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Volume 94

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Institute for the History of
Arabic-Islamic Science

Edited by
Fuat Sezgin

ISLAMIC MATHEMATICS AND ASTRONOMY

Volume
94

Astronomical Instruments and Observatories in the Islamic World

Texts and Studies
Collected and Reprinted
X

1998

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

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ASTRONOMICAL INSTRUMENTS AND OBSERVATORIES IN THE ISLAMIC WORLD

TEXTS AND STUDIES

X

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by
Fuat Sezgin

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

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BY

ROBERT T. GUNTHER, M.A., HON. LL.D.

Curator of the Lewis Evans Collection in the Old Ashmolean Museum at Oxford

VOLUME I

THE EASTERN ASTROLABES

OXFORD

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1932

ORIENTAL ASTROLABES

THE ARABIANS

IT has been pointed out that the Koran does not contain a single precept that is favourable to the study of Natural Science. It is therefore scarcely a matter for surprise that for the first century after the Hegira in A.D. 622, the thoughts of the fanatical followers of Mohammed were directed to spread their creed by sword rather than by reason, yet when once they had obtained their desires, the Moslem conquerors themselves conserved what they could of older civilizations and sciences: indeed, but for their care these would have utterly perished.

No one contributed more to this Arabian Renaissance of Science, than the second Abbasid Calif, ABU JAAFAR ALMANSOR (A.D. 754–75), the immortal founder of Bagdad. His good work was continued by his grandson, the still more famous HAROUN AL-RASCHID (A.D. 786–809), and by his great-grandson AL-MAMUN (A.D. 813–33), who offered the Greek emperor five tons of gold and a perpetual treaty of peace provided that the philosopher Leo might be permitted to give him instruction.

Among the writers that belong to the califate of al-Mansur was MESSAHALLAH (*c.* A.D. 815), the author of a work on the Astrolabe, the original text of which is lost; but there is a Latin translation which, more than any other treatise, served to stimulate the use of the instrument in Europe. Little, however, is known of the author, who is believed to have been a Jew of Egyptian origin. The complete text with the explanatory figures has recently been printed by the present writer.

The oldest Arabic treatise on the Astrolabe which has come down to us is probably that of ALI IBN ISA who was a pupil of Ibn Khalaf al-Mahwarrudi who made observations in Bagdad and Damascus in A.D. 829 and 832 (Suter, *Mathematiker u. Astr. der Araben*, 1900, p. 13.) Another is that of MOHAMMED BEN MUSA AL-CHWARIZMI.

It is a matter for satisfaction that a scholarly investigation of several of these older Arabian and Persian treatises on the Astrolabe has been undertaken by Professor E. Wiedemann and his pupils at Erlangen. The texts of Chwarizmi and of Ali ibn Isa of the ninth century have already been printed and translated, and there seems to be good ground for hoping that the original Arabic text of Messahallah's treatise may one day also be found. A work by the later astronomer al-Biruni (973–1048) on the various shapes of astrolabes has been studied by Dr. Frank.

The work of the Syrian Severus, or others like it, had doubtless a wide circulation, and the use of the astrolabe became greatly extended by the Syrian physicians whose skill was celebrated even at the court of the Califs at Bagdad.

The cradle of Arabian astronomy has been located at Harrān, a capital town in Northern Arabia, noted both for the excellence of the locally-made balances[1] and as the place where repairs could best be made to Astrolabes and other measuring instruments (al-Hamadānī, *d.* A.D. 945). Yakub al-Nadīm has enumerated the names of a number of astronomical instrument-makers, and, if they read anything at all, the treatise of Severus Sabokt may have been a standard work. We may well believe that al-Battani obtained instruments for his observations in Rakka there, and that Ben Musa and the other astronomers of al-Mamun—perhaps through Thabit Ibn Kurra—patronized the same school of craftsmen.

Thus the use of the Greek Astrolabe was spread among the Arabs, and its utility was extended by various additions, such as lines on the tablets for showing the hour of prayer. The requirements of astrologers were met by special tablets of the horizons, and lines for the twelve hours. The back of the instrument was engraved with diagrams of the sines and cotangents of angles, for finding the altitude of the sun, or for showing the relation between the planets and the signs of the zodiac.

By the further investigation of the early manuscripts much will doubtless be discovered.[2]

The making of astrolabes became a highly skilled and an honourable profession. The secrets were transmitted from father to son, and many a craftsman felt distinguished when he could sign the honourable title of al Asturlabi after his name. This title goes back to the time of Al-Mamun and shows that the mechanical skill of the fabricator of instruments, conducing in the highest degree to accurate observations, was duly appreciated even in

[1] al-Mukaddasi (d. 985) Ahsan al-Takāsīm fi Ma'ri-fat al-Akalīm—The most beautiful division in the knowledge of the Climates.

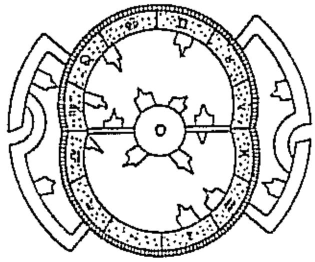
[2] A few titles of Arabic and Persian treatises on the Astrolabe are given on page 2, but a still more important contribution to our knowledge of their writers has been made by H. Suter's work, *Die Mathematiker und Astronomen der Araber und ihre Werke*, Leipzig, 1900.

the ninth century. The striving after meticulous accuracy in mensuration by modern astronomers and physicists therefore comes down to us from very ancient lineage.

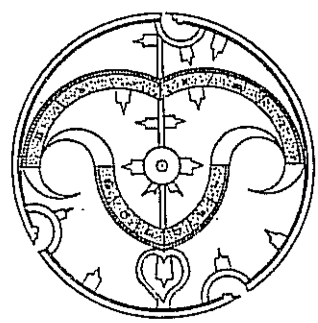
In the course of time some of the later Arabic writers even forgot the Greek source and meaning of the name 'astrolabe', but felt it incumbent on them to supply the etymological deficiency. One can well picture the satisfaction of the scholar who 'discovered' that the word was derived from *Lab* 'a man who traced some lines and founded upon them calculations; whence *asturu lab*, the lines of Lab'.[1]

Some Persian astrolabists devoted much ingenuity to the production of retes of special design for use in different climates. And they distinguished the more striking types by special names, e.g. the Quince or Drum (*a-safardjalī* or *al-mutabbal*); the Myrobalan or Myrtle (*al-ihlī lidji* or *al-asī*); and a curious form ascribed to Nastulus, called the Crab-wing (*al-musartan* or *al-sartani al-mudjannah*). Sédillot (1841) quotes Abul Hassan as the authority for six other varieties: the *sadafi* or shell; the *schachaichi* (Anemone); the *berdjesdani*; the *bisathi*; the *tsouri* (Bull); the *djamousi* (Buffalo); and the *selhafi* (Tortoise).

The Myrtle Leaf.



The Drum.



The Crab-wing.

FIGS. 59–61. VARIETIES OF ARABIAN ASTROLABES.

I have not had the opportunity of examining any actual example of any of these instruments, and I am inclined to regard them as freak-astrolabes, which were only figured in manuscripts and seldom or never used.

And, since the present memoir is confined to the consideration of Planispheric Astrolabes, neither the Spherical Astrolabe of al-Nairizi, which was a kind of simplified Celestial Globe, nor the Linear Astrolabe of al-Muzaffar al-Tusi who died *c.* A.D. 1213 will receive further attention here.

[1] Lane, *Arabic-English Lexicon.*

For convenience we propose to describe our Oriental Astrolabes in chronological order in four provisional main groups, the typical members of each of which are not difficult to distinguish, and are associated with the four geographical regions.

1. Persian.
2. Indian.
3. Arabian, Syrian, Mesopotamian, Egyptian.
4. Moorish, including N.W. Africa and Hispano-mauresque.

Although it is usual to describe the astrolabes of the third group as 'Arabian', the name must be taken to refer to the language in which they were inscribed, rather than to imply that there were factories of instruments among the burning sands of Arabia in the strict geographical sense. Astrolabes that were actually made in Mecca or any of the towns of Yemen or the Hadramaut are rare. The skilled workers in metal lived in Damascus, Bagdad, Cairo, and other towns in countries that were conquered by the Arabs, and wisely governed by them until the fall of the Califate of Bagdad in A.D. 1258. During the previous five centuries was the floruit of the 'Arabian' Astrolabe.

PERSIAN ASTROLABES

THE oldest Persian astrolabes that have come down to us from a remote antiquity take the instrument just half-way back to the presumed epoch of its invention by Hipparchus in 150 B.C. There are, of course, literary references to its construction and use during the intervening centuries, but we have no dated instrument that is known to be older than A.D. 984.

We might even be sceptical as to the high antiquity of this astrolabe, were it not for the preservation of others of the same period and type. All are characterized by a primitive simplicity of the ankabut and by the shape of the star-pointers. But in their design these earliest of known astrolabes come so close to the more highly elaborated instruments of half a millennium later, that it is obvious that as many centuries and more must have elapsed before the instrument reached that stage of evolution in which we first meet with it in the tenth century.

According to Morley the earliest Eastern astrolabe was in the Imperial Library of Paris, and was 'dated' A.D. 905; but as this instrument was considered by Dr. L. Evans to be at least fifty years later, and by da Schio to be only a twelfth- or thirteenth-century copy of an early original, it should rather be described as of the 'Type of *c*. A.D. 950', and it is interesting to compare it with Pope Sylvester's astrolabe of a few years later. Both will be described with the Arabian instruments.

The oldest known dated astrolabe then is the one in the Lewis Evans collection, which is believed to have been made at Isfahan two years before the death of one of the fathers of Persian astronomy, the great Al Sufi, Abd-al Rahman ben Omar abul Husain al Sufi, who recorded the magnitudes of the stars.

3. THE ASTROLABE OF AHMAD AND MOHAMAD OF ISFAHAN

Plates XXII and XXIII — A.D. 984

Purchased by Dr. Lewis Evans for £250 in April 1919 through Percy Webster from Professor Y. Daweed.

At the moment of writing, this venerable instrument is the oldest dated portable scientific instrument known.

It measures $5\frac{3}{16}$ inches in diameter and is $\frac{1}{8}$ inch thick, being built up of a back-plate soldered on to a circular rim, which has been cast in one piece with a high bracket or throne ornamented by 29 crescentic perforations. The total height, including the ring and shackle, is $8\frac{3}{16}$ inches.

The inscription on the back of the astrolabe is as follows:

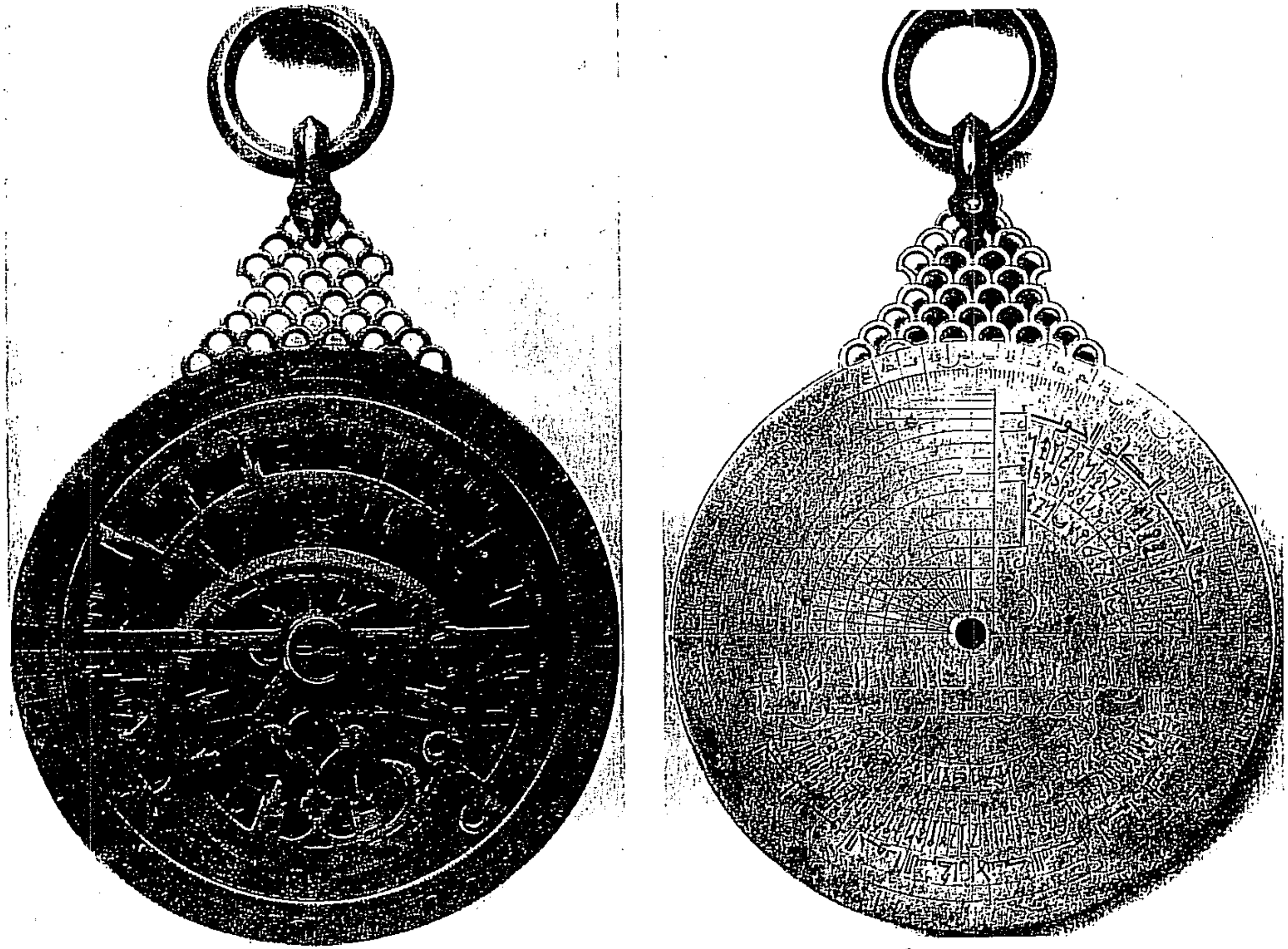
'*In the Name of God, and by the help of God. With prosperity and success and good fortune, and happiness [of this world and the next, and eternity], this Astrolabe was composed by Ahmad and Mohamad, the two Sons of Ibrahim, makers of Astrolabes, natives of Isfahan, the year four and seventy and three hundred.*'

The year A.H. 374 = A.D. 984.

The suspensory ring is $1\frac{5}{8}$ inch outside diameter and $1\frac{1}{16}$ inch inside, and is square in section, providing knife-edge suspension at all parts of the ring.

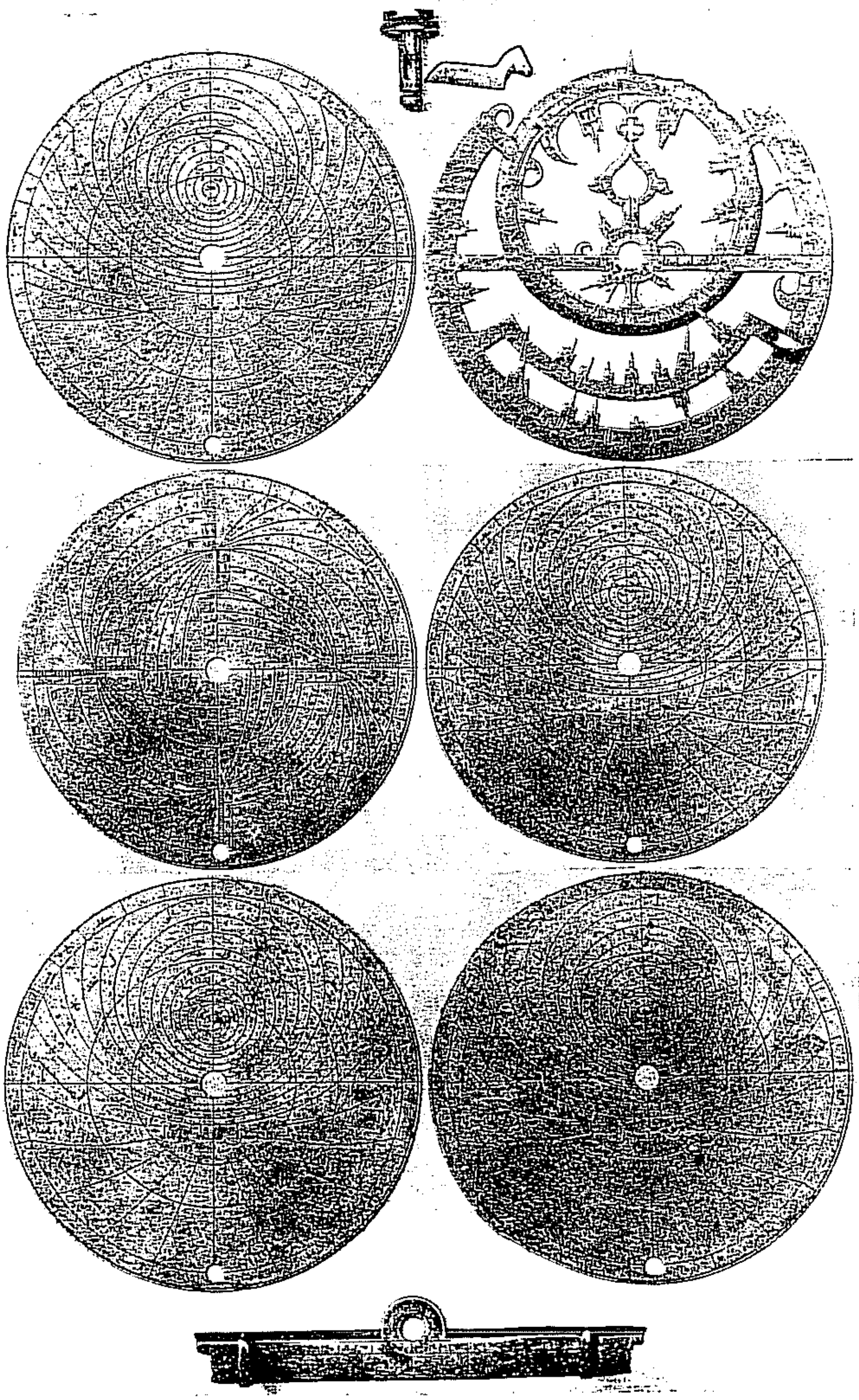
The rim is divided, with a precision that is surprising in so early an instrument, into 360 degrees, numbered by fives.

The ankabut is for 37 stars, and, though much corroded, most of the star names can be made out. A lug at one side serves for rotation. The simple design of the dagger-like star-pointers, mostly borne on the zodiac circle and on the peripheral and equinoctial bands, is also a feature of other early instruments, the only ornament here being an elaboration of the meridional diametric bar, in which quatrefoil and pear-shaped bands have been introduced. The same decorative elements are present in the instrument of A.D. 1223 described below.



ASTROLABE OF AHMAD AND MAHMUD, A.D. 984

From Gunther, Early Science in Oxford, vol. ii



ASTROLABE OF AHMAD AND MAHMUD, A.D. 984

The names of the stars have been read by Mr. H. Loewe of Exeter College, as follows:

3. Jihatu Qaitus.
4. Al-Kaf al-Jazma.
21. al-Ghul.
5. ['Ain] al-Thaur.
22. al 'aiyuq.
6. Yad al Jauza.
7. Yad.
8. Rijl al Jauza.
9. Rijl al Jauza.
10. al-Hai'ah, ?Han'ah.
11. al Yamaniyyah.
12. al Shamih.
13. Ras al Shira'i.
14. al Taraf.
15. al Fard.
16. Qalb al Asad.
23. Rukbat al Dubb.
17. Janah al Ghurab.
24. Adna al 'Anak ?
25. Taraf zanab [. . .]
18. [Simak] al A'zal.
19. [*Obliterated*].
26. [Si]m[a]k al Ramih.
27. [. . .]r [a]l Fakkah.[1]
28. ['Unq al-Hayyah] *obliterated.*
20. [Qalb al] aqrab.
29. Al-M . . . ?
30. [*Ras al Hawwa*].
31. al Waqi'.
32. Nasr al Ta'ir.
33. Janah al Dajajah.
34. Zanab al Dulfi[n].
35. ar-Ridf.
1. Zanab al Jadi.
36. al Akhbiyah.
37. Mankib.
2. [Z]anab Qaitus
38. al Kaff al Hadib.
39. al Maujad ?

Three tablets are provided, all pierced with round holes near the lower border for engaging in a steady-pin in the cavity of the Umm. They are accurately engraved as sexpartite plates (*sudsi*), with almucantars 6° apart, for

1*a*.	Latitude 30°	. .	hours 12. 53 min.
b.	,, 36°	. .	hours 14. 30 min.
2*a*.	,, 32°	. .	hours 14. 3 min.
b.	,, 12° (?=32°)	.	hours 14. 52 min.
3*a*.	,, 37°	. .	hours 14. 36 min.
b.	Tablet of Horizons in four groups of seven.		

On the Back the two quadrants of the upper semicircle are graduated in degrees for measuring altitudes. The left upper quadrant is ruled as a diagram of sines with parallel horizontal lines crossed by concentric quarter circles and radial lines for every fifth degree. The rim of the lower right hand quadrant is graduated as a shadow scale.

[1] The star-pointer appears to have been cut, eliminating the a of the article, but preserving the final r of the word Nayyir.

A remarkable Planetary Table for astrological use fills the greater part of the other three quadrants, the inscriptions being curious and uncommon. The names of the Signs of the Zodiac are arranged in two segments, 4 signs in one and 8 in the other. Following the direction *Commence from the Ram*, inscribed on the right-hand side of the rim, are the first 8 Signs, 'Ram, Bull, Twins, Crab, &c.' named in the segment in the lower semicircle, and the table is continued with 'Archer, Goat, Bucket, Fish', in the segment in the right upper quadrant.

Under the names of the signs are engraved the symbols of the 7 planets, ɨ Mercury, ɨ Venus, ∂ Sun, ⌣ Moon, ƚ Mars, ƺ Jupiter, and ꞁ Saturn. These symbols are unusual, and though the astrolabe is in Arabic, it is probable that they were derived from an Aryan rather than from a Semitic source. The five planetary symbols immediately below the names of the signs are those of the terms or limits (ὅρια) grouped according to the Egyptian system of Dorothea of Sidon and Paulus Alexandrinus. Within is a scale of numbers (?), perhaps to allot the appropriate fraction of the sign that is under the influence of a stated planet. Similarly, along the innermost border planetary symbols are grouped in threes to record the system of the decans or faces (πρόσωπα). If the first of each of the decans in each group be placed in order, they will be found to be in the order of the days of the week.

The 36 decans of the year were very important divinities. According to Hermes Trismegistus[1] they were 'vigilant guardians, inspectors of the universe', who not only exercised influence directly, but also through stars that might happen to rise at the same time.

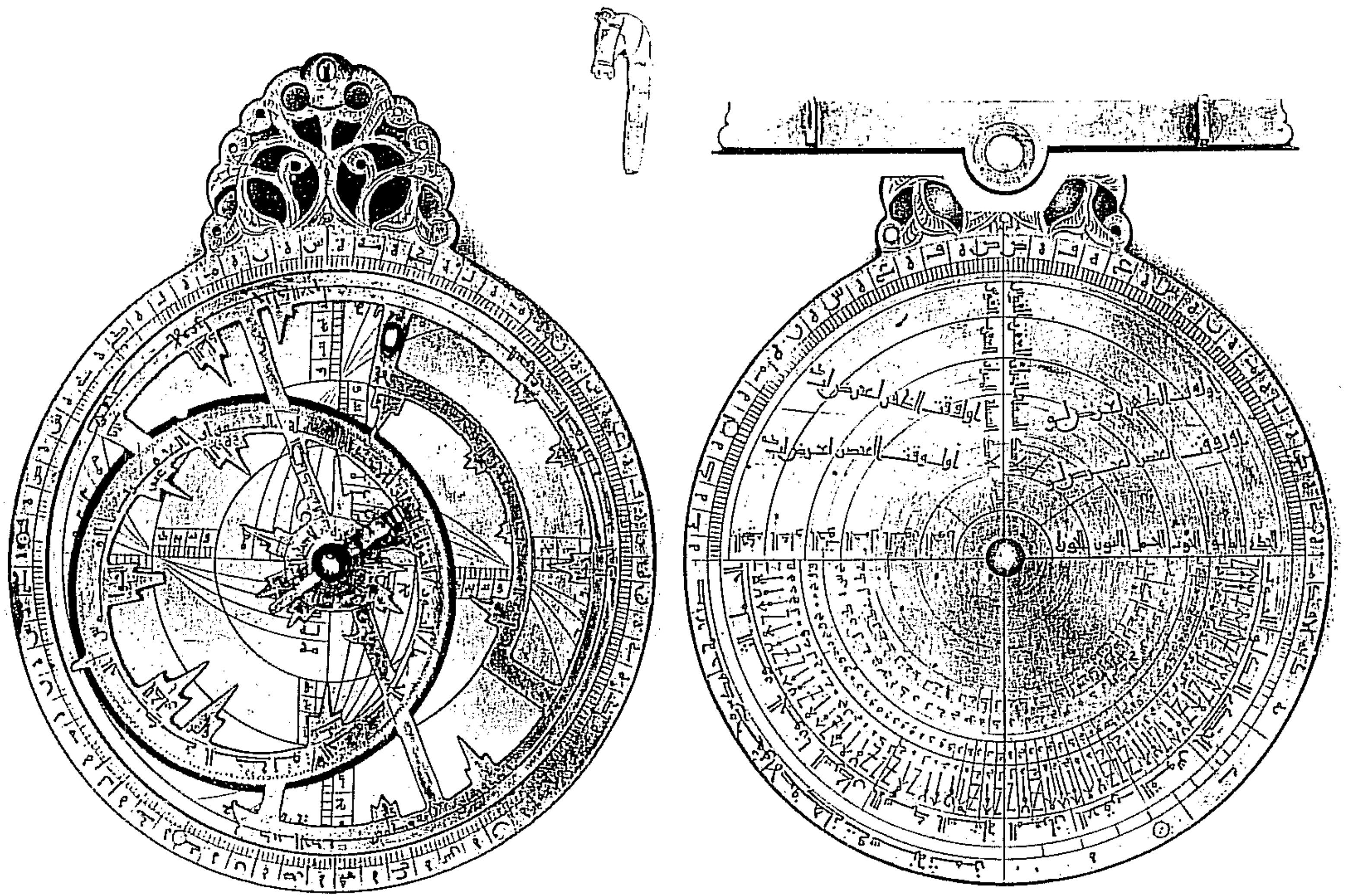
Across the back is the long Arabic inscription already translated.

The alidade or sight-rule is of the ordinary oriental pattern with a graduated fiducial edge along the upper border. The ends are ornamented with a deeply incised } ornament. The sight vanes are pierced with sight-holes which, unlike those of European alidades, are below the axis of the instrument.

The pin and wedge are typical.

The resemblance between this early astrolabe and one in the collection of Mr. S. V. Hoffman, next to be considered, is most remarkable.

[1] Cf. Bouché-Leclercq, *Astrologie grecque*.



AHMED IBN MOHAMED OF ISFAHAN

4. The Astrolabe of Ahmed ibn Mohamed of Isfahan *Undated.*

Pl. xxiv

$5\frac{1}{4}$ inches in diameter.

S. V. Hoffman Collection, No. 28.

The Inscription on the back is apparently unfinished.

The work of Ahmed ibn Mohamed of Isfahan in the year 8 . . .

It is unfortunate that the date is uncertain, for the instrument in many respects recalls the early Persian type just described. Both ring and shackle are missing. The high throne, ornamented with a pierced foliated pattern, has an eleven-lobed contour; the decoration is coarse.

The rim is divided in 360 degrees. The ankabut is of the type of Fig. 23 with dagger star-pointers—9 on the capricorn band, 4 on the equinoctial band, which carries a handle, and 14 within the zodiac, or 27 in all. The tablets are tripartite (except 2*a* which is sexpartite), with marginal notches. They are 3 in number.

1*a*.	Lat. 30°; hours	15	14′	
b.	„ 34°; „	14	19′	
2*a*.	„ 32°; „	15	14′	inscr. 'East', 'West', 'Dawn and Twilight' with lines for equal [hours.
b.	„ 36°; „	14	30′	
3*a*.	„ 31°; „	14	3′	
b.	Tablet of horizons in four groups of four.			

The lettering on the Back shows a tendency to imitate Cufic. We may distinguish (i) Two upper quadrants graduated to 90° in fives; (ii) Two upper quadrants with six concentric circles bearing the names of the 12 Signs beginning on the right 'Capricorn, Bucket, Fish, Ram, Bull, Twins' and continued along the meridional line 'Crab, Lion, Virgin, Scales, &c.', twice repeated. Across the quadrants is written

Right.	Commencement of the time of	noon	for lat.	36°	
	„ „	afternoon	„	36°	
Left.	„ „	noon	„	32°	25′
	„ „	afternoon	„	32°	25′

On the margin of the third quadrant is the maker's inscription, and on that of the fourth a marginal Shadow Scale is inscribed.

In the lower semicircle are astrological planetary scales very like those described on p. 116 and exhibiting the same peculiar planetary symbols.

5. THE ASTROLABE OF THE NEEDLE-MAKER OF ISFAHAN

A.D. 1223–4

Pls. XXV and XXVI

Purchased in 1913 by Mr. L. Evans from M. Heilbronner of Paris.

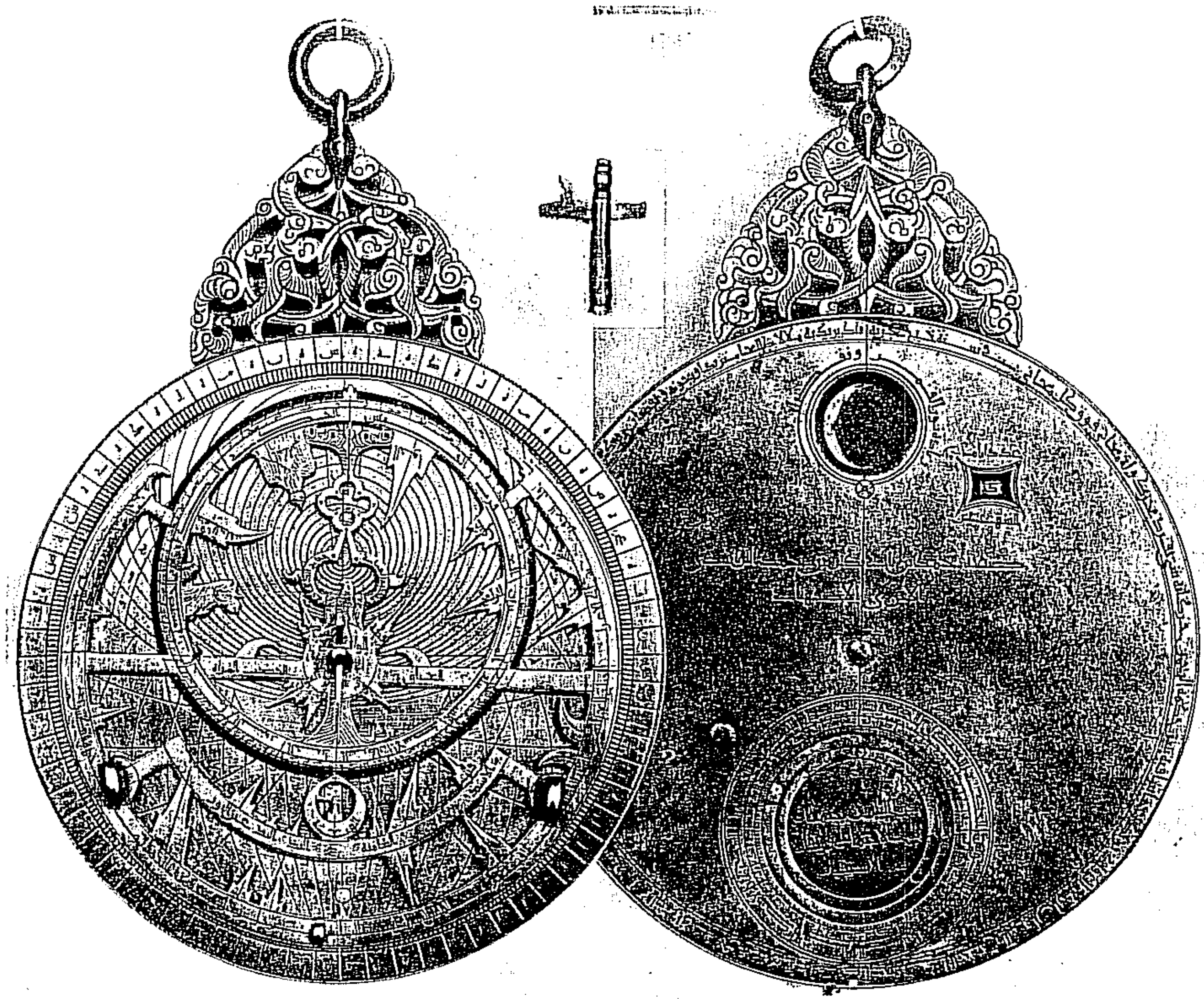
This early brass astrolabe, $7\frac{5}{16}$ inches in diameter and $\frac{11}{16}$ inch thick, is remarkable on account of a geared calendar movement which it contains. According to the inscription engraved straight across the back it was

The work of Mohammad ibn Abi Bekr ibn Mohammad al Rashidi al Ibari al Ispahini (= the needle-maker of Isfahan).

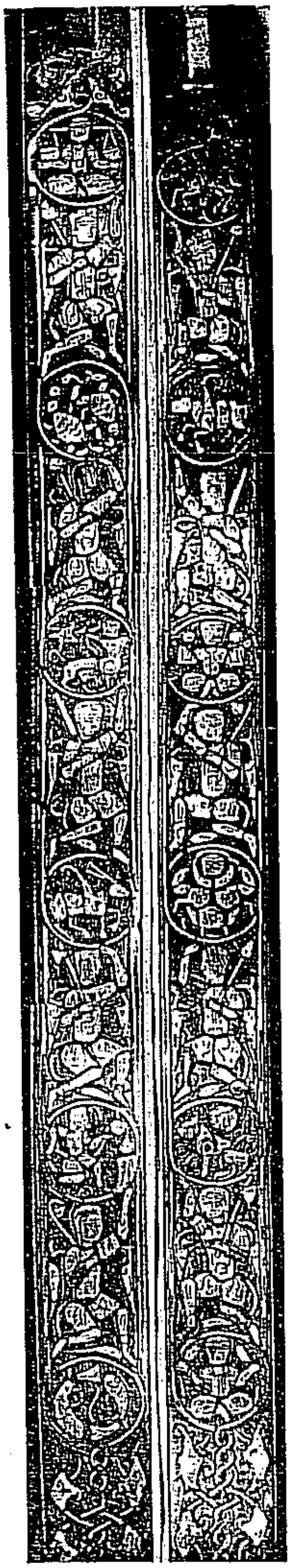
The date is given in words at the end of a long inscription round the back as *Hegira* 618 (= A.D. 1223 or 4).

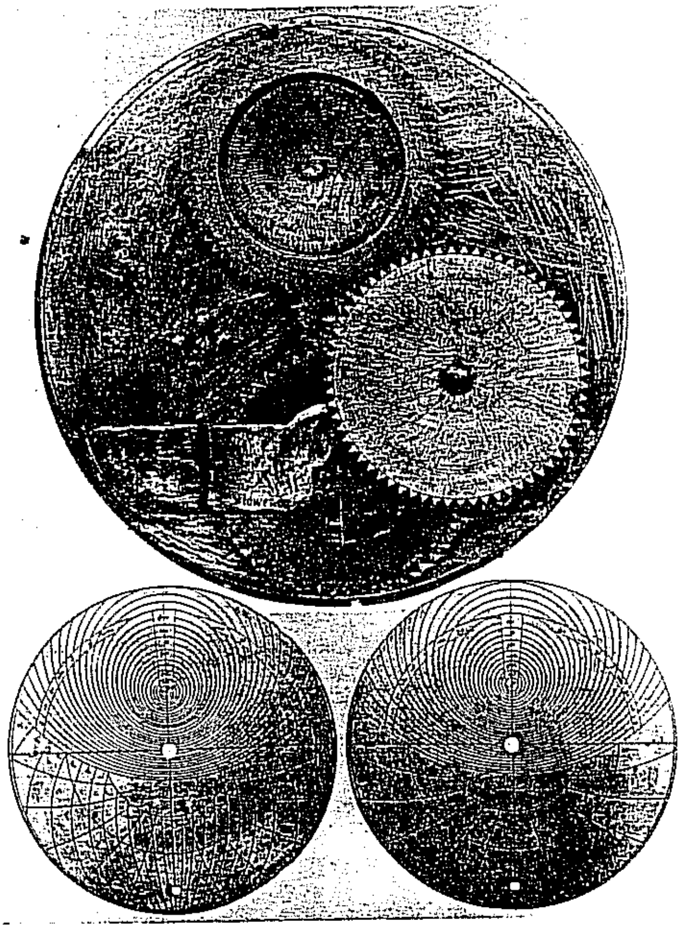
Suspension is by a relatively small ring and shackle attached to a large bracket decorated with intertwined foliage. The rim is $\frac{3}{8}$ inch wide. The instrument is unusually thick to contain the cog-wheels of the calendar movement, so the wide rim affords an extended surface for decoration, which the craftsman has utilized to the full by engraving and inlaying with silver a series of 12 roundels containing the 12 Zodiacal Signs separated by figures of warriors armed with battle-axes, swords, and clubs.

The ankabut presents several early characters. The design is simple and the star-pointers are mostly of the primitive dagger type, mounted upon bases. The majority of the pointers for 39 stars are three-cusped, but a few are curved and flame-like and three are animal-like. The inclusion of the Flying Eagle, Horse, and Falling Vulture as star-pointers for Altair, Mankib, and Waqi, suggests that this instrument was akin to the zoomorphic instruments of which the astrolabe of A.D. 1235 is so fine an example. Their inclusion is a direct reply to the remark by Morley in footnote 2 on page 15: 'I have not met with an Eastern Astrolabe in which the artist has allowed his inventive genius to overcome his religious prejudices by introducing the forms of animals.' We now record several other examples, particularly among the Mesopotamian instruments, cf. p. 237. A crescent and a quatrefoil also figure in this design, as in other early instruments of a period before the introduction of flowing tracery to support and ornament the essential parts of the ankabut. Mr. H. Loewe has deciphered the star-names as:



MOHAMMAD IBN ABI BEKR IBN MOHAMMAD AL-RASHIDI AL-IBARI, A.D. 1223–4





MOHAMMAD IBN ABI BEKR IBN
MOHAMMAD AL-RASHIDI AL-IBARI, A.D. 1223-4

3. Jihatu Qaitus.
4. Al Kaf al Jazma.
22. Al Ghul.
5. 'Ain al Thaur.
23. 'Aiyuq.
6. Al Yad.
7. Al Yad.
8. Rijl.
9. Rijl.
10. [Al Hai'ah]
11. Al Shamih.
12. Al Yamaniyyah.
13. Ras al Shira'i.
14. Al Taraf [al Asad].
15. Al Fard.
16. Qalb al Asad.
24. Rukbat al Dubb.
17. Qa'idat al-Batiyah.
18. Janah al Ghurab.
25. 'Anak.
19. Simak al A'zal.
26. [Simak] al Ramih.
20. Al R[as]. . . ?
27. Fakkah.
28. 'Unq.
21. Qalb al Aqrab.
29. Mankib al-Hayi.
30. Al Hawwa.
31. Waqi.
32. Al Ta'ir.
33. Janah al Dajajah.
34. Zanab al Dulfin.
35. Ridf.
1. Zanab al Jadi.
36. Al Jana[*h al Faras*].
37. Mankib al Faras.
2. Zanab Qaitus.
38. Al Hadib.
39. Al Mirah.

On the zodiac circle the degrees of the Signs are numbered by sixes.

There is no separate alidade; its place being taken by two pin-hole sights riveted to the rete itself at the bases of the bars of the equinoctial band, an arrangement not found in any other instrument in the collection.

The two tablets with almucantars inscribed for every third degree (*thulthi*) are (1) for lat. 32, hours 14 10′+lat. 36, hours 14 25′; and (2) for lat. 40, hours 14 40′+lat. 30, hours 14. The hour numbers were the accepted measure of the length of the longest day at the places for which the plates were constructed. The tablets are of thick metal and are keyed in position by holes and pegs near their lower border. Side 1*a* is marked with azimuth lines below the horizon in addition to the lines of the unequal hours. Cf. fig. 10.

On the Back a long arabic inscription round the rim, translated by Professor Margoliouth, sets forth the use of this part of the instrument:

' *Look at the Celestial Sphere, it will show you marvels: therein is displayed the wisdom of the merciful one. Its motions are diverse, by the individual who moves (=the Almighty), and it has meanings above all meanings in the year* *of the Hegira* 614.—*A Celestial Sphere which shows therein the new Moon rising, increasing and returning to waning. The body of the true luminary, the two of them confronting each other in opposition and in conjunction. It will show the amount of the course of each of them in the year and in the month. And in the present time let us occupy ourselves with scholarly mind in Arts which have been based upon exactitude and evidence.*'

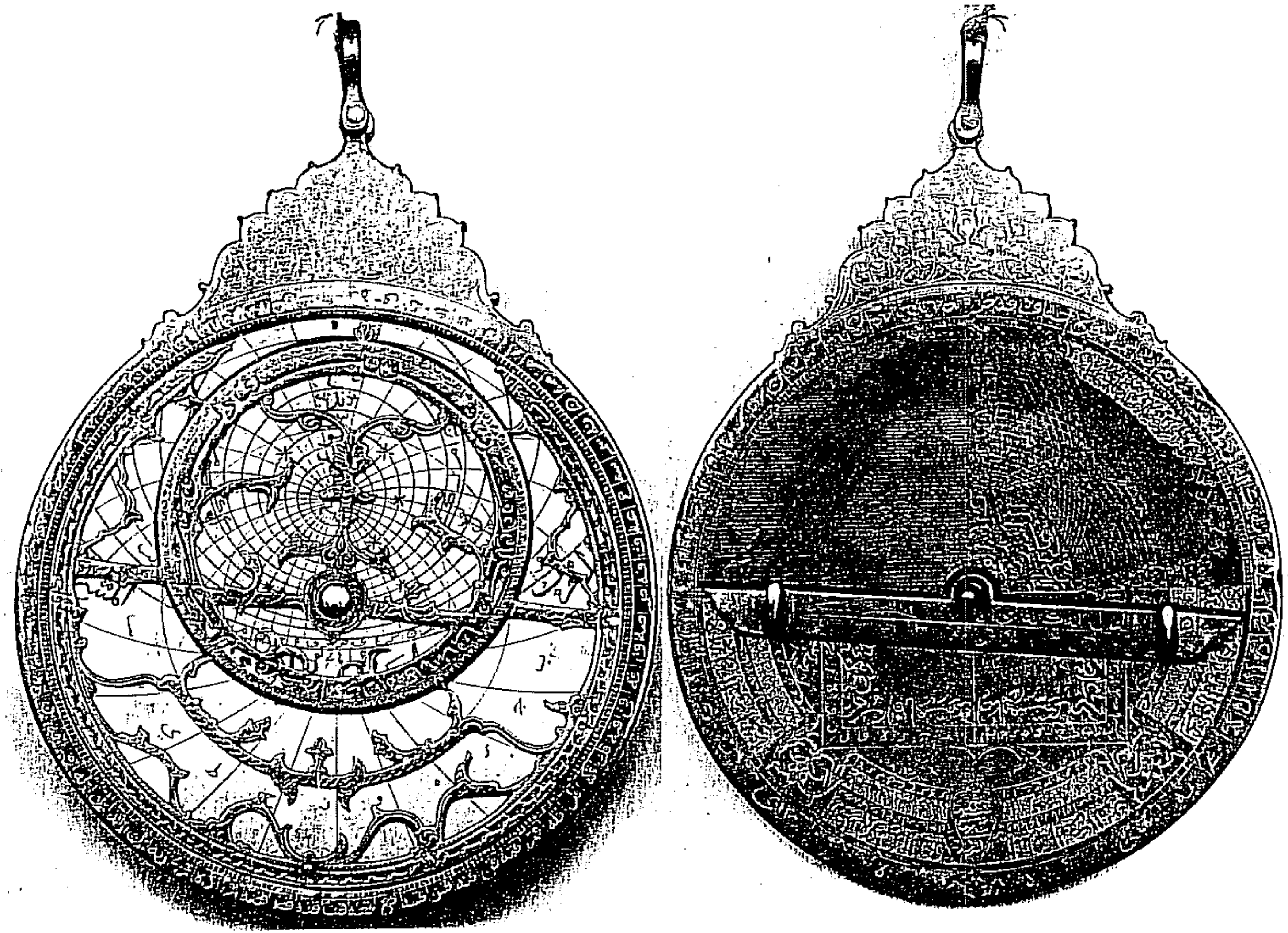
The Calendar arrangements are all attached to a removable back-plate which is ordinarily held in position by a pin and wedge, and is prevented from rotating by a small notch in the lower border which engages in the *mumsikah*. Three openings are cut in the plate, through which the underlying dials may be read. The first of these on the vertical diameter shows the Phases of the Moon and is surrounded by an arabic inscription reading *The increase of light of the Moon and its diminution.* Through an adjacent square orifice can be read *The number of Days of the Month*, up to 30 days. And below all is a dial inscribed *The Bodies of the two Luminaries meet on the day of Conjunction and face each other on the day of Opposition.*

To the other side of the back-plate is attached a train of cog-wheels by which the three dials are operated and their readings co-ordinated. Below the Moon-phase dial a double wheel of 64 teeth gears into a second wheel of 64 teeth, that by a pinion of 10 teeth engages with the wheel of 60 teeth to which the sun-circle is attached. The other part of the double 64-wheel gears with a small pinion wheel of 10 teeth, mounted on the centre-pin of the astrolabe, whose other 13 teeth drive a fifth wheel of 48 teeth, which last is fixed to the circle carrying the moon's 'body' on the dial of 'the two Luminaries'. It follows that the sun revolves once for every six revolutions of the astrolabe pin; and the ring attached to the 48-tooth wheel revolves once for every 3·6923 revolutions of the astrolabe pin. This gearing is now incorrect, and there are evidences that at one time there was another shaft and wheel.

On the cog-wheel is engraved *Its owner is the poor man Hassan Shah*, i.e. poor as compared with the Almighty.

It is hardly necessary to point out the extreme interest of these mechanical attachments to an early astrolabe. They represent the first step in the construction of astronomical clocks and orreries: they also illustrate the possible constructions of that remarkable instrument with internal cog-wheels that was dredged up from the Aegean Sea and was described by Lieutenant Perikles Rediadis as *Der Astrolabos von Antikythera.*[1]

[1] Cf. Svoronos, *Das Athener Nationalmuseum*, p. 44. 1903.



MEHDI OF YAZD, A.D. 1400–50

6. ALI BEN IBRAHIM'S ASTROLABE A.D. 1326.

Six inches in diameter.

Paris Observatoire. Given by Count Pertius of Beyrout.

The signature upon the instrument is

FIG. 62.

which has been read by Professor Margoliouth as

Wrought by Ali b. Ibrahim b. Muhammad b. Abi Muhammad b. Ibrahim year 726.

7. ANKABUT OF ASTROLABE OF ABUL FETIH MOOSA A.D. 1425

Pl. LIII.

L. Evans Collection.

This addition to a Syrian instrument of A.D. 1227–8 was made by a Persian craftsman two hundred years later. See p. 233.

8. MEHDI OF YAZD'S ASTROLABE A.D. 1400-50

Pl. XXVII

A nicely made astrolabe of gilt-brass, 4⅜ in. diam., ¼ in. thick and 5⅝ in. in length over all.

Bought by L. Evans, from Akchoté frères 214 Rue de Rivoli, Paris, £32.

On the cartouche on the back in Naskh characters is

'*The design of Mehdi of Yazd*'.

In A.D. 1319 Yazd, a town in Persia, was one of the important cities and the centre of Southern art.

The throne or *kursi* is entirely covered by a long quotation, also in Naskh characters, from the part of the Koran called 'The Throne', a very favourite source for the dedication of the brackets of Persian astrolabes: *God, there is no God but He; the Living, the Self-Subsisting, neither slumber nor sleep seizeth Him; to Him belongeth whatsoever is in heaven and on the earth. Who is he that can intercede with him, but through his good pleasure? He knoweth that which is past, and that which is to come unto them, and they* *shall not comprehend anything of His Knowledge, but so far as He pleases. His throne is extended over Heaven and earth, and the preservation of both is no burden unto Him. He is the High, the Mighty.*

Text of The Throne. Koran, 2nd Surat, verse 256.

The inscription round the edge of the astrolabe is:

O God do thou be gracious to bestow thy favour on Mohamet,
the chosen and well-approved Ali and others.

Then follow the names of the 12 Imams, or Saints of the Shiah sect, and the '*One that is to come*'.

The ring is missing. The contour of the *kursi* is enriched by the addition of small fillets to the large lobes that border the sides.

The tracery of the ankabut is symmetrically designed for 30 or 32 stars. The circle of Capricorn is supported by an east-west bar, and 4 ties. The Equinoctial band with some 6 star-pointers is unattached, except at the two ends.

With 5 tablets

1*a*.	Lat. 24°	4*a*.	Lat. 34°
b.	,, 33°	*b*.	Tablet of Horizons.
2*a*.	,, 30°	5*a*.	Lat. 34°
b.	,, 36°	*b*.	Ankabut co-ordinates.
3*a*.	,, 32°		
b.	,, 35°		

In the bottom of the *umm* is a circular gazetteer of towns and their latitudes in concentric bands divided into 32 divisions by radial curved lines.

The Back, which retains its original gilding and is fully inscribed, is of singular beauty, though it has less ornament than later instruments. The arcs of the two upper quadrants are graduated for measuring degrees of altitude; the arcs of the lower quadrants show Shadow scales.

i. The left upper quadrant is ruled as a sinecal quadrant.

ii. The right upper quadrant is the *Rub 'al Gharbi al-Janubi* engraved with parallel arcs drawn from scales of Signs of the Zodiac at each end.

The parallels of the Signs are cut by (*a*) the arcs of midday at 9 specified latitudes drawn towards the *kursi*; and by (*b*) the arcs of the azimuth of the Kiblah, i.e. of the altitude of the sun when it passes over the azimuthal circle of the Kiblah at five places.

iii, iv. The lower semicircle comprises the Squares of the Shadows and the Arcs of the Shadows above mentioned; and also four concentric bands divided into four sections. They are:

(*a*) Names of the Signs of the Zodiac, three in each section.
(*b*)
(*c*) The 28 Lunar mansions.
(*d*) The Faces of the planets.

The alidade is graduated with a scale of hours along one radius only. The sights have two pin-holes. *Faras* missing.

9. THE ASTROLABE OF MUHAMMAD MAHDI OF YEZD *Undated.*

Diameter 3¼ inches.

A very fine small astrolabe brought from Persia by the traveller, Claudius James Rich, and purchased in 1886 by the British Museum. It resembles No. 20, of A.D. 1659. The name of the engraver fills a cartouche on the back.

The tablets are tripartite:

1*a*.	Lat. 22°; hours	13. 32 min.			3*a*.	Lat. 32°; hours	14. 0 min.		
b.	,, 25°; ,,	13. 37 ,,			*b*.	,, 38°; ,,	14. 42 ,,		
2*a*.	,, 30°; ,,	13. 28 ,,			4*a*.	,, 34°; ,,	14. 12 ,,		
b.	,, 34°; ,,	13. 43 ,,			*b*.	,, 35°; ,,	14. 24 ,,		

In the *umm* is the usual list of towns with longitudes, latitudes, and *inhiraf*.

Back. Sinecal quadrant is ruled with horizontal lines for the degrees and radial lines for each 5°. The rt. hand quadrant is inscribed ' lines in the azimuth of the Kiblah and cities mentioned on their edges '.

Each of the alidade sight-vanes is pierced with two holes, the upper hole being the larger. The *faras* is missing, but the head of the pin is jewelled with a turquoise.

