Platinum and Palladium in Astronomy and Navigation

THE PIONEER WORK OF EDWARD TROUGHTON AND WILLIAM HYDE WOLLASTON

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Astronomy and navigation depend to a large extent on the ability to measure angular displacements with a high degree of accuracy, and since early times instrument makers have sought to improve the usefulness of their products by innovation. Shortly after ingots of malleable platinum and palladium became available commercially in England it was realised that these new metals had properties which were superior to those of silver, upon which the scales used for measuring angles were then engraved. The use made of platinum and palladium by one London firm of instrument makers in the first half of the nineteenth century is considered here.

The platinum that came to be used by makers of scientific instruments early in the 19th century had its origin in one of the Spanish colonies in South America, the Viceroyalty of New Granada. It occurred there as white metallic grains mixed with black magnetic sand and grains of gold, in alluvial deposits in the Chocó district of what is now the Republic of Colombia. The grains of both metals were rounded and of approximately the same size, the proportion of platinum present varying in different localities from one to four or even more ounces per pound of gold.

Grains of gold and those containing platinum were recovered together from alluvial deposits by washing, and the two kinds were then separated from each other by hand sorting, grain by grain. Any gold which still remained associated with platinum was then removed by amalgamation with mercury. No practical use was found during the greater part of the 18th century for these white metallic grains which, on the orders of the Spanish Government, were thrown into the Bogota river, that method of disposal being intended to prevent fraud which might otherwise occur by melting platinum-containing grains with gold (1).

One of the names applied in the gold mines of the Spanish West Indies to these white

William Hyde Wollaston
1766-1828

A sketch made by Francis Chantrey R.A., using the camera lucida. The device was invented by Wollaston in 1807 and soon came to be used widely as an aid to drawing

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metallic grains was "platina" and the name was accepted into the English language when samples were made available from Spam to interested persons in Europe In the year 1777, by which time European scientists believed that platina was a distinct metal, a Swedish chemist Torbern Bergman proposed that platina should be renamed platinum (2)

There appears to have been little support then for such a change of nomenclature, and it was not until early in the 19th century, when true platinum metal had been isolated from platina by chemical means, that the word platinum came to assume its current meaning

For some unknown reason several important British makers of scientific instruments still continued to use the word platina in preference to platinum until well into the 1840s, as will presently be made clear.

The Isolation of Platinum and Palladium

Ever since the 1750s chemists had been aware that grains of pure platina were in some small degree malleable, yet they could not be brought into fusion by the greatest heat attainable in ordinary furnaces The problem was finally resolved in a different manner during the first few years of the 19th century, when an informal partnership of two English chemists applied themselves to an analysis of crude platina

At that time it was common knowledge that when platina was dissolved in aqua regia there was always left a black insoluble residue The partners decided that one of them, William Hyde Wollaston, should investigate the soluble portion, leaving the other partner, Smithson Tennant (1761-1815), to concentrate his attention on the insoluble residue The mutual division of effort culminated in Wollaston discovering the presence of two new metals palladium in 1802 (3) and rhodium in 1804 (4) Tennant's discovery of another two new metals, indium and osmium, was announced in 1804 (5).

By the end of 1804 Wollaston had succeeded in isolating platinum by chemical means and in producing ingots of malleable metal large enough to be marketed commercially The method he used was kept a closely guarded secret and was not divulged by him until shortly before his death in 1828 (6) In brief, it consisted in adding ammonium chloride to the solution obtained by dissolving platina in aqua regia, thereby precipitating the platinum as chloroplatinate. Spongy metallic platinum was then obtained by carefully heating the precipitate, and it was then consolidated by compression, heating, and forging, to produce an ingot of malleable platinum.

Approximately three quarters of Wollaston's total output of malleable platinum was marketed for him commercially by William Cary (1759-1825), a mathematical instrument maker in the Strand, London (7) Some idea of the size of ingot that Wollaston was able to produce in those early days is to be seen in Wollaston's register of ingots sent to Cary, where one is noted as weighing just over 33 ounces troy (8).

