134 A. Moorish Astrolabe **XIIIth cent.**

The property of Dr. L. Knuthsen.

6 inches in diameter. Bracket with three perforations. Shackle original. Ankabut for 26 stars, of the type figured on p. 294.

Of the three tablets, one, perhaps the oldest of the set, is finely engraved and lettered. It is tripartite and is inscribed:

I*a*. For the latitude of Marakesh and for every town whose latitude is 31° 10′.
b. For the latitude of Fez and for every town whose latitude is 33° 40′.

The other two are roughly executed and sexpartite.

II*a*. For the latitude of Mecca 21° 40′.
b. For the latitude of Medina 25°.
Across the mid-line is the word *zawāl* or ' commencement of the going down of the sun '.
III*a*. For the latitude 90°.
b. Tablet with a ' general polar projection ' as described by Kaye, 1920, and figured by him, fig. 7. On the right-hand side it is inscribed with the name *El Medina* and ' The Places ', and on the left ' The Latitudes'. Another example is mentioned as Type Z on p. 280.

On the back: within a circle of degrees are circles of signs and months surrounding the four inner quadrants, the first and fourth of which contain an instrumentum horarum and a Shadow-square.

Fig. 120. Dr. Knuthsen's Moorish Astrolabe.

MOORISH ASTROLABES

We have no evidence of the use of astrolabes in north-west Africa during the three centuries when it was a Christian country under the African church of Tertullian and Cyprian, but doubtless the Arab invaders of A.D. 647 introduced them, and taught Moors their use when they persuaded them that to live as Mohammedans was more expedient than to perish as Christians.

From the same Arabian stock came the Moslem invaders of Spain. By their unexpected gift for civilization, architecture, and science, they raised that south-west corner of Europe to a cultural level that was far above the capability of any northern race of their time, or, one might almost say, of the south-west of Ireland at the present day. To the subjection of Spain to Eastern rule for seven centuries, from A.D. 711 to 1492, we owe the substructure for later advances in mathematical, medical, chemical, and astronomical science. To their faithful stewardship of the wisdom of eastern sages, to their high missionary task of transmitting and disseminating the hoarded knowledge which had filtered down from the Greeks among our relatively barbarous European ancestors, they have earned an inextinguishable debt of gratitude that is too great for busy modern men of science ever to find time adequately to repay.

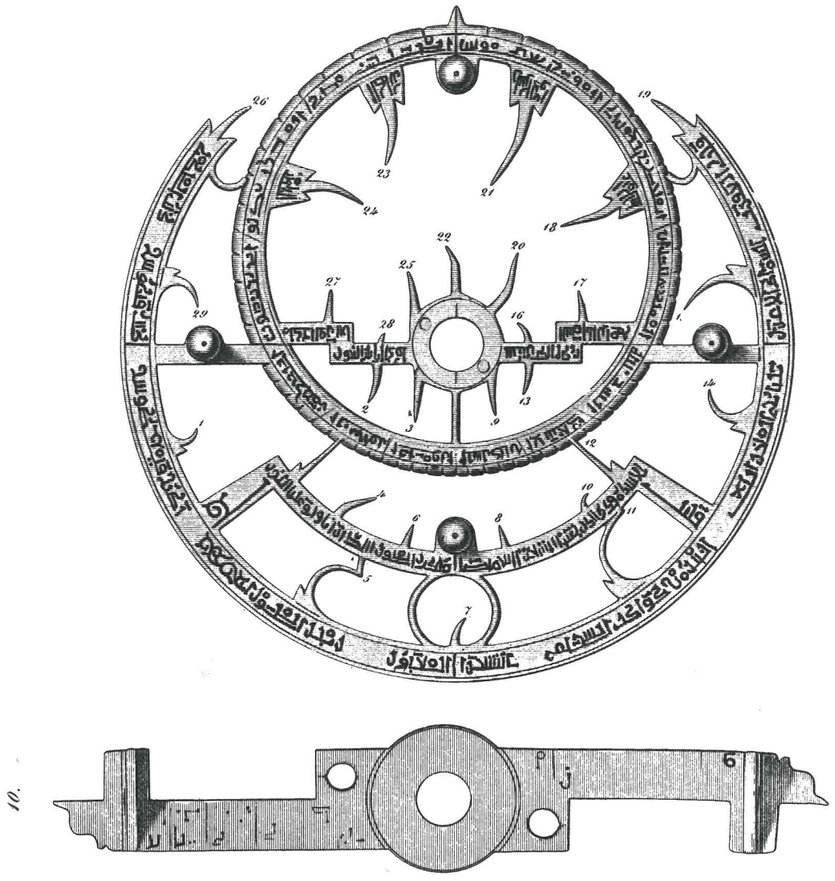
The few astrolabes that were actually made by Moors in Spain, that have escaped the vicissitudes of destructive fate, and can still be used, have the glamour of having been intimately associated with the greatest festival of living science, the birthday of modern Natural Science in Europe.

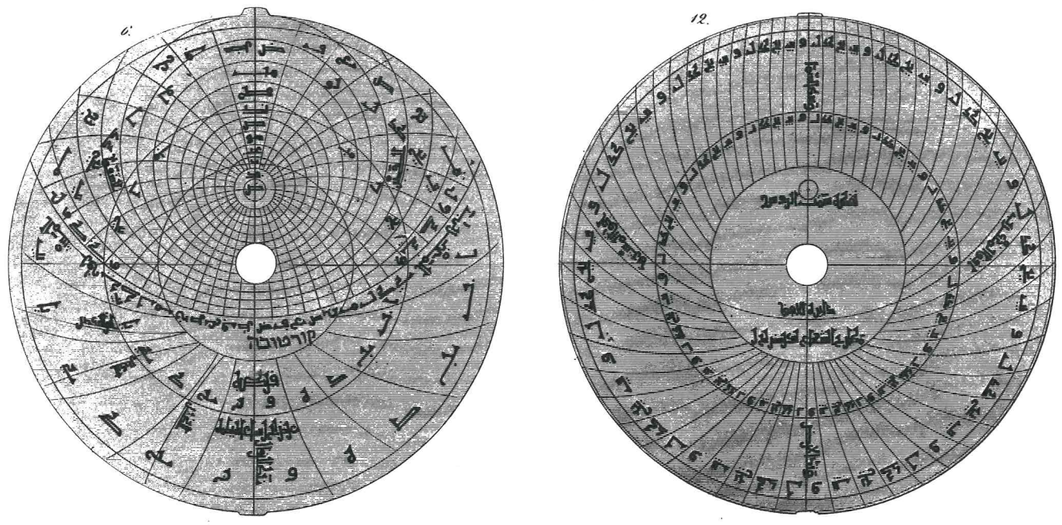
It was only to be expected that so enlightened and statesmanlike a policy as that of the three Abdurrahmans, continued in Spain for two centuries, A.D. 755–961, should have been followed by rich reward in the realms of learning and science. The successful high school of Cordova grew to rival the famous university of Bagdad, and by 977 the third Abdurrahman's successor had amassed a library of over half a million volumes. Unlike northern pedants, Arab scholars wasted but little time over the more trifling literature of Greece and Rome. They concentrated their attention on the important scientific writings of classical authors. The cosmology of Ptolemy was more to them than the love poems of Ovid. And to-day every civilized

nation in the world acknowledges a great debt to the Arabs for their legacy of improved and serviceable methods of calculation, for their words—zenith, algebra, alcohol, and all that they imply, and for the many other footprints they have left upon the sands of time.

The question is often asked: but did the Arabs show any signs of cultivating the inventive faculty, or were they merely transmitters of older inventions? The Astrolabe presents us with a reply. It was an Arab who effected one of the greatest possible improvements to it by rendering it a universal instrument, named an *Arzachel*, after AL ZARQALI, the inventor, a native of Cordova, who lived from about A.D. 1029 to 1087. As there are older Moorish instruments still in existence, the description of his inventions will be deferred to their chronological sequence, but we may here emphasize the enormous importance of the work for pure Science that was accomplished by that most enlightened of all Kings of Spain, ALFONSO X, THE WISE (1226–84), who, according to the popular story, assembled a committee of fifty of the most celebrated astronomers of the day, and set them to correct the Ptolemaic planetary tables. The revised *Alfonsine Tables* were completed in A.D. 1252. At about the same time he caused new copies to be made of such works by ancient Arabian men of science as might have still resisted the ravages of time. And in this collection, known as the *Libros del Saber*, were included certain illustrated works by AL ZARQALI on the Universal Lamina and the Saphea of two centuries earlier. It is satisfactory to note that Arzachels of A.D. 1216 and 1218 still survive, which are therefore long anterior to the publicity that was given to the writings of their inventor by Alfonso the Wise.

Moorish astrolabes, and especially those made in Spain at that early period, are characterized by certain readily recognizable features that distinguish them from Persian instruments of the same epoch. Their ankabuts are designed on a simpler plan. There are none of those elaborate intertwinings and serpentine tracery that give the astrolabes of the farther East their attractiveness and grace. But the Moorish instruments have a charm of their own, which is derived more particularly from the curvature and decoration of the star-pointers, than from any artistic treatment of supporting bands and bars, which in general are studiously plain. When ornament is introduced, it is frequently of a type suggested by the Moorish arch with its ogee point and cusped sides. In the lettering the Cufic prevails. The *kursi* or bracket is frequently far smaller than is usual in Eastern astrolabes.





MOHAMMED BEN AL-SAAL'S TOLEDO ASTROLABE, A.D. 1029.
(*After Woepcke*).

There is no throne inscription. *Mudirs* may be multiplied. Star-pointers are frequently embellished with bright silver knobs and perforate bases.

116. MOHAMMAD BEN AL-SAAL'S TOLEDO ASTROLABE. Pl. LIX (*facing*)
A.D. **1029–30.**

3 inches, 5½ lines (Rhenish) in diameter, with 9 plates.

Purchased by Herr A. Sprenger in the East and presented by him to the Royal Library, Berlin, No. 3. Woepcke, *Über ein in der Königlichen Bibliothek zu Berlin befindliches arabisches Astrolabium. Akad. Wissenschaften.* 1858.

Fabricated by Mohammad Ben Al-Saâl in the city of Toledo in the year 420.

The ankabut, for 29 stars, and 2 plates are figured on pl. LIX.

The Hebrew equivalents of certain of the Arabic names have been scratched on the instrument, showing that it was once in the possession of a Jew, presumably a Spaniard, since the plates for Toledo and Cordova have been marked in this manner.

The 8 sexpartite plates are inscribed for an interesting and comprehensive series of climates, some of which the owner could never have hoped to visit.

1. ' The land that is found under the equator, namely the peoples of the country of the equal days. The island Serendib (= Ceylon).
2. Lat. 10°. 30′ . . hours 12. 38. Ghanah.
3. ,, 14°. 30′ . . ,, 12. 52. Tsana.
4. ,, 17°. 30′ . . ,, 13. 4. Saaba.
5. ,, 21°. 40′ . . ,, 13. 20. Mecca.
6. ,, 25° . . ,, 13. 35. Medinah.
7. ,, 28° . . ,, 13. 49. Colsum.
8. ,, 30° . . ,, 13. 58. Cairo.
9. ,, 32° . . ,, 14. 8. Kerouan.
10. ,, 34°. 20′ . . ,, 14. 20. Sura-man-rah.
11. ,, 36°. 30′ . . ,, 14. 33. Samarkand.
12. Cordova Lat. 38°. 30′ . . hours 14. 45.
13. Toledo ,, 40° . . ,, 14. 54.
14. Saragossa. ,, 42° . . ,, 15. 8.
15. Constantinople. ,, 45° . . ,, 15. 30.
16. Limits of the inhabited earth. Lat. 66°, hours 24.
17. Lat. 72° (engraved in the *umm*).

These plates are marked with the temporal hours and the lines of the 2 hours of prayer: *al-dohr* or *al-zuhr*, the time of the midday prayer; *al-asr*, the time of afternoon prayer, and the ' end of the *asr* '.

A ninth plate, for latitudes 38° 30′ and 42°, and therefore obviously for use at Cordova and Saragossa, is marked with arcs of the Celestial Houses for astrological purposes. Pl. LIX, fig. 12.

The Back shows the following circles:

i. Circle of degrees numbered quadrantally.
ii. Circle of degrees of the signs of the zodiac and their names.
iii. Circle of months of the Julian Calendar.
iv. Circle of 12 letters, the numerical values of which indicate the day of the week with which the months begin.
v. In lower semicircle are shadow scales for finding the tangents of angles 0° to 45° and the cotangents of 45° to 90°.

In the upper semicircle is the maker's inscription.

The alidade is graduated with hour lines for use as a sundial (pl. LIX, fig. 10).

117. IBRAHIM IBN SAID'S ASTROLABE A.D. 1066–67.

9½ inches in diameter.

In the Archaeological Museum, Madrid. Electrotype in the Science Museum, S. Kensington, No. 1877, 6. Described by Don Eduardo Saavedra, *Museo Español de antiquedades*, vi, pp. 402–14.

Inscription across Back:

Of that of which the workmanship was elaborated by Ibrahim ibn Said al Mawazini Assohli at Toledo in A.H. 459 (= A.D. 1066–7).

Mawazini = the Scale-maker. An instrument, that is obviously by the same hand, is the oldest Moorish instrument in the Evans Collection.

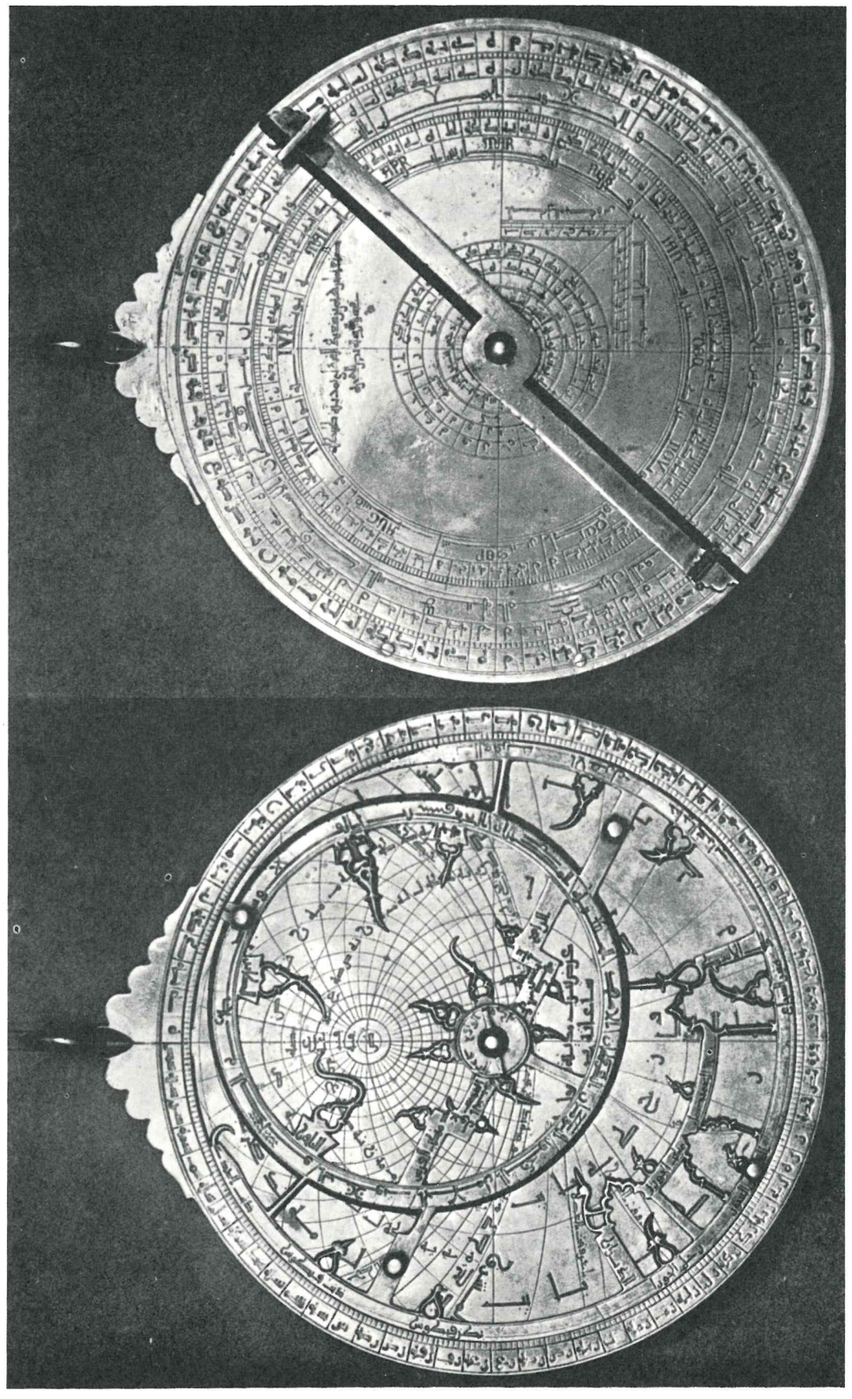
Suspension is by loop and shackle, with a pin through a low bracket.

The ankabut is for 24 stars (12 in + 12 out). East-west bar counterchanged 4 times as in the instrument next to be described, which resembles this in all important respects, but that the short equinoctial band is connected with the Capricorn band by 1 broad bar only, on the left side, and by a light arched framework which serves as a star-pointer. Also the 2 ties between the zodiac circle and the Capricorn band are ornamented with cusps. The star-pointers have bulbous bases, which are perforated with 1, 2, or 3 (trefoil) holes.

The tablets are 5 in number. Three are inscribed ' 25 ', ' 22 ', and ' 40 ' respectively.

Back:

i. The 4 quadrants of degrees numbered by fives 0–90°.
ii. Numbers of degrees of the zodiacal signs.
iii. Names of the signs in Arabic.



THE TOLEDO ASTROLABE, A.D. 1067

Eccentrically within which are

iv. Days of the months and their numbers.

v. Names of the months: *Mars*, *Mabril*, *Mayh*, *Yunyh*, *Yulyh*, *Agst*, *Stnbr*, *Octbr*, *Numbr*, *Dekhmbr*, *Ynyr*, *Fbryr*.

And within a large space containing the maker's inscription and a single shadow square in the right-hand quadrant, as in No. **118** in the Evans Collection, are the 5 circles as described on p. 256.

118. THE TOLEDO ASTROLABE. Pl. LX A.D. **1067–8.**

$6\frac{5}{8}$ inches in diameter.

Purchased by L. Evans in April 1899 for £12 of Cantoni, via Ugo Foscolo, Milan; L. Evans Collection, No. 5.

Inscription across Back:

MADE BY IBRAHIM IBN SAID ASSOHLI IN THE CITY OF TOLEDO IN SCHAWWAL IN A.H. 460.

A brass astrolabe measuring 8 inches from the top of the shackle to the bottom of the rim. It is built of 3 thicknesses of metal $\frac{1}{4}$ inch (7 mm.) thick. The engraving is in Cufic characters, and it is interesting to compare it with the larger astrolabe by the same maker, dated A.H. 459 and therefore a year older, which has just been described.

The bracket is low, with 3 lobes on each side of the loop for suspension. Original ring missing. The rim is divided into degrees numbered by fives.

The ankabut is made for 28 stars. The zodiac circle is engraved with the symbols of the constellations as well as with their names, a feature that is unusual in an oriental instrument, though not infrequent in later examples of European manufacture. The east-west bar is of the inverted type with the parts counterchanged 4 times on either side of the fiducial line. It is the chief connection between the axis, zodiac circle, and Capricorn band. The short equinoctial band is supported by 3 slender 'Moorish' arches enclosing star-pointers, which also serve as cusped canopies over the 3 important stars, Rigel, Sirius, and Alfard. There are 4 *mudirs* or knobs for turning the ankabut.

