

HISTORIC TRANSITS OF VENUS FROM A CANADIAN PERSPECTIVE

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ABSTRACT: [Transit observations](#) in Canada in 1761, 1769 and 1882 are discussed. The times of contact show a mean error of about 20 seconds with no significant improvement between the early and later observations. The importance of transits to the development of science in this country is considered. In the case of the transit of 1882, many newspaper articles are quoted which show the extent of public and amateur involvement.

1. INTRODUCTION AND HISTORICAL BACKGROUND

There is no shortage of sources on the historic role of transits in determining the distance from the Sun to the Earth (what is now called the astronomical unit or AU) and its related measure, the solar parallax, defined as Earth's equatorial radius/AU, whose modern value is about 8.794" (arc-seconds). A comprehensive bibliography, including references to Canadian articles not cited here, can be found at

<http://www.phys.uu.nl/~vgent/venus/venustransitbib.htm>.

The first recorded appearance of Venus on the Sun occurred in 1639 and it was only observed by two people, Jeremiah Horrox and his friend William Crabtree near Liverpool, England. Horrox did attempt to use his sighting to calculate the distance to the Sun but his method had nothing to do with parallax. James Gregory was apparently the first to suggest, in 1663, that the Earth-Sun distance could be found using the parallax of Venus as seen during transits. However, Edmond Halley is usually credited with the method since he developed it mathematically in 1691. The parallax of the Sun can be calculated from the shift in the position of Venus as seen from locations on Earth as far apart as possible. Since Venus appears to cross

the Sun at a known rate on parallel chords GH and KL (Figure 1) as seen from locations B and A on Earth, and since the angular radius of the Sun is known (or can be measured), the angular

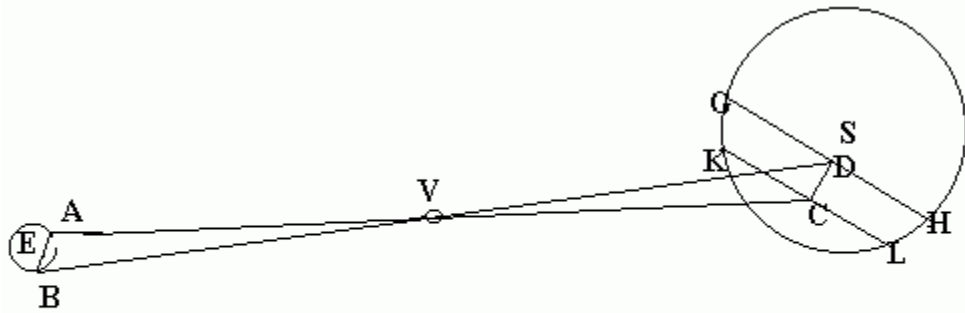


Figure 1. - A schematic diagram to explain how a transit of Venus (V) can be used to find the distance from Earth (E) to Sun (S).

distance between the chords CD can be easily deduced from the difference between the duration of the transit as seen by two observers. Since the relative distances of Venus and Earth from the Sun are known from Kepler's third law, similar triangles and the known distance between A and B can be used to find the actual distance CD on the Sun. So with CD known both in angular and linear measure, it is a straightforward matter to find the distance from Earth to Sun. While this is an oversimplified explanation, it is sufficient for understanding what measurements were

required and why. In order to make the separation CD appear as large as possible, A and B should be widely separated. For this reason, astronomers often had to travel great distances to remote sites. Their efforts were early examples of international co-operation (and to some extent, competition) on a scientific mission.

When Halley first published his proposal in 1691, he did not understand the regression of the nodes of Venus' orbit well enough to make accurate long-term predictions. Halley did correctly recognize that the next three transits would occur in 1761, 1769 and 1874 but he missed the one in 1882 and then went on to predict 1996 and 2004 (rather than 2004 and 2012).

2. ACCURACY OF THE OBSERVED TIMES OF CONTACT

There have been only three transits of Venus observed in Canada and only eight sets of observations which were used in parallax determinations. [They are listed in Table 1](#). The longitude and latitude of each place are taken from modern topographic maps. The telescope used in each case is described by three numbers, D, the diameter, f, the focal length, both measured in centimetres and P, the magnifying power. All the eighteenth century observers used Gregorian reflectors except Samuel Holland. The nineteenth century observers all used refractors. The principal observer at each location is listed first, and in boldface type. The contacts are numbered 1,2,3,4 corresponding to external ingress, internal ingress, internal egress and external egress. The observed times are local apparent time for the eighteenth century transits and local mean time for the 1882 transit. Using topocentric apparent right ascension and declination produced by an online ephemeris generator <http://ssd.jpl.nasa.gov/cgi-bin/eph> the calculated times of contact have been found when the separation of the centres of the Sun and Venus are equal to the sum and difference of their angular radii. The difference between the observed and calculated times is shown in seconds. In interpreting the accuracy of the observations, it should be borne in mind that the duration of the transit (between second and third contact) was the figure that was used in comparison with the duration at other sites to calculate the parallax by Halley's method. As an example, the duration was in error by only 8 seconds as timed by both Dymond and Wales. Observations of only one contact were still useful, nonetheless. If the longitude was known, other methods could be used to combine timings made at various locations to derive the parallax.

3. THE TRANSIT OF 6 JUNE, 1761

In a second more detailed paper on the use of transits to find the solar parallax, Halley (1715) actually discussed sites where the 1761 transit could be observed most advantageously. Here was the first time that Canada was mentioned. Halley suggested that Port Nelson (latitude 56°) on Hudson Bay could be paired with a location in the East Indies to give a long baseline. The Sun would have been almost setting just as the transit began and so his suggestion would not have worked out. In the event, no one was sent to North America from Europe in 1761 to attempt a sighting of Venus on the Sun.

The only part of Canada where the 1761 transit was visible in its entirety was the inaccessible high arctic and even from there, the Sun would have been at a low altitude. (The

circumstances for June 8, 2004 are rather similar.) The end of the transit was visible just after sunrise from the east coast but no astronomers normally associated with Canada observed the event because of the Seven Years' War (1757-63). By the time of the fall of Louisbourg in 1758, French astronomers like Father Bonnécamps who had lived in Quebec, and the Marquis de Chabert at Louisbourg, had left the country. On the British side, two naval men, Samuel Holland and James Cook, began mapping the Gulf of St. Lawrence. Under Holland's tutelage, Cook produced his first published map, "A Draught of the Bay and Harbour of Gaspee." Eventually, in 1769, both men would observe the next transit of Venus, but the War was a more important preoccupation in 1761. On a world-wide scale, the conflict made travel very difficult, but remarkably not impossible for scientific expeditions. As Maor (2000) has pointed out, "Some seventy stations spread around the globe [made this] the first large-scale scientific endeavour ever attempted."

Observations of the transit which were made suffered from an unforeseen problem – the so-called black drop effect which manifested itself as an apparent dark thread connecting the limbs of Venus and the Sun. It was not known whether to time the breaking/formation of the thread or the moment when the edges of the Sun and Venus appeared to be tangent; the two times could differ by as much as a minute. All known observations of the two eighteenth century transits were studied by Newcomb (1891) and he tried to deal with the black drop effect in a systematic way. The reason for its appearance has been recently studied by Schaefer (2001) who attributes it to irradiation.

