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AN ANONYMOUS OTTOMAN COMPENDIUM ON NAUTICAL INSTRUMENTS AND NAVIGATION: *KİTÂBÜ'L-MÜRÛRİ'L-UBÛR FÎ İLMİ'L-BERRİ VE'L-BUHÛR*

Abstract: *The number of historical studies investigating the art of navigation in the Ottoman Empire is rather limited. The accepted opinion is that the Ottomans who mostly sailed in the Mediterranean made only use of the compass and the map in navigation. The use of these tools alone, however, does not indicate how did Ottoman seamen find out the latitude, determine the time, made use of the meteorological information and most importantly, which other instruments did they refer to in navigation. An anonymous Ottoman compendium on nautical instruments and navigation, namely the Kitâbü'l-mürûri'l-ubûr fi ilmi'l-berri ve'l buhur (A book for navigating with the science of lands and seas) helps to provide the answers to the following questions. Which methods did the Ottomans use while sailing at sea? How did they detect the position of the ship and its directions? Which tools did they use? How and when new techniques and instruments were elaborated or introduced? The above mentioned compendium which was probably compiled for the training of Ottoman military and/or naval engineers sheds light on the modernisation of the Ottoman seafaring in the 19th century. Thus, the text allows us to comprehend and discuss the role of new navigational techniques and instruments in the reformation of the Ottoman navy. A preliminary assessment by the anonymous author is that the Ottomans, in order to modernise and enhance their sea power, gave the priority to the shipbuilding rather than to the application of new navigational techniques and instruments. He believes that the use of the newly developed European nautical instruments in the Ottoman navy would help the Ottoman seafaring to prosper. The present article aims to introduce and to evaluate the content of this anonymous text, to re-constitute the framework in which it was produced, and its probable impact on the modernisation of the Ottoman navy.*

Keywords: *Nautical instruments, Nineteenth century, Ottoman Empire, Mediterranean, Navigation, History of nautical science.*

UN TESTO ANONIMO OTTOMANO SUGLI STRUMENTI NAUTICI E LA NAVIGAZIONE: IL *KİTÂBÜ'L-MÜRÛRİ'L-UBÛR FÎ İLMİ'L-BERRİ VE'L-BUHÛR*

Sommario*: Il numero degli studi storici che trattano dell'arte della navigazione è piuttosto limitato nell'Impero Ottomano. L'opinione corrente è che gli ottomani che per la maggior parte navigarono nel Mediterraneo fecero uso solo della bussola e di mappe nautiche. L'utilizzo di questi soli mezzi, comunque, non permette di capire come gli uomini di mare ottomani trovassero la latitudite, determinassero l'ora, facessero uso di informazioni meteorologiche e, di particolare importanza, di quali altri strumenti facessero uso durante la navigazione. Un testo anonimo ottomano sugli strumenti nautici e la navigazione, chiamato il Kitâbü'l-mürûri'l-ubûr fi ilmi'l-berri ve'l buhur (Libro per la navigazione con la scienza delle terre e dei mari) aiuta a fornire risposte alle seguenti domande: Quali metodi itilizzarono gli ottomani mentre percorrevano il mare? Come trovavano la posizione della nave e la sua direzione? Che strumenti usavano? Come e quando nuove tecniche e strumenti furono elaborati o introdotti? Questo libro, che fu probabilmente compilato per l'istruzione di ingegneri ottomani militari e/o navali, getta nuova luce sulla modernizzazione dell'arte della navigazione ottomana nel XIX secolo. Così, il testo permette di comprendere e discutere il ruolo delle tecniche e degli strumenti di navigazione durante la riforma della marina ottomana. Una prima considerazione fatta dall'autore anonimo è che gli ottomani, al fine di modernizzare e aumentare il potere marittimo, diedero priorità alle costruzioni navali piuttosto che all'applicazione delle nuove e tecniche e strumenti di navigazione. Egli crede che l'utilizzo degli strumenti nautici, appena sviluppati dagli europei, nell'ambito della marina ottomana avrebbero aiutato la navigazione ottomana a prosperare. Il presente articolo vuole introdurre e valutare il contenuto di questo testo anonimo, riconsiderare lo sfondo su cui venne prodotto e il suo probabile impatto sulla modernizzazione della marina ottomana.*

Parole chiave: *Strumenti nautici, XIX secolo, Impero Ottomano, Mediterraneo, Navigazione, Storia della scienza nautica.*

The art of navigation which requires both theoretical and practical knowledge encompasses a variety of disciplines including geography, mathematics, meteorology and astronomy[1]. To which degree and how this knowledge was used by the seamen in the past has been researched mostly in the context of Arabic and European navigational history. Historical studies discussing navigational techniques, instruments and maps in the Ottoman period are relatively scarce. This lack is particularly obvious in the history of sailing techniques. «Which methods did the Ottomans use while sailing at sea? How did they detect the position of the ship and its direction? Which tools were used?» The studies performed so far showed that Ottoman sailors' major navigational tools were the compass and the charts. These tools were not sufficient enough to measure the latitude, to determine the time and the occurrence of the tides, to provide meteorological and geographical information necessary for navigation.

Researching Ottoman navigational techniques is not devoid of problems. The available literature on Ottoman maritime history does not aim at researching Ottomans' navigational techniques. It mostly highlights the Ottoman sailors' reliance on compass and charts, but does not endeavor to find if they used other tools to provide the above mentioned measurements. Another problem is the relatively small number of Ottoman nautical texts. These are mostly catalogued in a misleading way; the lack of information about the author and/or copyist, and the composition date often complicate the evaluation of the text. Considering the long history of Ottoman navigation, detecting and assessing the existing scientific developments becomes rather difficult. In this context, the following questions may help to classify and assess the texts: «Is there any period that differs in terms of sailing techniques in the history of Ottoman navigation? If any, which factors played a role in these technical changes?».

To answer these questions, we went through the library catalogues and searched for manuscripts on Ottoman navigation[2], from the 15th to the 19th century. We detected that a major shift had occurred within the context of sailing techniques from the 18th century.

The renewal of the Ottoman navy was deemed necessary particularly in early 18th century and it became an urgent issue in

[1] H. Grosset-Grange, *Arabic nautical science*, in *Encyclopedia of the History of Arabic Science,* vol. 1, R. Rashed (ed.), Routledge, London, New York, 1996, p. 202.

[2] G. Kut, H. Aynur, C. Üçer, F. Büyükkarcı Yılmaz (eds), *Kandilli Rasathanesi El Yazmaları 1: Türkçe Yazmalar*, Boğaziçi Üniversitesi Yayınevi, İstanbul, 2007; E. İhsanoğlu, R. Şeşen, C. İzgi, C. Akpınar, İ. Fazlıoğlu (eds), *Osmanlı Astronomi Literatürü Tarihi I-II*, IRCICA, İstanbul, 1997; E. İhsanoğlu, R. Şeşen, C. İzgi (eds), *Osmanlı Matematik Literatürü Tarihi,* IRCICA, İstanbul, 2000, vol. 2, p. 934; E. İhsanoğlu, R. Şeşen, M. S. Bekar, G. Gündüz, A. H. Fırat (eds), *Osmanlı Coğrafya Literatürü Tarihi,* Ircıca, İstanbul, 2000, vol. 2, p. 934.

1770 when Ottoman ships were destroyed by the Russians in Çeşme. Attempts were undertaken to reconstruct a new fleet, to renew the shipbuilding techniques, to improve the dockyards and to ameliorate the nautical knowledge of the seamen. However the training of army and navy officers in European style could not be possible until the opening of a School of Geometry (*Tersane-i Amire Hendesehânesi*) in 29th April 1775 in Istanbul within the imperial dockyards under the leadership of the French officer Baron de Tott[3]. This school was the core of the military engineering schools (*Mühendishane-i Berri-i Hümayun* and *Mühendishane-i Bahri-i Hümayun*) which were the main institutions responsible for the introduction of modern sciences and techniques in the Ottoman Empire in the 18th and 19th centuries.