Some of the stars seem to have been much altered, those marked * probably less than others.

Star List

H	*M.*		
I	8	Baten-Kaitus*	ζ Ceti.
I	56	Al-Gûl	β Persei.
III	54	Al-Debarân	α Tauri.
IV	8	Al-'Ayyûk (Alhaioth)	α Aurigae.
IV	36	*	β Orionis.
V	16	Menkib al-Gauzâ	α Orionis.
VI	10	Alhabor	α Can. maj.
VII	2	Algomeizâ	α Can. min.
VII	44	Ad-Dubb	ι κ Ursae maj.
IX			α Hydrae.
IX	20	Kalb al-Asad*	α Leonis.
IX	40		
XI	16	Ganâh al-Gurab*	ν Corvi.
XII	48	Al-Azâl*	Spica Virg.
XIII	20	Benat Nasch	η Ursae maj.
XIII	40	Ar-Râmî	α Bootis.
XIV	56	Al-Fakka	α Coronae borealis.
XIV	58	Al-Faras	κ Pegasi.
XV	44	Kalb al-Akrab	α Scorpii.
XVI	40	Al Hawwa ?	α Ophiuchi.
XVIII	16	Al-Wâkî	α Lyrae.
XIX	16	Al-Tair	α Aquilae.
XX	2	Al-Hayya	α Serpentis.
XX	24	Ar-Ridf	α Cygni.
XXI	4	Deneb Algedi	δ Capricorni.
XXII	24	Menkib al-Faras	β Pegasi.
XXIII	12	Al-Hadîb	β Cassiopeae.
XXIII	28	Deneb Kaitos	βω Ceti.

The plates are 6 in number, one being more modern (A.D. 1500?) and incomplete, and the bottom of the *umm* is also engraved as a plate. Almucantars drawn for every fifth degree (*khumsi*) are inscribed for the following places and their latitudes.

1*a*. Mecca, God guard her, and her Priesthood.
Latitude 21°: hours 13. 27.

b. Latitude of Yathrib, City of the Prophet (= Medina or Ptolemy's Iathrepta).
25°: hours 13. 35.

2*a*. Misr (= Cairo); 'Ainshems; Kirman; Kandahar; Mahbruban.
Latitude 30°: hours 13. 58.

b. Bagdad; Damascus; Caesarea; Tunis; Fez.
Latitude 33°: hours 14. 13.

3*a*. Moṣul; Ruṣafah; Mambiq; Safyah; Sicily; Ceuta.
Latitude 35°: hours 14. 27.

b. Seville; Malaga; Granada; Bokhara; Ruha (= Edessa); Rayy (= Teheran).
Latitude 37°: hours 15. 39.

4*a*. Medina; ' Harran '; Samarkand; Ras al 'ain; ' El Marna '; Sahahrzur.
Latitude 36°: hours 14. 38 (?).

b. Toledo; Talavera; Adhabaijan; Khálat.
Latitude 40°: hours 14. 54.

5*a*. Cordova; Murcia; Biassah; Gian; Mervarrud; Balkh; Djurdan.
Latitude 38°: hours 14. 45.

b. Saracosta; and the Kal 'at Ayyub (= Castle of Job); ' Washka '; ' Babeshtan '.
Latitude 41°: hours 15.

6*a*. Tablet engraved with almucantars for lat. ° (uninscribed).

b. ,, ,, ,, lat. ° numbered in Magrevi characters.

7. The inside of the *umm* is likewise engraved as a plate for lat. 28°. 20′; K | l z m ?; Maden; Cabul; Taus; Ghilan.

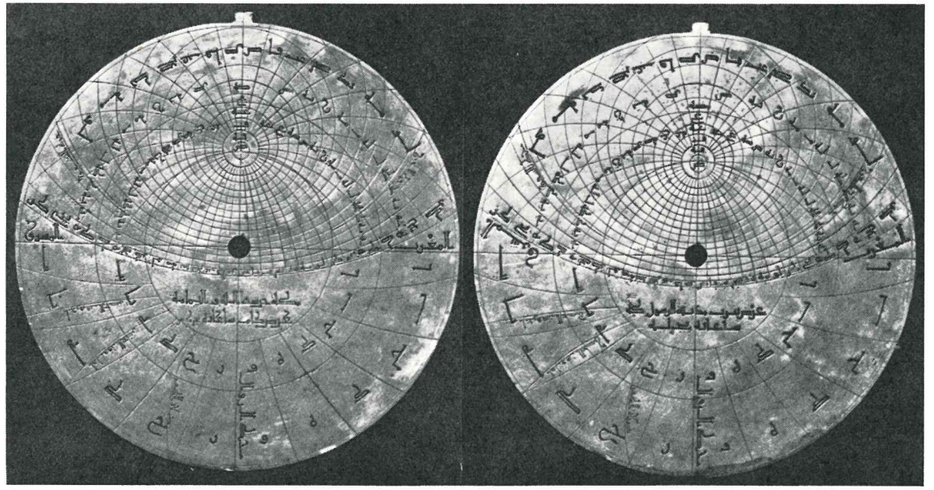


Fig. 121. Tablets for Lats. 21° and 25°. A.D. 1067–8.

As in many other astrolabes the plates are inscribed with arcs of the unequal hours and with arcs indicating the hours of prayer. These are

' Time of afternoon ' on the meridian line.
' Midday prayer-time ', ' line of the *zuhr* '.
' Commencement of the afternoon ' } ' line of the *aṣr* ' (i.e. ' the time of
' End of the time of the afternoon ' } the afternoon ').

The Back is engraved with 2 sets of Calendar scales. Proceeding inwards from the periphery are:

i. Four quadrants divided into degrees numbered by fives from zero on the horizontal to 90° at the poles.
ii. Circles of degrees and Signs of the Zodiac in Arabic.

iii. Circles of the days of the months, the Latin names of which are engraved both in Roman and in Arabic characters. The spelling *Mārs*, *Abril*, *Māyh*, *Yunyh*, *Yulyh*, *Aghst*, *Stnbr*, *Aktubr*, *Nunbr*, *Gnbr*, *Yanyar*, *Fbryr*, is considered by Professor Margoliouth to indicate an Italian rather than a Spanish source. 1st of Aries = March 14.

In the centre is a smaller circular scale in which 3 external circles served as a perpetual calendar of the type described by Sarrus as the calendar of Abu Bekr in an astrolabe of A.D. 1208, the letter K being 7 times repeated in the inner circle. See p. 267.

Within are 2 more circles, showing the names of the 12 months and their numbers. Their arrangement does not, however, seem to have any relation to that of the months in the larger scale, for January in the one comes opposite to June in the other.

THE ARZACHEL

The Zarquali Astrolabe or Arzachel

This invention is attributed to Ibrāhīm ben Yahya al-Naqqash (the engraver), born at Cordova, who lived from about A.D. 1029 to 1087. He was known as al-Zarqali (Arzachel) and he called his invention *al-ʿAbbādīyah* in honour of al-Muʿtamid b. Abbād, King of Seville (A.D. 1068–91),[1] but it became more generally known by his own name as the Tablet of al-Zarqali (*al-ṣafīḥat al-zarqālīya*) or *Saphaea Arzachelis*. It became of international importance. It was made even in India. An example is described on p. 212.

Excellent as is the ordinary planispheric astrolabe for use within a limited zone, its accuracy is confined to those latitudes for which tablets are provided, and to carry a large series of alternative latitude-tablets would necessarily greatly increase the weight or cumbrousness of the instrument. But by Zarquali's invention an astrolabe with but a single tablet became endowed with universal utility in all latitudes. For the usual polar projection of the sphere, suited to a single chosen latitude, he substituted a horizontal projection. He took one of the equinoctial points as his centre of projection, and made the solstitial colure the plane of projection. By

[1] C. Nallino, *Encyclopaedia of Islam*, p. 502.

this scheme the co-ordinates of the ecliptic and of the principal stars coincide; so an ankabut is unnecessary.

On the same diagram he gave us the equator with its parallels (*madarat*) and the circles of declination (*mamanat*), together with the ecliptic with circles of latitude and longitude.

At the common centre was pivoted a rule (*ufk mail*) which could be set in any direction to serve as the oblique horizon for the place of observation. It is graduated to show eastern and western amplitudes.

On the back of some of his instruments, e.g. p. 259, Arzachel added a 'circle of the moon' to facilitate the following of the apparently erratic course of that troublesome but important luminary.

The complete instrument was known as a *Saphea*, and, having no cargo of tablets, had no *umm*. The older instruments now to be described were made about 150 years after the date of the original invention.

119. The Lámina Universal of Arzachel A.D. 1070–5.

Figured in Alfonso X, *Libros del Saber*, iii.

Diameter 8 inches.

On the face of the base plate was engraved a circle of degrees numbered by fives quadrantally from 0° at the equator to 90° at the poles, to one of which the suspension ring and cord was attached. Within was a horizontal projection of the sphere, with the signs and degrees of the zodiac inscribed across the horizontal line.

The figure of the Rete (fig. 122) is most interesting, for it clearly shows the original of the type, comprising half a horizontal projection of the sphere and half a star-map, that was in after years republished by John Blagrave in England. In the crude figure 15 unnamed oat-shaped star-pointers are clearly indicated.

On the Back within a circle of degrees numbered in four quadrants is a circular calendar in which 1st Aries corresponds to 'Março 15', and in position to the suspension bracket. The upper hemisphere includes a rectangle of the shadows, with the *linea mediae umbrae*.

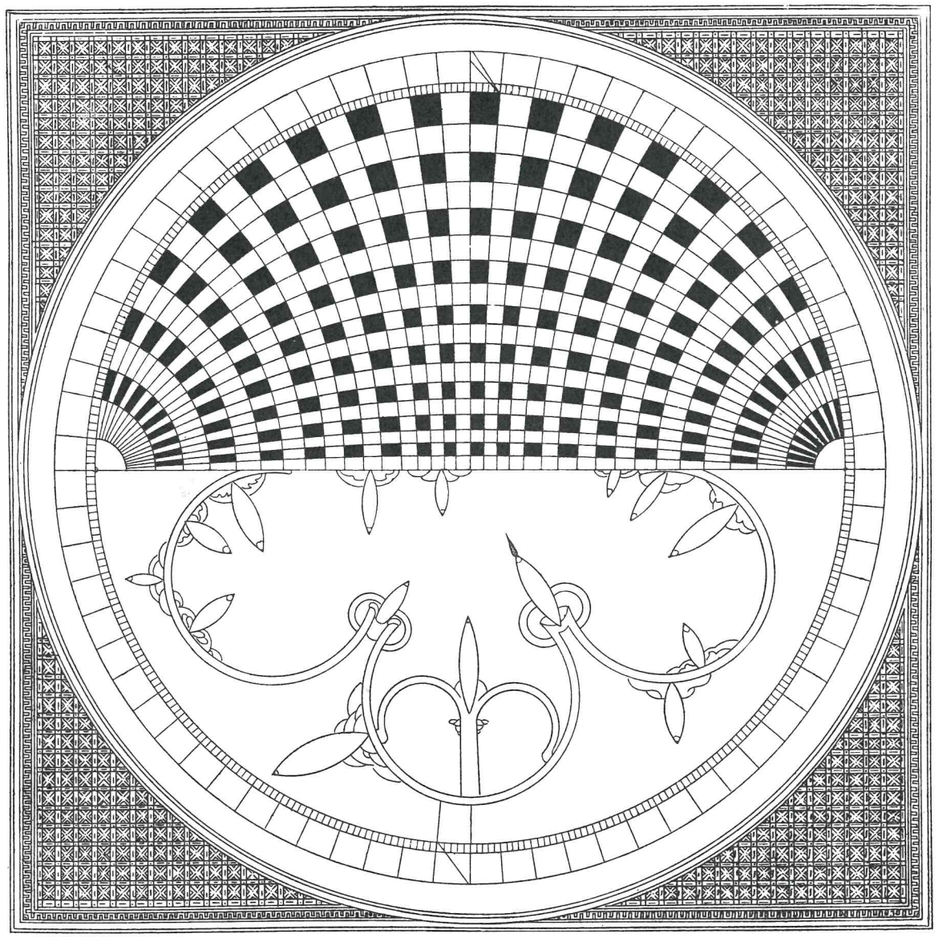


FIG. 122. RETE OF THE UNIVERSAL LAMINA. A.D. 1070–5.
From Alfonso X, *Libros del Saber*, 1864.

120. THE SAPHEA OR AÇAFEA OF ARZACHEL A.D. **1078–80.**

The construction of the face of the instrument is clearly shown in the figure on p. 261, while on the Back are engraved (i and ii) circular calendar scales of Signs of the Zodiac and the corresponding months (March 15 = Aries 1); (iii) a horizontal projection of the sphere in 3 quadrants, with (iv) sinical quadrant in the fourth quadrant, ruled with 60 lines. Below the centre is (v) the eccentric ' circle of the moon '.

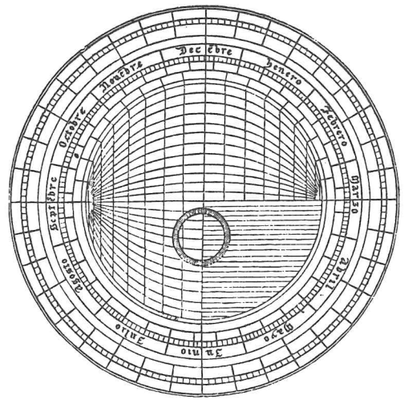


FIG. 123. BACK OF THE SAPHEA OF ARZACHEL.

In 1263 Arzachel's treatise on the Saphea was translated into Latin by Profacius and Johannes Brixiensis, and a copy is preserved in Paris MS. latin, No. 7195.

Incipit compositio tabulæ quæ Saphea dicitur sive astrolabium Arzachelis.—Siderei motus et effectus motuum speculator et duplex dux Ptholomæus, inter cætera sui ingenia, astrolabium edidit et unicuique climatum propriam tabulam deputavit, quas omnes Arzachel Tholetanus, admirabilis inventor, in unam tabulam reduxit, quæ, cum (sit) universis terris communis, Astrolabium universale non immerito nuncupatur. Cujus rei scientia usque ad hoc nostrum tempus, anno domini 1231, omnes fere modo nos latuit; viam itaque inventoris (imitantes), distinctiones ejusdem instrumenti primo in corpore, dehinc lineationes ejus in plano, postremo opus et utilitates ejus enodabimus.

Sequitur de distinctionibus ejus in corpore.—Signatis in sphera meridiano et æquatore, utrumque per intervalla quinos gradus continentia divide. Deinde æquidistantes æquatori per singulas punctationes altrinsecus in meridiano transeuntes facias, et hi circuli viam solis et stellarum erraticarum et fixarum ostendunt. Postea per polos et singulas punctationes in æquatore circulos magnos circumducas, et hi circuli ostendunt arcum de æquatore, qui interjacet meridianum, stellas et horizonta.

De divisione zodiaci in corpore.—Zodiaco in sphera designato, eum sicut in æquatore, per intervalla quinos gradus continentia divide, et (eidem) æquidistantes per quinos gradus incedentes altrinsecus facias; deinde per ejus polos et ejus punctationes singulas magnos (circulos) circum-

ducas; æquidistantes autem latitudines stellarum (magni vero circuli?) gradus eorum (designant). Ptholomæus quidem istius scientiæ fundamentum suum de hoc instrumento machinamentum super æquatorem in planum convertit. Hocque instrumentum super meridianum in planum componitur; et hoc est de corpore.

Sequitur de lineationibus ejusdem in plano.—Deinceps hujus instrumenti lineationes quæ in plano fieri debent exæquamur. Habita itaque lamina vel tabula in utraque parte sui planissima, in una ejus planitie fiant omnia quæ in dorso astrolabii fieri solent, videlicet limbus et alia sequentia, vel, pro tædio evitando, in quarta inferiori quæ est a dextris linetur quadrans sine cursore. Designantur horae (e) contrario ei quadranti qui annulum sive pendiculum habet, quia ibi movetur instrumentum, hic movetur regula, et consideretur quanta sit altitudo solis meridiana; numera in regione tua vel climate (quarto quantum quia) commune est omnibus terris, et nota eam in linea dividente quartam circuli ductam per medium, et secundum portionem ejus superiorem, versus centrum fiat quadratum orthogonium, secundum doctrinam Ptholomæi. Deinde lineentur horæ secundum doctrinam datam de quadrante, tamen, *ut dixi*, e contrario ei quadranti qui movetur, et sistant omnes ad contactum orthogonii; et dividantur (latera) orthogonii in 12 puncta sicut in astrolabio fiunt, sicut etiam patet in subscripta figura. Deinde fiat regula cum pinnulis et clavus regulam tabulæ conjungens; similiter et armilla, sicut in astrolabio fieri solet, et hoc in exteriori planitie opus complebitur.

Sequitur de lineatione ejus ex parte alia.—(Consequenter) est ut lineationes et mensuræ quæ in aliâ planitie, scilicet matre, fieri debent subsequantur. Inprimis igitur limbum, ad mensuram ejus qui in alia parte vel planitie factus est, facias. Et simili modo distinguas postea planitiem per duos diametros in centro tabulæ sese orthogonaliter secantes; in quartas partes divide et per has litteras diametros signa AB, CD. Diameter AB sit æquator, CD sit horizon. In sphera recta intimus vero circulus in limbo meridianus erit. Deinde pone unum caput regulæ in puncto B et aliud extende ad quintum gradum juxta C versus A, et ubi secat diametrum CD puncta, et ita incede per quinos gradus versus A semper punctando in diametro CD. Similiter extende regulam a puncto B ad quintum gradum juxta A versus D, et ubi secat diametrum CD puncta, et sic incedas donec pervenias ad quintum gradum juxta D. Postea extende diametrum CD ex utraque parte longe extra tabulam. Deinde pone pedem circini in linea extensa ex parte C, et coapta circinum ita ut unus ejus pes attingat quintum gradum ab A versus C et transire possit per primam punctationem in diametro CD, juxta centrum usque ad quintum gradum juxta B versus C, et lineam curvam facias; simili modo per sequentes gradus et punctationes incede, donec IG lineas completas curvas habeas. Eodem modo facies in alia medietate ex parte D, et aliud extende ad quintum gradum juxta C versus B, et ubi secat diametrum AB puncta et sic incede, donec pervenias ad quintum gradum juxta B; eodem modo facias in alia medietate. Extende postea diametrum AB ex utraque parte longe extra tabulam. Deinde pone unum pedem circini in lineâ AB ex parte D, ipsum coaptando, ut transeat ex C per primam punctationem in AB juxta centrum versus A in punctum D, et curvam lineam facias. Simili modo facias de omnibus punctationibus et hoc in utraque medietate tabulæ. Et erunt ex utraque parte IG lineæ curvæ et isti sunt circuli qui a polo ad polum per gradus æquatoris diei oppositos transeunt.

Sequitur de signatione zodiaci.—Zodiacum autem sic signabis. Enumera declivationem solis maximam scilicet 24 gradus ab A versus D et pone ibi F in G, et hic est zodiacus. Item AC versus A 12 gradus enumera et ibidem pone H et duce lineam ab H in I, quæ est axis zodiaci; H et I sunt poli deinde æquidistantes zodiaco et circulos transeuntes de polo ad polum zodiaci simili inventione et mensura qua in æquatore dictum est facias. Deinde juxta F ex parte A scribe Cancrum ita quod G de circulis transeuntibus per polos zodiaci capiat; simili modo scribe Leonem, Virginem, Libram, Scorpium et Sagittarium; vice versa juxta ex parte B scribe Capricornum et cætera signa, ut sese sequuntur, prout patent in præcedenti figure.

