Encyclopædia Iranica

Published: December 15, 1992
Last Updated: June 25, 2013

CLOCKS

CLOCKS (Pers. *sāʿat*), devices for measuring and registering time.

Early time-keeping devices. The sundial (*sāʿat-e āftābī*, *sāʿat-e šamsī*) was already known in antiquity. According to Vitruvius (9.8.1), in the early 4th century b.c.e. the Babylonian priest Berossus invented a simple version consisting of a hemisphere hollowed out of a cube and inscribed with a series of seasonal arcs divided into twelve hours each, over which a pointer cast its shadow. It is more probable, however, that Berossus had simply described a device already in use in Babylon (Pauly-Wissowa, VIII/2, col. 2419). Because the length of the hour varied with the time of day and the season, this sundial was not entirely accurate; the Greeks and Romans made some improvements on it (and also developed moondials), and, according to the Syrian astronomer Battānī (Albategnius; ca. 244-317/858-929), it was still in use in the 4th/10th century (Rohr, p. 10).

Gnomonics, the science of constructing sundials, was particularly important to Muslims because it helped them to determine correctly both the times for the five daily prayers and the *qebla* (direction of Mecca, to ward which Muslims turn while praying). The earliest known portable sundials of the Islamic period are both dated 554/1159, one in the collection of the Aḥmadīya Madrasa in Aleppo (*Science*, p. 15), the other, made for the Zangid ruler of Syria Nūr-al-Dīn Maḥmūd (d. 569/1174), in the Bibliothèque Nationale, Paris (Mayer, pp. 52-53). That Persians were also familiar with such timepieces is clear from the names of some craftsmen. For example, Moḥammad b. ʿAlī b. Rostam Ḵorāsānī Sāʿātī rebuilt a large clock on one of the city gates at Damascus after

564/1168-69; his son Faḵr-al-Dīn

Reżwān, himself a physician by profession and the author of a book on astronomical clocks (*Resāla fī ʿamal al-sāʿat wa esteʿmālehā*), subsequently repaired it (Hill, 1978, pp. 224-25, 1984, pp. 234-35; Wiedemann and Hauser, pp. 176-266; Mayer, p. 62). In the 7th/13th century the Moroccan ʿAlī Abu'l-Ḥasan wrote extensively about various designs for sundials and is believed to have used trigonometry to equalize the hours for astronomical purposes (Ward; cf. Rohr, pp. 15-16). Sundials remained in use in Persia even after the mechanical clock (see below) was introduced. A combination sundial and *qebla* indicator (now in the Time Museum, Rockford, Illinois) is known to have been manufactured there as late as ca. 1120/1708 (*Science*, p. 16).

Simple water clocks (clepsydras, *pangān*, *sāʿāt-e ābī*) were also known in antiquity. A vessel was filled with water to the topmost of twelve calibrations on the interior surface. The water was then allowed to drain off through an outlet pipe; the vessel was shaped so that the water level fell at an approximately uniform rate. The Byzantines had perfected this instrument to such an extent that bells could be struck or musical automatons moved to make people aware of the passage of the hour. Similar devices were made by craftsmen for the early Muslims; in 191/807 one example was presented to Charlemagne by an ambassador of the caliph Hārūn al-Rašīd, "the king of the Persians" (170-93/786-809; Tessier, pp. 175-76). During the early ʿAbbasid period a great many Greek works were translated into Arabic, including such technical treatises as the *Pneumatica* (*Ketāb fi'l-ḥīal al-rūḥānīya wa majānīq al-mā'*) of Philon of Byzantium (3rd-2nd century b.c.e.; Hill, 1984, pp. 188, 201), the *Mechanica* (*Ketāb fi'l-ḥīal al-rūḥānīya*) of Heron (Īron, Hīrūn) of Alexandria (60 c.e.; Hill, 1984, pp. 188, 201), and a treatise on a type of water clock attributed to Archimedes (Ar. Aršemīdes, d. 212 b.c.e.; Hill, 1978, pp. 12-13; 1984, 230-31). One of the three Persian brothers known as Banū Mūsā, who were active in this translation movement, probably Aḥmad b. Mūsā b. Šāker, wrote *Ketāb al-ḥīal* (Book of mechanical devices) in about 236/850 (p. 12; Wiedemann and Hauser, pp. 176-266; Hill, 1978, pp. 226-27; 1984, pp. 202-03); it probably included discussion of waterclocks. Ḵʷārazmī, in *Mafātīḥ al-ʿolūm* (Keys to the sciences, written during the reign of the Samanid Nūḥ b. Manṣūr, 365-87/976-97), also included a chapter on *ḥīal* (pp. 246-55). Muslim scientists and craftsmen continued to design and manufacture such devices, many of which were described in detail in Jazarī's *Ketāb fī maʿrefat al-ḥīal al-hendasīya* (602/1206), written for the Artuqid prince of Āmed (modern Diyarbakır in

