

# Abstract

Bernard R. Goldstein

## **Levi ben Gerson and the Cross Staff Revisited**

On the occasion of the issuance in 2009 of an Israeli postage stamp honoring Levi ben Gerson (d. 1344) and the astronomical instrument he invented, we offer a brief survey of descriptions of this instrument, illustrations of it, and names that have been used for it over the centuries in Hebrew, Latin, and the vernacular European languages. Also, the images on the stamp are put in historical perspective.

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# Levi ben Gerson and the Cross Staff Revisited

## Introduction

Levi ben Gerson (Rabag or Gersonides), who lived in southern France in the fourteenth century, was a highly skilled astronomer. He was particularly proud of the instrument he invented which he simply called המקל (the staff; Latin: *baculus*) or מגלה עמוקות (revealer of profundities; Latin: *revelator secretorum*).<sup>1</sup> In fact, in his *magnum opus* on astronomy, written in Hebrew and translated into Latin in his lifetime, Levi included two original poems about his invention.<sup>2</sup> In recent books and articles about this instrument, it is generally called a cross staff (rather than a Jacob's staff, etc.), and this is the convention adopted here.<sup>3</sup>

- 1 In this article I do not trace subsequent usages of מגלה עמוקות as a name for the instrument.
- 2 For text and translation of the two poems, see Bernard R. Goldstein, *The Astronomy of Levi ben Gerson (1288–1344)* (New York and Berlin: Springer, 1985), pp. 71–72, 264–265. The Hebrew text of one of the poems was first published by Hirsch Edelman, “על המקל,” *Dibrej Hefhez — “Acceptable Words”* 1 (1853): 7; and then the Hebrew text of both poems was published by Joseph Carlebach, “לקוטים מכתבי הרלב”ג,” in Moritz Stern, ed., *Festschrift zum vierzigjährigen Amtsjubiläum der Herrn Rabbiners Dr. Salomon Carlebach in Lübeck* (Berlin: “Hausfreund,” 1910), pp. 151–178, on pp. 152–153.
- 3 See, e.g.: Willem Mörzer Bruyns, *The Cross-Staff: History and Development of*

The occasion for revisiting this astronomical instrument which I discussed in detail in 1985<sup>4</sup> is the recent issuance of an Israeli stamp in celebration of the International Year of Astronomy (2009) on which it is named *מטה יעקב* (Jacob's staff), together with images of a ship (to indicate the use of this instrument in navigation) and an individual using the instrument to measure the altitude of the Sun. After a brief description of Levi's instrument, I focus on published illustrations from the sixteenth to the twentieth century as well as on names for this instrument after Levi's time. Most of the references are in Latin and the European vernacular languages, but we will pay particular attention to those in Hebrew.

In the first instance the Latin version of Levi's *Astronomy* (translated by a certain Peter of Alexandria, where Alexandria refers to a place in northern Italy) has *baculus* where the Hebrew has *המקל*.<sup>5</sup> Neither the Hebrew nor the Latin of Levi's *Astronomy* has an expression equivalent to "Jacob's staff." This association probably derives from a verse in one of the poems that Levi composed to celebrate his invention of this instrument, *לולי ידי הנה לבן את יעקב ריקם שולח*,<sup>6</sup> which alludes to Gen 30:37: *...ויקה לו יעקב מקל...* However, in the dedication to the Pope (then resident in Avignon) of the Latin translation (which has no counterpart in Hebrew), one finds the expression *baculus Jacob* for this instrument, and this seems to be the basis for one of its names in the subsequent literature.<sup>7</sup>

Levi's instrument consists of two pieces of wood<sup>8</sup> such that the shorter piece can slide along the longer piece. The eye is at one end of the graduated longer piece (the staff) and the shorter piece (or crosspiece) is then moved so that a star is seen at each end of the shorter piece (see Fig. 1). The observer can then determine the angular separation between the two stars. Levi also describes a "mounted" version of his instrument where the staff is attached to fixed legs standing on the ground that can be used for observing the altitude of the Sun, the Moon, or a star (see Fig. 2). Levi says nothing about using this instrument for navigation at sea, and there is no evidence that he gave any thought to astronomical navigation. Two aspects of Levi's description of his instrument were

often overlooked by his successors: (1) the eccentricity of the eye, that is, the center of vision is inside the eye and so one has to take into account the distance from the center of vision to the end of the staff nearest the eye; and (2) a diagonal scale to allow for fine graduations on the staff.<sup>9</sup>

