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TIME SIGNALS FOR MARINERS IN THE ATLANTIC ISLANDS AND WEST AFRICA

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Abstract: The first time ball on an Atlantic island was established at Jamestown, St Helena in January 1834. It was one of the earliest operational time balls. New insights into preceding time ball trials at Portsmouth, England in 1829–1830 are presented. The primary time ball in St Helena was erected at the Ladder Hill Observatory, with a repeater time ball and a time gun. The Observatory was closed in 1836, but the time ball service continued with limited apparatus into the twentieth century. Notices about a time ball at Ascension were published in 1860 and 1865.

A time ball at the Cape Coast Castle in Ghana was erected in July 1839 but may not have existed for long. A flag and time gun at Accra were listed by 1898. In 1932, there was a combined time ball and time gun service at Takoradi but no service at Accra. A time ball at St. Paul de Loanda in Angola was regulated by the observatory there from 1879. It was later replaced by time lights. There had also been a short-lived time ball at Tokonu in Nigeria, noted as being regulated from Loanda.

Clocks were available for chronometer calibration in the Azores at Punta Delgada by 1904 and at Horta by 1908, regulated from Lisbon and Hamburg respectively. Telegraph office signals were available at Tenerife and Madeira by 1911. The most northerly time ball on the west coast of Africa at Dakar in Senegal was established in the early twentieth century but then withdrawn. It was re-established in 1911 and was still operating in 1920. New time signals were introduced on São Vicente Island in the nearby Cape Verde islands in February 1922, including a time ball. Telegraph signals had previously been available in the islands.

Keywords: Time balls, Portsmouth, Ascension, Azores, Cape Verde Islands, Madeira, St Helena, Tenerife, West Africa.

1 INTRODUCTION

1.1 Geographical Scope

The aim of this paper is to describe time signals for mariners that used to exist on the Atlantic islands and the west coast of Africa, before the introduction of radio signals. Early time balls in Africa were concentrated around the Cape of Good Hope, but time signals were also needed at other locations for strategic reasons and to serve the principal trade routes between Europe, Asia and Australasia. Figure 1 shows the locations of signals that are described in this paper. They were introduced by many different countries. Details of time signals were available to all nations through unclassified lists that supported world trade.

1.2 Early Time Signals

The need for land-based signals that would allow chronometer calibration at different ports followed the increasingly wide availability of chronometers in the nineteenth century. Robert Wauchope (1788–1862) is credited with invention of the time ball concept by 1824, followed by successful experiments at Portsmouth in 1829 that led to the Greenwich time ball in 1833. He had previously considered various ideas for signals that could be telegraphed to ships and discussed these with his brother officers while serving at the Cape of Good Hope from 1818 (Bartky and Dick, 1981).

Long before 1818, the flash of a gun had been used as an approximate time signal, but the guns were not then under observatory control and there was no preparatory signal. Much later, guns could be fired electrically from an observatory and became precision signals. An interim solution, unpopular with mariners, was to watch for the flash of gun, usually within a minute or two either side of a nominal time, and await receipt of the exact time of firing from an observatory on the following day. The army could look after the gun and the observatory did not have to divert resources to time ball operation.

The earliest accurate visual signal appears to have been designed by Fearon Fallows (1788–1831), the first Astronomer at the Cape who arrived there in 1821. He introduced a shuttered oil lamp in about 1823. There is no evidence that he ever met Wauchope, but he may have been aware of earlier discussions.

1.2.1 The Time Ball at Portsmouth

The nature and extent of the time ball trials at Portsmouth, and the subsequent erection of an operational time ball there, are still shrouded in mystery, but it is now possible to add significantly to earlier research (Bartky and Dick, 1981). The Portsmouth time ball experiments

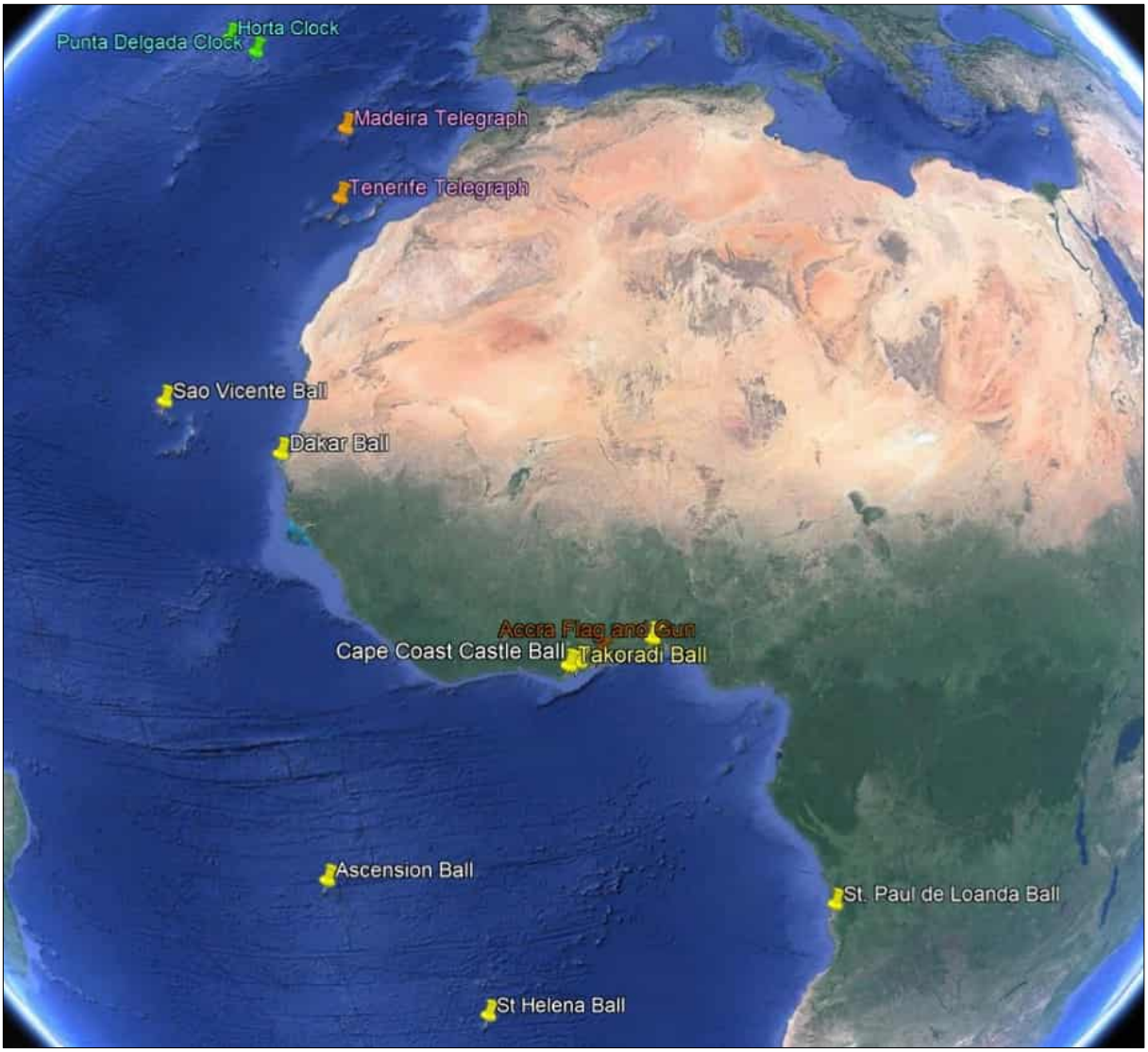


Figure 1: Principal time signal locations in the Atlantic and West Africa (courtesy Google Earth; map modifications: Roger Kinns).

may have been based on Wauchope's conceptual design (Wauchope, 1830), but a press announcement dated 22 October 1829 showed that the Admiralty had introduced some important design modifications (Barrow, 1829):

> The Lords Commissioners of the Admiralty hereby give notice that a BALL will be dropped daily (Sundays excepted) from the High Tower of Portsmouth Dock Yard, at *the moment of One o'clock, mean time at Greenwich;* by observing the first movement of which Ball, all Vessels at Spithead and in Portsmouth Harbour may have an opportunity of regulating their Chronometers.

John Barrow, who signed the notice, was the Second Secretary of the Admiralty. The location is likely to have been on top of a square tower, close to the Saluting Platform, which had been used as a semaphore station since the early 1820s (MacDougall, 2017). Wauchope had proposed that a moving ball should be raised to the level of a fixed ball and that the signal time should be when the lower ball had dropped by one diameter. It was in fact decided to use the time of release from the outset. The double ball feature was no longer necessary when the signal was the time of release. Wauchope was informed of the success of the experiments by Barrow in July 1830 (Wauchope, 1836: 462).

The arrangement used a manually operated shutter signal at the Dockyard Observatory to alert the time ball operator, who then dropped the ball. The design of a reliable braking system to arrest the ball descent would have been a particular challenge. It is not clear whether the apparatus was used after the trials, or whether it was withdrawn until erection of a more permanent arrangement that took advantage of trials experience. A new Semaphore Tower was erected at Portsmouth in 1833 (MacDougall, 2017). It was given as the time ball location in 1856 correspondence and in Admiralty

notices until it burned down on 20 December 1913. The black ball on the Semaphore Tower had a diameter of 3 feet 9 inches and a drop height of 18 feet (Lists of Time Signals; 1880, 1898, 1908).

The early arrangement at Portsmouth was not highly regarded by the Editor of *The Nautical Magazine*. He made various uncomplimentary remarks about the Portsmouth arrangement in an introduction to the arrangement at St Helena (Editorial, 1835: 658–659):

> … we find by a printed document before us, that a plan was established at Portsmouth in 1830, and certainly the drawing on the plate which accompanies it represents a very inferior one, compared with that of the Greenwich time-ball, in which elegance and durability are combined on truly scientific principles … At Portsmouth, the plan of giving the time is far from being perfect. And it has besides the additional disadvantage of being signalized twice over, instead of being communicated directly to the shipping … and we could wish that the first naval arsenal of the country was as well provided in this respect as the first observatory in the world.

Criticism of the time ball system at Portsmouth continued for decades after 1856. Astronomer Royal George Airy (1801–1892) had recommended provision of a new apparatus by Maudslay, Sons & Field, supplier of the 1833 Greenwich apparatus. He received a quotation in November 1856 for a system based on those manufactured for Deal and Sydney, Australia (Maudslay,1856). The necessary funding was not made available and Portsmouth used an alternative arrangement on the Semaphore Tower. A small time ball at the Observatory, regulated using a transit telescope, was used to signal time to the Semaphore Tower until January 1878, when automatic operation by electric telegraph had long been preferred (Airy, 1878). A clock regulated by telegraph from Greenwich was used for automatic release of the main ball from February 1878 (Swainson, 1878). The arrangement for dropping the ball used the 'Devonport Principle' from 1892 (Lewis, 1910; Tate, 1910).

