's map for the probable error of 3′ 40″, and applying the distance of our station east of the town —42″ to the result, we have for a preliminary longitude 80° 0′ 8″ W.

Bringing forward to the morning of the eclipse the errors of the chronometers by the rates given me at leaving New York, the results are:—

Longitude by Arnold N°. 6220	79° 17′ 36″.6
" " Barraud N°. $\frac{2}{739}$	79° 27′ 20″.1
Mean	79° 22′ 28″.4

From Payta to the station, these instruments were carried, during the day, in inside pockets of my vest, and were necessarily jolted by the motion of the mule. At night they were placed in the travelling bag which constituted my pillow. There is no doubt that their rates were changed; for the mean daily rate of Arnold N°. 6220 was $—7^s.85$ between the morning observations of the 5th and those on the afternoon of the 8th, against a daily losing rate of $1^s.8$ with which it left New York, and that of Barraud N°. $\frac{2}{739}$ was $—6^s.57$ daily against $—3^s.5$ daily.

Using the *preliminary* longitude, and assuming as correct the tabular places given in the American Ephemeris for 1858, Mr. F. G. Hesse, Assistant U. S. Astronomical Expedition, has computed the following longitude whilst these pages have been in preparation:—

West 79° 42′ 53″.4

THE ECLIPSE.

The telescope specially completed and most courteously lent for the occasion by Mr. Henry Fitz, of New York, is an achromatic, having an object-glass of 4¼ inches clear aperture with a focal length of 5 feet 4 inches. It is supported upon

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[1] 70 observations of moon culminations subsequently made at the Santiago observatory, and computed by Dr. Moesta, give for its longitude $4^h\ 42^m\ 32^s.37$. Still less!

[2] Capt. Fitzroy says of his chain of chronometric differences round the globe: "It ought to be clearly stated, however, that the sum of all the parts which form the chain amounts to more than 24 hours, therefore error must exist somewhere; but what has principally caused the error, or where it may be said to exist, I am unable to determine. The whole chain exceeds 24 hours by about thirty-three seconds of time."—*Narrative of the Surveying Voyages of His Majesty's Ships Adventure and Beagle*, Appendix to volume II. page 345. London, 1839.

a mahogany tripod with a cast-iron mounting, having equatorial motion and adjustable to every latitude. It was counterpoised in all positions. The eye-piece selected for use magnified 60 times, and the screen of glass was of a moderately dark green color. The latter was not fitted on the rim of the former, but was held in the hand so as to be removed at pleasure, and without the risk of disturbing the instrument whilst so doing.

In anticipation of the difficulty which would attend micrometrical measures of either kind during the very brief period the total eclipse would continue, a cross of wires, at right angles to each other, was inserted in a perforated card disk, and fitted to the eye-piece. Then, to facilitate the location of, and approximate to the elevation of such solar protuberances as might become visible, a diagram was prepared. Three concentric circles were drawn upon a page of the note book. The inner one—to represent the moon—was of 4 inches diameter—a black continuous line; the outer ones respectively one-eighth and one-quarter of an inch greater, but with broken lines. The inner circle was divided into equal segments of $22\frac{1}{2}°$ each, the vertical diameter on the page to correspond with the zenith and nadir of the station. The outer circles were to facilitate estimations in altitude of the protuberances, by comparison with the visible lunar diameter, all of which was in the field of the telescope.

The night of the 6th and until daylight of the morning of the 7th September was bright and faultless; but just before sunrise, a few banks of heavy cumuli formed over and near the distant mountains to the eastward, the part of the sky least obscured being in the direction of the sun. Some of the intermediate peaks became enveloped in fog banks at the same time, whilst thin cirri stretched to near the zenith. The wind was then from the westward and the atmosphere humid, under the influence of which, the lower strata of clouds increased in numbers and density, and the sun continued invisible until after the eclipse had made considerable progress. By $6^h\ 30^m$ all the fog banks to the north and west were drifting towards the valley of Olmos, and at 7^h there was no portion of the sky entirely unclouded. Whenever the sun became momentarily visible during that period, the cusps could not be satisfactorily seen because of the masses of vapor continuously rolling across its disk. At about $7^h\ 15^m$ there was a striking change; the whole mass of cumuli to the eastward was lifted towards the zenith, leaving that portion of the sky clear, and it was only by close examination that a delicate film of vapor could be detected between us and the sun. At this period, the general light did not greatly differ in intensity from that of the moon when nearly full, though its color resembled more that from burning spirit than that of the sun. Both intensity and color changed under the feeble and gloomy illumination with perceptible rapidity, and for a minute before the first internal contact of the limbs, the hills near us appeared of a *black* hue.

