

## SOME NEW INSIGHTS INTO THE HISTORY OF THE GLASGOW TIME BALL AND TIME GUNS

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**Abstract:** The 1857 time ball machinery at the Glasgow Sailors' Home was supplied by Alexander McKenzie, mechanist, using a design that had much in common with the 1853 Edinburgh apparatus. It was operated using electrical connections to a mean time clock in the Home. This clock required adjustment by hand each day to compensate for its losing rate. Such manual intervention and lack of independent verification of accuracy undermined the authority of the signal.

The relative prestige of the Glasgow and Edinburgh Observatories was an important issue. There was no telegraphic link between Glasgow Observatory and the City until the end of 1863, but it had been demonstrated as early as October 1855 that a time ball could be dropped by telegraph from Edinburgh. Another Edinburgh initiative in September 1863 using time guns fired from Edinburgh caused offence in Glasgow and the trials were terminated in February 1864. Professor Grant, Director of Glasgow Observatory, argued successfully that a system of slave clocks controlled from Glasgow Observatory would be far superior to either a time ball or time guns which only provided a signal once per day. He won the debate in March 1864.

**Keywords:** Glasgow, time ball, time gun

### 1 INTRODUCTION

This paper developed from contact between the authors during September 2011. David Clarke was completing a book about the astronomy of Glasgow (Clarke 2012) and found a reference to the paper about Glasgow time signals which Roger Kinns had published in this journal (Kinns, 2010). We were not previously aware of each other's work, but it rapidly became clear that we had been using different principal sources and that we could clarify a complicated story by combining references from material at Glasgow University, the Royal Greenwich Observatory archives, now in Cambridge University Library, and contemporary newspaper articles published in Britain and Australia.

Details of the 1857 Glasgow time ball are described here and the way it was operated. It had much in common with the Edinburgh time ball, both being raised and released using electrical signals from a mean time clock. The difference was that the Glasgow clock was adjusted by hand every day, just prior to the drop, to compensate for its losing rate, with occasional chronometer checks by the company which operated it, but with no independent checks on accuracy. That led to protests from John Nichol and Robert Grant, successively Regius Professors of Astronomy and Directors of Glasgow Observatory during the period of time ball operation. Edinburgh Observatory kept daily records of the time ball drop, which were open for public inspection.

Glasgow trials with time guns, controversially operated by telegraph from Edinburgh, gave rise to strong protests that Glasgow Observatory had an obligation to the Crown to provide a time service for shipping on the Clyde and would not be usurped by Edinburgh. Trials with a single gun in October 1863

led to vigorous complaints about disturbance and damage to property. That almost ended the trials within days, but reduced powder charges and the addition of two more guns in Glasgow and another at Greenock extended their combined existence for a further four months. Robert Grant argued in favour of multiple clocks, controlled from Glasgow Observatory, and visible both to shipping and the citizens of Glasgow. These provided an accurate reference at any time, whereas guns and time balls provided only a single daily signal. Following experiments and demonstrations at the end of 1863, involving telegraphic signals despatched from the Observatory some five km away to the turret clock at the Old College and a slave clock within its courtyard, he won the debate in 1864.

### 2 DESCRIPTION OF THE GLASGOW TIME BALL

The best available description of the Glasgow time ball and its operation is by James Brown (1862), but there is little information about the mechanical apparatus. Brown stated that it was erected by Alexander McKenzie in 1857 and operated by McGregor & Co. of Clyde Place from the outset. He also noted that this company used a transit instrument at their premises, as reported by Nichol (1859). Their business was on the south side of the Clyde, nearly opposite the time ball on the other side of the river:

On the Tower of the Sailors' Home, is the Harbour Time-Ball, (which was erected in 1857, by Mr Alexander McKenzie, mechanist, and has been worked, from the commencement, by the firm of McGregor & Co., chronometer makers, who have an observatory at the south-side), the transit instrument in which is mounted on one block of polished marble, cut down centrally, to a certain extent, so to allow the instrument to traverse in the plane of the meridian.