Troughton's Association with Wollaston

Edward Troughton was the foremost maker of scientific instruments in Britain during the first quarter of the 19th century He made considerable improvements in many types of instruments used in astronomy, navigation and geodetic survey, and such was the excellence of his work that there was a great demand for his products from many parts of the world In 1826 Troughton took as his partner another and younger London instrument maker, William Simms (1793-1860), the name of the firm then being changed to Troughton & Simms (9) After the death of Troughton ten years later, the business was carried on by Simms, and the name of the firm remained unaltered until 1922 when, following a merger, the firm became known as Cooke, Troughton and Simms

One of the most important improvements Troughton introduced was a new method of dividing the arcs of astronomical and some other instruments, this was first used by him in 1785, and after he had given a description of the method to the Royal Society of London in

1809, the Society awarded him its Copley Medal (10).

Prior to Wollaston's isolation of platinum and palladium, instrument makers usually engraved the angular scales of sextants and similar instruments on a thin strip of silver laid in a groove cut in the brass frame to receive it. Silver has the unfortunate property of tarnishing and, if not cleaned, will eventually turn black in colour. However, repeated rubbing gradually wears away the silver, which is fairly soft, and in time the incised divisions become less and less distinct and may eventually be lost altogether. The alternative was to use a strip of gold, which does not tarnish but is far more expensive.

When Wollaston's malleable platinum became available Troughton realised that the metal had properties that would make it more suitable than silver for use as an inlay on which to engrave the angular scale of a sextant. It could take a fine polish, had a silvery appearance but did not tarnish, was dearer than silver but cheaper than gold, and was harder than both those metals (11).

Wollaston's record of his own income derived from chemical activities shows that in the year 1806 he supplied Troughton direct rather than through Cary with 48 oz 8 dwt of malleable platinum, at a cost of 15s. an ounce (12). Further supplies were obtained at intervals over the period from 1810 to 1820 inclusive (see Table), the final delivery being made only a few months before Wollaston gave up his refining process owing to the difficulty of obtaining supplies of crude platina from South America (13).

From an invoice preserved in Wollaston's

[Illustration not reproduced]

Edward Troughton
ca. 1753-1836

This marble bust of Troughton costing £105 was subscribed for by his friends and executed in 1825 by Francis Chantrey R.A. At Troughton's request it was placed in the Royal Observatory at Greenwich in 1834

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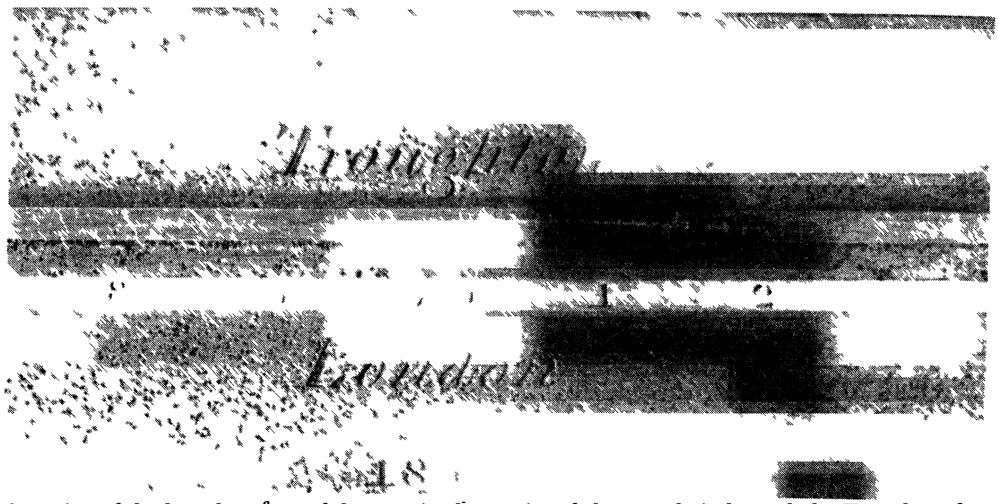
Wollaston's Sales of Malleable Platinum to Troughton

