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Making Visible the First Women in Astronomy in Australia: The Measurers and Computers Employed for the Astrographic Catalogue

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Abstract

In Australia a significant number of women were employed to measure and compute the position of stars for the Astrographic Catalogue at Adelaide, Sydney, Melbourne and Perth Observatories. New archival research has provided evidence that the first women employed in astronomy in Australia were engaged due to this project.
This paper focuses on Mary Emma Greayer, who was employed as a computer at Adelaide Observatory from 1890, and Charlotte Emily Fforde Peel, employed as a star measurer, computer and astrographic assistant at Melbourne Observatory from 1898. The measurement bureaux at Melbourne, Perth and Sydney Observatories are examined within the context of women working on the Astrographic Catalogue in other observatories during the late nineteenth century.
Evidence is presented that individuals, such as Greayer and Peel, were vital to the completion of the Astrographic Catalogue and other astronomical work. Furthermore, it is argued that this evidence points to women having a broader role and greater agency within observatories in Australia and in astronomy than has previously been acknowledged.

Keywords: astrometry – catalogues – history and philosophy of astronomy – sociology of astronomy

INTRODUCTION

This paper aims to re-insert women back into the history of astronomy during the colonial epoch in Australia through analysis of new archival evidence of the extent and nature of women's work on the Astrographic Catalogue at Adelaide, Melbourne, Perth and Sydney Observatories.

In Section 1, I examine the extent of Australia's involvement in the Astrographic Catalogue (AC), the reasons for participation and the historiography of the project within the context of how the AC created work for women in astronomy. In Section 2, the women working in Britain, North America and France on star catalogues provides a context for the career opportunities, employment conditions and acknowledgment of women in Australia. In Section 3, I present new evidence about the extent of work performed by two women employed by observatories in Australia. In Section 4, I analyse the gendered nature of history and how this has impacted on the visibility of women in the history of astronomy in Australia.

Past assumptions about the nature and extent of women's work for the AC and in astronomy during the colonial period are challenged by the new evidence presented in this paper and I conclude that this changes the authorised history of astronomy in Australia.

1. The astrographic catalogue and Australia's participation in context

The AC was arguably the most significant astronomy project undertaken in the late nineteenth and early twentieth century in Australia as made evident by the Government Astronomer of New South Wales's report to the Australasian Association for the Advancement of Science in 1893 in which he explained the emergence of photography to astronomy and highlighted the scientific endeavours of the AC (Russell 1893). Further to this the number of regular reports presented by the respective State Government astronomers to the Monthly Notices of the Royal Astronomical Society (MNRAS) and the financial and human resources applied to the project indicate it was considered of utmost importance (Haynes et al 1996).

1.1. Colonial observatories join an international network

The first international Astrographic Congress was held in 1887 at Paris Observatory. It was at the recommendation of British astronomers, William Huggins and David Gill, who wrote to the director of Paris Observatory, that Sydney and Melbourne Observatory were invited to

Table 1. Stars measured and resources applied to the Australian zones of the Astrographic Catalogue (Cooke 1912, Curlewis 1914, Greaves 1949, Wood 1971).

Observatory	# Stars	# Plates	# Female computers	From / To	# Years*
Adelaide Observatory	6 818	0	2	1891 / 1898	8
Sydney Observatory	740 000	1400	22	1916 / 1963	174
Melbourne Observatory	392 615	1149	26	1898 / 1930	104
Perth Observatory	228 000	944	11	1906 / 1922	57
Royal Observatory Edinburgh	194 000	139	12	1908 / 1914	35**

*Cumulative total year estimates.
**Estimate due to unknown impacts such as delivery delays on the Perth Observatory plates due to WWI.

participate from the onset (Huggins 1886). Sydney Observatory was allocated zone −52° to −64° and Melbourne Observatory −65° to the south celestial pole. Adelaide Observatory undertook to provide a catalogue of positional stars for the Melbourne Zone. William Cooke, director of Perth Observatory, actively sought to participate in this prestigious project (Baracchi 1898c) and in 1900 the Western Australian government officially accepted the zone −32° to −40°. The correspondence between the colonial state astronomers and astronomers around the globe shows that one of the many attractive aspects of this program was the engagement in the growing international astronomical networks this project offered.

At a following congress held in 1892 it was decided that, rather than establish a central bureau in Paris to measure the stars on the glass plate negatives and reduce the co-ordinates of the zones to a single epoch, each observatory would make its own arrangements for measurement and preparation for publication (Gill 1892). This decision was pivotal in changing the nature of observatories around the world. Standard measurement techniques were established for the AC, and one of these standards was to recommend the establishment of bureaux of women to measure and catalogue each star (Bigg 2000).