1.2.2 Early Operational Time Balls

The time ball at Port Louis, Mauritius was operational in April 1833 and preceded that at Greenwich by six months. It used an apparently unique arrangement of a static ball behind a shutter in an observatory tower (Lloyd, 1833; Herschel, 1836). Its design and those of later time balls in Mauritius have been described by Kinns (2020a; 2020b). Wauchope had no direct involvement in the Port Louis design by John Augustus Lloyd (1800–1854). The time ball at Greenwich became the standard for later developments, offering high accuracy and reliability.

The time ball at St Helena was operational in January 1834 under observatory control, using Wauchope's ideas. It used a ball sliding on a mast and an arrangement of ropes and weights to arrest its descent. A repeater time ball was also available and there was initially a time gun. The Observatory was closed in 1836, but the time ball service continued into the twentieth century. The location of the primary time ball was changed after observatory closure. Ascension Island, further north and west, also had a little-known time ball in the 1860s.

The St. Helena time ball preceded those at Calcutta in 1835 (Phillimore, 1958; Kinns, 2020c) and the Cape of Good Hope in 1836 (Bartky, 1987; Bartky and Dick, 1981; Kinns, 2021).

1.3 Admiralty List Entries

The British Admiralty published lists of time signals for mariners at regular intervals. The first edition was "Prepared from official sources to December 1880", so was applicable in 1881. The list dated 1898 was "Prepared from official sources to 31st December 1897". This had become the usual practice, but there was some variation of the closure date between editions. It was usual to include details of preparatory signals and the procedures adopted in case of a signal failure. The style of presentation varied between editions, but similar levels of detail were retained. In order to expose changes between successive editions, the data from successive editions have been restructured for each location that had time signals, while retaining the key elements concerning location, signal type, timing and reliability.

The Admiralty lists provide a remarkable record of the changes that occurred at particular locations after 1880, but there is always a need to check the accuracy of entries against local announcements that may have been missed. Earlier records are used to define signal introductions from the 1820s onwards. Entries from lists for 1880, 1898, 1904, 1908 and 1911 are used in this paper. Other sources have been used to determine the existence of signals before 1880 and after 1911. Later Admiralty lists for West Africa and the Atlantic islands have not been seen by the author.

2 ATLANTIC ISLANDS

Several Atlantic islands were important as locations on trade routes for sailing ships and were colonised for that purpose. Many had

strategic importance and were occupied by European powers or trading companies. The islands of St. Helena and Ascension became British Dependencies. The Azores and Madeira are autonomous regions of Portugal. There is no record of a visual time signal at Madeira. The Cape Verde islands were a Portuguese colony and nearby Senegal was a French colony, prior to independence. The Canary Islands are an autonomous region of Spain. Some visual time signals were discontinued when trade routes changed while others were late introductions.

2.1 St Helena

The island of St Helena is believed to have been discovered by the Portuguese in May 1502. The island was uninhabited, but with an abundance of trees and fresh water. The Portuguese imported livestock, fruit trees and vegetables, and built a chapel and one or two houses, but did not establish a permanent settlement. The island was an important rendezvous point and source of food for ships returning from Asia to Europe. Sick mariners were frequently left on the island to recover before taking passage on the next ship to call at the island. The following historical summary is derived primarily from Saint Helena Island Info (2021).

The existence of St Helena was known only to the Portuguese until it was visited by Captain Thomas Cavendish in 1588 on his return from a voyage around the world. The Dutch are believed to have occupied St Helena for some years before 1649 when the British East India Company ordered all of its homeward-bound vessels to wait for one another at St Helena. The Company was granted a charter to govern the island by Oliver Cromwell in 1657. A fleet commanded by Captain John Dutton arrived at St Helena in 1659 and took control of the island. Dutton was the first Governor, from 1659 to 1661. A fort was completed within a month and houses were built. The Company lost control of St Helena for five months in 1673 when it was occupied temporarily by the Dutch. It flew the Union Flag from 1687, having previously flown the Company flag.

The remoteness of St. Helena made it attractive to European powers as a place of permanent exile for the Emperor Napoleon, and he was confined on the island from October 1815 until his death in May 1821. During that period the island was under the jurisdiction of the British Crown. The East India Company resumed control in 1821. A provision of the India Act of 1833 transferred control of St Helena from the East India Company to the Crown with effect from 22 April 1834. The last Company Governor, Charles Dallas, stayed in post after the India Act came into force, not leaving until the first Crown Governor, General George Middleton, arrived on 24 February 1836.

Subsequent administrative cost-cutting triggered a long-term population decline as well as a reduction in observatory facilities. The latter half of the nineteenth century saw the advent of steamships not reliant on trade winds and diversion of trade from routes via the Cape of Good Hope to routes via the Suez Canal. The number of ships calling at the island fell from 1100 in 1855 to only 288 in 1889.

The extent of the population decline in St Helena after the opening of the Suez Canal was well described in an article published in the *Inverness Courier* (St Helena, 1900).

> Passengers to the Cape who have never taken the trouble to go up to the high ground of St Helena can have little idea (says a correspondent) of what a beautiful combination of semi-tropical and temperate growth is to be found there. The hills range up to about 2000 feet above the sea. There is no harbour, but only an open roadstead off Jamestown, sheltered from the south-east trade wind, which blows ninety-nine days out of the hundred. At one time, the population approached 20,000, and it managed to get along somehow by supplying provisions to homeward bound vessels returning round the Cape. But the opening of the Suez Canal led to fewer vessels calling there, and those that anchored off the island only came there to correct the Greenwich time. The salvation of the place has been the development of the South African goldfields, for though the population is now under 4000, there is no work for them except to take off watercress and cabbages to passing ships. A feature of the island is "Jacob's Ladder". A wooden staircase of 699 steps, with an average slope 39 degrees to the vertical.

Figure 2 shows a historic map of St Helena. Ladder Hill is located near the capital Jamestown on the NW coast of the island, and the aforementioned 'Jacob's Ladder' is clearly visible in Figure 3.

2.1.1 Ladder Hill Observatory

The Ladder Hill Observatory was commissioned by Governor Walker in the 1820s. Its foundation stone is dated 13 September 1826. It was directed by Lieutenant Manuel Johnson (1805–1859) of the St Helena Artillery, whose work in cataloguing stars of the Southern Hemisphere is still highly regarded (Johnson, 1835). The observations were made between November 1829 and April 1833. He received the Gold

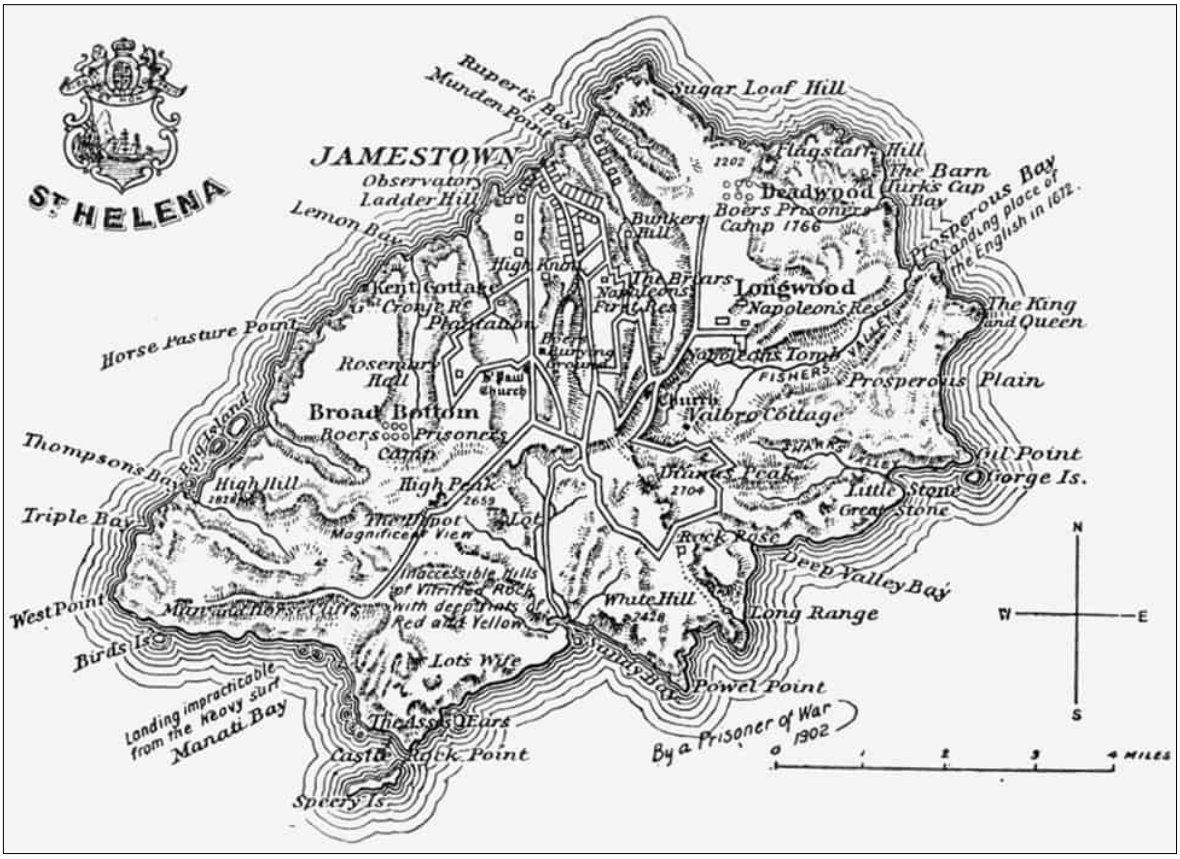


Figure 2: Historic map of St Helena **(sainthelenaisland.info)**.

