

MICHAEL E. CHAUVIN

Astronomy in the Sandwich Islands: The 1874 Transit of Venus

ON SEPTEMBER 9, 1874, fewer than seven months after the ascension to the throne of Hawai'i's last king, David Kalākaua, a ship from England, H.M.S. *Scout*, arrived in Honolulu carrying an expedition of seven astronomers. They came, as Captain Cook had come almost 100 years earlier, as the beneficiaries and instruments of a rich astronomical heritage that had found its visible embodiment in the Royal Observatory at Greenwich; and it was from Greenwich that Western astronomy had reached out to touch Hawai'i in 1778, and was to do so again in 1874.

The mission of the 1874 expedition was to observe a rare transit of the planet Venus across the sun for the purpose of better determining the true value of the Astronomical Unit (the AU, i.e., the Earth-sun distance) and, thereby, the absolute scale of the solar system. For although Copernicus (1473-1543) had put the planets in their correct order, and had derived from his model of the solar system a set of *relative distances* among its members (table 1), their *absolute distances* were hostage to the uncertain value of the AU. Astronomers still needed a celestial yardstick of known length to measure distances among the planets and to link the planets to the stars beyond.

King Kalākaua manifested a personal interest in the transit of

Michael E. Chauvin, an erstwhile lecturer at the Bishop Museum Planetarium, has taught astronomy at the University of Hawai'i at Hilo and is now assistant director of the Program in Applied Philosophy at the University of Hawai'i at Mānoa.

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TABLE I
RELATIVE DISTANCES OF THE PLANETS, IN AU

PLANET	COPERNICUS	MODERN VALUE
Mercury	0.3763	0.387
Venus	0.7193	0.723
Earth	1.0000	1.000
Mars	1.5198	1.524
Jupiter	5.2192	5.203
Saturn	9.1743	9.529

Copernican values are taken from Van Helden, *Measuring the Universe* 44; modern values from Roy L. Bishop, ed., *Observer's Handbook 1993* (Toronto, 1992) 10.

Venus operations in his kingdom. And although he was absent from the islands when the much-awaited event occurred, he visited the transit of Venus observatory, as did other members of Honolulu's society, both before and after "Transit Day."

The transit operations in Hawai'i extended over a period of six months and attracted much attention—not all of it welcome. The daily journal kept by the expedition's leader, George L. Tupman, and the correspondence between Tupman and England's astronomer royal help to flesh out the larger story of the development of astronomy in Hawai'i.

THE BRITISH INTEREST IN THE 1874 TRANSIT OF VENUS

Although the 1874 transit of Venus was the first such transit observed by the British from Hawai'i, that nation's interest in this rare astronomical phenomenon had important antecedents.

Since the advent of telescopic astronomy in the early seventeenth century, there have been but six transits (in three pairs) of the sun by Venus, those of 1631/1639, 1761/1769, and 1874/1882. (The next transit pair will occur in 2004/2012.)

Observations of the 1639 transit are the first of which there is

any known historical record—and this record is distinctly, and solely, English: foreseen by only one man, the English churchman Jeremiah Horrocks, he and his friend William Crabtree are the only two persons known to have observed the event.¹

The next transit of Venus did not occur until 1761. And it was again an Englishman—England's second astronomer royal at Greenwich, Edmund Halley (1656–1742)—who played a historical role. Having opined as early as 1691 that Venus, observed from different vantage points during a transit, offered the only hope to those for whom the AU was the *primum desideratum*, Halley, in 1716, in the *Philosophical Transactions*, trumpeted the prospects of the 1761 transit, arguing that the accuracy of the parallax measurements that might result could be unprecedented: the value of the AU could be gotten, he averred, to within one-fifth of 1 percent!² And aroused by Halley's call to arms, the transits of Venus of 1761 and 1769 enlisted observers around the globe.

Britain's Royal Society, in due course, sent observers abroad in order to espy the 1761 transit. These included Nevil Maskelyne (soon to become astronomer royal and, in 1767, father of the *Nautical Almanac*), who went to St. Helena. Remaining on English soil to observe the transit at Greenwich under the supervision of Nathaniel Bliss was Charles Green, who, in 1769, was to observe his second transit of Venus, this time from the island of Tahiti and in the company of a man who would return to Polynesia twice more, each time bringing English astronomers with him. That man was James Cook.

In 1768, only one year after Maskelyne's *Nautical Almanac* had made its debut, Lieutenant Cook embarked upon his first Pacific voyage aboard the *Endeavour*. The paramount raison d'être of this voyage, and Cook's preeminent task, was not exploratory but was, rather, astronomical: he was to proceed to Tahiti in order to observe the impending transit of Venus in June 1769.³ But Tahiti was only one of the numerous sites, including those in its North American colonies,⁴ from which the British viewed the 1769 transit: observing from Hudson Bay was William Wales and from the North Cape of Norway, William Bayly—two astronomers who would sail with Cook as “supernumeraries” on his second Pacific

voyage (1772–75). When Bayly, importantly, returned with Cook on his third voyage (1776–80), British astronomy—persons, ideas, and instruments—made its first impact on Hawai‘i.

With respect to the eighteenth-century transit of Venus pair, Halley had understood this much: The apparent path of Venus across the sun would not be the same for terrestrial observers at different locations: parallactic effects would cause two observers at different latitudes on the Earth to see Venus sweep across the sun along two different chords. Halley pointed out that solar parallax⁵ could be obtained by finding the difference between the lengths of the two chords, and that these lengths could be easily obtained by precisely timing the moments of ingress and egress of the planet on the sun at each place.⁶ Halley’s plans for observing the transit of Venus from various terrestrial stations were implemented in 1761 and 1769, resulting in a “considerable improvement” in the scale of the solar system (within an accuracy of about 5 percent).⁷ Although the first transit (1761) produced a wide range of values for solar parallax (from 8.28 to 10.60 seconds of arc) which the second transit (1769) considerably refined (narrowing the value to between 8.43 and 8.80 seconds), nevertheless, one of the practical problems of “the Halley method” was that it required the precise timing of the moments of both Venus’s ingress and her egress—something difficult to realize in practice if, for the observer, the sun rose after ingress or set before egress. To obviate this concern, Joseph-Nicolas Delisle devised an improved method making it possible to obtain the desired measurement by combining the results of two separate observations made in similar latitudes—one observation of ingress, the other of egress. The success of “the Delisle method,” however, was contingent upon the ability to determine accurately the longitude of, and thus the distance between, the two observing stations⁸—a contingency that did not pass neglected in 1874 when the Delisle method was employed in Hawai‘i, where the task was to observe only the ingress.

Early in 1869, one hundred years after British transit of Venus observations were made by James Cook and Charles Green from Tahiti,⁹ George B. Airy, the seventh astronomer royal at Greenwich, wrote to the secretary of the Admiralty:

It appears from the calculations of Astronomers that there will occur, on 1874 December 8 and 1882 December 6, Transits of the planet Venus over the Sun's Disk. This phenomenon (which has not presented itself since the year 1769) is peculiarly favorable for determination of the Earth's Distance from the Sun upon which depend all the dimensions of the Solar System. On account of the importance and interest of this determination, the observations of the two Transits (1761 and 1769), the only ones which have been visible since Astronomy became an accurate science, received the cordial support of the principal civilized nations of the world; and Astronomers now look with hope, for similar assistance in the observations of 1874 and 1882, to their Governments, especially to that of Britain, which from the wide distribution of its possessions may give more efficient aid than any other.¹⁰

Although the 1761 and 1769 transit pair "gave rise to the first international, cooperative scientific expeditions in modern history," they did not produce results of the precision that Halley had envisioned. They did, nevertheless, produce a solar parallax seemingly accurate to the nearest second of arc—a remarkable achievement not possible just one century earlier. Still, the difference between a parallax of 8.4 seconds and one of 8.8 seconds is not inconsiderable: this amounts to a difference (in the Earth-sun distance) of more than 4,000,000 miles!¹¹

Furthermore, Airy had detected what seemed to be a serious flaw in the 1769 transit of Venus data, namely, observations made in Lapland, to which Cook's Tahiti observations were to be compared for the purpose of calculating parallax, appeared "untrustworthy."¹² Such misgivings, Airy reckoned, needed to be remedied.

But by 1874, the value of the solar parallax had, by a variety of methods, the transit of Venus method being but one of them, been confined to a remarkably narrow range (table 2). So, it may be wondered, why should there have been, at this historical moment, any but the most trivial concern—in England or elsewhere—about the residual ignorance?

The answer to this probing question is not to be found entirely in astronomers' mad Faustian thirst after "knowledge for knowl-

TABLE 2
 VALUES FOR SOLAR PARALLAX AND THE
 ASTRONOMICAL UNIT (AU) OBTAINED BY VARIOUS METHODS
 BEFORE THE 1874 TRANSIT OF VENUS

METHOD	PARALLAX IN ARC SECONDS	AU IN MILES
Transit of Venus	8.91	91,580,000
Opposition of Mars	8.943	91,240,000
Lunar Theory	8.916	91,520,000
Lunar Theory	8.850	92,200,000
Planetary Theory	8.859	92,110,000
Jupiter's satellites and velocity of light	8.86	92,100,000
Constant of aberration and velocity of light	8.86	92,100,000

Adapted from George Forbes, "The Coming Transit of Venus," IV, *Nature* (May 14, 1874): 28.

edge's sake," but in the practical spheres of navigation and cartography, where the British persona loomed large.

When, in 1675, King Charles II established his Royal Observatory at Greenwich, he had his eye upon the stars—and his feet firmly anchored in British maritime ambition. Because it had been long recognized that the navigational problem that most afflicted British seamen was the determination of longitude, it was no mere passing fancy that prompted the king, in establishing his observatory, to direct John Flamsteed, its first astronomer royal,

to apply himself with the most exact care and diligence to the rectifying the tables of the motions of the heavens and the places of the fixed stars, so as to find out the so much-desired longitude of places for the perfecting the art of navigation.¹³

This conscription of science by government had repercussions in Hawai'i a hundred, and two hundred, years later. It was not, for

example, mere happenstance when Captain Cook embarked upon his series of explorations in the company of Greenwich-affiliated astronomers that he had with him the Royal Observatory's brainchild for longitude-finding, the *Nautical Almanac*, ready at hand. And it was at that historical juncture that the matrimonial pairing of *positional astronomy* with *positional geography* was elevated to a state of refinement, resulting in the mapping of parts of the world unknown to European communities. And so it was that Captain Cook, the commonly understood European "discoverer" of Hawai'i, did what is not commonly understood and what no one before him had ever done: he placed Hawai'i on a map astronomically by pinpointing its latitude and longitude.

