Refereed article

The 1882 transit of Venus: The British expeditions to South Africa

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Abstract. Prior to the 19th century transits of Venus, the Cape Observatory already had a long history of involvement in parallax observations. The results of the 1874 transit were not particularly encouraging, compared to alternative methods of measuring the astronomical unit devised by that time. Nonetheless, the British decided to send out expeditions to seven countries, equipped for doing timed contact observations and supplemented by heliometer measurements.

The British party to South Africa headed for Montagu Road (Touws River today) and brought with them several instruments for use by local expeditions arranged by David Gill. These included a party to Aberdeen Road and the start of a permanent observatory in Durban. At the Cape, six observers independently observed this rare event. A number of colourful characters and interesting experiences got interwoven in the process of obtaining these observations.

Fine weather prevailed at all of the local stations, but the final results confirmed that the timing uncertainties introduced by the 'black drop' effect and the atmosphere of Venus were just too great to improve the solar parallax by this method when it was compared to competing methods.

Keyword: history of astronomy

1. Introduction

Please allow me to start with a brief personal account.

I grew up in the small dusty railway town of Touws River where it was common knowledge that in the courtyard of the Douglas Hotel there was a monument (Figure 1) commemorating a site "…where a piece of a star once fell". As kids, on our way to the 'matinée' at the local 'bioscope' we would often take a shortcut through this courtyard and sometimes briefly stop to have a look at this monument. However, we were never able to figure out the connection between two concrete pillars (one bearing a handwritten inscription titled "Transit of Venus") and a fallen piece of a star! It would take me 15-odd years, after being employed at the South African Astronomical Observatory, to clear up this local misconception for myself.

I later unknowingly completed the circle by moving to Wellington where Newcomb's American expedition had observed the 1882 transit of Venus and then I found employment at the Observatory where Gill arranged the South African observing efforts that are described here.

Figure 1. The only remaining piece of direct evidence of any Venus transit expedition to South Africa are two piers in the courtyard of the former Douglas Hotel in Touws River. (Source: SAAO Archives)

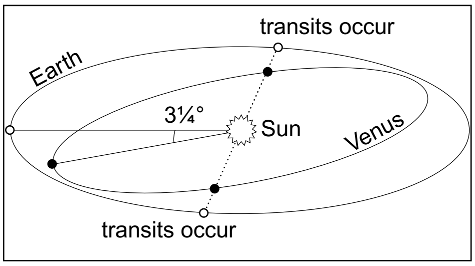

Figure 2. Because the planes of the orbits of the Earth and Venus differ by 3¼°, transits can only occur when they are simultaneously on the same side of the Sun and at one of the 'nodes' where the orbits cross (dotted line). Both planets then need to be within ±1.7° of a node for a transit to occur.

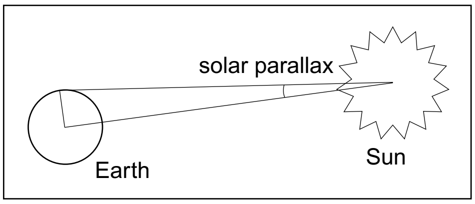

Figure 3. The solar parallax is the angular size of the Earth's radius, as seen at the distance of the Sun (picture not to scale).

My interest in these rare events was sparked off one day in April 1997 when Case Rijsdijk and myself were driving back from Sutherland. As we approached Touws River, I mentioned that I grew up there and Case asked me to show him the monument. After seeing it again, I started researching its history, casually at first but with more and more earnest as I discovered the Wellington connection and realised that the next transit was not too far away. Initially, 8 June 2004 sounded very far off but after my *MNASSA* article on the American expedition in October 2003, I suddenly found that I had to hurry to finish this follow-up paper in time for the big event.

2. Transits and parallaxes

Only the two inner planets, Mercury and Venus can transit the disk of the Sun, as seen from the Earth (Figure 2). Transits of Mercury are more common, occurring at a rate of 13 to 14 per century, compared to Venusian transits, happening on average 13.7 times per millennium (Meeus 1958). The previous transit of Venus was in 1882, when two international expeditions came to South Africa and a number of local efforts were mounted to observe this rare event, in order to investigate the solar parallax.

The solar parallax is not a distance but an angle: the angle subtended at the centre of the Sun by the Earth's radius (Figure 3). Determining the solar parallax was one of the great fundamental problems in astronomy. This provided a measure of the distance to the Sun (the 'astronomical unit'), which effectively determined all other distances in the solar system.

As long ago as 130 CE, Hipparchus and Ptolemy attempted such measurements by estimating the dimensions of the Earth's shadow cone during a lunar eclipse (obtaining a value of 7 308 808km for the astronomical unit!). In 1676 Ole Römer noticed that eclipses of Jupiter's moons occurred progressively later the further Jupiter moved away from the Earth and he correctly attributed this to the finite speed of light. Since the speed of light is constant and as its value became better determined it provided an increasingly accurate measure of the size of the solar system. Other methods included measuring the parallax of Mars or minor planets against the background stars, the motion of the Moon, perturbation of asteroids and even artificial satellites and finally, by bouncing radar echoes off Venus. In 1976 this last method fixed the solar parallax at its modern value of 8″.794148 ± 0″.000007, equating to a mean solar distance of 149 597 870 km.

Because of the proximity of Venus to the Earth, simultaneous observations of transits of Venus from widely-separated stations seem ideal as a method for obtaining an accurate measurement of the solar parallax. This idea was first proposed by James Gregory in 1663 and later refined by Edmond Halley, who unfortunately did not live to see his method tested in such grand style when numerous expeditions set out for the far-flung corners of the Earth in order to observe the 1761 and 1769 transits – and continued with almost the same vigour through to the 1874 and 1882 transits. Even though Venus gets relatively close to the Earth, the actual parallax angle is still incredibly small. Halley hoped that the event could be timed to one second, which would yield the astronomical unit to an accuracy of 0.17%. In practice, this proved quite difficult, with a parallax error of as little as 0.01 arcseconds equating to 160 000 km difference in the solar distance.

3. The Cape's parallax history

The Cape Observatory (also known as the Royal Observatory in later years) had a long involvement in addressing the solar parallax problem.

During his memorable visit in 1751–1753, La Caille made observations of the declination of Mars, obtaining a value of 10″ for the mean solar parallax, equating to a distance of 131 500 000 km.

Charles Mason and Jeremiah Dixon, on their ill-fated expedition to Bencoolen in Sumatra, were running late and ended up successfully observing the 1761 transit from Cape Town. In fact, they managed the only observations from the south Atlantic region.

During Mars's opposition in 1832, Thomas Henderson (Her Majesty's Astronomer at the Cape of Good Hope, 1831–1833) collaborated with observers at Cambridge, Greenwich and Altona and obtained values of 8″.588, 9″.343 and 9″.105 respectively. Although Thomas Maclear (H.M. Astronomer at the Cape, 1833–1870) observed the opposition of Mars in 1849/50 and 1851/52, unfortunately no complementary Northern Hemisphere observations were made to determine the solar parallax.

