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TIME BALLS, TIME GUNS AND GLASGOW'S QUEST FOR A RELIABLE LOCAL TIME SERVICE

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Abstract: Edinburgh has had a time ball since 1853 and a time gun since 1861. In Glasgow, a time ball was erected in 1857, but the service was of questionable accuracy and had ended by March 1864. A new time service involving time guns controlled by Edinburgh Observatory was proposed in 1863, but a controversial experiment using four time guns was terminated in February 1864. Later that same year Glasgow received a reliable time service whereby public clocks were controlled from Glasgow Observatory.

Keywords: time balls, time guns, Glasgow Observatory, Edinburgh Observatory

1 INTRODUCTION

Glasgow and Edinburgh, the two principal cities of Scotland, have a long history of rivalry and differences of character that persist even today. Edinburgh, the seat of government and at the heart of political thought for centuries, is on the Firth of Forth to the east. Glasgow, one of the world's great industrial cities and at the heart of international trade by sea, is on the River Clyde to the west and remains much the larger; its modern history is rooted in ship-building and scientific achievement during the nineteenth and twentieth centuries. Both can justly claim high international stature for their universities and cultural lives.

While Edinburgh had a local time service based upon a time ball from 1853 and a time gun from 1861, Glasgow struggled to establish its own local time service. After starting with a time ball in 1857 it moved to an experiment involving time guns controlled from Edinburgh Observatory, and finally settled on a network of local public clocks controlled by signals from Glasgow Observatory. After discussing the critical roles that the Astronomers Royal, and particularly Sir George Airy, played in establishing reliable time services throughout the British Isles and the British Empire, we examine the short-lived yet painful path that Glasgow followed between 1857 and 1864 before it too finally acquired an accurate local time service.

1.1 Local Time Services and the Influence of the Astronomers Royal

The man at the centre of time signal provision was the Astronomer Royal, based at the Royal Greenwich Observatory. In an informative brief history, Malin (1987) records how the Observatory developed to the present day. It had been founded specifically for the accurate determination of longitude in 1675, with John Flamsteed (1646–1719) as the first Astronomer Royal. Flamsteed established that the rate of rotation of the Earth was constant (modern measurements have shown that there are tiny variations), so that it was possible to develop the 'method of lunar distances', using the position of the Moon against the background of stars as a clock. Earlier observations were of insufficient accuracy to allow determination of longitude for safe navigation, so he set out to improve the quality of measurements. King Charles II (1630–1685) "... certainly did not want his ship-owners and sailors to be deprived of any help that the heavens could supply, whereby navigation could be made safer." (ibid.: 248). Finally, in 1766, the fifth Astronomer Royal, Nevil Maskelyne (1732–1811), published the *Nautical Almanac* that would enable longitude to be determined in 1767 using the method of lunar distances. It was a triumph, but it was a method that tested the most skilled of navigators. Another solution was about to become practicable.

In a remarkable achievement which took most of his working life, John Harrison (1693–1776) in 1759 was able to produce his compact 'H4' timekeeper, which allowed Greenwich Time to be known accurately on a ship that had been at sea for many weeks (Sobel, 1995). Local time, determined from the Sun's position, then allowed accurate determination of longitude. However, it was not easy to manufacture accurate, reliable chronometers in the large numbers that would allow them to be carried by all ocean-going vessels, so the method of lunar distances remained in use for a long time. The general transition to chronometers actually took until about 1830, which marks the start of the time ball story (Rooney, 2009).

A few seconds of time represents a significant error in longitude. In 4 seconds of time the Earth rotates 1 minute of arc, which corresponds to a nautical mile at the equator and half a mile at Latitude 60^{o}. A chronometer error of only ten seconds could be critical to a navigator trying to avoid hazards such as reefs. Accurate land-based time signals, visible or audible to nearby ships, were the key to chronometer calibration.

The concept of the time ball was developed by Captain Robert Wauchope, R.N. (1788–1862). His idea was that a large ball, visible to ships in harbour, would be dropped from a tower at an exact predetermined time each day (Bartky and Dick, 1981). This would be published in nautical almanacs, together with the latitude and longitude at the time ball location. Repeat measurements on successive days would allow the chronometer rate to be determined. Among other benefits, this removed the need for delicate chronometers to be moved ashore for calibration, a process that could easily lead to accidental damage.

An experimental time ball operated at Portsmouth for the first time in 1829. Wauchope proposed the construction of a public time ball at Greenwich, having seen hundreds of ships being made ready for sea in London docks, "… all of which could most distinctly see a chronometer signal from Greenwich Observatory." (ibid.) A letter from the Admiralty on 20 June

1833 stated that his plan had been referred to John Pond (1767–1836), the sixth Astronomer Royal, and construction started in August that year.

The 1833 Greenwich apparatus was supplied by Maudslay, Sons & Field. The same company built the apparatus for Edinburgh, Deal, and Sydney (N.S.W.) between 1852 and 1855 (Kinns and Abell, 2009). It has been shown recently that Maudslays replicated the Sydney apparatus for Lyttelton (New Zealand) in 1873-1874; it was shipped from London by Siemens Brothers and was long thought to have been built by that company (Kinns, 2009). All of these have survived, although the time ball at Deal is now operated using a modern apparatus. They were dropped automatically by electric telegraph, but are now operated manually. Many other companies built time ball apparatuses. For example, those at Liverpool and Quebec were built by Messrs. Forrester of Liverpool (Airy, 1871). Time balls for the Cape of Good Hope and the first (1864) time ball at Wellington (New Zealand) were supplied by Sandys & Co. of London (Maclear, 1863). None of these is still in existence.

The 1833 Greenwich apparatus was operated manually at first, but automatic electric operation was introduced during the 1850s. From the outset, the Edinburgh time ball apparatus had automatic triggering by telegraph from Edinburgh Observatory. It used a rack and pinion mechanism for hoisting the time ball with that at Greenwich having used a chain hoist. The 1853 design for Deal was similar to Edinburgh, but included a return signal to Greenwich. The 1855 time ball for Sydney Observatory used a further development of the mechanism, also with automatic electric operation, which was replicated at Lyttelton.

1.2 George Airy and the Development of the Time Signals

Sir George Airy (1801–1892; Figure 1) was Astronomer Royal at the height of time signal provision around the world, and his correspondence—now held in the University Library at Cambridge University—shows that he had a considerable influence on time signal development (see Airy, 1896) He often provided advice to those seeking to provide time signals, but he did not exercise control over the selection of designs or manufacturers, which was left to local initiative and budget constraints. The time ball at Deal was the only one outside Greenwich that was under his direct control. Airy often supplied the Deal drawings to third parties. There were many exchanges of letters about time signals from the 1850s onwards, showing the extent to which they were considered essential for navigation worldwide.

