AUSTRALIAN ECLIPSES: THE WESTERN AUSTRALIAN ECLIPSE OF 1974 AND THE EAST COAST ECLIPSE OF 1976

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Abstract: In 1974 and 1976 total eclipses of the Sun were visible from Australia for the first time in over 50 years. For the 1974 eclipse only the northern limit of totality touched land and observers were scattered across the few towns along the south-west coast of Western Australia. Clouds disturbed most scientific observations, while two rocket flights with instruments to image the Sun in ultraviolet light failed to obtain useful results. However, some amateur astronomers were fortunate with the weather at their locations so that they could observe the totally eclipsed Sun. The eclipse was notable for a viewing flight on a Boeing 727 passenger aircraft organised by an American travel company. This was the first commercial eclipse flight. The 1976 eclipse attracted many scientists, both local and from overseas, who mainly gathered in the NSW town of Bombala. Once again, clouds prevented observations. Unusually, the path of totality included the major city of Melbourne with its almost three million inhabitants. To try to prevent eye damage, the authorities encouraged the population to stay indoors during the eclipse and only watch on television. They were generally successful, though with the consequence that millions of people missed out on a once-in-a-lifetime chance to view a total eclipse from their own backyards.

Keywords: 1974 total eclipse, 1976 total eclipse, solar filters, eye damage, commercial eclipse flight

1 INTRODUCTION

Two total eclipses of the Sun, two years apart, were visible from Australia in the mid-1970s. Though the path of totality was below the Australian coastline for the first, on 20 June 1974, its northern limit clipped the south-west corner of the state of Western Australia. The second, on 23 October 1976, had the path of totality cross the south-east part of the continent, passing through the states of South Australia, Victoria and New South Wales. Total eclipses tend to happen in remote parts of the world, so it was unusual that in 1976 totality passed over the city of Melbourne, a city then of 2.8 million people and the capital of the state of Victoria. Figure 1 gives an overview of the paths of totality for the two eclipses in the vicinity of Australia.

These two eclipses were the first seen from Australia since the important eclipse of 1922, at which astronomers from Lick Observatory, stationed in Western Australia, verified Einstein's prediction of the deflection of starlight near the Sun[1] (Treschman, 2014). In the following 50 or so years, there were major developments in technology, in the available equipment and in the direction of eclipse research. In the 1970s the emphasis was on the study of the corona as total solar eclipses, then and now, provide the best way of examining the hot outer atmosphere of the Sun.

In the half century since the previous eclipse, the number of amateurs had also grown and they had access to better equipment such as the common 20-cm aperture Schmidt-Cassegrain telescopes manufactured by Celestron (Anonymous, 2017) and aperture solar filters. This meant that amateurs took a much greater role in eclipse observation than at earlier eclipses. As emphasised in previous papers on historical eclipse expeditions (Lomb, 2016; 2020), one of the most important aspects of considering eclipses is the glimpses they provide of astronomers away from their normal routine. For the 1974 and 1976 eclipses, these glimpses apply not just to professional astronomers but also to amateurs. Unlike those earlier eclipses, there are still people with us, who were observers at one or other of the two eclipses, and their recollections greatly assist with understanding what happened at those events.

Though observations at both eclipses were disturbed by clouds, many people managed to observe totality. This paper first looks at the 1974 eclipse and the associated activities of professional and amateur observers. An important part of the 1974 eclipse was the first commercial eclipse flight, on which those onboard were guaranteed a good look at the eclipsed Sun without the fear of clouds. The 1976 eclipse is considered next. Probably, the most important aspect of that eclipse was that totality encompassed a highly populated city. This paper considers questions such as: How did the authorities cope with the coming eclipse? What advice did they give? What planning did they do?

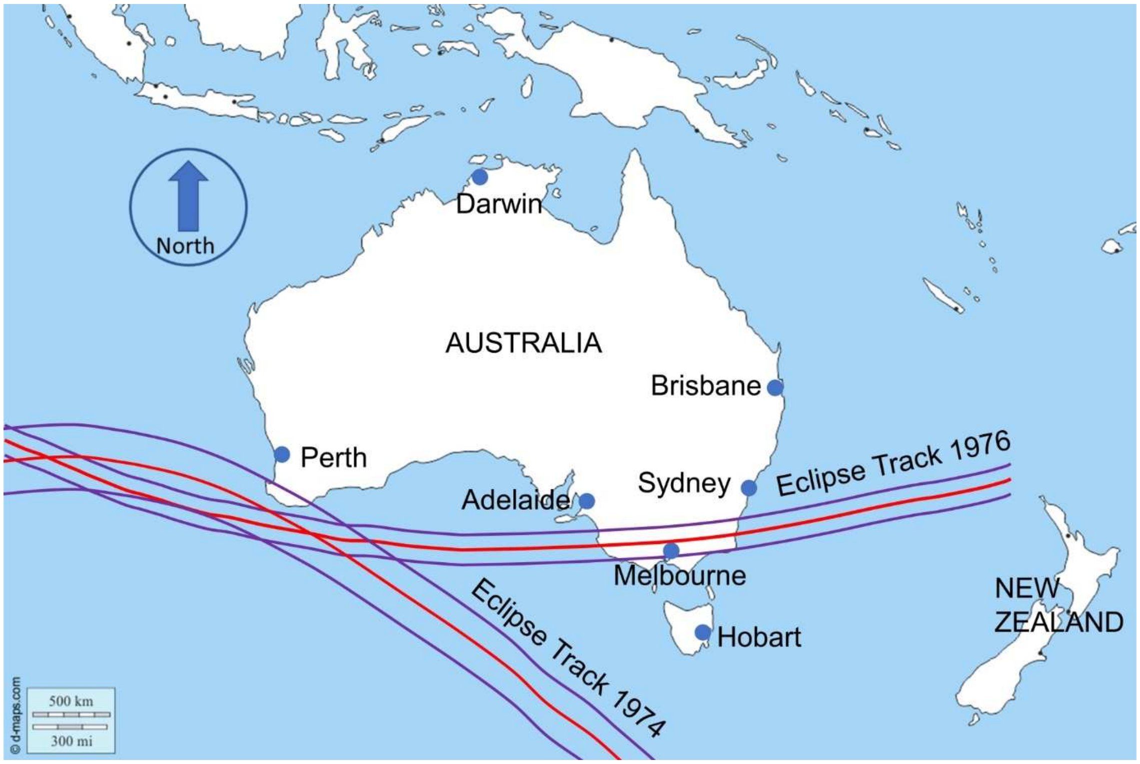

Figure 1: Map of Australia with its main cities and showing the tracks of totality with their northern and southern limits for the 1974 and 1976 eclipses (map: Nick Lomb, eclipse track information from http://xjubier.free.fr/en/site_pages/Solar_Eclipses.html, based on map from d-maps.com).

2 TOTAL SOLAR ECLIPSE OF 20 JUNE 1974

The only landfall of the central line of totality of this eclipse was on the tiny volcanic Amsterdam Island, which is in the Indian Ocean, roughly halfway between the Cape of Good Hope and the Western Australia coast (Duncombe, 1973). Though the central line did not touch the Australian mainland, the northern limit of totality clipped the south-west corner of Western Australia (see Figure 2). Scientists and amateur astronomers, local and international, sought observing locations among the few towns sited along the coastline to maximise the length of totality that they could view.

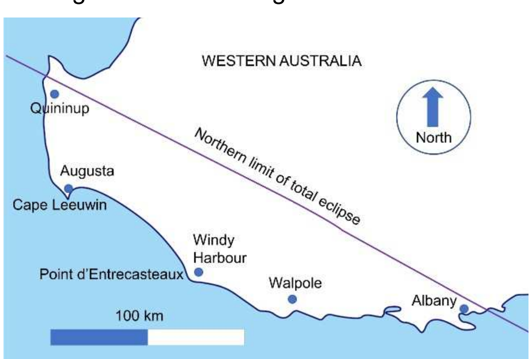

Figure 2: Map of the south-western part of Western Australia showing the northern limit of the 20 June 1974 eclipse, as well as the places mentioned in the text (map: Nick Lomb, based on map from d-maps.com).

Weather prospects for the eclipse were investigated by Robert Roosen of the Goddard Space Flight Center. He arrived in Perth on 11 February 1973 after observing at Orroral Valley Tracking Station near Canberra. Perth Observatory Director and Government Astronomer John Harris met him at the airport, looking out, as Roosen (1973a) suggested, for "… a tired young man, six feet tall, with gold rimmed glasses and brownish beard." Back at Goddard after having visited Perth and inspected possible observing sites, Roosen (1973b) wrote, "There is some debate here as to whether a 50% chance of clear weather is good or bad." At Roosen's request, Harris tried to add to the sparse climate information for the eclipse area by contacting the Country Water Supply and asking for rain gauge data and the possibility of rain gauge observers also obtaining cloud cover observations during June 1973. Roosen with two colleagues wrote up the available information in an article for *Sky & Telescope* magazine (Roosen et al., 1973). Harris referred enquiries about weather and the best sites to the article, even before it was published. In a letter to the Australian Tourist Commission, he added that,

> The meteorological data at present available do not indicate any area which has a greater chance of clear skies at the time of the eclipse; in fact, they indicate that it is likely to be raining wherever you may be! (Harris, 1973).

The synoptic chart for eclipse day indicated a cold front just off the west coast of Western Australia and an intense high to the south of the state with close together isobars indicating strong winds between the two weather systems (Weather, 1974).