Turkey), Maḥmūd b. Moḥammad b. Qara Arslān (Brockelmann, *GAL*, S. I, pp. 902-03). D. H. Hill, who has translated and annotated this treatise, has also constructed some of the devices described in it; all of them, including a water clock, work as prescribed (Hill, 1978, pp. 229-32). Some of the terms Jazarī used are of Persian origin, which suggests that some of the devices also originated in Persia. For example, one particular type of water clock that is known only from his work incorporates a *tarjahār*, a submersible bowl with an opening in the bottom. *Tarjahār*, that is, *tarkehār*, is a Persian term, meaning “crock” (Hill, 1978, p. 231; 1984, pp. 213, 237-38).

There is little available information on the existence and use of clocks in Persia itself before the Il-khanid period (654-736/1256-1336), however. Ḵalīl b. Abū Bakr b. Moḥammad Āmolī built a water clock in the Roknīya *madrasa* in Yazd in 725/1324. According to two 9th/15th-century descriptions it included a copper tank (*tanūra*) twice as tall as a man, which had to be filled every day with water. The water escaped through a hole (*ṭoqba*) into a tube (*mary*) through the support (*ʿeżāda*) of a bronze device, similar to an astrolabe, that was placed under the tank and flowed into a well. On top of the water floated a weight (*langar*) attached to a chain, to which were connected 150 ropes, each with a wooden counterweight dangling from the other end. As the water level in the tank dropped, the floating weight moved, pulling the chain and the ropes and setting the clock in motion. This particular clock also served as an astronomical device, indicating not only the passage of hours, days, months (Turkish, Christian [*rūmī*], Arab [lunar], and *jalālī* [solar]), and years but also the motion of the stars. A metal bird on top of a turret always turned to face the sun (Jaʿfarī, pp. 81-83; Aḥmad Kāteb, pp. 123-25).

Mechanical clocks. The mechanical clock, in which a weight-driven device moves a counting mechanism at regular intervals, appears to have been invented in Europe about 1300 c.e. (Baillie). Watches, which are portable clocks, became common after 1500, when the German Peter Henlein probably invented the mainspring. Both clocks and watches were introduced into Persia at about that time (Baillie). Moḥammad-Ḥāfeẓ Eṣfahānī in *Ketāb natījat al-dawla*, probably written between 928/1522 and 950/1543 (see Nūrbaḵš, p. 400 n. 29), mentioned what may have been the first clock brought from Europe, which he saw in Herat, the capital of Sultan Ḥosayn Bāyqarā (873-911/1469-1506; see Suppl.). The Ottoman sultan (probably Bāyazīd II, 886-918/1481-1512) and the king of Persia (probably the Āq Qoyunlū Yaʿqūb, who ruled at Tabrīz in 883-96/1478-90) sought to have it copied as it passed

through their lands, so that the art of making clocks would not remain the monopoly of non-Muslims. Besides, it was a necessary tool for determining the correct times for prayer. They were unsuccessful, however, and Eṣfahānī himself was the first to grasp its workings and make a copy; he confessed himself amazed at the intricacy of the design. In addition to the instrument that he made at Herat, he built another at Samarqand for the Timurid prince Solṭān-Aḥmad Gūrkānī (873-99/1469-94; Eṣfahānī, p. 85; cf. Nūrbaḵš, pp. 400-01). The latter clock must have been made before the death of Solṭān-Aḥmad and the one in Herat earlier. Apparently he made a third clock for the city of Kāšān (Nūrbaḵš, p. 401). According to Moḥammad-Taqī Dānešpažūh, there were two master clockmakers in Herat (?) in the 10th/16th century (apud Nūrbaḵš, p. 401 n. 32).