Mars again presented a favourable opposition in 1862 when Winnecke observed its position against comparison stars from Pulkova and the Cape, deriving a value of 8″.964 while Edward James Stone (H.M. Astronomer, 1870–1879, Figure 4) obtained 8″.918 ± 0″.042 and 8″.943 ± 0″.031 using observations from the Cape, Greenwich and Williamstown (Gill 1913).

South Africa was not well placed for viewing the 1874 transit of Venus so no international expeditions visited then. Local efforts to observe the event were limited to Stone, Finley and G. Maclear (observing from the Cape) and Mr H.L. Spindler (from Port Elizabeth) (Tupman 1878).

4. The British involvement

After the initial disappointments of 1761 and 1769, great expectations were put on further refining the solar parallax in 1874. To ensure success, virtually every scientifically-aware country at the time observed and/or sent expeditions all over the world to observe this event. Exorbitant sums of money were spent on equipment, personnel and other resources.

Figure 4. Edward James Stone was appointed directing astronomer for the 1882 British Venus transit expeditions. He was responsible for arranging the expeditions and subsequent data reduction. (Source: *The Royal Observatory at the Cape of Good Hope, 1820 - 1970.*)

The British were no exception and after reducing the 1874 observations, they initially announced a value of $8''.754$ for the solar parallax (Airy 1877). However, when the detailed report reached the Cape, Stone studied it and noticed serious discrepancies between the accounts of the individual observers with "…numerous phases which were noted at different stations by the different observers" (Gill 1913: 68). Stone immediately set to work, identifying four such 'phases' and derived a very different value of $8''.897 \pm 0''.02$ from the same observations (Stone 1878). Prompted by this, a few months later, Tupman (1878) revised the official British result to $8''.85 \pm 0''.03$. Stone's re-work pointed out a great inadequacy in the contact method of observing Venusian transits in order to obtain accurate values for the solar parallax.

Despite this concern, the British Government, driven by the momentum of past expeditions, in a parliamentary paper dated October 1881, published their intention to send out expeditions at Government expense to observe the transit of Venus of December 6, 1882.

A Transit Committee was created and its members were selected by the Royal Society for the purpose of advising the Treasury and Admiralty on how the observations were to be conducted. With his prior involvement in transit observations and reductions, Stone was an obvious choice and he was appointed directing astronomer responsible for the arrangements and subsequent data reduction.

5. Method of observation

The first and most important decision the Committee had to make was the exact method of observation to be employed. Three main methods had been employed worldwide up to that point: observed contacts, photographic observations and heliometer observations.

5.1 Contact observations

With contact observations the phenomenon was visually observed through an ordinary telescope fitted with some means of ensuring safe solar viewing, generally by using a Herschelian wedge, supplemented by an adjustable neutral density or polarizing filter for setting a comfortable viewing intensity. Observation relied on the precise timing of the instants when their limbs 'touched' at first and second contact as Venus moved onto the Sun (ingress) and third and forth contact as it finally moved off the solar disk during egress (Figure 5). Only ingress was visible from South Africa in 1882 since the event took place in the late afternoon and was still in progress at sunset.

Obtaining a good timing of first contact is very difficult since Venus is invisible in the Sun's glare before it actually takes its first 'bite' out of the solar disk. Anticipating exactly where this will happen is not easy. It is thus not surprising that where first contact timings were reported, all were found to be late. This is understandable considering that by the time first contact could actually be verified, the event had already passed. No first contact timings were used in the final data reduction in 1882.

Accurate timing of second contact was thus the only reliable observation possible from South Africa in 1882. Although it sounds relatively simple to do, experience proved that there were numerous complications associated with deciding the actual instant of this event. Timings differing by up to 52 seconds by observers from the same site were recorded during the previous transit. Chief culprits here were the notorious 'black drop effect' as well as the interaction of Venus's atmosphere, backlit by the Sun, causing great uncertainties in the precise instant of contact (Figure 6).

Instead of two tangential disks, the limbs of Venus and the Sun tend to stretch out and stay attached by a small meniscus, like a water droplet dripping from a tap (Figure 6 a), making the timing of the exact instant of the internal contacts very difficult. Over the years, numerous reasons for this effect have been suggested, like diffraction effects, atmos-

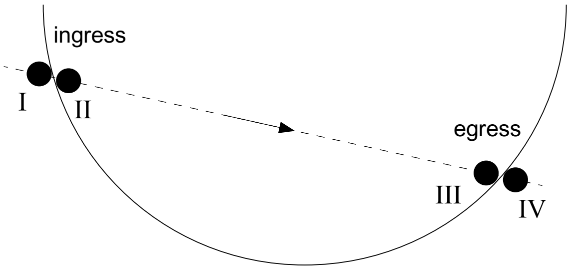

Figure 5. I, II, III, IV respectively indicates first, second, third and fourth contacts. As indicated, first and second contacts occur during the 'Ingress' and third and fourth contacts during the 'Egress'. I and IV are so-called 'external contacts' with II and III, 'internal contacts'.

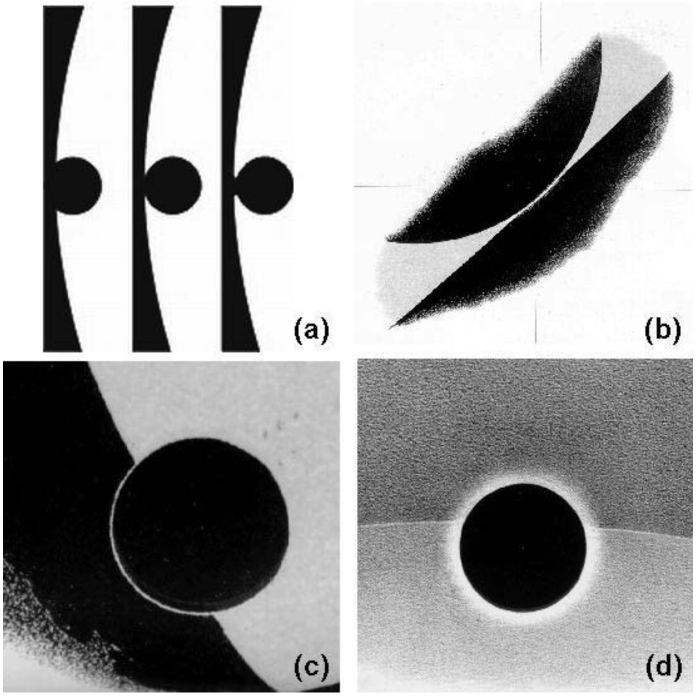

Figure 6. These sketches of the 1874 transit, observed from New South Wales, show some of the phenomena that troubled observers trying to obtain accurate contact timings. (a) The notorious 'black drop' effect. (b) Venus's atmosphere, backlit by the Sun, causing distortion of the solar limb. (c) Numerous observers noticed a ring of light around Venus while it was partially on the solar disk. (d) A halo around Venus. (Source: *Observations of the Transit of Venus, 9 December, 1874; Made at stations in New South Wales*, Government Printer, Sidney, 1892.)

pheric disturbance, imperfections of the eye, instrumental deficiencies, irradiation, etc. but Schaefer (2001) has recently shown it to be due to smearing of the Venusian image, caused mainly by atmospheric seeing and diffraction in the telescope. The black drop effect seemed to be more troublesome with smaller aperture, inferior quality telescopes and when the Sun was at lower altitudes.

