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INFLUENCES OF GERMAN SCIENCE AND SCIENTISTS ON MELBOURNE OBSERVATORY

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ABSTRACT: The multidisciplinary approach of Alexander von Humboldt in scientific studies of the natural world in the first half of the nineteenth century gained early and lasting acclaim. Later, given the broad scientific interests of colonial Victoria's first Government Astronomer Robert Ellery, one could expect to find some evidence of the Humboldtian approach in the operations of Williamstown Observatory and its successor, Melbourne Observatory. On examination, and without discounting the importance of other international scientific contributions, it appears that Melbourne Observatory was indeed substantially influenced from afar by Humboldt and other German scientists, and in person by Georg Neumayer in particular. Some of the ways in which these influences acted are obvious but others are less so. Like the other Australian state observatories, in its later years Melbourne Observatory had to concentrate its diminishing resources on positional astronomy and timekeeping. Along with Sydney Observatory, it has survived almost intact to become a heritage treasure, perpetuating appreciation of its formative influences.

Keywords: Melbourne Observatory, 19th century, Neumayer, German science

The pioneering holistic approach of Alexander von Humboldt in his scientific expeditions to study the natural world had a substantial, lasting and international influence on a broad range of scientific fields. For instance, Charles Darwin openly acknowledged the early inspiration he received from Humboldt's *Kosmos* (McCann & Joyce 2012: 11). Government Astronomer Robert Ellery, the first Director of Williamstown/Melbourne Observatory, was also President of the Royal Society of Victoria from 1866 to 1884, so it would hardly be surprising to find evidence of the Humboldtian approach filtering through to the tasks and methods of the observatory. On examination, and mindful of the strongly international nature of astronomy, Melbourne Observatory appears to have been disproportionately influenced to advantage by Humboldt and other German scientists. Relevant individuals, connections and events are identified in this paper.

Early in the nineteenth century, Earth's magnetic field was considered primarily as a practical aid in navigation, mapping, surveying and building alignment. Humboldt made a case for geomagnetism to be studied scientifically because of its possible influences on living things and phenomena such as weather. He gave the name 'magnetic storm' to the rapid variations that are occasionally observed, and identified the need for worldwide scientific study of the geomagnetic field. The potential of geomagnetism for additional purposes was gradually recognised thereafter and further uses were brought into practice. These include mineral exploration, probing the Earth's crust and deep interior, and understanding solar–terrestrial relationships (Geoscience Australia 2015). In 1838 Carl Friedrich Gauss helped put Humboldt's call into practice by setting up the *Göttinger Magnetische Verein* (Göttingen Magnetic Society), which quickly gained extensive non-British international support.

THE ROYAL NAVY'S GEOMAGNETIC STUDY

Lieutenant Colonel Edward Sabine of the Royal Artillery was another early supporter of the need for geomagnetic studies, although at least part of his motivation was his belief that adverse effects of temporal and spatial variations in compass direction on gunnery and navigation were as important for the army as they were for the navy. As an outcome of necessarily private discussions between the jingoistic Sabine and Humboldt, and separate meetings between Sabine and Sir John Herschel with Gauss's colleague Wilhelm Weber, Sabine and Herschel (representing the British Association for the Advancement of Science) managed to convince the British Admiralty to study the global magnetic field and to establish a chain of magnetic observatories in British colonies (Schröder & Wiederkehr 2001). Spurred by French efforts in extending the chain of magnetic observatories to further parts of the globe, Lord Melbourne (Queen Victoria's first prime minister) approved this (Savours & McConnell 1982; Clark, S. 2007: 57). Accordingly, the British Admiralty set up an expedition for HMS *Terror* and HMS *Erebus* under the command of Captain James Clark Ross from 1839 to 1842.

One of the observatories built in 1840 was at Rossbank in Hobarton, Van Diemen's Land (Hobart, Tasmania). This was the most southerly of all geomagnetic observatories then, and the closest to the South Magnetic Pole. It was put in the charge of Lieutenant Henry Kay RN, with two Mates as assistants and two marines to protect the equipment against vandalism and theft by transported convicts. The ships then sailed off towards Antarctica, leaving the unfortunate staff to pursue their tedious and onerous duties almost without relief for a planned three years (Savours & McConnell 1982). They had to record the three geomagnetic field components (dip, azimuth and strength) at *hourly* intervals in Göttingen Mean Time throughout the day *and night*, Sundays excepted, as well as keep the observatory clocks accurate by stellar meridian transit observations. On 'Term Days', Rossbank and other magnetic observatories around the globe took more frequent measurements in concert. The life of the project kept being extended at the urging of Sabine and other leading scientists. Kay was rewarded with fellowship of the Royal Society in 1846 for his diligence in data collection, and a promotion to commander in 1849 (Green 1967). Rossbank Observatory was relinquished by the British Admiralty in 1853, probably as an economic measure necessitated by the Crimean War, and then shut down by the colony at the end of 1854 (Savours & McConnell 1982) despite its status since 1847 as the Royal Observatory, Hobart Town.

COLONIAL VICTORIA'S FIRST ASTRONOMICAL OBSERVATORY

Ellery had completed training as a medical practitioner when he left England for Victoria about a year after the start of Victoria's major gold rush in 1851. He set up a medical practice in Melbourne's Bourke Street soon after arriving (IANHR 1868; Chronicle 1908). But he also had an interest in astronomy, and had spent some time learning its techniques at observatories in England, including the Royal Observatory at Greenwich. His letter to the editor of *The Argus* newspaper of 7 May 1853 drew attention to the unreliability of public clocks in Melbourne and the need of mariners on ships in Port Phillip Bay for accurate local time (Ellery 1853). He called for the establishment of a small observatory to provide a time-ball service.

The colonial government took up the suggestion quickly and directed Pownall Pellow Cotter to set up the service. Cotter had acted as the sailing master of HMS *Terror* during Ross's magnetic expedition. He had settled in Melbourne and was in charge of a naval depot at Williamstown, one of Melbourne's two ports then. Minimal progress had been made in several weeks when the Governor appointed Ellery in Cotter's place. The first public time-ball drop from the flagstaff (Figure 1) was in August 1853.

Figure 1: Williamstown Observatory in 1853, with the time-ball pålatform on the flagstaff and the basalt tower still operating as a lighthouse. Lithographed by C. Turner from drawing by E. Thomas. Image H90.91/604, State Library of Victoria.

