منشورات جامعة حلب
معهد التراث العلمي العربي

أبحـــــــاث

المؤتمر السنوي السابع عشر

لتاريخ العلوم عند العرب

المنعقد في السويداء

٢٠-٢٢ نيسان ١٩٩٣م

إعـــداد
الدكتور مصطفى موالدي
المهندسة ياسمين شويش

إشراف
الأستاذ الدكتور علاء الدين لولح
عميد معهد التراث العلمي العربي

١٤٢٨هـ / ٢٠٠٧م

دراسة الآلات الفلكية العربية

الإسطرلاب - الأرباع - الساعات الشمسية (الواقع والأهمية)

د. سامي شلهوب
معهد التراث العلمي العربي
حلب - سورية

بدأت الدراسات الأوروبية حول الآلات الفلكية العربية بشكل كثيف منذ القرن التاسع عشر واتسعت وتعمقت خاصة بعد أن ترجم جان جاك سيديو Sédillot كتاب جامع المبادىء والغايات في علم الميقات لأبي علي الحسن بن علي (أو أبي الحسن علي) بن عمر المراكشي (القرن السابع الهجري، الثالث عشر للميلاد) واصدر ابنه لويس أميلي سيديو عام ١٨٤٤ الدراسة المتخصصة حول الآلات الفلكية العربية وساهمت أبحاث هؤلاء العلماء الأوروبيين في تصحيح كثير من الأخطاء التي كانت شائعة.

وتعتبر هذه الدراسات الأوروبية حول الآلات الفلكية العربية في بدايتها، إذ أنها لم تتناول مصادر كثيرة وصلت إلينا وعُرفناها مؤخراً حول موضوع الآلات الفلكية العربية بعد أن اكتشفت مخطوطات كثيرة لم تعرف من قبل كما أن كثيراً من الدراسات التي نشرت حول هذا الموضوع لم تتناول حتى المخطوطات التي كانت معروفة آنذاك والموزعة في المكتبات العالمية المختلفة أو أنها كانت تقتصر على تعريف موجز لهذه الآلات الفلكية.

إذا استعرضنا مجمل الأبحاث والدراسات التي تناولت الآلات الفلكية في العالم حتى الآن نجد وصفاً موجزاً لحوالي /٥٥٠/ إسطرلاباً موزعاً في مجموعات مختلفة في العالم منها /٣٠٠/ إسطرلاباً موجوداً في الوطن العربي والعالم الإسلامي و /٢٥٠/ إسطرلاباً موجوداً في أوروبا وأمريكا وأعطت هذه الدراسات أيضاً معلومات موجزة عن حوالي /٢٠٠/ ربعاً منها /١٠٠/ ربع ، موجودة في الوطن العربي والعالم الإسلامي، و/١٠٠/ ربع موجودة في أوروبا وأمريكا، كما أعطت وصفاً موجزاً لعدد من الساعات الشمسية والآلات الفلكية الأخرى، يعمل في هذا الموضوع الأستاذ الدكتور كنج مدير معهد تاريخ العلوم في جامعة فرانكفورت منذ أكثر من عشر سنوات وهو يعد فهرساً يشمل أكثر من /١٠٠٠/ إسطرلاب

3450 JARRAY, Fathi. De la *mizwala* musulmane à l'horloge européenne. Quelques précisions sur la contribution des musulmans dans la genèse de la gnomonique en Europe. *Héritages arabo-islamiques dans l'Europe méditerranéenne.* Ed. Roland-Pierre Gayraud, Jean-Michel Poisson, Catherine Richarté. Paris: La Découverte, 2015, pp. 409-423. In medieval Europe.

2931 JARRAY, Fathi. De la *mizwala* musulmane à l'horloge européenne. Quelques précisions sur la contribution des musulmans dans la genèse de la gnomonique en Europe. *Héritages arabo-islamiques dans l'Europe méditerranéenne.* Ed. Roland-Pierre Gayraud, Jean-Michel Poisson, Catherine Richarté. Paris: La Découverte, 2015, pp. 409-423. In medieval Europe.

2945 NASH, Harriet. Star clocks and water management in Oman. *Handbook of archaeoastronomy and ethnoastronomy*. New York: Springer, 2015, pp. 1941-1948.