10. ABD AL'ALI'S ASTROLABE A.D. 1469.

Pl. XXVIII

Diameter 4¼ inches; total length including shackle and ring 6½ inches; thickness ¼ inch.

Bought by L. Evans on 5 May 1921 from Fenton, 33 Cranbourne St., W.C. 2. £52 10s.

The whole instrument is extremely well engraved. The front of the ' kursi ' or throne is decorated with foliated ornament within which, in a fairly large cartouche, with engraving on it, is contained the familiar text from the Koran:

His throne is the capacity of heaven and earth.

L

ABD AL-'ALI, A.D. 1469

The words in a smaller cartouche, beneath the Squares of the Shadows, on the back read:

The fabrication of Abd al'Ali. A.H. 874.

On the back of the ankabut, on the *muri*, there is '1119' or A.D. 1707, no doubt the date when some later owner acquired it.

This and the next following astrolabe of the same date are by the same maker. Dr. E. Knobel considers both as undoubtedly Persian, but engraved by an Arab, for the arabic words have in some cases accents, which are unused in Persian. The foliated design on the back of the kursi is so similar to that of No. 18 in the Hoffman Collection that it seems more difficult to explain the persistence of such a pattern through 200 years than to assume an error in the dating of this instrument.

To the ring is attached a faded silk cord or *ilakha*.

The ankabut shows 12 named stars within the zodiac and 16 outside. The tracery is devoid of the east-west bar and equinoctial band, that within the zodiac being of what may conveniently be termed the 88-type, thus resembling Astrolabe B illustrated in Lady Huggins' *Astrophysics* and the next example from the Evans Collection.

The 5 tablets are tripartite (*thulthi*), the almucantars being 3° apart, and, as is not unusual in these astrolabes, the lettering on the tablets is partly in relief, partly incised. On 3 of the sides it is in relief, like the inscription on the kursi, while on the other sides it is incised.

1*a*.	Lat. 22°	. .	hours	13. 21	min.	Lettering in ornamental relief.
b.	,, 27°	. .	,,	13. 42	,,	,, ,,
2*a*.	,, 32°	. .	,,	14. 50	,,	(should be 14.7'). Lettering in relief.
b.	,, 36°	. .	,,	14. 28	,,	Lettering incised.
3*a*.	,, 30°	. .	,,	13. 54	,,	,,
b.	,, 39°	. .	,,	14. 45	,,	,,
4*a*.	,, 34°	. .	,,	14. 17	,,	,,
b.	,, 37°	. .	,,	14. 34	,,	,,
5*a*.	,, 41°	. .	,,	14. 58	,,	,,
b.	Tablet of horizons drawn in 4 groups of 9 each.					

The edge of the *umm* is plain. In the interior are two circular tables containing the names, latitudes, and longitudes of 48 places. Both tables are engraved in 6 circular bands: the outer table is divided by curved radial lines into 32 divisions for as many places, and the inner table is divided into 16 divisions for 16 places.

ABDULLAH A'IMMAH, A.D. 1469

On the Back:

i. Quadrant ruled with 90 horizontal lines, one for each degree of altitude. Cf. fig. 25.

ii. Zodiacal quadrant.

iii, iv. Semicircle with Shadow Squares included within 6 concentric bands as in Astrolabe next to be described.

The wedge or *faras* has been restored. The horary divisions on the alidade are marked and lettered on an ornamented background.

11. An Astrolabe by Abdullah A'immah — A.D. 1469.

Pl. xxix

A brass astrolabe of 4$\frac{13}{16}$ inches diameter and very similar to the last.

Purchased at Sotheby's on 24 June 1921. From the collection of Sir William Townley, K.C.B.

Inscribed in a cartouche below the Shadow Scales with the name of the maker:

The work and the writing of Abdullah A'immah

followed by a date which Mr. Knobel read as ض = 800, ع = 70, د = 4, A.H. 874, or A.D. 1469. If this reading be correct, the maker can hardly have been the same Abdullah A'immah or Servant of the Imams as the one who turned out such fine work about A.D. 1700.

Below this is a marginal cartouche with the somewhat enigmatical remark in Persian, translated by Professor Margoliouth as

He omitted to write the latitude.

The Ring is provided with a brown cord or *ilakha*.

The *kursi* is nicely pierced with 18 holes producing a well-designed arabesque pattern.

The ankabut, for 29 stars, is without an east-west bar, and the tracery within the zodiac circle is of the 88 type, in which it resembles the last.

The 4 tablets are bipartite or *nisfi*, having almucantars for every second degree.

1*a*.	Lat. 30° . .	hours 43. 16 min.	(doubtless intended for 13 hours, 16 min.)
b.	„ 36° . .	„ 14. 28 „	
2*a*.	„ 32° . .	„ 14. 7 „	
b.	„ 34° . .	„ 14. 16 „	
3*a*.	„ 37° . .	„ 14. 38 „	
b.	„ 38° . .	„ 14. 39 „	
4*a*.	„ 40° . .	„ 14. 51 „	
b.	Tablet of horizons arranged in 4 groups of 6 each.		

The last plate resembles those figured by G. R. Kaye, Nos. 6 and 9. The lines for the unequal hours are numbered both in ciphers and hours. Dr. Knobel commented on the fact that several latitude plates show the number 8 = ح engraved ح (the origin of the figure 8), which is unusual, and Professor Margoliouth suggests that this may have been intended to take the place of dots.

On the Back we have in the four quadrants:

i. Sinical quadrant ruled with 60 lines each way. Cf. fig. 28.

ii. Zodiacal quadrant, similar to the one on the Morley Astrolabe, Pl. XVII. It is inscribed *Lines of the zeniths of the Kibla in those countries of which the extremities are noted on the western section.*

iii, iv. Semicircle with Shadow squares included within 6 concentric bands. These from without inwards are:

a. Shadow scales.
b. Planets.
c. Limits.
d. Zodiacal Signs.
e. Faces of Planets.
f. 28 Lunar Mansions.

The Squares of the Shadows are inscribed *Shadow feet* and *Shadow inches reversed* to left and right respectively. Below them the word *Equator* is twice repeated.

12. The Astrolabe of Shukr Allah Mukhlis — A.D. 1486

6 inches in diameter.

Exhibited by R. A. Harari, Esq., at the International Exhibition of Persian Art at the Royal Academy, January 1931.

Signed: *Shukr Allah Mukhlis of Shirwan*, (8)91.

Two verses in Persian give the name of Sultan Bayazid (Bayazid II of Turkey, 1481–1512). The *kursi* is inlaid with silver.

The suspension shackle is ornamented with roughly carved heads.

The design of the ankabut owes its peculiar character to the shape and size of the large leaves, which serve as star-pointers in addition to a few of the earlier dagger-type. In the centre in a trefoil space in the tracery the star *waqi* is indicated by a small bird. The workmanship is perhaps Syrian rather than Persian.

Note.—In the official catalogue the same signature is attributed to a much later and smaller astrolabe distinguished by the letter 'J', which shows that the organizers of the exhibition were none too sure of the instrument to which the description should apply, although the dimensions given should have served as a clue.

13. Astrolabe Delhi B. *c.* A.D. 1495.

Diameter 3.75 inches.

Delhi Museum. G. R. Kaye, 1920. Figs. 3, 4.

A well-constructed gilt, but undated, instrument. Inscribed in *nashki* script. Kursi, plain with two perforations. Ankabut of early type for 16 stars. The average precession is 49 minutes after the time of Ulugh Beg's catalogue of A.D. 1437.

The Tablets are sexpartite and 6 in number.

1*a*. *ba'ard S* 'for latitude 90°', engraved with concentric circles of declination which are numbered from the equator outwards to the tropic of Capricorn and inwards to the Pole.

b.	Lat. 0°	hours 12.	With azimuth circles and unequal hours.
2*a*.	,, 18°	,, 13. 5.	,, ,, ,, equal hours dotted.
b.	,, 20°	,, 13. 13.	,, ,, ,, ,, ,,
3*a*.	,, 21° 40′	,, 13. 21.	
b.	,, 23°	,, 13. 25.	
4*a*.	,, 25°	,, 13. 34.	Azimuth lines below horizon only.
b.	,, {28° 30°	,, 13. 46. ,, 13. 56.	
5*a*.	,, 32°	,, 14. 6.	} Divided along mid-line for use with one of the special plates.
b.	,, 36°	,, 14. 27.	}
6*a*.	,, {40° 60° 30′	,, 14. 51.	The second half is therefore a plate of 'the measure of the ankabut' and gives celestial latitudes.

b. Tablet of horizons from 8° to 71°.

The Back:

i. Margin graduated in degrees numbered quadrantally 5 to 90.
ii. Instrumentum horarum inequalium in left top quadrant.
iii. Graphical table of inverse sines and cosines in right top quadrant.
iv. Set of Polar co-ordinates in left bottom quadrant.
v. Shadow square and arc in right bottom quadrant.

14. The Astrolabe of Khalil b. Muhammad A.D. 1506

Exhibited by R. A. Harari, Esq., at the International Exhibition of Persian Art at the Royal Academy, January 1931.

Described in the Catalogue as signed:

Khalil b. Muhammad 912

and as engraved with a small panel containing the name of

Muhammad Baqir Isfahani.

A small astrolabe with a tassel of green silk.

The kursi is chased in a masterly manner with a symmetrical arabesque design.

15. THE ASTROLABE OF JA'FAR IBN OMAR. Figs. 63–65 A.D. 1566

S. V. Hoffman Collection No. 13.

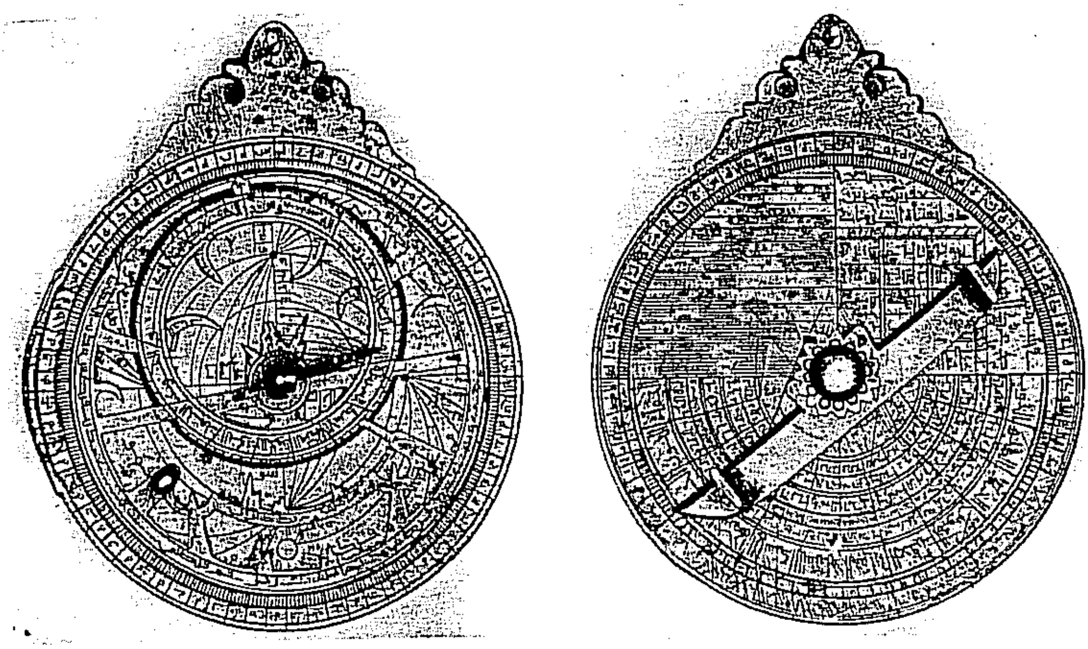
Diameter 2⅞ inches. Inscribed:

The Work of Ja'far ibn Omar son of Daulat-shah of Kirman A.H. 974.

This Ja'far must not be confounded with the Mohammad ibn Ja'far ibn Omar who made a globe, which is in the British Museum, in A.D. 1430.

Shackle and ring lost: bracket pierced with two holes.

Ankabut of early design, with dagger-like star-pointers below the east-west bar, and curved pointers elsewhere. The ends of the Equinoctial band



FIGS. 63, 64. JA'FAR IBN OMAR. A.D. 1566.

are looped exactly as in Shems al-Din's instrument (p. 241). The longitudes of some of the stars are between 5° 18′ and 6° more than Al Sufi. Taking the mean as 5° 30′, then with Precession of 51″, this gives an interval of 388 years. The epoch of Al Sufi = A.D. 964, add 388 = A.D. 1352, which may have been the date of the instrument from which this one has been copied.

In the 3 sexpartite tablets, 5 sides show the unequal hours, 3 sides show equal hours. All are drilled for a steady pin.

1*a*. Latitude 30°; hours 13. 18′
b. „ 32°; „ 14. 8′, with azimuths drawn below horizon.
2*a*. „ 36°; „ 14. 30′
b. „ 30° and 36°; a double plate.
3*a*. „ 34°; hours 14 19′
b. Tablet of horizons in four groups of 4. Inscribed ' To-day 80–46, to-day 80–54 ', &c.

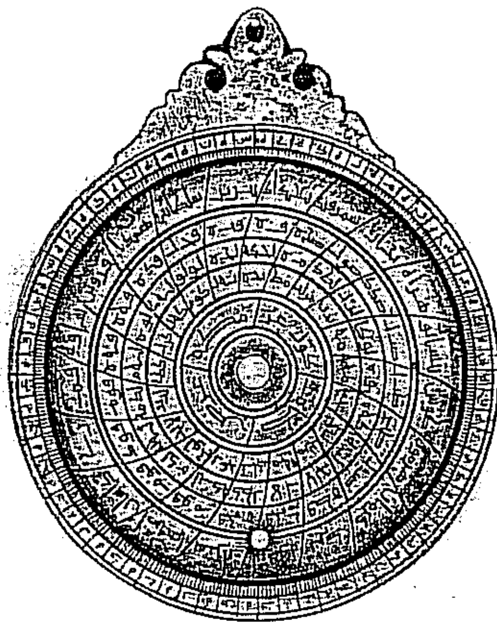


FIG. 65. GAZETTEER. A.D. 1566.

The *umm* is engraved with the longitudes, latitudes, and *inhiraf* of 20 towns. In the centre is ' *Longitude 72° or longitude from Mecca, latitude* 21° 40′. Reading from right to left the list is:

Tabriz 84° 30° ? 5 55. 30.	Abarkuh.
Sultanieh 81° 30 36° 36 26. 40.	Yezd.
Hamadan.	Kirman.
Kaswin.	Hormuz.
Saabah.	Tus.
Kum.	Nizapur.
Rayy.	Herat.
Kashan.	Bokhara.
Isfahan.	Samarcand.
Shiraz.	Bagdad 85° 31° 25 11. 5.

The alidade is roughly made: the pin and washer may be ancient.

16. THE ASTROLABE OF JA'FAR IBN OMAR. A.D. 1582

Inscribed :

The Work of Ja'far ibn Omar al Kirmani in the year A.H. 990.

Among some photographs of astrolabes which were sent to me by Mrs. Kaye on the death of her husband was one of great interest, which shows features resembling the last. The bracket is designed on similar lines, while the tracery of the ankabut is precisely of the same pattern as that of Shems al Dīn's instrument of A.D. 1288. The bird is also included, but the star-pointers are sickle-shaped.

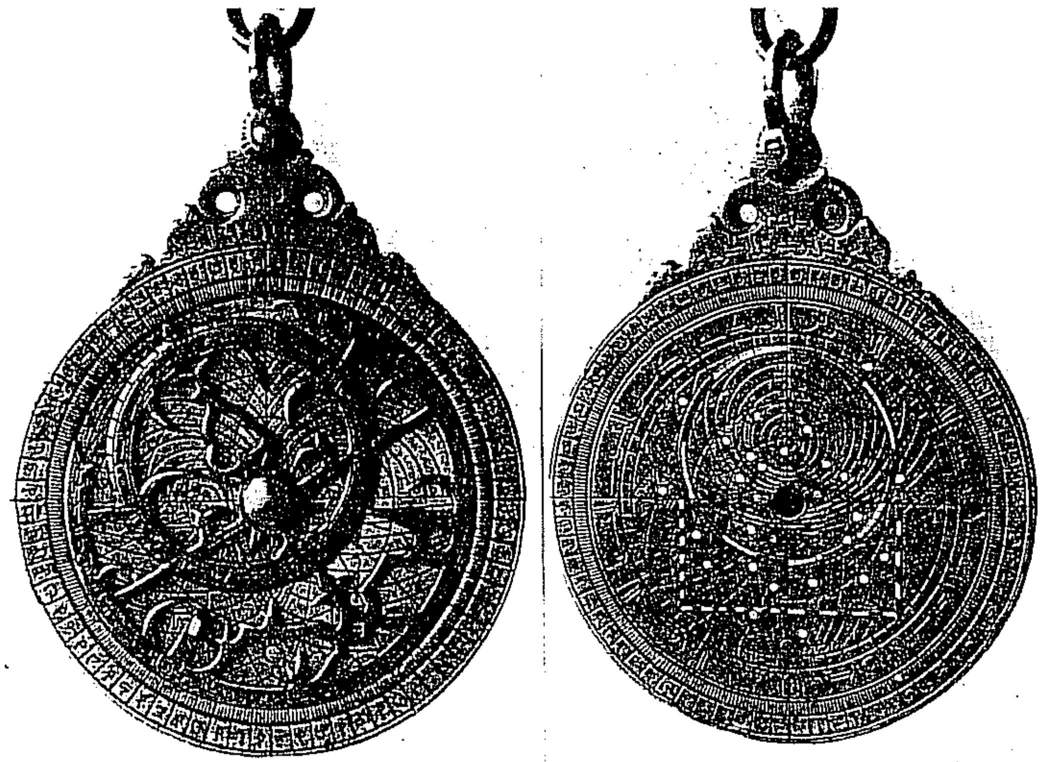


FIG. 66. JA'FAR IBN OMAR. A.D. 1582.
From a photograph by G. R. Kaye.

The Back presents the unusual feature of being marked as a star-map, with the positions of the 28 stars that are included in the ankabut, an arrangement which we have not seen on any other astrolabe.

We figure the instrument in the hope that its owner may communicate its whereabouts to us.

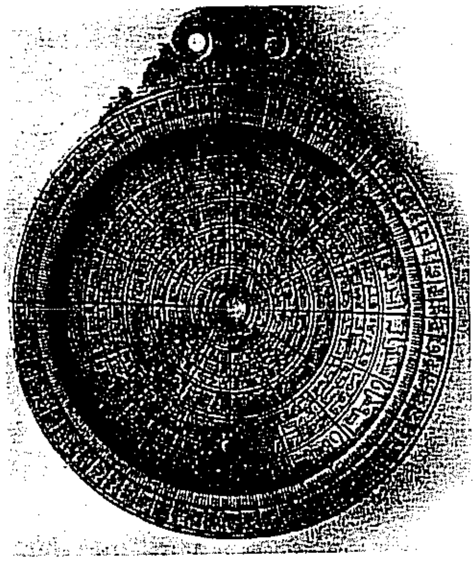


FIG. 67. JA'FAR IBN OMAR. A.D. 1582.
From a photograph by G. R. Kaye.

17. THE ASTROLABE OF MOHAMMED EL KALIL A.D. 1612.
Diameter $7\frac{1}{4}$ inches.

Property of R. Said-Ruete.

Made by the poor and humble Muhammad el Kalil son of Hassan Ali at Isfahan.

The name of the owner appears to be *Mohammed Bager*, *Isfahan* 1019 (i.e. A.D. 1612); Hassan Ali is mentioned by Chardin, vol. ii. 121. There are 6 plates. The upper right quadrant on the back is crossed by 6 lines of the azimuths of the kiblah at *Cufa*, *Bagdad*, *Isfahan*, *Simnan*, *Barat* and *Susa*.
(*Information from* Mr. Rudolph Said-Ruete.)

M

18. THE LARGE ASTROLABE OF SHAH ABBAS II A.D. 1647.

Pls. XXX–XXXII

Brass, 12 inches in diameter; 17 inches long; ⅝ inch thick; weight 18 lb. 4 oz.

This Astrolabe belonged to the family of the late Amir of Kabul, it was taken out of the Bala Hissar, and purchased at the prize sale of all property in Sherpore, by Colonel Cramer-Roberts in March 1879. It was exhibited at the Victoria and Albert Museum, was sold at Foster's Sale Rooms in Oct. 1921, being finally purchased by L. Evans from Mr. P. Webster of Great Portland St. for £120.

A perfect or *tamm* astrolabe showing almucantars for each degree. The tracery of the ankabut contains the name of Abbas II who was Shah of Persia in 1647.

The inscription, measuring 3½ in. × 2 in., on the front of the kursi is engraved on a floral background:

By The Order of His Most Excellent Majesty The Sultan The Just, The Great, Lord of the centres of command. Remover of the causes of tyranny and rebellion, King of the Kings of the age, Abu' Muzaffar Sultan Shah 'Abbas the Second, the Safawi, the Musawi, the Husaini, Bahadur Khan.

The inscription is continued on the back of the kursi also with interlinear foliate decoration.

May God Almighty perpetuate his Kingdom and his Empire and cause to spread over the worlds his justice and his benefits while the Spheres revolve and the Planets continue their courses.

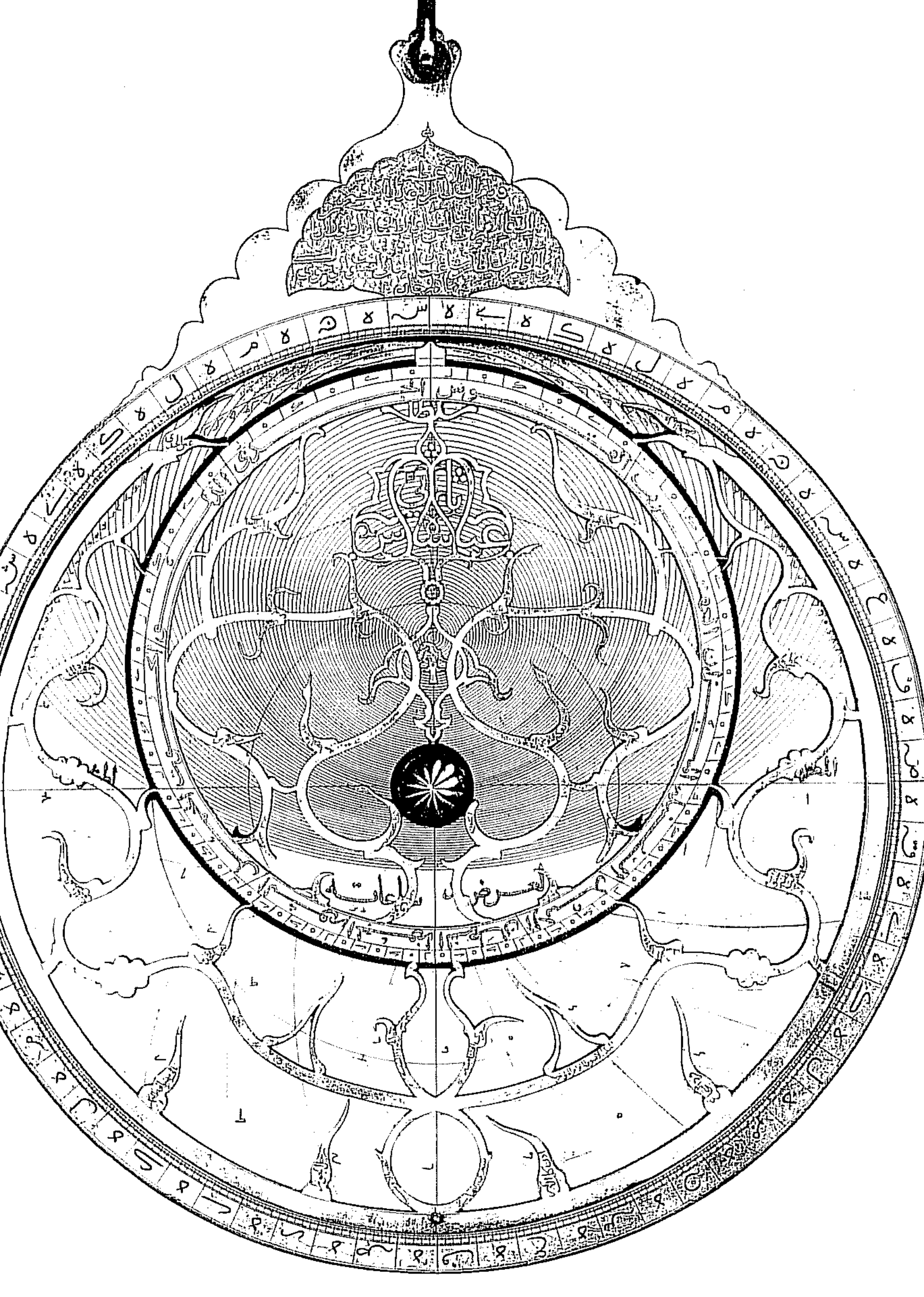
In the triangular inscription near the lower margin of the back is:

This Astrolabe was constructed, In accordance with the science of the least of the servants of the 'Aliyan, Sublime and Imperial Court, Muhammad Shafi' the Astronomer of Janabad and the skill of Muhammad of Yazd. In the year 1057 A.H.

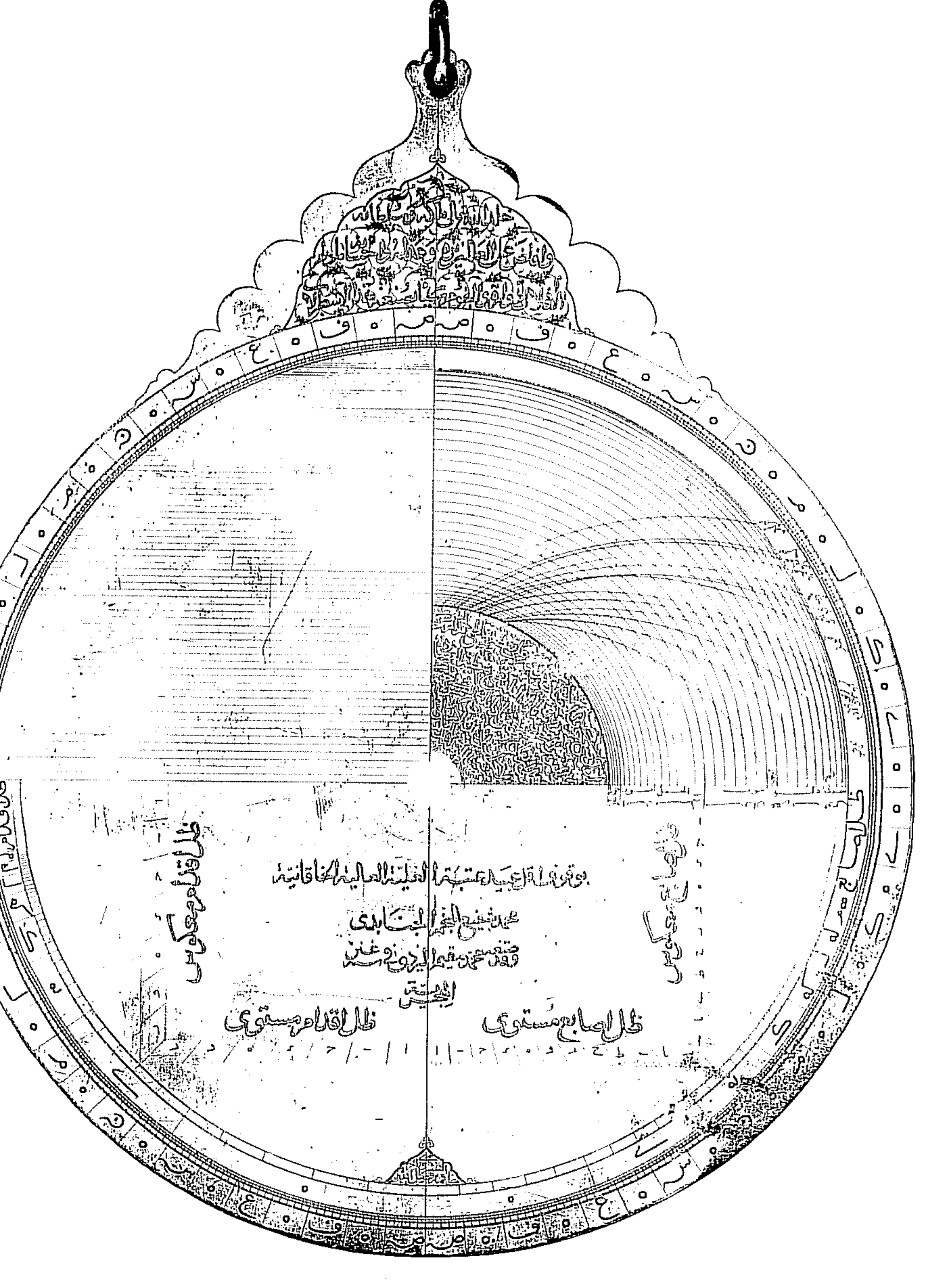
Suspension is by a ring and shackle attached to the massive *kursi*, which is cast in one piece with the mother. A leather strap takes the place of the usual plaited cord *ilakha*, being more suitable for so heavy an instrument.

The rim is divided in 360 degrees numbered in fives.

The ankabut is finely designed and wrought for 45, or perhaps 46, stars. The tracery is in the serpentine style without an east-west bar, but the



THE ASTROLABE OF SHAH ABBAS II, A.D. 1647



THE ASTROLABE OF SHAH ABBAS II, A.D. 1647 equinoctial band is continued like the tendril of a climbing plant between the Capricorn and Zodiac circles, to which it is lightly bonded by slender ties. Within the zodiac the pattern includes the first inscription, and a bird representing the star Waqi (Vega) in an enclosed space in the meridional line, which is flanked by two symmetrically reversed serpentine bands carrying lambent star-pointers.

STAR LIST outside the Zodiac.

Qalb al-'Aqrab	α Scorpii.
Simak al-'Azal	α Virginis.
Shafahah al Batiya al Janubiya	δ Crateris.
Qalb al-Asad	α Leonis.
Fard u'sh Shuja'	α Hydrae.
Al Mankibu 'lyusr min al tauam muakhir	Gemini.
Uzn Qalb al-Akbar	γ Canis majoris.
Shira al-Yamani	α ,,
Shi'ra al Shamiya	α Canis minoris.
Qatan'u'larnab	α Leporis.
Kit fu'l Jauza al Yusra	γ Orionis.
Yad al Jauza	α ,,
Rijl al Jauza	β ,,
Ainu's Sur	α Tauri.
Tali Masafat al Nahr	δελ Eridani.
Kaff al-Jazma	α Ceti.
Zanab al Qitus al Janubi	β ,,
? al Faras	?
Ain al-Jadi	Capricorni.

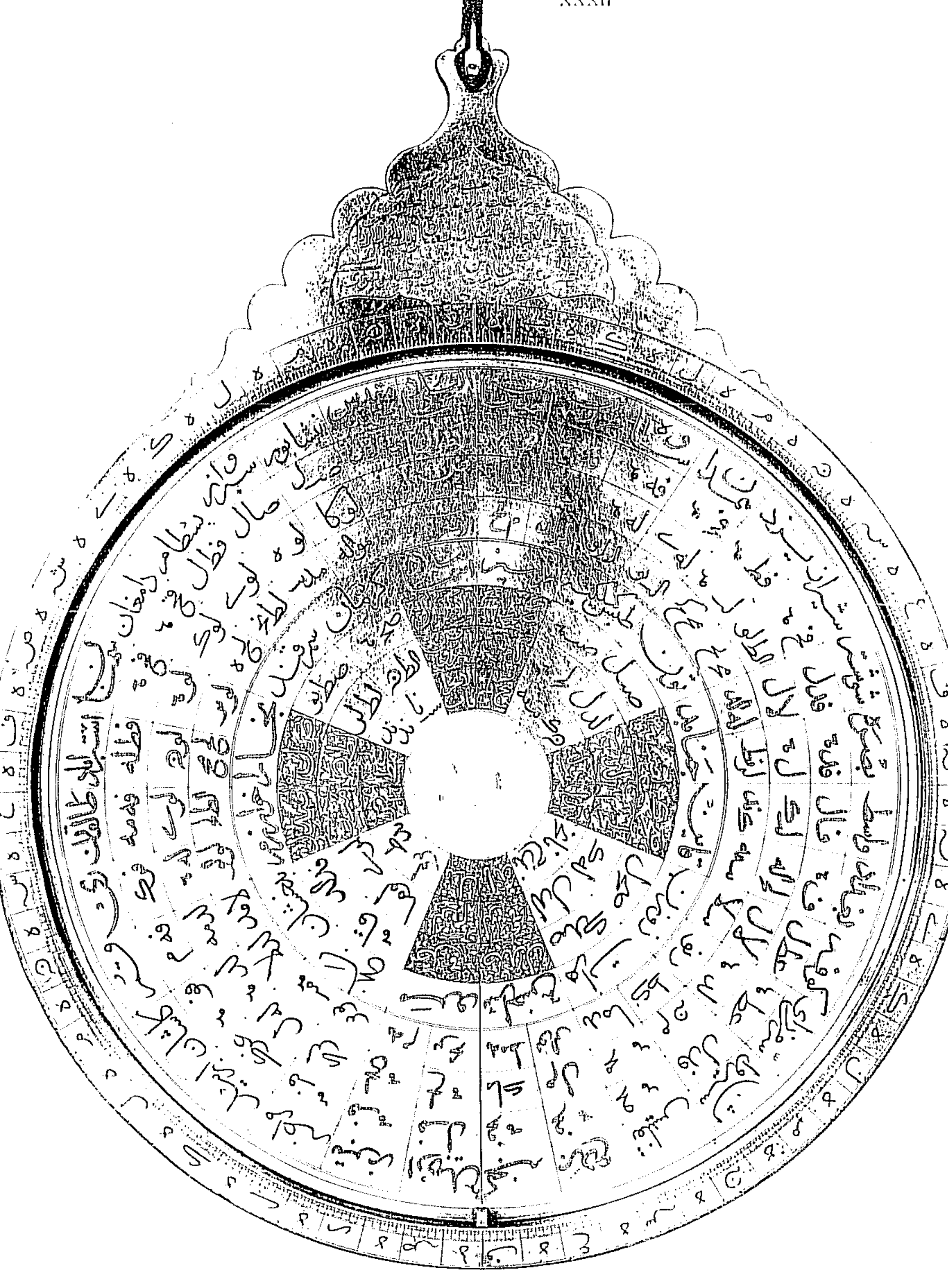
The instrument is furnished with 5 tablets, each 11 inches in diameter. Four of the tablets are of the ordinary type; the fifth shows on one side a tablet of horizons with four scales of 14 each, and on the other a variant of one figured by Morley, see Pl. VII, in which the original four quadrants are transposed.

1*a*.	Lat. 23°	4*a*.	Lat. 36°
b.	,, 43°	*b*.	,, 37°
2*a*.	,, 29°	5*a*.	Tablet of horizons in four groups of 14.
b.	,, 30°	*b*.	Lat. 35°, with quadrants transposed, as in fig. 12.
3*a*.	,, 33°		
b.	,, 37°		

The interior of the *umm* is very beautifully engraved and ornamented with two concentric circular tables, each of four circles, showing the names of towns, their longitudes, their latitudes, and their *inhiraf* or angle of the horizon intercepted between their meridians and the vertical circle joining their zeniths and the zenith of Mecca. A rich decorative effect is obtained by the shading of the central segments like an ancient cross.

The circles are cut into 8 sectors, of which 7 contain 6 towns, and the first, under the *kursi*, 4, the strip to the left of the middle line, carrying a legend for each circle.

Sectors.	*Towns.*	*Longitudes.*	*Latitudes.*	*Inhirafat.*
1	Mashhad	92° 30′	37°	49° 52′
	Isfahan	86 40	32 25′	40 38
	Quazvin	85	36	27 34
	Turshiz	92	35	48 11
2	Sawa	85	35	29 16
	Hamadan	83	35 10	22 16
	Yazd	87	32	48 28
	Shiraz	81	29 36	43 18
	Tabas	92	33	52 55
	Tun	92 30	34 40	50 20
3	Shustar	84 30	31 30	35 24
	Busrah	84	30	37 59
	Wasit	81 50	32 20	20 54
	Baghdad	80	33 25	33 25
	Janabad	92	34	52 35
	Qain	93 20	33 40	54 01
4	Kufah	79 30	31 30	12 31
	Surra man rai	79	34	7 56
	Shirwan	84 30	40 50	20 09
	Tiflis	83	43	14 41
	Zuzan	93 30	35 30	51 53
	Herat	94 20	34 30	54 08
5	Barda'	83	40 30	56 24
	Kajana	83	41 20	45 49
	Ardabil	82 50	38	17 13
	Tabriz	82	38	15 40
	Serrakhs	94 30	34	11 14
	Madu	90	34 40	12 30
6	Maragha	82	34 20	16 4
	Arbil	77 20	35 40	42
	Kashan	86	34	44 41
	Qum	85 40	34 45	41 44
	Balkh	101	36 41	14 34
	Badakhshan	84 24 ?	34 10	14 09



THE ASTROLABE OF SHAH ABBAS II. A.D. 1647

7	Rai	84° 20′	35°	36° 26′
	Taligan	85 45	36 10′	29 23
	Astarabad	89 25	36 50	38 48
	Samnan	88	36	36 14
	Khwarizm	94 30	42 04	40 44
	Bukhara	97 30	39 50	18 49
8	Damghan	88	36 20	38 05
	Bastam	89 30	36	39 53
	Sabzawar	91 30	36	44 12
	Nishabur	92 30	36 21	46 25
	Samarqand	99 16	39 34	54 54
	Kirman	93	29 50	62 51

On the Back the rim is divided into four quadrants of 90 degrees numbered in fives, each degree being divided into quarters.

In the upper semicircle are:

i. A sinical quadrant on the left.

ii. Zodiacal quadrant with arcs of the Kiblah as described on p. 18.

iii, iv. Quadrants below the horizontal with shadow scales graduated both along the peripheral arcs and at the sides of the squares of the shadows.

The alidade, with hole-and-slot sights, is graduated with declination scales.

19. Abd-ur-Razzak's Astrolabe. Pl. xxxiii. A.D. 1651.

A brass Arabic astrolabe 4⅛ inches in diameter; length 6⅝ inches from the top of the suspension shackle to the bottom of the instrument; thickness $\frac{5}{32}$ inch.

Bought in March 1905 by L. Evans in Paris for £10.
Described as No. 19, L. Evans, *Arch. Journ.*, 1911, Pl. V.

The *kursi* inscriptions are contained in two cartouches. The upper:

According to the order of Maulana (our master) *Fadilat Shah*;

the lower bears the maker's name:

Abd-ur-Razzak, of Ghilan in the month Sha'bān A.H. 1051 (=November A.D. 1651).

In a later hand round the rim seems to be '*The writing is manifest upon the* [surface ?], *and it is its owner ? Ibrahim* (?) *son of Sharaf ud-Din Husain*'.

A gazetteer is engraved on 8 concentric bands in the *umm*.

The ankabut is made for 27 stars. Its tracery is of the serpentine type that includes an east-west bar. Star-pointers are foliate.

Four tablets are provided for the following latitudes:

1*a*.	Lat. 21° 40 min.	hours	13. 32.
b.	,, 38°	,,	14. 40.
2*a*.	,, 29°	,,	13. 52.
b.	,, 34°	,,	14. 14.
3*a*.	,, 32°	,,	14. 7.
b.	,, 32° ?	,,	14. 32.
4.	Tablet of horizons.		

20. The Astrolabe of Muhammad Mahdi al-Khadim A.D. 1659.

Figures on p. 49.

Diameter 4½ inches; total height to top of shackle 6$\frac{3}{16}$ inches.

Owner in 1855, Mr. Williams, Assistant Secretary to the Royal Astronomical Society. Later it passed into the possession of Professor Couch Adams, P.R.A.S., the discoverer of Neptune, at whose death in 1892 it was presented to the Ethnographical Museum at Cambridge by his widow.

This beautiful small astrolabe has been partly described by Morley, pp. 48–9. It is inscribed in Persian (*nastalik*) and in Arabic (*naskh*) characters.

On the Back is the name of the maker,

Muhammad Mahdi al-Khadim,

and on the *kursi*,

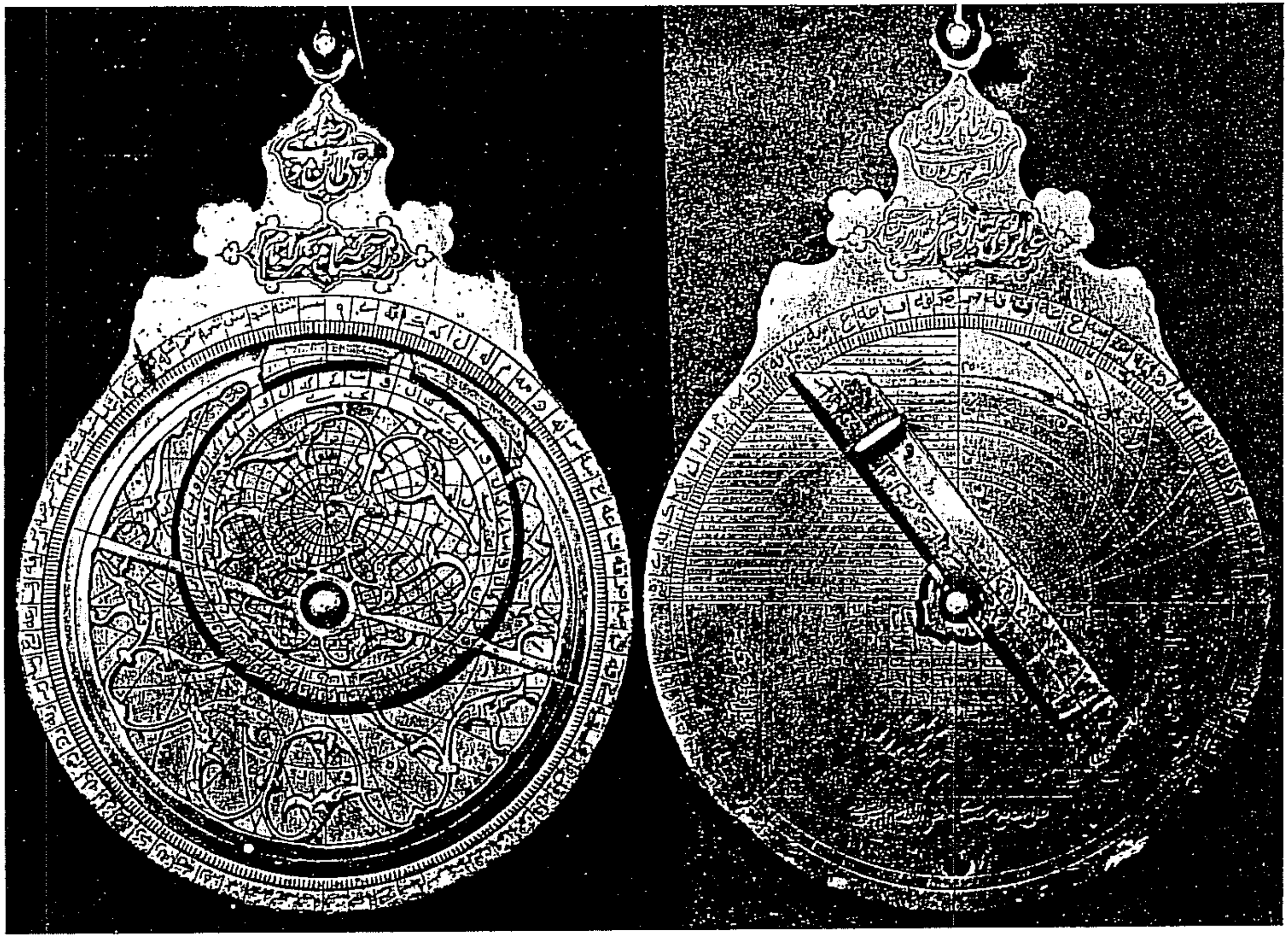
Constructed for Muhammad Bákir Isfahani.

On the circle round the ankabut are verses, the last of which is a chronogram giving the date according to the Abjad notation,

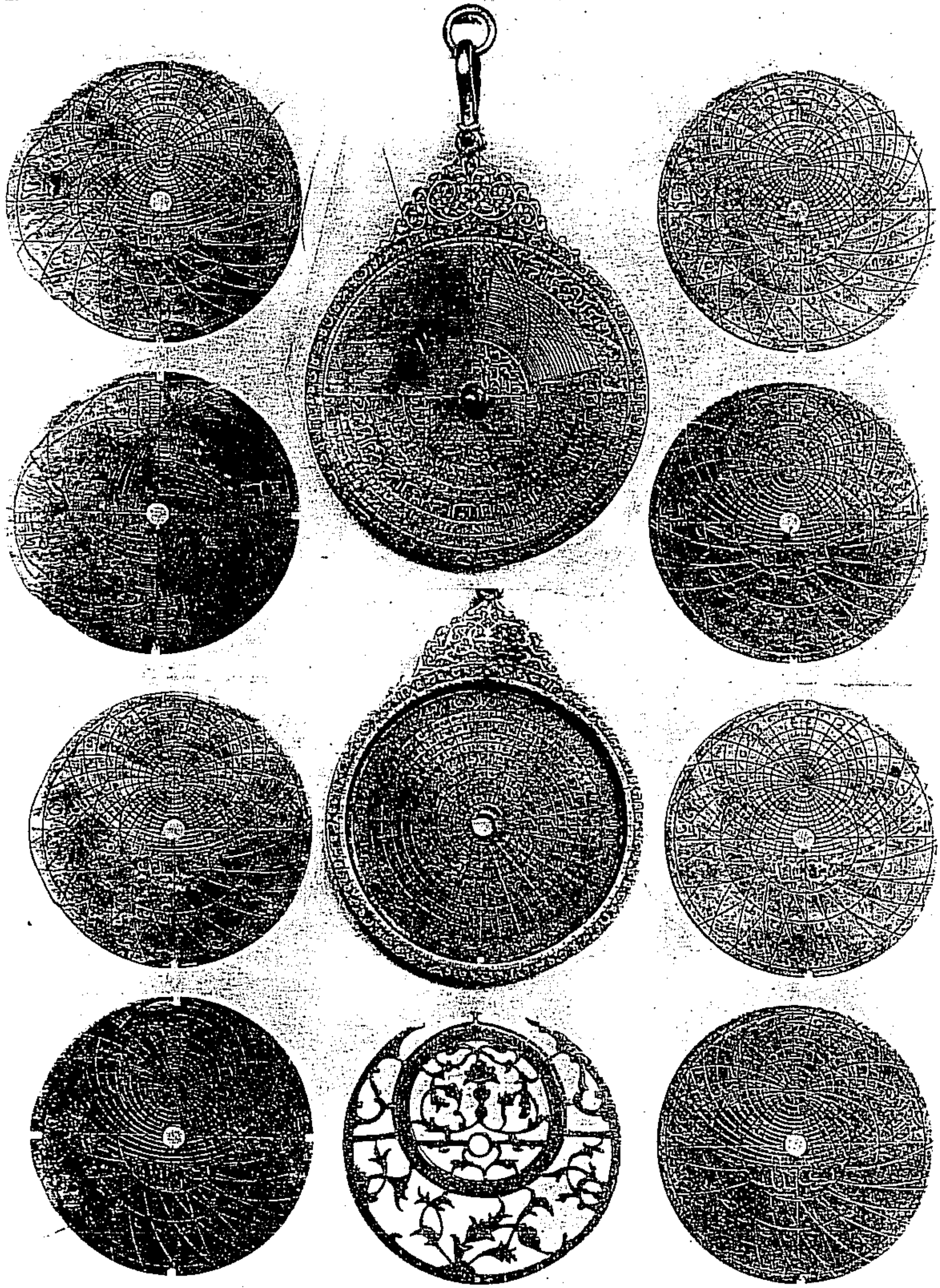
It is the mirror of Alexander and the mirror representing the whole Universe, whence A.H. 1070, or A.D. 1659.

The central part of the *kursi* is divided from two lateral portions by two pear-shaped perforations, and in its well-designed contour the repeated ogees are an important element. Upon it is inscribed the entire *Verse of the Throne.*

The ankabut is an exquisite work of art in which the star-pointers are all formed of large leaves with serrate edges, growing upon a slender spiral stem arising within the zodiac circle near the *almuri*. The leaves representing the southern stars mostly spring from three flower-like mounds on the band of Capricorn. The east-west bar, counterchanged, is the only structural, as opposed to the purely decorative, feature which has been retained in the design. The free ends of the Capricorn band have been enriched by inlaid turquoises.



ABD-UR-RASSAK OF GHILAN, A.D. 1651



MOHAMMAD TAHIR

A small compass-box of silver is fitted into the back of the *kursi*, which is the earliest example of such an addition to a Persian astrolabe known to us. It would have been useful as a guide to direct the gaze and genuflexions of faithful Mussulmans towards Mecca. Compasses had been fitted to European astrolabes quite a century earlier.

There are four sexpartite tablets, and a fifth with the most remarkable star-maps shown on p. 49. The others are for latitudes.

1*a*.	Lat. 30°.	With azimuths in addition to hour lines as shown on Pl. VIII.
b.	„ 33°.	
2*a*.	„ 30°.	With hour lines as shown on Pl. IX.
b.	„ 39°.	
3*a*.	„ 36°.	
b.	„ 33° and 42°, a double projection.	
4*a*.	„ 42°.	
b.	Tablet of horizons with 4 notches for the *mumsikah*.	
5.	Northern and southern planispheres.	

These planispheres are figured and described on p. 49. They are an unusual feature, but must have been very useful for enabling the astrolabist to set the star-pointers in their right positions.

An undated astrolabe by Mohammad Tahir in the Evans Collection, No. 21, is evidently a rather poorly executed, diminutive copy of this masterpiece by Muhammad Mahdi—in fact its poor relation—and as such may conveniently be considered next. No. 9 probably also belongs here.

21. Mohammad Tahir's Astrolabe. Pl. xxxiv *XVIIth Cent.*

L. Evans Collection.

Diameter $2\frac{5}{8}$ inches; total length $4\frac{3}{4}$ inches; thickness $\frac{1}{16}$ inch. Made in Teheran, and brought thence in 1920 with a leather case.

Inscribed in a cartouche below the shadow scales on the back:

The work of Mohammad Tahir.

And on the bottom edge: *Finished by Abdullah A'immah.*

The *kursi* is decorated with arabesque foliations in front, flowers at back. The degree numbers on the rim are in relief on a shaded background.

The ankabut, which is made for 23 (?) stars, is of an attractive design, though not specially remarkable for a high finish. As in the last, the foliate southern star-pointers spring from the mounds.

The 4 plates are *sudsi*, with almucantars for every sixth degree. They are inscribed for:

1*a*.	Lat. 33° . .	hours 14. 12.	3*a*.	Lat. 35° . .	hours ? 13. 34.
b.	„ 34° . .	„ 14. 16.	*b*.	„ 38° . .	hours 14. 39.
2*a*.	„ 35° . .	„ 14. 12.	4*a*.	„ 37° . .	„ 13. 42.
b.	Tablet of horizons.		*b*.	„ 38° . .	„ 13. 47.

On the bottom of the mater is a gazetteer of 54 places with their latitudes engraved in 10 concentric circles in 2 series.

On the Back:

i. Left, a quadrant of sines for every 5 degrees, crossed by a dotted chord.

ii. Right, a quadrant with the zodiac scales, and parallel arcs crossed by (1) arcs of the azimuth of the Kiblah at 3 places and (2) arcs of mid-day at 5 latitudes.

22. Persian Astrolabe A.D. 1663.

Diameter 7½ inches.

South Kensington Museum, No. 530. 76.

Uninscribed with any name, but said to be dated A.H. 1074.

The *umm* has been deepened by the addition of two thin brass circles, riveted and soldered between the rim and the base-plate. The ankabut for 31+18 stars is rudely fashioned. The star-pointers on the zodiac are long and incurved; a cluster of short pointers flanks the broadened meridional bar, which includes a triangle, quatrefoil, and circle in its somewhat heavy scheme of decoration. A small *mudir* is attached to the middle of the equinoctial band.