Devices other than time balls and time guns were sometimes selected. For example, a collapsible cone was introduced at Devonport in 1861 (Notice to Mariners, 1861); Admiralty lists of time signals show that this was replaced by a time ball at some time between 1880 and 1898. Airy himself suggested occasionally that a large semaphore arm with a disc at the end might provide a cheaper alternative to a time ball. In a letter of 28 January 1859 concerning a time ball for the Tyne, Airy comments "What shall be your signal? Drop of Ball? Drop of Semaphore Arm?" (Airy, 1859a).

Correspondence in 1860 concerning a possible time ball at Gravesend illustrates how the Astronomer Royal was asked for advice and how he responded. The approach was from Stephen Leach (1860a) at the Thames Conservancy. His letter to Airy includes the following remark:

> Mr Main, upon whom I called with reference to the subject, in your absence, informed me that Messrs. Maudslay & Field supplied the mechanical part of the apparatus & in order to save you trouble I have written to them for particulars.

Airy (1860) promptly replied:

> In regard to the Time Signal, if you decide on having a Ball, you cannot do better than consult Messrs. Maudslays but it has long since appeared to me probable that an efficient construction might be made on the Semaphore principle, at a much smaller expense. If yourself, or a good mechanical engineer in your company, could call on any morning at an early time, say 11 o'clock, I shall be happy to talk over the matter and to explain my views more fully.

Figure 1: Sir George Airy (after *Daily Graphic*, 1892).

Leach (1860b) wrote to Airy again a fortnight later:

> I have made a drawing of a Semaphore signal which I think would answer the purpose & which I shall be happy to submit to you. I find however a strong preference on the part of the Conservancy for a Ball, as being the commonly recognised mode of exhibiting the signal.

Semaphore signals were used in South Africa, but most were replaced by time balls. Gill (1913:) recorded that "… a time ball was dropped at the Docks in Cape Town; a Disc at the end of an arm was dropped at Simons Town, and similar Discs at the Light House, Port Elizabeth and at East London." Discs at Simons Bay (sic.) and Port Elizabeth were included in the first edition of the Admiralty list of time signals (List of time signals, 1880). The fifth edition showed that time balls were then in use at Port Elizabeth and East London; only the semaphore disc at Simons Bay remained (List of time signals …, 1898).

Conspicuous time balls were the favoured time signals, followed by time guns. If an audible signal was used, it was necessary to allow for the transmission of sound at about 340 m/sec in calculating exact time at the receiving location; the delay could be several seconds in a typical port location.

2 THE GLASGOW TIME BALL

2.1 Founding of the Time Service

The well-known Scottish astronomer, Sir Thomas Brisbane (1773–1860; Morrison-Low, 2004), spent some weeks studying the action of the Edinburgh time ball atop the Nelson monument on Carlton Hill before recommending that similar time balls should also be erected in Glasgow and Greenock (*The Practical Mechanic's Journal*).

Figure 2: The Glasgow Sailors' Home, in the left foreground (courtesy: Glasgow City Archives and Special Collections).

This suggestion was eventually acted upon, for the following note was published in the Edinburgh newspaper, *The Scotsman* on 6 June 1857: "A time-ball has been hoisted on the pole surmounting the Sailors' Home at the Broomielaw [a major road in Glasgow beside the Clyde—see Jones, 2010]." (Time Ball …, 1857), while a report in the 4 May 1859 issue of the *Glasgow Daily Herald* newspaper confirmed that the time ball was located on top of the Sailors' Home at 150 Broomielaw, on the north side of the Clyde near the City Centre. A manuscript in the Glasgow City Archives and Special Collections at the Mitchell Library reveals that the Glasgow Sailors' Home

> … was opened in 1857. The association which administered it was registered as a company in 1869 and subsequently acquired other properties in Govan and elsewhere, including Atlantic House. Atlantic House, at the corner of Argyle Street and York Street, was opened as a hostel during the Second World War, and was known latterly as Atlantic House Hotel. The original Sailors' Home was closed in 1960, and the company, by then the Glasgow Sailors' Hotel Ltd., was liquidated in 1979. (The Glasgow Sailor's Home, n.d.).

Figure 2 shows the Sailors' Home before its demolition in 1971. The photograph appears to date from the 1960s, long after the time ball had ceased to operate. The circular tower would have supported the time ball apparatus. The dome in the distance is part of the Clyde Port Authority building at the corner of Robertson Street and Broomielaw, which survives to this day.

Glasgow's time ball was intimately connected with the industrial development of the city, which depended crucially on the deepening of the River Clyde. Work began on this major undertaking in 1770 and by 1812 Glasgow no longer had to depend on its outports at Port Glasgow, Greenock and Dumbarton.

The Glasgow City Council had become trustees of the River Clyde in 1770, with responsibility for managing the River, dredging and harbour development. The River Improvement Trust was set up in 1809, but was superseded by the Clyde Navigation Trust, which was established by an Act of Parliament in 1858. The Clyde Trustees were representatives of the ship owners and harbour ratepayers, together with appointees by Glasgow Corporation; Glasgow Chamber of Commerce; the Merchants' House; the Trades House; the county councils of Lanark and Dunbarton; and the burghs of Dumbarton, Clydebank, Renfrew, Govan and Partick. Trust meetings were chaired by the Lord Provost of Glasgow (*The Glasgow Story*).

Although construction of the Glasgow Sailors' Home was completed early in 1857 it is not clear that a regular time ball service started at this time, but the following letter to the Clyde Trustees dated 14 December 1858 clearly indicates that by July 1858 the local firm of Duncan McGregor & Co., chronometer-makers, had entered into a contract with the Trustees to determine Greenwich Mean Time using astronomical observations and to operate the Glasgow time ball:[2]

> Dear Sir
>
> Your favour of yesterday to hand, and as requested beg to state that our duties with reference to the Time Ball are as follows –
>
> 1st To furnish the observations required in keeping the Time Ball regulator at Greenwich Mean time –
>
> 2nd To attend daily, and set the regulator at absolute Greenwich M. T. –
>
> 3rd To furnish & maintain the chemicals required in forming the Magnetic connexion between the regulator & Time Ball –
>
> 4th To attend daily for the purpose of putting the Battery in Action, Hoisting the Ball, seeing that it drops accurately, and generally to see that the whole Apparatus is kept in proper working order –
>
> The foregoing we undertake to perform from 1st July 1858 till 1st July 1859 for the sum of Sixty pounds stg. payable half yearly. (McGregor & Co., 1858).

Although this letter implies that the time ball service began on 1 July 1858, it is possible that earlier correspondence has been lost and that the contract actually started in 1857 soon after the installation of the time ball.

