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SOME BOARD OF LONGITUDE INSTRUMENTS IN THE NINETEENTH CENTURY

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A series of calamitous British disasters at sea occurred at the turn of the 17th century, many of which can be attributed to poor navigation compounded by inability to find longitude. Perhaps the most momentous was that of Sir Cloudsley Shovel's returning Mediterranean Squadron which was comprehensively wrecked on the Scilly Islands in 1707 with the loss of four large warships and nearly 2000 men.[1] An increasing public outcry at this regular loss of life and keenly felt loss of trade revenue resulted in an Act of Parliament which was intended to improve the inadequate state of navigation by stimulating an answer to the seemingly impossible problem of finding longitude at sea.

On 20th July, 1714 Queen Anne gave her assent to "A Bill for Providing a Public Reward for such Person or Persons as shall Discover the Longitude at Sea". £ 20,000, an enormous sum of money at that time, was to be awarded to anyone who could provide a practical solution of general utility which would enable a navigator to find his ship's position to within twenty geographical miles. Lesser sums were to be awarded for methods which produced less accurate results.[2]

To oversee the management of these awards and to judge the practicability of the solutions proposed, the Act provided for a Board of Commissioners. This was composed of the best scientific and seafaring minds of the day in addition to the inevitable political appointments. The Board of Longitude , as the Commissioners became known, was in theory comprised of such luminaries as the First Commissioners of the Admiralty, the Navy, and of Trade. The Speaker of the House of Commons and ten Members of Parliament were also included. In reality the Board's Minutes show that over the 114 years of its existence, 1714 to 1828, the work was carried out by a more select group headed by the Astronomer Royal, the President of the Royal Society and various Naval Admirals and mathematical professors from Oxford and Cambridge, overseen in later years by the Board's Secretary.

In addition to the terms of the Longitude award, the Act also contained a sensible provision which authorised the Board to award sums of money, up to £2,000, to projects which they considered worthy of encouragement or which, although not fulfilling the conditions of the

Act, were for the public good.[3] The significance of this proviso cannot be overemphasised, for here, for the first time, was a Government fund to finance technological and scientific experiments which, as we shall see later, had a direct influence on the productivity and excellence of scientific and mathematical instruments made in England during the second half of the 18th and early 19th century.

The role of the Board of Longitude gradually changed over the years as, in company with the Royal Society, it became the advisory body to which the Admiralty turned when planning and fitting out scientific or explanatory expeditions. Instruments to equip these expeditions were ordered by the Board from the London instrument making trade so that gradually there was built up a collection of navigational, astronomical and scientific instruments which were stored at various depots and warehouses when not in use.

Unfortunately the Act did not provide for a Secretary for the Board so that by 1762 they had to admit that "the Minutes and Papers, since the first appointment of Commissioners of the Longitude to the present time, are in great disorder and confusion...". They resolved to petition the King that a "fit person should be appointed..." and in 1763 the first of the Board's five Secretaries, John Ibbetson, was appointed.[4]

Initially, when there were few instruments, they appear to have been kept either at the Royal Observatory at Greenwich or at the rooms of the Royal Society. Some time after the appointment of Ibbetson in 1763 the main store was situated in a room in or near the east dome of the Seamans' Hospital (now the Royal Naval College) at Greenwich.[5] This odd site is not so surprising when one considers that Ibbetson had been also recently appointed as Secretary to the Hospital. However, a disastrous fire on 2 January 1779 totally destroyed the chapel and its dome, together with many of the Board's instruments.[6] As a consequence in 1782 the Board of Longitude entered into a partnership with the Royal Society to share a warehouse and the expense of a Storekeeper in Catharine Street, London.[7]

The main purpose of this paper is to discover what happened to some of these instruments in the 19th century after the winding up of the Board of Longitude in 1828. In following up the main theme much additional instrument information has come to light, and some of this has been included also. The main sources consulted have been the papers of the Board of Longitude, held for the Public Record Office by the Royal Greenwich Observatory, Herstmonceux, and the records of the Royal Society.

As a result of the poor housekeeping prior to 1763 the earlier minutes

are not complete, the earliest surviving being those for 30th June, 1737. Thereafter until Ibbetson's appointment, they appear to have been selected to record the progress of John Harrison's timekeepers in his dealing with the Board. This story is too well known to be gone into here but it is worth mentioning that the 2 foot focal length reflector and equal altitude instrument ordered from John Bird in 1761 and used at the observations required to test H.4 at Portsmouth and Jamaica, are amongst the earliest instruments purchased for the Board's use.[8]

The *first* instruments ordered by the Board were probably through the Astronomer Royal, James Bradley (1693-1762) in March 1756 when he was requested "...to cause Three Instruments to be made under his immediate direction such as he should judge most proper for the taking Observations necessary to be made on Shipboard in the intended trials of Mr Mayer's Method of finding the Longitude of a ship at Sea ...".[9] Tobias **Mayer's** (1713-1762) lunar tables had come before the Board for evaluation together with the Gottingen Professor's description of a circular instrument which he considered necessary to observe the lunar distances to the required accuracy. This instrument was based on the combined properties of Hadley's reflecting quadrant and Mayer's own goniometer, a device for repeating an observed angle.[10]

James Bradley seems to have initially ordered only one instrument from John Bird, an example of Mayer's reflecting circle, 16 inches in diameter, which proved so heavy it required a pole to support it. Captain John Campbell (1720-90) who had been selected to try the new instrument in the course of testing Mayer's tables found it so awkward to handle that in 1757 he had Bird make him a sextant with which to continue the observations." This instrument, basically a Hadley octant with its arc extended to 120°, but made to comtemporary astronomical standards, was the first marine sextant. Its scale was laboriously hand divided by Bird, who to get the desired accuracy made the instrument with a radius twice that of the circle.