By 949/1542 there was a clock in Tabrīz, housed in a separate pavilion in the *bāzār*. Michele Membré described (pp. 37-38) it as having been built by a Persian with a white beard: It was "set inside a square enclosed pavilion of painted planks 4 ells high and two wide. [This clock] had these things, that is, on the summit of the said pavilion there was a bell with a clapper that struck the hours, which stood in the middle of the pavilion on the top, and in front of the said pavilion there were two men with horses and lances, as big as a hen, next to two buffoons as big as a large mouse, the size of those in a house, so that, when it came to strike the hour, however many hours the bell had struck, then so many times those horsemen with the lances thrust them forward, and those buffoons banged their foreheads together, and that all at once; it also showed the moon during the eclipse. There was also another thing in the clock: There was a hole under it where women and men came to learn their futures. They put in this hole a copper farthing of their money, called altun [Turk. *altın* "gold"; see coins], and that fell down inside the pavilion, and immediately one heard the noise of a door opening, and out of it came a dragon, and from its mouth a small iron ball fell; under this door opened another one, and from it a cat came out. The said small ball fell into the mouth of this cat. Furthermore, on the other side another door opened, and a snake appeared, and from its mouth fell a written card. They read what was written on this card, and in this manner they learned their fortune. I also have learned my fortune, and my card said that soon great riches would come to me, which I am still waiting for. I asked the old craftsman who had made it if he had ever seen another like it and if somebody had taught him; he said that he had never seen one, nor had anybody taught him, but that he had found such a thing only in books." Despite these early examples, however, the art of making

clocks was soon lost in Persia.

In the time of Shah ʿAbbās I (996-1038/1588-1629) clocks and watches were much sought after. The first European watchmaker (*sāʿatsāz*) probably arrived there about 998/1590, for the Sherley brothers observed that, when they themselves reached the court in 1007/1598, "we also found an old Frenchman, a clockmaker, who is among the King's artisans; although he is decrepit and cannot work any longer, the King keeps him by charity" (Ross, pp. 158-59). In 1017/1608 the shah requested that another clockmaker be sent to him (*Chronicle* I, p. 165). Clocks did indeed have such high value in Persia that they were considered appropriate diplomatic gifts. For example, in 1022/1613 Shah ʿAbbās sent to the Mughal emperor Jahāngīr a crystal watch that he had in turn received from one of the rulers of Europe, probably the king of Spain Philip III (1598-1621; Riazul Islam, I, p. 167). An English report on suitable commodities to be traded with Persia, prepared in 1027/1618, included mention of "Clockes—Watches and Horyzontall dyals which maye answere to the latytude of Spahan which lyeth in 32 degrees whereof one of each for the kinge of substantiall and ritch worke the rest to be gyven to such of his nobylitie or neere attendants as shall deserve the same these in England are of noe greate value and here highlye esteemed" (Ferrier, p. 214). The Augustinian fathers presented the shah with a large clock, which was installed at the entrance to the royal *bāzār* in Isfahan; a church bell that had been captured during the conquest of Hormuz in 1031/1622 was mounted on its top but never sounded. An Englishman by the name of Fessy was responsible for maintaining the clock, which fell into disrepair after he was executed for murder (Gemelli-Carreri, II, p. 110). Adam Olearius, who saw it in 1047/1637, when it was no longer functioning, claimed that Fessy had actually made the clock himself. He noted that it was considered by the Persians to be a miraculous work and that no other such town clock existed in the country (p. 559). According to Jean Chardin, who saw it several decades later, this clock was three feet square and had been deliberately neglected because Muslims were not allowed to toll bells (VII, p. 357, pl. XXXVII).