1.2. The richest section of the sky

Altogether the area of sky the Australian observatories were allocated accounted for 18% of the entire project (White 1987), with the richest section of sky to contend with and the largest number of stars to be measured and reduced (Wood 1971). Table 1 shows that the Sydney Zone had the largest number of plates and stars and the resources applied to the extensive program undertaken by these observatories. The photography was a challenge, however the time taken to measure and compute the data has been described as 'the real brake on the project' (Lomb & Pickett 2001).

1.3. The historiography of the AC in Australia

Since the completion of the AC in 1961 its historiography has focussed on the longevity of the project and its impact on resources available for other astronomy research in Australia in the early twentieth century (Haynes et al 1996, Hearnshaw 1996, Orchiston 1988, White 1987). The reliability of the AC results have been questioned (Hearnshaw 1996) and analysed in terms of the value of the project for 'determining proper motions when combined with modern observations' (Urban, Corbin & Wycoff 1988). Analysis of the accuracy of the Sydney Zone concluded that the emulsion on the glass plates was the cause of greater error than the measurement techniques (Wood 1960).

This paper does not attempt to analyse these aspects of the historiography of the AC but to focus on the women who were variously called 'astrographic assistant', 'star measurer', 'clerk', 'junior computer' and 'astrographic computer'. My research has uncovered that in the logbooks the majority of women did star measurement, magnitude determination, computation and made notes about irregularities, including double stars. Some women also managed the bureau, checked errors, calibrated instruments and prepared the documents for printing.

Records of the AC measurement work are embodied in the volumes of the Sydney (Cooke 1923 to 1925, Nangle 1929 to 1941, Wood 1945 to 1971), Melbourne (Baldwin 1926 to 1929, Wood 1945 to 1964) and Perth Astrographic Catalogues (Cooke 1911 to 1912, Curlewis 1913 to 1921) and the three volumes of the Perth Zones measured at the Royal Observatory Edinburgh (Greaves 1949, Wrigley 1952). There are summary reports for each observatory outlining how the project came about, the techniques used and most of the people involved (Cooke 1912, Baldwin 1926, Wrigley 1952, Wood 1971). Tables list the women's initials next to the plates that they measured in most of the catalogues.

The Double Star research and magnitude comparative studies that emerged from the AC did not acknowledge the women whose observations, as they measured, detected and noted the double stars (for example Wrigley 1911, Pocock 1915, Barton 1937a, 1937b). I have located only three scientific papers where the work of an individual female astrographic worker in Australia is acknowledged (Baldwin 1917, 1918; Wood 1971). James Baldwin, then Director of Melbourne Observatory, acknowledged Charlotte Peel's measurement of the position and magnitudes of two comets. Harley Wood, New South Wales Government Astronomer, published the final explanatory volume of the Sydney Zone in 1971 and named the women who worked on the Melbourne and Sydney Zones. Wood acknowledged the contribution made by Winsome Bellamy and Margaret Colville in completing the AC (Wood 1971).

Minimal information about the women is to be found in more recent publications (Barker 2009; Lomb & Pickett 2001; Russell 2008; Stevenson 2012) and, in reference to Wood (1971), Bhathal highlighted C. Peely (sic) and W. Bellamy for their length of service (Bhathal 2001) but not for their contribution to astronomy. Sydney Observatory and the Royal Botanic Gardens, Melbourne, developed minor exhibits about the AC inclusive of the computers and measurers.

During the late nineteenth and early twentieth centuries the news and popular media in Australia showed intermittent interest in the AC. Unlike the male astronomers and technicians who are named, the women are most often referred to as the 'girls' or 'ladies' (for example Brisbane Courier 1902, The Argus 1908). There is one exception in which the Women's Supplement of The Sydney Morning Herald (1938) named astrographic computers at Sydney Observatory, Muriel Mills and Beth Macara.

2. Women who measured the stars

The AC was pivotal to the introduction of women into the paid workforce in many Nineteenth Century observatories around the globe, but, as is examined in this section, it was only in rare circumstances that this led to acknowledgment and a career in astronomy.

2.1. Star measurers and computers in Britain, France and North America

According to Oxford College Observatory Director, Herbert Hall Turner, the normative structure of the AC observatories was established for economic reasons with women employed for the greatest quantity of the work because they were a proven and reliable cheap source of labour (Turner 1912). Science historian Mary T. Brück called the female computers working at the Royal Observatories in Greenwich and Edinburgh 'Slave Wage Earners' (2009).

The Astronomer Royal, William Christie, employed four female Cambridge mathematics scholars, including Alice Everett, in 1890–91 for the Royal Observatory Greenwich (ROG) zone of the AC in temporary positions at a salary of £30 per annum (Brück 2009). Everett undertook a program of photographing the stars by night and plate measurement by day. In 1896 Everett joined the AC project at Potsdam Observatory as the first woman to be employed in astronomy in Germany. In 1898 Everett was employed for a year at Vassar College, in New York State, however, despite applications made for positions in observatories back in Britain, she was not successful in establishing a further career in astronomy because, according to Brück, she was female (2009).