It has always remained a mystery that this milestone of an instrument should have disappeared without trace but during the course of examining the Board's papers, further clues have come to light. In September, 1763, the Minutes record "That a letter be wrote to Lord Howe to desire the Sextant, now in his Lordship's custody may be delivered to Mr Green". Green was about to assist Nevil Maskelyne in the second testing of Harrison's H.4.[12]

In November 1768 the Board "understanding that Mr Bird has made some late Improvement which he is desirous of adding to the Sextants made by him for the service of this Board" resolved "That the Sextant which was lent to Capt. Campbell and that which Capt. Wallis had during his late voyage, be sent to Mr Bird to have those improvements

made to them accordingly".[13] These two statements infer that John Bird made two sextants for the Board, Campbells and one other, in addition to the Mayer circle, most probably the "...Three Instruments" ordered by James Bradley in 1756. This appears to be borne out by later inventory lists for on the back of a list headed "Instruments in the Possession of Mr Ibbetson Nov 1st 1779" is another headed "Instruments belonging to the Board of Longitude", which includes Mr Kendall's three marine time-keepers and Ramsden's dividing engines. Among this distinguished company appears: -

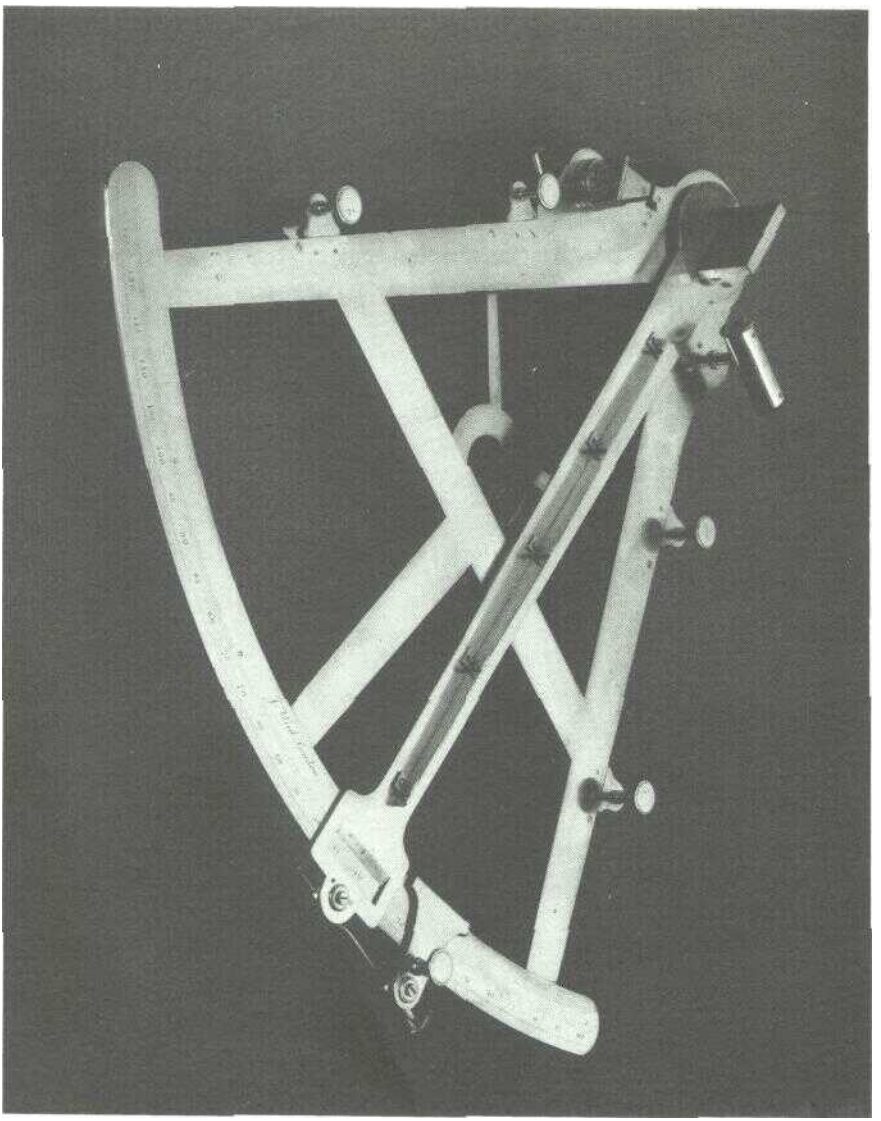
"1 Brass Circular Instrument on the plan of Hadley's Quadrant made according to the late Professor Mayer's plan, by Bird
2 Brass Hadley's Sextants of 20 inches radius, made by Bird".[14]

Confirmatory evidence is provided by an undated inventory of the 1780's in the Royal Society records with itemises

"1 brass circular instrument by Bird — with Admiral Campbell
1 brass Hadley sextant of 20 inch radius by Bird — with Admiral Campbell
1 brass Hadley sextant of 20 inches radius by Bird lost in the fire at Greenwich..."[15]

This entry is the last in the Board's records in which these three instruments appear, for a schedule of instruments dated 5th February, 1785 does not list any of them.[16] However the Board's final word was provided by Thomas Hurd about 1805 who had made a valiant effort to discover just what instruments the Board did own by drawing up "A list of instruments lent by the Board of Longitude which do not appear to have been returned. Extracted from the Minutes". Under November 1768 there appears "A sextant — Captain Campbell".[17] It would seem therefore that of Bradley's "three instruments" the circle and one sextant 'got away' with Campbell while the remaining 20 inch sextant, Wallis's, was burnt in the fire at Greenwich.