Four tripartite tablets are provided for latitudes 32° and 33°, 33° and 34°, 39° and 40°, 16° and a tablet of horizons. They were fixed by a steady pin which has been torn out of the *umm*. The pin has a screw which is secured by a fluted, conical nut with small lugs.

The arrangement of the quadrants on the back is somewhat unusual:

i. Quadrant of sines, with radii to every fifth degree and concentric circles.

ii. In the left upper quadrant is a shadow square divided to 12 parts, within which is a rectangular table.

iii. Within a lower shadow scale are scales of the zodiac and of the 28 manzils.

23. The Tattah Astrolabe. Fig. 22. A.D. 1665.

H.E.I.C. Museum. Described as Morley D on pp. 37–9.

A 4⅝-inch *sudsi* instrument, inscribed in clumsy but legible Naskh characters within the shadow squares:

Made by Muhammad Sálih, (at) Tattah, in the year (of the Hegira) 1076.

24. Clarke-Thornhill's Astrolabe A.D. 1666.

Presented by T. B. Clarke-Thornhill to South Kensington Museum, Nos. 38–9, 1916.

About 4½ inches in diameter. The design of the ankabut is like that of No. 20, with three groups of leaves.

It is accompanied by a manuscript containing a date of ownership corresponding to A.D. 1405, so that it may have been written in the fourteenth century. It is entitled *Risaleh dar ma'rifat i usturlab*, or ' Treatise on the knowledge of the Astrolabe '.

25. The Astrolabe of Mohammad Mahdi. Pl. xxxv and fig. 68. A.D. 1667.

4½ inches in diameter.

S. V. Hoffman Collection, No. 12.

Inscribed in cartouche on Back:

Engraving completed by Mohammad Mahdi ibn Mohammad Amin Alradi.

And on border below is a chronogram giving the date:

. . . *the date was 1078.*

On the front of the throne is written ' *He is God the exalted and his throne is the width of the Earth* ', &c., and at the back is a recess for a magnetic compass, then a novel feature in Oriental astrolabes. On either side of this cavity is a list of place-names, starting at the apex with the name *Hut*, which signifies the constellation Pisces.

Left.	*Right.*	
1. Haleb (Aleppo).	1. Damdam̄.	8. Qum.
2. Tabriyyah (Tiberias).	2. Samari.	9. Istana.
3. Tabriz.	3. Shamakh.	10. Ajmere.
4. Derbend	4. Taif.	11. Bander Surat.
5. Mahdyyah.	5. Bistan.	12. Somnath.
6. Habasha.	6. Tun.	13. Nejd.
7. Schacha Buwana.	7. Homs.	
8. Bahr.		

N

The ankabut has the equinoctial band and a counter-changed east-west bar, but is devoid of tracery, space being filled by the enlargement of roughly foliate star-pointers. The Capricorn band includes 3 panels of decorative inscription, an unusual feature.

The stars are grouped 10 in and 11 out of the zodiac circle.

Five tripartite plates are provided for latitudes 24° and 32°, 29° and 35°, 32° and 36°, 30° and ankabut co-ordinates, 40° and tablet of horizons in 4 groups of 7.

The gazetteer in the *umm* is engraved in two circular bands and includes the *inhiraf*.

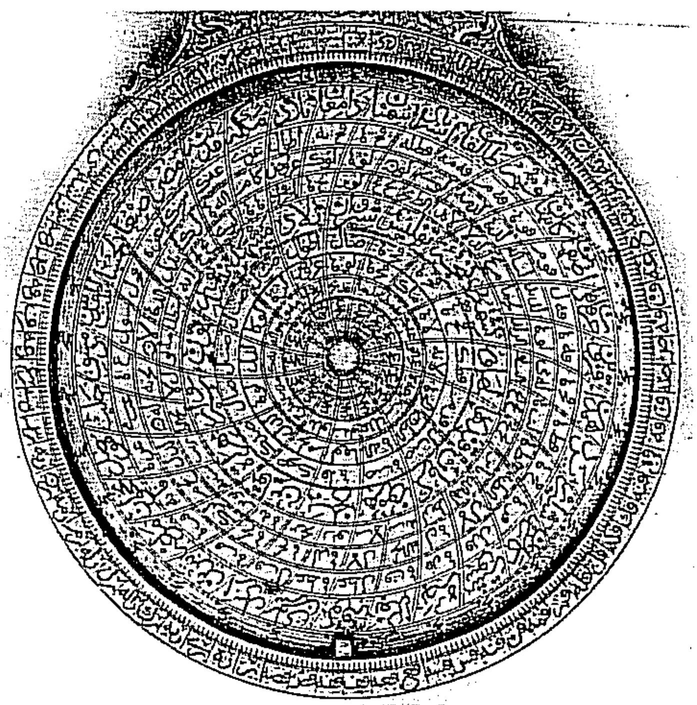
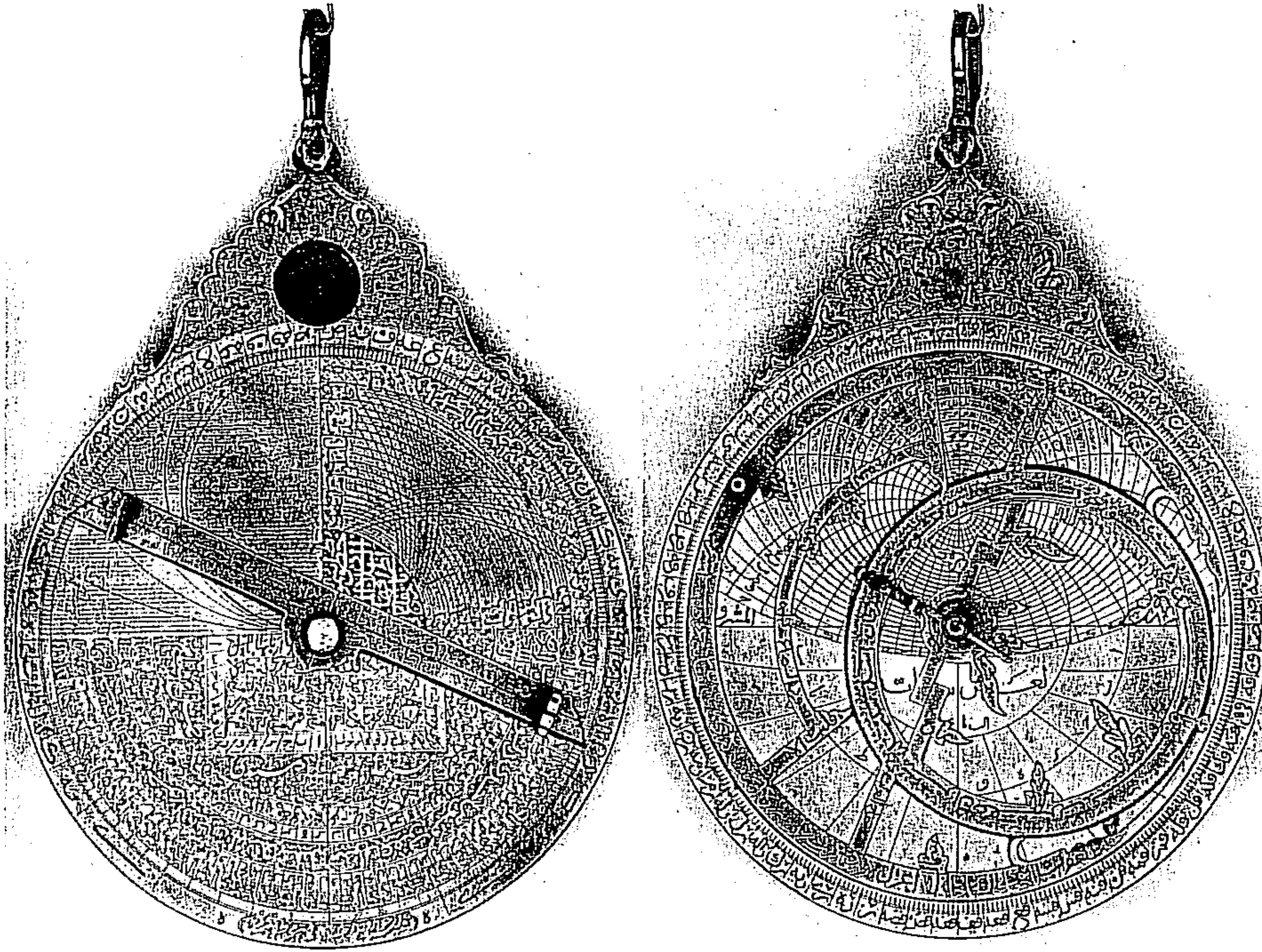


FIG. 68. MOHAMMAD MAHDI'S GAZETTEER. A.D. 1667.

The Back closely resembles that of the fully engraved example figured on Plate XVII, which is 45 years more recent. In the first quadrant horary lines have been superimposed upon the sexagesimal series of *mabsut* sines.



MOHAMMAD MAHDI, A.D. 1667

26. The Literary Astrolabe of Mohamed son of Mohamed Al-Umari A.D. 1670.

Diameter $3\frac{1}{2}$ inches; highly decorated with bracket inlaid with 4 patches of red enamel; shackle of silver.

Said to have been taken as loot by a New Zealander during the Senussi campaign, and submitted to me for examination by an officer in the R.A.F.

Inscribed on Back in a cartouche below the squares of the shadows:

By the art of Mohamed son of Mohamed Al-Umari, the servant.

A continuation in the border appears to read:

The Latitude is the engraving which is wanting (?).

On the border of the ankabut:

By association with thee Oh Ali, Oh Ali, Oh Ali, call unto Ali, the manifestor of marvels, thou shalt find him an assistance to thee in all calamities. Every trouble and grief shall be dispelled by association with thee Oh Ali.

And elsewhere:

The buildings of Alexander and marble.

The date is at the left-hand end of the border of the ankabut *A.H. 1079* (=A.D. 1670).

On the alidade:

From the depth of grief unto the sun of thy horoscope, In order that thou mayest receive the fragrance of the continuation of life, take the Astrolabe.

The plates are engraved for the following latitudes:

1*a*.	Lat. 30°	. . hours	8. 8.
b.	„ 36°	. . „	14. 8.
2*a*.	„ 32°	. . „	18. 32.
b.	„ 34°	. . „	14. 17.
3*a*.	„ 32°	. . „	14. 6.
b.	„ 38°	. . „	14. 42.
4*a*.	„ 38°	. . „	14. 12.
b.	„ 45°	. . „	41. 15.
5*a*.	„ 34°	. . „	8. 30.
b.	'Total Inclination Scales.'		

6, 12, 8, 34. 'Longitude of the total Inclination.'
6, 12, 8, 34.

Within the outer circles of numbers and divisions of degrees, arranged in groups of 5, are the usual quadrants:

i. Quadrant of sines, with hour-lines superimposed.
ii. Zodiacal quadrant fully inscribed.

iii, iv. Semicircle with marginal shadow scales and squares of the shadows, with planetary, zodiacal, and lunar mansion scales worked in between.

The ends of the alidade are pierced with decorative holes. Cf. Haj Ali's astrolabe and the one described on p. 145.

27. HAJ ALI'S ASTROLABE A.D. 1788.

In the Collection of Bassermann Jordan at Munich.

Diameter 92 mm.

Inscribed in a cartouche below the squares of the shadows and between the words meaning 'Level':

Made by Haj Ali in the year 1203.

Kursi beautifully ornamented with a symmetrical arabesque design thrown into high relief by being pierced in 46 places.

Border divided into 24 spaces indicating hours, within which is the divided circle of degrees.

The design of the ankabut resembles that of No. 26, with the E.-W. bar across the zodiac, and ⏟-shaped band in the lunar space.

The diametric label has two ornamental perforations near the ends, and is counterchanged on alternate sides of the fiducial line.

On the Back the radii of the Sinecal Quadrant are divided into 60 equal divisions from which vertical and horizontal lines are ruled in both directions.

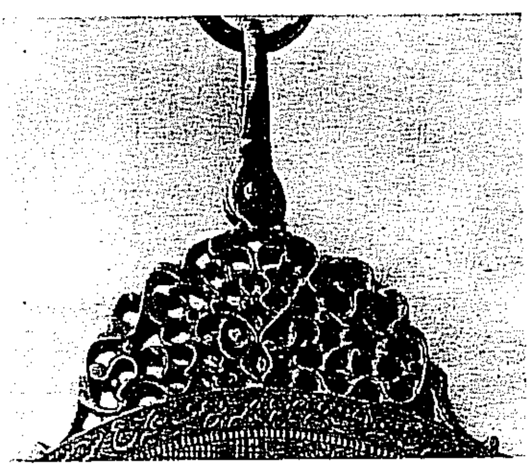


FIG. 69. BASSERMANN JORDAN'S ASTROLABE.

28. Persian Astrolabe of A.H. 1089. Pl. XXXVI A.D. 1688.

Diameter $3\frac{5}{16}$ inches; thickness $\frac{3}{16}$ inch.

Bought by L. Evans in February 1911 from Vitali Francis Frères, Algeria.

Bracket simple and solid. Dated '١٠٨٩' (=A.H. 1089 or A.D. 1688).

The ankabut, for 21 stars, is characterized by having an east-west bar, but the extra-zodiacal star-pointers are all carried on two independent serpentine tendrils that do not touch the zodiac circle.

The *umm* is left quite plain.

The 4 plates are *sudsi* and are marked as follows:

1*a*.	Lat. 36° Mosul.	3*a*.	Lat. 42° Adrianople.
b.	„ 41° Aswan.	*b*.	„ 43° Trebizond.
2*a*.	„ 38° Diarbekr.	4*a*.	„ 21° of the Kaba.
b.	„ 39° Erzeroum.	*b*.	Tablet of horizons.

The engraving on the Back is devoid of ornament. The two upper quadrants are graduated in two-degree spaces, numbered by tens.

i. Quadrant with 12 concentric circles traversed by 9 radii.

ii. Sinical quadrant ruled in squares, 10 to a side.

iii, iv. Squares of the shadows, with the *linea mediae umbrae* as in No. 108.

29. Persian Astrolabe *c.* 1650–1700.

A somewhat weighty little instrument made from a single massive casting, $3\frac{1}{4}$ inches in diameter; total height $5\frac{3}{8}$ inches.

Purchased by L. Evans with Mr. S. Waters's Collection, No. 60.

No name or date. The ring and shackle are of ◇-section.

The *kursi* is pierced with 6 perforations shaped to produce a bold arabesque design.

The ankabut is for 22 stars. Tracery is reduced to an east-west bar within the zodiac and to 4 ties between the zodiac and the Capricorn circles. The equinoctial band is represented by a V-shaped band.

Star List

	H.	M.			H.	M.	
Algol	II	12	—	Elfeta	XV	8	+
—	III	46	+	—	XVI	4	+
Hircus	IV	4	+	—	XVI	18	—
Rigel	V	12	—	—	XVII	8	+
—	V	40	+	Vega	XVIII	44	+
Algeuse	VI	28	—	Altair	XIX	40	+
Algomeisa	VII	52	+	—	XX	28	+
Alphard	IX	24	—	Alrif	XX	56	+
Algorab	XII	4	—	—	XXI	20	+
Alramec	XIII	28	—	—	XXII	28	—
—	XIV	40	+	Denebkaitos	XXIII	52	—

The 6 tablets have almucantars for every sixth degree (*sudsi*). One of them is engraved with a table of ankabut co-ordinates.

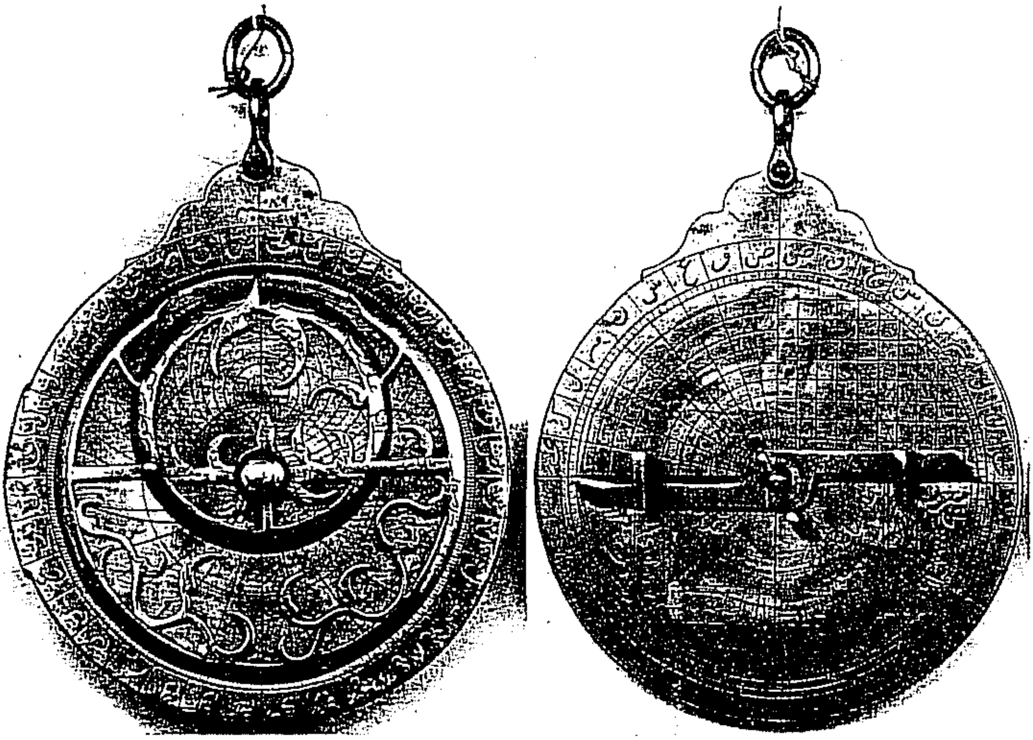
1a.	Lat. 29°	hours 13. 52.		*4a.*	Lat. [blank (72°)].	
b.	„ 30°	„ 13. 57.		*b.*	„ 40°	hours 14. 12.
2a.	„ 32°	„ 14. 7.		*5a.*	„ 38° ?	„ 14. 40.
b.	„ 34°	„ 14. 17.		*b.*	„ 41°	„ 14. 18.
3a.	„ 36°	„ 14. 18.		6.	Tablet of horizons.	
b.	„ 37°	„ 14. 34.				

Within the *umm* is a short list of towns which is far from filling up the available surface, space being left for additions.

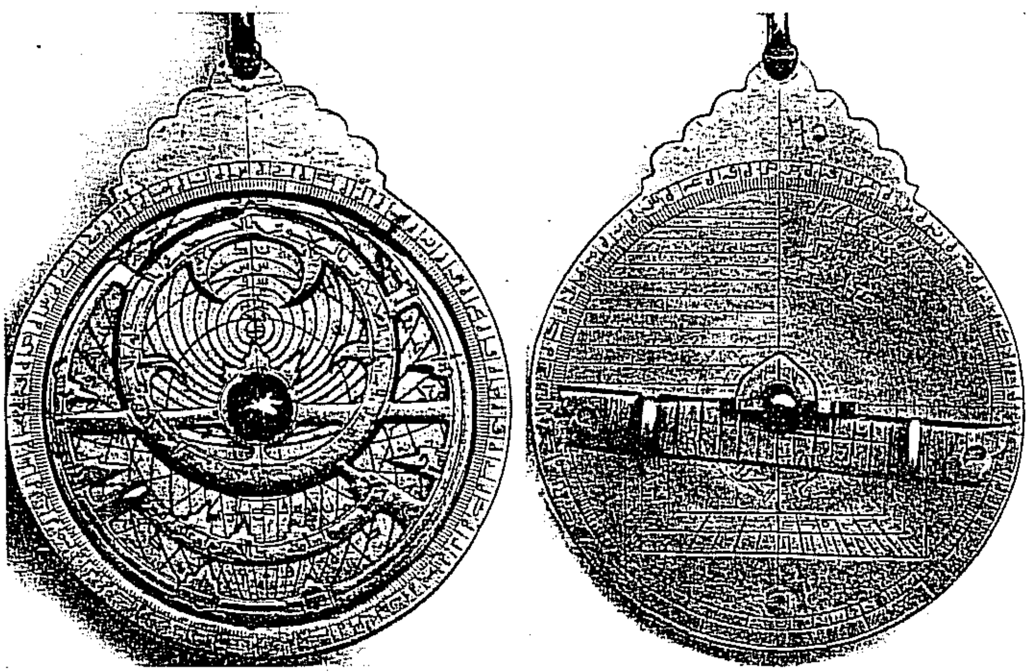
The Countries.	Ispahan.
Mecca.	Kasan.
Rayy.	Shirwan
Mosul.	Nizapur.
?	Tus.
Tabriz.	Herat.
Ardabil.	Kazwin.
Bagdad.	Asabard ? Asterabad.
Shiraz.	Hamadan.

On the Back are two quadrants of altitude; the usual left-hand upper quadrant of *Mabs'ut* sines; the quadrant of arcs of the parallels of the signs of the zodiac, 5 to each sign, half of the names of the signs being written at either end. The parallels of the arcs are cut by those of the azimuth of the Kiblah, but no places are specified.

In the two lower quadrants are shadow scales, both on the peripheral arcs and on the inscribed squares. The graduations are named *shadow feet* and *shadow inches reversed* on the arcs, and *shadow feet reversed* and *shadow inches straight* on the squares.



A.D. 1688



LEWIS EVANS COLLECTION NO. 30

30. PERSIAN ASTROLABE. Pl. XXXVI. *Undated.*

Diameter $2\frac{13}{16}$ inches; thickness $\frac{1}{8}$ inch.

Bought by Mr. L. Evans in March 1918 from Gélis of Paris, through P. Webster.

The *kursi* is plain with 3 lobes on each side.

Ankabut for 18 stars, with east-west bar, equinoctial band, and dagger-shaped star-pointers—all of primitive type.

Back of mother plain, with 2 tablets with 15 almucantars (*sudsi*).

Lat. 30°	.	hours 13. 18.
„ 34°	.	„ 14. 8.
„ 36°	.	„ 14. 24.
„ 38°	.	„ 14. 39.

Tablet of horizons.

On the Back:

i. Sinical quadrant ruled horizontally for every fifth degree.

ii. The north-east quadrant is plain but for the names of 6 places under the following degrees in the marginal latitude scale:

13°	33°
20°	42°
27°	47°

iii, iv. Squares of the shadows and marginal shadow scales.

The stumpy little alidade is rudely divided by a dozen transverse hour-lines. The ends are ornamented with a comma-shaped perforation that does not occur in any other instrument in the Evans Collection, though it is paralleled by the ornament on one of A.D. 1670 (p. 141).

31. THE ASTROLABE OF MOHAMMAD AMIR SON OF MOHAMMAD TAHIR

Diameter $2\frac{15}{16}$ inches.

S. V. Hoffman Collection, No. 39.

There are 2 cartouches with inscriptions, one within, the other below, the shadow squares. The upper inscription reads:

Made by Mohammad Amir son of Mohammad Tahir.

The lower reads:

Slave of the Imams in love.

The *kursi*, engraved with foliations, is drilled with 2 holes. The flowery ornament is a simplification of the one used by Mohammad Tahir in the astrolabe described on p. 137, but the son's engraving is not nearly as good as that of his father, perhaps because he was 'in love'.

The tracery of the ankabut is of the V-type, but differs from the other examples described in the absence of the lateral extensions below the east-west bar. Here the V-band is stopped at 2 radial bars, beyond which are large lateral star-pointers. There are 10 named stars within, 12 outside, the zodiac.

The 5 plates are sexpartite.

1*a*.	Lat. 25° . .	hours 13. 34.	4*a*.	Lat. 32° . .	hours 14. 7.
b.	„ 36° . .	„ 14. 16.	*b*.	„ 38° . .	„ 14. 19.
2*a*.	„ 27° . .	„ 13. 14.	5*a*.	„ 24° . .	„ 13. 30.
b.	„ 36° . .	„ 14. 19.	*b*.	Tablet of horizons in 4 groups of 4.	
3*a*.	„ 30° . .	„ 13. 16.			
b.	„ 33° . .	„ 14. 12.			

In the *umm* the gazetteer is engraved in a single ring with full particulars as to longitudes, latitudes, declinations, and directions.

The Back is fully engraved with the usual scales arranged as on Plate XVII. The sinical quadrant is crossed by a chord of the entire angle of 90°.

The alidade is original, with slit sights (type of Fig. 43). The axis is a pin and fly nut. A label is also provided.

32. MUHAMMAD AMĪN'S ASTROLABE '*Herat C*' *c.* 1700.

Diameter 7·3 inches.

Indian Museum at Calcutta: described as having come from Herat by Kaye, 1918. Figs. 9, 12, 15–18.

Designed by Muhammad Amīn bin Muḥammad Tāhir and engraved by Abdul A'īmmah.

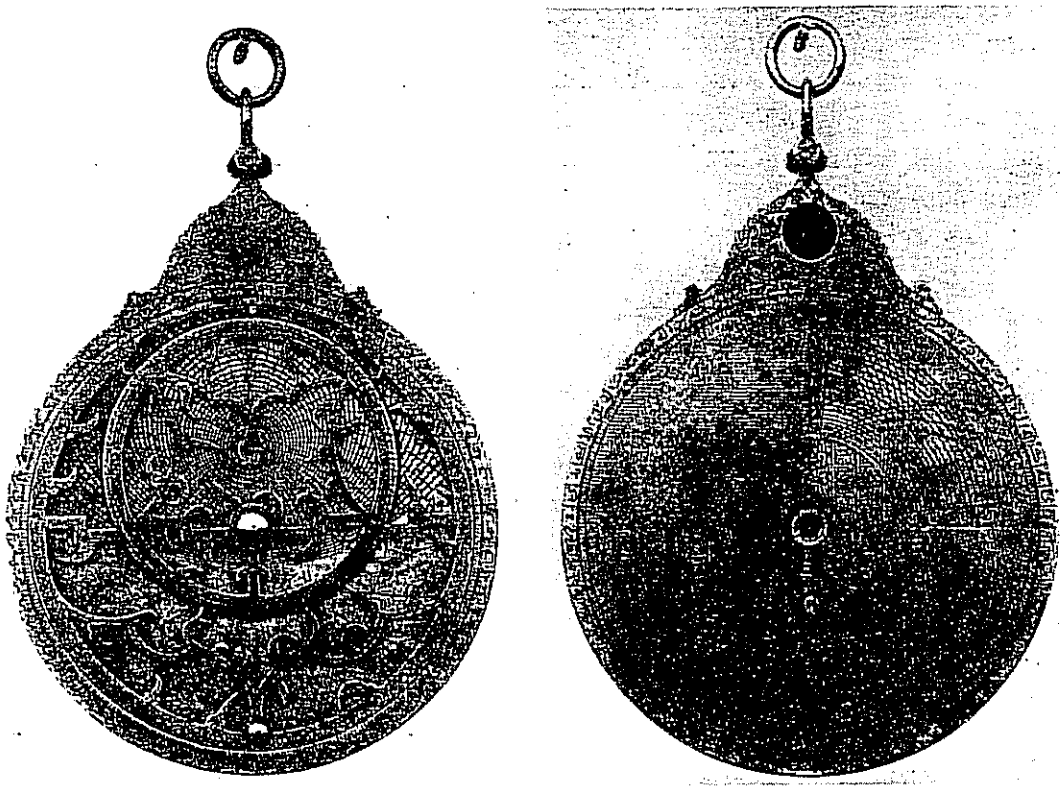
The face of the *kursi*, engraved with flowers, foliage, and arabesques, contains an inscribed cartouche. On the reverse is a circular recess which appears to have been made to contain a magnetic compass.

In the *umm* is a gazetteer of 44 places with *inhiraf* and *jihat* or compass-bearing of Mecca.

The ankabut is for 19 + 22 = 41 stars. The pointers are thick and clumsy, about one-half having bulb-like bases. East-west bar present, but the place of the equinoctial band is taken by a ⏝⏝-shaped bar with a *mudir* at the apex. The uninscribed surfaces are covered with light scroll-and-flower surface engraving.

Three sides of the tablets (*nisfi*) are figured by Kaye:

Lat. 28°	Type of Pl. XIV	(Kaye, Fig. 18).
„ 32°	„ Pl. VIII	(„ Fig. 17).
Tablet of horizons.		(„ Fig. 15).



FIGS. 71, 72. HERAT C.

33. SHAH HUSAIN'S GREAT ASTROLABE. A.D. 1712.

Plates I–XVII.

Constructed by the least of the students Abd-al-Ali son of Muhammad Rafi al Juzil, and the engraving was *Written by the least of the students, the brother of the constructor, Muhammad Bakir.*

This, perhaps the most beautiful astrolabe in the British Museum, came into the National Collection as a part of the great Sloane Collection in 1753. It is not known how Sloane acquired it. It is most fully described by W. H. Morley in his large book *A Description of a planispheric Astrolabe made for Shah Husain Safawi, King of Persia*, 1856, of which a facsimile forms the first chapter of this volume.

Shah Sultan Husain Safawi reigned over Persia from A.D. 1694 to A.D. 1722 and was the last independent sovereign of the Dynasty of Safawīyah kings who had governed Persia for 231 lunar years. The dedication of the instrument to him is inscribed on the *kursi*, p. 22.

This masterpiece by a Persian scientific instrument-maker measures 15⅞ inches in diameter, or 2 feet in total height, each of the tablets being 14⅞ inches across. When described by Morley it was the only *tamm* instrument known.

The ankabut is for 63 stars, pp. 28, 29. At my request the list was examined by Mr. G. R. Kaye, shortly before his death, with the result that he found, on comparing the positions with those given in Ulugh Beg's catalogue, that Nos. 1, 8, 24, 25, 26, 27 are out of position, or have been wrongly identified; that No. 36 = δ *Scorpii* and that No. 56 = γ *Eridani*. He added, 'I intend sometime to make a more accurate drawing, but it requires much labour and must——' and there he stopped. Perhaps they were the last words he wrote on an astrolabe in this life.

The tablets are 7 in number and range from latitude 22° to 43°, p. 26. Morley describes the tablet for lat. 30° (cf. also pl. XIX, fig. 12) as bearing a double projection, but it is a single projection rearranged by cutting up the ordinary projection into 4 quadrants, and then altering their juxtapositions symmetrically, so as to produce the new pattern (cf. pl. VII).

103 localities are listed in the *umm* with their latitudes, longitudes, *inhirafat*, *masafat*, and *jihat*, p. 24. The longitudes are measured from a point of origin about 35° west of Greenwich, i.e. the Azores.

34. ASTROLABE BY ABDULLAH A'IMMAH — A.D. 1715.

Diameter 4⅞ inches; whole length 8 inches.

South Kensington Museum, No. 458, 1888.

Like most of the work of this celebrated maker, this astrolabe is completely chased or engraved all over. It bears the maker's name

Abdullah A'immah A.H. 1127.

35. ABDULLAH A'IMMAH'S ASTROLABE *Undated.*

A fully engraved small brass astrolabe $2\frac{13}{16}$ inches in diameter; length to top of bracket $3\frac{5}{8}$ inches; total length $4\frac{11}{16}$ inches including shackle and ring; thickness $\frac{3}{16}$ inch.

Bought by L. Evans in April 1913 from Akchoté Frêres, 214 Rue de Rivoli, Paris.

The face of the *kursi*, flanked by perforated ornament, bears a cartouche which is not inscribed. The maker's name is written in Naskh characters in a cartouche near the centre of the back

The handiwork of Abd el A'immah.

A further inscription on the back of the *kursi* reads: '*He is not burdened by maintaining them* (i.e. the heavens and earth) *but he is the Exalted, the Mighty.*'

The ankabut is for 26 stars.

There is a gazetteer in the mater, engraved in 8 concentric bands.

Five *sudsi* tablets:

1*a*.	Lat. 30°	hours	[blank].
b.	" 36°	"	"
2*a*.	" 32°	"	14. 7.
b.	" 33°	"	[blank].
3*a*.	" 32°	"	"
b.	" 37°	"	"
4*a*.	Lat. 18°	hours	[blank].
b.	" 39°	"	"
5*a*.	Tablet of horizons.		
b.	[Lat. 36°] uninscribed.		

36. AZERBAIJAN ASTROLABE BY ABD AL A'IMMAH *Undated.*

A fully inscribed instrument of brass; diameter $3\frac{11}{16}$ inches; thickness $\frac{1}{4}$ inch full; total length including the ring 6 inches.

Purchased by L. Evans on 28 April 1922 from Lowe of 138 Wardour St.

The maker's name is on the back on the lower part of the margin:

Made by Abd al A'immah (= made by the slave of Imams).

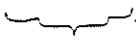
Around the edge of the rim is:

In accordance with the command of the servants of the Pillars of high birth, and the Courtier of the Khāqān, Rustam Khan Dunbali, the son of Ali Khan who is called the son of Badāf Khān Begler Bey of the whole of Azerbaijan, this thing was completed.

On the *kursi* surrounded with foliage is:

Oh Thou true to promise.

The back of the kursi has no inscription on it, but is ornamented with foliage and flowers. The ring has a ◇-section, and is threaded by a nicely plaited brown *ilakha* with a tassel.

In the ankabut the outer Capricorn band is devoid of lettering, but is decorated with foliage ornament. The tracery outside the zodiac is of the -type. There are 27 stars, 11 within the ecliptic and 15 without.

List of Stars (read by Professor R. Levy).

Outside zodiac.

Qalb al 'Aqrab	α Scorpii.
Simāk al Azal	α Virginis.
Janab al Ghurab	γ Corvi.
Qā'ida	η Urs. maj.
Fard al Shuja	α Hydrae.
Shirā Yamāni	α Can. maj.
Rigl al Yusra	β Orionis
Masāfat	δελ Eridani.
Sadr al Qitus	π Ceti.
Saq Aiman	δ Aquarii.
Shira Shāmī	α Can. min.
Yad al Aiman	α Orionis.
Ain al Sur	α Tauri.
Fam al Qitus	γ Ceti.
Zanab al Qitus	ξ Ceti.

Inside zodiac.

Ras al Hawwa	α Serpentarii.
Unq al Haiyat	α Serpentis.
Ramih	α Bootae.
Marfaq	λ Serpentarii.
Kaff al Khazib	β Cassiop.
Mankib al Faras	β Pegasi.
Fam al Faras	ε Pegasi.
Nasr	α Aquilae.
Zahr al Dubb	α Urs. maj.
Ridf	α Cygni.
Nasr Waqi	α Lyrae.
Naiyir al Fakka	α Cor. bor.

There are 5 *nisfi* or bipartite plates, one having a tablet of horizons showing 7 horizons in 4 groups:

1*a*.	Lat. 32°.
b.	„ 40°.
2*a*.	„ 36°.
b.	„ 38°.
3*a*.	„ 38°.
b.	„ 40°.
4*a*.	Lat. 38°.
b.	„ 42°.
5*a*.	„ 30°.
b.	Tablet of horizons.

On the bottom of the *umm* is a gazetteer of cities, their longitudes, latitudes, and *inhiraf* (?) in circular bands. The outer scale comprises 24 names. The inner deals with 12 localities.

The Back is very fully engraved according to the standard pattern figured in Fig. 25, except that the left upper sinical quadrant is ruled with 60 lines both ways, and every fifth line is picked out by dots, a very helpful arrangement where the graduations are so minute.

37. ASTROLABE BY ABD AL A'IMMAH

S. V. Hoffman Collection, No. 20.

$3\frac{3}{4}$ inches in diameter.

Inscription in cartouche on back, '*Made by Abd al A'immah*'.

A finely executed example of this beautiful class of astrolabes marked with the well-known signature. The cartouche on the front of the kursi has been left blank.

Four tablets for lats. $30° +$ tablet of horizons; $30° + 36°$; $32° + 38°$; $35° + 38°$.

38. NISFI ASTROLABE OF ABDULLAH A'IMMAH. Pl. XXXVII A.D. 1730.

Diameter $7\frac{3}{8}$ inches; length over all, $11\frac{5}{16}$ inches; thickness $\frac{3}{16}$ inch.

Bought by L. Evans in July 1922 for £55 from J. Lowe, 138 Wardour St.

The throne is very nicely ornamented with foliage, and is inscribed in a cartouche measuring $1\frac{1}{8} \times 1\frac{7}{8}$ inches,

According to the command of the sublime abode (= person of the sovereign) *of the Khahan who had visited the true sacred shrines Haji Ismail Bev. In the second Jumada of the year 1240 this was completed.*

And near the bottom of the back is the maker's inscription in a cartouche ($1\frac{1}{8} \times \frac{15}{16}$ inches):

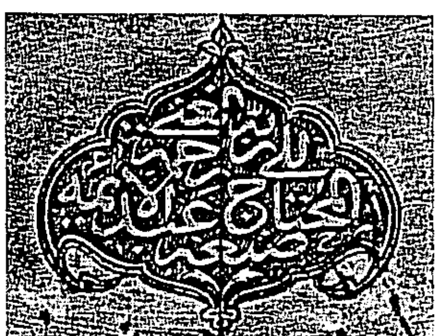


FIG. 73. SIGNATURE OF ABDULLAH A'IMMAH

This was made by Abdullah A'immah who needs the mercy of his all-sufficient Lord.

The ankabut is $6\frac{1}{4}$ inches in diameter and shows 35 stars.

As in many other instruments of this period the tracery does not include either east-west bars or an equatorial band. The design within the zodiac is of the type we have designated the 88-type, while without the zodiac all the leaf-like star-pointers are carried on a symmetrically disposed serpentine band of ⌣⌣-shape.

There are 5 *nisfi* or bipartite tablets, one of which is slightly different from the others, in that it is engraved with a double projection. No scale of ankabut co-ordinates is provided.

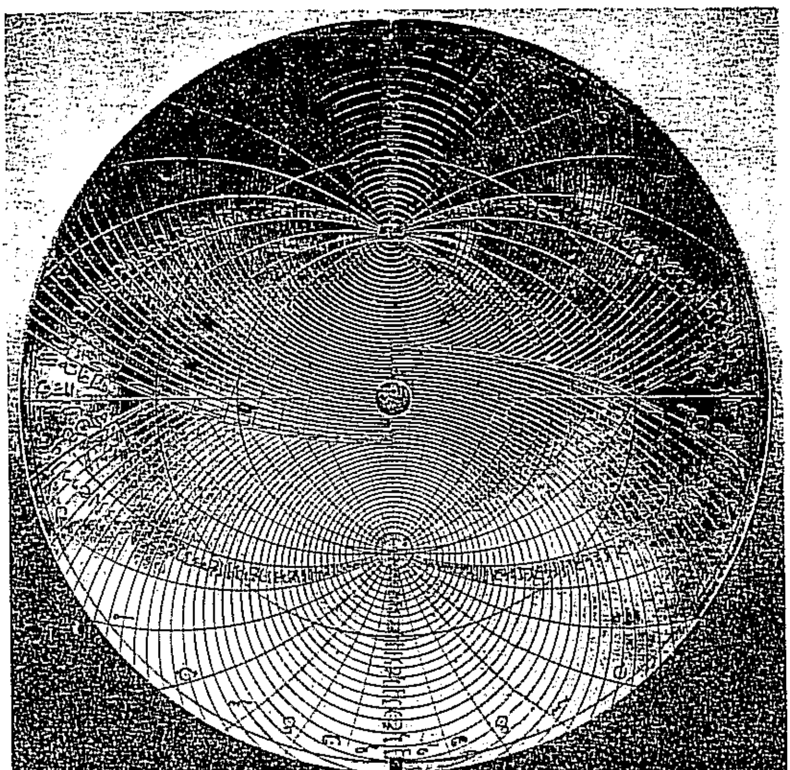
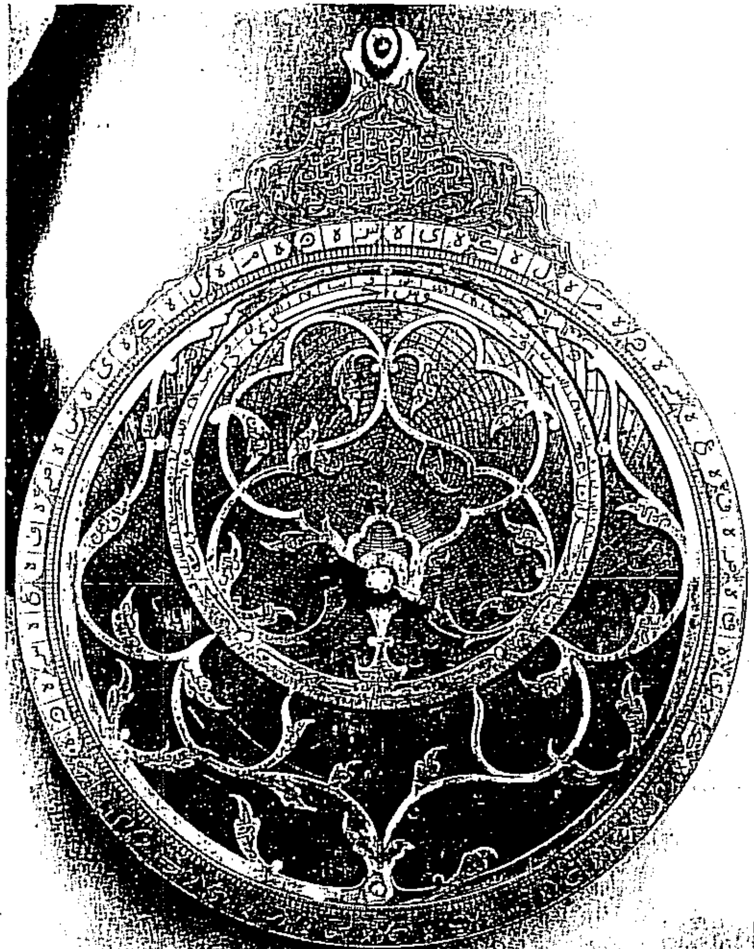
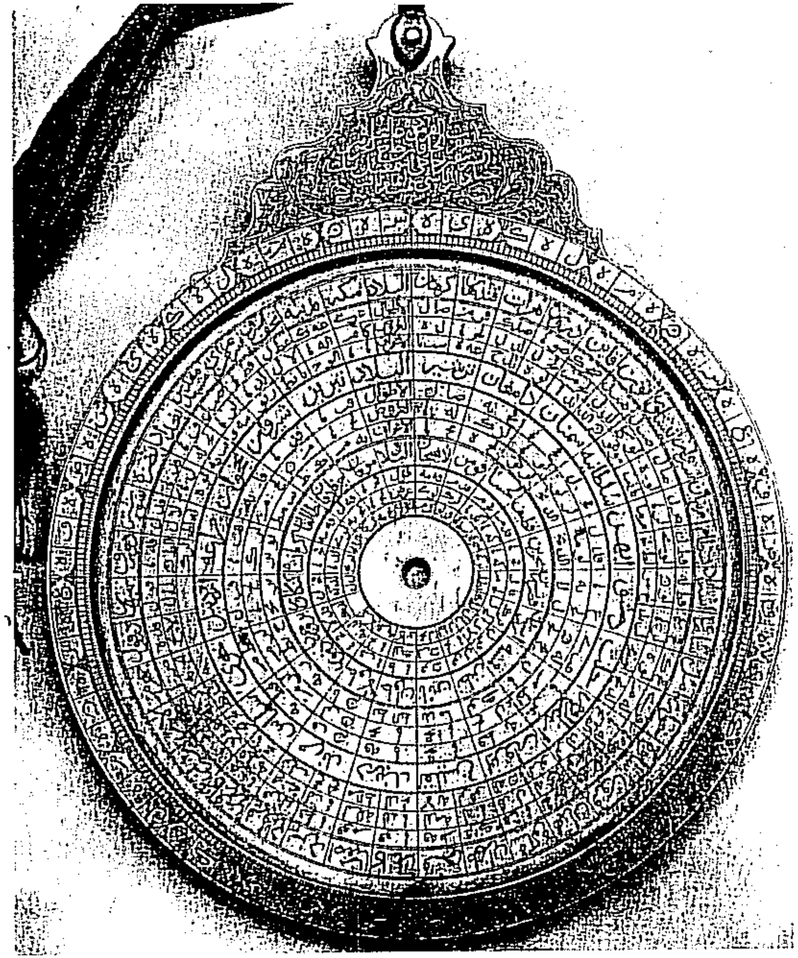


FIG. 74. DOUBLE PLATE BY ABDULLAH A'IMMAH. A.D. 1730.
For lats. 21° and 25°

1*a*.	Lat. 30° . .	hours 48. 57.	4*a*.	Lat. 35° . .	hours 14. 32.
b.	„ 32° . .	„ 14. 50.	*b*.	Lats. 21° and 25°.	
2*a*.	„ 31° . .	„ 14. 20.	5*a*.	Lat. 37° . .	„ 14. 34.
b.	„ 33° . .	„ 14. 12.	*b*.	„ 38° . .	„ 14. 40.
3*a*.	„ 34° . .	„ 14. 16.			
b.	„ 36° . .	„ 14. 38.			





ABDULLAH A'IMMAH, A.D. 1730

The *umm* has 3 concentric tables of towns, each divided into 4 spaces for the names of the towns, their longitudes, latitudes, and *inhiraf*.

On the Back:

i. The upper left sinical quadrant ruled with 60 lines both ways.

ii. On the right is the unusual scale figured below.

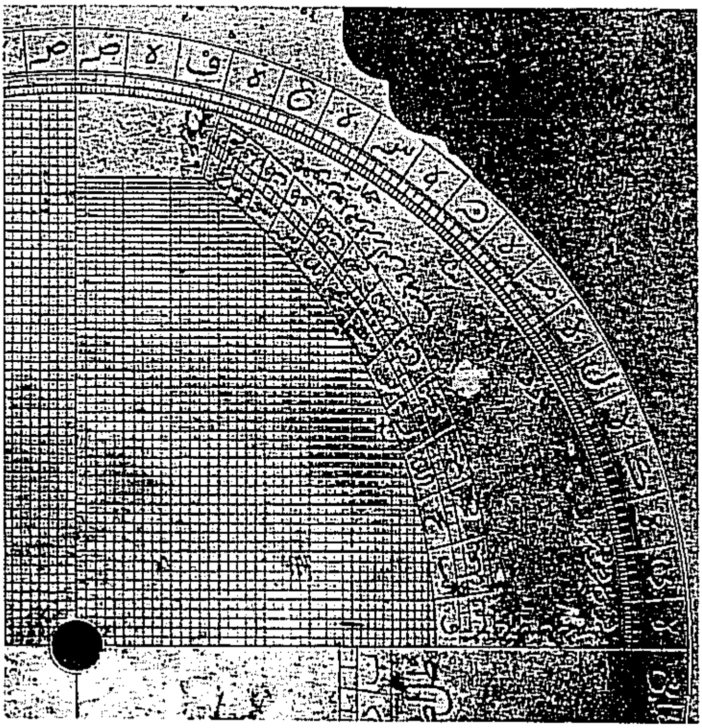


FIG. 75. RIGHT-HAND QUADRANT. A.D. 1730.

iii, iv. In the lower semicircle are the scales of umbra versa and recta, having 7 divisions on the left and 6 on the right.

The rule is not inscribed; the vanes have both notched and pin-hole sights.

The *kutb* or pin has a turquoise mounted in silver at its upper end.

The *faras* or wedge is unusually well-fashioned so as to resemble a horse's head.

39. THE ASTROLABE OF ABD AL A'IMMAH AND MIRZA ISHMAEL

S. V. Hoffman Collection, No. 16.

$3\frac{5}{8}$ inches in diameter.

Inscribed:

i. In cartouche on back, '*Made by Abd al A'immah*' (= the slave of the Imams).

ii. On the front of the kursi with the throne inscription '*The Heavens and Earth*'.

iii. On back, '*Unto God there have been completed for the sake of the most excellent master, the pillar of the Gesiret, the namesake of the person sacrificed by Abraham, the pole of knowledge, Mirza Ishmael, may God preserve him, the Astronomical Tables*'.

iv. On margin, '*The longitude of the engraving is 27 degrees . . .*'

The contour of the bracket is formed of 3 lobes and 2 ogees. Its surface is fully covered with the inscriptions. The ilakha is preserved. The ankabut is for $11+15=26$ stars. The tracery of the ⌣⌣-type is confined to the extra-zodiacal portion, as in figures on pl. XXXIX. The gazetteer in the *umm* is for $32+16=48$ places in two circles.

Three tablets, for 26° + tablet of horizons; $30^\circ + 36^\circ$; $32^\circ + 38^\circ$.

40. THE ASTROLABE OF ABD AL A'IMMAH AND H.H. MADHI KULI

S. V. Hoffman Collection, No. 18.

$3\frac{3}{4}$ inches in diameter.

Inscribed:

i. In cartouche on back, '*Made by Abd al A'immah*'.

ii. On front of throne, '*In accordance with the command of His Highness Mahdi Kuli, ... this was finished*'.

Very similar to the last.

Five tablets, for lats. 30° + tablet of horizons; $30^\circ + 36^\circ$; $32^\circ + 38^\circ$; $38^\circ + 39^\circ$; $36^\circ + 40^\circ$.

Gazetteer in the *umm* for $24+12=36$ places in two circles.

41. Hajji Ali's Astrolabe

Sir John Findlay Collection.

Inscribed:

The work of Hajji Ali.
May the object of the engraver not be frustrated.

Gazetteer in the *umm* contains the following towns, with their longitudes, latitudes, and *inhiraf*.

Mecca.	Sawah.	? Hirtru.
Medina.	Hamadan.	Ardabil.
Bagdad.	Samman.	Abruan.
Basra.	Danaghan.	Sierivan.
Shiraz.	Bistan.	?
Schuster.	Shirwas.	Gundra.
Jarbadakan.	Nizapur.	Kazran.
Ispahan.	Mashad.	Kirman.
Kashan.	Herat.	Asterabad.
Kumm.	Merv.	Amool.
Ray.	Kandahar.	Bushir.
Kaswin.		

42. Hajj Ali's Astrolabe. Pls. xxxix–xli

Diameter $3\frac{9}{16}$ inches.

S. V. Hoffman Collection, No. 37.

Inscribed in cartouche below the shadow scale:

The work of Hajj Ali,

and in the border on the back,

Work 15th.

The *kursi* is engraved on both sides with symmetrical foliations grouped round a 'cypress-tree' figure in the midline. The rim is divided into 24 decorated panels, in which flowers are conspicuous, bearing the numbers of the degrees (?) which are marked out inside the panels.

The flower *motifs* figure even more conspicuously on the zodiac circle of the ankabut, the tracery of which is of the V- or bracket-type. There are 12 stars north and 16 south of the ecliptic.

Six sexpartite tablets are said to be marked for latitudes ranging from 30° to 39°, but the markings are quite unreliable on several of them. On one plate is a tablet of horizons for 16 latitudes in 4 groups. The hours of the longest day are marked upon the tablets.

The interior of the *umm* is marked as a gazetteer for 36 places in 2 rings.

P

The Back is fully inscribed with the details shown on Pl. XVII.

The engraving of the alidade is unworthy of that of the rest of the instrument and cannot be original.

The quadrant of the Kiblah is inscribed with lines for the 4 places, *Shiraz*, *Bagdad*, *Ispahan*, *Tus*.

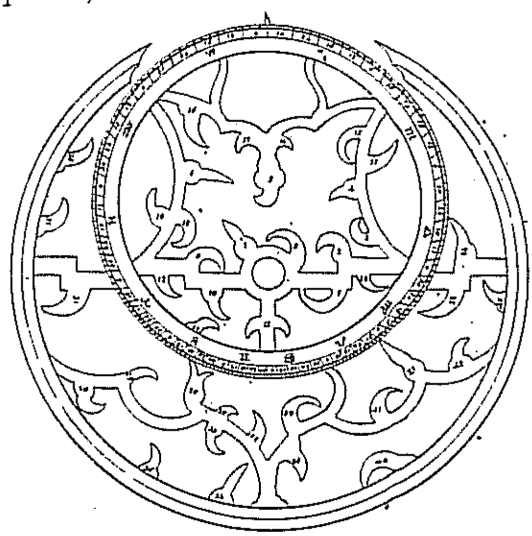


FIG. 76. RETE OF MAJOR POTTINGER'S ASTROLABE.