At from twelve to fifteen seconds before the beginning of totality the entire lune—then perhaps 35° in extent—broke up into masses of unequal length, showing detached portions wholly separated from the rest by dark lines. The occurrence was so sudden as to startle me, and although within the ten following seconds, the remaining visible fragments had become brilliant globules of nearly equal size, they differed from Baily's beads as seen by me during the annular eclipse of September, 1838, by the darker spaces which separated them from one another.

When the total obscuration took place at $7^h\ 30^m\ 42^s.5$, four masses of luminous clouds became immediately visible at as many positions of the lunar circumference. Perhaps that to the left on the drawing was the first one seen, because my attention was directed there in watching the disappearance of Baily's beads, but I cannot say that they were not all simultaneously perceptible. The screen of glass was hurriedly removed, and in the brief instant of doing so I found, to my surprise, that all the phenomena were distinctly visible to the unassisted eye. Every effort has been made by the artist to represent in the accompanying lithograph—drawn from the sketch and notes—the scene then before me, and which still remains strongly impressed upon my memory.

Of the four cloud-masses which had become visible, that on the upper border was much the most extended and serrated. It was more than 30° in extent, with an altitude, in the highest part, of about 30″. All of them were of as nearly the form, and at the relative positions given in the plate which the most careful estimations enabled me to assign to them, and sketch roughly in the note-book, whilst they were still in sight. Neither of them exceeded 1′ or 1′ 10″ in height. I could not discern any rose or pink color on either of them, but they all resembled irregular masses of illuminated clouds of leaden hue fringed with bright light, more especially at the edges farthest from the sun. Surprised at the absence of red—a color I fully expected to witness—and for the moment supposing my physical condition might have some influence, Mr. Raymond was requested to note the colors carefully.

A corona light flashed out at the instant of totality. It extended farthest from the sun, in lines drawn from the centre through the solar clouds, but was nowhere traceable more than 15′ or 16′ beyond the lunar disk. There were no radial streamers, or bundles of rays, but only a uniformly diminishing, and slightly orange-tinted light, whose brightness and extent were apparently influenced by the mist-film, as the color of the clouds also may have been. Beyond the corona light, the color of the sky was of a grayish-black.

It was a far more imposing sight without than with the telescope, and long as has been my experience in the observation of celestial phenomena, and calm and unimpassioned, at such times, as my temperament has become, the sublime majesty of the scene thrilled me with excitement and humble reverence. Nor was it less effective upon others. Two citizens of Olmos stood within a few feet of me, watching in silence, and with anxious countenances, the rapid and fearful decrease of light. They were wholly ignorant that any sudden effect would follow the total obscuration of the sun. At that instant, one exclaimed, in terror—"*La Gloria!*" and both, I believe, fell to their knees, filled with awe. They appreciated the resemblance of the corona to the halos with which the old masters have encircled their ideals of the heads of our Saviour and the Madonna, and devoutly regarded this as a manifestation of the Divine presence.

Every second of the time during which the total obscuration continued—*only sixty and a half*—was fully occupied in storing my memory with facts, and in tracing outlines of the solar clouds and corona. They did not permit me to turn

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away for the observation of collateral phenomena, before it was necessary to watch for the sun's reappearance. This took place at $7^h\ 31^m\ 43^s$. The emersion was sudden. But, though the limb was then sharp, and without the least appearance of dislocation, during the next two or three seconds, there were faint vertical striæ over the lune which gave to it a slight oscillating motion. Assuredly neither the illuminated clouds nor the corona disappeared, at the actual instant of the return of light, but there was a brief period afterward, when their images were still upon my retina.

Though Mr. Raymond found a candle necessary to enable him to read satisfactorily the seconds-dial of the chronometer, and vernier-scale of the barometer, the darkness during totality could not have been very great, for my sketches were completed without the aid of artificial light. For some minutes previous, all work in the valley below us had ceased, and even the strains of martial music, which the Governor of Olmos employed to cheer laborers digging for water, two or three miles from the town, were no longer audible. Superstition is still dominant here, and we could hear the solemn toll of the church bell, whose sounds were intended to drive evil spirits from its vicinity. Neither at Olmos nor Piura, did any *enceinte* woman leave her room during the eclipse, whilst some from curiosity, but more through fear, were in the streets, yet not daring to look upon the sun, lest malady befall them. The sombre greenish light gave them the appearance of corpses, and they apprehended that a plague might be visited upon them. Afterwards, the muleteers told us that their animals stopped eating, and huddled together in evident alarm.