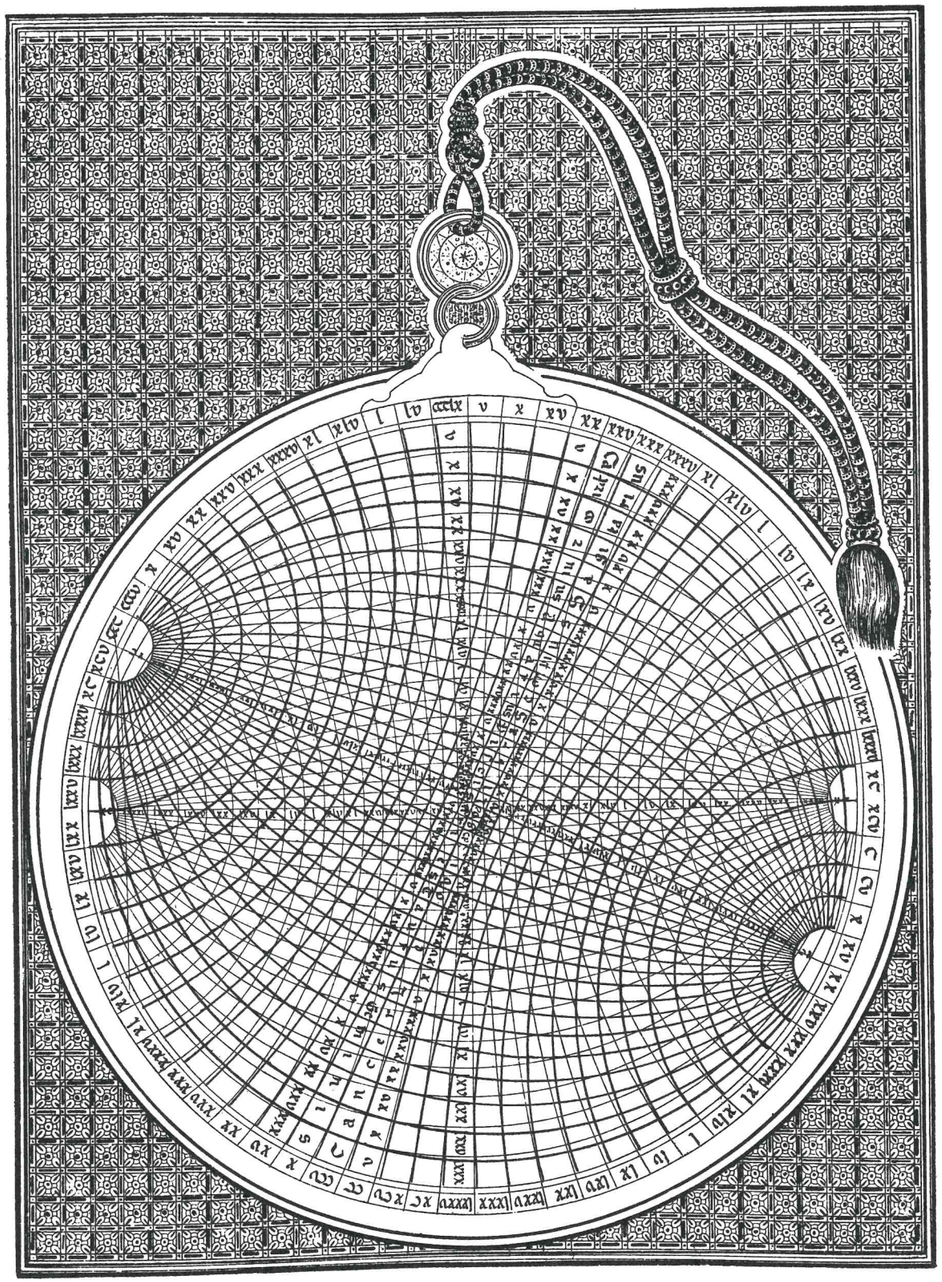


FIG. 124. FACE OF THE SAPHEA OF ARZACHEL. A.D. 1078–80.
From Alfonso X, *Libros del Saber*, 1864.

Sequitur de horizonte obliquo.—Ad ultimum horizon hoc modo fiat; enumeretur latitudo regionis AC versus A, et ibidem fiat minutissimum foramen et similiter in ejus opposito. Deinde filum sericum bene extensum et bene firmatum in prædictis colloces, et sicut variantur latitudines regionum, sic variabitur fili positio; et hæc de compositione astrolabii universalis dicta sufficiunt.

. . . . . .

Liber operationis tabulæ quæ nominatur Saphea patris Isaac Arzachelis. Primum capitulum, de nominibus descriptionum positarum in tabula communi.—Descriptionum quæ sunt in facie prima earum est circulus, super quem sunt partes graduum, qui est circulus meridiei, et illi gradus dividuntur quini et quini. Et diameter qui transit per armillam usque ad inferiorem locum tabulæ est vice circuli æquatoris diei. Et diameter qui secat orthogonaliter illum est vice circuli horizontis recti. Et arcus qui secant hunc diametrum, transeuntes per quinas et quinas divisiones, dicuntur revolutiones, et illæ quæ sunt ex parte sinistra, dum aspicitur tabula et suspenditur per armillam, sunt septentrionales, et quæ sunt ex parte dextra sunt meridionales, et longitudines revolutionum ab æquatore diei scriptæ supra circulum meridiei, incipientes ab utraque parte ipsius æquatoris, donec terminentur in 90. Et punctus in quo numerus 90 terminatur, in parte in qua sunt revolutiones septentrionales, est polus æquatoris septentrionalis. Et punctus sibi oppositus est polus meridionalis. Arcus vero qui concurrunt in ipsis duobus polis describunt ascensiones circuli recti. Et horizon rectus est in medio illarum ascensionum, ut longitudines prædictarum ascensionum, incipientes ab armilla, sunt scriptæ in parte septentrionali, infra æquatorem diei et principium revolutionis septentrionalis donec perveniant ad 180, videlicet usque ad partem inferiorem tabulæ. Deinde crescit numerus ascendendo inter æquatorem diei et principium revolutionum meridionalium, donec finiant in 360, in circulo meridiei sub armilla; et linea recta ex cujus utraque parte scripta sunt nomina signorum, vocatur linea longitudinis sive linea circuli signorum. Et spatia contenta inter arcus concurrentes, in duobus punctis diametri secantis orthogonaliter dictam lineam, dicuntur partes signorum; et illa 2 puncta sunt poli circuli signorum, et minimi circuli supra quos scripta sunt nomina stellarum sunt stellæ fixæ. Et stellæ quarum nomina scripta sunt ascendentia versus armillam sunt in medietate signorum ascendentium ad illam partem, et quarum nomina scripta sunt ex eis descendentia ad inferiorem partem tabulæ sunt in medietate ex signis ad illam partem. Et regula recta quæ volvitur super faciem tabulæ, in qua non sunt tabulæ perforatæ, illa est vice horizontis obliqui, et divisiones in prædicta regula signatæ sunt; sive gradus horizontis obliqui et longitudines graduum a foramine quod est in medio regulæ scriptæ sunt in superficie ipsius regulæ ex parte acuitatis ejus. Et nomina descriptionum in dorso tabulæ; prima est circulus altitudinis, infra illum circulum est circulus signorum, et infra circulum signorum est circulus mensium et dierum ipsorum. Deinde sequitur quadrans (complectens) duas umbras; post hoc regula, in cujus duobus capitibus sunt duæ tabulæ erectæ perforatæ, ad altitudines accipiendas.

The Treatise on the Saphea is accompanied by list of stars chosen by William the Englishman, so that there shall be two to each sign of the zodiac.

De stellis fixis. Est tabula de stellis fixis secundum Arzachelem: huic operi necessarium adjungere ad minus unam vel duas stellas in quolibet signo, *et novit Deus quod ego Guillelmus Anglicus ibi cogitavi per sex annos; hoc meum principium non fuit, nisi quod Arzachel spheram super meridianum, ut dictum est superius, compressit; completum est* 1231, *secunda die januarii.*

The *Saphea* concludes with the names of the translators.

Explicit liber tabulæ quæ nominatur Saphea patris Isaac Arzachelis cum laude Dei et adjutorio; translatum est hoc opus, apud Montem Pessulanum, de arabico in latinum, in anno domini N. J. X. 1263. *Profatio gentis Hebræorum vulgarizante, et Johanne Brixiensi in latinum reducente. Amen.*

121. The Valencia Astrolabe at Cassel — A.D. 1086.

Cassel Museum: the British and Science Museums have electrotypes.

Diameter $6\frac{1}{10}$ inches.

Made by Ibrahim ibn Assohli at Valencia A.H. 478.

It resembles the astrolabe of A.D. 1066–7.

The 8 tablets are marked in Roman numerals for the following latitudes:

XIII XIX	XXV XXXII	XXX XXXVIII	XXXII XXXV	XXXVII XXXIX	XXX XL	XXXVIII XLI	LXVI XLII

and the *umm* is inscribed as a tablet for LXXII or 72°. There is one special plate.

The alidade has a square middle piece, as figured on Pl. LIX.

122. Prince Corsini's Moorish Astrolabe — A.D. 1118.

In possession of Prince D. Tomaso Corsini.

5 inches in diameter.

A.H. 496 or A.D. 1118. It was exhibited as No. 24 in the Oriental Exhibition of 1878 in Florence. (*Not examined.*)

123. The Valenza Astrolabe — A.D. 1197.

Museo Kircheriano, Rome.

$9\frac{3}{8}$ inches in diameter.

Made by Ibrahim ibn Said in Valenza A.H. 593.

28 stars: 10 plates.

124. Abu-Bekr's Moroccan Astrolabe — A.D. 1208.

F. Sarrus, *Description d'un Astrolabe construit à Maroc en l'an 1208.*

Diameter $6\frac{1}{2}$ inches.

Described by F. Sarrus as being in the old observatory of Strasburg. A similar instrument was in the possession of Baron Larrey in 1852.

Made by Abu Bekr ibn Joseph in the town of Morocco in the year of the hegira 605.

Suspension by large ring and shackle of ◇-section. Bracket with small arabesque ornament between 2 larger scrolls. Rim divided to 360°. Ankabut with 27 slender hook-like star-pointers mounted on round bases with silver

knobs, all attached to a symmetrical framework of broad bars and bands. The names of the Signs of the Zodiac are given in Latin as well as Arabic.

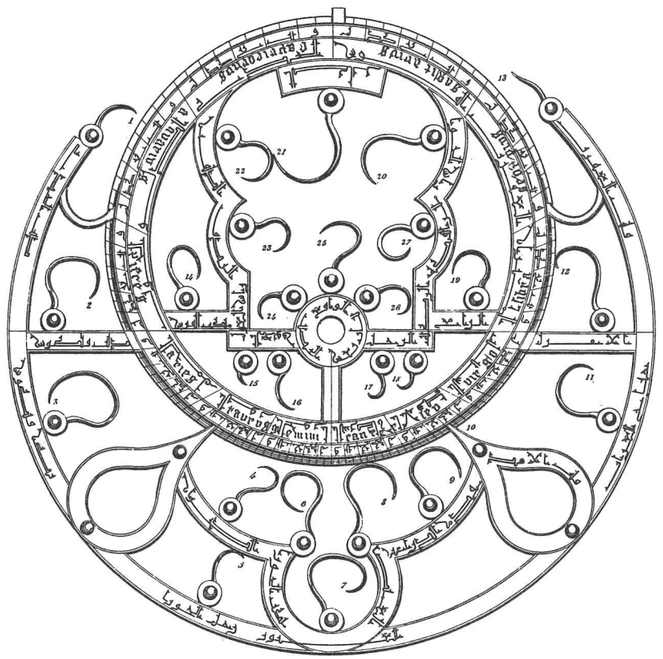


Fig. 125. Abu Bekr's Ankabut. a.d. 1208.

Star List

Outside zodiac.

1. Queue du Capricorne.
2. Queue de la Baleine.
3. Ventre de la Baleine.
4. Aldebaran.
5. Pied d'Orion.
6. Épaule d'Orion.
7. Sirius.
8. Procion.
9. Avant-bras.
10. Régulus.
11. Aile du Corbeau.
12. Épi de la Vierge.
13. Cœur du Scorpion.

Inside zodiac.

14. Épaule du cheval.
15. Tête de Méduse.
16. Chèvre.
17. Pied.
18. Genou.
19. Lance du Bouvier.
20. Tête du Serpentaire.
21. Althair.
22. Dauphin.
23. Suivante du Cygne.
24. Algésib.
25. Wéga.
26. Filles du Cercueil.
27. Brillante de la Couronne.

There are 5 tripartite plates marked with arcs of *'aṣr* and *dhor* and most fully inscribed for 10 places.

Sigelmassé	Lat.	29°	and climate of hours	13. 53′.
Morocco	,,	31°	,,	14. 3.
Fez	,,	33° 40.	,,	14. 17.
Ceuta	,,	35° 20.	,,	14. 27.
Almeria	,,	36° 30.	,,	14. 32.
Seville	,,	37° 30.	,,	14. 39.
Cordova	,,	38° 30.	,,	14. 45.
Toledo	,,	40°	,,	14. 55.
Saragossa	,,	41° 30.	,,	15. 4.
Jerusalem	,,	32°	,,	14. 8.

A peculiar feature of these plates is that instead of having a dawn-line in the usual position, the almucantar for the 18th degree is drawn thicker than the others to indicate its use as a dawn-line. The inscriptions 'dawn' and 'twilight' are accordingly reversed, the former being placed on the west and the latter on the east.

Two other plates of the Celestial Houses divided into 36 parts consecrated to the 36 decans are provided for latitudes 31°; 33° 40′; 37° 30′; 38° 30′.

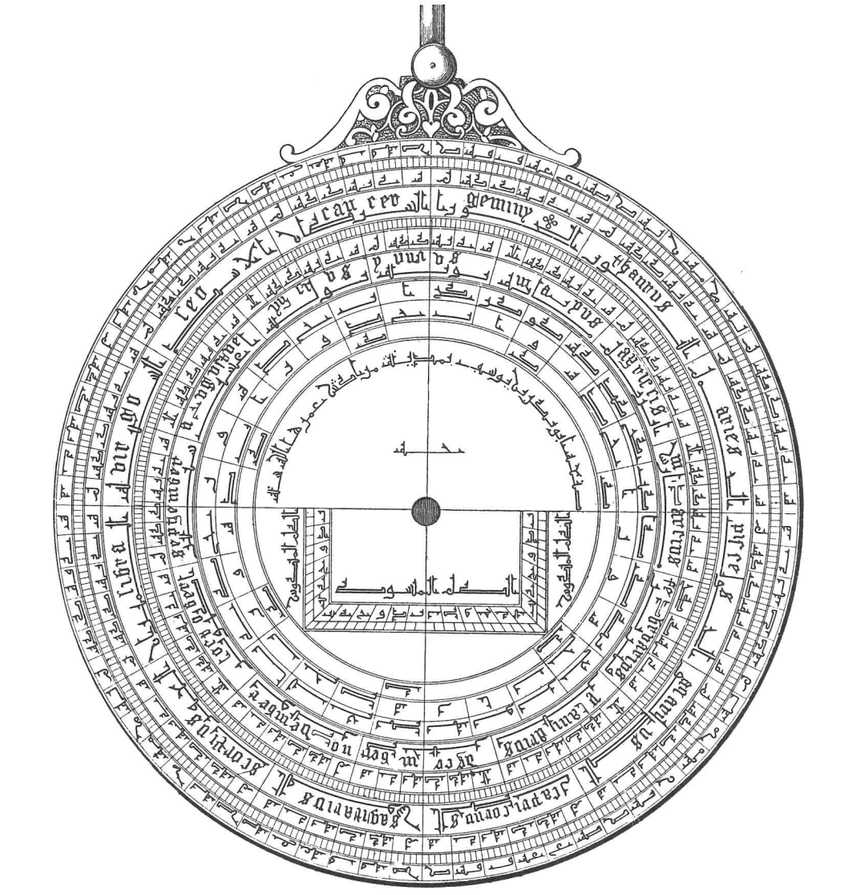
The *umm* is engraved with a most elaborate circular table, the use of which is explained by the innermost inscription, which has been translated by Sarrus: '*I have defined in the tables the limits, the dignities, the faces and the triplicities, the characters of the planets by means of the last letters of their names.*'

Around this inscription are the following circles:

ii. Triplicities.
iii. The 12 Signs.
iv. Faces.
v. Dignities.
vi. Increases of fortune.
vii. Degrees of fortune.
viii. } Limits according to Ptolemy.
ix. }
x. } Limits according to the Egyptians.
xi. }

The Back sets forth:

i. Four marginal quadrants 0–90°.
ii. Degrees, numbers, and names of the Signs in Cufic, Arabic, and Latin.
iii. Days and names of the months. 1st Aries = 14 March.
iv. Circular calendar of Abu-Bekr, described in detail by Sarrus.
v.
vi. Shadow scales.



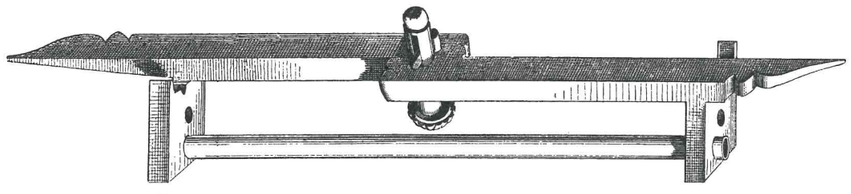


FIG. 126. ABU BEKR'S ASTROLABE AND ALIDADE. A.D. 1208.

The 3 circles have been explained by Sarrus as a Perpetual Calendar.

The 28 consecutive numbers of the sixth circle are the 28 years of a solar cycle, after which the days of each of the weeks of the year ought to repeat. The years of the cycle which ought to be bisextile correspond to the letter K of the first ring, ك, initial of the adjective *Kbysh*, which means intercalary, and is used to mark those years.

The numbers 1 to 7 of the second ring indicate the first day of October of each year of the cycle, 1 standing for Sunday, 2 for Monday, &c., and 7 for Saturday. The first year of the cycle adopted by Abu Bekr begins on a Tuesday. It precedes a bisextile, it corresponds to the second year of the Greek era of the Seleucids, and to the fifteenth year of the Christian era.

125. BARON LARREY'S ASTROLABE A.D. 1218.

Sédillot, *Memoire*, p. 175.

3 inches in diameter.

Constructed by

Abu-Bekr, son of Joseph in Morocco. A.H. 615.

With 4 plates. (*Not seen.*)

The ankabut shows 21 stars:

1. Serpentaire.
2. Col du Serpent.
3. Aigle volant.
4. Cheval.
5. Épaule [du Cheval].
6. Capella.
7. Suivante [du Cygne].
8. Aigle tombant.
9. Al-Fekka.
10. Arcturus.
11. Patte de l'Ourse.
12. Queue de Capricorne.
13. Al-Tharf.
14. Ventre de la Baleine.
15. Main coupée.
16. Épaule d'Orion.
17. Procyon.
18. Sirius.
19. Cœur du Lion.
20. Aile du Corbeau.
21. Cœur du Scorpion.

Four plates marked with almucantars, azimuths, and unequal hours also show lines of *asr* and *dohr*, but no dawn lines.

1. For the latitude of Mecca and of all the places of which the latitude is 21° 40′.
   For the latitude of Medina " " " 25°.
2. Sebta (= Ceuta) 35° 20′.
   Almeria 36° 30′.
3. Séville 37° 30′.
   Cordova 38° 30′.
4. Toledo 40°.
   Saragossa 41° 30′.