2.1 Scientific Research

A major research effort for the eclipse was a joint one between scientists from the CSIRO's Division of Physics and American scientists. Three separate experiments were to yield, at many points on the corona, the electron temperature, the electron density and the proton temperature (Beckers, 1985).

As shown in Figure 3, the CSIRO team, led by the Chief of the Division, Ron Giovanelli (1915–1984), aimed to image the Sun through a 0.4-m reflecting telescope. With a radially graded filter, they were planning to measure the electron temperature of the corona along selected paths (Giovanelli, 1974). The theoretical basis for this was calculated by Lawrence Cram, who had recently completed his PhD thesis in the Department of Applied Mathematics at Sydney University, and was then employed as a Technical Officer by the CSIRO (Cram, pers. comm, March 2021). Building on observations by Walter Grotrian (1931), Cram developed a technique to measure the electron temperature by the ratio of the intensities at two wavelengths in the coronal spectrum (Cram, 1976). For comparison with the results from the other experiments, the points of measurements on the corona had to be determined to a few seconds of arc. To help with this task, Giovanelli asked the Western Australia Government Astronomer, John Harris, for Perth Observatory to supply the co-ordinates of their observing location, Inglewood Lodge, Walpole, and the exact circumstances of the eclipse there (Giovanelli, 1974). This information was provided Birch (1974a) and Harris (1974a). Sadly, all the effort was to no avail as clouds spoiled the view (The Australian eclipse of the Sun, 1974).

The electron density was to be measured at Windy Harbour by Dutch-born American astronomer Jacques Beckers (1934–2021), then at Sacramento Peak Observatory, New Mexico. To do this, he was using a specialised eclipse telescope that recorded a white light image of the corona (Beckers, 1985). The telescope was designed by Gordon Newkirk (1928–1985) of the High Altitude Observatory in Boulder, Colorado (Eddy, 1989). It had a circularly symmetric variable density (graded) filter placed just before the focal plane of the telescope to bring the changing brightness of the corona into the dynamic range of the film being exposed. To maximise the stability of the 11-cm aperture telescope, instead of the usual arrangement of driving the whole telescope east to west to compensate for the motion of the sky, only its focal plane was driven. Newkirk, with a colleague, first tried out the coronal telescope at

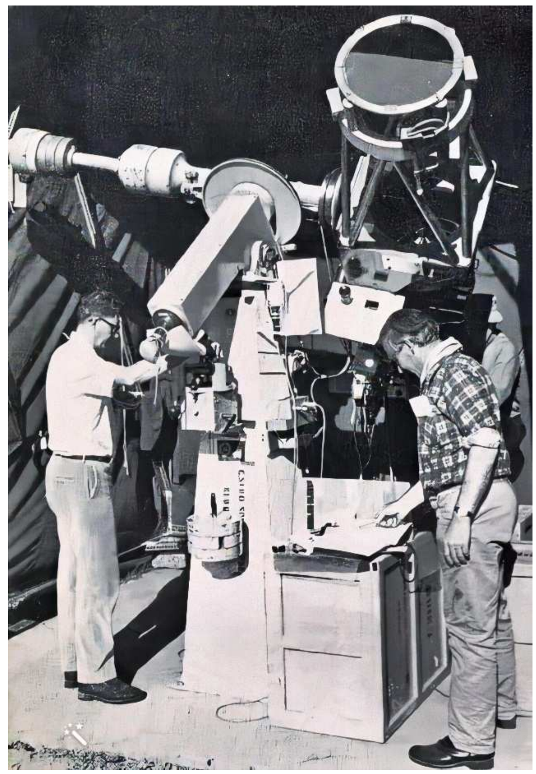

Figure 3. CSIRO astronomers Ralph Loughhead, J. Shaw and Ron Giovanelli (partially hidden) preparing their 0.4-m telescope at Walpole, prior to the eclipse (photo: Jay Pasachoff).

an eclipse in Bolivia in 1966 and succeeded in obtaining with it the best images of the corona taken up to that time. Figure 4 shows Beckers explaining the coronal telescope to local school children.

The final part of the three collaborative experiments was to obtain proton temperatures from rockets designed to image sections of the coronal spectrum unavailable from the ground. In his letter to Harris, Giovanelli (1974) explained that the aim of the experiments was

> … to obtain the width of the Lα [Lyman alpha] line at a large number of points in the corona, and … to derive the hydrogen gas temperature from this.

The rocket experiments were organised by four

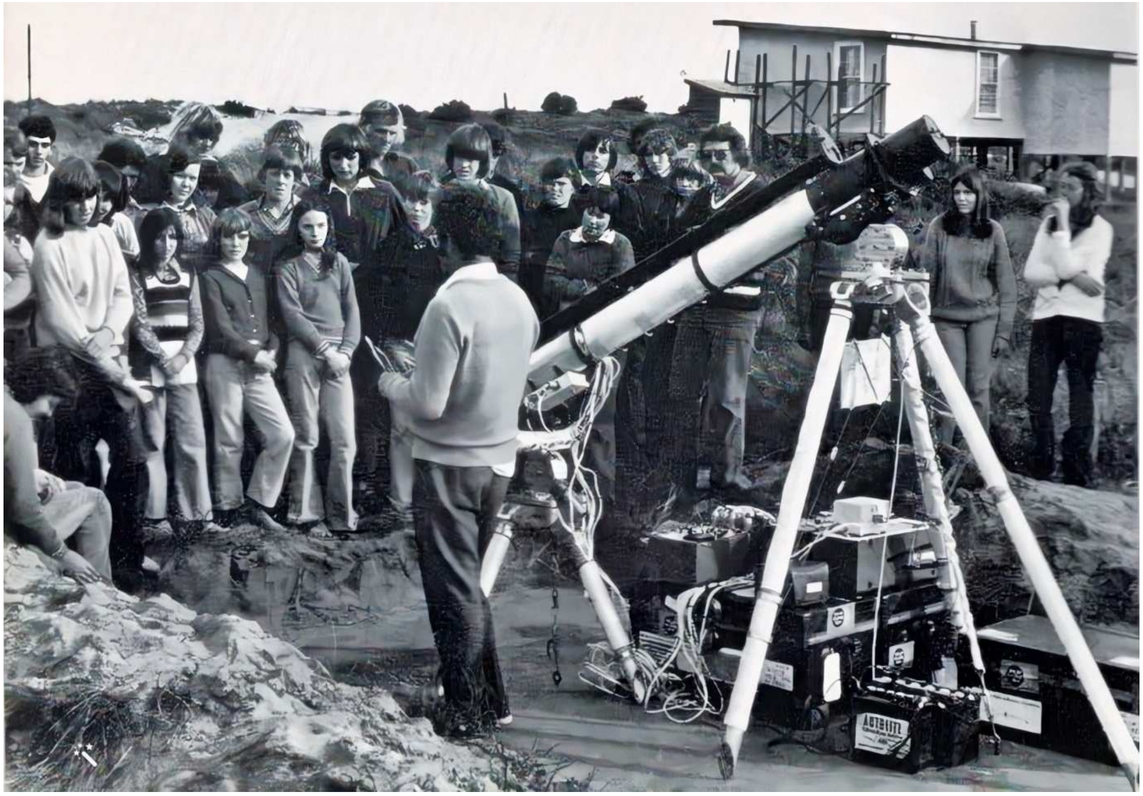

Figure 4: Jacques Beckers explaining his solar telescope to school children at Windy Harbour (photograph: Jay Pasachoff).

United States laboratories, Sandia, Los Alamos, Laboratory for Atmospheric and Space Physics of the University of Colorado and Sacramento Peak Observatory. Two Sandhawk-Terrier rockets were to be launched from Lancelin, north of Perth, 30 seconds apart (Rockets to chase eclipse, 1974). The northerly location was chosen as at the 30 km operational altitude of the rockets the eclipse track shifted north from its location on the ground. Each rocket carried a payload of a telescope connected to a high-resolution spectrograph and camera. Before launch, the Bureau of Meteorology set up a 30-metre tower and a portable radar system to give information on high altitude wind movements. The launch complex was built by local contractors with the assistance of several Commonwealth Government agencies (Lathrop, 1975). The rockets were duly launched. Telemetry indicated that one successfully acquired the Sun and made the planned observations, while the other did not. One capsule was recovered, while the other was not, due to heavy seas and a weak signal from its electronic beacon. As luck would have it, the recovered capsule was the one that had not observed the Sun. Sandia Corporation offered a $1000 reward for the recovery of the missing capsule, explaining that it had to be found within five days for otherwise the film containing the results would deteriorate ($1000 offered for lost probe capsule, 1974). It was not found.

Among other observers was the trio of Jay Pasachoff of Williams College, Massachusetts with his wife, Naomi, and Stephen Edberg of the University of California at Santa Cruz (Figure 5), who set up their equipment near Giovanelli's team at Walpole (June Solar Eclipse: A First Word, 1974). To cover every eventually, they had a Piper plane on standby in case of clouds. When the clouds did roll in and looked persistent, the two Pasachoffs took that option and took off with only four minutes to go before totality. The small plane could not fly high enough so that all they saw of the corona was, as reported by Pasachoff, "… a light ring around the dark moon." Pasachoff saw his first eclipse in 1959, while a first-year student at Harvard University (Kersten, 2017). He is one of three umbraphiles or eclipse chasers, who have seen a record setting 33 total eclipses, as of 2017. Glen Schneider (Section 2.3) is one of the other record setters. Two years later, Pasachoff (pers. comm., April 2021) and Schneider had both increased their tallies to 35.