Güneş Saati
070348

Güneş Saati
070348

1614 ETHERIDGE, Christian. Lund astronomical clock. *Muslim heritage: discover the golden age of Muslim civilisation.* Manchester: Foundation for Science, Technology and Civilisation (FSTC), 2015? Unpaginated article, online at http:// www.muslimheritage.com / article/ lund-astronomical- clock Representation of Muslim astronomers.

1623 MOZAFFARI, S.Mohammad. Annular eclipses and considerations about solar and lunar angular diameters in medieval astronomy. *New insights from recent studies in historical astronomy: following in the footsteps of F. Richard Stephenson. A meeting to honor F. Richard Stephenson on his 70th birthday* / Wayne Orchiston, David A. Green, Richard Strom, eds. Cham: Springer, 2015, (Astrophysics and Space Science Proceedings, 43), pp. 119-142. Incl. references to Islamic astronomy.

-Güneş Saati

5531- Michel, H., "Un service de l'heure millénaire", *Ciel et terre*, 1952, 68: 64-8.

On late Moroccan astrolabes and the function of the *muwaqqit* in the Moroccan mosques.

دربارهٔ اسطرلاب های مغربی و وظیفهٔ "موقت"در مساجد مغرب .

Güneş Saati

5669- Kennedy, E.S., "A set of medieval tables for quick calculation of solar and lunar ephemerides", *Oriens*, 1965-6, 18-19: 327-34.

Study of the Bodleian Arabic MS Marsh 374 concerning the calculation of solar and lunar ephemerides based on the ancient linear method.

بررسی نسخهٔ خطی کتابخانهٔ بودلیان (شمارهٔ عربی مارش ۳۷۴) دربـــــارهٔ
محاسبهٔ جدول حرکت روزانهٔ شمس وقمر از راه " روش خط راست " که در دوران
قبل از اسلام متداول بوده و بین منجمین اسلامی نادر است .

-Güneş Saati

5591- Süheyl Ünver, A., "Sur les cadrans solaires horizontaux et verticaux en Turquie", *AIHS*, 1954, 33: 254-66.

Lists and describes some of the horizontal and vertical sun dials in Turkey, with pictures and designs of some of them.

فهرست و شرح برخی شاخص های آفتابی که به نحو افقی و عمودی ساخته شـــــده
است با تصویر و طرح ساختمان بعضی از آنها .

5592- Suter, H., "Zur Geschichte des Jakobsstabes", *Bibl. math.*, 1895: 13-8; 1896: 13-5.

-Güneş Saati

5616- Wiedemann, E. and Würschmidt, J., "Über eine arabische kegelförmige Sonnenuhr", *Archiv für Gesch. der Naturwiss. und der Technik*, 1916, 7: 359-76.

On a sundial described by Abū ʿAbdallāh Muḥammad ibn ʿUthmān al-Ṣiqillī.

پیرامون یک ساعت خورشیدی که توسط ابوعبدالله محمدبن عثمان الصقلی توصیـــف
شده است .

Güneş Saat

5496- Jener, S. de los Santos, "Un reloj del sol hispano-árabe hallado en Córdoba", *Bol. de la Real acad. de Córdoba de ciencias, bellas letras y nobles artes*, 1955, 26: 299-305.

Description of a medieval Islamic sun dial discovered in Cordoba.

توصیف یک ساعت آفتابی اسلامی که در قرطبه کشف شده است .

-Güneş Saati

5798- Kennedy, E.S., "A set of medieval tables for quick calculation of solar and lunar ephemerides", *Oriens*, 1967, 18-19: 327-34.

Study of the Bodleian Arabic MS Marsh 374 concerning the calculation of solar and lunar ephemerides based on the ancient linear method.

بررسی نسخهٔ خطی کتابخانهٔ بودلیان (شمارهٔ عربی مارش ۳۷۴) دربـــــارهٔ
محاسبهٔ جدول حرکت روزانهٔ شمس و قمر از راه " روش خط راست " کـــــه در
دوران قبل از اسلام متداول بوده ولی بین منجمین اسلامی نادر بوده است .

-Güneş Saati

Rohr, Rene R. J.,

. *Les Cadrans Solaires* (containing a chapter on Islamic Gnomonics), Paris, Gauthier-Villars, 1965, 2nd edition revised, Paris, Alain Brieux, 1978.

. "Sonnenuhr und Astrolabium im Dienste der Moschee", *Centaurus*, 18 (Copenhagen, 1974) no. 1.