43. MAJOR POTTINGER'S ASTROLABE.

With 5 plates. Found at Herat by Major Pottinger: described by J. Middleton, *J. Asiat. Soc. of Bengal*, x, pp. 759–77. See pp. 4, 12, 18.

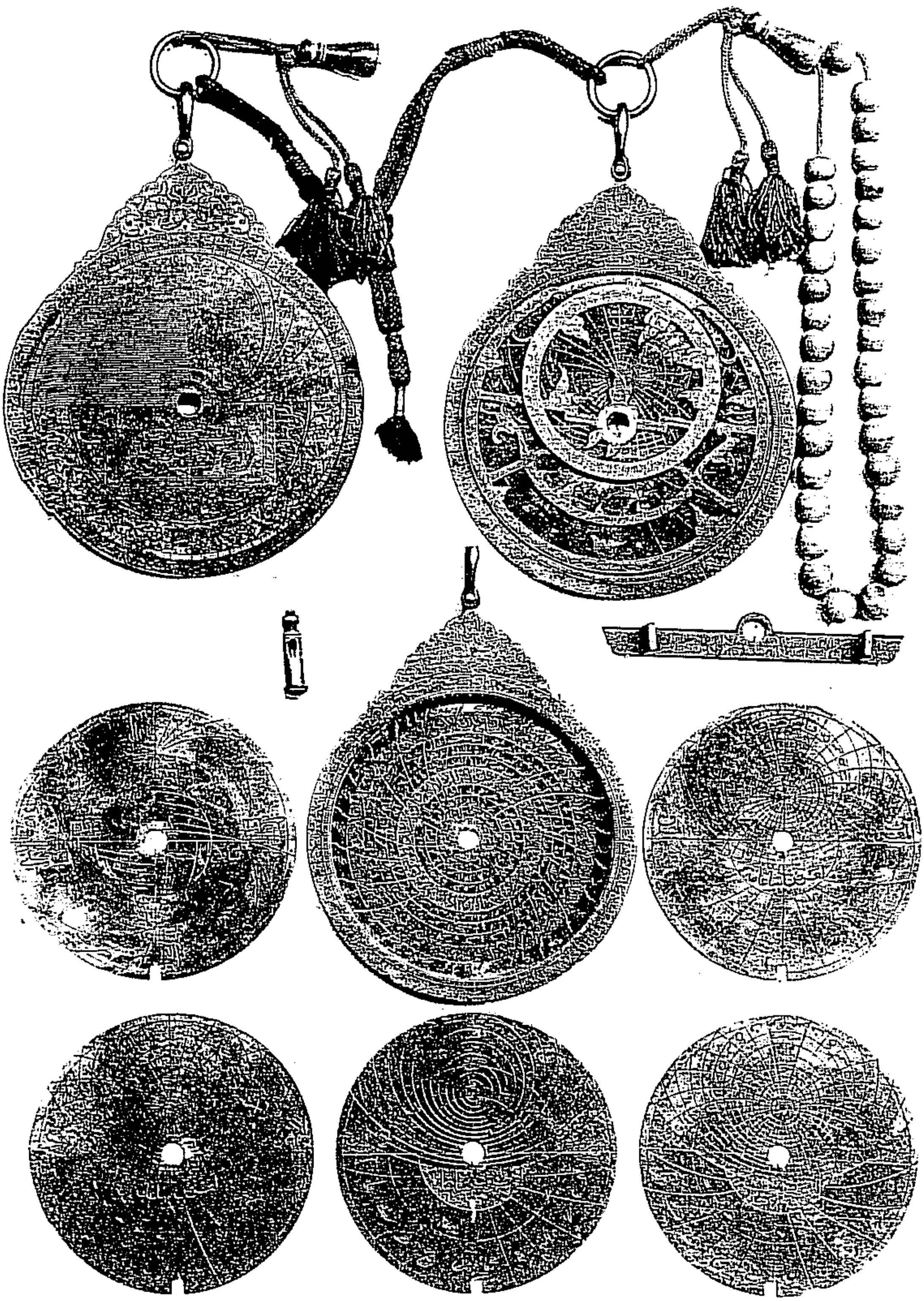
The names of the 43 stars, numbered on the diagram, are mostly given in the longer list on pp. 28, 29, where they may be found by the following table.

1 = 24	14 = 3	24 = 37	36 = 56
2 = 25	15 = 6	28 = 63	37 = 62
3 = 13	16 = 10	29 = 57	38 = 46
4 = 14	17 = 4	30 = 58	39 = 44
5 = 16	18 = 21	31 = 59	41 = 41
6 = 9	19 = 12	32 = 47	42 = 40
9 = 28	20 = 50	33 = 53	43 = 38
12 = 32	21 = 42	34 = 49	
13 = 35	23 = 22	35 = 47	

In addition No. 11, Ras al Gul, and No. 27, Kalb al'Akrab, occur on p. 37, but the following do not appear in our other lists.

7. Zanab-i Dajajah (α Cygni).
10. Marfak ' ussoreya ' (α Persei).
22. Sak al-Asad.
25. Kaff-i Shamali (β Librae).
26. Kaff-i Janubi.
40. Tarf i Saphinah (ζ Navis).

The ' Kutb i Buruj ' or Pole of the Ecliptic is also shown as No. 8.



ALI HASSAN'S ASTROLABE

44. MOHAMMED MAHDI'S ASTROLABE. Pls. XXXIX–XLI *Undated.*

Diameter 3½ inches.

S. V. Hoffman Collection, No. 26.

Inscribed in cartouche on the back:

Mohammed Mahdi,

and in the margin below:

The *kursi* is prettily ornamented with flowers, an iris between 2 asters (?) on the face and with intertwined arabesques on the reverse. Two lobes between 2 ogees outline the contour.

The ankabut for 28 stars is of the type of No. 65, but like the scientific, as opposed to the purely decorative parts of this instrument, is crude in execution. The 'faras' is bird-shaped.

The 5 tablets (sexpartite) show several errors. They appear to be for latitudes 27°+30°; 32°+32°; 30°+34°; 33°+36°; 0°+ tablet of horizons in 4 groups of 6.

The gazetteer in the *umm* is the work of a better engraver: the names of the cities are in relief on a shaded background.

On the Back (Pl. XLI) within the altitude quadrants are a sinical quadrant (scribbled) and a zodiac quadrant. The shadow squares within a decorated border include a table.

45. THE NOBLE ALI HASSAN'S ASTROLABE. Pl. XXXVIII *Undated.*

Acquired for the Lewis Evans Collection by purchase from Major Ross in 1925–6.

Perhaps the most highly finished small astrolabe in the collection. It measures 3½ inches in diameter and 4 inches in length including the shackle. All uninscribed surfaces, including the edge, are covered with a beautiful flowing foliated ornament. The cartouche on the back contains the name of the over-modest maker:

The poor, the contemptible in the eyes of God, namely Ali [ibn] Hassan [ibn] Mohamed, the noble son of a noble man fabricated it.

The *ilakha* is of red plaited cord bound with silver wire, with a rosary of 33 olive-green beads. The solid *kursi* is covered with the usual throne inscription (p. 123), the letters being chased in relief on a stippled background. On the back of the *kursi* is a floral ornament.

The ankabut although highly decorated is of a simple pattern. The zodiac is traversed by the horizontal bar and is connected with the Capricorn band by this and 4 other ties, 2 of which help to support an equinoctial band.

Five plates (*sudsi*) are inscribed for:

1*a*.	Lat. 30°	hours 13. 17.	4*a*.	Lat. ? 32°	hours 14. 7.
b.	„ 36°	„ 14. 18.	*b*.	„ 38°	„ 14. 40.
2*a*.	„ 32°	„ 13. 32.	5*a*.	„ 39°	„ 14. 46.
b.	„ 34°	„ 14. 17.	*b*.	Tablet of horizons inscribed 'complete declination for [latitudes] 34, 18, 12, 6' four times repeated.	
3*a*.	„ 33°	„ 14. 12.			
b.	„ 37°	„ 15. 15.			

The second and third plates are engraved with large, ornate numerals for the unequal hours, whereas the other 3 plates have small numerals.

The Back is beautifully engraved with a sinical quadrant, a quadrant for the planetary hours, and scales of the shadows.

The 2 marginal scales on the lower quadrants are inscribed *shade feet* on left, and *shade inches* 5, 10, 15, 20 . . . on the right.

The alidade, with vanes with 2 pin-holes each, is engraved with a declination scale.

46. FAZL-ALI'S ASTROLABE *Undated.*

A nicely made white brass astrolabe 3⅞ inches in diameter and ⅛ inch thick.

Bought by Dr. L. Evans on 14 March 1911 as No. 205 at the Roussel Sale in Paris.

On the front of the throne in Nastaliq characters is:

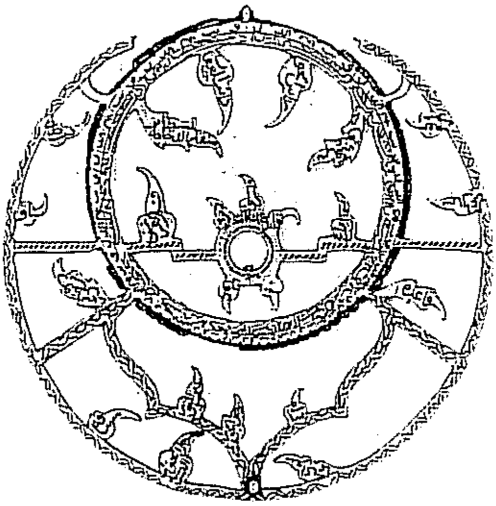
The aim of the engraving is that it should remain after me, for I see not the continuity of earthly existence.

The maker's signature is in a circular cartouche on the back:

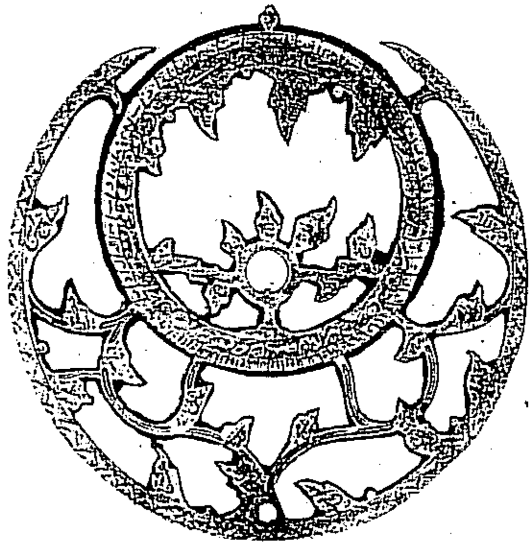
The work of the most humble (of the believers in God) *Fazl-Ali.*

On the bottom of the *umm* in 5 concentric circles having curved diagonal divisions is a table of the latitudes, &c., of various places.

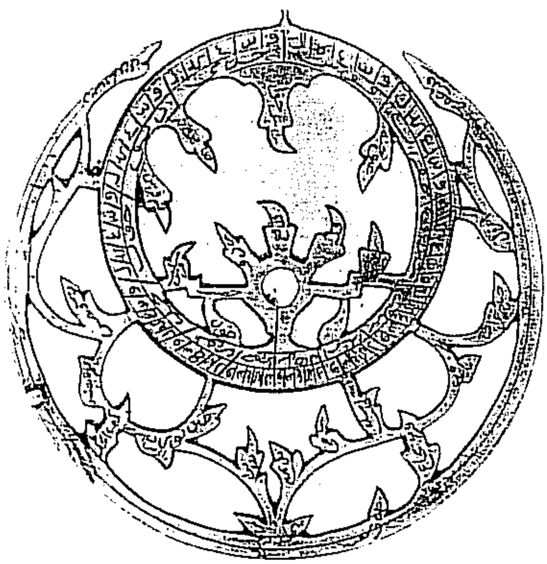
XXXIX



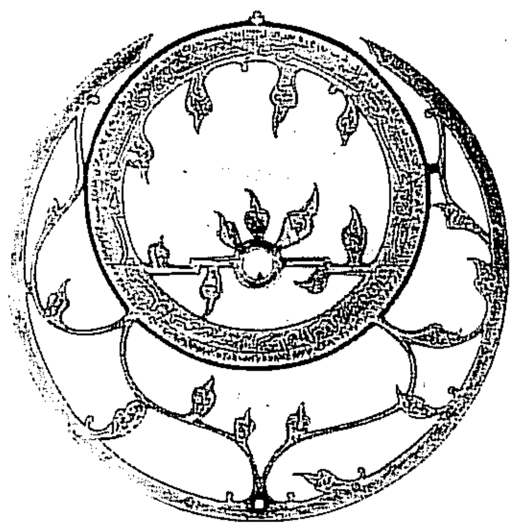
MOHAMMED AMIR



HAJJ ALI

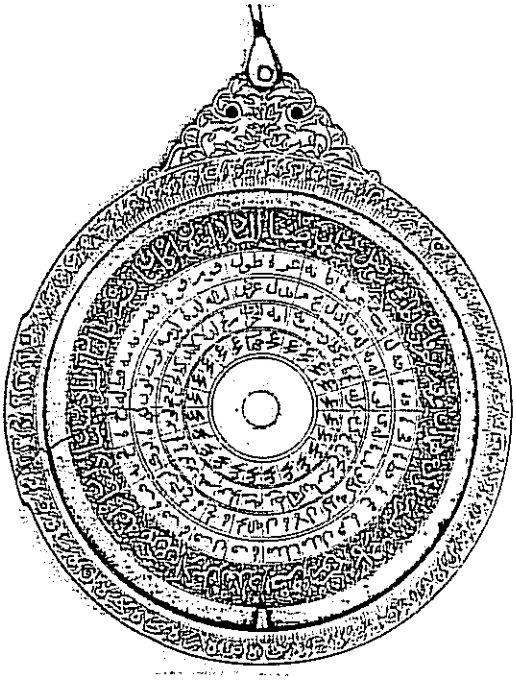


MOHAMMED MAHDI

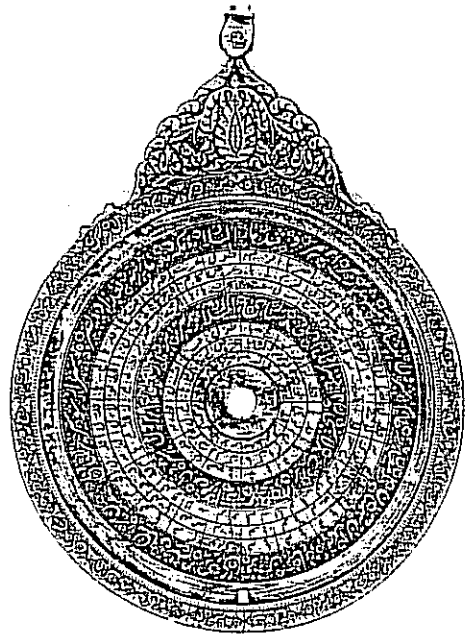


NO. 65. HOFFMAN COLLECTION NO. 32

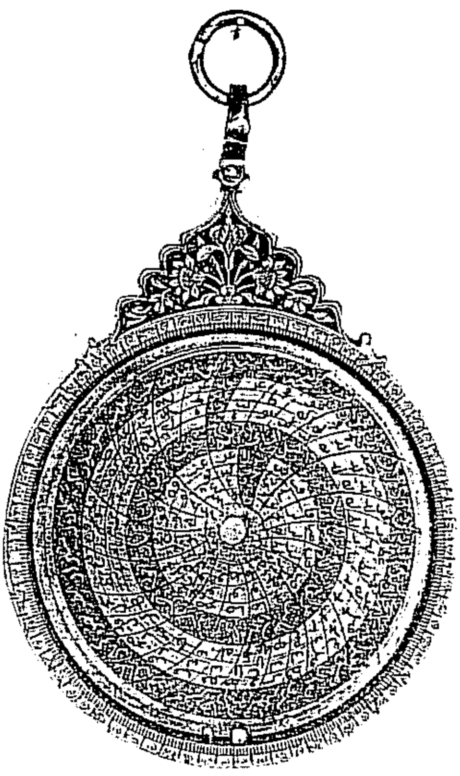
ANKABUTS



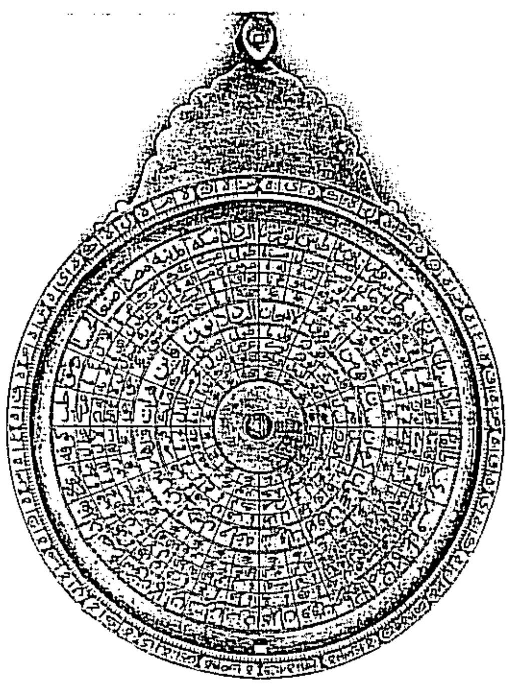
MOHAMMED AMIR



HAJJ ALI



MOHAMMED MAHDI



NO. 65. HOFFMAN COLLECTION NO. 32

GAZETTEERS

The ankabut is for about 29 stars.

There are 4 plates:

1*a*.	Tablet of horizons.			3*a*.	Lat. 30° .	hours 13. 57.	
b.	Lat. 29° .	hours 13. 52.		*b*.	„ 40° .	„ 14. 12.	
2*a*.	„ 32° .	„ 14. 6.		4*a*.	„ 36° .	„ 14. 17.	
b.	„ 34° .	„ 14. 17.		*b*.	„ 38° .	„ 14. 40 silvered.	

The following anonymous instrument in the Hoffman Collection exhibits a similar technique in its finish and is almost certainly by the same maker.

47. Uninscribed Astrolabe

Diameter 3¾ inches.

S. V. Hoffman Collection, No. 6.

Uninscribed with name of maker, but for several reasons I am inclined to attribute it to the maker of the foregoing work, Fazl-Ali. The shackle is fixed to a head which is divided from the rest of the bracket by a narrow neck. The degrees of the rim are numbered 0–90 in all 4 quadrants in a clockwise direction. The ankabut is of the type with a complete equinoctial circle, 17 stars are named, and the *mudir* is at the east end of the east-west bar.

Tablets:

1*a*.	Lat. 26°.		3*a*.	Lat. 34° .	hours 14.
b.	„ 32° .	hours 14. 17.	*b*.	„ 38° .	„ 14. 40.
2*a*.	„ 30° .	„ 13. 12.	4*a*.	Polar projection.	
b.	„ 42° .	„ 15. 5.	*b*.	Tablet of horizons in 4 groups with an inscription.	

The ring of 25 towns is classified according to a note in the middle of the *umm*, into those on the left that lie '*south-west*', and those on the right that lie '*north-east*'.

The Back is obviously unfinished. The first quadrant is ruled with radii and horizontal lines to every fifth degree, and also with 10 quadrantal arcs. The names of the 28 manzils are written within the semicircle of signs and the interior of the shadow squares is uninscribed.

48. The Hunter's Astrolabe *XVIIth Cent.*

Diameter 4⅝ inches; thickness ¼ inch; total length 7⅛ inches.

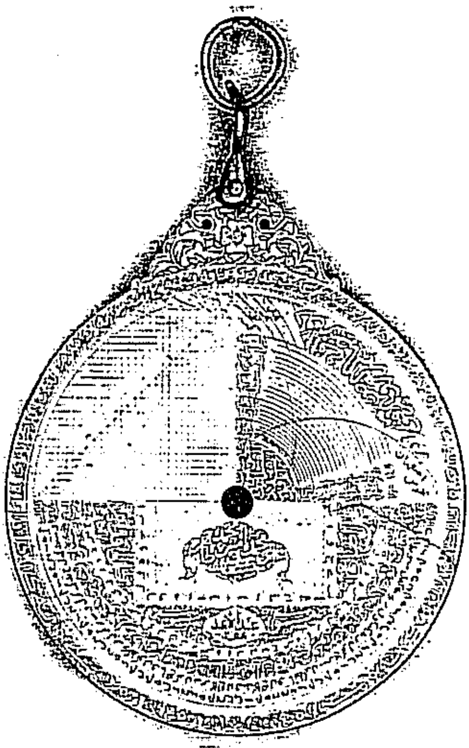
Bought by L. Evans about 1880 from Garcia, Red Lion St., £5.

The *kursi* is engraved with a hunting-scene in relief on a flowery background. The triumphant hunter on horseback has seized a lion by the neck, while a second is watching, and a long-eared hare looks coyly away.

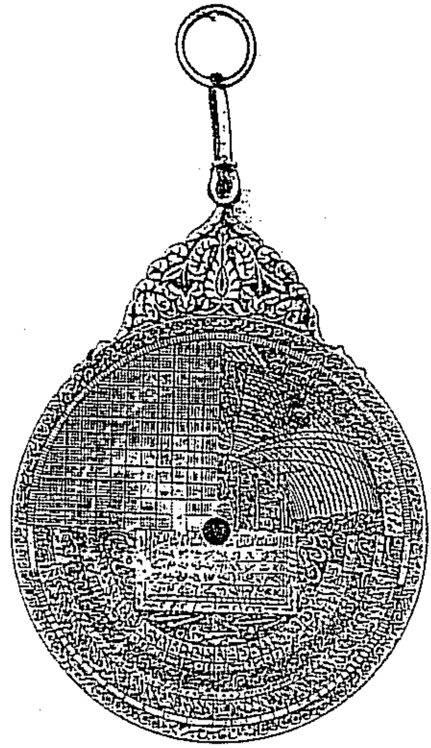
Fig. 77. The Hunter.

The ankabut is made for 28 stars. Its tracery is of the 88- and bracket-type, without a bar. The following stars are marked:

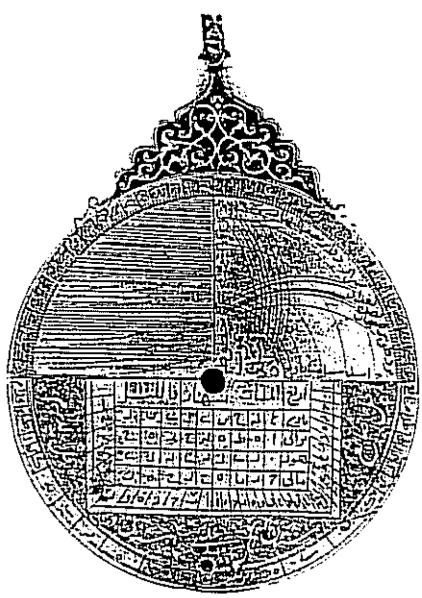
	H.	*M.*			*H.*	*M.*	
Baten Kaitos	—	12	—	Algorab	XI	56	—
Mirac	—	32	+	Alchimech	XIII	—	—
Memkar	II	44	+	Benenas	XIII	48	+
	III	12	—	Elfeta	XV	28	+
Augentenar	III	44	—	Yed	XV	44	+
Aldebaran	IV	36	+		XVI	20	—
Rigel	IV	56	—	Rasalhague	XVII	16	+
Algeusa	V	40	+		XVIII	20	+
Alhabor	VI	32	—	Vega	XVIII	48	+
Algomeisa	VII	36	+	Altair	XIX	36	+
Aldwim	IX	24	—	Ariot (Dasypus lupus)	XX	30	+
Cabalased	IX	48	+	Alferat	XXI	28	+
[Corvus]	X	44	—		XXII	48	—
Dubhe	XI	8		Alferas	XXIII	—	+



MOHAMMED AMIR



HAJJ ALI



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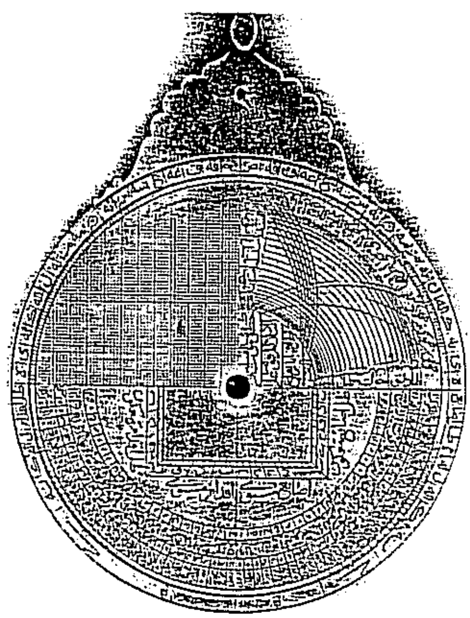


NO. 65. HOFFMAN COLLECTION NO. 32

BACKS OF ASTROLABES

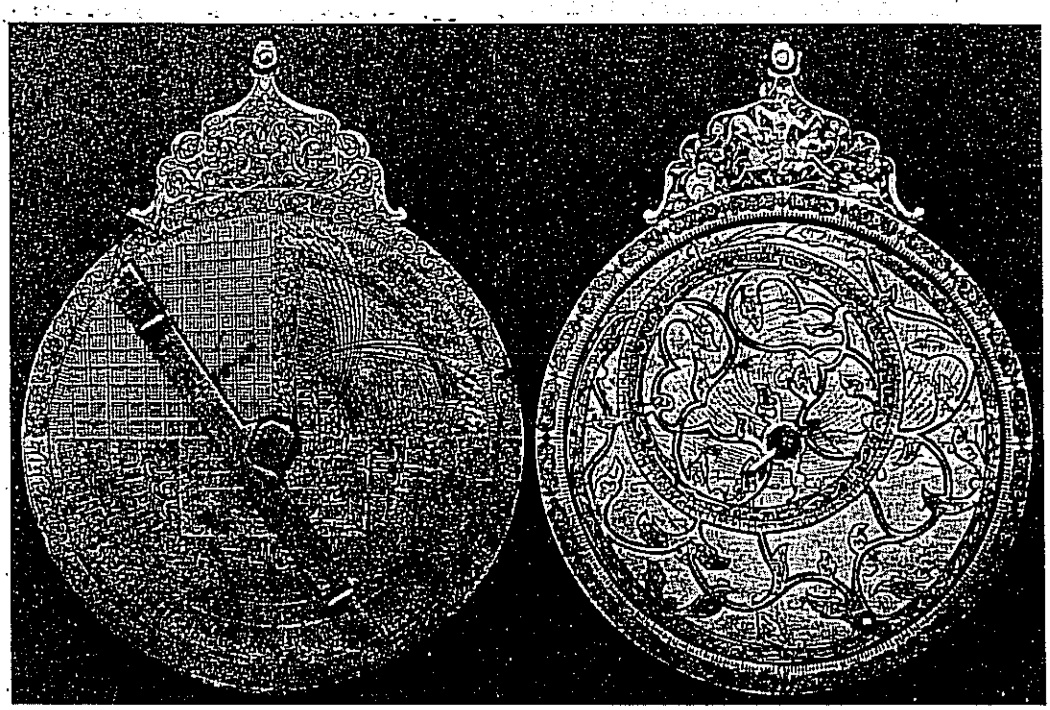


FIG. 78. THE HUNTER'S ASTROLABE.

There are 5 plates:

1*a*.	Lat. 31° .	. hours 14	4*a*.	Lat. 34° .	. hours ? [overstamped].
2*a*.	,, 40° .	. ,, 14. 11.	*b*.	,, 37° .	. ,, 14. 38.
3*a*.	,, 34° .	. ,, 14. 16.	5*a*.	,, 39° .	. ,, 38. 12.
b.	,, 37° .	. ,, 14. 38.	*b*.	Tablet of horizons for 4 places.	

A tablet of horizons, *at Safīhat al-āfāqiyah* (G. R. Kaye, p. 20), is engraved in 8 concentric circular bands in the *umm*.

An instrument of the same type is No. 49, in the Hoffman Collection.

49. UNINSCRIBED ASTROLABE

Diameter 4⅝ inches.

S. V. Hoffman Collection, No. 8.

Kursi ornamented with flowing foliated design enclosing small flowers. Degrees of rim numbered by fives, each set of 3 figures being enclosed in a panel, of which there are 24 in the periphery.

The tracery of the ankabut includes the 88- as well as the V-bands. Stars 28 in number.

Five tripartite tablets for latitudes 30° + 36°; 32° + 42°; 34° + 37°; 36° + 40°; 39° + tablet of horizons.

Sixty towns are listed in the *umm*.

The Back is most admirably engraved, as is also the alidade. It is remarkable that the craftsman should have left no note of his name upon his work. The kiblah lines are for *Bagdad*, *Ispahan*, *Yezd*, and *Tus*.

50. The Beggar's Persian Astrolabe

Diameter 4⅝ inches.

South Kensington Museum, No. 26, 1889.

Uninscribed. The *kursi* is engraved with figures in relief. On one side are 2 beggars separated by a cypress tree. One is leaning on a crutch, the other is squatting with a hanging begging-bowl (*jholī* or *tūmbā*) made from a gourd by his side for the reception of alms. On the reverse is an eagle and his quarry.

Four birds have also been introduced into the ankabut as extra-zodiacal star-pointers, and just above the centre is a human head. The tracery is of the 88-type with the bracket band outside the zodiac.

Tablets: 5 in number.

51. 6¼-inch Persian Astrolabe *XVIIIth Cent.*

Diameter 6¼ inches.

Sir John Findlay Collection.

The imperforate *kursi* is chased with a representation of a flowering shrub, roots, stems, flowers, and leaves on a stippled background.

The tracery of the ankabut is devoid of the usual cardinal and equatorial bars and band, their place being taken by a finely designed serpentine stem and foliage. The leaves are ornamented with an engraved contour. There are only 7 named stars within and 11 outside the zodiac, which is a small number for an instrument of this size and importance.

The 4 tablets are *tamm*, with almucantars for every degree.

One is engraved as a tablet of 10 horizons.

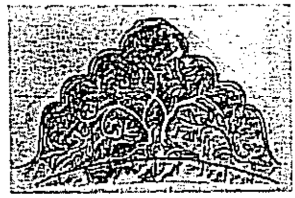


FIG. 79. KURSI OF NO. 51.

On the Back:

i. The quadrant of sines is engraved with a series of concentric arcs and with radii, one to every fifth degree.

ii. To the right is a quadrant with the arcs of the parallels of the signs of the zodiac, traversed by the circles of midday for certain latitudes and by the arcs of the azimuth of the kiblah.

iii, iv. In the lower semicircle are the squares of the shadows inscribed within 7 semicircles of numbers.

52. MOHAMED SADIK'S ASTROLABE. Fig. 80 A.D. 1775.

3⅞ inches in diameter.

S. V. Hoffman Collection, No. 24.

Inscribed on the back in a large cartouche in one of the quadrants: *Wrought by the person who needs the forgiveness of his wealthy Lord Mohammad Sadik*[1] *son of Isa. May both be pardoned by the right of my Concealer, the gentle Creator. In the year 89 after 1000* [*and 100* (added in block script)]. [=1189 *Hegira.*]

Professor Margoliouth points out that the words 'by the right of my Concealer, the gentle Creator' are a rhyming chronogram which gives the date 1185.

Throne without inscription with cavity for a small compass. Ankabut devoid of tracery, for few stars, 6 in and 9 outside the zodiac. The equinoctial band is complete

Tablets for 30°+39°; 32°+36°; 32°+38°; 42°+42°; 32°+ tablet of horizons in 4 groups of 6.

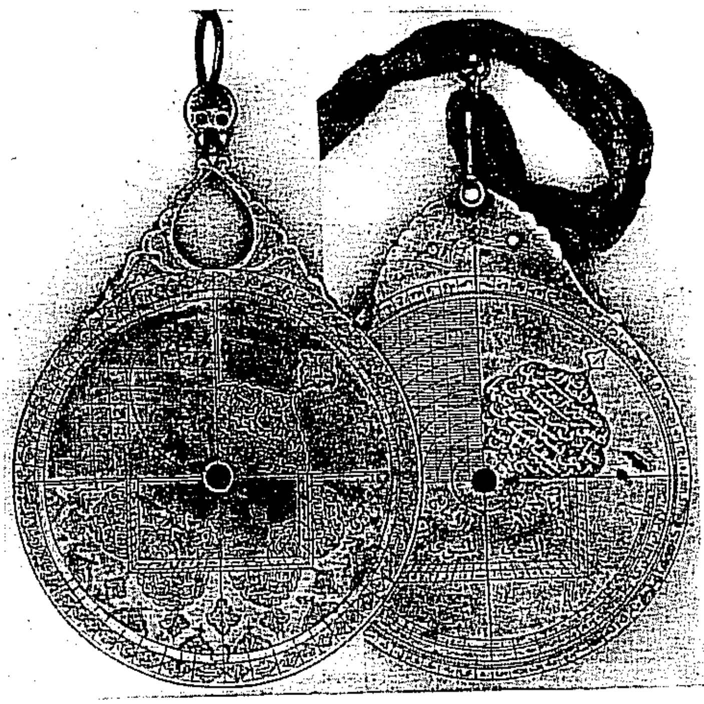
Gazetteer in *umm.*

The sinical quadrant is ruled with 60 horizontal lines, 12 vertical and arcs of circles.

There is an unusual scale inside the peripheral shadow scale.

[1] An Astrolabe by Ali ibn Sadik and 93 mm. in diameter was listed in the Catalogue de la Collection Mercator, Paris, 1928.

Q



A.D. 1781 — A.D. 1775.
FIG. 80. Hoffman Collection, No. 27. — No. 24.

53. ASTROLABE OF MOHAMMAD IBN NASR ABDALLAH AL-RIDEWI A.D. 1781.
Fig. 80

3¾ inches diameter.
S. V. Hoffman Collection, No. 27.

In a quadrant at the back are the owner's and maker's names:

Belonging to the most honourable of the descendants of the Sayyids Mohammad ibn Nasr Abdullah al-Ridewi was made by Wassaf.

and in the shadow rectangle

The engraving by Abd al Karim in 1314.

The suspension is peculiar in that a small, perforated shackle-plate is pinned to the tip of the *kursi*, which is turned at right angles to the usual fashion. The *kursi* itself is pierced with a large pear-shaped hole.

Like No. 98 the ankabut is characterized by the presence of a complete equinoctial band and the absence of flowing tracery.

Plates are for latitudes 30° + 38°; 32° + 38°; 32° + 35°; 32° + 35°; 38° + 39°; 36° + ankabut co-ordinates; 42° + tablet of horizons in 4 groups of 9.

The names of places in the *umm* are arranged in 24 radial arcuate spaces recording longitude, latitude, declination, and (?) elevation. In the centre is written '*The Kaaba most holy, its longitude* 77°; *its latitude* 21° 40′ 354″'.

The decorative effect of the back is obtained by the repetition of the chief inscription cartouche below the shadow scale. These 'labels' refer to '*shadow reversed of feet*' and '*shadow equal of feet*' on the right. and ditto '*of fingers*' on the left. In the corners we read, left, '*shadow straight*', right, '*shadow reversed*'.

54. ASTROLABE BY [ABD AL GHAFUR]. Pl. XLII A.D. 1780.
(*Uninscribed.*)

$3\frac{3}{16}$ inches diameter.

S. V. Hoffman Collection, No. 30.

The high pierced throne of beautiful design bears a double inscription:

He is the forgiving.
Oh Noah of Mysteries.

and on the back is the year of the Hegira 1194.

The whole of the suspensory arrangement is extremely dignified in its scheme of ornament. The *kursi* has the form of a small cartouche superimposed on a larger one supported by 2 pierced arabesque foliations which are themselves almost separate from the rim of the astrolabe.

The tracery of the ankabut is also simple and well-planned. Within the zodiac 6 foliate star-pointers spring from 2 reversed S-shaped bands; outside it are 7 stars on a foliated band, which is detached from the zodiac and Capricorn bands except for a dozen small supports. There were 2 *mudirs* near the axil of 2 leaves right and left.

The 5 sexpartite tablets are for latitudes 29° + 35°; 32° + 32°; 36° + 37°; 37° + 38°; 34° + tablet of 18 horizons in 4 groups, but the latitude numbers are not inscribed: all plates are marked for both kinds of hours.

The *umm* is prepared for a gazetteer, but has not been engraved.

The Back has also been left unfinished.

i. The right quadrant is ruled with 18 *mabsut* sines and hour arcs.
ii. The left quadrant is laid out as a zodiacal quadrant.
iii. The engraving of the shadow scales is completed, but the spaces within and outside them are bare.

Alidade is plain.

The instrument is unfinished.

55. ABD AL GHAFUR'S SECOND ASTROLABE. Pls. XLII, XLIII A.D. 1783.

5¼ inches diameter; height including shackle 8⅜ inches.

S. V. Hoffman Collection, No. 31.

A strikingly beautiful instrument by a most accomplished craftsman who signed his name in a cartouche below the shadow scales:

Made by Abd al Ghafur.

On the back of the throne:

In the year (4) or 8 and 190 after 1000 of the Hegira of the Prophet.

In the uppermost lobe of the *kursi* is the invocation,

O Noah of Mysteries,

an ornament that lends great dignity to the parts below, which are inscribed with the usual throne inscription, which is continued on the back.

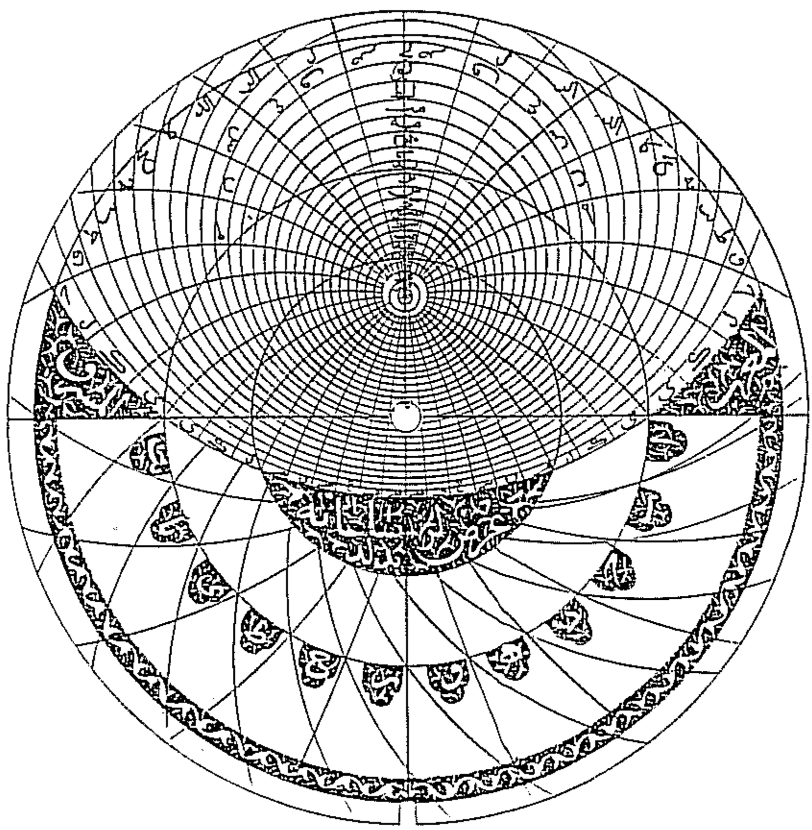
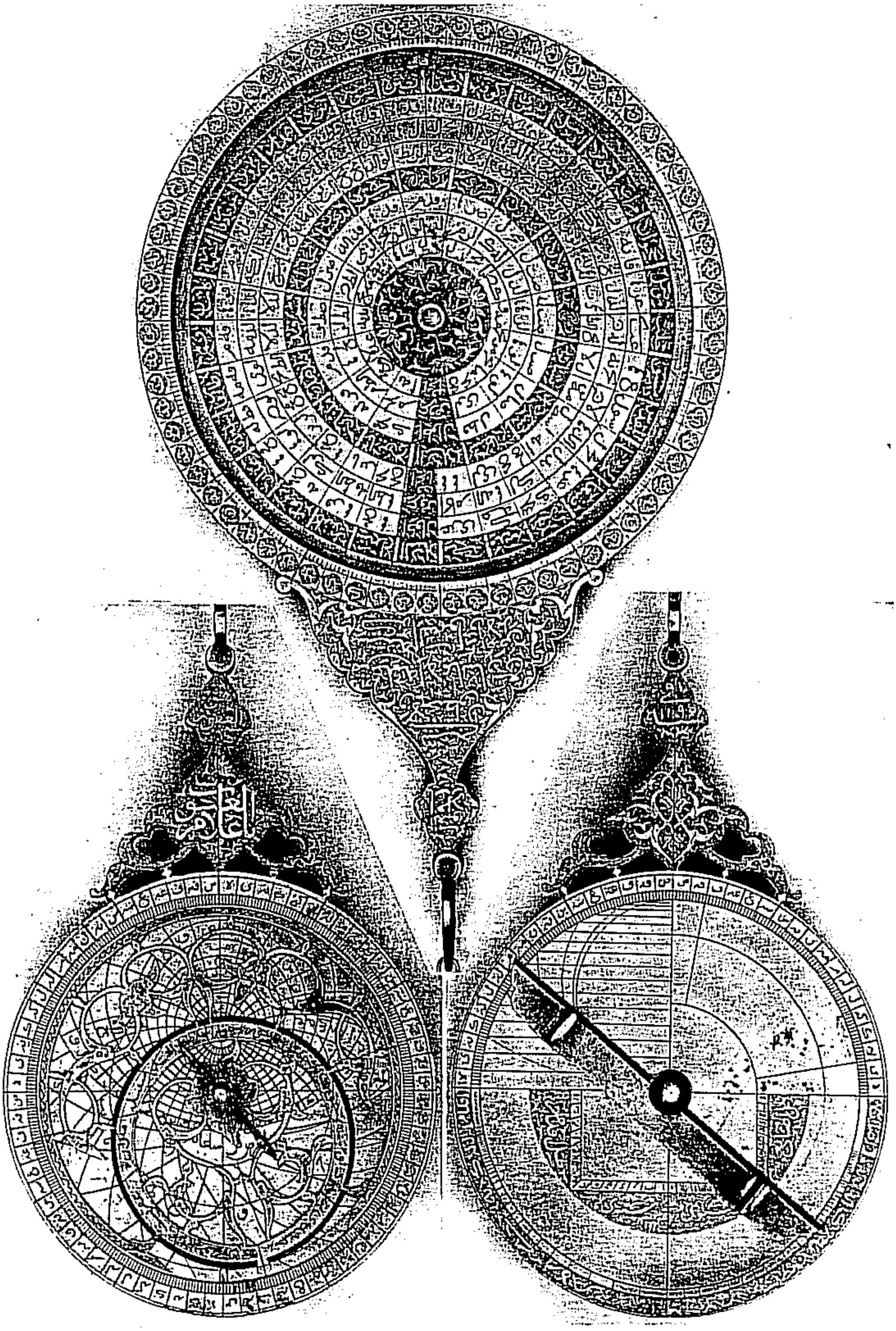
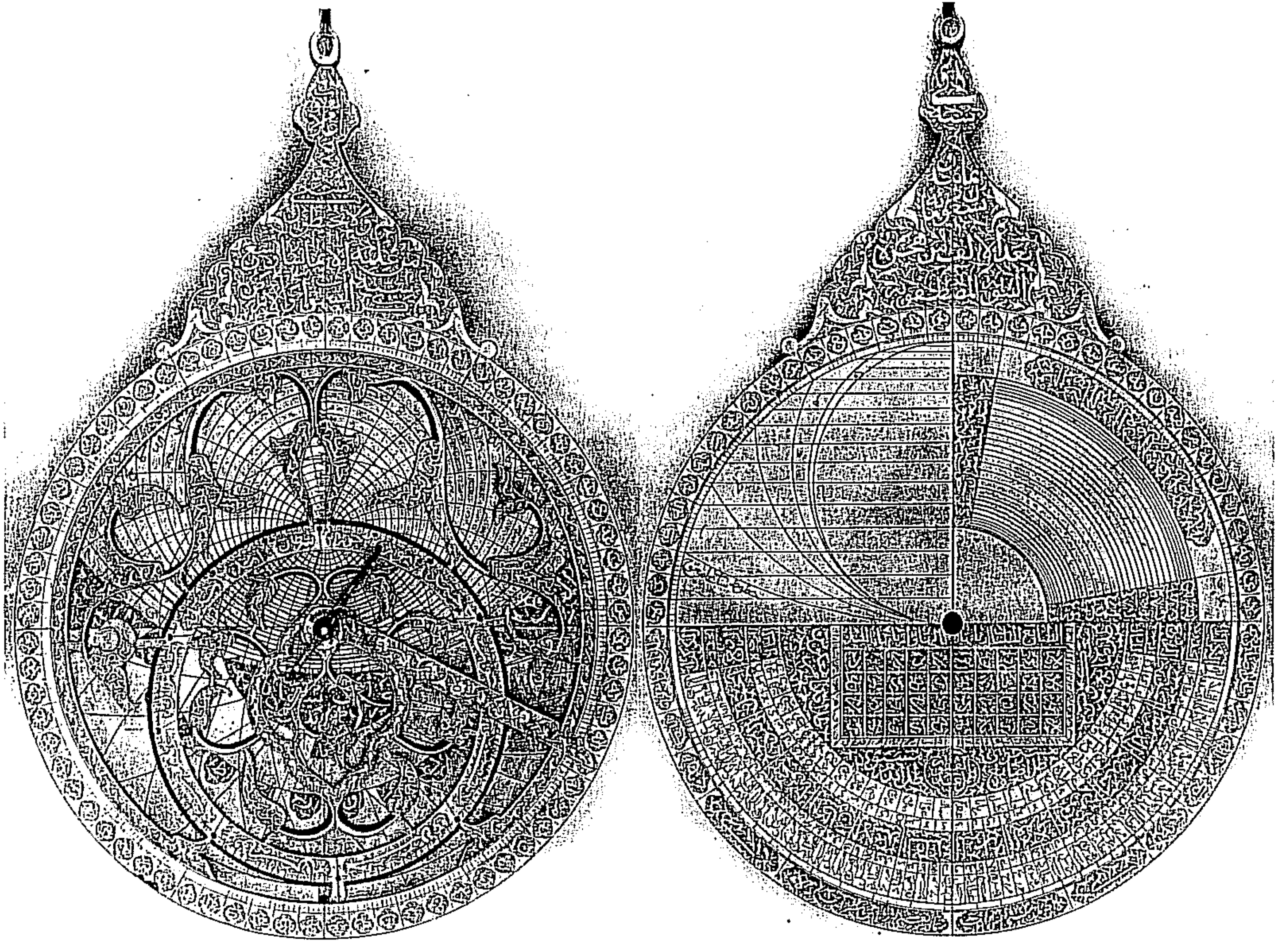


FIG. 81. PLATE FOR LAT. 36°. A.D. 1783.



ABD AL GHAFUR'S ASTROLABES, A.D. 1780 AND 1783



ABD AL GHAFUR, A.D. 1783

XLIII

The degrees around the rim are divided into 4 quadrants numbered clockwise 5°–90°, the numbers being in relief on shaded quatrefoil spaces. In the finely balanced design of the ankabut, the equinoctial band and diametric bars have been dispensed with, the stems and tips of the foliate star-pointers giving sufficient support, except in the middle of the zodiac where a -shaped band further enhances the design. The label is similarly enriched with surface ornament.

The tripartite tablets are for latitudes 29°+40°; 30°+36°; 33°+35°; 32°+36°; 32°+ tablet of horizons.

The gazetteer in the *umm* gives latitudes, longitudes, and inhiraf in 2 bands.

The treatment of the Back is very like that adopted by Abd al Ali for his great astrolabe (Pl. XVII) which is 71 years older than this instrument. The chief differences are the introduction of the lines of an horary instrument over the lines of sines in the left quadrant. The lower hour-line is inscribed 'Lines of the Temporal Hours'.

The drawing of the right quadrant has not been completed.

56. Astrolabe by [Abd al Ghafur] A.D. 1797.

133 mm. in diameter.

Mensing Collection, No. 41.

No name of a craftsman is discoverable; indeed, the cartouche below the shadow scales has been left blank, but the very close resemblance between this instrument and the two last leave very little doubt as to the maker. And this is borne out by the date:

In the year 1212 A.H.

The Persian sentences state that the name *Muhammad* was written on the stand made for every Astrolabe.

Every available space is decorated with flowers and foliage on a stippled background. There are 4 tablets.

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56 A. An 8-inch astrolabe of similar craftsmanship has been given to the Victoria & Albert Museum by the executors of Lady Marling, C.B.E. M. 826, 1928.

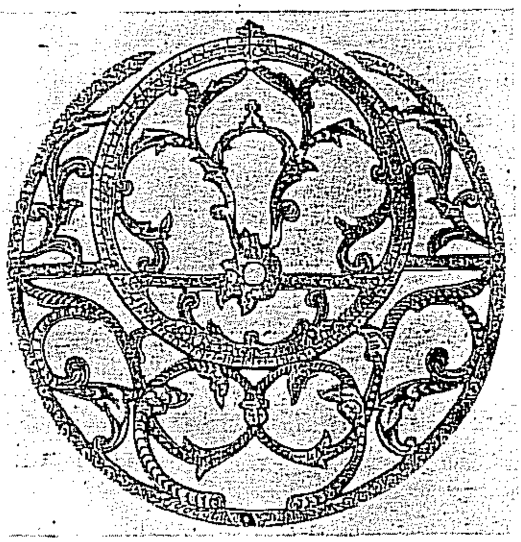


FIG. 83. MOHAMMED AKHBAR'S ANKABUT. A.D. 1818.

The mudir is in the centre.

The tablets are bipartite and appear to be for latitudes 34° + 40°; 40° + 40°; 42° + 46°; 44° + 48°; 42° + tablet of horizons in 4 groups of 5. A sixth plate is ruled in squares and is unfinished.

The *umm* is filled with a 2-ring gazetteer of 72 places surrounding a pretty central ornament of 9 radially arranged flowers.

The Back is completely covered with engraving of the type shown on Pl. XVII.

The left upper quadrant of sines is sexagesimal and ruled with radii to every fifth degree of arc.

Alidade divided.

59. THE ASTROLABE FOR PEOPLE OF LEARNING A.D. 1829

3½ inches diameter.

S. V. Hoffman Collection, No. 14.

In marginal cartouche on back:

Fabricated by Hamza 1245.

And on the *kursi*:

The family of Hamza bequeathed it for the people of learning who are in the House of Beneficence, not to be removed except in case of necessity. 1248.

The rim is divided into 24 panels inscribed with the hours (?) within which is a circle of 360°. The ankabut is devoid of tracery within the zodiac, but the star-leaves in the crescent are borne on a bracket-shaped band ⏟. There are 28 stars.

The tablets are sexpartite for latitudes 30°+32°; 33°+35°; 22°+ tablet of horizons in 8 groups of 6 or 7; 36°+ plate of ankabut co-ordinates.

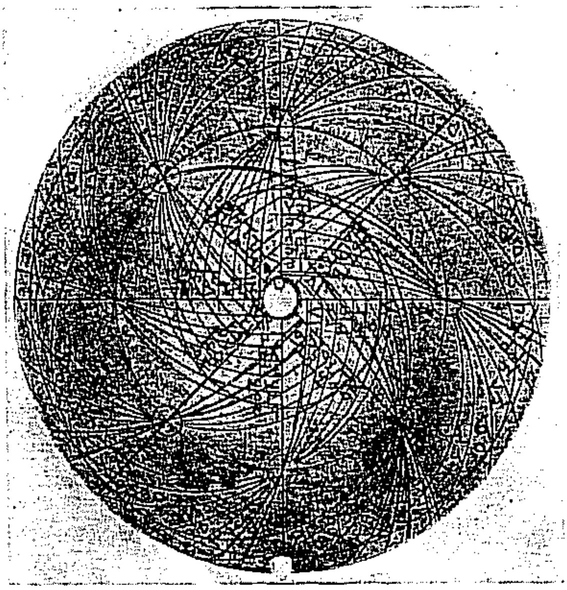


FIG. 84. TABLET OF HORIZONS. A.D. 1829.

The table of cities in the *umm* gives longitudes, latitudes, and inhiraf in 2 rings, so that there are 10 circles in all.

The Back is of the type of No. 42, and the alidade is fully graduated and numbered for horary purposes.