Curiously, on a couple of occasions Ellery's publications gave 'Altona Observatory' as the name of the observatory at Williamstown, possibly in honour of the active observatory founded by the German instrument maker Repsold in the Hamburg suburb Altona. (Repsold measuring machines were used later at Melbourne Observatory and elsewhere for measuring star positions on photographic plates in the Astrographic Catalogue project.) However, Ellery's choice of name may have been more influenced by the suburb to the immediate south-west of Williamstown: it had been named Altona in 1862 by a coal mine developer who came from the Hamburg suburb (Wikipedia Altona 2015).

Introduction of telegraphy

Commercial development of telegraphy took place primarily in the USA, Britain and Germany after Gauss had demonstrated its basic principles by sending time signals from his observatory about a kilometre to Weber's laboratory at Göttingen University in 1833.

In 1853 Scots-Canadian entrepreneur Samuel McGowan arrived in Melbourne with the intention of making his fortune by setting up the first telegraph company in the southern hemisphere. The Victorian colonial government decided it would own the company instead but contracted McGowan to install the first line and its terminal equipment. This line ran for 17 kilometres between the new Chief Telegraph Office in Melbourne and a terminal set up initially at Williamstown Observatory (Figure 2) (Gittins 1974). Clearly Ellery had influenced this choice and soon he was using the telegraph system to actuate time-ball drops in the city and in country towns (Ellery 1866, 1869). Telegraphic remote control of important city clocks followed. As the colony's railway system expanded, its telegraph system expanded in parallel. In turn, this

Figure 2: Williamstown Telegraph Office and transit building, from the *Illustrated Melbourne News*, 30 January 1858. Image pi005842, State Library of Victoria.

facilitated the synchronisation of railway clocks across the colony, an important safety factor in a railway system with few duplicated tracks. Meanwhile, Williamstown Observatory flourished under Ellery's energetic direction (Andropoulos et al. 2011).

The telegraph system was also used to derive local longitude differences during the Victorian Geodetic Survey headed by Ellery from 1858. Pendulum beats of clocks set to local sidereal time by astronomical observations were transmitted. Exchange of beats between stations allowed greater accuracy. This was done in 1858 between Williamstown Observatory and Flagstaff Observatory (see below) to determine their longitude difference (Figure 3) with improved accuracy.

In 1860 a Morse fillet telegraph signal recorder by the briefly independent London branch of Siemens, Halske and Co. was delivered to Williamstown Observatory. Such paper tape devices were easily adapted to measure

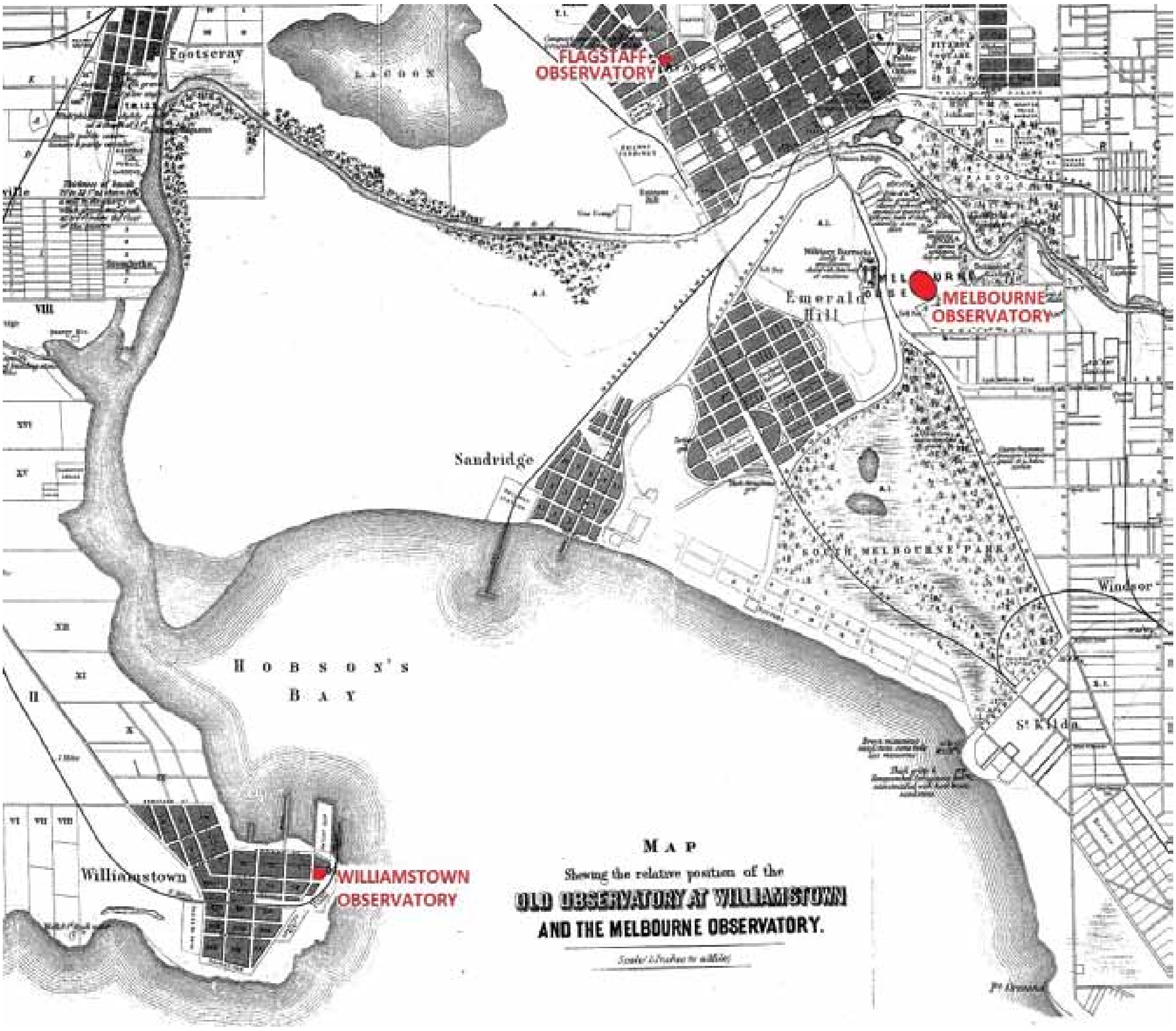

Figure 3: Positions of Williamstown, Flagstaff and Melbourne Observatories, adapted from Ellery (1866: Plates).

