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ASṬORLĀB

ASṬORLĀB (or OSṬORLĀB), astrolabe, an instrument used in astronomy for a variety of purposes, e.g., demonstration and solution of problems in spherics, measuring altitudes, and telling time. The word is derived from the Greek *astrolábos* (for some fanciful etymologies proposed by medieval Iranian and other scholars see King, "Origin"). Indeed, the principle of the instrument, stereographic projection, was probably known already to Hipparchus (2nd cent. B.C.), and the instrument itself was referred to by Ptolemy (see Neugebauer). Knowledge of its construction and its uses was transmitted to early Islamic astronomers through various Greek and Syriac treatises on the instrument and through their Arabic translations. The following aspects of astrolabe in Persia are treated here: description, Persian authorities on its construction and uses, and Persian makers of the instrument.

Description. The earliest form of the instrument, and the one most commonly described and used, was the plane astrolabe (*asṭorlāb mosaṭṭaḥ*); the normal Persian version is the one here described. (For illustrations of astrolabes see, e.g., *Survey of Persian Art* III, pp. 2538-50, and *EI*^{2}I, pp. 724-26.) It consists principally of a circular body with two parallel flat surfaces to which are attached various other parts. At one point on the circumference is a piece, usually triangular, called the throne (*korsī*); to it, near its apex, is fitted a handle (*ʿorwa*) bearing a suspension ring (*ḥalqa*). This apparatus allows the instrument to be hung so that, like a plumb-line, it remains vertical—that is, so that the "east-west" line or straight horizon (*ofq*, *estewāʾ*) engraved on the face (*wajh*) or on each tympan (*ṣafīḥa*) and the horizon line engraved on the back

(*ẓahr*) remain parallel to the local horizon—while it can be swung in a circle about its axis that is perpendicular to the horizon. The edge of the face is graduated for the 360 degrees of a circle in a clockwise direction, starting with 0° = 360° at the point directly below the apex of the throne. If the instrument is made for just one terrestrial latitude, the stereographic projection of the heavens for that latitude is engraved on the face; if it is designed for use in several latitudes, the face within the rim (*ḥaǰra*) is recessed to form the mother (*omm*) into which the tympans bearing various projections will fit, held rigidly in place by tabs inserted into a slot in the rim. On the recessed surface of the mother is usually engraved a list of cities with their geographical coordinates, and sometimes as well their inclinations (*enḥerāf*), that is, the angles between their and Mecca's azimuths.

The center of the body and of each tympan has a hole through which is inserted a pin (*qoṭb*) with a head at one end and a slot at the other; this pin holds the diopter or alidade (*ʿeżāda*) to the back with its head and the rete (*ʿankabūt*) to the front by means of a wedge, called a horse (*faras*), inserted into the slot. The alidade is usually graduated, and has two vertical plates pierced with small holes through which sightings are made. The rete is a circular piece of flat metal that just fits within the rim over the tympans or over the projection on the face; all of the rete is cut away except a narrow outer strip, a circle representing the zodiac, and pointers indicating the relative positions of a selected number of stars. Both the alidade and the rete freely rotate about the pin.

The stereographic projections engraved on the face or on the tympans and the star positions indicated on the rete result from marking on each the point where a line proceeding from a pole of the heavens (the South Pole for a northern astrolabe, the North Pole for a southern astrolabe) to a determined point in the heavens passes through the plane of the equator. The projection on the face or on a tympan of a northern astrolabe represents by three concentric circles the Tropic of Capricorn (the outermost), the equator (between the two others), and the Tropic of Cancer (the innermost); the two Tropics' positions are interchanged in a southern astrolabe. The center of the projection represents the North Pole in a northern astrolabe, the South Pole in a southern astrolabe; at a distance corresponding to the terrestrial colatitude of the latitude for which the projection is made and lying on the meridian (*ḳaṭṭ-e wasaṭ-e samāʾ*) is the zenith for that latitude. The circles of altitude or their segments, called almacantars, are constructed for every one, two, three,

five, six, nine, ten, or fifteen degrees; according to which number the astrolabe is characterized as *tāmm*, *neṣfī*, *ṯolṯī*, *ḵomsī*, *sodsī*, *tosʿī*, or *ʿošrī*. The segment of the outermost circle, which passes through the two points of intersection of the "east-west" line and the equator, represents the local horizon (*dāʾera moqanṭara*). Between the horizon and the altitude circle closest to the zenith, usually at intervals of 10°, and perpendicular to all the altitude circles are drawn the vertical circles or azimuths (*samt*, plur. *somūt*). In the lower half of the instrument are drawn lines for unequal (*sāʿāt zamānīya*) and equal (*sāʿāt-e eʿtedāl*) hours and for the times for prayers. Other methods of projecting produce different shapes after which the astrolabe is named (e.g., *mosarṭan* "crab-shaped" or *mobaṭṭaḵ* "melon-shaped").