Brown (1862) then gave a comprehensive description of the way in which the astronomical clock, located in the basement of the Sailors' Home, provided signals to the ball operator. It was connected electrically to the time ball apparatus in the tower above. The clock had electrical contacts which provided signals a few seconds prior to 5 minutes before 1 pm, when the operator raised the ball to half-mast high, and just prior to 2 minutes before, when he raised the ball to the top. Presumably, the operator then set triggers which were pulled by electromagnets to release the ball, although this was not stated by Brown. Another signal at 1 pm released the ball automatically. This was the procedure established at Edinburgh in 1854 (Kinns, 2011a).

According to Brown:

The Time-Ball is dropped daily, exactly at one o'clock, Greenwich mean-time, by an electric current from an astronomical clock, which is attached to the basement of the building; and a brief account of the mode of working it, may prove interesting, as many persons have been led to suppose that the ball is dropped by hand. The dial of the clock is cut through, above the figure 60, on the seconds-dial, and through the opening projects a thin plate of pure gold, which is inclined to the seconds-hand, also of gold, at an angle of about eight degrees. Concentric, and revolving with the minute-wheel, is a wheel, notched out in three places, above which rests a lever, connected with the gold plate or trigger. At a few seconds before five minutes to one o'clock, the lever drops into the first notch, allowing the gold trigger to fall into position for contact with the seconds-hand, which, as it completes the 60<sup>th</sup> second, touches the gold plate, and a minute bright spark is seen. The signal is conveyed to the attendant, at the top of the Tower, and the ball is wound up half-mast high. The seconds-hand, after making the contact, pushes back the gold plate, which is very flexible, and continues its course; but before it completes another circuit, the trigger is lifted above the point of contact by the mechanism of the clock. At a few seconds before two minutes to one, the trigger again drops, the second contact is made, signalling as before, and the ball is wound up to the top of the staff; and when the seconds-hand completes the last second of the hour, it again touches the trigger, and the ball instantaneously descends; and no one who ascends the Tower to witness the working of it, can fail to remark the unerring precision with which the ball is discharged by the clock below. The hands of this clock are never altered. It has a small losing rate, and a little before one o'clock, every day, the pendulum is accelerated for a few beats, which brings it to the exact time.

The last sentence is significant. The clock itself was adjusted every day, shortly before the time ball drop, by speeding up the pendulum manually to compensate for its losing rate. There was no electrical connection to McGregor's premises, so a chronometer had to be brought across the river from time to time to check the controlling clock. It was these aspects, as well as the lack of independent checks on observations made with the transit instrument, that so disturbed the Director of Glasgow Observatory (Nichol, 1859). They were also of concern to Robert Grant, Nichol's successor, and led to some occasionally heated correspondence in the *Glasgow Herald* during 1863, described later. Unwillingness to allow independent verification helped to precipitate the end of the Glasgow time ball.

Brown then described some features of the ball and mechanism, but there are several errors in his account as are discussed subsequently. He relates that:

The entire weight to be lifted is fifteen cwt., the ball itself being four cwt., and is five feet diameter, built of mahogany, and covered with zinc, nearly 1-16<sup>th</sup> in thickness. It rises fourteen feet, near to the model of a ship at the extreme point of the rod. The Tower, with the Time-Ball rod, measures 217 feet from the ground, and at the highest story, the view compensates the labour of the narrow ascent – the river in its windings, in its freights, in its bustle, and in its expanse, is seen and can be studied with advantage. In Edinburgh, where there is a time-ball on the top of Nelson's monument, Calton Hill, the apparatus, designed and erected by Messrs J. Ritchie & Son, is connected by a wire to a gun in the Castle; and at the same moment the sense of seeing is gratified, the hearing also. At one o'clock P.M., the report of the cannon is heard in every quarter; and if Glasgow Time-Ball had such an apparatus ....

