

A movie of the 1882 Transit of Venus assembled from plates taken at Lick Observatory by David P. Todd

Anthony Misch¹ and William Sheehan²

(1) University of California Observatories/Lick Observatory, P.O. Box 38
Mount Hamilton, CA, 95140, USA

(2) Willmar, Minnesota, USA

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Abstract

We present a series of 141 photographic plates of the 1882 Transit of Venus, taken by David P. Todd at Lick Observatory. To our knowledge, the plates – which were recently rediscovered on Mount Hamilton – are by far the most complete photographic record of the transit. We also present the plates in the form of a high-resolution time-lapse movie, showing nearly all of the more than four hours of the transit visible from Mount Hamilton. The movie is notable for making visible an event that no living person has seen, but that has been lying dormant in the Lick archive for 120 years. The series also has a place of importance in the history of photography, and especially in the then-emerging art of chronophotography, the serial recording of a moving event.

1 Construction of Lick Observatory

Construction of Lick Observatory on Mount Hamilton in the Diablo Range east of San Jose, California, began in earnest in the summer of 1880 with the removal, by hand, of 70,000 tons of rock to clear a level platform for the observatory buildings. Years had been lost to legal entanglements since the ailing, eccentric James Lick had first promised a portion of his fortune for the



Figure 1: David Peck Todd (no date). Photo courtesy of *The Mary Lea Shane Archive* of the Lick Observatory.

construction of the observatory, but by 1881 the first instruments – a 12-inch Clark equatorial and a 4.1-inch Fauth transit telescope – had been installed on the mountaintop. Adjoining the transit house, a 40-foot Clark photoheliograph was also taking shape.

Though the casting of the glass for its lenses delayed completion of the observatory’s centerpiece – the great 36-inch equatorial – for another five years, scientific work was begun on the mountain with the smaller instruments. With the important transit of Venus approaching and no formal scientific staff yet appointed, Captain Richard S. Floyd, president of the Lick Trustees, tried to persuade Simon Newcomb – dean of American astronomers and an advisor to the Lick Trust – to observe the transit from Mount Hamilton. When Newcomb opted for a better view from South Africa, Floyd invited young David P. Todd (Fig. 1), newly appointed professor of astronomy at Amherst College, to direct observations from Mount Hamilton. Todd accepted with alacrity. In addition to the 12-inch and 4.1-inch telescopes, Todd would have at his disposal the 40-foot photoheliograph, an instrument ideally suited to the observations.

2 David P. Todd's expedition

Though Todd's expedition was not one of the eight outfitted that year by the United States Transit of Venus Commission, it may be regarded as a ninth, unofficial one. Before coming to Mount Hamilton, Todd and his assistant J. L. Lovell visited Washington, D.C., where they received special instructions for photographic work from U. S. Naval Observatory astronomer William Harkness, at whose urging the Commission's 1882 expeditions had been mounted. Lick's Clark photoheliograph was nearly identical to the eight constructed by the same maker for the Commission expeditions, and Harkness surely briefed Todd and Lovell in the techniques that would make their observations compatible with those of the other parties.

Like its Commission cousins, the Lick instrument was a horizontal telescope consisting of a 7-inch heliostat mirror and 5-inch objective of 40-foot focal length (see Figs. 2 and 3 for the photoheliograph house, and Fig. 4 for the site plan of Lick Observatory). Mirror, lens, and a photographic plate holder were mounted on piers, the last inside a light-tight photographic building. A long tube enclosed the path between objective and focal plane.

Todd and Lovell arrived on Mount Hamilton with just over two weeks to



Figure 2: The photographic house of the photoheliograph is the small building with the vaulted roof just left of center in this view looking northeast (no date, but before 1907). Photo courtesy of Darrell Severinsen, Lick Observatory.



Figure 3: The photographic house of the photoheliograph is at center, with its horizontal tube extending north toward the heliostat. Dome of the 36-inch refractor is in the background. View is looking southwest (no date, but between 1888 and 1907). Photo courtesy of Darrell Severinsen, Lick Observatory.

prepare for the transit. Todd regarded the photographic observations as of primary importance, and brought his considerable gifts as mechanical engineer to bear on the new photoheliograph, bringing it to completion with various modifications and making a painstaking determination of its photographic focus. His work was aided by a long run of fine weather, unusual for that time of year on Mount Hamilton. Fig. 5 shows the house of the photoheliograph and the dome of the 36-inch refractor in a later photograph.