That Britain's astronomical interests were married to her inveterate longitudinal interests was manifested again in the context of the 1874 transit of Venus. One nineteenth-century Englishman who understood those inveterate interests was George Forbes.

Professor Forbes, who was among the seven astronomers dispatched to Hawai'i from England to observe the 1874 transit, had authored a series of articles on "The Coming Transit of Venus," which appeared in seven installments in the British journal *Nature* between April and June of 1874.¹⁴ As a post-Newtonian astronomer, Forbes noted there that

The law of gravitation says that the attraction of each body for each other one depends upon the distance between them. The moon is attracted to the earth by a force, depending upon the distance of the moon, which is known in miles. But the moon is caused to deviate from its natural course on account of the sun's attraction. This depends upon the distance of the sun from the earth, and if this be not known exactly in miles we shall see that it is impossible to apply calculation to foretell the motions of the moon.¹⁵

Probably not unmindful of his own nation's astronomical history, Forbes presumably knew that the *Nautical Almanac* contained tables—as it had since Captain Cook's day—predicting the position of the moon at selected intervals of (Greenwich) time and,

further, that by employing what is called the lunar-distance method, these lunar data could be used in the determination of longitude.¹⁶ Moreover, Forbes may have, by the early 1870s, already seen a copy of the 1874 edition of the *Almanac*, printed in 1870, which contained an appendix giving (*inter alia*) “The Particulars of the [1874] Transit of Venus over the Sun’s Disc at the Stations selected for Observation,” as well as the familiar tables of “Lunar Distances.” But Forbes, realizing that the lunar tables were “by no means perfect,” theatrically summoned Venus as the nineteenth-century *deus ex machina* that could help put things right. He set the stage for Venus’s 1874 entry upon the sun thusly:

The coming transit of Venus will be observed from about 75 stations, at many of which there will be a large number of instruments. . . . [and] these expeditions will lead to most valuable results.

And what are these “most valuable results”?

. . . the transits [*sic*] of Venus will aid materially in perfecting the Lunar Tables. The motions of the moon are rendered irregular by the disturbing attraction of the sun. But we cannot determine with great accuracy either the amount or the direction of the sun’s attraction upon the moon until we know accurately the sun’s distance. Hence if we wish to be able to compute tables of the moon sufficiently correct for the exact determination of longitude, we must employ every means in our power to perfect our knowledge of the sun’s distance.¹⁷

Because the problem of “solving the longitude” had been so intimately a part of the *raison d’être* of the Royal Greenwich Observatory (RGO) since its founding in 1675, it is not surprising that it should linger on, even if subliminally, into the reign of George Biddell Airy (1801–92), who accepted the post of astronomer royal in 1835. It was at Greenwich that Airy undertook preliminary work in preparation for the 1874 transit of Venus. The entire control of the various British expeditions—of which there were five, including the Hawai‘i contingent—was in his hands;

and the *Account* embodying the results of that enterprise was issued in 1881, with Airy serving as editor.¹⁸

By his own reckoning, Airy began to call public attention to the nineteenth-century transit pair as early as 1857; and several years before the 1874 event, Airy had come to realize that a Hawai'i-based contingent was both scientifically attractive and politically convenient.¹⁹ There were several reasons for this:

1. Insofar as it was desirable to select a station for observing the transit of Venus from a place on the Earth where the planet's ingress would be apparently accelerated by parallax, Airy averred that "Owhyhee and the neighbouring islands are excellent."
2. Airy understood that the Hawaiian Islands "are just within the tropics"—where, as one member of the expedition was later to write, "the weather can be depended upon."²⁰
3. Airy could find some comfort in knowing that there existed "English society at Woahoo."²¹

ESTABLISHMENT AT APUA

Airy's intimation that an English expedition would be well received in Hawai'i was almost prescient. The expedition destined for the Hawaiian Islands left Liverpool, England, in June of 1874, proceeding by way of the Straits of Magellan to Valparaiso, Chile. There, personnel and baggage were transferred to another vessel, which sailed on August 4. Arriving in Hawai'i five weeks later were the expedition's seven astronomers (fig. 1), variously appointed from academic, military, or civilian life: George Lyon Tupman, captain, RMA; George Forbes, professor; F. E. Ramsden, lieutenant, RN; E. J. W. Noble, lieutenant, RMA; J. W. Nichol, Esq.; Richard Johnson, Esq.; and H. G. Barnacle, Esq.²²

In September of 1874, Captain Tupman, the leader of the expedition, wrote to the astronomer royal. This letter, one of several from Tupman to Airy now in the RGO file at Cambridge University Library among the voluminous Airy papers, begins with the



FIG. 1. Transit of Venus party, Honolulu, 1874. (AH.)

heading "Hawaiian Hotel, Honolulu 1874 Sept 17" and reads, in part:

My dear Sir,

It is with very great pleasure I write to inform you of the safe arrival here of the H.M.S. "Scout" bearing the whole of the "Transit" Expedition. We arrived Sept. 9, having made a very quiet and quick passage of 35-1/2 days.

I immediately called upon Major Woodhouse [*sic*], Her Majesty's Commissioner, who kindly conducted me to the Minister of the Interior, the Governor of Oahu and other officials and persons of distinction, all of whom accorded me a courteous welcome and expressed their desire to afford every possible assistance to the Expedition.

The Hawaiian Government was pleased to allow all our stores to be landed without examination & free of all duties and allowed them to be temporarily located in the Customs House Stores. I need hardly say that this courteous action greatly facilitated our operations.

After consultation with numerous residents, well able to advise in the matter, I saw no reason to alter the original choice of Honolulu itself for the Head Station. Some difficulty was experienced in



FIG. 2. Transit of Venus dwelling house, Honolulu, with government offices in the distance. (RGO archives, Cambridge University Library.)

finding a suitable place of observation, as I considered it of great importance that the observers should be lodged very close to the instruments; and house accommodation is rather limited. However we have been enabled to rent a cottage [fig. 2] belonging to the Princess Ruth, Governess of Molokai, capable of accommodating the Head Station observers, and adjoining some land owned by His Majesty the King who has kindly given us permission to erect our instruments Etc. and enclose as much land as may be necessary.

The site is probably as good as could be found on the Island and . . . it is admirably suited to the purpose. . . .²³

The site mentioned by Tupman had an area of approximately 1,600 square yards—"ample space for all the instruments and storing sheds," he thought. The property had not been developed, but was an "open piece of grass land in the district called Apua . . . south of Punchbowl Street and west of Queen Street" (fig. 3).²⁴ Here, not far from the waterfront, the observatory would command an unobstructed view of the southwestern sky,

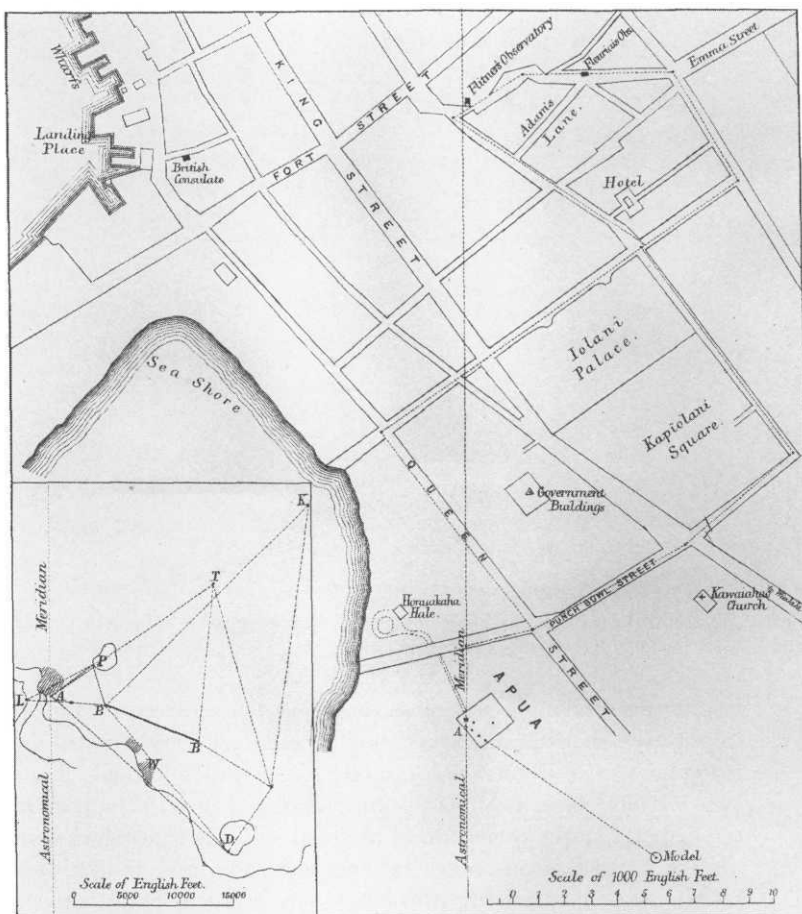


FIG. 3. Map showing the location of the 1874 transit of Venus station in the district called Apua. The inset shows the position of the station relative to the principal points of the Government Trigonometrical Survey: P is Punchbowl, D is Diamond Head, T is Tantalus, and W is Waikiki. (G. B. Airy, *Account of Observations of the Transit of Venus, 1874.*)

where the sun would be on the day of the transit—an important consideration of which Tupman was surely aware when he noted to Airy:

The Setting Sun in December will be visible, as far as terrestrial objects are concerned, to within half a degree of the horizon, the line of vision passing entirely over water, except for about 200 yards which are grass & mud.²⁵