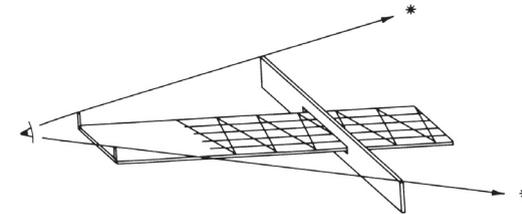


Fig. 1. The cross staff drawn according to Levi ben Gerson's description, as in Goldstein, *Astronomy of Levi ben Gerson*, p. 147.

*a Navigational Instrument* (Amsterdam: Vereeniging Nederlandsch Historisch Scheepvaart Museum, 1994); Alan Stimson and Christopher Daniel, *The Cross Staff: Historical Development and Modern Use* (London: Harriet Wynter, 1977).

4 Goldstein, *Astronomy of Levi ben Gerson*, pp. 51–73 and 143–158.

5 For *baculus* see, e.g., José Luis Mancha, "The Latin Translation of Levi ben Gerson's *Astronomy*," in G. Freudenthal, ed., *Studies on Gersonides: A Fourteenth-Century Philosopher-Scientist* (Leiden: Brill, 1992), pp. 21–46, on pp. 23–24 (corresponding to the Hebrew text in Goldstein, *Astronomy of Levi ben Gerson*, p. 278). For the identification of Alexandria as a city in Italy, see Mancha, "Latin Translation," p. 25.

6 See Goldstein, *Astronomy of Levi ben Gerson*, p. 264.

7 Gilbert Dahan, "Les traductions latines médiévales des oeuvres de Gersonide," in G. Dahan, ed., *Gersonide en son temps* (Louvain and Paris: Peeters, 1991), pp. 329–368, on p. 351, line 1; Mancha, "Latin Translation," p. 36, n. 2.

8 Levi does not, in fact, specify the material but, in the Latin translation, it is said that the instrument may be made of "copper, bronze, or light wood"; see Mancha, "Latin Translation," p. 28.

9 Goldstein, *Astronomy of Levi ben Gerson*, pp. 143–149.

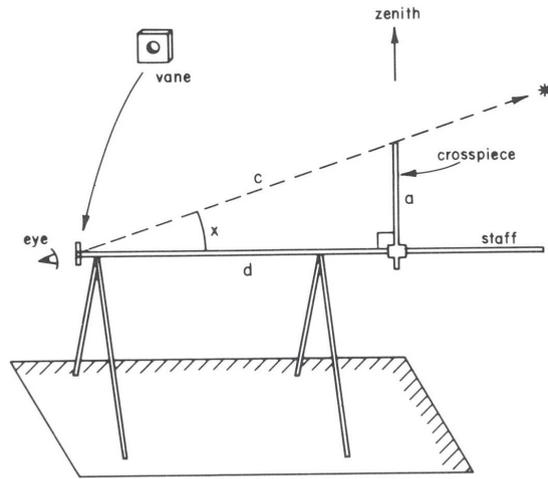


Fig. 2. The mounted version of the cross staff, where the staff is in the horizontal plane, drawn according to Levi ben Gerson's description, as in Goldstein, *Astronomy of Levi ben Gerson*, p. 154.

### 1. Descriptions and Illustrations of the Cross Staff after the Time of Levi ben Gerson

The most detailed description of the cross staff in Latin in the fifteenth century is due to Regiomontanus (d. 1476), the leading astronomer of his generation. He had a manuscript (now lost) of the short version of Levi's *Astronomy* in Latin,<sup>10</sup> but he does not refer to Levi in connection with this instrument. The discussion comes in Regiomontanus's *Sixteen Problems on Comets* which was published in 1531. Problem 12 describes a cross staff (simply called *instrumentum*) consisting of a staff (*regula*) and a movable crosspiece (*regullela mobilis*).<sup>11</sup> No mention is made of the eccentricity of the eye or of a diagonal scale, and nothing is said about navigation. The figure in the edition of 1531 is quite simple (see

Fig. 3). The instrument was used for making astronomical observations by Regiomontanus and then by his disciple, Bernhard Walther of Nuremberg (d. 1504).<sup>12</sup> In the introduction by Johann Schöner (d. 1547) to the list of observations by Regiomontanus and Walther there is a description of the instrument and an illustration of it (see Fig. 4).<sup>13</sup> Note that in Figure 4 the staff and the crosspiece are divided uniformly in a linear measure, and that trigonometry is required to find the angle CAD from the size of the crosspiece and its distance from the eye.