60. SIR HENRY ELLIOT'S ASTROLABE A.D. 1849.

A modern brass astrolabe of 6·125 inches in diameter and ⅛ inch thick.

In the possession of the Rev. H. L. Elliot, Gosfield Rectory, Essex, 1919.

Inscribed on the edge of *hajrah*:

This Sulsi Astrolabe with the Majayyab (Sinus) Quadrant and beneath it the Hajrah, was designed for the honourable Sir Henry Elliot, K.C.B., Chief Secretary of His Lordship the Governor-General in Kayroorthalla by Balhoomal, the Astronomer of Lahore in that gentleman's employ, A.D. 1849.

Suspension is effected by a 3-lobed *halkah* or shackle attached by a riveted pin to the *kursi*. There is no ring. Attached to the *halkah* is the *ilakah* of crimson cord, 7 inches in length, bound at either end by gold thread. The *kursi* of scroll type is pierced with 3 holes.

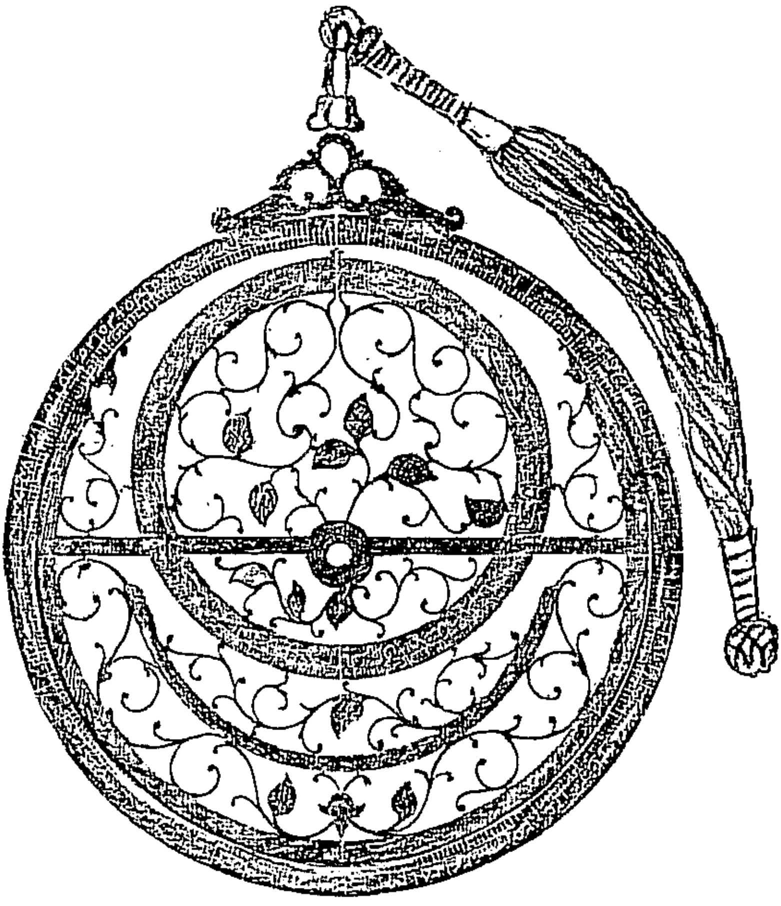


FIG. 85. SIR HENRY ELLIOT'S ASTROLABE.

The tracery of the ankabut is admirably designed; the entire space between the 12 large leaves, which are inscribed with the names of the stars whose positions they mark, is filled with delicate tendril ornament. The zodiac circle is supported by an east-west bar above the centre line. The equinoctial band is not connected with others by any broad bar or band, being supported solely by the tendrils of the fretwork.

A single knob serves as a handle (*mudir*) for turning the rete.

The tablets, 5·5 inches in diameter, and 7 in number,[1] are coarsely engraved. Six are marked for latitudes 17° and 20°; 23° and 26°; 29° and 32°; 35° and 38°; 41° and 44°; 47° and 50°. All plates show the lines of equal and unequal hours, and one shows azimuths below the horizon as in pl. XIX, fig. 10. The seventh plate is engraved on both sides with the tablet of the horizons.

The Back is graduated 0° to 90° in all 4 quadrants, and with a scale of sines in the right upper quadrant, the other 3 quadrants being bare.

61. Sahib Ali's Astrolabe A.D. 1864.

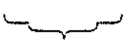
Diameter 4⅝ inches.

S. V. Hoffman Collection, No. 7.

In cartouche on back:

Ṣahib Ali Kabir Khan. 1281.

The back of the *kursi* is filled with the 'Throne' inscription from the Koran, Surat, 68, 51. On the face are the names of the Prophet and the Twelve Imams.

The degrees on the rim are numbered 0–90 quadrantally. The ankabut for 26 stars is practically identical with the last described with the bracket  in the crescent.

The tablets have been carefully engraved, with ornamental spandrels.

1*a*.	Lat. 22°	hours 13. 21.	4*a*.	Lat. 35°	hours 13. 16.
b.	,, 25°	,, 13. 30.	*b*.	,, 38°	,, 14. 39.
2*a*.	,, 28°	,, 13. 47.	5*a*.	,, 45°	,, 22.
b.	,, 34°	,, 14. 17.	*b*.	Tablet of horizons in 8 groups of either 6 or 7.	
3*a*.	,, 32°	,, 14. 7.			
b.	,, 36°	,, 14. 38.			

The gazetteer is in 2 rings containing 36+18 place-names with longitudes, latitudes, and inhiraf.

The Back is fully inscribed. The direction inside the shadow squares reads:

You are to put behind the second letters . . . (rest unreadable).

[1] 'And he arose, and stretching forth his hand, took out a handkerchief and opened it; and lo, there was in it an Astrolabe consisting of seven plates,' *The Story of the Tailor*, Lane's Edition, vol. I, p. 372, *Thousand and One Nights*.

62. Ala'uddin's Astrolabe A.D. 1865.

$4\frac{3}{4}$ inches in diameter.

S. V. Hoffman Collection, No. 22.

Inscribed in cartouche on back:

Made by Ala'uddin. 1281.

Roughly finished. Ankabut for 26 stars is of the No. 44 type with bracket-band in the crescent.

Tablets are tripartite for:

1*a*.	Lat. 22° .	hours 13. 21.	4*a*.	Lat. 36° .	hours 14. 27.
b.	„ 27° .	„ 13. 30.	*b*.	„ 38° .	„ 14. 39.
2*a*.	„ 28° .	„ 13. —	5*a*.	„ 45° .	„ 15. 22.
b.	„ 34° .	„ 14. 17.	*b*.	Tablet of horizons in 8 groups of 6 each.	
3*a*.	„ 30° .	„ 13. 16.			
b.	„ 32° .	„ 14. 7.			

All are held by a nut and screw.

The *umm* is incompletely inscribed with cities.

The Back is of the usual type, with a few minor departures from it.

63. The Greenwich Astrolabe of Mirza Jahan Bakhsh *Undated.*

Diameter 5 inches

S. V. Hoffman Collection, No. 25.

The face of the *kursi* bears the usual ' Throne ' inscription; the writing on the back has been translated by Professor Margoliouth as follows:

Longitude and Latitude of countries are recorded on the Hajrah (i.e. of the astrolabe).

Longitude from the Observatory of Greenwich, London.

Latitude from the Equator, as is well known, is taken from dictionaries, and the Declination from Mecca extracted from the European Sine of Shadow. All completed by Mirza Jahan Bakhsh.

Unfortunately he omitted the date.

The sides of the *kursi* are scolloped. The ankabut shows 9 stars inside and 12 outside the zodiac. The pointers are mostly sickle-shaped. The treatment of the region of the equinoctial band is peculiar, as is the stubby pointer for Sirius.

The 8 plates are executed in a slovenly manner, one for latitude 18° being drawn upon paper glued to a brass plate.

The Back also lacks the marks of careful finish. The quadrant of sines is of the radial-line type, cf. Fig. 92. In the lower semicircle the shadow scales are surrounded by 3 half-rings in which the 28 manzils are intercalated between the signs of the zodiac and the 12.

The following 3 instruments in the Hoffman Collection are unnamed and undated:

64. UNINSCRIBED ASTROLABE *Undated.*

$5\frac{7}{8}$ inches diameter.

S. V. Hoffman Collection, No. 23.

A roughly finished instrument devoid of inscription.

The *kursi* is perforated with 3 holes flanked by ogees and 2 lobes. The ring is 9-lobed.

The ankabut with a *mudir* near the Dog-star has no tracery except the 3 supports for the equinoctial band. Twenty-one stars are shown. The star-pointers are lambent rather than foliate.

The 4 tablets (bipartite) are for latitudes $30° + 38°$; $32° + 32°$; $36° + 42°$; $36° +$ tablet of horizons in 4 groups of 7. As a detail it may be noted that on these plates the lines of unequal hours are dotted, those for the equal hours being drawn in full. Azimuths are drawn on some of the plates.

The steady-pin perforates the plates.

On the Back we find the entire periphery divided into 4 quadrants of 90° each, the peripheral shadow scales being drawn inside, as in an astrolabe No. 15 in the Hoffman Collection.

The left upper quadrant is completely inscribed for 90 *mabsut* sines.

The right quadrant is blank.

The shadow scales are without tables or embellishment.

The alidade is plain and has slit sights.

The names of the towns in the *umm* have been partly erased.

65. Uninscribed Persian Astrolabe. Pls. xxxix–xli.

Diameter $4\frac{1}{2}$ inches. S. V. Hoffman Collection, No. 32.

Kursi plain with 3 lobes between 2 ogees.

Rim divided into 24 ' hour spaces ' by X-shaped marks.

Ankabut of type of No. 44, with the metal tracery band reduced to the most slender proportions. The bases of the leaf star-pointers are occasionally finished off with small knobs. Twenty-two stars are shown. The *mudir* is median.

The tablets are tripartite, for latitudes 28° + 30°; 32° + 34°; 36° + 38°; 42° + tablet of horizons in 8 groups of 7.

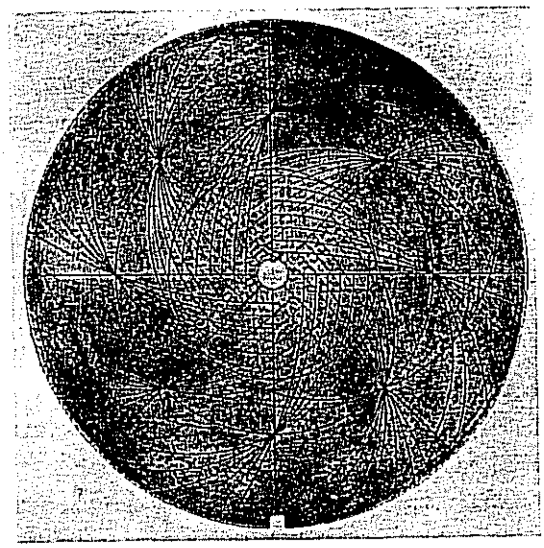


Fig. 86. Tablet of Horizons in 8 Groups.
Hoffman Collection, No. 32.

Unlike the majority of Persian astrolabes the plates are marked with the lines of the Celestial Houses in addition to the unequal hours and azimuths below the horizon. They may have been suggested by a European instrument. The equal hour lines are not inscribed.

The gazetteer in the *umm* contains 32 + 16 = 48 names of places.

On the Back are:

i. Sinical quadrant (sexagesimal).

ii. Zodiacal quadrant with a projection for the arcs of the signs.

iii. Shadow scales rectangular and peripheral.

iv. Semicircular table of planetary influences, signs and faces.

66. Astrolabe with a Tablet for London *Undated.*

$3\frac{1}{2}$ inches diameter.

S. V. Hoffman Collection, No. 21.

On the face of the high triangular *kursi* is written the throne inscription.

The ankabut for 13 stars (4 in + 9 out) is built to a symmetrical foliate design. A *mudir* is fixed at the tip of the Capricorn band near Aquarius.

The tablets, with the exception of one for latitude 32° + a tablet of horizons in 4 groups of 8, are poor. Two are for latitudes 30° and 33°, and 32° and 52° respectively, and two have been wrongly inscribed. They are all sexpartite, and the introduction of a plate for London may be significant.

The *umm* is engraved as a gazetteer.

The Back shows *mabsut* sines (30), a zodiacal quadrant, and shadow squares, all inaccurately engraved.

INDIAN ASTROLABES

IT has been erroneously believed that the astrolabe, or *Yantra Rāja*, was a very ancient instrument of Hindu origin.[1] The earliest Hindu work on the subject is by MAJENDRA SURI, the pupil of Madana Suri, the court astrologer of Bhrigapura. It was written about 1370, and would have been based upon one of the numerous Persian and Arabic works of the preceding

FIG. 87. JAI SINGH OF JAIPUR.

three centuries. Indeed, Majendra acknowledges his indebtedness: 'Many Yawanas have also composed scientific works on this instrument in their own language, and according to their own particular understanding. . . . Having found them like oceans, I now compose this work, like nectar, as the essence of them all.'

In his own estimation his treatise on the good *Yantra Rāja*, full of much variety and wonder-causing, for the benefit of the people was 'abridged, essence-like, exhaustive, but very simple and delightful to the heart'.[2]

Whether the oldest Indian astrolabes are derived from Majendra's work, or whether they have been copied from instruments of more recent intro-

[1] Garrett, *Jaipur Observatory*, 1902. [2] Kaye.

S

duction into India from Persia we do not know. They certainly have a character of their own.

The few Indian astrolabes in the Lewis Evans Collection are of especial importance because they take us back to the days before the foundation of the Royal Society in the West, and illustrate a period anterior to the advent of that most enlightened Hindu ruler in India, MAHARAJAH SAWAI JAI SINGH II, who founded a new capital, named Jai Pur in his honour, and binding 'the girdle of resolution about the loins of his soul' he enriched the scientific literature of his people by causing European and Muslim astronomical books to be translated into Sanskrit. He built and equipped astronomical observatories at five of the principal cities of Hindustan, at Delhi, Jaipur, Ujjain, Benares, and Mathurā. This paragon of a despot was born in 1686 and died in 1743.

Among the older of the instruments still at Jaipur,[1] one presently to be described is dated 1657. The Evans astrolabes are dated 1634 and 1644 respectively. In common with the Jaipur instruments they present several characteristics, which, taken together, appear to distinguish them clearly from the Persian astrolabes which we have just described. They show a widespread scientific cult among the Moslems long before the Hindu prince Jai Singh, with the aid of the Arabian scholar, Jagannath, caused Ptolemy's Almagest to be translated into Sanskrit.

Special Indian features are the large and often elaborately pierced and fretted *kursi* or throne, showing that the makers came of a class which had inherited a mastery of the craft of the metal-worker. Star-pointers of the ankabut are foliate; the right-hand upper quadrant on the back is a zodiacal quadrant traversed by a sigmoid curved line, the declination graph; the two lower quadrants frequently contain elaborate astrological tables; the tablets are often inscribed with a bewildering tangle of horary and astrological lines in addition to the legitimate complement of almucantars and planetary hour lines; in the gazetteer in the *umm* the towns are grouped according to their several climates, and their longitudes, latitudes, and *inhiraf* stated. The longitudes are reckoned from the Fortunate Isles which are believed to have been 35° west of Greenwich.

Many of the Indian makers of astrolabes have exercised a great amount of ingenuity in covering the plane surfaces of their instruments with useful tables. The lines with which many of these Indian astrolabes are engraved

[1] G. R. Kaye, *The Astronomical Observatories of Jai Singh.*

are of such complexity that the present may be a convenient place to explain the general methods in use for their construction, and in this the diagram (fig. 88), made by the late Mr. G. R. Kaye, F.R.A.S., and presented to me by his widow, will be found of great assistance.

THE PLATES.

The lines engraved on the plates are as follows:

Almucantars or circles of altitude range from the largest or horizon circle marked 0° to 90° at the zenith. Their number varies with the size of the instrument; if there is one for each degree it is *tāmm* or perfect; if for every second degree *niṣfi*, bipartite; if for every third degree *thulthi*, tripartite; if for every sixth degree *sudsī* or sexpartite.

Construction. Draw the circle of the Tropic of Capricorn ABCD with AC the meridian and AF an arc equal to $22\frac{1}{2}$ degrees, the obliquity of the ecliptic. Join BF, cutting AC in S. Then the concentric circle SENW is the equatorial circle with the points of the compass as indicated by the letters. Draw ES^1 parallel to BF cutting AC in S^1, which is the southern point of the Tropic of Cancer.

So far the construction is of general application. To find the centres of the altitude circles or almucantars, make arcs SL and WL_1 each equal to the latitude of the place. Join LE and L_1E cutting NS in Z the zenith, and in H the meridian point on the horizon. The opposite point on the horizon is H^1, where EL_2 ($= \phi$) meets the meridian line produced.

To obtain a circle (almucantar) for altitude a, mark off angles (latitude of place $\mp a$ 90°) from S, the south point of the equator (positive direction SW) and join both these points to E, the east point on the equator: the distance between the points intersected on the meridian line NS is the diameter of the circle of altitude a or the almucantar required.

Azimuth lines are drawn at right angles to the almucantars. In the diagram portions of nine of the azimuth circles (Z_{60}, Z_{42}, &c.) are drawn.

Construction. Make arc NL_3 equal to the latitude of the place. Join EL_3 and produce it to cut the meridian line NS in n, then n is the nadir. The horizon is graduated by joining the zenith Z and the graduations on the equator (previously made), and azimuth circles are drawn through the zenith, nadir, and these points on the horizon from centres on a line parallel to EW and bisecting Zn. In some tablets the azimuth circles are continued below (to the north of) the horizon.

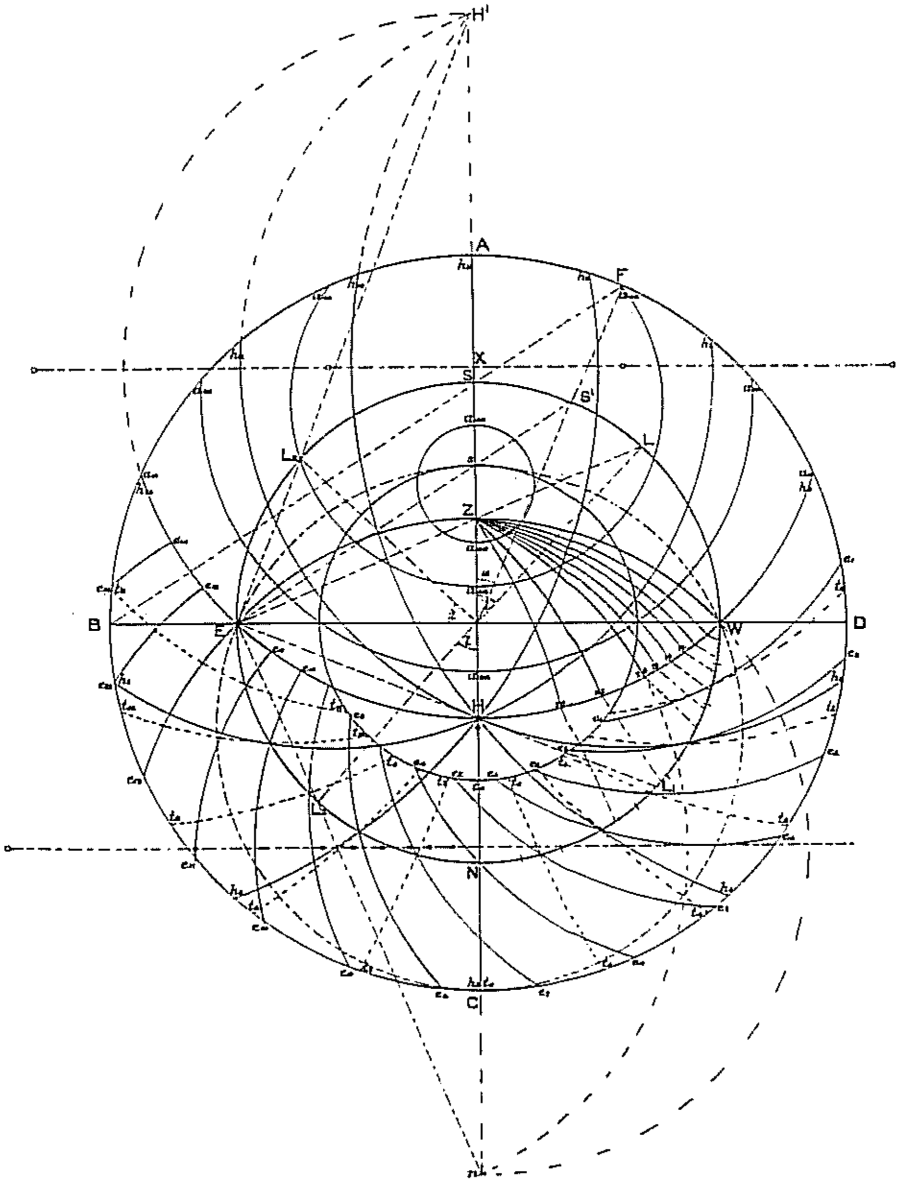
THE UNEQUAL HOURS.

The Unequal or planetary hour lines are usually traced across the crescentic area outside, i.e. to the north of the horizon circle. They divide the period that the sun is above the horizon into twelve equal periods which change with the season, being longer in summer than in winter, and are therefore known as the unequal hours. Only at the equinoxes did they become the equivalent of hours in the modern sense.

Construction. The arcs of the three great circles, the tropics of Capricorn and Cancer and the equator, that are outside the horizon are divided into twelve equal parts. The lines of unequal hours are the parts of circles drawn through each set of corresponding points. They are marked t_1t_1, t_2t_2, &c. in the diagram.

THE EQUAL OR EQUINOCTIAL HOURS.

It has been suggested that the change from the unequal hour to the equal hour system was a natural consequence of the use of mechanical clocks. Abdul Hasan (al-Ḥasan b. 'Ali b. 'Omar



CONSTRUCTIONS FOR ASTROLABE TABLET.

FIG. 88.

al-Marrakōshī, Abu 'Ali) was the first to advocate the use of equal hours among the Muslims (Delambre), and in course of time they came to supersede the Unequal hours.

Construction. With centre C and radius CX draw a circle and starting from X where it cuts the meridian, divide it into 15° arcs. Then successively using these divisions as centres, strike a series of arcs between the tropics each with radius equal to XH. It follows that any point on the ankabut, when rotated, will pass from one equal hour to the next in one twenty-fourth of a revolution. It will, moreover, be noticed that on the equator these arcs intersect the Unequal hour lines.

HOUSES OF HEAVEN.

The lines delimiting the twelve celestial ' houses ' all pass through H and H_1, where the horizon intersects the meridian, and through twelve equally-spaced points on the equator, 30 degrees apart. They are struck from five centres on the line passing through X in an east-west direction.

The points of intersection of these lines with the Ecliptic are termed *cusps*,[1] and they have been almost universally used by astrologers since they were proposed by Sextus Empiricus in the third century A.D.

Inscription. The latitude for which a plate has been drawn is usually inscribed on the right of the north-south line, and the length of the longest day is stated on the left. Thus:

S.

Hours.	*Latitude.*
13. 47.	28.

N.

Occasionally the names of one or more places are added.

SPECIAL PLATES.

i. *Tablet of the Horizons.* One side of one of a set of plates (*al-Ṣafīḥat al-āfāgiyah*) is generally engraved with horizons arranged quadrantally in sets each comprising some four to seven horizons. To each quadrant belongs a scale of the ' total obliquity (northern or southern) ' *al-mail al-kullī* (*shamālī* or *janubī*). See Pl. XV; Pl. XX, Fig. 16. See p. 12.

ii. *Tablet of Ankabut Co-ordinates.* This, the ' tablet of the latitude of the complement of the total obliquity ', gives the longitudes and latitudes of the stars of the rete. It is therefore rightly termed *Safīḥah mizan al-'ankabut*, ' the tablet of the measure of the rete'. See Figs. 14 and 97.

iii. *Tablet for the latitude of the equator.* The oblique and straight horizons coincide, and this line is marked *al-maghhrib al-'arḍ lah* ' the west no latitude ' and *al-mashriq al-'arḍ lah*, ' the east no latitude '. Below the horizon are concentric semicircles, which appear to be circles of declination. See pp. 12–13, Pl. XX, Figs. 17 and 18.

iv. *Tablet for 72° N.* which is the only number inscribed on the plate. Engraved with the three circles and the almucantars, none being numbered. Cf. the Jaipur niṣfi astrolabe and the India Office Hindu astrolabe marked aṁsá 72, horā 23

v. *Double plates* with co-ordinates for two sets of latitudes engraved on same side are not uncommon among Indian instruments.

vi. *Double plates* split into two halves along the meridian are rare. One for latitudes 32° (14h. 6m.) and 36° (14h. 26m.) has been described by Kaye in the Delhi ' Q ' astrolabe.

THE BACK.

The Back of the Astrolabe (*Ẓahr al-aṣṭurlāb*) bears the alidade, the position of which is read on a marginal scale of degrees, which is present in all instruments, and surrounds two upper quadrants, a quadrant of sines on the left, and a quadrant of declination on the right, under which are the shadow scales, and in the more elaborate instruments tables for astrological purposes.

[1] Stöffler, *Elucidatio*, 1524.

i. The *Quadrants of Degrees* are numbered from 0° at the east and west points to 90° at the zenith. In a 13-inch Jaipur astrolabe the degrees are subdivided into quarters.

ii. The *Quadrant of Sines* filling the left upper quadrant may be variously divided.

a. It is traversed by sixty (or thirty) horizontal lines drawn from as many equal divisions on the vertical radius to the periphery (Fig. 27).

b. It is traversed by between eighty and ninety horizontal lines drawn from every degree marked on the periphery of the quadrant (Fig. 25).

c. It is traversed by sixty horizontal and sixty vertical lines from as many equal divisions on both vertical and horizontal radii (Figs. 26 and 28).

In all cases the vertical and horizontal scales indicate the sines and cosines of the corresponding angles.

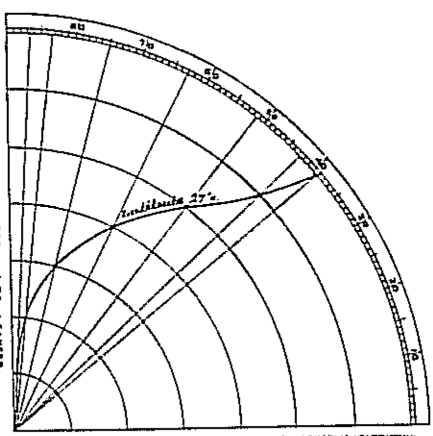
iii. *The Calendar Quadrant* occupies the right upper quadrant. In this quadrant both horizontal and vertical radii are divided into six divisions which are named or numbered after the signs of the zodiac. These zodiacal divisions may be (*a*) equal or (*b*) proportional to the declination of the sun (e.g. Herat, Fig. 12).

They are arranged in order thus:

8 Sagittarius
7 Scorpio
6 Libra
5 Virgo
4 Leo
3 Cancer

Gemini	Taurus	Aries	Pisces	Aquarius	Capricornus
2	1	0	11	10	9

The scales of signs with the quadrant of degrees supply the circular and angular co-ordinates on which special graphs may be traced, for the purpose of showing the following:[1]



DECLINATION GRAPH.
FIG. 89.

a. The relation between the sun's right ascension and meridian altitude. The graphs take a characteristic sigmoid form and are diagnostic of Indian astrolabes.

Construction. 'For each pair of signs, radii marking the angle of the meridian altitude of the sun are drawn, and the points of intersection of these radii with the corresponding arcs of the signs are joined. To make the graph perfectly correct, intermediate points must of course also be fixed' (Kaye).

b. The meridian altitudes for certain latitudes.

c. The altitude of the sun when it traverses the azimuthal circle of the Ka'bah at Mecca.

d. The Unequal and Planetary hours, according to an ancient scheme described by Sacrobosco *c.* 1250.

Construction. The periphery of the quadrant is divided into six. A semicircle described on the vertical radius and a series of arcs are drawn from centres on the vertical radius so as to pass through both the peripheral division and through the centre of the quadrant. It is not a very accurate scheme.

[1] We follow Kaye.

iv. *The Shadow Scales* are usually arranged in two pairs, a marginal pair on the periphery of the disc and a pair in a central rectangle. The left-hand members of each pair are usually constructed with 7-unit scales, those on the right with 12-unit scales. The method of construction has been described by Kaye, p. 22 and Fig. 23.

v. *Astrological tables* engraved on semicircles round the shadow rectangle.

They comprise lists of signs, manzils, terms, and faces.

vi. *Table of times of rising of the Signs* for the latitudes ranging from 39° to 20° of certain cities in India.

A good example is contained in the central rectangle of ' Jaipur B '. From this table of the times of the rising of the Signs, the ascendant could be calculated, if the position of the sun were known for any latitude between 20° and 39°.

The ascendant is the point of the ecliptic rising to the horizon at any given moment. By the astrolabe its determination is easy. The rete is turned until the sun's place in the ecliptic is brought to its proper altitude circle, then the point of the ecliptic on the horizon can be read off.

Cf. *Almagest* Book ii.

vii. *Table of the Regents of the Trigons.* Figured in the centre of fig. 25.

Nature of Triplicities.	*Fiery.*	*Earthy.*	*Airy.*	*Watery.*
Day Lords	Sun, Jupiter, Saturn	Venus, Moon, Mars	Saturn, Mercury, Jupiter	Venus, Mars, Moon
Triplicities	Aries, Leo, Sagittarius	Taurus, Virgo, Capri.	Gemini, Libra, Aquarius	Cancer, Scorpio, Pisces
Night Lords	Jupiter, Sun, Saturn	Moon, Venus, Mars	Mercury, Saturn, Jupiter	Mars, Venus, Moon

Trigons or triplicities are groups of three signs, each of which is situated 120 degrees from the other two.

Saturn, Mars, Jupiter, and the Moon occur in their respective triplicities both as day and night regents, and they are sometimes therefore termed ' common regents '.

viii. *The Table of Climates*, probably inherited from the ancient Greek system of geography, is engraved on Jaipur A, fig. 7, but nowhere else. The length of the day was taken as the measure and an extra half hour was the criterion of another climate up to a total of seven.

ix. *A table of the Length of the Year* in Jaipur A, fig. 7, and in an astrolabe of Mohammad Muqim of Lahore of A.D. 1659–60 show multiples of the differences between the approximately correct length of the tropical year and 365 days. An example is mentioned on p. 211.

67. Professor Wilson's Astrolabe A.D. 1270–1.

Procured by Professor Wilson at Benares (Morley).

The oldest known astrolabe made, or perhaps we should say, modified for use in India, belongs to the period of the Mohammedan dominion, and was essentially an instrument of the Arabian type inscribed in Cufic which has been altered and reinscribed for use in India.

It is small, copper gilt, and 3¾ inches in diameter: inscribed on the back on the edge of the lower left quadrant:

*Constructed by Mahmud Ben Ali Ben Yusha Al**ri, in the year 669 Hegira*, which began on A.D. August 20, 1270.

Also across the middle of the lower quadrants:

For the Museum of the honoured Prime Minister, the supreme Lord, the Assisted (by God), the Wise, the Just, the King of the Amirs, the Khusru of the quarters of the World, the Splendour of the State, and of the Faith, the Sun of the Islam and of Muslims, the Succour of princes and lords, Al-Hasan Ben 'Ali Ash-Shadid: may God glorify his friends and double his dignity.

This dignitary is supposed by Morley to have been the chief Wazir of the Sultan Bibars who died A.D. 1278.

Further datings in Cufic occur on the face of the *kursi*,

The year 193 Malikshâhi (era),

and on the back of the *kursi*,

(The year) 640 of the Yazdajir diyah (era), 1582 of the Iskandar Rumiyah (era).

For further description see pp. 32–4.

The numbering of the degree circle is to 360°, the letter ɛ or 5 occurring in every alternate division, e.g. 5, 10, 5, 20, 5, 30, &c., 5, 360.

The ankabut comprises 22 *shaziyahs* for stars besides the *muri Ras al-Jadi*.

Two tablets (*sudsi* or sexpartite) are retained in place by a small peg, the *mumsikah*, projecting from the lower part of the face of the *umm* at a little distance from the *hajrah*. The tablets are engraved for:

1a. Lat. 36° . . hours 14. 30.
b. ,, 37° . . ,, 14. 33.
2. A double projection of the sphere, exhibiting 2 diameters.
a. Lat. 24° and 30°. [Morley, Pl. XIX, Fig. 12].
b. ,, 27° and 32°.

The list of Indian cities on the interior of the *umm* is more modern, being engraved in Devanagari characters.

Dilli	28°	39′	Bijapur	16°	20′
Agra	26	43	Bhagnagar	19	20
Multan	29	40	Sironj	24	10
Kabul	33	45	Buhranpur	20	40
Ajmer	26	—	Ujjain	22	20
Ahmadabad	23	—	Lahore	31	50

The Rule is graduated with divisions to correspond with the lines in the Rub'al-Irtifá, or left upper quadrant.

68. Isa's Astrolabe — c. A.D. 1600.

Information from Mr. Percy Webster, Nov. 1928.

Diameter 10½ inches; thickness ½ inch; weight 13 lbs.

Inscription:

Made by the most modest of slaves Isa, the son of Haddad the maker of astrolabes of Lahore, the Royal Astronomer.

This fine piece appears to have been made by the father of Mohammad and Mukim whose work will presently be described. The bracket is solid. The rim is divided to half degrees. The ankabut is a most accomplished piece of tracery designed for some 50 stars. There are 5 plates.

69. The Astrolabe of the two Sons of Isa ibn Al-Haddad — A.D. 1609.

Kestner Museum, Hamburg. Described and figured by Frank and Meyerhof, *Ein Astrolab aus dem Indischen Mogulreiche. Heidelberger Akten der von-Portheim Stiftung*. 13. 1925.

A rudely fashioned instrument 84 mm. in diameter and 8 mm. thick.

The suspension ring is small in proportion to the somewhat heavy shackle, and may be a later addition. The high and solid bracket is inscribed on both sides. On the face:

Its making was completed by the two hands of the weakest of servants the two sons of Isa ibn al-Haddad in the year 1018 in the town of the house of the Kalif, Lahore. God the Everlasting preserve it from the chances of fortune.

Then follow two numbers which correspond to the longitude and latitude of Lahore, 109° 20′ and 31° 50′.

The back and borders of the bracket and other parts of the instrument are also inscribed with the geographical positions of other towns as given below:

	Long.	*Lat.*
Lahore	109° 20′	31° 50′
Mecca	77 0	21 40
Medina	75 20	25 0
Jerusalem	66 30	31 50
Kufa	79 30	31 30
Basra	84 0	30 0
Bagdad	82 0	33 25
Aden	76 0	11 0
Djidda	76 0	21 0
Jemen	77 0	15 30
Ahmadabad	108 40	23 15
Kambajat	109 20	22 20
Somnat	106 0	17 0
Tanesar	112 25	30 10
Panipat	113 10	28 52
Ajmere	111 5	24 —
Agra	117 0	26 38
Delhi	113 20	28 12
Gwalior	115 0	26 29
Kanauj	112 50	26 36
Kora	107 6	26 36
Benares	117 20	26 15
Badaon	114 19	27 37
Baran	114 0	28 45
Jawnpur	119 6	26 36

	Long.	*Lat.*
Oudh	118° 6′	27° 21′
Sonnam	110 0	30 30
Sumbhul	115 15	28 20
Hansi	112 25	29 15
Coil	114 19	28 0
Gopamao	116 38	26 45
Lahore	109 20	31 50
Multan	107 35	29 40
Daulatabad	102 0	20 30
Ahmednagar	107 0	19 0
Rajgar	109 15	18 20
Buhranpur	—	—
Ujjain	112 0	22 30

Mongir, Pandwa, Sonnargano, Satgano, Khairabad, Surat, Bidschapur, Golkonda, Amarkot, Sultankot, Ilahabad.

Hanja	67° 75′	12° 15′
Sarangpur	67 55	11 40
Sironj	67 83	14 55
Narwar	68 45	15 25

Kalinjar, Schukrpur
Bidar, Gulbarga, Parenda
Jaul, Kabul, Peshawar
Kandahar, Herat, Meshed, Teheran.

The ankabut presents the somewhat rare feature of an almost complete band along the equinoctial circle, which is only interrupted below the east and west horizontal bar. The 4 cardinal bars are complete and counter-changed on either side of the fiducial lines. The star-pointers are foliate.

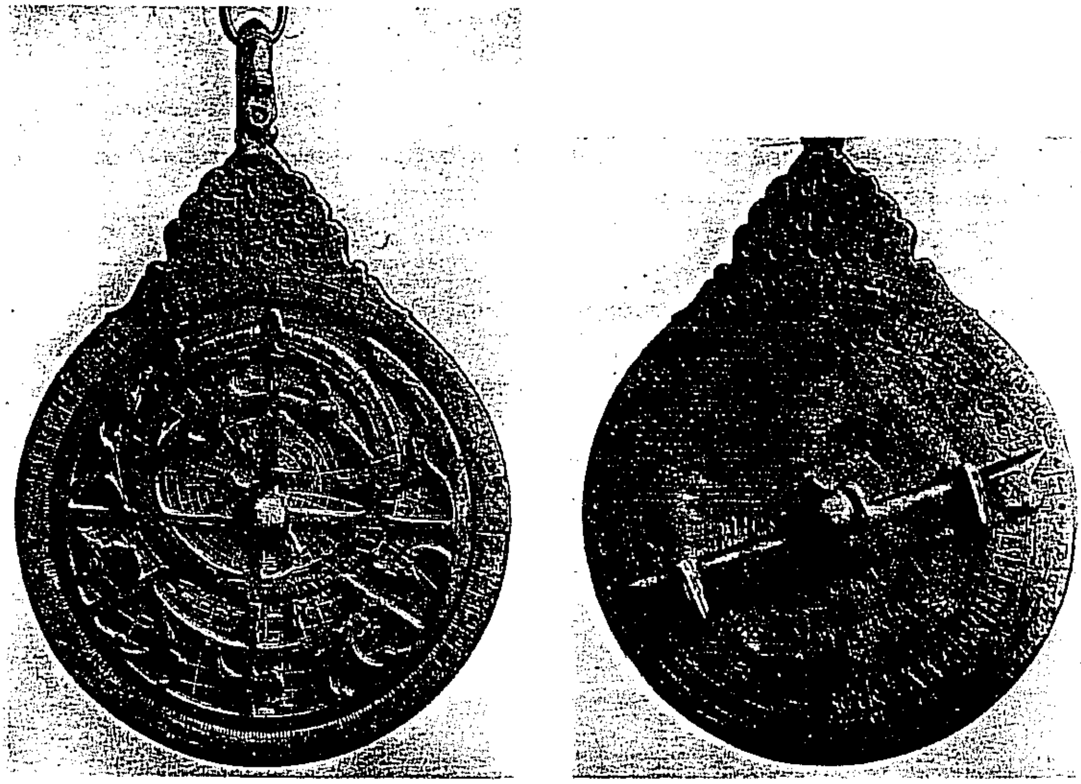
List of 17 Stars

North.

Ras algati α Herculis.
Nasr-i-tair α Aquilae.
Najjir-i-fakka αβ Coronae borealis.
Tauam-i-muqaddam and ras α Geminorum.
Kaff alhadib β Cassiopeiae.
Danab aldagaga α Cygni.

South.

Qalb al aqrab α Scorpii.
Simak i-azal α Virginis.
Qaidat albatija α Crateris.
Fard i suga α Hydrae.
Dira ain and saq ? Cancer.
Sira jamani α Canis majoris.
Rijl-i-gauza aljusra β Orionis.
Famm alqitus γ Ceti ?
Batn-i-haut ζ Ceti ?
Danab qitus-i-samali ι Ceti.
Danab algadi δ Capricorni.



FIGS. 90, 91. BY THE TWO SONS OF ISA. A.D. 1609.

The tablets are *sudsi*, and for latitudes 18°; 21° 40′ (Mecca); 24°; 27°; 32°; 35°; 39° 37′; and a tablet of horizons.

The Back is inscribed with:

i. Two quadrants divided into degrees numbered by fives.

ii. A sinecal quadrant, *al-rub' almuqajjab*, ruled with 30 equidistant lines. Sine 90° = 60.

iii. A zodiac quadrant in which 5 concentric equidistant quadrantal arcs separate 6 intervals, each corresponding to the 2 signs of the zodiac which are at equal distances from the celestial equator. These arcs are crossed by the curved line of midday giving the meridian altitude of the sun for the various months throughout the year for the latitude 32°.

A method for the construction of lines for other hours is given by Al Biruni in his *Kitab al-isti'ab*.

70. THE ASTROLABE OF THE CONTEMPTIBLE ALI. Figs. 92–3. A.D. 1611.

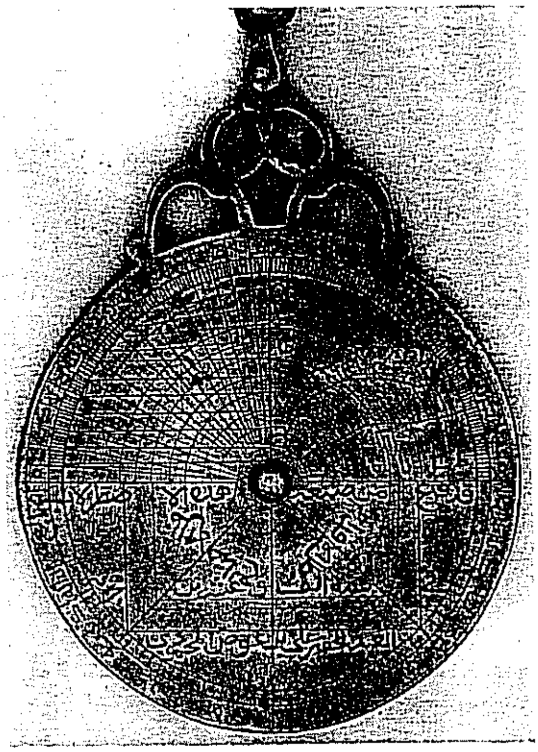
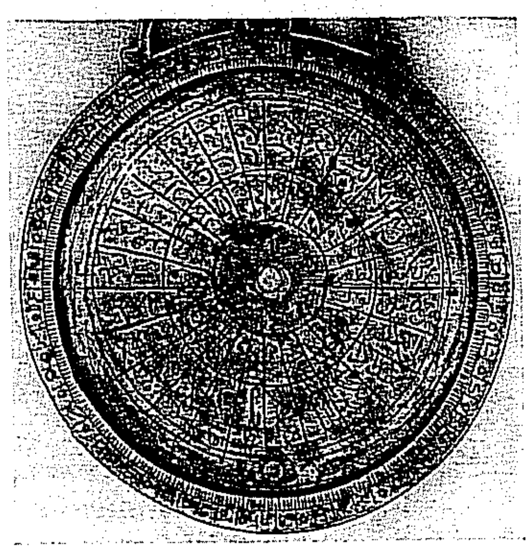
3⅜ inches diameter; height 5 inches without ring.

S. V. Hoffman Collection, No. 4.

Finished from the construction of this astrolabe in the year 1020 Hegira the contemptible slave Ali son of 'Iwad al Mahmudi.

Throne high, reduced to a mere framework owing to the size of 5 large apertures.

Ankabut for 24 stars, of crude workmanship, witness the unequal cutting of the east-west bar. Tablets missing. The interior of the *umm* is inscribed with a circular table of 25 towns, including Lahore, with their positions.

FIGS. 92, 93. ALI B. 'IWAD AL MAH MUDI. A.D. 1611

On the Back, within the (i) two upper marginal quadrant scales, are:

ii. a quadrant of sines, of type with 12 concentric circles and radii to every fifth degree.

iii. a Zodiacal quadrant traversed by sigmoid lines, rudely scratched, and inscribed '*the commencement of noon in lat.* 38°' and '*the beginning of afternoon*'.

iv. in the lower semicircle are Shadow scales, both in the rectangle and on the margin.

71. MOHAMMAD IBN ISA'S LAHORE ASTROLABE A.D. 1634.

Pls. XLV, XLVI; Figs. 94–97.

7⅝ inches in diameter and ⅛ inch thick; total length including the shackle and ring being nearly 11¼ inches.

Bought by Dr. L. Evans, 23 September 1921, from Fenton, Cranbourne St.

Inscription on the back of the ankabut:

Made by the least servant of God Mohammad Ibn Īsa Ibn El Haddād, Asturlabi Lahori Hamayuni (= the Royal Astrolabist of Lahore).

The latitude given is 32°, which is correct for Lahore.

To the left of the shadow scale on the back is a date, '*8 sanat Julus Shah Jehan*', *the eighth year from the accession of Shah Jehan*, the Emperor at Delhi who in 1627 succeeded on the death of Jahangir. Eight years from 1627 brings us to 1635, corresponding to the Hegira date, inscribed on the other side of the shadow scale, '*Year of Hejira 1044*', which began in June 1634. Above is a third dating, '*Senat Rumi 1946*', which again corresponds to A.D. 1634.

The *kursi* or throne is enriched with very beautiful examples of fretwork in thick metal. It is irregularly pierced in 37 places and the appearance is further enriched by surface engraving. The alidade or rule, 6⅞ inches long, is complete, with double sights, but the original *faras* is lost.

The rim is graduated to 360° commencing at the top and going with the sun; it is numbered at each fifth degree, and sub-divided in half-degrees.

The ankabut, 6⅝ inches diameter, is made for about 47 to 50 stars, several of the names of which are not easily found in the books.

Near the centre of the ankabut there are 2 arcs of circles nearly parallel to one another. On the upper arc are engraved the names of 6 zodiacal signs:

Al Hamal	*Thaur*	*Jauza*	*Saratan*	*Asad*	*Sunbula*
Aries	Taurus	Gemini	Cancer	Leo	Virgo.

This is a most unusual feature.

The lower arc has words, beginning, شق, '*The Horizon of the Western Solid*'[1] and '*The Horizon of the Eastern Solid*', the use of which Dr. Knobel could not discover.

STAR LIST

Terf al Safinah	ε Argus.
Dzaneb al Qitus	β Ceti.
Kalb al Aqrab	α Scorpii.
Kafa Djenubi	α Librae.
Djenah al Ghurab	γ Corvi.
Simak Ayzael	α Virginis.
Quidat al Batiha	α Crateris.
Kalb al Asad	α Leonis.
Ferd al Schudsha	α Hydrae.
Sahabi	λ Orionis.
Minchir Schudsha	υ Hydrae.
Schire Schami	α Canis majoris.
Schiri Yamanih	α Canis majoris
Rigil al Jauza	β Orionis.
Jad Jauza	α Orionis.
Ain al Thaur	α Tauri.
Masef al Nahr	Eridani.
Serref al Qentaurus	Centauri.
Fam al Qitus	γ Ceti.
Sag al Mah	δ Aquarii.
Dzeneb al Gedi	γ Capricorni.
Baka al Toua	η Ophiuci.
Dhakr al Dub	α Orionis.
Airik al Hea	λ Serpentis.
Nesr al Waki	α Lyrae.
Dzeneb al Rachab	—
Mingur al Sedjadja	β Cygni.
Mitan al Ferabi	—
Betn Jauza	α Orionis.
Ras Aoula	α Ophiuci.
Aiouq	α Aurigae.
Thanskia	—
Al Sarfa	β Leonis.
Dzeneb al Dub	η Ursae majoris.
Marfak al Nazboh	—
Saria al Feras	δ Pegasi.
Miri al Feras	α Pegasi.
Al Delfin	ε Delphini.
Minkeb al Feras	β Pegasi.
Min al Feras	α Pegasi.
Fam al Feras	ε Pegasi.
Ras al Jathie	α Herculis.
Ras al Storeti	α Ophiuchi.
Al Fecca	α Coronae Borealis.
Simak al Rami	α Bootis.

And in addition these duplicate names:

Rigil al Jauza al Yemeniah	κ Orionis.
Rigil al Jauza al yssi	β ,,
Yed Jauza Yemeniah	α ,,
Yed Jauza Shuriati	—
Dyneb al Qitus	Shimali.

[1] Nallino, p. 327.

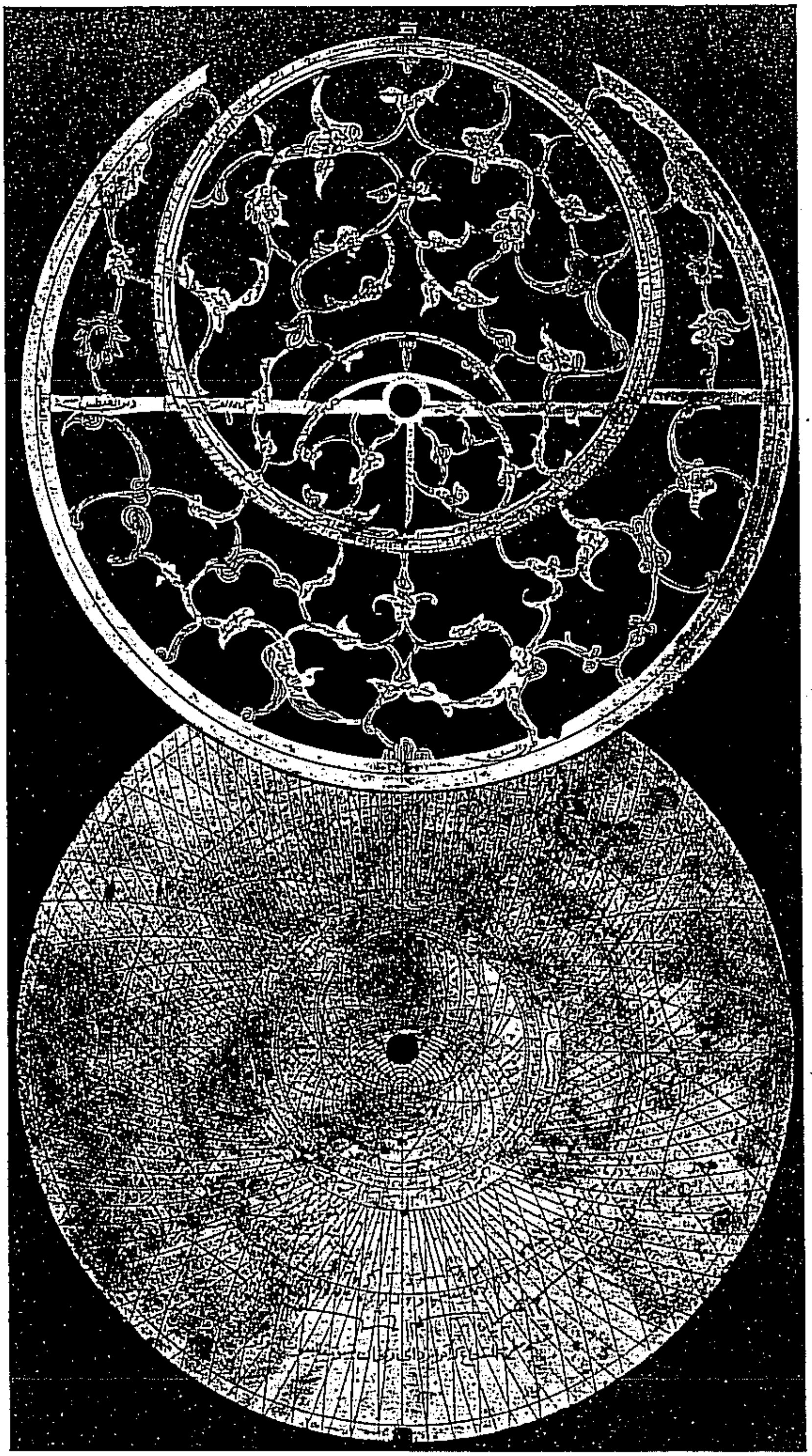


FIG. 94. MOHAMMAD IBN ISA. A.D. 1634. RETE AND TABLET *g*.