Date supplied	Troy Weight oz	dwt	gr	Cost £	s	d
8 Mar 1806	48	8	0	36	6	0
14 Jul 1810	14	2	0	10	11	6
11 Jan 1812 }	39	2	10	18	0	0*
16 Jun 1812 }				8	10	0*
17 Jul 1813	25	10	0	17	4	3*
6 Apr 1815	30	0	0	22	10	0
May 1816	28	6	0 }	43	2	6
Feb 1817	29	3	0 }			
21 Sep 1818	30	12	0	22	19	0
17 Jul 1820	21	5	0	15	18	9
Totals	266	8	10	£195	2	0

* A 10 per cent discount had been allowed by Wollaston off the usual price of 15s per ounce



A section of the broad surface of the exterior brass rim of the mural circle made by Troughton for the Royal Observatory at Greenwich The six-foot circle was mounted with its plane vertical, so Troughton's name was closest to the stone pier on which the circle was supported, next came the auropalladium inlay, and then the platinum inlay on which was engraved the figures that indicated the degrees. Furthest from the pier was the date when the circle was completed.

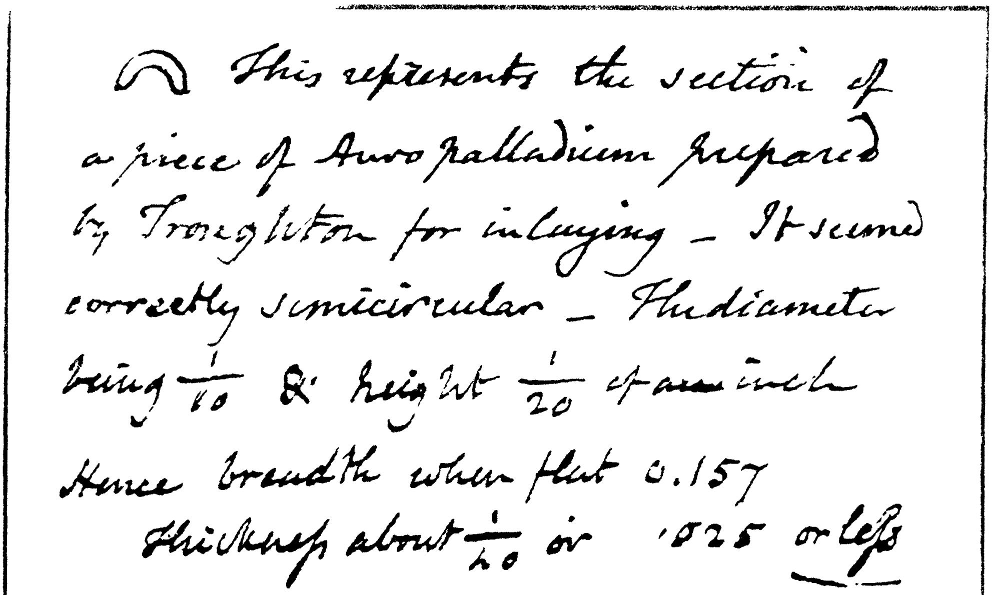
papers (14) we know that in August 1814 the price for gold purchased from a London gold and silver merchant was £4 8s an ounce, so Wollaston sold his platinum at less than one-fifth the price of an equivalent volume of gold

Troughton's Early Use of Platinum and Palladium

In the year 1806 the Royal Society appointed a committee to consider a recommendation from the fifth Astronomer Royal, Nevil Maskelyne, that the Observatory at Greenwich should be equipped with a new mural circle (15), to replace the mural quadrant that had been in use since 1768 but could no longer be trusted. A model of a proposed instrument which was designed to measure the polar distances of stars was shown to the committee by Troughton and in 1807 he received an order to make a circle of that type having a diameter not exceeding six feet (16). An order for the optical components of the instrument was placed with the firm of P & J Dollond (17), for Troughton suffered from colour blindness and on that account did not undertake optical work himself, usually sub contracting it to the firm of Dollond or to another named Tulley.

Troughton's design envisaged two metallic strips, each about 0.25 inch in width, laid in parallel channels cut about 0.25 inch apart in the broad outer surface of a brass ring which formed the outer edge of the circle. As constructed, one of the strips was engraved over its entire length with the integral figures from 1 to 360, spaced at positions corresponding to the relevant degrees of arc. The other strip was engraved with transverse lines corresponding to degrees, and each degree was further subdivided into twelve equal parts by shorter lines, to indicate five-second intervals. Mounted outside the circle and separate from it were six reading micrometer-microscopes, spaced at equal intervals around the periphery, so that it was possible for an astronomer carrying out observations with the mural circle to measure angles to an accuracy of less than one second of arc (18).