The text we propose to study in this article, is one of the texts composed within the framework of military engineering training in Istanbul. It is titled *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr* (A book for navigating with the science of lands and seas). According to the anonymous author it contains information for miners (*lağımcı*) and tunnelers (*suyolcu*) and for navigation on sea. In this context, we believe that examination of this text is important because it witnesses the modernization of Ottoman navigational techniques. This text which is compiled to provide information about the methods and tools used in finding direction both on land and in sea, is particularly striking because the author criticizes the actual state of Ottoman navigational techniques and geographical knowledge and evaluates them as out-dated. Additionally the text gives hints regarding the evolution of Ottoman navigational techniques; especially from where and by whom these new techniques were transferred. It also helps to find out how the maritime reforms that began in the 18th century contrinuted to the adoption of new sailing techniques and tools.

[3] M. Kaçar, *Osmanlı İmparatorluğu'nda askerî sahada yenileşme döneminin başlangıcı,* in *Osmanlı Bilimi Araştırmaları I,* F. Günergun (ed.), Istanbul Üniversitesi Edebiyat Fakültesi, İstanbul, 1995, p. 209; M. Kaçar, *Osmanlı İmparatorluğu'nda askeri teknik eğitimde modernleşme çalışmaları ve Mühendishanelerin kuruluşu (1808'e kadar)*, in *Osmanlı Bilimi Araştırmaları II*, F. Günergun (ed.), Istanbul Üniversitesi Edebiyat Fakültesi, İstanbul, 1998, pp. 60-137; M. Kaçar, *Tersâne Hendesehânesi'nden Bahriye Mektebi'ne Mühendishâne-i Bahrî-i Hümâyûn*, in *Osmanlı Bilimi Araştırmaları,* F. Günergun (ed.), 9/1-2 (2008), p. 51; K. Beydilli, *Türk Bilim ve Matbaacılık Tarihinde Mühendishane, Mühendishane Matbaası ve Kütüphanesi (1776-1826)*, Eren Yayıncılık, İstanbul, 1995, p. 23.

Description and analysis of the *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*

The title of this anonymous text is given as *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr* in the introduction of the undated manuscript kept at the Atatürk Kitaplığı (Istanbul Metropolitan Municipality Atatürk Library) in Istanbul[4]. This text seems to be the author's copy. Another copy is available at the Dar al-Kutub (The National Library and Archives of Egypt) in Cairo[5]. The present study is based on the Istanbul copy.

The work is written in Turkish with Arabic letters. It is composed of 33 folios. The first two folios are unnumbered and the last folio is blank. The numbering of the pages is made twice. Firstly by the author in Arabic numerals in red (from 1 to 58), then by a librarian in Latin numerals (from 1 to 30). In the present paper we will only refer to the numbering with Latin numerals. On folios 30a and 30b, there are two tables related to the measurement of Sun's altitude. The first unnumbered folio bears two seals. The first one reads "Es-Seyyid Mehmed Nuri" and accompanied by an acquisition note: «İsteshabe-hü'l-fakîr Es-Seyyid Mehmed Nuri Mühendis, Fî 3 Receb Sene 276». This note makes clear thet the manuscript was owned by the engineer Seyyid Mehmed Nuri on the 3rd Receb 1276 (26th January 1860)[6]. The second seal is that of Süleyman Nazif, the identity of whom could not be determined. On the first unnumbered folio there are three couplets[7],

[4] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* İstanbul Büyükşehir Belediyesi Taksim Atatürk Kitaplığı, *Muallim Cevdet Collection*, MS. K.354, 29 fols. The unnumbered first folio bears an acquisition note by Seyyid M. Nuri, dated 1276.

[5] E. İhsanoğlu, R. Şeşen, M. S. Bekar, G. Gündüz (eds), *Osmanlı Askerlik Literatürü Tarihi (History of Military Art and Science Literature during the Ottoman Period)*, IRCICA, İstanbul, 2004, pp. 814-815.

[6] Two manuscripts other than the *Kitâbü'l-mürûri'l-ubûr* bear the seal of the engineer Mehmed Nuri. One of the manuscripts is a treatise on the octant (*Risale-i Oktant*) translated in 1830 by Mehmed İzzet. The treatise was copied by the engineer Seyyid Mehmed Nuri in 1860. A second seal on the same work also belongs to Süleyman Nazif that owned the manuscript in 1861. The other work which bears the seal of the engineer Mehmed Nuri is a work on the geographical statistics of European states (*Avrupa Devletlerine ait Coğrafya İstatiği*). Interestingly, Mehmed Nuri acquired both works in 1860. Coşkun Çakır claimed that the engineer Mehmed Nuri may have been Mehmed Nuri Pasha, a former graduate from the School of Naval Engineering and a professor at the Military Academy (*Mirat-ı Mekteb-i Harbiye*) in Istanbul in the last years of his life. The geometry textbook (*Usûl-ı Hendese-i Cedide*) he compiled was used by the students at the Military Academy for many years long. (C. Çakır, *İktisat tarihi çalışmalarına bir katkı:* Avrupa Devletlerinin Nüfus ve Arazi İstatistiği, «Divan», 1998/1, pp. 191-192.) The common point of those works is that es-Seyyid Mehmed acquired and copied those works on 24th January 1860.

[7] «Ser-âgâzî elbi şîrin ü güftem/Zebân-ı tûtî-i kandî zi-gül-fem/Ser ü pâ gûş edenler ser-güzeştem/Safâlar bahş eder câna dem-â-dem/Bu Nuri kemteri gûş eyleyenler/Olur bezminde cânâ şâd u hurrem!».

the last one bearing the name of Nuri, the owner of the manuscript. Other information on the second unnumbered folio are short notes about the powers of ten[8].

The copy we examined is undated but it is possible to give an approximate date for its compilation. The note «İsteshabe-hü'l-fakîr Es-Seyyid Muhammed Nuri Mühendis, Fî 3 Receb Sene 276» on the first unnumbered folio implies that the text was written at least before 26th January 1860. On the other hand, the work should have been written in a period when galleons were active in the Ottoman Navy because the author refers from time to time to the terminology of the period. Accordingly, the work should have been compiled some time between mid-17th and mid-19th century, the "age of galleons" of the Ottoman Navy[9]. Another clue related to the compilation date is the presence of the *palastire* and the *octant* among the instruments introduced by the author. The author, when introducing the *palastire*, gives the description of both the cross-staff and the backstaff. It is also significant that the author specified in the epilog that the use of the cross-staff was abandoned because its impracticability and preferred to account for the use of the backstaff. The back staff produced by the English sailor John Davis (1550-1605) in 1598, became popular from the 18th century on and it gradually replaced the cross-staff[10]. Consequently, the abandonment mentioned by the author should have been realized only after the 18th century. On the other hand, the English mathematician John Hadley received in 1734 a patent for the reflecting quadrant which he had invented in 1731 and then published the image of the instrument in the *Philosophical Transactions*. This instrument was in fact the *octant*. However the octant was not used commonly at sea before 1750s. Its use in navigation was adopted in The Netherlands more quickly than in England and France. Although the octant was first used in the ships of the Dutch East India Company in 1741, its wider use in navigation occurred after 1750s[11].