5.2 Photographic observations

Two photographic methods were employed during the 1874 event with differing levels of success.

5.2.1 British photographic method

The British method involved a 'secondary magnifier', projecting the solar image formed by the telescope objective onto a photographic plate. No results were ever published based on the numerous plates taken in 1874, using this method. This was mainly because the undefined scale values and image distortion introduced by the projection system were impossible to characterise.

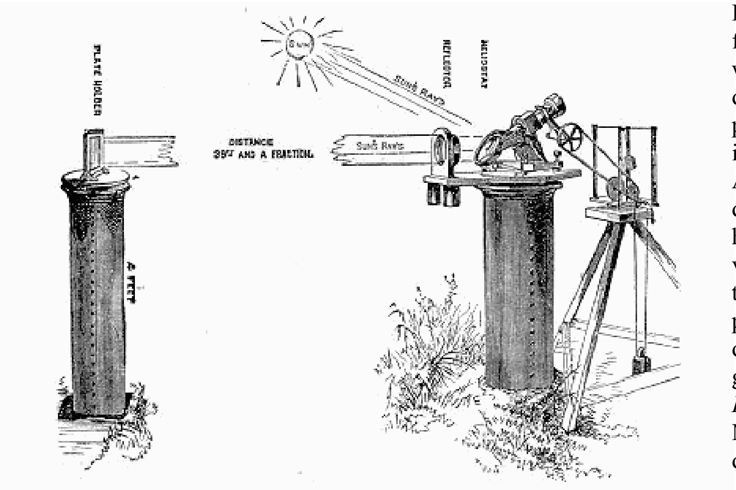

Figure 7. This delightful sketch illustrates the working of the purpose-designed horizontal photo-heliographs used in the 1874 and 1882 American transit expeditions. A clock-driven heliostat with an unsilvered mirror reflected the sunlight onto a lens, projecting a solar image directly onto a photographic plate. (Source: *Popular Astronomy*, Macmillan & Co, London, 1878).

5.2.2 American photographic method

The Americans employed a custom-made photoheliograph, consisting of a long focal length objective, producing a distortion-free solar image of 4½-inches diameter directly onto a photographic plate (Figure 7). The scale was determined by accurately measuring (to ¼mm) the distance between the optical centre of the object-glass and the surface of the photographic plate using a measuring rod and purpose-designed micrometer. To correct for the expansion and contraction of this rod, its temperature at various points along its length had to be measured. However, some concern was raised about possible uncharacterised distortion introduced when the Sun heated the heliostat flat and objective glass. A ruled graticule, mounted directly in front of the photographic plates, provided additional scale and distortion information (Koorts 2003).

The Americans set themselves up to equip a total of eight expeditions: four of these remained in the Northern Hemisphere while the other four were dispatched to the Southern Hemisphere. The same instruments served both the 1874 and 1882 transits, with a slight upgrade in-between.

5.3 Heliometer observations

A heliometer was a telescope that had its objective lens cut in half across its diameter. When moving the two halves laterally with respect to each other, the images of two nearby objects (like a double star or a star and a planet, etc.) could be brought into coincidence. The amount of movement was set very accurately using micrometers, giving an exact measure of the angular separation between the observed objects. This method produced much more accurate results than earlier designs that used a micrometer at the eyepiece end of the telescope. The accuracy of heliometer observations, however, was greatly dependent on the observer's skill, patience and understanding of the actual measurement.

5.4 And the method is …

The British Transit Committee considered these three options in order to decide which method to employ. The British method of photography was immediately condemned because of its scale and distortion problems. Although the American photographic method produced favourable results in 1874, for the British there was insufficient time left for experimentation, equipping and training of the parties to successfully observe the transit.

Not many Venus transit heliometer observation results were available but the method showed good potential for a skilled observer when employing the necessary characterisation and elimination of all sources of errors. Careful heliometer observations made by the Germans during the 1874 transit gave comparable results to the other methods.

The range of different observed 'phases' seen by observers of contact observations, identified by Stone, was a cause for concern. However, it was believed that with prior knowledge of these four phases, by encouraging observers to identify them and supply timings for as many of them as possible, fairly accurate results were still possible from contact observations. By employing the above measures, hopes of reducing the error to 0.01 arcseconds were raised.

It was thus decided that for the 1882 British expeditions the main method of observation would be contact observations, supplemented by heliometer observations, where possible.

6. Site selection

Observations of the 1874 event were severely hampered by bad weather. To improve the odds for 1882, a wide range of sites was selected, carefully considered for their weather patterns in December. Another factor influencing site selection was ease of accurately determining the longitude. Internationally, longitude determination was done by carrying chronometers or by use of transit instruments. Although transit instruments were supplied, within South Africa extensive use was made of a procedure pioneered by Dr (later Sir) David Gill (H.M. Astronomer at the Cape, 1879–1907, Figure 8), of transmitting time signals telegraphically from the Cape Observatory. Sites were thus selected to be close to the telegraph network, which mostly coincided with the railways at the time.

Figure 8. David Gill was H.M. Astronomer at the Cape in 1882 and arranged all the local efforts to observe this rare event. He also greatly assisted the American expedition to Wellington. (Source: SAAO archives)

Eventually, expeditions were sent out directly from England to Jamaica, Barbados, Bermuda, Montagu Road, Madagascar, Burnham (New Zealand) and Brisbane

(Australia). It was also arranged for local astronomers to make supplementary observations at the Cape Observatory, Aberdeen Road, Natal, Mauritius, Australia, New Zealand and Canada.

This time, favourable weather was experienced at all stations worldwide, except Brisbane where dense cloud and rain rendered observations impossible (Stone n.d.).

7. The South African observations

Table 1 summarises the details of British and local observations of the 1882 transit from South Africa.

Mr A Marth was sent out from England as chief observer to Montagu Road. Apart from the instrumentation brought out for this expedition, three additional 6-inch Grubb equatorial telescopes (Figure 9) were supplied by the Commission, one for the Cape Observatory and two for Aberdeen Road. For longitude operations, a Troughton & Simms vertical circle was supplied, with a 3-inch transit instrument specifically destined for Durban (Figure 10).

All the South African parties experienced perfectly clear conditions and although some stations were troubled by high winds, all managed useful observations. It would seem that the American party in Wellington experienced the best conditions. Despite temperatures reaching 37°C, the expedition leader, Dr (later Professor) Simon Newcomb described the conditions as "…not a particle of vapour obscured the sky" and during the transit "…the definition of the Sun was as fine as I had ever seen it in my life" (Stone 1883: 35).

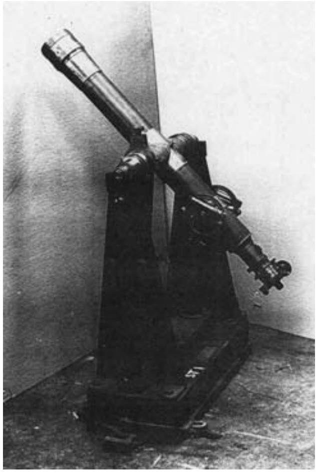

Figure 9. (left) The 6-inch Grubb refractor, still in good working condition at SAAO, Cape Town today, used by Gill to observe the 1882 transit of Venus. The Transit Committee placed an order for six such telescopes from Grubb for the event (Glass 1997). Four of these were sent to South Africa – one for Cape Town, one for Montagu Road and two for Aberdeen Road. The latter three telescopes were returned to England but Gill arranged beforehand for the telescope he used to remain in Cape Town.
Figure 10. (right) The 3-inch Troughton and Simms Transit Telescope of the Natal Observatory. (Source: Andrew Gray, courtesy Local History Museum, Durban.)