Like Fessy Rudolph Stadler, a Swiss clockmaker who arrived in Persia in 1041/1631, met with an unhappy fate there. Shah Ṣafī I (1038-52/1629-42) had been pleased with a watch that Stadler had made in Isfahan and employed him at court; it took him three years to repair the shah's watches (Tavernier, pp. 172-79; tr. Eqbāl, pp. 7-18). When he sought to return to Europe with the Holstein embassy, led by his brother-in-law Otto Bruggeman in 1047/1637, the

shah offered him a considerable sum to stay. Before Stadler could make a decision, however, he shot a man who had broken into his house at night; according to Jean-Baptiste Tavernier, the man was not a burglar but the lover of Stadler's wife. Stadler refused to convert to Islam, and thus the shah was unable to pardon him; he was sentenced in court and executed in the same year (Olearius, p. 294; Tavernier, loc. cit.).

Shortly afterward Shah ʿAbbās II (1052-77/1642-66) had a special clock pavilion built in the royal square (*meydān*) of Isfahan, on the occasion of his coronation. According to Chardin (VII, pp. 355-56), figures were painted on the walls and movable wooden heads, arms, and hands holding musical instruments were attached. There were also moving birds and other painted wooden animals. The clock struck every hour, and, despite its crude design, the Persians looked at it with wonder, as "we do when looking at the clock of Strassbourg or Antwerp." Both of the large public clocks at Isfahan were mentioned by the Dutch painter Cornelis de Bruijn, who visited the city in 1115/1703: "Above [the gate of the *bāzār*] there is a striking clock, the only one in Persia, and on the same side you have the pavilion of the machines or of the clock [which he also called *Wagtis-sai-aet*, i.e., *waqt-e sāʿat* "timepiece"], which moves some wooden puppets in a wheel, not worthy to be seen by an European" (I, p. 195). In addition, he included both in his drawings of the *meydān* (I, p. 196, pls. 75, 76). Neither of these two clocks was mentioned by other 18th-century European travelers or depicted in subsequent views of Isfahan. It must therefore be assumed that they were dismantled, probably during the Afghan occupation in the 1130s/1720s. In 1225/1810 James Morier (p. 174) looked in vain for traces of them; even the bell had disappeared.

Shah Ṣafī I is also reported to have sent a letter to Charles I of England, in which he asked among other things that watchmakers (*waqt wa sāʿatsāz*) be sent to him (Qāʾemmaqāmī, p. 34). By 1062/1652 there were three French watchmakers at the Persian court (Hotz, p. 133); slightly later Chardin mentioned "three or four" (IV, p. 151). At about the same time Jean de Thévenot traveled through the country with a watchmaker, who "told me that men of his profession make use of this stone [a kind of black marble] for polishing that which hath been filed, before it be guilt" (II, p. 74). While they were in Kermānšāh the local vizier "would not suffer us to go, till first he knew, whether the Chan would buy any Watches; Wherein I observed that it is not good to travel in that Countrey with Watch-makers, because in this manner they stop all Caravans" (II, p. 70). Although there were Muslim clock

repairmen in Persia in 1070/1659-60, Raphael Du Mans found them less able than the French. They could clean or change parts in a clock, but they could not make new parts or difficult repairs (p. 207). In the 1070s/1660s there was still a Swiss watchmaker in Persia, for in 1679 a watchmaker formerly in the service of the shah, is reported to have died in Geneva (Kurz, p. 63 n. 2; see also Tavernier, pp. 183, 223). Furthermore, the making of new instruments remained entirely a European craft. Chardin stated categorically that "the art of clock-making is unknown here" (IV, p. 151) and ascribed the lack to the unchanging nature of the days: People could tell the hour more or less by looking at the sun and "did not even use the sundial." Chardin, a jeweler, traded in watches, in which connection he seems to have been involved in shady business practices (*Chronicle* I, p. 442 n. 9). According to Tavernier (p. 64), every Armenian merchant returning from Europe brought six or seven watches. Engelbert Kaempfer, who was in Persia in 1096/1684-85, observed that even the royal physician wore a watch as part of his official paraphernalia (p. 82). Nevertheless, fine timepieces were not always appreciated; Kaempfer (pp. 51, 218) also reported that a beautiful clock sent as a present by King Gustavus Adolphus of Sweden (1594-1632) was gathering dust in a storeroom.