Very little actual change of temperature was to be expected. The coldest hour of the day had just passed, and as the sun rose above the Andes, its rays had greater power with each passing minute. But the thermometrical record shows that the rapid interposition of the moon absolutely arrested the normal increase of heat, and as late as 8 A. M., a half hour after total obscuration, the thermometer showed only 58°, whilst the mean temperature experienced by us, at that hour of the day was 72°! The light air from the westward, already mentioned, continued through the whole eclipse, and there were constant changes in the clouded portions of the sky during the same period. From shortly after noon, until the tent was closed after midnight, clouds obscured the whole sky.

Descending to Olmos early on the 8th, we left it on the afternoon of the 9th, and reached Payta, without mishap, on the afternoon of Sept. 14th.

The observations of time were as follows:—

Beginning of eclipse	Not seen.	
First internal contact of limbs	$7^h\ 30^m\ 42^s.5$.	Good.
Second " " "	7 31 43.0	Good.
End of eclipse	8 47 35.5.	Doubtful.
Duration of total eclipse	1 0.5.	

The chronometer was in charge of Mr. Raymond, and the records given by me are in *mean time* of the station. Observations of the altitude of the sun's limb, to determine the error of the chronometer on local time, were made before the end of the eclipse. Its rate in the interval was inappreciable.

OBSERVATIONS BY MR. C. H. RAYMOND.

Just before sunrise, the horizon was entirely obscured by clouds, but as the sun appeared above the eastern mountains, the sky became clear in that direction, and even there only in spots. As totality approached, however, there was only a thin fleece of clouds just before the sun, and this did not interfere with the vision.

Four solar protuberances were plainly visible to the naked eye, but they appeared to be of very nearly the same color as the corona, making it look more intensely bright. There was no pink or red color exhibited. They were distributed at pretty nearly equal distances round the moon, one being near each of the N. E., S. W., S. E., N. W. points.

As I was occupied with the meteorological instruments, I was unable to notice all the phenomena which took place. I did observe, however, that as the darkness came on, the birds ceased singing, and some laborers, digging a well near by, stopped working. All nature assumed a ghastly appearance, resembling a moonlight night.

So dark was it during the totality, that in order to distinguish the figures on the dial of a chronometer, I was obliged to hold it close to the lantern. While it was darkest, I looked at the sky to see if there were any stars visible, but there were so many clouds, that those which might have been seen were covered by the cumuli.

OBSERVATIONS OF THE FRENCH OFFICERS.

TRANSLATION OF A LETTER FROM CAPTAIN H. VIALETES D'AIGNAN,

Commanding the War Steamer Mégère.

PAYTA, *September* 10, 1858.

SIR: I fulfil a duty in thanking you for the instruments which you had the kindness to lend us. At the same time I beg to make known to you the result of our observations.

The observers were on shore in longitude 81° 3′ 20″ west from Greenwich, as taken from the chart of Capt. Fitzroy, and in latitude 5° 50″ south. The ship was one and a half miles N. 39° E. from the spot occupied by the observers.

Clouds prevented us from observing the first contact. The others took place at the following instants:—

	Observed on Board.	Observed on Shore.
First internal contact	$7^{h.}\ 24^{m.}\ 8^{s.}$	$7^{h.}\ 24^{m.}\ 8^{s.}$
Second internal contact	7 25 7	7 25 7
External contact (end)	8 39 38	8 40 15

The instants given are in *mean times* of the place of observation. We are not able to explain the difference which appears in the observations of the last contact.

If it be desired to refer the times of observation to the meridian of Payta, as we determined it on the morning following the eclipse, it is necessary to subtract $32^{s}.7$.

The barometer rose one millimetre:—

Mercurial Barometer.	Aneroid Barometer.
$0^m.761.5$	$0^m.751.5$
$0^m.762.5$	$0^m.752.5$

Most generally the aneroid coincides with the other barometer; the difference between the two instruments was constant on this day.