## 2.1 Time Ball Weight and Construction

The time ball's description of having a 5 ft. diameter is likely to be correct, as this was the diameter used for the principal time balls at Greenwich, Deal and Edinburgh. The ball construction is also consistent with other time balls of the period. A zinc spherical surface with 5 ft. diameter and 1/16<sup>th</sup> inch thickness would itself have weighed about 1.5 cwt (75 kg). The wooden frame would have added significant mass, so a ball weight of 4 cwt is plausible, if higher than usual. It is highly improbable, however, that the total moving weight would have been as much as 15 cwt.

A description of the Strand time ball was published by its supplier and is likely to have been authoritative (Clark, 1852). The Strand ball had a diameter of 6 ft. and also used a zinc skin on a wooden frame, but weighed only 2.5 cwt, including the piston which entered an air cushioning cylinder to stop the ball. It is worth noting that there were two time balls in central London, both operated by telegraph using time signals from Greenwich. One was in the Strand and was operated by the E & I Telegraph Company with official sanction from Astronomer Royal, George Biddell Airy. The other was at Cornhill in the City of London, the location of chronometer makers, and was often described, rather confusingly, as being at the "City Observatory" (Howse, 1997). Both were included in Airy's 1861 list (see Kinns, 2010, Page 203, but note that the author had not then appreciated the equivalence of Cornhill and the City Observatory). Neither time ball appears to have survived beyond the 1860s.

There was a tendency to exaggerate time ball weights, perhaps to impress the reader. Smyth (1853), writing about the new Edinburgh time ball, said "... the ball is made very heavy, say 15 cwt." The ball must have weighed much less than that, judging simply from the dimensions of the air cylinder that was designed to cushion its descent (Kinns, 2011a). More plausibly, Airy (1857) stated that 5 ft. diameter time balls weighed about 200 lbs, in correspondence concerning possible developments at Portsmouth Dockyard (Wood, 1856) and with the

Astronomer at Copenhagen. Another description of the time ball apparatus had been published in 1858 (Glasgow Harbour Time Ball). The description of the electrical apparatus is similar, but more detail is given about the mechanical design. The ball was hoisted using a rack and pinion arrangement, and an air-cushioning cylinder was used to control its descent. The rack was fixed to a 36 ft. long mahogany shaft which linked the ball and piston. The drop height was stated to be 8 ft., much smaller than the 14 ft. stated by Brown, while the ball diameter was given as 4 ft. 9 in. The total moving weight was given as 15 cwt.

## 2.2 Time Ball Drop Height

The drop height of 14 ft. and the raising of the ball "... near to the model of a ship at the extreme point of the rod ..." (Brown, 1862) are not consistent with later photographs, but there may have been alterations to the mast after the time ball ceased to operate in 1864. The views in Figures 1 and 2 are from photographs taken in 1876 and 1897. Both show compass cardinal point arms between the ball and the ship model and suggest that the distance between the ball and the compass arms was two ball diameters. The print in Figure 3 shows the ball and mast at its left hand edge above the Broomielaw and is consistent with the photographs. The ball would have

been raised to the compass arms, not the ship model. If this arrangement existed in 1862, the drop height would have been 10 ft. as at Edinburgh, not 14 ft. The same print shows the first Caledonian Railway Bridge, apparently in an incomplete state during its construction between 1876 and 1878, so it too post-dates time ball operation.



Figure 1: The Glasgow Time Ball in 1876 (courtesy: The Graham Lappin Collection).

The photographs and print all show the pole that was used to display Fitzroy's storm signals. This pole was erected on 27 February 1862 (Clarke, 2012).



Figure 2: The Glasgow Time Ball in 1897 (courtesy: The Graham Lappin Collection).

### 2.3 Suppliers for Edinburgh

The Edinburgh apparatus was supplied by Maudslay, Sons & Field from London in 1853 (Kinns, 2011a), not Ritchie & Son. The solar mean time clock at Edinburgh Royal Observatory was, however, modified by Ritchie to allow automatic ball release, before the time ball started official operation on 20 March 1854. Ritchie also modified the ball release mechanism on 22 August 1861 to increase its reliability (Time ball & Mean Time Clock Register, 12 June 1861 to 23 January 1863).

