## THE FLORIDA EXPEDITION TO OBSERVE THE TRANSIT OF VENUS.[1]

IN selecting the four stations in the northern hemisphere from which to observe the transit of Venus on Dec. 6, 1882, the probable weather at that season, together with the geographical position of the various points considered, were the principal terms in the problem. It was desirable to find points where good weather would be likely to prevail, and where all the contacts, both at ingress and egress, could be seen. Considerable advantage being gained by increasing the distance between the southern and northern stations, those in the United States were chosen as far north as possible, and fulfil the first two conditions.

With these views, the transit of Venus commission selected a point near Fort Selden, New Mexico, San Antonio, Tex., Cedar Keys, Fla., and the naval observatory at Washington. The three southern stations, all between 29° and 33° N. Lat., presented marked differences in their surroundings. The station in New Mexico was about 5,000 feet above the sea, with the air dry and cool. San Antonio has an elevation of about 600 feet, with a dry, warm climate. Cedar Keys is barely above the water of the Gulf of Mexico. In November the weather was hot and comparatively dry, with increasing dampness as the nights became cooler, about the first of December. Washington was chosen because a complete set of apparatus was in working order at the observatory.

The party under my direction was assigned to Cedar Keys, which point we reached Nov. 4. The name Cedar Keys was formerly applied to the whole group of keys between the mouths of the Suwannee and Withlacoochee rivers, but is now used to designate an active business town on Way Key, the largest of the group. This town sprang into existence after the close of the war, and is chiefly interested in the lumber, shipping, and fishing interests, while it is the shipping-point for all the cedar used by the Faber and the Eagle pencil companies, in the manufacture of pencils, etc.

A site for the observing station was selected in a small park at the eastern end of the town; and the construction of the buildings and mounting of the instruments were pushed forward as fast as possible. The so-called soil of Way Key is simply a mass of white sand; and in the grounds of the station, where a pipe well, with a pump, was sunk, the sand existed at a depth of at least fifteen feet.

[1] Abstract of a paper read by Prof. J. R. Eastman before the Washington philosophical society, March 24, 1883.

The buildings for the protection of the instruments were a transit-house, photograph-house, and the building to contain the equatorial telescope; while a small storehouse was built to protect the stores, etc. The principal instruments were a portable transit, a 5-inch equatorial telescope, and a photoheliograph. The first two require no description. The photoheliograph consists of an objective of 5 inches aperture and about 40 feet focus, a heliostat for throwing the sun's rays on the objective, and a plate-holder at the focus of the objective. The objective and the mirror of the heliostat are mounted on the northern pier at northern stations, and the plate-holder is mounted on a similar pier in the photograph-house. The accessory apparatus consists of a measuring-rod, permanently mounted, for accurately measuring the distance from the objective to the photograph-plate; a movable slide, with a slit of adjustable width for exposing the plates; and a circuit connecting with the chronograph in the transit-house, so arranged, that when the exposing-slide is moved to expose the plate, and when the centre of the slit is opposite the centre of the plate-holder, the circuit is broken, and the record made on the chronograph. A black disk is painted on the north side of the slide, and so placed, that when the slide is at rest at one end of its course, and the image of the sun is adjusted concentric with this disk, it will fall on the centre of the plate-holder when the slide is moved. When all the adjustments are made, the exposing of the plates is quite a simple matter. The image of the sun is thrown by the heliostat upon the black disk and centred, the sensitive plate is fixed in the plate-holder, the operator moves the exposing-slide, and the time of exposure is recorded on the chronograph. The plate is now ready to be developed; and here the ablest photographer has an ample field for the exercise of all his skill. The first photographs were made Nov. 23.

The weather was excellent till the last of November, when we had our first norther and a frost, followed by rain and another norther; but Dec. 4 and 5 were clear and mild. At sunset on the 5th, a low bank of clouds was spread along the south-western horizon; but the sky was clear at midnight. On the morning of the 6th, the southern and eastern sky was nearly covered with light cirrus and stratus clouds, with an upper south-west wind, while the surface wind was from the east. All the apparatus was examined, and found to be in good order; and the astronomers went to the equatorial telescope to observe the first contact.