The temperatures observed were as follows:—

6^h 0^m	20°.0	Centigrade.
7 0	17.0	
7 15	16.5	Total eclipse.
7 30	17.0	
7 45	17.5	
8 0	18.5	
8 15	19.5	
8 30	20.3	
8 45	21.0	

Although the sky was somewhat cloudy, we perceived several stars during the total eclipse. The obscurity was very sensible, and it seemed to pass off more rapidly than it came on.

I remit herewith a note and a design from M. Pinelais, who observed the eclipse with the telescope you had the goodness to lend us. M. Laultré, who observed the contacts on shore, very distinctly saw the whitish corona that surrounded the moon during the total eclipse.

In repeating my thanks to you, permit me to ask that you leave for us, in Valparaiso, a copy of your own observations.

Accept, sir, the assurance of my most distinguished consideration.

VIALETES D'AIGNAN.

M. Gilliss, *Lieut. U. S. N.*

TRANSLATION OF NOTE FROM M. PINELAIS, FRENCH NAVY.

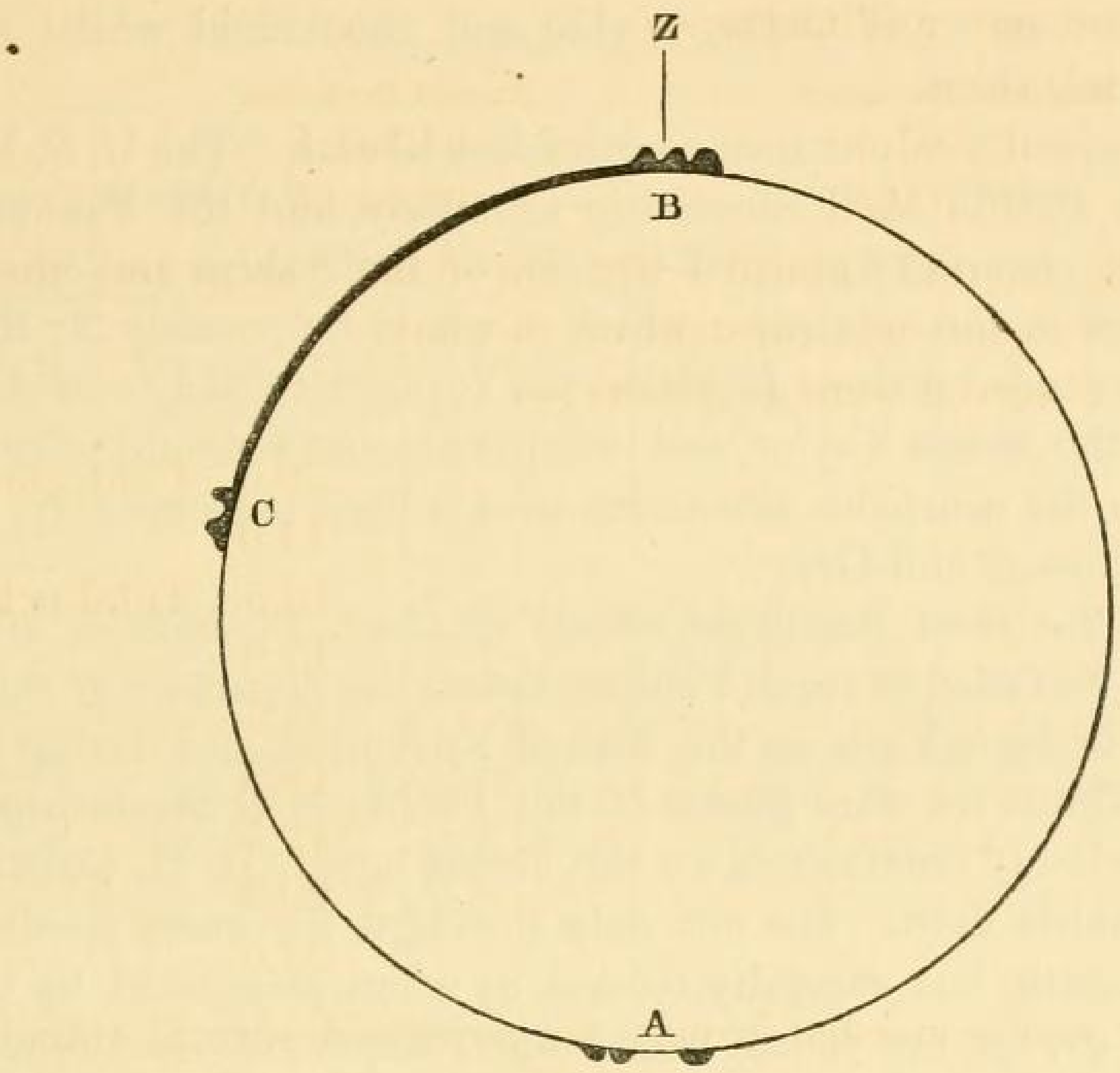
The spots observed appeared of a fine bright-rose color. Their maximum height may be valued at most 1′. The first to appear were those at A; then those at B, and finally, about the first third of the period of the eclipse, those which extend from B to C. The height of these last was less than that of the protuberances of A and B, except at the point C, where it was very nearly the same.