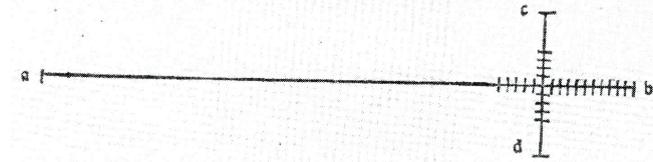


Fig. 3. Regiomontanus, *Sixteen Problems*, 1531, f. C ii v.

- 10 H. Petz, "Urkundliche Nachrichten über den literarischen Nachlass Regiomontanus und B. Walthers 1478–1522," *Mitteilungen des Vereins für Geschichte der Stadt Nürnberg* 7 (1888): 237–262.
- 11 Ioannis de Monteregio, *De Cometae magnitudine, longitudineque ac de loco eius uero problemata XVI* (Nuremberg: Peypus, 1531), repr. in Jane Jervis, *Cometary Theory in Fifteenth-Century Europe*, *Studia Copernicana* 26 (Wrocław and Warsaw: Polish Academy of Sciences Press, 1985), pp. 171–193, on p. 190.
- 12 Johann Schöner, ed., *Scripta clarissimi mathematici* (Nuremberg: Montanus and Neuber, 1544), ff. 27r–34r and 36r–60v. This volume also includes a second edition of Regiomontanus's *Sixteen Problems on Comets* (ff. 79r–88r).
- 13 Schöner, *Scripta clarissimi mathematici*, ff. 34v–35v, on f. 34v. Pedro Nunes (1502–1578) has a description of a *radius astronomicus* in his *De Arte atque ratione navigandi* (Coimbra: António de Mariz, 1573), pp. 47–48 (repr. in Pedro Nunes, *Obras* [Lisbon: Fundação Calouste Gulbenkian, 2008], vol. 4, pp. 104–106), in which he cites several relevant items in Schöner's *Scripta clarissimi mathematici*.

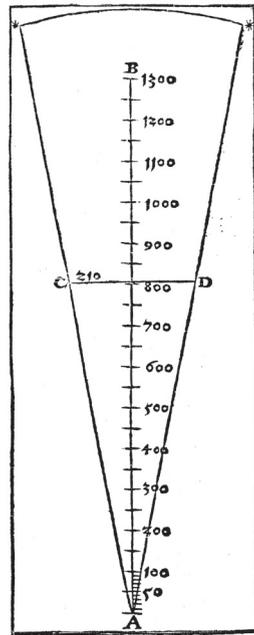


Fig. 4. Schönner, *Scripta clarissimi mathematici*, 1544, f. 35r.

After the death of Walther a number of scholars in Nuremberg had access to unpublished scientific works in Regiomontanus's estate,<sup>14</sup> and in 1514 Johann Werner (d. 1522), probably taking advantage of Regiomontanus's description, was the first to publish an illustration of the cross staff, again for astronomical purposes.<sup>15</sup> Werner's innovation was to divide the staff such that the angular distance between the two stars could be read directly on the staff, without requiring any computation (see Fig. 5). For this reason, the divisions on the staff are no longer equal, and the angle (noted to the left of the staff) is greater as the crosspiece approaches the eye.<sup>16</sup> The cross staff was

generally abandoned for astronomical purposes after the end of the sixteenth century, for Tycho Brahe (d. 1601) developed new and better instruments and disparaged the cross staff as inaccurate:

Frankly, however, no matter how this [astronomical] radius is constructed, it cannot, as I intimated before, give stellar distances precisely in accordance with reality.<sup>17</sup>

Brahe suggested a way to eliminate the difficulty, but apparently this had little impact on his contemporaries and immediate successors.<sup>18</sup>

The application of the cross staff to aid in navigation probably began in Portugal. The earliest reference is in a manuscript of João de Lisboa, said to date from 1514.<sup>19</sup> The earliest illustration of a person holding the cross staff comes in a treatise on navigation by Pedro de Medina in 1552 (see Fig. 6).<sup>20</sup>