The firm of Duncan McGregor & Co. did not derive local Glasgow time from the Glasgow Observatory, or even from Edinburgh Observatory or the Royal Observatory at Greenwich. Rather, Duncan McGregor maintained a private observatory on the top of his house and presumably carried out transit observations there. McGregor's observatory was located about

200 yards from the Glasgow Sailor's Home and the time ball tower (Nichol, 1859b).

2.2 Disquiet Over the Operation of the Time Ball

From the start there was concern over the accuracy of the time ball service, primarily because (a) local Glasgow time did not originate from an 'official' (i.e. professional) observatory, and (b) the time ball mechanism was activated by hand and not by an electric current from an observatory.

One of those leading the charge to improve Glasgow's time service was John Pringle Nichol (Figure 3), Regius Professor of Practical Astronomy at the University of Glasgow from 1836 up until his death in September 1859. After his appointment to the Chair at the University, Nichol

> … became famous not only for his inspiring lectures to students but for those he delivered to huge audiences at public meetings in the city … His lectures are said to have inspired the young student William Thomson, later Lord Kelvin. (The University of Glasgow Story. Biography of John Pringle Nichol).

Nichol played a key role in 1841 when the Astronomical Institution of Glasgow raised funds for a new observatory at Horselethill in the West End of Glasgow.

On 26 April 1859 Nichol wrote to Airy expressing his concern about the Glasgow time ball, and his letter includes the following comment:

> I have been doing utmost to get them to put their Time-Ball here in a right state. It is kept by a watchmaker, who has a rickety [observatory] in the top of his house. (Nichol, 1859a).

With his letter, Nichol also included a newspaper article by a Mr Allan, one of the Clyde Trustees, which stated:

> … it should be known that Professor (sic) Hartnup of Liverpool does not recommend time-balls being dropped by electric current transmitted from Greenwich .... A time-ball was erected in Liverpool some time ago by the Electric Telegraph Company, and wrought from London, which had to be discontinued, as its signals were found not to be so correct as those dropped by hand in Mr. Hartnup's observatory. And, remarkably enough, the time-balls in Liverpool Observatory and at the Liverpool docks, are all at this moment dropped by hand, and not by electric currents ...

Airy (1859b) sent Nichol an immediate reply, where he corrected some of the erroneous statements made by Allan:

> In the extract from a letter in a Glasgow newspaper which you have sent me there are some inaccuracies which are important in reference to the question now before you.
>
> 1. The time-ball erected by the Electric Telegraph Company is in daily use at Liverpool, and is dropped with perfect accuracy (as regards the instant of time) by the current which originates at Greenwich. Occasionally, from defect of insulation, in damp weather, &c., it fails, but the failures are rare. 2. The time-ball at Greenwich is always dropped by the galvanic clock. It has not been dropped by hand for several years, except when the mechanism has been under repair or cleaning.
>
> I do not know precisely what is contemplated at Liverpool in reference to the proposed new time-balls, but remarking that there is at the Liverpool Observatory a first-class transit instrument, used by an accomplished and long experienced observer, and remarking that the longitude of the Liverpool Observatory from Greenwich has been determined with great care, I should think it prudent (in order to avoid the difficulties incidental to a long line of telegraph) to drop the balls by galvanic current from the Liverpool Observatory.
>
> I should recommend a similar course at Glasgow. – dropping the balls by current from the Glasgow Observatory. The distance of two or three miles offers no difficulty.

On 27 April 1859 John Hartnup (Director of the Liverpool Observatory) sent Nichol details of the set up at his Observatory:

> It is quite true that I have recommended the new time-ball, about to be erected on the top of the Victoria Tower, to be dropped by the large turret clock in that tower by a mechanical arrangement. In the event of this being done the turret clock will, of course, be controlled by our normal clock at the Observatory, and thereby made to keep time throughout the day with the same degree of accuracy that we could drop the ball ...

Figure 3: John Pringle Nichol, 1804–1859 (courtesy: Archive Services, University of Glasgow).

Hartnup (ibid.) also discussed the problem of trying to operate a local time service without the aid of a professional observatory. When the Liverpool Observatory was being planned

> … the Greenwich time obtained from various celebrated chronometer makers who had transit instruments of their own, had been found to differ from the correct Greenwich time sufficiently to cause a wreck; and it was recommended by scientific gentlemen, who were consulted by the Liverpool Corporation, and particularly by the Astronomer Royal, that an astronomical character should be given to the Liverpool Observatory ...

Finally, Hartnup (ibid.) made the following poignant comment that reflected directly on the operation of Glasgow's all-too-inadequate time service:

> The scientific public and intelligent shipmasters will never have confidence in either time-balls or clocks, which are not placed directly under the control of the officers of an astronomical observatory.

In a letter dated 30 April 1859 to David Dreghorn, a prominent local citizen, Nichol also discusses some of the issues raised in the afore-mentioned letters by Airy and Hartnup:

> I. I repeat emphatically, in reference to the use of "electric currents", that the thing requisite, and which alone is of much moment, is this:- The working current ought to pass to the machinery of the ball directly from the transit clock, and be set in action, automatically, by that clock. No intervention of "a man with a watch" is now permissible at any part of the process. The objection is to intervention of any kind; it is of no consequence at what part of the process such intervention may take place.
>
> II. Statements are made and vouched for that an "adequate observatory" exists, and is in operation, within two hundred yards of the turret of the Sailors' Home. I have only to express a hope that the Clyde trustees have an easy and comparatively inexpensive task before them. They have merely to lay a conducting wire through these two hundred yards; and to ensure that records of the working of the institution be regularly kept, and remain open to examination.

Nichol (ibid.) concluded that:

> It is plain enough that public controversy on such matters can lead to no good result. It is really a technical and strictly scientific subject, and the state of information of the public mind on questions of this description does not offer adequate security against the acceptance of reiterated and plausible statements, how inaccurate soever they may be.

Nichol (ibid.) then went on to suggest that the Clyde Trustees

> … request a visit and report from the Scottish Astronomer Royal, Professor Piazzi Smyth of Edinburgh ... [A] visit of half a day would enable him to report definitively concerning the "observatory", and every other arrangement connected with the time-ball.

For his part, Dreghorn (1859) identified the anticipated outcome of these discussions:

> I am sure if we set ourselves to the work, there can be little difficulty in placing Glasgow – as far as her great navigation interests are concerned – under the system to which Mr. Hartnup alludes, as already existing and about to be greatly extended and perfected in London and Liverpool.

The *Glasgow Daily Herald* editorial published on 30 October 1863, described later, displayed a subsequent souring of relations between Glasgow and Edinburgh on the matter of transmission of time.