2.2 The Eclipse Flight

Despite cloud over much of the eclipse area, about 40 lucky amateur astronomers enjoyed

Figure 5: Stephen Edberg with Naomi and Jay Pasachoff and their equipment (photograph: Jay Pasachoff).

an uninterrupted view of the eclipse for just over seven minutes. They were on an especially charted eclipse fight, the first commercial eclipse one. There had been eclipse flights previously but only for scientists carrying out experiments. The most famous of these flights was the flight of the prototype Concorde 001 to observe a total eclipse over Africa on 30 June 1973 (Guillermier and Koutchmy, 1999: 132–135; Léna, 2016). Organised by French astronomers, the flight took off from La Palma in the Canary Islands and followed the arc of the Moon's shadow to provided totality for a phenomenal 74 minutes. This was only possible due to the aircraft flying at speeds of over twice the speed of sound. Concorde 001 is now on display at the National Air and Space Museum of France, located within the Paris-Le Bourget airport (Lemaire, 2015–2021).

The 1974 flight was organised by Horst Engel, the president of VIP Travel, a company located in Sierra Madre, California, a small town near Pasadena, which was the home of NASA's Jet Propulsion Laboratory (JPL) and the California Institute of Technology (Caltech). Horst Engel (pers. comm., October 2020) and VIP Travel had organised eclipse expeditions before but this one was a little tricky because of the poor weather prospects and the eclipse path being over water. Instead, one of the JPL scientists, noting the success of the Concorde flight, suggested using an aircraft instead of trying to observe from the ground. VIP Travel contacted Ansett Airlines, which they had used previously for travel within Australia. After seeking more details and getting in touch with the Astronomical Society of Victoria (henceforth ASV),[2] the airline agreed. Fortunately, Ansett had two Boeing 727s that were certified for travel over water, with both aircraft having periscopic sextants in the roof of the cockpit to allow celestial navigation when out of range of electronic navigational aids.

The passengers for the flight consisted mainly of an American party of keen eclipse observers led by Harry Nelson, Professor of Mathematics at Augustana College, Rock Island, Illinois (Trainor, 1974). Before reaching Melbourne, from where the flight was to originate, the party had visited the main astronomical sites in Australia, including Sydney Observatory, the Parkes Radio Telescope and the Tidbinbilla tracking station. The Americans were joined by Jim Trainor from the ASV, who was the main contact for the Society, Arthur Coombs, President of the ASV, plus three other

Figure 6: Inside the plane during the 1974 eclipse flight, showing telescopes and other gear pointed out through the windows (photograph: Arthur Coombs; courtesy: Barry Clark).

Society members, as well as a couple from the Astronomical Society of South Australia and two from the Astronomical Society of New South Wales. The whole group left Melbourne for Perth on the evening before the eclipse, flying on the same plane as was to make the eclipse flight.

While the flight participants slept at a Perth Airport hotel, technicians removed the seats on the left-hand side of the aircraft. When the observers boarded the plane the next morning, they found that "The left half of the plane is like a carpeted cricket pitch". Soon after take-off at 10:40 am local time, the passengers were free to set up their cameras, tripods and other equipment on the cricket pitch (Figure 6). Numbers on the flight had been limited so that each participant had their own window. The flight plan was to fly west to reach the central line near the point of maximum duration of totality and then fly along the line. The plane flying at about 950 kilometres per hour could not keep up with the Moon's shadow, which was moving at about 2250 kilometres per hour, but would extend totality compared to the stationary maximum of five minutes nine seconds. The altitude of the Sun was 34°, so that it could be easily observed through the windows.

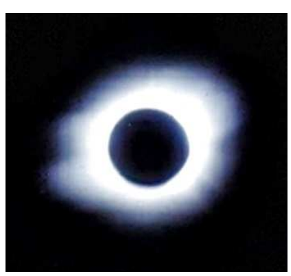

Figure 7 (left): The diamond ring at the beginning of totality, photographed from onboard the Ansett aircraft (photograph: Arthur Coombs; courtesy: Barry Clark).

Figure 8 (right): The eclipsed Sun and its corona, photographed from onboard the Ansett aircraft (photograph: Arthur Coombs; courtesy: Barry Clark).

The flight, piloted by a senior Ansett pilot, Captain Ken Morris, who was a member of the ASV, went to plan apart from running into cloud just before totality. Though the plane's navigator was certain that they would break out of it before the crucial time, it was decided to increase altitude from 30,000 feet to 32,000 feet and the cloud vanished. As from the ground, the eclipse began with the sight of the diamond ring (Figure 7) and then the corona (Figure 8) came into view, as well as the planets Venus and Saturn and the bright star Sirius. For seven minutes and nine seconds participants could take their photographs and make other observations. The Perspex windows were, of course, not ideal to look through plus there was a vibration that would have affected longer exposures from the constant movement of people; a movement that disturbed the stability of the aircraft. One participant had allowed for the vibration of the plane by having gyro stabilisers fitted to her camera equipment (Carlos, 1996–2007). This was prolific eclipse observer and well-known New York musician, Wendy Carlos.

After totality was over and the observing gear stowed, the plane landed at Perth airport and the elated passengers disembarked (Figure 9). From there they returned to Melbourne on a scheduled flight.

2.3 Ground-based Observers

Those people who set up at Cape Leeuwin and nearby Augusta were fortunate as the clouds there cleared for the duration of the eclipse and almost four minutes of totality could be seen. Among the crowd of mainly Western Australians near the Cape Leeuwin lighthouse (Figure 10), there was a coach load of about a dozen people from New York City. One of them was Glenn Schneider, then an undergraduate but later to become a well-known astronomer at the Space Telescope Science Institute and at the University of Arizona. He has retained his interest in solar eclipses, attending his 35th total eclipse in 2019 (Schneider, 2019). In his 1974 notebook Schneider recorded his concern about the weather preventing viewing of the eclipse. However, this concern was ameliorated by a long phone call to the Bureau of Meteorology in Perth, where the forecaster indicated that the clouds would pass before the eclipse (Schneider, 1974). Schneider set up his extensive equipment—a Questar telescope, a spectrograph and a 400 mm lens, all with cameras on tripods with weights for stability. When totality commenced

> There was not any diamond ring at second contact nor any shadow bands. The chromosphere was visible for about 12 seconds, and [a] naked eye prominence visible 15° above the contact tangent point.

Later a coronal streamer could be seen growing to 6½ solar radii. At mid-totality Schneider could see Achernar, Sirius, Canopus and, with averted vision, Rigel. Venus became visible five minutes before totality and faded into the daytime sky about five minutes after. There was a diamond ring at third contact and afterwards weak shadow bands could be seen on a sheet of paper.

Frankston's Bruce Tregaskis (1927–2008) (Skilton, 2009) was another observer in the vicinity of Cape Leeuwin lighthouse. Tregaskis, together with his daughter and a colleague from the ASV, drove to Cape Leeuwin from Perth after hearing a radio interview indicating there were clouds in the Walpole area (Tregaskis, 1974). They set up Tregaskis' home-built 10-cm cm reflector and a pair of binoculars on a stand in a sheltered area among trees. As totality approached, Tregaskis noted that "… an eerie bluish sunset …" seemed to occur. Pink and orange colours appeared on clouds low in the south-west. He took a photograph of totality by holding a camera to the eyepiece of the 10-cm telescope. Just before the end of totality he saw that "… the west limb of the Sun appeared mauvish-red as the chromosphere came into view for some seconds." After the diamond ring and the end of totality, Tregaskis had a better view of the shadow bands on a sheet laid on the ground:

Figure 9. After the eclipse flight, Horst Engel (left) and Arthur Coombs (right) with the four hostesses, who had been on board (photo: Arthur Coombs).

Figure 10. Cape Leeuwin lighthouse (photograph: Amanda Slater; courtesy Flickr, (CC BY-SA 2.0)).

> The bands, which were not continuous but were often broken up into short sections of no more than a foot [30 cm] in length, were separated from each other by 7 to 15 cm. They moved slowly across the sheet approximately towards the east and lasted for about two minutes.

Canadian journalist Peter Faulkner (pers. comm., October 2020) was close to Cape Leeuwin, at the Flying Doctor airstrip at Augusta (Faulkner, 1974). Faulkner had seen a total eclipse two years earlier at Nova Scotia in Canada and had learnt from that experience. On this occasion he planned meticulously in advance, even arriving at the site two days before the eclipse. Faulkner's main instrument at Augusta was an 800-mm telephoto lens with a camera coupled to it and supported on two tripods for rigidity. With this arrangement he planned two series of shots, one on colour slide film and the other on black and white negative film. A second instrument was a 200-mm lens with a 2X teleconverter and a camera, all on one tripod. He had two more cameras: one with a wide-angle lens that was placed on top of his hired car with a small camera and one for miscellaneous shots. At 1 pm he tuned into the ABC for the hourly time signal and a few minutes later started a tape recorder to be ready to record impressions of totality due at 1:12 pm WAST. As the sky darkened before second contact, Faulkner noted that the high-altitude cirrus clouds that remained after the clouds had cleared earlier in the day, "… were seen radiating in advance of the approaching shadow in a fanlike configuration." Just before the appearance of the diamond ring at third contact Faulkner saw Saturn, which was only 10° from the Sun. During totality, he had felt a chill in the air as the temperature had dropped by 15° F [8° C] since first contact. Faulkner was satisfied with the results of his photography and he summed up the eclipse by stating:

> All aspects of the event were near perfection: the Sun itself was in an ideal position in the sky, it was mid day, the atmosphere was relatively free of clouds, and of course totality was a generous four minutes in length.