The only observation of the 1761 transit recorded in North America was made by Professor John Winthrop of Harvard College, who travelled to St. John's, Newfoundland, since the phenomenon was not visible from Massachusetts (Shute 1980). Brasch (1916) says that Winthrop established "America's independence in scientific development," and that he was "regarded as the greatest mathematician of his age on this side of the Atlantic, ... equally keen as an observer of natural phenomena; accurate, methodical, and skilful." Winthrop (1764a) found his latitude in Newfoundland from several observations to be 47°32'N but was very unsure of his longitude. In the end he used 52°50'W (3^h31^m20^s). From Winthrop's description of the place, Smith (2003) has identified the site as Kenmount Hill (47°31'54"N, 52°47'32"W = 3^h31^m10^s).

Winthrop described his equipment - a pendulum clock, an octant, a refractor and a reflecting telescope made by Benjamin Martin. And he explained how he and his assistants set up tents, and sank three pillars into the ground, one to support the clock, another for the refractor, and a third, "above 8 feet high, for a Style, having at top a plate of lead with a little hole for transmitting the Sun's rays." These rays fell on a platform which was carefully levelled and on which Winthrop traced a meridian line which he apparently found by bisecting line segments joining images at equal altitudes on either side of the meridian. With an accurate meridian line, it was possible to read the clock at apparent noon each day, and thus find the clock correction. The reflector had its own spirit levels at right angles to each other and the eyepiece was fitted with horizontal and vertical cross wires.

On the morning of the transit, Winthrop and his two student assistants, Samuel Williams and Isaac Rand, watched from the hill where they had a good view of the part of the horizon where the Sun would rise. For biographies of the three observers, see <http://www.famousamericans.net/> . Quoting Winthrop:

Thus prepared, we waited for the critical hour, which proved favorable to our wishes. The morning of the 6th of June was serene and calm. The Sun rose behind a cloud that lay

along the horizon, but soon got above it; and at 4h 18m we had the high satisfaction of seeing that most agreeable Sight, VENUS ON THE SUN, and of shewing it in our telescopes to the Gentlemen of the place, who had assembled very early on the hill to behold so curious a spectacle. ... In memory of so rare an observation, the Gentlemen present agreed to give the hill, where our observatory was situated, the name *Venus's Hill*.

Venus was already on the face of the Sun at sunrise. First and second contact had passed but by using the reflector with its filar micrometer, Winthrop was able to calculate the differences in celestial longitude and latitude between the centres of the Sun and Venus and to make a diagram showing the planet's progress across the solar disc. From this he inferred the four times of contact. He also timed and corrected the third and fourth contacts with the clock and these are listed in [Table 1](#).

What happened to his observations is a confusing story, complicated by the long delay in transatlantic communications. Winthrop communicated his results to Benjamin Franklin who in turn was to send them to his friend James Short of the Royal Society in London. Franklin couldn't remember whether he did so or not. Winthrop also sent them to Astronomer Royal James Bradley (though they may not have reached him before his death in July, 1762) and to his successor, Nathaniel Bliss, who never sent him a reply. So eventually Winthrop (1764b) sent them directly to Short who published them in the *Philosophical Transactions* and who combined them with observations at the Cape of Good Hope to derive a solar parallax of 8.25". However, Short (1762) had already studied observations from different places in Europe and, comparing them with observations at the Cape, had deduced a parallax of 8.65", only 0.14" shy of the true value as we now know it. Apparently Ben Franklin had done as Winthrop asked, for in this 1762 paper, Short referred to Winthrop's observation but said he did not use it since the longitude provided by Winthrop was uncertain. However, Short worked backwards from the parallax to deduce the longitude of Winthrop's station at St. John's as $3^{\text{h}}31^{\text{m}}12^{\text{s}}$. This is just 2 seconds of time different from the longitude of Kenmount Hill.

The way in which Short handled the times of contact collected from many different places highlights a big problem with the eighteenth century values of the parallax: statistical knowledge had not advanced to the point where anyone knew how to deal with many observations. All they could do was to combine them, as Short did, two at a time and then average the results. Eventually, when statistical analysis had matured, Simon Newcomb (1891) was able to carry out an exhaustive study of both the eighteenth century transits and arrived at a solar parallax of 8.79" with a mean error of ± 0.051 ".

4. OBSERVING TECHNIQUES IN THE EIGHTEENTH CENTURY

During the transits, astronomers made two types of measurement: (a) the times of contact of Venus with the limb of the Sun and (b) angular distance of Venus from the limb. It may come as a surprise that eighteenth century observers in out-of-the-way locations knew their time within a few seconds. The errors that did arise in timing the contacts came less from problems with the timing method, and more because of the slow motion of Venus relative to the Sun (less than 0.1" in a second of time). Moreover, the limb of the Sun is not sharply defined, and the black drop after second contact and before third contact, makes the time of contact somewhat subjective.

In order to time the contacts, an observer could not rely on a clock by itself but with the help of celestial observations could determine the clock error and the rate at which it was gaining

or losing. While John Harrison had just begun to have success with his famous chronometers which eventually led to timepieces which could keep accurate time during long voyages at sea, they were still unavailable in 1769.

In *The Nautical Almanac* for 1769 (published in 1767), the Astronomer Royal, Nevil Maskelyne, set out over 40 pages of instructions for observing the ensuing transit of Venus. He explained the nature of the phenomenon and its expected duration, told how to smoke glass in order to protect the eye from the Sun's light, and recommended telescopes and methods of adjustment. He told how to set up a pendulum clock and how to use its audible beats to time events such as the contacts of the limb of Venus with the Sun. in Maskelyne's words:

The Astronomical Clock should be regulated to keep mean solar Time. The readiest Method for occasional Observers to regulate their Clock is by taking equal Altitudes of a fixed Star or the Sun's upper or lower Limb, on each side of the Meridian ... The Mean of the Times of the equal Altitudes of a Star as shewn by the Clock, gives the Time shewn by the Clock when the star passes the Meridian. But the Mean of the Times of the equal Altitudes of the same Limb of the Sun must be corrected by the Equation of corresponding altitudes, to find the Time of his Centre passing the Meridian by the Clock [since the declination of the Sun changes]. ...

Maskelyne went on to say that for observing equal altitudes, the most exact instrument in general use was the astronomical quadrant. He took several pages to describe in detail how to set up and use such an instrument, in particular the astronomical quadrant of 1-foot radius constructed by John Bird (see Figure 3). For those not equipped with such an instrument, Maskelyne outlined how noon could be found using double altitudes measured with a Hadley's quadrant, or as a last resort by using a plate with a hole in it (as Winthrop did).

The other type of measurement made during a transit, namely the angular separation of the limbs of Venus and the Sun, could be made using a filar micrometer (again such as Winthrop used) but Maskelyne advised that the most convenient and exact instrument for the purpose was a split objective micrometer or heliometer as it was later called. This device was placed at the front end of a telescope, the standard being a 61 cm long Gregorian reflector of 11cm diameter (see Figure 4) made by James Short, the same person to whom Winthrop sent his observations of 1761. Maskelyne gave a thorough description of how to use the micrometer which consisted of two halves of a lens, one half moveable by means of a screw. Each half lens produced an image. If the observer wished to measure the angular diameter of the Sun, for example, he would turn the screw which moved one of the half lenses until the two images of the Sun were tangent to each other. The distance through which the lens was moved was calibrated so that the angular measure could be found.