. "Deux Astrelabes-Quadrants turcs", in collaboration with M. Louis Janin, Sèvres, *Centau,sr* 19 (1975), no. 2.

. *Sundials*, Toronto, Toronto Universiy Press, 1970.

03469 KING, D.A. Three sundials from Islamic Andalusia. *J. hist. Arab sci.* 2 (1978) pp. 358-392.

Güneş Saati 070348 (Endülüs'ten üç güneş saati)

-Güneş Saati

Muhammed Suud,

. "Copernican Solar System in its historical perspective", Science Chronicle, 39, September, Karachi 1973.

-Güneş Saati

Janin, Louis Rene,

1. "Le cadran solaire analématique: Histoire et developpment," *Centaurus*, 18 (1974), pp. 1-37.

-Güneş Saati

4719- Winter, H.J.J., "Some features of the mathematical sciences in Islam", *Endeavor*, 1969, 28: 135-8.

Summary of Muslim achievements in making sun-dials and instruments for observatories, geometry and physics.

خلاصه‌ای از خدمات مسلمین درساختن ساعتهای آفتابی وآلات رصد وهندسی و فیزیکـــی
و غیره .

Publications of the
Institute for the History of
Arabic-Islamic Science

Edited by
Fuat Sezgin

ISLAMIC
MATHEMATICS
AND
ASTRONOMY

Volume
87

Astronomical Instruments
and Observatories
in the Islamic World

Texts and Studies
Collected and Reprinted
III

1998

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

ISLAMIC MATHEMATICS AND ASTRONOMY

Volume
87

ASTRONOMICAL INSTRUMENTS AND OBSERVATORIES IN THE ISLAMIC WORLD

TEXTS AND STUDIES
III

Collected and reprinted
by
Fuat Sezgin

in collaboration with
Mazen Amawi, Carl Ehrig-Eggert,
Eckhard Neubauer

1998

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

50 copies printed

Beethovenstrasse 32, D-60325 Frankfurt am Main
Federal Republic of Germany
First published in 1991 in the reprint series
(Reihe B - Nachdrucke. Abteilung Instrumentenkunde. Band 3)
under the title "Arabische Instrumente in orientalistischen Studien.
Dritter Band: Astronomische Instrumente. Publikationen 1893-1917".

Printed in Germany by
Strauss Offsetdruck, D-69509 Mörlenbach

INHALTSVERZEICHNIS

Publications of the
Institute for the History of
Arabic-Islamic Science

Edited by
Fuat Sezgin

ISLAMIC
MATHEMATICS
AND
ASTRONOMY

Volume
90

Astronomical Instruments
and Observatories
in the Islamic World

Texts and Studies
Collected and Reprinted
VI

1998

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

ISLAMIC MATHEMATICS AND ASTRONOMY

Volume
90

ASTRONOMICAL INSTRUMENTS AND OBSERVATORIES IN THE ISLAMIC WORLD

TEXTS AND STUDIES
VI

Collected and reprinted
by
Fuat Sezgin

in collaboration with
Mazen Amawi, Carl Ehrig-Eggert,
Eckhard Neubauer

1998

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

CONSTRUCTION OF CLOCKS AND ISLAMIC CIVILIZATION.

I

It is well known that ancient Muslims—Arabs as well as non-Arabs,—like many other peoples knew the sun-dial and such other instruments of a very primitive type as must have enabled them to know the different periods of day and night; but few of us to day have any idea of how ingeniously and with what admirable skill the Arabs used to construct clocks, deriving their inspiration from the Byzantinians. Faithful disciples of the Greeks, as they were in almost all the sciences and arts of that age, they based also their art of horology on the experiences of Greek scientists. The study of Greek sciences though begun as early as in the Umayyad period, was taken up in right earnest during the reign of Ma'mūn (198-218 A.H., *i.e.*, 813-833 A .D.), the time when flourished the first Arabic writer on Mathematics, Abú Abdulláh Muhammad al-Khwârazmi (about the year 205 A.H.=820 A.D.) whose works have come down to us. Similarly the oldest writer on Astrology, Abū Yúsuf Ya'qúb ibn 'Ali al-Qarashî al-Qarsarāní, wrote[1] during the reign of the same Caliph.