It was essential that these strips should have a bright or silvery appearance and would not tarnish on exposure to the atmosphere, and for advice on that subject Troughton may well have consulted Wollaston. The latter would have been aware of investigations carried out more than forty years earlier by William Lewis, who had found that an alloy obtained by fusing


This represents the section of a piece of Auro palladium prepared by Troughton for inlaying – It seemed correctly semicircular – The diameter being $\frac{1}{10}$ & height $\frac{1}{20}$ of an inch
Hence breadth when flat 0.157
Thickness about $\frac{1}{40}$ or .025 or less

Wollaston's note recording Troughton's method of preparing a flat strip of auropalladium intended to form an inlay for a mural circle. The cross-section of the strip was first made semicircular, and it was then laid in a channel cut to receive it in the brass frame of the instrument. It was fixed in place by hammering, and engraving was carried out after the surface of the inlay had been smoothed and polished

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twenty carats of gold with only four of platina proved to be pale in colour, "could scarcely be judged by the eye to contain any gold", and "hammered well into a pretty thin plate" (19).

For trial purposes Wollaston prepared sample specimens of a gold-platinum alloy, one containing 20 per cent and the other 25 per cent platinum, but it seems that neither specimen met Troughton's requirements and both were returned by him. Some years earlier Wollaston had melted six parts of gold with one part of palladium and obtained an alloy which was "nearly white" in colour (4), and this may have led him to try the effect of fusing gold with other proportions of palladium. A specimen containing 25 per cent palladium was found to be satisfactory; as Wollaston recorded in one of his notebooks, the alloy was "white & free as need to be" (20).

In the two years from May 1808 Wollaston provided a total of 9.5 ounces of this 4:1 specification of auropalladium (21), for which Troughton paid £48. 2s. 9d. Of that quantity some 6.6 ounces went to form only one of the strips of the Greenwich mural circle, namely that engraved with transverse incisions.

According to Wollaston the strip of auropalladium intended for use as an inlay was first formed semicircular in cross-section, and was then hammered into place in the channel cut to receive it (22). The dimensions as recorded by Wollaston would be inappropriate for the Greenwich mural circle, however, but might have applied to an inlay intended for a sextant.

Platinum was used for the other strip on which the figures 1 to 360 were engraved. On the assumption that both channels cut in the brass rim to receive the inlays were of the same depth, some 8 ounces of malleable platinum would have been required for that purpose; but at the price Wollaston was then charging for platinum, 15s. an ounce, the cost of such a strip would not have been much over £6. The great disparity in price between strips of these two

[Illustration not reproduced]

Part of the brass arch of a sextant of 10-inch radius, made by Edward Troughton about the year 1819. The scale is divided into degrees and minutes from —5 to +140 degrees, and by using the vernier provided it is possible to take readings to 10 seconds of arc. To indicate that the scale was divided on platinum, Troughton engraved the word Platina on the adjacent brass frame.

metals, around £25 say, may well have influenced Troughton in deciding to restrict the use of auropalladium to only one of the strips and to use platinum for the other.

Troughton's mural circle was completed in 1810, and after its installation at Greenwich it was in use from June 1812 until 1851. It is now to be seen in the Pond Gallery of the Old Royal Observatory at Greenwich, which forms part of the National Maritime Museum (23).

Troughton was not the only person to use auropalladium for a mural circle. In July 1819 Wollaston received a letter from François Arago informing him that the French instrument maker, Jean Nicolas Fortin, wanted a bulk of auropalladium equivalent to 190 grammes of silver, for use in the mural circle that he was making for the Paris Observatory. Wollaston calculated that 315 grammes of his auropalladium alloy would be required, and at the end of the month he sent 318 grammes (just over 10 25 ounces) to Arago (24). At the same time he provided a small piece prepared by Troughton for laying into a sextant, with the comment that any length of it could be laid at once into a groove cut to receive it and by hammering fixed in its place. Wollaston intimated that he would like to hear from Arago how work on the Paris mural circle was progressing, and expressed the hope that the alloy 'would be found to answer the expectations formed of its qualities.' Apparently he heard nothing (25).