For observing contacts I used an eye-piece magnifying 216 diameters, attached to a Herschel solar prism, and a sliding-shade glass with a density varying uniformly from end to end. The limb of the sun was remarkably steady. The assistant astronomer, Lieut. J. A. Norris, U.S.N., was to take the time of my signals from a mean-time chronometer, while with an observing-key I was to make a record on the chronograph as a check.

About forty seconds before the computed time of first contact, a narrow stratus cloud passed upon the south-eastern edge of the sun, and shut out all the light. The cloud remained about three minutes; and, when it passed off, the notch in the sun's limb was plainly marked. Two photographs were taken to test the apparatus and the plates; and then the time before *second* contact was devoted to an examination of the limbs of Venus and the sun. Both were perfectly steady. In observations of the sun for the last twenty years I never saw it better. At about thirteen minutes after first contact, the outline of the entire disk of Venus could be seen, and seemed perfectly circular. About two minutes later, a faint, thin rim of yellowish light appeared around the limb yet outside the sun. This rim was at first broadest near the sun's limb, but soon the width of the light became uniform throughout. The light was wholly exterior to the limb of Venus; i.e., the black limb of Venus on the sun, and the dark limb outside, formed a perfectly circular disk with the rim of light, or halo, outside the portion off the sun. As the time of second contact approached, Lieut. Norris again took up his station at the chronometer. As the limbs neared geometrical contact, the cusps of sunlight began to close around Venus more rapidly; and the perfect definition of the limbs, and the steady, deliberate, but uniformly increasing motion of the cusps, convinced me instantly that the phenomena attending the contact would be far more simple than I had ever imagined. I had only to look steadily, to see the cusps steadily but rapidly extend themselves into the thinnest visible thread of light around the following limb of Venus, and remain there without a tremor or pulsation. At the moment the cusps joined I gave the signal, and also made the record on the chronograph. Still keeping my eye at the telescope, I saw nothing to note save the gradually increasing line of light between the limbs of the two bodies. The disk of Venus on the sun was black. All the apparatus connected with the photographic work was again examined; and, at about ten minutes after second contact, each member of the party was at his station. Lieut. Norris, who had charge of the chronograph and the heliostat, was stationed at the latter instrument to see that at certain intervals the motion of the heliostat was corrected, and the sun's image thrown in the proper direction. In the photograph-house, the assistant photographer, Mr. G. Maxwell, took each plate from the box, placed it in the plate-holder, called its number, and, after exposure, returned the plate to the proper box. My own share of the work was to record the number of the plate, move the exposing-slide, record the time of exposure of each plate from a chronometer as a check on the chronograph record and as a means of identification, and communicate with Lieut. Norris by a system of signals on the measuring-rod. The chief photographer, Mr. G. Prince, developed the last plate exposed until nearly all the clouds had disappeared, carefully watched all the photographic manipulations, advised in regard to the length of exposure, etc., and prepared and developed, with occasional aid from Mr. Maxwell, all the wet plates used during the day. After the clouds disappeared, measures of the diameter of Venus were made with a double-image micrometer attached to the 5-inch telescope; and then the photographic work was resumed more leisurely. It was intended to use dry plates for all the work; but difficulty in drying the first 150 which were coated, led me to the determination to coat anew only 150 plates, and leave the others to be used as wet plates if the dry plates should unexpectedly fail at the last hour. After eleven o'clock A.M., the clouds disappeared; and, finding we had plenty of time on our hands, we exposed *six* wet plates after each group of twelve dry plates.

At about ten minutes before *third* contact we had exposed 150 dry plates and 30 wet ones. The majority of the dry plates were exposed with a slit 1.5 inches wide, while with the wet plates the width was three-eighths of an inch. On going to the telescope to observe the last contacts, I found the limbs of Venus and the sun as steady as in the morning; and, though there was now some haze over the sun, it did no harm. The third contact was observed with great accuracy, nothing occurring to obstruct or complicate the very simple and definite phenomena which was in the reverse order of that seen at second contact. The rim of light appeared around Venus as soon as the limb was visible beyond the sun, and was seen for nearly ten minutes. The complete outline of Venus was visible for two minutes later. No phenomena worthy of note were seen between third and fourth contacts. The lapping of the limb of Venus over that of the sun gradually but steadily decreased, until the final separation was observed with great accuracy for such a phenomenon. Soon after the last contact, the entire apparatus was again carefully examined, and the necessary observations made to determine the errors of the chronometers. All the measures were made, also, for determining the exact position of the photoheliograph.