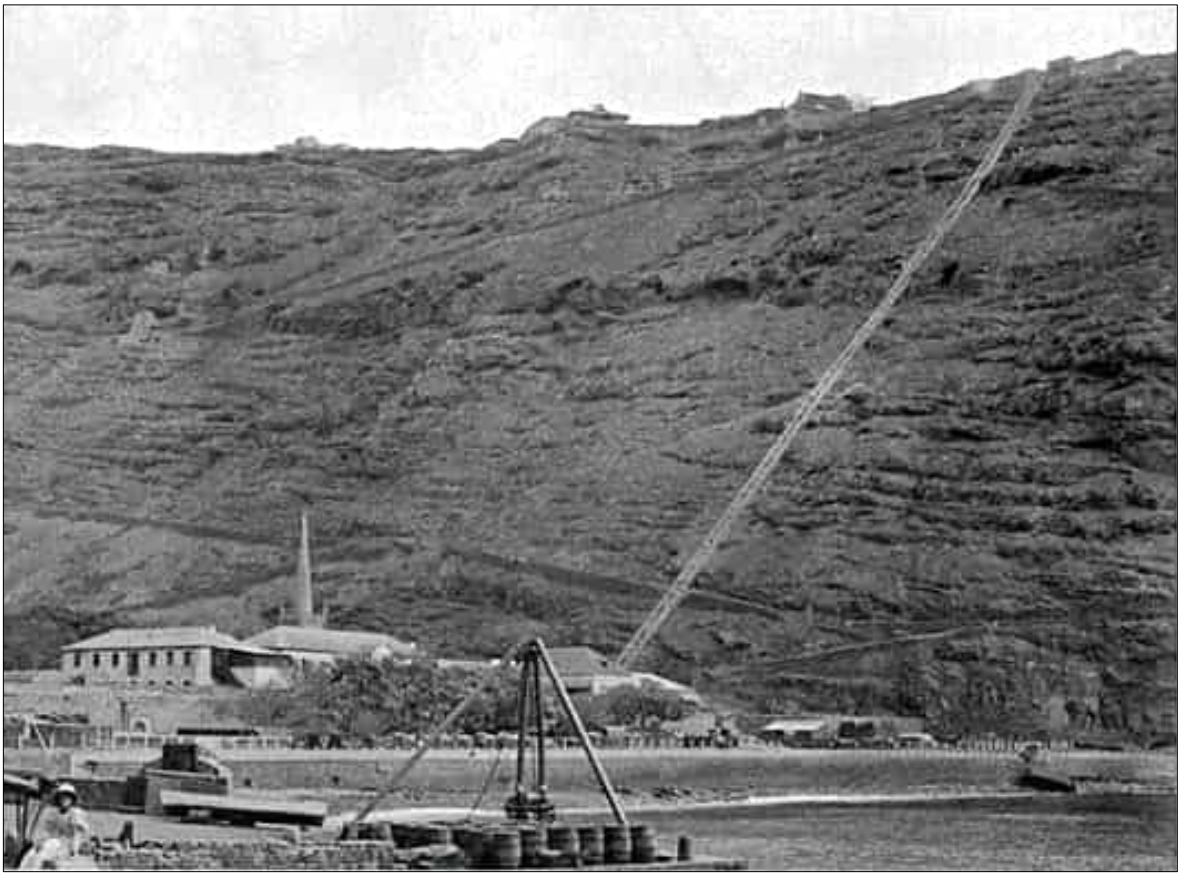


Figure 3: This photograph shows Jacob's Ladder from the Wharf at Jamestown. The old Ladder Hill Observatory can be seen at the centre top of the hill (sainthelenaisland.info).

Figure 4: The disused Ladder Hill Observatory during the nineteenth century (sainthelenaisland.info).

Medal of the Royal Astronomical Society for that work. His major contributions to astronomy in St Helena have been described by Warner (1981). He left St Helena in 1833 and built a distinguished career as an astronomer at Oxford.

The observatory was closed on 29 February 1836

> … due to its uselessness and immense annual cost of £300, the Crown Commissioners reporting that they had been unable to learn its establishment had been attended with any important result to science. (Saint Helena, 2021).

That was a remarkable assertion, given Johnson's achievements. Most of the instruments were sent to Canada, although the clocks were retained. The building was then used as a mess hall for the fort and the Ladder Hill Observatory was never re-established.

Navigation guides for the South Atlantic included the following note about rockets in the entry for St Helena (Findlay, 1867; 1883):

> The practice of discharging rockets for rating the chronometers of vessels touching here has also been discontinued and a time ball has been substituted. This ball was originally hoisted at the Observatory …

The firing of rockets to indicate time had been proposed at the Cape of Good Hope in about 1826 but the plan appears to have been rejected there (Editorial, 1835: 658).

A nineteenth century photograph of the observatory building is shown in Figure 4.

2.1.2 The First Time Ball at St Helena

An editorial concerning the St Helena time ball has been noted previously (Editorial, 1835). The parts of that editorial relating specifically to St Helena are reproduced below:

> We shall now extract from the remarks of H.M.S Thalia, Captain R. Wauchope, his account of the St. Helena Time-ball, on the arrival of that ship there in December last [*1834*]:–"On our arrival at St. Helena, after an eighteen days' passage from Prince's Island, we found my chronometer-signal established there. The ball drops at mean noon, St. Helena time, for the benefit of the inhabitants; and at one P.M. mean time at Greenwich, for the advantage of the shipping. The ball is hoisted half-mast high

> five minutes before the time, and at one minute before to the mast-head.
>
> It gives universal satisfaction both to the inhabitants and to all ships touching at the island; so much so, that I understood that several ships touched there in consequence of the signal, that otherwise would not have done so. On board the Thalia, we found the observations come out every day accurately to a second, which is much more correct than any observations that can be made by means of the sextant and artificial horizon."
>
> We shall not stop to question this latter assertion, our object being to describe the apparatus, which we may briefly do as follows …

The article went on describe the apparatus, using the diagram reproduced in Figure 5. The description is restructured as Table 1, using the original wording.

The building and cupola are recognisable from the photograph in Figure 4. The diagram suggests that the drop height was about 11 feet, given a ball diameter of 2 feet 8 inches. It is difficult to understand from the information in Table 1 how the apparatus actually worked. The ball appears to slide down a tapered mast, rather than being suspended from a gaff, but no ropes for hoisting it are shown. The ball had a mass of 22 lbs and its descent appears to have been controlled using lead weights attached to ropes. These were stated to have masses of 8 lbs and 10lbs. The smaller weight was lifted when the ball had fallen to the half-mast position, presumably freely under gravity, while the larger mass was lifted when the ball was only 2 feet from the cupola. The combined mass of the two lead weights was less than that of the ball, so would not even have prevented its continuing downward acceleration in the absence of friction. The arrangement clearly worked in practice, so there is great deal missing from the description.

The description of the apparatus was followed by reproduction of a notice issued by the Observatory at St Helena that was dated 21 January 1834. It included the observation that the astronomer would allow for the delay of a fraction of a second in releasing the ball and that this applied both to the Observatory time ball and the repeater ball, which also appears to have been at Ladder Hill. A gun would also be fired. Although firing was not automatic, the gun responded to the observatory signal rather than being fired at a nominal time which might be in error by a minute or more. Furthermore,

> To prevent mistakes, a *White Ball*, hoisted upon a Staff over the Observatory, will denote the time, agreeably to the following instructions:–
>
> The ball will be hoisted half mast at *five* minutes, and close up at *two* minutes before *twelve o'clock*.
>
> At the instant of the *Mean Time*, at noon of St. Helena, the ball will drop from the top of the Staff, when the gun will be fired at High Knoll.
>
> The signal will be repeated at *one o'clock*, at the instant of *Greenwich mean time*, for the benefit of the shipping.
>
> A ship wishing to correct her chronometers, and *arriving* after *one* P.M., and not likely to remain the twenty-four hours, may hoist the "Blue Peter" at the main-topgallant mast-head, when the same method will be adopted, at the next ensuing hour after the signal. Foreign ships to substitute their ensign for the "Blue Peter."
>
> Should there be any uncertainty, and the ship wishes to have the signal repeated, she will dip the flag, and rehoist it, on observing the ball half-mast. The ball will again drop, at the ensuing quarter of the last hour.
>
> Ships concealed from a view of the Observatory, will attend to the Repeating Ball at Ladder Hill, and in neither case is any allowance to be made for loss of time, since the astronomer will make the calculation of the few tenths required.

It was a controversial editorial, because it led to a protest from Wauchope (1836) that his invention of the time ball and consideration of other visual signals had not been recognised

Table 1: Features of the 1834 time ball apparatus at St Helena (from *The Nautical Magazine*, 1835: 659).

Identification (see Figure 5)	Description
a	The ball, half-mast high: a globe of canvas, 22 lbs. weight, and 2ft. 8in. diameter.
b, c	The covering of the building in which the mast is fixed
c to d	Imaginary, since the rope only goes from the roof to the floor of the cupola
e	The stopper fixed to the floor, by which the ball is let fall.
f and g	The figures f and g represent the stopper on a larger scale; the former as it is closed, ready for letting the ball fall; the latter, as opened after the ball is down.
h	The whole mast-ring, or the eye in the rope, through which the tongue e of the stopper is passed, when the ball is hoisted to the masthead.
i	Half mast-ring, with 8 lbs. of lead attached, to check the fall of the ball when it reaches half mast high..
k	10 lbs of lead, to provide a second check when it reaches within two feet of the dome of the cupola, to prevent staving of the ball, or injuring of the dome.

