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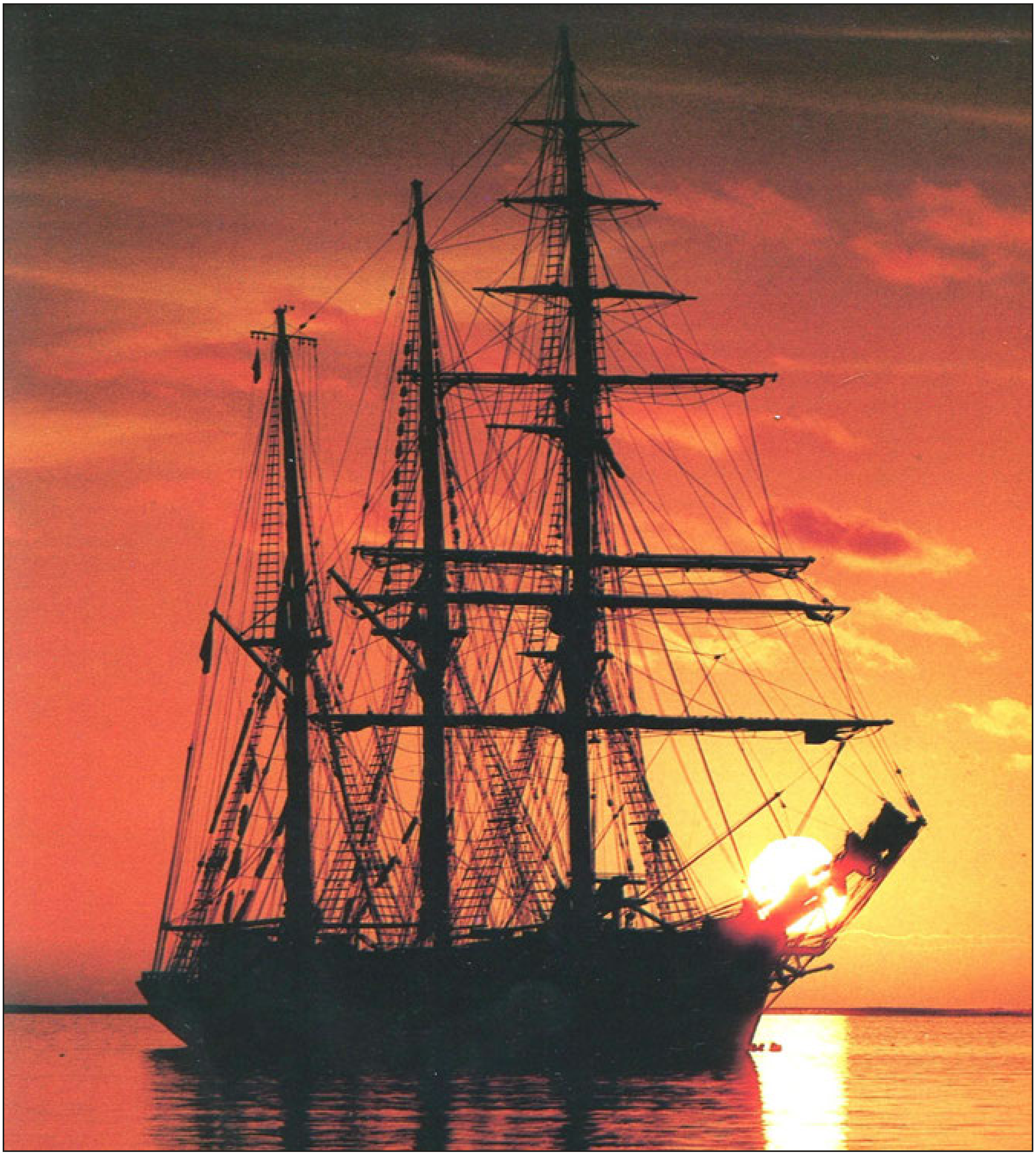
The Village Pioneer

Journal of the Sheffield Village Historical Society & Cultural Center



This issue of The Village Pioneer *commemorates the significance of Captain Cook's observations of the Transits of Venus and Mercury in the South Pacific. Captain Cook's ship, HMS* Endeavour, *is illustrated here preparing to observe the 1769 Transit of Venus in Tahiti. In the early evening of June 5, 2012 a rare Transit of Venus across the face of the Sun will be visible from Sheffield, an event that will not take place again until December 2117.*

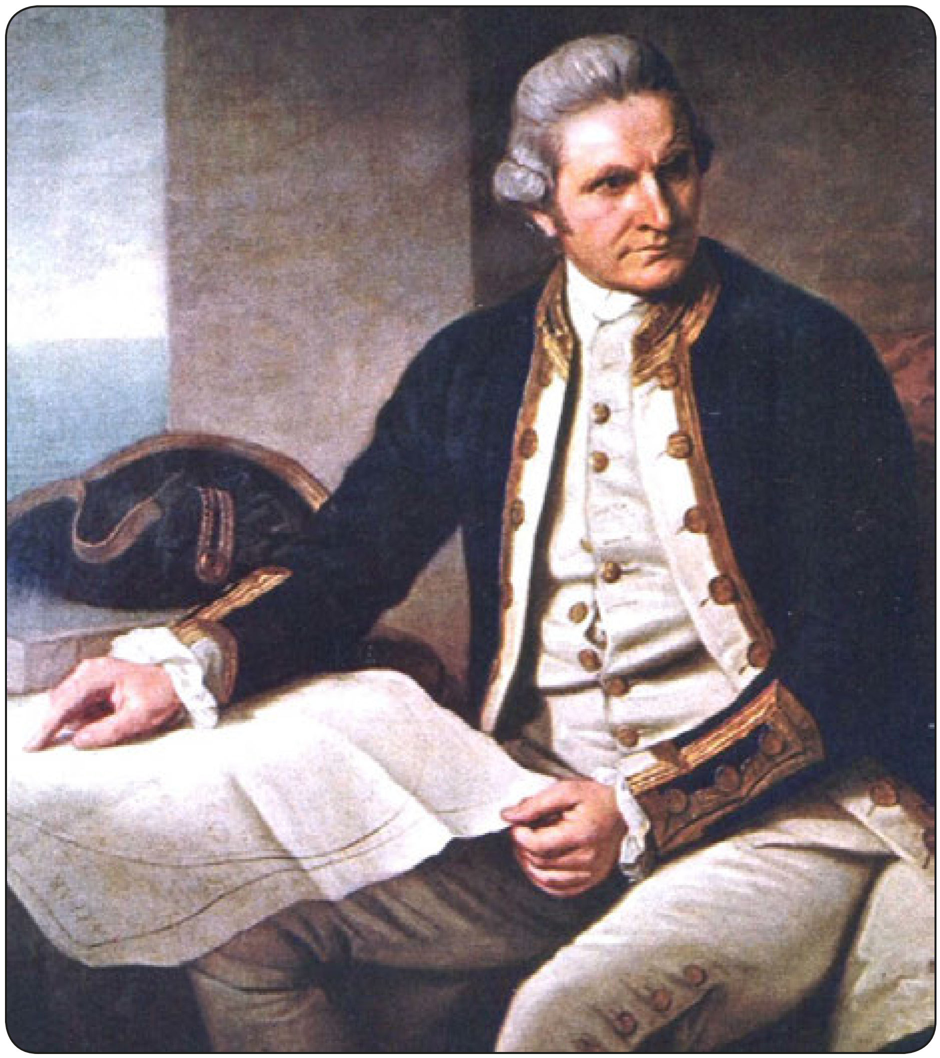
Captain James Cook an the Transits of Venus and Mercury

On June 5, 2012, a special and astronomically important event will take place in the sky over Sheffield—the Transit of the planet Venus across the face of the Sun. It will be somewhat like a mini eclipse—Venus will only appear as a small dot against the giant ball of the Sun. This is a rare event and will not happen again until December 2117, so get ready. The entire Transit will take 6 hours and 40 minutes, but we will only be able to view the early portion of the crossing here in Ohio—a few hours before sunset (about 6:10 pm) we should be able to see Venus beginning its journey across the upper half of the Sun. One would have to travel to Councilman Walter Min's homeland in Hawaii to observe the entire crossing. In fact that is just what Captain James Cook did in June 1769. He was commissioned to sail to Tahiti and then on to New Zealand to make precise measurements of the Transits of both Venus and Mercury. Of significance to our understanding of the Solar System's dimensions, these measurements—coupled with Transit observations from Norway's Lapland—permitted the first reasonably accurate calculations of the distance to the Sun. The principle of parallax was used to make these calculations (the difference in the apparent position of an object viewed along two different lines of sight as measured by the angle of inclination between the two lines—but more about this latter). The distance so determined between the Earth and the Sun has come to be known as *one astronomical unit* [1 AU], a unit that is now used to describe distances to all objects in our Solar System.