This is not quite the end of this story because in 1963 the Royal United Service Museum, which was founded by King William IV in 1831, closed its doors for the last time and its collections were dispersed. Among the maritime material which was presented to the National Maritime Museum was a large brass sextant of twenty inches radius overall, signed on the limb "J. Bird, London".[18] The instrument is supported on a pole with a universal joint attached to a frame on the back of the instrument, similar to that used with Mayer's circle. The limb is hand divided and with a vernier can be read to one minute of arc. The instrument came to the National Maritime Museum without provenance other than appearing in the 1908 catalogue of the R.U.S.I. Museum as item '2662' which showed that at one time it retained its two telescopes; probably a sight tube and a telescope.[19] Subsequent research has failed to improve on this. It is the only surviving brass framed sextant by Bird of this size (two



A 20 inch sextant by John Bird, London. This instrument is almost certainly that made for Captain John Campbell in 1757. The telescope and tangent screw are modem replacements.
(NMM reference: S. 225).

wooden framed instruments of similar construction and several small brass sextants are known) and the circumstantial evidence indicates that it is probably that originally made by John Bird for Captain Campbell.[20]

At the same time that John Bird was laboriously making his hand divided sextants, another London instrument maker, Jesse Ramsden (1735-1800) put his mind to the problem of rapidly and accurately dividing instrument scales. It is said that Ramsden first had his attention drawn to the subject of dividing engines in 1760 by the reward which was presented by the Board of Longitude to John Bird for his method of dividing.[21] Ramsden made his first engine by 1768 but although it proved better than the results achieved by the ordinary dividing plate method it was not accurate enough for astronomical instruments.[22] However by June 1774 he had completed his second engine and had presented a memorial to the Board of Longitude. By May 1775 the Board had sought John Bird's opinion and he reported that he had found the divisions of the scale of a Hadley sextant divided by the new engine "...extremely exact...".[23]

On the 1st June 1775 Nevil Maskelyne and Professor Shepherd reported favourably to the Board on the dividing engine and as a result Ramsden was awarded the sum of £ 300 and allowed £ 315 for the engine. The dividing engine had become the Board's property but Ramsden was allowed the use of it provided he agreed to certain conditions.

He was to provide a "full and complete written explanation of his engine" and had to agree to instruct up to ten other mathematical instrument makers appointed by the Board how to make such a machine. In return Ramsden was to "...divide all octants and sextants by the said engine which shall be brought to him by any mathematical instrument makers... at the rate of 3 shillings for each octant and at the rate of six shillings for each brass sextant, with nonius divisions to half minutes".[24]

This resulted in a very profitable trade for Ramsden, as no retailer of octants and sextants could afford not to advertise that his instruments were engine divided. The octant and increasing sextant trade induced by the 'new' navigation, ably demonstrated by Captain Cook and others, was an important branch of many makers trades.[25] Both Ramsden's and the Troughton business sold about forty sextants each a year, quite a steady income at about £ 15 each in addition to the dividing trade.[26]

Obviously the other instrument makers were well aware of this and the competent ones quickly constructed their own engines, John Troughton in 1778 and his brother Edward an improved version in 1793.[27] John Stancliffe, one of Ramsden's workmen, is reputed to have made an engine about 1788 while still an apprentice, this engine later becoming the property of William Cary.[28] The importance of this rapid tooling up of

(Figure not reproduced)

Jesse Ramsden (1731-1800), a mezzotint by John Jones after Robert Home, about 1791. The original painting is in the Royal Society.

John Troughton's dividing engine, completed in 1778 after three years work. Courtesy of the Science Museum, London.

the instrument trade was well summed up un Rees *Cyclopaedia,* 1819. "Among all the improvements in chronometers and nautical instruments, that owed their origin during the last century to the munificent encouragement of the Honourable Board of Longitude there is none that has so much contributed to the interest of navigation, considered as a science as the engine [Ramsden's] to be described".[29]

Evidence of the value of this increasing trade is illustrated by the many instruments which survive bearing a dividing engine stamp, usually the Admiralty foul anchor with the initials of the owner of the dividing engine either side of it. The practice of stamping brass sextant scales was, understandably, short lived but octants were so marked at least until the demise of the Board of Longitude in 1828 and probably some time after this. Ramsden's mark has been found on instruments sold by Nairne &

A T

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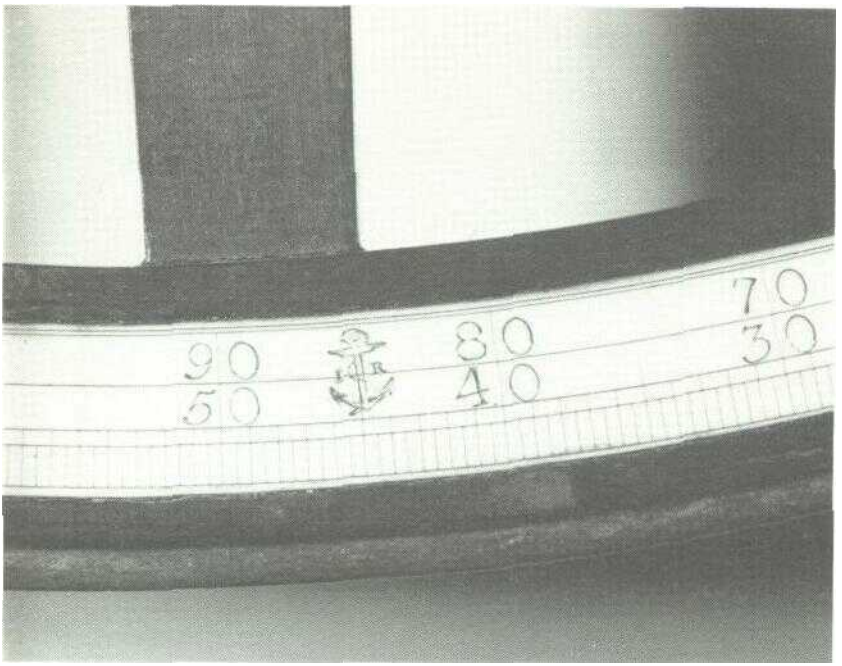
An advertisement from John Hamilton Moore's DAILY ASSISTANT, 2nd edition 1785. At this time only Ramsden's and John Troughton's dividing engines were in existence.

Blunt, Benjamin Martin, Adams, Watkins and others, while Troughton's mark is on the work of Ripley, Harris, Banks, Jones and many unsigned octants.