Figure 4: The 1860 Siemens, Halske & Co. of London fillet (paper tape) chronograph of Williamstown and Melbourne Observatories in 2007 after refurbishment. The electromagnets at the front actuate a stylus that indents the paper to mark events. A parallel arrangement, hidden here, marks seconds. The yellow tape is a demonstration loop. The white tapes were used in 1943. The black handle rewinds the drive weight without slowing the clockwork drive. Image: author.

time intervals with an accuracy approaching a hundredth of a second. This one was always the Williamstown/ Melbourne Observatory's principal chronograph and it is still in operating condition (Figure 4). It replaced an electric chronograph assembled locally from telegraphic equipment. The earlier chronograph was lent to Sydney Observatory in 1861 to facilitate exchange of pendulum beats between the two observatories, improving the accuracy of their longitude difference.

NEUMAYER'S EXTRAORDINARY CONTRIBUTIONS TO SCIENCE IN AUSTRALIA

Professor Dr Georg Neumayer followed in the direct line of Humboldt's colleagues and successors, Gauss, Weber and Lamont. He was an epitome of Humboldtian science, an explorer with extraordinary energy, insight and skills across a broad range of practical and scientific disciplines, carefully documenting and measuring environmental variables in the face of physical hardship (e.g. von Guérard 1863) and seeing the results through to publication in meticulous detail.

As one of many German scientists inspired by Humboldt to explore Australia voluntarily in the nineteenth century, Neumayer visited Australia twice, in 1852–1853 and 1857–1864, including a sojourn in Tasmania for several weeks from April 1864 (Neumayer 1867: Pt 2, 157). Others came and stayed. Overall, they tended to take on scientific leadership roles to a disproportionally large extent (Home 1995).

Germany also exported science and scientists in the eighteenth and twentieth centuries but the circumstances were quite different from the nineteenth-century case (Home 1995). In the eighteenth century, the export was a result of an agreement reached between Tsar Peter the Great and Liebnitz, President of the new Prussian Academy of Sciences, to set up the Russian Academy of Sciences in St Petersburg. Early in the twentieth century, German governments set up scientific institutions in other countries as instruments of cultural imperialism. When Hitler came to power in 1933, Nazi persecution of minorities forced many individuals to leave the country. This added greatly to Germany's twentieth century export of science and scientists (Home 1995), the best known example being Albert Einstein.

Flagstaff Observatory

To boost geophysical data collection from the southern hemisphere, in 1858 Neumayer (1859) set up a meteorological, magnetic, solar and nautical observatory (Figures 3 and 5) in what is now the Melbourne Flagstaff Gardens with funds and equipment primarily from King Maximilian II of Bavaria, supplemented by a substantial donation from Melbourne's German community (Neumayer 1860a, 1860b; Home & Kretzer 1989). Until the closure of this Flagstaff Observatory in 1863 it was Earth's most southerly magnetic observatory and also the one closest to the South Magnetic Pole. One of its main functions was to record geomagnetic variables following the cessation of observations at Hobart some four years earlier. This illustrates the commitment of German science at the time to global geomagnetic study.

Neumayer had originally asked the colonial government for a site in the magnetically stable Domain near the Botanic Garden but was offered the less suitable Flagstaff site where the naval signal station and its flagstaff were redundant (Neumayer 1860b: iii, iv) because of the introduction of telegraphy. After the colonial parliament eventually provided adequate supplemental funding, the facility became subject to government oversight through a 'board of visitors'. Neumayer was obliged to report his observatory's activities to the board and did so in remarkable quantity and quality, particularly given that English was not his native language; for example, see his accounts of investigation of potential sites for Melbourne Observatory in Board of Visitors Report (1860: 8, 17–20, 22–28).

Figure 5: The former signal station building converted into Flagstaff Observatory, between 1857 and 1863. Image H96.160/1679, State Library of Victoria.

The Meteorograph

Neumayer was politically astute enough to avoid duplicating the work of Williamstown Observatory but complemented it where justified, as in the visual observation of meteor paths and collection of public reports of such observations. Faced with the poor accuracy of extent and direction of meteor paths when all such observations were visual, he invented a fascinating equatorially mounted sighting device that recorded the start and finish celestial coordinates of individually observed meteor tracks (Neumayer 1867: Pt 1, 120–123). The device was constructed in Melbourne by H. Schreiber and the engraving of the 'Meteorograph', reproduced here as Figure 6, was done afterwards. No additional information has been found about the subsequent history of the device, so it is presumed that it was among the equipment not purchased for Melbourne Observatory in 1863 and taken back to Germany by Neumayer on the *Garrawalt* in July and August of 1864. It would be many decades before its function was surpassed by photography.

Oceanic data collection

Neumayer worked as an ordinary sailor on his early voyages and later acquired marine qualifications. For him, voyages represented great opportunities to collect meteorological, oceanographic and magnetic data. In Melbourne, he was successful in inviting captains of ships in port to allow him to inspect the ships' logs for time, date and weather details, thereby gaining more extensive datasets than he could ever have achieved solely on his own voyages. Neumayer was visited by 250 mariners in the first twelve months of this scheme. In return, repairs to ships' instruments were done gratis in the workshop at Flagstaff (Neumayer 1860b: 169, 170). (Later, Melbourne Observatory likewise rated ships' chronometers as a free service.)

Solar photography

Although Warren De La Rue had been photographing the solar disk routinely with his photoheliograph at Kew