5. THE 3 JUNE, 1769 TRANSIT

With the experience of the 1761 transit behind them, astronomers were better prepared and international tensions had eased by 1769. Also the parts of the Earth where the entire transit could be observed were more accessible. Perhaps the most famous transit expedition was that of James Cook to Tahiti.

There were at least four observing sites in Canada. At Quebec City, Samuel Holland (who had been Cook's instructor a few years earlier and now the Surveyor-General for North America) began three months before the transit by finding his latitude using Bird's astronomical quadrant. Holland (1769) found his latitude (the mean of nine observations) to be $46^{\circ}47'15''$. To

get his longitude, he observed three immersions and two emersions of Jupiter's first satellite between March and June with a refracting telescope by Dollond. From the times of these phenomena, the Astronomer Royal, Nevil Maskelyne, deduced Holland's longitude to be $71^{\circ}10'15''$. However, we know from the situation of Holland's house and modern maps that his longitude was $71^{\circ}14'49''$ and his latitude just as he said. When it came to the actual transit, Holland used the same refractor and M. St. Germaine of the Quebec Seminary, observing with Holland, used one of the standard reflectors of 61 cm focus made by Short. The observers were only able to time the first contact, clouds preventing further timings.

Holland's assistant, Thomas Wright, observed the transit from Isle aux Coudres, about 90 km downstream from Quebec City. From several observations with "a brass Hadley's sextant of about 15 inches radius", Wright (1769) derived his latitude as $47^{\circ}16'30''$ using several observations of two altitudes with the interval of time between them. According to modern topographic maps the latitude of the north-west side of the island where Wright was located, is $47^{\circ}25'$. Something seems to be wrong with his observations and Newcomb (1891) noted, "The observer at this station seems to have been most unfortunate in his determination of his position, his printed computations being full of blunders."

Wright did not give his longitude, saying he would find it in the coming months, but from modern maps it appears to be about $70^{\circ}24'$ and Newcomb figured it was $4^{\text{h}}41^{\text{m}}39^{\text{s}}$ or $70^{\circ}24'38''$. To observe the transit, Wright used a standard Gregorian reflector equipped with "two oblong smoked glasses with different shades, made to slide in a groove fixed to my telescope." Maskelyne used Wright's observations and made slight corrections, finding for second contact $2^{\text{h}}50^{\text{m}}19^{\text{s}}$ or $2^{\text{h}}50^{\text{m}}50^{\text{s}}$ depending on whether the time was determined by the round appearance of Venus or by the breaking of the dark thread respectively. The observations at Quebec and Isle aux Coudres were also published in the *Transactions of the American Philosophical Society* in 1771 (Vol. 1, Appendix, p. 15)

The Hudson's Bay Company (which controlled much of what is now Canada) took an interest in the transit. This is not too surprising since some of its London governors were also prominent in the Royal Society. As Ball and Dyck (1984) pointed out, the Company asked at least one of their chief factors, Ferdinand Jacobs at York Fort, to observe the transit. This he did "with a very good Telliscope Armed wth a Smooted Glass next the Eye." Unfortunately, he only reported the times of contact to the minute and gave no information on whether he corrected his clock, so his results were of no use. A much better course of action was taken in the case of two astronomers sent out by the Society to Fort Prince of Wales at Churchill. With the support of the Company, instructions from the Astronomer Royal, equipment from the Royal Society, and favoured by good weather, they made the only complete timing of any transit of Venus ever observed in Canada. William Wales (1734-98) and Joseph Dymond (1746-96) were two young Yorkshire men who had worked under the Astronomer Royal, Nevil Maskelyne, at Greenwich and he recommended them to the Royal Society for the transit expedition. The Society appointed them and arranged with the Hudson's Bay Company for their transportation and accommodation. Because ice usually chokes Hudson Strait until June each year, they had to arrive nearly a year ahead of time, in the summer of 1768. These observers and their accomplishments have been the subject of many articles, including a very recent one by Griffin-Short (2003). One aspect of the Wales and Dymond expedition that does not seem to have been noticed elsewhere is that they took with them a prefabricated wooden observatory designed by the great British engineer, John Smeaton. This is mentioned in the minutes of the Council of the Royal Society in March and April, 1768, and briefly in Wales' (1770) descriptive journal and in the Churchill post journal.

Unfortunately, no illustration of the observatory is extant among the Smeaton drawings at the Royal Society.

Wales and Dymond (1769) made hundreds of astronomical observations during their long year at Churchill. They used Bird's astronomical quadrant to find their clock correction just as Maskelyne had outlined in *The Nautical Almanac*, and to take nearly two hundred meridian altitudes to find their latitude. All their observations included thermometer and barometer readings so that refraction could be taken into account. Though Wales was puzzled by the large scatter in the values he got for latitude, careful examination now shows that the best values were obtained using the Sun near summer solstice (when it was as high as it gets) and using stars whose declinations were well-known (e.g. α Persei) and which transited at zenith distance less than 10° , in other words where refraction was minimized. If Wales had restricted himself to these situations, he could have found his latitude within 2" of its modern value ($58^\circ 47' 48''$). Using standard Gregorian reflectors made by Short, Wales and Dymond also observed six occultations of stars by the Moon and one immersion of Jupiter's first satellite. These would have been useful in determining the longitude of Churchill, though it appears from Maskelyne's (1771) report that observations at Greenwich, or some other established observatory, would also have been needed to serve as a basis of comparison. Results from the Ephemeris Generator show that the Churchill occultation observations were remarkably accurate. If the events at the Moon's bright limb are excluded as well as the one event which was nearly a grazing occultation, their timing errors of the remaining five events were -7, 0, -8, 0, 0, seconds. Recalling that in 2 seconds of time, the Moon moves about 1 arc-second, and that the error in longitude would therefore be 30" for every 2 seconds error in the time of the occultation, it seems safe to say that the longitude of Fort Prince of Wales could have been determined within 1 minute of arc. Dymond and Wales did not calculate or even state their longitude but Hornsby (1772) who used their observations along with others to calculate a mean solar parallax of 8.78", gave the longitude of the Fort Prince of Wales just 19" (or about 300 land metres) short of the modern value ($94^\circ 12' 41''$). Hornsby did not say how he calculated this.

To observe the transit itself, Wales and Dymond had the two Short telescopes, one with a split objective micrometer attached to it. This was used to measure the distance between the limbs of Venus and the Sun about fifty times as the transit progressed. It was also used to measure the angular diameters of Venus and the Sun which can now be used to check the micrometer's accuracy. It had a mean error of $\pm 2''$.

An interesting personal sidelight is that Wales had married Mary Green in 1765. She was a sister of Charles Green who was the astronomer on James Cook's expedition to observe the transit at Tahiti. Wales was the astronomer on Cook's second and third voyages. About 1780, Wales became mathematical master at Christ's Hospital in London where he was a popular teacher of navigation for the rest of his life. He wrote a number of papers and books, mainly relating to navigation and was appointed to the Board of Longitude in 1795.

Nothing is known of Dymond's career after 1769 and even his dates have not been verified but were taken at face value from a website <http://www.brierly59.freemove.co.uk>. Thanks to the initiative of Peter Jedicke, asteroid 15045 has recently been named Walesdymond in honour of these two dedicated observers.

6. THE NINETEENTH-CENTURY TRANSITS

A lot changed in the century following the transit of 1769. Canada became a nation and now had the ability to co-ordinate observations. On the technological front, the invention and spread of telegraphy allowed observers to get accurate time signals, a vital aspect of accurate observations. Perhaps most significant as far as Canada was concerned, was the heightened interest of the general public in the transit. The rise of the middle class and much better access to education had assured that. How much of a boost is difficult to quantify, however, since few newspapers which are the main indicator of widespread interest existed in the previous century.