Table 1. British and local observations of the 1882 transit of Venus from South Africa

Station	Observer	Assisted by	Telescope	Power	Chronometer
Durban 31° 00′ 17″.7 E 29° 50′ 47″.4 S	E. Neison	P. Sandford	8″ Grubb equatorial (stopped down to 6″)	160	Poole 1407
Aberdeen Road 24° 18′ 54″.3 E 32° 45′ 56″.5 S	W.H. Finlay	—	6″ Grubb equatorial	180	Molyneux 2184
	R.T. Pett	—	6″ Grubb equatorial	180	Molyneux 2275
Montagu Road 20° 02′ 09″.6 E 33° 20′ 23″.0 S	A. Marth	Corp. Thornton	6″ Grubb equatorial	180	Birchall 308
	C.M. Stevens	J.E. Willis	4.5″ Dallmeyer equatorial	145, 185	Arnold 227
Cape Observatory 18° 28′ 41″.1 E 33° 56′ 03″.5 S	D. Gill	Mr. Gamble & Mr. Fry	6″ Grubb equatorial	110	Dent 1681 Molyneux 3299
	G.W.H. Maclear	Mr. Coakes	7″ Merz equatorial	184	Parkinson & Bouts 801
	W.L. Elkin	—	4.2″ Dun Echt heliometer	180	Gill
	J. Freeman	—	3.5″ theodolite	74	Arnold 1167
	C.R. Pillans	M.W. Theal	3.5″ equatorial	120	Barraud 618
	Capt. M. Jurisch	—	2.5″ Reinfelder & Hertel	135	Murray 753

7.1 Montagu Road

The official British expedition to South Africa set up camp in Montagu Road, a small village about 200 km inland from Cape Town, on the edge of the Great Karoo.

With any research into the early history of Touws River, as Montagu Road was known after 1883, it is almost impossible not to encounter two of the town's greatest influences. Firstly, the railways probably played the biggest role for over a century, from the time the first train steamed into town at the end of 1877 until the shunting yards next to the national road became a landmark as the graveyard for hundreds of steam locomotives in the 1980's.

The railway generally meant prosperity for these small towns, but one man in particular benefited greatly by the inland expansion of the railway. A mere eight years before the transit, the Australia-bound "Rockhampton" with the 17-year old sailor, Jimmy Douglas Logan on board, limped into Simonstown, waterlogged after just surviving a severe Cape storm. With only £5 in his pocket, he left the ship, walked to Cape Town and soon got a job as a porter with the infant Cape Colonial Railways, earning 5s (50c) a day. With some prior experience on the North British Railway and being a man of tremendous drive, intelligence and ability, he rocketed up the ranks. At age 20 he became stationmaster of the newly-completed Cape Town Railway Station and one year later (in 1878) became District Superintendent of the section between Hex River and Prince Albert Road, based at Montagu Road.

The businessman in him soon recognised the potential presented by the ever-increasing traffic to the newly discovered diamond fields of Kimberley. Logan bought the local railway hotel, renamed it after the then Prime Minister, Lord Frere and started supplying in the needs of the tired, hungry and thirsty road and rail travellers. Supplemented by the good income from a retail business in Cape Town, he resigned from the railways a year later and in 1883 moved to Matjiesfontein where he founded the town, bought land eventually totalling 25 000 ha and ultimately owned numerous business enterprises stretching from the Cape to Bulawayo (Stassen 1977).

Figure 11. A view of the butchery and house of Mr. Robert Brown (far right, behind the horse-cart) taken in 1895, the site from where the British expedition observed and where the Douglas Hotel was built in 1902 (Source: *Silverjubileum*, Ned. Geref. Gemeente, Touwsrivier, 1962)

In fact, Logan made Matjiesfontein such a household name in Britain that when the monument commemorating the bloody battle of Magersfontein, 800 km up-country, was shipped to South Africa it was addressed to Matjiesfontein, because 'Magersfontein' was thought to be a spelling mistake. This totally unrelated monument is still there today, towering above the Logan family cemetery near Memorial Station next to the N1 highway.

While Logan was still at Montagu Road, the British expedition, consisting of astronomers Mr. A. Marth and Mr. C.A. Stevens, assisted by Corporal J. Thornton, arrived to observe the transit. Mr. Stevens was actually a former 3rd Assistant at the Cape Observatory, who had resigned in 1876 and was working for the Cape Civil Service at the time. They selected a site close to the station, near the butchery of Mr. Robert Brown (Figure 11). Being a few weeks early, they had sufficient time to build two concrete piers to support their telescopes. The party also had time to determine the longitude telegraphically with the Cape Observatory, recruit and train an assistant and get a feel for the local weather. The night before the transit they observed an occultation of Spica in perfectly clear conditions.

Two telescopes were supplied: a 6-inch Grubb equatorial used by Mr. Marth and a 4½-inch equatorial by Dallmeyer, which Mr. Stevens manned. The shipping crates of their equipment served as huts to house the telescopes (Figure 12). To distinguish the huts, they were referred to as the 'Grubb-hut' and the 'Dallmeyer-hut'. Reference is also made to a third hut, the 'Transit-hut' and although not directly mentioned in the records, this indicates that a transit instrument was also supplied. These were required to determine longitude and time.

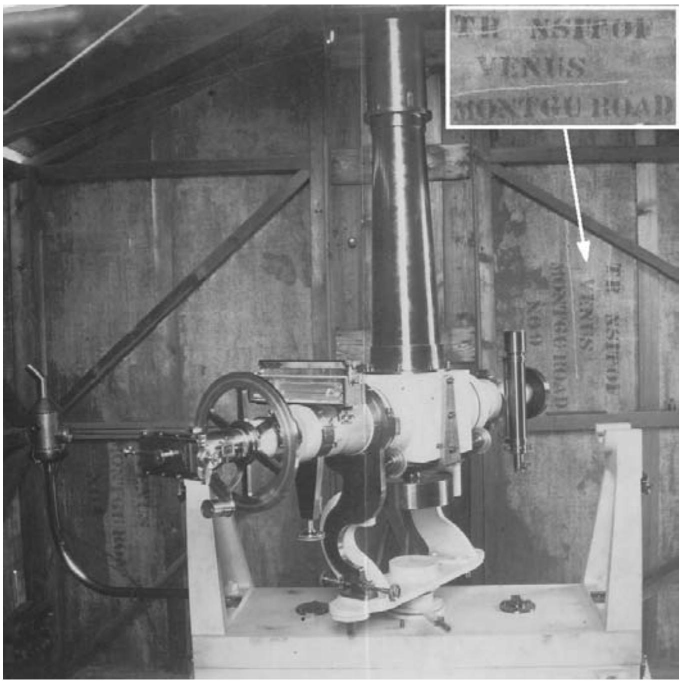

Figure 12. A zenith telescope, mounted in one of the huts (probably the 'Transit Hut') originally used at Montagu Road, as can be seen from the labelling (enlarged insert) on the inside of the crate. (Source: SAAO archives)

The morning of 6 December 1882 started out cloudless and calm. However, the afternoon breeze they had got accustomed to, started early and by 9 o'clock became gusty and very strong. Despite this northerly wind, it stayed clear all day. With the summer Sun baking down, afternoon temperatures reached "…considerably over 100°F [38°C] in the shade." (Stone n.d.: 18). The transit started in the late afternoon.