It is not clear when the Ottomans first used the octant as a nautical instrument. An order list compiled soon after 1775, that is following the establishment of the Engineering School (*Hendesehane*) in the

[8] Âhâd (1), Aşerât (10), Mîât (100), Ülûf (1000), Aşerât-i ülûf (10 000), Mîât-i ülûf (100 000), Aşerât-i mîât-i ülûf (1 100 000), Mîât-i Mîât-i ülûf (11 000 000), Ülûf-i mîât-i ülûf (110 000 000).

[9] İ. Bostan, *Beylikten İmparatorluğa Osmanlı Denizciliği*, Kitap Yayınevi, İstanbul, 2006, p. 184.

[10] See the section on the backstaff, or Davis Quadrant in W. F. J. Mörzer Bruyns and R. Dunn, *Sextants at Greenwich: A Catalogue of the Mariner's Quadrants, Mariner's Astrolabes, Cross-staffs, Backstaffs, Octants, Sextants, Quintants, Reflecting Circles and Artificial Horizons in the National Maritime Museum, Greenwich*, Oxford University Press, Oxford, 2009. This catalogue is non-paginated.

[11] *Ibid*., see the section on the invention of the octant, and its development and diffusion.

dockyard, included «12 octants for nautical use». It is not recorded, however, whether these octants ordered to Paris with other instruments arrived to Istanbul and used either by mariners or students or not[12]. A 1784 list of instruments kept at the same school also records an octant "made in England"[13]. However, the Turkish works accounting for the use of the octant came only after 1830. Two examples are İshak Efendi's (d.1836) *Aksü'l-merâyâ fî ahzi'z-zevâyâ* (Measuring the angles through reflection on the mirrors)[14] and the *Oktant Risalesi* (Treatise on the octant) translated by Mehmed İzzet (d. after 1858) from French into Turkish[15]. Besides, the fact that the author of the *Kitâbü'l-mürûri'l-ubûr* incorrectly gives the invention date of the octant as 1802[16], makes us think that he has written the treatise at least after 1802.

This information altogether implies that *Kitâbü'l-mürûri'l-ubûr* was compiled sometime in the first half of the 19th century, when the use of the octant was taught to the students aspiring to become marine officers.

The Content of *Kitâbü'l-mürûri'l-ubûr fî ilm el-berr ve'l-buhûr*

The manuscript text is composed of an introduction *(mukaddime)*, five chapters *(bâb)* and an epilog *(hatime)*. The introduction informs that the text will give the descriptions and explain how to use maps with the following instruments: *pusula* (magnetic compass, boussole), *sarko karta* (sine quadrant, quart de cercle), *palastire* (cross-staff / backstaff), *kotrant* (quadrant), *oktant* (the octant) and *parekete* (the log). As mentioned in the title of the manuscript, these were used for the finding the direction and the latitude both on land and at sea. A synopsis introducing the above mentioned instruments are given before presenting them separately in the following chapters.

The text treats the deviation of the compass for each latitude (1st chapter)[17]; the use of maps in navigation (2nd chapter)[18]; the instrument *sarko karta* (quart de cercle) which resembles the sine-quadrant (*rub-*

[12] M. Kaçar, *Osmanlı İmparatorluğu'nda askeri teknik eğitimde modernleşme çalışmaları ve Mühendishanelerin kuruluşu (1808'e kadar)*, p. 84.

[13] *Ibid*., p. 90. This octant should be the same octant "made in England" (*İngilterekâri oktant*) recorded in the 1816 list. See K. Beydilli, *Türk Bilim,* p. 384.

[14] E. İhsanoğlu, *İshak Efendi, Başhoca,* in *Türkiye Diyanet Vakfı İslam Ansiklopedisi*, Türkiye Diyanet Vakfı, İstanbul, 2000, vol. 22, p. 530.

[15] Mehmed İzzet, *Oktant Risalesi,* H. 1245 (1829/1830), İstanbul Büyükşehir Belediyesi Taksim Atatürk Kitaplığı, Muallim Cevdet Collection MS. K.420: fols. 11; for other copies see *Osmanlı Astronomi Literatürü*, pp. 600-601.

[16] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fol. 20a.

[17] *Ibid*., fols. 3a-5a.

i müceyyeb) and its use in navigation (3rd chapter)[19]; the setting and casting of the log and measuring the speed (4th chapter)[20]; the structure of the cited instruments and measuring the altitude by using them (5th chapter)[21]. The epilog[22] summaries the previous chapters. It also evaluates the state of the science of geography and that of the nautical science (*derya ilmi*) in the Ottoman Empire from the 16th to the 19th century. Then the author gives additional information to help the reader in better comprehending the European techniques and instruments. These include the following: Description and use of the scale line *(mikyas [ölçek] hattının tarifi ve kullanımı)*[23]; description of a pair of compasses (*kumpas [pergel] tarifi*)[24]; description and use of the cross staff / back staff *(palastire aletinin tarifi ve kullanımı)*[25]; the use of nautical units of measurement *(beyân-ı isti'mâl-i mikyâsü'l-bahr)*[26]; the measurement of distances (*buud isti'mali*)[27]; techniques of port entry (*beyân-ı tarîk-i duhûl-i limân*)[28]; on the application of some important operations in the measurement of altitudes (*Fî ma'rifeti ba'zı ümûri mühimmeti bahsi'l-irtifâ'*)[29].

Explanotary examples given in the text

The author provided various examples in every chapter in order to explain a variety of navigational subjects such as the deviation of the compass, the measurement of altitude and so on. These examples give the impression that they were selected carefully in order to enable the reader to grasp the issue correctly. These examples treat the issues starting from the simplest to the complex cases. However, explanations are not always clear. The reason may be that the author targeted an audience already in possession of some technical knowledge. The fact that most of the examples are related to sailing methods at sea suggests that the targeted audience were the students of the Naval Engineering School which became separated from the Land Engineering

[18] *Ibid*., fols. 5a-11a.
[19] *Ibid*., fols. 11a-16b.
[20] *Ibid*., fols. 16b-18b.
[21] *Ibid*., fols. 18b-20b.
[22] *Ibid*., fols. 20b-30b.
[23] *Ibid*., fols. 23b-24a.
[24] *Ibid*., fols. 24a-25a.
[25] *Ibid*., fols. 25a-27a.
[26] *Ibid*., fols. 27a- 28a.
[27] *Ibid*., fols. 28a-29a.
[28] *Ibid*., fols. 29a-30a.
[29] *Ibid*., fols.30a-30b.

School in 1806 when a special section on "Navigation and Cartography" (*Seyrüsefer ve Haritacılık*) was created within the former school[30]. The content of manuscript appeals more particularly to the students of this section. The presence of information about "land navigation" (i.e. mining and tunneling) was probably due to the continuing collaboration – especially in terms of teaching staff – between the Naval and Land Engineering schools despite the latter leaving the dockyards in 1806.

The purpose and method of the work

The writing purpose of the book was given both in the introduction and epilog section. According to the title, it was written for finding direction both on land and at sea; but it mostly contains information about nautical science and instruments. The purpose in more clearly expressed in the introduction than in the epilog. The main aim of the author in compiling this treatise was to introduce the instruments (most of them being European) used for determining position and direction on land and at sea. In the *epilog,* the author also stated that he wrote this work for those who do not consult a master in order to perfect their technical skills. According to him, the reader should consult a master in order to correctly apply the techniques given in the text. He will need to practice constantly to develop his skills. Some people, however, abstain from consulting a master because of their disdain; this text was compiled for them[31].

Discrepancies between the information given in the epilog and the presence of repetitions in the previous chapters implies that the work is a compendium. Both discrepancies and repetitions disrupt the integrity of the work and leads one to think that the chapters and the epilog were written in different times.