A little while before the commencement of the total eclipse, I saw, towards the centre of the moon, a spot of yellowish light of feeble intensity, but I was not able to follow it during totality.

The small extent of the field of the telescope prevented me from observing the luminous corona, which should have surrounded the moon during the total eclipse.

The position of the spot chosen for observation is long. 81° 3′ 20″ west from Greenwich (Fitzroy), latitude 5° 50′ south.

The instrument employed was a (zenith) telescope. The image given (on following page) is reduced.



[M. Pinelais translated all the important portions of the pamphlet containing "Suggestions to Observers," &c., by R. C. Carrington, Esq., and made copies of its diagrams prior to my departure for the interior.

The zenith telescope used by him has an object glass with an aperture of $3\frac{1}{4}$ inches, and a focal length of $43\frac{1}{4}$ inches. J. M. G.]

ACKNOWLEDGMENTS.

Through the courtesy of his Excellency, J. Y. de Osma, Minister Resident from Peru, official letters were received for the Prefect of the Province of Piurá, the Captain of the Port at Payta, and others, stating the objects of and asking for the expedition such facilities and aid as they could afford to it. The gentleman holding the latter office instantly directed that the cases containing our effects should be passed through the custom house unopened, and offered his services in any other way in which he could be useful. And on leaving Piura, the Prefect had the goodness to furnish me with a letter instructing the Governor of Olmos to see that all our wants were properly supplied. Without such support by the political authority—who has military as well as civil power—a traveller vainly contends against excessive demands made of him by the more than semi-Indian population of the interior. The Governor was both extremely attentive and kind.

Especial acknowledgments are due to the British Steam Navigation Company. The directors not only granted free transport with great cordiality, but also instructed their agents to facilitate the objects of the expedition by every means in their power. And so faithfully were these instructions carried out that I cannot too earnestly express my appreciation of the considerate kindness shown me by Messrs. Petrie, Hall and Bidwell, the manager and agents of the line at Callao,

Valparaiso and Panama; or of Capts. Wylde and Bloomfield whilst making the voyages on board their ships.

Nor were the companies of our own country less liberal. The U. S. Mail Steamship Company, the Pacific Mail Steamship Company, and the Panama Railroad Company each most cheerfully granted the use of their ships and cars, proffering every other assistance to the enterprise which it would be possible for their officers to afford. I had the good fortune to make the voyages to and from Aspinwall in that rapid steamer, the Moses Taylor, and it is proper that I should offer my tribute of commendation to the courteous attentions shown their passengers on these occasions by Capts. McGowan and Gray.

Notwithstanding the most strenuous efforts of Capt. Bloomfield, after leaving Payta for the north, we failed to reach Panama before the departure of the American steamer which left for New York on the 20th of November, and during two weeks' detention on the isthmus we were guests of the Pacific Mail Steamship Company. We were most hospitably entertained by the acting agent, D. M. Corwin, Esq., to whom we owe a double debt. He not only provided for every possible comfort whilst we were in health, but carefully tended us when prostrated by the fever of the isthmus. I say *we*, for my young friend—Mr. Raymond—had fairly earned a right to participate in courtesies offered to me, and was a fellow guest.

I abstain from naming my accomplished host at Payta from motives of delicacy.

METEOROLOGICAL OBSERVATIONS.