The Back, according to Sédillot, shows:

i. Degrees numbered to 90° by fives in 4 quadrants.
ii. Three concentric circles divided into 28 parts.
  a. 1 to 28.
  b. 1 2 3 4 6 7, 1 2 4 5 6 7, 2 3 4 5 7, 1 2 3 5 6 7, 1 3 4 5 6, thus giving 4 series of 7.
  c. The letter K[1] repeated 7 times under the numbers 1, 3, 5, 7, 2, 4, 6.
iii. Shadow scales and the inscription.

126. DORN'S ALEPPO ASTROLABE — *? XIIth Cent.*

Described by Dorn, *Journal de l'Institut*, Oct. 1839. Cf. Sédillot, *Mémoire*, p. 178; Morley, p. 4.

This is of very doubtful antiquity.

STAR LIST

Cœur du Scorpion.	Avant-bras.
Lancier désarmé.	Ophthalmique (Petit Ourse).
Aile droite du Corbeau.	Épaule d'Orion.
Étoile du Dragon.	Deux Hyades.
Messager (Sirius).	Porte-lance.
Pied d'Orion.	Main colorée.
Ventre de la Baleine.	Épaule du Cheval.
Queue de la Baleine.	Poule.
Queue du Capricorne.	Petite Ourse.
Cœur du Lion.	Vautour tombant, &c.

Seven sexpartite plates.

1*a*.	Lat. of Mecca	hours 12 ?		
b.	,, 24° . .	,,	—	
2*a*.	,, 27° . .	,,	13. 44′.	
b.	,, of Malaga 37°;	,,	14. 36.	
3*a*.	,, 30° . .	,,	14.	Misr (Cairo).
b.	,, 45° . .	,,	15.	
4*a*.	,, 33° . .	,,	14. 13.	Bagdad.
b.	,, 36° . .	,,	14. 30.	Almeria.
5*a*.	,, 39° . .	,,	14. 48.	Denia.
b.	,, 41° . .	,,	15. 3.	Saragossa.
6*a*.	,, 48° . .	,,	15. 55.	
b.	,, 51° . .	,,	16. 21.	
7*a*.	,, 66°[2] . .	,,	24.	
b.	Isle of Serendib (Ceylon) which has no latitude, since it is on the equinoctial line; hours 12.			

[1] Interpreted by Sédillot as the number 20.
[2] Chosen because the length of the longest possible day occurs under this parallel.

Below the Signs of the Zodiac are the initial letters of their Latin names. On the Back are the usual calendar circles. The Latin months are marked by their initial letters. In a smaller circle M. Dorn thought he recognized the 7 letters indicative of the days of the week. Below the centre are the shadow scales.

M. Dorn considered the instrument to have been made in Sicily in spite of the fact that the sheik Abdullah of Aleppo attributed it to the celebrated Nasir-eddin Tusi.

THE ASTROLABES OF MOHAMMAD BEN FOUTOUH AL-KHEMAIRI IN THE CITY OF SEVILLE

The following five works by this distinguished maker are still extant. They range from A.D. 1212 to A.D. 1224.

127. SEVILLIAN ASTROLABE — A.D. **1212.**

Described and figured by Sauvaire and de Rey-Pailhade, *Sur une mère d'astrolabe arabe du XIII siècle*, Paris, 1893.

6½ inches in diameter.

Only the mater, engraved with Mohammedan and Christian perpetual calendars, has been preserved. It is inscribed

The work of Mohammad ibn Fatouh al-Khemairi in the city of Seville in the year 609.

Bracket small. Rim divided into 360 degrees, numbered in fives by letters of the western Abjad alphabet, in which 60 is represented by s, ص, whereas in eastern Abjad it is س.

The Back is engraved with:

i. Quadrants of altitude in upper semicircle.
ii. Shadow scales in lower semicircle.
iii. Zodiac.
iv. Names of months, Julian Calendar, and their division into days. 1st Aries = 13½ March.
v. Circle of 360 degrees.

In the middle:

vi. Upper semicircle ruled with parallel lines in both directions for finding sines and cosines, the radius being divided into 30 parts, so that each division = $\frac{2}{60}$ of the radius. An example will show the use of such an instrument. First find the angle 60°. The

2 lines that meet there are an horizontal line giving the cosine and a vertical line giving the sine. From point 60 to the horizontal line one reads 30, i.e. cos 60° = 30, and from point 60 to vertical central line is 52: ∴ sine 60 = 52, the radius being 60 parts.

vii. The lower semicircle contains 10 ellipses, the use of which has been explained by de Rey-Pailhade, who has published a very full exposition of the correspondence of the Julian, Christian, and Mohammedan calendars with rules for the conversion of dates.

127A. The Valdagno Saphea by the Son of Foutouh al-Khemairi A.D. 1216.

A. da Schio, *Di due Astrolabi in caratteri cufici occidentali trovati in Valdagno*, 1880. *Atti del IV Congresso internazionale degli Orientalisti*, Firenze, 1880, p. 368.

c. 8½ inches diameter; weight 999 gm.

The invention of Arzachel, and described by him *c.* 1078–80.

Inscribed in 2 lines on the back of a 5-lobed bracket:

This Saphea was made by Mohammed son of Foutouh al Khemairi in the city of Seville, may God protect it, in the year 613 *of the Hegira.*

On the face are engraved 2 stereographic projections of the sphere on the plane of the solstitial colure. The vertical diameter corresponds to the equator. Meridional circles and parallels are described for every 5°.

When the first sphere has been projected, an identical net of co-ordinates is described on the ecliptic, which makes an angle of 23½° with the equator.

The face is traversed by a rule, the fiducial edge of which is used to mark the oblique horizon.

On the Back are:

i. Two quadrants of altitude and a marginal Scale of Tangents.

ii. Zodiac circles.

iii. Circles of Days and Julian Months. 1st Aries = March 13.

iv. Three quarters of the central area are taken up with a projection of the sphere.

v. The remaining quarter is ruled as a sinical quadrant with 60 parallel lines giving the cosines of the arcs of altitude marked on the limb. The translators of Arzachel called these lines *linnas de l'ordenamiento*, from which our word *ordinate* has been derived.

vi. The small excentric ' circle of the moon '.

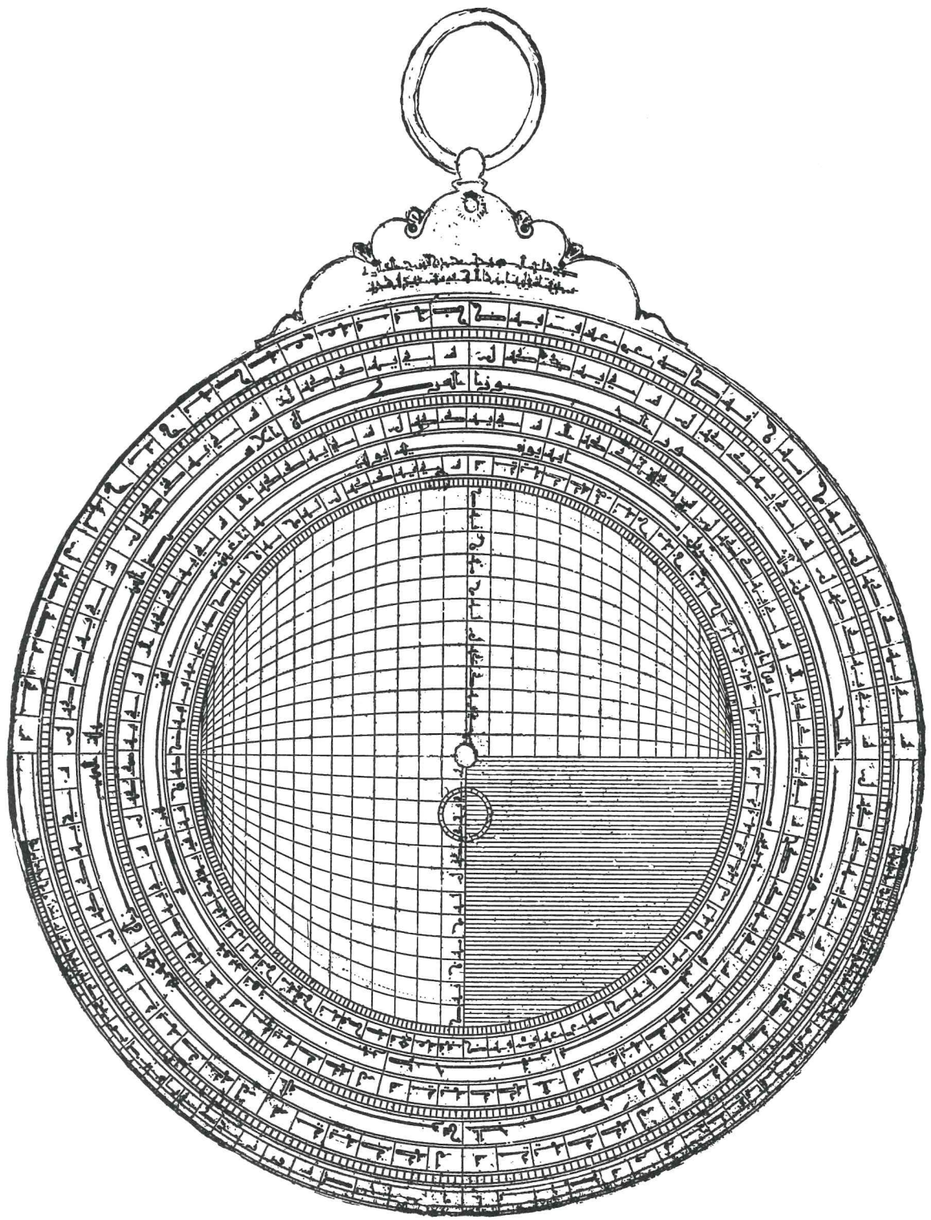


Fig. 127. The Valdagno Saphea. A.D. 1216.
After Schio.

Combined Star List of the Two Arzachels of 1216 and 1218.

*Stars on the latter are distinguished by asterisks *.*

1. *Dhahr ad-dubb (Back of bear)	α Urs. maj.
2. *Al-hadib (Stained hand)	β Cassiopeae.
3. *Al-qaid	η Urs. maj.
4. Ras at-tinnin	γ Draconis.
5. *Al-ayyuq (Capella)	α Aurigae.
6. *Ar-ridf (Deneb. Follower)	α Cygni.
7. *Al-waki (Falling Vulture)	α Lyrae.
8. *Ras al-gul (Head of Medusa)	β Persei.
9. *Ras al-tau'am (Head of Twins)	α Gemin.
10. Qalb al-hut (Mirach)	β Androm.
11. *Nair al-fakka (Brilliant of the Crown)	α Cor. bor.
12. *Surra al faras (Navel of the horse)	δ Pegasi.
13. *As-simak ar-rami (Arcturus)	α Bootae.
14. *Al-sarfa	β Leonis.
15. *Qalb al-asad (Heart of Lion)	α Leonis.
16. *Ad-dabaran (Aldebaran)	α Tauri.
17. Ras-al-hawwa	α Ophiuchi.
18. Gakfala al-faras (Enif)	ϵ Pegasi.
19. *Al-gumaisa (Procyon)	α Can. min.
20. *At-tayir (Flying Vulture)	α Aquilae.
21. *Rigl al-gauza (Foot of Orion)	β Orionis.
22. *Matan-qaitus (Back of Whale)	ζ Ceti.
23. *Al-abur (Sirius)	α Can. maj.
24. Rukba al-gauza	γ Eridani.
25. *Danab qaitus (Tail of Whale)	ι Ceti.
26. *Qalb al-aqrab (Heart of Scorpion)	α Scorpii.
27. *Ibt ar-rami (Armpit of Archer)	ζ Sagit.
28. *Assaula (Sting of Scorpion)	λυ Scorpii.
29. *Ahir an-nahri (End of the River)	α Eridani.
30. Rukba ar-rami	α Sagit.
31. *Rigl qanturus (Foot of Centaur)	α Centauri.
32. *Muqdaf as-safina (Oar of Ship)	δ Navis.
33. *Suhail (Canopus)	α Navis.

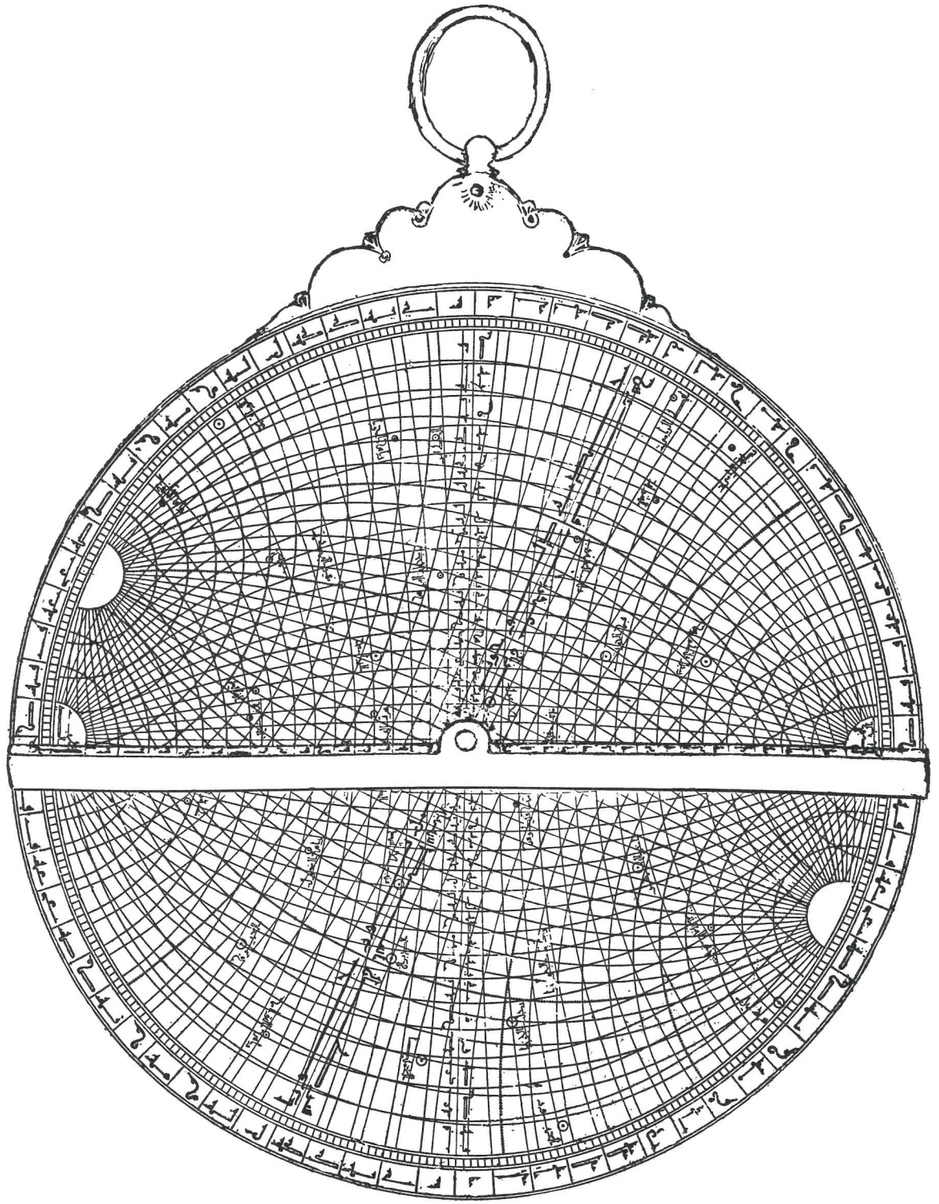


Fig. 128. The Arzachel of the Valdagno Saphea. A.D. 1216.
After Schio.

128. Arzachel of M. ibn Foutouh al-Khemairi A.D. 1218–19.

In the Bibliothèque Nationale, Paris. Described by F. Woepcke in a letter to B. Dorn published in *Mélanges Asiatiques* in *Bull. Acad. Imp. des Sciences de S. Pétersbourg*, v. 1864. Also in Sédillot, *Mémoire*, 1841, pp. 184, 190.

Diameter 22½ cm. (8⅞ inches).

Inscribed on the back of the bracket:

This Saphea has been fabricated by Mohammad ibn Foutouh al Khemairi in the city of Seville. May God protect him, in the year of the Hegira KhYH (= 615).

Although it has been stated that this astrolabe was accompanied by a separate plate when it was first acquired by M. Schultz in Constantinople, Woepcke regarded it as complete in itself, and the plate as belonging to some other instrument.

On the face is a double net of polar co-ordinates. It is a stereographic projection of the equator, ecliptic, the circles parallel to them, and the great circles passing through their respective poles.

This instrument gives the names of 32 stars, 27 marked with asterisks are listed on p. 272. And in addition there are:

Al ferkad.
Épaule d'Orion. (Mankib al-gauza.)
Délaissé. (Al azal.)
Fomalhaut. (? Zafda.)
Brilliante du Navire.

On the Back:

i. Two upper quadrants of altitude with degrees numbered by fives, 0°–90°.
ii. Two lower tangent scales in $\frac{1}{12}$ths of the radius.
iii. Circle of the 30 degrees of the 12 Signs of the Zodiac, their numbers, and names.
iv. Circles of Days and Julian Months. 1st Aries = March 13·3.
v. Two quadrants on right divided into degrees 0–90. Semicircle on left divided into 180 degrees.
vi. Three central quadrants engraved with an orthographic projection of the sphere, so that the equator and circles parallel to it appear as straight lines and the hour circles as ellipses.
vii. The fourth central quadrant is ruled with 60 parallel lines for use by which sines, cosines, and versed sines of arcs can be found.
viii. Over all is engraved the small excentric 'circle of the moon.'

Another Arzachel of A.D. 1337 *is described on p.* 287.

129. Mohammad ibn Foutouh's Seville Astrolabe A.D. 1221.

Bought by L. Evans in Paris through Vitali for £50, April 1910. L. Evans, *Some European Astrolabes*, No. 13.

Brass, 7⅞ inches in diameter by ⅜ inch thick.

Inscribed on back of throne:

Bismillah—Made by Mohammad Ibn Foutouh Al Khemairi in the city of Seville the year 618 *Hegira.*

The bracket is of the plain type usual in early Moorish instruments, but lack of ornament is compensated by the design on the lugs of the shackle which has been much worn by the ring (now missing), which like the shackle would have been ◇-shaped in section.

The massive rim, soldered to the base plate, bears the usual circle of degrees, and in addition at every hour is a notch, perhaps for facilitating use in a dim light, or at night.

The ankabut is for 29 stars which are the same as those on No. 130. Four of the star-pointers within the ecliptic are broken. It was originally provided with 4 knobs of silver, now lost. The central hole is fitted with a washer of silver.

The 4 tablets are all marked with dawn-lines, but vary as regards the presence or absence of the prayer lines, which have been carefully inserted on plate No. 2, rudely incised on 2 plates [1 and 3], and are absent on 1 plate [No. 4].

1*a*.	'For every place'	whose	latitude	is 30°.
b.	,,	,,	,,	36°.
2*a*.	,,	,,	,,	31°.
b.	,,	,,	,,	37°.
3*a*.	,,	,,	,,	33°.
b.	,,	,,	,,	34°.
4*a*.	,,	,,	,,	34°.
b.	,,	,,	,,	41°.

In the middle of the *umm*, in a circular ring 2⅜ inches outside diameter and 1¼ inches (full) wide, is an inscription similar to that printed above on p. 265.

I have set in the table the limits, dignities, and the faces, and the triplicates and the signs of the stars according to the last letters of their names.