The state of geographical knowledge and marine science of the Ottomans

The epilog begins with the author's evaluation about the state of geographical knowledge and nautical science of the Ottomans from the 16th to the 19th centuries. He criticizes the fact that the "new meaning" of geography was overlooked while more significance was attached to the construction of a greater number of ships for the Imperial Navy. The author thinks that Piri Reis and Kemal Reis created elaborate portolan maps; but failed to examine the geographical knowledge of the period on

30 K. Beydilli, *Türk Bilim*, p. 60.

31 *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* fols. 20b-30b.

the contrary of the Europeans. Because these Ottoman captains were not acquainted enough with the geometrical knowledge underlying the figures, the book produced [*Kitab-ı Bahriyye* ?] did not prove useful and suitable. The various industries and instruments elaborated in Europe after Piri Reis's death (1553) up to the 19th century, enabled the Europeans to organize maritime campaigns to the New World and to Indochina. The indifference of the Islamic states, however, towards expeditions became an object of derision for the Europeans («the unbelievers») who enjoyed their lack of interest. The author, afflicted by this situation, suggested to learn the art of traveling at sea from the Europeans, and to profit from their geographical and nautical knowledge.

Sources of the *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*

To compile *Kitâbü'l-mürûr*, the author relied both on Ottoman geographical works and European nautical texts (*efrenc bahriyyeleri*) of which he does not name any. Among the Ottoman sources, he first cites *Cihannüma* (The Mirror of the World), the famous work of Kâtib Çelebi (d. 1657). In all likelihood the author had in his hands the printed version of *Cihannüma* (1732). Other works he cited are *Atlas-ı Kebir* (The Great Atlas) and *Atlas-ı Sagir* (The Small Atlas) which should be the Turkish translations of Joan Blaeu's *Atlas Major* and the Mercator-Hondius's *Atlas Minor*. He also mentioned among his sources the works of the 16th century Ottoman admirals: the *Kitab-i Bahriyye* (Book of Navigation) of Piri Reis (d. 1553), that of the Kemal Reis and finally the *Vakayiname* (Chronicle) of Seyyid Ali Reis (d.1562). Interestingly, no such a work is attributed to Kemal Reis. The work the author named as *Vakayiname* should be the *Mirat el-Memalik* in which Seyyid Ali Reis related his travel from India back to Istanbul. Most of these works were available at the library of the Engineering School from the late 18th century on. The library had also a good number of European books on geography, navigation and astronomy; as the author did not specify his sources, it is difficult to find out the books he used for the compilation.

Instruments and methods for finding direction, position and distance on land and at sea

The text answers, rather shortly, the following questions in various sections: «Which instruments do miners (*lağımcı*) use to determine the position of the locality to be reached during military campaigns? Which tools do tunnelers (*suyolcu*) use for the same purpose? How to measure the time necessary to get over a certain distance on land? Which instrument is used in this measurement?».

The instruments used on land include the compass (*pusula*), the quart de cercle (*sarko karta*) and log (*parakete*). The author stated that the compass is used both on land and at sea to determine the four cardinal directions, and described it in the section related to sea navigation. He also mentioned that in some provinces it is named *kıblenüma*, an instrument for finding the direction of Mecca[32].

In the introduction, the author stated that tunnelers and miners can find how many Turkish yards (*arşın*) they moved forward and the position of the locality they should reach by using a quadrant (*rub-ı daire)* that the author also named *sarko karta*[33]*.* More detailed information about *sarko karta* is provided in the third section where the author explains that this instrument is the famous *rub-ı müceyyeb* (sine quadrant)[34]. The author, however, is mistaken in stating that distance is measured by this instrument, because the quadrant is used for finding position rather than measuring the distance taken. The mistake is corrected later on, and the author explicitely states that a log should be used in measuring the distance taken. The log is a rope bearing knots at regular intervals. A person holds one end of the rope and stands in a fixed position. While the other person begins to walk, a sandglass set to run one-half minute starts to operate. The distance taken in half a minute is measured by using the rope. This method helps to calculate how many miles were taken in an hour[35].

Besides giving information about "navigation on land", the *Kitâbü'l-mürûri'l-ubûr* also explains, and this in more details, how to navigate from one harbor to another, what routes to follow and which instruments to use at sea. The information provided by the text can be classified and examined in the following headings.

Seafaring techniques introduced through nautical instruments

Direction and position are the two basic elements to be determined for navigating at sea. The seamen need to answer the following questions: "Where am I?" and "Where am I going?" Compasses and maps were indispensable tools used for navigating in inland seas such as the Mediterranean and Aegean. These tools, however, were not sufficient for safe navigation. *Kitâbü'l-mürûri'l-ubûr* introduced other nautical instruments used in the several navigational techniques that Naval School students should learn: *Sail navigation, piloting, dead*

[32] *Ibid*., fol. 2b.
[33] *Ibid*., fol. 2b.
[34] *Ibid*., fols. 11a-11b.
[35] *Ibid*., fol. 18b.

reckoning and *astronomical navigation*. The author did not account for these techniques in separate chapters but the description of these techniques are imbedded in chapters introducing the nautical instruments. On the other hand, terms such as *weather side, lee side, wind-side, stern, counter flag, counter landing* that are frequently encountered in the text, especially in paragraphs dealing with the *sarko karta* (quart de cercle), emphasizes the role of this instrument in sail navigation.

The use of the log and the sandglass to calculate the distance taken by the ship is described in the fourth chapter. This calculation method is related to the calculation of the distance to be taken at a certain speed in a certain time without taking into account the factors such as currents and winds[36]. In the second chapter, the subject is determining the route on the map by taking bearings. The author noted that it was also possible to calculate the distance of the ship to the shore by using compass and map in case the ship sails close to the shore[37]. Here, he implies to piloting in which the position of the ship is calculated on the basis of lighthouses, towers, big buildings on the map and marking buoys. Finally, we see in the text that nautical astronomy was used from time to time as well. Nautical astronomy helps to determine the position and direction of a ship by observing celestial bodies[38]. To express more clearly, the seaman may sail by observing bright stars, certain planets, the Moon and the Sun. The author introduces two different methods: One of them is to observe the rising and setting points of the Sun in order to determine the compass deviation amount[39]. The second is to find the latitude by measuring the Sun's altitude in the case the shore is invisible[40].

Equipment used in sea navigation

Ottoman documents and collections comprise little information and a small number of objects witnessing the use of nautical astronomy on Ottoman ships. Therefore, the description of nautical instruments given in *Kitabü'l-Mürur*, most of which being of of European origin, are significant in terms of enabling us to obtain new and useful information about seafaring in the Ottoman Empire. The equipment under study are the following:

[36] Distance = speed x time.
[37] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* fols. 5a-11a.
[38] S. Baytura, *Astronomik Seyir I*, İstanbul, Tüdev, 2000, p. 9.
[39] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fols. 3b-5a.
[40] *Ibid*., fols. 9a-9b.

The compass and the determination of the compass deviation

The author first defines the compass deviation, the variation of the deviation in different latitudes and in time[41].

Then the methods for determining the deviation value are explained through examples. The author gave the deviation values of the Marmara Sea, the Mediterranean, the English Channel, the Canary Islands and Istanbul. The given deviation values are as follows[42]:

Place	*Deviation value*
Marmara Sea	14.5°
Mediterranean (Tunis, Algeria, France, The Coasts of Spain)	16.5°-17°
English Channel	15°
Canary Islands	0°
Istanbul	11°

The author notes that the deviation value of the English Channel was given as 7.5° in a number of books; and adds that this value is 15°-16° in his time.

The author did not specify for which dates those deviation values were valid. In order to determine those dates, we used *NOAA: National Geophysical Data Center, Magnetic Field Calculators*[43] program which calculates the compass deviation values of the past years. We observed that the compass deviation value of the English Channel was 7°02 53 (W) in 1700 and 15°21 19 (W) in 1740. This value becomes higher than 24° in the 19th century. According to *NOAA*, the approximate deviation values for the English Channel for the years between 1678-1860 are as follows:

[41] *Ibid*., fols. 3a-5a.