Most observers sought out a site to maximise the duration of the eclipse. One, who did not, was David Herald of Canberra. Herald was following the advice of American astronomer David W. Dunham, then at the University of Texas, Austin. Dunham's suggestion was to observe from just inside one of the limits of a total eclipse to maximise the visibility of Baily's beads—these bright spots, due to mountains and valleys at the edge of the lunar disc, are seen as the Moon moves in front of the Sun. Herald and a companion set up their equipment about 6 km from the northern limit of the eclipse, near Quininup Beach, at the intersection of two roads (Herald, 1976). Their equipment was simple: a 60-mm refractor or lens telescope that projected a 10-cm wide image of the Sun onto a screen. As well, they had a portable tape recorder to record a voice commentary of what was seen, together with time signals from radio station VNG at Lyndhurst in Victoria. Fortunately, the sky was clear at the time of the eclipse, apart from high cloud that did not affect the image. Playing back their recording after the eclipse, they found 72 events associated with Baily's beads, with the time of each event established to ±0.3 second. From this data Herald identified the lunar feature responsible for each event using a published lunar profile (Watts, 1963). Armed with this information, Herald derived corrections to the ecliptic longitude and latitude of the ephemeris position of the Sun as well as the radius of the Sun; these corrections turned out to be small compared to the calculated mean errors associated with them.

Another eclipse observer was Friedhelm (Freddy) Dorst from the Astronomy Institute at Münster University, Münster, Germany. He wrote to Perth Observatory requesting assistance to reach his chosen eclipse site at Point Entrecasteaux and listed his instruments as a 1000-mm focal length photo lens with a focal ratio of 5.6 and four cameras (Dorst, 1974a). According to Martin Mobberley (2007: 180), Freddy Dorst is Germany's top eclipse chaser with a record of 21 successes from 24 total eclipses. He has a reputation for arriving at a continent different to his own, seeing an eclipse and heading straight back to Germany. On this occasion he lived up to his reputation as he spent only one week in Perth. Perth Observatory assisted by hiring on his behalf a VW Combi van equipped as a caravan and providing a driver for the trip to the eclipse site (Harris, 1974b). On returning home he sent his thanks to Harris together with some photos that he said indicated the bad seeing conditions during totality (Dorst, 1974b).

Most of Perth Observatory staff went to Windy Harbour, near Dorst's location, and judging by the photographs (Figures 11 and 12) made it a pleasant day's outing. Unfortunately, thin cloud spoilt the view and no successful photographs of the eclipse were taken (Birch, 1974b). However, a recently appointed Observatory Assistant, Celia Blackshaw, was at Augusta and took a photo of the eclipse that the Observatory could happily distribute (Harris, 1974c).

Figure 11 (left): Perth Observatory staff at Windy Harbour preparing for totality. Left to right: Greg Lowe, Mike Candy, Dennis Harwood and Dick Gans (photograph: Perth Observatory; courtesy Craig Bowers).

Figure 12 (right): Perth Observatory staff member Dennis Harwood with his wife, Derice, at Windy Harbour before totality (photograph: Perth Observatory; courtesy Craig Bowers).

Dave Marshall, a guide-lecturer at the Science Museum of Victoria in Melbourne, was another successful observer at Augusta. He took with him a simple, yet ingenious device consisting of a photometer, a watch and a 15-cm aluminium mirror that formed an image of the Sun (Marshall, 1974). A movie camera imaged all the instruments at 15-second intervals. With the data collected during the eclipse, he could plot the overall sky brightness during the eclipse against time and compare the results with a theoretical curve based on the eclipse geometry. Marshall also noted what he saw around him. Animals he found just stopped and [laid] down as it became dark. Most of the human onlookers, he said, were school parties brought by buses. There were others as well:

> Generally, the overseas visitors were equipped with telephoto cameras. One visitor who was photographing his nineteenth eclipse had a stack of filters looking like exposed film, which he kept whipping in front of his camera in some obviously planned schedule.

2.4 The Public

In 1974 there were no generally accepted solar filters available for the public (further discussed in Section 4). Aluminised mylar film was only just becoming available and, in fact, Glenn Schneider at Cape Leeuwin was giving them away, but they were not yet officially recognised. As a result, the Australian College of Ophthalmologists issued a warning for people not to view the eclipse directly or through any kind of glasses such as sunglasses, oxy-welder goggles, sooted glasses or dark coloured glasses (Warning on eclipse, 1974). The College said that at the previous Australian eclipse "170 people, most of them children, permanently damaged the sight in one or both eyes after looking directly at the eclipse." Some of these people had looked for less than ten seconds. With these and other warnings in mind, most people in the Western Australian capital of Perth, where the Moon covered 96 per cent of the width of the Sun, stayed indoors and watched on television. Some people were understandably confused: one wanted to know if it was safe to do her washing, another whether keeping hats on would provide protection and yet another whether she should protect her elderly dog's eyesight by keeping it indoors (Eclipse causes fears, 1974). The Australian Broadcasting Commission (ABC) televised the eclipse from its outside broadcast unit at Albany until "… just before the clouds closed in." (Bunbury, 1974).

3 THE TOTAL SOLAR ECLIPSE OF 23 OCTOBER 1976

The eclipse began at sunrise in Tanzania, in eastern Africa, with the central line crossing the Indian Ocean, passing to the south of Western Australia and central Australia before reaching the coast of south-eastern Australia (Fiala and Duncombe, 1975). From South Australia it entered Victoria, passed over Melbourne and moved into New South Wales (NSW), exiting the Australian mainland to the south of Sydney (Figure 13). The Moon's shadow travelled quickly, crossing the almost 11,000 km from the African coast to Melbourne in just over three hours. Melbourne experienced two minutes and forty-five seconds of totality centred on 4:41 pm AEST in the afternoon.

Most serious observers sought out locations on the central line with towns such as Millicent in South Australia, Ballarat in Victoria and Bombala and Merimbula in New South Wales being the most popular. Weather prospects were no better than for the 1974 Western Australian eclipse. According to the USNO circ-

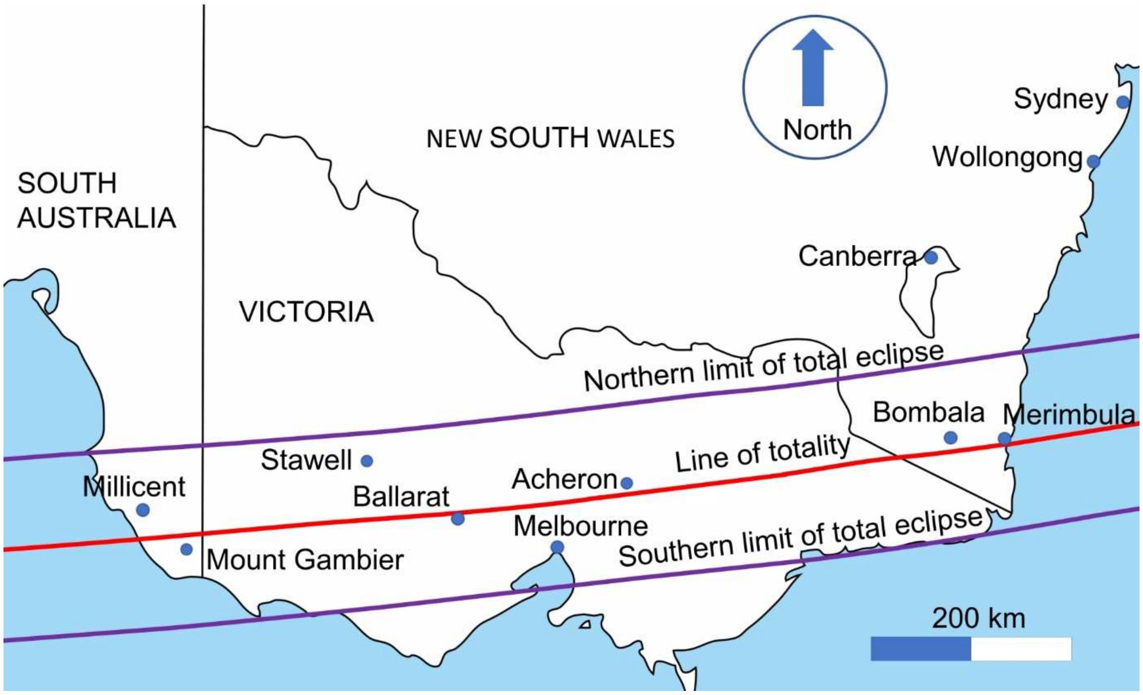

Figure 13: Map of south-east Australia showing the central line, together with the northern and southern limits of the 23 October 1976 eclipse. Places mentioned in the text are marked (map: Nick Lomb, based on map from d-maps.com).

ular (Fiala and Duncombe, 1975), rainfall was to be expected one day in two in southern Victoria but the prospects improved to the east towards the south coast of NSW with rainfall only on one day in three. Mean afternoon cloudiness was 6.4 eighth of the sky at Ballarat, 5.4 at Melbourne and 4.4 at the south coast. The Astronomical Society of Victoria's eclipse subcommittee suggested that the Bombala area, just to the north of the Victorian border, would be good for observing, explaining that it was between two mountain ranges that provided protection from "… moisture-bearing airstreams." (Lawrence, 1976). Climate data can give an indication of weather prospects but more definite indications can only be obtained from weather forecasts much closer to the date and time of the eclipse. On the morning of eclipse day, the latest satellite image showed a large bank of cloud about to move in from south of the continent and head over the eclipse track from South Australia to New South Wales (Sinnot, 1976). Eclipse viewing prospects seemed poor at all Australian locations.