The mountings of these 6-inch Grubb telescopes, designed for field use, were notorious for not really being sufficient to carry the weight of the telescopes. They were just about usable in calm conditions, but far from adequate in a gale. With lots of ground left bare from the newly-developed railway and its infrastructure, the wind kicked up huge dust clouds. At times visibility was so bad that Mr. Marth's assistant, Corporal Thornton, could "… scarcely recognize the outlines of the other huts at a distance of only nine steps" (Stone n.d.: 16). Corporal Thornton had his hands full devising windbreaks, using poles and tarpaulins borrowed from the railways. These had to be constantly adjusted with the movement of the Sun but it was not always possible to prevent sunlight falling on Mr. Stevens's chronometer.

Mr. Stevens enlisted the services of Mr. J.E. Willis from the Telegraph Department as his assistant for checking the chronometer times.

Marth and Stevens developed a unique technique to help them observe the external (first) contact. They devised a crude position angle scale by using a combination of a home-made divided eyepiece drawtube scale and an eyepiece crosshair set parallel to the Sun's limb at the expected point of first contact.

Stevens also tried something not attempted by anyone else: he changed eyepieces during the observation. He started off using 145 power, yielding a wider field of view for observing first contact and then changed to power 185 in order to observe the subtle detail and numerous phases of second contact.

Figure 13. A recent picture of what remains of the former Douglas Hotel complex. The tarmac on the left used to be the parking area in front of the hotel. The main part of the hotel was a double-story building, occupying the overgrown field in front of the white wall. This wall, built after the hotel's demolition in 1982, encloses the former courtyard where the monument remains, flanked by rooms and a liquor store (pitched roof, far right).

Despite these adverse conditions, both observers managed successful observations.

When the party departed, they left behind their hand-inscribed piers. Still expanding his business ventures, a few years later Jimmy Logan bought this plot of land, demolished Mr. Brown's house and butchery and in 1902 erected the Douglas Hotel there. Amazingly, the piers were saved, ending up in the courtyard of the hotel complex.

Almost half a century later, Mr. H.E. Wood of the then Union Observatory in Johannesburg, visited Touws River and found the piers still intact. By this time Logan (Snr.) had passed away (in 1920) and another hotel bearing the Logan name, the Loganda Hotel had since appeared next to the N1. Both the then owner of the Douglas Hotel, Mr. James Douglas Logan Junior and his manager, Mr. A. Ginsburg, favourably received Wood's interests.

Wood (1937) wrote a short article about the transit observations and a series of letters to Logan (Jnr.) and the then National Monuments Council (Malan 1963) suggesting the preservation of these important relics. His plea was well received and the piers were proclaimed in 1938 (Oberholster 1972). Just as well, since they subsequently survived the demolition of the main part of the Douglas Hotel in 1982 (Figure 13).

7.2 Aberdeen Road

One cannot help but wonder if the selection of this site had anything to do with the fact that Gill came from the town of Aberdeen in Scotland.

Furthest inland, well into the Great Karoo, Gill sent out a party to Aberdeen Road, manned by Mr. W.H. Finlay and Mr. R.T. Pett (Figure 14). William Henry Finlay was appointed First Assistant at the Cape Observatory in 1873 during Stone's reign and kept this position until 1898. Finlay had prior experience when he observed the 1874 transit from Cape Town. Pett held the position of Third Assistant from 1876 to 1919.

This party was equipped with two identical 6-inch Grubb equatorial telescopes (Figure 9), supplied by the British Transit Commission. The longitude of the station was again determined telegraphically from the Cape with the help of Gill.

Figure 14. Mr. R.T. Pett, Third Assistant at the Cape Observatory, observed the transit from Aberdeen Road. (Source: SAAO archives)

In contrast to Montagu Road, no wind was reported on the day of the transit in Aberdeen Road but it was equally hot. Despite this, observing conditions were not ideal. The appearance of the Sun was described as "…excessive boiling", "…bad definition" and "…quivering to an extent never before witnessed" (Stone n.d.: 14). No serious black drop was reported but the usual atmospheric effects of a ring of light around Venus were seen. Otherwise this expedition went off without incident.

7.3 Durban

While doing survey work in Natal, Gill got the idea of setting up an observatory in Durban. The approaching transit of 1882 prompted this and plans were quickly put in place to make this event the Natal Observatory's inaugural purpose. In June 1882 the Durban Corporation voted a sum of £350 and by July the Legislative Council added another £500 towards this purpose.

A prominent businessman Mr. (later, Sir) Harry Escombe worked closely with Gill on this project and, using his own money, bought an 8-inch refractor from Grubb for £600 (Figure 15). Gill worked closely with Grubb on the design of this telescope and dome (Glass 1997). The Government provided a 3-inch transit instrument (Figure 10). An Observatory site on Currie Road, near the top of the botanical gardens, was selected (Figure 16).

Gill, thinking long term, wanted to appoint a skilful and permanent 'Government Astronomer at Natal' and approached Edmund Nevill (who published under the surname Neison), an ardent lunar observer. Neison accepted and eventually arrived in Durban only six days before the transit and on investigation, he found the Observatory far from ready to use. The telescope and dome was rendered immovable by thick layers of grease and paint, the supplied Mertz polarizing eyepiece did not fit the telescope and the transit instrument was still in Cape Town. However, with some frantic improvisation, sometimes working late into the night, Neison overcame all these technical difficulties and managed to get everything ready for the big event of 6 December 1882 (Gray 1977; Gordon 2002).

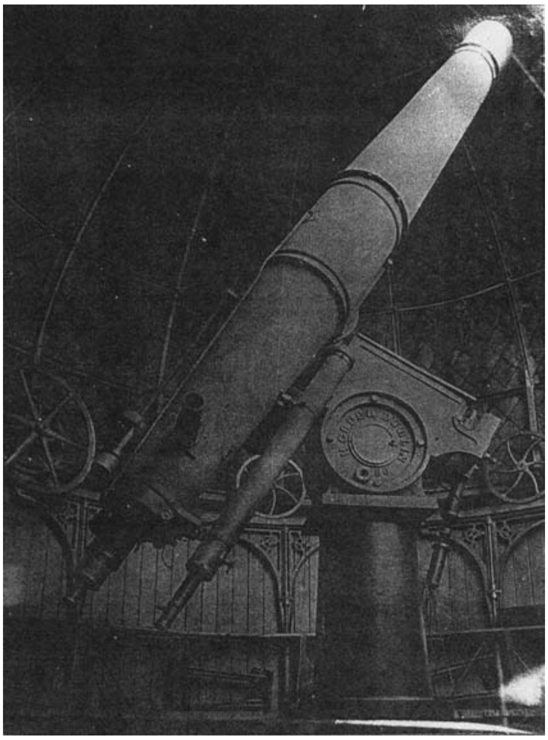

Figure 15. This 8-inch Grubb refractor, the principal instrument of the Natal Observatory, was donated by Harry Escombe and used by Neison to observe the transit. Photo c. 1926. (Source: Andrew Gray, courtesy Local History Museum, Durban.)