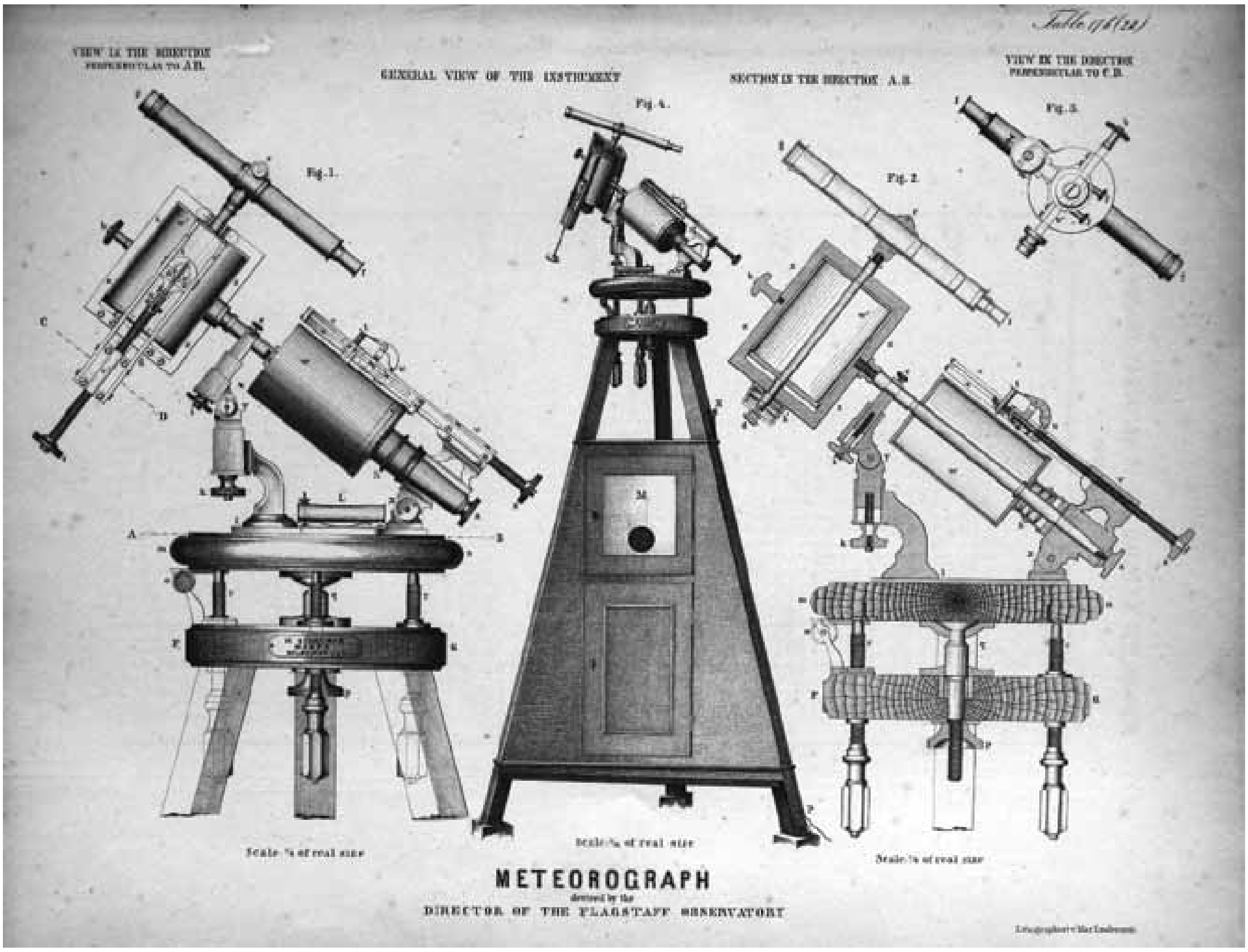

Figure 6: Neumayer's extraordinary 'Meteorograph' (Neumayer 1867: Table 176 (22)). Drums on both axes are each wrapped in a sheet of paper. Marks are made on the paper to indicate celestial coordinates when the telescope is aimed at the beginning of a meteor track and again at the end.

Observatory on wet plates in the 1850s, he did not make the first successful picture of totality at a solar eclipse until July 1860 (Clark, S. 2007: 106). This gives an idea of the state of the art of solar photography in the late 1850s. Neumayer (1860b: 262) reported that he was experimenting with solar photography at Flagstaff but gave no further details. Nevertheless this was another leading-edge facet of science introduced to the colony by Neumayer.

Geomagnetic data collection

A large part of Neumayer's resources in Australia was devoted to the recording and analysis of various forms of geomagnetic data such as magnetic surveys (Neumayer 1869), the secular changes in absolute values over time in the values at particular stations such as Flagstaff, and short-term (horary) variations also at these stations (Neumayer 1867). All of this has a direct connection with the global geomagnetic project initiated by Humboldt and Gauss and bolstered by Weber, Lamont, Sabine, J. Herschel and others.

Atmospheric electricity

Much effort was expended at Flagstaff and then Melbourne Observatories in measuring and recording variations in atmospheric potential gradient. This work was abandoned in the 1870s as it was seemingly of little practical value. Recently, Aplin and Harrison (2014) used modern knowledge of atmospheric electricity effects in relation to solar flares and magnetic storms to re-analyse known data at the time of the well-known Carrington white-light flare of 1 September 1859. They included hitherto overlooked atmospheric electricity and magnetic storm data from Neumayer (1860b). It is not often that data over 150 years old turns out to be so important. Neumayer's work has long been valued highly. Now it can be seen to have exceeded preceding assessments.

The Burke and Wills Expedition

In 1858 Neumayer took on William Wills as an assistant at Flagstaff. The two became close friends, sharing their passion for science (Wills Sr 1863). Wills developed skills in astronomy, surveying and navigation. This gained him a position in the ill-fated Victorian Exploring Expedition of 1860–1861, now commonly known as the Burke and Wills Expedition, which set out from Melbourne with an aim of being the first to cross the Australian continent from south to north and back. Here is an extract from Neumayer (1860b: 165) about Wills in October 1858:

> On the 8th the electric tension was much disturbed throughout the whole day, and at 1h. 30m. a thunderstorm occurred. Mr. W. Wills (one of the assistants at the Observatory) was in the vicinity of a post in North Melbourne, when it was struck by the last discharge of electric fluid which took place; the post, which extended about eight feet above the ground, was thrown to a considerable height, the lower part of it being burned and shattered to pieces. On examining the hole in the ground from which the post was propelled smoke was found to issue from it, and a sulphurous smell was perceptible. About thirty feet from the spot where this occurrence took place several high buildings and a short iron fence were situated.

Had Wills actually been a victim it would have changed the course of Australian history, as there would have been few if any other available individuals with his combination of training, ability and persistence. Without his remarkably accurate navigation (Leahy 2012) up until his death from starvation in 1861, such success as the expedition did have would hardly have been possible.