European clockmakers were still in demand at the court of Shah Solṭān-Ḥosayn (1105-35/1694-1722), who wrote to Louis XIV of France, probably in 1709, requesting that some be sent to him (Qāʾemmaqāmī, p. 73). In 1112/1700 he received from the papal ambassador, Fr. Peter Paul of S. Francis, Archbishop of Ancyra, "a large clock striking the hours and with an alarm, valued at 140 "ungari"; another smaller specimen, also striking; with a gilt case and enamelled, valued at 210 "ungari"" (*Chronicle* II, p. 981; cf. pp. 967, 1035). De Bruijn reported three watchmakers from Geneva in Isfahan in 1116/1704; they had all married Armenian women and were living "à la persane" (p. 187). Twenty years later they were still there; the Carmelites mentioned having been helped by the Swiss watchmaker Jacques Rousseau (*Chronicle*, I, p. 585).

Shah Ṭahmāsb II (1135-45/1722-32) and Nāder Shah (1148-60/1736-47) also employed watchmakers, some of them natives; in 1143/1730 "Chodja Ischack" (Ḵʷāja Esḥāq) was the chief watchmaker (Algemeen Rijks Archief, the Hague, VOC 2253, 1 July 1730, fol. 903). Majd-al-Dīn Ḥosaynī, the author of *Zaynat al-majāles* (before 1195/1781), wrote that in the *bāzār* of Kāšān a certain Mawlānā Moḥammad Moḵtareʿ ("the inventor") "built a small edifice next to

the *dār al-šefāʾ* (infirmary), on top of which was a wooden box. When one hour had passed a wooden rooster, which was seated on top of the box, moved around" (quoted by Narāqī, p. 114).

Clocks and watches became more common in Persia during the 13th/19th century. E. Scott Waring noted in 1217/1802 that at Shiraz watches were a novelty: "They delight in our watches, particularly if they get them for nothing; their curiosity, however, soon spoils them, and if this were not the case, their perverse mode of counting time renders the best watch of little service" (pp. 126-27). In 1826 J. B. Fraser listed watches among possible imports for the Persian market: "Such toys are very much liked, and if showy and not dear would probably sell. Such fancy articles are, however, at least dangerous, for if the king or princes, or other great men do not choose to purchase them, they become a dead loss, at the same time a judicious occasional investment might do well" (p. 370). That Fatḥ-ʿAlī Shah was interested in clocks is clear from one of the articles of the Franco-Persian treaty of 1808 in which it is stated that France would undertake to send clockmakers (Kurz, p. 84). By mid-century, according to Jakob Eduard Polak, a watch was highly valued. It would be carefully kept in a pouch in the sash and consulted frequently during Ramażān, the month of fasting, to mark the time at which food could be taken. Persians often showed their watches to Europeans in order to learn their prices, on the assumption that the latter would know, just as they knew the prices of horses and shawls. English products were preferred, especially the hunting watch, which Polak calls *sāʿat-e šekārī*, because glass, if it were broken, was difficult to replace (I, p. 156).

The craft of watchmaking had become well established in Persia by the mid-13th/19 century. Eʿtemād-al-Salṭana (p. 171) listed among the accomplishments of Nāṣer-al-Dīn Shah's reign (1264-1313/1848-96) that "watch making has become widespread." Other observers were more specific. Ernst Hoeltzer noted that there were two such artisans in the Isfahan suburb of Jolfā in 1292/1875 but as many as sixty in Isfahan itself, a figure that may have included apprentices (pp. 21, 81). The market for pocket watches in Persia, though small, was clearly growing. At the end of the century, according to the British consul H. W. MacLean, there was "a small trade in cheap watches of Continental make" (p. 48). By 1328/1910 about 50 percent of the watches sold in Persia came from Switzerland, the remainder from Great Britain and France. Annual sales ranged from 35,000 to 70,000 tomans. The price of a silver watch was DM 20-80, of a thinly plated gold one somewhat higher (Kuss,

pp. 120-30). In such provincial towns as Yazd only the cheapest European watches were sold, though local watchmakers were considered indifferent workmen (*Diplomatic and Consular Reports* [London, HMSO], 4838, 1911, p. 29). As of 1850 Swiss musical boxes became very popular and sold well in Persia (Chapin, pp. 278ff.).