The scale marks of other engine dividers are included in an appendix to this paper and their diversity confirms the statement by Baxandall that "...there were in London in 1830 some ten or twelve circular dividing engines...".[30]

Ramsden, of course had further improved his position at the pinnacle of the London instrument-making trade by inventing by 1777 an engine for dividing straight lines. The Board was favourably impressed by this engine also and Ramsden was awarded a total of £ 400 on conditions similar to that for the circular engine.[31]



Ramsden's dividing engine scale stamp. This clear example is from an ebony framed sextant made by Nathaniel Worthington about 1850. (NMM reference: S. 287). Note the pointed crown of the anchor and the trend of the rope end.

Ramsden's business continued to flourish until his death in 1800 when the Board of Longitude had the thorny problem of what to do with two dividing engines. On 6th December 1800 the Minutes record that applications to use the engines were received from "...Mr Matthew Berge, S & W Jones and Mr Bennet...". They decided in favour of Matthew Berge "...who had been many years with Mr Ramsden and in the habit of using them and to whom the shop and business of Mr Ramsden devolves...".[32] Berge was to borrow the two engines under the same terms as Ramsden for the next nineteen years until his death in 1819. Ramsden's fame was such that Berge traded under the title of 'Berge late Ramsden' and marked all his instruments thus until almost the end of his life. He also continued the sequence of manufacturing serial numbers begun by Ramsden and stamped on each sextant, so that it is possible to see that the volume of this trade for Berge began to decline, perhaps the inevitable result of stiffer competition from the Troughton business and others.[33]

At Berge's death in 1819 the Board had once again to decide who should have the use of Ramsden's dividing engines A very businesslike request was received from Thomas Jones of 62 Channg Cross in November 1819 addressed to Dr Young, Secretary to the Board of Longitude which respectfully begged " that the Board of Longitude will be graciously pleased to Honor me with the Custody and use of the Circular and Right Line Engines for the public service on the same terms as granted to the Celebrated Inventor and the late Mr Berge" [14]

At the meeting of the Board in February 1820 it was resolved that "...Mr Ramsden's dividing engine for straight lines should be entrusted to Mr Jones for his use...", but the Committee found that the circular engine which they tested against several other engines now had a mean error amounting to 'near five seconds' It was resolved to leave its disposal for further consideration [35] Thomas Jones meanwhile carried off the straight line engine and had by 21 April 1820 drawn up a scale of charges for dividing for the Board's approval These varied from 3 shillings and six pence for Gunners calipers, five shillings for "Rules with brass edges" and ten shillings, the most expensive, for barometer scales for altitudes [36]

The Board meanwhile had very thorougly investigated methods for determining the errors of circular dividing engines, sparked to a certain extent by the persistence of James Allan Allan had corresponded with the Board as early as 1811 about the merits of his improved circular dividing engine for which he had received the gold medal from the Society of Arts the previous year A sub-committee of Captain Kater, Dr Wollaston and Mr Barrow with the assistance of William Gary (who had been trained by Ramsden) and a Mr Parsons, made a series of comparison tests between Ramsden's engine and those of Stancliffe and Allan.[37] They reported on 20th January 1820 that Allan's divisions had been "...somewhat more accurate..." than those made by Mr Parsons with Ramsden's engine As a consequence Allan was encouraged with a grant of £ 100 but does not appear to have capitalised on his invention. A letter in the *Mechanic's Magazine* dated 27 November 1824 replying to an enquiry for Allan and his dividing engine, is told "...that Mr Allan is dead and that his son has since sold it to Mr Cook, the optician of Wapping, but I do not know whether it is in use beyond Mr Cooke's own trade" This engine is now in the Science Museum, London [38]

Whether the errors in Ramsden's engine were eliminated during the trials of Allan's machine is unclear but something obviously prompted Nathaniel Worthington to write in March 1820 a petition to the Board couched in extremely humble terms requesting its use Worthington explained that he had served an apprenticeship of seven years to Berge "...during which time my sole occupation was the dividing of his

instruments and I was employed by him in the same branch of his business during four subsequent years." He also claimed since then to have divided several instruments tor the East India Company [39] The Board obviously reconsidered their earlier decision because in November 1821 the Secretary, Thomas Young, reported that Mr Worthington had "...signed the required acknowledgement and obligations respecting the circular dividing engine belonging to the Board."

Information on Ramsden's dividing engine now begins to be more difficult to come by The trade directories show that Worthington continued in business until 1852, first as Worthington & Allan between 1822 and 1832, and as plain Worthington from 1833 to 1852 He remained at 196 Piccadilly, three doors away from the old Ramsden and Berge premises, until 1850, when the business changed addresses three times in rapid succession, perhaps an indication of a failing firm [40]

That Worthington was Berge's successor there can be no doubt because Captain Kater writing in 1821 stated that Ramsden's brass standard yard had passed to Berge and on his death to his *successor* Mr Worthington [41] Whether the Allan of the partnership is the man who improved the dividing engine, James Allan, or his son, remains to be discovered It seems likely that Allan may have given Ramsden's engine, now fifty years old, a new lease of life and been taken into partnership as a consequence James Allan was dead by 1824, as we have seen, but Worthington perhaps did not bother to change his business name .for some years

Jesse Ramsden's famous dividing engine and the machine by which the endless screw and the teeth on the plate of the engine were cut are now in the Smithsoman Institution in Washington They were presented by Professor Henry Morton, President of the Stevens Institute of Technology, Hoboken, New Yersey, in March 1890 Morton, in his letter of presentation states that "... these machines were sold by the heirs of Ramsden to Messrs Knox & Sham of Philadelphia from whom I bought them about 10 years ago" [42]

It seems odd at first that these celebrated engines should have ended their working life on the other side of the Atlantic, particularly as they were presumably still the property of the Admiralty But it was at the time of Worthington's death in the 1850's that the American instrument making trade became less dependent on European imports and began to acquire the necessary skills to produce its own instruments The U S. Coast Survey already had a Troughton dividing engine while in Philadelphia William Young constructed a dividing engine on Ramsden's principles in the early 1830's[43] The need to keep abreast of the competition or be squeezed out of the market would be incentive enough for Knox & Sham to import a dividing engine, however old. The fact that Ramsden's

dividing engine continued in use until about 1880 and was copied so many times speaks volumes for the good sense of the Board of Longitude in encouraging Ramsden in the first place and insisting that the invention was published Machine dividing marked the beginning of the break-up of the many small instrument firms because it quickened up the process of scale dividing to an undreamed of extent and concentrated the trade in fewer, more efficient hands.