And so it was at this location that “a portion [of the land], in every way suitable for our purpose, was enclosed with a wooden fence, and the instruments . . . set up” while water was “being laid on, of very pure quality, by pipes from the road 100 yards distant.”²⁶ Within these confines there came to be erected the pieces of a well-equipped nineteenth-century astronomical observatory: a transit instrument, a photoheliograph, an altazimuth, two equatorial telescopes, and a platform for observing a mechanical model intended to simulate the appearance of the upcoming transit (fig. 4). Tupman’s letter also informs Airy:

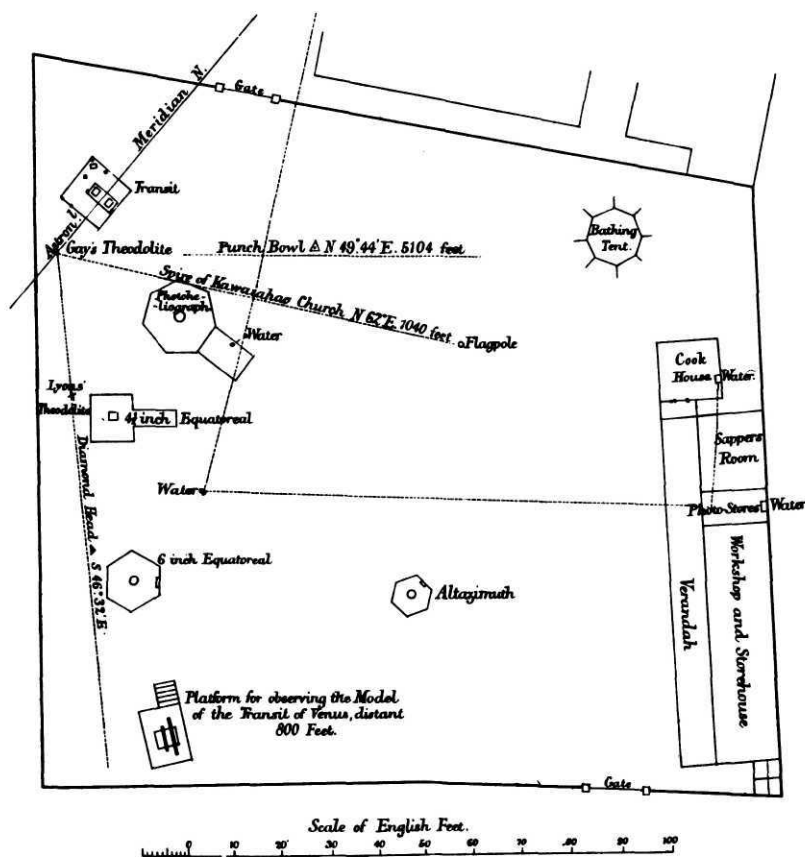


FIG. 4. Ground plan of the Transit of Venus observatory at Honolulu. (G. B. Airy, *Account of Observations of the Transit of Venus*, 1874.)

We are all located for the present at this Hotel. The Princess' House will probably be occupied next Monday (Sept 21). . . . We are all in excellent health & anxious to begin work. The thermometer ranges from 85° by day to 78° by night. I find it very trying running about all day in the sun, but it is the only way of getting the work done.²⁷

At the time of the expedition's arrival in the islands, Kalākaua had occupied the throne a mere seven months. But the neophyte king evidenced, early on, a considerable personal interest in the transit of Venus operations in his kingdom; and within the very first week of their presence in Hawai'i, the members of the expedition were formally received by the king at the palace in Honolulu. Tupman's letter continues:

At His Majesty's request we were all presented to him, Sept 15. I considered it my duty to express our thanks to His Majesty for the nature of our reception here—the cordial welcome and generous assistance accorded us by His Majesty himself, his Ministers and every one with whom we had been brought into contact. His Majesty was pleased to read an exceedingly graceful reply, expressing the pleasure our visit gave him, and his earnest wish to assist us to the utmost.²⁸

On September 19—four days after the reception at the palace, and only two days after Tupman penned his letter to Airy—Kalākaua's "graceful reply" was published by the *Pacific Commercial Advertiser* and captured the public persona of a neophyte and visionary king: for, even though it was, as Tupman remarks, "read" and may have been prepared for the king by a ghost writer, Kalākaua's regal salutation was as scientifically informed as it was amiable:

It gives me great pleasure to receive you and the members of the expedition sent by Her Majesty Queen Victoria to observe the approaching transit of the planet Venus across the Sun's disk. I have requested My Ministers, and through them all the officers of My Government, to grant you every facility in their power, in carrying out the very important objects which you have in your

charge. I trust you will not hesitate at once to inform them of anything that you may require to facilitate your operations.

It will afford me unfeigned satisfaction if My Kingdom can add its quota towards the successful accomplishment of the most important astronomical observation of the present century, and assist, however humbly, the enlightened nations of the earth in these costly enterprises to establish the basis of astronomical distances.²⁹

Although the impression left by this newspaper report of an early encounter seems to indicate friendly, though formal, efforts at rapprochement on both sides, Tupman's sentiments toward Hawai'i and its king began to sour in the days to follow.

In his next letter to Airy, dated October 13, after reporting that the Head Station (in Honolulu) had been "completely established" and that "regular [astronomical] observations" were "in full swing," Tupman began to demonstrate a private irritation for the situation in which he now found himself, where both nature and society were proving troublesome.³⁰ "A good deal of wet weather" is his simple statement to Airy—though he would frequently repeat this lament, in refrain-like fashion, in his private journal.³¹ Becoming miffed by tropical rains (in a place where "the weather can be depended upon"!), Tupman was likewise vexed by the tropical heat, already mentioned in his letter of September 17, but underscored here because of its adverse effect on the photographic work of the expedition: "At first the heat of the dark room was intolerable . . . [until] I had it covered with a roof of rushes . . ." (fig. 5).³²

And with the heat and the rain of the tropics came another of nature's impediments to the scientific enterprise—insects:

. . . When it became necessary to commence the computing we found the mosquitoes so troublesome it was almost impossible to do anything. Nichol presented a mass of sores over his face and hands and Ramsden couldn't sit at the table five minutes.³³

But the disruptions of nature were, for Tupman, further aggravated by the delicacies of conducting serious astronomy in a society that was both technologically impoverished and scientifi-



FIG. 5. Transit hut and photo hut, Honolulu, with roofs partially covered with rushes to counter the tropical heat. (RGO archives, Cambridge University Library.)

cally ill-informed, and where the consequent misunderstandings could wear both a mildly tragic and a mildly comic face. And so he wrote to Airy: “Numerous inhabitants imagine we have come all this way on purpose to satisfy their curiosity to see Saturn’s Rings and Jupiter’s belts through a telescope.”³⁴

By this time, Tupman’s *prima facie* impressions of the scientific sobriety of King Kalākaua had likely undergone an unfavorable mutation. For although the obtrusiveness of unwanted visitors to the observatory “wasted” a great deal of valuable time, Tupman felt obliged to “give up work” for, *inter alia*, “members of the Royal Family.”³⁵ And so he must have had his teetering equanimity especially disturbed when such events transpired that prompted this journal entry:

His Majesty paid us a private visit in the evening and remained 2 hours. He proposed that as soon as all the Instruments were mounted we should throw open the grounds to the public for a week at a charge of a dollar or so a-head and he would send his Military Band down every day!³⁶

Whether or not such suggestions were given, or taken, seriously, Tupman probably understood that he and his scientific cohorts were the king's "guests" in the king's backyard.³⁷ And so, soon after he recorded the above episode, and perhaps in a diplomatic display of obeisance to the king and his subjects, Tupman reported that, on October 31

the public of Honolulu was admitted from 3-5 p.m. by tickets obtained through Consuls and other influential persons from me. It poured with rain the whole day without a moment's cessation, nevertheless some 150 ladies & gentlemen availed themselves of the opportunity.³⁸

Tupman did not report whether or not those tickets were sold for a dollar a head.

In addition to the main transit of Venus observatory in Honolulu, two auxiliary stations were established on the Neighbor Islands—one at Waimea, Kaua'i, and the other at Kailua-Kona, Hawai'i. The effective use of these stations required that their "absolute longitude" be "accurately determined" (as the astronomer royal had pointed out³⁹), so they were eventually connected to the Honolulu site by the carriage of chronometers between the islands aboard the H.M.S. *Tenedos*.⁴⁰

The precise location of the main transit of Venus station in Honolulu, therefore, was a major concern with respect to the success of the enterprise, and much care was taken in the establishment of its correct geographic coordinates—coordinates that were established astronomically, though they had a genuine down-to-Earth application that extended well beyond the exigencies of the 1874 celestial pursuits. And so it was that the observatory coordinates at Apua were determined with great punctiliousness "with the object of serving as a point of reference for the Trigonometrical Survey of the kingdom of Hawaii by the Government of His Majesty King Kalakaua." This survey was already in progress by the time the expedition visited the islands and was under "the able management of Professor W. D. Alexander."⁴¹ Indeed by early 1874, Alexander was already anticipating the arrival of the

transit of Venus expedition, expecting that it would render “invaluable assistance” to the Hawaiian government survey by obtaining latitude and longitude measurements “with a degree of accuracy never before attained in these islands.”⁴²

The intimate relation between the apparent abstruseness of astronomical pursuits and the more mundane nature of terrestrial concerns—in this case, the relation between astronomical and terrestrial measurements—was further evidenced when, with the assistance of James N. Gay, surveyor of Honolulu, the British station at Apua was connected, by theodolite and chain, to a pair of previously existing observatories in downtown Honolulu—those of Flitner and Fleuriais (see fig. 3), two individuals whose influence on the 1874 transit operations should not pass unmentioned.