- 14 Ernst Zinner, *Regiomontanus: His Life and Work*, trans. Ezra Brown (Amsterdam: North Holland, 1990), p. 158; cf. Mörzer Bruyns, *Cross-Staff*, p. 20.
- 15 Johann Werner, *Noua translatio primi libri geographicae Cl. Ptolomaei* (Nuremberg: Stüchs, 1514), f. d5v.
- 16 For illustrations in publications of the sixteenth century of ways to graduate the staff geometrically see, e.g., Mörzer Bruyns, *Cross-Staff*, pp. 29 and 42–43.
- 17 Hans Raeder, Elis Strömngren, and Bengt Strömngren, *Tycho Brahe's Description of His Instruments and Scientific Work* (Copenhagen: Munksgaard, 1946), p. 97.
- 18 John J. Roche, "The Radius Astronomicus in England," *Annals of Science* 38 (1981): 1–32, on pp. 28–32.
- 19 João de Lisboa, *Tratado da agulha de marear*, in Jacinto Ignacio de Brito Rebello, ed., *Livro de Marinharia* (Lisbon: Libanio da Silva, 1903), p. 41; Mörzer Bruyns, *Cross-Staff*, p. 24.
- 20 Pedro de Medina, *Regimento de nauagation* [1st ed., 1552], 2nd ed. (Seville: Simón Carpintero, 1563), f. 35v; Mörzer Bruyns, *Cross Staff*, p. 14.

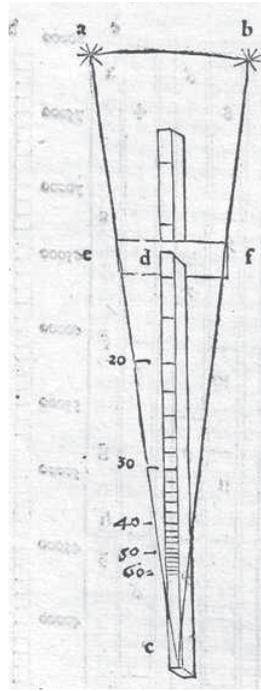


Fig. 5. Werner, *Noua translatio*, 1514, f. d5v.

The use of the cross staff for navigation seems to have spread from Spain and Portugal to northern Europe in the mid-sixteenth century, in some cases by means of personal contacts and in others by translations. In at least one case a navigator trained in Seville moved to England.<sup>21</sup> The earliest extant cross staff is dated “before 1596” and is now in the Rijksmuseum in Amsterdam.<sup>22</sup> Recently, a cross staff on a ship that sank in the mouth of the River Scheldt in 1735 has been recovered.<sup>23</sup> In the second half of the eighteenth century the cross staff was gradually replaced by other instruments for astronomical navigation.<sup>24</sup>

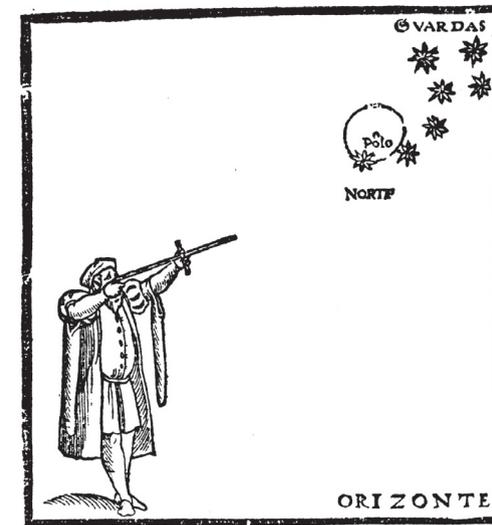


Fig. 6. Pedro de Medina, *Regimento de nauegacion*, [1552] 1563, f. 35v.