A development which was very important to transit studies in the United States, photography, made no impact in Canada. Even though E.D. Ashe had photographed the Sun at the Quebec Observatory in 1868 and had travelled to Iowa to take pictures of the solar eclipse the following year, there is no record of any Canadian attempting to photograph the nineteenth century transits. Part of the reason was probably the reliance on the advice of the Astronomer Royal who wrote, "It is decided by almost unanimous consent, that no real assistance can be obtained by application of photography" (Airy 1880).

7. THE TRANSIT OF 9 DECEMBER, 1874

The transit of 1874 was not visible in North America since it occurred between 01:49 and 06:26 UT. Nonetheless the rare event stimulated interest even in Canada. In 1873, the Toronto firm of Rowsell & Hutchison (who later printed early volumes of our Society's *Transactions*), published a 48-page book by Joseph Morrison, entitled *The computation of the transits of Venus for the years 1874 and 1882, and of Mercury for the year 1878, for the Earth generally and for several places in Canada, with a popular discussion of the sun's distance from the earth, and an appendix shewing the method of computing solar eclipses*. Morrison computed the times of contact for 1882 for a number of sites including three in Canada – Toronto (about 2 minutes late compared to those derived from the Ephemeris Generator), Bishop's College, (Lennoxville, Quebec) and Acadia College (Wolfville, Nova Scotia). In the preface to the book, the author stated, "This is, I believe, the first work of the kind ever published in Canada, and therefore I hope it will tend to encourage, in this country at least, the study of the grandest and noblest of the Physical Sciences." While his phrase "of the kind" is open to interpretation, there does not seem to be any earlier Canadian example in science of such a mathematical nature. According to *American men of science* (1906), Joseph Morrison was born in Oxford (between Kingston and Ottawa) in 1848, and graduated from the University of Toronto in 1872, the year before he wrote his book on the transits. He may at this time have been a high-school teacher for by 1880 when he wrote a textbook on trigonometry, he was "Principal of the Walkerton High School, and Ex-Principal of the Newmarket High School." He went on to get his M.D. and Ph.D. and to work at the Nautical Almanac Office in Washington, D.C. He later was an Honorary Member of our Society.

The United States sent expeditions abroad to photograph the transit, but Canada was much too young and had no substantial resources to contemplate such an undertaking. Canadians had to content themselves by reading articles, and there were several about Venus in various newspapers. One article noted, "For considerably over a year the papers have been full of her name and her doings and her approaching transit" (*The Daily Globe*, Toronto, 12 June, 1874). A full page spread in the *Canadian Illustrated News* for 5 September, 1874 showed observatories set up in Japan for the transit (see Figure 6). Some of the illustrations were identical to those published in the *Daily Graphic* of New York on 9 July, 1874. The *Canadian Patent Office*

Record and Mechanics Magazine reported differences of opinion concerning the American and European methods of photographing the transit. It was felt that the method used at the Kew Observatory of enlarging the focal image could introduce errors of scale.

Following the 1874 transit, Alexander Johnson (Carpmael et. al. 1883), Professor at McGill College, wrote to the Montreal papers lamenting the poor equipment at his institution and stressing the need for proper instruments at the next transit of 1882. His plea eventually bore fruit, most notably in the donation by E. T. Blackman of a 16 cm equatorial of 213 cm focal length and other important equipment.

So, even though the transit of 1874 was not seen in Canada, it still raised public awareness and eventually resulted in improved facilities at one Canadian university and gave a budding astronomer a chance to try his wings.

8. THE 6 DECEMBER, 1882 TRANSIT

The entire transit of 1882 was visible in the central part of Canada and in the Maritimes. The beginning occurred before sunrise to the west of Winnipeg; the end took place after sunset in Newfoundland and Labrador. In December, the Sun was at a low altitude even at noon throughout Canada, and in most of the country weather prospects were not very bright. Nonetheless the public and scientists alike were determined to see the event. The daily newspapers generally provided commentary on the 6th of December or in some instances on the 5th or 7th. Even a lengthy poem appeared in both *The Toronto World* and *The Evening Telegram*, Toronto, on December 6, spoofing the interest of astronomers in the love goddess. A few lines give the flavour:

But ne'er the less she stands to-day the watched of every nation,
Who see her make her little bow in silent admiration.
Methinks I see bald heads, you've seen them at the ballet,
With glasses levelled at the nymphs as forth to dance they sally;
You know how fond they are of that, we'll keep the fact between us,
But lo! this morn they sally forth to have a look at Venus;
For every one of them will feel it is his bounden duty
To have a good square look at her, the highest reigning beauty.

8.1 Preliminary advice

There were some instances of dubious advice in the press just prior to the big event.

Ordinary observers will require only a piece of smoken glass, or of colored glass, dark brown or blue. ... They will not be favored with the opportunity of seeing it through the official telescope, as no one will be allowed to approach the vicinity of the observers, as the exceedingly nice observations required demand absolute freedom from interruption. (*Manitoba Daily Free Press*, Winnipeg, 5 Dec.)

A good view of the sun may be had, by anyone who has a common telescope [by fitting] ... a cap of tin over the large end, having previously punched in the centre of this cap a round hole about an eighth of an inch in diameter. The lenses should all be carefully wiped ... with a silk handkerchief. ... "J. Peeper" (*The Evening Telegram*, Toronto, 5 Dec.)

The transit ... will doubtless be viewed by thousands whose sole object will be ... to gratify motives of curiosity. Providing the weather is clear and the sky generally unclouded a view of the transit is within the reach of all. Even spyglasses and binoculars may be dispensed with, and provided with nothing more expensive than a piece of smoked glass the transit of the planet over the surface of the sun may be seen from its first contact to its close. It is even quite possible to see it with the naked eye if the observer's [optics?] are sufficiently powerful to stand the intense light projected upon them from the sun. In the event of the atmosphere being hazy, the likelihood of its being visible to some with the unaided vision will be largely increased. (*Globe*, Toronto, 6 Dec.)

As it turned out, the advice at least for Torontonians, probably did no harm since they only got a few glimpses through clouds of the planet on the Sun.

8.2 Newspaper accounts:

Before considering the scientific observations at Winnipeg, Kingston, Ottawa, and Cobourg and newspaper accounts of them, here are a few excerpts from the press describing what was seen (or not seen) elsewhere.

London: ... Messrs. [William] Saunders and [W. D.] McGlohan were to assist each other in the work; but unfortunately the sky was ... densely covered with clouds ... Momentary glimpses were secured between 12 and 2 o'clock, sufficient to give an opportunity to those who were fortunate enough to be on the spot to obtain very fair views (*The Free Press*, London, 7 Dec.).

Woodstock: The transit of Venus was visible through light but continuous clouds here today. On account of cloudiness no observations of any benefit could be made at the observatory (*The Free Press*, London, 7 Dec.). [For full information see Mozel (1982).]

Toronto: ... Early [in the] morning the gentlemen who had obtained permission to view the transit from the tower of THE MAIL placed their telescopes in position and, hoping against hope, awaited the result. Outside of the Observatory, THE MAIL offered the best position anywhere near the business part of town for observing the phenomenon as it towers far above every other building in the neighbourhood. ...