[42] *Ibid*., 3a-3b.

[43] NOAA: National Geophysical Data Center, Magnetic Field Calculators, http://www.ngdc.noaa.gov/geomag-web/ (09/05/2015).

Date range	*Events*	*(Approximate) Deviation value*
1648	Katip Çelebi starts writing down his geography, the *Cihannüma*	-2° 15' 28" (W)
1700	The date corresponding to the 7° deviation given by the author of *Kitâbü'l-mürûr*	-7° 02' 53" (W)
1730	Invention of the octant	-13° 50' 2" (W)
1740	The date corresponding to the 15° deviation given by the author of *Kitabü'l-mürur*	-15° 21' 19" (W)
1759	No special event	-18° 37' 54" (W)
1800	The publication date of shak Efendi's treatise *Aksü'l-meraya fi ahzi'z-zevaya* introducing the octant and the sextant	-24° 08' 09" (W)
1830	Mehmed İzzet Efendi's treatise *Risale-i Oktant*	-24° 25' 40" (W)
1860	The date accompanying the seal of the Engineer Mehmed Nuri on *Kitâbü'l-mürûr*	-22° 36' 23" (W)

We also checked with the same computer program of NOAA, the deviation values given by the author for the Marmara Sea, the Mediterranean and the Atlantic Ocean. The values given in *Kitâbü'l-mürûr* for the Marmara Sea and the Canary Islands between 1678-1860 conflicted with those given by the NOAA program. On the other hand, the deviation values given for Algeria for the period 1759-1800, for France for the period of 1740-1759, for Spain for the period of 1740-1759 roughly corresponded with those of the computer program. The authors's sources for these values are not clear. The compass deviation value (11°) he gave for Istanbul, however, is taken from Katip Çelebi's *Cihannüma*[44]. Thus we may conclude that the author borrowed the compass deviation values from his source books and did not adapt them to his own period, the 19th century.

To determine the compass deviation amount, the author suggested to refer to astronomical observations. He stressed the necessity of observations through a number of examples. The essential point is to determine the real eastern point (*maşrık*). For this, the East point of the compass is orientated towards the real eastern point from which the rise of the Sun is measured with the octant. Assuming that Sun rose not at the real eastern point, but at 14.5° further to the Southeast means a deviation of 14.5° in this latitude[45]. The Sun, however, does not rise at

[44] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fol. 3b.
[45] *Ibid*., 4a.

the real eastern point every day. The sun rises at the real eastern point only at equinoxes. For that case, it is essential to know whether the Sun is at the southern or northern Zodiac signs or not[46]. Then one must determine the distance of the Sun to the exact eastern point. An example is the following: Assume that the Sun is at the southern signs and its distance to the real eastern point is 20°. On the other hand, assume that the value of rise of the Sun is measured 35° with the compass. After that, one should substract 20° from 35° to obtain 15° which is the compass deviation amount for that latitude[47]. The author specifies that in case the Sun is at the northern signs, the distance to the real eastern point will be added to the value measured with the compass[48].

If the compass needle does not stop at any point, this indicates a problem. In the epilog, *t*he author explained how to correct this situation. Firstly, the point of a knife is inserted into the northern point to let the air enter. On the other hand, the magnet should not be wrapped with red broadcloth which leads to the elimination of its attractive power (*puhte).* When the magnet looses its attractive power, it recovers its power when soaked into vinegar or a goat's fresh blood. If olive oil is applied on the magnet it does not attract the iron. It should be soaked in goat's blood to let it recuperate its attractive capacity[49]. This information matches up with Seydi Ali Reis' Kitabü'l-*Muhit fi Ilmü'l Eflak ve'l Ebhur (Book on the Art of Navigation)* which was written in Turkish in 1554[50]. *Shortly known as Kitabü'l-Muhit or al-Mohit,* the book involves information about nautical astronomy and geography that Ali Reis has drawn heavily from the works of famous Arabian and Indian sailors[51].

Using nautical charts

The author provides information about how to use maps in various sections of *Kitâbü'l-Mürûr.* He clearly specifies that the Ottomans used both English and French maps. French sea charts were particularly

[46] The signs of the zodiac, positioned between the celestial North pole and the Equator are described as the northern signs: Aries, Taurusi Gemini, Canser, Leo, Virgo. The signs of zodiac, positioned between the South pole and the Equator are called the southern signs: Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces.

[47] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fol. 4a.

[48] *Ibid*., fols. 4a-4b.

[49] *Ibid*., fols. 29b-30a.

[50] Himmet Büke, *Seydi Ali Reis- Kitabü'l Muhit,* unpublished master thesis, T.C. Pamukkale University, Pamukkale 2010, pp. 83-85.

[51] Gaye Danışan Polat, *A Treatise by the 16th Century Ottoman Admiral Seydi Ali Reis on Rub-ı Muceyyeb (Sine Quadrant)* in Seapower, Technology and Trade Studies in Turkish Maritime History, D. Couto, F. Günergun, M. P. Pedani (eds.), Denizler kitabevi, İstanbul 2014, pp. 337-341.

used for sailing in the Mediterranean[52]. The second chapter explains how maps are used in navigation. The main issues discussed are the following: The correct determination of directions on the map; the use of compass and charts; to determine the distances of reference points by taking bearings, and determining ship's position on the map.

In order to correctly find directions on a map, one should first place the map so that its North and the South corresponds with the celestial pole, without considering the compass deviation of the map. Four cardinal directions are thus determined. The seaman should also remember that the compass deviation on his route will change with the latitude. The author gave many examples for determining ship's route. In one of the examples, he assumes that a ship departs from a place with 15° of compass deviation, and wants to run 40 and 50 miles to the North. If the ship directs from North to North-east with a deviation of 15°, then the ship will reach the desired direction, the due North[53].

To sail correctly, a sailor should also know about the 32 winds on the map. The latter are classified in three groups. Knowledge of these groups will help the seaman to determine the deviation of the route due to the wind and correct it[54].

A sailor should also be able to find the distance of the ship to any point. It is possible to determine on the map, the distances to any of the two points taken outside the ship by taking bearings. The author considers two islands and explains in a concise way how to calculate the distance between the ship and the islands. He assumes that one of the islands is at the Northwest and the other is at the North. He places one of the legs of the first divider on an island and one leg of the second divider on the other island. Then he makes the divider "walk" along the North and North-west directions until the dividers meet each other. The place they meet is the place where the ship is located. Then, he calculates the distances between the islands and the ship. He also mentions that this method is not convenient at night. His description of finding distances lacks precision. The author does not mention that the map's scale should be taken in consideration and the space between the two legs of the divider be adjusted when calculating the distances. The lack of these details will be discussed later. Seemingly, he does not draw bearing lines and the distance he finds is approximate.

The information given by the author indicates that a chart alone is not sufficient to navigate. In the chapter titled *Beyân-ı isti'mâl-i mikyâsü'l-bahr* (On the use of a nautical scale) he explains that in case

[52] *Ibid*., fol. 17a.
[53] *Ibid*., fols. 4a-4b.
[54] *Ibid*., fols. 9b-10a.

the land is invisible or during at night-time navigation, one should know the distance between the ship and the land. This information prevents the ship from running ashore and crashing. In order to find the distance to the land, the author proposes to find the latitude and longitude by measuring the altitude. Although he does not specify the details, he implies that one should find the latitude by measuring the altitude of celestial bodies and the longitude by means of the charts. Later on, the miles traveled would be calculated by dead reckoning. These operations would allow the captain to sail safely throughout the night[55].