Dorothea Klumpke was employed by Paris Observatory to establish and head its 'Bureau des Mesures'. Klumpke wrote one of the first descriptions of a measuring bureau and acknowledged the work of her staff, Mme Schott and Mlle Marquette (Klumpke 1895). Klumpke presented a paper about women's work in astronomy to the International Congress of Women in London which described the tedious work of producing astronomical almanacs as 'astronomical labour' (Klumpke 1899). According to Klumpke this work was 'truly scientific' in its nature and women have:

> 'qualities prerequisite for producing lasting results – concentration and enthusiasm, powerful levers that move worlds. Ours is a work of the night and day! ... astronomical science now becomes universal! She knows no boundaries, no rank, no sex, no age! ... In photographic astronomy women in the national observatories of Paris, the Cape of Good Hope, Helsingfors, Toulouse, Potsdam, Greenwich, Oxford, have contributed to the International Photographic Chart of the heavens. Day by day, women bending over the micrometers examine the photographic skies and measure the star-positions to form the catalogue which is to be a legacy of our century to future generations.'
>
> (Klumpke 1899)[1]

Klumpke's analysis that astronomy was now 'a science of gender equality' reflected only the small number of women who were encouraged and paid to pursue new research. In North America at Vassar College and Harvard College Observatory women progressed to senior positions, made new discoveries and published independent research (Klumpke 1899, Larsen 2009, Mack 1990a, 1990b, Rossiter 1980,1983). Williamina Fleming published several papers on spectral analysis and was acknowledged by Harvard College Observatory Director, Edward Pickering (Fleming 1893, Fleming & Pickering 1896) and Caroline Furness published over 90 papers including a catalogue of stars reduced from four photographic plates taken at Vassar College (Furness 1905).

At Oxford College Observatory Ethel Bellamy gained astronomy experience from working with her uncle, Frank Arthur Bellamy. Bellamy measured and reduced most of the Oxford AC Zone plates for Turner (Brück 2009). After the Oxford zone was complete Bellamy finished and checked the Vatican Observatory AC Zones. Bellamy published her astrographic findings on proper motions (Bellamy 1919) and was awarded an honourary Masters Degree (Brück 2009, Hutchins 2008).

The exceptional women I have described in this section were well educated or had a family member prominent in astronomy. Extensive research into women in astronomy in the United Kingdom (Brück 2009, Kidwell 1999), in North America (Mack 1990a, 1990b, Rossiter 1980, 1983) and in Paris, the Vatican (Bigg 2000) and Toulouse (Lamy 2006) has revealed that star catalogue measurement was not a pathway to a career in astronomy for the majority of women. Most women measurers and computers were employed on fixed

[1] It is possible that Klumpke did not know about the women working at Adelaide and Melbourne observatories, who were not included in her list. In 1899 the Melbourne Observatory bureau was only recently established.

salaries at low rates in observatories around the globe and rarely recognised within publications or otherwise formally acknowledged for their objective and scientific contributions to astronomy (Rossiter 1980, Brück 2009).

2.2. *Star measurers and computers in Australia*

The women employed in Australia for the AC were significant in number and their employment spanned a period from 1890 to 1961 as illustrated in Table 1.

In 1890 Charles Todd, Government Astronomer for South Australia, employed a 'female computer', Mary Emma Greayer, and a second computer, Miss Pittman, in 1892 (Adelaide Observatory 1893). In 1898 Pietro Baracchi, the Government Astronomer for Victoria, established a star measuring bureau of six women at Melbourne Observatory. As agreed between Baracchi and Russell, Misses Peel, Phillips, Skoglund, Lewis, Harker and Hall would undertake measuring and reducing the Sydney and Melbourne Zones (Baracchi 1898a). In 1907 at Perth Observatory Cooke established a bureau of two 'star measurers', Prudence Williams and Minnie Harvey (Cooke 1908), and by 1909 there were seven women computing the reductions as well as measuring (Commissioner's Office, 1910). Cooke became the NSW Government Astronomer in 1912 and by 1916 established a measuring bureau at Sydney Observatory with Miss Digby and Miss McDonald working on the Sydney Zone.

A few women, such as Mary Emma Greayer (Adelaide Observatory employee 1890 to 1898), Charlotte Peel (Melbourne Observatory employee 1898 to 1918), Prudence Valentine Williams (Perth Observatory employee 1907 to 1918) and Winsome Bellamy (Sydney Observatory employee 1948 to 1968) worked for many years at the respective observatories. Exposing the barriers women, such as Greayer, Peel, Williams and Bellamy, faced in their employment has been identified as essential to making women's work and its value to the whole more visible (Nugent 2002). As discussed in the next section the employment conditions for women were implicit in restricting the acknowledgement and advancement of women in astronomy.