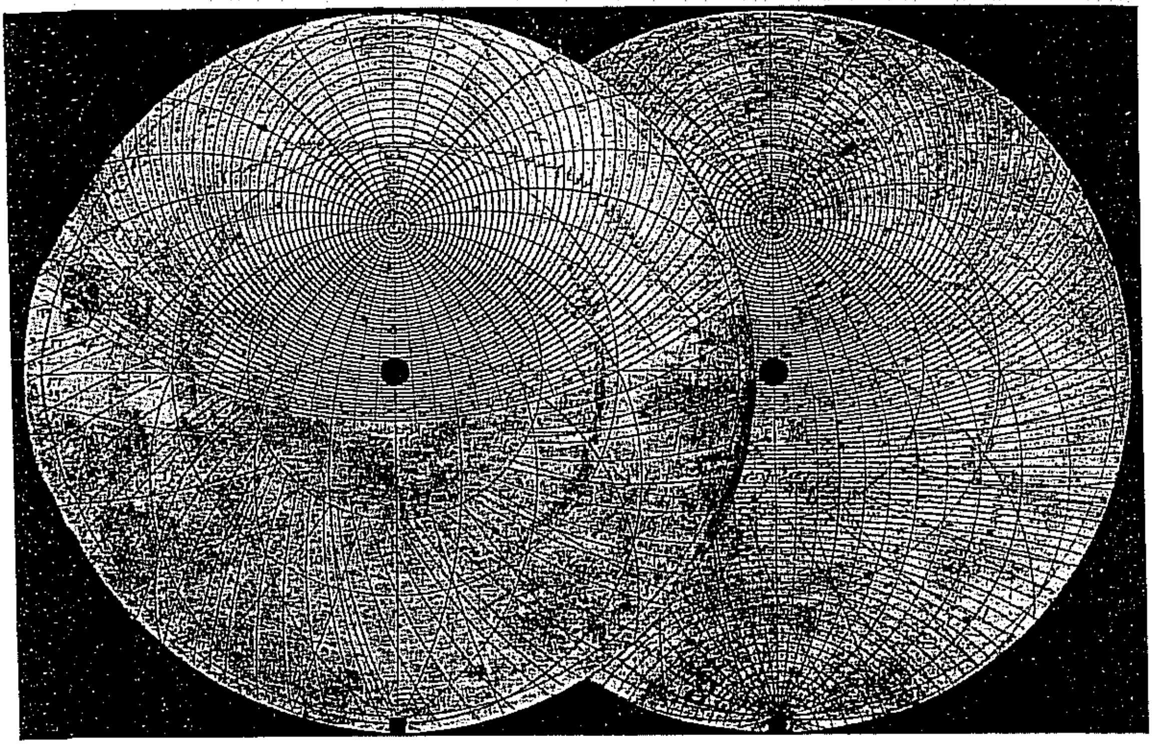


FIG. 95. PLATE FOR LAT. 25°. 23° 30′. A.D. 1634.

The 7 latitude tablets (*çafihat*), about 6⅝ inches diameter, are bipartite. Several plates give stereographic projections of the sphere for different latitudes on the same plate, thus: 30° and 36°; 44° and 28°; 14° and 22°. The others are for:

a. Lat. 23°. 30, hours 13, south lat. 13+ ?
b. Lat. 25°, hours 13 + a double plate inscribed 'Evidence for knowledge of rising' and 'Evidence for knowledge of setting'.
c. Lat. 32°, hours 14. 8 + lat. 37°, hours 13. 20. [The lat. of Lahore, where the instrument was made.]
d. Lat. 35°, hours 15. 27 + a double plate.
e. Lat. 38°, hours 14. 38 + a plate inscribed 'For knowing the rising of Canopus'.
f. Lat. 0° + a tablet of horizons in 4 groups of 15.
g. 'Table of the scale of the Spider' + a complicated plate in the centre of which is a miniature tablet for lat. 42°, hours 15. Across the bottom is written 'A table of the projection of rays', which according to Albiruni is also called 'equalization of houses' (= areola, Nallino, p. 324).

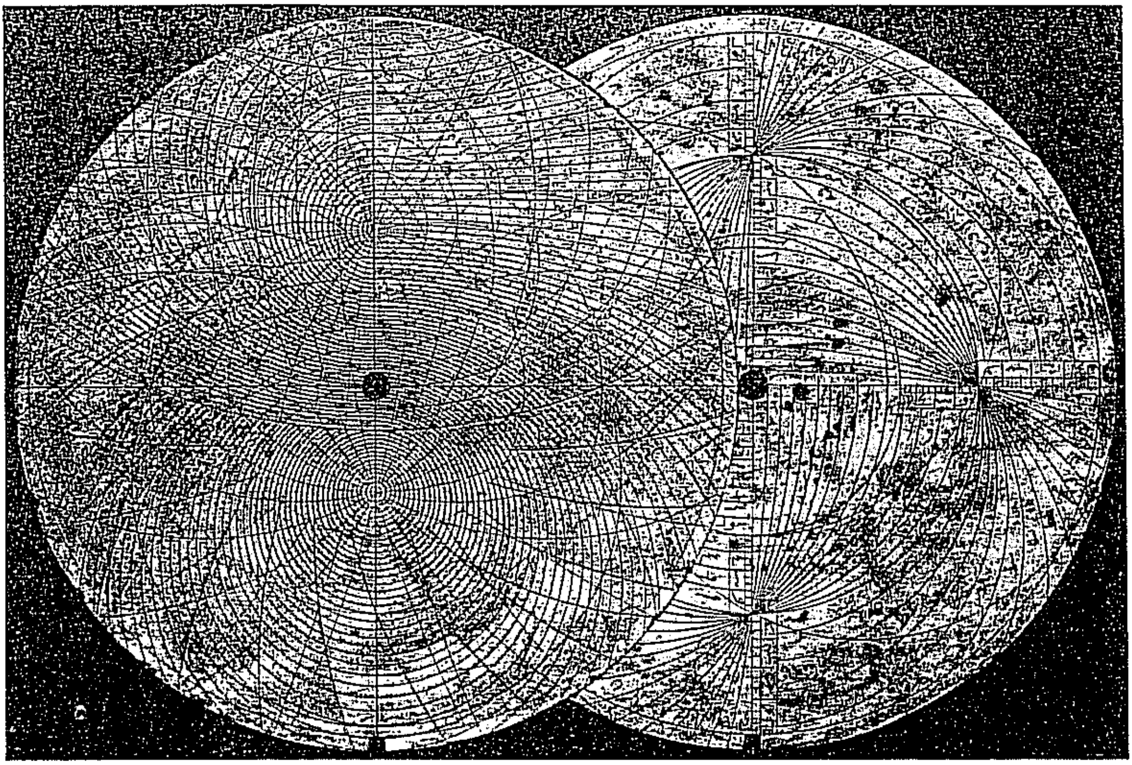


FIG. 96. DOUBLE PLATE FOR LATS. 20° AND 40°. TABLET OF HORIZONS. A.D. 1634.

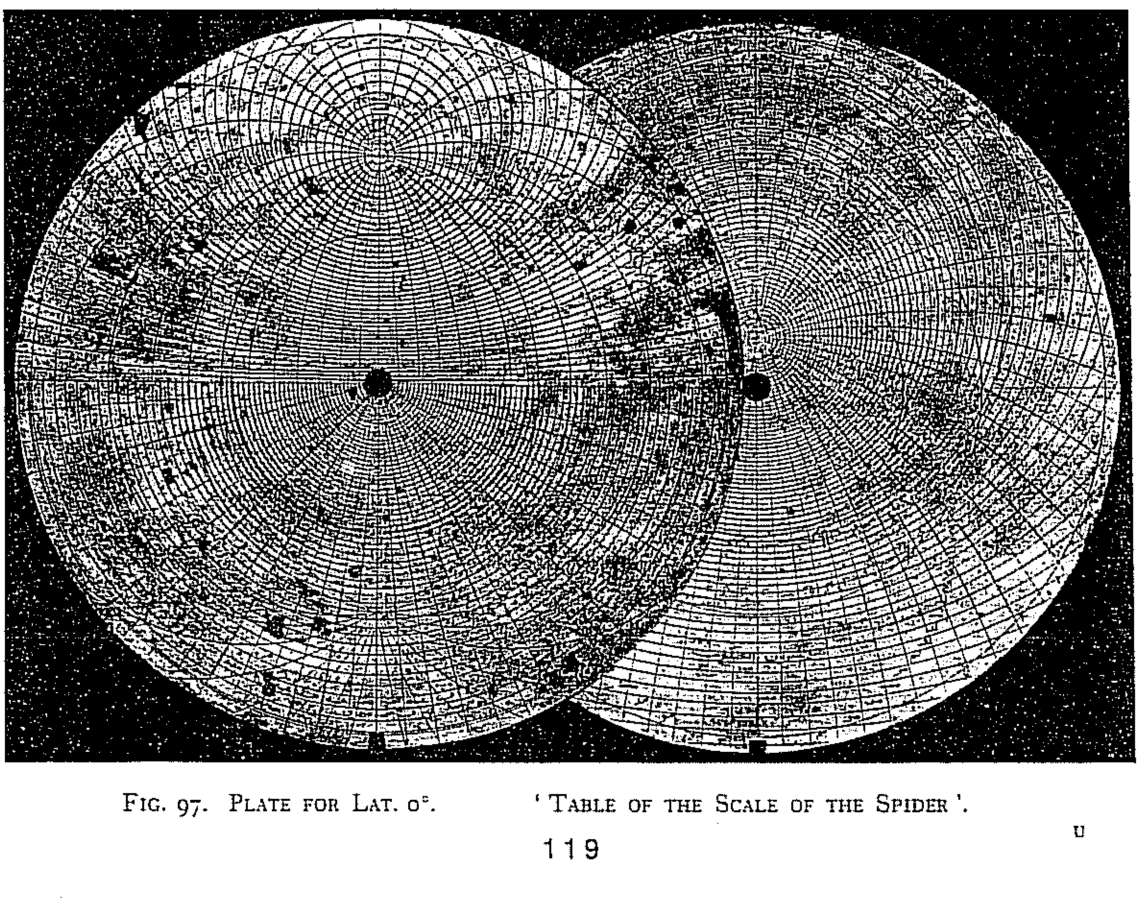


FIG. 97. PLATE FOR LAT. 0°. 'TABLE OF THE SCALE OF THE SPIDER'.

The outer circle is clearly for astrological use, being inscribed with 12 words, beginning with طالع, which means 'Fortune or horoscope destiny' followed by the numbers 'second, third . . . to twelfth' in words, referring to the ascension points on the ecliptic (*v.* Nallino, p. 342).

The interior of the *umm* gives the names of cities, 128 in all, arranged in 4 concentric circles, according to the climates, with their latitudes and longitudes.

The Back of the astrolabe is as carefully engraved as the face.

i. The upper semicircle is graduated right and left from 1° to 90° showing half-degrees.

ii. The lower rim is graduated in diminishing degrees from 1° to 90° as 2 marginal scales of shadows. That on the right is inscribed '*The front extended shadow*'.

iii. The next circles contain the names and degrees of the zodiacal signs, each graduated 0° to 30°.

iv. Then follow the circle of the 28 lunar mansions, or stations of the moon, with numerals to 360°.

v. Then the circle of the Syriac Months, placed eccentrically, = *Elir* September. 1st Aries = March 12.

In the central area below 2 quadrants of altitude are:

vi. In the left-hand upper quadrant a quadrant of sines, every fifth of the 60 horizontal lines being dotted, and of the vertical lines continuous.

vii. In the right-hand quadrant is a scale of the signs of the zodiac crossed by a curved line, '*The line of half the day, lat. 32°*.

It is the curve which for the latitude of Lahore, 32°, shows the altitude of the sun at noon when in the different signs. The line marks 35° when the sun is in Capricorn, 32° + 23° subtracted from 90° = 35°. The use of this curved line is almost entirely confined to instruments of Indian origin, and there may be 1 to 3 of these curves on one instrument.

The Indian astrolabes in the Lewis Evans Collection have 1, 2, 2 and 3 of these lines; which are also to be seen on the instruments described by Mr. G. R. Kaye.

Below the horizontal diameter are:

viii. A semicircular astrological table with the zodiacal signs, and then the sun, moon, and planets—a table of triplicities.

ix. Squares of the shadows, within which is x.

x. A centre table is divided into 2 halves, the one on the right designated for the nights '*Lords making three nights*', and the left for days, '*Lords making three days*'. (See Kaye, p. 23.) Four columns in each table are headed: *Fire*; *Earth*; *Air*; *Water*.

Mr. Knobel wrote: 'The instrument is beautifully engraved and possesses many features of interest—I have not been able to solve some of the projections on the çafihat.'

72. THE ASTROLABE OF MOHAMMAD MUKIM IBN ISA. Pl. XLVII A.D. 1644.

Noted in *Arch. Journ.*, 1911, Pl. V, No. 20. Bought by L. Evans, at a sale at Carpenden Park, Bushey, Watford, July 1909.

A brass astrolabe 6 5/8 inches diameter; 13/64 inch thick; the total length is 8 7/8 inches solid, or 10 3/4 inches with shackle and suspension ring.

The inscription reads:

'*The work of the weakest of servants of God, Muhammad Mukim ibn Isā ibn al Haddad Asturlābi Humayuni Lahori*' (royal astrolabe maker of Lahore). Dated on the right, '*In the year of Hegira* 1053' (=A.D. 1644) both in letters and in figures, 1. θ μ. Also on the left, '*In the year of Alexander* (Seleucidae) *1955*', both in letters and figures ۱۷۵۵. And further below the first date on the right has been engraved '*In the year 1221*' (=A.D. 1806).

As in the case of the last-described instrument the suspension-ring and shackle have knife-edges. The bracket is also of elaborate fretwork of 18 irregular perforations forming a symmetrical design of a high degree of art craftsmanship.

The mother is made from one piece of brass, but in 2 places, where the casting was faulty, has been repaired by skilful plugging with other metal of a somewhat different colour.

The ankabut is made for 38 or 40 stars.

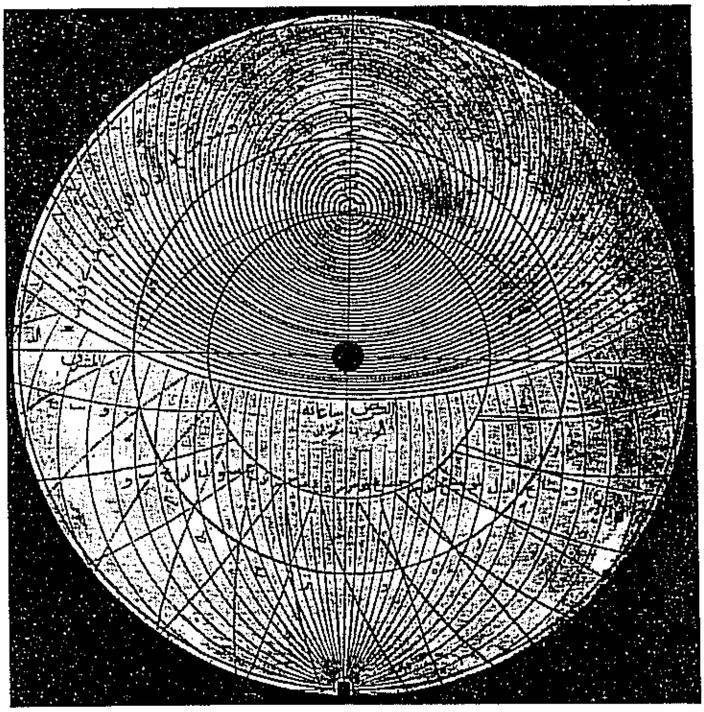


FIG. 98. TABLET FOR LAT. 22°. A.D. 1644.

Five bipartite tablets are provided for the following latitudes:

1*a*.	Lat. 23°	. .	hours 13. 24.
b.	A triple tablet (tripartite) for 0° latitude and 75°, with a polar projection in 1 quadrant.		
2*a*.	Lat. 22°	. .	hours 13. 21.
b.	,, 25	. .	,, 13. 25.
3*a*.	,, 27	. .	,, 13. 46.
b.	,, 32	. .	,, 14. 8.
4*a*.	,, 36	. .	,, 14. 32.
b.	,, 40	. .	,, 14. 52.
5*a*.	Tablet of horizons in 4 groups of 15.		
b.	Tablet of ' Ankabut Co-ordinates ' (longitude and latitude).		

By the aid of the last, ' the tablet of the latitude of the complement of the total obliquity ', the position of the stars on the ankabut can be at once read off.

Both planetary or unequal and equinoctial or equal hours are shown on the tablets.

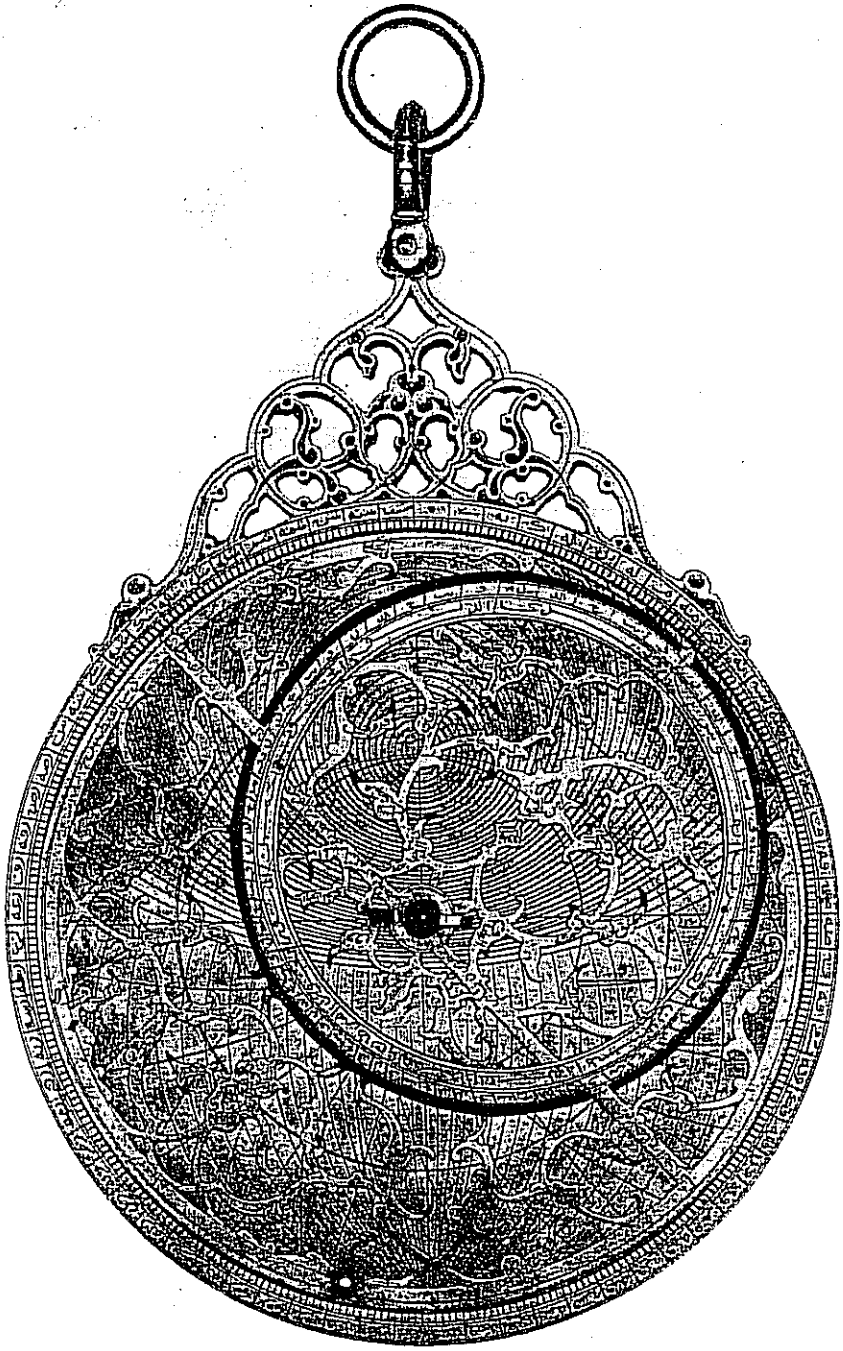


FIG. 99. MUHAMMAD MUKIM IBN ISA IBN AL HADDAD. A.D. 1644.

The bottom of the *umm* is fully engraved with a gazetteer of 120 places arranged according to climates in 4 circular double bands.

On the Back of the instrument we note:

i. The upper part of periphery graduated in degrees as 2 quadrants of altitude.
ii. Shadow scales (lower periphery).
iii. Sinical quadrant.
iv. Zodiacal quadrant with declination graphs.
v. Rectangular Table.
vi. Squares of the shadows.
vii. 28 Houses.
viii. 12 Signs of Zodiac.
ix. Astrological Table.
x. Table of Climates.

The nephew of this maker became a globe-maker of repute who also made astrolabe No. 77, described below.

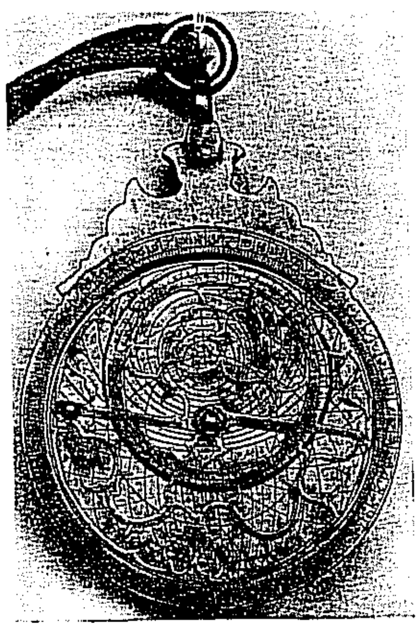
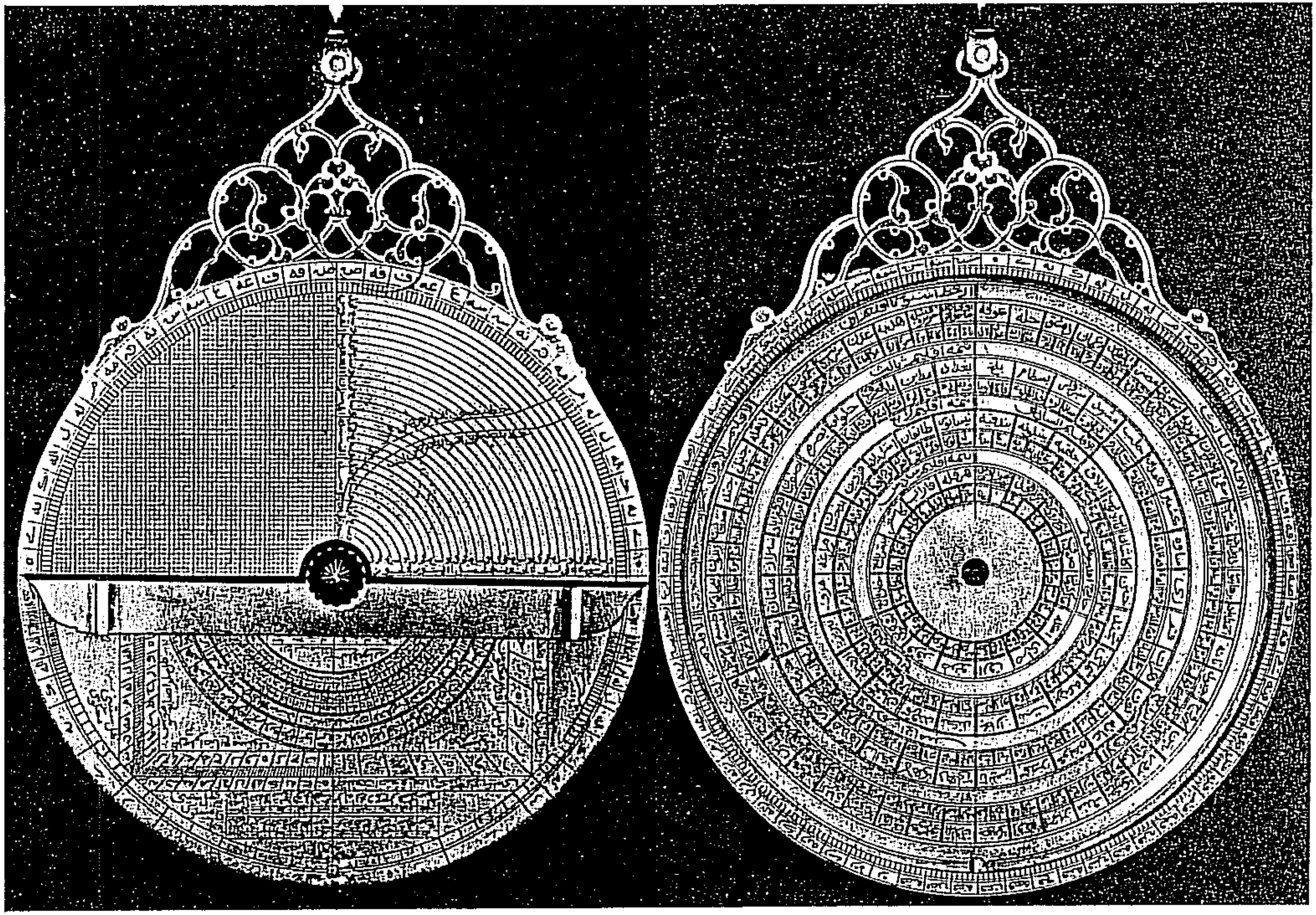


FIG. 100. IBN MUHIBB HAQIQAH. A.D. 1653.



MUHAMMAD MUKIM IBN ISA IBN AL HADDAD, A.D. 1644

73. Ibn Muhibb Haqiqah's Astrolabe. Figs. 100, 101. A.D. 1653.

Purchased by L. Evans in Paris.

A brass astrolabe $3\frac{7}{16}$ inches in diameter.

Inscribed on Back:

Ibn Muhibb Ḥaqiqah, may God forgive his sins in the year [ ].

The *kursi* has a lobed and shouldered contour that is unlike those of the other Indian instruments in being unpierced. It is soldered to the rim of the mother. The ring retains its green cord (*ilakha*).

The tracery of the ankabut resembles that of the instrument of 1668 though in a simplified form proportionate to its much smaller size. The tendrils supporting the star-leaves are simple instead of being intertwined. About 17 stars are named.

Both the *umm* and the tablets have been perforated with a hole for a steady-pin near the key between the central hole and the bottom.

Six plates (sexpartite): all except one show the unequal hours and the azimuths below the horizon: 3 show the equal hours.

1*a*.	Lat. 18° . .	hours 13. 47.	4*a*.	Lat. 32° . .	hours 14. 8.
b.	„ 36° . .	„ 13. 43.	*b*.	„ 37° . .	„ 13. 43.
2*a*.	„ 18° 14 .	„ 13. 9.	5*a*.	„ 34° . .	„ 14. 20.
b.	„ 39° . .	„ 13. 52.	*b*.	„ 36° . .	„ 14. 32.
3*a*.	„ 21° 40 .	„ 3. 32 ?			
b.	„ 35° . .	„ 13. 35.			

6*a*. 'Ankabut mizan' = balance of the spider, or plate of ankabut co-ordinates in which the Signs in the zodiac circle have their names inscribed.

b. Horizontal saphea = a tablet of the horizons in 4 groups of 8.

On the bottom of the *umm* are the names of the following 33 towns with their longitudes and latitudes, arranged in 2 circles.

Outer circle.		*Inner circle.*
Mecca.	Herat.	Names of the cities.
Medina.	Khorbes.	Buhranpur.
Kufa.	Candahar.	Daulatabad.
Rum.	Cabul.	Ajmeer.
Damascus.	Cashmir.	Gwalior.
Tabriz.	Lahore.	Kanuj.
Bagdad.	Multan.	Jawnpur.
Yezd.	Mashed.	Akbarabad.
Ispahan.	Sabzawar.	Dhakagala.
Tus.	Shiraz.	Patna.
Balck.		Achnadabad.
Bokhara.		
Hamadan.		

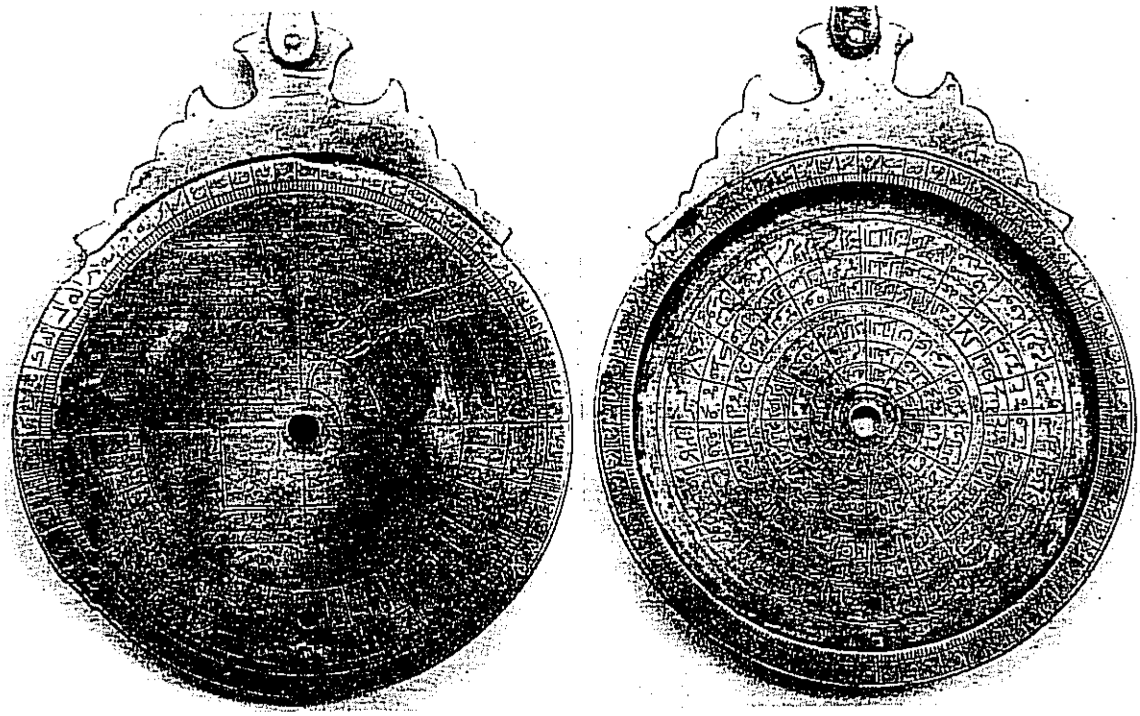


FIG. 101. IBN MUHIBB HAQIQAH. A.D. 1653.

The Back carries the maker's inscription below the centre.

i. Two quadrants of altitude.

ii. Marginal shadow scales.

iii. Sinical quadrant ruled with 30 horizontal lines.

iv. The zodiac quadrant is traversed by 2 curving lines of midday which are usual on Indian instruments. They are inscribed, '*Line of the half day in the latitude of* 37°' and '*Line of the half day in the latitude of* 32°'.

v. The lower semicircle is surrounded by the names of the 12 zodiacal constellations.

vi, vii. Between it and the shadow scale '*shadow inches reversed*', '*shadow straight*' in the third quadrant, and radially disposed is a table of names of the 28 lunar mansions, see p. 30.

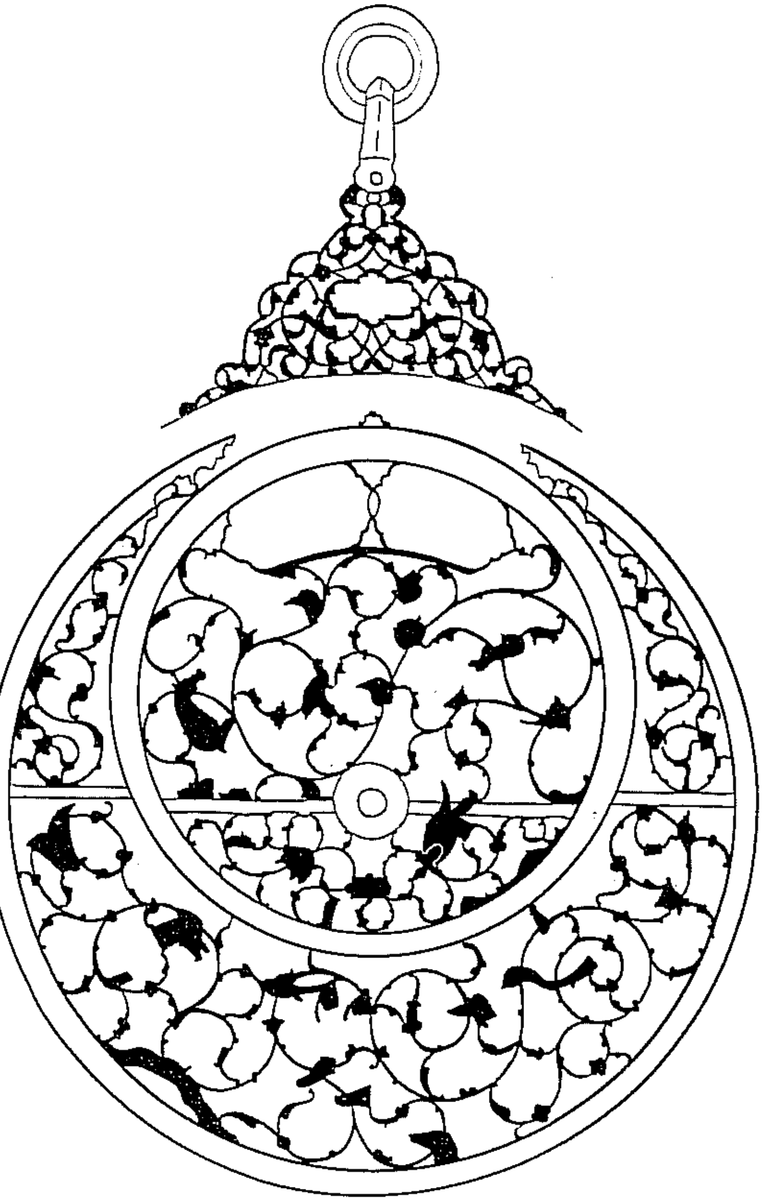


FIG. 102. JAIPUR A. *c.* A.D. 1650.

74. JAIPUR A ASTROLABE. Figs. 102, 103. *c*. A.D. 1650.

Diameter 13 inches.

Figured and described by Kaye, 1918. Figs. 5 and 7.

Suspension by a ring ◇-section and shackle. Both sides of the *kursi* are beautifully chased with foliation, enclosing a cartouche with an inscription.

The ankabut presents what is perhaps the finest example of tracery known to us, comprising foliations and star-animals most artfully disposed along the course of stems and tendrils that branch but never cross. The structural diametral bar traversing the zodiac is retained.

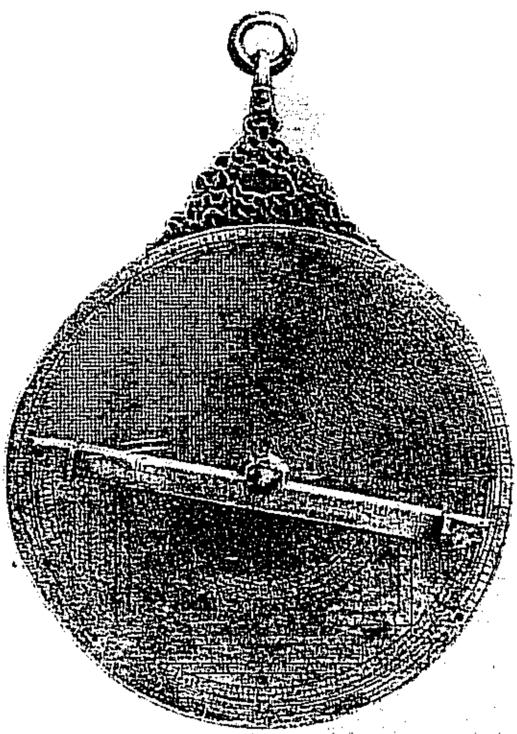


FIG. 103. JAIPUR A. *c*. A.D. 1650.

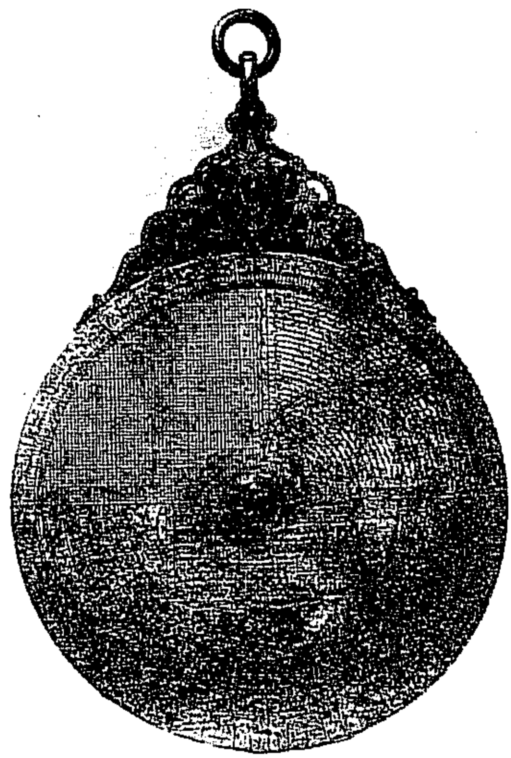


FIG. 104. JAIPUR B. A.D. 1657.

On the Back, the periphery of the quadrants is divided into degrees, each of which is subdivided into quarter degrees, an unusual striving after accuracy in the measurement of altitudes. Within are inscribed:

i. Quadrant of Sines.

ii. Zodiacal quadrant in which the horizontal and vertical radii are divided into 6 equal divisions with names of Signs inscribed. A graph shows the relation between the sun's R.A. and the meridian altitude.

iii, iv. Squares of the shadows: sides divided into 12 units to left, and into 7 units to right.

v. Table of Climates below the shadow scale. Cf. Kaye, l. c., p. 24.

vi. Table of Days of the Year, to left of shadow scale.

vii. Peripheral shadow scales.

Alidade with bevelled edge divided into 60 parts, every third part being numbered. The left upper edge is divided into 6 equal parts corresponding to the arcs of the Zodiacal Signs in quadrant ii. The right lower edge is divided into 6 divisions numbered 1 and 12, 2 and 11, &c.

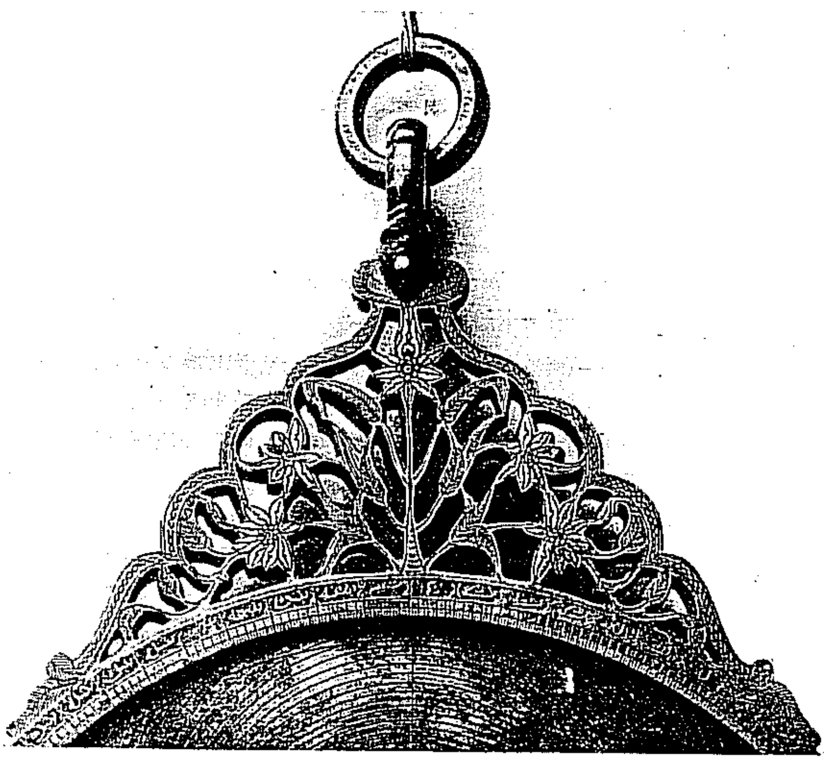


FIG. 105. THRONE OF JAIPUR B. A.D. 1657.

75. Jaipur B Astrolabe. Figs. 104–106 A.D. 1657.

Diameter 13 inches.

Figured and described by Kaye, 1918. Figs. 6, 8, 13.

The *kursi* is pierced with 42 holes. Both throne and ankabut are embellished with a design of flowering plants naturalistically treated with their leaves and flowers so displayed as completely to fill up the areas to be decorated. On the *kursi* is 1 plant with 5 flowers; inside the zodiac are 2 plants, and 1 outside it. The leaves are the star-pointers.

In 6 concentric circles in the *umm* is a list of 210 places with their longitudes and latitudes, but not the *inhiraf* or ' inclination '. Kaye states them to have been taken from the table of Ulugh Beg, with the substitution of certain Indian towns for localities in the country of Rūm. The dividing lines between the columns of figures are not radial, but are sloped differently in adjoining circles.

On the Back are marginal scales of altitude and shadows, surrounding:

i. Sinecal quadrant.
ii. Zodiac quadrant with graphs.
iii, iv. Squares of shadows inscribed within, and also including Astrological Tables.

76. Jaipur D Astrolabe. Figs. 107, 108 *? XVIIth cent.*

Diameter 6 inches.

Described and figured as D by Kaye, 1918. Figs. 11, 14.

The high *kursi* is pierced with 23 holes.

The ankabut is for 23 stars, whose pointers are carried on arch-like bands shaped like inverted and cusped arches. The artist has achieved remarkable symmetry of the 2 sides. The tablets are *sudsi* or sexpartite. A list of 36 places figures in the *umm* (Fig. 14, Kaye).

On the Back inside the usual marginal scales are:

i. Sinical quadrant.
ii. Zodiac quadrant with 6 arcs at equal distances, crossed by lines for the unequal hours, inscribed *temporal hours*.
iii. Left quadrant blank
iv. Right quadrant with a square table.
iii and iv are surrounded by a semicircular table (probably astrological), above which is the inscription '*The limits, the — and the faces of the stars*'.

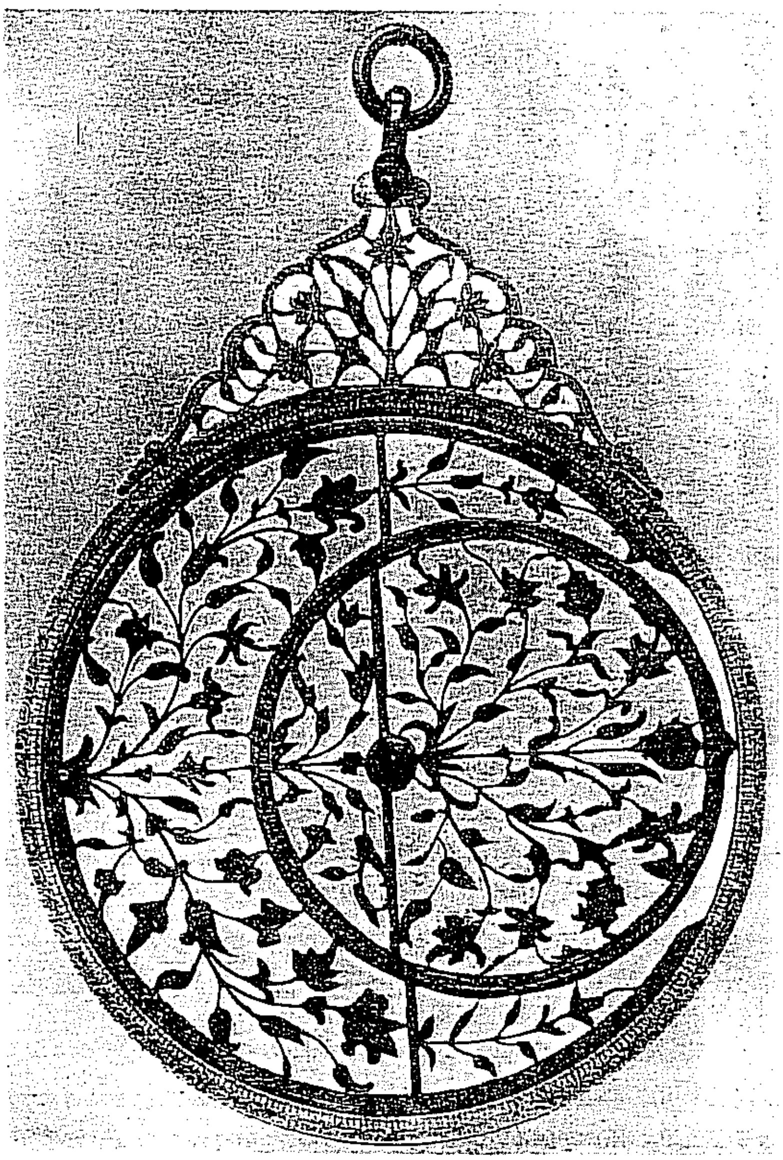
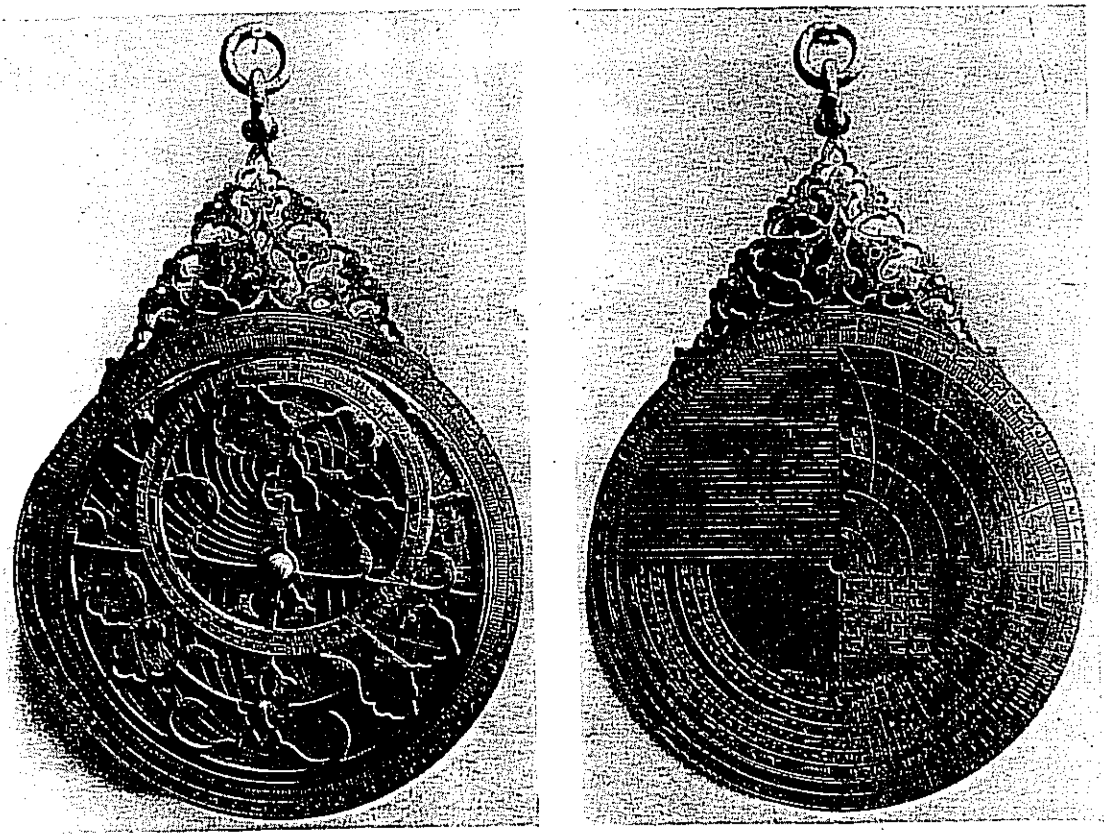


Fig. 106. Jaipur B. A.D. 1657.



FIGS. 107, 108. FACE AND BACK OF JAIPUR D. c. A.D. 1650.
From photographs by Kaye.

77. THE ASTROLABE OF THE SON OF SHEIK AL HADDAD OF LAHORE A.D. 1658.

A brass astrolabe 7 inches in diameter; ¼ inch thick; length, including shackle and ring, 10½ inches.

Purchased by L. Evans of Vitali Fransis, Algeria, in July 1911.

Inscription above the shadow scales on the back:

The work of the humblest of the servants Ḍiya al-Din Mohammad the son of Sheik al Haddad the Royal Astrolabe maker, the son of Kasim Mohammad son of Mulla Isa of Lahore in the year 1069 A.H.

The date is repeated in Arabic letters.

The throne is embellished with a pierced pattern of 3 flowers and leaves, a design that is also carried out on the reverse.

The ankabut is somewhat overfilled with the large leaf-like pointers of 54 stars. A considerable effort has been made to secure the symmetry on which the successful balancing of the instrument depends.

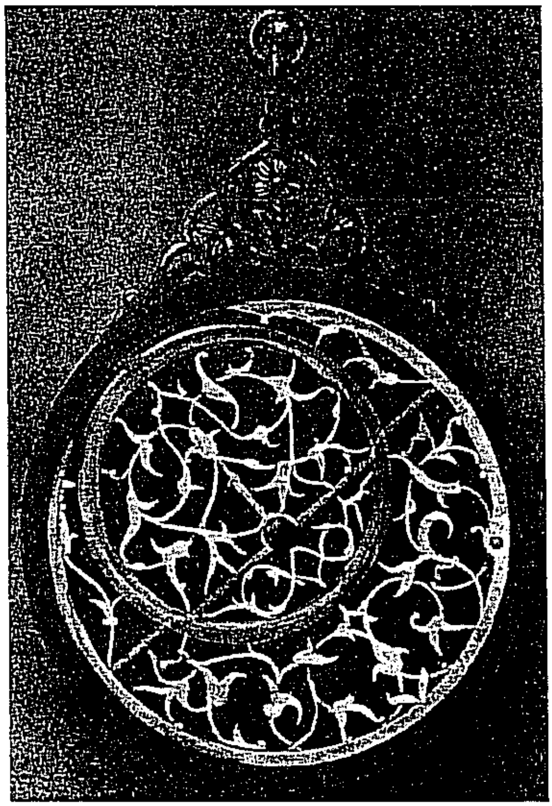


FIG. 109. DIYA AL-DIN MOHAMMAD. A.D. 1658.

The 5 plates are *tamm*, and all engraved with unequal and equal hours and azimuths below the horizon. They are inscribed for:

a.	Lat. 18° . .	hours 13. 12.	*c.*	Lat. 29° . .	hours 13. 52.
	„ 22° . .	„ 13. 35.		„ 32° . .	„ 14. 8.
b.	„ 25° . .	„ 13. 35.	*d.*	„ 35° . .	„ 14. 24.
	„ 27° . .	„ 13. 43.		„ 38° . .	„ 14. 44.

e. Tablet of horizons: 'The apportioning of the general southern inclination' arranged in 4 groups of 22 each.
Tablet of the 'Spider' or of 'Ankabut co-ordinates'.

The bottom of the *umm* is engraved with latitudes and longitudes of 92 important cities in 3 circular bands with slanting divisions. They are classified according to climates.

On the Back:

i. Two upper quadrants of altitude.
ii. Two lower peripheral shadow scales.
iii. Sinical quadrant, with 60 lines each way.
iv. Zodiac quadrant with 3 declination graphs for latitudes.
v. Names of the 12 Signs.
vi. Names of the 28 Mansions.
vii. Tables of the planets, terms, faces, &c.
viii. Squares of the shadows.
ix. Times of the rising of the Signs.

The alidade is *tamm* and original; type of Fig. 43.

Among the astronomical instruments in the Delhi Museum, described by G. R. Kaye,[1] there is a sphere inscribed by the same maker:

Dia al-Dīn Muhammad ibn Mullā Qāsim Muhammad ibn Hāfiz 'Isā ibn Shaikh Allāhdād, Humāyūnī, Sana 1087.

And a second globe dated A.D. 1658 in the Indian Museum is inscribed:

Zia-ud-din Mohamed son of Kia Mohamed son of Mollah Esa son of Sheikh el addad, astronomer of Humayun A.H. 1068.

'This individual appears to have belonged to a family of Astrolabe Makers of Lahore. He himself was the maker of the very accurate instruments shown in figures 6 and 19 of my "Astronomical Observatories of Jai Singh". And an uncle of his, described as Muhammad Muqim ibn 'Īsā ibn Allahadād, Ustūrlābī Humayūnī of Lahore made in A.H. 1053 an instrument in the Lewis Evans Collection (No. 72) and also one dated A.H. 1070 in the British Museum.' (Kaye.)