Besides this, the seaman should know whether the port of entry is on the right, on the left or at the opposite direction. This subject was discussed in the *epilog* under the title of *Beyân-ı tarîk-ı duhûl-i limân* (About the way of entering the port). To achieve this, the latitude and longitude of the port of entry is found on the map. The latitude of the ship is calculated by using the altitude. If the ship is right across from the port of entry, this is a good situation. If the port is on the left or on the right, one easily enters the harbor by performing *orsa* (wind side) or *boca* (lee side)[56].

The log

The author deals with the setting of the log (*parakete)* and its use in the fourth chapter. The rope to be tied to the log is a “European rope” (*Frenk ipi*). The rope is made wet five to ten times in order to prevent stretching and shrinking. Later on, the rope is checked against the floating line and marked by knots. One continues in this manner so as to have one knot at the first mark, two knots at the second mark and so on. Later on, the wooden board (the log) that the author calls a quadrant (*rub-i daire*), is crafted. A piece of lead is fixed to the quadrant in order to keep it in water. The marked rope is then tied to the log. Finally, the sandglass is involved in the operation as well[57]. Interestingly, the author does not mention in this paragraph that the log line is used for measuring the speed of the ship. The calculation of speed is mentioned only 8 folios later, that is in the epilog.

The author emphasizes that the intervals between the knots should correspond to the scale of the map. As nautical charts are scaled to English and French miles and that French charts are the commonly used in the Mediterranean, the conversion of the nautical units of measurement becomes of prime importance.

[55] *Ibid*., fol. 29b.
[56] *Ibid*., fols. 29a-30a.
[57] *Ibid*., fols 18a-18b.

The divider (the compasses)

The author described the divider (*kumpas*) and its use in the epilog where he mentioned that the word kumpas was introduced into Turkish from Europe. The term kumpas, however, is mentioned only once in the text. He often used the term *perger* which was derived from Persian and popularly used by the Ottomans. Without mentioning the original French or the English name (*compas*, *compasses*) of the tool, the author gave its Turkish translation: *geçerger*, in short *geçi*. This word does not exist in Turkish, and should have been coined by the author. In Turkish, the word *geçer* means "which passes by" (Eng.) or "qui passe" (Fr.); the suffix *ger* (Persian) is used like the suffix "er" in English to denote persons that do a particular activity (sing, singer). Thus *geçerger* (passes-com) is the reverse of com-passes. The word *compas* (Fr.) is related to the verb *compasser* (to measure with compasses) which is derived from *passus* (Lat.) meaning *pace* in English. The word *geçerger* coined by the author does not have the meaning of measurement and/or pace. He seems to have literally translated the term *compasse* by translating *passer* as *geçer* and adding *ger* for *com*[58]. Despite his proposed Turkish name (*geçerger*) for the divider, this term, like the *kumpas*, was used only once in the text.

The author repeats and complements in the epilog the information he previously gave about the use of the divider in the section for finding the position of the ship by means of a map[59].

The cross-staff and the backstaff

The author names a tool *palastire* among the tools used for altitude measurements[60]. A tool named *palastirilya* is mentioned in the *Ruzname-i Cedid*[61], a 18th century anonymous Ottoman text dealing with calenders and including a number of astronomical tables. *Palastire* and *palastirilya* should be the same instrument. While the *Ruzname* informs us that this tool was merely used at sea to measure Sun's altitude[62], *Kitâbü'l-Mürûr* accounts for its structure, types, and usage.

[58] The words *compas* (Fr.) and *compasses* (Eng.) are composed of the prefix *com* (*cum* in Latin, *with* in English) and the noun *pas* (*passus* in Latin, *pace* in English).

[59] *Ibid*., fols. 27a-29a.

[60] *Ibid*., fols. 25a-27a.

[61] *Ruzname-i Cedid*, Kandilli Rasathanesi, MS. 138/2: fols. 58b-59b. Copied probably in hijri 12th c.

[62] *Ibid*., fols. 46b-73a.

In the epilog of *Kitâbü'l-mürûr,* the author mentioned two types of *palastire*[63]: *Çatal palastire* (lit. *palastire* in the form of a fork) and *yeke palastire* (lit. single *palastire*). He specified that since the use of *yeke palastire* is difficult, *çatal palestire* became popular. Therefore, besides accounting for the use of the latter, he added some information about its form and usage. From the information given in the epilog it is clear that *yeke palastira* is the cross-staff, and *çatal palastire* is indeed the backstaff invented in 1595 by John Davis, the English seaman[64]. Furthermore, the author specified that the instrument originated in Europe (*Efrenciye*) and its name was transmitted to Turkish in its original pronunciation that remained unchanged because it was not popular among the Ottomans. The backstaff used in navigation was named *balestilha* by the Portuguese*, balestilla* by the Spanish, *balestiriligia* by the Italian*, arbalète* or *arbalestrille* by the French and *Jacob's staff, fore-staff, cross-staff* or *ballastella* (from Italian) by the English[65].

The quadrant

The author provided less information about the quadrant (*kotrant*) when compared with the information he gave for other instruments. He only noted that it was used to measure the altitude of the Sun, an operation necessary for calculating the latitude at sea. He also drew attention to its deficiencies. Although the quadrant was a significant instrument in celestial navigation on the open sea during ancient times, the instrument had two main limitations. Firstly, it was difficult to keep the tool precisely vertical and to fix it at celestial bodies at rough sea. Secondly, it was not easy to keep the plumb still. The author referred to this second deficiency in chapter five where he provided information on the altitude measuring instruments. He mentioned that the Europeans, in order to discard the second deficiency, invented the *palastire* and the "quadrant"[66]. This statement makes us think that the instrument introduced in the text is not the classical quadrant with a plumb line, but a reflecting quadrant.

[63] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fol. 28a.

[64] W.F.J. Mörzer Bruyns, *Cross-Staff*, in R. Bud, D. Warner (eds), *Instruments of Science: An Historical Encyclopaedia*, Garland Pub., New York, London, 1998, pp.159-160, in particular p. 159.

[65] W.F.J. Mörzer Bruyns, *The Cross-Staff: History and Development of a Navigational Instrument*, Walburg Pers, Amsterdam, 1994, p. 23; *Nautica Mediterranea di Batolomeo Crescentio Romano. All'illustriss. e. reverendiss. s. Card. Aldobrandino*, Bartolomeo Bonfadino, Roma, 1602, p. 455; E.G. Ravenstein, *Martin Behaim: His Life and his Globe*, G. Philip & Son Ltd., London, 1908, p. 16.

[66] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* fol. 18b.

The author, explained in detail how altitude was measured in the Northern hemisphere using a *palastire* and a *quadrant* to calculate the latitude of a place. He suggested two ways for calculating the latitude. The first method consists of measuring the meridian altitude of the Sun (*gayetü'l-irtifa*) and then substracting it from 90°. The result is the complement of altitude (*yükseklik tamamı*). By adding the Sun's obliquity (*meyl-i afaki*) to the complement of altitude, one finds the latitude. In the second method, one subtracts Sun obliquity from the meridian altitude to obtain the complement of latitude (*enlem tamamı*). The result of the subtraction gives the latitude.

The author noted that one should also take into account the altitude of the place where measurements were made. The observer should mesure this altitude in terms of *zira*s (0,75 cm) and subtract this value from the Sun's altitude[67].

Octant

The author attached particular importance to the octant (*oktant*). The reason is that the octant is more precise when compared with the other mentioned instruments. According to the author, there is no big difference in measuring the altitude with an octant or a sine quadrant; the superiority of octant lies in being more precise[68]. For example, in order to measure the compass deviation, the Sun should be observed with an octant[69]. Besides this, in the epilog, the author listed the backstaff, the quadrant and the octant as the instruments for measuring the Sun's altitude; however, it was only for the octant that he formulated a numerical example to illustrate its use[70]. For him, the use of the octant is rather different from the other tools: 16 minutes (') should be added to the numerical value of the altitude measured with this instrument[71].

