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ORIGINAL PAPER

Delayed progress in navigation: the introduction of line of position navigation in Germany and Austria

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Abstract In 1843 the American sea captain Thomas H. Sumner published a small book on a new navigation technique, which forms the basis of celestial navigation until present time. Sumner's line of position navigation was adopted immediately in the US Navy and also accepted readily in the Royal Navy. But its introduction in Germany took well over six decades—at least, so far the merchant navy is concerned. In contrast, the German Imperial Navy incorporated state-of-the-art nautical techniques from its very beginning. In Austria Sumner's method found a dedicated advocate in Eugen Gelcich, a deserving supervisor and reformer of nautical education in the Austro-Hungarian Empire.

Keywords Line of position · History · Navigation · Sumner · Marcq Saint–Hilaire

Mathematics Subject Classification (2000) 01-XX

1 Public tribute to a new method of navigation

In 1903–1905 a new building for the navigation school of Hamburg designed by Albert Erbe (1868–1922) was erected in the style of the Dutch Renaissance (Erbe 1906; Mosel 2006). The building survived the devastating bombing of Hamburg during Second World War and since 1946 it houses the German Maritime Meteorological Service. On stone cartouches the names of the heroes who unfolded the art of navigation were

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Fig. 1 Navigation school of Hamburg, 1903/1905 (contemporary postcard)

immortalized (Figs. 1, 2): Flavio Gioja, (the legendary inventor of the mariner's compass), Mercator, Hadley, Harrison, Friedrich Bolte (then director of the school), Maury and Thomas Hubbard Sumner (1807–1876), the American captain who had published his *New and Accurate Method of Finding a Ship's Position at Sea by Projection on Mercator's Chart* in 1843 (reprinted in Vanvaerenbergh and Ifland 2003). The method in its amplified and improved form published by Marcq de Blond de Saint-Hilaire (1832–1889) in 1873–1875 (Saint-Hilaire 1873, 1875; reprinted in Vanvaerenbergh and Ifland 2003) finally had found its way into the curriculum for prospective German navigators. This incidence happened almost simultaneously to the erection of the building: In 1904 the "New Navigation" had been introduced in German navigation schools officially (Schilling and Meldau 1912, 75), and shortly before the Royal Prussian Headmasters of navigation schools Heinrich Adolf Jungclaus (1838–1903), Gustav Holz (1845–1922) and Wendtlandt had agreed upon writing a treatise on Saint-Hilaire's method, which should be included in the 7th edition of the textbook by Albrecht and Vierow used in the navigation schools of Prussia to be printed in 1899. The treatise was composed by Holz and submitted to the Prussian Ministry for Trade and Commerce in May 1899 (Berlin, Geh. Preuß. Staatsarchiv PK, I. HA Rep. 120 MfHuG C XVII 3 Nr. 26, vol. 5, fol. 103r–123r). In the same year an entirely revised edition of the textbook used in Hamburg [which had been written originally by Reinhard Woltman (1757–1837) and Ernst Wilhelm Schuback (1798–?) in 1819 and edited by Charles Rümker from 1844 onwards] had appeared. This new version (Bolte 1899) had been compiled by Friedrich Gerhard Bolte (1860–1940), who had studied mathematics, astronomy and natural sciences in Marburg, Berlin, Göttingen und Bonn and was appointed as director of the Hamburg navigation school in 1901 (Steppes 1940). Bolte was an assiduous advocate of line of position navigation (Fig. 3). He had published a study on the practical application of Sumner's method already in 1894, in which he remarked

Fig. 2 Stone cartouches on the frontage (author)

Fig. 3 Portrait Friedrich Bolte [*Festschrift zum 200jährigen Bestehen der Hamburgischen Seefahrtschule*. Hamburg (1949)]

regretfully: "It is a remarkable fact that the simple and transparent method of Sumners' position lines did not find its way into the questions of nautical examinations up to now" (*Es ist eine auffallende Thatsache, dass die einfache und durchsichtige Methode der Sumner'schen Standlinien bis jetzt in die obligatorischen Prüfungsaufgaben der nautischen Prüfungen keinen Eingang gefunden hat;* Bolte 1894, 1). In his textbook Bolte treated St. Hilaires's method extensively. But all this happened well over half a century later after Sumner had published his basic discovery in 1843, which was the result of an accidental observation made 6 years before.