Brown's description of the Edinburgh gun operation is also misleading. The Edinburgh time gun was fired using a clock at Edinburgh Castle. This gun clock, supplied by Ritchie, was controlled by electric telegraph from the same mean time clock that released the time ball. The telegraph wire was routed via Nelson's monument, but it was separate from the wire that released the time ball (Kinns, 2011a). The Edinburgh time gun service commenced officially in June 1861, inspiring the observation by Brown (1862) that such a service might be introduced in Glasgow.

### 3 THE EDINBURGH INITIATIVES

Sir Thomas Brisbane promoted the idea of a Glasgow time ball when the Edinburgh ball was first erected in 1853 (Kinns, 2010). He took a close interest in the Edinburgh signal and helped to fund developments that would enhance its accuracy and usefulness (Kinns, 2011a).

### 3.1 The Telegraph Link with Glasgow

The Edinburgh time ball register includes a note on 12 September 1855 that the ball was dropped by hand "The necessary arrangements for dropping a Time Ball in Glasgow being in process of being made." ('Time Ball & Mean Time Clock' Register, 1854-55; see Kinns, 2011a: 273). These new arrangements culminated in a demonstration of a model time ball at a meeting of the British Association in Glasgow during October 1855 (Smyth, 1855):

Furthermore our lines of wire from the Obs<sup>y</sup> to the Railway were tested during the Association week by the carrying out also at Sir T. Brisbane's expense, his favourite desire of introducing Time Ball signals to the notice of the people of Glasgow.

Extra batteries having therefore been brought up here, & temporary wires laid down in Glasgow from the Telegraph Station to Section G room in the College a large model Time Ball was dropped every day during the Association week, by the Edinburgh Obs<sup>y</sup> Mean Time Clock.

The experiment was noted by Smyth in his 1858 report (see Kinns, 2010: 199). It was clearly feasible to drop a Glasgow time ball from Edinburgh by telegraph. Indeed, the Deal time ball was dropped by telegraph from Greenwich with a return signal to confirm the drop, from the start of its official operation on 1 January 1855. The 102 km distance between Greenwich and Deal, on the Kent coast, was 50% further than the 68 km distance between Glasgow and Edinburgh. At that time, there was no telegraph link between Glasgow Observatory and the



Figure 3: Print showing the Glasgow Time Ball and mast at extreme lower left, in the late 1870s (published by James Deas; courtesy: Royal Scottish Geographical Society).

City Centre. Such a link was not established until 1863, when another Edinburgh initiative using time guns brought matters to a head.

### 3.2 The Time Gun Experiments

Edinburgh inaugurated a time gun signal in June 1861. The gun on Edinburgh Castle was fired by a slave clock at the Castle whose pendulum was synchronised with the Observatory mean time clock by Jones's method. It was an accurate signal, well-received by the citizens of Edinburgh, and inspired developments elsewhere. The gun on Edinburgh Castle, high above most Edinburgh residences, could use a charge that made it audible over large distances. That was much more difficult to replicate in locations such as Glasgow, with building density and topography making it difficult to strike an acceptable balance between audibility and damaging disturbance.

The plan to introduce time guns in Glasgow that were controlled from Edinburgh was hatched without involving the relevant Glasgow authorities. A summary of the experiments is given by Kinns (2010). The initial announcement was published in Glasgow on 26 September 1863 with the following opening paragraph (The New Time Gun, 1863):

The arrangements for the new time gun experiment - the report of which came upon the community a day since with startling suddenness - are now progressing steadily, but there still remains so much to be done that the trial cannot be made for several days yet. The approaching experiment has originated with the Universal Private Telegraph Company, who have very spiritedly set to work to carry out their plans. Mr. Nathaniel Holmes, the engineer of the company, has undertaken the superintendence of the arrangements, and the valuable co-operation of Professor Piazzzi Smythe [*sic*], Astronomer Royal for Scotland, has been obtained in furtherance of the scheme. In casting about for a suitable site for the gun, the attention of the Company was directed to a green which forms an eminence overlooking Sauchiehall Street and is entered from Renfrew Street, at the west side of the Corporation Galleries. This ground belongs to the City Bank, and the directors, on being applied to, generously granted it for the use of the experimentalists, while Mr. Long, at the back of whose gymnastium it is situated, frankly sanctioned the placing of this probably rather noisy neighbour in the immediate vicinity of his establishment, and on ground which he held as tenant.