The face of the astrolabe, then—the projection of the celestial circles and the hour lines and prayer-time lines over which rotates the rete with its projection of selected fixed stars—can be used as a clock since its motion is an analogue of apparent celestial motion. When the position of the sun in the ecliptic or the pointer of a star is moved to its observed altitude circle in the east or the west, the time can be read off in the lower half of the face.

The altitude of the sun or of the star is determined by an observation through the alidade on the back; the rim of the upper two halves of the back is graduated from 0° to 90° from the horizontal diameter (horizon) to the apex (zenith). The altitude of a terrestrial object can also be observed so that, once one knows either its height or its distance from the observer, the other dimension can be computed. There are many other applications of the astrolabe in the field of surveying. In addition, the upper left quadrant of the back has horizontal and vertical lines representing the cosines and sines of the angles. The upper right quadrant in Persian astrolabes usually has curves representing the altitudes of the sun throughout the year when it crosses the *qebla* of several named cities, and others representing the noon altitudes of the sun throughout the year at several terrestrial latitudes. Centered below the horizon line on the back is a shadow square for a gnomon of seven feet to the left, for one of twelve digits to the right; on the horizontal of the shadow-square are read the cotangents of altitude, on the vertical the tangents. These allow one, by turning the alidade to the observed shadow of a vertical or horizontal gnomon, to read off on the graduated upper quadrants the altitude of the sun.

Within the shadow square are often inscribed the diurnal, nocturnal, and common planetary lords of the four triplicities together with the element of

each. Further astrological information is contained in concentric semicircles within the rim of the lower half of the back; this consists of the planetary lords of the zodiacal signs, the decans, and the terms; the boundaries of the terms; and the positions of the lunar mansions.

Persian authorities. It used to be thought that the earliest extant treatise on the astrolabe written by an Iranian was that ascribed to Māšāʾallāh (Messahalla), a Persian Jew who flourished from ca. 143/760 till 200/815, and preserved in a Latin translation that was used by Chaucer; however, it has recently been demonstrated by Kunitzsch that this treatise is a Western compilation bearing no relation whatsoever to Māšāʾallāh. It remains true, however, that an Arabic work on the construction and use of the astrolabe (Awad, no. 117; Sezgin, *GAS* VI, p. 128) is ascribed to Māšāʾallāh by Ebn al-Nadīm (p. 273). But the earliest extant treatise is that by Abū ʿAbdallāh Moḥammad b. Mūsā Ḵᵛārazmī (fl. ca. 205-34/820-50); the first part, on the construction of the astrolabe, has been analyzed by King (*Al-Khwārizmī*, pp. 23-30); the second is on its use (Awad, no. 146; Sezgin, *GAS* VI, p. 143). Both of Ḵᵛārazmī's works are preserved in the valuable manuscript (Landberg 56 in Deutsche Staatsbibliothek, Berlin) that preserve the *al-Kāmel fī ṣaṇʿat al-asṭorlāb*) (Awad, no. 149; Sezgin, *GAS* VI, pp. 150-51) of his later contemporary Aḥmad b. Moḥammad Farḡānī (Affraganus), which is among the more impressive of the extant treatises on the instrument; in it Farḡānī refers to the present as the Yazdeǰerdi year 225/857-58.