2 The discovery of line of position navigation

When Sumner was sailing from Charleston, South Carolina, bound for Greenock, Scotland into the entrance of St. George's channel between England and Ireland under unfavourable weather conditions on 17 December 1837, observations had been impossible for days, and the ship's position was only known approximately by dead reckoning. In the forenoon the sun appeared through a break in the clouds, and Sumner hastily took an altitude. He used his dead reckoning latitude for calculating longitude, which placed him farther east than expected. With a shore in close proximity, and, being unsecure about the accuracy of his observation, Sumner calculated possible positions of his ship with three assumed latitudes. Figure 4 When plotting these on his Mercator chart he noticed that they all laid on a straight line. In Sumner's own words, the discovery took place in this manner: "*Having sailed from Charleston, S.*[outh] *C.*[arolina], *25th November, 1837, bound to Greenock, a series of heavy gales from the westward promised a quick passage; after passing the Azores, the wind prevailed from the southward, with thick weather; after passing longitude* 21° *W., no observation was had until near the land; but soundings were had not far, as was supposed, from the edge of the bank. The weather was now more boisterous, and very thick; and the wind still southerly; arriving about midnight, 17th December, within 40 miles, by dead reckoning, of Tuskar light; the wind hauled S.E., true, making the Irish coast a lee shore; the ship was then kept close to the wind, and several tacks made to preserve her position as nearly as possible until daylight; when nothing being in sight, she was kept on E.N.E. under short sail, with heavy gales; at about 10, A.M. an altitude of the sun was observed,*

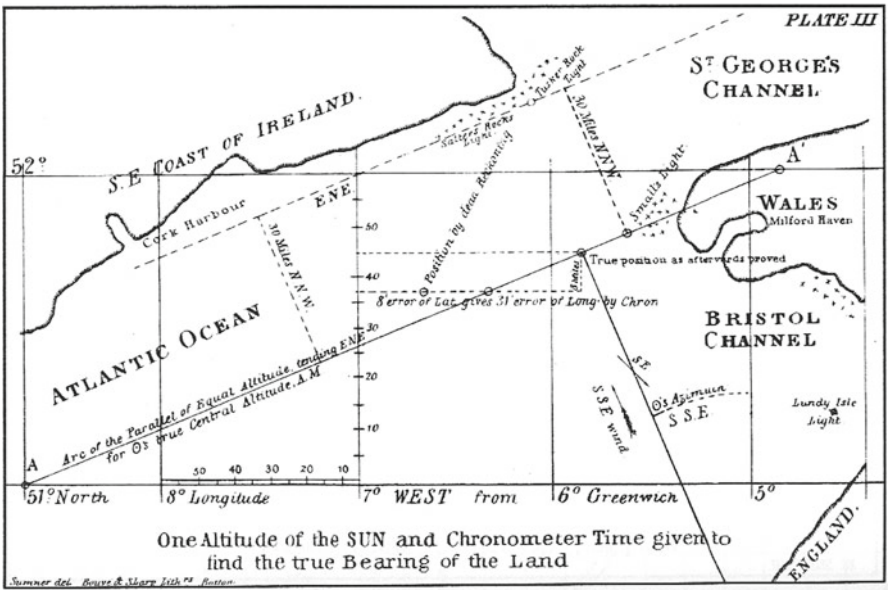


Fig. 4 Plate III from Sumner's *A new and accurate method of finding a ship's position at sea*, Boston (1843)

and the chronometer time noted; but, having run so far without any observation, it was plain the latitude by dead reckoning was liable to error, and could not be entirely relied on. Using, however, this latitude, in finding the longitude by chronometer, it was found to put the ship 15′ of longitude E. from her position by dead reckoning; which in latitude 52° N. is 9 nautical miles; this seemed to agree tolerably well with the dead reckoning; but feeling doubtful of the latitude, the observation was tried with a latitude 10′ further N., finding this placed the ship E.N.E. 27 nautical miles, of the former position, it was tried again with a latitude 20′ N. of the dead reckoning; this also placed the ship still further E.N.E., and still 27 nautical miles further; these three positions were then seen to lie in the direction of Small's light. It then at once appeared that the observed altitude must have happened at all the three points, and at Small's light, and at the ship, at the same instant of time; and it followed, that Small's light must bear E.N.E., if the chronometer was right. Having been convinced of this truth, the ship was kept on her course, E.N.E., the wind being still S.E., and in less than an hour, Small's light was made bearing E.N.E. 1/2 E., and close aboard." (Sumner 1851, 48–49).