This is how the Transit of Venus may appear in the early evening of June 5, 2012 from Sheffield Village, Ohio.

Observing the Transit

WARNING— Staring at the brilliant disk of the Sun with the unprotected eye can quickly cause serious and often permanent eye damage. An inexpensive way to observe the Transit is to construct a pinhole projector. Simply take a piece of stiff card. Pierce it with a pin. Line the pinhole up with the Sun **(while looking away from the Sun)** and adjust the angle of the card so the sun is projected through the pinhole onto another card that is shaded. The pinhole should be adjusted so that an image of the Sun can be seen near the middle of the shadowed area. Adjust the distance between the two cards to get the best picture—more distance gives a larger, but fainter image. If you have time you can get elaborate and attach the two parts together with rigid dowel rods. The hole must be clean and **as small as possible**—otherwise you will simply get a shaft of light rather than a disk. Venus will appear as a small black object on the white image of the Sun. This is also a great way to plot sunspots on the surface of the Sun. By noting the time when each sunspot is plotted on the card it is possible to determine the rate of solar rotation.



Portrait of Captain James Cook with his chart of the Pacific Ocean, painted in 1776 by Nathanial Dance (courtesy of National Maritime Museum, Greenwich).

Early Career of James Cook

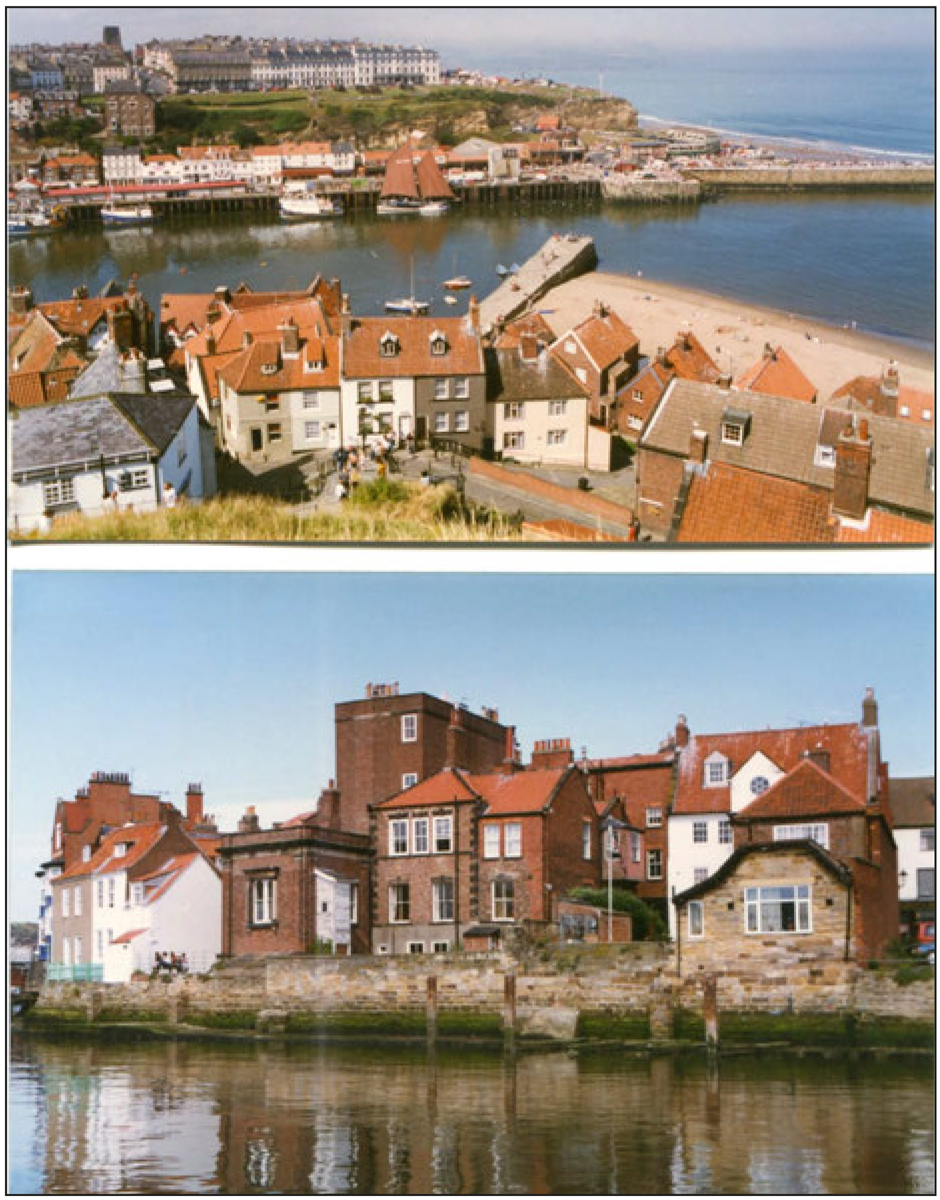
I have long been fascinated with the life of Captain James Cook, the master explorer and cartographer of the Pacific Ocean. Over the years I have traced his voyages from his first ventures to sea at Whitby, England to romantic places—among them the L'Anse-aux-Meadows coast of Newfoundland, Rio de Janeiro, Cape Horn, Easter Island, Tahiti, Bora Bora, New Zealand, Great Barrier Reef of Australia, Papua New Guinea, Cape of

Good Hope, Antarctic ice fields, Vancouver Island, the Kenai Peninsula of Alaska, and finally to where Captain Cook met his death at Kealakekua Bay on the "Big Island" of Hawaii. I guess my fascination was solidified in the 1980s while I was working as a coastal oceanographer for the New Zealand government. We were conducting tidal studies on the Coromandel Peninsula of the North Island. At the port of Whitianga, on Mercury Bay, I came across a small monument describing how in 1769 Captain Cook observed the Transit of Mercury here, which permitted him to accurately determine the longitude of New Zealand. This was enough to send me wondering about the Transit of planets across the Sun and just how they could be used to make astronomical calculations. This article will attempt to demonstrate the significance of these rare events.

James Cook, destined to become one of the most celebrated explorers and navigators in the history of seafaring, was born on October 27, 1728 in the small Yorkshire farming village of Martin-in-Cleveland in northern England. Restless with routine of life on the farm, at 17 he ventured to the seacoast and soon became apprentice to ship owner John Walker in the port of Whitby. He served for several years on Walker's collier barks transporting coal on the stormy North Sea. At age 21 he was rated as an Able Seaman. He learned his seamanship in these dangerous waters, which served him well as he later voyaged the world's oceans. He was promoted to Mate in 1752 and offered command of a bark three years later, after only eight years at sea.