2.3. *Conditions of employment for astrographic assistants*

An Australian Heritage Office report on women's employment and professionalism (Nugent 2002) revealed that at the end of the nineteenth century women had access to education and some university courses. It was these middle class, educated women, who entered public life because opportunities for women to gain employment other than in domestic duty, in factories or as barmaids, were limited (Nugent 2002). The colonial governments offered public service examinations for women in non-clerical positions, primarily as 'Female Telephone Operators', in post offices, as electoral registrar assistants and in teaching. It was from these lists that most of the women were drawn to work in the observatories.

Throughout much of the 1890s rural areas across Australia were in prolonged drought (Todd 1897a). This caused a severe financial depression which directly impacted on resources for astronomy (Ellery 1892) and it was accepted, though not initially legislated, that women would be paid less than men (Nugent 2002). In Australia a marriage bar was introduced via the Commonwealth Government Act in 1902 and from 1907 it was legislated that women were to be paid 54% of a male salary (Higgins 1907). There was a clear distinction between men's work and women's work and acknowledgement for women whose work may have been considered 'men's work' was likely kept hidden due to the impact it could have had on their salary conditions (Kramar 1990). The marriage bar was not completely lifted until 1966 and in 1972 equal pay was legislated (Kramar 1990, Nugent 2002).

The Melbourne Observatory computers were tested for mathematical ability, and as decided between Baracchi and Russell, their wages were drawn from funds totalling £300, paid equally by Sydney and Melbourne Observatories (Baracchi 1898a, 1898b). The women's wages of £40 per annum were comparative with 'female pupil teachers' (trainee teachers), who in Victoria earned between £24 and £60 per annum (Victoria Gazette 1896). Four years later their salary remained unchanged and, as remarked in a popular news paper about the 'Women's work at the Melbourne Observatory', was comparatively low:

> 'Their hours are from 9 am to 5 pm on weekdays and to noon on Saturdays, an hour being allowed for lunch. Their salary is £40 a year. (The editor has only one remark . . . no man would undertake it at more than double the amount).'
>
> (Brisbane Courier 1902)

At Perth Observatory the base salary of £40 continued until 1913 when Prudence Williams, Minnie Harvey, Ethel Allen and Ida Tothill, measurers and computers, complained about the rate of pay and that the work was 'hard on the eyes' to Harold Burnham Curlewis, Government Astronomer Western Australia (Williams et al 1913). Curlewis wrote to the Under Secretary rejecting a recent order to restrict the women's employment to a maximum of three years and questioned why the women's rate of pay had not been increased as recommended:

> 'The minimum fee of £40 was inadequate for the class of work which is of a technical character, so much so that the first six months is spent by a newcomer in qualifying for the position . . . ' According to the recommendations of the Classification Board the Astrographic Assistants (plate measurers) were to be placed on the permanent staff at a commencing salary of £48 rising to £96.'
>
> (Curlewis 1913)

Williams argued that the work required training and skill (Williams 1914). Curlewis appreciated this and requested

that the regulation of a maximum 4 years employment be changed (Curlewis 1913). Through her written submissions and representation Williams influenced the salaries offered and also the conditions under which the women at Perth Observatory worked.

2.4. Measurement techniques and error checking

The summary reports (Cooke 1912, Baldwin 1926, Wood 1971), standard format of the logbooks and more recent interviews with two computers who worked at Sydney Observatory confirm that the methods used to measure the glass plates in Australia were identical to those used for the Oxford University Observatory zone (Turner 1912).

According to Sydney Observatory Astrographic computers, Winsome Bellamy and Verlie Lee (nee Maurice), each plate was assigned to two women to measure, one in the positive, the other in the reverse. Every thirty minutes, or so, the women would swap positions, one measuring, the other notating. In general the measurement was done in the morning and the computational work in the afternoon, and the measurement machine was located near a window facing south for even light (W. Bellamy 2009; V. Lee 2011, private communication).

The logbooks in the Perth Observatory archives show that the pace and accuracy of measurement was constantly checked and compared. For example, on plate 3365 it took Williams 4.5 hours to measure 161 stars in positive and reverse, whereas on plate 3366 Allen took 4 hours to measure 154 stars in positive and reverse. Nossiter complained in length about the women's accuracy and the slow speed of work (Williams 1914). Williams, on behalf of the other women, argued that they were also doing much of the computational work assigned to Nossiter, and although they did not mind doing the work, they wanted to be paid for it (Williams 1914).