78. MUHAMMAD MUQIM'S ASTROLABE A.D. 1659–60.

British Museum, from the Spitzer Collection.

Diameter 5⅝ inches. Made by *Muhammad Muqīm of Lahore*, A.H. 1070. The tablets are both bi- and quinquepartite.

1*a*. Lat. 9°; hours (*no number*); no lines below the horizon.
b. ,, 11°; ,, 12. 20.
2*a*. ,, 25°; ,, 13. 25; no azimuth lines.
b. ,, 27°; ,, 13. 43; azimuth lines below the horizon.
3*a*. ,, 29°; 13. 52.
b. ,, 32°; 14. 8.
4*a*. Tablet of horizons.
b. Ankabut co-ordinates (celestial latitudes and longitudes).

[1] *Memoirs of the Archaeological Survey of India* No. 6, Calcutta, 1920.

The *umm* contains a gazetteer divided into 8 sections and carefully engraved. On the back the right upper quadrant shows a declination graph; the left upper quadrant is ruled with equally spaced horizontal lines.

A noteworthy feature is a rectangular table of multiples of the differences between the approximately correct length of the tropical year and 365 days. A similar table is upon the Jaipur A Astrolabe. (Kaye, 1918, p. 24.)

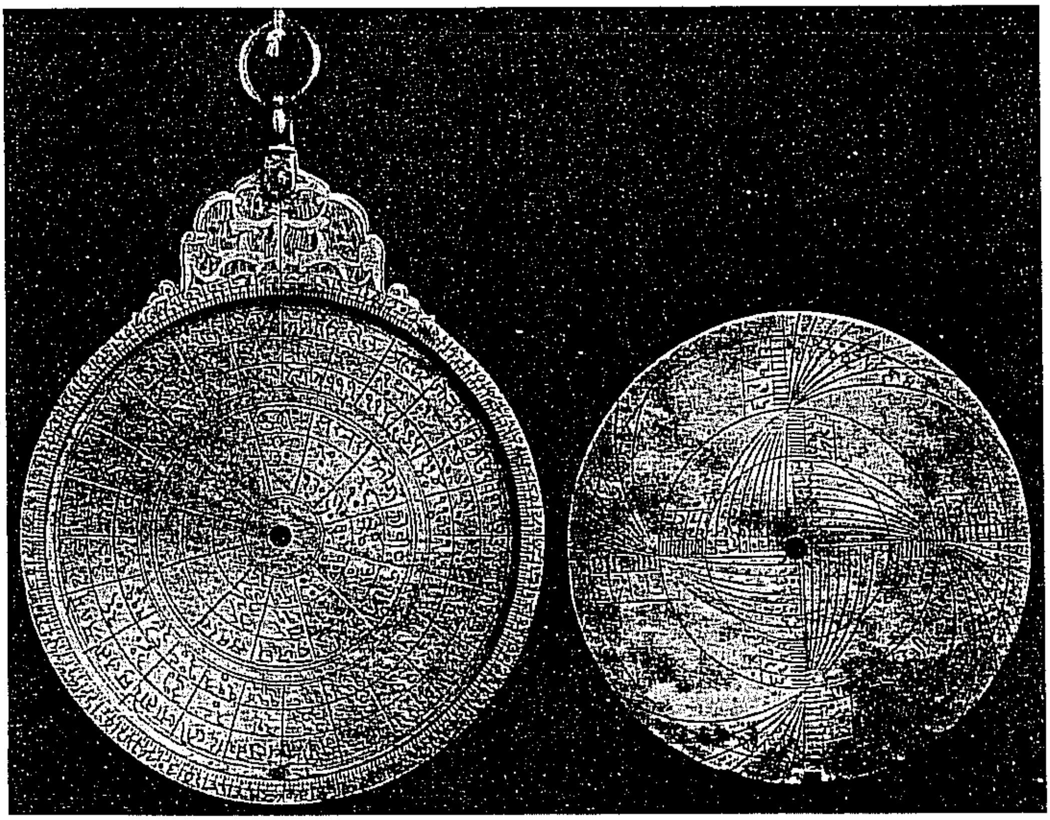


FIG. 110. INDRAJI'S ASTROLABE. A.D. 1673.

78 A. DIYA AL-DIN'S ASTROLABE A.D. 1663.

See p. 228.

79. INDRAJI'S ASTROLABE A.D. 1673.

Diameter $4\frac{1}{2}$ inches.

Pitt Rivers Museum. Described in Gunther, *Early Science in Oxford*, ii, p. 198.

Y

80. Zia al-Din's Arzachel — A.D. 1680.

Jaipur Museum. Kaye, 1819, Figs. 19, 20.

Diameter 2 feet.

This unique instrument is dated the 23rd year of the reign of Aurangzeb, and A.H. 1091 (=A.D. 1680). It was made at Delhi for *Nawab Iftikhār Khān of Jaunpur* by *Ziā al-Dīn b. Mullā Qāsim Muḥammad b. Ḥāfiz Isā b. Allah Dād, Humāyūni, asṭūrlāb* maker of Lahore, whose name is well known to us as the maker of the 13-inch Jaipur Astrolabe (B) of 1657, and also of No. 71 in the Evans Collection.

It is probable that this astrolabe is a copy of an Arzachel from a western, and ultimately from a Moorish source.

On the plate, circles of declination and latitude are drawn for every degree, and are numbered from the centre to the poles. The circles for right ascension and longitude are drawn for every 3 degrees: the ecliptic is marked with the zodiacal signs from Aries at the centre to Gemini at the periphery, from Cancer to Sagittarius, and back to Pisces at the centre. Each sign is graduated in spaces of 3 degrees. On the other hand, the graduations on the equator begin at the periphery, proceed across to the other end at 180° on the north side of the line, and return on the south side to 360° at the starting-point.

The instrument is provided with a sight rule and an index in the form of a cross with arms at right angles.

Star List

Dhanab al-Qitus	β Ceti.	Zahr al-Asad	α Leonis.
Sadr al-Qitus	ϵ Ceti.	Simak Ramih	α Bootis, *Arcturus*.
Fam al-Qitus	α Ceti, *Menkar*.	Nasr-Waqi	α Lyrae, *Vega*.
Rijl al-Jauza al Yasri	β Orionis, *Rigel*.	Dhanab al-Dajajah	α Cygni.
Farad al-Shuja	α Hydrae.	Dhanab al-Jadi	ζ Capricorni.
Ras al-Asad	μ Leonis.	Fam al-Faras	ϵ Pegasi, *Enif*.
Qada Batih	α Crateris.	Mankib al-Faras	β Pegasi.

Inscribed in Devanāgarī characters are:

Marichi	η Ursae Majoris.	Pulaka	α Ursae Majoris.

Some town names, among others, Halab (Aleppo), Tus, Kabul, Jahanabad (Delhi), and Lahore, have also been inserted, so that Bagdad comes on the axis of the map.

On the Back are the following instruments and tables:

i. The 2 upper quadrants are graduated for every 3 degrees (numbered in the Abjad notation), also in degrees, divided to sixths, numbered in the Arabic numerals from 1 to 90.

ii. Peripheral shadow scales, a 12-scale to left, and a 7-scale to right, on the 2 lower quadrants.

iii. Circle of 12 signs subdivided to intervals of 12 minutes.

iv. Circle of manzils or lunar mansions.

v.	Planets,	12	to each sign,	with graduations for every $2\frac{1}{2}$ degrees.
vi.	,,	9	,,	,, ,, $3^\circ 20'$
vii.	,,	5	,,	with their limits or terms indicated.
viii.	,,	7	,,	at intervals of $4\frac{2}{7}$ degrees.
ix.	,,	3	,,	at the 'faces' of the particular sign.
x.	,,	3	,,	repeated.

xi. Shadow scales.

xii. Names of European months with scale of days. 1st of Aries = 10th March.

xiii. A projection of a sphere.

xiv. Quadrant of Sines. The periphery is graduated to 90 degrees, and from every point lines are drawn at right angles to the horizontal radius. The vertical radius is divided into 60 equal parts, for which perpendiculars are drawn to the periphery.

81. JAMAL-UD-DIN'S ASTROLABE A.D. 1681.

Diameter $6\frac{1}{2}$ inches; total height 9 inches.

Indian Museum, 1882.

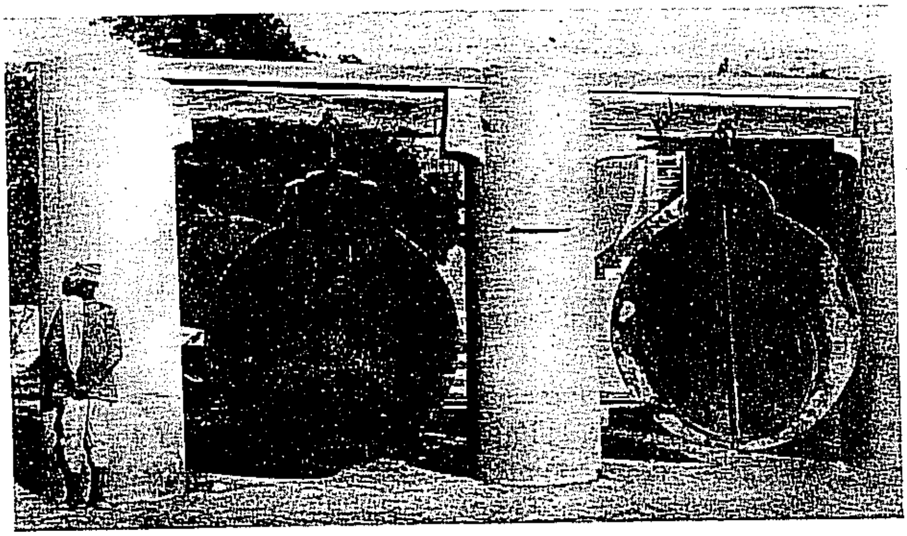
Jamal-ud-din of Lahore, A.H. 1092.

The work on the *kursi* is somewhat coarser than that executed by Mohammad ibn Isa, who appears to have been the senior maker at Lahore. There are 20 symmetrical perforations through the kursi.

82. Jai Singh's 7-foot Iron Astrolabe. 'Jaipur H.' Fig 111. *c.* 1724.

Kaye, 1918, Pl. IX, Fig. 28.

A single disc made of some 60 sheets of iron riveted together. The graduations have disappeared. Kaye suggests that this instrument and the next were a part of the original equipment of Jai Singh's observatory at Delhi which he brought to Jaipur.



Jaipur H Jaipur I

Fig. 111. Jai Singh's Seven-foot Astrolabes.
From a photogaph by G. R. Kaye.

83. Jai Singh's 7-foot Brass Astrolabe. 'Jaipur I.' Fig. 111.

Kaye, 1918, Pl. IX, Fig. 29.

This large but simple instrument has a zodiac circle and a modern tube sighter. The single tablet is *tamm* for latitude 27°.

These are probably of very great historic interest as having been among the first brass instruments of the astrolabe type that Jai Singh constructed at Delhi ' agreeable to the Mussulman books ', as he himself acknowledged. Owing, however, to their relatively small size, and the displacement of the centres of the circles, the observations made did not attain to his standard of accuracy, and so he replaced them by the great masonry instruments of 20 to 50 feet radius, that have made his reign famous.

84. The Vaux Astrolabe. Pls. xx and xxi A.D. 1813.

Morley, E. See p. 39.

2⅜ inches in diameter.

This small instrument has been described on pages 39–41.

The outer edge is inscribed with six lines of verse in which reference is made to a *Sultan Muhammad*:

When Ahmad its maker asked its year (of construction)
The Lord of the age said ' The Balance of the Sun '.

The last words form a chronogram and the numerical values of the letters added together make the year of the hegira 1228 (= A.D. 1813). *See* p. 41 and pl. xxi, figs 45 and 52; pl. xx, fig. 18.

The following Indian instruments are undated. Two bear Persian place-names, but they appear to have been constructed for use in India.

85. The Kaïn Astrolabe

9¼ inches diameter.

S. V. Hoffman Collection, No. 38.

Inscribed in the centre of the *umm*:

Mohammad Taqi son of Muhibb Ali Qa'ini is the possessor of it. May anyone who covets it be captured by the Curse of God and the wrath of the family of the possessor.

The owner is Kassim Ali, astrolabe maker at Qa'ini.

Kaïn is one of the cities in Khorassan in Persia mentioned on p. 24.

The *kursi* is an elaborate piece of fretwork pierced with 43 holes, at the summit of which is a relatively small shackle and ring, and in this the instrument resembles those of the Lahore astrolabists already described. The degrees round the rim are subdivided into thirds.

I have not seen the ankabut.

The plates are *tamm*, engraved for both kinds of hours and azimuths.

1*a*.	Lat. 0°.	4*a*.	Lat. 32°.
b.	,, 24°.	*b*.	,, 36°.
2*a*.	,, 22°.	5*a*.	,, 0° + Tablet of horizons.
b.	,, 27°.	*b*.	,, 18°.
3*a*.	,, 25°.	6*a*.	Tablet of horizons in 4 groups of 23.
b.	,, 32°.	*b*.	,, ankabut co-ordinates.

In the *umm* are the names of 96 cities with their longitudes and latitudes grouped radially in 3 concentric circles.

The arrangement of the scales and tables on the back is essentially similar to that of the astrolabe No. 71.

In the zodiacal quadrant there is only 1 line, '*The Line of Midday Lat. 32°*', which corresponds very closely to the latitude of Lahore, 31° 50′. Kaïn is on latitude 33° 40′.

Within the shadow scales is the Table of the Regents of Day and Night, triplicities, the 4 heads, Fire, Earth, Wind, and Water, and names of constellations.

86. ? Lahore Astrolabe

5⅝ inches diameter.

S. V. Hoffman Collection, No. 29.

Inscribed on Back:

A much-repaired instrument with crudely scratched plates. The *kursi* is contoured with 8 lobes, each with a fillet. The degrees on the rim are numbered in each quadrant from 0–90° in clockwise direction. The leaf-like star-pointers of the ankabut are too symmetrically disposed upon serpentine tracery to indicate that the artist was influenced by thoughts of truth of position. One ingenious feature is the *muri* which is made broad and perforated so that underlying lines may be readily seen.

The 5 tablets are tripartite for latitudes 22° and 25°; 30° and 32°; 36° and 40°; 36° and 40° or 46° (rough); tablet of horizons in 4 groups of 8 and tablet of ankabut co-ordinates.

The gazetteer in the *umm* is for 76 places in 3 rings.

The Back is simpler than usual owing to the omission of astrological details.

The two midday lines on the right upper quadrant are for latitudes ° and °.

87. 3½-inch Astrolabe made at Lahore?

S. V. Hoffman Collection, No. 19.

Apparently a small specimen of the same school of workmanship as the last instrument, but owing to its small size of no great scientific merit.

The *kursi* is perforated with 14 holes.

The zodiac ring of the ankabut is not complete, and the perforated *muri* has been inserted within its circumference. The gazetteer is in 2 rings.

88. INDIAN ASTROLABE *End of XVIIIth cent.*

6¼ inches diameter.

S. V. Hoffman Collection, No. 5.

With a modern inscription on edge:

Sahib Maghfur Al-husaini al-gilani.

The triangular *kursi* is pierced with an effective design of 6 perforations. Five plates:

1*a*.	Lat. 21° 40′	.	hours	13. 35.
b.	,, 25° .	.	,,	13. 35.
2*a*.	,, 27° .	.	,,	13. 44.
b.	,, 31° 50′	.	,,	14. 8.
3*a*.	,, 38° .	.	,,	14. 42.
b.	,, 45° .	.	,,	15. 38.

4*a*. Lat. 36° . hours 14. 30.
b. Ankabut co-ordinates.
5*a*. Tablet of horizons in 4 groups of 8.
b. ? for 0° lat. or lat. 30°.

The *umm* is engraved with a list of 48 cities in an outer circle.

Back is almost devoid of elaboration:

i, ii. Quadrants of altitude and peripheral shadow scales below.
iii. Sinical quadrant with 60 horizontal lines only.
iv. Three midday lines marked.
v. Shadow squares.

89. 4⅝-INCH INDIAN ASTROLABE

Sir John Findlay Collection.

Kursi high and solid, contoured by 1 lobe between 2 ogees.

Ankabut for 20 stars (9 in+11 out). Tracery somewhat heavy in design owing to the impossibility of reducing the leaves that have to carry the star-names beyond a certain size.

Tablets 5 in number, one being a tablet of horizons.

The margin of the Back is engraved with 2 quadrants of altitude, and 2 of shadow scales.

i. The quadrant of sines is ruled in both vertically and horizontally by 30 equidistant lines, every fifth being picked out by dotting. The vertical and horizontal scales indicate the sines and co-sines of the corresponding angles. The lines are crossed by a radial line at 45° and by the 2 semicircular arcs.
ii. The right quadrant of arcs of the parallels of the signs of the zodiac is traversed by a declination graph.

iii, iv. The squares of the shadows, with sides divided into 12 on the left and 7 on the right. Within them is a table of 18 (?) in 2 columns.

90. Ship Astrolabe. Pls. XLVIII, XLIX

5 15/16 inches in diameter.

Owned by Dr. R. Gunther.

Kursi of moderate height pierced by 16 holes. The edge of the rim which is a full ¼ inch wide is engraved with the names of 15 (?) cities with their latitudes and longitudes. The face of the rim is divided into 360° numbered by sixes.

The ankabut is of a peculiar character, quite unique among those which I have examined, in that both meridional and east-west bars are complete and to them are added 2 oblique horizons, *ufk* or *ufk al mashrik wa al-Maghrib*, intersecting at the heads of Aries and Libra, for latitudes 36° and 39°. The inscriptions on the meridional bars, which Prof. Margoliouth has been good enough to translate for me as *The mast of the upper zaourak—the lower*, twice repeated, taken in conjunction with *Mast of the lower zaourak* on the Capricorn band, show that the instrument is evidently the one

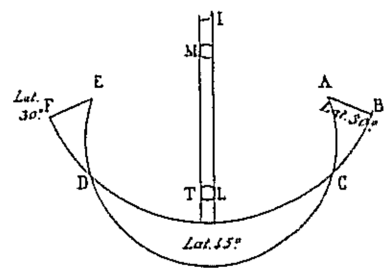
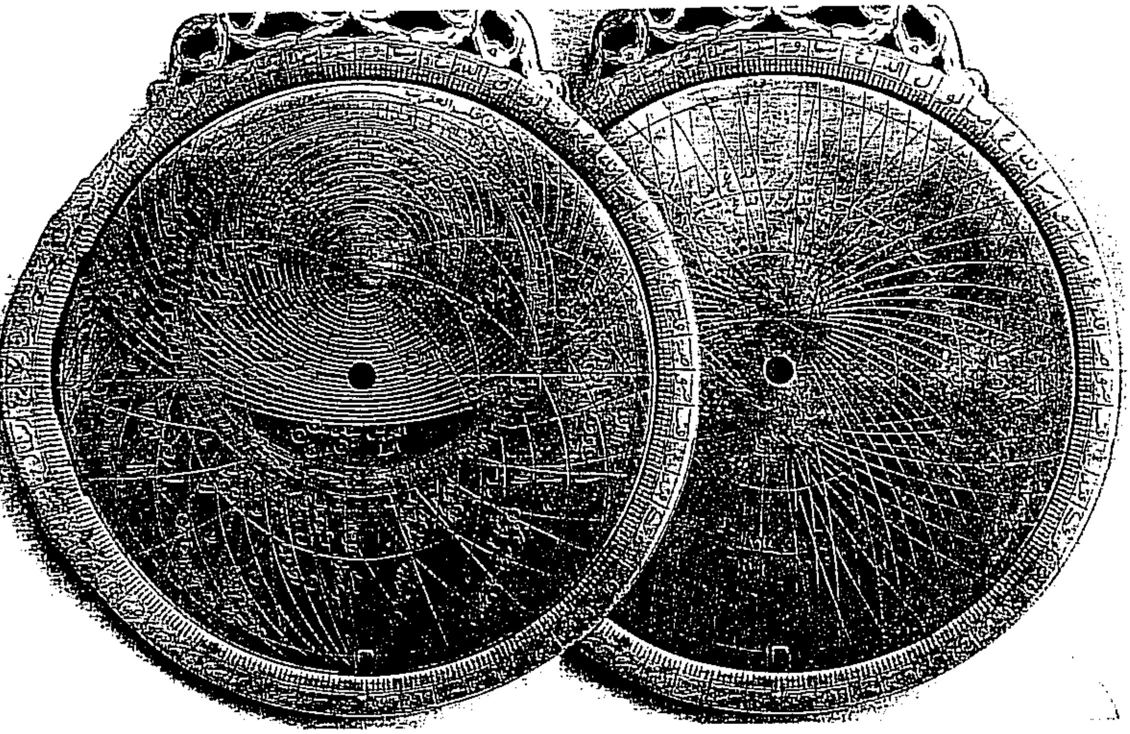


Fig. 112. Zaourakh or Ship.
After Sédillot.

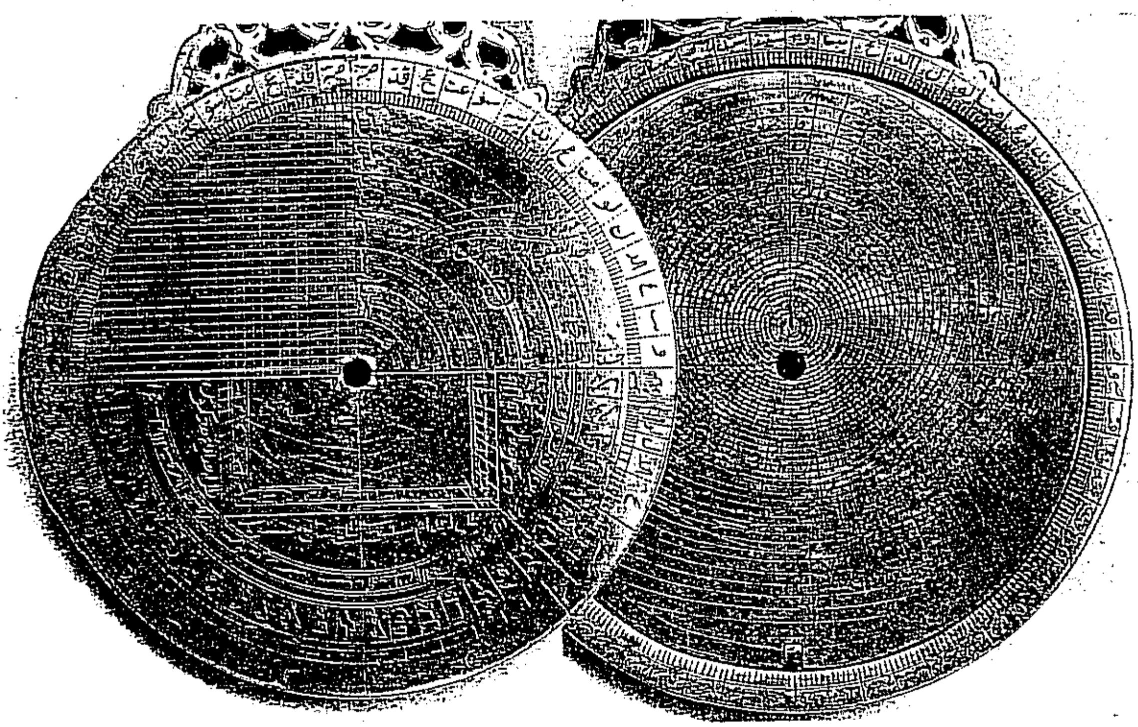
described by Abul Hassan under the name of *zaourakh* or the 'ship'. As interpreted by Sédillot,[1] the upper plate, corresponding to the ankabut, is shaped as in fig. 112, ABCDFE, and is superimposed on one of the ordinary latitude plates so that lines AB and FE fall upon the circle of Capricorn and arcs BCDF and ACDE mark on the almucantars the latitudes of 30° and 45° respectively. The meridian is shown by the line TI, and the meridional bar in the instrument before us is described as the 'mast' of the 'ship'. Some 24 stars are named. The star-pointers are quite unlike those

[1] Sédillot, *Mémoire*, 1841, quoting from Paris MS. arab. 1148.

INDIAN SHIP ASTROLABE



8*a* TABLETS 7*b*



BACK 6*a* 'TABLET OF THE MEASURE OF THE ANKABUT'

INDIAN SHIP ASTROLABE

of any other astrolabe. Their positions are recorded upon an extra plate provided with the instrument. A *mudir* is attached to the outer band.

Plates are tripartite.

1, 2*a*.	Lat. 18°.	6*a*.	Ankabut co-ordinates '*mizan al ankabut*'.
b.	,, 21°.	*b*.	Tablet of horizons in 4 groups of 8.
3*a*.	,, 24°.	7*a*.	Lat. 0° and lat. 72°.
b.	,, 27°.	*b*.	Tablet of the 'falling-places of the rays in latitudes 32° and 39°.'.
4*a*.	,, 27°.	8*a*.	Star plates for lat. 33°.
b.	,, 33°.	*b*.	,, ,, 37°.
5*a*.	,, 36°.		
b.	,, 39°.		

The last-mentioned plate is quite unique. It has engraved upon it, superimposed over the ordinary lines of a tripartite plate, a zodiac circle and star positions of the ankabut stars, each indicated by a dot in a circle, ⊙, and its name.

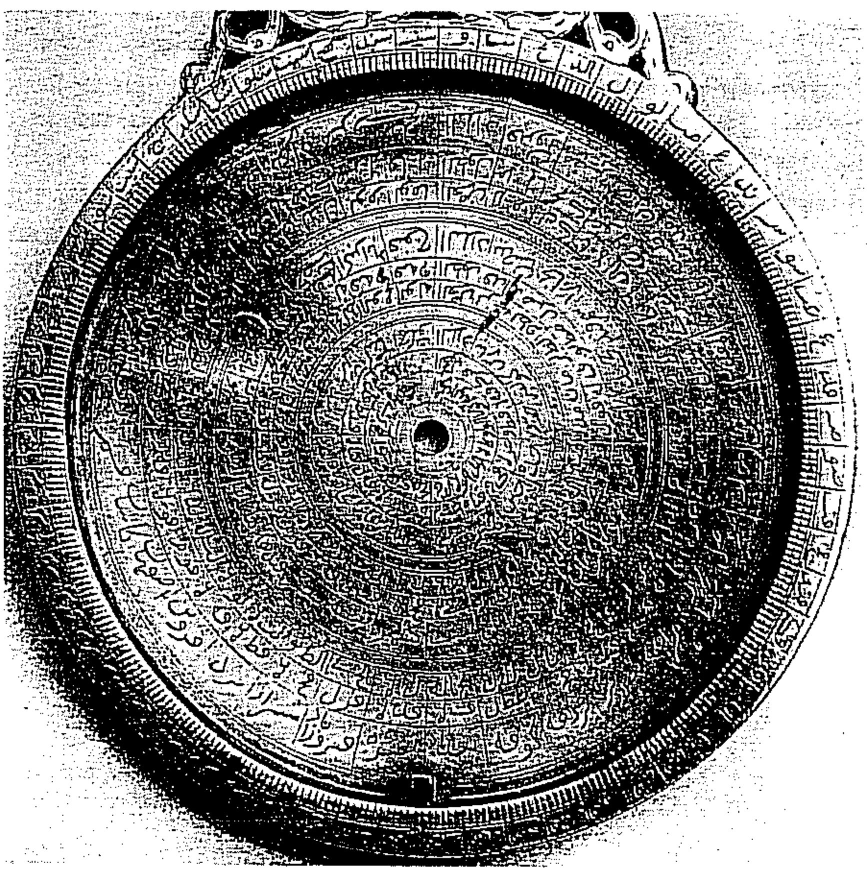


Fig. 113. Gazetteer of Ship Astrolabe.

z

On the Back:

i. Two quadrants of altitude.
ii. Peripheral shadow scales.
iii. Sinical quadrant 30.
iv. Quadrant with 4 lines inscribed for lats. 34°, 39°, 32°, and the line of midday for lat. 36°.
v. Semicircle of 28 houses.
vi. Semicircle of 12 signs.
vii. Squares of the shadows.

Alidade is *tamm*.

The only other instrument of which we have information that at all resembles No. 90, is a small astrolabe in the Mensing Collection.

91. SMALL SHIP ASTROLABE *Undated.*

Mensing Collection, No. 39.

$3\frac{7}{8}$ inches in diameter.

According to the Mensing catalogue this astrolabe is dated as *c.* 1600 and is provided with four silvered plates. The illustration shows it to have an unusually high throne fretted in the Indian manner with over 30 perforations, the height being nearly equal to half the diameter of the disc. The ankabut apparently shows no stars, but is crossed with the two arcuate bands and bars which we have described above as belonging to the *zaourakhi* or ships. Both ships and masts are inscribed, but on so small a scale as not to be legible in the photograph.

The *umm* appears to be engraved with (i) a peripheral scale of degrees; (ii) sinical quadrant; (iii) zodiacal quadrant?; (iv) Squares of the shadows enclosing (v) a planetary (?) table.

L

SANSKRIT WHEEL ASTROLABE

HINDU ASTROLABES

'THE Hindus were practical astronomers only in so far as they could calculate from a given starting-point with given rules, the positions of planets, eclipses, &c. . . . but they had no instruments of precision before Jai Singh's time.'[1]

92. HINDU ASTROLABE OF THE ROYAL ASIATIC SOCIETY. Pl. xx, Figs. 23, 44

Indian Museum, No. 409, 1924. Figured and described by Morley as 'F', p. 41.

A brass instrument, 6¾ inches in diameter, made for a single latitude 24°. Its early history is not recorded, J. Hart's first account of it dating only from November 1828.

The inscription is in Devanagari script. Considerable interest centres round the ankabut, for not only are the star-pointers of a very early and non-Indian type, but the equinoctial band forms a complete circle, a feature unknown in any other oriental astrolabe.

The *kursi* is tastefully ornamented with a palmette *motif*, 3 leaves on each side, with pierced interstices. The *umm*, which is in the same plane as the *hajrah*, is inscribed as a plate with almucantars, 2 by 2, suited for latitude 24°, and also with a set of arcs of azimuths below the horizon. The *hajrah* is divided into 360° numbered by sixes.

The ankabut shows 11 stars within and 10 outside the zodiac. The list is printed on p. 42. The Signs of the Zodiac bear their Hindu names:

Mésha (Ram).	Tulá (Balance).
Vrisha (Bull).	Vrischika (Scorpion).
Mithuna (Pair).	Dhanus (Bow).
Karkata (Crab).	Makara (Sea Monster).
Sinha (Lion).	Kumbha (Urn).
Kanyá (Virgin).	Mína (Fish).

On the Back, the boundary arcs of all 4 quadrants are divided into 90 degrees numbered by sixes, commencing on each side of the horizontal.

The upper left quadrant bears a sexagesimal series of sines and cosines, also the arc of the obliquity of the Ecliptic.

[1] Kaye, *Astronomical Observatories of Jai Singh*, p. 89.

The upper right quadrant is occupied with arcs of parallels of the Signs of the Zodiac arranged from either end of the boundary arc and proceeding to the centre. At the top of the meridional line is Sagittarius; Capricorn is at the end of the horizontal diameter. Each sign is divided into 5 parts, and arcs of the parallels corresponding to the Mabsút lines are drawn from the whole sines where such arcs touch the latter.

Below are the shadow squares. In the left, the vertical shadows are denoted by '*the opposite shadow of a gnomon 7 feet*[1] *long*' and the horizontal shadows by '*the right shadow of a gnomon 7 feet*[1] *long*'. In the right, the corresponding inscriptions are '*Opposite shadow of a gnomon 12 fingers long*' and '*Right shadow of a gnomon 12 fingers long*'.

The *Izadah* or Rule has supports for a sight tube. Its graduations correspond to the arcs of the parallels of the Signs of the Zodiac, and with the sexagesimal division of the whole sine and cosine.

93. LARGE HINDU ASTROLABE AT JAIPUR. 'Jaipur G.' ? *c.* A.D. 1670.

Diameter 16 inches.

Kaye, 1918. Figs. 26, 27.

A Hindu copy of a Persian instrument that was apparently never completed, since most of the star-pointers have no names. The wheel-like design of the ankabut is most unusual, but occurs in the Sanskrit astrolabe described below.

The tablets, engraved with almucantars for every third degree (*thulthi*), are for latitudes 27° and 72° and for celestial latitudes and longitudes.

The second tablet was used for reading off the position of stars upon the ankabut. It is named the *Ṣafīhah mīzān al-'ankabūt*, 'Tablet of the measure of the ankabut'. The tablet for 72° is engraved with 3 circles and almucantars only; none are numbered. The Hindu astrolabe of the E. India House (Morley G.) contains a similar projection marked *aṁśa* 72, *hora* 23.

On the Back are:

i. Sinical quadrant.

ii. Quadrant with declination graphs for 27° and 28° 39′.

iii, iv. Shadow scales.

[1] Morley read 'fingers', p. 42.

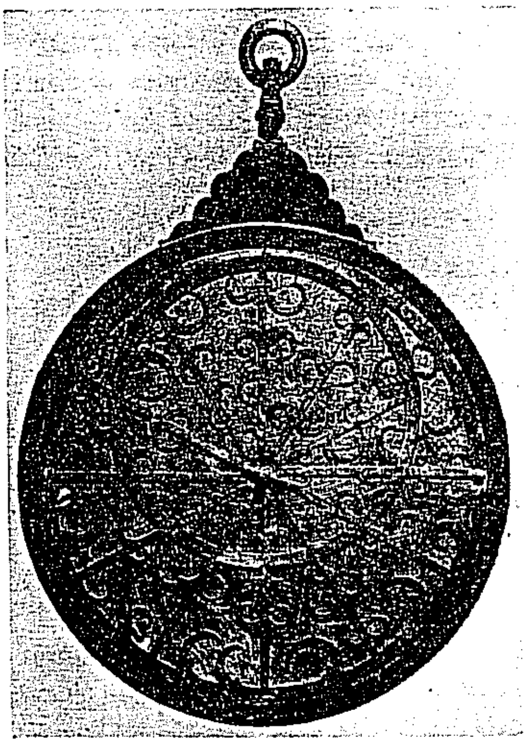


FIG. 114. JAIPUR G. *c.* A.D. 1670.

94. 8-INCH WHEEL SANSKRIT ASTROLABE. Pl. L *Undated.*

From photographs in G. R. Kaye's possession, 1929.

This instrument closely resembles the larger astrolabe described as Jaipur G, the date of which has been put at about A.D. 1670. It is, however, one half the size, and the star-pointers are leaf-like, stalked, and fewer in number. The ends of the capricorn band are supported by an artistically disposed scroll, which is absent in Jaipur G.

The rim is divided into degrees numbered in sixes.

For the names of the Signs of the Zodiac see p. 41.

On the Back are:

i. Quadrantal scales of altitude.
ii. Sinical quadrant ruled in squares.
iii. Zodiacal quadrant inscribed with names of the Signs from the Crab at the centre to Capricorn at the periphery.

iv. Squares of the Shadows.
v. Peripheral Shadow scales marked *chhaya* (twice) = shadows.
vi. A table of the Year, showing multiples of the differences between the approximately correct length of the tropical year and 365 days.

According to Mr. Gambier Parry's transcript, the Table reads as follows:

PRATIVARṢALANA BHAMA SĀRINĪ

1 87°–33′	2 175°– 6′	3 262°–38′	4 350°–12′	5 77°–45′	6 165°–18′
7 252°–51′	8 340°–24′	9 67°–57′	10 155°–30′	20 311°– 3′	30 106°–33′
40 262°– 3′	50 57°–33′	60 213°– 3′	70 8°–33′	80 164°– 3′	90 319°–33′

A similar Table (with minor differences in the minutes) is given on Jaipur A and in Mohammad Muqim's Astrolabe of A.D. 1660. The Table gives $n\ (87°\ 33'\ 6'')-a\ 360°$, where n ranges from 1 to 9 and from 10 to 90, and a is a whole number. Now 87° 33′ 6″, expressed in time, is 5 hours 50 minutes 12.4 seconds, and the length of the tropical year was supposed to be 365 days, 5 hours, 50 minutes, 12.4 seconds (Kaye).

95. SAPHEA INSCRIBED 'JANNA'. Pl. LI *Undated.*

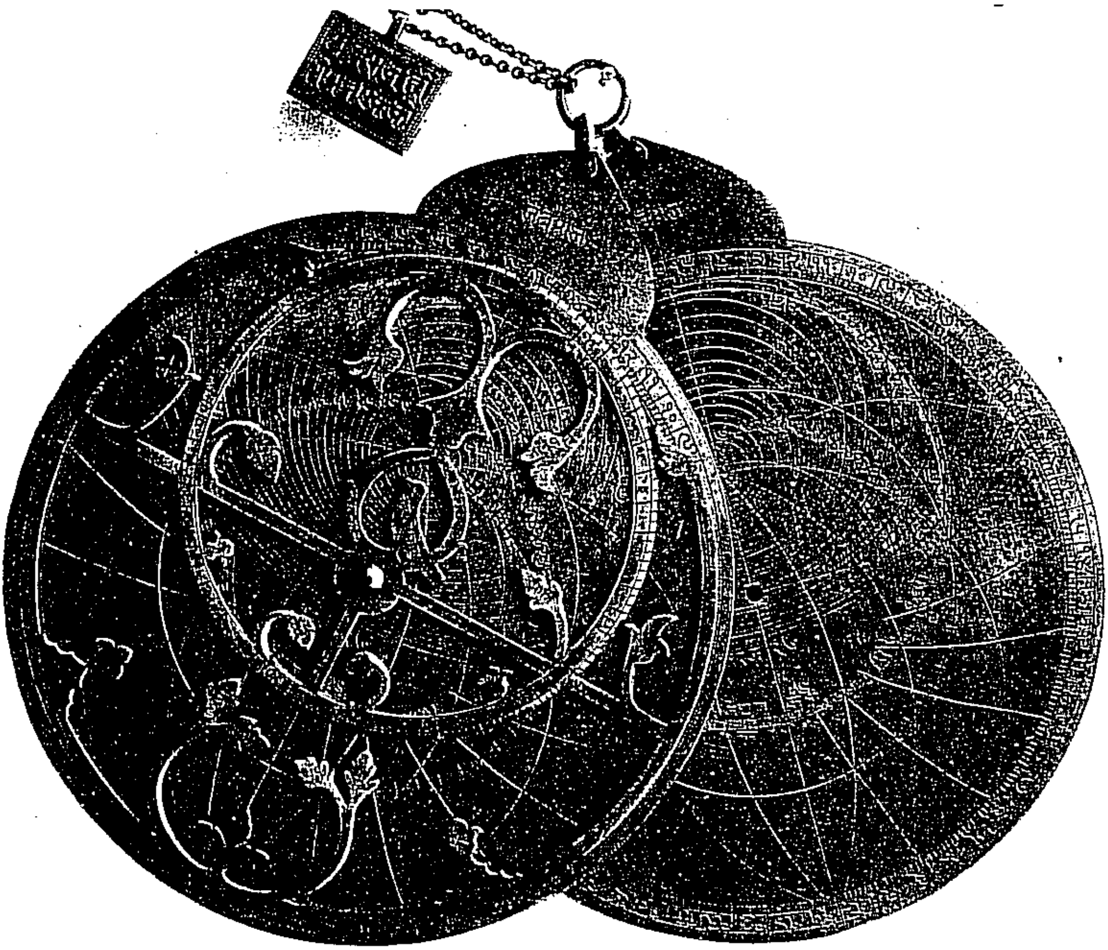
From photographs taken by G. R. Kaye.

A label is attached to the suspension-ring, inscribed:

Yant[r]a raja choto
yatra eka ko

The face of the saphea is engraved as a tripartite plate for latitude 27°, or close on the latitude of Agra or Jaipur. It also shows the lines of the Unequal hours, the celestial houses, and a zodiac circle.

The ankabut suggests the influence of a modern art school. The greater number of the star-pointers are formed of leaves on long stalks. The star *abhijit*, which is also the name of the 22nd lunar mansion, is represented by a bird. There are 10 stars within and 9 outside the zodiac.



SAPHEA INSCRIBED 'JANNA'

96. Hindu Astrolabe of the East India House ? A.D. 1700.

Morley G., p. 42, Pl. XX, Figs. 19, 20.

A small modern sexpartite astrolabe of 3 11/16 inches in diameter inscribed in Devanagari characters.

The *hajrah* is divided to 360° numbered in sixes. The ankabut carries 18 star-pointers illegibly inscribed. The *umm* contains a small gazetteer of the latitudes and longitudes of 16 Indian towns; the latter being reckoned from the Fortunate Isles.

	Lat.	*Long.*		*Lat.*	*Long.*
Dálatabád	20° —	111° —	Góyálúr	26° 29′	114° —
Jayanpur	26 36′	119 6′	Agra	26 43	115 —
Ayodhya	26 32	118 6	Dilli	29 —	113 —
Badanu	27 32	114 50	Láhor	31 50	109 20
Gólkundá	18 4	115 19	Burhanpur	21 21	110 —
Khawäït	22 —	109 —	Amadnagar	19 —	115 —
Aladábád	23 —	108 40	Tháneswar	30 10	112 30
Ujjeyaní	23 30	110 50	Banóras	26 15	117 20

The 7 tablets (*sudsi*) closely cover all but southern India.

1*a*.	Lat. 17°	hours 13.	4*a*.	Lat. 26°	hours 13.
b.	„ 18°	„ 13.	*b*.	„ 27°	.. 13.
2*a*.	„ 20°	„ 13.	5*a*.	„ 29°	„ 13.
b.	„ 21°	„ 13.	*b*.	„ 32°	„ 14.
3*a*.	„ 23°	„ 13			
b.	„ 24°	„ 13.			

6*a*. Thirty-two horizons with degrees of the obliquity of the Ecliptic, marked 2 and 2 and numbered by sixes.

b. Safihahi Arz-i Tamám-i Maili Kulli, projection for latitude 66°, with Signs of the Zodiac denoted by figures 1, 2, 3, &c., instead of names.

7*a*. Lat. 72° (*aṁśa* 72, *horā* 23) (cf. the Jaipur Hindu *nisfi* astrolabe, p. 222).

b. Projection for a place without latitude (XX, 17, 18, 19) (?), i.e. for the latitude of the equator. A similar plate is in the Lahore Museum astrolabe where the oblique and straight horizons coincide and are inscribed *al-'arḍ lah* ' the west—no latitude ' and *al-mashriq al-'arḍ lah* ' the east—no latitude '.

The concentric semicircles below the horizon appear to be circles of declination (Kaye).

On the Back the boundary arcs of the 2 upper quadrants are divided to 90 and numbered in sixes. The left quadrant has cosines of altitude sexagesimally arranged, with an arc of the obliquity of the Ecliptic which is produced through the adjoining upper right quadrant. Between it and the periphery are parallels of the zodiac, whose signs are identified by numerals.

97. DELHI C. HINDU ASTROLABE *c.* 1700.

Diameter 7 inches.

Delhi Museum. Figured by G. R. Kaye, 1920, Figs. 5, 6.

A rudely constructed, unsigned instrument. *Kursi* with 15 perforations. The ankabut has 37 pointers of which only 21 are named.

Samudrapaksha (ϵ *Ceti*).	Visakha.
Manushyasirsha (*Algol*).	Matrimamdala.
Rohini (*Aldebaran*).	Chitra (*Spica*).
Manu . . .	Svati (*Arcturus*).
Mithuna . . . dadakshina (*Rigel*).	Dhanub koti.
Hasta.	Abhijit (*Vega*).
Mithuna.	Sravanah (*Altair*).
Ardra Lubdhaka (*Sirius*).	Kakumdapuchha [1] (*Deneb*).
Magha (*Procyon*).	Asvanabha (α *Andromedae*).
Uttara Phalguni (*Regulus*).	Purvabhadrapada.

The 2 tablets are tripartite. They are for Avanti or Ujjain and Ahmedabad.

1a. Inscribed 22, Chhaya 5, Karnah 13, Paramadinam 33 30, Avamtikayam
= (latitude) 22, Shadow 5, Hypotenuse 13, Longest day 33 30, at Avanti.

b. Palamsah 37, Chhaya 9, Karnah 15, Paramadinam 36 24
= (latitude) 37, Shadow 9, Hypotenuse 15, Longest day 36 ghatis 24 palas.
Unequal and equal hour lines are drawn on both.

2a. Palamsah 23, Chhaya 5 6, Karnah 13 3, Paramadinam 33 50, Amadavad

b. Tablet of horizons.

The Back shows:

i. Sinical quadrant.
ii. Quadrant with 15 equally spaced concentric arcs.
iii. Shadow scales in lower semicircle.

98. MR. PLIMPTON'S SANSKRIT ASTROLABE

Diameter $7\frac{1}{32}$ inches; weight $14\frac{1}{4}$ oz.

Mr. Plimpton's Collection.

The bracket, with 5 lobes and ogees, bears the inscription '*Srī-Yantra-rāja*'.

Glorious King of Instruments.[2]

The rim is divided in each quadrant into 60 divisions, each of which is subdivided into 6 degrees. The divisions are numbered 1 to 60, so that '30' = 180°, '1' = 6°, '60' = 360°. The numerals are written 1 2 3 ४ ५ ६ ७.

The ankabut is for 11 stars, 6 outside and 5 inside the zodiac.

[1] Marked by the beak of a bird.
[2] We are indebted to Prof. F. W. Thomas for the reading of this astrolabe.

Star List

1.	Ṣamudra-pakṣin ' Bird of the Sea '.	Denebkaitos.
2.	Rohini ' a daughter of Daksha ' (4th Lunar Month).	Aldebaran.
3.	Pim.	
4.	Ārsā.	
5.	Lubdhaka ' Hunter '.	Sirius.
6.	Citra ' the Variegated ' (14th L. M.).	Spica Virginis.
7.	Svati ' Sword '.	Arcturus.
8.	Abhijit ' a sacrifice ' (22nd L. M.).	Vega.
9.	Śravana (23rd L. M.).	Altair.
10.	Sata-bhisa ' Physician '.	
11.	U[thara] Bhādrapada (27th L. M.).	α Andromedae.

Nos. 10, 1, 5, 6 are on the Capricorn band.
Nos. 2, 4, 7, 9 are on the Equinoctial band.
Nos. 3, 8, 11 are near the Pole.[1]

The Signs of the Zodiac are as described on p. 41.

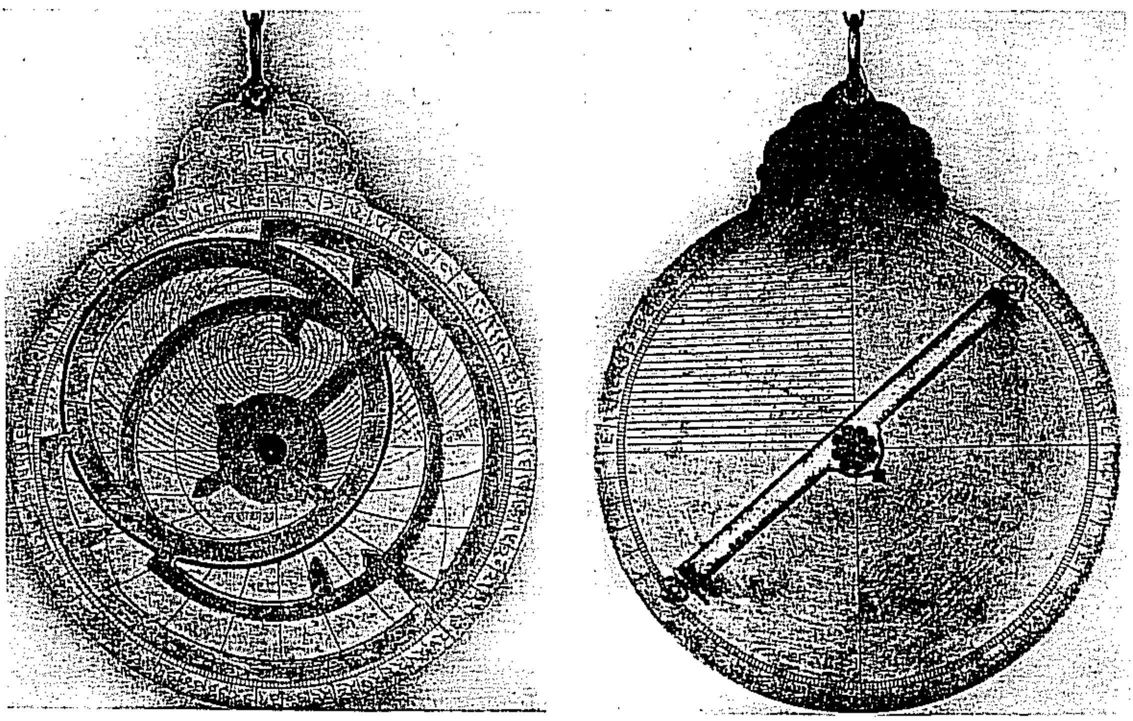


FIG. 115. SANSKRIT ASTROLABE.

The plate for latitude 27° is tripartite, with every third circle dotted.

[1] We are indebted to Prof. F. W. Thomas for the reading of this astrolabe.

The ends of the horizon are marked '*Purva-ksiti-ja*' (= 'sprung from the eastern Earth') and '*Paścima-ksiti-ja*' (= 'sprung from the western Earth'); also '*Aksāmśa* 27' (= 'parts of the axle 27').

The Back has a 360° circle, but the degrees are only numbered in sixes as degrees of altitude 6, 12, 18, &c. to 90 in the 2 upper quadrants. On the left is a sinical quadrant with 30 equidistant lines. The other 3 quadrants are blank.

Alidade original, with trefoil-shaped ends and sight-vanes projecting over the fiducial line.

78 A. The Astrolabe of Diya al-Din, son of Mohammad, son of Mullah Isa, son of Sheik [al Haddad] in the year A.H. 1074 A.D. 1663.

Described and figured by Padmākara, 1928.

5 1/10 inches in diameter.

The bracket, pierced with 18 holes, closely resembles that of No. 72, made at Lahore twenty years earlier. The ankabut is for 56 stars, 44 of which are named.

The 5 bipartite tablets are for:

I*a*.	Latitude 18°;	hours 13. 9.		III*a*.	Latitude 29°;	hours 13. 52.
b.	,, 22°;	,, 31. 21.		*b*.	,, 32°;	,, 14. 8.
II*a*.	,, 25°;	,, 13. 35.		IV*a*.	,, 34°;	,, 14. 20.
b.	,, 27°;	,, 13. 43.		*b*.	,, 36°;	,, 14. 32.

V*a*. Tablet of four sets of ten horizons, with scales of northern and southern total obliquity.
b. Tablet of ankabut co-ordinates.

A gazetteer in the *umm* gives the latitudes and longitudes of 77 towns.

The Back is inscribed with:

i. A peripheral semicircle of degrees.
ii. Peripheral shadow scales.
iii. Quadrant of Sines with vertical radius divided into 60 parts.
iv. Quadrant of the Calendar traversed by graphs showing the relation between the sun's R.A. and the meridian altitudes for latitudes 27°, 29°, and 32°. In the lower semicircle are:
v, vi. Tables of Signs and Lunar Mansions drawn round a central rectangle with shadow squares enclosing a table of the multiples of the differences between the approximately correct length of the tropical year and 365 days.

ARABIAN ASTROLABES

INCLUDING

ARABIAN, SYRIAN, MESOPOTAMIAN, EGYPTIAN ASTROLABES

THE grouping of astrolabes produced in such widely separated geographical regions as Arabia, Syria, Mesopotamia, and Egypt under a single head has already been suggested on page 112, and in the present imperfect state of our knowledge, we find some justification in the fact that even experts who had been entrusted with the arrangement of the exhibits at the recent International Persian Exhibition in London had difficulties in distinguishing between the metal-work of Persia and of Mosul, and this is hardly remarkable when it is remembered that the craftsmen themselves migrated from town to town.

The scientific study of Astronomy by the Arabs in Egypt began during the reign of the Fatimid Caliph al-Aziz, A.D. 975–96, when the observatory at Cairo was founded. From A.D. 977 to 1007 Ibn Yunus observed there, and on the basis of his observations the Hakimid Tables were drawn up.