- 21 Alison Sandman and Eric H. Ash, “Trading Expertise: Sebastian Cabot between Spain and England,” *Renaissance Quarterly* 57 (2004): 813–846; Francis Maddison, *Medieval Scientific Instruments and the Development of Navigational Instruments in the XVth and XVIth Centuries* (Coimbra: Junta de Investigações do Ultramar–Lisboa, 1969), pp. 46–51; Mörzer Bruyns, *Cross-Staff*, pp. 14–15, 32. David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (New Haven: Yale University Press, 1958), pp. 82 n. 1, 100–105, 502–503.
- 22 Mörzer Bruyns, *Cross-Staff*, p. 48.
- 23 Willem Mörzer Bruyns and A. J. van der Horst, “Navigational Equipment from ‘t Vliegend Hart (1735),” *International Journal of Nautical Archaeology* 35 (2006): 319–325.
- 24 Mörzer Bruyns and van der Horst, “Navigational Equipment,” p. 320; Mörzer Bruyns, *Cross-Staff*, p. 44.

The cross staff was represented on a Dutch stamp in 1986, where the image, called in Dutch *Jacobsstaf*, was taken from a navigational manual but, given the “recycling” of images, it is not easy to say which book was used (see Fig. 7). The illustration on this stamp appears in several books, including one by Wakely which, in turn, is dependent on the illustration of a “Cross-Staff” in a book by Seller (see Figs. 8 and 9).<sup>25</sup>



Fig. 7. A Dutch stamp illustrating a Jacob’s staff (or cross staff).

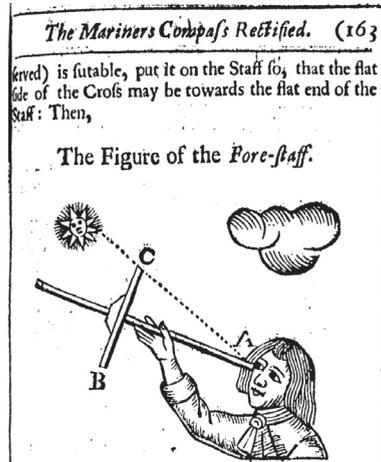


Fig. 8. Wakely, *Mariners Compass Rectified*, 1694, p. 163.



Fig. 9. Seller, *Practical Navigation*, 1669, p. 200.

The image of the cross staff on the recent Israeli stamp (Fig. 10) also has a “pre-history,” for it is strikingly similar to an image published in 1991, designed by a Canadian, Francis Back (see Fig. 11).<sup>26</sup> Note, for example, that in both cases the staff is graduated non-uniformly into degrees (following the precedent of Werner and many of his successors), that the crosspiece in both illustrations is at the same place on the staff, and that the left hand holds the staff in the same way.

25 Andrew Wakely, *The Mariners Compass Rectified* (London: Richard Mount and Thomas Passenger, 1694), p. 163; John Seller, *Practical Navigation* (London: J. Darby, 1669), p. 200. The image in Wakely’s book had already appeared in Nathaniel Colson, *The Mariners New Kalendar* (London: J. Darby, 1677), p. 80.

26 Robert McGhee, *Canada Rediscovered*, with Illustrations by Gilles Archambault and Francis Back (Hull: Canadian Museum of Civilization and Libre Expression, 1991), p. 91 (this drawing is attributed to Francis Back on the reverse title page).



Fig. 10. The Israeli stamp issued in 2009 honoring Levi ben Gerson.



Fig. 10a. Detail of Fig. 10

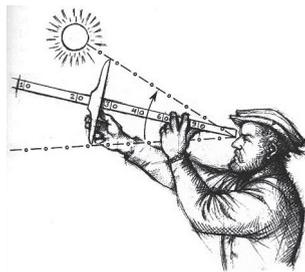


Fig. 11. A modern drawing by Francis Back of a person using a cross staff: McGhee, *Canada Rediscovered*, p. 91 (Copyright Canadian Museum of Civilization).

## 2. Terminology for the Cross Staff in Latin and Vernacular Languages after the Time of Levi ben Gerson

In Latin texts of the fifteenth century, Levi's cross staff is simply called an instrument (Latin: *instrumentum*), and there are few detailed descriptions of it. For example, it is mentioned by Giovanni Pico della

Mirandola (d. 1494) in his *Disputationes adversus astrologiam*, but it is not clear if his information on this matter came from a Latin source or a Hebrew text.<sup>27</sup> Pico did have access to Hebrew astronomical material with the help of one of his associates who called himself Flavius Mithridates, a Jewish convert to Christianity and now identified as Samuel ben Nissim, originally from Sicily.<sup>28</sup> In the sixteenth century Schöner inserted an introduction to the list of observations by Regiomontanus and Walther in which the instrument is given a variety of names, including *radius astronomicus* and *baculus*.<sup>29</sup>

In the vernacular languages, the earliest name for this instrument is *balbestilha* in Portuguese (mod. *balestilha*), and then in Spanish *ballestilla*.<sup>30</sup> In French it was called *arbaleste* (mod. *arbalète*),

27 Giovanni Pico della Mirandola, *Disputationes adversus astrologiam*, IX.8; ed. Eugenio Garin (Florence: Vallecchi, 1946–1952), II, p. 324.