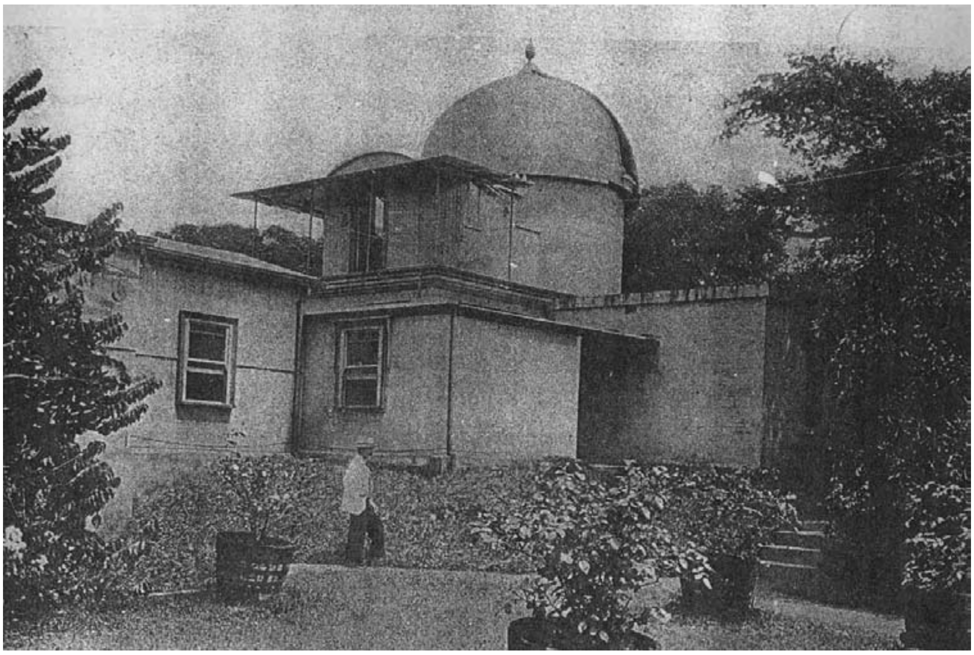

Figure 16. View of the Natal Observatory from the North East. The Transit Instrument was housed in the room with the veranda. The figure in the foreground is Neison, who had an intense dislike of being photographed, resulting in only a handful of photographs of him in existence today, none being very good close-ups. (Source: Andrew Gray, originally published in the *Natal Illustrated Railway Guide of 1903*, courtesy Don Africana Library, Durban.)

He stopped down the telescope to 6-inch aperture using cardboard and managed to fit the Mertz eyepiece, yielding a power of 160. The longitude was determined telegraphically from the Royal Observatory and Mr. P. Sandford, from the Durban High School, was called in to read out and record the chronometer times. The observations went off without further difficulty.

After a productive lifetime, the Observatory was finally closed down in 1912 when its funding was completely cut. Neison retired and returned to England. For the next fifty years the Natal Observatory was a white elephant, being passed around between the Union Government, the City of Durban, the Technical College and the University of Natal without ever finding a proper home again. The last serious work done there was by the late Dr. Alan Cousins while he was still employed at the Congella Power station before becoming a professional astronomer. He exploited the blackouts during the Second World War to measure double stars and make variable star estimates. In the 1950's a public program was run with mixed success but the Observatory was dealt a final blow when vandals broke in and destroyed some of the equipment. The Observatory was subsequently demolished at the end of 1957. Sadly, the 8-inch Grubb telescope did not survive this ordeal but the two other instruments found secure resting places (Gray 1978).

7.4 Cape of Good Hope, Royal Observatory

Back in Cape Town, Gill deployed a total of six observers, scattered all around the grounds of the Royal Observatory (Figure 17).

7.4.1 Dr. (later Sir) David Gill

Gill (Figure 8) was a seasoned parallax observer by then (Forbes 1916). His first experience with precision telescopic observations was gained at the start of his astronomical career, at the Dun Echt Observatory. His background as watchmaker enabled him to master Lord Lindsay's 4-inch heliometer, which he used with great skill. On expeditions to Mauritius and Ascension, Gill observed the 1874 transit and pioneered parallax observations involving minor planets and Mars, using this instrument.

To observe the 1882 transit, Gill manned the 6-inch Grubb equatorial, specifically sent out to the Cape in time for this event. An observatory was set up for it in the former 'Wind Tower' in the SE corner of the Cape Observatory grounds (Figure 17, position No.7). This building got its name since it resembled the Tower of Winds in Athens. It previously supported an anemometer. To house the telescope, a pier surrounded by a spiral stairway was installed in the tower and the building was covered by a revolving dome (Figure 18).

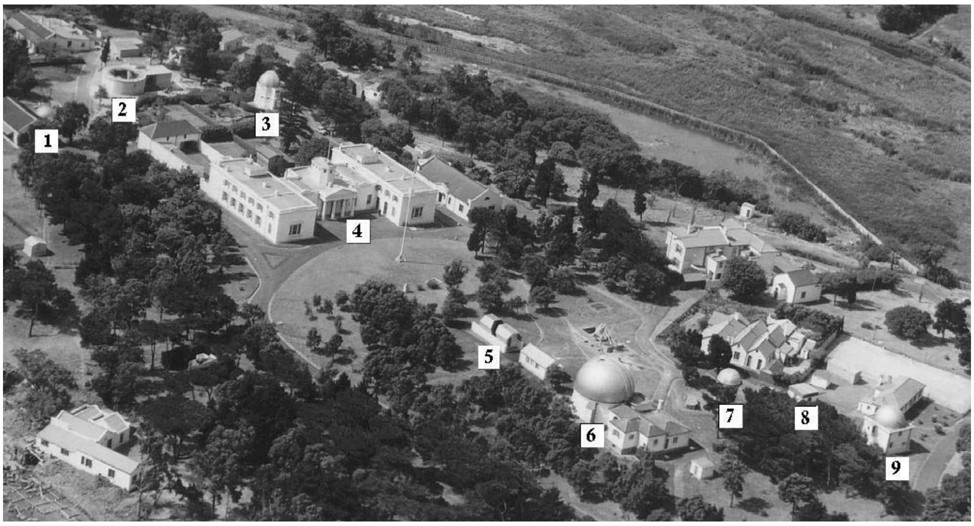

Figure 17. An aerial picture of the Cape Observatory in the early 1960's, indicating the relative positions of some of the Cape observers described in the text. (1) The 14-foot dome from where George Maclear observed, using the 7-inch Merz refractor. (2) The 40-inch Elizabeth Telescope dome (demolished today), under construction. (3) A different dome occupied the position of the present metal and wooden Grubb observatory, from where Elkin observed the transit, using the 4-inch Lord Lindsay heliometer. (4) Cape Observatory Main Building. (5) The Lyot heliograph. (6) McClean telescope. (7) The 'Wind Tower', occupied by Gill and the 6-inch Grubb refractor at the time of the transit. (8) Roll-off-roof building, occupied by the 6-inch Grubb refractor today. (9) Astrographic telescope. (Source: SAAO archives)

A few weeks before the transit this telescope found an even more famous use. On the morning of 8 September 1882, Finlay was on his way home after a night's work when he noticed a bright comet. He turned back and used the 6-inch to make a precise positional observation of this comet, which later became known as the Great Comet of 1882 (C/1882 R1) and became bright enough to be visible in the daytime. After seeing a badly trailed photograph of this comet, Gill got the idea of mounting a portrait camera on the 6-inch Grubb. This successful attempt not only produced the first good-quality comet photograph ever, but it also registered pinpoint star images, which put Gill onto the idea that eventually led to the photographic era of astronomy (Glass 1989).