Ma'mún's father, the great Hárúnu'r-Rashíd is said to have sent to Charles the Great a clock which, according to Einhard's report, was received by Charles in 807 A.D[2]. About the same time, or perhaps even a little earlier, the Arabs must have begun to construct astrolabs and other instruments, mention of which has incidentally been made by Jáhiz[3], in his well known book, the *Kitabu'l-*

(1) About 200 A.H.—815-16, A.D.

(2) *Einhardi Annales*, edidit G. H. Pertz. p. 53-54. Hannover 1845 *Eihnards Jahrbuecher* (German translation by O. Abel), p. 108-09. Berlin 1850. *Vide* Eilhart Wiedemann and Fritz Hauser, *Die Uhr im Bereich der islam-ischen Kultur*, p. 36, to which work I am greatly indebted.

(3) Jàhiz died in 255 A.H.=869 A.D.

Haywan. In the first volume of that admirable work[1] we read how the Byzantinians used to ascertain the hours of a day by means of certain instruments or apparatus. In the second volume of the same book[2] Jáhiz tells us that certain hours of the day were ascertained, (he means by his own countrymen), by the crowing of a cock or the braying of a donkey and such other things. Then he says:

> "Our monarchs and scholars use astrolabs during day and waterclocks during night to ascertain the hour. At day time they have, besides astrolabs, also certain other instruments for measuring the shadow of the Sun, and the Sun-dials, which enable them to know how much of the day has elapsed and what part of it still remains."

In this connexion Jáhiz remarks further that experienced gaderners are able to know the time by the smell of flowers at particular hours.

Thus we see that clocks in those days were in no way used by people generally; they were rather a luxury for kings and a hobby-horse of the scientist; but we learn from a number of works, of later date, written by specialists that Muslims had begun as early as about the third century of the *Hijra* to construct instruments with the help of which they used to ascertain the hour. Ancient books on Arabic bibliography, such as the *Fihrist* of Muhammad ibn Is-hàq ibnu'n-Nadím of Bághdád which was compiled about 378 A.H.=988 A.D.[3], mention an Arabic version[4] of a book on clocks ascribed to Archimedes[5]. In the original writings of Archimedes there is no such book to be found, nor do we know the name of the author of this Arabic version; but the description of the clock contained in that book shows that it must have been in respect of the type of clocks used in Byzantine. It seems rather probable that the original work of Archimedes was lost after the Arabic version had been composed.

Abù Ja'far al-Kházinì wrote his " Book of the Balance of Widsom " in 515 A.H.=1121 A.D. A considerable

(1) Cairo edition 1323 A.H., p. 41.

(2) Ibid, Vol. II., p. 107.

(3) The author died in 385 A.H.—995 A.D.

(4) MSS. in the British Museum, London, and in Paris. A German translation of the Arabic text was published by Wiedemann and Hauser in the *Nova Acta*, Vol. III. Halle 1918.

(5) *Kitabu'l-Fihrist*, edited by G. Fleugel (Leipgig 1871-72) p. 266. also see Inbu'l-Qiftis' *Ta'rikhu'l-Hukama*, edited by J. Lippert, p. 67.

of the graduation, may point at the pole whatever the latitude of the observer may be. The dial is then fixed in position by means of a ratchet prop. It is interesting to note that the latitude scale materialized by the position of the ratchet is given not in degrees or by the names of cities, but by the twenty-four fortnightly periods (*chi*) into which the ecliptic (the band of the zodiac through which the sun apparently moves in its yearly course) was subdivided in traditional Chinese astronomy. The hour lines of the equinoctial dial plate are also expressed in the so-called Chinese "double-hours" associated with the twelve ideograms of the duodenary cycle. In fact, despite their everyday, popular origin, these timekeepers seem to embody elements of the long tradition of Chinese geomancy or topomancy, divination by means of configurations of earth.

So we must believe that Chinese equinoctial sundials belong to the pure Chinese chronometric tradition, an interpretation that takes us back to the origin of the Chinese science known as *Feng shui* (geomancy, wind and water), based on the use of the geomantic compass, and of the ancient divinatory system based on the *Yijing* (I Ching, Book of Changes).