This introduction was followed by details of the gun and its charge, including an assurance about the care that would be taken to avoid damage:

The proper charge of powder for the piece is 6 lbs, but owing to the present position of the gun in the midst of dwelling houses, not more than from 1½ lbs. to 2 lbs., will be used. As it is to be placed under the care of an experienced gunner, every assurance may be felt that no damage will be caused to the property in the vicinity, nor any unnecessary alarm occasioned to neighbouring residents.

A letter by Grant in response to the announcement of the time gun experiments was published simultaneously on 26 September (Grant, 1863a). Clearly, he had been invited by the Editor of the *Glasgow Herald* to comment on the forthcoming development of which Grant was completely unaware. At the

time, Grant was busy promoting his preferred system of controlled clocks, referring particularly to their successful introduction in Liverpool some years before. The complete announcement and response by Grant are included in Clarke (2012).

Following overtures already made, Grant immediately wrote to the Lord Provost of Glasgow, Chairman of the Clyde Navigation, emphasising his responsibility as Director of Glasgow Observatory. His letter of 28 September (Grant, 1863b) was published in the *Glasgow Herald* on the following day:

My Lord. - You will no doubt have perceived, from a statement which appeared in the *Herald* of Saturday last, that arrangements are being made by the United [*sic*] Private Telegraph Company for firing a time-gun in Glasgow in connection with the Edinburgh Observatory. It would seem, also, that the originators of the scheme contemplate establishing the gun permanently, and placing similar guns on different points of the Clyde.

Permit me to inform you in reference to this matter, that by an express engagement entered into and with her Majesty's government, the University of Glasgow is charged, through the instrumentality of the Observatory established in connection with it, to afford all necessary facilities for supplying the shipping of the Clyde with correct time.

I need scarcely assure your Lordship that under no circumstances whatever will the University consent to forgo this engagement, or permit the usurpation by any other observatory, of the duties which it imposes.

The importance of placing the arrangements for the transmission of correct Greenwich time from this Observatory on a better footing than heretofore, has not failed to occupy the attention of the Professor of Astronomy, who, some time since, submitted his views on the subject to the consideration of the Town Council. I beg further, as a proof of the desire of the University to fulfill the obligation which it has contracted with the Crown in reference to this object, to call your attention to the enclosed copy of a memorial on the Observatory, which has been recently addressed by the Senatus Academicus of the University to the Lords Commissioners of Her Majesty's Treasury.

I would earnestly invite the Clyde Trustees to a consideration of the urgent necessity which exists for rendering the resources of this Observatory more effectually available to the shipping of the Clyde. Our instrumental means for the determination of correct time are unsurpassed anywhere, but they are rendered to the great extent powerless by the isolated condition of the Observatory, in regard to electric communication with the City of Glasgow and the Clyde. The Observatory will cordially receive from the Trustees any proposal in reference to this important object.

Grant had made his points well. The Glasgow time gun experiments proceeded, but their days were numbered.

Notwithstanding prior assurances to the contrary, initial firings of a single gun during the first week of October 1863 did cause damage to property. This is illustrated by the following letter, signed with an appropriate pseudonym (Fugit, 1863):

Without attempting to question the scientific merit of this experiment, I venture to call the new time-gun a nuisance if it is to remain longer where it now stands. For the first two or three days we were a little startled in this neighbourhood when we heard the one o'clock

explosion, but for the sake of the Broomielaw and science, we did not care to complain. Today, however, the charge of powder has been increased, if we are to judge by the increased din. Now, I am a tenant in this locality, and I find my ceilings cracking, and in some places giving way altogether. That this is the result of the explosion there can be no manner of doubt, as, at one o'clock today one of the youngsters narrowly escaped a thump on the head from a yard or so of falling plaster. Nor is it all. The neighbourhood is surrounded by educational institutions, and I am told that some of the children attending them get quite sick when the gun is fired, and that, today, many of them got a greater fright than usual. On the whole, I think there is exhibited a woeful lack of common sense in placing the gun where it now is, more especially since, as I am informed, there be few at a distance that can hear it. Hoping to hear of its speedy removal, I am &c. T. FUGIT