The next extant treatise on a type of astrolabe written by a Persian is Abu'l-ʿAbbās Faẓl b. Ḥātem Nayrīzī's (fl. ca. 920) on the use of the spherical astrolabe (*Ketāb fi'l-ʿamal be'l-asṭorlāb al-korawī*; Awad, no. 140; Sezgin, *GAS* VI, p. 192), which is reported by Seemann and Mittelberger (pp. 32-40) to be the best available treatise on that instrument. Nayrīzī's work was succeeded by ʿAbd-al-Raḥmān Ṣūfī's (291-376/903-86; q.v.) enormous treatises on the uses of the astrolabe (Awad, nos. 44-45). Later in the tenth century Aḥmad Ṣāḡānī (q.v.) wrote on the hour-lines drawn on the tympans of astrolabes and on projecting the sphere on a plane; Abū Sahl Vīǰan Kūhī (q.v.) wrote on constructing an astrolabe (*Ketāb ṣaṇʿat al-asṭorlāb*; Awad, no. 115); and Ḥāmed b. Ḵeżr Ḵoǰandī wrote on the "general instrument" (*Ketāb al-āla al-šāmela*; Sezgin, *GAS* VI, p. 221).

More important, so far as can be determined at present, are the three extant works on the instrument by Abū Saʿīd Aḥmad b. Moḥammad Seǰzī and the four by Abū Naṣr Manṣūr (q.v.). The former (ibid., pp. 225-26) composed treatises on constructing all astrolabes, a letter on using the crab-shaped astrolabe

addressed to a certain Abū Moḥammed ʿAbdallāh b. ʿAlī Ḥāseb, and a book on using the tympan of horizons dedicated to a certain amir Abu'l-Ḥosayn Ṭāher b. Moḥammed Seǰzī, while the latter was the author of an epistle on constructing an astrolabe addressed to a certain Abū ʿAbdallāh Moḥammad b. ʿAlī Maʾmūnī, another on the azimuth circles (Awad, no. 93), the third on the circles for unequal hours (ibid., no. 80) addressed to Abū Rayḥān Bīrūnī, and the final one on a quarrel between Ṣāḡānī and the astrologers of Ray concerning the use of the astrolabe.

The first scholar to have written on the astrolabe in the Persian language appears to have been the Syrian ʿAlī b. Aḥmad Anṭākī (d. 376/987), who wrote, probably in Baghdad, a *Moḵtaṣar-ī dar maʿrefat-e asṭorlāb-e mosarṭan* (Awad, no. 72; Storey, II/1, p. 42) on the crab-shaped astrolabe, though at about the same time Moḥammad b. Ayyūb Ṭabarī wrote his *Ketāb maʿrefat al-asṭorlāb* (Awad, no. 172; Storey, II/1, p. 43) in six chapters (*faṣl*s). Their contemporaries, ʿAlī b. Aḥmad Nasawī and Kūšyār b. Labbān, wrote in Arabic—the one on the calendar and the astrolabe (*Fī maʿrefat taqwīm wa'l-asṭorlāb*; Awad, no. 98; Sezgin, *GAS* VI, p. 246), and the other on the construction and use of the instrument (*Ketāb fī ṣaṇʿat asṭorlāb wa'l-ʿamal behe*; Awad, no. 171; Sezgin, *GAS* VI, pp. 248-49).

Before he wrote his *Chronology* in the year 1000 Bīrūnī had composed a treatise on all the possible methods of constructing an astrolabe (*Estīʿāb al-woǰūh al-momkena fī ṣaṇʿat al-asṭorlāb*; Awad, no. 6; Sezgin, *GAS* VI, p. 268), which he dedicated to a certain Abū Sahl ʿĪsā b. Yaḥyā Ṭabarī. In this he described not only the usual northern and the uncommon southern astrolabe, but also a mixed astrolabe combining the two, a melon-shaped projection, and an oven-shaped or "perfect" projection, among others (Wiedemann and Frank). In the course of his discussion of these varieties of astrolabes he provides extremely important information concerning earlier authorities on the theory and construction of astrolabes. To the same Abū Sahl he dedicated a treatise on facilitating the projection on a plane (Awad, no. 36; Sezgin, *GAS* VI, pp. 269-70). Other works of Bīrūnī's on the astrolabe (ibid, pp. 268-69) include a treatise on constructing an astrolabe, another on using different kinds of astrolabes, a separate book on using an astrolabe, another on realizing the possibilities of an astrolabe (Awad, no. 92), and an epistle on the astrolabe (ibid., no. 47). Bīrūnī also includes a short description of the astrolabe in his book on astrology, the *Tanǰīm* (secs. 324-46), of which his own Persian version exists (*al-Tafhīm le awāʾel ṣenaʿat al-tanǰīm*; Storey, III/1, pp. 44-45).