Outside this direction is the 'table', a circular scale, 2 7/16 inches inside diameter, 6 3/16 inches outside, which is subdivided into 10 smaller circular scales; and in the upper part is a segment in which is given the title of each

scale, the remainder being divided into 12 rather larger segments corresponding to the Zodiacal Signs.

These circular scales agree with those described by Sarrus in the astrolabe of A.D. 1208, but the arrangement differs in the two instruments. In the astrolabe before us the order of the scales from without inwards is as follows:

i, ii. Limits according to the Egyptians.
iii, iv. Limits according to Ptolemy.
v. Triplicates of day-time.
vi. Constellations (of the Zodiac).
vii. Triplicates of night.
viii. Increases of fortune.
ix. *Dorangānat* or Dignities.
x. Faces.

130. ASTROLABE OF MOHAMMAD IBN FOUTOUH. Pls. LXI, LXII A.D. **1224.**

$7\frac{3}{8}$ inches diameter × $\frac{3}{8}$ inch.

Purchased in November 1911 for £120 by Dr. Evans from Dr. E. B. Knobel, F.R.A.S., who had bought it at a small second-hand furniture shop in Edinburgh in 1876 for £1. It was said to have come from the Sale of a Colonel North. No. 14.

Inscribed:

Bismillah. This is what was made by Mohammad Ben Foutouh al Khemairi in the city of Seville, in the year 621 *Hegira* (A.D. 1224).

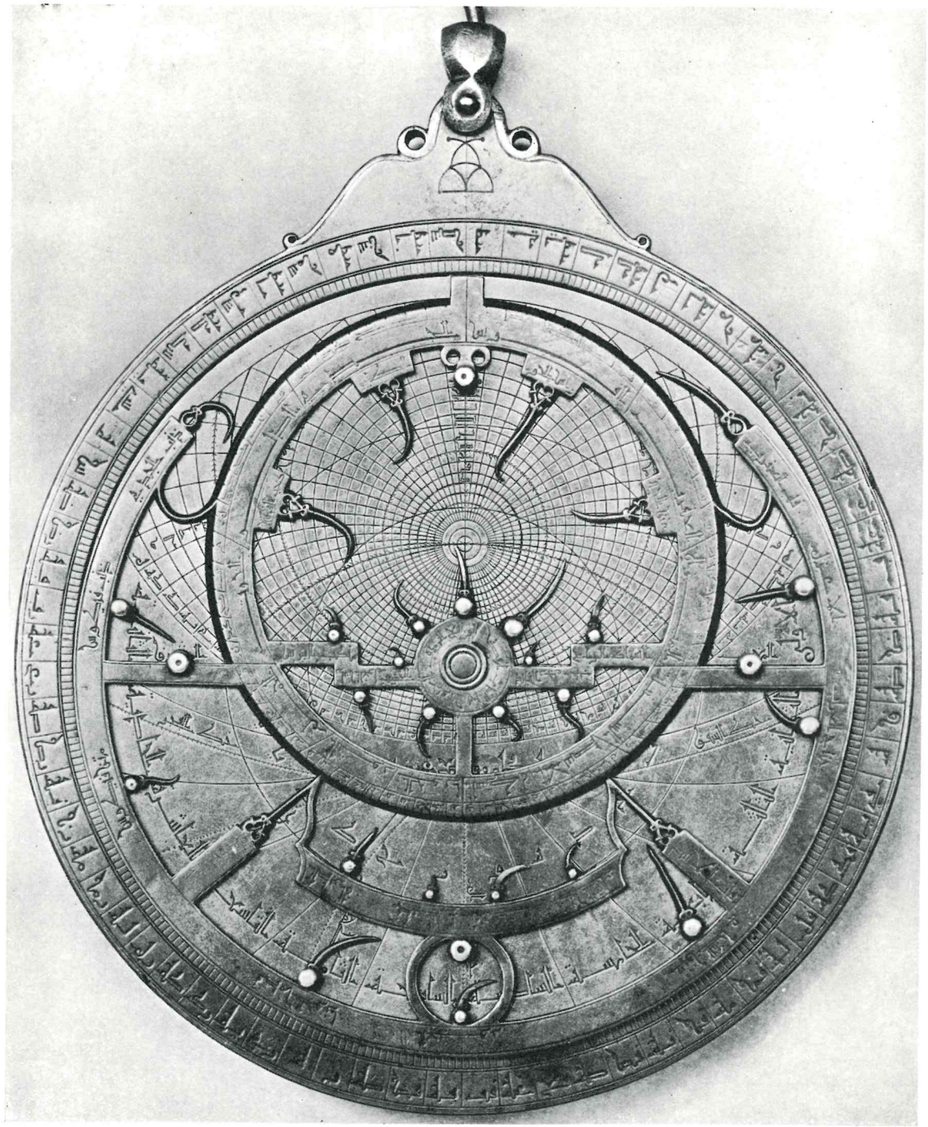
The shackle, suspension hook, pin, wedge, and alidade are not original.

The ankabut, for 29 stars, is provided with 4 bosses of silver for use as handles when turning, and with 22 bosses on the bases of stars which are graded in magnitude.

STAR LIST

Matn Ketus	I	27	ζ Ceti.
Al Debaran	IV	10	α Tauri.
Ras al Ghul	II	26	β Persii.
Al Aiouk	IV	44	α Aurigae.
Kedern al Jauza	IV	54	β Orionis.
Menkib al Jauza	V	29	α Orionis.
Al Abour	VI	26	α Canis majoris.
Al Ghomeisa	VII	13	α Canis minoris.
—	VIII	8	—
Dzakan al Shugja	VIII	20	ζ Hydrae.
Unk al Shugja	IX	4	α Hydrae.

LXI



MOHAMMAD IBN FOUTOUH OF SEVILLE, A.D. 1224

LXII

MOHAMMAD IBN FOUTOUH OF SEVILLE, A.D. 1224

Kalb al Asad	IX	27	α Leonis.
Rijil al Dubb	IX	40	
Gjenah al Ghurab	XI	42	γ Corvi.
(Al Simak) Al Dezd	XII	54	α Virginis.
Al Kaid	XIII	9	η Ursae majoris.
Al Simak al Ramih	XIII	49	α Bootis.
Al Phecca	XV	7	α Coronae.
Unk al Haiya	XV	43	β Serpentis.
Kalb al Akrab	XV	50	α Scorpii.
Ras al Haoua	XVII	9	α Ophiuchi.
(Al Nesr) Al Waki	XVIII	16	α Lyrae.
Al Tair	XIX	20	α Aquilae.
Al Ridph	XX	22	α Cygni.
Dzaneb al Gjedi	XXI	11	δ Capricorni.
Kaab al Feras	XXI	21	κ Pegasi?
Menkib al Feras	XXII	32	β Pegasi.
(Caph) Al Chadib	XXIII	16	β Cassiopeia.
Dzaneb Ketus	XXIV	44	δ Capricorni.

The tablets are for latitudes 31° and 36°, and for 36° and 42°, and are tripartite (*thulthi*); the *umm* is engraved as a tablet for latitude 66°.

The Back is inscribed with 8 concentric circles, within which are the scales of the shadows.

i. In the outermost circle degrees are numbered by fives from 0° on the horizontal to 90° at the zenith in the 2 upper quadrants. In the 2 lower quadrants are 2 shadow scales.

ii. Within a circle of 360 degrees are the numbers of degrees in each Sign.

iii. The Latin names of the Signs, but inscribed in Cufic characters.

iv. Within a circle of days of the month, numbered e.g. 5, 10, 15 20, 28 for Feb., 5, 10, 15, 20, 25, 30 March, &c.

v. The Latin names of the months, inscribed in Cufic characters.

vi. Twenty-eight consecutive numbers.

vii. Twenty-eight houses numbered:

3 4 6 7, 1 2 4 5 6 7, 2 3 4 5 7, 1 2 3 4 5 6 7, 1 3 4 5 6 1 2.
\+ + + + + + +

viii. The character K (= 20) repeated 7 times under each fourth division of the circles 6 and 7.

It is obvious that the general scheme is similar to that on the back of the Moorish astrolabe of 1208, p. 267, but the latter instrument is without the special shadow scale in the lower quadrants, while it is inscribed with the Latin names of months and signs both in Latin and in Arabic.

131. The Valencia Astrolabe of Ibrahim ibn Alnu'man A.D. 1264.[1]

? Original in Madrid. Electrotype in Science Museum, No. 1877. 8.

Diameter $6\frac{1}{4}$ inches.

Inscribed on Back:

The work of Ibrahim son of Alnu'man in Valencia at the end of the year 662 (= A.D. 1264).

Suspension by a large ring ($1\frac{7}{8}$ inches diameter) of diamond section. The low bracket with lobed contour has been partly covered over with a ⊥-shaped plate used by a repairer.

The ankabut is for 13 + 13 = 26 stars. The pointers have perforate bulb-like bases. Of the original 4 *mudirs*, only 1 remains. The equinoctial band is interrupted in the middle to give place to a Moorish arch over the star Sirius.

The 9 tablets, provided with 2 teeth apiece, are inscribed with Roman numerals for the following range of latitudes:

Latitude 0°	marked XII.	Latitude 0°	marked XXXV.
,,	XIII.	,,	XXXVII.
,,	XIX.	,,	XXXVIII.
,,	XXV.	,,	XXXVIII.
,,	XXX.	,,	XXXIX.
,,	XXX.	,,	40.
,,	XXXII.	,,	41.
,,	XXXII.	,,	LXVI.

Two sides are also inscribed as a 'Positionsscheibe', cf. Nallino, astrological, *alchoodin*. The *umm* is engraved as a tablet for latitude LXXII and with lines of the planetary hours.

The Back shows the following circles:

i. Degrees 0–90 in each of the 4 quadrants.
ii. Degrees.
iii. Names of the 12 Signs.
iv. Names of the 28 Manzils.
v. Stars of the 28 Manzils.
vi. Months.
vii. Days.
viii. ? of Months.

In the centre are the maker's inscription and relatively small shadow-scales. The alidade is clumsy, without marks, and with fiducial edge counter-changed. Probably not original.

[1] This instrument has also been dated *c.* A.D. 1086.

132. African Astrolabe by Ahmad ibn Hosein ibn Bes A.D. 1265–6.

In possession of Don Pascual de Gayangos.

Diameter *c.* 6 inches; for 28 stars. Made by *Ahmad ibn Hosein ibn Bes* in the year 664 Hegira, apparently at Oran. The *umm* is engraved with a scheme of the Celestial Houses for latitude 37° 30′.

(*Not seen.*)

Professor Wilson's Astrolabe A.D. 1270.

See p. 32.

133. The Fez Astrolabe 'xiii cent.'

Diameter $6\frac{1}{8}$ inches.

Described as Morley 'C.' on p. 36. British Museum.

The rete is for 24 stars: the inscriptions are in Cufic.

The 3 tablets (*thulthi*) have denticles (*mumsikahs*) at their summits. They are inscribed:

1a. ' For every place the latitude of which is 21° 40′.'
b. ,, ,, ,, 25° 30′.
2a. ' For every city the latitude of which is 30°.
b. ,, ,, ,, 31° 30′.
3a. ,, ,, ,, 35°.
b. ' For the latitude of Fás (Fez) '.

The *umm* is engraved with a projection of the sphere for latitude 66°.

In the Calendar circle on the back the names of the Months are Roman.

In the centre the 4 quadrants are filled with:

i. *Instrumentum horarum inequalium.*
ii. Quadrant ruled for sines and cosines (sexagesimal).
iii, iv. Shadow squares with the *linea mediae umbrae*, which is of more frequent occurrence than Morley believed, p. 37.

134. Delhi A Astrolabe *Undated*, *c.* A.D. 1280.

Diameter 5·7 inches.

Delhi Museum. Figured and described by Kaye, *Astronomical Instruments in the Delhi Museum*, Figs. 1, 2, 7, 8.

Inscription in Cufic.

Suspension by loop, ring, and shackle. The rim is divided into 360°.

Ankabut for 29 stars, star-pointers with bulbous bases, 11 of which have white metal bosses. There are 4 *mudirs* for rotation. Mr. Kaye has made a special comparison of the longitudes of the stars with those given in Ulugh

Beg's catalogue, with the result that he finds an average difference of $-2° 3'$, which indicates A.D. 1289 as the approximate date of this instrument.

The *umm* is engraved with a projection of the sphere, Type Z (Fig. 7), and 1 of the tablets is a tablet of ankabut co-ordinates (Fig. 8).

The Back is peculiar:

i. Margin of upper semicircle is divided for measuring altitudes.
ii. Margin of lower semicircle is divided as a shadow scale.
iii. Upper semicircle is engraved as the half of an Arzachel.
iv. Lower left quadrant sinical.
v. Lower right quadrant horary.

Alidade is probably a later addition.

134A. DR. KNUTHSEN'S ASTROLABE. See p. 248.

135. SPANISH ASTROLABE *XIIIth–XIVth Cent.*

British Museum.

c. 5 inches in diameter.

With 2 plates on which, and in the *umm*, are projections for:

Latitude 35° Cairo, Kerman.
,, 36° Elmeria, Harran, Samarcand, Tarsus.
,, 37° Cordova, Jezira.
,, 39° Toledo, Valencia, Badajoz.
,, 41° Saragossa.

On the Back are Calendar circles engraved with the Latin names of the Signs and Months.

136. THE CADIZ ASTROLABE A.D. **1320.**

In possession of Don Pascual de Gayangos.

Diameter *c.* 5 inches, for 28 stars with 1 plate.

By *Ibrahim ibn Arrocan in Cadiz* in the year 720 of the Hegira.

(*Not seen.*)

137. THE ASTROLABE OF REGIOMONTANUS '*XIIth Cent.*'

Date on bracket '1468'.

This instrument, stated to have once belonged to Regiomontanus (1436–†1476), is now in the Nuremberg Library. Stated to have been made by Es-Sahl for the Prince Melik al Muszaffer Taky-Eddin, C. M. Fraehn, *Antiquitatis Muhamedanae monumenta varia* 4to Petrop., 1820, p. 73. See Sédillot, *Mémoire*, p. 176, note. (*Not seen.*)

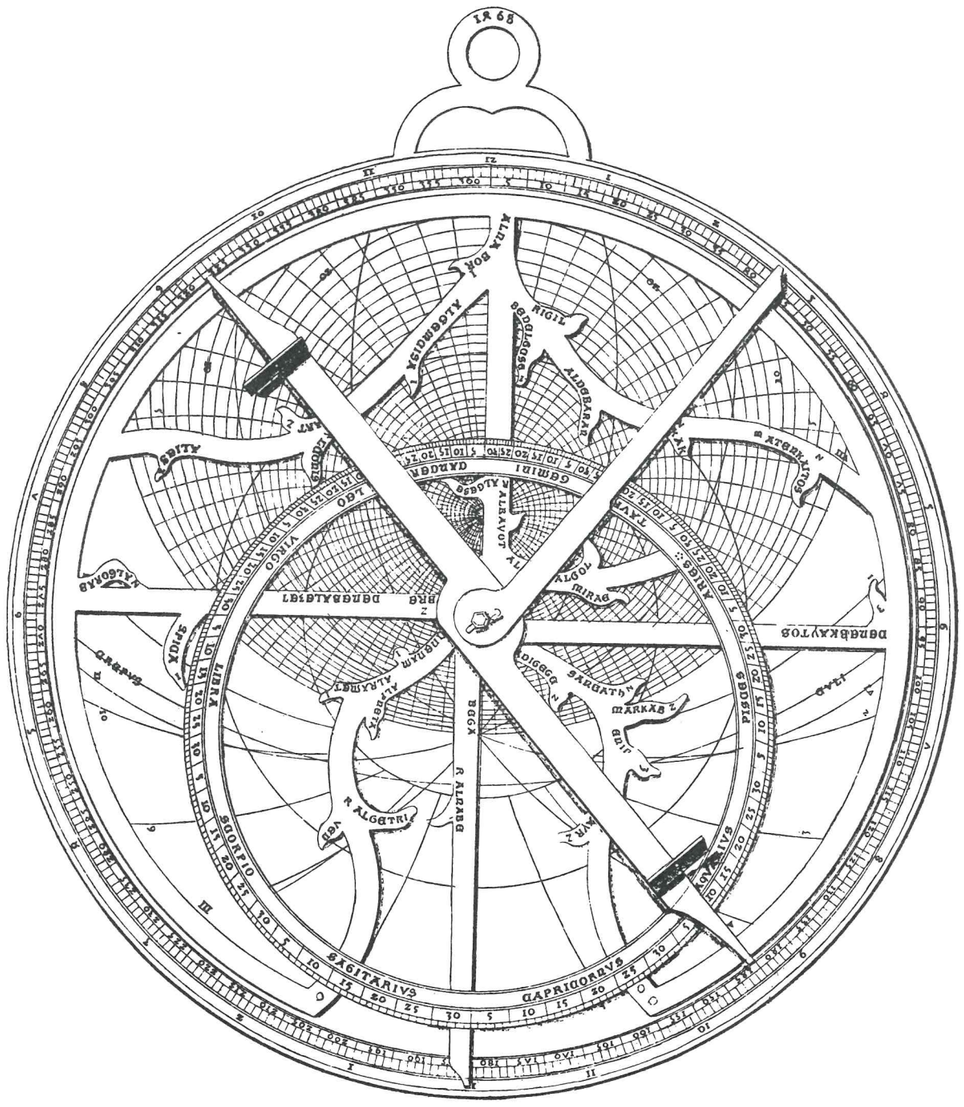


FIG. 129. ASTROLABE OF REGIOMONTANUS. 'A.D. 1468.'

FIG. 130. MARCEL'S ASTROLABE.

138. MARCEL'S ASTROLABE *? XIIth Cent. or later.*

(*Now lost.*)

Described in Napoleon's *Description de l'Égypte*; *État Modern.* t. ii. Pl. HH; Sédillot, *Mémoire*, 1841, Pls. 13–24; Morley, p. 4.

The inscriptions were in Cufic characters.
The ankabut was figured as showing 26 stars:

Within the Zodiac.	*Outside the Zodiac.*
Serpent.	Aldebaran.
Serpentaire.	Menkhib.
Aigle volant.	Algomeisa.
Talon.	Deux Serres.
Arcturus.	Queue du Capricorne.
Pied.	Queue de la Baleine.
Patte antérieure de l'Ourse.	Ventre de la Baleine.
Aiouk.	Rigel.
Ridfe	Al-abor.
Alghol	Hydra.
Menkhib al-feras.	Extrémité de la Coupe.
Aigle tombant.	Épi.
Al Fakka.	Cœur du Scorpion.

Four plates[1] are sexpartite and engage in the mater with teeth.

1*a*. Mecca and places whose latitude is 21° 40′.
b. Medina, city of the Prophet, latitude 25°.

And unlocalized plates, 2–4, for latitudes 31°, 32°, 33°, 35° 30′, 36° 30′, 37° 30′, all of which are marked with the unequal hours and with lines of *asr* and *zuhr*, and six show the *ligne crépusculine* or dawn-line.

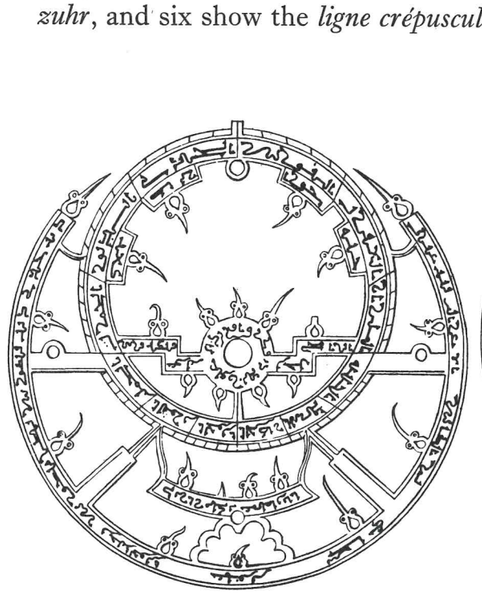


FIG. 131.