The sun rose into a clear sky at 7 a.m. on the day of the transit. Exposures began about a quarter of an hour after sunrise with Venus already well advanced on the sun's disk¹. The first dozen plates were underexposed due to the considerable extinction near the horizon, and the sun's disk was distorted by

¹The first picture was taken at what Todd calls "*19h 11m local mean time*". Since it was soon after sunrise, it likely refers to local time, counted from noon of the previous day and is thus about 7am. The time of each image, though faithfully recorded when they were taken, appears to have been lost.

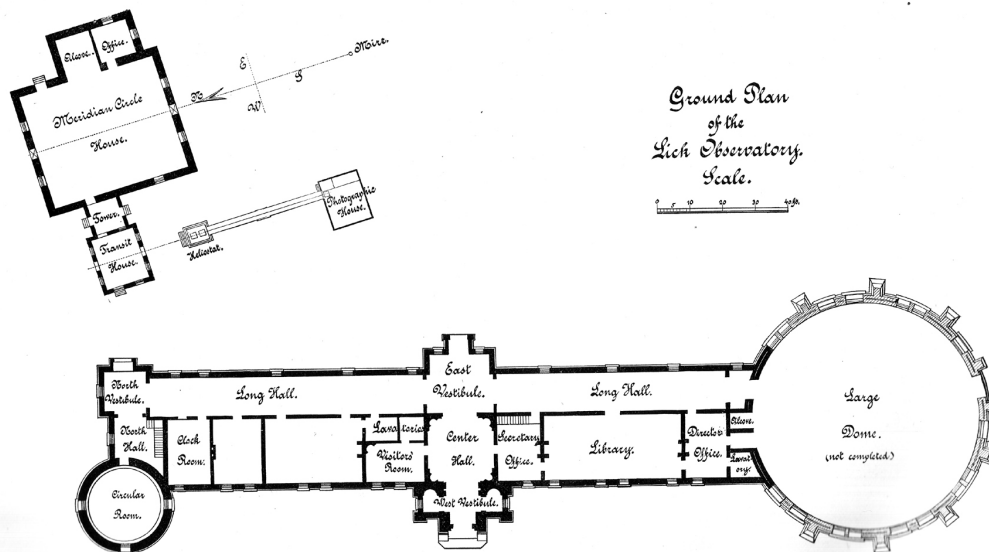


Figure 4: The site plan of Lick Observatory, showing the location of the photoheliograph (Photographic House and Heliostat). From *Publications of the Lick Observatory*, Vol. I, Sacramento, 1887.

atmospheric refraction². But as the sun gained altitude image quality rapidly improved, and another 135 wet-process plates, most of excellent quality, were exposed over the next 3 hours and 48 minutes. Figs. 6 and 7 show some sample images.

Captain Floyd, in the meantime, followed the progress of the transit using the 12-inch equatorial, making several drawings and observing the third and fourth contacts. As the end of the transit neared, Todd left the photoheliograph to visually observe the two contacts with the transit telescope. Photographic observations were suspended soon after third contact.

The importance accorded the photographic observations is borne out by the great care taken to record the times of exposures: an electric chronograph, triggered by the photographic shutter, recorded the times automatically. Todd kept a second record by hand, and Mrs. Cora Floyd and Mrs. Fraser, the wife of the observatory superintendent, made yet another record by listening to the

²All exposures were 0.25 seconds, but the width of the slit in the focal plane shutter was reduced as the sun rose. The initial width of 0''.75 was narrowed in several steps to a final width of 0''.25 over the course of about two hours. This width was then used for the remainder of the pictures. Todd's publication on the observations does not give very precise information in this regard.



Figure 5: The photographic house of the photoheliograph is at right, with its horizontal tube extending north toward the heliostat. Dome of the 36-inch refractor is in the background. View is looking southwest (no date, but between 1888 and 1907). Photo courtesy of Darrell Severinsen, Lick Observatory.

clicks of the chronograph armature from their station in the transit house. But despite the doubly redundant timekeeping, we could find no record, in print or otherwise, of the times of the individual exposures. So much for the durability of the scientific record!