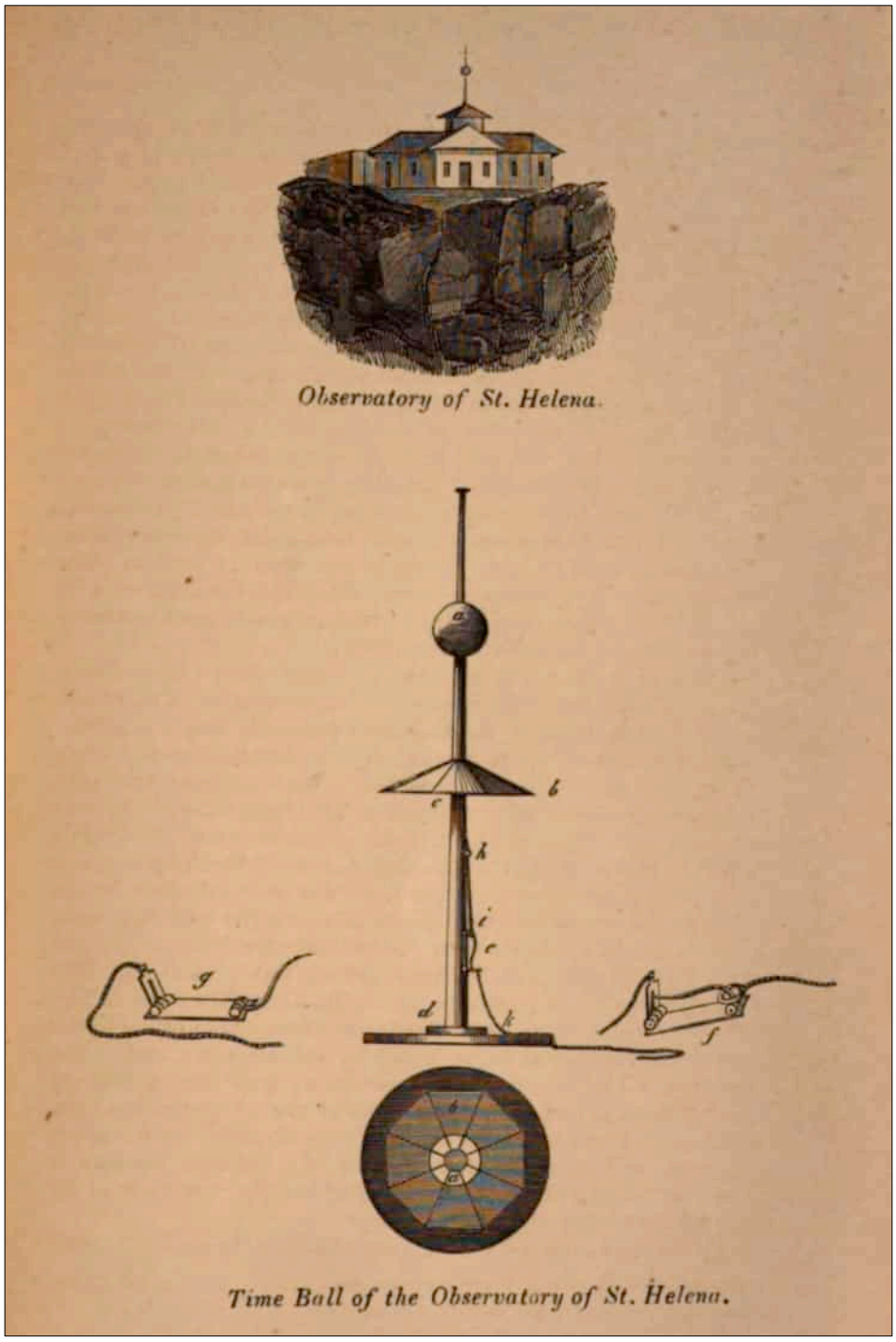


Figure 5: The St Helena Time Ball (after *The Nautical Magazine*, 1835).

properly. That was accepted by the editors of *The Nautical Magazine*. He was still writing similar letters to newspapers in 1852 as a Rear-Admiral, when a new time ball at The Strand in London was announced without mentioning his invention of it (Wauchope,1852).

The arrangement at St Helena was unusual during the first half of the nineteenth century. At many other places, time guns were fired by the Army at a nominal time and the precise time of firing was noted by the local observatory. This time would only be available to ships on the following day, if at all. It was never a popular arrangement. The following letter relates to the Madras time gun in 1841 and represents typical criticism (Madras, 1841: 363):

> For ascertaining the error of chronometers, you must note the time of the flash of the 8 P.M. gun fired at the fort, and the corresponding Madras mean time, as noted at the observatory, will be sent off the next morning from the master attendant's office; but as the flash is not always distinctly seen at the observatory, too much reliance is not to be placed on this mode of ascertaining the

error.

By the 1860s, time guns could be fired electrically from an observatory and became precision signals.

2.1.3 Continuation after 1836

A letter published in *The Nautical Magazine* confirmed that the time ball service continued after closure of the Ladder Hill Observatory (Liddell, 1837). The Observatory time ball had been removed and the original repeater ball was not mentioned, but a repeater time ball on Ladder Hill was included in later Admiralty notices. The principal time ball was now located in Jamestown itself. There had also been changes to unhelpful regulations concerning ship movements:

> Perhaps it is not generally known to your maritime readers, interested in our eastern trade, that since the island of St. Helena was transferred from the Company's to the King's government, the port regulation, obliging ships before anchoring to send their boats to Bank's Battery, and others equally absurd, have been rescinded.
>
> On our homeward voyage last year, I wrote to the governor, General Middlemore, from Ascension, stating how unnecessary and annoying it was to the shipping; and I was glad to find, on our visit to the island in March last that this regulation, with others, preventing ships entering before sunrise, or departing after sunset, had been abolished many months before.
>
> It gave me also great pleasure to observe, that, although General Middlemore had brought out instructions to shut up the beautiful little observatory, and send home the valuable instruments so munificently provided by the East India Company, the admirable system of dropping a ball for regulating chronometers was still kept up as efficiently as ever. The ball has been removed from the hill to the town, and is now in charge of the master-attendant, Mr. Gulliver, late master of H.M.S. Thalia, whose attention to it is unremitting. It is dropped at two stated times every day, and oftener, if requested by any commander.

Liddell also encouraged the British Government to provide time balls at Liverpool, Deal, Plymouth and Falmouth in England. It was many years before they were actually erected.

The photograph in Figure 6 shows the lower level time ball on a tall mast. It was taken on Queen Victoria's birthday in 1866. By that time, the Ladder Hill Observatory had been long closed and this was the primary signal.

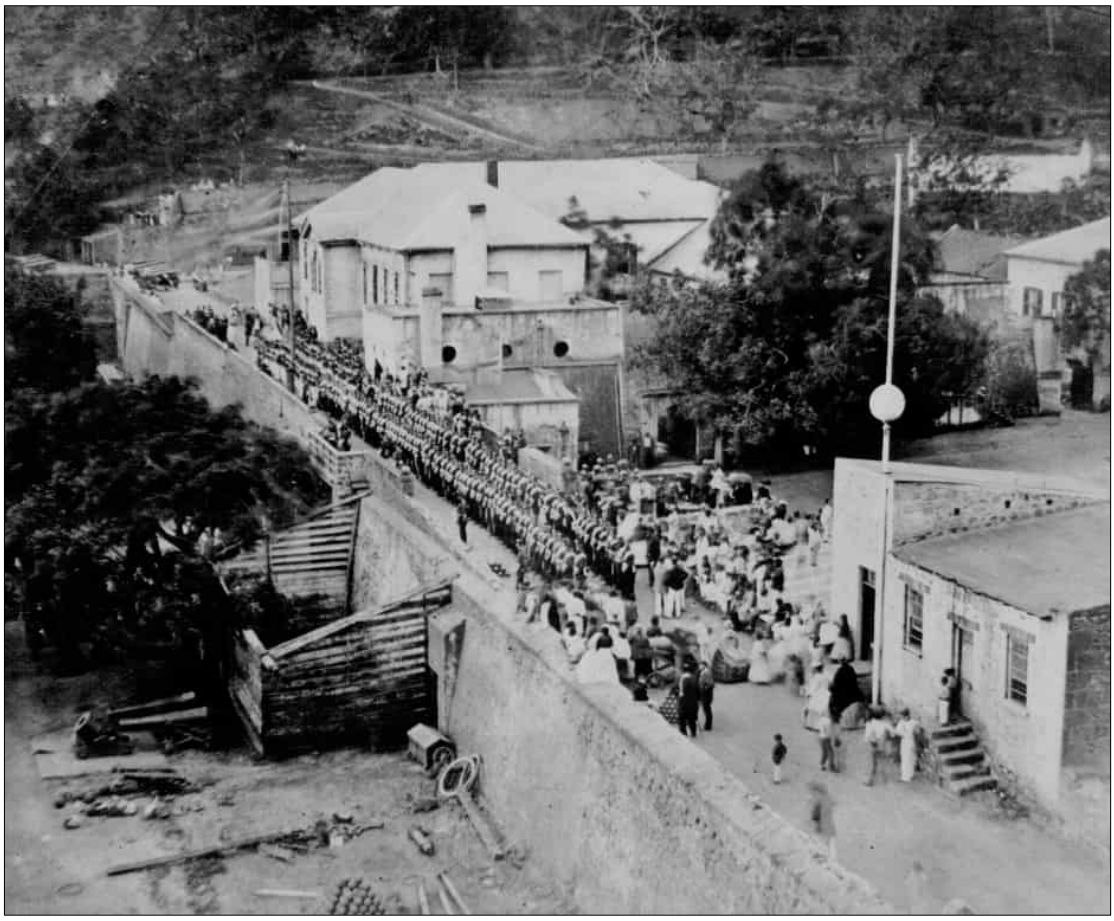


Figure 6: The St Helena time ball in 1866 (photograph by John C. Lilley, St Helena Museum).

2.1.4 Admiralty List Entries for St Helena

Table 2 shows Admiralty list entries for St Helena between 1880 and 1904. The Time Office ball and the repeater time ball at the top of Ladder Hill had been discontinued by 1908. The repeater time ball was released from a yard arm on a flagstaff and had a much larger drop height than the primary ball. This may have been the original repeater time ball arrangement in 1834.

The Admiralty lists note that 'Ladder Hill Observatory' time was used in St Helena. The Observatory had ceased operation in 1836, but its latitude and longitude are likely to have been measured by Johnson when extensive instruments were available. Astronomical clocks had been retained after Observatory closure and were probably regulated using a sextant and a nautical almanac. It has been shown recently that the longitude in use up to 1990 was in error by 732 m (Saint Helena, 2021). The GPS latitude and longitude of the Observatory site are are approximately 15° 55′ 30″ S.; 5° 43′ 07″ W.

There was a fee of 5 shillings for provision of the time ball service in April 1859 (Russell, 1859: 343). This fee was noted by Findlay in 1867 and 1883 and was still extant in 1888 (notice in St. Helena Museum). It appears to have been accepted without complaint.

There are no known photographs of the repeater time ball on Ladder Hill, but a drawing of the rear of the observatory was made by Durand Brager, the artist who was present for the exhumation of Napoleon in 1840. Figure 7 shows the central part of the drawing, including a flagstaff which may have been used for dropping the repeater ball listed in Table 2.

The sketch shown in Figure 8 is highly stylised and not to scale. The flagstaff and gun locations are shown but there is no indication of a nearby observatory. The sketch is believed to date from 1789, long before time balls were introduced. Two balls or discs are shown sus-

Table 2: Admiralty list entries for James Town, St Helena.

Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880	15° 55' 0″ S. 5° 42' 30″ W.	Ball	Time Office west side of the lines, James Town Valley. 74 feet above high water. 40 feet above ground. (Drop 13 feet.)	01 00 00	00 37 10	Ball is hoisted half way up as a preparatory at 5 minutes before signal. Ball hoisted close up at 2 minutes before signal. Ball dropped at 1h 0m p.m. Greenwich mean time, which corresponds to 0h 37m p.m. St. Helena (Ladder Hill Observatory) mean time. [*Note.*.–Signal not made on Sundays. Ships desirous of rating or comparing chronometers may send them to the Time Office, or, on application, may have the signal repeated at any hour.]
	[not stated]	Ball	Yard arm of the flag staff on Ladder Hill. 653 feet above high water. 45 feet above ground. (Drop 40 feet.)	01 00 00	00 37 10	Ball is hoisted half way up as a preparatory at 5 minutes before signal. Ball hoisted close up at 2 minutes before signal. Ball dropped at 1h 0m p.m. Greenwich mean time, which corresponds to 0h 37m p.m. St. Helena (Ladder Hill Observatory) mean time. [*Note.*.–Signal is in sight of the whole anchorage, and can easily be observed by ships passing within a few miles of the harbour. Signal not made on Sundays.]
1898	15° 55' 20″ S. 5° 42' 25″ W. Approximate.	Ball	[As for 1880]	01 00 00	00 37 10	[As for 1880]
	15° 55' 17″ S. 5° 42' 42″ W	Ball		01 00 00	00 37 10	
1904	.	Ball Ball				
1908 1911	No reported signal at St. Helena					

Figure 7: Part of an 1840 drawing by Durand Brager, showing a flagstaff on Ladder Hill (courtesy: St Helena Museum).

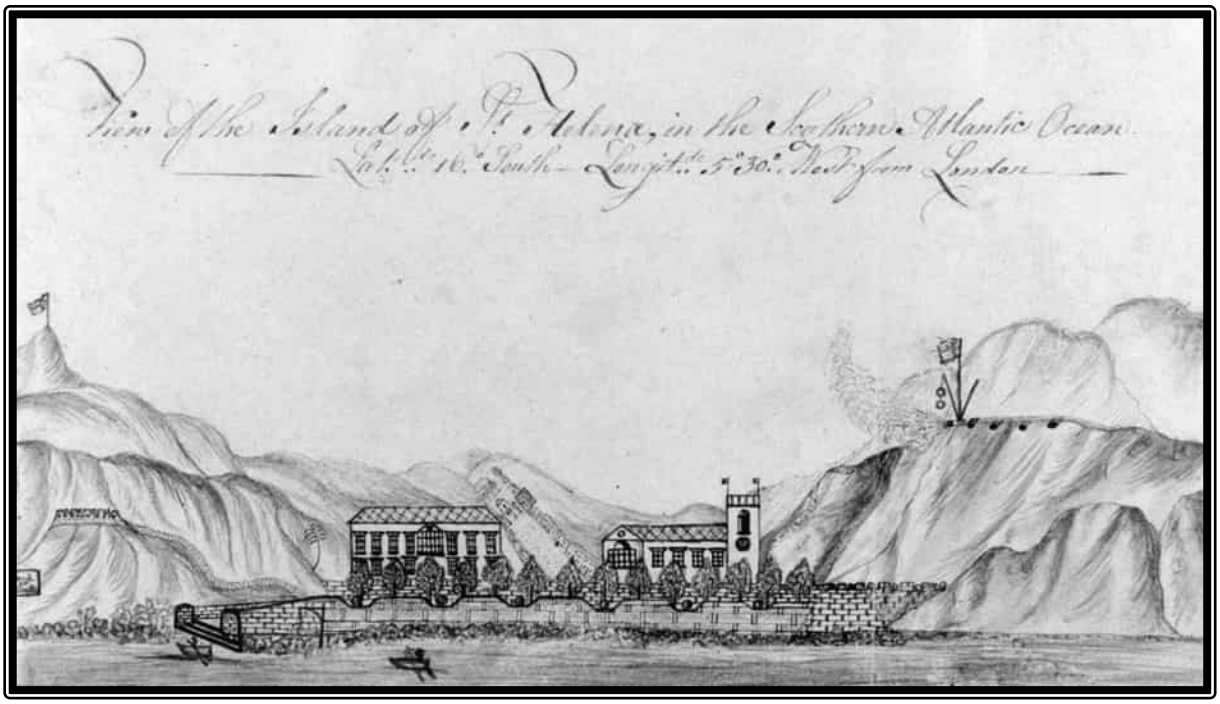


Figure 8: 1789 sketch of St Helena by an unknown artist (courtesy: St Helena Museum).

pended from a sloping arm, but these were probably used for purposes other than signalling time. The sketch shows a signal gun being fired. This may have been adopted as a time gun, after the observatory had been constructed.

2.2 Ascension

Like St Helena, Ascension Island was discovered as an uninhabited island by the Portuguese in about 1502. There was then almost no vegetation on an extinct volcano that had risen from the Atlantic, about 1300 km from St Helena, 1600 km from Africa and 2200 km from

South America. Its area is only about 90 km^2, with EW and NS dimensions of about 14 and 11 km. The extraordinary history and administration of Ascension are described in detail by Hart-Davis (2016).

Ascension became important as a victualling centre for ships on long voyages. Its flora and fauna were developed by importing species from many different countries. It was first colonised by the British in 1815, in order to discourage any attempt to rescue Napoleon from St Helena. After the death of Napoleon in 1821, it became an important centre for interception of slave ships sailing from the west coast of Africa to South America. From 1815 to 1922, Ascension was run as a naval shore establishment with a detachment of marines. Its Commanding Officers were in either the Royal Navy or the Royal Marines (Hart-Davis, 2016: 233–234). Ascension became a dependency of the Crown Colony of St Helena in 1922.

Ascension was never strongly defended and its garrison was only a few hundred strong. The island was close to being abandoned in the 1860s, when the Admiralty found it hard to justify continued expenditure on the garrison and its facilities. It again became important in the twentieth century for communications, first as a telegraph station in 1901, then for radio communications during WWI and later for tracking of vehicles in Space. Its airfield was developed by the United States during WWII and further extended later. It continues to be an important military facility.

The islands of Tristan da Cunha and Gough Island were administered as dependencies of St Helena. No evidence has been found of visual time signals for mariners on those islands.

2.2.1 The Ascension Time Ball

Hart-Davis did not mention the existence of a time ball or associated observatory facilities on Ascension. He noted that David Gill (later Director of the Cape Observatory) and his wife had stayed there for several months in 1877 to observe the Opposition of Mars, but they brought their own equipment and set up a temporary observatory. Gill's observations were published in *Monthly Notices of the Royal Astronomical Society* (Gill, 1879).

Facilities for time determination in the 1860s were probably limited to sextants, chronometers and almanacs carried by naval vessels stationed there. Despite those limitations, there was a time ball service.

A notice concerning a time ball at Ascension was published in *The Nautical Magazine* (Time Signal Ball, 1860) and is transcribed below.

> *Time Signal Ball at Ascension.* — In order that vessels calling at Ascension may readily find the errors and rates of their chronometers, a Time Ball is dropped daily (Sundays excepted) from a flagstaff at the Master's cottage, precisely at one o'clock of Greenwich mean time. The Master's cotage is to the southward of Hayes Hill, and is the only one near it bearing a flagstaff. The Ball when hoisted ready to be dropped is at a height of ninety feet above the level of the sea, and may be readily seen from the anchorage. Considering the longitude of the flagstaff to be 14° 26′ 30″ W. or, in time, 0h. 57m. 42s; the ball falls at 2m. 18s. after noon of Ascension mean time, the first instant of falling being that which is to be noted by the chronometer. Vessels not intending to remain for the usual signal hour may have the ball dropped at any convenient period of the day for Greenwich time by applying for it to be done at the cottage.

Another, much shorter, notice was published in 1865, but the drop times had changed (The Time Ball, 1865).

> The Time Ball is now dropped from a staff on Hayes Hill at 8h. a.m. and 1h. p.m. mean time at Ascension. The corresponding mean times at Greenwich will be 8h. 57m. 42. and 1h. 57m. 42s. respectively. Should the ball fall at the wrong time, the negative pendant will be hoisted, and the ball will be again dropped at ten minutes after the times stated.

In 1860, the time ball had been dropped at 1 pm Greenwich mean time. By 1865, the ball was dropped twice daily, first at 8 am and then at 1 pm Ascension mean time. Both notices pointed out its proximity to Hayes Hill. Other records of the time ball have not been found. It probably had a short life, given continuing budgetary pressures (Hart-Davis, 2016).

Figure 9 shows a map of Ascension published in 1876. Hayes Hill is very close to George Town on the western side of the island, as detailed in Figure 10. The GPS latitude and longitude of Hayes Hill are 7° 55′ 57″ S.; 14° 24′ 52″ W. The longitude stated in 1860 and 1865 was therefore 1′ 38″ too far west. This corresponds to an error of about 2.5 km.

There were no entries for Ascension in Admiralty lists between 1880 and 1911.

2.3 Cape Verde Islands

Table 4 shows Admiralty list entries for the Cape Verde islands. There was no reported time signal in 1908 but a telegraph signal was available in 1911.