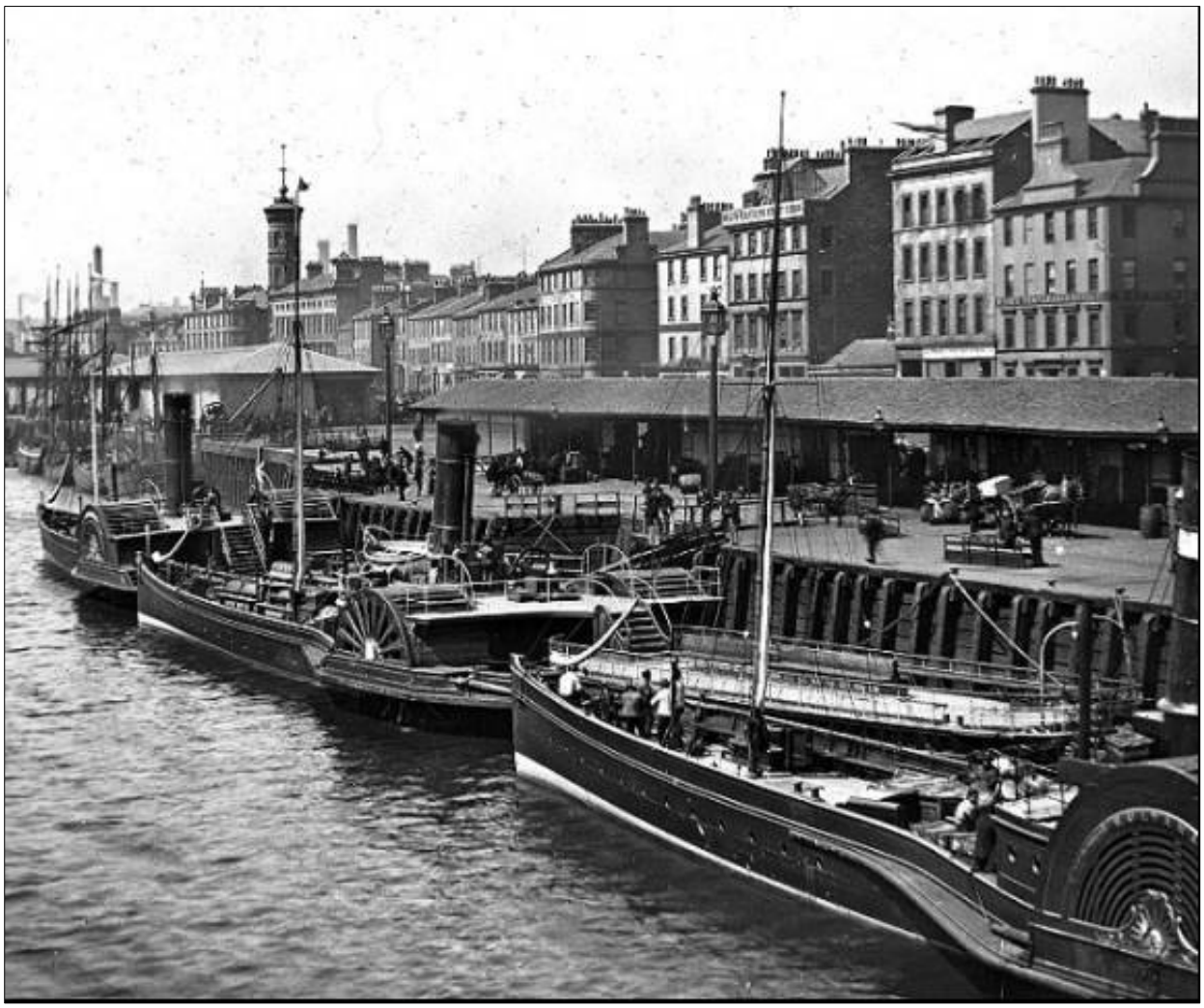

Figure 4: The Broomielaw in about 1870 (courtesy: the Graham Lappin Collection).

2.3 Demise of the Time Ball Service

A letter from Duncan McGregor & Co. dated 3 December 1859 shows that his firm continued to supply the Clyde Trustees with a time ball service for the period 1 July 1859 to 1 July 1860, but this time for the twice-yearly amount of £40.

Further annual endorsements of the contract dated 1 July 1862 and 1 July 1863 were prepared (see McGregor & Co., 1859), suggesting that it was intended to operate the Glasgow time ball until at least the end of June 1864. The final contract between the Clyde Trustees and McGregor & Co. is likely to have been terminated early. In a letter to Airy dated 8 January 1878, Professor Robert Grant, who succeeded Professor Nichol as Director of Glasgow Observatory in 1859, stated that "… when this Observatory was finally, in 1863, connected electrically with the City of Glasgow the dropping of the time ball was discontinued." The 1863 date is probably an error of memory. Letters and editorials in the *Glasgow Daily Herald*, described later, show that the electrical connection to the City was implemented in March 1864.

Concerns about the accuracy of the Glasgow time ball service probably lay at the heart of its demise, but the fact that the time ball was not visible to larger vessels in the Clyde at a critical time in Glasgow's maritime development must also have played a role.

Although the time ball had ceased to operate by 1864, later photographs of the Broomielaw show that the ball and mast were not removed for a long time. Figure 4 is a photograph taken by George Washington Wilson in about 1870. It shows three paddle steamers and various small sailing vessels alongside the Broomielaw on the north bank of the Clyde near the centre of Glasgow. The tower of the Sailors' Home can be seen behind the mast of the middle steamer, with the ball in its lowered position (Jones, 2010). Figure 5 is a close-up of the time ball tower as photographed in 1876, and the mast and ball also appear in an 1897 collotype (private communication, Professor A Graham Lappin), so they certainly survived until the end of the nineteenth century.

3 THE TIME GUN PROPOSAL FROM EDINBURGH

In October 1863 the *Glasgow Daily Herald* published a 2,000 word editorial about time signals (*Glasgow Daily Herald*, 1863). Unknown to the leading astronomers and most authorities in Glasgow, Professor Charles Piazzi Smyth (1819–1900; Figure 6), the second Astronomer Royal for Scotland (see Brück and Brück, 1988), proposed to introduce a Glasgow time gun, controlled from Edinburgh Observatory. The following newspaper report, titled "Proposed time-gun in Glasgow" (1863), was published in the *Scotsman*, an Edinburgh newspaper, on 24 September 1863:

> We are informed that experiments are likely to be made this week with a view to the establishment of a Time-Gun in Glasgow. The gun will be fired from the Edinburgh Observatory, in the same way as that now fired in Newcastle. Instead of an electric clock being used to pull the friction tube as in the Castle, a small fuse filled with powder placed in the vent of the gun will be exploded by means of a spark evolved from Wheatstone's "magnetic exploder" – the electric current being transmitted precisely at one o'clock from the Observatory through one of the Electric Telegraph Company's wires to Glasgow.

