THE ARABIC ORIGINS OF THE *SCIENTIFIC* SUNDIAL

(Sometimes called the "Moorish" sundial.)

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The origins of the sundial are lost in the mists of antiquity; but there is no doubt that the very earliest civilisations made use of the shadows of objects to gauge the time of the day and the season of the year. The ancient Eqyptians made use of a device for measuring the length of shadows as early as c 1500 BC, whilst the ancient Greeks had a thorough understanding of the construction of sundials, albeit instruments that indicated unequal or seasonal hours. Nevertheless, the origin of the construction of the *scientific* sundial, indicating *equinoctial* or equal hours, as are in use today, in which the *style* or gnomon of the instrument lies in the meridian, in the *polar axis* of the earth, is attributed to the brilliant scientists of Islam.

The Islamic era dates from the Prophet Muhammad's migration (*Hejira* or *Hijrah*) from Mecca (*Makkah*) to Medina (*Al Madīnah*) in AD 622. Muhammad (c. AD 570 – 632) was born in Mecca, which at that time was a centre of the Arabian caravan trade, in what is now Saudi Arabia. At the age of 25 he married Khadija, a wealthy widow who had employed him to conduct a caravan to Syria. About the year 610, when Muhammad was forty years old, he began receiving the divine revelations, which led to the foundation of the religion of Islam; but the authorities in Mecca opposed his teaching and, such was the increasing danger to his person and to his followers, that, in 622, he fled some 220 miles north to Medina, where he settled. Subsequently, he took up arms against the Meccans and, in 631, raised an army for an attack on Mecca. Faced with such a powerful force, Mecca surrendered without giving battle. On entering the town, Muhammad's first act was to turn the Ka'aba shrine of the old religion into the holiest shrine of Islam. The following year, in 632, Muhammad himself led the people of Medina on their pilgrimage to the Ka'aba in Mecca; but, succumbing to ill health, he died on his return home.

In the hundred years after the death of Muhammad, but under his inspiration, the armies of Islam quickly conquered Syria, making Damascus their new capital, thence continuing their conquests, taking Mesopotamia and Persia. Swiftly, their great armies spread their religion over vast areas of the known world, from the borders of China in the east, across North Africa to Morocco and Spain in the west. History has named the Muslim conquerors of Spain as *Moors*, probably because they came via Morocco; but their leaders were Arabs from Damascus, who had gathered their armies from the converted Berber tribes of North Africa. In the spring of the year AD 711, under the command of Tariq ibn Ziyad, an army of 12,000 Muslims crossed the strait between the *Pillars of Hercules*, now the Strait of Gibraltar, and marched north into Spain. By 732, they had all but conquered the Iberian Peninsula and had crossed the Pyrenees, where, at last, their advance was halted, near Poitiers, in southern France. Nevertheless, it took 760 years before the Christian princes of Spain finally regained their country in 1492, albeit at the cost of the culture that Islam had brought in the wake of its Moorish conquests.

In the ensuing relative peace of the Islamic empire, science and art flourished and whilst the Muslim armies had sacked Alexandria in 642 and burnt the great library, the Arabs inherited much that had survived. This included treatises from the famous Greek school of astronomy and, indeed, Ptolemy's great work, bearing the Arabic name *Almajest,* owes much to the esteem in which it was held in the new cultural climate of Islam. Many distinguished Arab scientists emerged in the dawn of this civilisation and mathematical astronomy was one of the disciplines in which they excelled. However, of those who were skilled in mathematical astronomy and who had acquired the knowledge to invent the scientific sundial, the most notable included such bright luminaries as Al-Khwārizmī, Al-Battani, Al-Haitham, Al-Biruni and the lesser known Aboul Hhassan.

Al-Khwārizmī (AD 783 – c.850.) – *Abū Jacfar Muhammad ibn Mūsā al-Khwārizmī* – was born in the sultanate of Khwarizm, probably near the capital city of Kath, close to the ancient town of Kiva, which lies to the south of the Aral Sea, some 620 miles to the north-east of Tehran, in Uzbekistan. However, he spent much of his life in Baghdad, where he studied mathematical astronomy and became the leading scientist of his day. Lunar crescent visibility tables are attributed to him, for predicting the sightings of the lunar crescent, in connection with the regulation of the Islamic lunar calendar. He wrote works on the construction of astrolabes and sundials, and compiled tables of coordinates for this purpose for horizontal and vertical sundials at different latitudes; but the title of his work, in which the word *al-jabr*, i.e. "algebra" appears, is his best claim to fame. (1)

Figures 1 and 2. Left: Al-Haitham (artist's impression). Right: Al-Biruni (artist's impression).