The first portable (and fixed?) horizontal solar time pieces were introduced into China starting from the end of the sixteenth century by Matteo Ricci and other Jesuit missionaries. Indeed, Father Ricci himself, in the preface to his memoirs, wrote: "As for their clocks, there are some which use water, and others the fire of certain perfumed fibers made all of the same size; besides this they make others with wheels which are moved by sand, but all of them are very imperfect. Of sundials they have only the equinoctial type, but do not know well how to adjust it for the position (i.e. the latitude) in which it is placed" (cited in Needham). The structure of these Chinese horizontal sundials which have come down to us is perfectly similar to that of the European "diptych" sundials, whose center of diffusion in Europe appears to have been Nuremberg in the late sixteenth century. Chinese horizontal sundials were not constructed before the end of the Ming dynasty (second half of the seventeenth century), and we have significant evidence showing that this kind of sundial was also employed more for geomantic purposes than as simple timekeepers.

Besides the two types of portable sundials so far mentioned, few specimens of a third kind of sundial, probably horizontal, consisting of a rectangular ivory plate, each one ruled for a different latitude, with hour and declination lines engraved, exist in China. The time of day and the period of the year were presumably indicated by the shadow of a style fitted into a central hole.

Unfortunately, given our still insufficient knowledge on the latter, as on other Chinese sundials previously discussed, it is often difficult to know exactly on what working principle they were based and the precise uses for which they were constructed and put to use. Even more uncertain is the epoch in which many portable Chinese sundials, still extant in museums and on exhibition, were built, where they were built, and by whom.

EDOARDO PROVERBIO

REFERENCES

Bedini, Silvio A. "The Scent of Time." *Transactions of the American Philosophical Society* 56(5): 3–51, 1963.

Gouk, Penelope. *The Ivory Sundials of Nuremberg*. Cambridge: Whipple Museum of the History of Science, 1988.

Iannacone, Isaia. "Il 'Feng Shui' e la Bussola Geomantica all'Istituto e Museo di Storia della Scienza di Firenze." *Nuncius* 2: 205–219, 1990.

Needham, Joseph. *Science and Civilisation in China* Cambridge: Cambridge University Press, Vol. III, 1962.

Needham, Joseph, Wang Ling, and Derek J. de Solla Price. *Heavenly Clockwork*. Cambridge: Cambridge University Press, 1986.

Proverbio, Edoardo and Giuliano Bertuccioli. "On a Singular Chinese Portable Sundial." *Nuncius* 1: 47–58, 1986.

Wgite, W.C. and P. M. Millman. "An Ancient Chinese Sundial." *Journal of the Royal Astronomical Society* 3: 417–431, 1938.

See also: Ge Heng – Geomancy

SUNDIALS IN ISLAM The first sundials were formed by nomads who made holes in the tops of their tents. The sunbeam entered the tent through the hole and reached the floor or walls at different places at different hours. The time could be determined by the positions of these spots. From these developed the mural sextant described by the Islamic scientist and traveler al-Bīrūnī (973–1048) in his *Ḥikāya al-āla al-musammā al-suds al-Fakhrī* (Information on the Instrument Called the Fakhri Sextant) and instruments in the observatories of Ulugh Beg (1394–1449) in Samarqand and of Jai Singh (1686–1743) in Jaipur, Delhi and, other cities of India. In these instruments the sunbeams entered the instrument through the hole in its top and reach a special scale in its lower part.

The ancient Greeks invented sundials with gnomons, so that the time could be determined by the position of the shadow of the end of the gnomon on the plane or curved surface. The theory of sundials with gnomons obtained the name *Gnomonic*. Analogous sundials were used by ancient Arabs, Indians, and Chinese. Al-Bīrūnī in *Kitāb fī ifrād al-maqāl fī amr al-aẓlāl* (The Exhaustive Treatise on Shadows) wrote about all of these. All three nations measured the

Publications of the
Institute for the History of
Arabic-Islamic Science

Edited by
Fuat Sezgin

NATURAL SCIENCES
IN ISLAM

Volume 41

Badīʿazzamān Ibn ar-Razzāz
al-Jazarī
(d. after 602/1206)

Texts and Studies
Collected and reprinted

2001

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

NATURAL SCIENCES IN ISLAM

Volume
41

BADĪʿAZZAMĀN IBN AR-RAZZĀZ AL-JAZARĪ
(d. after 602/1206)

TEXTS AND STUDIES

Collected and reprinted
by
Fuat Sezgin

in collaboration with
Carl Ehrig-Eggert, Eckhard Neubauer,
Farid Benfeghoul

2001

Institute for the History of Arabic-Islamic Science
at the Johann Wolfgang Goethe University
Frankfurt am Main

Güneş Saati

Über eine arabische kegelförmige Sonnenuhr. (Mit J. Würschmidt.). 830-347
Archiv für die Geschichte der Naturwissenschaften und der Technik 7. 1916. S. 359–376.