3.1 Scientific Research

In 1976 opportunity was taken of the total eclipse to try to carry out a large variety of scientific research. Some of this was optical as would be expected. For instance, the whole of the Department of Physics of the University of Wollongong travelled to Bombala to conduct experiments looking at

> … such features as the chromospheric boundary, shadow bands, light intensity and the infrared and polarization properties of the outer corona. (The University of Wollongong, 1976: 38).

Glen Moore (pers. comm., September 2020), Wollongong University, says that the chromospheric boundary was to be imaged using the Fe XIV emission line at 5303 Angstroms using a special interference filter. However, due to an airline handler strike the filter was held up at Melbourne airport. It required an appeal to the head of the Australian Council of Trade Unions (ACTU), Bob Hawke, later to become Prime Minister, for an exception to be made. The handlers found the filter and delivered it to Bombala. Unfortunately, all to no avail as clouds prevented observations.

A variety of other research was carried out during the eclipse. Norman Labrum with two colleagues from CSIRO Radiophysics, John Archer and Christopher Smith, observed the eclipse at 3-mm wavelength using a specially-built 1-metre radio telescope (Figure 14) (Labrum et al., 1978). The eclipse provided the opportunity to map the solar brightness with a resolution of only a few arc seconds, a resolution that could not then be reached by other techniques. To maximise weather prospects and for technical reasons, a site at Stawell in Victoria was chosen for the location of the radio telescope. On eclipse day clouds built up that prevented observations at the beginning of the

Figure 14: John Archer working on the 1-metre telescope, with which he, Norman Labrum and Christopher Smith observed the Sun at 3 mm from Stawell during the 1976 eclipse (courtesy: CSIRO Radio Astronomy Image Archive).

eclipse, however, during totality there was a break in the clouds with only a thin layer of cirrus remaining. Though the cirrus cloud interfered with the observations, useful results were obtained. The radius of the radio Sun was determined to be 0.7% greater than when viewed visually. As well, at 3-mm wavelength the Sun was found to be slightly brighter at its edge or limb than the rest of its disc.

Astronomers talk about the Moon's shadow moving along the Earth's surface and note the temperature drop around the time of totality. Of course, the reduced heating in the region of the shadow also affects the atmosphere. It has hence been suggested that the supersonic motion of the cold patch associated with the shadow of the Moon should create bow shocks, as from a fast-moving boat in a river. These bow shocks could extend from the lower atmosphere to the ionosphere. To examine this possibility, Goodwin and Hobson (1978), both from the South Australian Institute of Technology, looked for pressure variations during the eclipse using four microbarographs. They found gravity waves with peak-to-peak amplitudes of 0.1 to 0.2 Pascals and a period of 23 minutes.

Three researchers from the University of Adelaide looked for variations in winds at around 90 km height in the atmosphere using a ground station in the path of totality and two, at Melbourne and Woomera, outside the path (Ball et al., 1980). No variation was found that could clearly be connected to the eclipse.

Kenneth Lynn from the Australian Defence Scientific Service examined the ionosphere using very low frequency (VLF) signals at two wavelengths from three navigation or communication transmitters, including one on the North West Cape, on the coast of Western Australia (Lynn, 1981). He found deviations in the phase of the signal that were less than expected from the usual daily variation. The pressure changes and the ionospheric results were suggestive of the atmospheric bow wave associated with the eclipse. However, the phenomenon was not definitely established until 2017. During the eclipse of 21 August that year, the ionosphere was probed with a network of around 2000 navigation satellite receivers scattered across North America (Zhang et al., 2017). Disturbances in electron content emanating from the eclipse region were clearly found with a duration of about one hour and a wavelength of 300 to 400 kilometres.

The effect of the decrease in light during total eclipses on animals like horses and birds has often been observed, but is there an effect on aquatic animals? Two sets of researchers set out to find out during the 1976 eclipse. Phillip Suter and Bill Williams of La Trobe and Adelaide Universities, respectively, investigated stream flow in the Acheron River, Victoria, near the centre line (Suter and Williams, 1977). They took hourly samples for almost the entire day of the eclipse using a steel frame with nets of 0.1 metre sampling area. No increase in the numbers of drifting organisms was found though, as expected, there was an increase after sunset.

Another set of researchers sampling at a creek did find the looked for increase during the eclipse but only for some species, or more precisely some taxa (Cadwallader and Eden, 1977). These taxa were larvae of four species that exhibited increased abundance both during the eclipse and after sunset. Larvae from another taxa, that is active during the day, showed the opposite effect of a decrease in abundance during reduced light levels.

3.2 Eclipse Flights

The success of the 1974 Boeing 727 eclipse flight led the Astronomical Society of Victoria to arrange a similar flight to view the October 1976 eclipse. Jim Trainor, who had been the local contact for the previous flight, was the organiser. Again, the plane was to be chartered from Ansett with a maximum of 36 passengers so that each would have their own window to observe the eclipse. The plan was for the aircraft to depart from Melbourne (Tullamarine) Airport at about 4:00 pm and return an hour and a half later. Like on the previous flight, the pilot was to be ASV member Ken Morris and the navigator was also to remain the same. The plane was to intercept the central line above a spot near Mount Gambier, where totality was longest on land, and then fly on a track arranged to provide a good view of the Sun at its elevation of approximately 27°. The cost was given as $180 (equivalent to about $1150 in 2019 dollars) per passenger, with a ballot if more than the allocated number of passengers wanted to be onboard (Reserve Bank of Australia, 2021).

There were others observing the eclipse from the air, but with smaller aircraft. One such flight was with five people, four of them members of the Astronomical Society of Western Australia (White, 1977). For people in Western Australia wanting to see the eclipse, it was cheaper and quicker to hire an aircraft to fly a return trip of 1200 km to intercept the central line 240 km off the coast then to undertake the much longer return trip to the eastern states, where the line passed over land. A five-seater aircraft with twin engines was hired for the flight. Leaving Perth at 11:15 am WAST, the aircraft first flew to refuel at Albany, where the weather was cloudy and wet. From there the aircraft flew towards the central line and by climbing to 3900 metres, slightly above the plane's permitted altitude, the pilot managed to find a clear patch in the clouds just in time for second contact and totality. One of those onboard, A.G.T. White, reports that at totality,

> In the immediate vicinity of the Sun, pastel blue streamers contrasted with the intense black of the Moon's unilluminated hemisphere … [and that] As far as the eye could see, the clouds were bathed in various shades of yellow, orange, pink and mauve, due to the refraction of light.

White, sitting in the co-pilot's seat, could identify the planets Mercury, Venus and Mars together with the bright star Spica in the darkness of totality. During the eclipse, the temperature outside the aircraft dropped by 5.5°C to –6.7°C. After totality concluded with the diamond ring, the aircraft returned to Perth.

Other people, who saw or tried to see the eclipse from small aircraft included Graeme White[3] and Gordon Robertson, then postgraduate students in astrophysics at Sydney University. An aviation engineering student friend of White (pers. comm., January 2021) offered to fly them with friends to Merimbula from Sydney in a hired Piper light aircraft, giving them the flexibility to relocate to avoid poor weather. The group camped at the airfield prior to eclipse day (Figure 15). On the day, with clouds closing on the Merimbula airfield, White asked the pilot to

Figure 15: A group at Merimbula airport in front of the Piper aircraft with which Graeme White and friends flew from Sydney and then observed totality from the air. Graeme White is second from the right. A tent draped over the wing of the aircraft can be seen, as well as two other small aircraft (photograph: Gordon Robertson).

try to take the plane to find a gap in the clouds. He failed to do so and returned to be above the airfield when totality occurred. To the pleasant surprise of White and friends, they found the clouds had thinned sufficiently to view the eclipse, however, the pilot was unhappy with the sudden darkness for he had no experience of night flying.

Robertson (pers. comm., January 2021) tried to view the eclipse from another small aircraft. He could not see the fully eclipsed Sun, but he was impressed with

> … the amazing speed with which the shadow raced in from the horizon and then out again at the end of the eclipse [totality, and with] … the rather strange sight of a bright sunlit strip at the horizon while it was dark where we were.

Maurice Clark, who later obtained a PhD from Murdoch University in Western Australia and is now at Texas Tech University, reports that he observed the eclipse from near Millicent in South Australia (Clark, n.d.). There he met up with friends from the Astronomical Society of Western Australia, two of whom had a light plane on standby in case of poor weather. The two decided to take the plane only 20 minutes before totality, so they raced the 35 km to the airport in 15 minutes. After they had run to the plane, the pilot took off and climbed steeply to an altitude of 16,000 feet (~5000 metres) to find a hole in the clouds. They successfully saw totality and took photographs but suffered from the lack of oxygen at that altitude.