David Flitner of Honolulu, who was himself to observe the ingress of Venus from Waikīkī, was, reportedly, also a “maker” of chronometers who “most generously” lent six of these timepieces to the transit of Venus expedition “to assist in the longitude operations.” But Flitner’s interests in matters astronomical were more enduring than an ephemeral transit: He had his own observatory in Honolulu—an observatory that, even if Airy’s account is only partially correct, had itself an interesting history.⁴³ For, by this account, Flitner—whether or not he “made” his own chronometers (which may be doubted)—did not make his own transit instrument nor build his own observatory, but, rather, acquired them. “In or about the year 1845,” reads Airy’s report,

[a certain] Professor Lyman, now of Yale College, Connecticut, then residing in Honolulu for the benefit of his health, made a number of meridional observations of the Moon in order to determine the longitude. It is supposed that these observations have never been published, but their utility was such that in 1874 the Hawaiian Surveyor-General was still using the longitude communicated to him by Professor Lyman. The observatory and transit instrument of Professor Lyman passed into the hands of David Flitner, Esq., chronometer maker, of Honolulu, and in 1874 they were in perfect order.⁴⁴

The Lyman referred to here was Chester Smith Lyman (1814–90), who by 1874 had become a professor of physics and astron-

omy at Yale, but who in earlier life, after studying theology at Yale and holding a pastorate over the First Church in New Britain, Connecticut, was "obliged to travel for his health." After spending more than seven months at sea, Lyman reached the Sandwich Islands via Cape Horn in May 1846. He remained in Hawai'i little more than a year, and during his stay in Honolulu he taught briefly at the Royal School, where among his pupils was the chiefess who was later to become Queen Emma. His *Hawaiian Journals* detail, in diary-like fashion, his travels through the islands.⁴⁵ And although they reveal only a glimmer of his astronomical interests, there is enough therein to corroborate, and to amend, Airy's groping account of the traveling astronomer.

Between May 15 and June 17, 1846, we find Lyman, by his own rendering, paying several calls on a "Mr. Boardman, watchmaker." This is the same Boardman who is credited with the establishment of a Transit Observatory on Union Street near Hotel—an observatory which, by the 1860s, had become known as Flitner's Observatory.⁴⁶

That Lyman was involved in the early history—and possibly the establishment—of the Boardman-Flitner Observatory is attested by the account given in Lyman's *Hawaiian Journals*. On May 25, 1846 (this record states), Lyman saw Boardman's "fine new Transit"; and by June 1, he was "Assisting Mr. Boardman part of the day in adjusting his Transit Instrument." On the evenings of June 4 and 5, he was making transit observations of stars (not of the moon, as is stated in Airy's account), which he then reduced the following mornings (June 5 and 6), obtaining thereby longitude figures of $157^{\circ}45'25''$ and $157^{\circ}47'50''$. These longitude figures for Honolulu compare favorably with those given elsewhere by Tupman, who stated that

Professor Lyman determined the position of Mr. Flitner's observatory as follows:—

Latitude $21^{\circ}18'22''.75$ North

Longitude $10\text{h } 31\text{m } 15\text{s}.00$ West of Gr.

The observations were made with the Portable Transit Instrument now in Mr. Flitner's possession. . . .⁴⁷

Tupman further indicated that the observatory's coordinates, as determined by Lyman, "were reduced by the aid of the *Nautical Almanac* only"—indicating once again, though perhaps unwittingly, the close historical relation between British maritime practice (as embodied in the *Nautical Almanac*) and the astronomical determination of the terrestrial coordinates of distant parts of the world.

The desirability of knowing what such coordinates were in Hawai'i in the last quarter of the nineteenth century can perhaps be somewhat understood by a look at the *Hawaiian Almanac* for 1875. There, where the coordinates for Flitner's observatory are given ($21^{\circ}18'23''$ and $157^{\circ}48'45''$), this historically illuminating note is added:

The . . . Latitude and Longitude of Flitner's Observatory is from combined observations of C. S. Lyman, M. Fleurrier [*sic*] and Capt. Daniel Smith, and is taken as an initial point for all the Latitudes and Longitudes of the Island Triangulation.⁴⁸

This unabashed association of astronomy with the practice of land surveying has a significance that should not be lost: the land-grabbing precipitated by the Great Mahele had already resulted in many a muddled property line as the islands were being surveyed, measured, and divided up. The confusion and discord consequent upon the parceling of Hawai'i's tiny amount of real estate was to continue into the 1870s and beyond.⁴⁹

If the desire of the 1874 transit of Venus expedition to obtain precise longitudinal measurements explains the presence in the historical record of references to Flitner's Observatory, then the story of Fleuriais's Observatory should be equally interesting for that same reason. In truth, however, it has an additional interest—and for an additional reason.

M. G. Fleuriais was an officer in the French navy. In 1868, while visiting Hawai'i, he made numerous astronomical observations between October and December for the purpose of determining Honolulu's longitudinal distance not from Greenwich, but from Paris. His results were published in the *Connaissance des Temps* of 1872.⁵⁰

The relocation and preservation of the precise site of Fleuriais's observatory eventually involved Tupman in an astronomical treasure hunt. His *Journal* records the story as follows:

In the years 1867-8 [*sic*] M. Fleuriais, a Lieutenant in the French Navy, determined the Longitude of Honolulu by Moon Culminations, his observations extending over several months. His results are published (I believe) in the "Connaissance des Temps".

Considering it desirable that the Station of the Transit of Venus Instruments should be geodetically connected with Mr. Flitner's observatory and the site of Fleuriais' transit, I instituted a search for the latter. In a few days, chiefly through the friendly and energetic cooperation of Mr. James N. Gay, Surveyor, of Honolulu, the foundations of his (Fleuriais') pier were found upon the Coral, 5 feet below the surface, on the North side of Union [Emma] Street, immediately opposite the end of Adam's Lane. His observatory stood in the road just clear of the carriage track. The Mason who built the pier & who afterwards removed the material identified the spot, and pointed out to me some portion of the fencing which had been removed to clear his North Meridian line.

Using our own Meridian line as a basis of Azimuth, Mr. Gay, with theodolite and chain ran a traverse along the streets to Flitner's & Fleuriais' piers, and back again by a different route. Mr. Gay also connected our station with surrounding permanent objects & localities and also with the nearer Government Trig. Stations, on Diamond Head & Punch Bowl Hills. According to the traverse, Flitner's pier (which was Lyman's) is $2370\frac{1}{4}$ feet *North* and $12\frac{1}{2}$ feet *East* of the centre of the "Transit of Venus" transit pier. Fleuriais' pier was 2474 feet *North* and 456 *East* of our pier.⁵¹

The care taken to mark the location, to a fraction of a foot, of Fleuriais's observing site is itself remarkable. But, as if unsatisfied by these measures alone, Tupman took additional precautions in order to safeguard his work and protect his discovery:

To prevent the site of Fleuriais' pier being lost, I built on it a small square pier of brick & cement on the coral, up to within 18 inches of the surface of the ground, & deposited a bottle containing a paper.⁵²

The subsequent fate of Tupman's buried treasure is not known.

A faithful description of the Fleuriais site was lodged in the French consulate, Tupman further reported, and placed among the archives by the commissioner for France, Theodore Ballieu. That the French, in 1874, would maintain an interest in the astronomical legacy of a naval officer should not be surprising: By 1873 it had already been settled that Fleuriais would observe the 1874 transit of Venus from the Marquesas Islands of French Polynesia.⁵³

AUXILIARY STATIONS

By mid September 1874, efforts were already being made to secure information regarding suitable ancillary observatory sites on islands other than O'ahu. Although Kealakekua Bay (Hawai'i), the island of Ni'ihau, and Haleakalā (Maui) were all considered, the choice, in the end, settled upon Kailua-Kona (Hawai'i) and Waimea (Kaua'i).⁵⁴

Assigned to observe the transit from the Hawai'i location was George Forbes (1849–1936), a professor of natural philosophy from Anderson's College, Glasgow (whose trenchant understanding of British transit-related aspirations has already been noted). Having received his degree from Cambridge, Forbes was a versatile man with aptitudes for physics, astronomy, and electrical engineering alike and, in later life, became involved in plans to harness the hydroelectric potential of Niagara Falls, working at Niagara from 1891 to 1895. Forbes was only 25 years old when he left Honolulu in November of 1874 aboard the H.M.S. *Scout* to take charge of the station at Kailua.

Having been dispatched to a location where the accoutrements of English civilization were uncomfortably absent, Forbes found it necessary to adapt. In a letter to the astronomer royal, Tupman described his colleague's plight:

Having taken the opinion of every one acquainted with the locality who could be communicated with, either personally or by letter, I decided upon stationing Prof. Forbes in the district of Kona on the West Coast of Hawaii. The only habitation available is a coral-

built house on the shore of Kailua Bay, some 12 miles to the North of Kalakakua [*sic*] Bay, the property of the Princess Ruth, Governess of Hawaii, who has given permission for the Transit party to occupy it.

It is furnished in the native sense of the word, but wholly unfit for Europeans. . . .⁵⁵

Although such modest tribulations could be minimally mitigated by Tupman's sending resources from Honolulu, Forbes suffered other jolts of culture shock. And so, in a letter to Tupman, dated November 11, 1874, an obvious bathos is discerned in the all-too-easy diversion of Forbes's attention from the astronomical to the gastronomical:

My dear Tupman,

. . . I am sure you will be glad to hear that this place appears almost unexceptional. There is a high mountain "Hualalai", in the N.E. but tho' it often attracts clouds I find that the nights are always clear. . . . We have settled down pretty well. There was but little furniture in the house, but we are getting on well now. . . . There are no white men living here, and Captain Cator has lent me his man Jim to act as interpreter. The place is rather uncivilized, and it is difficult to get the men to work. . . . Our chief difficulty is in getting provisions. There is no meat to be had here, but we get it occasionally from Kealakakoa [*sic*]. There are hardly any vegetables. Jim cannot even get Poi and he needs it so much that I went to considerable trouble to get him some.

Major Wodehouse insisted on our having the protection of the British Flag here in case of any disturbance (a very unlikely event) so Captain Cator is going to provide one & it will be up soon.

The people here are all very civil, and willing to oblige so long as we do not wish them to work. . . .