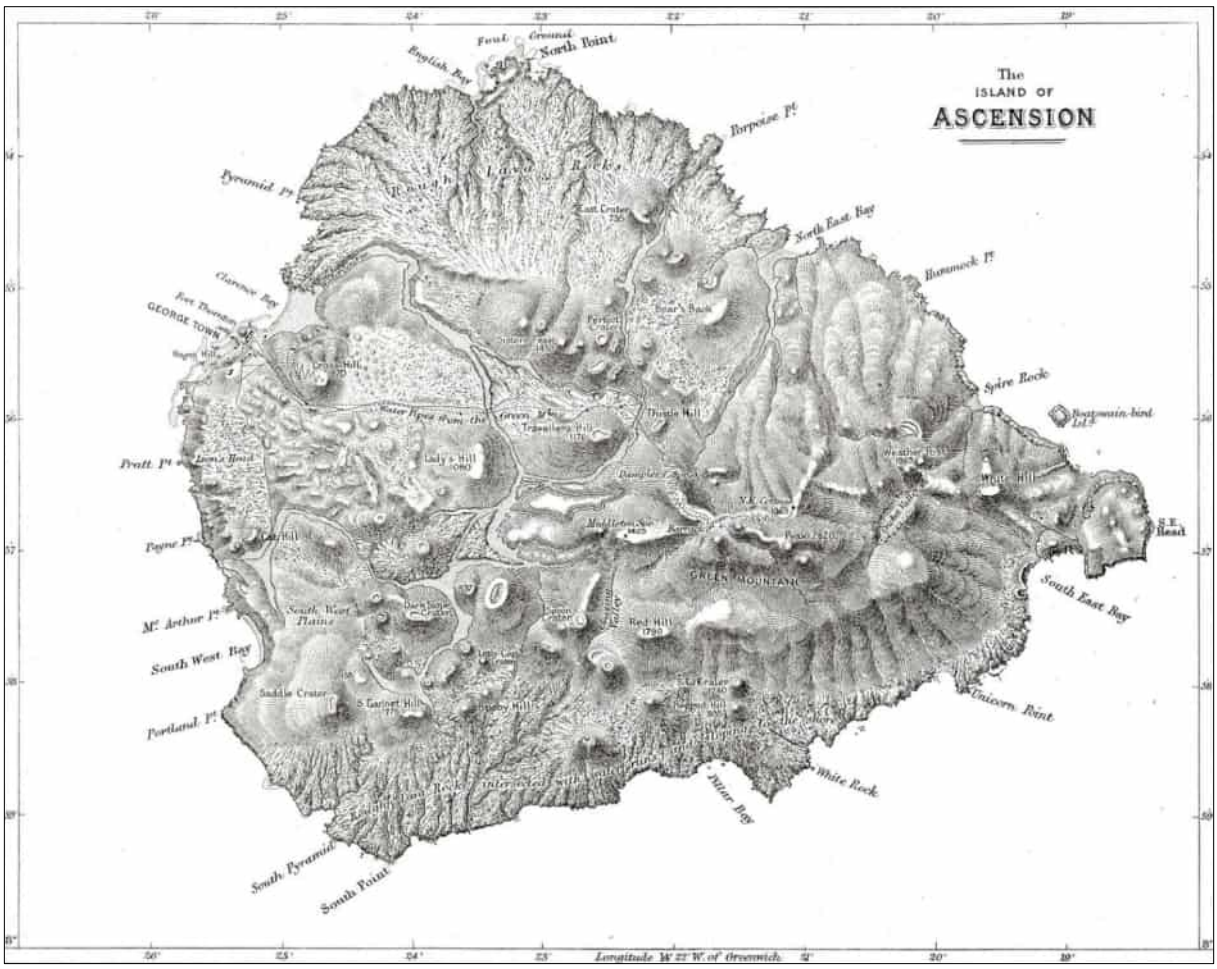


Figure 9: Map of Ascension (Science History Images ID: 2BE1090).

Three time signals were introduced on São Vicente island in February 1922, all at 10 am local time, corresponding to noon at Greenwich. There was a time ball at the port captain's office, plus a diamond-shaped repeater signal and a gun at the fort (Notices, 1922: 510). The complete notice is transcribed below.

> (1641) CAPE VERDE ISLANDS—São Vicente Island—Porto Grande Visual time slgnal—Information.—Since February 9, 1922, the time signal at Porto Grande has been made in the following manner from the signal mast of the meteorological station located in the building of the captain of the port:
>
> The ball (sphere) is hoisted at half must at 9h 55m; mastheaded at 9h 58m, and dropped at 10h a. m., the time corresponding to that of the 30° meridian of longitude west of Greenwich.
>
> This signal is repeated from the semaphore mast at the fort with a black diamond-shape. The dropping of the diamond-shape is accompanied by the firing of a gun at the saluting battery on Mondays, Wednesdays, and Fridays. Approximate position of Porto Grande: latitude 16° 53′ N., longitude 24° 59′ W.

The time ball and flagstaff signals were still in use in 1942, but the time gun had been discontinued (Sailing Directions, 1942; 273):

> **Time signals** are made on the flagstaff at the captain of the port's office and at the

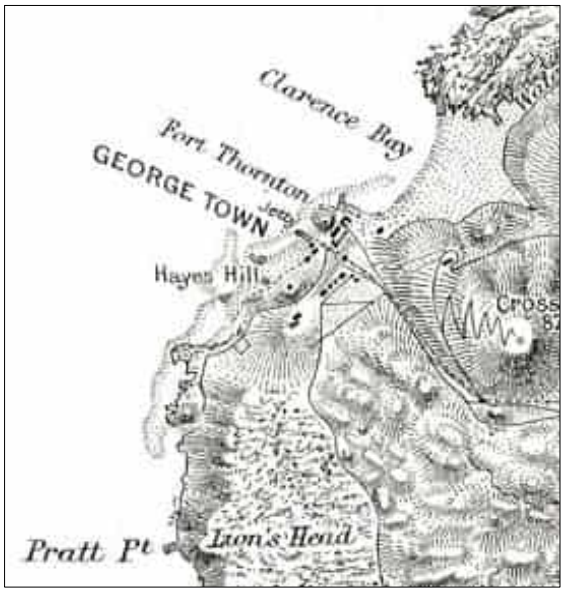


Figure 10: Detail from Figure 9 showing Georgetown and Hayes Hill.

Table 4: Admiralty list entries for the Cape Verde islands

Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880 1898 1904 1908	No reported signal at Cape Verde Islands					
1911		Telegraph				Telegraph Office

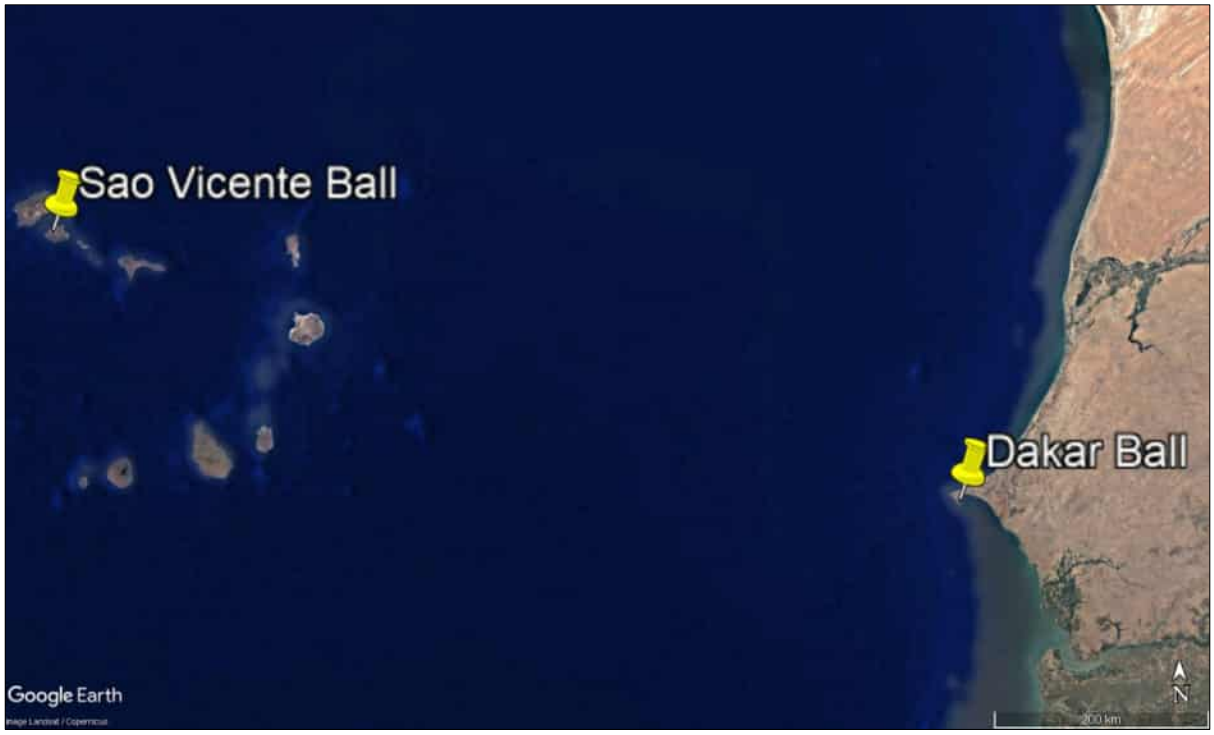


Figure 11: Locations of time balls in the Cape Verde islands and Senegal.

> semaphore on the fort on Monte Videa. A ball is hoisted half way up at 5 minutes before and close up at 2 minutes before the signal; it is dropped at 10h. 00m. 00s. standard time, corresponding to 12h. 00m. 00s. Greenwich civil time.

Figure 11 shows the location of the time ball at Porto Grande on São Vicente island in the Cape Verde Islands, as specified in the 1922 notice. The map also shows the location of the time ball at Dakar in Senegal (see later). The two signals were separated by about 870 km.

2.4 Canary Islands and Madeira

There were no entries in Admiralty lists for either Madeira or the Canary Islands before 1908, as indicated in Table 5. Telegraph signals had become available to mariners at Madeira and Tenerife by 1911. Their locations are shown in Figure 1.

2.5 Azores

Table 6 shows Admiralty list entries for the Azores. A clock was available at Punta Delgada by 1904 and another was available at Horta by 1908. Their locations are shown in Figure 1.

3 WEST AFRICA

3.1 St. Paul de Loanda, Angola

St. Paul de Loanda (now Luanda) is the capital and largest city of Angola. It is located on Angola's coast with the Atlantic Ocean and serves as Angola's chief seaport and administrative centre. Portuguese explorer Paulo Dias de Novais founded Luanda in 1576 as 'São Paulo da Assumpção de Loanda'. It is the world's third most populous Portuguese-speaking city, behind only São Paulo and Rio de Janeiro in Brazil. Angola has had a chequered colonial and post-colonial history but was a Portuguese colony during the period of visual time signals.

The Admiralty list entries for St. Paul de Loanda are shown in Table 7.

Table 5: Admiralty list entries for the Canary Islands and Madeira

Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880 1898 1904 1908	No reported signal at Tenerife or Madeira					
1911		Telegraph	Tenerife Madeira			Telegraph Office Telegraph Office

Table 6: Admiralty list entries for the Azores

Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880 1898	No reported signal at Punta Delgada or Horta					
1904		Clock	Punta Delgada			
1908	37° 44' 20″ N. 25° 40' 30″ W. 38° 50' 00″ N. 28° 37' 30″ W.	Clock Clock	Meteorological Observatory, Punta Delgada Offices of Telegraph Company, Horta (Fayal).			There is a standard clock in the Meteorological Observatory, regulated through the electric telegraph by the mean clock of the Lisbon Observatory, where chronometers can be compared. There is a standard clock in the offices of the Telegraph Company regulated from Hamburg Observatory, where chronometers can be compared.
1911		Clock Clock	Punta Delgada Horta			Observatory Telegraph Office

Although there was no entry in the 1880 Admiralty list, the time ball at Loanda was operational in 1879 (Nautical Notices, 1879).

> A Time Ball is hoisted half-mast on the staff of the observatory tower at 0h. 50m. p.m.; close up at 0h. 55.m.; and dropped at 1h. 0m. p.m. mean time, St. Paul de Loando (*sic*).
>
> *Note*. —It is reported that dependence cannot always be placed on the accuracy of this time ball.