After Bīrūnī two centuries were to pass before another Iranian wrote a work on the astrolabe that has survived into our time. Moẓaffar b. Moḥammad Ṭūsī (d. 610/1213-14) invented the linear astrolabe, which he described in an epistle (Awad, no. 67). Towards the middle of the 7th/13th century Ḵᵛāǰa Naṣīr-al-dīn Ṭūsī wrote his highly influential *Bīst bab dar asṭorlāb* in Persian (ibid., no. 25; Storey, II/1, pp. 52-54), on which there are many commentaries including the *Meftāḥ-e bīst bāb* composed by Šams-al-maʿālī Moḥammad Kīā Jorǰānī in 817/1414-15 (Awad, no. 174) and an important one completed by ʿAbd-al-ʿAlī Bīrǰandī (q.v.) in 899/1493-94 (ibid., no. 108). In 697/1297-98 Naṣīr-al-dīn Ḥaydar Šīrāzī wrote an *Eršād* on the astrolabe in fifty chapters, probably at Isfahan (ibid., no. 4; Storey, II/1, pp. 63-64).

In the early 8th/14th century—probably in 703/1303-04 the date of the unique manuscript—Šams al-monaǰǰem Vābkanavī (sometimes called Boḵārī) wrote a *Ketāb-e maʿrefat-e asṭorlāb-e šamālī* in two parts, consisting respectively of two and thirty-two chapters (Storey, II/1, p. 65); its relation to the Byzantine translation of a work on the astrolabe by Šams Boḵārī in forty-six chapters has yet to be investigated.

Again a century passed before significant activity resumed at the court of Ologʾ Beg (r. 850-53/1447-49) in Samarqand; there Ḡīāṯ-al-dīn Jamšīd Kāšī wrote on the astrolabe a *Resāla dar sāḵt-e asṭorlāb* (Awad, no. 82; Storey, II/1, p. 73). At Herat in 860/1456 Rokn-al-dīn Ḥosaynī Āmolī wrote a *Panǰāh bāb-e solṭānī* (Awad, no. 18; Storey, II/1, pp. 73-74).

In the 10th/16th century Ḡīāṯ-al-dīn Manṣūr Šīrāzī wrote a *Resāla dar ṣanʿat-e tasṭīḥ-e asṭorlāb* (Awad, no. 85; Storey, II/1, p. 83), and his student, Abu'l-Ḵayr Moḥammad Taqī Fāresī composed an *Āḡāz o anǰām* (Awad, no. 8; Storey, II/1, p. 84). The last works of any significance, however, are those of Bahāʾ-al-dīn ʿĀmelī (Shaikh Bahāʾī), who died at Isfahan in 1031/1621-22 (ibid., pp. 86-87); these include his *al-ṣafīḥa* in Arabic (Awad, no. 111) and his *Toḥfa-ye ḥātemī* in Persian (ibid., no. 26), while his *Resāla dar asṭorlāb* (ibid., no. 51), based on Ṭūsī's *Bīst bāb*, was translated by Mollā ʿAlī (ʿAlāʾ-al-dīn) b. Ṣādeq Dāḡāstānī of Damascus (ibid., no. 79). Bahāʾ-al-dīn's pupil, Moḥammad Amīn Naǰafī Ḥeǰāzī, also wrote a *Resāla dar asṭorlāb* (ibid., no. 60; Storey II/1, p. 98).

The last Persian treatise to be written on the astrolabe was the *Rafīʿ al-ṣanʿat dar bayān-e osṭorlāb*, composed by ʿOmdat-al-dawla Moḥammad Rafīʿ-al-dīn Khan in 1269/1852-53 (Awad, no. 102; Storey, II/1, p. 100).

Greek and Sanskrit Translations. In about 699/1300 Šams Boḵārī, the teacher of Gregory Chioniades (Pingree, *Astronomical Works* I/1, p. 17), dedicated a treatise on the use of the astrolabe (for the contents see Segonds, pp. 80-83) to the Byzantine emperor Andronicus II; it is clear that it was translated from Persian, presumably by Chioniades, but its relation to Šams al-monaǰǰem Vābkanavī's *Ketāb-e maʿrefat-e asṭorlāb-e šamālī* of 703/1303-04 has not been determined.