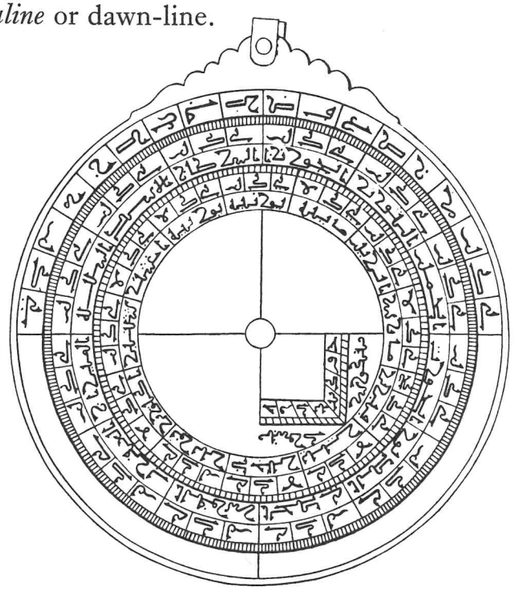


FIG. 132.

MARCEL'S ASTROLABE.
From Napoleon's *Description de l'Égypte.*

To this toothed series a second series of 5 notched plates has been added, including unlocalized plates suitable for the holy places, while the others are for use in Spain.

5. Latitudes 22° and 25°.
6. Carthagena and Ascalon, latitude 32°.
   Jaen, Dénia, and Tlemcen, latitude 39°.
7. Almeria, Harran, and Samarcand, latitude 36° 30′.
   Toledo, Talavera, Khelat, Azerbaijan, latitude 40°.
8. Grenada, latitude 37° 30′.
   Cordova, Marsala, Jordan, Balkh, latitude 38° 30′.
9. Saragossa, Calatayud, Roumah (= Rome), latitude 41° 30′.

One half of these Spanish plates show the unequal hour lines only. Dawn-lines and the *asr* and *dohr* lines occur on the plates for Almeria and Grenada, and the plate for Saragossa is also marked with the Celestial Houses.

[1] Sédillot, p. 171.

139. Mr. T. Barnett's Arabian Astrolabe. Pl. LXIII *Undated.*

T. Barnett Collection. *Information from W. Corner.*

Diameter 9 inches.

There is no inscription of any name of maker or owner, but it is known that the last owner was Ali Hikmet, the late Kadhi of Kirkuk in Northern 'Iraq, who died in 1924. He was an old man of Kurdish origin aged between 65 and 70 at the time of his death.

Suspension by a ring ($1\frac{3}{4}$ inches diameter), of diamond section, and shackle ornamented with a lion head on either side. A low bracket with double ogee contour is cast in one piece with the rim and joined to the back plate by 3 rivets; 17 other rivets secure the rim to the back plate.

The bracket is inscribed with the words *dill* or 'shade' on the *umm* side and '*artifa* or 'height' on the back.

The rim is divided into 360 degrees numbered by fives, 0°–360°, and the margin is also divided into 4-degree numbered intervals of uncertain significance. The spaces are engraved with numerals in 3 rows, but they are much rubbed and not easy to identify.

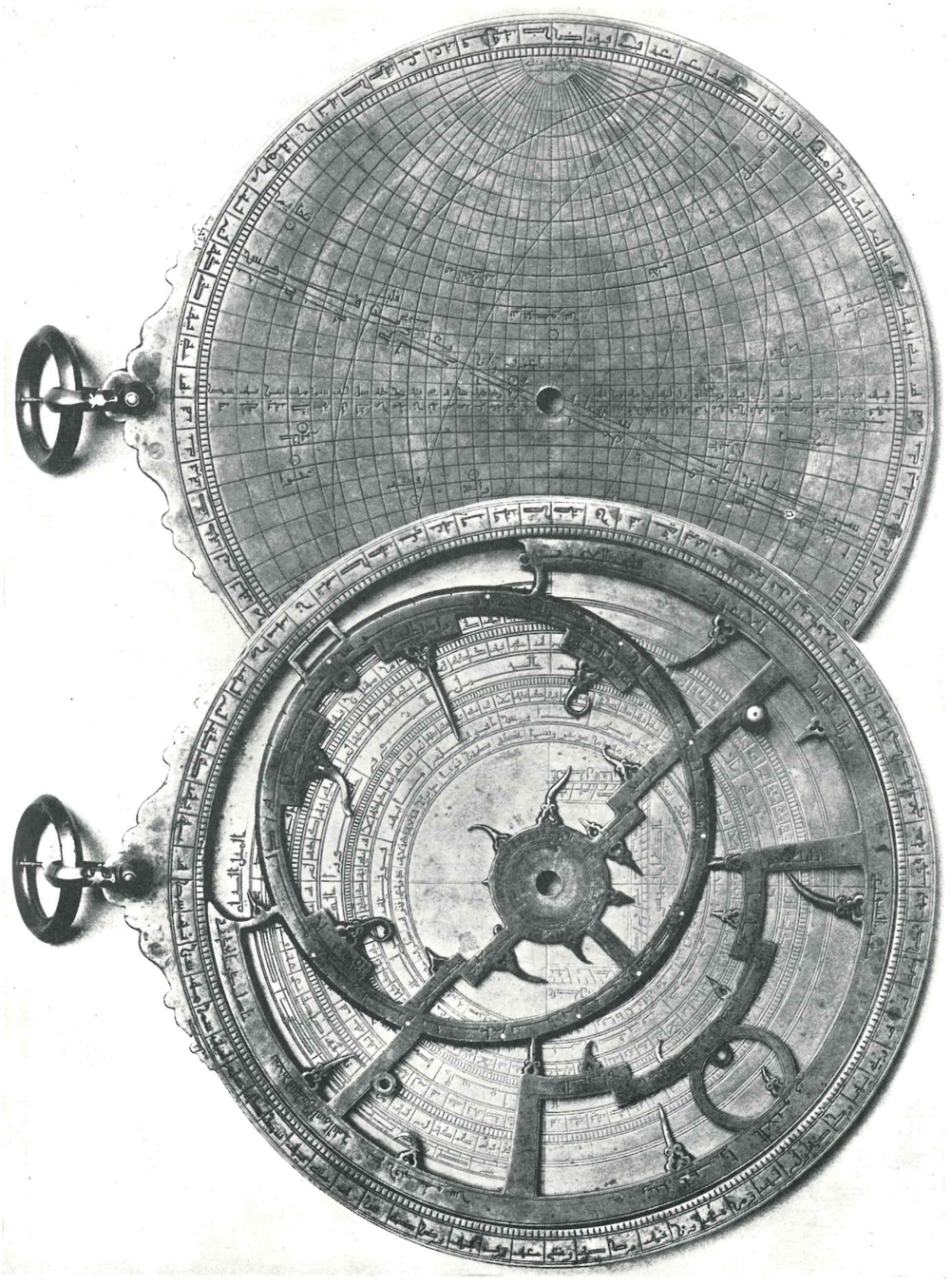
The ankabut is for 15+15=30 stars. The pointers have trifoliate perforate bases.

Each of the zodiacal signs is divided into 5 spaces each of 6 degrees, and is separated from its neighbours by inlaid silver points. Of the original 4 *muidirs*, only one remains.

The 4 sexpartite tablets are inscribed 'for every place of which the latitudes' are 31° and 33°; 32° and 42°; 40° and 41°; 44° and 47°, of which the first tablet seems to have been one of an original set. It is inscribed with the dawn line and also with *asr* and *dohr* lines. The 41° tablet is similarly inscribed and, in addition, bears the lines of the 12 houses. All the other tablets are marked with the unequal hours only.

The *umm* is engraved with a circular calendar scale. At the top is a title *mail kuli* signifying 'Universal Inclination'.

i. Tangent scales in two upper quadrants, numbered 3, 6, 9, 12, 15, 18, 21, 24, 24, 21, 18, 15, 12, 9, 6, 3.
ii. Two quadrants of altitude, with degrees numbered in fives 5° to 90°.
iii. Circle of 360 degrees.
iv. Circle of numbers of degrees of signs of zodiac.
v. Names of 12 signs: Aries 1 corresponding to March 22.



vi. Circle of days.
vii. ,, ,, numbers of days of months.
viii. ,, ,, names of months.
ix. ,, ,, 28 mansils.

Below the centre are the Shadow Scales, marked ' shadows standing ' and ' shadows oblique '.

The Back is engraved as an arzachel, like the instrument described on p. 273. It shows the positions of 26 named stars. The Poles are named *North Pole* and *South Pole*.

The alidade and pin are not original.

In spite of the fact that this astrolabe is reported to have been used, perhaps for centuries, in the East, we see no reason for separating it in our scheme of classification from the very similar instruments that are known to have been made by Moors in North Africa and in Spain in the thirteenth and preceding centuries. It may have been copied from a Moorish astrolabe, but until we find similar examples which are properly documented with the name and address of an oriental maker, we consider it best to keep it with its western prototypes.

140. ARZACHEL UNIVERSAL ASTROLABE ?A.D. **1329.**

No. 401. *Morancé Album*, Pl. 8. Figured in the *Burlington Magazine*, Oct. 1928.

The date ' 729 Hegira ' in Cufic Arabic is stated to have been read by M. Combe.

The ring affords knife-edge suspension to the shackle which bestrides a *kursi* decorated with pierced arabesque foliations. The degrees of the rim are numbered in fives 0°–90° in each of the 4 quadrants and correspond to the ends of the parallels of the ankabut.

The ankabut is of a unique type. It is that of Arzachel's Lamina Universal and so an early precursor of the rete of Blagrave's Mathematical Jewel, which will be described among the English instruments of the later sixteenth century. The upper semicircle comprises a lattice-work projection of the sphere, with a bar to every fifth degree both of altitude and of azimuth. The lower semicircle, traversed by an ecliptic band marked with the 12 Signs of the Zodiac, shows the position of 18 stars, 10 above and 8 below the ecliptic. The star-pointers are dagger-shaped: the one for

Sirius is enclosed under a Moorish arch, and the one for Vega (?) is in a lozenge in the meridional bar.

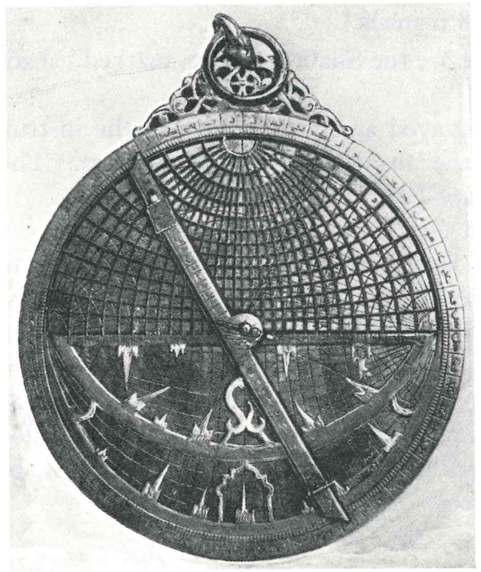


FIG. 133. ? A.D. 1329.

The alidade is graduated with 15 five-degree spaces corresponding to those of the ankabut.

The *umm* is engraved as an arzachel, viz. as a plate with 2 horizontal projections of the sphere, one with equator and circles of latitude and longitude, the other with ecliptic and circles of declination and right ascension. When the instrument is suspended by the ring the equator hangs vertical and the poles lie to the right and left.

If this instrument, which we have not examined, be all of one period, it is an important and early example.

141. ST. PETERSBURG ASTROLABE DATED A.H. 734 A.D. **1333.**

(*Query Moorish.*)

142. THE SAPHEA OF ALI-BEN-IBRAHIM ALMUTHIM A.D. **1337.**

Collected by M. Jomard for the Bibliothèque Royale of Paris. Sédillot, *Mémoire*, p. 192.

Inscribed below the suspension ring on both faces:

[*An instrument*] *which combines the operations and the latitudes, constructed and tried by Ali ben Ibrahim Almuthim for the Sheik Ali ben Mohammed al-Derbendi, in the year* 738.

On the ankabut 58 stars are indicated:

Capilla.	Mirzam.
Tête de Méduse.	Alhénah.
Chèvres.	Queue du Capricorne.
Ombilic du Cheval.	Australe de la Jambe drt. du Verseau.
Épaule du Cheval.	Corps de la Baleine.
Main teinte.	Racine de sa Queue.
Aigle tombant.	Corps du Lièvre.
Ventre du Poisson.	Ceinture d'Orion.
Bec de la Poule.	Pied.
Suivante.	Pied gauche.
Al-kaid.	Al mirzam.
Fémur droite de Bootes.	Sirius.
Brillante de la Couronne.	Alferd.
Alfekkah.	Base de la Coupe.
Septentrionale d'Alzubra.	Épi.
Genou de l'Ourse.	Couronne.
Dos de l'Ourse.	Celle du milieu des trois d'Al-djeba.
Aldébaran.	Aile droite du Corbeau.
Main droite d'Orion.	Cœur du Scorpion.
Main gauche d'Orion.	Suivante d'Al-schaulah.
Main coupée.	Épaule gauche du Sagittaire.
Aile de Pégase.	Épaule droite du Sagittaire.
Paleron.	Main gauche du Sagittaire.
Lèvre de Pégase.	Tibia.
Aigle volant.	Première d'Al-naaim.
Serpentaire.	Fomalhaut.
Arcturus.	Acarnar.
Méridionale d'Altharf.	Plaine.
Procyon.	Bras droit du Centaure.

143. MOORISH ASTROLABE. Pl. LXIV *c.* A.D. **1340.**

Purchased by Dr. L. Evans from Harding on 4 November 1894 for £4, who bought it at one of Weishaupt's sales at Puttick & Simpson's.

$5\frac{3}{16}$ inches in diameter; $\frac{1}{4}$ inch thick.

A roughly-fashioned brass instrument inscribed in Cufic character of

the fourteenth century, but with no maker's name, built up of a back soldered to an annular rim and bracket, which was originally perforated with a design of 6 holes, now closed by a repair. The shackle and swivel project 1½ inches. The workmanship on the face is superior to that on the reverse or back.

The ankabut is made for 27 stars, with silver studs. Five brass knobs serve for turning it.

RIGHT ASCENSIONS OF THE STARS

	R.A.				*R.A.*		
Baten kaytos	I	2	S	Alramech	XIII	54	N
Mirach	I	32	N	Elfeta	XV	22	N
	II	48	N		XV	28	N
Aldebaran ?	IV	8	N	Antares	XVI	8	S
Capella ?	IV	48	N	Altair	XVII	—	N
Rigel ?	V	—	S		XVII	16	N
Betelgeuse ?	V	36	S	Wega	XVIII	20	N
Algomeisa	VII	16	N		XIX	32	N
Alphard	VIII	48	S		XIX	44	S
	IX	4	N	Alrif ?	XX	36	N
Regulus	IX	32	N		XXI	20	N
	X	56	S		XXI	22	S
Algar	XI	—	N	Alferaz	XXII	40	N
Alchimech	XIII	6	S		XXII	58	S

Four of the 5 tablets are of the ordinary type. They (except 2*a*) are marked with the unequal hours, arcs of *asr* and *zuhr*, and dawn-lines. They appear to be for latitudes:

1*a*.	Lat. 21°.	3*a*.	Lat. 33°.
b.	,, 24°.	*b*.	,, 36°.
2*a*.	,, 30°.	4*a*.	,, 42°.
b.	,, 33°.	*b*.	,, 45°.

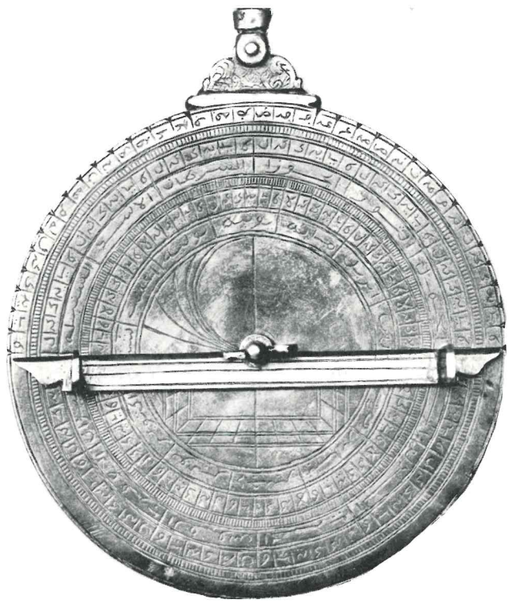
The fifth tablet is marked for latitude 0° on one side (cf. Kaye, Fig. 12) and on the other as a tablet of horizons (cf. Kaye,[1] Fig. 7). Cf. also the scale for ' All Latitudes ', A. Schio, Pl. IV.

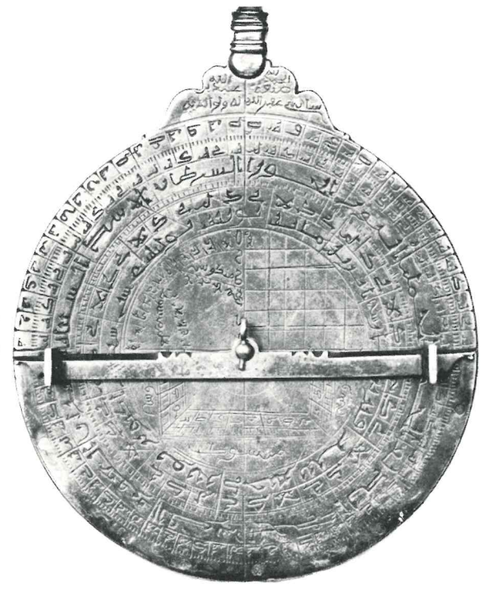
The Back shows:

i. Two quadrants of altitude 0–90°, notched at every fifth degree for use at night.
ii. Zodiac.
iii. Concentric Month circles in which the 1st Aries corresponds to 10 March.
iv. Instrumentum horarum.
v. Squares of the shadows, not numbered or inscribed.

[1] *Memoirs of the Archaeological Survey of India*, No. 6.

NO. 143. *c.* A.D. 1340





ABDULLAH SON OF SASI *c.* A.D. 1400

144. THE ASTROLABE OF AHMAD SON OF HASSANAIN *Undated.*

S. V. Hoffman Collection, No. 2.

Diameter 6½ inches; total height 8½ inches.

Inscription on back in Cufic characters:

The work of Ahmad son of Hassanain son of Barakah (?), *the year of* —

Suspension by a relatively thick and small shackle and ring 1⅛ inches diameter. Bracket of symmetrical foliate design, inlaid with ? silver.

The rim engraved with a circle of 360° is broad and is riveted to the base plate.

The ankabut differs from the ordinary Arabian type in that the greater number of the star-pointers are of a two-pronged design, recalling the tip of a boat-hook. They are, moreover, singularly symmetrically disposed. Among the structural elements we find the east-west bar, and two portions of the equinoctial band, one within, the other outside the zodiac. Two unnamed ' star-pointers ' and the pointer to the star Vega have perforate, trefoil bases. Eighteen silver knobs give the spider a rich appearance.

The inside of the *umm* is unfinished. It is engraved with a ' spider's web ' of 9 circles and 36 radial lines.