The fact that the author makes an analogy between the octant and the sine quadrant and points to the similarities in their usage provides us with a significant clue. This indicates that the sine quadrant was probably used in navigation by the Ottomans. This is possible, bearing in mind that the Imperial Engineering School in Istanbul had in his collection an *İngilterekâri* (made in England) octant in 1816[72].

67 *Ibid*., fols. 19a-19b.
68 *Ibid*., fol. 20b.
69 *Ibid*., fol. 3b.
70 *Ibid*., fols. 18b-20b.
71 *Ibid*., fol. 20b.
72 K. Beydilli, *Türk Bilim*, p. 384.

The sine quadrant

In the introduction and the third chapter, the author described an instrument named *sarko karta*[73]. In the 1801 list of instruments and books kept in the Imperial School of Engineering (Istanbul), is found an instrument registered under the same name. It has been previously asserted that *sarko karta* was a kind of map[74], based on the assumption that karta (derived from Italian) here, meant a chart[75]. The author of the manuscript under study, however, stated in the epilog that sarko *karta* is a quadrant (*rub-ı daire*)[76]. In the 3rd chapter, he affirms that it is essentially the well-known sine quadrant (*rub-ı müceyyeb*). Both statements clearly indicate that *sarko karta* is an instrument and not a map. According to the author, its difference from the sine quadrant is that four principal winds are drawn on the instrument[77]. It is not clear, however, why the author used the term *sarko karta* for the sine quadrant. Was this a wrong pronunciation of the "quart de cercle", the French term indicating a quadrant? It is possible that "cercle" has been transformed to *sarko* and "quart" to *karta.*

The author stated that this instrument, besides the seamen, is used by tunnelers (*suyolcu*) and miners (*lağımcı*)[78]. The author explained by means of examples, that the person who will use this device could determine the latitude of his destination before he departs, as well as the route he should follow to reach destination[79].

The sandglass

One of the tools used in navigation is the sandglass. The author answers to the question «When to have recourse to the sandglass and how to use it?» in the section accounting for the usage of the log[80] and also in the epilog. He informs that the sandglass is used during the measurements made with the log line. A half-minute or a one-minute sandglass may be used for this purpose[81]. When a ship sails, the piece of wood named log is dangled down the stern of the ship. The sandglass

[73] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* fol.11a.
[74] K. Beydilli, *Türk Bilim*, p. 374.
[75] F. Sarıcaoğlu, *Harita*, in *Türkiye Diyanet Vakfı İslam Ansiklopedisi*, vol. 16, Türkiye Diyanet Vakfı, İstanbul, 1997, p. 210.
[76] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* fol. 20b.
[77] *Ibid*., fols. 12b-13a.
[78] *Ibid*., fol. 2b.
[79] *Ibid*., fols. 3b-4a.
[80] *Ibid*., fols. 18a-20a.
[81] *Ibid*., fols. 18a-20a; 28a-29a.

is turned over at the moment when the log weighted with lead sinks into the water. After quarter or half a minute, the top bulb of the sandglass is empty and the operation is completed. The distance taken in fathoms is calculated by measuring the wet part of the rope and the speed information is thus obtained. For example, if the ship runs at 100 fathoms per minute, the 100 fathoms is multiplied with 60 minutes. According to this calculation, this means that a distance of 6000 fathoms was covered in 1 hour[82].

Besides this, it is again possible to use a sandglass if one wants to find the distance covered per hour. The end of the rope which is tied to the log line is given to a man. Half a minute sandglass is turned at a certain starting point. The miles per minute may be calculated depending on the distance covered in half a minute. For instance if there are 7 marks on the rope tied to the log, one will say "it will go 8 miles". If the sandglass is a quarter minute one will say "it will go 14-16 miles"[83].

The measurement units used in navigation

Regardless of the navigation technique used, finding the latitude and the longitude of the current location and the destination is the most significant and sensitive work. Latitude and longitude is measured in angular distance and angle value. While angular distance is given in miles, the angle value is indicated in degrees, minutes and seconds. Therefore, the units of measurement employed in finding the coordinates become a crucial issue. The value of the units of length in use in the Ottoman Empire, usually differed according to the regions and in time[84]. On the other hand, Ottoman engineers felt the need to know the equivalence between Ottoman and European units of measurement in order to be able to use the techniques introduced from European texts. As a result, European and Ottoman units of measurement were compared and their equivalence were established at the Imperial School of Engineering in Istanbul. While introductory information about Ottoman and European measurement systems was given in the Turkish textbooks prepared through translation, conversion tables were prepared and published in those books[85]. Thus,

[82] *Ibid*., fols. 28a-29a.

[83] *Ibid*., fols. 18a-18b.

[84] F. Günergun, *Osmanlı ölçü ve tartılarının eski Fransız ve metre sistemlerindeki eşdeğerleri: İlk karşılaşmalar ve çevirme cetvelleri*, in *Osmanlı Bilimi Araştırmaları II*, F. Günergun (ed.), I.U. Edebiyat Fakültesi, İstanbul, 1998, p. 23.

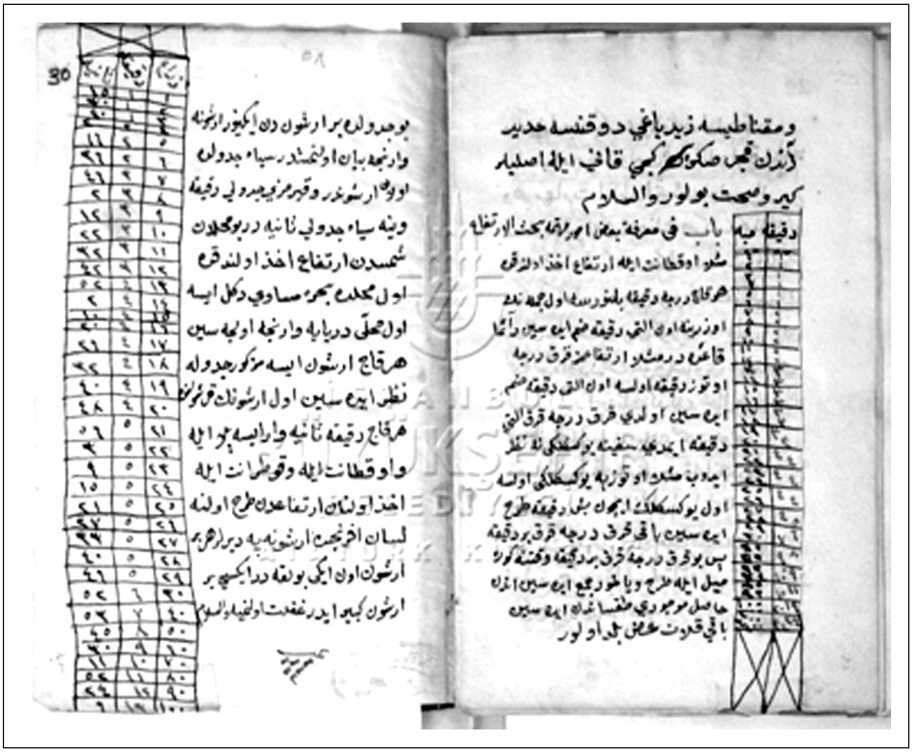
[85] *Ibid*., p. 24.

Ottoman and ancient French measures of length were compared in the 18th century and their equivalence was established[86]. After that time, it became possible to calculate the equivalence between the measures of various countries and the Ottoman measures, since the ratio between French measures and those used in various other countries were already known[87].