Despite Ellery's subsequent leading role in the Royal Society of Victoria, his name is conspicuously absent from the records of the Royal Society's Exploration Committee meetings to plan the expedition. On the other hand, his colleague and friend Neumayer played a prominent role. Both were experienced inland travellers, as was Wills. Ellery did his best to deter Wills from joining the expedition as potentially dangerous (Wills Sr 1863) but Neumayer prevailed in encouraging Wills to go. Neumayer actually travelled with the expedition from Swan Hill in Victoria to as far as Menindee in New South Wales before returning to Melbourne, leaving Wills to continue with a Humboldtian range of physical sciences observations and tasks set primarily by Neumayer in addition to navigating the expedition. Other German members of the expedition, especially Beckler and Becker, also had substantial scientific workloads (primarily set by Dr Ferdinand von Mueller, the Government Botanist), which they performed creditably (Joyce & McCann 2012). Becker had made fine drawings of Donati's comet at Flagstaff Observatory in 1858 (Baracchi 1914), possibly the earliest telescopic sketches made in Victoria.

Ellery's main connection with the expedition arose only after its disastrous end – the unhappy task of examining the surviving navigation records as part of the extensive formal inquiries into the expedition's failure.

Meteorology

In the 1850s, 'Melbourne Observatory' was the name of the government weather office in Melbourne set up by Robert Smyth (1858) to collect weather data from a small team of observers at various places in the colony, sometimes including Ellery at Williamstown Observatory. As well as being the colony's Director of the Magnetic Survey, Neumayer also became Director of Meteorology when he took over the weather facility in 1857 and incorporated it into his Flagstaff Observatory (Neumayer 1860b). He then greatly expanded the weather observer network across Victoria (Neumayer 1864).

Closure of Flagstaff Observatory

Because the Flagstaff and Williamstown Observatories were both in unsuitable locations (Figure 3), Neumayer and Ellery agreed that it would be better to have their operations transferred to a new site more suitable for astronomical and geomagnetic research. Neumayer (1860a: 19) considered 'that the requisite buildings should be so constructed that the management of one institution should in no way interfere with that of the other, and that the labours of each should be quite distinct and separate from one another'.

When the hapless Henry Kay was eventually recalled to England in 1853 after thirteen years of drudgery and broken sleep at Rossbank, the navy considered him out of touch and unsuitable for further seagoing service. Fortunately he was appointed as private secretary to Victoria's new Lieutenant Governor Hotham. Kay also accepted a position on the Board of Visitors to Williamstown Observatory, reflecting the heavy reliance of the navy on astronomical data and observations for navigation. Five years later, Kay became a member of the new Board of Visitors to the Astronomical and Magnetic Observatories, with the new Governor Sir Henry Barkly as its first chairman. He remained on the board three years later when it became the Board of Visitors to Melbourne Observatory. The board certainly had a powerful advocate for ongoing monitoring of the geomagnetic field.

The closure of Flagstaff Observatory took place in the six months following the complete transfer of Williamstown Observatory's staff, equipment and operations to the new Melbourne Observatory in June 1863. Some of the Flagstaff equipment was purchased for transfer and the rest was apparently returned to Germany. The transferred equipment included a full set of German magnetic instruments, meteorological instruments and an exquisite theodolite by Ertel (described by Neumayer as a 'Universal instrument') and now at Museum Victoria (Figure 7). (In the course of Neumayer's onerous and risky magnetic survey of Victoria and beyond, the Universal was in its box being carried by a pack horse when the horse fell into a deep flooded roadside 'pothole'. Neumayer (1869) saved the horse from drowning by jumping into the icy water and releasing the heavy box.)

Figure 7: Universal instrument by Ertel & Sohn, Munich, ca 1850s. After travelling on adventurous expeditions with Neumayer, this instrument was transferred to Melbourne Observatory during the closure of Flagstaff Observatory. Item ST 022212, Museum Victoria.

Despite Neumayer's earlier insistence on co-located separately operating observatories, all of the transferred Flagstaff resources were fully integrated into Melbourne Observatory. This included Neumayer's assistant since 1860, Charles (Carl) Moerlin. After 30 years as Ellery's second deputy, Moerlin and other long-standing assistants, including Ellery's deputy Edward White, were made redundant in compliance with the colonial government's expenditure-cutting response to the financial crisis of 1890–1895.

None of the buildings of Flagstaff Observatory survive. A commemorative plaque now marks its former position in the Flagstaff Gardens and records that Neumayer 'fostered the development of science in Victoria and, almost single-handedly, made a thorough magnetic survey of the colony, travelling 11,000 miles on foot or by pack-horse'.

MELBOURNE OBSERVATORY

A sad negative influence

The great value of Ellery's contribution to the colony of Victoria was duly recognised in June 1863 when the Williamstown Observatory's equipment and staff were shifted from its unsatisfactory site to a substantial new observatory building (Figure 8) on high ground in the Domain, less than two kilometres south-east of Melbourne. The land was excised from Government House Reserve with the wholehearted agreement of Governor Sir Henry Barkly. This site had been suggested by Mueller (who was also director of the abutting Botanic Garden) apparently in the belief that the Governor would not agree. Mueller was hostile to the prospect of an observatory in the Domain as it upset his plans for the Botanic Garden and formal paths to extend across the whole area of parkland surrounding Government House. The original site proposed for the observatory, a little south of the eventual location, had put Mueller's recently built Botanical Museum under threat of demolition and its valuable collection of plant specimens at risk pending relocation to appropriate alternative storage.

Figure 8: The new Melbourne Observatory, with Neumayer's two magnetic houses shown left and right. The view is from the position of the present Shrine of Remembrance. Engraver, S. Calvert. From the *Illustrated Melbourne Post*, 25 April 1863. Image IMP04/04/63/1, State Library of Victoria.

After Melbourne Observatory commenced operations Mueller continued the battle by planting trees that would grow tall around its border to block out the horizon sky (as some still do) and arranging for paths to be laid to an abrupt end at the observatory fence in the hope that the public would object to the presence of the observatory. His irrational behaviour made no friends but he kept working on his plant collection. This collection has long been one of the world's great botanical assets, housed in the National

Herbarium that was built nearby when the Botanical Museum was demolished to make way for construction of the Shrine of Remembrance in the 1930s. The large lecture room at the National Herbarium is named Mueller Hall in honour of his towering contributions to botany.

A very positive influence

Neumayer's contributions to the success of Melbourne Observatory have already been described by Gillespie (2011a). He had a major role in the negotiations for its site. Indeed, his examination of sub-surface stability and magnetic properties at several potential sites around Melbourne was key factor in the high ranking the Domain site had been given for astronomical and geomagnetic observations. He also had an input into the functional design of the main building. This proved excellent and suitable for expansion as required.