There is a full complement of 9 sexpartite tablets:

1*a*.	Lat. 22°.	5*a*.	Tablet of houses only *c.* 31°–32°.
b.	,, 31°.	*b*.	,, ,, ,,
2*a*.	,, 30°.	6*a*.	,, ,, ,,
b.	,, 33°.	*b*.	,, ,, ,,
3*a*.	,, 31°.	7*a*.	,, ,, ,,
b.	,, 32°.	*b*.	Lat. 66° on plate of ankabut co-ordinates.
4*a*.	,, 35°.	8*a*.	Lat. 32°.
b.	,, 40°.	*b*.	Horizons, two-pole.
		9.	Lat. 30°, rudely engraved.

On the Back are:

i. Two altitude quadrants.
ii. Two tangent scales.
iii. Zodiac circles.
iv. Eccentric circles of Months, 1st Aries = 13·5 March.
v. Maker's inscription.
vi. Scales of the shadows.

The alidade appears to be a later addition: it is not inscribed.

145. The African Astrolabe of Abdullah son of Sasi

Pl. LXIV *c.* **1400** and **1687.**

$4\frac{7}{8}$ inches in diameter; about $\frac{3}{16}$ inch thick; total length including ring $7\frac{1}{4}$ inches = 184 mm.

Bought by L. Evans from Webster, March 1918, who bought it through M. Gélis of Paris, price £30.

An African instrument, inscribed on the back of the bracket:

Thanks be to God ! The workmanship of Abdullah the son of Sasi, may God forgive him and his father.

And in Maghrebi characters on the front of the bracket ٥٩٩٩هـ = '*In the year 1099*', A.D. 1687. But this is probably not the date of its manufacture, which Dr. Evans put at *c.* 1400.

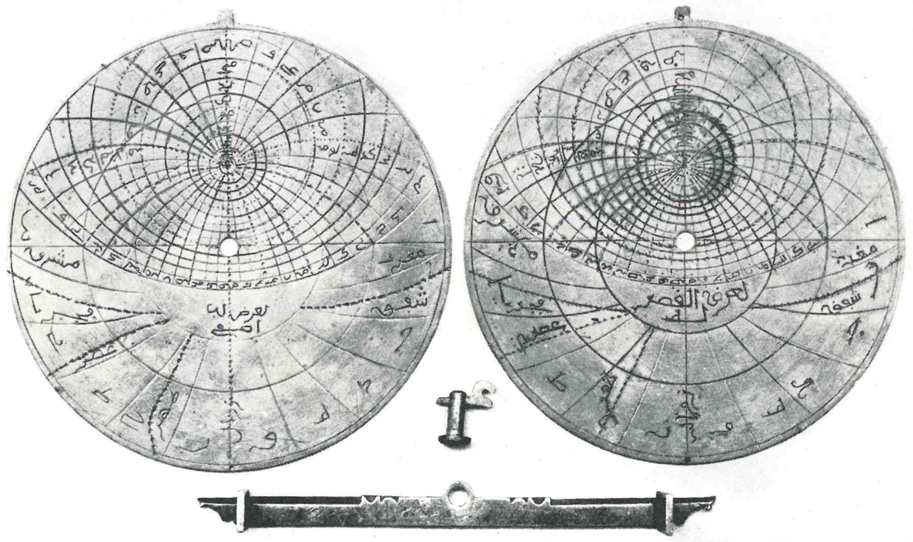


Fig. 134. Tablets for Abdullah son of Sasi's Astrolabe.
For Lats. 32° and 35°.

Though rough, this instrument presents some interesting features. The shackle is square in section. The bracket, devoid of surface ornament, is contoured by one lobe and an ogee on each side. On the rim the 24 hours are marked by small dotted circles, ⊙.

The ankabut was formerly provided with 2 knobs under the east-west bar. It shows 25 stars.

There are 2 sexpartite plates, marked with *asr*, *zuhr*, and dawn-lines.

1*a*. Lat. 30°.
b. ,, 32°.
2*a*. ,, 35°.
b. (blank).

On the Back:

i. Two quadrants of altitude, notched.
ii. Zodiac circles.
iii. Circles of Days and Months, 1st Aries = 9 March.
iv. In the left-hand upper quadrant in the middle is a scale of the shadows in an unusual form. Two chords, meeting the arc of the quadrant at an angle of 60°, are inscribed *Inverted shadow* and *Extended shadow* and are divided 14, 18, 24, 36, 82, the corresponding parts of the arc 'length' being numbered 12, 16, 21, 25, 48.
v. Left upper quadrant is a rudely ruled sinical quadrant.
vi. Squares of the shadows.

146. Moorish, ? Portuguese, Astrolabe *c.* A.D. **1490.**

Diameter $7\frac{3}{4}$ inches.

Science Museum, No. 1919. 462.

This instrument is described by the authorities of the Science Museum as 'Persian': but the names of the months in conjunction with other features incline me to suggest a more western origin. It is uninscribed.

The suspension-ring is small, and the bracket very low. Swivel and shackle and *ilakha* original. Lettering is in rudely engraved Cufic, indicating degeneration in craftsmanship. The limb is graduated quadrantally, the degrees being numbered by fives.

The ankabut, fitted with 4 *mudirs*, shows 13 + 13 = 26 stars. The pointers have bulbous bases, usually with a single lateral bract: the bases of 3 are drilled with 4 holes. The east-west bar and the equinoctial band are both counterchanged.

There are 3 typical bipartite tablets.

The Back is riveted to the rim with about 18 large rivets.

i. Two upper quadrants graduated 0°–90°; lower semicircle blank.
ii–iv. Circles of Signs.

v–vii. Circles of Months, *Marsa*, *Yabryl*, *Mayh*, *Yunryh*, *Yulyah*, *Yagst*, *Sebtemvyr*, *Yaktobr*, *Novnbr*, *Dkhtnbr*, *Ynvrver*, *Frbuyayr*. It is suggested that these represent Portuguese forms.

viii. Shadow scales.

Alidade straight with a notched border.

147. The Astrolabe of Mohammad son of Ahmad al-Batuti

A.D. **1494–5.**

Purchased by Dr. Evans in Sept. 1909 and described by him *Arch. Journ.*, No. 18.

8¼ inches in diameter with shank, swivel, and small ring.

Inscribed in Cufic characters:

Its maker is the humble servant of his Lord Muhammad the son of Ahmad al-Batūti, God support him. Year 900 of the Hegira.

The *kursi* is high, contoured by a prominent ogee scroll on each side. The rim is riveted to the base plate.

The ankabut, made for 27 stars, is of inferior workmanship and of later date than the rest of the instrument. The star-pointers are ornamented with silver knobs.

The plates are 3 in number and bipartite. They are apparently for latitudes 15° and 16°; 20° and 21°; 23° and 24°—a somewhat unusual assortment.

Within the *umm* is a calendar drawn on 5 concentric bands.

From without inwards the number of divisions in the circles is:

i. 28. ii. 28.

iii. K, seven times repeated.

iv. 12. v. 12.

The Back is graduated for:

i. Two quadrants of altitude with a notch at every fifth degree.

ii. Circles of Zodiac.

iii. Circles of Days and Months. 1st Aries = 9⅓ March.

iv. Circle with five long divisions.

v. 28 × 3 divisions. vi. 28 divisions.

vii. *a*. Sinical quadrant with 12 parallel lines each way. *b*. Instrumentum horarum. *c*. *d*. Squares of the shadows.

148. The Valdagno Astrolabe

A.D. **1543.**

6¾ inches diameter.

A. da Schio, *Di due Astrolabii Cufici trovati a Valdagno*, R. Istit. Veneto Sci., 1875, printed 1880.

Fabricated by two masters Abul-Hassan Ali and Abd-alla Mohammad sons of Mohammad Al-Azidi known by the name Fulus in the school of law, Abu Abd-Alla Mohammad the little, son of Al-hagg; the year 950 of the Hegira. No place being mentioned.

Further:

The sun, the moon and the stars are subject to his commands.

The *kursi* is hollowed out with a round recess, presumably for a small compass.

The ankabut closely resembles that of No. 130. It is provided with 4 knob-handles for rotation; the bases of the more important star-pointers are perforate and trifoliate. Sirius is enclosed in a circular ' house '. Twenty-nine stars are named.

Star List

Danab al-gadi	δ Capricorni.	Ras al-hawwa	α Ophiuci.
Danab qaitus	ι Ceti.	Unq al'hayya	α Serpentis.
Matan qaitus	ζ Ceti.	Mankib al-faras	Scheat.
Qaddama al gauza	Rigel.	Al-hadib	β Cassiopeiae (stained hand).
Al-abur	Sirius.		
Unq as-suga	α Hydrae Alfard.	Ar-ridf	α Cygni Deneb.
Kalb al-asad	Regulus.	Al-waqi	Vega.
Ganah al-gurab	γ Corvi.	Al-fakka	α Coronae.
Al-azal	Spica.	Al-qaid	η Ursae majoris (Benet nasch).
Qalb al-aqrab	Antares.		
Ad-dabaran	α Tauri.	Assimak ar-rami	Arcturus.
Mankib al-gauza	α Orionis.	Ras al-gul	β Persei (Algol).
Al-gumaisa	Procyon.	Al-ayyuq	α Aurigae Capella.
Doqn as-suga	?	Yad ad-dubb	ι & κ Ursae majoris.
Kab al-faras	κ Pegasi.	Rigl ad-dubb	ν & ξ Ursae majoris.
Al-tayir	Altair.		

There are 5 tripartite plates inscribed with arcs of unequal hours (with their numbers written in full), arcs of *asr* and *zuhr*, and dawn-lines. They are marked for latitudes 21°, 24°, 30°, 31°, 32°, 33°, 34°, 35°, 37°. They bear no place-names, but a list of towns is engraved on the edge of the rim, Morocco, Fez, Tlemcen, Tunis, Cairo, Constantine, Jerusalem, Damascus, Aleppo, and Medina, which are all within the range of the plates.

FIG. 135. ASTROLABE OF ABUL HASSAN ALI AND ABD-ALLA MOHAMMAD. A.D. 1543.

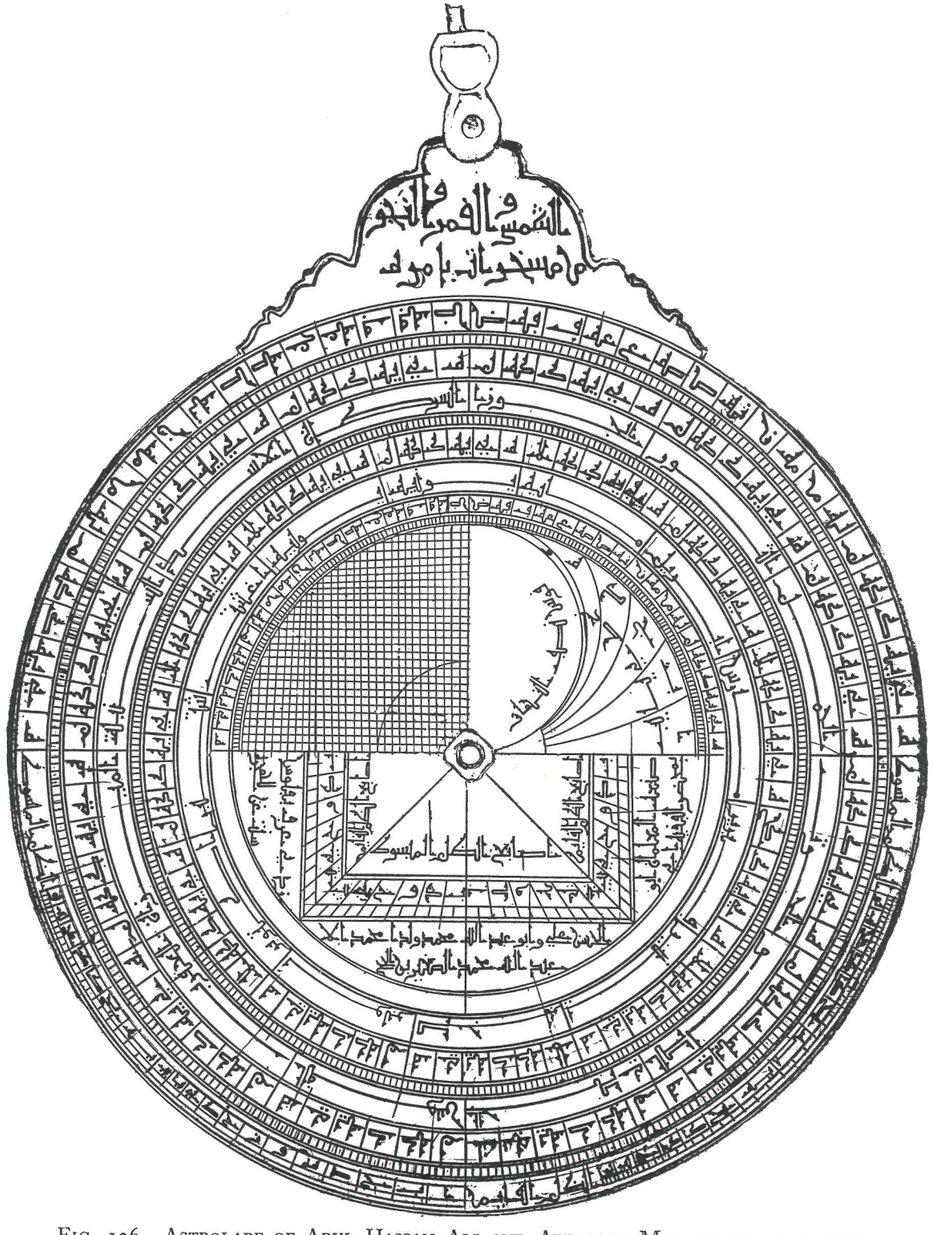


FIG. 136. ASTROLABE OF ABUL HASSAN ALI AND ABD-ALLA MOHAMMAD. A.D. 1543.
After Schio.

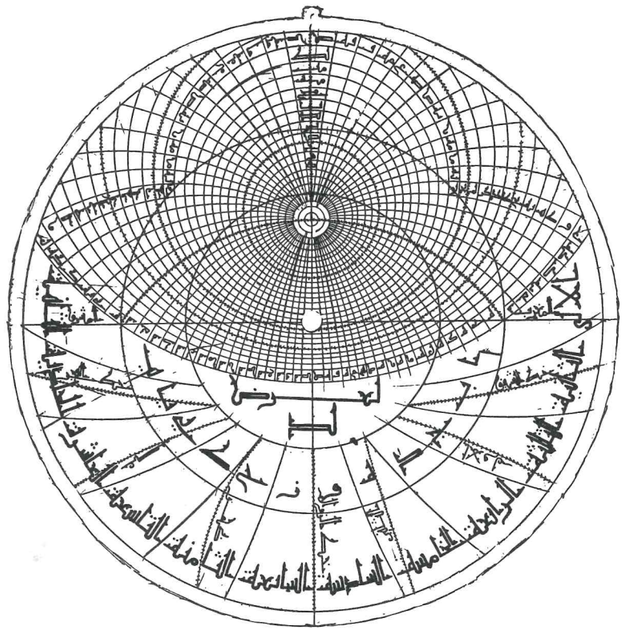


FIG. 137. PLATE FOR LATITUDE 34°.
After Schio.

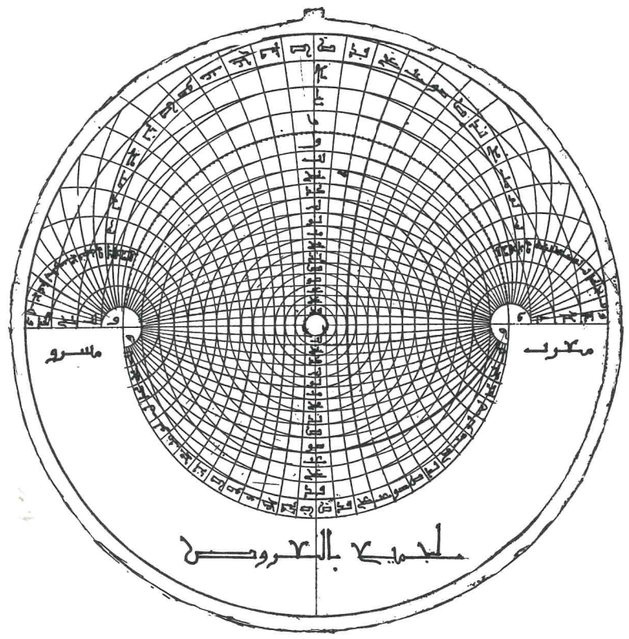
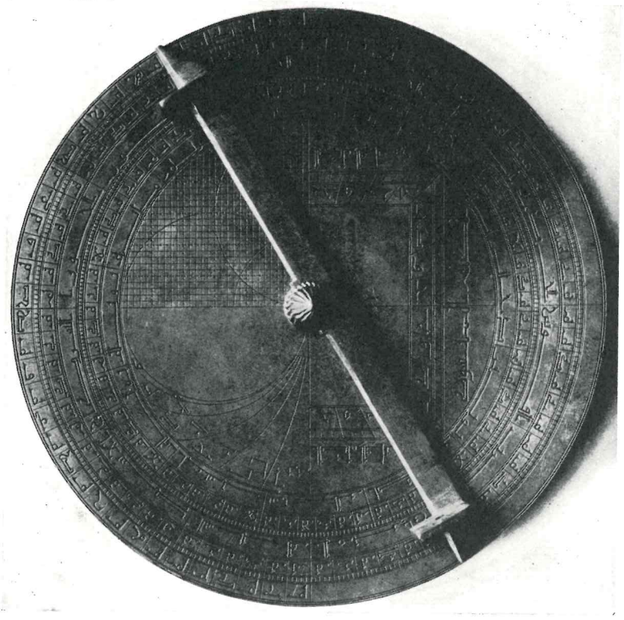


FIG. 138. TABLET OF HORIZONS FOR ALL LATITUDES.
After Schio.



SELDEN'S ASTROLABE

From Gunther, *Early Science in Oxford*, vol. ii

One side of one plate is marked as a table of horizons ' *For all latitudes* '.
The Back is engraved with 9 circles:

i. Two quadrants of altitude (above) and 2 tangent scales (below).
ii. Zodiac circles.
iii. Circles of Days and Julian Months. 1st Aries = 10 March.

In the middle:

iv. *a*. Quadrant *destur* or sinical quadrant ruled with 30 vertical (*menkus*) and 30 horizontal (*mabsut*) equally-spaced lines. *b*. Horary quadrant. *c*. *d*. Shadow squares.

An undated instrument of similar character but of later construction was given to the Bodleian Library by Selden.

149. The Selden Astrolabe. Pl. LXV *Type of* **1224**. **XVII Cent.**

Bodleian Library, Oxford. Figured and described in Gunther, *Early Science in Oxford*, ii, p. 194.

Although we at first deferred to authority and described this instrument as of the ' Type of 1224 ', our present wider experience leads us to the belief that it is of relatively modern construction, and not older than the end of the sixteenth century, when the insertion of small compass-needles into the thrones of astrolabes was being widely practised by European makers. The character of the shackle, too, is essentially modern.

The next two instruments, inscribed in Cufic, are placed here with some diffidence. Both seem to have Moorish affinities.

150. Cufic Astrolabe ' *16th Century* '.

Mensing Collection, No. 35.

$7\frac{1}{2}$ inches in diameter.

Bracket low, with ogee contour.

Ankabut devoid of tracery other than the crossed bars supporting the zodiac circle. In the meridional bar are 2 circles so that the bar may be well away from the star-positions of Vega and Sirius. The equatorial band is also looped up at the sides. The bars are fitted with 2 *mudirs* and are not counterchanged. The more important of the 22 star-pointers are mounted on perforate bases.

There are 5 plates. It is not clear whether the Back is engraved as an Arzachel or not.