The Commission prescribed a minimum of 150 power for observing the transit, but not enough eyepiece sets were supplied to the Cape for all observers so Gill and George Maclear had to share a set. The standard eyepiece set magnified 110, 180, 300 and 400 diameters so Gill gave Maclear the 180 power and reserved the choice of 110 and 300 for himself. Unfortunately atmospheric conditions did not allow 300 power, so Gill was forced to observe at 110 power.

In an attempt to improve the timing of his observations, Gill employed the services of two timekeepers. Mr. Gamble, hydraulic engineer of the Colony, and Mr. Fry, Meteorological Secretary, manned a sidereal and a mean-time chronometer respectively. When Gill shouted out an event, they had to independently note down the time on their chronometers to the nearest second. During the reduction of the observations, all times were related to Greenwich Mean Time and the mean of the two times was then taken as the exact moment of the event.

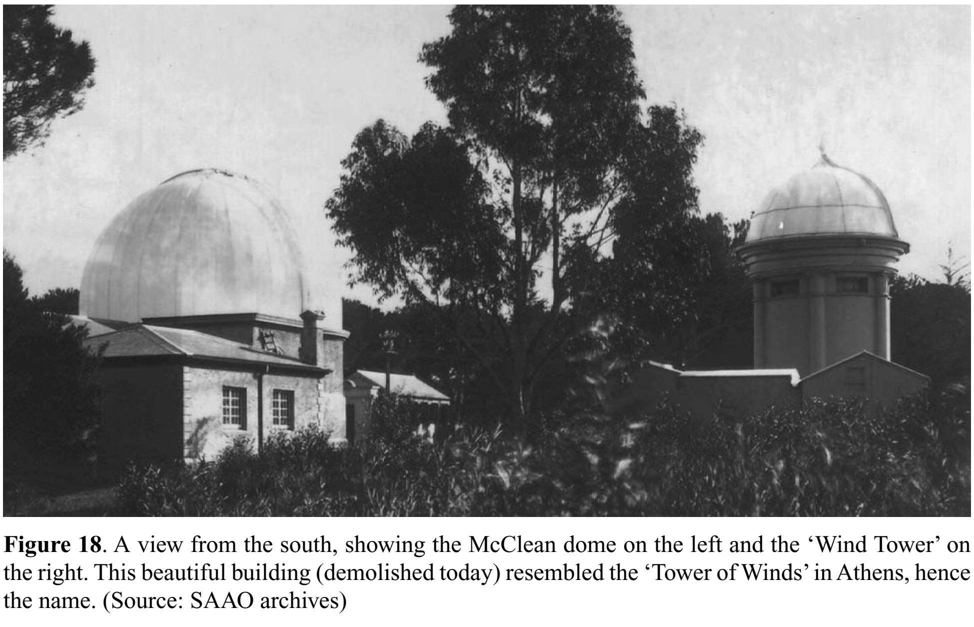

Figure 18. A view from the south, showing the McClean dome on the left and the 'Wind Tower' on the right. This beautiful building (demolished today) resembled the 'Tower of Winds' in Athens, hence the name. (Source: SAAO archives)

The mounting of the 6-inch telescope was unstable and after numerous complaints by Gill, Grubb later exchanged it for one designed for an 8-inch telescope (as can be noted today by the date on the mounting, Figure 19) (Glass 1997). The telescope is currently housed in a roll-off-roof observatory close to its original position (Figure 17, position No. 8) where it is today used for public nights as well as by the members of the Cape Centre of the Astronomical Society of Southern Africa.

7.4.2 George William Herschel Maclear

Thomas Maclear appointed his son, George (Figure 20), as Second Assistant in 1852, a position he held until June 1893. He had some previous transit experience when he observed the 1874 event from Cape Town. George Maclear, assisted by Mr. Coakes, took up position at the newly refurbished 7-inch Merz equatorial telescope to observe the transit. His father erected this telescope in 1849, mounted in a 14 foot (4.3m) diameter dome (Figure 21) on the NW side of the Cape Observatory grounds (Figure 17, position No. 1). A unique feature of this dome is the fact that it revolves on six cannon balls (Figure 22).

Figure 19. The mountings of the original 6-inch 'Transit of Venus' telescopes were made to be portable but were found to be very unstable. After numerous complaints by Gill, Grubb later replaced it with a mounting designed for an 8-inch telescope, as can be seen from the date on the mount.

Although the telescope had a major re-work in 1880, including its lens being re-ground, the equatorial drive was still problematic. In fact, in 1913 Gill still described it as "…practically useless" (Gill 1913: 41). This problem actually caused Maclear to miss the first contact, but he managed a set of successful timings of the internal ingress contact.

After the event, despite the problems with its drive, the 7-inch Merz continued a productive life, observing comets, occultations, double stars, variable stars, etc. It was later removed and in 1910 a 4-inch heliograph, giving an 8-inch solar image, was installed in this dome. This telescope still exists today where it is occasionally used for public solar viewing.

7.4.3 Mr. (later Dr.) W.L. Elkin

Despite his skill with the heliometer, Gill assigned an equally-competent observer to the 4.2-inch Dun Echt Repsold Heliometer. Before coming out to the Cape, Gill purchased this heliometer from Lord Lindsay (later Earl of Crawford) with his own funds and he installed

Figure 20. (above) George William Hershel Maclear, eldest son of Sir Thomas and Lady Mary Maclear, Second Assistant at the Cape, observed the transit using a 7-inch Merz refractor. (Source: SAAO archives) **Figure 21**. (right, top) The 14-foot dome, dating from 1849, housed the 7-inch Merz refractor, manned by George Maclear. **Figure 22**. (right, bottom) When the Admiralty engineers needed to solve the problem of a suitable bearing for the 14-foot dome, they found the solution in a very familiar and abundant source at the time – cannon balls!

it in a dome on the NE side of the site (Figure 17, position No. 3). This dome was later demolished to erect a metal and wood Grubb dome, today occupied by the 18-inch reflector.

Elkin was a young American doctoral student who lived as a guest with the Gills for three years, receiving no salary. He and Gill were busy with pioneering work, doing heliometer parallax measurements of nine southern stars, including Alpha Centauri.

Being equally proficient with the heliometer, Elkin managed observations of "…considerable accuracy" (Gill 1913: 69) of the transit, greatly supplementing the contact observations.