Most certainly he was not the first sailor who had noticed such an occurrence—it has been stated, that line of position navigation had been practised by officers of the Royal Navy under the name of "Cross Bearings" before (Martin 1888, 322; no sources for this statement are given, however)—but Sumner, who had studied mathematics and astronomy and graduated at Harvard in 1826 (Richardson 1946) drew the correct conclusions by clever reasoning and recognized the importance of his observation immediately: The ship's position must have been on a line of equal altitude of the sun for the given time, and this line formed but a small part of a great circle projected on the earth, which has its centre directly below the sun. Thus, the sun's azimuth will be perpendicular to the tangent of the circle at the point of observation. Because of the immense radius of the sun's circle a short segment of it could fairly assumed being straight. The fact, that a single observation of a celestial body defined a line on which the observer must be located somewhere, enabled him to set the correct course: His position line pointed E.N.E directly to Small's lighthouse on the Welsh coast, and steering the ship on this course he in fact sighted it a short time later.

The Sumner method requires the solution of two time sights to obtain a line of position. Many older navigators preferred not to draw lines on their charts, but to fix their position mathematically by a method which Sumner had also devised and included in his book (later called "Double Altitude"): If another observation of the same celestial body would be taken after an appreciable change in azimuth, two lines of position could be laid off to obtain a fix. The mathematical procedure devised by Sumner was extremely cumbersome and involved an immense amount of logarithmical calculations, however. Sumner published his findings in a small booklet issued first 1843 in Boston (Sumner 1843; for a comprehensive, still unsurpassed survey of the history of the "Double Altitude Problem" see Weyer 1884/1885).

3 The reception of Sumner's method

The discovery of the line of position was rightly called *"the commencement of a new era in practical navigation"* by Matthew Fontaine Maury (1806–1873) and forms

the basis of celestial navigation until present time. Sumner's method was adopted immediately in the U.S. Navy and also accepted readily in the Royal Navy. Henry Raper (1799–1859), a British Royal Naval lieutenant who became a nineteenth-century authority on navigation, commented very favourably on it: *"This method consists in a new use or application of a single altitude observed for the longitude by chronometer, and as the solution is highly ingenious, and very useful when the ship is near the land, it will be rendering a service to our seamen, few of whom can yet have heard of it, to make it known to them in the pages of the Nautical Magazine.* [. . .]*As the method arises out of the employment of the chronometer, it may be said greatly to enhance the utility of that instrument"* (Raper 1844 [1], 205, 207). He also included Sumner's method in the third edition of his nautical textbook, for which he was awarded the Founder's Medal of the Royal Geographical Society in 1841 (Raper 1849, 345–347).

Knowledge about the new method soon spread to the continent; already in 1847 an abstract was published in France (Barthet 1847). It became also known in Denmark very soon; Raper's paper of 1844 was published in Danish in the same year (Raper 1844 [2]), Frederik August Paludan (1792–1872), Georg Emil (1814–1885) and Johan Cornelius Tuxen (1820–1883), all officers in the Danish Navy (Topsøe-Jensen and Marquard 1935, II, 292–293; 638–640) included Sumner's method in their nautical textbooks (Paludan 1852, 148–160; Tuxen and Tuxen 1858, 331–344), and Lieutenant commander Stephan Middelboe (1802–1856; Topsøe-Jensen and Marquard 1935, II, 190–191), navigation examiner in Tönning and Flensburg, characterized it as *"Sumners Theorem"* in his handbook for navigators (Middelboe 1854, 139–141).

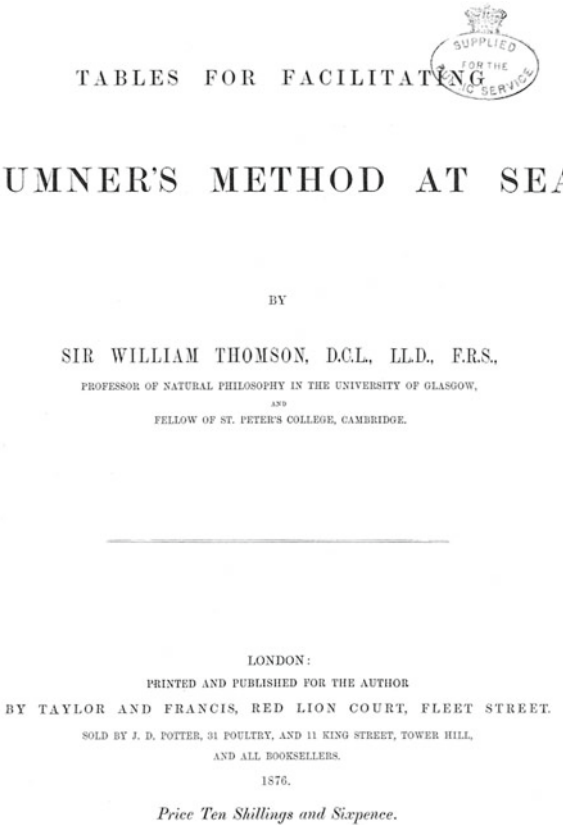
The reception of Sumner's method in the mercantile marines of England and the Netherlands took a much slower pace—only in 1878 it was introduced in the examinations in England (Anon. 1882, 512). The first Dutch navigation textbook treating Sumner's method appeared in 1882 (Brouwer 1880/1882, II, 305–307, 384–427; see also Crone 1970, 392–386), and 4 years later a Royal order was issued to include it in the examinations of helmsmen (Cornelis 1918, 86).