Al-Battani (c.AD 850-929.) – *Abu-'Abdullāh Muhammed Ibn-Jábir Ibn Senán Al-Battáni* (Latinized as 'Albategnius') – was born in Batan, in what is now Iraq; but spent much of his life in Damascus. The son of a builder of astronomical instruments, he determined the length of the year with remarkable accuracy, the times of the equinoxes and the angle of the tilt of the earth's axis to the plane of its orbit. (2)

Al-Haitham (AD 965-1039.) – *Abu Ali Al-Hasan ibnul Hasan ibn al-Haitham* – (better known as Alhazen in the western world) was born in Basra, in what is now Iraq. Known as "The Father of Optics," Al-Haitham was one of the greatest of all scientists that the world has ever seen. Although he is famed for his work in optics, he devoted his spare time to acquiring knowledge in other fields, including mathematics, physics, astronomy and medicine. One of his studies concerned the annual phenomenon of the flooding of the river Nile delta, when he conceived a scheme for a dam, suggesting a site near Aswan. Invited to Cairo, perhaps about the year AD 1005, by Al-Hakim, the ruling Caliph, Al-Haitham found the task too daunting with the resources at his disposal. Alarmed at the prospect of a horrible fate, he feigned madness and suffered imprisonment c.1007, being released only after Al-Hakim's death in AD 1021. Thereafter he settled for a scholarly life in the University (*Jamia*) of Al-Azhar in Cairo, where he engaged in scientific pursuits. Apart from his major treatise on optics, he also wrote works on such matters as the determination of time with precision, the determination of the meridian, the determination of the altitude of the celestial pole and various treatises on sundials. **(3.)**

Al-Biruni (AD 973-c.1050.) – *Abu al-Rayhān Muhammad ibn Ahmad al-Bīrūnī* – was born near Kath, the capital of the sultanate of Khwarizm, close to Khiva, in what is now Uzbekistan. Of Persian descent, he was born into a climate of advanced culture; but, evidently orphaned in his infancy, he was fortunate to have a member of the Khwarizmian royal family, a distinguished mathematician and astronomer, as his foster father. Thus, Al-Biruni began studying astronomy and other scientific subjects. At the age of 17 he was making astronomical observations and, from measuring the sun's meridian altitude, with his own self-made instrument, calculated the latitude of the city of Kath. Astronomer, mathematician, physicist, geographer, historian, linguist, ethnologist, pharmacologist, poet, novelist and philosopher – Al-Biruni became one of the most brilliant scholars of his age. He travelled widely, not least because he was taken prisoner in 1017 by the armed hosts of Mahmud of Ghazna, who overran Khwarizm in that year. Al-Biruni was deported to Ghazna in Sijistan, now a part of northern Afghanistan, where, already famous, the brilliant scientist was probably seen as an enhancement to the sultan's court. He was evidently allowed to travel and was given official support for his work. Thus, he determined the latitude of Ghazna – about 75 miles south of Kabul – observed eclipses, demonstrated that the earth was spherical, and calculated its radius as 6,338.80 kilometres. He travelled to India, studied Hindu astronomy and trigonometry, and wrote an encyclopaedic work *India*, which he completed soon after Sultan Mahmud's death in AD 1030. His scholarship and output was phenomenal and not the least of his works was an exhaustive treatise on shadows, in which he describes instruments which employ shadows in their operation, including the astrolabe and the sundial. **(4.)**

Aboul Hhassan of Morocco (c. AD 1230.) was an astronomer, about whom little is known; but who is associated with the practical development of equal or equinoctial hours and the invention of the so-called 'Moorish' scientific sundial, with its inclined gnomon directed to the celestial pole. It is perhaps possible that he was a Moroccan ruler who was the forebear of Abu al-Hasan, a Moroccan king, who refurbished the 80-foot-high stone tower of the hillside Arab fortress at Gibraltar in AD 1333. **(5.)**

There were many bright stars in the glittering Arabian firmament of science and art; but these were perhaps the brightest of those most able to invent the scientific sundial. Whilst astronomers evidently used equinoctial hours in their observations, Islamic religious services were commonly governed by the use of temporal, seasonal or unequal hours. Thus there was no real requirement for a sundial that would indicate equal hours. Nevertheless, the invention is attributed to the Arabs and it has been thought that this form of dial might have been introduced into Christian Europe through the medium of the Crusades, or, perhaps more likely, via the established centres of Arabic learning in Spain. Here it is known that Christian scholars were able to study freely and benefit from the then tolerant culture of Islam. Thus, the scientific sundial may have reached Germany, in the first place, in the late 14th or early 15th century. However, the question of its origin and its inventor still remains a matter of speculation.

References:

(1.) D. A. King: *al- KHWĀRIZMĪ and New Trends in Mathematical Astronomy in the Ninth Century*, The Hagop Kevorkian Center for Near Eastern Studies, New York, 1983.

(2.) I. Asimov: *Biographical Encyclopedia of Science and Technology*, Doubleday & Company, Inc., New York, 1964.

(3.) H. M. Said (Editor): *Ibn Al-Haitham*: *Proceedings of the Celebrations of* [*the*] *1000th Anniversary*, Hamdard National Foundation, Pakistan, 1970.

(4.) E. S. Kennedy: *The Exhaustive Treatise on Shadows* by Abū al-Rayhān Muhammad b. Ahmad al-Bīrūnī, translation and commentary, 2 vols., Institute for the Hisrory of Arabic Science, Aleppo, Syria, 1976.

(5.) C. St J. H. Daniel: *Sundials – Instruments of Time*, The Proceedings of the Oxford 2000 Convention, The Antiquarian Horological Society, Ticehurst, 2000.

CAPTIONS:

(1) **Al-Haitham –** *an artist's impression*.

(2) **Al- Biruni –** *an artist's impression***.**

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