By the end of the 18th century the Board of Longitude had accumulated a considerable collection of instruments They had been involved in organising and equipping all the important voyages of exploration, the most celebrated of which were Captain Cook's two last voyages of 1772-1780, George Vancouver's surveys in the north-east Pacific of 1791-1795 and Matthew Flinders' exploration of Australia, 1801-1803

That comprehensive outfits of astronomical, navigational and surveying instruments were supplied, can readily be seen from the "Schedule of Mathematical, Optical and Astronomical Instruments put into the hands of Mr William Gooch going as astronomer to the North West Coast of America", i.e. to Join Vancouver[45] By the 19th century, inventory lists of instrument stocks show that many were either broken or required cleaning Reading between the lines, one gets the impression that the warehouse in Cathanne Street was not a particularly clean or orderly place The Board of Longitude had by this time fallen into disrepute so that there were many criticisms of its activities and its Commissioners, many of whom lived so far away that they did not bother to attend its meetings This air of inefficiency was highlighted by the way the new Astronomer Royal, John Pond, had allowed errors to creep into the *Nautical Almanac*[46] As a result, after much Parliamentary debate, a new Act was passed on 8th May 1818 redefining the objectives of the Board and appointing three salaried Resident Commissioners[47]

The Board continued to encourage new navigational inventions and projects but its prize awards were now directed towards finding the north-west passage and getting to the North Pole Despite this reorganisation and change of objectives, the Board of Longitude never again recovered its vitality and an Act was passed in 1828 to abolish it[48] The last recorded meeting of the Commissioners of Longitude was on the 5th June 1828 but there is no indication in the minutes of whether they knew that this was to be their final meeting

Upon the abolition of the Board of Longitude it was arranged that three scientific advisers to the Admiralty should be nominated, the selection being limited to the council of the Royal Society Michael Faraday, Thomas Young, and Edward Sabine were appointed, the latter not without a certain amount of acrimony[49] Edward Sabine (1788-1883)

was an officer in the Royal Artillery and a friend of Henry Kater His scientific interests had always taken precedence over his military career so that his early interest in magnetism led to his becoming a Fellow of the Royal Society by 1818 He participated in the flurry of exploratory voyages in search of the north-west Passage generated by the terms of the 1818 Longitude Act, having been astronomer with John Ross in ISABELLA in 1818 and later with Edward Parry in HECLA (1819-20).[50]

The winding up period took over a year to accomplish and Sabme, temporarily a Secretary to the Royal Society, during a break in his military servic, was prominent in organising the disposal of the Board's possessions It could have been no easy task because the instruments of the Board of Longitude and those of the Royal Society had long been thoroughly mixed up m their common warehouse in Cathanne Street Of the known surviving instruments of both organisations it is now in many cases impossible to distinguish their original owners. It seems that Sabine sorted the instruments as best he could and organised the transfer of the Board's collection to the Hydrographic Department of the Royal Navy.

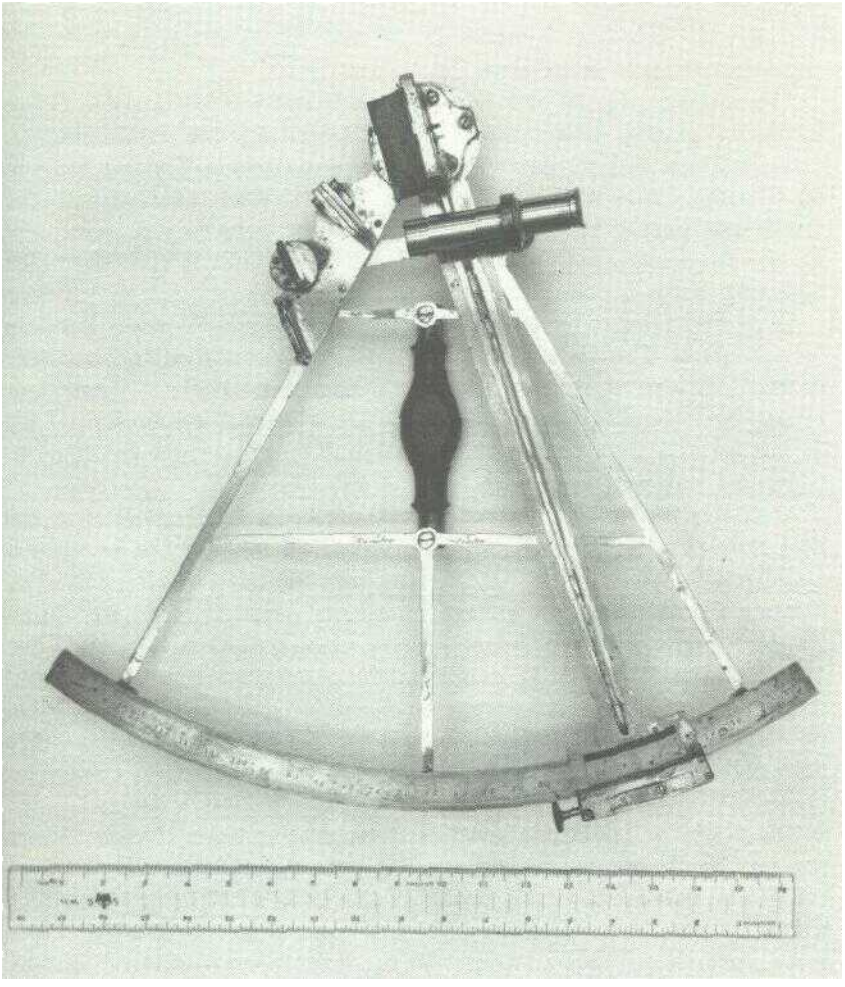
A letter survives from Captain Francis Beaufort, recently appointed to succeed Parry as Hydropgrapher, to Captain Edward Sabine dated 14th December 1829 which makes absolutely clear the final arrangements.