In India the first work on the astrolabe, the *Yantrarāja*, based on the translation of an Arabic or Persian text, was composed at the request of the Tughluqid Fīrūzšāh 772/1370 by Mahendra Sūri of Bhṛgupura (Pingree, *Census* 4, pp. 393b-395a, and 5). The next treatise to deal with the subject also drew upon a source or sources emanating from Persia; this is chapter 3 of the *Yantraśiromaṇi* written in 1615 by Viśrāma of Gurjaramaṇḍala (Pingree, *Census* 5).

Much more was written under Persian influence in the 1130s/1720s and 1140s/1730s at the court of Jayasiṃha in Jayapura (Pingree, *Census* 3, pp. 63a-64b, 4, p. 97b, 5). He himself wrote a *Yantrarājaracanā*, and one of his *paṇḍita*s, Nayanasukhopādhyāya (Pingree, *Census* 3, p. 132a, 4, p. 122a, and 5) translated from Persian into Sanskrit the *Bīst bāb* of Ḵᵛāǰa Naṣīr-al-dīn Ṭūsī (*Vimšādhyāyī*) and from Arabic or Persian a treatise on Zarqāllu's universal astrolabe (*Sarvadeśīyajarakālīantra*). In 1771 Nandarāma Mis`ra of Kāmavana in Rājasthāna (Pingree, *Census* 3, pp. 128b-130b, 4, p. 121b, and 5) wrote a *Yantrasāra* describing the astrolabe among many other instruments utilized in Jayasiṃha's observatories.

Persian Makers of Astrolabes. The oldest surviving Persian astrolabe appears to be one made by Ḥāmed b. Ḵeżr Ḵoǰandī, one of the authors mentioned above, in 374/984-85 (Mayer, 1956, p. 45; wrongly described), though another was made by Aḥmad and Moḥammad, the two sons of Ebrāhīm, at Isfahan in 374/984-85 or 394/1003-04 (Mayer, 1956, p. 36; wrongly dated). The next group of surviving instruments comes from the 6th/12th century. They include those made by Moḥammad b. Abu'l-Qāsem Eṣfahānī in 496/1102-03 (Mayer, 1956, p. 59); by Hebatallāh b. Ḥosayn of Baghdad (his family came from Ṭabarestān and he died in Isfahan) in 513/1119-20; by Badr b. ʿAbdallāh, Hebatallāh's associate, in 525/1130-11 (Pingree, "Catalogue," no. 9); by Ḥāmed b. Maḥmūd Eṣfahānī in 547/1152-53 (Mayer, 1956, p. 46; Gibbs and Saliba, pp. 62-64); and two by the son of the last, Moḥammad, of which one is dated 553/1158 or 558/1163 (Mayer, 1956, p. 67).

It appears that only two instruments survive from the next century; one was also made by an Eṣfahānī, Moḥammad b. Abū Bakr, in 618/1221-22) (Mayer, 1956, p. 59), and the other by Sahl Naysābūrī for a certain Moẓaffar Maḥmūd of Ḥamā, who died in 698/1299 (Mayer, 1956, pp. 82-83). But late in the century was founded a family of astrolabists in Kermān; their genealogy is shown in Chart 1.

Of these Jaʿfar is known from four astrolabes constructed between 755/1354 and 790/1388 (Mayer, 1956, pp. 53-54; Gibbs and Saliba, pp. 64-65) and Maḥmūd from astrolabes dated 837/1433-34 (Pingree, "Catalogue," no. 10) and 889/1484 (Mayer, 1956, p. 58).

In 929/ 1522-23 Yūsof b. Ḥājjī Jīlānī made an instrument (Mayer, 1956, p. 84), in 986/1578-79 and 989/1581-82) ʿAbd-al-Aʾemma the Elder made two (Mayer, 1956, pp. 23, 85), and in 996/1588 Moḥammad Amīn b. Amīrzā Khan Qomī made one (Mayer, 1956, p. 63; cf. Pingree, "Catalogue," no. 36). But the 10th/16th century also was the time of the rise of the preeminent family of Indo-Persian astrolabists. They worked in Lahore and bore a title Homāyūnī, which connects their ancestor with the Mughal emperor Homāyūn (r. 937-62/1530-56). Their genealogy is shown in Chart 2.