Cold and miserable, the amateur astronomers stuck to the roof of THE MAIL until the transit was over. Then, as they packed their instruments, a gentleman remarked that he hoped they would have better luck on the next occasion. ...

At the Observatory, besides the regular staff, two or three gentlemen brought their own instruments to the Observatory, so as to get the correct time should a chance present itself of viewing the transit. One of these, Mr. Roberts, used an eight-inch reflector of his own manufacture and which, by the way, is an excellent instrument. Mr. Miller, secretary to the hospital, was there also with a four-inch refractor, whilst Mr. Menzies was prepared to do his part with an altazimuth transit. All these gentlemen waited patiently until the hour of the last contact had passed. They were rewarded early in the day by a glimpse of the planet on the sun, but only for a few seconds. Mr. Carpmael spent a couple of hours beside the

new six-inch equatorial which was recently mounted in the tower, and although he got one or two views of the sun, was unable to get any of the contacts.

Mr. G. P. Hector, a gentleman connected with the Meteorological staff, busied himself in timing the period at which the sun was visible ... (*The Toronto Mail*, 7 Dec.). [For more information on the equatorial, see Beattie (1982).]

Whitby: ... The transmission of the time from the Toronto observatory was eagerly waited for at the Great Northwestern Telegraph office in Whitby, while arrangements were being completed at the Ontario Ladies College by Rev. Mr. Hare and Mr. Christopher Johnson for observing the transit. The exact time was received, and a chronometer was carefully set in accordance therewith at the College. A splendid 6-inch object glass, with a focal length of nine feet six inches, had been placed in position. This splendid instrument, with magnifying powers from 60 to 300 diameters, was secured [from Fitz of New York] by Rev. Mr. Hare for the College at an expense of \$1,200 ... From 12 o'clock the weather continued cloudy, preventing anything like accurate observation up to 1:50 p.m., when the clouds cleared away and the sun shone out brilliantly. No time was reported by the College authorities, but the following was taken by outside parties: - At 2 hours, 29 minutes, 34 seconds, the point of internal contact at egress was observed; at 2 hours, 46 minutes, 44 seconds, the planet appeared on the edge of the sun like the indentation of the tooth of a saw on its rim, and at 2 hours, 48 minutes, had disappeared. (*The Gazette*, Montreal, 7 Dec.). [An image of the Whitby Ladies College is at <http://www.castle-ed.com/>. The calculated local mean times of third and fourth contact are $14^{\text{h}}32^{\text{m}}41^{\text{s}}$ and $14^{\text{h}}53^{\text{m}}18^{\text{s}}$ respectively.]

Belleville: M. Shearmen du bureau meteorologique de Toronto a pris ses dernieres dispositions pour observer le passage de Vénus aujourd'hui. Les observateurs seront prises près de l'église St. Thomas (*Le Monde*, Montréal 6 Dec.). [Mr Shearmen observed with a 10 cm achromatic telescope. (Carpmael et. al. 1883)]

The sky was heavily clouded with occasional glimpses up to about 11:35 local time ... after that time the sky became clear and the passage of the planet over the sun's disc was plainly visible. This favourable state continued until the time of the third and fourth contacts, of which good observations were had, although the third or inner contact was much interfered with by the black drop (*The Globe*, Toronto, 7 Dec).

Picton: ... A good sized telescope belonging to Lieut.-Col. Begg showed the transit to advantage, and a large number of persons took the opportunity ... (*The Free Press*, London, 7 Dec.).

Montréal: ... The citizens of Montreal generally seemed to take a great interest in the event as well, and on most of the streets of the city, during the morning, people were to be seen looking through smoked or colored glass, or anything through which the phenomenon could be seen.

... the sky was completely covered with clouds until ... five minutes past ten, when the sun came out, and Venus was seen well in upon the sun's disc. It was also seen through colored glass at some of the stations, and others saw it – when a slight haze passed over the sun –

with the naked eye. A representation of the sun about 4½ inches in diameter was projected on the wall of the observatory by means of the finder telescope, on which the image of Venus was very distinctly marked, its diameter being apparently about one-thirtieth part of the sun's diameter. The clouds came again over the sun about ten minutes past eleven, and continued the rest of the day. ... The snow coming on, the observers put the cap on the telescope, closed the shutter in its roof, and withdrew (*The Gazette*, Montreal, 7 Dec.). [For information on the McGill Observatory and its equipment see Carpmael et. al. 1883 and <http://www.radar.mcgill.ca/3McGillObs.pdf> and <http://blackader.library.mcgill.ca/campus/buildings/Observatory.html>]

Les gamins qui se tenaient au coin des rues et vendaient aux passants des morceaux de verre enfumés, n'ont pas fait de brillantes affaires, sans compter qu'il y a beaucoup de mortes saisons dans cette branche d'affaires.

Sur la rue St-Louis, le désir de voir Vénus a fait faire des prodiges. Quelqu'un qui n'avait pu trouver un morceau de verre et qui ne voulait pas encourir les frais de casser un carreau, imagina de détacher la fenêtre entière et après avoir enfumé un carreau, il commença ses observations.

Beaucoup de personnes ont pu le voir dans sa cour et sur le trottoir portant sa fenêtre à bras tendu au-dessus de sa tête. Mais lui il n'a pas vu Vénus. (*Le Monde*, Montréal, quoted by *L'Evenement*, Québec, 7 Dec.).

Québec: Il paraît que nous anticipions hier, en annonçant que le transit de Vénus ne pourrait être observé à Québec, à raison de la neige qui tombait depuis le matin. Les rares personnes qui ont eu le courage de demeurer à l'affût toute la journée, ont eu le bonheur de voir le phénomène, dans une éclaircie qu'il y a eu à 1:30 heure et qui a duré environ minutes. C'était, paraît-il, quelque chose de splendide (*L'Evenement*, Québec, 7 Dec.).

... great is the disappointment ... among amateur astronomers. When day broke a heavy snow storm was raging, and continued to prevail with more or less violence ... Shortly after one o'clock when for a brief space say from ten to fifteen minutes, the disc of the great luminary became visible. Even then, however, the view was partially obstructed by the light vapoury clouds passing across the face of the orb of day, so that for one who chanced to catch a momentary glimpse of Venus hundreds were disappointed. (*The Globe*, Toronto, 7 Dec.). [The 20 cm Clark refractor at the Quebec observatory was used by Lieut. Gordon and W. A. Ashe, son of the E. A. Ashe mentioned in section 6. The telescope is at the Centre muséographique de l'université Laval, Quebec.]

Saint John, N.B.: ... The sky was obscured in St. John throughout the day, though about 3 o'clock a break in the clouds afforded occasional glimpses of the transit. The members of the Commons Council armed with opera glasses made several observations from the Court House, and Venus was plainly visible at times to the naked eye, as a small black sphere on the face of the sun (*The Daily Sun*, Saint John, 7 Dec.).