The women were kept strictly segregated from the male astronomers, not so much to protect them and to avoid scandal, but to stop the loss of productivity that would supposedly follow from distraction of the male staff (B. Clark 2012, private communication). At Sydney Observatory the measurement bureau was located on the top floor of a now demolished northern wing of the observatory building[2], and at Melbourne Observatory they were in a south-facing wing, now called the 'Ellery Room'. This physical isolation was typical for measurement bureaux globally.

One of the major impediments to women pursuing more research-based work in observatories in North America and in Britain was the exclusivity of the main instruments in observatories to males (Larsen 2009, Brück 2009). There was further social discouragement for women to work at night as the observatories were, by their nature, in isolated and poorly lit locations but according to social scientists, in Europe (Brück 2009) and in North America (Rossiter 1980,1983; Mack 1990a, 1990b; Larsen 2009), some women did 'breach the divide' (Larsen 2009). I will now examine two outstanding individuals, Greayer and Peel, and how their work 'breached the divide' in Australia.

[2] This building was constructed in 1906–7 for the establishment of the new Federal Bureau of Meteorology. Instead the building was used for the Astrographic measuring bureau. In the 1980s refurbishment of Sydney Observatory the building was demolished.

Figure 1. Adelaide Observatory staff c1895 (left to right) Charles Todd, William Ernest Cooke and Mary Emma Greayer. Collection and copyright permission Perth Observatory, donated B. Minchin.

3. Outstanding individuals

3.1. Mary Emma Greayer (b.1861 to d.1910)

Mary Emma Greayer worked at Adelaide Observatory from 1890 to 1898. She was employed as a temporary assistant at Gepps Cross and then Angaston public school in 1886 (South Australian Register 1886). In 1887 her sister, Jessie Greayer, married William Ernest Cooke, assistant government astronomer. The photograph in Figure 1 shows Mary Emma Greayer with Charles Todd, Government Astronomer South Australia, and Cooke.

Because Greayer was not a permanent staff member her name does not appear in the Public Service Gazette or in official staff records in which only permanent staff are listed. It is through the Time Book, as shown in Figure 2, that evidence of Greayer's regular night work from December 1890 is found and the 1897 Adelaide Observatory MNRAS report (Todd 1897b). Furthermore the initials 'M.E.G.' in the handwritten logbooks of observations and reductions recorded the extent of Greayer's work, which included observing through and calibrating telescopes.

Greayer regularly worked in partnership with Cooke on three or more nights per week from 1891 and when Cooke resigned in 1896 Richard Fletcher Griffiths became her observing partner. The 1893 observing logbook lists Greayer as the main observer of Individual Zenith Stars (Adelaide Observatory 1893). She took micrometer readings and reduced the nadirs. The diary notes indicate that she adjusted the 6-inch Troughton and Sims Transit Circle telescope pictured