After concluding his letter, Forbes added this postscript:

P.S. Since writing the above we have had a great ceremony here. All the natives belonging to the Governess arrived from the country on horses carrying with them fruits & vegetables. They assembled at the house and we received them in State. They laid down their fruits etc at our feet & then shook hands & passed on. Then I

had to make a speech which was translated to them. They stared a little & then went away. There were over a hundred of them. It was rather amusing. As a result of this I send you now by the Kilauea some of our surplus stock. I daresay you won't thank me for it.⁵⁶

One may wonder if this "gift" of surplus stock of native foodstuffs was a sort of gentleman's revenge that Forbes was visiting upon Tupman; for the latter had assigned, as Forbes's observing partner, H. G. Barnacle—a man of whom Tupman had a decidedly unflattering opinion. And, on November 1, the day immediately preceding the departure of Forbes and Barnacle for Hawai'i, Tupman had entered into his journal this unseemly portrait:

Mr. Barnacle is apparently out of his mind. Nothing will induce him to discontinue playing the same tune over and over again on the piano forte. I doubt if I ought to send him back to England immediately, as it is almost impossible to get any work of him & no faith can be placed in anything he says.⁵⁷

Still, it is not unlikely that Tupman felt some sympathy for Forbes's situation—a sympathy that may have been considerably amplified when the news came on November 28 that Forbes had nearly lost his life in heavy surf in a vain attempt to save the life of another man.⁵⁸

The position of Forbes's observing site (fig. 6) was close to the coral house (Hulihe'e Palace?) which was the probable scene of the "great ceremony" described above. The brick pier for his transit instrument, which rested firmly on solid rock, was placed 200 feet to the southwest of "the most southern corner of the stone church" (Moku'aikaua Church?) which stood across the road. The instrument itself had a 2.75-inch objective lens with a focal length of approximately 3 feet and was enclosed by a "commodious wooden observatory," 13 feet by 10 feet, built in Honolulu.⁵⁹

By late November, Forbes was busy making lunar observations for the purpose of inferring the longitude of his station. (As already noted, this was contingent upon the determination of the longitude of the main station at Honolulu, with which it was eventually connected by the transportation of chronometers.)

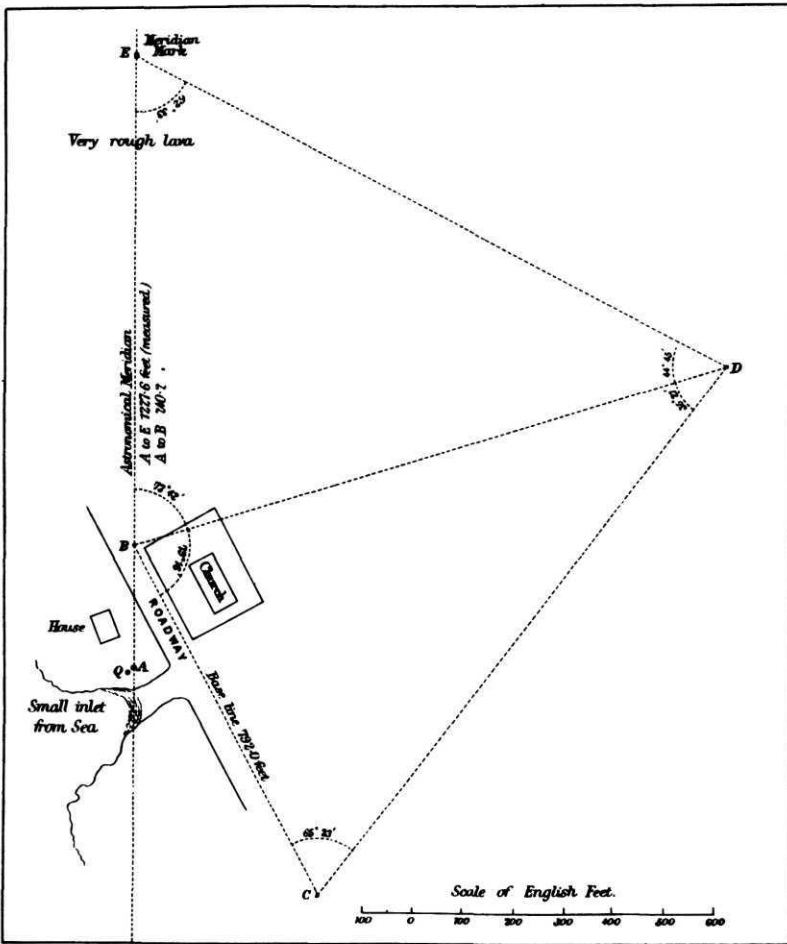


FIG. 6. The observing site of George Forbes at Kailua-Kona, Hawai'i. Q marks the position of the equatorial telescope and A the transit instrument. The "House" is probably Hulihe'e Palace, and just across the road stands Moku'aikaua Church. (G. B. Airy, *Account of Observations of the Transit of Venus, 1874.*)

For the determination of latitude, Forbes obtained shots of the noonday sun. From these operations, his adopted coordinates were:

latitude: $19^{\circ}38'.4$ North
 longitude: $10^{\text{h}} 24^{\text{m}} 15.7$ West.⁶⁰

The task of observing the transit from the other auxiliary station was given to Richard Johnson, who left Honolulu on November 6. After reaching Kaua'i, Johnson wrote to Tupman in Honolulu, reporting of his early efforts to establish himself in a strange place—and among a strangely friendly people:

1874 Nov. 9

Dear Tupman,

We arrived here in safety on Saturday last at about 2 o'clock p.m. The landing was simply horrible. The Schooner lay off the shore $\frac{3}{4}$ of a mile and a boat brought us and our gear 20 yards from the beach, the natives then waded into the surf and carried us in their arms ashore.⁶¹

Although Johnson proceeded in his letter to complain that he had to pay "2 dollars a week for getting water brought up from the river" (in addition to 15 dollars a month for the renting of a house!), he had apparently found, with the assistance of a "Mr. Kanutsen, the principal resident" (probably Valdemar Knudsen), a "suitable dwelling-house" at Waimea—where Captain Cook had first made landfall in 1778. A portion of the ambient ground was fenced in for Johnson's observatory, and its position relative to surrounding objects (fig. 7) was surveyed and plotted by the same man who had rendered similar services at the Honolulu site, J. Gay.⁶² Additionally, as at the Honolulu site, prophylactic measures were instituted in order to preserve a knowledge of the precise location of Johnson's observatory. Its remote position—on the margins of an obscure Polynesian village, 80 feet above the sea and a half mile inland—could be recovered, Johnson surmised, from this description:

Near the edge of the rocky cliff overhanging Valley Road, 35 feet E.S.E. from the S. corner of the dwelling-house, a mark [in the shape of an arrowhead] has been chiselled in the rock and filled with cement. . . . Two similar marks were cut in the rock on the edge of the cliff to the S.W., distant 90 and 346 feet respectively from the above-mentioned mark, and distant 174 and 199 feet respectively from the transit pier.⁶³

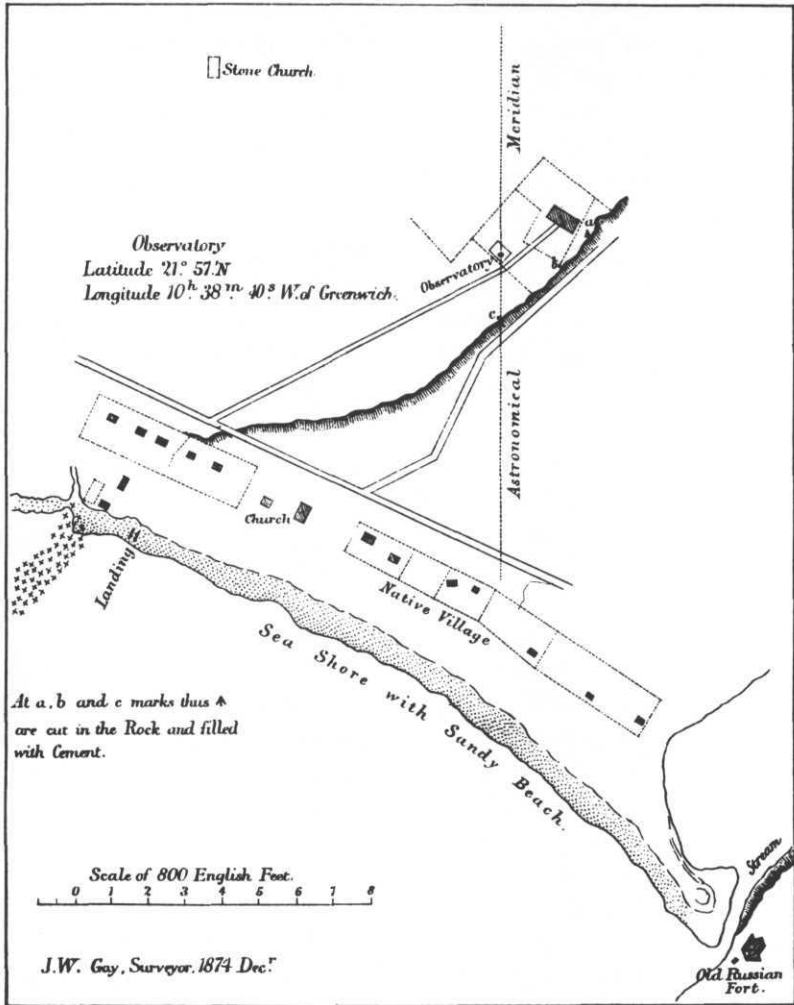


Fig. 7. Johnson's observatory at Waimea, Kaua'i. (G. B. Airy, *Account of the Observations of the Transit of Venus, 1874.*)

From the first of these three marks, compass bearings were taken to four places: (1) to Johnson's transit pier, 231 feet distant; (2) to a "sharp peak" in the Kaua'i mountains; (3) to the Old Russian Fort; and (4) to the highest peak of "Lehau Island."⁶⁴

Johnson was provided with a transit instrument having a 2-1/8-

inch aperture and a focal length of 31 inches, as well as three chronometers, one keeping mean solar time, the other two sidereal time. The transit instrument was sheltered by "a small hut" which was almost entirely removed when astronomical observations were being made.