Fredericton, N.B.: The observation of the transit of Venus to-day at the N. B. University Observatory was only a partial success. ... Dr. Jack, the President, and Mr. John Babbitt

were there, but the cloudy weather interfered seriously with their vision. The result of the observations, however, were kindly furnished THE SUN'S correspondent by Dr. Jack: "It was cloudy all day till about 3 p.m. when the sun appeared. I had a very distinct view of Venus on the sun's disc. I watched it there for about fifteen minutes or until about five minutes before the calculated time of the last internal contact and was rejoicing over the prospect of getting it, but unfortunately clouds now rendered the sun invisible and I got no view of him till Venus was about one-third across the sun's disc, when I caught a passing glimpse of both. Clouds then covered them both from sight and nothing more was seen." (*The Daily Sun*, St. John, N.B., 7 Dec.). [For information on W. B. Jack, the observatory and telescope, see Kennedy (1955) and other papers by the same author. The observatory stands on its original site, and since 1985 has been operated as a museum. The original 15 cm f/15, mahogany and brass refractor, by Merz of Munich, is under the octagonal dome. Image of observatory and brief description <http://www.unb.ca/welcome/Histbldgs.html>]

Halifax, N.S.: Very rainy and dark here all day. Astronomers made no observations (*The Daily Sun*, St. John, N.B., 7 Dec.). [According to Carpmael et. al. 1883, A. Allison had planned to use a 10 cm refracting telescope by Dollond.]

Charlottetown: This was a bad day for the transit. We sympathise with Dr. Leeming, Captain Maxwell, Mr. Cundall and others who are deeply interested in the event (*The Daily Examiner*, Charlottetown, 6 Dec.). [H. J. Cundall had a 10 cm refracting telescope, according to Carpmael et. al. 1883.]

In the newspapers, there seem to be only a couple of allusions to students observing the transit. On December 7, the Montreal *Gazette* reported that "The young ladies of the [Ontario Ladies College at Whitby] crowded out in numbers and had a splendid chance for witnessing it." The Toronto *Globe* stated that "At the Royal Military College [Kingston] Lieut.-Col. Oliver, Major Kensington, and a number of the cadets obtained a good view of the ingress through a three-inch telescope." The University of Toronto's student newspaper, *The Varsity*, reviewed a lecture on the subject on the eve of the transit but gave no hint that any readers attempted to see the actual event.

8.3 The scientific observations:

By 1882 it was doubtful that transits of Venus provided the best means of finding the astronomical unit. Nonetheless, Harkness at the United States Naval Observatory spent years reducing photographic measurements of both nineteenth century transits. Many astronomers made visual observations, and their results were used to find the solar parallax, at least in England.

In Canada, only the times of contact were found and considerable effort went into obtaining the best times possible. By 1882, there was already a network of meteorological observers under the supervision of Charles Carpmael in Toronto. He had had some astronomical training in England before emigrating to Canada in 1872 and was eager to combine solar and meteorological research. Perhaps he saw the transit as an opening for him to get a decent telescope which would enable him to do that. By 1881 he was Superintendent of the

Meteorological Service and was the organizer of the scientific transit observations of 1882 in Canada. One of the tasks he and his assistants undertook each year was the preparation of the astronomical part of *The Canadian Almanac*. For the 1882 edition, he gave formulae to calculate the Greenwich mean times for each of the four contacts of Venus with the Sun during the transit, and listed in tabular form what the times were for Fredericton, Quebec and Toronto. These formulae, taken from *The Nautical Almanac and Astronomical Ephemeris for the year 1882*, required the distance to the centre of the Earth, the geocentric latitude and longitude to be known.

The times calculated using these formulae are about 2 minutes ahead of the times found using the online ephemeris generator. Presumably this discrepancy is a measure of the error in contemporary theory which world-wide observations of 1882 would have helped to improve.

A large part of the work of Carpmael and his tiny staff was in making weather forecasts from observations telegraphed to Toronto by a large network of observers, mainly unpaid volunteers. Some of these observers, such as H. J. Cundall at Charlottetown, and the Bishop of Rupert's Land at Winnipeg also played a part in preparing for the transit. Some other official transit observers, W.A. Ashe at Quebec, Professor Clement H. McLeod of McGill College in Montreal and Professor James Williamson at Queen's University in Kingston, were at established observatories which were partly supported by the Meteorological Service. Still others such as Professors William Brydone Jack in Fredericton, A. R. Bain in Cobourg, J. J. Hare at Whitby and Newton Wolverton at Woodstock, Ontario, were at universities and colleges with no connection to the Meteorological Service. There was no national society bonding scientists together until the establishment of the Royal Society of Canada which also happened in 1882. So it is not surprising that Carpmael had to ask Jack and Bain, for instance, what telescopes they had in his efforts to enlist their aid in a comprehensive Canadian effort and he seemed completely unaware of the plans to view the transit by Lt.-Col. Oliver at the Royal Military College in Kingston and by Lindsay Russell, Deputy Minister of the Interior in Ottawa. There were others with telescopes who hoped to observe the transit who did correspond with Carpmael. They included William Saunders of London, Ontario, Canada's foremost expert on agriculture, Alan Miller and Mungo Turnbull who were early members of the Toronto Astronomical Society (of which Carpmael became President in 1890-94), and a Mr. Williams of Leamington who intended to buy a 6 inch (15 cm) telescope to make observations of the transit.

The impetus to make accurate timings of the transit seems to have come from an outside source. Carpmael wrote to G. G. Stokes, the Secretary of the Royal Society, on 10 October, 1881:

A copy of the report of the Committee of the Royal Society appointed for the purpose of advising the Treasury and Admiralty with respect to the conduct of the transit of Venus observations in 1882, which was forwarded through the Colonial Secretary to the Government of Canada, was submitted to me ...

By the end of the year in his annual report to the Minister of Marine and Fisheries, Carpmael stated:

Having been requested to report for the information of the Department on the advisability of Canada taking part ... I should deem it exceedingly unfortunate if the opportunity were allowed to pass without being utilized to the utmost.

Parliament responded in May, 1882, by granting \$5000 to cover expenses in connection with the transit. This was in addition to the regular Meteorological Service annual budget of \$37 500.

Carpmael lost no time in despatching his assistant, Andrew Gordon, to England to learn firsthand how observers were being trained, to purchase equipment, including a 15 cm refractor from Thomas Cooke and Sons (Beattie, 1982) and to visit observatories such as Radcliffe and Kew to see what other useful information (or equipment) he could obtain. Gordon returned with a mechanical model of the transit, solar wedges and a couple of borrowed chronometers. Using the model, Carpmael organized two training locations – one at McGill which followed directly after the AAAS meeting there, and a later one at Toronto. Arrangements were made to connect observers telegraphically so that they could receive reliable time signals on the night before the transit (and the night after, if necessary), and chronometers were lent to observers who did not have any, so that accurate time could be kept during 24 hours between telegraphic signals. At some of the observing sites with uncertain latitude and longitude a series of accurate stellar measurements had to be made with a meridian telescope in order to improve the geographic coordinates. The details of the thirteen sites, names of the observers, equipment, and times can be found in Carpmael et. al. (1883). In recent years, they have also been listed by Thomson (1978) and discussed by Jarrell (1988). Only at Winnipeg, Kingston and Ottawa were the skies clear enough to time more than one of the contacts. At Belleville and Cobourg, third contact was timed through an unsteady atmosphere but the Belleville results were further vitiated by uncertainties in the time signals. All the observations which Carpmael reported to the Royal Society are listed in [Table 1](#). Local mean times are used since standard time zones were not adopted until 1884. Carpmael also co-ordinated observers at other sites (Woodstock, Toronto, Whitby, Montreal, Quebec, Halifax, Charlottetown, Fredericton) but as there were at best only short breaks in the clouds allowing Venus to be seen briefly, no useful observations could be made at those locations.