7.4.4 Mr. J. Freeman

Through a tiny 3.5-inch theodolite, working at the lowest power of all (74 times), Freeman saw "…both Sun and planet boiling, with no interval of steadiness, but definition withal of a uniform character" (Stone n.d.: 25). Despite this, he did not report seeing the black drop effect.

7.4.5 Mr. C.R. Pillans

With an equally small 3.5-inch equatorial, at 120 power, using a "…yellow slide" (Stone n.d.: 26), Mr. Pillans reported substantial trouble from the black drop effect. Chronometer times were noted by Mr. M.W. Theal.

7.4.6 Capt. M. Jurisch

The smallest telescope of all was used by Captain Jurisch, namely a 2.5-inch refractor by Reinfelder and Hertel, München, working at 135 power. Despite its size, this telescope was claimed to be capable of splitting β Orionis, showing the Cassini Division in the rings of Saturn and 'rice grains' on the Sun in good seeing conditions (Stone n.d.: 27).

Some evidence of an "…appearance as if some black liquid were filling the thinnest parts of the cusps by adhesion to both the planet's and the Sun's limbs" (Stone n.d.: 27) was noted.

7.5 Visitors

Apart from the already-mentioned visitors from Britain who manned the Montagu Road observing post, an American party led by Professor Simon Newcomb (Figure 23) set up an observing post in Wellington, about 70 km from Cape Town (Koorts 2003). Gill (1913: 146) reported that "…our visitors were welcomed with the utmost pleasure and interest and received every assistance that the Observatory could give them", verifying that they were well looked after.

Not a lot has been recorded about the British visitors but there seems to have been considerable interaction between the Americans and those at the Cape Observatory. Gill advised Newcomb on possible observing sites, initially suggesting Beaufort West, but Newcomb eventually opted to set up his observing post in the grounds of the Huguenot Seminary in Wellington, mainly

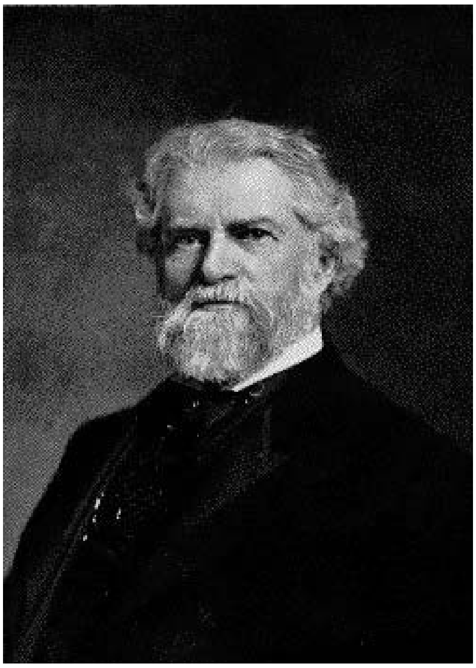

Figure 23. This picture of Prof Simon Newcomb appeared in his autobiography, *The Reminiscences of an Astronomer* (1903). Newcomb led the American expedition to Wellington.

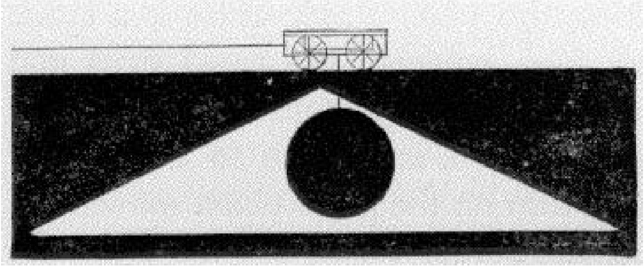

Figure 24. A sketch from Newcomb's *Popular Astronomy* (1878) shows what the 'Model Transit' looked like. The contacts were simulated by a black sheet-metal disk (representing Venus), one foot in diameter, being pulled by clockwork via the trolley, causing it to appear and disappear behind the white triangular opening (simulating the Sun). The whole apparatus was then placed on a building 1 km away and observed through a telescope to practice contact observations.

because of better weather prospects and its American connection. Long after the event, Newcomb and Gill continued exchanging correspondence, right up to the end of their professional lives.

Although not directly documented, there must have been contact between the local, British and American parties. In their reports, both Stevens and Elkin, made reference to the "model transit", an American apparatus for simulating an artificial transit (Figure 24), suggesting they had opportunity before the event to practice with it.

8. Results

In total, 24 successful observations of the internal contact at ingress and 33 of the egress were used in the final reductions of the international British transit programme. Most of the observers reported timings for two or three of the four possible 'phases' identified by Stone. By taking these into consideration, Stone calculated a value of $8''.942 \pm 0''.047$ for the solar parallax, which came nowhere near achieving the expected $0''.01$ error margin.

Both Gill and Newcomb were early critics, believing that transits of Venus did not provide the best method of determining the solar parallax. This was mainly due to the uncertainties introduced by the black drop effect and the atmosphere of Venus.

Gill and Newcomb were not the only critics. A very noticeable drop in interest in the results of the 1882 transit is obvious from the number of publications, pictures, etc between the 1874 and 1882 transits. With a recent request for material from the Royal Greenwich Observatory Archives, the archivist, Mr. Perkins confirmed my experience of a ratio of around 90% (1874) to 10% (1882) material available.

Gill's reservations started long before coming to the Cape when he mounted an expedition to Mauritius to observe the 1874 transit. Although he managed some useful photographs of the event, he really wanted to test a technique proposed by J.G. Galle in 1872 and observe the close approach of the asteroid Juno using the Dun Echt heliometer. However, the heliometer arrived late and then bad weather interfered, but the results obtained were encouraging, showing that a single observer from a single site could obtain comparable results to an entire international transit of Venus observing programme at a fraction of the expense and effort.

With a follow-up expedition to Ascension in 1877, Gill observed a close approach of Mars using this heliometer. By doing corresponding evening and morning observations, he exploited the rotation of the Earth, which provided him with a baseline for the parallax calculation. Gill obtained the most accurate determination of the solar parallax up to that time: his value outlived the entire 1882 Venus transit efforts and he was even able to improve on it a few years later. This momentous work earned him two prestigious medals (Warner 1979 and Fernie 1976).

Previously, Newcomb did a major re-work of earlier transit of Venus observations and although he managed to improve the results, he became very aware of the shortcomings of this method to accurately determine the solar parallax. He spent a large proportion of his career studying the motion of the Moon and measuring the speed of light. In 1896 he adopted an extensive system of astronomical constants, which was still in use well into the twentieth century.

With the writing on the wall after 1874, it is actually quite surprising that such a large effort and expense was still expended to observe the 1882 transit (for example, the U.S Congress alone, appropriated $85 000 for the 1882 American expeditions). In fact, both Newcomb and E.C. Pickering suggested that the American efforts should be confined to home. It seems that the rarity of the event combined with the momentum from all the previous occurrences just carried it over the try line (Dick et al. 1998).

Either way, when you observe Venus crossing the disk of the Sun on 8 June 2004, spare a thought for the momentous achievements of these early pioneers and think of the ordeals they endured trying to solve one of the fundamental problems in astronomy that we take for granted today.

9. Acknowledgments

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