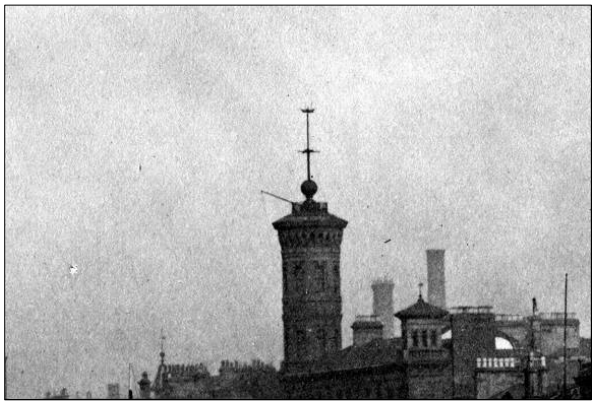

Figure 5: An enlarged image of the Glasgow time ball, taken in 1876 (courtesy: A Graham Lappin).

Meanwhile, Smyth had already demonstrated the feasibility of telegraphic control from Edinburgh in 1858:

> The subject of time-ball extension – that is, giving to other localities connected by telegraph the same electric signal as that which drops the Edinburgh ball – has likewise been discussed on former occasions by members of the Board, and an experiment of this sort was made during the meeting of the British Association at Glasgow, with the countenance of Professor Nichol; when a model apparatus was dropped daily in the mechanical section, meeting in Glasgow College, by the signal from the Edinburgh Observatory. (The Royal Observatory …, 1858)

Smyth's time gun proposal caused considerable offence in Glasgow, which can be illustrated by extracts from an editorial in the *Glasgow Daily Herald*:

> More than a month has now elapsed since the intelligence that a Time-Gun was to be introduced into Glasgow burst upon its inhabitants. An Edinburgh journal, in its impression of September 24, first gave currency to the report of the good things in store for Glasgow; for, up till then, the project had been matured with unac-

Figure 6: Charles Piazzi Smyth (after: http://pinetreeweb.com/pb-piazzi-smyth.htm).

> countable quietness. It was stated, further, that the gun was to be fired in connection with the Edinburgh Observatory. In our impression of September 26 there appeared fuller details, by which the public were informed that the scheme had originated with the Universal Private Telegraph Company, which had secured the co-operation of Professor Charles Piazzi Smyth, Director of the Edinburgh Observatory – that the arrangements were all but complete – that a site had been procured for the firing of the gun, and that maps, to enable the public to take advantage more effectually of the new time signal, had been *already prepared*, and might be seen in a bookseller's shop window. On the same day there appeared a letter from the Professor of Astronomy in our own University, by which it appeared that he had some time previously, submitted to the Town council a scheme for the transmission of time, of a totally different character, but which had been practised with admirable success in Liverpool for several years past. It was plainly apparent that neither the University of Glasgow nor Professor Grant had received any information respecting the Edinburgh project until it was announced in the public journals; and this was confirmed by a subsequent letter which the Professor addressed to the Lord Provost, in his capacity of Chairman of the Clyde Navigation. Referring to a special arrangement with her Majesty's Government, by which the University of Glasgow, as represented by its Observatory, is pledged to furnish the shipping of the Clyde with correct time, he assures his Lordship "that, under no circumstances whatever, will the University consent to forego this engagement, or permit the usurpation, by any other observatory, of the duties which it imposes." (*Glasgow Daily Herald*, 1863).

The intermediate paragraphs attack Smyth's presumption in behaving like the Astronomer Royal at Greenwich, and emphasized the comparable status of the observatories in Glasgow and Edinburgh. The following extract further demonstrates the disquiet in Glasgow about Smyth's approach:

> Professor Smyth speaks of Glasgow having *applied* for a signal gun; of its being the only Scottish city which had hitherto accomplished the object of its wish; of its citizens having locally provided a cannon; of their strong common sense in perceiving the superiority of the new system, and of their having vigorously adopted a new and more suitable locality for the firing of a gun. In reply to these statements, we have simply to say that in this city of half a million inhabitants, there were probably not more than half a dozen of persons who were recognisant of the project of the Private Telegraph Company and Professor Smyth, previous to the announcement of the Edinburgh *Scotsman*. (ibid.).

Notwithstanding the public disquiet, the plan by the Private Telegraph Company succeeded, and an experimental time gun service was initiated. Of all places, details of it were published in an 1865 Australian newspaper:

> The first Glasgow time-gun was supplemented by a second one in St. Vincent's Place on the 29th of October [1863], and these two by a third at the Broomielaw, on the 10th of November, while a fourth gun was added to the system at Greenock on the 21st November, all four being simultaneously fired through the agency of the electric current from the [Edinburgh] Observatory. (Time signals, 1865).

However, the service did not last for very long as the 3 February 1864 issue of the *Glasgow Daily Herald* contained the following report:

> I desire through your columns to inform those interested in the establishment of correct time signals for Glasgow, Greenock, and the surrounding parts, that the four time-guns hitherto fired daily at 1 P.M., Greenwich Mean Time, will cease firing on Saturday the 6th instant. The experiment I had the honour of introducing to this city has proved successful; and if it is desired to have guns – having laid the matter before the several authorities – the guns can be resumed as soon as the necessary arrangements have been made. (Holmes, 1864).

As it happened, the concluding section of the editorial that had been published in the 30 October 1863 issue of the *Glasgow Daily Herald* already set the scene for the developments that would occur in Glasgow over the following months:

> It is not within our province to pronounce an opinion on the respective merits of the different methods of transmitting time which are now before the public. The University, we believe, are quite prepared to co-operate in adopting, according to circumstances, whatever may be considered most suitable; and that, too, utterly irrespective of anything that may be done from any other quarter. (*Glasgow Daily Herald*, 1863).

4 THE TRANSITION TO CONTROLLED PUBLIC CLOCKS IN GLASGOW

When he wrote to Nichol on 27 April 1859, John Hartnup from the Liverpool Observatory foreshadowed the approach that Professor Nichol would take in establishing a reliable public time service in Glasgow:

> The practicality of controlling clocks by weak galvanic currents, is now attracting great attention in London, and … It is quite certain that we now have it in our power to control all the public clocks in a large town, thereby making them all strike simultaneously, and show the same time throughout the day as the normal clock at the observatory by which they are controlled.
>
> By a single wire you might control all the important clocks in Glasgow …

The Editorial published in the *Glasgow Daily Herald* on 30 October 1863 indicates that by this date Professor Grant at Glasgow had been working on a system whereby public clocks, and indeed any other public time signals, would be controlled from Glasgow Observatory.