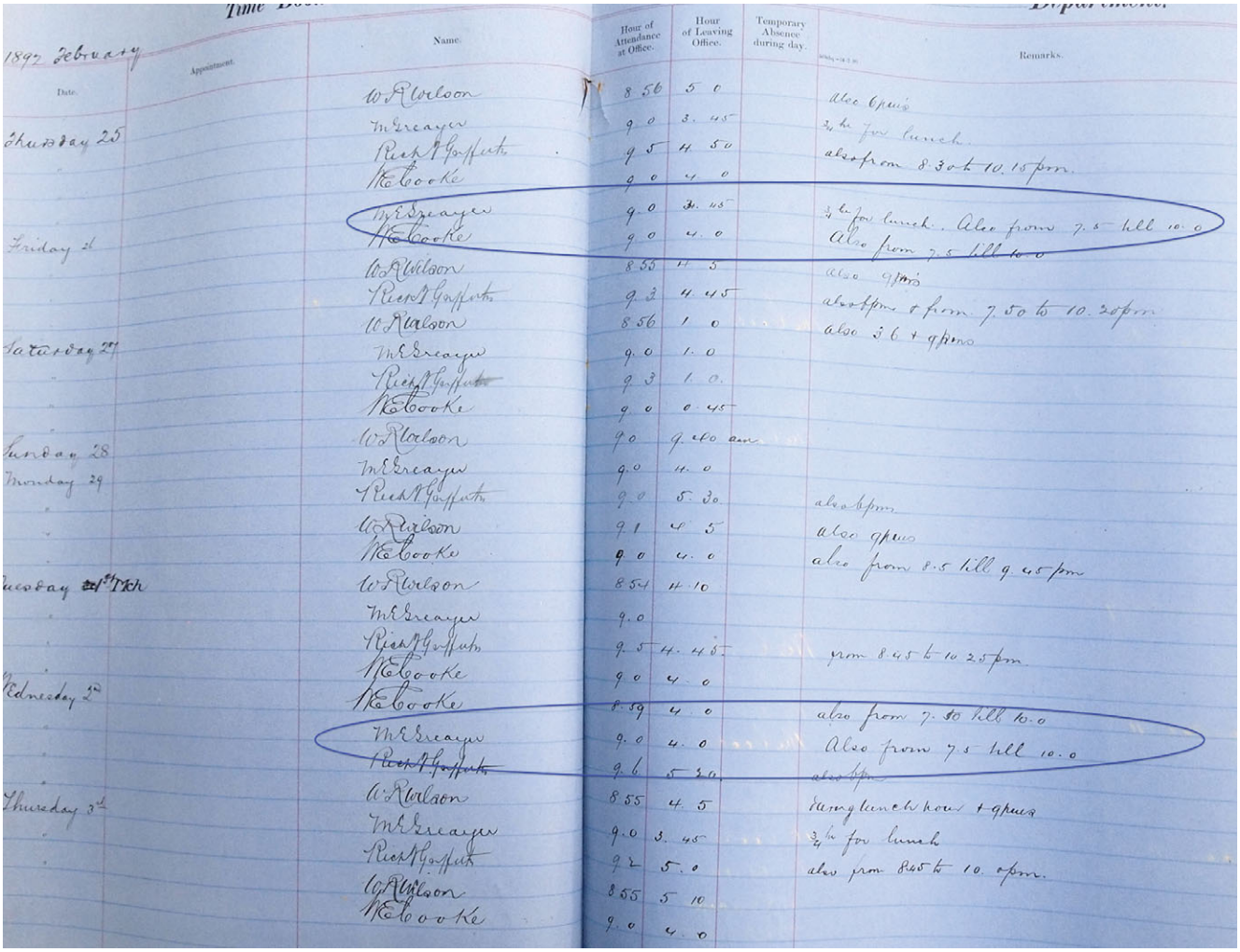

Figure 2. 'Time Book' Adelaide Observatory 1890–1898. Greaver's night work on 25 February and 2 March 1892 is circled. State Records South Australia GRG 31/19. Photographed with permission, T. Stevenson.

in Figure 3 and calibrated other instruments. This work is in six volumes and each volume holds details of an estimated 990 stars. Greaver observed and reduced many hundreds of clock stars also with the transit instrument.

At night Greaver observed over one third of the positional stars for the Melbourne AC zone between 1894 and 1898 using the 8-inch equatorial telescope shown in Figure 4 (Adelaide Observatory 1898). During the day, between 1895 and 1897, Greaver reduced the Melbourne Astrographic Zone stars (−65° to the South Pole) from apparent to mean RA and NPD (Adelaide Observatory 1897). Cooke and Greaver observed the Stars from the General Argentine Catalogue to compare magnitude observations (Adelaide Observatory, 1892).

Greaver's interest in astronomy and curiosity about new developments led her to be one of the first three women to join the Astronomical Society of South Australia (ASSA) in 1893. Her acceptance into the society with Lorna and Alice Maud Todd was reported in the newspaper (The Advertiser 1894), as the ASSA was one of the first astronomical societies to enrol women as members without prejudice. In 1895 South Australia was the first state in Australia to grant women suffrage.

Greaver's significant contribution to the astronomical work was highlighted at the time of her resignation in 1899 from the correspondence between Todd and Baracchi:

> 'Since Mr Griffith's marriage which has deprived me of Miss Greaver's services we have been unable to observe any of your Astrographic stars . . . '
>
> (Todd 1899a)

Todd also wrote to NSW Government astronomer, H.C. Russell, about Greaver, praising her as 'a veritable Caroline Herschel' bemoaning that, after Greaver's departure, the work of measuring standard stars for the AC 'stalled' for a number of years (Todd 1899b). Greaver married Griffiths in 1898 and they had four children. Greaver died on 3 September 1910 aged forty-nine in Victoria.