The notice in 1898 shows the correct drop time under the "Time of Signal being made" as being at 1 p.m. Loanda local time, but there was a mistake under "Additional Details", highlighted in red: the drop time was not at noon local time. The indicated times of the preparatory signals at 5 and 2 minutes before the time signal differed from those reported in 1879 and 1908, but were consistent with later notices (Notices, 1912: 393; Africa Pilot, 1916: 396). The 1912 notice indicated that the time of the signal was changed from 1 p.m. local mean time to noon Greenwich mean time on 1 January 1912. Figure 12 shows the time ball above the tower in its lowered position.

A 1932 notice indicated that the time ball had been discontinued and replaced by an evening time light signal (Sailing Directions, 1932: 284). A flag signal, accompanied by the firing of time gun, was made a 1 pm, but was presumably less accurate and was intended for local use only.

> **Time signal. –** A time signal is made by means of lights on the observatory tower which are lighted at 8:55 p.m. and extinguished at 9 p. m. There may be an error of 1 second in this signal.
>
> A time signal, consisting of the lowering of a flag at 1 p. m. accompanied by the firing of a gun, is made for the convenience of the residents.

3.2 Gold Coast

3.2.1 Cape Coast Castle

A time ball on the Gold Coast (now Ghana) was announced on 27 July 1839. The notice was published in the *Naval Chronicle* for 1840 (Maclean, 1839). It is reproduced in Figure 13.

George Maclean (1801–1847) was Governor of the Gold Coast from 1830 until 1844

Table 7: Admiralty list entries for St. Paul de Loanda, Angola

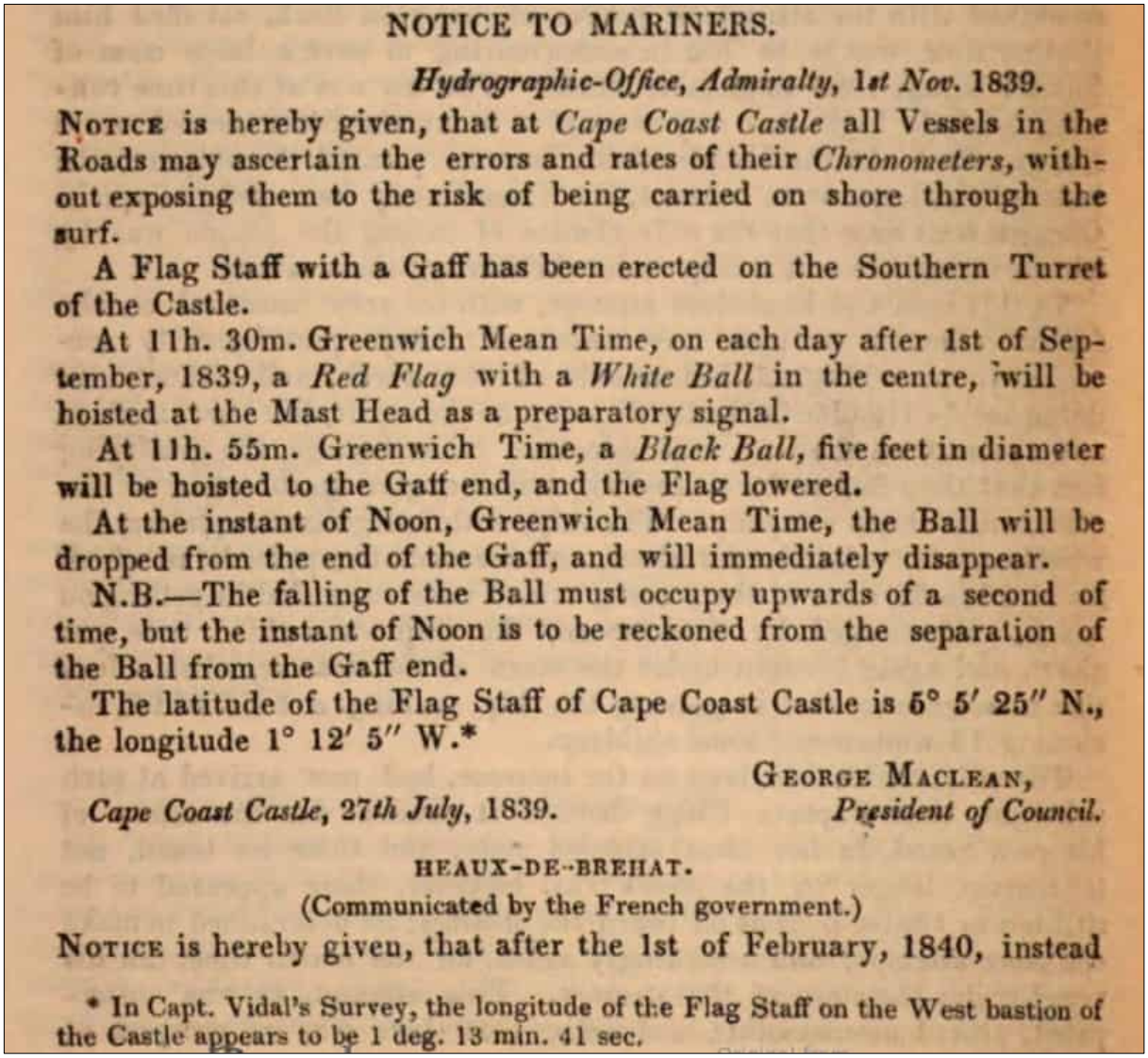
Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880	No reported signal at St. Paul de Loanda					
1898	8° 48' 45″ S. 13° 13' 20″ E..	Ball	At the Observatory	24 07 6.7	01 00 00	Ball is hoisted half way up as a preparatory at 5 minutes before signal. Ball hoisted close up at 2 minutes before signal. Ball dropped at noon St. Paul de Loanda (Observatory) mean time. This signal has been reported to be inaccurate.
1904		Ball				
1908	8° 48' 46″ S. 13° 13' 19″ E..	Ball	At the Observatory	24 07 6.7	01 00 00	Ball is hoisted half way up as a preparatory at 10 minutes before signal. Ball hoisted close up at 5 minutes before signal. Ball dropped at 1 p.m. St. Paul de Loanda (Observatory) mean time. Ball not dropped on Sundays or public holidays. This signal has been reported to be inaccurate.
1911		Ball				

Figure 12: Loanda Observatory (Klaus Hülse Collection).

(Wikipedia). The apparatus at the Cape Coast Castle was similar in many respects to the 1836 arrangement at the Royal Observatory, Cape of Good Hope, with a ball having a diameter of 5 feet that was dropped from a gaff (Kinns, 2021). The footnote in Figure 14 suggests that the stated longitude was too far east by more than 2 km. The time ball may have had a short life.

3.2.2 Accra

The Admiralty list entries for Accra are shown in Table 8. There was no entry in 1880.



NOTICE TO MARINERS.

Hydrographic-Office, Admiralty, 1st Nov. 1839.

NOTICE is hereby given, that at *Cape Coast Castle* all Vessels in the Roads may ascertain the errors and rates of their *Chronometers*, without exposing them to the risk of being carried on shore through the surf.

A Flag Staff with a Gaff has been erected on the Southern Turret of the Castle.

At 11h. 30m. Greenwich Mean Time, on each day after 1st of September, 1839, a *Red Flag* with a *White Ball* in the centre, will be hoisted at the Mast Head as a preparatory signal.

At 11h. 55m. Greenwich Time, a *Black Ball*, five feet in diameter will be hoisted to the Gaff end, and the Flag lowered.

At the instant of Noon, Greenwich Mean Time, the Ball will be dropped from the end of the Gaff, and will immediately disappear.

N.B.—The falling of the Ball must occupy upwards of a second of time, but the instant of Noon is to be reckoned from the separation of the Ball from the Gaff end.

The latitude of the Flag Staff of Cape Coast Castle is 5° 5′ 25″ N., the longitude 1° 12′ 5″ W.*

GEORGE MACLEAN,
President of Council.

Cape Coast Castle, 27th July, 1839.

HEAUX-DE-BREHAT.

(Communicated by the French government.)

NOTICE is hereby given, that after the 1st of February, 1840, instead

* In Capt. Vidal's Survey, the longitude of the Flag Staff on the West bastion of the Castle appears to be 1 deg. 13 min. 41 sec.

Figure 13: Announcement of the Cape Coast time ball (*Naval Chronicle*, 1840: 128)

A flag and gun were in use by 1898. The signal was of doubtful accuracy until at least 1908, because of the need for re-transmission of telegraph signals from London. Editions after 1911 have not been seen by the author.

3.2.3 Takoradi Time Ball and Gun

Another time ball had been erected by 1932, as shown in the following entry for Takoradi (Sailing Directions, 1932: 75).

> **Time signal**. - A time signal is made from the Prince of Wales Clock Tower. The time used is that of Greenwich meridian from January 1 to August 31 and that of 5° E. (0h. 20m. fast on Greenwich mean time) during the remainder of the year. Simultaneously with the dropping of the time ball a gun is fired from the harbor signal station.

Takoradi, now joined with Sekondi in Ghana, is about 200 km WSW of Accra. The time ball was operated in conjunction with a time gun. Unusually, the local time was advanced by 20 minutes between 1 September and 31 December each year. The drop time was not stated in the notice. There was no mention of a time signal at Accra.

3.3 Tokonu, Nigeria

A time ball existed in 1893 at the port of Tokonu on the Bight of Benin, now part of Nigeria (West Coast of Africa, 1893: 232).

> **Time ball**.- A time ball is hoisted on the flagstaff of the telegraph office; the time is given from Loanda …

The time was regulated from Loanda, in Angola, but no further details were specified in the notice. It was not mentioned in the subsequent 1908 edition, so it probably had a short life. It did not appear in Admiralty lists between 1898 and 1911. Tokonu is about 110 km from Lagos, the capital of Nigeria.

Table 8: Admiralty list entries for Accra.

Date	Latitude & Longitude	Signal	Location of Time Signal	Time of Signal Being Made		Additional Details
				GMT h. m. s.	Local Time h. m. s.	
1880	No reported signal at Accra					
1898	05° 31' 48″ N. 0° 11' 30″ W.	Flag and Gun	Direct Company's Telegraph Office	11 00 46	11 00 00	Flag dropped at 11h 00m 00s Accra mean time. Greenwich mean time is received daily, Sundays excepted, at 10h 00m 00s a.m., from London by Post Office Chronograph; but being re-transmitted through several stations is not exact.
1904		Flag and Gun				
1908	05° 31' 48″ N. 0° 11' 30″ W.	Flag and Gun	Direct Company's Telegraph Office	11 00 46	11 00 00	[As for 1898]
1911		Flag And Gun				

3.4 Dakar, Senegal

Dakar is at the western end of the Cape Verde peninsula, with the Cape Verde Islands further west. It was the most northerly of the signals in Sub-Saharan Africa. Senegal had been a French colony, becoming independent in 1960.