The instruments with which the following meteorological observations were made, were constructed for the Smithsonian Institution by Mr. James Green, of New York. The barometer, a syphon (Bunten's form), reads to $^{\text{in}}.002$, and was hung within the tent. All the thermometers are divided to 1° upon scales of ivory. The air and wet bulb thermometers were placed a few feet above the ground, and in the shadow of the tent. The black bulb was suspended beneath the telescope, its bulb within an inch of the ground.

Meteorological Observations at Camp during the Eclipse.

Hour.	Barometer.	Att'd ther.	Air.	Wet bulb.	Black bulb.	Remarks.
	in.	°	°	°	°	
$6^{h.}$ $20^{m.}$	29.128	57.0	56.4	56.2	58.0	The sun was obscured.
30		57.5	56.3	56.2	59.1	do. do.
40		57.2	57.2	57.1	66.9	
50	.142	58.8	57.8	57.2	66.0	
7 0		59.3	57.7	56.9	67.2	
10		59.4	57.6	57.1	66.3	
20	.162	58.6	57.7	56.9	62.2	
30		58.6	57.6	56.8	59.1	
40		58.4	57.5	56.9	60.5	
50	.168	58.6	57.6	57.0	64.3	
8 0		58.9	57.9	57.1	67.9	
14		60.0	58.7	57.4	69.8	
20	.176	60.5	59.3	57.8	74.8	
30		61.6	59.9	58.0	79.0	
40	29.184	62.6	61.1	58.6	84.1	

Meteorological Observations at Payta.

Day and hour. 1858.	Barometer.	THERMOMETERS. Att'd.	Air.	Wet.	WIND. Direction.	Force.	Weather.	Remarks.
	in.	°	°	°				
Aug. 22, 3 P. M.	29.966	72.5	71.9	64.9	South	4	0	
6 "	30.104	70.5	68.1	62.8	S. by E.	3	0	
9 "	.084	70.3	67.0	62.0	"	4	K. S. 5	
" 23, 9 A. M.	.128	68.0	67.0	62.3	"	1	K. 10	
Noon	.078	70.5	70.8	64.0	"	2	K. 4	
3 P. M.	30.018	72.1	71.6	64.3	S. S. E.	1	0	
6 "	29.918	70.4	67.4	62.4	S. by E.	3	0	
9 "	30.044	70.0	66.8	61.5	"	1	C. 7	
" 24, 9 A. M.	30.046	67.6	67.7	63.2	S. S. E.	1	K. S. 10	
Noon	30.014	71.5	74.1	65.5	S. by E.	1	0	Haze about high land.
3 P. M.	29.976	72.7	73.0	64.5	"	3	C. 1	do. do.
6 "	29.925	70.0	67.5	62.6	"	2	0	
9 "	30.038	69.6	67.0	62.1	"	1	C. K. 9	Observations a little late.
" 25, 9 A. M.	.096	67.9	66.5	62.0	N.W.byW.	2	0	
Noon	.078	71.5	73.2	65.5	S. W.	3	0	
3 P. M.	.054	71.3	71.2	64.0	"	2	C. S. 10	
6 "	.092	69.5	67.3	63.0	S. by W.	1	K. S. 10	Observations late.
9 "	.114	71.0	67.0	62.2	"	1	K. S. 10	do.
" 26, 9 A. M.	.186	68.7	68.8	63.0	S. E.	1	K. S. 9	
Noon	.166	72.5	75.8	66.0	S. by E.	1	C. 1	
3 P. M.	.064	73.1	73.4	63.9	S. S. W.	4	0	
6 "	.088	70.0	68.0	62.5	"	2	K. 3	
9 "	.112	70.5	67.0	62.0	S. W.	2	C. 1	
" 27, 9 A. M.	.128	68.5	68.0	62.7	S. E.	1	C. S. 10	
Noon	.074	72.5	75.0	66.1	"	3	C. 5	
3 P. M.	.006	73.0	74.2	65.1	S. S. E.	2	C. 1	
6 "	.020	71.9	69.2	63.1	S. by E.	1	C. 1	Haze over sea horizon.
9 "	.092	71.3	67.0	62.7	E. S. E.	1	C. K. 7	Observations late.
" 28, 9 A. M.	.118	68.9	68.2	62.9	"	1	K. S. 10	
Noon	30.084	70.5	74.3	65.3	East	1	0	

The preceding observations, with the same instruments, were made at Payta before proceeding to the interior. The instruments were suspended in a balcony having a northern exposure, and 27 feet above the sea level. In the column "*Force of Wind*," 0 signifies "Calm;" 10 a "Gale." In the column "*Weather*," 0 signifies "Clear;" 10 "Entirely Clouded;" "K"—Cumuli—"C"—"Cirrus," &c. After the noon observations of 28th, the thermometers were packed.