28 Bernard R. Goldstein and José Chabás, “Isaac Ibn al-Ḥadīb and Flavius Mithridates: The Diffusion of an Iberian Astronomical Tradition in the Late Middle Ages,” *Journal for the History of Astronomy*, 37 (2006): 147–172.

29 Johann Schöner, “In constrvctionem atqve vsvm rectanguli siue radij Astronomici annotationes,” in idem, ed., *Scripta clarissimi mathematici* (Nuremberg: Montanus and Neuber, 1544), ff. 34v–35v, on f. 34v. A lost work by Georg Peurbach (1423–1461), *Compositio novae virgae visoriae cum lineis et tabula nova*, cited in Zinner, *Regiomontanus*, p. 28, refers to an astronomical instrument, called *virga visoria*, that may be a cross staff, but this is uncertain. See C. Doris Hellman and Noel Swerdlow, “Georg Peurbach,” in Charles C. Gillespie, ed., *Dictionary of Scientific Biography* (New York: Scribner, 1981), 15:473–479, on p. 478. For a general discussion of terminology, see Maddison, *Medieval Scientific Instruments*, p. 47 n. 142.

30 João de Lisboa, *Tratado*, p. 41; Pedro de Medina, *Arte de nauegar* (Valladolid, Francisco Fernández de Córdoba, 1545), f. 76v. In an undated Portuguese manuscript ascribed to André Pires the cross staff is called *balhistinha*: see Bibliothèque Nationale de France, cod. 44340 [= MS port. 40], f. 31r, in Luís de Albuquerque, ed., *O Livro de*

*arbalestrille*, *baston de Iacop* (mod. *bâton de Jacob*), and *rayon astronomique*.<sup>31</sup> In German it was called *Jacobsstab* (or *Jacobstab*) and *Gradstock*,<sup>32</sup> and in Dutch *staf*, *baculus*, *graadboog*, *graadstok*, *stok*, and *Jacobsstaf*.<sup>33</sup> In English one finds *Jacob's staff*, *cross staff*, *fore-staff*, and *Balla Stella* (presumably a corruption of the Spanish or Portuguese name for this instrument).<sup>34</sup>

### 3. Terminology for the Cross Staff in Hebrew after the Time of Levi ben Gerson

In most instances Levi's Hebrew terminology was maintained, but a variant is found in a work by Yoḥanan Alemanno (d. after 1504), a mystical philosopher, closely associated with Pico della Mirandola.<sup>35</sup> Surprisingly, he refers to several astronomical instruments:<sup>36</sup>

כלים שונים כמו הכדור האישפיר"ה והאסטרוולובי"א והקררי"ן ומטה לוי ורבים  
כמו אלה לא יסופר.

... different instruments [for observing the altitude of stars] such as the armillary sphere, the astrolabe, the quadrant [as emended by Steinschneider], Levi's staff, and countless others like these.<sup>37</sup>

As far as I can determine, *מטה לוי* does not occur in any other text in the sense of a cross staff before Steinschneider first called attention to this Hebrew expression in 1862, and rarely afterwards. And since this is not an expression previously used in Hebrew for this purpose, it is unclear on what sources Alemanno depended. I suggest that he became aware of the instrument indirectly from someone in Pico's circle, and made up his own name for the instrument which was known to have been invented by Levi ben Gerson. This passage would probably have gone

*Marinharia de André Pires* (Lisbon: Junta de Investigações do Ultramar, 1963), p. 217; cf. p. 136. It is claimed that the relevant part of this manuscript was written between 1500 and 1520 (ibid., p. 31). See also Luís de Albuquerque, *Astronomical Navigation* (Lisbon: Navigational Board for the Celebration of the Portuguese Discoveries, 1988), pp. 14 and 125; and Maddison, *Medieval Scientific Instruments*, p. 47.