8.4 Additional information at the sites of the scientific observations

Many interesting details are found in the official reports (Carpmael et. al. 1883) but they will not be reiterated here. The following newspaper accounts from centres where accurate timings were made add some colour to the formal reports. Similar reports are often found in several different papers and so these are only a sample.

Winnipeg: ... A small and unpretentious looking rough board shanty has been constructed a few rods east of Main Street, a little north of the St. John's Ladies College. The only circumstance likely to attract the attention of the passer-by is the divergence of the telegraph wire from its line along the street, and its attachment to the building. here is the spot from which the important and anxiously expected observations are to be taken. ... [Aside from the times of contact] efforts will be made to discover whether or not Venus has any satellites; though from previous observations it would seem to pretty well established that there are none. The appearance of the planet in its various positions will also be carefully noted, as, for example, the ring of light which has been seen to surround it when about half of its surface is upon that of the sun. ...

Winnipeg is the most northerly station in America at which observations are to be taken; and it was selected on account of the greater probability here than elsewhere of favourable weather at this time of the year. ... (*Manitoba Free Press*, Winnipeg, Dec. 5)

The only shelter which the observers enjoyed was that afforded by the walls of the building, as the roof had to be opened for the taking of the observations. It may readily be supposed that the exposure was trying in no small degree on such a day, when the cold was by far the most severe of the season. At one o'clock or about the time when the last observations were taken, the temperature as recorded at the St. John's College meteorological observatory, was about eighteen degrees below zero [Fahrenheit]. The velocity of the wind was about twenty-three miles per hour. Fortunately the drifting snow did not greatly obstruct the vision at the time of the internal contact at egress. (*Manitoba Free Press*, Winnipeg, Dec. 7)

[The observers and equipment came from McGill College, Montreal. See Carpmael et. al. (1883).]

Yesterday, during the time in which the transit took place, smoked glass, opera glasses, telescopes and theodolites were universally in requisition. ...

The amateur astronomers retired early [the night before], buoyed up by the hope that their observations would result in incalculable benefit to the human race. ... In their great joy at beholding the sight, our friends quite forgot to take the time, or make any calculations. The golden opportunity having slipped away and ... vowing to be more cautious in future, the embryo astronomers dismounted the apparatus, and went their way sadder, and it is to be hoped, wiser mortals (*Manitoba Daily Free Press*, Winnipeg, 7 Dec.).

Cobourg: ... Internal contact at egress was observed and time taken, but the external contact was hidden by clouds. The illumination of the atmosphere of Venus after internal contact at egress was very distinct, and observed independently at the station by the three parties entrusted with the observations. The planet, when on the sun's disc, appeared of a greenish-grey colour, probably due to earthshine. No black drop was seen (*The Globe*, Toronto, 7 Dec.).

Kingston: ... The ring of light around Venus long before internal [2nd] contact was very manifest. ... The following facts have been made public by Col. Oliver, of the Royal Military College. Venus appeared on the edge of the sun about 9 o'clock. The internal contact occurred at 9h, 18m, 10s. The conclusion of the transit was clearly viewed, the heavens being without a cloud. The internal contact, when the planet was even with the edge of the sun, occurred at 2h, 42m, 30s. Venus passed the outer edge at 3h, 2m, 30s. (*The Gazette*, Montreal, 7 Dec.). [Assuming the times are LMT, the errors (observed - calculated) for the 2nd, 3rd and 4th contacts respectively are -88, +7, -34 seconds.]

Ottawa: ... Many persons interested in the transit visited the observatory on Nepean Point this morning, and viewed the progress of Venus across the sun's disc. Astronomers and curiosity seekers wended their way across the fields... The "observatory" ... is a small tent, about twenty feet square, arranged in such a manner that the top can be thrown back, thus allowing free scope for the observations ...

Shortly after half-past two o'clock the clouds cleared away, the snow stopped, and the sun came out bright and shining. The great opportunity for taking observations [at egress] had come, and the discouragement previously felt was entirely dispelled.

Quite a number of persons were present at the "closing ceremonies" of the observations. Among those in the observatory were the Hon. A. W. McLelan, Minister of Marine and Fisheries [the government department responsible]; and Mr. William Smith, the Deputy Minister; besides Mr. [B. C.] Webber, the "Young Probs" of the Meteorological Service, and Mr. Frank L. Blake, who was in charge of the observations. (*The Free Press*, Ottawa...)

Through the politeness of Mr. Frank Blake, D.L.S. who conducted the observations in Ottawa, a representative of THE CITIZEN had the pleasure of witnessing the transit. ... Many citizens took advantage of the information supplied in this journal and made observations on their own accord through telescopes and opera glasses, and many through plate smoked glass (*The Daily Citizen*, Ottawa, 7 Dec.).

Lindsay Russell, Surveyor-General, took observations at his residence on Cooper Street with a more powerful glass. He could not get the time of contact owing to the operations of a cloud at the critical moment, but reports having observed the "black drop." (*The Evening Telegram*, Toronto, 6 Dec.)

8.5 Concluding remarks concerning the 1882 transit

Generally speaking, the papers were supportive of the scientific efforts but *The Evening Telegram* of Toronto had some reservations. They noted, "the observatory is not situated in a good place. It is too far to the north of the city. The chimneys and housetops are in the way." They did concede, "The transit will be a good thing for science, but it will not do much for humanity."

Carpmael forwarded the results from the four centres which had been able to time one or more contacts to E. J. Stone, the astronomer in England whose responsibility it was to reduce observations of timed contacts from throughout the British Empire. Eventually Stone (1892) completed his task and it is clear from his earlier report (1888) that he made use of six Canadian internal contacts among 56 in all and deduced a solar parallax of $8''.850 \pm 0''.022$. The American astronomer, Harkness, at the U.S. Naval Observatory, measured photographs and came up with $8''.842 \pm 0''.011$. The Germans, apparently used heliometer measurements and the French a combination of procedures. But in spite of the years of labour that went into the preparation for the transit and the reduction of the results, no one was too surprised that there was still a lot of uncertainty in the solar parallax. The situation was neatly summarized in *Scientific American* (1884):

Prof. Young, after showing in the fullest manner the many methods of measuring the distance from the earth to the Sun, and detailing all that had been hoped for, ... concluded that this last [transit] was a disappointment. ... The measurements made with the planet Mars by the astronomer Gill were upon the whole more satisfactory. ... The fact was becoming known that the system pursued by the French scientist Leverrier, that of calculating the earth's distance by the perturbations of the Moon, seemed to contain the best elements of approximation to the absolute truth.

9. THE CANADIAN LEGACY OF THE TRANSITS

The transits of Venus had important repercussions in the development of astronomical science in Canada. William Wales, who observed the 1769 transit with the co-operation of the Hudson's Bay Company, later taught mathematics and navigation to boys at Christ's Hospital in London. So when the Company began to realize the need for accurate maps of their vast Canadian territory, they turned to Wales to recommend an astronomer. He had firsthand experience with the harsh conditions such a person would face and also knew his boys' abilities. Wales recommended Philip Turnor who spent years in Canada and in 1790, at Cumberland House, trained two of our foremost map-makers, David Thompson and Peter Fidler.