The text we examined gives special emphasis to the differences that existed between the units of measurement used in navigation. This difference is particularly considered important in the use of sea maps and dead reckoning. Particularly in the fourth chapter related to the log, the author advised to know how many *zira* (Ottoman measure of length of 75 cm) one *mile* is, how many *mile*s one *league* is and how many *usbu* (Ottoman measure of length of 3,2 cm) one *zira* is. The author noted that a variety of measures are used in navigation and that French and English miles are commonly utilized in nautical charts. For this reason, it is vital to know those measurement units. The fact that in the charts of the Mediterranean, the scales represent the distances in French miles[88] explains clearly why comparisons of maps in terms of scale and mile are important. He gives the following information of the French and English measures of length without mentioning their original names: «The French *zira* and English *zira* are each twelve *usbus*. However the French *zira* is longer than English *zira*.» It is not clear to which French unit of length the "French zira" corresponds. The "English zira" should be the *yard* (0,9144 m). The author also says «What we need is the French *arşın* (*zira*). All of Mediterenean *karta* (charts) are made by the French»[89]. He noted the principal units of length that a sailor should know[90]. The author also felt the need to add to the epilog the units of measure that Kâtip Çelebi mentioned in his geography book *Cihannüma*, as units adopted by the engineers of the 17th century. These were the *mil* (mile), *kulaç* (fathom), *zira* (cubit) and *usbu* (thumb)[91].

The text includes two numerical tables in the section titled *Fî ma'rifeti ba'zı ümûr-i mühimmet-i bahsi'l-irtifâ* (On some important operations made by measuring the altitude). The first table deals with the relation between the minute (*dakika*) and the grain (*habbe*), and the second table with the Turkish cubit (*zira*), minute (*dakika*) and seconds (*saniye*). The concise instructions given by the author are not

[86] *Ibid*., p. 25
[87] *Ibid*., p. 44.
[88] *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr*, fols. 17b-18b.
[89] *Ibid*., fol. 17a.
[90] *Ibid*., fols. 17a-17b.
[91] *Ibid*., fol. 28b.



Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr fol. 30a-30b
Istanbul Büyükşehir Belediyesi Taksim Atatürk Kitaplığı,
Muallim Cevdet Collection MS. K.354

clear enough to understand how to make use of these tables. The title of the section suggests that these tables are used to find out the distance (in *ziras*) between two points when the difference in latitude (in minutes and seconds) is calculated by measuring the altitude. The folios bearing these tables are reproduced above[92].

Concluding remarks

The purpose of studying *Kitâbü'l-mürûri'l-ubûr fî ilmi'l-berri ve'l-buhûr,* an Ottoman text giving information on navigation and nautical instruments, was to find out which sailing techniques and instruments

[92] *Ibid*., fols. 30a-30b.

did the Ottoman sailors used in seafaring. As the manuscript is anonymous and undated, it was rather difficult to ascertain the context in which it was produced. The present study, however, provided us with some clues about the possible framework in which it was compiled as well as the techniques and instruments that an Ottoman sailor was expected to know. The author's purpose of writing this work, the terminology used in the text, the way of treating the subject, the European instruments it accounted for, and the two seals it bears made us possible to decipher the approximate date and the context in which it was produced. Both the information given about the instruments and the seal bearing the date 1860 of the engineer Mehmed Nuri, the owner of the text, implies that the text has been written in the first half of the 19th century.

It is clear that the author relied mostly on European nautical works (*Efrenc bahriyyeleri*) in compiling the text. Although he does not name his sources, these were probably the books on seafaring and nautical instruments kept in the library of the Engineering School. The reliance on European sources matches with the 18th century move towards the modernization of the engineering education by taking Europe as a model. Most of the texts that were translated or compiled within the reformation movement were the course books published as teaching material for the students of the Engineering School. The content and style of the *Kitâbü'l-mürûri'l-ubûr fi ilmi'l-berri ve'l-buhûr* makes us think that this manuscript is closely related with the teaching at the Imperial School of Engineering. The respect paid by the author to geography and nautical science in the *epilog* invigorates this assessment.

The author referred to the principal Turkish works on navigation and geography, namely the 16th century *Kitab-ı Bahriye* of Piri Reis, *Kitabü'l-Muhit* of Seydi Ali Reis, and the 17th century *Cihannüma* of Kâtip Çelebi. The fact that these books are referred in a 19th century text witnesses the continuity of a tradition in the nautical and geographical literature.

The text is not systematically designed. One can even argue that the work has been composed of concise notes written with a flowing pen. What is clear is that the author abstained from details. The information provided in the epilog is generally a repetition of the information given previously, and sometimes complements the lacking information.

The text bears a number of contradictory information, especially regarding to the terminology used. To give an example; the wooden board is named *rub-i daire* because it resembles a quadrant in the chapter describing the log; in the epilog, the same wooden board is named a *müselles mikyas* (a triangular scale), while the term *mikyas* refers to the scale of the maps in other parts of the text. Despite that the author notes in the epilog that he enriched the text with figures, the text we studied is devoid of figues. The absence of figures makes difficult to understand the functioning of the instruments. Therefore the information given about these instruments and the techniques for finding the latitude and the route becomes unclear. If one considers the text as a course book, its pedagogical features are absent.

Additionally, the mistakes in the examples given to “facilitate” the comprehension, indicate that the text has been composed by a nonexpert. These may also have been the notes taken from an European nautical book by a professor of the Engineering School (Land and/or Naval) who was entrusted with the teaching of seafaring. It is possible that the present text was the draft of a book that the author projected to publish. Future studies on the history of the mentioned schools will hopefully provide more precise information about the author of this text.

Although the work was written for the purpose of finding direction both on land and in sea, it predominantly gives information about nautical science and navigating at sea. The title does not precisely reflect the content as well. The technical analysis of the text provides us with information about the operations to be performed by a seaman who would navigate in the first half of the 19th century, the problems he may encounter during the cruise, and the solutions to those problems. The examples given in the text implies that the audience was familiar with the subject. In addition to this, the text was written to introduce the use of sailing equipment rather than teaching the sailing techniques. Accordingly, the Ottoman seamen were expected to use the following sailing techniques as late as the first half of the 19th century: *Sail navigation, piloting, dead reckoning* and *astronomical navigation.* On the other hand, the text shows that instruments such as *palastire* (cross-staff and backstaff), *sarko karta* (quart de cercle, sine quadrant), *quadrant* and *octant* were among the instruments used by Ottoman seamen for astronomical navigation. This implies that they used instruments other than the compass and maps. Those were introduced to the Ottoman navy from Europe. The fact that the author says, however, that the sarko karta is no different from the famous *rub-i müceyyeb* (sine quadrant) and that the use of the octant was similar to that of the *rub-i müceyyeb* indicates that the sine quadrant was the essential instrument used by the Ottomans in seafaring.

If a seaman wants to knows his route from the departure point to the destination or wishes to learn his whereabouts, he has to answer the following questions: «What is the latitude of my current place? Which wind(s) should I follow? How will I find my current place, the route I will follow, my destination, etc., on the map? How will I sail in case the shore is invisible? How will I detect my current place? How will I calculate the average navigation period?» The text we studied was designed for answering all of those questions. It makes us understand why and where we need a compass, a map, astronomical instruments and other equipment necessary for navigation. Finally, we should note that the author qualified his work as a detailed and elaborated book on new nautical techniques. The author seem to believe that the use of nautical instruments elaborated in Europe would help the reformation of the Ottoman marine. A comparison of the manuscript text studied in the present article with the copy kept in Cairo may unveil in the future the uncertainities mentioned above and clarify the role of the text, if any, in Ottoman seafaring.