> It is understood that the preliminary permissions for laying down a wire from the Observatory to the College Clock have been already obtained, and that actual operations will be commenced in the beginning of next week. We may expect, therefore, that in about three weeks hence the College Clock will be maintained in perpetual control by the Normal Clock of the observatory, and it will then be an easy matter to extend the system indefinitely.

Robert Grant (Figure 7) was the Regius Professor of Astronomy at the University of Glasgow and Director of the Observatory from 1859 to 1892. He succeeded John Nichol. After his *History of Physical Astronomy from the Earliest Ages to the Middle of the Nineteenth Century* was published in 1852 "… Grant became a well-respected figure in the world of astronomical research." (The University of Glasgow Story. Biography of Robert Grant).

The following editorial, titled "Controlling of the public clocks by an electric current from the Observatory of the Glasgow University" (1864), was published in the 5 January 1864 issue of the *Glasgow Daily Herald* and gave full support to Professor Grant's proposal

for Glasgow and the Clyde:

> We understand that the University of Glasgow has submitted to the Town Councils of Glasgow, Paisley, Port Glasgow, and Greenock, a plan for the controlling of all the public clocks in the former towns, by means of a current of electricity directed from the standard mean time clock of the Observatory of the University, in accordance with the ingenious invention of Mr. Jones of Chester, which has been for several years in practical operation at Liverpool, where it has been attended with the most complete success. If this proposal be adopted, the result will be that the pendulum of all the clocks under control will vibrate in perfect unison with the pendulum of the Observatory clock, and the first blow of the hammer for the successive hours will indicate Greenwich mean time, and will, in the case of every clock, occur at the instant when the seconds' hand of the Observatory clock points to sixty. It may be interesting to the public to know that this beautiful result has been already realised in the most satisfactory manner in the case of the University turret clock, which was connected by an electric current with the Observatory clock about ten days ago. This will be apparent from the following letter, addressed to Professor Grant by Mr. Macfarlane, the senior assistant of Professor William Thomson who very obligingly undertook to compare daily the University clock with the indications of the Observatory clock. In order to appreciate the exact force of Mr. Macfarlane's observations it may be well to mention that at every second of the minute, except the thirtieth second, a current or pulse of the electric fluid is transmitted from the Observatory clock to the University clock. This effect is indicated at the University clock by a corresponding deflection of the needle of a galvanometer placed in the circuit, occurring at every second except the thirtieth, when, there being no current, the needle will stand for an instant in the vertical position. Now, if the two clocks beat simultaneously, this position of the needle, indicative of the absence of a current, ought to occur invariably at the instant when the seconds' hand of the University Clock (which, we may remark, is not seen from the outside of the College buildings) points to thirty. How far this result has been realised will be seen from Mr. Macfarlane's letter.

Here is Donald Macfarlane's letter:

> Sir, I have regularly observed the working of the College clock several times a day from Saturday the 26th of December last till to-day, with the exception of Friday and Saturday last, when my place was supplied by Mr. Tatlock, and we have invariably found the *no current* beat of the Observatory clock to coincide exactly with the 30th second of each minute of the College clock.

The editorial refers to an invention by R.L. Jones, Station Master of Chester, who was a pioneer in clock sychronisation:

> In his patent no. 702 of 1857, Jones adopted Bain's system of sympathetic pendulums. A mechanical master clock provided the electric pulses to keep the pendulums of his ordinary key-wound clocks in step. The bob of these key-wound clocks consisted of a coil sliding over two permanent magnets. The electric pulses received from the master clock kept these secondary clocks in harmony with his master clock. He used the tower clock of Chester as master clock providing the electric pulses to control his secondary clocks. (Bosschieter, 2000).

Another editorial about Glasgow time signals was published a little over one week later in the *Glasgow Daily Herald* (1864), and included the following paragraph:

> We have, then, submitted to us two projects for supplying the City and the Port of Glasgow with correct time – the one emanating from our ancient University, and having the source of operations included within the extreme boundaries of the City; the other offered from an establishment, under the joint management of Professor Piazzi Smyth, of the Edinburgh Observatory, and of Mr. Nathaniel Holmes, of the Private Telegraph Company. Discounting all extraneous considerations, it may not be an unprofitable task to cast a glance at the relative advantage of the two schemes.

Figure 7: Robert Grant, 1814–1892 (courtesy: Archive Services, University of Glasgow).

Later in the same editorial there is a comment about the arrangements for the Tyne:

> ... about two months ago there was a good deal said respecting the rapid progress of the time-gun system at Newcastle, Sunderland and North Shields, under the joint management of Professor Smyth and Mr. Holmes. Recently, however, we are informed the tie which connected each of these three "affiliated cities" with their elder sister had been severed. Newcastle, while welcoming any useful suggestions from without, has reserved to itself the right of managing its own affairs in the way that may seem most conducive to its own interests, and neither of the gentlemen just mentioned have any connection with the gun which is fired daily in that town. We would desire to speak with the utmost respect of both Professor Smyth and Mr. Holmes – and, indeed, we thank them for the interest which their operations have excited in this quarter – but we cannot help thinking that if Newcastle, which has no Astronomical Observatory of its own, has been enabled to provide itself with correct time independently of either of these gentlemen, surely so can Glasgow, which is so much more favourably circumstanced in respect to astronomical advantages ... (ibid.).

Just four weeks later, on 3 February, one of two articles about Glasgow's time service that was published in the *Glasgow Daily Herald* reported that of the two options before it the Clyde Trust now favoured

the use of telegraph signals from Glasgow Observatory to control public clocks in Glasgow:

> The Sub-Committee of the Harbour reported that, in accordance with a remit from the Committee of Management, they had considered a communication from Professor Grant regarding certain proposed arrangements for transmission by telegraph of correct time for the use of shipping of the Clyde and a communication from Mr. Holmes in relation to time-gun signals. The committee were of opinion that the Trustees should not entertain Mr. Holmes proposal as to time-gun signals; and, with regard to Professor Grant's communications as to the transmission of correct time by telegraph, they had remitted to the chairman and Messrs. Allan Gilmour and W. Allan to consider the proposal and report. (Clyde Trust, 1864).