Sumner's method became also known in German territories: The astronomer Charles Rümker (1788–1862) had mentioned it in the 6th edition of the textbook used in the navigation school of Hamburg (Rümker 1857, 250–251), and the method was described in an appendix to the second edition of the nautical textbook by Michael Friedrich Albrecht (1811–1883) and C. S. Vierow used in Prussia (Albrecht and Vierow 1857, 635–644). There was also a German and Dutch translation of Sumner's treatise available by a certain Henry A. Tobiesen (Tobiesen 1855, 1856; Crone 1970, 352 was not aware of its author). Notwithstanding this reception the situation in Germany was different, however. Two of the most eminent German teachers of navigation, Wilhelm v. Freeden (1822–1894) and Arthur Breusing (1818–1892), ignored Sumner's method (Fig. 5, 6). This was certainly not due to poor competence and professional experience, since both had received a sound academic training: Breusing studied 1838–1843 in Bonn, Berlin, and Göttingen (Gelcich 1893; Schilling 1896), and v. Freeden 1841–44 also in Bonn and Göttingen (Oestmann 2007), where they attended *inter alia* the lectures of Carl Friedrich Gauß. In 1889 Breusing was elected corresponding member of the Academy of Sciences of Göttingen. But when v. Freeden published his textbook (Freeden 1864) he did not mention Sumner at all, and in his acclaimed textbook *Steuermannskunst*, which was a didactical masterpiece and marked a notable advancement

Fig. 5 Portrait Arthur Breusing [*Deutsche Rundschau für Geographie und Statistik*, 15, 231 (1893)]

Fig. 6 Portrait Wilhelm v. Freeden [Oldenburgische Landschaft and Freunde der Seefahrtschule Elsfleth e.V. (eds.), *„Sehr zweckmäßig": Navigationsschule - Seefahrtschule–Fachbereich Seefahrt in Elsfleth 1832–2007* Oldenburg (2007), 42]

in nautical teaching, Breusing only remarked: "Sumner has made a very ingenious, although for practice quite worthless use of Mercator's map"(*Einen sehr sinnreichen, wenn auch für die Ausübung ziemlich werthlosen Gebrauch von der Mercatorschen*


TABLES FOR FACILITATING

SUMNER'S METHOD AT SEA.

BY

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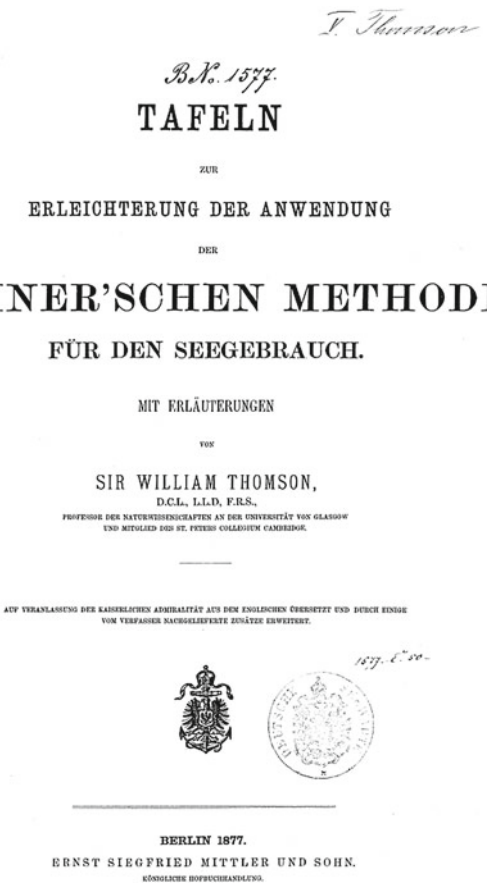
AND ALL BOOKSELLERS.

1876.

Price Ten Shillings and Sixpence.