His latitude was obtained by noontime observations of the sun made by his assistant, Lieutenant R. H. Wellings, using an ordinary navigator's sextant. This was likely an easy matter as the southern sea-horizon, straight and well-defined, would have been easily visible from the Waimea area. The longitude was gotten via chronometric comparison with Honolulu. The resulting values were:

latitude: $21^{\circ}57'.2$ North

longitude: $10^{\text{h}} 38^{\text{m}} 39^{\text{s}}.8 (\pm 2\text{s})$ West.

TRANSIT DAY—DECEMBER 8, 1874

The 1874 transit of Venus was predicted to occur in Hawai'i on the afternoon of December 8. When that day finally dawned in Honolulu, King Kalākaua was nowhere to be seen. A few weeks earlier, the king, whose unbridled enthusiasm for the transit event had perhaps by that time brazenly transgressed the bounds of propriety, importuned at the Apua observatory, not alone and discreetly, but in the company of "many ladies of the Court"—and returned the very next day with his wife, Queen Kapi'olani, and "a host of followers," remaining for two hours! Tupman, who had already come to scorn visitors as "an intolerable nuisance," was prompted by the November 15th visit of the king and his entourage of noblewomen to slur them all as "savages."⁶⁵ Two days later, however, Kalākaua was out of Tupman's hair, and out of the kingdom entirely. For although the approaching transit of Venus may have provided the Merry Monarch with an entertaining and harmless diversion, his prime focus in late 1874 was not at the telescope, but at the negotiating table; and on November 17, in the company of Governor John Dominis, he left Honolulu for Washington, D.C., to negotiate the contentious Reciprocity Treaty with the United States. That treaty was signed in January

1875, and Kalākaua did not return to Hawai‘i until February. In his absence, Lili‘uokalani—the wife of Governor Dominis and Kalākaua’s eventual successor to the throne—remained in Hawai‘i as regent.⁶⁶ But the king’s absence as 1874 drew to a close, and the resulting lack of firm and ostensible leadership, was probably responsible for the social confusion surrounding the events of December 8.

The transit of Venus occurred as predicted. On the following day, news reached Tupman in Honolulu from astronomer Johnson reporting “success” on Kaua‘i; while from Forbes at Kailua-Kona came news on the 10th of “ill success” due to cloudy weather.⁶⁷

Meanwhile, in Honolulu, the day of the transit fell upon Tupman with much excitement—not all of it welcome. Awash in a kingdom with an absentee king, Tupman and company were forced to cope with not a few royal but misguided subjects who, carrying with them the popular and persistent delusion that the public could gain easy access to the observatory and would, moreover, be permitted entry on this historic occasion, brought a pathetically festive appearance to the observatory site. Unremarkably, in the absence of the king, not one but two of Hawai‘i’s queens, anticipating possible unrest in downtown Honolulu, became at least peripherally involved in the attempt to maintain public order. And although some may have chuckled at such gracelessness, others found in the comedy a nascent calamity. Around the walls of the observatory—now, on the eventful day, looking ominously like a military fort (fig. 8)—a simple display of force by uniformed men was able, mercifully, to dispel the incipient pandemonium.⁶⁸

Tupman’s journal for that eventful day, beginning with a tone of joyful anticipation, is predictably modulated by the exigencies of the fleeting event and quickly succumbs to serious business:

1874 Dec 8 A superb cloudless day. Our joy is great. . . . H.M. Queen Kapiolani sent a messenger to say that Silence had been ordered throughout the Royal grounds & would be observed. . . . At 2h a detachment of 12 Marines and a Sergeant came from H.M.S. “Scout” to keep the ground. They were posted round the enclo-

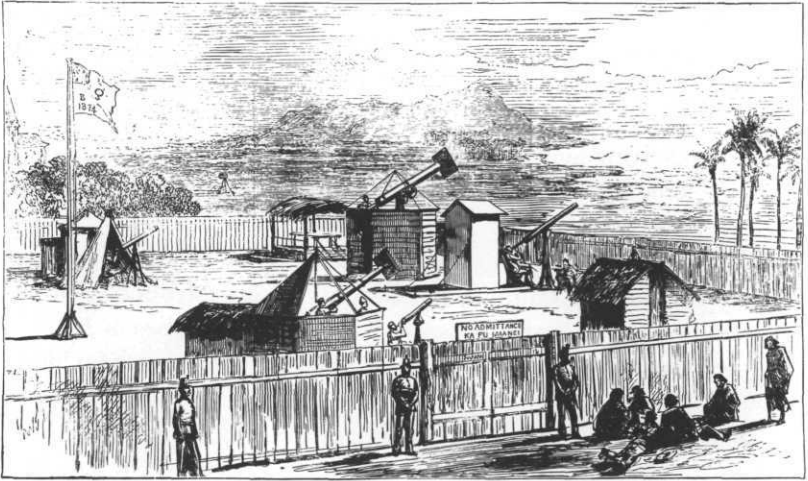


FIG. 8. An artist's rendition of "The Transit of Venus: Waiting for Contact at Honolulu" published in the *Illustrated London News* on January 23, 1875. On transit day, a detachment of Marines was posted around the enclosure in order to prevent any disturbance. The British observed the 1874 transit from five principal stations scattered around the world. Honolulu was station B, hence the B on the flag above the date. The astronomical symbol for Venus appears on the flag near the Union Jack. (BPBM.)

sure, with orders merely to prevent talking or noise. There was a general feeling among the Native population that the observatories would be open to the public on this day. H.M. Queen Emma communicated this to Major Wodehouse in the morning. It was quite true for many hundreds of natives came to the gates about 3 o'clock in their holiday clothes! The sight of the red coats, however, had the desired effect. . . .

All being in readiness, a little after 2 p.m. the gate was locked & silence enjoined. Every observer went to his station.⁶⁹

Astronomers Tupman (fig. 9), Nichol, and Noble took up positions at three separate telescopes, while supernumeraries—Lieutenants Clapp, Oldham, and Shakspear—were employed counting the time aloud for each of the three astronomers. In this presumably quiet and somber sanctuary, Ramsden posted himself at the photoheliograph. And in order to obviate any contamination of the raw data by untimely fraternizing, "conversation was not permitted among the observers until they had made their notes."⁷⁰



FIG. 9. George Lyon Tupman, head of the 1874 transit of Venus expedition in Hawai'i, at the telescope. (A.H.)

The main goal of the Hawai'i expedition was to observe, record, and photograph the exact instant of "internal contact" as Venus began to encroach upon the solar disk. These data would then be compared with data obtained elsewhere, from which, via "the Delisle method," the sun's parallax and distance would be obtained. The *Nautical Almanac* of 1874 predicted a time for internal contact in Honolulu of approximately 3:33, the sun then being about 21 degrees above the horizon and sinking in the southwest as it approached the winter solstice.⁷¹ As the moment drew nigh, Tupman, observing with a spectroscope attached to his 4.5-inch equatorial telescope, reported seeing "the limb of Venus impinge upon & sever the stratum of hydrogen commonly called the 'chromosphere.'" This observation enabled Ramsden at the photoheliograph to begin taking pictures with "the Janssen." "Unfortunately," Tupman lamented, "the Photoheliograph was pointed a little to one side of Venus in order to prevent the crosswires interfering with the point of Contact, and was moved a trifle too far . . . [so that] Venus is cut in half by the side of the picture."⁷² But although Tupman later came to grieve the "unfortunate failure in the application of photography" to the general 1874 British effort, the telescopic observations were much more positive.⁷³ The notorious "black drop" effect (which had tarnished the eighteenth-century transit observations) was not seen at all in Honolulu; but, rather, Venus always appeared "perfectly circular and uniformly black"; and, *mirabile dictu*, internal contact was recorded by both Tupman and his colleague Noble at the same instant—3h 35m 54s Honolulu mean time.⁷⁴ The accompanying photograph (fig. 10) was taken in Honolulu approximately five minutes later. The sun dropped into the sea at approximately 5:18, while the transit was still in progress.

AFTERMATH

Just as the work of the expedition had begun upon its arrival in Honolulu many weeks before the day of the transit, so too was the work to continue for many weeks thereafter.

From mid-December 1874 to mid-January 1875, efforts to connect the two auxiliary stations with the main station in Honolulu

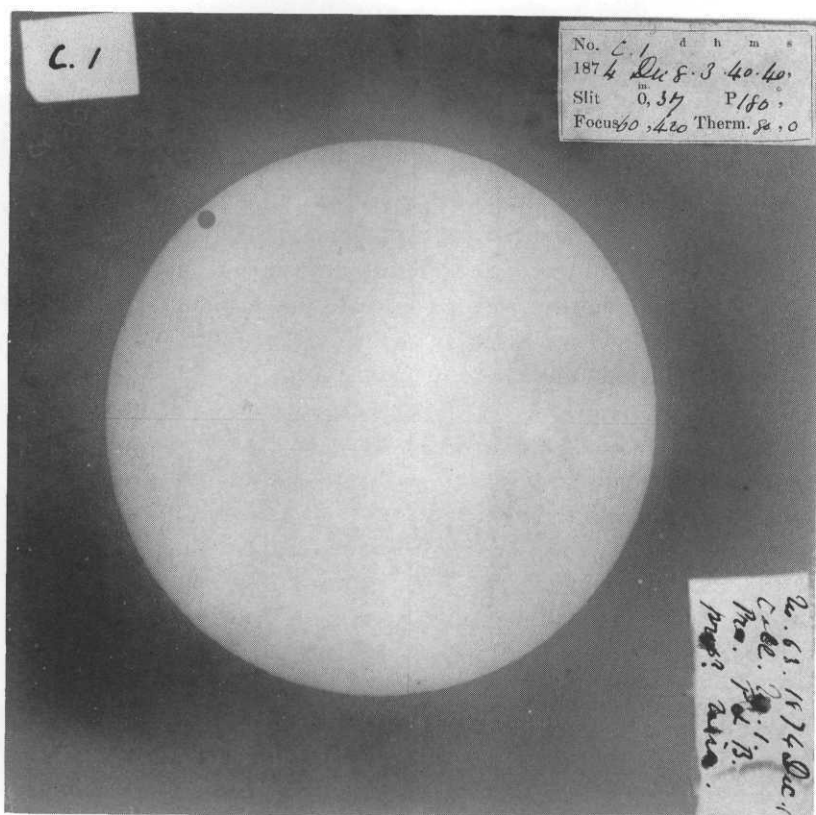


FIG. 10. This photograph of Venus in transit across the sun was taken in Honolulu on December 8, 1874, at 3:40 P.M. (± 40 seconds). The *Nautical Almanac and Astronomical Ephemeris* for 1874 had predicted a time of approximately 3:33 for internal contact (at ingress), the sun then being about 21 degrees above Honolulu's horizon and sinking in the southwest. This photograph, therefore, was taken about 7 minutes after the predicted time of internal contact. (RGO archives, Cambridge University Library.)