Although watches were no longer a novelty and were seldom mentioned in the later literature, clocks were still regarded as curiosities. In the royal museum at the Golestān palace there was a substantial collection that had been developed over the years. E. A. Powell, who visited the museum in 1341/1922, reported “clocks of every size, model, and material, from gilt-and-glass extravagances incrusted with jewels to those atrocities in the form of a Swiss chalet, which indicate the hour by the door’s suddenly flying open and a little wooden bird’s squawking “Cuckoo! Cuckoo! Cuckoo!”” (p. 278).

In 1342 = 1303 Š./1924 there were only seventeen master watchmakers in Isfahan (Janāb Eṣfahānī, p. 73). At about the same time there were 48 watchmaking shops in Tehran, operated by fifty-six masters (*ostād*), twenty-three journeymen (*kārgar*), and twelve footboys (*pādū*; Second Yearbook, pp. 76-77). In 1305 Š./1926 the taxes on a number of guilds (*aṣnāf*), including that of the watchmakers, were abolished.

BIBLIOGRAPHY

Abū ʿAbd-Allāh Moḥammad b. Jāber Battānī Ḥarrānī Ṣābeʾ, *al-Zīj al-ṣābeʾī*, ed. C. A. Nallino as *Opus astronomicum . . .* , 3 vols., Milan, 1899-1907.

Aḥmad b. Mūsā b. Šāker, *Ketāb al-ḥīal*, ed. A.-Y. al-Ḥasan, Aleppo, 1981.

G. H. Baillie, *Clocks and Watches*, 1344-1800, New York, 1981.

C. de Bruijn, *Travels into Muscovy, Persia and Parts of the East Indies*, 2 vols., London, 1727.

A. Chapin, *Histoire de la boîte à musique*, Paris, 1958. J. Chardin, *Voyages*, ed. L.

Langlès, 10 vols., Paris, 1811.

A Chronicle of the Carmelites in Persia and the Papal Mission of the 17th and 18th Centuries, ed. H. Chick, 2 vols., London, 1939.

Moḥammad-Ḥāfeẓ Eṣfahānī, *Se resāla dar eḵterāʿāt-e ṣaṇʿatī: Sāʿat, āsīā, dastgāh-e rowḡan-kešī, "Natījat-al-dawla,"* ed. T. Bīneš, Tehran 1350 Š./1971.

Moḥammad-Ḥasan Khan Eʿtemād-al-Salṭana, *Čehel sāl tārīḵ-e Īrān dar dawra-ye pādšāhī-e Nāṣer-al-Dīn Šāh* I. *al-Maʾāṯer wa'l-āṯār*, ed. Ī. Afšār, Tehran, 1363 Š./1984.

R. W. Ferrier, "An English View of Persian Trade in 1618. Reports from the Merchants Edward Pettus and Thomas Barker," *JESHO* 19, 1976, pp. 182-214.

J. B. Fraser, *Travels and Adventures in the Persian Provinces on the Southern Banks of the Caspian Sea*, London, 1826.

G. F. Gemelli Carreri, *Giro del mondo del Dottor D. Gio. Francesco Gemelli Carreri II. Contenente le cose più ragguardevoli vedute nella Persia*, 2nd ed., Naples, 1708.

F. J. Goldsmid, *Telegraph and Travel. A Narrative of the Formation and Development of Telegraphic Communication between England and India*, London, 1874.

D. R. Hill, *On the Construction of Water-Clocks*, London, 1976.

Idem, "Medieval Arabic Mechanical Technology," *Proceedings of the First International Symposium for the History of Arabic Science* 1976, Aleppo, 1978, pp. 222-37.

Idem, *A History of Engineering in Classical and Medieval Times*, London and Sydney, 1984.

E. Hoeltzer, *Persien vor 113 Jahren*, ed. M. Assemi (ʿAṣemī), Tehran, 2535 = 1355 Š./1976.

A. Hotz, *Journaal der reis von den gezant der O. I. compagnie, Joan Cunaeus naar Perzier in 1651-52*, Amsterdam, 1908.

Jaʿfar b. Moḥammad Jaʿfārī, *Tārīḵ-eYazd*, ed. Ī. Afšār, 2nd ed., Tehran, 1343

Š./1964.