> "1 have spoken to their Ldships about the books, papers & instruments of the late Board ot Longitude They have permitted me to give you up the former to be kept at the Roval Societv but they wish that you should carefully catalogue them as belonging to the late Board of Longitude and therefore easily reclaimable by the Adm When necessary
>
> Their Lds entirely approve of your sending all your instruments to their office, and they beg thdt you will examine them with me when here — and at once separate the valuable part from the trash"

In february 1830 Beaufort wrote again to say that he had not yet had time "... to read the list of the Bd of Longitude Instruments, which were sent here" Unfortunately this list cannot now be found so that the composition of the collection of instruments transferred is not known. [51]

Just when Beaufort and Sabine met to separate the 'valuable part' from 'the trash' is not recorded but I suspect that much of the broken and obsolete material was thrown out at this time Beaufort was not a man to harbour rubbish Much of the'valuable part'still survives The Harnson and Kendall timekeepers are, of course, well known and many of the instruments taken on Captain James Cook's three voyages have been identified. These last have been summarised in a recent edition of *The Mariner's Mirror* by Derek Howse.[52]

That some of the older material was retained is amply illustrated by the recent surfacing in the sale rooms of two 15 inch sextants by Ramsden,



A 15 inch sextant by Jesse Ramsden, about 1772. The index arm is engraved 'D.32'. A Board of Longitude instrument used during Captain Cook's second and third voyages to the Pacific. It was transferred to the Hydrographic Department in 1829. (Private collection).

both of which were said to have Captain Cook associations. Establishing the provenance of this type of claim is invariably difficult but absolutely necessary to maintain their credibility. They are both of Ramsden's early pattern constructed with heavy, cast brass frames and incorporate the improvements described by Nevil Maskelyne in the 1774 edition (printed 1772) of the *Nautical Almanac.* They are not serial numbered by the

manufacturer, indicating a pre- Board of Longitude dividing engine date but they do bear the numbers D. 32 and D. 33 respectively, clearly engraved on their index arms.[53]

The numbers D. 32 and D. 33 are Admiralty Hydrographic Office inventory marks. This system first proposed by the Hydrographer, Captain Parry, in February 1828, was put into effect by Thomas Jones of 62 Charing Cross who had for some time repaired the Hydrographic Office instruments. Parry classified the instruments by type, sextants were D, and Jones engraved their class and inventory numbers upon them (See appendix B for a complete list of the class marks).[54]

D. 32 first came to recent notice in 1968 when it was in private hands in New Zealand. This owner had purchased it from another private owner in the U.K. who in turn had it from a dealer in the 1930's.[55] The sextant retains its original box (also marked D. 32), which has a manuscript label in the lid in a 19th century hand claiming "This sextant belonged to Captain Cook and went with him in DISCOVERY".

A similar instrument marked D. 33 was known to have been in the McLean Museum, Watt Institution, Greenock in 1937 but by 1969 it could not be found.[56] This instrument bore the label "Sextant used by Captain Cook during his voyage round the world in HMS RESOLUTION. Presented by Mr George Wilson, George Square, Greenock. Oct 1856". Similar Ramsden 15 inch sextants are known to have been carried in both of Cook's last two voyages and additional evidence is provided in the list of instruments prepared in 1771 for Cook's second voyage where there is itemised "2 brass Hadley's extants with Mr Maskelyne's improvements".[57]

The Board of Longitude inventories record two brass Hadley 15 inch sextants by Ramsden as early as 1779 while the 1785 inventory shows three. The third sextant was probably that owned by the Royal Society which by this date was sharing the Catharine Street warehouse. These three sextants continue to appear in the inventories to the end, usually described as "wanting cleaning" with the only break occurring when "An old Hadley's sextant by Ramsden, about 14 or 15 inch radius..." was lent to Lieutenant Dawes who sailed with the First Fleet to Australia in 1788. This was returned in 1794.[58]

That the Hydrographic Office was offered three old Ramsden sextants from the defunct Board of Longitude by Sabine, is not in dispute. That sextants, sixty years old, were not considered 'trash' by Beaufort, is possibly a tribute to Jesse Ramsden's reputation and workmanship and perhaps also to the esteem in which James Cook is held by all surveyors.

Evidence suggests that many more of the Board of Longitude's instruments continued to be used well into the 19th century, the Shelton regulators for example are still giving useful service today.[59] There is

much work still to be done to identify further instruments from this collection and who knows, perhaps one day John Bird's Mayer circle will turn up?

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2. *An Act for providing a Publick Reward for such Person or Persons as shall Discover the Longitude at Sea* 1714 Q Anne, cap 15.

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7. Board of Longitude, Confirmed Minutes **for 7 December** 1782.

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11. See Maskelyne, N *Tabulae motuum soils et lunae navae et correctae; auctore Tobiae Mayen* Londim 1770. pp CXI-CXVI.

12. Board of Longitude Confirmed Minutes for 5 September 1763.

13 Ibid. Confirmed Minutes for 3 November 1768. There are also bills from John Bird to the Board of Longitude "For a partial cleaning of a brass sextant to be sent on his Majs ship DOLPHIN ..." 5 shillings, dated 4 August 1766 and another dated 27 September 1766 for "Repairing a brass Sextant ..£ 2.18 0".(B of L Vol 5 12 December 1767).

14. Royal Society. Miscellaneous Manuscripts 7.13.

15. Ibid. MM 7 146

16. Ibid. MM 7 49

17. Board of Longitude. Letter from Captain Thomas Hurd RN to **Dr** Young, Secretary to the Board. Dated about 1805. (B of L Vol 12 (1) p 21).

18. NMM reference: 63-22/S. 225.

19. *Official Catalogue of the Royal United Service Museum,* RUSI, 1908, item 2662 "A large Brass Sextant, 20 in radius, attached to brass tube by universal joint and socket. It has two telescopes. Made by J Bird, London. Probably intended for horizontal angles".