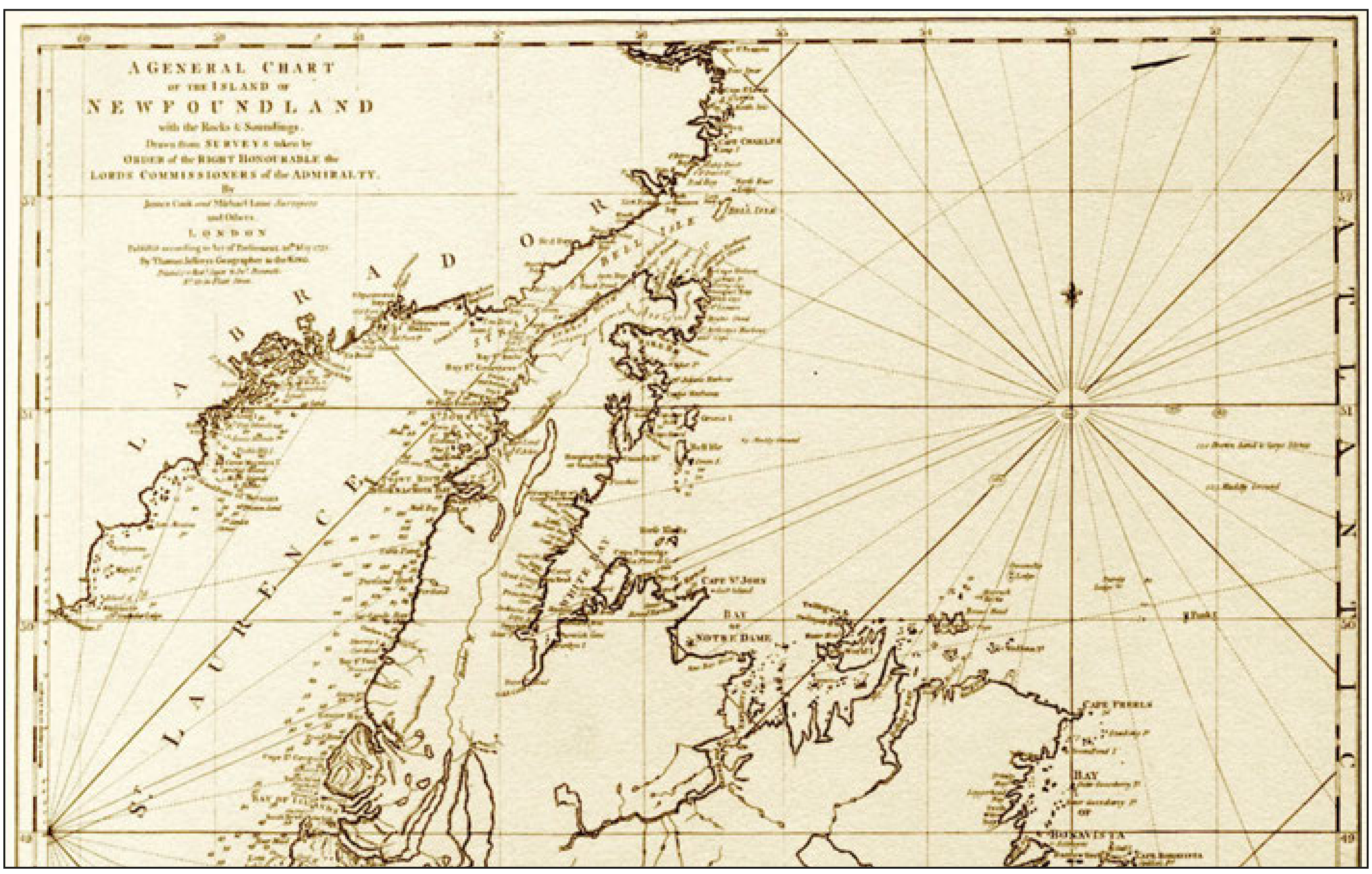
Seeking further adventure, James Cook then volunteered as an Able Seaman in the Royal Navy. After advancing to Master's Mate and Boatswain, he was made Master of the HMS *Pembroke* at age 29. During the Seven Years' War between Great Britain and France (1756-1763) he saw action in the Bay of Biscay off the coast of France and was given command of a captured ship [readers may recall that Captain William Day, the father of Sheffield's founder John Day, captured a fleet of French ships in the Bay of Biscay during the same war—see Vol. 3, No. 1, page 20 and Vol. 6, No. 4, page 5 of *The Village Pioneer*]. An exceptional mathematician, James Cook had honed his navigational and cartographic skills during these early years in the Navy. Recognized for this skill, Cook was sent to Canada during the North American phase of the war [our French and Indian War]. Here, he was placed in charge of mapping the rapids and rocks in the St. Lawrence River. His charts contributed to the successful amphibious assault against Quebec by General Wolfe. Based in Halifax, Nova Scotia during the winters he mastered additional coastal surveying techniques and after the war (1763-1768) he was assigned the task of charting the coast of Newfoundland while commander of the schooner *Greenville*. In 1766 he observed the eclipse of the Sun and sent the details to the Royal Society in London—an unusual activity for a noncommissioned officer.

Soon Cook's accomplishments were noted not only by the Navy, but also by the prestigious Royal Society. In 1768 when the Royal Society, in conjunction with the British Admiralty, was organizing their first scientific expedition to the Pacific Ocean, the name of the rather obscure 40-year-old James Cook came to the fore. Hurriedly commissioned as Lieutenant, he was appointed commander of the expedition and given a somewhat homely appearing, but extremely sturdy 4-year-old Whitby coal-hauling bark, purchased by the Navy and renamed HMS *Endeavour*, for the occasion. Lt. Cook's story is a fascinating chapter in the dawn of modern scientific thought. But first, let's return to the primary reason for the expedition—the observations of the Transits and to my ponderings at Mercury Bay.



Whitby Harbour, Yorkshire in 1996. This port has changed little since James Cook served as an apprentice seaman there in the 1740s. The building on the right in the lower view is where Cook resided when onshore.

General Wolfe's successful amphibious landing at Quebec in 1759, during the French and Indian War, was largely the result of James Cook's charts for safe passage through the treacherous maze of rocks in the St. Lawrence River.



Newfoundland coastline as charted by James Cook in the mid-1760s (courtesy of British Museum, London). Cook's reputation for hydrographic excellence won him command of the Pacific Expedition in 1769.

The Transits of Mercury and Venus

Mercury Bay is a serene inlet on the east coast of New Zealand's Coromandel Peninsula. Most New Zealanders know that Captain Cook anchored here to observe the *Transit of Mercury*, having voyaged here from Tahiti where after observing the *Transit of Venus*. But just what are the Transits of these planets? And why were these events important enough to send the King's navy around the world to measure them from the South Pacific?

These are the questions I pondered while looking out over Mercury Bay from atop the cliffs north of Hahei. It was nearly midnight on that cool May evening. The Moon was full, illuminating the white bluffs of Cathedral Rock and giving a sparkle to the gently rolling sea. The Mercury Islands were in full view and one could almost imagine the *Endeavour* at anchor, busy with preparations to observe the Transit at daybreak.

Mercury and Venus have orbits, which lie between the Earth and the Sun. Thus, they are the only planets that have the possibility of making a Transit across the face of the Sun observable from Earth. However, such events only take place at rare intervals. The passage of these planets is the same phenomenon as the more familiar eclipse of the Sun by the Moon except for the important difference that the apparent size of these planets is too small to cause any noticeable diminution in the Sun's 1ight. By aiming a telescope at the Sun during a Transit and focusing the Sun's image on a white screen behind the eyepiece, Mercury or Venus will appear as a small black dot crossing the solar disk. Recording a complete Transit requires several hours.

Because Mercury's orbit is very close to the Sun, this planet can never be seen overhead during the night. Thus the only times when Mercury can be observed satisfactorily are just after sunset or just before dawn. Another consequence of Mercury's orbit being closer to the Sun than the Earth's is that it exhibits moonlike phases–crescent, half, and full. Only about 13 times each century, a Transit of Mercury across the face of the Sun can be observed from Earth.

Venus resembles Mercury in several respects from an observational point of view. Venus appears both as a "morning star" and an "evening star" for the reason that it too, is closer to the Sun than the Earth. It also exhibits phases, as does the Moon. At crescent phase Venus is closer to the Earth and appears brighter than when showing a full disk. At its maximum brilliancy, Venus outshines all other objects in the sky except the Sun and the Moon. At times it remains above the western horizon for several hours after sunset as the most conspicuous celestial body. Venus also transits the Sun's disk, but because of its more inclined orbit, these occur at rarer intervals than for Mercury. Since the earliest glimpse of a Transit of Venus in 1631 only seven more Transits of Venus have been observed.

in the South Pacific in June of that year, as well as one of Mercury in November. The Transits occured as predicted, but the success of the observations of Venus was, and still are, a matter of debate and perspective.

An additional benefit of a Transit is the ability to accurately calculate the observer's longitude, otherwise, a particularly difficult and imprecise determination at that time. It was for this purpose that James Cook landed on the shore of what is now called Mercury Bay, to observe the Transit of Mercury, on November 9, 1769, and firmly fix the position of New Zealand.

Mercury Bay, New Zealand in 1985. The author ponders the achievements of Captain James Cook.

In James Cook's time, the dimensions of the Solar System were only crudely known, although the German astronomer Johannes Kepler (1571-1630) had worked out the geometry over a century earlier. New theories held that accurate timing of a Transit could provide the essential information necessary for calculating the precise distance between the Earth and the Sun, variously referred to as the "solar parallax" or the "astronomical unit." If this distance could be determined, then the distances to all the other planets could be found.

This was one of the principal reasons James Cook was dispatched on his voyage of exploration in 1769. A complete Transit of Venus was predicted to be observable

Age of Enlightenment

The 18th century has been called the *Age of Enlightenment* in the arts and sciences. It marks the period when scientific observation replaced supposition as the method for formulating and testing theories. Sir Isaac Newton and his contemporaries had articulated many of the physical laws, which govern the dynamics of Earth and the Solar System, but one measurement eluded them. That measurement was called the "solar parallax" or more simply the mean distance between Earth and Sun. If this fundamental unit was known, then Kepler's laws could be used to determine the dimensions of the Solar System. Thus, in the 1760s, the scientific community turned its attention to solving this "final" problem of astronomy.

In astronomy, the word "parallax" means the angular difference between (1) the direction to a celestial body as seen by an observer on the Earth's surface and (2) the direction projected from a standard reference point (normally the center of the Earth). Therefore, the "solar parallax" is the angle formed at the Sun by lines drawn from the center of the Earth and from the observer's location on the circumference of the Earth. Because the radius of the Earth at 6,378 km (3,963 miles) was reasonably well established in the l760s, if the angle of parallax could be measured, then the actual distance to the Sun could easily be found by simple trigonometric calculations (altitude of an isosceles triangle). In practice, the measurement of solar parallax is beset with numerous problems and requires the intercession of one of the planets with an orbit between the Earth and the Sun, namely Mercury or Venus.