engaged the assiduity of Captain Van der Meulen, commander of the H.M.S. *Tenedos*, who undertook no fewer than five separate interisland voyages—three to Waimea and two to Kailua—carefully carrying chronometers to and fro for the purpose of ascertaining longitudes.⁷⁵

As late as February 1875—during which month Tupman was at work with Flitner's transit—efforts to determine the azimuth error of the expedition's own transit instrument were still being conducted in Honolulu.⁷⁶ This was being done via observations of

a meridian mark that had been erected, with difficulty, in early November—in the mountains above Honolulu, at a height of 1,540 feet and a distance of more than four miles to the north of the transit instrument itself!⁷⁷

As transit-related observations continued to be made into the first several weeks of 1875, Tupman was kept alert—that is, distracted—by numerous non-astronomical matters. And, as before, these emanated from two sources: nature and society. Nature served up both the surprising (an earthquake, December 28) and the unsurprising (more rain!). Society did the same.

On January 11, the egregious Mr. Barnacle, who continued to bring “daily fresh discredit on the expedition,” was banished to San Francisco. And although this may have relieved Tupman of a major source of exasperation, it alone was not a palliative for all the social ills that seemed to plague the expedition. The flood of intrusive guests continued, prompting Tupman, on January 27, to report “Visitors all day—most annoying”; and on February 2 to deem such visitors not only “numerous” but positively “inconsiderate.”⁷⁸

Moreover, thievery and drunkenness erupted among some of the military men involved in the transit operations; and among those individuals (we begin to suspect that there were many) who did not ingratiate themselves to Tupman were the two marines that “turned out to be drunken rascals who stole our wines & beer to supply their shipmates & for 3 days gave us much trouble.” Such dissolute behavior had, seemingly, unhappy repercussions elsewhere, for on February 9 Tupman wrote: “One of our Servants drunk on stolen liquor.”⁷⁹

Thankfully, not all elements of Honolulu’s citizenry were this unsavory; and before their final departure, members of the expedition were to find themselves in the more refined company of high society, dining, for example, with the French commissioner and his wife (on February 12), or with “the High Chiefess [Bernice Pauahi] Bishop” (on February 24). And although two prominent members of the expedition—Forbes and Johnson—had departed from Hawai‘i aboard the *Tenedos* on February 6, others who remained behind were able to attend, on February 26, a state ball given by King Kalākaua, who had returned to the islands, amidst “great rejoicings,” on February 15.⁸⁰

Finally, on March 10, the expedition broke up the “establishment at Apua” and three days later conducted a sale that attracted, predictably, much attention, including that of the king:

Mar. 13. The Sale. Our household goods sold well, many friends desiring to obtain a memento of our visit. The long shed, Cook house, walls of huts, transit hut complete, water pipes & taps, 6-foot fencing and a large pile of lumber were knocked down to His Majesty the King for a very small sum, as no one would bid against him. We were not altogether sorry for this as His Majesty has given us the land rent free & had aided us in many ways tending to save expense to the British Government.⁸¹

After spending more than six months in Hawai‘i, the last of the transit of Venus party was to be conveyed from Honolulu to San Francisco aboard the H.M.S. *Reindeer*. Her departure was fixed for March 20.⁸² On March 16, his sojourn in Hawai‘i now drawing to a close, Tupman, undeterred by “very wet weather,” attended a farewell state dinner at the palace.⁸³ Three days later, final valedictions were pressed. Tupman’s last journal entry, serious and business-like, came on March 19:

Continuous heavy rain. . . . Paid numerous farewell visits. Busy packing & preparing for final departure . . . arranged . . . the shipment of the Instruments Etc for Europe (in all 73 Cases). Ramsden, Noble & Nichol went to farewell State breakfast at the Palace. Tupman paid farewell visits to the British & French Commissioners; turned over the Observatory Grounds (Apua) to Major Boyd, His Majesty’s Chamberlain; settled all accounts & gave to the French Commissioner a letter concerning the site of Lieutenant Fleuriais’ pier. . . .⁸⁴

Tupman’s departure from Hawai‘i did not bring his transit of Venus labors to a rapid conclusion. After his return to England, he continued to be engaged in voluminous calculations and in the reduction of the gargantuan amount of data generated by the transit observations. This work, which continued for several years, prompted the astronomer royal to regard his efforts as “heroic.”⁸⁵

Neither did the departure of the transit of Venus expedition

bring to an end the mutual concerns of England and Hawai‘i, still manifest in the late nineteenth century, with respect to issues of longitude and longitudinal precision. When, in 1884, just ten years after the transit, it appeared desirable to governments around the world that the Earth be divided up into 24 longitudinally based time zones, the cynosure of that newly spinning and clock-mesmerized world was the still royal, and still proud, Greenwich Observatory. This pièce de résistance was to flavor the political menu of the still-reigning Kalākaua, whose two delegates to the 1884 International Meridian Conference in Washington, D.C., voted with the majority in favor of adopting the meridian at Greenwich, England, as the prime meridian of the world.⁸⁶ One of those delegates was none other than the man under whose “able management” the Trigonometrical Survey of Kalākaua’s kingdom was already in progress by the time of the arrival of the transit of Venus expedition—W. D. Alexander.

Nor could the British who were present in Hawai‘i in late 1874 neglect the memory of their most famous explorer. H.M.S. *Scout*, which had transported the transit of Venus expedition to Honolulu, also carried to the island of Hawai‘i on November 2 not only the astronomer George Forbes, but British Commissioner James Wodehouse and a party of men—including an architect—who went to Kealakekua Bay. And there, in a place whose longitude had been astronomically determined in January 1779, they erected a monument to the man whose longitude-finding ability had, one century earlier, pulled the Sandwich Islands into the orbit of the British Empire—Captain James Cook.⁸⁷

Nor could the 1874 transit of Venus expedition so quickly pass into and out of Hawai‘i without a fitting island memento: the creation of a Transit of Venus lei—

[a] white paper star lei that was in vogue here in the ‘70’s, commemorating the Transit of Venus of 1874. They were appropriately called Hoku (star), and were made of stiff, white paper, forming many points, to convey the idea of scintillation. They were fashionable for some time, for head or hat decoration, and were known to foreigners as Venus leis.⁸⁸

But to remember the significance of a historic undertaking with such a sentimental flourish is not to forget its scientific importance, nor to mute its scientific success. And successful it surely was.

In 1877, three years after the British had equipped five separate expeditions to make transit of Venus observations from five separate locations (Egypt, the island of Rodriguez, Kerguelen Island, New Zealand, and Hawai'i), Astronomer Royal George B. Airy published his computed results for the British telescopic observations of that phenomenon.⁸⁹ The figures he obtained—a solar parallax of $8.754''$ and a corresponding solar distance of 93,375,000 miles—are very close to the modern values.⁹⁰

The importance with which the Sandwich Islands were regarded in the overall enterprise was perhaps nowhere better intimated than in Airy's decision to send his top man—George Tupman—to Honolulu. For Airy, as early as 1868, in a letter to the hydrographer of the Admiralty, had already surmised that the "Owhyhee" site would be, in a word, "indispensable."⁹¹

NOTES

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¹ "Jeremiah Horrox," *Nature* (12 and 19 June 1873): 117–18, 137–38. The story of Horrocks and the 1639 transit was reconstructed in "Transit of Venus. Historical Events," *PCA*, 19 Dec. 1874.

² Albert Van Helden, *Measuring the Universe: Cosmic Dimensions from Aristarchus to Halley* (Chicago: U of Chicago P, 1985) 152, 155.

³ A. Grenfell Price, ed., *The Explorations of Captain James Cook in the Pacific as Told by Selections of His Own Journals 1768–1779* (New York: Dover, 1971) 17; J. C. Beaglehole, *The Life of Captain James Cook* (Stanford: Stanford UP, 1974) 148–49, 151.

⁴ Albert E. Lownes, "The 1769 Transit of Venus and its relation to early American astronomy," *Sky and Telescope* 2.6 (1943): 3–5.