3.3 Ground-based Observers

3.3.1 Melbourne

The Moon's shadow passed directly over Melbourne, the capital of the State of Victoria and a major city of 2.8 million people at the time. There was considerable cloud covering the city but many serious observers managed to see totality. (Public observation of the eclipse is covered in Section 4.) One such observer was defence scientist and ASV member, Barry Clark. Clark (per. comm., October 2020) obtained permission from the then custodian of Melbourne Observatory, the Science Museum of Victoria, to use the historic 20-cm lens telescope (Figure 16) at the Observatory during the eclipse. Strangely, he was alone in an almost deserted Observatory, apart from his family outside the telescope dome and another ASV member, Robert Luke Bryant, who had previously been the Deputy Curator of the telescope. Most others were trying to observe from their homes, from the aircraft hired by the ASV or had travelled to sites like Ballarat. Clark was fortunate that dur-

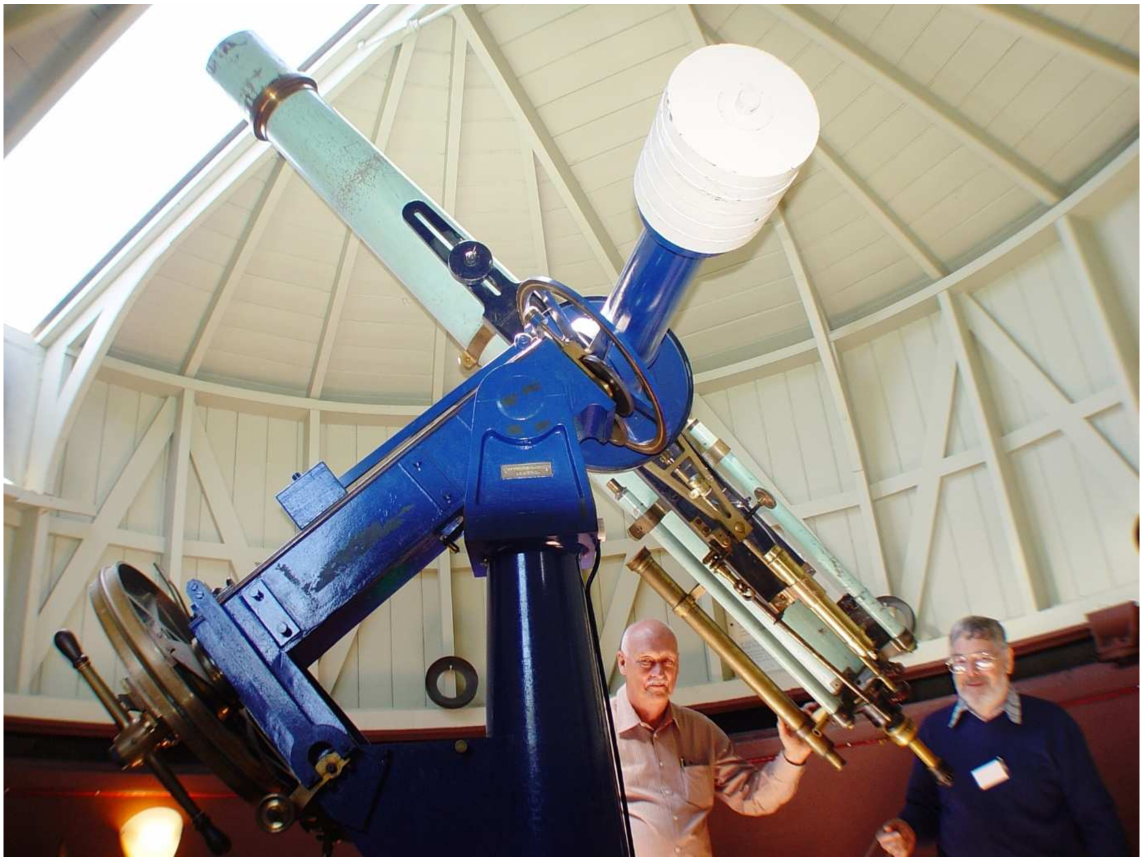

Figure 16: The historic Troughton and Simms lens telescope (the South Equatorial) in its dome at Melbourne Observatory. Barry Clark, who used the telescope during the 1976 eclipse is on the right, with another ASV member Barry Cleland (photograph: Barry Clark).

ing totality he could observe through a patch of sky that was clear, apart from some thin cirrus. Bravely, during the 2 minutes and 45 seconds of totality, he looked directly at the covered Sun with low and medium power eye-pieces. He was "… astounded to see that the directly visible prominences were not brilliant red but 'electric blue'". Being an expert on optics and light, he now says that he "… should have expected to see a slightly desaturated red with a bluish tinge." This is exactly what he saw at two subsequent eclipses.

Russell Cockman (pers. comm., January 2021), an ASV member and the current (2021) Director of the Society's Solar Section, also saw totality. He was then living in suburban Melbourne, to the south-east of the city centre. On the morning of 23 October, the sky was blue and clear but around lunchtime clouds started covering the sky. Still, he set up his 60-mm refractor in the backyard and managed to take a few photographs of the partially eclipsed Sun from a white card, on which he was projecting the image. When the clouds thickened and completely hid the Sun, he went inside to watch the eclipse on television. Noticing the sudden darkness outside, he went outside and fortuitously he saw

> … the totally eclipsed sun clear in a sizable hole in the clouds. I was mesmerised. I remember the black moon, the bright corona and the unreality of the scene, but before I had time to savour the spectacle the moon moved on to 3rd contact and the diamond ring.

Robin Hirst, then an astronomy lecturer at the State College of Victoria at Melbourne and later the Director of the Melbourne Planetarium, saw it from the roof of an eight-storey building at the College, together with 60 students (Duncan, 2016). Hirst (pers. comm., January 2021) had the students project the partial phases through a Celestron and a few 10-cm Newtonian reflecting telescopes onto cards. Only when the eclipse was total did he give the signal for the students to view the Sun directly through the telescopes. Forty years afterwards he said of the eclipse:

> It's burned into my memory. To see this shadow race across the landscape and come across you, everything seemed to go extremely still. It was very quiet, and it was

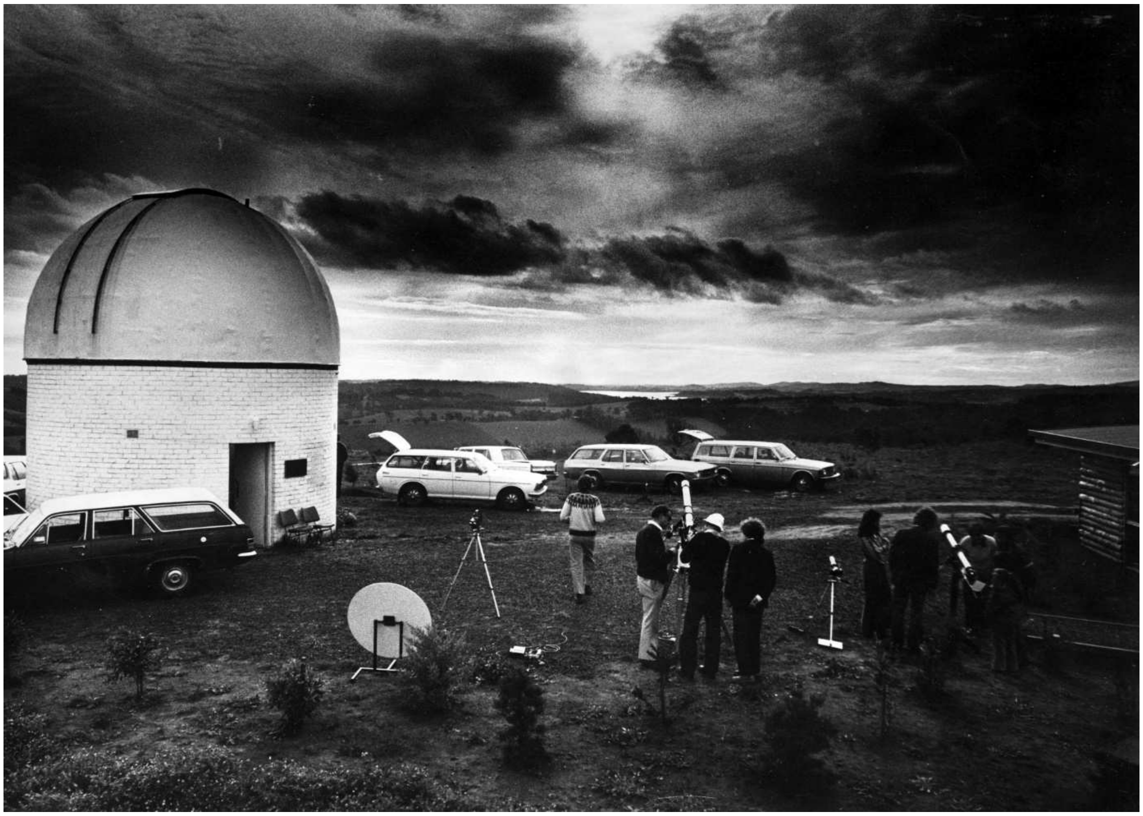

Figure 17: Dark clouds prevented viewing from Monash University's Mt Burnett Observatory. The dome at left housed a 0.4-m reflecting telescope, while on the right part of the log cabin used as the observers' quarters can be seen (photograph: John Clasper; courtesy Monash University Archives).

> a very eerie feeling with the Sun just disappearing. (Duncan, 2016).

Monash University staff and students attempted to view the eclipse from the University's observatory at Mt Burnett. The equipment at this observatory, in the Dandenong Ranges, about 60 km east of Melbourne, at that time consisted of a 0.4-m Newtonian telescope that was used for photometric observations of short period pulsating stars (Innis et al., 1986). From there dark clouds hid the Sun, preventing observations (Figure 17).