Troughton's Sextants

The instruments used by astronomers, navigators, hydrographers and surveyors were of particular interest to Troughton, and catering for their needs constituted an important part of his business. In 1788 he patented an improved form of sextant having a double frame construction joined together by pillars (26); it achieved a useful reduction in weight yet without any sacrifice of rigidity, a considerable advantage where sextants of large radius (8 to 10 inches) were concerned. Such was the nature of Troughton's design that instruments of that pattern have since come to be known as pillar sextants.

None of Troughton's sextants constructed before 1788 earned a manufacturer's serial number, and this was still the case after that date in respect of his pocket sextants (radius about 3 inches). The practice of stamping a serial number on the frame of every one of his pillar sextants was introduced in or soon after 1788, and the numbering started then was carried on sequentially and without interruption after Simms became Troughton's partner in 1826, and was continued by the firm for many years after the death of Simms in 1860.

A study carried out a few years ago by Stimson has revealed documentary evidence which serves to establish the relevant dates when several Troughton sextants of known serial numbers came into, or were already in, use. From an analysis of that data Stimson was able to establish that Troughton's rate of production of the pillar sextant from 1788 onwards was fairly uniform and amounted to about forty-three a year (27).

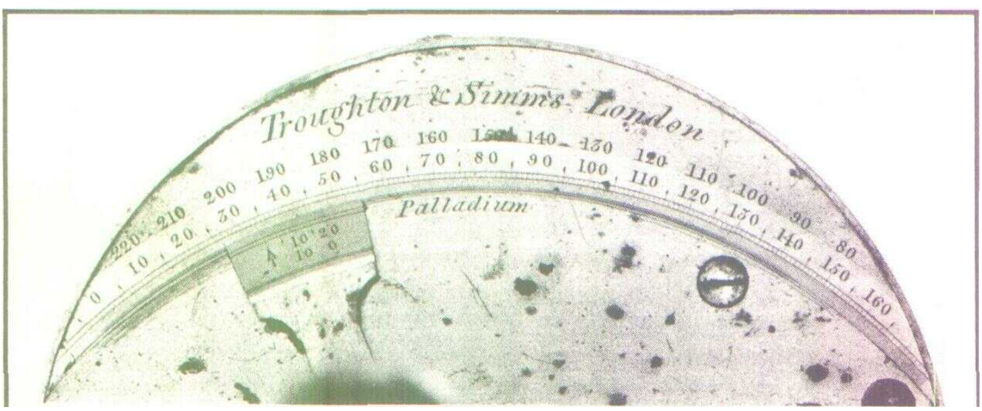
On that basis Troughton must have sold some seven hundred pillar sextants by the time he acquired his first stock of malleable platinum from Wollaston, and it is probable that a large majority of those instruments would have been provided with inlaid scales of silver, the remainder being of gold.

Following his introduction of platinum scales it would not have been possible to tell at a glance whether some of his sextants had a new or recently cleaned inlay of silver, as distinct from one of platinum. To remedy this situation Troughton had the word "Platina" or "Silver" engraved on the inner part of the brass arc frame supporting the engraved inlay. The name occupied an area equidistant from both ends of the divided scale, as appears in the reproduction of a portion of the brass arch of a Troughton 10-inch pillar sextant made about 1819 and now preserved in the Royal Museum of Scotland (28).

Examples of 8-inch pillar sextants bearing the inscription "Platina" are to be seen in museum collections in Britain: one made by Troughton around 1813 is in the National Maritime Museum, Greenwich (29); and another made about 1844 by Troughton & Simms is in the Royal Museum of Scotland (30).

Among the large collection of astronomical instruments assembled by a keen amateur astronomer, Richard Sheepshanks (31), after he had settled in London in 1824, was a 3-inch box sextant made by Troughton & Simms (32). The sextant is of some interest in that the scale was engraved on palladium. Nothing is known of its date of manufacture save that it must have been later than 1825. After the death of Sheepshanks in 1855 his sister presented all his astronomical and other scientific instruments to the Royal Astronomical Society (33), and the box sextant remained there until it was given to the Oxford Museum of the History of Science (34).