Various time gun locations were then tried, as exemplified by an article published on 7 October:

The present position of a gun in Garnethill being too confined to admit to a proper charge of powder, arrangements are being made to remove the gun to a more elevated position, from the immediate vicinity of the houses, so that the volume of sound from the gun can be increased to be audible over the entire City. It is expected that, about Wednesday next, the gun will be fired from its new position.

The subsequent search was for an effective compromise between audibility and unwanted disturbance. According to an article published in Hobart, Tasmania, four guns were operating in parallel by the end of November 1863 (Abbott, 1865; see Kinns, 2010: 200). Three were near the centre of the City. The other was at Greenock, a port on the Clyde 38

km west north west of Glasgow. Their dates of introduction were:

- 1) October 1863; initially Sauchiehall Street but then moved (as described above);
- 2) 29 October 1863: St. Vincent's Place (Abbott);
- 3) 10 November 1863: The Broomielaw (Abbott);
- 4) 21 November 1863: Greenock (Abbott).

The letter of 3 February 1864 that gave notice of the end of the time gun trials was explicit about the use of four guns (Holmes, 1864):

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 6<sup>th</sup> 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.

The early problems with damage to property led to reduction of the powder charge, leading to poor audibility of a single gun. The same problem arose in Hobart (Tasmania) during 1875, but it was possible to relocate the Hobart gun and restore its audibility. The Hobart time gun service then continued for half a century (Kinns, 2011b). The addition of other guns in Glasgow increased the area over which they could be heard, but it is easy to imagine the confusion caused by the slow speed of sound propagation (about 340 m/sec) and the multiple echoes from nearby buildings. Simultaneous firing of several guns by telegraph was technically successful, but fundamental problems with sound propagation in a densely populated area were insuperable.



Figure 4: Photograph showing McGregor's premises on the south side of the river, 1876 or earlier (courtesy, the Thomas Annan Collection, Glasgow City Libraries).

#### 4 RENEWED CRITICISM OF THE TIME BALL OPERATION

Correspondence about the time guns soon extended to consideration of the way the Glasgow time ball was being operated, reviving concerns expressed years before (Nichol, 1859). Figure 4 includes a red arrow to indicate the location of McGregor's business and transit instrument, on the opposite side of the Clyde to the time ball. The precise date of the photograph is uncertain, but it clearly predates the 1876-1878 construction of the first Caledonian Railway Bridge (cf. Figure 3).

A published letter suggested that McGregor's transit instrument was subject to traffic-induced vibration and that it would be an excellent idea for the transit observations to be subject to independent scrutiny by Grant (Taylor, 1863). The following paragraph is an extract:

Now, if the Town Council, or the Clyde Trustees, or whoever the gentlemen may be who sanction the dropping of the time-ball, could only visit the place of observation annually, or say half yearly to see that the instrument is in a state of efficiency, the instrumental adjustments and the general routine necessary for obtaining Greenwich time properly conducted, they would act very judiciously. This inspection shall take place not as a matter form, but as a matter of real utility and consequently should be superintended by the astronomer to the University - a gentleman who is really practically acquainted with these affairs, and who would conscientiously report when he considered the present place of observation in any way suited for the mounting of a transit instrument, and whether there is sufficient stability in the building itself to depend upon the instrumental error deducible from the observations (if any).