The usefulness of the Transits of Mercury and Venus in determining the distance to the Sun was first demonstrated by Edmond Halley, popularly known as the discoverer of the periodic occurrence of the comet which bears his name [Halley's Comet returned in 1986 after a 76-year journey through the solar system and will not be seen again until 2062]. In 1677, at the age of 21, Halley persuaded the Royal Society of London to finance an expedition to St. Helena, a tropical island off Africa's South Atlantic coast, so that he could observe and catalogue the Southern Hemisphere stars. While there he also observed the Transit of Mercury across the Sun's disk. He later compared his results with measurements of the same phenomenon made at Avignon, France and arrived at a rough calculation of the distance to the sun. His 30,000,000 km estimate is only about one-fifth of the actual value, but it is of historic importance because it suggested to Halley the idea of utilizing a Transit of the larger planet Venus to obtain a more precise measurement. In the closing years of the 17th and the early decades of the 18th century, Halley published a series of papers encouraging his colleagues to plan for worldwide observations of two Transits of Venus, which he predicted would take place in the1760s.

Halley's calculations revealed that, at very rare intervals, the planet Venus would pass in front of the Sun. Through a combination of the motions of Venus and of the Earth, favorable conditions happen at intervals of 8 years, 121.5 years, 8 years, and 105.5 years, after which the cycle is repeated. Halley believed the observation of a Transit would provide 18th century astronomers with a unique opportunity to determine this fundamental unit of astronomical measurement. In 1716, he predicted a Transit of Venus would take place in June of 1761 and again in June 1769, and after which it would not recur for over a century.

Halley encouraged his fellow scientists to occupy as many observing stations as possible throughout the world to time the ingress (entrance) and egress (exit) of the planet Venus on the solar disk. He reasoned that differences in the duration of time that Venus appeared to spend in Transit across the surface of the Sun, observed at widely spaced locations on the Earth, would permit an accurate calculation of the solar parallax. This in turn would allow calculation of the astronomical unit—the true distance to the Sun. Halley's idea sprang from the circumstance that the path of Venus across the Sun is not the same for observers at different locations on Earth. Thus two observers at different latitudes will see Venus sweep across the Sun along two different chords, the amount of difference depending on the degree of latitudinal spread on Earth. Hence the distance to the Sun can be deduced if the difference between the chords can be measured with adequate accuracy.

Thus by the mid-1700s a major scientific aspiration was that of solving the problem of the actual dimensions of the solar system by using Kepler's Third Law of Planetary Motion, which gives the "relative distances" of the planets from the Sun. But not knowing what the actual distances were, astronomers of the day simply called the gulf between the Earth and the Sun an astronomical unit (or 1 AU), having a value of one. This made possible the calculation of distances from the Sun to the other planets, but only on the basis of this arbitrary value. One might compare this to expressing the mileage between Sheffield and Cleveland as "1" without knowing the length of a mile.

Transit Expeditions

By the beginning of the 18th century Halley had been appointed as Astronomer Royal and Director of the Greenwich Observatory. As such, he was one of the most influential scientists in Europe. He knew that he would not live to observe the Transits himself, but in his final years he continued to use his reputation to bring attention to the importance of these events.

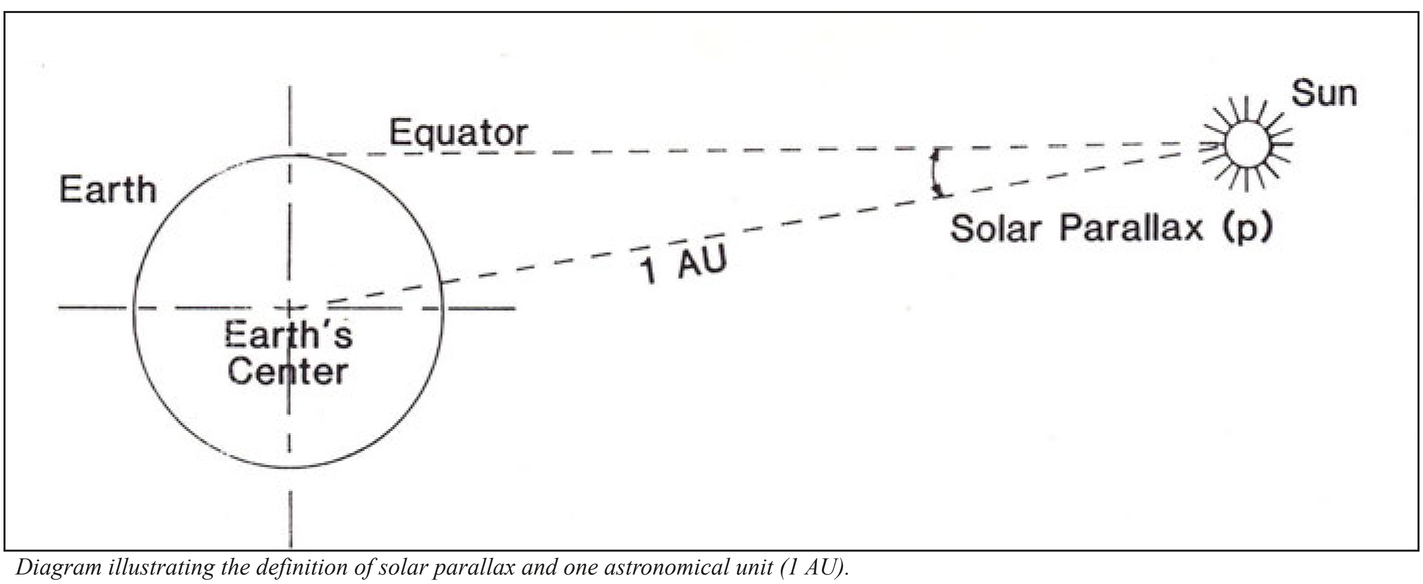


Diagram illustrating the definition of solar parallax and one astronomical unit (1 AU).

Following the death of Halley in 1742, Joseph-Nicolas Delisle, Astronome de la Marine in Paris became the champion of the Transit concept. He shared Halley's enthusiasm in the project and was able to modify Halley's method so that observations of contact at either ingress or egress could also be used in the calculations of the solar parallax. It was through Delisle's worldwide correspondence that interest in the Transits was solidified. His office served as a "clearinghouse" and the plans for major expeditions were laid.

The observation of the Transits of Venus in the 1760s represents the first international scientific endeavor undertaken by mankind on a global scale. Although the English and the French took the lead in organizing the project, other nations sponsoring observations included Holland, Russia, Denmark, Sweden, Germany, Spain, Italy and Portugal and colonists in Canada, America and India.

The 1761 Transit of Venus was observed at over 60 locations throughout the then known world, including observations in Europe, Russia, India, China, South Africa, and Canada. The results, however, were inconclusive, but the prospects for obtaining more refined measurements for the 1769 Transit were considered very good by the astronomers of the day.

To get the maximum benefit from the Transit of 1769, deficiencies in the 1761 observations would have to be corrected. Improved telescopes were developed and plans were made to locate stations at more widely separated latitudes. In 1764, the French astronomer, Joseph Lalande, published a map that divided the globe into regions in which the start and end of the Transit of Venus could and could not be seen. It became immediately obvious that a station would have to be occupied somewhere in the South Pacific. In Paris, one of Lalande's colleagues, Alexandre Pingre, drew up a memoir on the choice of stations for the coming Transit. He stressed the need for stations in the far north and in the Southern Hemisphere. Pingre calculated that from a station in the South Pacific the shortest complete Transit could be observed. This information could then be compared with results from the longest duration station, which was predicted for Scandinavian Lapland, above the Arctic Circle. He believed his theoretical Pacific station (placed at about latitude 28°S and longitude 120°W) was reasonable because earlier explorers, such as Magellan, had spoken of groups of islands in the region, although no island was then known to exist at this location. Tahiti, which lies over 2,000 km (1,200 miles) to the northwest, was eventually selected for the station largely because Captain Wallis returned to England from his Pacific voyage in 1768 with news of the discovery of this tropical paradise [incidentally, there is an island very near Pingre's theoretical station—Pitcairn, where the mutineers of the *Bounty* settled in 1790].

Thus, arrangements were made on an international scale to observe the 1769 Transit of Venus from as many places as possible. To England fell the responsibility of occupying a station in the little-known South Pacific. The Royal Society petitioned King George III to direct the British Admiralty to dispatch a ship to the area identified by Pingre. The Admiralty agreed to participate in the expedition, although for somewhat ulterior motives.