In addition to the examples already quoted, it is clear from notes set down by Wollaston in 1819 that at least two sextants made by Troughton had been provided with scales engraved on inlays of auropalladium (35). In one instance Troughton was said to have



The scale of a 3-inch radius box sextant made by Troughton & Simms probably in the late 1820s for Richard Sheepshanks, a keen amateur astronomer and great friend of Edward Troughton. The palladium inlay is divided to degrees and minutes, and by using the vernier shown it is possible to take readings to 10 seconds of arc.

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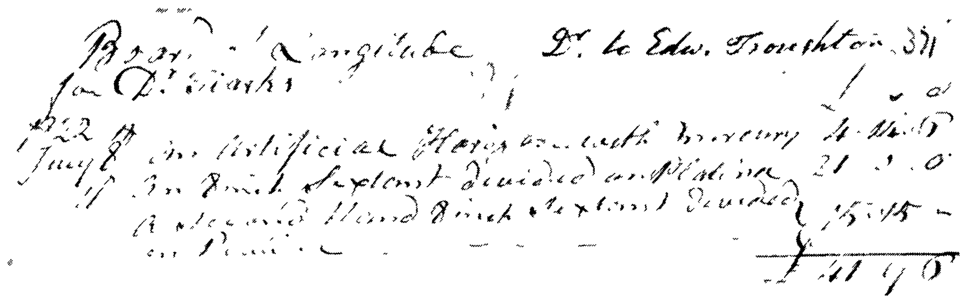
Board of Longitude Dr. to Edw. Troughton
for Dr. Tiarks
1822 July 8 An Artificial Horizon with mercury 4.14.6
An 8 inch Sextant divided on Platina 21.0.0
A second Hand 8 inch Sextant divided on Platina 15.15 -
£41 9 6

Edward Troughton's invoice for the supply to the Board of Longitude of an artificial horizon with mercury, and two 8-inch radius sextants, both described as having been divided on Platina. The instruments were issued to Dr. J. L. Tiarks for his use when determining the longitude of Funchal in the island of Madeira

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prepared a strip 9.8 inches in length and weighing 134 grains, ready for laying into a sextant; the dimension quoted leads one to believe that the inlay was intended for a sextant of 8-inch radius.

It is also evident from another note by Wollaston that he had been approached by Dollond regarding the supply of a strip of auropalladium 12.2 inches in length and 0.0375 inches in thickness, suitable for laying into a sextant (36). The length specified by Dollond suggests that he wanted the inlay for a sextant of 10-inch radius. Wollaston calculated that 280 grains of his auropalladium would be required for that purpose, and from the dimensions supplied by Dollond one can deduce that in this particular instance Wollaston adopted a figure of 17.2 for the density of the alloy that he intended using to meet Dollond's needs.

Wollaston did not indicate the thickness of inlay (about 0.04 inch) that Troughton used in his pillar sextants. However, Usselman has found by analysing original samples of Wollaston's platinum and palladium derived from crude platina, that a purity in excess of 99 per cent was attained for platinum but only 90 per cent for palladium (37). So by assuming a density for platinum of say 21.2, and taking Wollaston's own determination of 17.2 for auropalladium, the weight of platinum that would be required to replace the same bulk of auropalladium in a Troughton 8-inch sextant is about 167 grains.

On that basis one can say that the stocks of platinum that Troughton purchased from Wollaston over the years say from 1812 through to 1820 were more than enough to enable him to furnish his total output of sextants over that period with platinum inlays, should customer demand have made it desirable.

Once platinum was no longer available from Wollaston, it would have been necessary for Troughton to seek further supplies from abroad, perhaps from France. A note recorded by Wollaston in 1820 shows that Cary acquired some platinum ingots from the firm Cuoq, Couturier et Cie., in Paris; the price charged was equivalent to 16s. 1d. an ounce, of which 1s. 10d. covered freight charges (38).

Sextant Prices

Troughton produced a printed catalogue in 1782 (39) and so far as is known he issued no more catalogues during the next forty-three years (40). During that period he never lacked for work and may well have felt that there was no need for him to produce a catalogue in order to advertise his wares. However, the price of a Troughton 8-inch sextant divided on platinum is known from an invoice sent to the Secretary of the Board of Longitude in July 1822 and preserved with the Board's papers. Two such sextants were provided, only one of which was new and priced at £21; the second-hand instrument cost five guineas less (41).