Mīr Sayyed ʿAlī b. Moḥammad-Bāqer Ḥosaynī Janāb Eṣfahānī, *al-Eṣfahān*, one vol. published, Isfahan, 1343/1924-25.

Abu'l-ʿEzz Badīʿ-al-Zamān Esmāʿīl b. Razzāz Jazarī (or b. Razār Jazīrī), *Ketāb fī maʿrefat al-ḥīal al-hendasīya*, tr. D. R. Hill as *The Book of Knowledge of Ingenious Devices*, Dordrecht, 1974.

E. Kaempfer, *Am Hofe des persischen Grosskönigs*, tr. W. Hinz, Berlin, 1940.

Abū ʿAbd-Allāh Moḥammad Ḵʷārazmī, *Mafātīḥ al-ʿolūm*, ed. G. van Vloten, Leiden, 1895.

Aḥmad b. Ḥosayn b. ʿAlī Kāteb, *Tārīḵ-ejadīd-e Yazd*, ed. Ī. Afšār, Tehran, 1345 Š./1966.

O. Kurz, *European Clocks and Watches in the Near East*, Leiden, 1975.

H. Kuss, *Handelsratgeber für Persien/Nāṣeḥ-e tejārat-e Īrān wa Ālmān*, Berlin and Tehran, 1326/1911.

H. W. MacLean, "Report on the Conditions and Prospects of British Trade in Persia," *Accounts and Papers* (UK Parliament), 1904.

R. du Mans, *Estat de la Perse en 1660*, ed. C. Schefer, Paris, 1890.

L. A. Mayer, *Islamic Astrolabists and Their Works*, Geneva, 1956.

M. Membré, *Relazione di Persia (1542). Ms. inedito dell'Archivio di Stato di Venezia*, Studie e materiali sulla conoscenze dell'Oriente in Italia 1, ed. G. R. Cardona, Naples, 1969.

J. Morier, *A Second Journey through Persia, Armenia and Asia Minor to Constantinople 1810-1816*, London, 1818.

Ḥ. Narāqī, *Tārīḵ-eejtemāʿī-e Kāšān*, Tehran, 1345 Š./1966.

M. R. Nūrbaḵš, "Sāʿat-e mekānīkī dar Īrān," *Āyanda* 13, 1366 Š./1987, pp. 395-408.

A. Olearius, *The Voyages and Travels of the Ambassadors Sent by Frederick Duke of Holstein, to the Great Duke of Muscovy, and the King of Persia*, tr. J.

Davies, London, 1662.

J. E. Polak, *Persien. Das Land and seine Bewohner. Ethnographische Schilderungen*, 2 vols. in one, Leipzig, 1865.

E. A. Powell, *By Camel and Car to the Peacock Throne*, New York, 1923.

S. J. Qāʾemmaqāmī, *Yak ṣad o panjāh sanad-e tārīḵī az Jalāyerīān tā Pahlavī*, Tehran, 1348 Š./1969.

Riazul Islam, *A Calendar of Documents on Indo-Persian Relations (1500-1750)*, 2 vols., Tehran and Karachi, 1979-82.

R. R. Rohr, *Sundials. History, Theory, and Practice*, Toronto, 1970.

E. D. Ross, ed., *Sir Anthony Sherley and His Persian Adventure*, London, 1933.

Science and Technology in Islam, London, 1976.

J.-B. Tavernier, *Voyages en Perse et description de ce royaume*, ed. P. Pia, Paris, 1930.

Jean de Thévenot, *Voyages*, 3 vols., London, 1686.

G. Tessier, *Charlemagne*, Le mémorial des siècles. Les hommes, 8th cent., Paris, 1967.

F. A. B. Ward, *Time Measurement* I. *Historical Review*, 4th ed., London, 1961.

E. S. Waring, *A Tour to Sheeraz*, London, 1807.

W. Wiedemann and F. Hauser, “Über die Uhren in Bereich der islamischen Kultur,” *Nova Acta* (Halle) 100, 1915, pp. 176-266.

(Willem Floor)