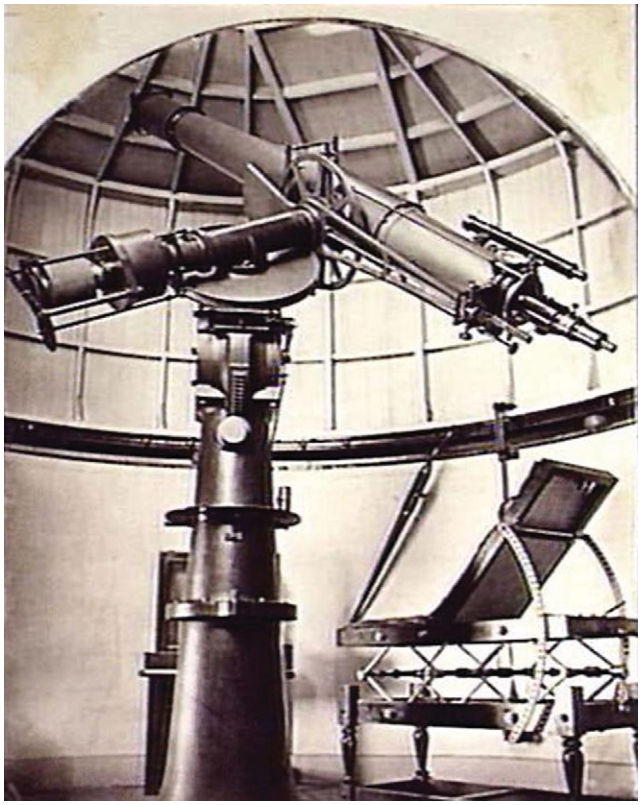

Figure 3. Transit telescope used by Greayer at Adelaide Observatory, pictured with Richard Griffiths. State Library of South Australia B22764/1.

3.2. Charlotte Emily Fforde Peel (b.1876 to d.1974)

Charlotte Emily Fforde Peel had a career at Melbourne Observatory from 1898 to 1918. Peel passed the State Government public service exam for non-clerical positions and switch operators (Victoria Gazette 1896) and was appointed to the Education Department as teacher number 12 698 at Patyah School in rural Victoria (Victoria Gazette 1900a). It is unclear as to how she was temporarily transferred to Melbourne Observatory in 1898 at age twenty-two.

Peel was one of six temporarily employed star measurers for the Melbourne zone of the AC but by 1900 she was appointed to the permanent staff of Melbourne Observatory (Victoria Gazette 1900b). Peel was the first woman to be permanently employed in astronomy in Australia and was elevated in rank to 'assistant astronomical computer' as reported to the Board of Visitors (Baracchi 1901). Peel had a senior position overseeing the work of the bureau in much the same way as Dorothea Klumpke had at Paris Observatory. The logbooks demonstrate that Peel measured stars, reduced the co-ordinates using a logarithmic formulae, managed the errors of the other workers and the measuring machines which she calibrated as needed. Peel was selected to work alongside James Baldwin, the Government Astronomer for Victoria, on comet observations. She measured Comet C/1913 YI (Delavan) and comet C/1915 CI (Mellish) as acknowledged by Baldwin (1917).

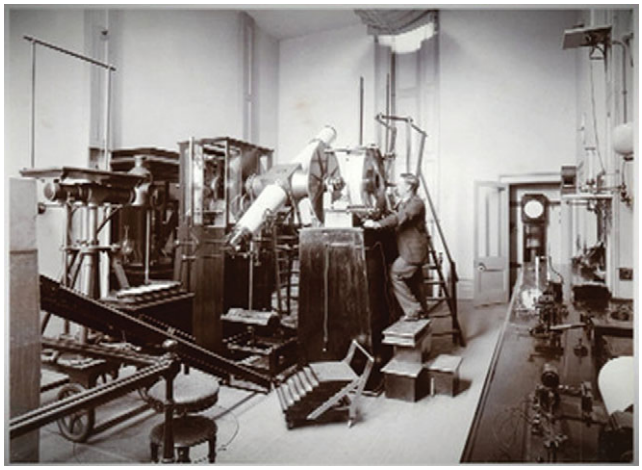

Figure 4. Thomas Cooke and Sons Equatorial telescope used by Greayer at Adelaide Observatory. Collection and copyright permission Museums Victoria, MM068176.

The photograph in Figure 5 is of Melbourne Observatory staff. According to Clark (2012) this photograph may have been taken for the 84th meeting of the British Association for the Advancement of Science in 1914. Clark has identified the woman on the right as Peel and the woman on the left as meteorologist Miss Moroney.

Peel was a permanent staff member and her employment is therefore recorded in the published State Government Gazette. Her logbooks are now in the distributed collection of State Records Office, NSW. At Melbourne Observatory the rooms and some of the furniture used for measuring still exist. In 1918 Peel resigned in order to marry Robert Sangster, the librarian and clerk at Melbourne Observatory (Victoria Gazette 1919). They lived in Caulfield, Melbourne, where Peel died in 1974 at age 98.

Peel represents a large number of women who were chosen for the AC because of their mathematical acuity, accuracy, patience and willingness to do repetitive work precisely (Bigg 2000). The work required adherence to the rules of documentation, as is shown by the archived logbooks, and excellent eyesight. The required pace for measuring the stars, around 40 stars per hour (Baracchi 1898b), meant that there was little time to reflect, compare or work outside the standard regimen.