James Cook was one of the most qualified navigators and cartographers in the Royal Navy, but at this time was only a warrant officer serving in Newfoundland. He had

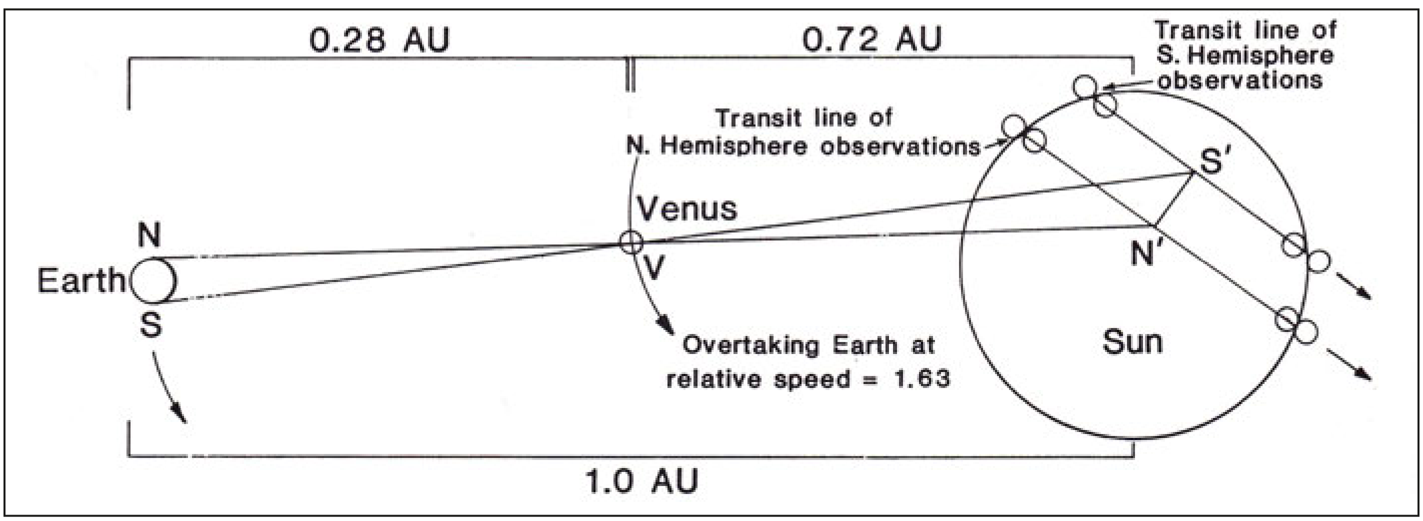


Diagram illustrating the Transit of Venus as viewed from two remote locations on the surface of the Earth and how the observation of a planet's passage across the face of the Sun can yield the information necessary to calculate the distance to the Sun. Two observations of the Transit of Venus are depicted, one in the Northern Hemisphere (N) and one in the Southern Hemisphere (S). If the linear distance between the observing stations is known, the distance on the Sun's surface between the transit lines (S'N') can be determined. From Kepler's Third Law, if the Earth is 1 astronomical unit from the Sun, then Venus is 0.72 AU from the Sun and 0.28 AU from the Earth. If observation stations on the Earth are selected at 10,800 km apart, then the distance between the transit lines on the Sun's disk can be found as a simple ratio. This yields a distance of 27,700 km on the surface of the Sun.

At this point in the calculation, the timing of the Transit at the two locations becomes important. The northern station (N) would yield a longer passage time than the southern one (S). For example in 1769, Cook's Transit observation in Tahiti was about 22 minutes shorter than the one measured above the Arctic Circle in Norway. The time required for the Transit as observed at N and S, is proportional to the length of the chords on the Sun's disk (S' and N'). This information permits drawing the position of the two chords on a diagram of the Sun. It is then possible to scale the perpendicular distance between the observation chords in relation to the total diameter of the Sun. For the above example an approximate proportion of 1/50 would be obtained, yielding the Sun's diameter of about 1,392,000 km.

risen in the ranks from a seaman to ship's master in two short years. Then, during the next ten years he became a self-taught expert in mathematics, astronomy and hydrographic surveying. Now it was 1768, and his abilities were recognized by the Royal Society over his seemingly "obscure birth." He was commissioned as lieutenant in the Royal Navy and appointed commander of the bark HMS *Endeavour* [apparently the Admiralty could not bear to send a mere warrant officer on such an important mission].

Voyages of James Cook

The British Admiralty's orders to Lt. James Cook in 1768 were brief and uncomplicated. He was to sail the *Endeavour* to the island of Otaheite (Tahiti) in the South Pacific, with a team of scientists from the Royal Society, to observe the Transit of Venus. In addition to this publicly announced mission, Cook carried with him sealed orders not to be opened until after the Transit had occurred.

> *Pursuant to His Majesty's pleasure, so soon as the observation of the Transit of the planet Venus shall be finished, you are to put to sea with the bark you command and proceed to the southward to a latitude of 40°S in order to make discovery of a southern continent. But not having discovered it or any evident signs, you are to proceed in search of it to the westward until you discover it, or fall in with the eastern side of the land discovered by Tasman and now called New Zealand.*

Lt. Cook was further instructed to make a detailed survey of the coastline of the southern continent and document its flora, fauna, and inhabitants. He was to cultivate a friendship and alliance and attempt to establish trade. The orders required him to obtain the consent of the natives before taking occupied territory or if uninhabited, take possession for His Majesty. The secret orders concluded:

> *You will upon falling in with New Zealand carefully observe the latitude and longitude, and explore as much of the coast as the conditions of the bark, the health of her crew, and the state of your provisions will permit, having always great attention to reserve as much of the latter as will enable you to reach England.*

Cook himself can be counted among the scientists aboard the *Endeavour* as a result of his report on a solar eclipse he observed while commanding the HMS *Mercury* off the east coast of Canada. The other scientists were Charles Green, assistant to the

Captain Cook's ships HMS Adventure *and HMS* Resolution *anchored in Matavai Bay at Venus Point, Tahiti (painting by William Hodges, artist on Captain Cook's second voyage).*

Astronomer Royal; Joseph Banks, a wealthy young naturalist and a Fellow of the Royal Society; and Dr. Daniel Carl Solander, a Swedish botanist and pupil of Linnaeus [developer of the binomial system for scientific naming of plants and animals]. Alexander Buchan, a landscape painter; Sydney Parkinson, a natural history artist; and Herman Spöring, technical secretary, completed the scientific contingent. Dr. William Monkhouse the ship's surgeon also assisted with some of the scientific observations.

The *Endeavour* sailed from Plymouth England in late August 1768. But, political events, particularly naval wars, hampered free ocean travel in the 18th century. Cook knew well how hostile nations could endanger his mission; the vessel that carried the French astronomer Le Gentil to India had to make wide detours to escape English men-of-war, and unfortunately Le Gentil arrived in Pondicherry [Indian Ocean] after the 1761 Transit of Venus was over. As a sign of the international importance of the 1769 observations in the South Pacific, the French government instructed all its men-of-war to leave Cook's ship unmolested, because he was "out on enterprises that were of service to all mankind." Even so, the Portuguese viceroy at Rio de Janeiro found it hard to believe that the *Endeavour* was sailing round the world merely to make

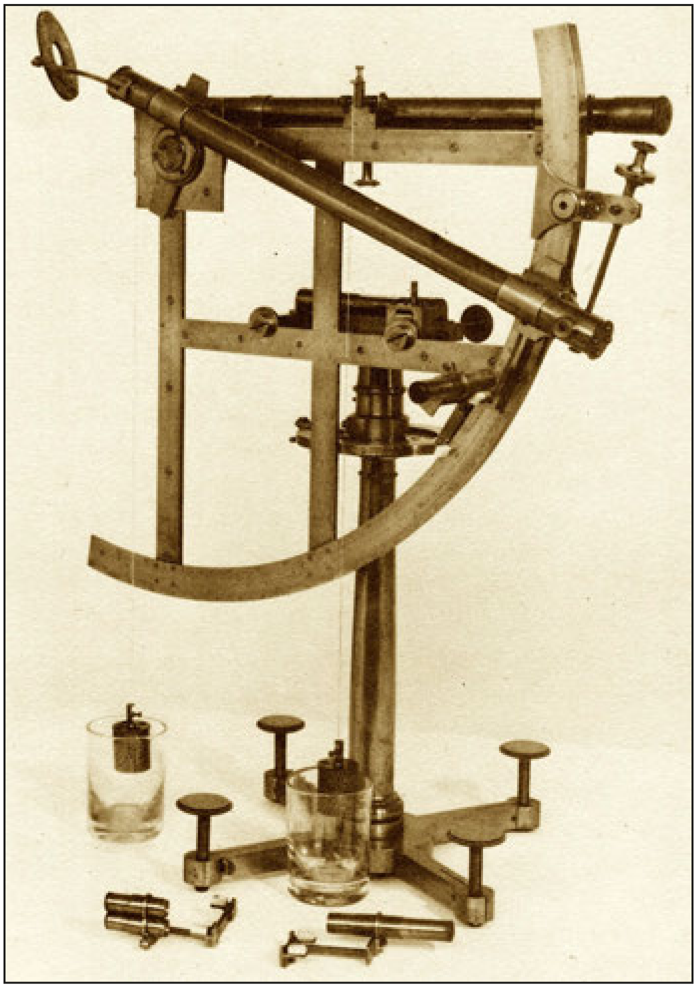
*Scarlet wisteria (*Sesbania grandiflora*) drawn by Sydney Parkinson, botanical artist during James Cook's first voyage of discovery.*

Statue of Captain James Cook at Young Nick's Head on Poverty Bay, the point of land on the New Zealand coast that was first sighted in 1769 by Nicholas Young, seaman aboard the HMS Endeavour.

an astronomical observation. When Cook attempted to sail from the harbor, the *Endeavour* was fired on from the fort. After being detained for nearly a month the ship was permitted to sail, but Cook was concerned about the time he had lost.