Fig. 7 William Thomson, *Tables for Facilitating Sumner's Methods at Sea*, Frontispiece (Greenwich, National Maritime Museum)

Karte hat Sumner gemacht; Breusing 1857, 286–287). This statement was repeated in all subsequent editions. In the 6th edition published in 1890 shortly before his death Breusing alleviated his valuation to a certain degree and deleted the expression "for practical exercises worthless use", but added: "At all, one must not believe that one could solve an exercise more correctly by drawing, than by calculation" (*Überhaupt darf man nicht glauben, daß man eine Aufgabe durch Zeichnung richtiger lösen könnte, als durch Rechnung*; Breusing 1890, 386). It is difficult understanding the reasons for his negative assessment, because Breusing was a very competent and knowledgeable teacher, who had even travelled in England to become acquainted with the state-of-the-art of nautical education and the relevant literature (see his account *Zur Reorganisation der Navigationsschule* of 1852; Bremen, State Archive: 2-R.11.h.7.a, No. 42). So the often cited conservatism of navigators cannot be accounted for it. He obviously distrusted graphical solutions of mathematical problems principally. At any rate Breusing seemed not to be aware of the potential of Sumner's method. He was a distinctive character among German navigation teachers arguing vigorously and did not shy away from intimidating polemics against colleagues. Breusing's textbook was widespread and well-known, so his negative attitude may have accounted


W. Thomson

B.N. 1577.

TAFELN

ZUR

ERLEICHTERUNG DER ANWENDUNG

DER

SUMNER'SCHEN METHODE

FÜR DEN SEEGEBRAUCH.

MIT ERLÄUTERUNGEN

VON

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UND MITGLIED DES ST. PETERS COLLEGIUM CAMBRIDGE.

AUF VERANLASSUNG DER KAISERLICHEN ADMIRALITÄT AUS DEM ENGLISCHEN ÜBERSETZT UND DURCH EINIGE VOM VERFASSER NACHGELIEFERTE ZUSÄTZE ERWEITERT.

1877. C 88.

BERLIN 1877.

ERNST SIEGFRIED MITTLER UND SOHN.

KÖNIGLICHE HOFBUCHHANDLUNG.

Fig. 8 William Thomson, *Tafeln zur Erleichterung der Anwendung der Sumner'schen Methoden für den Seegebrauch*, Frontispiece (Hamburg, Bundesamt für Seeschiffahrt und Hydrographie)

at least partially for the hesitant adoption of line of position navigation in the German mercantile marine. Thus the reception of Sumner's method was impeded by certain obstacles, but it took quite another way in the German Imperial Navy, which was built up after the Reich had been newly founded after the victorious war against France in 1871.

In 1876 Sir William Thomson (later Lord Kelvin, 1824–1907) published his *Tables for Facilitating Sumner's Methods at Sea* (Thomson 1876; Fig. 7). According to his own account Thomson was introduced to 'Sumner Lines' by Captain Henry Augustus Moriarty (1815–1906) on board H.M.S. *Agamemnon* lent by the Admiralty to lay the first Atlantic telegraph cable in 1858, and Thomson held Sumner's method in high esteem. The short-method table proposed by him was designed to bring Sumner's method into more general use. Thomson's rules were too complex however, and therefore his tables did not become popular, but they formed the starting point for a spate of 'short-method' tables in the following decades, which enabled the navigator to obtain a heavenly body's true bearing by simple inspection instead by tedious calculations

(Cotter 1974, 487–496). Nonetheless Thomson's tables were published at the instigation of the Imperial Admiralty in German translation only 1 year after its original publication (Thomson 1877) (Fig. 8), and in 1879 a manual for instruction in navigation was issued by the Hydrographic Office of the Prussian Ministry of Naval Affairs. Its subheading promised a consideration of the newest techniques for ascertaining geographical coordinates, and thus a thorough treatment of both Sumner's and St. Hilaire's method was offered (Handbuch der Navigation 1879, 293–304, § 102). It is yet unknown who the authors of the book were, and no relevant archival records could be found so far. In adopting modern techniques of navigation the German Imperial Navy was obviously far ahead of the mercantile marine from its very beginning.

In Austria Sumner's method found a dedicated advocate in Eugen Gelcich (1854–1915), Austrian professor at the navigation school of Cattaro (Kotor on the Dalmatian coast). In 1881 he was appointed as director of the nautical school in Lussinpiccolo and in 1895 he assumed control of the nautical section of the Commercial and Nautical Academy in Triest (Anon. 1915/1916). Gelcich was recognized as a deserving supervisor and reformer of nautical education in the Austro-Hungarian Empire, and when he revised the third edition of a textbook on nautical astronomy for the Austrian Navy he included Sumner's method (*Die Sumnerische Positionsbestimmung*; Schaub 1878, 155–161). In an extensive paper he argued vigorously for the "New Navigation", although he did not discard older navigation techniques (Gelcich 1892; see also Gelcich 1878, 1889).

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