3.3.2 Ballarat

Most of the activity at Ballarat, especially for tourists and international visitors, was at the local airport. During the Second World War it was an air force training field but by the time of the eclipse it was owned by the local Council, the City of Ballarat. It was suitable for observing as it was a flat site and the Council could set up amenities, such as toilets. Among the international visitors there was a party of 18, led by George Abell (1927–1982), who was Professor and Chairman of the Department of Astronomy at the University of California, Los Angeles. One member of his group was Charles Richter (1900–1985), who had developed the Richter magnitude scale indicating the strength of earthquakes (Figure 18). Richter was making his third try at seeing a total eclipse and was hoping he would be successful this time (Noted scientist here to see eclipse, 1976).

Another notable visitor was Max Waldmeier (1912–2000), from the Swiss Federal Observatory, who was attending his 18th solar eclipse expedition (Anonymous, 1977). He was a noted solar astronomer and the keeper of the Zurich sunspot number series (Stenflo, 2016). Waldmeier was there with his astronomical secretary Susan Weber (Figure 19). The young Secretary of the local astronomical society, the Ballarat Astronomical Society (BAS), Graeme Hood (pers. comm., October 2020), met the two of them at a civic reception for international visitors and offered to transport them to and from the observing site, while the American tour group was taken by bus to and from the airport and to their hotels. Hood relates that on the day of the eclipse everyone was tense as the sky was covered by clouds. However,

> … at the last moment the clouds moved away from the Sun, the site went dark … like a picture theatre and for 3½ minutes everything was silent and still.

Figure 18: George Abell (white shirt) and Charles Richter (hat) at Ballarat airport preparing for the eclipse of 23 October 1976 (photograph: Graeme Hood).

A group of 13 BAS members elected to watch the eclipse from the top of a small hill called Mount Hollowback that is only a few kilometres from the centre of Ballarat (Willsher, 1976). They had with them a 15-cm reflecting telescope and a 60-mm refractor or lens telescope that were intended to be used for projectjecting the image of the Sun, but heavy clouds made this difficult. Though the Sun was covered in cloud during the partial phase, the elevated site allowed the approach of the Moon's dark shadow to be tracked from the brightness of nearby lakes. Lake Learmonth to the west, turned an 'inky black' just before the shadow reached the watchers on Mt Hollowback. During totality, the clouds thinned allowing glimpses of the corona. Spica and Canopus were visible but no planets due to the clouds. Streetlights in Ballarat came on during the eclipse, as well as the headlights of cars passing below. As the shadow swept past, Lake Learmonth was seen to change colour from black to silver. Some observers managed to glimpse the diamond ring, while others saw it as bright spikes of sunlight through the clouds.

In the months preceding the eclipse, some members of BAS put in considerable effort to interest and educate the local community about the forthcoming event.[4] A booklet was published, television and radio appearances were made and tours of Ballarat Observatory were used to give talks. On the day of the eclipse the President of the Society, Bruce Allen (pers. comm., October 2020), and other members gathered at the Observatory to observe the event and to provide public viewing. Two telescopes were provided, a 12.5-cm refractor

Figure 19: Susan Weber, Max Waldmeier and Graeme Hood at Ballarat airport waiting for the eclipse of 23 October 1976 (photograph: Graeme Hood).

and a 20-cm reflecting telescope, both projecting the Sun onto white cards. As at the nearby Ballarat Airport, clouds dispersed just before totality and allowed a view of the diamond ring and the eclipsed Sun. An unfortunately located cloud blocked the Sun, about two thirds of the way through totality, but more than one hundred visitors and members were grateful for what they had managed to see. The next day the local newspaper published on its front page a photograph of the partially eclipsed Sun taken from the eclipse projection with the 12.5-cm telescope.

BAS also had a radio section, the members of which set up two VHF antennas facing west at Ballarat Observatory. They also had a single wire antenna to receive short wave time signals at 15 MHz from the radio station WWV that broadcasted from Colorado (Lindorff, 1976). The two VHF antennas and their receivers were tuned so that several frequencies could be monitored during the eclipse. Some of these were only noise, while others were carrier frequencies, including that of Channel 0 transmitted from Mount Dandenong near Melbourne. Obvious changes were noted during the eclipse: the noise at frequencies without a transmitter decreased, while the carrier signals plus the signal from WWV increased.

3.3.3 Bombala

Bombala, lying near the centre line, is a town in the south-east corner of NSW, close to the Victorian border. With a population at the time of around 1500 people, it and the surrounding properties were one of the main centres for eclipse observers. The rush to Bombala was triggered by Roger Giller, the Eclipse Coordinator and soon-to-be President of the NSW Branch of the British Astronomical Association in Sydney. In a letter published in the February 1976 issue of *Sky & Telescope* magazine, Giller (1976) pointed out the advantages of Bombala, including, he claimed, the best weather prospects for any site, and the support of the local Lions Club. He emphasised that he had access to a sheep and cattle property outside of town that was only five kilometres north of the central line. This property of 4000 acres or 16 square kilometres was 'Tregedar', owned by a fellow amateur astronomer, Roger Morgan-Bruce. There was a huge response to the letter from astronomers around the world and the whole project became larger than Morgan-Bruce and the Lions Club could handle.

The other service clubs in the town, Rotary, Apex and Rotoract, became involved, as the newspapers reported that Bombala was the best eclipse viewing spot (Macklin, 1976). In addition to professional eclipse observers and amateur astronomers, thousands of public visitors were expected and the town planned a festival of the eclipse. The problem of how people could safely observe the eclipse was solved with the arrival in town of the American astronomy retailer Roger W. Tuthill with his aluminium-coated mylar Solar Skreen. The combined service clubs purchased $1200 worth of his solar filters and thought that they had overcome the problem. However, the local member of the NSW Parliament, John Akister, asked the Minister of Health whether the filters were safe (Akister and Stewart, 1976). In reply the Minister, Kevin Stewart, referred to advice from the Department of Optometry at the University of New South Wales that the filters should not be used by 'untrained persons' and he advised anyone interested to watch on television (more on filters in Section 4).

In the end the optometrists and ophthalmologists were pleased and everyone else was disappointed as heavy clouds covered the sky, with only about five minutes when the partially eclipsed Sun could be glimpsed (Hefner, 1976). The service clubs were disappointed as there were only about 3500 people at the town's racecourse for the planned day's activities, instead of the expected over 10,000, so that much of the food and drink purchased to feed the visitors remained unsold. The astronomers, who set up their equipment at 'Tregedar' and other surrounding properties were obviously disappointed, with one astronomer overheard to make the hyperbolic comment, "I think I'll commit suicide."

3.3.4 Merimbula

Merimbula is a small city to the east of Bombala, about 500 km to the south of Sydney and right on the coast. There, as the Moon's shadow left mainland Australia, the eclipse duration was two minutes and 47 seconds with the Sun 19° above the horizon at mid-eclipse. The Astronomical Society of Australia, the country's association for professional astronomers, selected the town for its first Beach Meeting (Goss, 1977). Held at a local caravan park, the meeting was held from 22 to 24 October 1976, that is, bookending the day of the eclipse. More than 50 members of the Society attended, so that together with families and friends there were about 180 people present. Some people camped, some stayed in the caravans and some at a nearby motel. Catering was provided by the local scout troop at an average cost of $1.50 per adult meal. The scientific sessions were held on each morning of the three days with only a blackboard available as a visual aid.

There were also evening talks 'suitable for wives and older children' and a public talk at the local scout hall.

On the afternoon of eclipse day most participants drove to Roger Morgan-Bruce's 'Tregedar' property near Bombala, to try the view the eclipse and take part in a communal barbecue. As previously mentioned, from there clouds prevented sighting totality. Most of those who stayed at Merimbula, including the Director of Sydney Observatory, Harley Wood, his wife, daughter and the daughter's soon-to-be husband, did manage to see it (Russell, 2008: 181). Ros Madden, Wood's daughter, recalled that after they chose a viewing spot, her father "… organised his viewing device and two sheets of paper, one with a hole in the middle." With this projection technique and despite some cloud, they could view the partial phase of the eclipse. Looking directly during totality, they could see Baily's beads "… flickering around the Sun."

4 DISCUSSION: FILTERS AND THE PUBLIC

In a detailed paper published in the August 1976 issue of the *Australian Journal of Optometry*, ASV member Barry Clark considered possible solar filters for use by the public at the forthcoming eclipse (Clark, 1976). He explained that at previous Australian eclipses there were always people who had suffered eclipse blindness or solar retinitis. These people were usually under 20 years old and mostly male. They sustained the eye injury because they did not use a filter, used one that was inadequate or did not follow instructions. The common suggestion of using pinhole projection as a safe way of looking at the Sun was often misunderstood with people looking through the pinhole.

The damage from direct solar viewing is mainly from visible and infrared wavelengths, with ultraviolet wavelengths only making a small contribution. Clark suggested that for safety and comfort a suitable solar filter should only transmit 0.0001 per cent in visual and somewhat higher in infrared. Discussing available filters, namely sunglasses, welding filters, smoked glass and exposed black and white photographic film, he only suggests the last as a possible safe filter. He mentions a Melbourne photographic company planning to distribute photographic filters mounted in cardboard frames printed with warnings about direct viewing of the Sun. These filters were tested in a research laboratory and found to have visible transmittance of 0.0003 per cent and infrared below 0.001 per cent. Clark suggested that further reductions in transmittance were needed for these filters. He did not discuss the aluminised mylar filters being sold by Roger W. Tuthill at Bombala, probably as they were too new and not widely distributed.