It took five arduous weeks for the *Endeavour* to round Cape Horn at the tip of South America. It was late January 1769, before Cook entered the Pacific. He arrived at Matavai Bay of Tahiti in mid-April with only seven weeks to prepare for the Transit of Venus that was predicted to take place in early June. Cook decided to construct a fortification on a sand spit, which he named Venus Point, at the northeast end of Matavai Bay to observe the Transit. One of the prime reasons for constructing Fort Venus was to thwart the Tahitians "propensity for theft."

In early May, the astronomical instruments were taken ashore and installed in the fort. They included Georgian reflecting telescopes (2-foot to 3-foot focus, 140 magnification), a Shelton astronomical clock, and a Bird astronomical quadrant. There was good reason for Cook's caution. The heavy, brass quadrant was stolen from its wooden case the first night. Cook immediately ordered the bay sealed off so that the culprit could not escape by sea. With some difficulty Banks and Green recovered the battered quadrant after a 10 km (6 mile) pursuit into the Tahitian hills. Some damage had been done and parts were missing but Spöring, who had worked as a watchmaker in London was able to make repairs in time for the Transit. The quadrant was critical to the observation because it was used to calibrate the astronomical clock.



Quadrant, made in 1768, of the type used by James Cook at Venus Point on Tahiti. Cook's instrument was stolen and damaged by the natives; but retrieved and repaired in time to observe the Transit (courtesy of National Maritime Museum, Greenwich).

On Saturday, 3 June 1769, the day was favorable on Tahiti for observing the long-awaited Transit, not a cloud in the sky the whole day. The winds were calm and the unshaded mid-day temperature rose to over 40°C (104°F). Cook and his colleagues took advantage of the day to observe the entire passage of the planet Venus over the Sun's disk. He, Solander, and Green made their measurements from Fort Venus on Tahiti, while Dr. Monkhouse and Mr. Spöring observed the Transit from neighboring York Island [Moorea].

Although the observations were successful, Cook was concerned by the differences among the five independent observers in the times of the inner contacts with the Sun's disk. He noted in his journal that they could very distinctly see a dusky haze around the body of the planet that disrupted the accurate timing of the contacts. This so-called "black-drops" effect caused Cook to record a difference of 32 seconds between the real and apparent contact at egress, while Green found the difference to be 48 seconds. It had been hoped that the various observers would agree within a second in order to provide the precision necessary to accurately measure the distance to the Sun.

In addition to the measurements for solar parallax purposes, from the Transit observations Cook was able to deduce the longitude of Venus Point, the most northerly tip of Tahiti from which he made his observation. His longitude calculation is within 3'45" (about 7 km or 4.3 miles) of what is accepted today. To commemorate Cook's achievement, an attractive lighthouse now stands on the black beach where history was made.

By early July, Cook was anxious to put to sea and undertake the mission disclosed in the sealed envelope. Tupaia, a Tahitian priest, volunteered to journey back to England with Cook and to serve as pilot among the islands, reefs, and atolls of the tropical Pacific. For several weeks they sailed westward through chains of volcanic islands, surveying their coastlines. On the island of Raiatea, Tupaia's birthplace, Cook raised the British flag and took possession of the entire group, naming the Society Islands in honor of his sponsor, the Royal Society, and "because of their contiguity." Local legend had it that voyagers from Raiatea had colonized a large island to the southwest, probably New Zealand. Obeying the secret orders Cook then sailed southwest for nearly 2,000 km in search of the supposed southern continent [*Terra Australis Incognita*], although Tupaia's description reinforced his own opinion that there were only islands to be found. His explorations even took him well below the Antarctic Circle, but no large land mass was to be found.

Tasman had only seen the west coast of New Zealand; therefore, the question of whether New Zealand formed the west coast of a great continent was unresolved as Cook sailed southwestward. On October 7, Cook resolved this by sighting the east coast of the North Island. But, he was uncertain of the longitude and would need to wait for the Transit of Mercury to confirm the position of New Zealand.

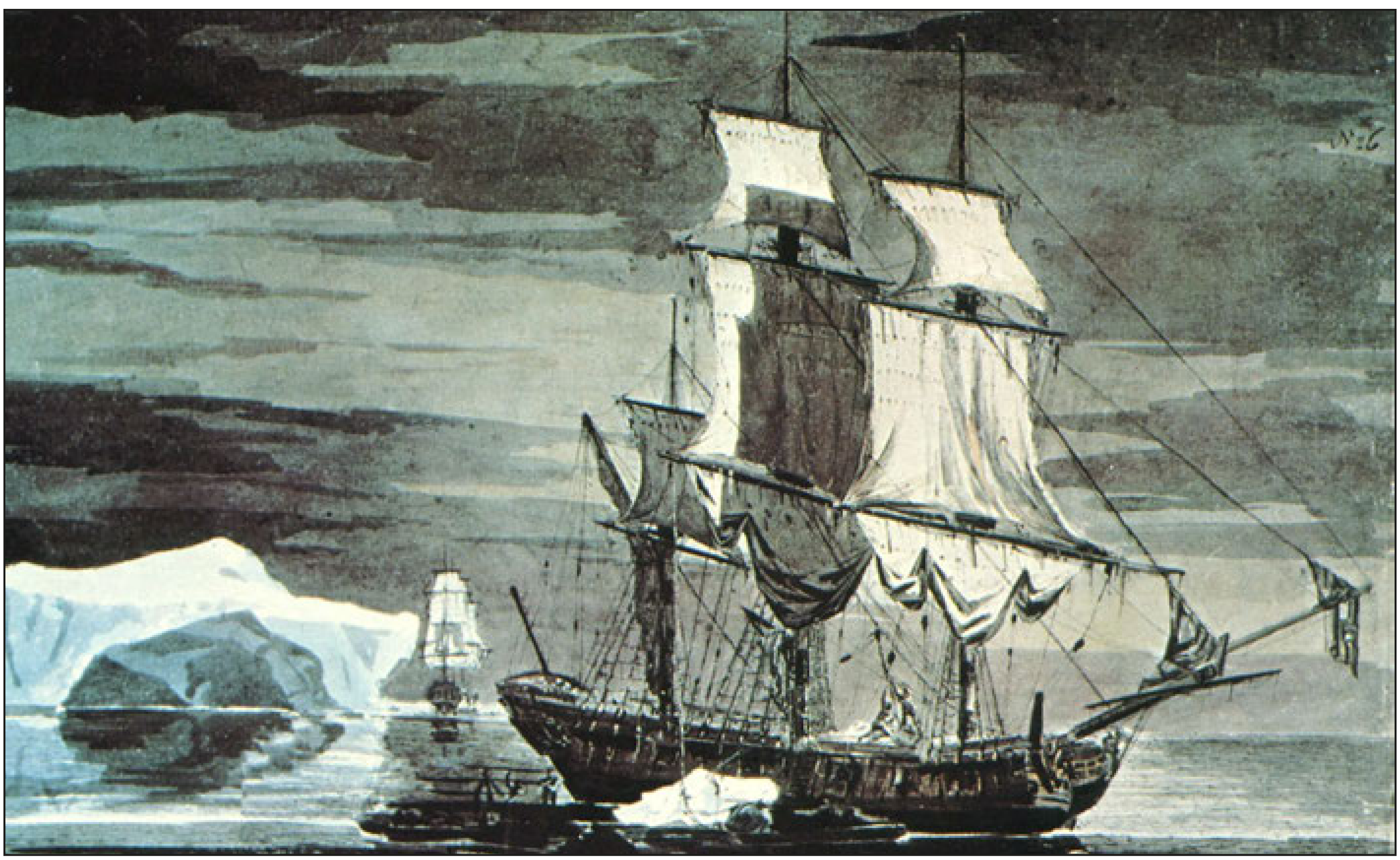
Venus Point on the north shore of Tahiti. Here Lt. James Cook made his observation of the Transit of Venus on June 3, 1769.

Lighthouse constructed on Venus Point, Tahiti to commemorate Captain James Cook.