Taylor concluded with a statement that was hardly likely to appeal to McGregor & Co., who had a contract to operate the time ball:

Only imagine that Glasgow, boasting, as it does, of its nearly half a million of inhabitants, is rendering itself conspicuous in astronomical history by allowing the time-ball to be dropped by an agency altogether independent of the Professor of its University. If I were a member of the Town Council, I would blush to think that a city like Glasgow, superior both in population and wealth to Edinburgh, should bow so humbly as to accept of the proposed scheme for giving us Greenwich mean time. What would be the natural conclusion arrived at by a person unacquainted with histories of the two cities? Why, that Edinburgh possesses facilities for determining Greenwich mean time which Glasgow was deficient of. But such is not the case. Glasgow has both a scientific institution generously equipped with instruments by its own citizens, and a Regius Professor possessing both zeal and abilities and all the necessary qualifications for superintending time-ball regulations. Professor Grant states that the method of having the time by a signal-gun "has much of a sensational character, which cannot fail to recommend it to popular feeling, but on grounds of real utility and methods practised at Liverpool appear to me vastly preferable!" Now this opinion must evidently be unanimous in the minds of those who give the least attention to this matter.

This led to an immediate response from W. Church, an employee of McGregor & Co. Church (1863) found it insulting to think that the astronomical observations made by his company should

be subject to independent scrutiny. The tenor of his rather intemperate response is illustrated by the following extract:

The firm of D. M'Gregor & Co., will not notice attacks upon their establishment, except where principals are concerned; but I, as being employed in the working of the time-ball, would request your permission to reply to some portions of Mr. F.G. Taylor's letter. I am not acquainted with the writer, but I infer from his letter that he possesses a very comfortable assurance of the value of his judgment and authority in matters relating to time-measurement, and that he shares a delusion, fostered by professional prejudice, that accurate time cannot be got or maintained outside the precincts of a public observatory. The firm of M'Gregor & Co., however, are not likely to attach much importance to his opinions respecting the transit observations, and they are certainly quite as well aware as he is of the great importance of attending to the adjustment of a transit instrument, as, without such attention, it would be impossible to obtain true time.

He then sought to defend the quality of the company's transit observations before commenting on the history of the arrangement with the Clyde Trustees. He argued, fairly, that Glasgow Observatory was not equipped to control time ball operation when the ball was first erected in 1857, but made only a qualitative remark about signal accuracy:

Mr. Taylor expresses astonishment at the apparent anomaly of a time-ball being worked independent of the Observatory; but if he is really ignorant how the matter stands, the explanation is easily rendered. At the time when the time-ball was first established, the Observatory, whatever its present position may be, was not in a proper state of efficiency to maintain a correct standard of time; and the Clyde-Trustees, to whom the time-ball belonged, appointed the firm of M'Gregor & Co. to manage it, having, I suppose, sufficiently valid reasons for the confidence which they placed in them. I intend no illusion here to the astronomical instruments of the Observatory. Its transit circle might have been unsurpassed anywhere, but that could only have been used for the purpose of getting, but not maintaining, true time. The maintenance of a correct standard of time during intervals of bad weather, so frequent in our climate, must depend solely on the clocks of the Observatory, which ought to have been of the very first class, and sufficiently numerous for the purpose.

If the Observatory is now in a high state of efficiency - and we have Mr. Grant's assurance to that effect - by all means let it provide the time for the city of Glasgow; but I certainly consider that it is a very paltry mode of trying to attain this object, on the part of the advocates of the Observatory, by attempting to lower the credit and depreciate the services of other parties, and the Observatory might well exclaim "Oh! save me from my friends." Being itself not quite invulnerable, it has hitherto acquired no laurels in such a contest, the initiative in which has never been taken by the firm M'Gregor & Co., nor is it likely to do so in the present instance through the advocacy of Mr. F.G. Taylor; for, notwithstanding what he, or other parties, may assert, who possesses not the means of forming a judgment as to facts, I have no hesitation in saying that the time-ball has been, and is now, a standard of time sufficiently accurate for the purpose of rating chronometers the most important of all uses to which it can be applied.