Filters became an important issue before the eclipse. As previously mentioned, Tuthill's filters were discussed and advised against in the NSW Parliament. There was a similar discussion in the Victorian Parliament. On 22 September 1976, Thomas William Roper, the Shadow Minister for Health, asked the Premier, Rupert Hamer, about the photographic film type solar filters (Victoria Parliamentary Debates (Hansard), 1976–1977: 2700–2704). He said, one copy of the device, made by Academy Film Productions Pty Ltd, has been tested by a research laboratory of the Department of Defence and has been found to be safe. However, he thought that does not mean that all other copies are safe and mentioned that he had two copies of the filter and they were already scratched. He requested the Government to control these devices or prevent their distribution. In reply the Premier said the company had wanted their filter to be advertised together with Government eclipse warnings. This was not acceptable and he said further:

> The safest thing is not to look at it but to wait until it is shown on television a little later. Whatever device may be tested, it cannot be guaranteed to be safe in every case.

In a further question to the Premier, on 5 October 1976, Roper asked about the composition of the Government's Solar Eclipse Committee that had evaluated the photographic filter (Victoria Parliamentary Debates (Hansard), 1976–1977: 2891–2892). Hamer in reply gave a full listing of the 14 members of the Committee. It included representatives of the ASV, the Science Museum of Victoria, the Premier's Department, the police, Australia Post, the Surveyor-General and the Department of Health.

Though the Australia Post's representative on the Committee was from its Philatelic Section, it seems that there was no stamp issued in association with the eclipse. However, there was a special eclipse day postmark available (Figure 20).

There were plenty of warnings in Melbourne and other cities, where the eclipse was only partial, for the public to only view the eclipse on television. The Health Commission of NSW, the Australian College of Ophthalmologists and the Australian Optometrical Association were among those that stated that there was no way to safely view the eclipse except by trained scientists (Scanlan, 1976). In Melbourne there were even large posters hanging on street corners headed, "WARNING! SOLAR ECLIPSE TODAY" as well similar flyers inserted into newspapers on eclipse day, all author-

Figure 20: An unposted envelope with a postmark for the eclipse of 23 October 1976 (collection: Nick Lomb).

ised by the Solar Eclipse Committee (Schneider, n.d.). These warnings had strong effects. In Melbourne the horse racing at Moonee Valley was timed so that the second last race started well before totality and the last race started well after (Scanlan, 1976). In Sydney, where the eclipse was 93% complete, grade cricket was disrupted with the team captains at one match agreeing to stop early, while at another, one team walked off to protect the players' eyesight and the opposing team claimed a forfeit (Confusion over eclipse, 1976). Also, in Sydney, the author failed in getting his seven-year-old nephew to look at the projection through a 60-mm refractor of the partially eclipsed Sun onto card, as the child was so indoctrinated from school that he insisted on only watching on television.

Television was certainly popular during the 35 minutes of the eclipse broadcasts with the number of sets in use increasing from the usual Saturday figure of 16% to 63% (Rating figures: ABC won eclipse audience, 1976). That meant that television sets were in use in 546,000 homes. Of the three TV stations carrying the event, the transmission by the Australian Broadcasting Commission (ABC) was easily the most watched. The ABC broadcast the eclipse from Ballarat Airport with a specially devised equatorial-like camera mount that could track the Sun, as well as from Mount Hollowback, outside Ballarat, Mt Dandenong, outside Melbourne and from the roof of their Melbourne studios (Australian Television Archive, 1976). Due to clouds, the presenter Ralphe Neill could only show totality from Ballarat Airport, but he could demonstrate the darkness due to totality from the other sites. A few members of the public did not heed the warnings and tried to watch the Sun directly during the eclipse.

In Melbourne 150 people, who feared eye damage, visited the Victorian Eye and Ear Hospital afterwards (Six have possible injury, 1976). Of these 150, doctors cleared all but five. These included two little girls aged four and six, but none of the cases was serious. There was another eye injury in Adelaide, where a drunken man had stared at the partially eclipsed Sun for 10 minutes.

5 CONCLUDING REMARKS

The 1974 and 1976 eclipses were the first to be visible from Australia since 1922. In the interim there had been great advances in technology and available equipment. Sophisticated filters, telescopes and radio instruments were pointed at the Sun at both eclipses by local scientists and a large cohort from overseas. Unfortunately, cloud cover at the main sites, at which the scientists were concentrated during both eclipses, frustrated research efforts. There were some useful results though, in radio observations of the Sun and in fields only tangentially related to astronomy, such as gravity waves in the atmosphere and stream drift.

Amateur astronomers came into their own at these two eclipses with better telescopes, telephoto lenses and aperture filters available than at earlier eclipses. For most, the two eclipses were the first total ones that they observed, as the relatively cheap airfares that allowed the practice of travelling the world to witness total eclipses elsewhere were not yet available. Despite cloud and inexperience with eclipse observations, some, like David Herald at Quininup Beach, managed to do serious research, while others obtained spectacular photographs of the corona.

The most memorable part of the 1974 total eclipse was the successful eclipse flight, which was the first commercial eclipse flight. This was followed by a similar flight for the 1976 eclipse. It set up a trend for astronomy flights in Australia such as the series of Halley's Comet viewing flights in 1986 conducted by Trans Australia Airways (TAA); the author was the lecturer on a number of those.

Providing information to the public about eclipses, especially a total eclipse, is always a fine balance. People are being told that something exciting is happening in the sky above their heads but under no circumstances should they look. In Melbourne, a major city lying in the path of totality, the authorities decided to take no chances. The public was warned not to look at Sun under any circumstances and to watch only through the medium of television. The use of all filters, even those that were safe or close to being safe, was disparaged, as was the use of pinhole projection on the basis that instructions for its use could be misunderstood. Repeated warnings, together with widespread cloud during the eclipse, had the beneficial result that in Melbourne only a few people sustained eye damage and none seriously. However, the hidden cost of all the warnings and the lack of proper information being provided was that the city's over two million inhabitants were deprived of the chance to see, for the first and probably the last time in their lives, the wonderful sight of a totally eclipsed Sun. We will never know how many children would have been stimulated by the sight to choose to study science and go on to make major contributions to society.

On the early afternoon of 22 July 2028, another Australian city will experience totality. The city is Sydney with a current population of over 5 million people. There will be almost four minutes of totality and again it will be a Saturday so most of the city's population will be free to view the eclipse. The chances of being able to view it is high, as in July the mean number of cloudy days recorded at Observatory Hill is only 8.7, which is one of the lowest values for the year (Australian Government Bureau of Meteorology, 2021). With eclipse glasses easily available, with public outreach at places like Sydney Observatory and by amateur groups and, if astronomers take a leading role in educating the public, many more people will have the opportunity to be safely awed by the spectacle of the eclipsed Sun than in Melbourne 52 years earlier. Those, who are willing to travel a little, can follow up two years later with the total eclipse of 25 November 2030 that will pass to the north-west of Adelaide, South Australia and end at sunset just to the west of Brisbane, Queensland.

6 NOTES

1. It is often said that the deflection of starlight by the Sun as predicted by Einstein was confirmed by Arthur Stanley Eddington at a 1919 eclipse (Kennefick, 2019). However, as shown by Treschman (2014: 147–152), that earlier verification was too readily accepted despite it being based on limited and arbitrarily selected data.
2. The Astronomical Society of Victoria was then, as it is now, a large and active organisation with some of its members doing serious research. These included Bruce Tregaskis (Section 2.3), who made visual observations of variable stars and Barry Adcock, who used his home-built telescope to study the planets (Orchiston, 2000: 21–23). Other members built unusual telescopes of the folding-mirror variety, some of which were the largest, or among the largest, of their type anywhere in the world. As well, there was research into the history of astronomy and a commitment to education and outreach (Orchiston, pers. comm., March 2021).
3. Before commencing his PhD Graeme White was an amateur astronomer, who was the first to sight Comet White-Ortiz-Bolelli (C/1970 K1), one of the Kreutz family of sungrazing comets (Orchiston et al., 2020).
4. Education is not new for the Ballarat Astronomical Society as it is linked to the Ballarat Municipal Observatory. The Observatory was opened in 1886 for use by students at the Ballarat School of Mines and a regular astronomy class was taught there (Burk, 1986). The total eclipse revived local interest in astronomy and led to the Society greatly increasing its educational activities for the public.

7 ACKNOWLEDGMENTS

The author is grateful to Dr Barry Clark, who provided his recollections of the 1976 eclipse, appropriate articles including his own paper on solar filters for the public, and slides taken by Arthur Coombs on the 1974 eclipse flight, as well as comments on the draft paper. Arthur Coombs shared his memories of the 1974 eclipse flight and provided an extra photograph. Dr Craig Bowers, historian at Perth Observatory, scanned and provided the Observatory's entire file on the 1974 eclipse, as well as scanned photographs from the eclipse. Glen Moore kindly provided relevant articles and recollections. Dr Graeme White and Dr Gordon Robertson provided images and their reminiscences of the 1976 eclipse. Graeme Hood, Horst Engel, Peter Faulkner and Mark Rigby shared their memories of the 1974 eclipse, as did Dr Russell

Cockman, Ian Sullivan, Dr Robin Hirst and Bruce Allen of the 1976 eclipse. Judith Bailey of Ballarat Observatory, Karen Rogers of Monash University Archives, Dr Ron Ekers and Dr John Archer were all most helpful. Professor Lawrence Cram provided much useful information and references, while Professor Jay Pasachoff greatly improved the paper with his comments, information and photographs. The Managing Editor of *JAHH*, Professor Wayne Orchiston, was also of great assistance. Some of the photographs in this paper were enhanced through MyHeritage.com.

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