The 1874 transit, though invisible here, still stirred interest and probably launched the astronomical career of Joseph Morrison. The transit of 1882 helped to build a sense of community among astronomers in Canada and perhaps more broadly among Canadian intellectuals. Though Hogg (1982) associated the transit with the founding of the Royal Society of Canada, she did not claim, and there are no known records to prove, that the transit influenced the Society's establishment in the same year. Still, it is not hard to imagine that Carpmael, who was one of eleven members of the Provisional Council which met in 1881 (Burpee 1932), recognized that Canadian results could be an important contribution to the new Society, as indeed they were. The transit motivated improved longitude determinations of places such as Winnipeg and Cobourg and it was the reason for acquiring at least two good telescopes, the Toronto Observatory's 15 cm Cooke and Alan Miller's 10 cm Wray refractor. The former instrument is now at the National Museum of Science and Technology in Ottawa and the latter is owned by the Victoria Centre of the RASC.

The transit attracted the attention of thousands of members of the public. Such a memorable event may have been a factor in forming a basis for public support when government astronomy in Canada began to develop in the early years of the next century.

In a sense, the historic transits of Venus continue to pay dividends as they prompt us to look into, and perhaps preserve, some of our scientific heritage. The astronomers of the eighteenth century deserve our admiration for their persistence and the care and accuracy of their observations. The activities of many amateur astronomers with telescopes in 1882 shed a bit of light on the shadowy past of our Society between 1868 and 1890. Perhaps readers will feel motivated to find out more about observers named in the newspaper accounts and find out what became of the equipment they used. Perhaps someone with more patience and resources than the author will be able to say if the tendency to negative values between the observed and calculated times in [Table 1](#) hint at an error in the theory of Venus' orbit.

10. CONCLUDING COMMENTS AND QUESTIONS

For everyone hoping to see the transit on June 8, 2004, there are certainly lessons to be learned from the past. Those who wish to time the contacts would be well advised to practise ahead of time with computer simulations and to be well aware of the different stages that might be observed near internal contact such as the halo that surrounds the planet before, and the formation and breaking of a dark thread after contact. Even with such modern trappings as radio-time signals, video and digital recording, can any observers time the contacts better than their forebears of the nineteenth or even the eighteenth century? Will we do better than our great-grandparents did in providing good information to the public for safe viewing? Will the media cover the event as thoroughly as they did in 1882? Will we be better at encouraging young people, especially, to get up early in the morning to see something no living person has ever

seen? Who knows how many of them will be motivated to learn more about the heavens when they see the next occurrence of this rare spectacle unfolding exactly as predicted on 8 June, 2004?

NOTES AND SELECTED REFERENCES

Carpmael's letter books are at Environment Canada Library, Downsview (Toronto).

The numerous unauthored newspaper sources have been listed in the body of the text, rather than here. They are all from the year 1882 unless otherwise stated.

- Airy, G. B. 1880, MNRAS, 40, 381
Ball, T. and Dyck, D. 1984, *The Beaver* (Autumn 1984), 51
Beattie, B. 1982, JRASC 76, 109
Burpee, L. J. 1932, *Fifty Years Retrospect* (Ryerson Press, Toronto) p.1
Carpmael, C. et. al. 1883, *Trans. Roy. Soc. Canada* 1, 87. This includes reports by Bain, Blake, Johnson, McLeod, Williamson.
Griffin-Short, R. 2003, *The Beaver* 83 (2), 8
Halley, E. 1715, *Phil. Trans. Roy. Soc.* 29, 454
Hogg, H. S. 1982, JRASC 76, 362
Holland, S. 1769, *Phil. Trans. Roy. Soc.* 59, 247
Hornsby, T. 1772, *Phil. Trans. Roy. Soc.* 61, 574
Jarrell, RA 1988, *The cold light of dawn* (University of Toronto Press: Toronto) p. 48-50.
Following p. 26 are illustrations of W. B. Jack, the Quebec Observatory, the McGill College Observatory and the Toronto Observatory.
Kennedy, J. E. 1955, JRASC 49, 151
Maor, E. 2000, June 8, 2004, *Venus in transit* (Princeton University Press: Princeton NUJ) p. 91
Maskelyne, N, 1771, *Trans. Amer. Phil. Soc.*, Appendix, 4
Morrison, J. 1873, *The computation of the transits of Venus for the years 1874 and 1882, and of Mercury for the year 1878: for the earth generally and for several places in Canada, with a popular discussion of the sun's distance from the earth and an appendix showing the method of computing solar eclipses* (Rowell & Hutchison: Toronto)
Morrison, J. 1880, *An elementary treatise on plane trigonometry ... designed for the use of high schools and colleges*, (Canada Publishing: Toronto)
Mozel, P. 1982, JRASC
Newcomb, S. 1891, *Astron. Papers ... Amer. Ephem.*
Schaefer, B. E. 2001, JHA 32, 325
Scientific American 1884, 50, 117
Short, J. 1762, *Phil. Trans. Roy. Soc.* 52, 611
Shute, M. N. (ed.) 1980, *The scientific work of John Winthrop*, (Arno Press: New York)
[Stone, E. J.] 1888, MNRAS 48, 201
Stone, E. J. 1892, MNRAS 52, 124
Thomson, M. M. 1978, *The beginning of the long dash* (University of Toronto Press, Toronto) p. 25-27. Following page 30, are photographs of the Jack Observatory in Fredericton, C. H. McLeod, the McGill Observatory, a Troughton and Simms transit instrument, J. Williamson and T.S.H. Shearman, all of whom are mentioned in this paper.
Wales, W. and Dymond, J. 1769, *Phil. Trans. Roy. Soc.*, 59, 467

Wales, W. 1770, Phil. Trans. Roy. Soc., 60, 100
Wheatland, D. P. 1969, The apparatus of science at Harvard 1765-1800 (Harvard Univ. Press)
Winthrop, J. 1764a, Phil. Trans. Roy. Soc. 54, 279
Winthrop, J. 1764b, Phil. Trans. Roy. Soc. 54, 277
Wright, T. 1769, Phil. Trans. Roy. Soc. 59, 273

Suggested illustrations:

Figure 1. - [A schematic diagram to explain how a transit of Venus \(V\)](#) can be used to find the distance from the Earth (E) to the Sun (S).

Figure 2. - Portrait of John Winthrop by J. S. Copley, ca. 1773. Winthrop points to his diagram of the transit of 1761. A telescope is shown, similar to the Gregorian reflector he used, and in the background the pink dawn sky is seen above a hill perhaps referring to the site where he made the observations near St. John's, Newfoundland. (Taken from <http://www.npq.si.edu/exh/franklin/winth.html> and reproduced **by permission** of the president and Fellows of Harvard College, Harvard University)

Figure 3. - [Twelve-inch astronomical quadrant by John Bird](#), ca. 1767. SM 1900-138 **Courtesy of SSPL**. This is identical to the instrument described by Maskelyne in the *Nautical Almanac* for 1769 and used by Wales and Dymond at Churchill and Holland at Quebec. Illustration from Bud, R. and Warner, D. J., *Instruments of Science*, Garland, New York and London, 1998.

Figure 4. - [Gregorian reflecting telescope by Short](#), used to observe the 1769 transit of Venus. Also shows split objective micrometer in same illustration. (Used by W. Orchiston and D. Howse in *Astronomy & Geophysics* 39 6.21-6.24 (1998) **Get original and permission from The Science Museum, London**)

Figure 5. - [Portrait of William Wales by John Russell](#), 1794. **Original, Permission from Christ's Hospital?**

Figure 6. - The coming transit of Venus (Illustration from the Canadian Illustrated News at <http://www.nlc-bnc.ca/cin/h1-118-e.php?kwq=Observatory&searchBtn=Search&kwf=TRUE>)