20. A large 20.7 inch radius sextant by J Bird is in the Science Museum, South Kensmgton collections, reference 1908-159. It has a wooden frame, although the scale is divided on brass, and the frame is fitted for a similar pole support. This sextant is said to have belonged to Captain James Cook. A similar, but smaller instrument is displayed in the Rijksmuseum Nederlands Scheepvaart Museum, Amsterdam, See Moskowitz S *Historical Technology, Inc.* Catalogue 122. Fall 1981, pp. 39-40.

21. Watkins J. Elfreth "The Ramsden Dividing Engine", *The Smithsonian Report for 1S90.* Washington, 1891, p 732. See also John Smeaton "Observations on the

graduation of Astronomical Instruments " *Philosophical Transactions of the Royal Society* 1786

22 Rees *Cyclopædia* London 1819 Under "Graduation '

23 Board ot Longitude C onfirmed Minutes for 25 June 1774 and 27 May 1775 Vol 5(2)

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25 Finding a ship's longitude by either the lunar distance method or by chronorreter was now a practical proposition and the demand for octants and sextants increased

26 Stimson A N "The influence of the Rova! Observatory at Greenwich upon the design of 17th and 18th century Angle Measuring instruments at sea" *Vistas in Astronomy* 1976 Vol 20 pp 128 130

27 Baxandall D The Circular Dividing Engine of Edward Troughton, 1793" *Transactions of the Optical Society* Vol 25 3 1924 pp 136-138 Both engines are in the collections of the Science Museum South Kensington

28 Taylor E G R *The Mathematical Practitioners of Hanoverian England 1714-1840* Cambridge 1966 896 p 323 Alos a manuscript by Angus Thirl dated 24 October 1931 "Up to a few years ago there was a dividing engine at the works of the late firm of Cary Porter, with the name Stanforth (sic) and date 1791 this man like William Cary was an apprentice of Ramsdens" NMM Nav Pamphlet B 26

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31 Board of Longitude Confirmed Minutes for 7 June 1777 and 7 March 1778

32 Ibid Confirmed Minutes for 6 December 1800

33 Stimson A N *op cit , p* 128

34 Board of Longitude Letter from Thomas Jones dated 25 November 1819 (Bof L Vol 12 (2) p 139)

35 Board of Longitude Confirmed Minutes for 17 February 1820-

36 Ibid Letter from Thomas Jones dated 21 April 1820

37 Ibid Confirmed Minutes for 11 February 1819 and 2 March 1820

38 *Mechanic's Magazine* Vol 3 1825 p 172

39 Board of Longitude Letter from Nathaniel Worthington dated 3 March 1820 (B of L Vol 12 (2) p 140)

40 *Trade Directories* Guildhall Library London

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42 Letter to the Smithsonian Institution from Henry Morton, dated 14 March 1890 A copy of this letter was kindly supplied by Ms Carlene Stephens, National Museum of American History Washington DC USA

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44 Ramsden, Jesse *Description of an engine for dividing mathematical instruments* London 1777

45 Board of Longitude Vol 12 (1) p 155-156

46 Howse D "The British Board of Longitude" Unpublished paper read to the Bureau de Longitude, Pans June 1977 (NMM ref Nav **Hi** 39)

47 Act 58 George III cap XX

48 Act 9 George IV cap LXVI

49 *Dictionary of National Biography* London 1897 Charles Babbage violently attacked the appointment of Sabine to this post on the grounds that Sabine was an amateur scientist Babbage published a pamphlet generally denouncing the Royal Society entitled "Reflections on the Decline of Science in England and some of its causes", 1830

50 Ibid

51. Royal Society DM 4 128 and Hydrographic Department Letter Book No 2 p. 478. I am indebted to Lieutenant Commander A.C.F. David for these references.

52. Howse H.D. "The Principal Scientific Instruments Taken On Captain Cook's Voyages of Exploration 1768-80". *The Mariner's Mirror* Vol 65 No. 2 1979 pp. 119-135.

53. "D. 32" is privately owned in the UK. "D. 33" was purchased for the National Maritime Museum. NMM reference: N 82-12/S. 326.

54. Hydrographic Department Minute Book No. 1 p. 144.

55. See correspondence between E. Cheeseman and the Secretary for **the Society for** Nautical Research dated 14 May 1930. NMM reference: file X 82/059.

56. See correspondence between the curator of the McLean Museum **and the** National Maritime Museum dated 21 September 1937. NMM reference: file X 82/059. Also Angus C. "A Famous Sextant Maker". *The Nautical Magazine* May 1922.

57. Board of Longitude Vol 5 dated 28 November and 14 December 1771.

58. Ibid. Vol 5 1787.

59. Howse H.D. and Hutchinson B. "The Clocks and Watches of Captain James Cook 1769-1969". *Antiquarian Horology* 1969, pp. 62-76, 138-145, 190-205 and 270-288.

APPENDIX A

A preliminary survey of scale dividers marks

Scale dividing has always been a specialised skill within the generally unknown structure of the 18th and 19th century instrument trade. I suspect that there were also specialists in frame making, the casting of brass fittings and the optical parts. The products of these subcontractors were bought in, assembled and 'finished' by a number of instrument makers who then sold them under their own name or through other outlets.

After the introduction of Jesse Ramsden's dividing engine in 1774, the early, hand divided octants were quickly superseded by the engine divided examples. To show that they were enigine divided, and therefore superior, a mark was stamped on the centre of the scale. This mark, introduced by Jesse Ramsden, usually takes the form of an anchor (or 'foul' anchor) with initial letters either side, but plain monograms were introduced also as early as 1791 by Spencer, Browning & Rust. The anchor mark was probably made to indicate the use of a dividing engine copied from the Board of Longitude example designed and used by Jesse Ramsden and his successors, but there is no documentary evidence for this.

At first sextants and theodolites were also marked in this way but it was quickly realised that striking a finely divided brass or silver scale was not good for the instrument and perhaps introduced distortion errors.