The Royal Society was not certain that the Transit of Mercury could be observed, mainly because there was no sure knowledge of land in the area where it would be visible. But Cook knew that if a landing could be made and if this Transit observed, then a longitude calculated from the results would "put this new land on the charts firmly and forever."

From Poverty Bay to the Bay of Plenty and eventually to the coast of the Coromandel, Cook searched for a place where he and Mr. Green could make their observations. Time was growing short. Then on November 4, only five days before the predicted Transit, he found a deep, sheltered bay with high, cream-colored cliffs, and wide sandy beaches that faced the northeastern sky—an ideal vantage point to observe Mercury's passage across the face of the Sun. Cook knew that if he was fortunate enough to obtain this observation, the longitude of the new land he had discovered could be accurately determined.

Fortunately, on 9 November 1769, the Sun rose in a cloudless sky. Cook and Green went ashore early in the morning, landing at a point on the sand spit beach about 300 m (1,000 feet) west of the mouth of the Oyster (Purangi) River. There they observed the Transit of Mercury that began at 0721 hours. Green observed the early stages of the passage on a white screen behind the telescope while Cook determined the Sun's altitude with a sextant in order to ascertain the apparent time. They both observed the egress some 4 hours later. From these observations Green calculated the longitude of the site as being equivalent to 176°55´. The latitude, calculated by Cook from the altitude of the Sun was found to be 36°48´ south of the equator. Although the calculation sheets showing the exact methods used by the observers have not



Exploring well below (61°S) the Antarctic Circle during Captain Cook's second voyage, his ships HMS Adventure *and HMS* Resolution*, take on ice for drinking water (watercolor by William Hodges).*

Mercury Bay Monument at Shakespeare Head, New Zealand. Inscription: In this bay was anchored 5–15, November, 1769 HMS Endeavour, Lieutenant James Cook, Commander. He observed the Transit of Mercury and named this Bay.

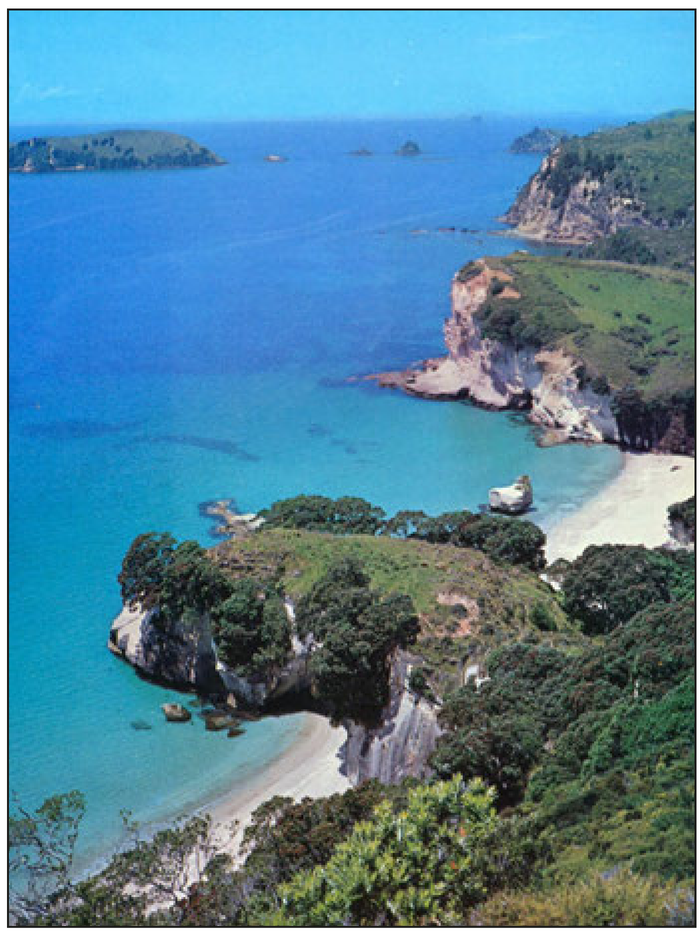
survived, there is no doubt about their accuracy. The position of the observation point, today known as Cook's Bay, is now computed to be latitude 36°50'18"S and longitude 175°45'23"E. Carrying their measurements all the way from England, they only differed less than 11 minutes (equivalent to about 19.7 km or 12.2 miles) from what is accepted today.

The primary instrument available to Cook for determination of latitude and longitude was the Ramsden sextant. Latitude could be determined directly by sights from the Southern Cross, or the Sun, but longitude required a precise knowledge of Greenwich Royal Observatory time for rare astronomic events such as Transits. On his first voyage to New Zealand (1769), Cook did not have an accurate way of maintaining correct time over long periods, he could only fix his longitudinal position during a Transit. But on his second voyage (1772–1775) aboard the HMS *Resolution*, he took with him a replica of John Harrison's prize winning "marine chronometer." It was the astonishing accuracy of this timekeeper that enabled Cook to determine the precise longitude and therefore enable him to construct the charts of New Zealand and the South Pacific with exceptional accuracy.

Cook's second voyage placed severe demands on Harrison's chronometer. Extremes of temperature were frequent; the *Resolution* had not only crossed and re-crossed the Equator, but it penetrated and probed deep into the Antarctic reaching as far south as 71°S latitude and only turned north when faced with unbroken pack ice. Mountainous seas, torrential rains, fog, and tropical humidity were all experienced during the voyage, which lasted nearly three years. As Cook sighted land near Plymouth, England at the end of his journey in July 1775, he checked the accuracy of the chronometer by determining the longitude. He found an error equivalent to only 14 km (8.7 miles). This was amazing considering the chronometer had not been set since the beginning of the voyage in July 1772. Eight months after the *Resolution* docked, the inventor, John Harrison, died in London on his 83rd birthday, content with the knowledge that his life's work had proven to be a complete success.

But back to James Cook's first voyage—following the observation of the Transit of Mercury, Cook made a complete circumnavigation of New Zealand, charting most of the coast in exceptional detail. This included a passage through the treacherous strait between the North and South Islands that now bears his name. In March 1770, Cook made a momentous decision to return to England via New Holland [Australia] and the Cape of Good Hope. On April 1, the *Endeavour* left New Zealand passing by Cape Farewell and crossed the Tasman Sea.

What was the fate of the scientific party aboard the *Endeavour*? Cook and Banks received a hero's welcome back in England. Cook was promoted to commander and then to Post-captain in the Royal Navy (1775) and was elected as a Fellow of the Royal Society. Banks eventually became the Society's president. Dr. Solander, also a Fellow of the Royal Society, resumed his post as specialist on the staff at the British Museum where he was generally conceded to be the ablest botanist in England. But other members of the party did not fare as well. The artist, Buchan, suffered an epileptic fit on the bitterly cold shore of Tierra del Fuego during the passage around Cape Horn, and died in Tahiti. This left only Parkinson to record the landscapes and the hundreds of hitherto unknown plants and animals. Parkinson produced over 1,500 drawings from the voyage. On the return voyage to England, Cook sailed the *Endeavour* to the Dutch colony of Batavia [Jakarta] for ship repairs. Notorious



White bluffs of Cathedral Rock, near Hahei on the south shore of Mercury Bay.

Captain Cook's voyages of discovery in the Pacific Ocean (base map courtesy of Encyclopedia Britannica*).*

as one of the unhealthiest places on Earth, many of the ship's company contracted malaria and dysentery there. Dr. Monkhouse and the Tahitian Tupaia died on Batavia. In late December 1770, the feeble crew of the *Endeavour* set sail for home, but the worst was yet to come. By the end of January 1771, the astronomer, Green, the secretary, Spöring, and the artist, Parkinson, had all perished. After a stop at Cape Town, on July 10, 1771 the *Endeavour* came into sight of the English coast. The person who sighted England was the same seaman Nicholas Young who had caught the first glimpse of New Zealand and for whom Cook named Young Nicks Head at the entrance to Poverty Bay.

Significance of the Transits

The story of the Transit of Venus is the saga of an 18^{th} century attempt to determine the dimensions of the solar system. Indeed, the rare Transit of Venus provided the incentive for the first worldwide scientific venture, and thus, the establishment of the modern international community in science.

The 1769 Transit of Venus was observed at stations ranging from Siberia to California, from Varanger Fiord, Norway [above the Arctic Circle] to Tahiti, and from Hudson's Bay to Madras, India. In all, 151 observers at 77 stations contributed to this effort, resulting in over 600 scientific papers dealing with the value of solar parallax. Alexandre Pingre of the French Academie Royale des Science produced some of the best analyses in 1772. By comparing the results of observations from “lands of the midnight sun [Lapland]” with observations of James Cook in Tahiti, Pingre was able to calculate a parallax angle of 8.8" for the 1796 Transit of Venus. Pingre’s calculations yield a distance of 149,450,000 km from the Earth to the Sun. In the 1960s, some 200 years after James Cook made his observations at Venus Point, power radars were trained on the Sun for the first time. Radar measurements made throughout an entire year yielded a mean solar distance of 149,600,000 km corresponding to a solar parallax of 8.79". Remarkably, as a result of Halley’s plan, the absolute scale of the Solar System was established in the late 18th century to within an accuracy that varies less than 1% from what is accepted today.