- 31 Jacques de Vault, *Les premières oeuvres de Jacques de Vault, pillote en la marine, au Havre* (1583), Bibliothèque nationale de France, MS français 150, f. 16: *arbaleste* and *baston de Iacop*; facsimile reproduction in Goldstein, *Astronomy of Levi ben Gerson*, frontispiece, which includes an illustration of the instrument as well; Jacques Ozanam, *Dictionnaire mathématique, ou Idée générale des mathématiques* (Amsterdam: Huguëtan, 1691), p. 256: "Les Astronomes se servent d'un grand *Quart de Cercle* pour prendre la hauteur du Pole, & des Astres, & les Pilotes, d'un instrument appelé *Arbalète, Arbalestrille, & Bâton de Jacob, & aussi Rayon Astronomique*." See also Mörzer Bruyns, *Cross-Staff*, p. 23.
- 32 Arthur Breusing, "Zur Geschichte der Geographie 2: Regiomontanus, Martin Behaim und der Jakobsstab," *Zeitschrift der Gesellschaft für Erdkunde zu Berlin* 4 (1869): 97–106, on p. 97; S. Günther, "Die erste Anwendung des Jacobsstabes zur geographischen Ortsbestimmung," *Bibliotheca Mathematica*, NF 4 (1890): 73–80; Maximilian Curtze, "Die Abhandlung des Levi ben Gerson über Trigonometrie und den Jacobstab," *Bibliotheca Mathematica* NF 12 (1898): 97–112; Joseph Carlebach, *Levi ben Gerson als Mathematiker* (Berlin: Lamm, 1910), p. 25: "Der Jacobstab."
- 33 Mörzer Bruyns, *Cross-Staff*, p. 23.
- 34 William Cunningham, *The Cosmographical Glasse* (London: Iohannis Daij, 1559) p. 106: "the Astronomers staffe, also called Iacobes staffe"; William Bourne, *A Regiment for the Sea* (London: Thomas Hackett, 1574), f. 25v: "Balla Stella or Crosse Staffe"; Wakely, *Mariners Compass Rectified*, p. 163; Seller, *Practical Navigation*, p. 200 (see Figs. 8 and 9).
- 35 B. C. Novak, "Giovanni Pico della Mirandola and Jochanan Alemanno," *Journal of the Warburg and Courtauld Institutes* 45 (1982): 125–147.
- 36 Jochanan Alemanno, *שער החשק* (Halberstadt: Fischl/Meyer, 1862), f. 10a.
- 37 Moritz Steinschneider, review of: "Jochanan Alemanno, *שער החשק* (Halberstadt: Fischl/Meyer, 1862)," in *Hebraeische Bibliographie* 5 (1862): 28–29, on p. 29.

unnoticed had it not been for Steinschneider: “מטה לוי ist offenbar das von Levi b. Gerson erfundene Instrument, auch als מקל bezeichnet.”<sup>38</sup>

In 1889 Steinschneider referred to this review of 1862 in his article, “Levi ben Gerson,”<sup>39</sup> which was then cited in 1893, rather obscurely, in a lengthy article on Levi ben Gerson in French.<sup>40</sup> Later authors who mention this name for Levi’s instrument probably depended on Steinschneider directly, or indirectly.<sup>41</sup> I have found only one instance of the expression מקל יעקב in the secondary literature.<sup>42</sup> As far as I can determine, the earliest usage of מטה יעקב for Levi’s instrument occurs in a Hebrew dictionary of 1966,<sup>43</sup> and this is the expression on the Israeli stamp of 2009. Both מקל יעקב and מטה יעקב seem to derive from the English expression, Jacob’s staff (or its German equivalent), which ultimately comes from the Latin *baculus Jacob*.

#### 4. Modern Reconstructions

The modern study of this instrument has involved reconstructions and some attempts to use them at sea. In 1974/75 Christopher Daniel participated in a voyage from Plymouth, England, to San Francisco, in a reproduction of Sir Francis Drake’s *Golden Hinde*, and carried out a program of observations with a modern cross staff (see Fig. 12). His comments are most interesting, among which are

1. Taking observations of the Sun, even with a smoked glass shade [see Fig. 12, upper end of the crosspiece] is “unpleasant,” and the higher the Sun, the more difficult it is to keep both the Sun and the horizon in view, while maintaining one’s balance on the moving deck of a ship.<sup>44</sup>
2. Larger cross staffs were more affected by wind than smaller ones.<sup>45</sup>