3 The photoheliograph plates

The 147 plates taken with the photoheliograph were left in the observatory plate vault on Mount Hamilton. To ensure the safety of the data, two complete copies were made and deposited with the Lick Trust in San Francisco and at Amherst College, respectively. Only the original negatives appear to have survived, largely undisturbed for more than a century, until 142 were relocated by the authors in the Lick plate archive.

They appear to be by far the most complete photographic record of a transit of Venus to have survived to the present. We know of no plates from the 1874 transit, and the only other collection known to us are the eleven plates that

survived from the 1882 Commission expeditions in the collection of the U. S. Naval Observatory, though others may exist elsewhere.

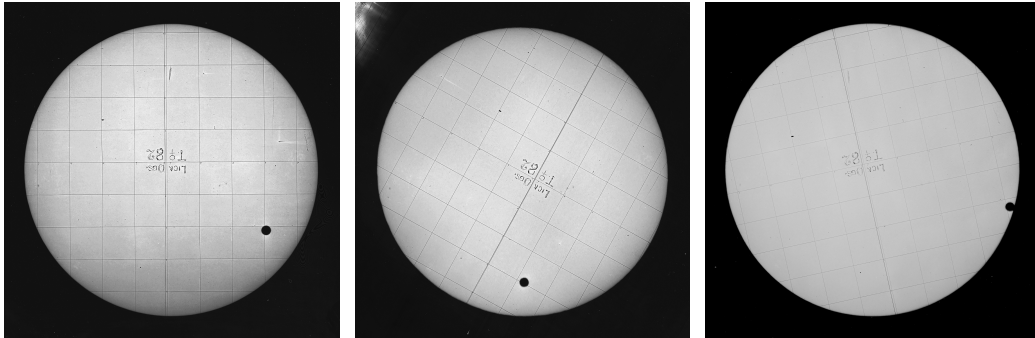


Figure 6: These are Todd’s images 11, 88, and 151, shown as positives and oriented (derotated) as they appear in the movie. (Note that the plate numbers were mostly but not completely continuous, with gaps in the numbering for unknown reasons. Todd records 147 taken. We found 142). Photos courtesy of University of California/Lick Observatory.

4 The movie and the photoheliographs

To assemble the Lick collection into a time-lapse movie, each plate was digitally scanned, the grayscale inverted to yield positive images, the rotation of the sun’s image inherent to the photoheliograph removed, and the images registered using the sun’s limb. Lacking the exact times at which each exposure was made, it was necessary to find a direct means to remove rotation. By good fortune, two well-separated sunspot groups could be seen on most of the plates. These were used to define an arbitrary horizontal on the first image, to which all subsequent images were aligned. No other processing was done. The movie at 1280×1024 image resolution is included as file `1882TOV.MOV`.

The time-lapse movie compresses nearly all of the more than four hours of transit visible from Mount Hamilton – from the first well-defined images in the early morning to the end of the series just after third contact – into a few seconds. It is remarkable in making visible an event that no living person has seen, but that has been lying dormant for 120 years in the Lick archive. The series of photographs also has a place of importance in the history of photography, and especially in the then-emerging art of chronophotography – the serial recording of a moving event – being explored in a more deliberate way by Marey, Jansen, Muybridge, and others.