⁵ The solar parallax, defined as the angle subtended by the Earth's equatorial radius at the sun's mean distance (or, more simply, the angular radius of the Earth as seen from the sun), is an exceedingly small angle—about 8.8 arc sec-

- onds. The human eye, which is not capable of distinguishing the spatial separation between any two objects if that separation is less than about 30 to 60 arc seconds (in which case the two objects appear to the eye to merge into one) would be incapable of perceiving such a tiny angle unaided.
- ⁶ Derek Howse, *Nevil Maskelyne: The Seaman's Astronomer* (Cambridge: Cambridge UP, 1989) 20.
- ⁷ Fred Hoyle, *Astronomy* (New York: Crescent Books, 1962) 158.
- ⁸ Howse, *Nevil Maskelyne* 20–21.
- ⁹ "Observations made, by appointment of the Royal Society, at King George's Island in the South Sea; by Mr. Charles Green, formerly Assistant at the Royal Observatory at Greenwich, and Lieut. James Cook, of his Majesty's Ship the Endeavour," *Philosophical Transactions* 61 (1771): 397–421.
- ¹⁰ George B. Airy to the secretary of the Admiralty, 9 Apr. 1869, RGO 6/267, File 1, Cambridge U Library.
- ¹¹ Harry Woolf, *The Transits of Venus: A Study of Eighteenth-Century Science* (Princeton: Princeton UP, 1959), 4; appendix 4, 208.
- ¹² George Biddell Airy, *Popular Astronomy: A Series of Lectures Delivered at Ipswich*, 6th ed. rev. (London: Macmillan, 1868) 145–46.
- ¹³ Eric G. Forbes, *Greenwich Observatory* (London: Taylor & Francis, 1975) 1: 19.
- ¹⁴ George Forbes, "The Coming Transit of Venus," 7 pts., *Nature* (9 Apr. to 4 June 1874).
- ¹⁵ Forbes, "The Coming Transit of Venus," *Nature* (23 Apr. 1874): 488.
- ¹⁶ Michael E. Chauvin, "Lunars and Automaton: Navigational Practices During the Voyages of Captain Cook," unpublished manuscript.
- ¹⁷ Forbes, "The Coming Transit of Venus," *Nature* (4 June 1874): 87, (21 May 1874): 51.
- ¹⁸ Sir George Biddell Airy, *Account of Observations of the Transit of Venus, 1874, December 8, Made Under the Authority of the British Government: And of the Reduction of the Observations* (London: Her Majesty's Stationery Office, 1881).
- ¹⁹ Airy, *Account* iii; *Monthly Notices of the Royal Astronomical Society* 29.2 (11 Dec. 1868): 35.
- ²⁰ Forbes, "The Coming Transit of Venus," *Nature* (14 May 1874): 30, wrote: "With regard to the British expedition, great care has been taken to choose stations where the weather can be depended upon."
- ²¹ A census of 1872, which found the total population of the Hawaiian Islands to be 56,897, placed the number of "Britons" at 619, of which 381 were living in Honolulu. Among full-blooded foreigners, only the Chinese (1,938) and the Americans (889) were more numerous. *HAA*, 1875: 6
- ²² RGO, 6/267, File 5, leaf 202, Cambridge U Library. See also *PCA*, 12 Sept. 1874: 3.
- ²³ Tupman to the astronomer royal, 17 Sept. 1874, RGO 6/270, File 5, leaves 212–17.
- ²⁴ Airy, *Account* 7.
- ²⁵ Tupman to Airy, 17 Sept. 1874.
- ²⁶ Airy, *Account* 7; Tupman to Airy, 17 Sept. 1874.
- ²⁷ Tupman to Airy, 17 Sept. 1874.

- ²⁸ Tupman to Airy, 17 Sept. 1874.
- ²⁹ *PCA*, 19 Sept. 1874.
- ³⁰ Tupman to Airy, 13 Oct. 1874. RGO 6/270, File 5, leaves 222–27.
- ³¹ G. Tupman, *The day to day journal of G. Tupman at Honolulu*, RGO 59/70, Cambridge U Library. See, for example, entries for 27 and 31 Oct.; 2, 8, 9, 18, and 19 Nov.; 3 and 4 Dec.
- ³² Tupman to Airy, 13 Oct. 1874. Captain Cator, of H.M.S. *Scout*, expressed similar concerns. In a letter to the secretary of the Admiralty, 27 Sept. 1874, he wrote of the “great difficulty experienced in keeping the chemicals sufficiently cool.” In another letter he detailed the expedition’s response to the heat: “Great trouble experienced with the chemicals from excessive heat. To mitigate this evil a frame work was erected over the chemical room to support a second roof of rushes. A reduction of 10° of temperature during the heat of the day was obtained by these means. The Transit hut was also partly covered with rushes for the same purpose.” RGO 6/267, Files 6 and 7.
- ³³ Tupman to Airy, 13 Oct. 1874.
- ³⁴ Tupman to Airy, 13 Oct. 1874.
- ³⁵ Tupman, *Journal* 37.
- ³⁶ Tupman, *Journal* 16.
- ³⁷ Although it appears that the king did not “invite” the expedition to Hawai‘i, but, rather, that the British “invited” themselves.
- ³⁸ Tupman to Airy, 1 Nov. 1874, RGO 6/270, File 5.
- ³⁹ *Monthly Notices of the Royal Astronomical Society* 29.2 (11 Dec. 1868): 35.
- ⁴⁰ RGO 6/267, File 8, leaves 366–77; RGO 6/267, File 9, letter from Captain Tupman RMA to Captain Van der Meulen RN, H.M.S. *Tenedos*, Honolulu, 14 Jan. 1875; Airy, *Account* 6, 30–35.
- ⁴¹ Airy, *Account* 20–21.
- ⁴² W. D. Alexander, *A Brief Account of the Hawaiian Government Survey, Its Objects, Methods and Results* (Honolulu, 1889) 11.
- ⁴³ Airy, *Account* 6, 7, 31, 63–65.
- ⁴⁴ Airy, *Account* 7.
- ⁴⁵ *The Hawaiian Journals of Chester Smith Lyman, May 15, 1846 to July 3, 1847*. HMCS.
- ⁴⁶ *HAA*, 1882:5. By a “transit” observatory is meant one used to observe the transit of astronomical bodies across the meridian.
- ⁴⁷ Tupman, *Journal* 124–25. The longitude figure given by Tupman in hours, minutes, and seconds of time west of Greenwich is equivalent to 157°48′45″.
- ⁴⁸ *HAA*, 1875:15. See also pp. 27–28 for a brief account of the transit of Venus of 1874.
- ⁴⁹ Gavan Daws, *Shoal of Time: A History of the Hawaiian Islands* (Honolulu: UP of Hawaii, 1968) 124–28.
- ⁵⁰ “Sur la longitude d’Honolulu (île Oahu, archipel des Sandwich) deduite des observations de la Lune faites par M. G. Fleuriais, Lieutenant de vaisseau,” *Connaissance des Temps . . . 1872* (Paris, 1871) 46–65.
- ⁵¹ Tupman, *Journal* 92–94. Although “Emma” (Street) has been deleted in the

- Journal* (and replaced by "Union"), it remains intact in Airy's *Account* (p. 8) as marking the relevant place of intersection with Adam's Lane.
- ⁵² Tupman, *Journal* 94.
- ⁵³ *Monthly Notices of the Royal Astronomical Society* 33.5 (14 Mar. 1873): 368.
- ⁵⁴ Tupman to Airy, 17 Sept. 1874; Tupman, *Journal* 17.
- ⁵⁵ Tupman to Airy, 1 Nov. 1874, RGO 6/270, File 5.
- ⁵⁶ George Forbes, Kailua, Hawai'i, to Tupman, 11 Nov. 1874, RGO 6/270, File 5, leaf 237.
- ⁵⁷ Tupman, *Journal* 39. It is unclear from Tupman's *Journal* (pp. 40, 60) whether Barnacle left for Kailua in early or late November.
- ⁵⁸ Tupman, *Journal* 59.
- ⁵⁹ Airy, *Account* 213.
- ⁶⁰ Airy, *Account* 218-19.
- ⁶¹ R. Johnson, Waimea, Kaua'i, to Tupman, 9 Nov. 1874, RGO 6/270, File 5.
- ⁶² Airy, *Account* 237.
- ⁶³ Airy, *Account* 237.
- ⁶⁴ "Lehau" was probably Ni'ihau rather than Lehua.
- ⁶⁵ Tupman, *Journal* 53.
- ⁶⁶ Gerrit P. Judd IV, *Hawaii: An Informal History* (New York: Collier, 1971) 94-96.
- ⁶⁷ Tupman, *Journal* 73.
- ⁶⁸ In a similar fashion, marines were called upon in Kailua-Kona to watch the grounds of Forbes's observatory and to prevent possible disturbance there. Memorandum (of George Forbes) of operations at Kailua 1874 Dec. 8 in Connection with the Transit of Venus, RGO 6/267, File 8.
- ⁶⁹ Tupman, *Journal* 65-66.
- ⁷⁰ Tupman, *Journal* 72.
- ⁷¹ *The Nautical Almanac and Astronomical Ephemeris for the Year 1874*. . . (London, 1870) appendix, 22.
- ⁷² Tupman, *Journal* 68, 70-71.
- ⁷³ G. L. Tupman, "On the Photographs of the Transit of Venus," *Monthly Notices of the Royal Astronomical Society* 38.9, supplementary notice (1878): 508-13.
- ⁷⁴ Tupman, *Journal* 69-70.
- ⁷⁵ Airy, *Account* 33-34.
- ⁷⁶ Tupman, *Journal* 106, 107, 108.
- ⁷⁷ Airy, *Account* 13-14; Tupman, *Journal* 42, 103.
- ⁷⁸ Tupman, *Journal* 87, 97, 99.
- ⁷⁹ Tupman, *Journal* 102, 105.
- ⁸⁰ Tupman, *Journal* 102, 107, 109, 111, 112.
- ⁸¹ Tupman, *Journal* 118.
- ⁸² Airy, *Account* 36.
- ⁸³ Tupman, *Journal* 119.
- ⁸⁴ Tupman, *Journal* 120.
- ⁸⁵ Airy, *Account* vi.
- ⁸⁶ Derek Howse, *Greenwich time and the discovery of the longitude* (Oxford: Oxford

UP, 1980) 146, 229. W. D. Alexander, "The Meridian Conference," *Report of the Minister of Foreign Affairs to the Legislative Assembly of 1886* (Honolulu, 1886) appendix A.

⁸⁷ James Cook, James King, and William Bayly, *The Original Astronomical Observations Made in the Course of a Voyage to the Northern Pacific Ocean . . . in the Years 1776, 1777, 1778, 1779, and 1780* (London, 1782) 57-61; HAA, 1912: 60-71; Tupman, *Journal* 40.

⁸⁸ HAA, 1922: 90.

⁸⁹ G. B. Airy, "On the Inferences for the Value of Mean Solar Parallax and other Elements deducible from the Telescopic Observations of the Transit of Venus, 1874, December 8, which were made in the British Expedition for the Observation of that Transit," *Monthly Notices of the Royal Astronomical Society* (Nov. 1877).

⁹⁰ A recently given value for the AU is 92,955,807 miles. *Sky and Telescope* (Jan. 1993): 68.

⁹¹ Astronomer royal to hydrographer of the Admiralty, 10 Oct. 1868, RGO 6/267, File 1.

