positions at any time, their right ascensions and declinations (or longitudes and latitudes) being given. For this purpose I use disks of cardboard, with small hooks attached by which they may be readily fastened to the wires. It is, besides, very convenient to use in the explanation of many questions and topics that arise in the course of the subject. A light rod or wire attached to a standard serves as a horizon when required.

The apparatus grew out of the need felt of something besides the celestial globe and the usual means of illustration for use in the lecture-room. The idea of it was suggested by a description of something like it which some one had seen; but the description was so vague, I am unable to say how nearly similar is this design, or whether it is any improvement or not on what may be used elsewhere. But I have found it to serve a very good purpose in the lecture-room, and think it may be serviceable to other teachers. G. B. MERRIMAN.

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## *HELL'S OBSERVATIONS OF THE TRANSIT OF VENUS IN 1769.*

PROFESSOR NEWCOMB has lately taken advantage of a visit to the Imperial observatory of Vienna to make, with the consent and support of its director, Prof. E. Weiss, an examination of Father Hell's manuscript record, with reference to deciding on the alleged falsification of these observations by Hell himself. The result of his examination was so different from that generally accepted, that Professor Newcomb prepared and presented to the Royal astronomical society a statement of the evidence and his conclusions. The story of Hell's supposed tampering with his observations of the transit, made at Wardhus in 1769, is, in substance, that he delayed publishing them so long as to give rise to the suspicion of intending to alter them; that he showed them to no one until after he had received the observations made at other stations; that a cloud was thus thrown over their genuineness; that the suspicions thus excited were confirmed in 1835 through the discovery and publication by Littrow of Hell's original manuscript journal, which its author had neglected to destroy; and that the examination of this journal showed numerous cases of alteration and erasure of the original observed figures, including the seconds of first interior contact, which had been completely erased, and replaced by new numbers inserted with different ink at some subsequent time. And the reason for all this was supposed to be, that Hell desired to publish, not his true observations, but results which should be in the best possible accordance with the observations of others. More precise statements on some points are these: the transit occurred 1769, June 3; Hell's party sailed from Wardhus, June 27, but meeting with delays from adverse weather, and stopping to make observations, they did not reach Drontheim until Aug. 30; after some stay here and in Christiania, Copenhagen was reached on Sept. 17; the observations were communicated to the Danish academy of sciences in November or December; the printing commenced Dec. 13, and on Jan. 13, 1770, Hell received twenty printed copies. Professor Newcomb remarks that he does not know the original authority for the statement that Hell was loudly called upon for his observations before he would consent to their publication.

The document which Professor Newcomb has scrutinized is a thin manuscript volume in folio, containing twenty-seven finely written pages, and nearly as many blank ones, bearing the heading "Observationes Astronomicae et Caetera in Itinere litterario Viennâ Wardöehusium factae. 1768. A. M. Hell." This volume is assumed to be in Hell's own writing, and to be his original journal of his observations. Littrow apparently treats of it as the actual first record of the observations, but to Professor Newcomb this seems very improbable. He concludes that the writing of this journal was done at the observing-station, probably at the close of each day's work or each set of observations. What Hell sent to press in December, 1769, was not a transcript of this journal, but a more copious account, containing eighty-one printed pages, with only an occasional identity of language. But, with a single unimportant exception, the numbers are all printed without change from the original manuscript journal, whether corrected or uncorrected in that journal. It is very clear to Professor Newcomb that nearly all the alterations were made at the station — two, at least, before the ink got dry. And he further concludes, that, *whatever the sources from which the corrections were derived, the numbers as printed by Hell were all but one or two obtained at Wardhus.* Going into these manuscript corrections more in detail, it seems quite clear to Professor Newcomb that the alterations in the numbers representing the observations of first contact were made with the same ink as the original; and he regards only one conclusion as certain, — that the corrections were made at the time of writing, and without the slightest intention of giving any thing but the actually observed moment when Venus was first seen.