During the year before the building was completed, Ellery made a decision that it would be best for the changeover from Williamstown to take place only when the building was complete so that disruption to the work would be minimised. However, Neumayer began geomagnetic jump observations at the new site in July 1862, started systematic geomagnetic registrations there on 21 September 1862, and also moved a barometer from Flagstaff into the completed new transit room on that day (Neumayer 1867: Pt 1, 27). At the time, Neumayer lived only about two hundred metres away in Domain Road, a magnetically stable site like that at the new observatory. His house had a magnetic laboratory in the basement. (The house still exists but the basement has been partitioned to suit later residents.)

Even when Neumayer had nearly reached home from Australia for the second and last time (1864), he still managed to do something more of lasting benefit for Melbourne Observatory (and indeed, for Australia). He broke his journey to meet Sabine in England, just at the right time to correct Sabine's misinterpretation of what the Victorian parliament wanted to do about whether to purchase William Lassell's 1.2 metre telescope in Malta or to buy the more expensive option – the Thomas Grubb version of the Great Southern Telescope. Neumayer passed on the news that the parliament was prepared to meet the extra cost as long as the Royal Society agreed that it was justified. This seems to have been an important step in Victoria's acquisition of the 1.2 metre Great Melbourne Telescope (GMT) (Figure 9) by Grubb Dublin (Gillespie 2011b: 43).

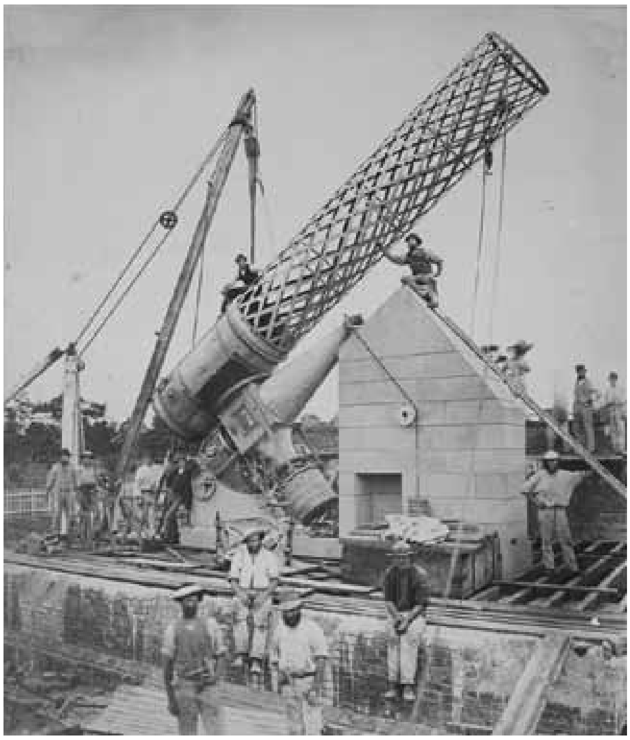

Figure 9: Assembly of the Great Melbourne Telescope at Melbourne in January 1869. The remainder of the building was added after the incomplete telescope reached the stage of 'first light' in April 1869. Neumayer's advice to Sabine in 1864 may have saved the colony from getting Lassell's much inferior instrument instead. The photograph is probably by Richard Daintree. Image MM 059385, Museum Victoria.

Influence at a distance

Neumayer always had the intention of returning to Germany after a few years of gathering data in south-eastern Australia, but politicians wasted his time at the start of his second visit. This, along with his methodical completion of what he set out to do, delayed his departure by about a year. After his return to Germany, Neumayer's third and fourth reports on his researches in Victoria were completed and eventually printed in Germany at the expense of the Victorian Government, and they carry the British royal coat of arms on the cover and title page. Neumayer actually raised the prospect with Ellery of returning to Australia in 1867, but Ellery advised that the economy was not right for getting government funding and in any case politicians had become uninterested in exploration (Gillespie 2011a).

As Baron von Neumayer, his ultimate career in oceanography and meteorology was outstanding by any measure. He and Ellery kept in touch for decades. In the 1890s and beyond, Melbourne Observatory took part in a laborious international cloud height measurement project (Baracchi 1898) involving Neumayer. Although Neumayer never realised his dream of exploring Antarctica, the German Antarctic station is named after him.

What drove Neumayer?

The text ending the preface in Neumayer (1860b: v) reveals the source of Neumayer's inspiration:

> Great as is the field of research great also should be our exertions to gain an approach towards the truth; and in order never to slacken in our zeal, we should bear in mind what the great philosopher said, whose death we recently lamented, and I may be permitted to conclude these few remarks with a quotation from the second volume of his Cosmos:-
>
> > 'Weak minds complacently believe that in their own age humanity has reached the culminating point of intellectual progress; forgetting that by the internal connection existing among all natural phenomena, in proportion as we advance the field to be traversed acquires additional extension, and that it is bounded by an horizon which incessantly recedes before the eyes of the enquirer.'

INFUSIONS OF GERMAN ASTRONOMY

Star catalogue

In 1862 the Royal Astronomical Society initiated a movement for carrying out by British effort a southern *durchmusterung* on the same basis and scale as that which Argelander was conducting for the northern hemisphere. The work was accepted by three southern observatories: Madras, Cape of Good Hope and Melbourne. From 1866 to 1872, Melbourne Observatory measured the positions to about arc-second accuracy for over 48,000 stars down to magnitude 10 (Baracchi 1914). (This can also be considered as an export of Australian science to Germany.)

Potsdam Observatory

Joseph Baldwin was an outstanding student in science at the University of Melbourne in the early 1900s. He went to Potsdam and other major European observatories to study astronomy for an intended two years (Ellery 1901: 6). After returning to Melbourne in 1907 (Baracchi 1909) he was awarded the degree of Doctor of Science, a rare honour. He obtained a position at Melbourne Observatory as deputy to the second Government Astronomer, Pietro Baracchi. Baracchi retired in 1915 and Baldwin was promoted to Government Astronomer in 1921. Like his predecessors he became President of the Royal Society of Victoria. He lived for only a couple of weeks after retiring in 1945 when Melbourne Observatory was being wound up.

Baldwin's exposure to German astronomy and culture and the friendships made with German astronomers doubtless had a positive influence on his work at Melbourne Observatory.