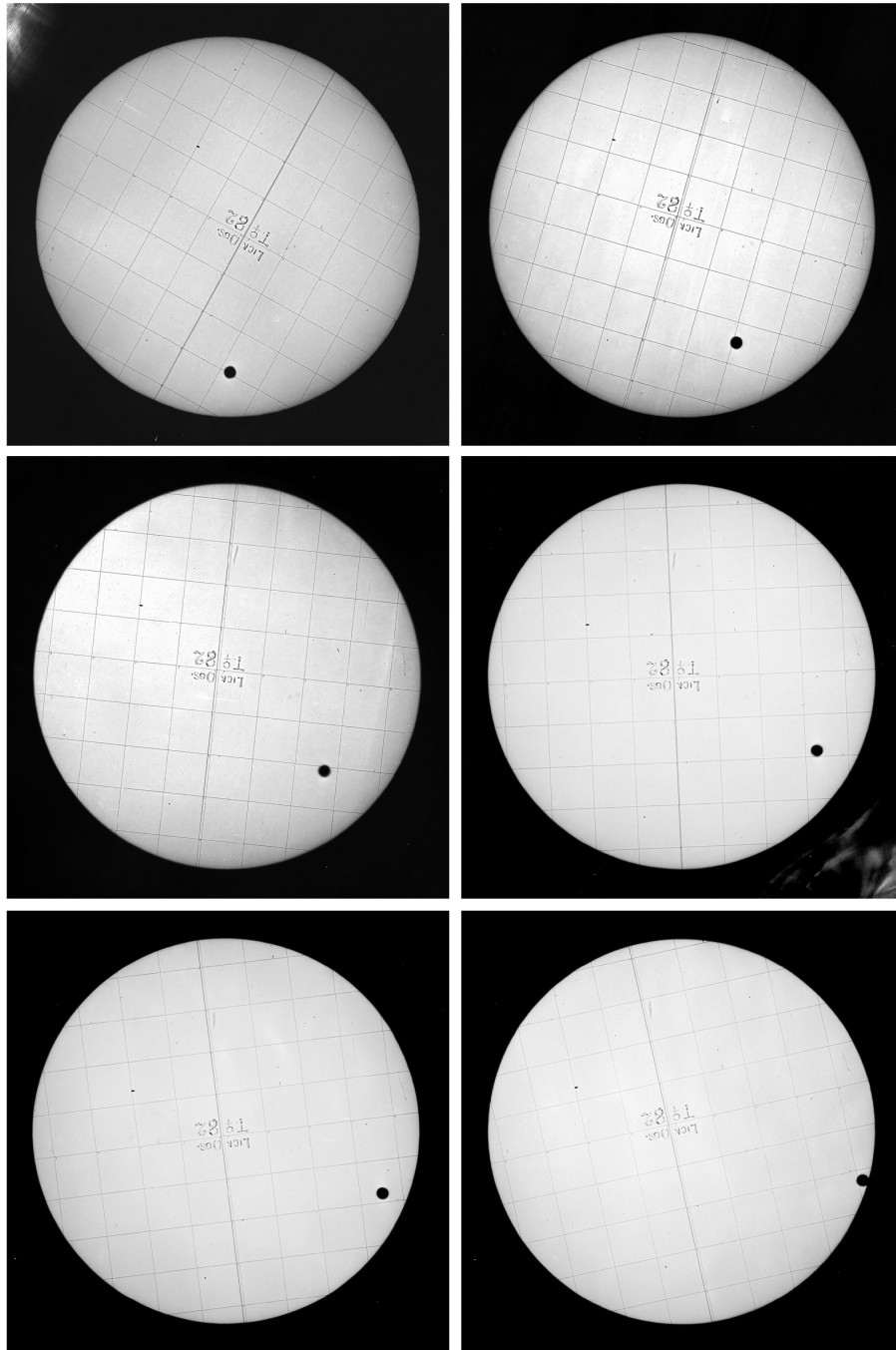


Figure 7: Six of Todd's photographs, from near the beginning to near the end of the transit as visible from Mount Hamilton. From *The Journal of the History of Astronomy*. Copyright UCO/Lick.

141 images are available as FITS files in directory `images`. Todd's original labels (as scratched by hand onto the glass side of each plate) are preserved in the filename: TV821.FIT refers to plate T ♀ 82 number 1.

5 Epilogue

It is not entirely clear whether the considerable efforts of the various transit expeditions succeeded in their scientific aim of refining the measurement of the earth-sun distance. Harkness spent years reducing the transit data, but it would appear that Todd himself did not follow up the observations, at least in print.

It is an interesting if sad footnote that Todd, 27 at the time of the transit, is now remembered more as famous cuckold than astronomer. During his absence from Amherst to follow the sun from Mount Hamilton, his beautiful and intelligent wife of three years, Mabel Loomis Todd, author and champion of Emily Dickinson, began a love affair with the poet's brother Austin that would continue for the rest of their lives (for details, see Sheehan & Misch 2004).

Acknowledgements

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