Both sextants were delivered to an astronomer, Dr. John Lewis Tiarks (42), who was sent by the Board on a mission to ascertain "with the greatest possible accuracy the longitude of Funchal'' on the island of Madeira (43). This action was made necessary after the sixth Astronomer Royal, John Pond, stated his belief that the longitude of the island, as then known to mariners, was in error (44). A new value for the longitude of Funchal was subsequently reported by Tiarks and was published by the Royal Society (45).

It may have been the influence of Simms after he became Troughton's partner that brought about a change of outlook by the firm regarding the need for a printed catalogue. In 1829 the editor of the *Astronomischen Nachrichten* must have had access to a copy of a Troughton & Simms catalogue, for he printed the details in a supplement to the December issue of that journal (46). It would seem that the catalogue in its original form would have been five pages in length.

Only one other separate catalogue is known to have been produced by the firm before the 1880s. It is an eight-page undated document, and is preserved with the papers of George Biddell Airy, the seventh Astronomer Royal (47). Some guide as to its approximate date can be derived from the document itself and indicates that the catalogue could not have been printed before September 1838, and probably no later than 1841.

The prices given in that catalogue and relating to the firm's 8-inch improved sextants with double frames are as follows

Divided on Silver to 10 seconds	£18	18s
Divided on Platina or Palladium	£21	0s
Divided on Gold	£23	2s

These same prices are present in all copies of the firm's catalogues that are present as end-papers to a book written by Frederick Walter Simms, the first edition of which appeared in 1834 (48), and in at least six of the seven later editions of the work that appeared over the next thirty-one years. No copy of the 5th edition has been located. Finally, there is another catalogue at the end of a book published in 1852 by William Simms (49).

A comparison of all the relevant catalogue entries dealing with the firm's sextants shows that the option of acquiring a sextant divided on palladium was not present in the catalogue reproduced in 1829, nor in any of the catalogues printed from 1844 onwards, but it does appear in all the firm's catalogues published from 1832 to 1838 inclusive.

As no catalogue listed auropalladium scales as an option, one may wonder whether the box sextant mentioned above as having been made for Sheepshanks is a unique example.

Some Followers of Troughton

Several well-known makers of sextants appear to have followed Troughton's practice of using the word platina to indicate that a scale was divided on platinum metal. The earliest example seen so far is in an advertisement present at the end of a work written for use by pupils at Oundle School under the patronage of the Grocers' Company of London (50). It carries "A list of such Instruments, as are requisite for the Young Surveyor, or Student in Mathematics, made at the lowest Prices, by R Banks, 441, Strand, London". The final entry on that list reads

> "A 3-inch Pocket Sextant, with recent improvements, the divisions on brass, silver, platina, or gold, to one minute, a most accurate, portable, and useful Instrument"

The price-range was from three to four guineas. No extant example of such a Banks sextant divided on platinum has yet been located.

Aberdeen University has an invoice dated 2nd May 1812 for the supply to Manshall College in Scotland by William Cary, of 182, near Norfolk Street, Strand, London, of a 10-inch reflecting circle costing £18 18s (51). A College inventory drawn up in 1823 describes the circle as having a "platina arch" (52).

In the collection of instruments preserved at the Italian Istituto Geografico Militare, in Florence (53), there is a sextant with the word "Platina" engraved close to and on one side of the divided scale, on the other side the maker's name is engraved "J D Potter, Poultry". From London trade directories we know that John Dennett Potter was the successor of another notable instrument maker at that address, namely Robert Brettell Bate who died in 1847.

As a final example, one may cite an 8-inch brass pillar sextant engraved "Lilley & Son, London" which has an inset platinum arc, and is labelled ''Platina'' (54). London trade directories indicate that John Lilley did not take his son into partnership until around 1845.

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52 Ibid Knight MS M 119

53 Address Via C Battisti 10, Firenze, Italy

54 D Coffeen Tesseract Catalogue B Early Scientific Instruments Hastings on Hudson New York, 1982, item 34