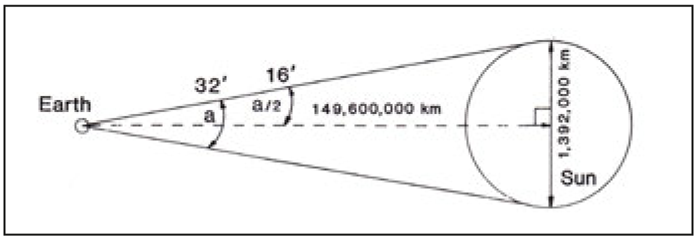


Diagram illustrating the calculation of the distance from the Earth to the Sun. From measurements of the Transit of Venus across the face of the Sun from two remote locations on Earth, it is possible to calculate the diameter of the Sun (1,392,000 km). Once this is known, it is a relatively simple matter to measure, by sextant, the arc (a) subtended by the solar disk (~32′). Then taking the tangent of half of this angle (a/2) divided into the radius of the Sun (696,000 km), the distance to the Sun can be obtained. Thus the approximate distance to the Sun, 1 AU, is equal to 149,600,000 km (92,960,000 miles).

However, in 1771, James Cook came home to find himself a national hero, but the Royal Society was by no means pleased with his report and data from the Transit of Venus. It was true that Cook’s Tahiti observers had had difficulties in the timing of the stages, but so had every other observer throughout the world. The stages consist of contacts: 1st contact when the dark dot (Venus) just touches the outside edge of the Sun; 2nd contact, when the dot is just completely within the disk of the Sun near the point of entry; 3rd contact, when the dot, having crossed the Sun’s disk, just touches the opposite edge of the Sun; 4th contact, when the dot is completely outside the Sun but still just touching the outer edge. A curious phenomenon occurs just after the 2nd contact. The planet appears to draw a tiny area of blackness after it, known as the “black drop.” By the time the black drop has disappeared the planet has already separated from the Sun’s inner edge and the moment for recording the time of the 2nd contact has been lost.

When the Society sought to lay the blame on the dead astronomer Green, Cook responded with a rebuke so sharp that his strong language was struck from the official proceedings of the Society. It soon became obvious that the numerous other observations taken elsewhere around the world were equally unsuccessful for the same reason—the nebulous haze which surrounds Venus when viewed through a telescope precludes the precise timing of the beginning and ending of the Transit.

But what of the Transit of Mercury? Captain James Cook wrote in his journal that he hoped ambition would lead him, “not only farther than any man had gone before, but as far as it is possible for man to go.” In 1986, I had the extreme pleasure to read Captain Cook’s original journal archived at the Australian National Library in Canberra. This passage is one of the few times in his journals that he exposes that tremendous drive which brought him to New Zealand and the Pacific again and again. At Mercury Bay he used the occasion of the Transit of Mercury to firmly anchor New Zealand’s position on his chart of the Pacific Ocean. In a way, Cook’s observation was a tribute to Halley who conceived the concept of determining the dimension of the Solar System after measuring a Transit of Mercury nearly a hundred years earlier in the South Atlantic.

Captain Cook would go on to make two more voyages to the Pacific, crossing both the Arctic and Antarctic Circles in his quest for discovery. His exploration firmly fixed the British claim to Australia, New Zealand, and the west coast of Canada. On February 14, 1779, at the age of 50, Captain Cook’s days of exploration sadly came to an end at the hands of Hawaiian warriors over a dispute involving a stolen boat. Cook’s remains were buried at sea on February 22, 1779. As a tribute to their fallen Captain, the crew continued his mission of the previous summer to find a northern passage from the Pacific to the Atlantic. Again they passed through the Bering Strait and into the Arctic Ocean, only to be blocked by ice flows. Turning southwestward, they arrived back in England four years and three months after Cook had set out onwhat was to be his last voyage.

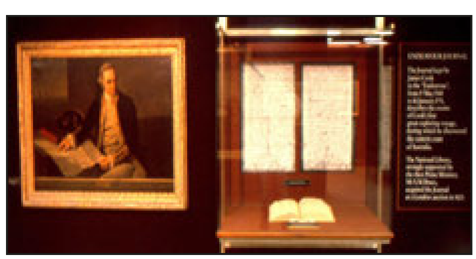
The news of Captain Cook’s death was devastating to his countrymen and to the world’s scientific community. Many honors were bestowed posthumously on him and his deeds live on in numerous geographic features with the name *Cook*. Statues, coins, metals and medallions bear his likeness throughout the world. To this day Captain Cook is synonymous with the quest for discovery. In more recent times, U.S. Navy Lt. Commander John Philip Sousa was so taken with the 1882 Transit that the next year he composed a new march titled, *Transit of Venus*, just one of his 136 marches.


Mount Cook in the Southern Alps of New Zealand named in honor of Captain James Cook.

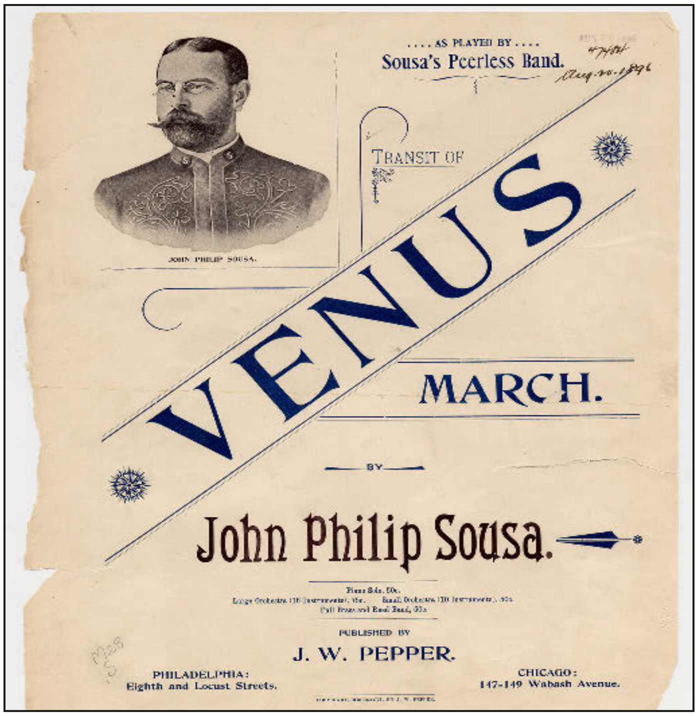
Captain Cook's death in Hawaii as depicted by artist John Webber who accompanied Cook on his final voyage.

Medallion portrait of Captain James Cook, cast by Josiah Wedgwood 1784 from a design by John Flaxman.

Monument marking the place of Captain Cook's death on the shore of Kealakekua Bay, Hawaii Island.



James Cook exhibit at the Australian National Library, Canberra in 1986. The holdings of this library include Lt. James Cook's original logbooks from the HMS Endeavour *and Captain William Bligh's logbook following the Mutiny on the HMS* Bounty.



Sheet Music for John Philip Sousa's 1896 Transit of Venus March.

Ricki & Eddie Herdendorf visit Venus Point, Tahiti Nov. 5, 2011.

Society Organization

The Sheffield Village Historical Society is a charitable nonprofit 501(c)(3) and educational organization dedicated to discovering, collecting, preserving, interpreting, and presenting Sheffield's rich heritage. Membership is open to anyone who wishes to support the Society's mission. For more information contact Eddie Herdendorf, President (440-934-1514 herdendorf@aol.com), Andy Minda, Vice President (440-537-0547 anmin36@aol.com), or Patsy Hoag, Secretary (440-934-4624 phoag@me.com).

Society journals can be found on the Village of Sheffield, Ohio official website: www.sheffieldvillage.com (click on the Sheffield Village Historical Society logo, then Pioneer newsletters. Page Layout is by Ricki C. Herdendorf, EcoSphere Associates, Put-in-Bay, Ohio.

The collections of the Sheffield Village Historical Society are housed in the Sheffield History Center at 4944 Detroit Road. The History Center is open to members and guests on Tuesdays 11 am to 3 pm and Thursdays 6 pm to 8 pm, or by appointment—please call Kathleen Yancer at 216-543-3651.

To raise funds to cover property tax the Society will be holding yard sales at the History Center this summer. We will be pleased to accept donations of sale items at the Center. For more information please call 440-934-1514.

Society members are encouraged to submit items for future issues. Please send your stories or ideas to the Editor.

Charles E. Herdendorf, Ph.D.
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