Another letter, supportive of independent scrutiny by Grant, was published on 8 October 1863 (*Tempus Verum*, 1863). The stature of the Edinburgh time ball had been enhanced by Smyth's willingness to allow public scrutiny of the measurements and calculations that demonstrated its accuracy ('Time Ball & Mean Time Clock' Registers). Church would have done better to welcome independent scrutiny than to oppose it quite so emotionally.

Towards the end of 1863, when the Observatory had been connected by telegraph with Glasgow College and the City, Grant wrote again to the Lord Provost (Grant, 1863c). He suggested the following arrangements:

1. The erection of a Turret Clock, with large dials, on some commanding position of the Broomielaw, the said Clock to be furnished with a Jones' magnetic-electric pendulum, and to be controlled by an electric current directed from the Standard Clock of the Observatory.
2. The erection of a small Seconds' Clock, similarly controlled from the Observatory ...
3. The dropping of the Time-Ball on the Sailors' Home by a mechanism acted upon electrically from the standard Mean-Time Clock of the observatory.
4. The firing of a Gun from some central position on the Broomielaw.
5. The establishment of an office for the rating of Chronometers, to be placed under the control of the Clyde Trust, and to be supplied with special facilities from the observatory for ascertaining the correct time.

It appears from this letter that the time ball was still in operation at the end of 1863, continuing the earlier arrangement with McGregor & Co. The experiment with time guns was underway at that time.

Grant noted in an 1878 letter to Sir George Airy that the time ball ceased to operate once the system of controlled clocks became operational (Grant, 1878). He said that the year was 1863 in his letter, but that is probably an error of memory for 1864 (Kinns, 2010: 202). The time gun experiments were terminated in February 1864 (Holmes, 1864). A large number of letters and articles in the *Glasgow Herald* from March 1864 onwards referred only to the system of controlled clocks. There was no further mention of the time ball or time guns (Kinns, 2010; Clarke 2012). The system of clocks was then extended over a period of more than 50 years and served Glasgow well (Clarke, 2012).

## 5 CONCLUSIONS

It is known from 1858 and 1862 articles that the 1857 Glasgow time ball machinery was supplied by Alexander McKenzie, mechanist, and operated by Messrs. McGregor and Co. The mechanical apparatus used a rack and pinion mechanism and an air-cushioning cylinder, while the ball had a thin skin on a wooden frame, as at Edinburgh. There is uncertainty about the drop height, variously given as 8 ft. and 14 ft. The weight of the ball and moving components was stated to be an implausible 15 cwt. The Glasgow time ball was operated using electrical connections to a mean time clock in the Glasgow Sailors' Home from 1857 to 1864. This clock had to be adjusted by hand each day, prior to the ball drop, to compensate for its losing rate. Occasional checks were made using a chronometer that was brought from the

premises of the McGregor & Co., chronometer makers, who had the contract for time ball operation and maintenance. No independent records were kept of the accuracy of the time ball drop. This lack of independent scrutiny and the requirement for manual intervention were criticised by Nichol and Grant, respectively Directors of Glasgow Observatory during the period of time ball operation. In other respects, the arrangement of the clock and its electrical connections were similar to those introduced in Edinburgh in 1853-1854.

When the Glasgow time ball was introduced in 1857, there was no telegraphic link between Glasgow Observatory and the City. It had been demonstrated in 1855 that a time ball could be dropped from Edinburgh, but the Clyde Trustees preferred a local arrangement. The relative prestige and status of Glasgow and Edinburgh observatories was an important issue and Grant had been pressing for the telegraphic connection since his appointment in 1859. Another Edinburgh initiative using time guns fired from Edinburgh caused great offence in Glasgow towards the end of 1863, partly because of the underhand way in which they had been introduced and partly because of poor audibility and damage to property. That stimulated renewed criticism of the way the time ball was operated without involvement by Glasgow Observatory. The time gun trials were abandoned in February 1864 and the time ball soon ceased to operate. Grant argued successfully that a system of slave clocks controlled from Glasgow Observatory would be far superior to either a time ball or time guns that gave a signal only once per day. Over 10 clocks were established in the City and along the Clyde from 1864 onwards and were in operation for over 50 years. The time ball and guns were never re-established.

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