4. *His*tory and *her*story: gender bias in views of the past

Within the field of heritage studies it is generally accepted that a male-centred view has dominated history and heritage in Australia (Nugent 2002). According to science historian, Claire Hooker, scientists as a whole are not well known in Australia and women scientists tend to be more easily 'erased' from the history than the men (2004). Hooker draws a link between the history of science and discrimination in science, which, she writes, is directly linked to segregation, one of the characteristics of the AC:

Figure 5. Staff at Melbourne Observatory, c.1914. Peel is middle row, far right. Collection and copyright permission Astronomical Society Victoria, courtesy B. Clark & D. Ferguson.

> 'It was the result of much more subtle perceptions of women scientists' strengths and weaknesses, and of the weight of experience as horizontal and vertical segregation became more entrenched'
>
> (Hooker 2004).

Gender bias has permeated the history of astronomy in Australia until recent times, not through intent, but due to the social milieu. Recent research efforts to re-insert women into the history of astronomy in Australia have focussed on the outstanding work of experimental radio astronomer, Ruby Payne-Scott, (Haynes et al. 1996; Hooker 2004; Goss & McGee 2009; Goss 2013). My research indicates that there are likely other women whose work in astronomy and related areas was cut short due to the gender specific nature of their employment conditions.

Social scientists researching women in astronomy in North America and Britain (Rossiter 1980,1983; Mack 1990a, 1990b; Benjamin 1991; Brück 1998, 2009; Larsen 2009) have established that there were common reasons as to why women were 'hidden' within the history of astronomy in most parts of the globe. These included the lack of educational opportunities, a failure to attribute women's work, restrictions placed on women's careers because of their gender and attitudes to the stereotypical nature of the work to which women were assigned. These same attributes have been articulated in regards to the history of women's participation and acknowledgement in the 'hard' sciences of maths and physics in Australia. 'Sadly women have tended to be regarded and employed as good calculators, and considered incapable of original thought' (Hooker 2004).

One of the common causes of anonymity has been attributed to the 'factory-like' hierarchy, which emerged in observatories in the late Nineteenth Century due in main to the rapid production of data using photography for star chart and spectroscopy projects (Bigg 2000; Lamy 2006; Larsen 2009). This created an anonymous and replaceable bottom rung. Greayer, Peel and all the women employed in astronomy in Australia through to the mid Twentieth Century were on that bottom rung and had no chance to rise up the astronomical pyramid of labour.

5. Conclusion

> I would venture to guess than Anon, who wrote so many poems without signing them, was often a woman.
>
> (Woolf 1929)

In this paper, I have described many women who worked in astronomy in Australia who, like Woolf's nameless poets, were not individually acknowledged. My research has shown that, whilst the AC is renowned, there is little written about the women responsible for observing and reducing positional and catalogue stars. Reasons for this anonymity have been found to include salary and workplace legislation, the gendered nature of heritage, and the emergence of a workplace hierarchy in astronomy with a replaceable and anonymous bottom rung. The women were rarely attributed in scientific papers for their work and this reflects that they were not considered contributors. The historiography of the AC in Australia has focussed on the project's failures in terms of providing timely and accurate astrometric data rather than the work that was done and its broader impact on astronomy.

By grouping the women who worked on the AC at Adelaide, Melbourne, Perth and Sydney Observatories together, it has emerged that there was a significant workforce of women in astronomy in Australia due to this project. Furthermore some women, whilst confined by the social and cultural milieu of the era, had a wider scope of work, observing through the telescopes, calibrating machines,

managing others and influencing the workplace behaviour and attitudes. Archival evidence has revealed that Mary Emma Greayer from Adelaide Observatory and Charlotte Emily Fforde Peel from Melbourne Observatory were intrinsically involved in astronomical work, and undertook roles not previously acknowledged as performed by women in astronomy in Australia during that epoch.

I have demonstrated that the lack of attribution of women in astronomy in Australia paralleled the invisibility of most women working in astronomy in Europe and North America. Unlike North American astronomers such as Fleming, who made original discoveries for Harvard College Observatory, Adelaide and Melbourne Observatory computers and star measurers, Greayer and Peel respectively, are unknown in the history of Australian astronomy. The logbooks show that whilst Greayer and Peel may not have developed new astronomical theories, their work was essential to the production of star catalogues and the identification of double stars and comet locations. This work was, as described by nineteenth century astronomer Dorothea Klumpke, 'truly scientific' in its nature (Klumpke 1899).

All of the State Observatories in Australia have ceased scientific research[3] but their social and scientific legacy lives on in the archival records, the instruments and the buildings. This heritage has potential for new social sciences research and has provided the foundation for making visible and acknowledging the first women who worked in astronomy in Australia.

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[3] Melbourne Observatory ceased research in 1945; Adelaide Observatory ceased operations in 1952 and was demolished; Sydney Observatory became part of the Museum of Applied Arts and Sciences in 1982 and Perth Observatory ceased research in 2013.

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