Coming now to the much disputed observations of internal contact, the figures of seconds seem at first sight to be corrected. Littrow says that the paper bears marks of having been scraped, and that the original figures of seconds had been carefully erased, the ink, in consequence, spreading in the paper. Professor Newcomb remarks, that one sees at a glance that the latter statement is erroneous; and he applies to the question of erasure the test of viewing the paper by oblique sunlight, and proves the texture of the surface to be still uninjured. The evidence thus leads to the certain conclusion, that no different figures from those now visible were ever written there. If, then, they are in any way the result of calculation from other observations, the place must have been left blank until Hell got back to Copen-

hagen, and made the necessary calculations, — an hypothesis too fanciful for serious discussion. Another part of the record looks more suspicious, — a line, 'fulmen 9 32 48,' is not only an interlineation, but is written in decidedly different ink from all the original manuscript. The original journal, up to the time that Hell left Wardhus, being all written in one kind of ink, we conclude that the insertion was made after he reached Copenhagen, and after he had seen the observations of others. Two hypotheses are before us as to how the insertion was determined, — we may suppose that Hell, when he found he had omitted what other observers considered an important phase, tried to remember how long after the recorded contact he first saw the sun's limb continuous, and wrote the result in his journal; or we may suppose that he made a memorandum at the time of the observation, but omitted to copy it in the journal, either through inadvertence, or because he deemed it too late for contact. When he found the phase important, he merely copied the omitted record in his journal. The use of the queer word 'fulmen,' which appears only in the manuscript, seems to Professor Newcomb to give color to the latter hypothesis. He can hardly conceive of one using it deliberately, after six months, to express the formation of the thread of light; whereas, at the moment of observation, in the excitement and hurry, it would be a very natural single word to designate the rapid increase of the effulgence of solar light around the following limb of Venus, which follows true contact at ingress. It is a strong confirmation of this view, that Mr. Stone, without apparently having made any comparison with Hell's printed observations, reached this same conclusion as to the probable use of the word 'fulmen.'

With regard to the egress of the planet, the times of Hell's notes of the 'gutta nigra' are each increased by two seconds; but obviously this correction was made at the time of writing. More serious is a correction of the time of observation by Sajnovics, the companion and assistant of Hell. They, no doubt, discussed their times; and, in consequence of such discussion, Sajnovics concluded that his times were late. In the exterior contacts, the only corrections are such as were made at the time of writing, and to which Professor Newcomb attaches no importance.

Regarding certain collateral circumstances which have been supposed to cast suspicion upon Hell's intentions, not only does Professor Newcomb see no suspicious delay in making known his observations (for the whole paper, containing an account of his instruments, observations, and results, including an investigation of his quadrant and clocks, a discussion of his latitude, longitude, and time, and a full statement of his observations, was written, printed, and ready for distribution, four months after his return to Copenhagen), but it seems difficult for him to suppose that Hell could have had time to make so complete a reduction of the observations of others as to be able to compare them with his own. That his observed times of the contacts were not published in advance, as were those of many other observers, but appeared first in an official form under the imprint of the Academy of sciences, seems to Professor Newcomb in accord with very proper feeling, as the observations were made under the auspices of the king of Denmark, and dedicated to him; and furthermore, owing to the position of the station being unknown, publication in advance could have served no useful purpose.

In his discussion, Professor Newcomb makes but slight allusion to the absence of many circumstances which might be expected to accompany manufactured observations; but he has presented all the positive evidence within reach so fully as to enable every one to draw his own independent conclusions. His own conclusions are, —

First, The belief that there was any suspicious delay in the publication of Hell's observations, or any thing in his course to give reasonable ground for a suspicion that he intended to tamper with his observations, is a pure myth.

Second, Excepting the time of formation of the thread of light at ingress; excepting, also, a discrepancy of one second in the time of internal contact, and a change of two seconds in one of Sajnovics's times, — it is proved, not only negatively and presumptively, but by positive evidence and beyond serious doubt, that all the essential numbers of observation given by Hell, whether relating to the transit, time, or longitude, are printed as concluded upon and written in his journal at Wardhus, before there was any possibility of communication with other observers.

Third, The addition of the time of the formation of the thread of light was suggested by the accounts of other observers; but the time itself is Hell's own, obtained possibly from estimation and memory, but more probably from a memorandum made at the time of observation, which he neglected to insert in his journal.

Fourth, The alterations in Sajnovics's time of second internal contact were probably made, because Sajnovics himself afterward concluded that his recorded time was too late; but it may be assumed, that, in reaching this conclusion, he was influenced by Hell's observations.

Professor Newcomb adds, respecting his own proceedings in investigating this subject, that, in commencing the examination of Hell's journal, he had no hope of doing more than deciding whether it was or was not safe to use Hell's numbers as actual results of observations, and no thought of doubting the commonly received view of the case. He soon became perplexed to find himself differing entirely from the conclusions of Littrow. Before the latter had found the manuscript, suspicion had rested upon Hell's truthfulness; so that when he looked into the manuscript, and saw such extensive alterations, the indictment seemed so clearly proven that Littrow's only duty was to make the facts which proved it, known to the world. He thus unconsciously assumed the tone of a public prosecutor, and saw all the circumstances from an accuser's point of view.