151. The Negrotto Astrolabe — *Dated c.* A.D. 1650.

Described by Remondini, Pier Costantino, *Intorno all' astrolabio arabico. posseduto dalla Societa Ligure de Storia Patria di Genova.* Presented by marchese L. Negrotto. *Atti del* IV *Congresso internazionale degli Orientalisti*, Firenze, 1880.

There are 7 plates for latitudes ranging from 21° 40′ to 45°, and one for the whole world and the Equator.

The supposed date *c.* 1650 has been conjectured from the fact that the star-positions are based on the Tables of the Almagest corrected for precession, perhaps by Clavius.

Star List

	Magnitude.	*R.A.*	*Decl.*	*Positions according to Lalande's Tables, 1750.* *R.A.*	*Decl.*
1. Danab qaitûs	2	7°	19° S	7° 45′	19° 21′ S
2. 'Al-gûl	2	41°	37° N	43°	39° 58′ N
3. Ad-dabarân	1	64°	16° N	65° 24′	15° 19′ N
4. Al-ʿayyûq	1	72°	46° N	74° 33′	45° 42′ N
5. Qadam al-gawza	1	74°	8° 5′ N	75° 38′	8° 30′ S
6. Mankib al-gawza	1	84° 30′	6° N	85° 24′	7° 20′ N
7. Al-abûr	1	97°	16° S	98° 32′	16° 23′ S
8. Al-gumaisa	1–2	111°	7° S	111° 32′	5° 50′ S
9. Yad ad-dubb (ι *Urs. maj.*)	3	132°	46° N	130° 29′	49° N
10. 'Unq as-suga (α *Hydrae*)	1	139°	2° 30 S	138° 49′	7° 35′ S
11. Qalb al-asad	1	145°?		148° 45′	13° 10′ N
12. Rigl ad-dubb (μ *Urs. maj.*)	3	150°	42° N		
13. Ganah al-gurab	3	178°	15° S	180° 44′	15° S
14. Al-azal	1	197°	9° S	198°	9° 50′ S
15. Al-qayd	2	201° 30′	50° N	204° 25′	50° 30′ N
16. Ar-ramih	1	210°	21° N	211° 3′	20° 29′ N
17. Al-fakkah	2	230°	29° N	231° 1′	27° 24′ N
18. 'Unq al-hayyah	1	231°	8° N	232° 19′	7° 13′ N
19. Qalb al-aqrab	1	237° *Error*	24° S	243° 31′	25° 51′ S
20. Ras al-hawwa	2	259° 30′	12° N	260° 50′	12° 45 N
21. Al-waqi	1	276° 30′	37° N	277° 7′	38° 34′ N
22. At-tayr	1–2	293° 30′	6° 30′ N	294° 38′	8° 13′ N
23. Ras al-gadi (α *Capricorni*)	2	300°?		301° 2′	13° 18′ S
24. Ar-ridf	2	310° *Error*	44° N	307° 13′	44° 23′ N
25. Danab al-gadi	3	315°?		321° 32′	17° 46′ N
26. Kab al-faras (κ *Pegasi*)	4	324°	24° N		
27. . . . (δ *Aquarii*)	3	336° 30′	17° S	340° 20′	17° 8′ S
28. Mankib (al-faras)	2	341° 15′	25° 30′ N	342° 55′	26° 43′ N
29. Al-kaff al-hadib	2–3	351°	44° N	358° 59′	57° 46′ N

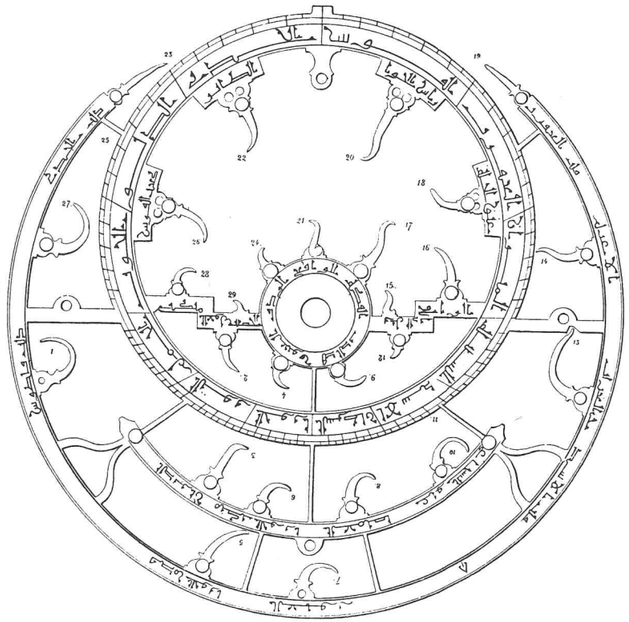


Fig. 139. Astrolabio Negrotto. *c.* A.D. 1650.
After Remondini.

152. Cufic Shafiah

Diameter 8⅞ inches.

Described by Morley as 'B.' or No. 1 of the East India House, see p. 34. Now in India Museum, No. 406. 1924.

The base plate is marked as a tablet for 34°, i.e. the latitude of Fez. It is inscribed on back of the low, lobed *kursi*:

Praise be to God.

The swivel, which is introduced between the ring and the shackle, is unusual in Oriental instruments.

The ankabut is for 16 stars, Pl. XX, Fig. 24.

Close examination of the engraved disk shows that it was once marked with numerous star-positions ⊙, which have been rubbed down, so that in many cases only the central dot remains. It is, therefore, a palimpsest.

Below the almucantars on the basal tablet are marked azimuths below the horizon and lines of the unequal hours.

On the Back are 10 circular bands relating to ' degrees of altitude '.

'Izadah or rule is of the inverted kind, half on opposite sides of the *linea Fiduciae*.

The names of the European months indicate European use.

153. ASTROLABE OF MUHAMMAD OF RADAYANAT. Pl. LXVI A.D. **1743**

Mensing Collection, No. 35.

About $7\frac{1}{2}$ inches in diameter.

Wrought by Muhammad son of al-Fatwili al Khama'ini (confectioner?) *in Radayanat al-Athbiliyya in the year* 1156.

Professor Margoliouth suggests that Radayanat may be Redana in Sous, a province of Morocco (Mercier, *Afrique du Nord*, iii. 330).

With 5 tablets.

154. MUHAMMAD SON OF YUSUF'S ASTROLABE. Pl. LXVII A.D. **1747.**

Mensing Collection, No. 36.

6 inches in diameter.

This Astrolabe was wrought by Muhammad son of Yusuf son of Hatim, whom may God forgive, in the year 1160.

This instrument was referred by Engelmann to the sixteenth century.

Bracket of pierced arabesque work.

Star-pointers large, anchor- or 'boat-hook' shaped, with small knobs near their points of insertion. E. W. bar counterchanged 4 times. Both equinoctial bands within and without the zodiac supported by quatrefoils, which suggest affinity with the Spanish astrolabe No. 163.

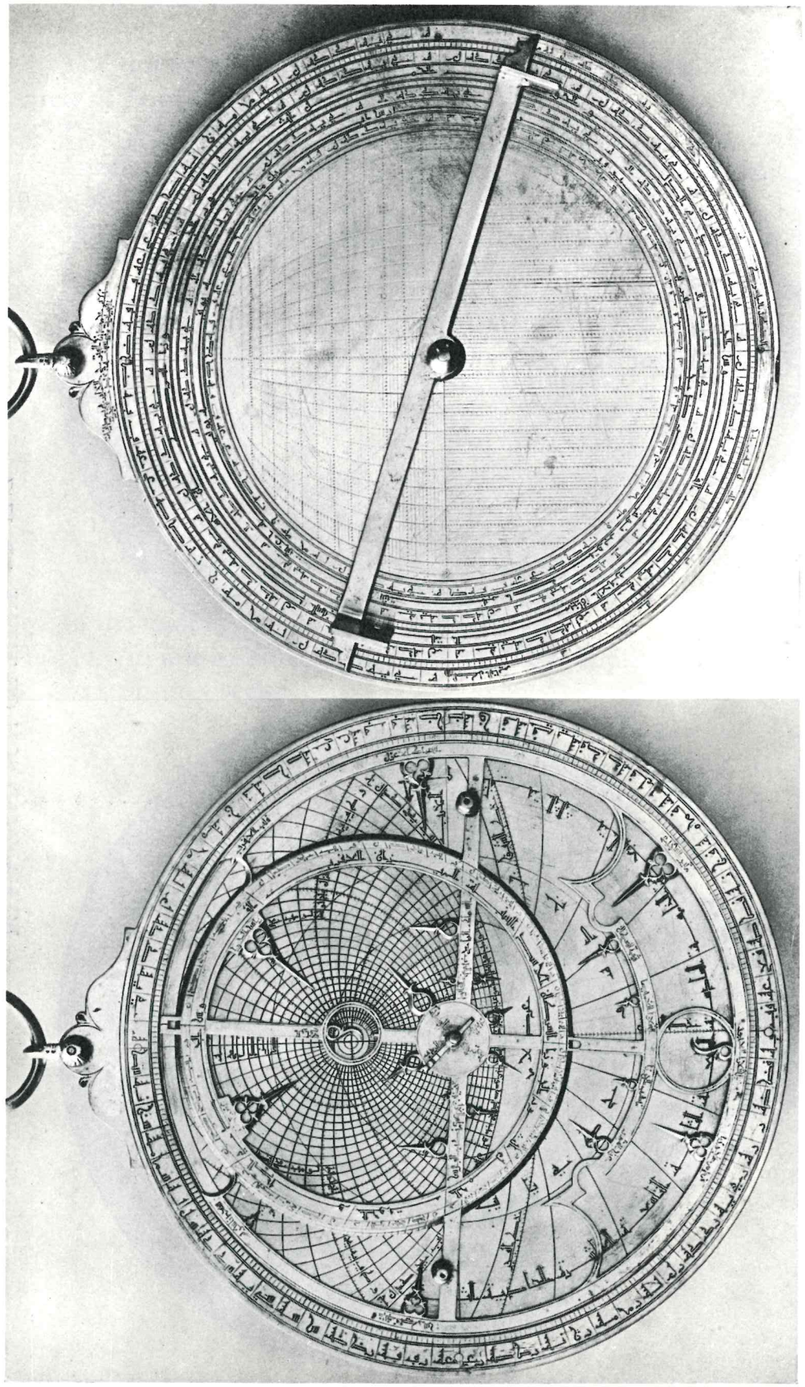
On the Back, inside the usual circular calendar-scales and a circle of the 28 mansils, is a square of the shadows which also carries the maker's inscription.

155. MODERN NORTH AFRICAN ASTROLABE. Pl. LXVIII *c.* A.D. **1780.**

$4\frac{13}{16}$ inches diameter; $\frac{1}{4}$ inch thick, with a thin back plate soldered to a thicker rim; total length including ring $8\frac{1}{2}$ inches.

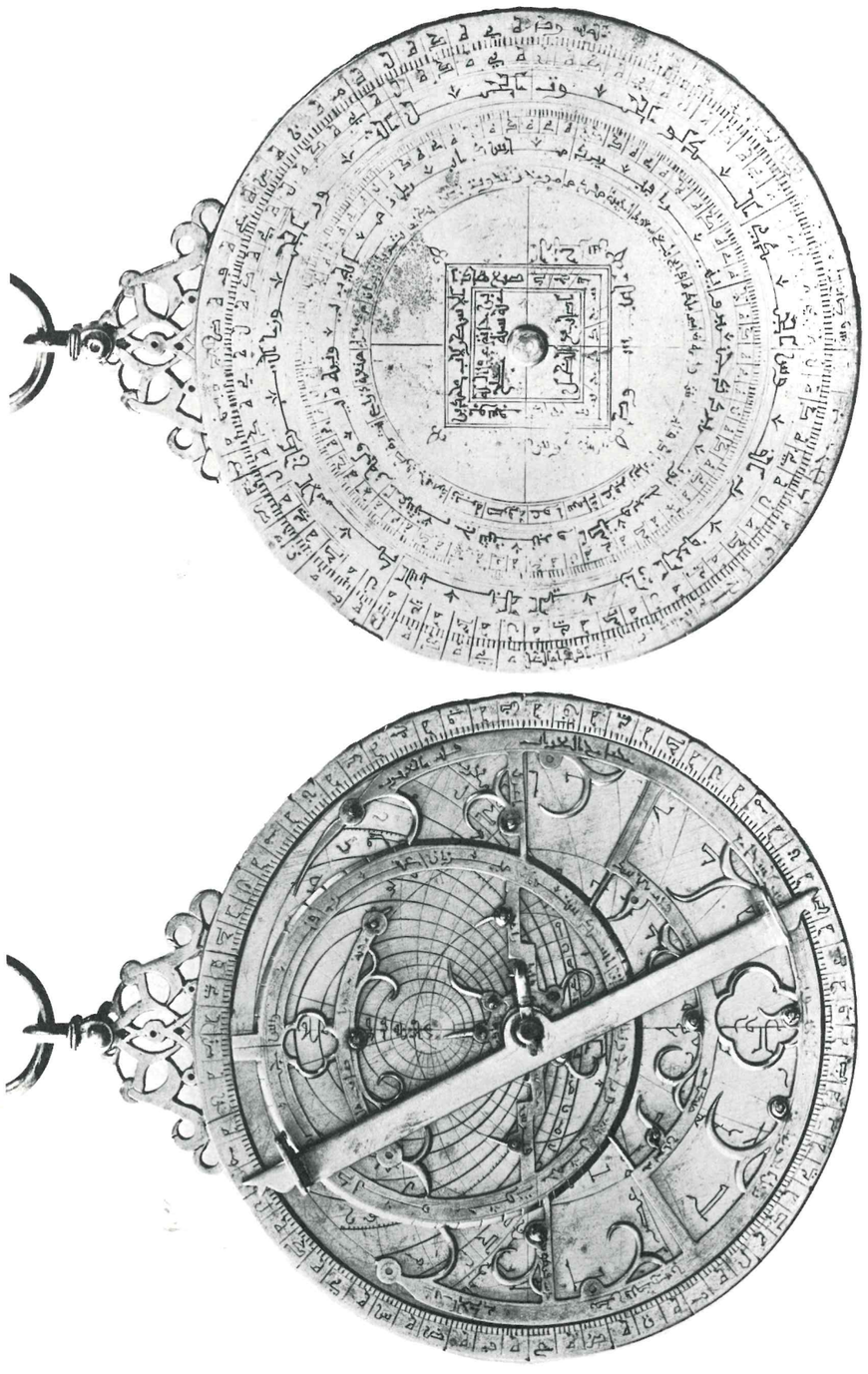
Bought by Mr. Evans in 1916 from P. Webster, 37 Gt. Portland St. £10 10*s*.

A roughly-made instrument, the word 'Patent' being stamped on the brass plate used for the rete. The ring, swivel, and shackle are clumsily executed in turned brass. Engraved with imitation Cufic script, with Magrevi numerals such as were used in Algeria.



MOHAMMAD SON OF AL-FATWILI AL KHAMÁ'IRI, A.D. 1743

LXVII



MUHAMMAD SON OF YUSUF, A.D. 1747

The rim shows an outer circle of the 24 hours, 1–12, 1–12, and an inner circle of degrees.

The bottom of the *umm* is plain.

Ankabut for 18 stars, with a small silvered stud to each star, and 4 large brass studs for turning it.

Three plates with almucantars for every 5 degrees with place-names.

1*a*. 21° 40′. Mecca and ———.
b. 26°. Country of the Sudan.
2*a*. 29° 20′. Medina e mushaffar (= the honoured).
b. 39°. ———
3*a*. 31° 20′. Morocco, Alexandria.
b. 34°. Marakesh, Fez, Miknas, ——bat.

The Back shows:

i. Two quadrants of altitude, degrees numbered by tens, 0–90°.
ii. Circle of degrees, numbers, and names of the 12 Signs.
iii. Circles of Days, numbers, and Latin names of Months. 1st Aries = 6⅓ March.

In the middle:

iv. An *instrumentum horarum* on the right upper quadrant.
v. Shadow scales.

This item should have appeared on page 215.

84A. THE ASTROLABE OF THE GREATEST MOSQUE **A.D. 1896.**

Diameter $4\frac{5}{8}$ inches.

S. V. Hoffman Collection, No. 1.

Inscribed on the Back in modern Arabic:

Bestowed on the Greatest Mosque the 6th of Muharram year 1308.

The year is expressed in a chronogram deciphered by Professor Margoliouth.

This instrument may be of much older date, but may have been renovated with the addition of etched plates. It is difficult to express an opinion from photographs alone. The Great Mosque may be at Delhi, or anywhere else.

The bracket is of medium height and perforated with 4 holes. The rim is fixed to the basal disk by 13 rivets. The greater part of the writing is in Cufic Arabic, but the more modern ankabut is in the usual modern script. Twenty-five stars are named.

The tablets are inscribed for:

1*a*.	Lat. 31° or 32°.	4*a*.	Lat. 32°.
b.	,, 33°.	*b*.	,, 38°.
2*a*.	,, 32°.	5*a*.	,, 37°.
b.	,, 32° or 33°.	*b*.	,, 40°.
3*a*.	,, 30°.	6*a*.	,, ?75°. Quinque-partite plate.
b.	,, 39°.	*b*.	Horizons, two-polar.

The *umm* is engraved with 144 radii traversing 14 concentric circles.

On the Back are:

i. Four quadrants for measuring altitudes, one being notched along the margin, probably for use at night.
ii. Zodiac circle.
iii. Circle of Months.
iv. The upper semicircle is blank, save for the modern dedicatory inscription.
v. The lower semicircle contains the squares of the shadows and a further inscription that may give further information as to the date of the instrument.

JEWISH ASTROLABES

A RECENT writer[1] has noted that although there were many works upon the astrolabe by Jews in the Middle Ages, there is no modern résumé of the contributions to the subject. With the exception of the early work by MESSAHALLA (770–820), we have no record of any Jewish treatise before ABRAHAM IBN EZRA produced his *Kᵉli Nᵉḥosheth* or '*The Brass Instrument*' (1146–8). Some years previously Abraham Savasorda (†1136) was assisting Rudolph of Bruges to translate his *De astrolabio*.

Mr. Gandz has collected the printed Hebrew sources in which some variant of the word אצטרולאב, or aṣṭrolāb, occurs. They are Benjacob, Ibn Ezra, Harkavy, Jehudah ibn Tibbon, who also called it 'scale' and 'circle of the astronomers', Maimonides, *Commentary to the Mishna*, Don Duran de Lunel, Abba Mari, Joseph ha-Sephardi, Tobiah ben Moses, Joseph Solomon del Medigo, Solomon ibn Adreth, Jacob Barukh Landau, Joseph Caro, Shemtob Shaprut, Yehudah Mosconi, Tobiah ben Meir Levi, and Solomon Abigdor. The word astrolabe is, however, spelt in so many ways that the writers could have had no knowledge of the derivation and meaning of the word, nor is this surprising, for many of their Arabian predecessors were equally ignorant. But the fact is significant as showing that these Hebrew writers were not acquainted with the earlier work of Messahalla in which the derivation of astrolabe is correctly given.

A collection of the technical names for the various parts of the instrument includes the following:

טבעת = Arabic al-ḥalaḳah = the Ring.
כורסיא or כסא kursi = the Throne.
אם = the Mother.
חיק hujrah = the Border.
{ בריח regula = Rule.
{ מעצד al-ʿidadah = Alhidade.
רשת al-ʿanḳabut = Rete.
דפין libnatāni = Sight-vanes.
סוס ורוכבו al faras = Horse and Rider?

[1] Solomon Gandz, 'The Astrolabe in Jewish Literature', *Hebrew Union College Annual*, iv. 1927, to which Mr. H. Loewe has kindly drawn my attention.