On 5 March an editorial in the *Glasgow Daily Herald* titled "Transmission of time from Glasgow Observatory. Electric operations" showed that the decision had been made: the Directors of the Exchange had given Professor Grant their enthusiastic support. The opening and concluding sections of the editorial show its tenor:

> We understand that the directors of the Exchange, at a meeting held on Tuesday last, decided upon taking immediate steps for introducing into the Exchange the system of controlling clocks by electricity, which has been recently established in this city, in connection with the Observatory of the Glasgow University. The wire extending from the Observatory to the College, being already attached to the building of the Exchange, the clocks of the latter may be connected with the system at a trifling expense. It is proposed to place under control the great public clock and the clock in the interior, which is above the entrance into the building. A conspicuous clock, in place of the present small clock, showing the time to seconds, will also be fitted up in the great room, and will be similarly placed under control ...
>
> The University of Glasgow has freely placed the resources of the Observatory at the disposal of the city, with a view to the establishment of a complete system of correct time indications; and we have no doubt that not only the various corporate bodies, but also the inhabitants generally, will reciprocate this act of courtesy, by cordially supporting the University in its present exertions. *We want no official meddling from without. We feel perfectly competent to perform our own work*, and we are confident that, in the present instance, it will be accomplished with the dignity and importance of our ancient city. (My italics).

The italicized section, above, shows that there was still considerable resentment about Edinburgh Observatory's possible involvement in Glasgow's time service.

Progress was then rapid and Glasgow soon had a widely-accessible reliable time service available through public clocks in Glasgow and at ports along the Clyde that were regulated by electrical signals from Glasgow Observatory. The use of time balls and time guns as principal time signals for the Clyde finally had been abandoned.

Professor Grant then wrote a long letter that was published in three instalments in the *Glasgow Daily Herald* between 16 and 26 March 1864. Each part was entitled "How time is determined at the Glasgow Observatory" (Grant, 1864a; 1864b; 1864c), and collectively they constitute a fine exposition on the use of astronomical observations to determine time, and the accuracy that could be achieved.

Although Glasgow's controlled clocks were not listed in the Admiralty lists, their existence would have been known to mariners, and they were recognised by astronomers elsewhere as being accurate to within one second (e.g. see Ellery, 1868). Many of the public clocks had large dials, and some of them may have been visible from ships on the Clyde.

5 PROFESSOR GRANT'S LATER RECOLLECTION OF THE GLASGOW TIME BALL

In response to a query from Airy, in 1878 Grant supplied the following history of the Glasgow time ball and clarified the provision of time signals for Glasgow and the Clyde ports (his underlining):

> The story of time signals in connexion with Glasgow may be briefly told. When I came down here from London in November 1859 I found that a time ball was being dropped daily from a structure built expressly for the purpose on the north bank of the river, but the time rested on no astronomical authority and when this Observatory was finally, in 1863, connected electrically with the City of Glasgow the dropping of the time ball was discontinued. Indeed under the most favourable circumstances the situation from which the time ball was dropped was adverse to its practical usefulness.
>
> The time-signal system of this Observatory has consisted exclusively of a clock controlling by Jones's method. A considerable number of clocks both in the City and upon the river are connected in this manner with the Observatory. Furthermore I understand that Messrs. D. McGregor & Co Chronometer makers receive daily a signal from Greenwich ...

This account is of particular interest on three counts. First, there is no mention of the trials of the four-gun time signal, which were terminated in February 1864. Second, note that the former operator of the Glasgow time ball, the firm of D. McGregor & Co. ended up obtaining their time signals directly from Greenwich rather than from the local observatory. Third, Grant states that the time ball service was discontinued when the electrical connection between Glasgow Observatory and the City was implemented, but probably makes an error of memory in stating that the year was 1863. Editorials in the *Glasgow Daily Herald* indicate clearly that the link was completed in March 1864. It is therefore likely that the time ball service continued until that date.

6 DISCUSSION

6.1 The Abortive Plans for a Greenock Time Ball

Sir Thomas Brisbane was one of Scotland's foremost astronomers (see Morrison-Low, 2004), and in 1853-1854 he proposed that a time ball should be erected at Greenock (*The Practical Mechanic's Journal*). The idea was considered seriously, and there was a plan to erect a time ball as part of a memorial to James Watt (The proposed tower …, 1859):

> The monumental tower which it has been proposed to raise in memory of Watt will be reared in the cemetery occupying the heights to the west of Greenock, the birthplace of the great mechanician ... The upper turret is adapted for the reception of an electric time-ball, and for nautical and astronomical observations. Thus it sought to make the structure useful to all engaged in the navigation of the noble estuary of the Clyde.

The tower was built, but no record has been found that

a time ball was ever erected at Greenock. Nevertheless, the idea was still current almost twenty years later:

> There has been talk about Greenock receiving a [time] signal from Greenwich. A time ball dropped there would be very desirable as it would enable the masters of ships leaving the Clyde to satisfy themselves respecting their chronometers ... (Grant, 1878).

6.2 Glasgow, and Airy's Lists of Time Balls and Time Signals

In May 1861 Airy compiled the following list of time balls, which shows that he was uncertain about the status of the Glasgow time ball:

> Greenwich;
> Deal;
> London (E and I Telegraph Co), City Observatory;
> Liverpool (E and I Telegraph Co), Victoria Tower;
> Portsmouth;
> Edinburgh;
> Glasgow (a ball was known to exist in 1859 but no particulars relating to it have been found);
> Cape of Good Hope (Simon's Town);
> Madras;
> Calcutta;
> Sydney;
> Quebec;
> Williamstown, Vic, Aus;
> Washington, US.

In fact, this list is not complete because time balls were also in operation at St. Helena and at the Royal Observatory in Cape Town, for example (see Bartky and Dick, 1981). But others, such as the one at Cornhill in London, were not useful to mariners and would have been excluded on that basis.

A high-level exchange of correspondence between Britain and Germany occurred during December 1877 and January 1878 when the German Government sought to obtain information about the British time signals. A letter was sent to the Astronomer Royal from the Foreign Office on 29 December 1877 (Foreign Office, 1877). Airy (1878a) replied initially with a holding letter to the Earl of Derby (who was then Foreign Secretary in the Disraeli Government) and he then wrote to various authorities, including Grant in Glasgow (Airy, 1878b; 1878c) and Smyth in Edinburgh, asking for detailed information about current time signals. The following letter to Grant shows that Airy (1878b) knew little about time signal provision in Glasgow at that time:

> I have been requested to procure some information respecting Time Signals. I know not whether there is such a thing in your important Port of Glasgow (I have not been there for some years) but I will suppose there is and will place before you all the questions which I wish to ask.

Airy then asked eleven questions concerning the type of signal, location, the authority for time and other operational features. He wrote another letter on the following day (Airy, 1878c), having forgotten to ask for the height of the signal above the ground and also above high water.

Replies to the twelve questions from the various correspondents were assembled into a large table in Airy's handwriting, which was then sent to the Earl of Derby with a covering letter (Airy, 1878d). Table 1 is a partial transcription of Airy's table, and shows the main part of the entries for Scotland. Additional columns in the complete table are headed: "Whether the signal reports the action to the Observatory; Action, in case of total failure; Action, in case of erroneous exhibition". Longitudes in this table are specified as time from Greenwich.