Eilhard Wiedemann

Gesammelte Schriften zur arabisch-islamischen Wissenschaftsgeschichte

2. Band: Schriften 1912–1927

Gesammelt und bearbeitet
von Dorothea Girke
und Dieter Bischoff

1984
Institut für Geschichte der Arabisch-Islamischen Wissenschaften
an der Johann Wolfgang Goethe-Universität
Frankfurt am Main

SANDOZ KÜLTÜR YAYINLARI NO:7

İSTANBUL'DAKİ GÜNEŞ SAATLERİ

WOLFGANG MEYER

1985

Kanz al-tuḥaf, B.L. ms. Or., 2361; Ibn Zayla, *Kitāb al-Kāfī fi 'l-mūsīḳī*, B.L. ms. Or., 2361; Muḥammad b. Murād, *Treatise*, B.L. ms. 2361; Ibn Ghaybī, *Djāmiʿ al-alḥān*, Bodleian ms. Marsh 828; Kaempfer, *Amoenitatum exoticarum....*; Villoteau, *Descr. de l'Égypte, état mod.*; Sachs, *Reallexikon der Musikinstrumente*; Delphin and Guin, *Notes sur la poésie et de la musique arabes*; Bū ʿAlī, *Kitāb Kashf al-ḳināʿ*; Höst, *Nachrichten von Maroko und Fes*, Riaño, ...*Notes on early Spanish music*; Ghazālī, in *JRAS* (1901-2); Seybold, *Glossarium Latino-Arabicum*; Maḳrīzī, *Hist. des sultans mamlouks*, tr. Quatremère; Niebuhr, *Voyage en Arabie*, 1776; Mushāḳa, in *MFOB*, vi; Lane, *Modern Egyptians* (5th ed.); Von Hornbostel, in *SIMG*, viii/i; *Rasāʾil... Ikhwān al-Ṣafāʾ*, Bombay ed.; Shalāḥī, *Kitāb al-Imtāʿ*, Madrid ms., no. 603; Ṣafī al-Dīn ʿAbd al-Muʾmin, *al-Sharafiyya*, Bodleian ms., Marsh 115; Ḥādjdjī Khalīfa, *Kashf al-ẓunūn*, ed. Flügel; Toderini, *Letteratura turchesca*; Christianowitsch, *Equisse historique de la musique arabe*; A. Shiloah, *The theory of music in Arabic writings (c. 900-1900)*, RISM, Bx, Munich 1979, index, 488 b.

For specimens of instruments: Brussels, *Catalogue descr.... du Musée Instrumental du Conservatoire royal de Musique*; New York, *Catalogue of the Crosby Brown collection of musical instruments*, 1st ed.

(H.G. Farmer)

EI, 7
Güneş Saati

MIZWALA (A.), sundial. This term and *sāʿa shamsiyya* are used in modern Arabic, but in mediaeval Islamic times horizontal sundials were referred to either as *rukhāma*, lit. "marble" or *basīṭa*, lit. "flat", and vertical sundials as *munḥarifa*, lit. "inclined". The gnomon was usually called *shakhṣ*, *shākhiṣ* or *miḳyās*. One expression of the Muslim concern with timekeeping and regulating the times of prayer [see MĪḲĀT] was an avid interest in gnomonics, the theory and practice of sundial construction. Muslim astronomers made substantial contributions to both aspects of the subject, and by the late mediaeval period there were sundials of one form or another in most of the major mosques in the Islamic world. Those which survived usually bear markings for the hours (seasonal or equinoctial) and for the midday (*ẓuhr*) and afternoon (*ʿaṣr*) prayers. Since the beginnings of the permitted intervals for these two prayers were defined in terms of shadow lengths, their regulation by means of sundials was singularly appropriate.