Lesser connections

Soon after its opening, Melbourne Observatory acquired a 170 millimetre aperture prime vertical instrument from Ertel of Munich. Its mounting fell well short of expectations. It was converted into a meridian transit instrument and then into an equatorial that was used by Moerlin to observe the 1874 transit of Venus. Apparently it ended up as a guider for a photographic telescope in Indonesia.

German names are connected with two other instruments at Melbourne Observatory. Sir John Herschel had much to do with the specification, testing and research topic of the GMT of 1869 but it was his more famous father, Sir William, who was German-born.

The observatory's photoheliograph of 1874 was built by John Henry Dallmeyer in London but his German origins were more remote.

TELEGRAPHY, ELECTRICS, MAGNETICS AND SPECTROSCOPY AT MELBOURNE OBSERVATORY

Telegraphy

Ellery was also in charge of the telegraph terminal at Williamstown until the expansion of his duties in 1858 to include direction of the Victorian Geodetic Survey precluded continuation of his telegraphic appointment. After the opening of Melbourne Observatory, use of the telegraph system for timekeeping and weather data transmission reached such proportions that the observatory was accorded the status of a telegraph office in terms of direct access to the telegraph lines. Ellery's expertise in telegraphy and electricity also allowed him to join McGowan (by then the Director of Posts and Telegraphs for Victoria) in teaching and examining trainee telegraphers, the majority of whom were females. This was a milestone in the expansion of fields of employment open to women in Australia.

In the late 1880s, Heinrich Hertz (1857–1894) demonstrated the physical existence of James Clerk Maxwell's predicted electromagnetic waves but thought they would have no practical value (Wikipedia Hertz 2015). Marconi's long-range radio transmissions in the 1900s laid the foundations for global communication by radio. From 1913, a radio telegraph station in the Domain was used daily for two years to receive weather observations from Mawson's Antarctic station at Commonwealth Bay via a relay station at Macquarie Island. Melbourne

Observatory used this link in 1913 to exchange clock beats with Mawson's station to determine its longitude (Baracchi 1913) and again in 1914 to determine the longitude of Mawson's winter quarters at Adelie Land (Baracchi 1915).

Another early scientific application of telegraphy was the facility it accorded for rapid announcements of astronomical discoveries of objects such as comets and novae so that confirmation and quasi-continuous observations of developing phenomena could be done on a global basis. By international agreement, this system's head office, the Central Bureau for Astronomical Telegrams (CBAT), was set up in 1882 at Kiel Observatory in Germany, which was then also the seat of *Astronomische Nachtrichten*, the leading journal for publication of astronomical observations at the time and often used for this purpose by Ellery (Andropoulos 2014). CBAT was moved to Copenhagen Observatory in Denmark when World War I started in 1914. It is now based in the USA.

The astronomical telegram system was arranged so that discoveries within individual countries or regional groups of countries were directed in the first instance to the designated national bureau. Likewise, national bureaus received news of discoveries elsewhere directly from CBAT and then had the responsibility for national or regional dissemination. For most of the time between 1882 and 1945, Melbourne Observatory was the regional bureau for Australasia.

Although telegraphy in its original form has been rendered obsolete by radio and internet-based communications, CBAT still retains its original name and is perhaps more important than ever in facilitating fast deployment of optical and radio telescopes to observe transient phenomena as diverse as gamma-ray bursters and passage of near-Earth objects, for example.

Electricity

Ellery's early exposure to telegraphy ensured his familiarity with the practical application of electricity at an early stage of its development. Just how early is illustrated by the Siemens chronograph in Figure 4; one of its three sets of electromagnets was dedicated to withdrawal of a mechanical stop in the air-braked governor of the weight-driven tape drive, making it a clockwork mechanism with an electrical stop-start switch (Clark 2011). Ellery (1862: 11) claimed that 'the galvanic train of this [Williamstown] Observatory is as complete as any in the world'.

Ellery became skilled in practical electricity – for example, he added Swan incandescent lamps for reading the setting circles of the South Equatorial Telescope and built Swan lamps into new bifilar micrometers completed for that telescope in Melbourne Observatory's workshop in 1883 (Ellery 1883), the same year that Edison installed the first standardised street lighting system.

As a necessity for its own work, Melbourne Observatory set up laboratory facilities for measurement of physical and electrical quantities. This activity was greatly facilitated by the efforts of Gauss, Weber and Lamont in particular in developing coherent electrical and magnetic units. In due course, a weights and measures section was set up in the observatory to provide a service to external clients as well. This section remained active in place for trade measures for nearly fifty years after professional astronomy ceased at the site.

Geomagnetism

After the geomagnetic program was transferred from Flagstaff to Melbourne Observatory, on the advice of Sabine in 1866 Ellery acquired continuous self-registering magnetometers patterned on those at Kew Observatory in England (Gillespie 2011a, 2011b: 83). Two buildings dedicated to the work housed the equipment and another, still existing, was added in 1877. This program was considered so important in 1868 that the observatory site had to be extended northwards to allow the Great Melbourne Telescope House to be placed far enough away on Sabine's advice for the ten tons of iron in the GMT to have no appreciable effect on the geomagnetic field at the instruments (Gillespie 2011b: 59).

During retrenchments of observatory staff in September 1892 and other economies required by the Victorian Government in the wake of the land crash and economic depression that started in 1891, Ellery (1892) decided '… but I propose to continue the magnetic observations, both for absolute determination and the continuous photographic record of variation; for if these be stopped an important link in the chain of the limited number of observing stations around the world would be lost'.

One of the areas of work cut back instead was the observing program with the GMT, then still the world's largest operational telescope and in better condition than it had ever been (Ellery 1891). After a paper on drawings of Mars by Baracchi using the GMT was published in Volume 1 of the Astrophysical Journal (Ellery 1895), the GMT was rarely used again for scientific work at Melbourne because of scarcity of resources.

In 1895 the observatory took an active role in supporting a three-year program of expeditions set up by the Bureau des Longitudes for global magnetic surveys. International scientific visitors frequently came to Melbourne specifically because of the observatory's geomagnetic expertise (Baracchi 1896). One such visitor in May and June of 1904 was Professor Dr Otto Hecker of the Prussian Geodetic Institute. As part of a global survey, he made gravitational and geomagnetic observations. Baracchi used the opportunity to check the calibration of observatory equipment, and on seeing the superiority of an earth-inductor for measuring magnetic dip, he promptly ordered one (Baracchi 1905: 6). Such interchanges helped keep the observatory aware of new technology.