Table 1: An extract from Airy's summary of British time signals, dated 22 January 1878.

Exhibition of Public Time-Signals on or near to the Coasts of Britain: (In all instances, the signal is exhibited every day at 1h.0m.0s Greenwich Mean Solar Time.)								
Locality.	**Approximate Latitude & Longitude.**	**Nature of the Signal.**	**Elevation above the Ground & above High Water.**	**Colour of Ball. Diameter. Rise for Signal.**	**Authority for Time.**	**Warning to the Public, of approaching Fall.**	**Specific Phase of Signal to be observed**	**Whether the signal is given by hand or by automatic action**
Calton Hill, Edinburgh	55°.57'.23" 0h.12m.43s. W	Drop of Ball.	110 feet 457 feet	Dark grey 5 feet 10 feet	Transits at the Royal Observatory, Edinburgh.	As at Greenwich.	As at Greenwich.	As at Greenwich.
Castle Battery, Edinburgh	55°.57' 0h.12m.47s. W	Gun-fire.	200 feet 437 feet		Transits at Edinburgh.			Current from a clock controlled by R. Observatory, Edinburgh.
Docks, Leith	55°.59' 0h.13m. W	Conspicuous Clocks.			Transits at Edinburgh.			Current from Edinburgh R. Observatory controlling the clocks.
Dundee	56°.28' 0h.11m.48s. W	Gun-fire.			Transits at Edinburgh.			Current from a clock controlled by R. Observatory, Edinburgh.
Inverness	57°.30' 0h.16m. W	Small time-ball in private shop.			Transits at Greenwich.			Current in the Post Office Wires. As at West Hartlepool.
Glasgow	55°.52'.45" 0h.17m.11s. W	Several controlled clocks.			Transits at the Glasgow Observatory.			By galvanic current from the Glasgow Observatory controlling the Clocks.

Finally, we should note in passing that no time signals for the West of Scotland were mentioned in any of the five editions of the Admiralty list of time signals for mariners published between 1880 and 1898. The number of listed time balls increased from 52 to 94 world-wide during this period, while the number of listed time guns grew from 9 to 30. Overall, the number of distinct time signal locations listed by the Admiralty increased from 71 to 154, some having more than one type of signal. However, many other time balls and alternative signals existed for public use, away from coastal regions.

6.3 Glasgow's Public Time Service and Australian Time Signals

It is perhaps surprising that the system used for a local time service in Glasgow was recognised internationally. A plan to maintain true time in Melbourne, Australia, was outlined in a paper presented to the Royal Society of Victoria by Robert Ellery, the distinguished Government Astronomer of Victoria, Director of the Melbourne Observatory and President of the Society (see Gascoigne, 1992). Ellery (1868) noted that Glasgow clocks were "… correct to a second …" and that synchronism with the Observatory clock was confirmed using a simple system:

> In Glasgow, as an extra security to the public, it is made a *sine qua non* that those using the supply should have a small, simple, galvanometer beside their clock, which shows by right and left deflections of its needle the alternating currents, and also by an omitted deflection at the sixtieth second of each minute, if the controlled indicated the same second as the Observatory clock.

Ellery went on to point out that "The heavy two seconds pendulum of large turret clocks can be just as readily controlled by the same main, by a different disposition of the permanent magnets." He then reported on his own work to allow control of half seconds pendulums using the same currents.

There is also a surprising mention of the Glasgow time guns in the leading Tasmanian newspaper, *The Mercury*. During 1865 there was considerable debate at the Royal Society of Tasmania in Hobart about the introduction of a local accurate time service (see Royal Society, 1865). Francis Abbott, Tasmania's foremost astronomer (see Orchiston, 1992), had read a paper to the Society, which was published in the same column of *The Mercury* (Abbott, 1865). He mentioned many successful time ball and time gun installations world-wide, although he argued strongly in favour of time guns for Hobart. A more detailed account was published later in the same year, which made specific reference to the four time guns that had been used in Glasgow (Time signals, 1865). Abbott appeared to be unaware that he was describing a system that had by that time been discontinued.

7 SUMMARY

In 1857 a Glasgow time ball was erected on a tower above the Sailors' Home on the Broomielaw. It was maintained by the Clyde Trustees but operated by the firm of D. McGregor & Co., chronometer-makers of Glasgow and Greenock, which used its own observatory to determine Greenwich Time.

The accuracy and method of operation of the Glasgow time ball were criticised by leading astronomers, because time was derived from an unofficial observatory and because the ball itself was dropped by hand rather than automatically using an electric signal. Correspondence between Professor John Nichol of Glasgow Observatory, Astronomer Royal George Airy and John Hartnup, Director of the Liverpool Observatory, was published in the *Glasgow Daily Herald* in May 1859 in an effort to persuade the Clyde Trustees to adopt an improved arrangement, but this did not produce the desired result and the service was subsequently terminated late in 1863 or in the first three months of 1864. The fact that the Glasgow time ball could not be seen from larger vessels in the Clyde probably also contributed to its demise.

An alternative approach to provide a reliable local time service for Glasgow emerged in 1863 when Professor Charles Piazzi Smyth, Director of the Edinburgh Observatory and Astronomer Royal for Scotland, proposed that time guns operated by electric telegraph from Edinburgh Observatory should be installed in Glasgow. Although the idea that Edinburgh should control Glasgow's time service was strongly opposed by Glasgow Observatory and the University, an experiment using four time guns was carried out, but this was terminated in February 1864.

While Smyth was angling to control Glasgow's time service, Professor Robert Grant, Regius Professor of Astronomy at the University of Glasgow and Director of Glasgow Observatory was busy arranging a reliable local time service and this was achieved in March 1864 when public clocks in the city were brought under the control of the Observatory.

After consulting Grant, Airy included Glasgow's controlled public clocks in a list of British time signals that he prepared in January 1878, but no entries for the west of Scotland were included in the Admiralty lists of time signals for mariners that were published between 1880 and 1898.

8 NOTES

1. The history of time balls has been derived largely from the archives of the Royal Greenwich Observatory, held at the University Library in Cambridge while information relating to the Glasgow time ball is in *Glasgow Daily Herald*, microfilm copies of which are held in The Mitchell Library in Glasgow. Other relevant records are also held in the Glasgow City Archives at the Mitchell Library.
2. The *Annual Reports of the Sailors' Home* do not mention the time ball, which confirms that its construction and operation must have been independent of the Home (Annual Reports for the Sailors' Home). The first five meetings of the Glasgow Sailors' Home were held on 7 April 1858, 12 May 1859, 23 May 1860, 14 May 1862 and 30 May 1867. These span the period of the time ball operation.

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