The earliest surviving Arabic treatise on sundials deals with their construction and is attributed to al-Khwārazmī [*q.v.*], active in Baghdād in the early 3rd/9th century. The work consists mainly of a set of tables of coordinates for constructing horizontal sundials serving 12 different latitudes. Each of al-Khwārazmī's sub-tables for a specific latitude displays for both of the solstices the solar altitude, the shadow of a standard gnomon, and the solar azimuth (see Pl. XVI, fig. 1). With these functions tabulated, construction of the sundial would have been almost routine. A 4th/10th-century treatise on the construction of vertical sundials has also survived. This is by one of the two Baghdād astronomers Ibn al-Ādamī or Saʿīd ibn Khafīf al-Samarḳandī (the copyist of the unique manuscript was not sure). Two auxiliary functions are tabulated with which one can generate pairs of orthogonal coordinates useful for marking vertical sundials serving any terrestrial latitude and inclined at any angle to the local meridian. Also from the ʿAbbāsid period, probably the 3rd/9th century, is the earliest text on the portable conical sundial.

Thābit b. Ḳurra (fl. Baghdād, *ca.* 300/900 [*q.v.*]) wrote a comprehensive work on sundial theory dealing with the transformation of coordinates between different orthogonal systems based on three planes: (1) the horizon, (2) the celestial equator, and (3) the variable plane of the sundial. As far as we know, Thābit's treatise, despite its merits, was not influential. Later Muslim astronomers were more interested in the practical side of gnomonics.

The major work on spherical astronomy and instrumentation in the later period of Islamic astronomy was the compendium by Abū ʿAlī al-Marrākushī [*q.v.*], who worked in Cairo *ca.* 680/1280. There are lengthy sections on sundials, with numerous tables and diagrams. The discussion concentrates on descriptions of the mode of construction; there is little underlying theory. The text deals with horizontal, vertical, cylindrical and conical sundials as well as simple, portable vertical sundials, in plane, cylindrical or conical format. Al-Marrākushī's treatise was widely influential in later astronomical circles in Egypt, Syria and Turkey.

A contemporary of al-Marrākushī in Cairo, Shihāb al-Dīn al-Maḳsī, prepared a set of tables for marking vertical sundials for the latitude of that city. For each degree of inclination to the local meridian he tabulated the coordinates of the points of intersection of the lines for the seasonal hours and the *ʿaṣr* curve with the shadow traces at the equinoxes and the solstices (see Pl. XVII, fig. 2). The astronomer Ibn al-Sarrādj, active in Aleppo some fifty years later, devised several ingenious sundials for all latitudes.

Only a few sundials survive from the mediaeval period. Hundreds or even thousands must have been constructed from the 3rd/9th century onwards, but the vast majority have disappeared without trace. The oldest surviving Islamic sundial (see Pl. XVIII, fig. 3) was made by Ibn al-Ṣaffār, an astronomer of some renown who worked in Cordova about the year 400/1000. Only one-half of the instrument survives, but the remains are adequate to establish that gnomonics was not the maker's *forte*. The sundial is of the horizontal variety and there are lines for each of the seasonal hours and the *ẓuhr* prayer; there would also have been markings for the *ʿaṣr*. The gnomon is now missing, but its length is indicated as the radius of a circle engraved on the sundial. Several other, later Andalusī sundials which survive are singularly poor testimonials to their makers' abilities; yet proper sundials must have existed in mediaeval al-Andalus.

The Tunisian sundial shown in Pl. XVIII, fig. 4 is a much neater production. It was made in 746/1345-6 by Abu 'l-Ḳāsim Ḥasan al-Shaddād, and it is of considerable historical interest because its markings display only the times of day with religious significance. For the afternoon (right-hand side) the curves for the *ẓuhr* and *ʿaṣr* are marked according to the standard Andalusī/Maghribī definitions. For the morning there is a curve for the *ḍuḥā*, symmetrical with the *ʿaṣr* curve with respect to the meridian, and a line for the time of the *taʾhīb* one equinoctial hour before midday, this institution being associated with the communal worship on Friday [see DJUMʿA]. It was the symmetry of the *ḍuḥā* and *ʿaṣr* on this sundial that first led to an understanding of the definitions of the times of the daylight prayers in Islam.

The astronomer Ibn al-Shāṭir, chief *muwaḳḳit* of the Umayyad Mosque in Damascus, constructed in 773/1371-2 a horizontal sundial, some 2 m × 1 m in size, which is undoubtedly the most splendid sundial of the Middle Ages (see Pl. XIX, fig. 5). It was erected on a platform on the southern side of the main minaret of the Mosque. It could be used to measure time after sunrise in the morning and time before