Also in 1895, Professor Bezold of the Berlin Meteorological Observatory arranged for all of the principal magnetic observatories to make simultaneous observations with the declination and bifilar magnetic instruments at five-second intervals for one hour at specified times. This and other activities led Baracchi (1896: 7) to state that:

> The interest in terrestrial magnetism is greatly increasing, and it seems that a revival of the Gaussian epoch is near at hand.
>
> When retrenchment came, the desirability of stopping the magnetic work was repeatedly considered, but the fact that this is the only institution in Australia where such work is performed always weighed in favour of it being continued…

In addressing the Board of Visitors in 1913, Baracchi stated that the magnetic work was the most important body of work of the Observatory from a worldwide point of view (Volpe 2005: 7). Volpe considered that this work was important 'for the growth of Australia as a country'.

The electrification of a nearby tramway in the 1900s introduced artefacts into the recorded data, prompting calls for the instruments to be moved into the countryside, far away from such interference. A site was chosen (Toolangi) but World War I delayed the shift until 1919. Monitoring of absolute magnetic values at the observatory itself was discontinued after February 1922 (Baldwin 1923).

Data collection by observatory staff continued thereafter at Toolangi until 1945, despite transfer of the facilities and work to the Commonwealth Government in 1943 during World War II (Clark 2015). The influence of Humboldt had therefore been evident at the observatory for over eight decades.

Figure 10 shows a measuring frame for taking geomagnetic readings from paper charts unrolled from barrel chronographs. The frame is thought to be the only surviving one of two made in 1900 to a British Association for the Advancement of Science design of 1859 by the observatory's instrument maker, Carl Max Otto (Baracchi 1900:4), who was apparently of German descent.

Figure 10: A measuring frame made by Carl Max Otto at or for Melbourne Observatory in 1900 for reading geomagnetic chart records. Image: author.

Spectroscopy at Melbourne Observatory

Early in the nineteenth century, Fraunhofer succeeded in making high quality optical glass types for his achromatic telescope objectives. He invented the slit spectroscope and made improved diffraction gratings and dispersive prisms for it. He even observed the spectrum of Sirius. Following Bunsen and Kirchhoff's use of the spectroscope to identify laboratory chemicals, Kirchhoff made the extraordinarily valuable connections between spectral lines from laboratory and celestial light sources in 1859. Astronomical spectroscopy was soon put on a firm practical basis by Secchi, Huggins and others.

Williamstown Observatory showed potential to lead the development of professional astronomy in Australia (Andropoulos et al. 2011). Ellery bolstered this potential at Melbourne Observatory by taking the trouble to familiarise himself with laboratory spectroscopy before the Grubb slit spectroscope for the 1.2 metre GMT arrived in 1870. The first two GMT observers used this spectroscope to good effect briefly in the early 1870s and Ellery likewise in the 1880s. Ellery (1889) and Baracchi (1889) both did a spectral survey of southern stars with a McClean direct-vision spectroscope on the 203 millimetre South Equatorial Telescope. In 1893 German physicist Wilhelm Wien discovered that the wavelength of peak spectral radiance of a hot body was inversely proportional to the absolute temperature of the body. This results in a progression in colour of a star from red through orange, yellow, white to bluish white as the star's temperature increases. But this insight was after publication of the Ellery and Baracchi spectral surveys. The observatory had started well in astrophysics (Andropoulos & Orchiston 2006) but, like Sydney and Perth Observatories, opted instead for involvement in the international Carte du Ciel – Astrographic Catalogue project.

MELBOURNE OBSERVATORY HERITAGE

Fortunately, Melbourne Observatory infrastructure has remained largely intact in its late nineteenth century form since its professional operations ended in 1945. Its survival resulted from a combination of factors, including adversity, the difficulty of adapting its purpose-built facilities for re-use and its continuing use for public astronomy (Clark 2015). Its 150th anniversary was celebrated in 2013 with a public re-enactment and a seminar. Of the other Australian colonial/state observatories, Sydney Observatory has likewise survived long enough to be recognised as a heritage treasure (UNESCO 2015). Consequently, the formative influences applying to these observatories are less likely to be forgotten. Both institutions took on Humboldtian approaches as circumstances allowed. Some substantial differences, such as the geomagnetic program at Melbourne, arose from the presence and activities of Neumayer in Victoria for seven years.

CONCLUSIONS

At the then new Williamstown Observatory in 1854, its Superintendent Ellery was placed in charge of one terminal of the southern hemisphere's first commercial telegraph line, reminiscent of the observatory beginning of Gauss's pioneering telegraph demonstration some twenty years earlier. Within a few years, the remarkable German explorer-scientist Georg Neumayer had set up a complementary meteorological, magnetic, nautical and solar observatory at the redundant Flagstaff signal station within the nearby city of Melbourne. Ellery and Neumayer became colleagues and friends, exposing Ellery to the powerful scientific and philosophical influences of Humboldt, Gauss, Weber and Lamont.

By the time that the indefatigable Neumayer had returned to Germany in mid-1864, the staff, equipment and program of Williamstown Observatory and parts of those at Flagstaff had been combined into the new Melbourne Observatory of 1863. Without discounting the importance of other international scientific contributions, it appears that the professional operations of Melbourne Observatory were substantially influenced by Humboldtian science, imported by a variety of means. In particular, the geomagnetic data recording program was long regarded as the most important work of the observatory. Although the precision timekeeping service for citizens and navigators was the observatory's primary function, meteorological data collection and analysis was also rated highly. This activity (along with meteorology at Sydney Observatory and the other state observatories) was taken over by the Commonwealth in 1908.

Among the international contributions to science that were important at Melbourne Observatory in the nineteenth century, several advances and initiatives by German scientists were paramount. Some of the ways in which this German influence acted are obvious, for example, the presence of Neumayer for seven years, but others are less so. In the twentieth century, the observatory was increasingly starved of resources and unable to publish its backlog of scientific results, let alone take on anything new.

As time passes, Melbourne Observatory is increasingly being recognised as a national and international heritage treasure worth preserving in as unalienated a form as is possible. One of many accompanying benefits flowing therefrom is an increasing appreciation of historical contributions to its success from other countries as well as Great Britain. Special mention of Germany is justified in this context.

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