There survive two astrolabes made by ʿĪsā, one in 1013/1604-05 (Gunther, p. 187; Pingree, "Catalogue," no. 11); two by both his sons, one in 1018/1609-10 (Frank and Meyerhof), twenty-three by Moḥammad Moqīm, of which the latest is dated 1070/1659-60 (Gunther, pp. 191-200; Behari and Govind, pp. 101-02; Gibbs and Saliba, pp. 129-32); twenty-six by Żīāʾ-al-dīn between 1046/1636-37 and 1091/1680-81 (Gunther, pp. 208-13, 228; Behari and Govind, p. 99; Gibbs and Saliba, pp. 132-34; Turner, no. 5; Pingree, "Catalogue," nos. 12-15), and at least one by Jamāl-al-dīn in 1092/1681-82) (Gunther, p. 213).

A number of Persian astrolabists of the 11th/17th century are known. Among them Ebrāhīm b. Šaraf al-dīn Ḥosayn made an instrument for a certain ʿAbd-al-Razzāq Gīlānī in 1051/1641-42 (Mayer, 1956, p. 49); Moḥammad Zamān of Mašhad made four between 1051/1641-42 and 1088/1677-78; and Moḥammad Moqīm of Yazd also made four, between 1052/1642-43 and 1057/1647-48 (Mayer, 1956, pp. 74-75). Associated in making one instrument with this last was Moḥammad Mahdī of Yazd, the son of a Moḥammad Amīn; Mohammad Mahdī made twenty-three astrolabes between 1059/1649-50 and 1078/1659-60 (Mayer, 1956, pp. 70-71, 87; Gibbs and Saliba, pp. 65-68, 79-82; Turner, no. 6; cf. Pingree, "Catalogue," no. 35). He serves as a link to the productive Isfahan

school whose most prominent member was ʿAbd-al-Aʾemma the Younger.

ʿAbd-al-Aʾemma made and/or decorated numerous astrolabes, of which at least fifty-one bear his name, though some of these are forgeries (Gingerich, King and Saliba). The dates on these instruments range between 1100/1688-89 and 1132/1719-20 (Mayer, 1956, pp. 23-26 and 86, and 1959, p. 293; Brieux, note 14; Gibbs and Saliba, pp. 69-77; Pingree, "Catalogue," nos. 19, 22-24, 26). Those astrolabists with whom his name is associated include: ʿAbd-al-ʿAlī b. Moḥammad Rafīʿ with instruments dated between 1119/1707-08 and 1126/1714-15 (Mayer, 1956, pp. 27-28; Pingree, "Catalogue," nos. 25-26); his brother Moḥammad Bāqer (Mayer, 1956, p. 64); Ḵalīl Moḥammad between 1093/1682 and 1<1>20/1708-09 (Mayer, 1956, pp. 54-57 and 1959, p. 295; Pingree, "Catalogue," nos. 18-19; see also Saliba, 1973-77); Moḥammad Ṭāher (Mayer, 78); and, finally, Moḥammad Amīn b. Moḥammad Ṭāher (Mayer, 1956, pp. 63-64; Gibbs and Saliba, pp. 68-69), who may be identical with the Moḥammad Amīn who made three astrolabes between 1085/1674-75 and 1097/1685-86 (Mayer, 1956, p. 63 and 1956, p. 296) and whose son, ʿAbdallāh, made one in 1127/1715 (Mayer, 1956, p. 28).

The end of the tradition of astrolabe making in Persia is represented by a handful of makers. Among them are: Moḥammad Moḥsen of Kermān in 1194 and 1195/1780-81 (Mayer, 1956, p. 74; Turner, no. 7; Pingree, "Catalogue," no. 29); Ḥāǰǰī ʿAlī b. Ṣādeq of Qom between 1200/1785-86 and 1208/1793-94 (Mayer, 1956, pp. 43-44; Gibbs and Saliba, pp. 77-79; Turner, no. 8); and Moḥammad Akbar between 1234/1818-19 and 1236/1820-21 (Mayer, 1956, p. 62; Turner, no. 10). Apparently the very latest is that made by ʿAlāʾ-al-dīn in 1281/1864-65 (Gibbs and Saliba, pp. 111-14).

This list is by no means complete; a full inventory will be available when the catalogue compiled by Brieux and Maddison is published. Important collections of astrolabes are found, e.g., in History of Science Museum, Oxford; British Museum, London; National Maritime Museum, Greenwich; Adler Planetarium, Chicago; Smithsonian Institution, Washington, D.C.; New York Historical Society.