COMPUTATION OF THE TOTAL SOLAR ECLIPSE OBSERVED NEAR OLMOS, PERU, SEPTEMBER 7, 1858.

BY F. G. HESSE, ASST. U. S. N. AST. EXP'N.

The general theory adopted in the following computations is that of Bessel, as developed in the second volume of his *Astronomical Researches*.

The following quantities have been interpolated from the computed places in the American Ephemeris for the Greenwich meridian:—

α = the moon's right ascension.
δ = the moon's declination.
π = the moon's equ. hor. parallax.
α' = the sun's right ascension.
δ' = the sun's declination.
π' = the sun's mean equ. hor. parallax = 8″.5776. (Encke.)

Greenwich m. t. September	α °	′	″	δ °	′	″	α' °	′	″	δ' °	′	″
6th, 23h.	163	56	27.30	+6	26	18.8	165	43	19.80	+6	6	32.85
7th, 0	164	27	40.05	6	9	57.9	165	45	35.10	6	5	36.60
1	164	58	49.35	5	53	36.0	165	47	50.40	6	4	40.32
2	165	29	55.35	5	37	13.2	165	50	5.55	6	3	44.03

	π ′	″	*log* Radius Vector. *log* Δ'
23h.	58	47.15	.0030942
0	58	45.71	896
1	58	44.25	850
2	58	42.78	804

If a and b represent the right ascension and declination of the sun's centre, as seen from that of the moon, and g the distance of sun and moon's centres expressed in parts of the equatorial radius of the earth, we have:—

$$a = \alpha' - \frac{\sin \pi'}{\Delta' \sin \pi} \frac{\cos \delta}{\cos \delta'} (\alpha - \alpha').$$

$$d = \delta' - \frac{\sin \pi'}{\Delta' \sin \pi} (\delta - \delta').$$

$$g = 1 - \frac{\sin \pi'}{\Delta' \sin \pi}.$$

and we obtain the following values:—

	a °	′	″	d °	′	″	*log g*
23h.	165	43	35.26	+6	6	29.99	9.9989500
0	165	45	46.38	6	5	35.97	— 496
1	165	47	57.50	6	4	41.93	— 91
2	165	50	8.48	6	3	47.88	— 86

If we refer the moon's centre to a rectangular system of co-ordinates, whose origin is at the centre of the earth, the right ascension and declination of the axis z being equal to a and d, and the axis x being contained in the plane of the equator, and its right ascension equal to $90 + \alpha$, we have:—

$$x = \frac{\cos \delta \sin (\alpha - a)}{\sin \pi}$$

$$y = \frac{\sin (\delta - d) \cos \tfrac{1}{2} (\alpha - a)^2 + \cos (\delta + d) \sin \tfrac{1}{2} (\alpha' - a)^2}{\sin \pi}$$

$$z = \frac{\cos (\delta - d) \cos \tfrac{1}{2} (\alpha - a)^2 - \cos (\delta + d) \sin \tfrac{1}{2} (\alpha - a)^2}{\sin \pi}$$

which equations furnish the following computed values for x, y, and z.

	x	y	$log\ z$
$23^{h.}$	—1.8107312	+0.3400625	1.7668066
0	—1.3214486	+0.0758885	1.7670886
1	—0.8321237	—0.1883356	1.7673333
2	—0.3427265	—0.4525875	1.7675401

If f = the angle which the axis of the cone forms with its side, and
c = the perpendicular distance of the vertex of the cone from the plane x, y, we shall have

$$sin\ f = \frac{1}{\Delta' g} (sin\ h - k\ sin\ \pi') \text{ (for internal contact)}$$

$$c = z - \frac{k}{sin\ f} \text{ (for internal contact)}$$

$$c\ tang\ f = l$$

according to Burckhardt's tables of the moon, the radius of the moon, or $k = 0.2725$, and the mean radius of the sun, or $h = 15' \ 59''.788$ (Bessel). Therefore:—

$log\ (sin\ h - k\ sin\ \pi') = \bar{7}.6666903$ (for internal contact), and

	$log\ tang\ f$	l
$23^{h.}$	$\bar{7}.6646527$	.0024447
0	$\bar{7}.6646572$	.0022662
1	$\bar{7}.6646618$	.0021107
2	$\bar{7}.6646663$	.0019787

Assumed longitude of place of observation $= 80° = 5^h\ 20^m$.