The dry plates were developed in a few days; and 146 dry plates and 30 wet ones were sent to Washington, all of which can be easily measured. Two dry plates were exposed in the forenoon, when the clouds were too dense, and no images were obtained; and two others were accidentally broken.

In the observations of interior contacts there was no trace of any tremor or fluctuation of the light in the cusps, as they closed around the limb of Venus; and it is almost needless to say, that there was no trace of a shadow or a black drop or ligament between the limbs at second and third contacts. The probable error of the second and third contacts was estimated at 0.3s.; for fourth contact, 0.5s.

Observers of transits of Venus and Mercury have written so much in regard to the obstacles encountered from the apparition of the shadow or black drop between the limbs of the two bodies at *second* and *third* contacts, and so full has been the testimony in favor of the existence, and the almost necessary occurrence, of this phenomena, that, at the transit of Mercury in 1878, many observers claimed, as evidence of their skill, that they *did* see it, while others less fortunate apologized for *not* seeing it. Observers of the black drop were so generally confined to those with imperfect apparatus, or to those unaccustomed to observations of the sun's limb or disk, that the true nature of the obstacle was pretty well understood before it was carefully investigated. It is now quite well settled, that the 'black drop' is due to bad eyes, imperfect apparatus, or the inexperience of the observer. With good eyes and proper apparatus, a good observer never should see the black drop: for, when it is seen, there is something wrong; it is a spurious phenomenon.

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## *A TELEPHONIC TIME-TRANSMITTER.*

Among the various methods of distributing time, the telephone affords one commendable for its simplicity. Its use for this purpose does not seem to be generally appreciated, and I know of only one contrivance adapted to it other than the one to be described. This one can be called a time-transmitter from its resemblance in appearance and action to the Blake transmitter in ordinary telephones. It is the invention of Mr. C. W. Ruehle of Detroit, and has been in use at the observatory at Ann Arbor for about six months. Its behavior is in every way satisfactory.

Its general character can be seen from the accompanying figures. Fig. 1 is the face view of the transmitter. At *a*, *a* are the binding-

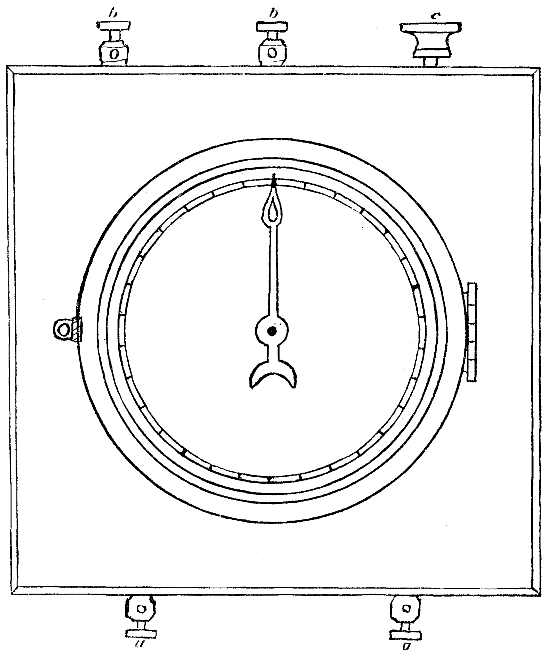


Fig. 1.

posts for the wires from the battery; *b*, *b*, those for the wires of the telephonic circuit. Between the latter is a switch, not represented in the drawing, which enables the operator to cut out the telephone circuit when any thing goes wrong. *c* is a button, by pressing which the instrument can be set going. When started, it runs for two and one-half minutes, during which time the hand in the centre completes a revolution. At the end of that time it stops, and can be started again only by pressing the button.

In Fig. 2 we have a view of the interior. We have here ordinary clock-work, with the addition of a Ruhmkorff coil at *d*, the unlocking part *e*, a circuit-breaker at *f*, and an intermitting-wheel *g*. This wheel moves to the right.