Nevertheless, Daniel succeeded in making observations of the Sun with sufficient accuracy for purposes of navigation. And at night the cross

38 Ibid.

39 Moritz Steinschneider, “Levi ben Gerson,” in Johann S. Ersch and Johann G. Gruber, eds., *Allgemeine Encyclopädie der Wissenschaften und Künste*, series 2, 43 (1889): 295–300, on p. 299 n. 40; revised version in Moritz Steinschneider, *Gesammelte Schriften*, Heinrich Malter and Alexander Marx, eds. (Berlin: Poppelauer, 1925; repr. New York: Arno, 1980), pp. 233–270, on p. 249 n. 44.

40 Ernest Renan [and Adolf Neubauer], *Les écrivains juifs français du XIV<sup>e</sup> siècle* (Paris: Imprimerie nationale, 1893), 586–644, on p. 620: “bâton de Lévi” (מטה לוי), with a marginal reference, “Encyc., XLIII, p. 299”, that is, Steinschneider, “Levi ben Gerson.”

41 See Carlebach, *Lewi ben Gerson als Mathematiker*, p. 30, where one of the names for Levi’s instrument is given as מטה לוי according to Alemanno, citing Renan-Neubauer, *Les écrivains*. See also Nechama Hirschensohn, “Levi ben Gerson,” in *Ozar Yisrael: An Encyclopedia of all Matters concerning Jews and Judaism in Hebrew*, 2<sup>nd</sup> edition (Berlin and Vienna: Menorah; London: Shapiro and Vallentine, 1924), 6:11–14 [in Hebrew], on p. 13: מטה לוי.

42 Carlebach, “לקוטים,” p. 151: מקל יעקב.

43 Abraham Even-Shoshan, *המלון החדש* (Jerusalem: Kiryath Sefer, 1966), 3:1311: מטה יעקב (“the name of an astronomical instrument invented by Levi ben Gerson for measuring angles in the sky”; labeled, incorrectly, “in medieval literature”). Note that this expression is not included in the edition of the same dictionary that appeared in 1960.

44 Stimson and Daniel, *Cross Staff*, pp. 12 and 16. For using a colored glass at the upper end of the crosspiece to shield the eye from the Sun’s rays, see Bourne, *Regiment for the Sea*, f. 27r, and Mörzer Bruyns, *Cross-Staff*, p. 25. For other solutions to this problem see, e.g., Maddison, *Medieval Scientific Instruments*, pp. 51–52; Stimson and Daniel, *Cross Staff*, pp. 6–7, 18.

45 Stimson and Daniel, *Cross Staff*, p. 16.

staff worked even better for observing the altitude of stars.<sup>46</sup> Daniel concluded that:

From my various observations during the voyage I believe the cross staff was a useful and reasonably accurate instrument in its day, giving results with a latitude range of about plus or minus 20 nautical miles.<sup>47</sup>



Fig. 12. Christopher Daniel observing the altitude of the Sun with a modern cross staff (color photo courtesy C. Daniel; a black and white version appeared in Stimson and Daniel, *Cross Staff*, p. 14).

## 5. Conclusion

This article is not intended to give a complete history of the cross staff which would require discussion of many more texts than those considered here. Moreover, there are a great many myths in the secondary literature, that is, claims for which there is no support in the historical documents, about the invention and diffusion of the cross staff (often repeated on the Internet), whose refutation would contribute little to this brief account. The focus of attention here has been on the background to the recent Israeli stamp. Despite the aesthetic qualities of this stamp, it is misleading in several ways: Levi did not call his instrument *מטה יעקב*, and he did not discuss its application to navigation; moreover, he used a linear graduation on the staff and did not graduate it in such a way that the angle in degrees separating two stars can be read directly on the instrument without requiring any calculation. On the other hand, Levi's achievement in inventing a diagonal scale is not displayed. And perhaps it should be added that the person depicted on the stamp is not Levi, for whom no portrait is known; rather, this individual is an ordinary seaman, as is the case in many other such illustrations including a few shown in this article. In sum, from an academic point of view the images on this stamp fail to convey the originality of Levi's contributions to practical astronomy.

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<sup>46</sup> Ibid., pp. 18–19.

<sup>47</sup> Ibid., p. 21.