	1st internal contact.	2d internal contact.
T = assumed corresponding Greenwich m. t. of observation	$0^{h.}\ 51^{m.}$	
x_0 = corresponding values	—0.9055260	
y_0 = " "	—0.1487045	
x_1 = hourly variation of x	+0.4893457	
y_1 = " " y	—0.2642366	
Θ = sideral time at instant of observation	89° 59′ 10″.00	99° 14′ 19″.95
a = corresponding values	165° 47′ 37″.83	
d = " "	6 4 50.04	
ϕ' = geocentric latitude of place of observation	5 57 37	
$log\ \rho$ = log earth radius	9.9999843	

The co-ordinates of place of observation are:—

$$\xi = \rho\ cos\ \phi'\ sin\ (\Theta - a)$$
$$\eta = \rho\ \{cos\ d\ sin\ \phi' - sin\ d\ cos\ \phi'\ cos\ (\Theta - a)\}$$
$$\zeta = \rho\ \{sin\ d\ sin\ \phi' + cos\ d\ cos\ \phi'\ cos\ (\Theta - a)\}$$

and the computed values:—

	First internal contact.	Second internal contact.
ξ =	—.914188	—.912450
η	—.144740	—.145167
ζ	+.378473	+.382480

	First.	Second.
Assuming $m\ sin\ M = x_0 - \xi =$	+.008662	+.006924
$m\ cos\ M = y_0 - \eta =$	—.003964	—.003537
$n\ sin\ N = x_1$	+.4893457	
$n\ cos\ N = y_1$	—.2642366	

and $\{l - \zeta\ tang\ f\}\ sin\ \psi = m\ sin\ (M - N)$, we find

	For first internal contact.	Second internal contact.
	° ′ ″	° ′ ″
$M=$	114 35 25.08	117 3 33.83
$N=$	118 22 5.28	118 22 5.28
$\log n =$	9.7451761	9.7451761
$\log m =$	7.9789079	7.8907060
$\psi =$	350° 41 36.1	182 36 17.51

If $T + T'$ represents the required time of the first meridian, at which a phase of the eclipse was observed, d the east longitude, and t the local mean time of observation

$$T' = -s\frac{m}{n}\frac{\sin(M - N + \psi)}{\sin\psi} = -86.33 \qquad -25.05 \quad \text{(First C., Second C.)}$$

$$d = t - T - T' + h\varepsilon + h\zeta \tan\psi$$

$$h = \frac{s}{2.06265\, n \sin\pi} = 1.8369$$

$$h \tan\psi = \begin{cases} -.30100 \text{ for first int. contact,} \\ +.08357 \text{ for second int. contact,} \end{cases}$$

$$\varepsilon = \sin N \cos\delta\, \Delta(\alpha - a) + \cos N\, \Delta(\delta - d),$$

$$\zeta = -\cos N \cos\delta\, \Delta(\alpha - a) + \sin N\, \Delta(\delta - d),$$

$$d = \begin{cases} 18^h\, 41^m\, 8.83 + 1.8369\,\varepsilon - 0.30100\,\zeta, \\ 18\ 41\ 8.05 + 1.8369\,\varepsilon + 0.08357\,\zeta. \end{cases}$$

The observations of the French officers furnish us with the following values:—

Approximate longitude = 80° 59′ 40″

Geocentric latitude = —5 47 40

$$t = \begin{cases} 19^h\, 24^m\, 8^s \text{ first internal contact,} \\ 19\ 25\ 7 \text{ second internal contact.} \end{cases}$$

Computing as before, we obtain the following values for the east longitude of their station from the Greenwich meridian:—

$$d' = \begin{cases} 18^h\, 35^m\, 53^s.89 + 1.837\,\varepsilon - 0.483\,\zeta, \\ 18\ 35\ 54.76 + 1.837\,\varepsilon + 0.284\,\zeta. \end{cases}$$

Therefore,

$$d - d' = \begin{cases} 5^m\, 14.94 + .182\,\zeta, \\ 5\ 13.29 - .200\,\zeta. \end{cases}$$

As no observations were made at a station whose longitude was known, the values of ζ and ε cannot be determined.