It is not yet clear whether all makers owning dividing engines used one stamp for the whole of their output or whether some individual dividing engine operatives were allowed to 'sign' their work by stamping their own initials either side of the anchor. The practice of stamping the scale appears to have been common from the late 1770's through to the mid 19th century by which time all octant and sextant scales were machine divided and the mark served no useful purpose.

Ramsden was required by the Board of Longitude to publish a description of his engine and instruct up to ten other makers in its construction. Whether he instructed other makers is not recorded but the number of scale marks found confirms Edward Troughton's statement in Brewster's *Edinburgh Encyclopedia* of 1830 that there were in London at that time ten or twelve circular dividing engines. An added complication is that as their original owners died the engines passed into the hands of other makers who may have used a different stamp.

The table is composed in the main from information compiled from the instruments in the collection of the National Maritime Museum, the Peabody Museum, Salem, Mystic Seaport and from information kindly supplied by many correspondents. It has not been possible to examine all the marks under a microscope so that the exact form of the stamp is not known in every case. In addition wear and tear to the scale sometimes makes the identification of the initial letters uncertain.

Scale mark	Identity of user if known	Found on instrument by			Remarks
	Jesse Ramsden (1731-1800)	J Ramsden	octant	c. 1783	First dividing engine 1768
		G Adams	octant	c. 1780	Second dividing engine
		G Adams	sextant	c. 1790	1774. Now in the Smithsonian Institution, Washington D.C.
		J & L Hardy	octant		
	Matthew Berge (?-1819)	J Hamilton Moore Benjamin Martin	octant	c. 1790	Note the characteristic point on the crown of the anchor and the trend of the rope end.
			two octants	c. 1780*s	
	Nathaniel Worthington(fll810-1852)	Nairne& Blunt	sextant	c. 1780	
		Nairne & Blunt	theodolite		
		Watkins	octant		
		Worthington	sextant	c. 1850	
		Unsigned - two octants			

	Probably John Troughton (? -1784)	Banks octant c. 1800 Bradford octant c. 1810 Barry octant Brown, Bristol octant		Engine constructed 1778. Now in the Science Museum, South Kensington.
	Probably Edward Troughton (1763-1836)	Cary octant c. 1825 J Collwell, Liverpool octant W Harris octant c. 1810 HHughes octant c. 1820 T Jones, Liverpool octant c. 1850 Ripley&Son octant c. 1795 M WardeU & Son octant c. 1820 Wilkinson & Sons octant c. 1800 Unsigned — four octants —onesextant		Engine constructed 1793. Now in the Science Museum, South Kensington.
?	John Stancliffe (fl1770-1807)			Engine constructed by 1791. Passed to William Cary and his successors Cary Porter Ltd.
	Spencer Browning & Rust (c. 1783-c. 1862) also Spencer Browning & Co.	Found on all Spencer Browning & Rust and Spencer Browning & Co octants and wooden framed sextants. Alexander, Yarmouth octant c. 1790 Fairey octant c. 1790 Many unsigned octants		The mark is first found on an octant dated 1791. The firm continues into the 19th century as John Browning.
	Possibly 'Mr Parson' who with William Cary examined James Allan's and Ramsden's engines for the Board of Longitude in 1820	Cary octants — two c. 1800 Chavalier Guernsey octant c. 1780 Thomas Jones octant Parker octant George Richardson octant c. 1800 B Wood, Liverpool octant Unsigned - two octants		This stamp often looks as though it were  Note the trend of the rope end and lack of point on anchor crown.
	Possibly James Allan (fl 1790-1820)	Bate octant		Engine constructed by 1809. Sold by Allan's son to Cooke of Wapping, 1824. Now in the Science Museum, South Kensington.
	?	Richard Patten octant		

	?	Blunt octant c. 1815 Unsigned octant c. 1790		
	Dring & Fage	Dring & Fage octant c. 1800		
	Probably Dring & Fage	Unsigned — two octants c. 1795 c. 1830		
	?	Dring & Fage octant 248 Tooley St.		At this address 1800-1822.
	?	Unsigned - two octants		
	?	Unsigned octant c. 1790		
	Blatchford & Imray (1836-1840)	Blatchford & Imray octant c. 1840		This firm operated as a navigation warehouse and chart seller whose founder was John Hamilton Moore. It is likely they acquired an engine second-hand.
	?	Brokovski, Liverpool octant c. 1840 Christian, Liverpool octant Hughes octant c. 1835 Norie&Co octant c. 1830 B Wood, Liverpool — two octants c. 1860		
	?	Messer octant c. 1820		

APPENDIX B

Marking of instruments in the hydrographic office adopted from 23 february 1828

On 23 February 1828 Captain Parry, the Hydrographer, wrote a minute to the Secretary of the Admiralty proposing that the surveying instruments of the department, which had been held by Mr Thomas Jones, Optician of Charing Cross since 7 January 1826, should be returned to the Admiralty. Captain Parry also proposed that the instruments should be marked A, B, C etc. These proposals were adopted. The system of marking has been gleaned from an examination of the letters sent to Mr Jones over the next 7 years (see the early Letter Books for details). These letters give the number of individual items but not usually sufficient for identification.

Letter	Type(s) of Instrument
A	Perambulators; Transit instruments
B	Theodolites
C	Altitude and Azimuth instruments; circles
D	Sextants
E	Star quadrants
F	Artificial horizons
G	Telescopes
H	Steering Compasses: Gilbert's Azimuth Compasses; Boats Compasses: Water Compasses: Kater's Compasses
I	Horse shoe magnets; dipping needles
J	Not known
K	Spirit levels
L	Massey Sounding Machines; Logs; Measuring Chains and Tapes
M	Marine barometers
N	Various thermometers
0	Hygrometers
P	Water bottles
Q	Reading lamps
R	Beam Compasses; wooden, horn or brass protractors; cases of instruments; station pointers
S	Scales: parallel rulers; box scales
T	Six part plumes (?)

Information supplied by Lieutenant Commander A.C. F. David for the Hydrographer of the Navy, 21 October 1980.