BIBLIOGRAPHY

G. Awad, “A on Astrolabes during the Islamic Period,” *Sumer* 13, 1957, pp. 154-78.

K. Behari and V. Govind, “A Survey of Historical Astrolabes of Delhi,” *Indian Journal of History of Science* 15, 1980, pp. 94-104.

A. Brieux, *Les astrolabes: Tests d’authenticité*, Paris, 1974.

J. Frank, *Zur Geschichte des Astrolabs*, Erlangen, 1920.

J. Frank and M. Meyerhof, *Ein Astrolab aus dem indischen Mogulreiche*, Heidelberg, 1925.

S. Gibbs and G. Saliba, *Planispheric Astrolabes from the National Museum of American History*, Washington, D.C., 1984.

O. Gingerich, D. King, and G. Saliba, “The ʿAbd al-Aʾemma Astrolabe Forgeries,” *Journal for the History of Astronomy* 3, 1972, pp. 188-98.

R. T. Gunther, *The Astrolabes of the World* I, Oxford, 1932.

W. Hartner, “The Principle and Use of the Astrolabe,” *A Survey of Persian Art*, ed. A. U. Pope, III, Oxford, 1939, pp. 2530-54; repr. in Hartner, *Oriens-Occidens*, Hildesheim, 1968, pp. 287-311.

Idem, “Asṭurlāb,” in *EI*^{2}I, p. 722-28, repr. in Hartner, *Oriens-Occidens*, pp. 312-18.

D. A. King, “The Origin of the Astrolabe According to the Medieval Islamic Sources,” *Journal for the History of Arabic Science* 5, 1981, pp. 43-83.

Idem, *Al-Khwārizmī*, New York, 1983.

P. Kunitzsch, “On the Authenticity of the Treatise on the Composition and Use of the Astrolabe Ascribed to Messahalla,” *Archives internationales d’histoire des sciences* 31, 1981, pp. 42-62.

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

Idem, “Islamic Astrolabists: Some New Material,” in *Aus der Welt der islamischen Kunst*, ed. R. Ettinghausen, Berlin, 1959, pp. 293-96.

H. Michel, *Traité de l’astrolabe*, Paris, 1947.

W. H. Morley, *Description of a Planispheric Astrolabe*, London, 1856, repr. in Gunther, *The Astrolabes of the World*, pp. 1-50.

O. Neugebauer, “The Early History of the Astrolabe,” *Isis* 40, 1949, pp. 240-56, repr. in his *Astronomy and History*, New York, 1983, pp. 278-94.

D. Pingree, *Census of the Exact Sciences in Sanskrit*, series A, vols. 1-5, Philadelphia, 1971.

Idem, *The Astronomical Works of Gregory Chioniades*, vol. 1, 2 parts, Amsterdam, 1985-86.

Idem, “Catalogue of the Oriental Instruments,” to appear in R. and M. Webster’s catalogue of the astronomical instruments in the Adler Planetarium, Chicago.

G. Saliba, “The Buffalo Astrolabe of Muhammad Khalil,” *al-Abhath* 26, 1973-77, pp. 11-18.

H. Seemann and Th. Mittelberger, *Das kugelförmige Astrolabe nach den Mitteilungen von Alfonso X von Kastilien und den vorhandenen arabischen Quellen*, Abhandlungen zur Geschichte der Naturwissenschaften und der Medizin 8, Erlangen, 1925.

A. P. Segonds, *Jean Philopon: Traité de l’astrolabe*, Paris, 1981.

A. Turner, *Catalogue of the astrolabes in the Time Museum*, Rockford, III, forthcoming.

E. Wiedemann, “Einleitungen zu arabischen astronomischen Werken,” *Das Weltall* 20/3-4, 1919, pp. 21-26; 15-16, 1920, pp. 131-34; repr. in his *Gesammelte Schriften zur arabisch-islamischen Wissenschaftsgeschichte*, 3 vols., Frankfort on the Main, 1984, II, pp. 886-97.

E. Wiedemann and J. Frank, “Allgemeine Betrachtungen von al-Bīrūnī in einem Werk über die Astrolabien,” *Sitzungsberichte der Physikalisch-Medizinischen Sozietät zu Erlangen* 52-53, 1920-21, pp. 97-121; repr, in

Wiedemann, *Aufsätze zur arabischen Wissenschaftsgeschichte*, 2 vols., Hildesheim, 1970, II, pp. 516-40.

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