Time signals at Dakar did not feature in Admiralty lists up 1911, but there was a time ball there for a limited period. The following notice was published in 1911, indicating that an earlier time ball had been re-established (Notices, 1911: 315).

> **AFRICA – West coast – Dakar –Time signal reestablished.** – Referring to Notice to Mariners No. 19(966) of 1909, the French Government has given further notice that the time signal at Dakar, west coast of Africa, has been reestablished.
>
> The signal consists of a black ball 3 feet in diameter dropped on a mast located at the southeastern angle of the Arsenal Grounds.
>
> It is hoisted 5 minutes before and dropped at 11h. 09m. 41.5s., Greenwich mean time, corresponding to 10h. 00m. 00s., Dakar mean time. The ball is immediately rehoisted and dropped again 2 minutes later.
>
> Should the signal fail a red flag is shown from the mast and the signal will be repeated 10minutes after the first ball was dropped.

In the above notice, times appear to have been based on zero hours at midnight, not zero hours at noon as usually expected for time ball data.

This time ball was noted in later United States sailing directions (East Atlantic Pilot, 1916: 426; 1918: 401; 1920: 412). By then Dakar mean time had been changed to 1 hour slow on Greenwich. The entry for 1920 is transcribed below.

> **Time Signal.** - A time signal is established at Dakar. It consists of a black ball hoisted on a mast in the eastern part of the arsenal five minutes before the hour and dropped at 22 hrs. 00 m. 00 sec. standard time, corresponding to 23 hrs. 00 m. 00 sec. Greenwich mean time. The ball will be rehoisted immediately afterwards, and dropped again 2 minutes later. Should the time be inaccurate, a red flag will be hoisted at the yardarm, and these signals will then be repeated at 22 hrs. 00 m. 00 sec. and 22 hrs. 12 m. 00 sec. standard mean time.

This notice gave the same information as in 1916 and 1918. Times were based on zero hours at noon for astronomical purposes.

Figure 14 shows the arsenal under construction, before erection of the time ball. The time ball is likely to have been in the vicinity.

4 CONCLUDING REMARKS

The first time ball on an Atlantic island was established at Jamestown, St Helena in January 1834, following only Mauritius and Greenwich in 1833 and the first experimental time ball at Portsmouth in 1829. The Portsmouth trials were declared a success in 1830, but the transition to an operational service at Portsmouth may not have occurred until long after introduction of the Greenwich service in 1833.

St Helena was then an important rendezvous and victualling centre for sailing ships returning from the Far East. The primary time ball was erected at the Ladder Hill Observatory, with a repeater time ball at a similar level and a

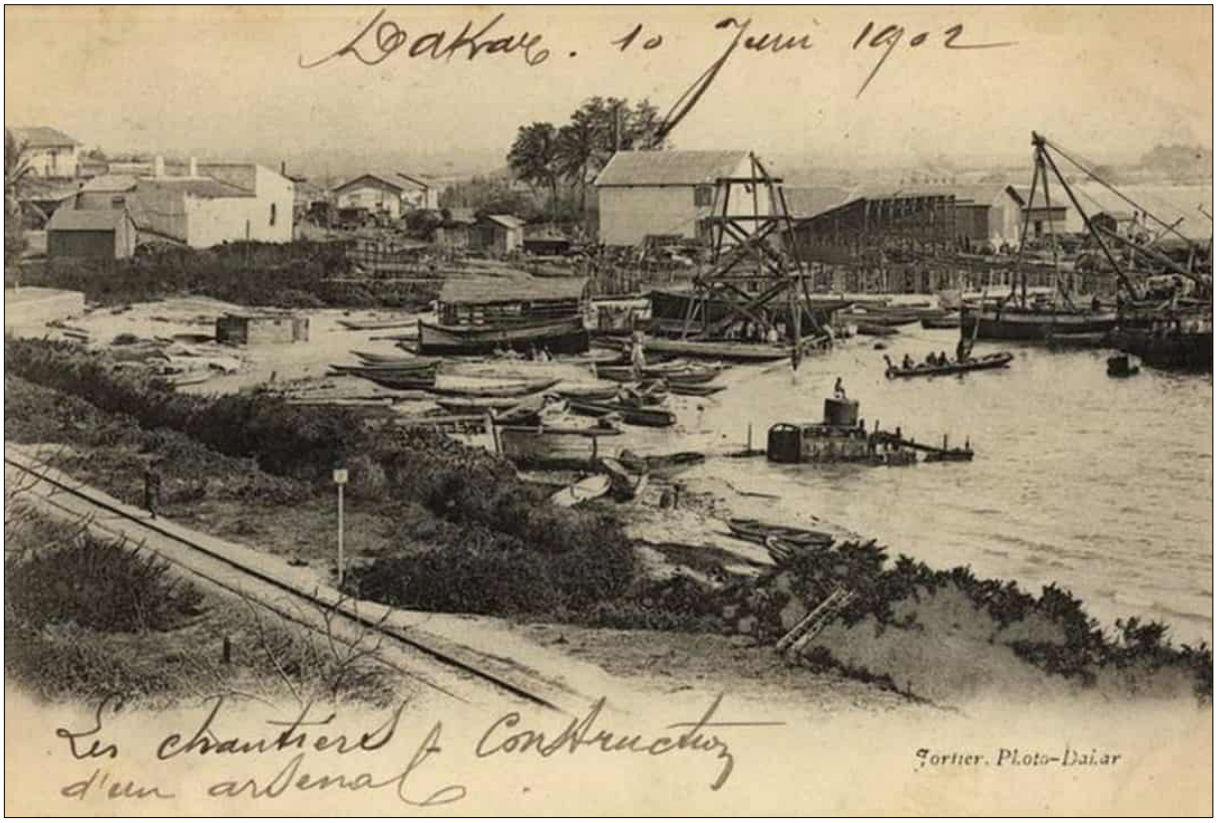


Figure 14: Dakar Arsenal under construction in 1902 (https://www.senegal-online.com/gallery/cartes-postales-anciennes-du-port-de-dakar/).

gun that was fired when the ball was dropped. A description of the apparatus, including a diagram, was published in *The Nautical Magazine* during 1835, but it was difficult to interpret. It indicated that the ball slid down a mast and was controlled using ropes and weights. There were no details of the triggering arrangement. The time ball had been reported by Captain Robert Wauchope as being an accurate signal, but the associated editorial was sceptical and led to a protest from Wauchope that his claim to time ball invention had not been recognised appropriately.

St Helena was transferred from the East India Company to the Crown in 1833, followed by cost-cutting. The well-equipped Observatory had been established in the 1820s and had been operated with distinction by Lieutenant Manuel Johnson, who made observations of the southern stars between 1829 and 1833. He published a catalogue in 1835 that is still highly-regarded. Despite that, the Ladder Hill Observatory was closed in 1836 and instruments other than astronomical clocks were withdrawn. The time ball service, but not the gun, continued under control from the Time Office in Jamestown, with a repeater ball on Ladder Hill that was dropped from a yard arm. It appears that the service was regulated using a sextant and the clocks. It had been discontinued by 1908.

Johnson had a distinguished career in astronomy after his return to England in 1833, rooted in the encouragement he received as a young man from the Governor of St Helena. He took his MA at Oxford University in 1839 and was Director of the Radcliffe Observatory from 1839 until his death in 1859. He was elected a Fellow of the Royal Society in 1856 and served as President of the Royal Astronomical Society from 1855 to 1857.

Many other Atlantic islands and various locations on the west coast of Africa had time signals. In several cases, their existence has only been identified from Admiralty lists, notices to mariners and sailing directions published in the United States, without supporting evidence from local historical records. Further research may expose other time signals.

Ascension had been garrisoned by the British in 1815 in order to inhibit any attempt to release Napoleon from exile in St Helena. Ascension then played an important role in capturing slave ships that were still plying between West Africa and South America. It was administered as a Royal Navy shore station with a detachment of marines until 1922. Notices about a time ball at Ascension were published in *The Nautical Magazine* in 1860 and 1865, at a time when the island was at risk of being abandoned through concern about the

cost of maintaining the garrison. There was never a permanent observatory and the time ball service must have been operated using equipment available on Royal Navy ships. There is no mention of the time ball in an otherwise comprehensive history of the island. Ascension became an important communications centre in the twentieth century, with extensive development during both WWI and WWII, and remains important strategically.

No signals in the Azores were reported in Admiralty lists up to 1898. A clock was available at the Meteorological Office at Punta Delgada by 1904, regulated by telegraph from Lisbon. Another was available at the telegraph office in Horta by 1908, regulated from Hamburg. Chronometers could be calibrated at the telegraph offices in Tenerife and Madeira by 1911.

The most northerly time ball on the west coast of Africa was at Dakar in Senegal on the Cape Verde Peninsular. It is likely to have been introduced in the early twentieth century but was not included in Admiralty lists between 1898 and 1911. It was re-established in 1911 and was still operating in 1920. Three new time signals were introduced on São Vicente Island in the Cape Verde islands in February 1922, including a time ball, a diamond-shaped repeater signal and a gun. That was a late date for introduction of a new time ball, given the increasing availability of wireless signals. A telegraph signal had been previously available. The first two São Vicente signals were still operating in 1941.

An early time ball had been erected at the Cape Coast Castle near Accra on the Gold Coast, now Ghana, in July 1839. Its arrangement was similar to that used in 1836 at the Cape of Good Hope. Its creator, George Maclean, had died in 1847 and the time ball service does not appear to have been maintained for long. There was no entry for Accra in the 1880 Admiralty list but a flag, accompanied by a time gun, was listed between 1898 and at least 1911. In 1932, there was a combined time ball and time gun service at Takoradi, about 200 km from Accra, but there was no indication of a continued service at Accra. There was also a short-lived time ball at Tokonu in Nigeria, noted in United States sailing instructions as regulated from Loanda in 1893, but not mentioned in later editions.

There was an important time ball at St. Paul de Loanda in Angola, regulated by the observatory there. It was announced in 1879. It had been replaced by a 9 pm time light at the observatory by 1930.

5 ACKNOWLEDGEMENTS

The research described in this paper makes extensive use of the excellent website “Saint Helena Island Info”, which includes a wealth of information about St Helena and its history from first discovery to the present day. Several illustrations have been taken from that website. I am grateful to John Turner, the website manager and to Nick Thorpe at the St Helena Museum in Jamestown, for additional images and for checking my draft text.

Paul Fuller located references concerning the first time ball experiments at Portsmouth that throw further light on early developments in England. I also thank Klaus Hülse in Germany for providing a postcard illustration from his extensive collection and reviewers for suggesting improvements to the paper.

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