It is important to note that there was a lull in the metal industry after the fall of the Caliphate in A.D. 1252, and Mr. Leigh Ashton and other experts take the view that many artists then migrated to Cairo, their successors continuing their work there until the fourteenth and fifteenth centuries, when, with the return of the Timurids, conditions became more favourable in Persia. In other art objects, the figures then assume the familiar Persian type and are no longer Arab, and the inscriptions are in Persian script, not in Cufic.

It will be generally admitted that the frequent inclusion of figures of animals and of other types of decoration makes the instruments in this group rather more interesting than those Persian astrolabes which owe their beauty solely to an elaborate interlacing of the bands and foliage of the design.

99. Djafar's Astrolabe. Pl. lii TYPE OF A.D. 950.

Diameter 5¼ inches; height 7¼ inches.

In the Bibliothèque Nationale, Paris. Acquired by M. Jomard through the intermediation of M. Amédée Jaubert.[1] It had previously belonged to M. Barbier.

Inscribed on the back

Made by Ahmed ben Khalaf for Djafar son of [the Khalifah] Moktafi Billah.

It has been dated as A.D. 905, but this is quite impossible, for the maker was not then alive. Djafar, according to Helal ben al-Hassan, was born in A.D. 916 and died in A.D. 987 and Casiri[2] gives an account of him that was printed by Sédillot. A. da Schio believes that this instrument is only a twelfth- or thirteenth-century copy of an early original.

The ankabut gives the names of 17 stars which are listed on p. 232.

There are 4 plates:

1*a*.	Mecca	Lat. 21°; hours 5	18′	18″	3*a*.	Lat. 34°					
b.		„ 24°; „ 5	18′	30″	*b*.	„ 36°					
2*a*.	Kathyeh	„ 30°; „ 5	14′		4*a*.	„ 39°;	hours 5	15′			
b.		„ 31°; „ 5	14′	6″	*b*.	„ 37°	Harran;	hours 5	14′	36″	

100. Hamed-ben-Ali's Astrolabe A.D. 964–9.

[Original not extant].

A *mater* of an astrolabe inscribed ' Made by Hamed-ben-Ali A.H. 348 or 343 ' (A.D. 964 or 969) is in the National Museum of Palermo. But it has been stated by that competent authority, Almerico da Schio, to be merely a twelfth- or thirteenth-century copy of an early original.

We have not seen the instrument. Is it possibly the one described as Dorn's ' Sicilian Astrolabe ', found in the citadel of Aleppo ?

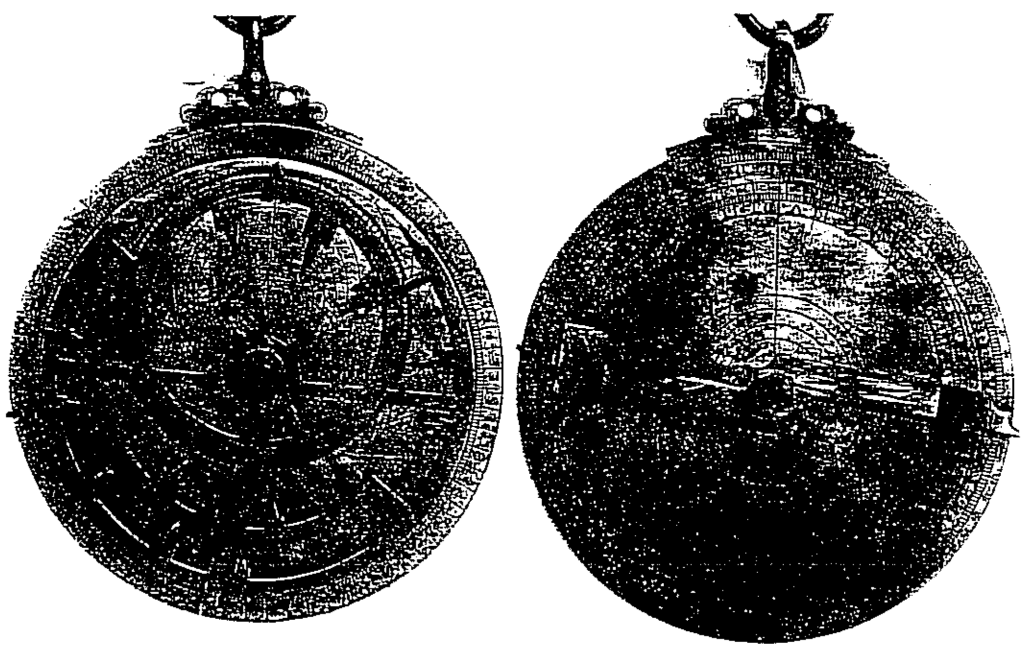
101. The Astrolabe of Pope Sylvester II. Pl. lii *c*. A.D. 990.

Diameter 6¼ inches.

In the Galileo Tribuna at Florence.

It is undated, but has been stated by Saavedra to have been made for the French Pope Sylvester II towards the end of the tenth century. This attribution would be of the highest interest if it could be substantiated, for Sylvester (died 1003) had studied under the Arabian savants of Cordova,

[1] Sédillot, *Mémoire*, 1841, p. 172.
[2] Casiri, *Bibl. ar. hisp. Escur.*, i. p. 422.



1. AHMED BEN KHALAF FOR DJAFAR, *c.* A.D. 950
2. THE ASTROLABE OF POPE SYLVESTER II, A.D. 990

thereby setting a fashion that was widely followed in after years. Travelling scholars from France and other European countries began to visit Spain in large numbers for the sake of that higher learning in mathematics and medicine which was to be obtained in the academies, schools, and libraries of the Arabs. The reward, after the return home, was only too frequently, as in the case of the Pope Sylvester, the title of 'Necromancer', sometimes accompanied by appropriate penalties.

Dr. L. Evans, however, considered that there is insufficient evidence for the pretended antiquity of this piece, except perhaps of the ankabut, which equally resembles one in the Evans collection dated A.D. 1223–4.

The *kursi*, pierced with two round holes, is much wider than high.

In the Ankabut the horizontal bar is straight, extending to the Capricorn band which is further attached by two ties and one star-pointer. The equinoctial band is supported by two radial ties, one of which bears the *mudir* or handle for turning. The star-pointers are all straight and dagger-like, with side cusps on squarish mounts: none are curved.

The Back has been engraved with a circle of Degrees numbered 0°–90° in each quadrant; inside this is a circle of Signs and an eccentric circle of Months, both with names in Latin. The 1st of Aries apparently corresponds to the $15\frac{1}{2}$ of March.

Round the centre are 5 concentric circles, and below them the Shadow scales, but without inscription, showing that the instrument was not finished. The engraving on the back and the Latin lettering is certainly of a more modern character.

Star Lists

Pope Sylvester's Astrolabe.	Djafar's Astrolabe.
1. Batn Qitus.	
14. Al Ghul.	
2. Ain al Thaur.	1. Al Dabarani.
15. Ayu[q].	8. [Ayuq] ?
3. Rijl al Jauza.	2. Rijl al Anak.
4. Yad al Jauza.	3. Mankib al Anak.
5. Al Shi'ri al Yamanih.	4. Yamaniyyah.
6. Al Shi'ri al Shamih.	5. Al Shamih.
7. Unk al Shuja.	
16. . . .	
8. Qalb bil Asad.	6. Qalb al Asad.
9. Janah al Ghurab.	
10. [S]imak Azal.	9. [Simak al Ramih].
17.	
18. Fakkah.	10. [Fakkah].
19. Ain al . . .	
11. Qalb al aqrab.	7. [Q]alb al aqrab.
20. Hawwa.	11. Ras al Hawwa.
21. Wa[q]i.	12. Waqi.
22. Al Tair.	13. Nasr al Tair.
23. Ridf.	
12. Zanab al Jadi.	14. Al Ruk.
24. Mankib.	15. Mankib.
13. Zanab Qitus.	
25. Al Hadib.	

In addition to these 15 stars which are shown in the figure, M. Sédillot mentions 'Tête de Méduse', 'Main teinte', and 'Épaule d'Orion' as having appropriate pointers.

102. Damascan Saphea of Arzachel A.D. 1202.

Diameter 8 inches; height 9¼ inches. Bronze gilt.

South Kensington Museum, No. 504. 1888.

On one side of the disc is an Arzachel projection of the 2 spheres superimposed.

Made at Damascus by Abdul Rahman, son of Jusuf. A.H. 598.

On the Back are circles of degrees, circular and calendar scales of the signs and months, 1st Aries = 12 March. Three-fourths of the central space is filled with a stereographic projection of the sphere on the plane of the solstitial colure, known as an Arzachel; the fourth is ruled as a sinical quadrant. Half an inch below the centre is a small circle divided into 24 parts; this is the 'circle of the moon'.

102 A. Damascan Astrolabe by Sarraj A.D. 1228–9.

See p. 247.

103. THE ASTROLABE OF SULTAN ABUL FETIH MOOSA

Plates LIII and LIV A.D. 1227–8.

A bronze astrolabe 10 11/16 inch diameter and 5/16 inch thick, enriched with gold and silver. Weight 8¾ pounds.

It was exhibited in Class 15 of the Exposition Internationale in Paris in 1900, and on July 7, 1902 was offered for sale at Christie's as 'the property of a lady of title' when it fetched 175 guineas. In March 1911 Dr. Evans acquired it for £250, and mentioned it as No. 15 in the *Archaeological Journal* for 1911. It has been figured in *Musée Rétrospectif*, No. 27, Pl. I, fig. 2, where it is thus described, pp. 21–2:

'Sur la face supérieure, incrustée d'or, se trouve l'inscription: "*De ce qui a été fait par l'ordre de Notre Maître le Sultan al-Malik-Achraf* (vient une série de titres honorifiques) *Moudaffar-ed-din, Châh d'Arménie, Aboul fath Mousa, fils d'Al-Malik al Adil, fils d'Ayoûb.*"

'Il s'agit d'un sultan Ayoubite, neveu de Saladin, qui régna en Mésopotamie de 607 à 628 de l'Hégira (1210–1230 A.D.). Sur la face postérieure, qui porte de curieuses figures représentant les constellations zodiacales, on lit: "*Œuvre d'Abd-el-Kerina, l'Égyptien, serviteur d'Al-Malek-al-Achraf, astrolabiste, en l'année 625 de l'Hégira.*"

This instrument is therefore coeval with the great astronomer of Maragha, Nasir al-Din al-Tusi (*b.* 1201), who compiled the Ilkhanic Tables and wrote commentaries on the Greek writers.

'Sur l'alidade incrustée d'argent, deux vers arabes et la date: "*en l'an* 625." Sur l'araignée est gravée l'inscription: "*En l'an 829 de l'Hégira et 793 de l'Ère de Yezdgerd*" (1425 A.D.).'' Translation by M. Casanova.

The complete inscription has been englished as follows:

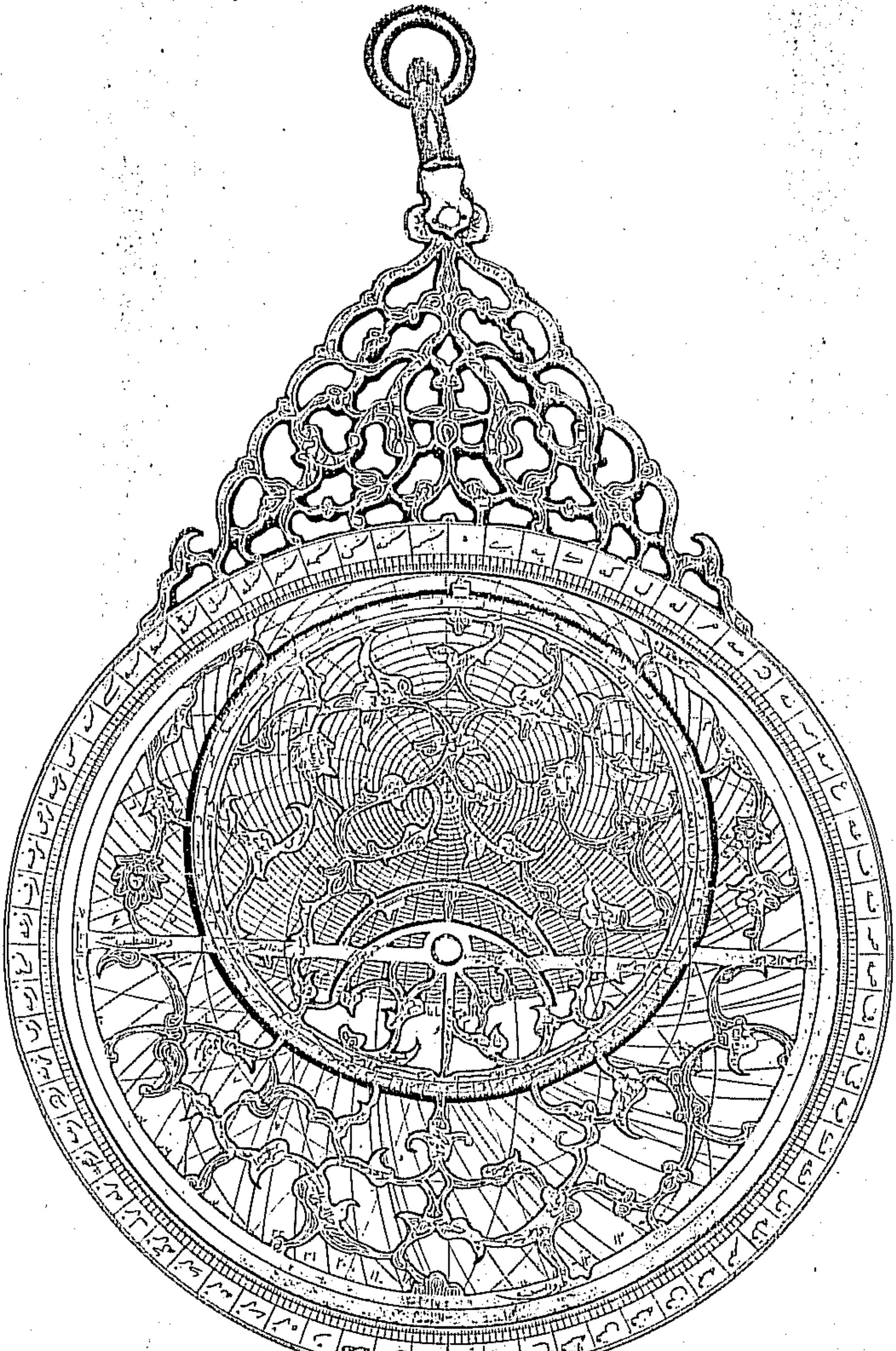
'*This is made by order of our Master King and Sovereign: the most noble, and the Great Prince, the glorious and the magnanimous; the learned and the just. The warrior and the constant, the strong and the victorious, the conqueror of the world of nations.*

'*The extoller of the true faith. The King of Mussulmans, the helper of Princes, the auxiliary of mankind, the treasure of the Empire. The accomplishment of the people; the glory of the religion; master of kings and monarchs; the shelter of the troops of the state, the destroyer of the infidels and idolators; the subduer of the schismatics and the rebels; the extirpator of the atheists; the consumer of the pertinacy; the dissipator of the injurious and the insolent people, the expeller of seditions from towns; the hero of the world; the Khosroe of Irak; the protector of the universe; the guarder of the defiles; the adjutor of the people; the King of Arabia, Persia and Armenia; and the victorious commander of the true believers. Abul-Fetih Moosa, son of the victorious King Abul-Bekr, son of Eoob (Ayub)*

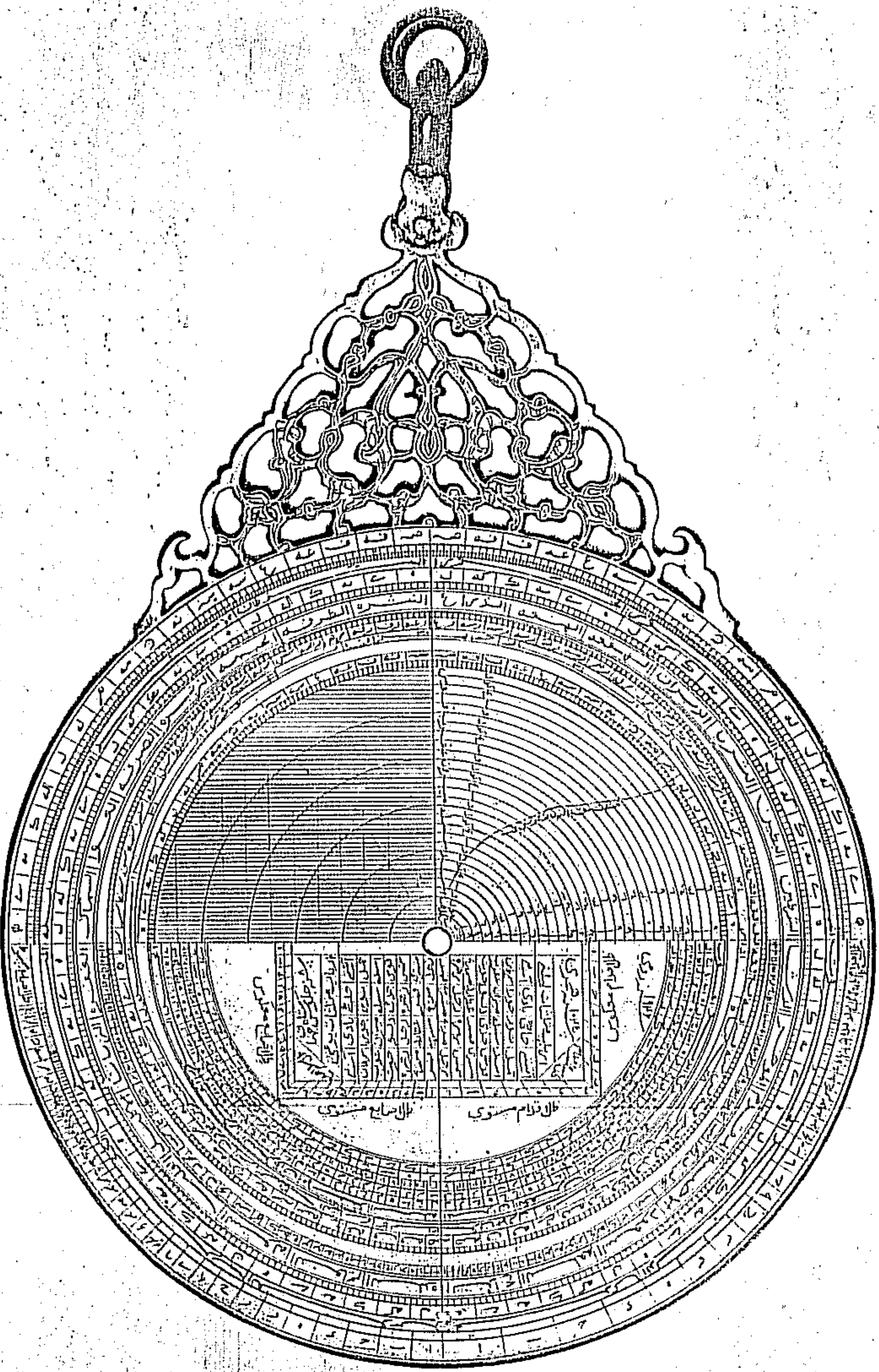
May God Almighty render him victorious.'

An interesting story is told of this instrument when it was being offered for sale in Paris. Somehow the German Emperor, who was then planning a trip to the Holy Land, heard of the existence of this magnificent astrolabe, and being much impressed by the honorific titles of Sultan Abul, engraved upon it, and by their applicability to himself, endeavoured to purchase it. He even sent an emissary to offer Dr. Evans 16,000 marks (£800) for it, but the offer was not accepted. The story suggests that he intended to substitute the name of Wilhelm Hohenzollern for that of Abul Fetih Moosa, and would thereby have greatly increased his reputation in the East, especially if he were accompanied by an astrolabist bearing so superb an astrolabe as this one.

The bracket is beautifully ornamented on both sides with silver and gold foliated inlay. The suspension ring is ◇-shaped in section.



MOHAMMAD IBN ISA OF LAHORE, A.D. 1634



MOHAMMAD IBN ISA OF LAHORE, A.D. 1634

The rim bears the long inscription, within which is a circle of degrees, each divided into thirds and numbered by fives.

The ankabut is imperfect, but now shows 25 stars. It was made in 1425, in the place of the original of 1227–8. The star-pointers are mostly trifoliate, the star names being engraved on the leaflets. The star Vega in the centre of the zodiac is represented by a falling Eagle, as in Nos. 104 and 108. This is significant, because, as Morley pointed out, representations of animals are not usual in Oriental astrolabes.

The 1st point of Aries is coincident with March 14.

On the bottom of the *umm* is engraved a scale of the 'ankabut co-ordinates' arranged in 4 groups of 15 each.

The three 'perfect' or *tamm* tablets are provided with projecting teeth or denticles, which were received in a cavity in the lowest point of the border or *hajrah*. They are engraved for the following latitudes:

1*a*.	Lat. 30°.	With unequal hours and azimuths.
b.	„ 44°.	With arcs of unequal or temporal hours and equal hours, the latter being dotted.
2*a*.	„ 33°.	With unequal hours and azimuths.
b.	„ 40°.	„ „
3*a*.	„ 35°.	„ „
b.	„ 66½°.	„ „

The last is the only tablet on which the azimuths are extended both above and below the horizon. It has the very special interest of being *the tablet of the latitude of the complement of the total obliquity* as described on page 12 and figured diagrammatically on pl. XIX, fig. 14. Although rare in Persian instruments, it was by no means unusual in Indian astrolabes, but this is the oldest example with which we are acquainted. My late correspondent, Mr. G. R. Kaye, has pointed out that Morley and other writers have not realized that this is a tablet of celestial latitudes and longitudes, and is therefore a most important aid in the construction of, and measurement of, the constructed star-map. When $\phi = 90° - \omega$ (the complement of the obliquity) the circles of altitude are parallel to the ecliptic and therefore the tablet can be used for reading of star co-ordinates, which is a help to their identification, position, and ultimately to the age of the instrument. Its Persian name was the *Safiah-i Arz-i Tamam-i Mail-i Kulli.* Cf. Kaye, Delhi Astrolabes, pl. IV, fig. 21.

The Back is most elaborately inscribed.

1. The rim is divided into 360 degrees, each subdivided into thirds. The degrees are numbered by fives 0°–90° in each of the four quadrants.

2. Next come the 12 Signs of the Zodiac separated by crescent moons. Each sign is drawn twice over, the figures being disposed symmetrically back to back. Numerous stars are represented, but symmetry in drawing has obscured truth of disposition.

3. The four concentric circles within which are contained the names of the principal stars of the Zodiac.

4. A circle of degrees.

5. Circles of the names and figures of the 28 Mansions of the Moon, by one of which the moon passes every day. They were not used solely for astrological purposes, as Morley believed. See G. R. Kaye, *Hindu Astronomy*, under ' nakshatras '.

6. Round the centre are 4 quadrants.
   i. Left upper quadrant with horizontal parallels, concentric arcs, and radial lines.
   ii. Right upper quadrant with 30 equidistant horizontal parallel lines.
   iii. Left lower quadrant Astrological table.
   iv. Right lower quadrant contains *a*. Diminutive Square of Shadows. *b*. Arcs of the temporal hours, which show the time by the intersection of the alidade placed at the altitude of the sun.

The two lower quadrants are enclosed by arcs of the shadows, graduated in feet on the left and in inches on the right.

The instrument is in a fine state of preservation and the pin, wedge, and alidade all appear to be original.

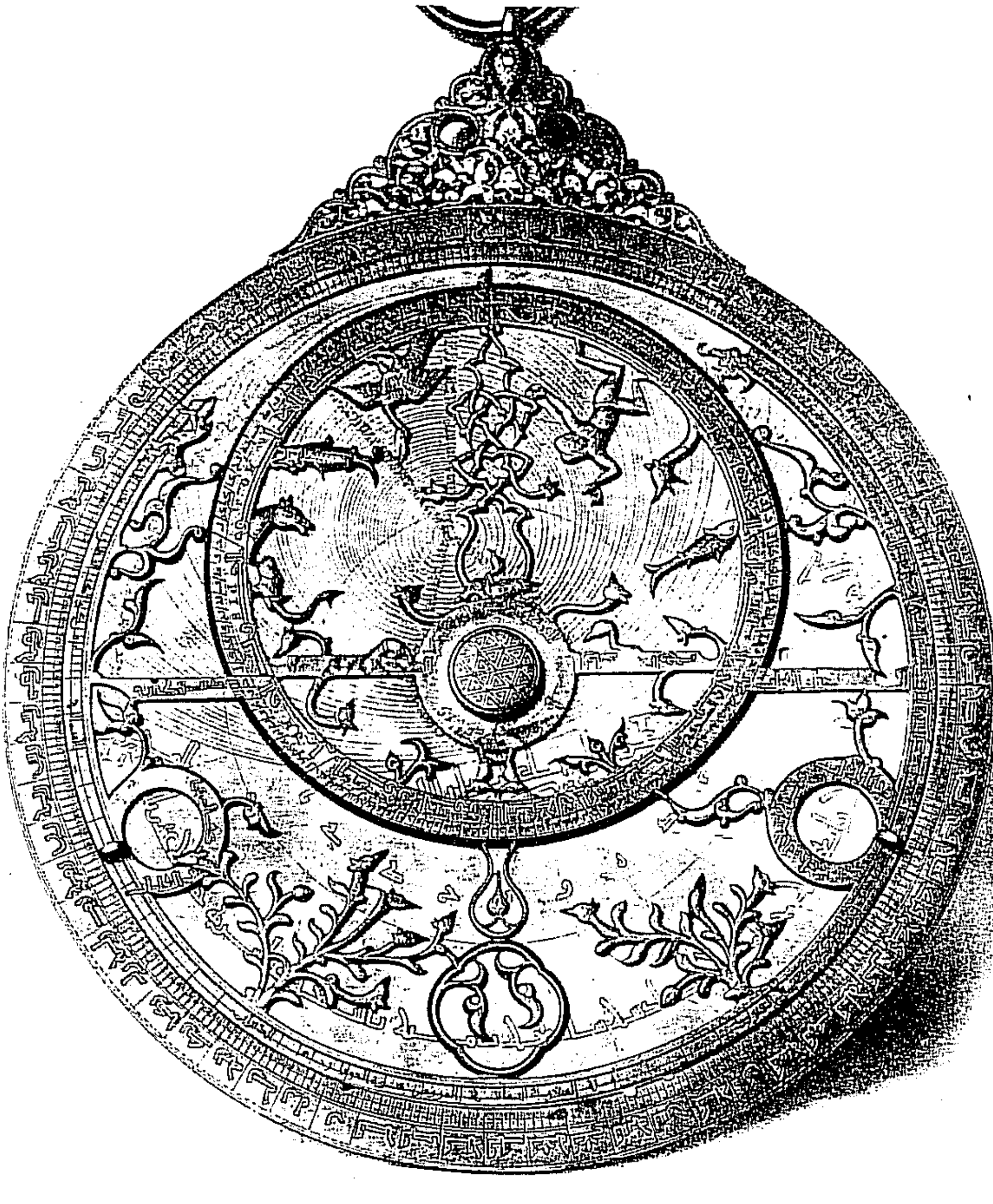
104. ABD AL-KARIM'S SYRIAN ASTROLABE. Pl. LV A.D. 1235.

British Museum. Described p. 47 and by Poole, *Art of the Saracens*, p. 212.

This large 13-inch astrolabe of brass inlaid with silver and copper was found by Augustus Franks in the shop of Pratt of Bond Street, and is now in the British Museum.

There is an inscription in Cufic characters to the effect that it was constructed for ' *Al-Malik al-Ashraf son of Al-'Adil and nephew of the great Saladin, by 'Abd al-Karim al-Misri al-Usturlábi*' in A.H. 633. Saladin was the founder of the Ayyubite dynasty in Egypt and Syria, and Al-Malik al-Ashraf of Diarbekr was the Sultan ruling at Damascus from A.D. 1228 to 1237.

Ring large; shackle small; *kursi* with 2 perforations, beautifully decorated



ABD AL-KARIM, A.D. 1235

with arabesque inlay in silver. The degrees on the rim are subdivided to quarter degrees.

The ankabut is practically devoid of tracery. The zodiac circle is connected by an east-west bar with the Capricorn band, which carries 2 small circular bands, each with a *mudir* to right and left and a slender quatrefoil on the meridian. From this quatrefoil to the *almuri* the meridional band is replaced by an elaborate piece of plaited work.

The signs are inscribed in Arabic, with abbreviated Latin equivalents:

A R	L E	S A
T A	V	C A
G	L I	A Q
C A	S C O	P I S

A peculiar feature is the introduction into the ankabut of forms of men and animals as star-pointers with some appropriateness to the stars indicated; for instance, Ras al-Jathi is represented by a man kneeling; At Tair by an eagle; Kalb al-Akrab by a scorpion; Unk al-Hayyah by the head of a serpent, &c. They are ornamented with inlaid copper.

The principal zoomorphic star-pointers within the zodiac are:

Two heads on long necks near 1st point of Aries.
Hand with extended index finger.
Four eared heads.
Fish (in Scorpio).
Head with jaws widely open.
Man kneeling.
Eagle (= Waqi).
Vultur volans.
Fish.
Horse's head.
Elephant's head.

South of the ecliptic is a jackal and 2 shrubs bearing dogs' heads. The other star-pointers are foliate.

There are 3 tablets (*tamm*), one being a Safihah al-Áfákiyah, with horizons traced at intervals of 8 and 8.

1*a*.	Lat. 30°;	*b*.	Lat. 42°
2*a*.	,, ;	*b*.	,,
3*a*.	,, 36°;	*b*.	Tablet of horizons.

The face of the *umm* is engraved as a Safihah Arz-i Tamam-i Mail-i Kulli, i.e. with ankabut co-ordinates (celestial latitudes and longitudes).

On the Back are planetary symbols, like those still in use. [Morley, p. 47.]

Shadow scales are on the lower periphery only. Below the name of each of the Signs are two figures in silver. The European months are in thirteenth-century characters IA FE MAR AP MAY IV IVL AVG SE OCTV NO DE. Upper quadrants are sinical. In the right lower quadrant are the unequal hours.

105. Saracenic Astrolabe. Pl. LVI XIIIth Cent.

Diameter $6\frac{5}{8}$ inches.

Purchased in 1880 for the British Museum.

Made for use between latitudes 21° and 33°. Inlaid with silver.

The bracket is inscribed الله خرخروطا

The ankabut is inlaid with copper.

Tablets three in number. No. 1 has lines for every 5°; the horizon is inlaid with silver; and the equal hours only are shown. Nos. 2 and 3 have lines for every 10° and are of the ordinary Persian type: they may be a later addition.

1*a*.	Lat. 30°; hours 13. 18				
b.	„ 31°; „ 14. 3				
2*a*.	„ 21°		3*a*.	Lat. 27°	
b.	„ 24°		*b*.	„ 33°	

The *umm* is blank.

The Back is of the calendar type with an inner rectangle of shadows done in silver.

The alidade is not graduated, but is ornamented with scroll pattern like that of Abd al-Karim's instrument of A.D. 1235.

106. Ibrahim's Damascus Saphea A.D. 1270.

Diameter $6\frac{1}{4}$ inches; thickness $\frac{3}{32}$ inch.

Purchased in 1890 for the British Museum.

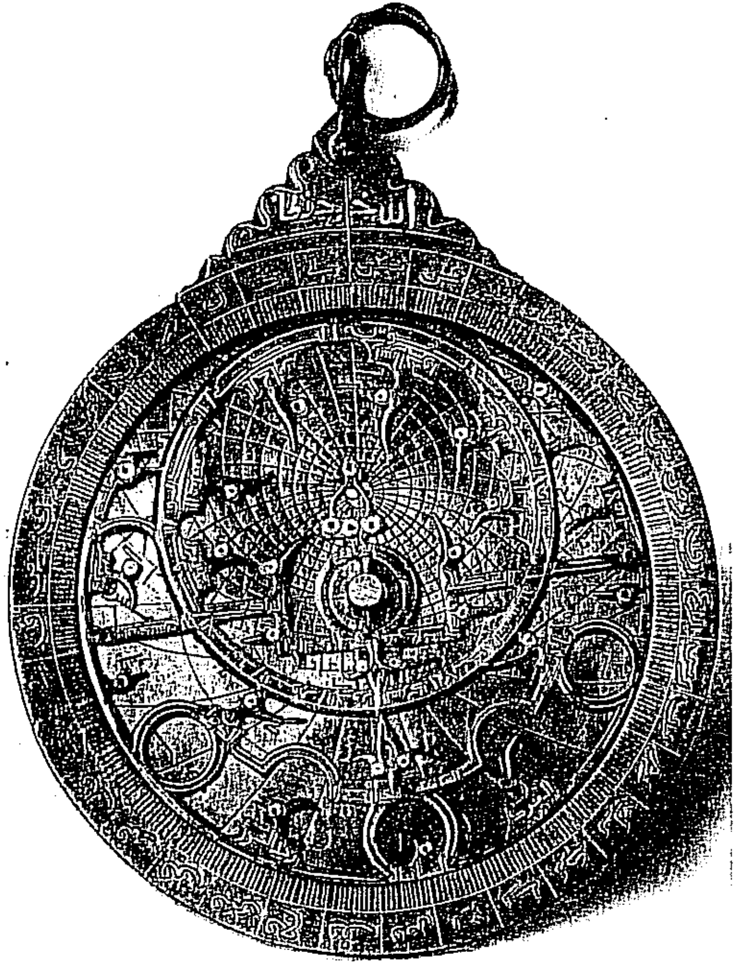
A single plate of bronze made in A.H. 669.

Face covered with an Arzachel with declination and right ascension lines for every 6th degree, but only 5 latitude circles are drawn. The positions of 13 stars are marked by inlaid silver discs.

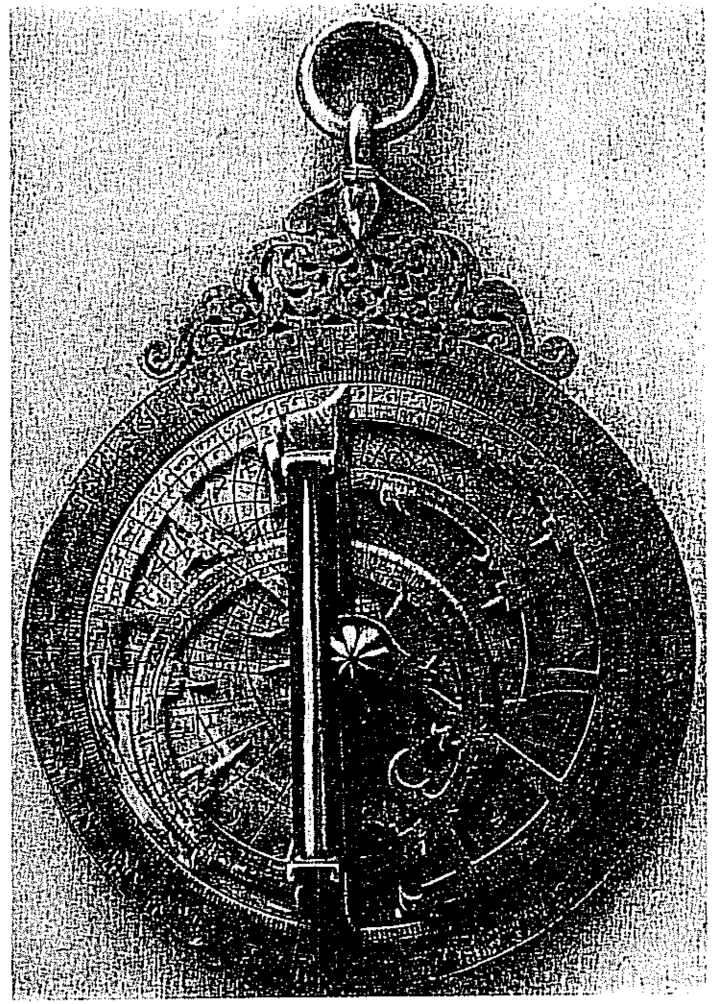
Asad	72° W.	45° N.	Famalhaut	26° E.	34° S.
	36° W.	39° N.		38° W.	14° N. (N. of ecliptic)
	24° E.	24° N.		14° E.	8° S. (on ecliptic)
	70° E.	6° N.		55° E.	24° S. (S. of ecliptic)
Rijl al jauza	71° W.	10° S.		87° E.	38° N.
al Saur	86° W.	16° S.		54° E.	43° N.
	87° W.	52° S.			

On the Back are rectangular shadow scales and a calendar.

At this time celestial Globes were being made at Mosul, witness the fine example in the British Museum, dated A.H. 674 (= A.D. 1275), by Muhammad ibn Kelal, astronomer of Mosul (*Trans. Asiatic Soc.* 1830).



105. SARACENIC ASTROLABE



RASULID ASTROLABE, A.D. 1296–7

107. HASSAN IBN ALI'S CAIRO ASTROLABE (Variety) A.D. 1282–3.

No. 17, L. Evans, *Arch. Journ.*, 1911. Purchased in London about 1880.

A brass circular plate 5⅛ inches in diameter; length 6 or 6½ inches including the suspension shackle; thickness about $\frac{1}{64}$ inch. Silvered on the front side.

Inscribed on bracket in 2 lines:

The work of the servant who is in need of forgiveness and mercy
Hassan ibn Ali in Cairo, the God-protected in the year 681.

On the upper half of the front side are 2 quadrants divided into degrees and numbered in fives, up to 90° at the top. Marked in Siyaq numerals, which are abbreviations of Arabic numerals.

The interior of the left-hand quadrant is divided sinically both ways by vertical and horizontal lines; it is marked 'Inclination' near the centre. The right quadrant is divided vertically in the same way, and over these are almucantars for each 5th degree; it is marked 'Cycle' near the centre.

On the limb of the lower right-hand quarter of the instrument is written 'Shadow inches'; beyond is a scale of half-tangents.

In the bottom right-hand quarter of this side is a Calendar table of Coptic names of months, stating when the 'sun takes up his abode' in each one of the 12 signs, beginning with Virgo. The Coptic months are:

Tût.	Amśyr.	Baûna.
Bâba.	Baramhât.	Abyb.
Hatûr.	Baramûda.	Misra.
Kijâk.	Baśans.	Ayjâm el nasy.
Tûba.		

In the left-hand quarter a table to 'Know the degree of the sun'.

The Arabic inscription at the upper part of this side reads:

10 Spica (= sheaf of corn)	60	30	7 Pisces	—	—
15 Libra	—	—	50 Aries	—	—
5 Scorpion	—	—	5 Taurus	—	—
7 Archer	—	—	60 Gemini	—	—
20 Capricorn	—	—	5 Crab	—	—
5 Aquarius	—	—	2 Lion	—	—

On the Back of the instrument are 17 concentric circles crossed with 2 diametral lines marked 'North', 'South', 'East', and 'West'. The names of the zodiacal signs have been roughly scribbled in the outermost circle. There is no alidade.

There are some 5 holes about a quarter of an inch from the edge, to one of which at the east is fastened a silver fish, by the tail, probably as an index;

a similar fish is placed at the north, but this is fastened by a second (? modern) rivet and cannot be moved.

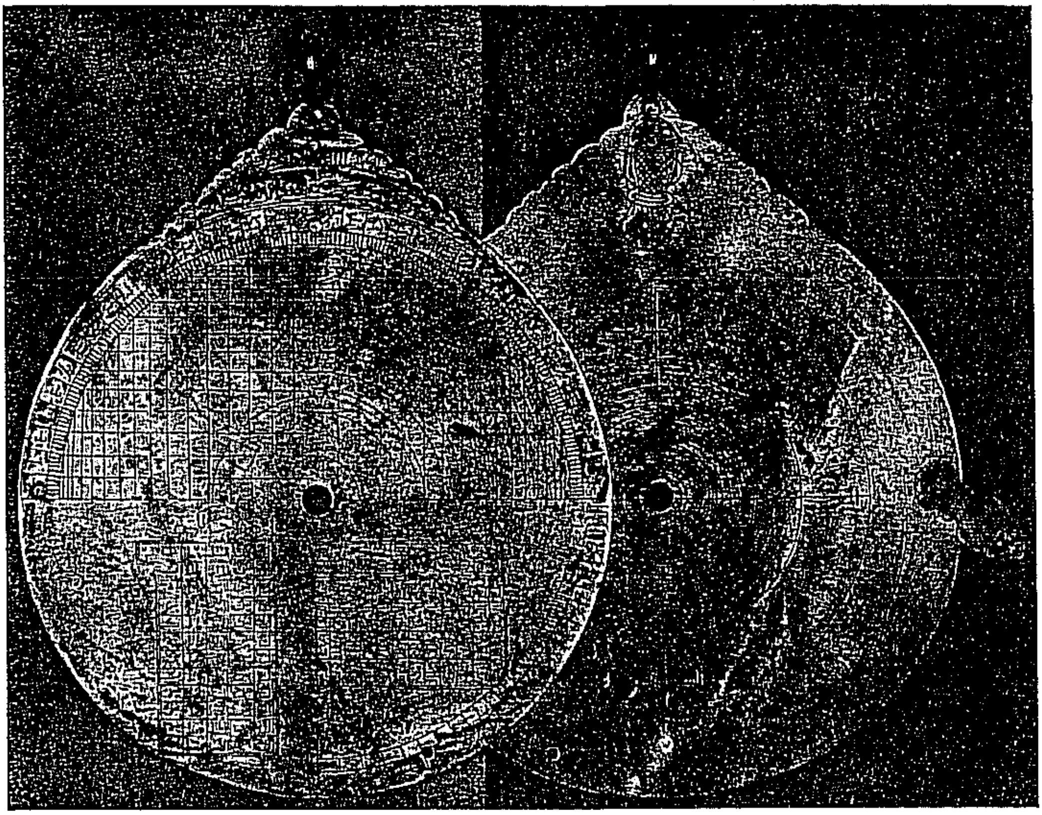
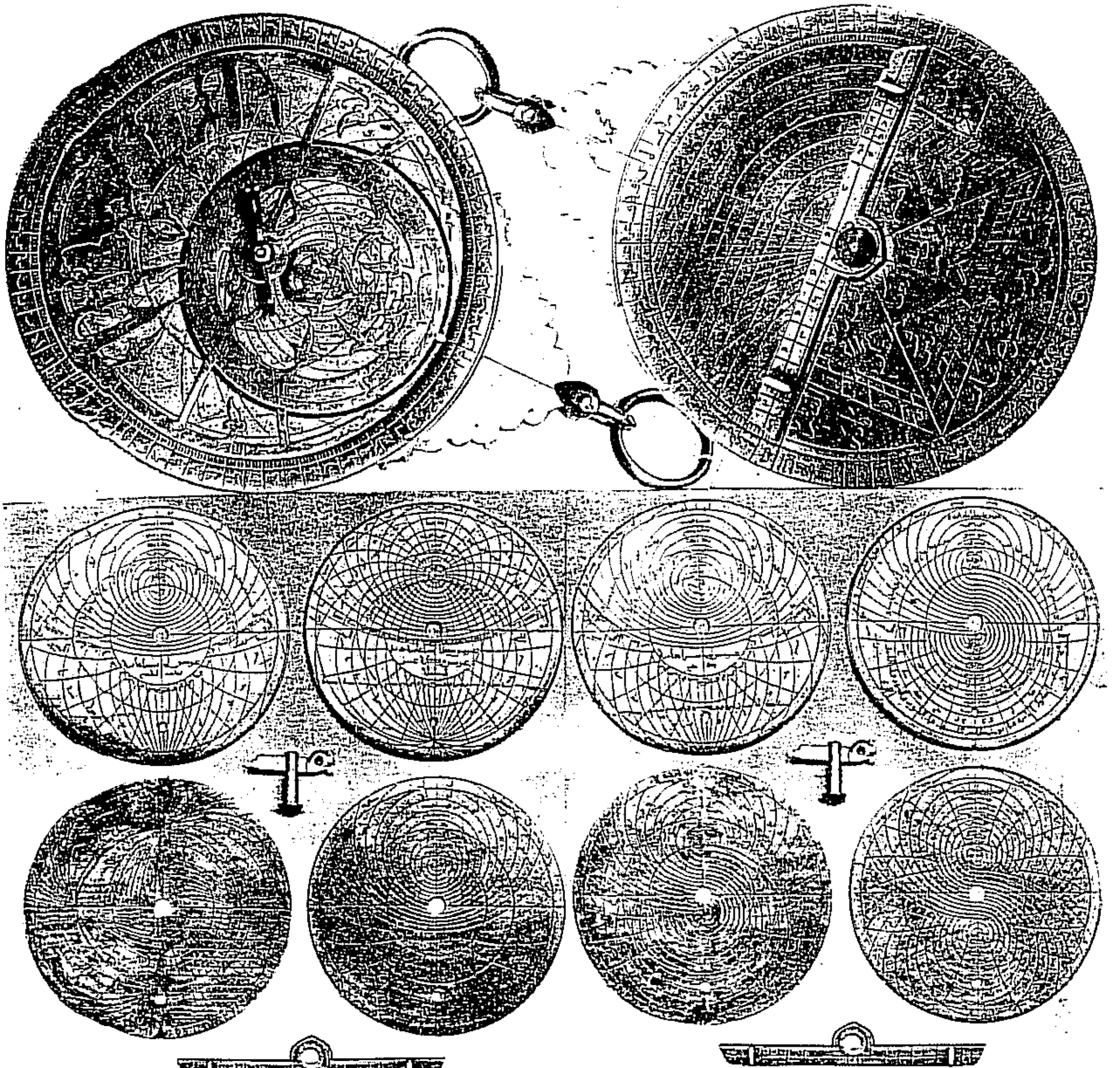


FIG. 116. ASTROLABE OF HASSAN IBN ALI OF CAIRO. A.D. 1282–3.

That there were skilful Arabian artisans in Egypt is proved by the notable celestial globes which they made both in copper and in silver. Such a master-craftsman was Ben-Alnabdi, an inhabitant of Egypt,

vir doctus et astrolabiorum et aliarum cœlestium machinarum insignis artifex. Cujus nos aliquot instrumenta adfabre elaborata ac peraccurate delineata mirati sumus cum Abul Cassem Ali ben-Ahmad Giorgianensis, regius ea tempestate administer, anno hegiræ 435 (A.D. 1043), bibliothecæ Cairensis rebus consulere decrevisset, ejusque indicem componendi, tum codices concinnandi, reparandique curam viris duobus demandasset, videlicet Aba Abdallæ Alcodhai dignitate judici et Ben-Khalepho bibliopolæ (utrique Hispano); illam ego inquit (Ben-Alnabdi suprà laudatus) post modum adii, absolutum ab utroque auctore opus spectaturus. Ibi præter selectos de astronomia, geometria, et philosophia codices numero sex mille et quingentos, vidi globos duos: alterum æneum à Ptolemæo olim confectum, cujus tempore, quo factus est, rite perspecto, subditisque calculis, annos MCCL elapsos fuisse comperimus: argenteum alterum ab Abil Hosein Alsuphi ad usum regis Adhadaldaulat jam pridem elaboratum, trium millium dracmarum pondere qui totidem nummis aureis emptus esse traditur.' (Sédillot, 1841.)



THE ASTROLABE OF SHEMS AL DIN MOHAMMED SAFFAR, A.D. 1288

108. SHEMS AL DIN MOHAMMAD SAFFAR'S ASTROLABE. Pl. LVII A.D. 1288.

Stated to have come from the celebrated Richard collection, it was bought by Mr. L. Evans on 13 July, 1921, from I. Sassoon & Co. of 62 Mortimer St. for £75.

Turned on a lathe out of a solid casting of bronze of 4$\frac{11}{16}$ in. diameter and about $\frac{3}{16}$ in. thickness, in one piece with the plain-sided, lobulated bracket. The total length is 7$\frac{1}{4}$ inches.

The maker's name is *Shems al din Mohammad Saffar*.

In Mr. Knobel's opinion, it is of Mosul make (Mesopotamia), being cast in an alloy of a peculiar reddish hue recalling that of the beautiful geomantic instrument in the British Museum. The ankabut is of yellow brass, but not original, being thin, rudely made, and carelessly engraved. Some ornamental engraving at the back of the rim indicates that the maker could have made a more solid rete and have engraved it better. At the same time the letters on it are similar to those on the *umm*. The date is given in an unusual form in words at full length instead of in cyphers.

Sanat sitt wathamanīna wathamāni mi'ah, = 886—Hegira not being mentioned.

There is a shackle and ring at the top of the throne, which is quite plain, except for a name roughly scribbled in a Persian hand on the obverse, *Mohammad Hashim*, doubtless that of a later owner.

The brass rule has single pin-hole sights. The *faras* is of an unusual form, and probably more recent.

In pattern and design the ankabut for 28 stars closely resembles the one made in 1425 for the fine Persian astrolabe of 1227 in order to bring the latter instrument up to date. And though the diameter of the present instrument is only 4$\frac{11}{16}$ inches, the rete includes a bird similar to the one in the 10$\frac{11}{16}$ inch instrument.

The four tablets (diam. 4 inches) are held in position in the *umm* by a circular pin or *mumsikah* projecting $\frac{1}{8}$ in. from inside of the rim. They are *sudsi* or sexpartite. One shows ankabut co-ordinates on three-quarters of its surface, but the right-hand bottom quadrant is marked with 13 equidistant concentric quarter circles, besides 18 radial lines, and a scale of sines drawn one to every five degrees. On the back this plate has two separate projections, cf. G. R. Kaye, Dehli Astrolabe B. fig. 18, pl. 4. A similar scheme is executed on two of the other plates. Four sides are engraved in the usual manner.

1a. Double projection for 18° and 72°. Inscribed with the names of the Signs of the Zodiac.
b. Latitude 21°; hours 13. 14 minutes. *Latitude of Mecca, which God may people.*
2a. Latitude 30°; hours 15. 13 minutes and 13 seconds.
b. ,, 32°; ,, 14. 8 ,,
3a. ,, 36°; ,, 14. 30 ,, with dotted lines for equal hours.
b. Double projection for 36° and 40°.
4a. Latitude 78° and the day.
b. ,, 84°; hours 14. 30.
5a. Double projection for 24° and 66°.
b. Tablet of horizons, arranged in 3 groups of 9. The quadrant mentioned above occupies the fourth quarter—a unique arrangement.

On the bottom of the *umm* is a single series of the names and latitudes of 32 cities divided by curved lines.

LIST OF CITIES

Kain.	Shiraz.	Damghan.
Amul.	Yezd.	Nizapur.
Tabreez.	Ispahan.	Tus.
Maragha.	Qumm.	Merv.
Ardabil.	—	Herat.
Astrabad.	—	Balad.
Samarkand.	Kaswin.	Tabas.
Bokhara	Hamadan.	Kilki (Cilicia).
Mak—	Bagdad.	Tibaz.
Hormuz.	Basra.	Kain.
Kerman.	Rayy.	

On the Back two quadrants in the upper half are divided into degrees numbered in fives with the sun.

The left quadrant is traversed by radii drawn one for every five degrees and crossing the horizontal or sine lines.

The right quadrant is engraved with six equidistant concentric arcs.

The border of the lower half is divided with marginal shadow scale inscribed on either side, within which are the usual rectangular shadow scales, inscribed on the left for *Shadows the feet*, graduated in 8 divisions; and on the right for *Shadows the inches*, graduated in 12 divisions. Both scales have the 'linea mediae umbrae' regarded by Morley as unusual in Oriental instruments. And finally, at the lowest part of the border is the only attempt at ornament upon this rather plain instrument: it consists of some three foliations in relief upon a mat stippled background.

109. Rasulid Astrolabe. Pl. lvi A.D. 1296–7.

Diameter *c*. 6½ inches.

M.S. Dimand. Metropolitan Museum of Art, New York. *Dated Specimens of Mohammedan Art*. Metropolitan Museum Studies, from Vol. I, Part 1, 107.

Inscription:

This astrolabe is made with care and specially for Omar ben Youssouf ben Omar ben Ali ben Rasul el Mazaffar (the victorious). Year 695.

Omar ben Youssouf ben Omar ben Ali ben Rasul (1295–7) was a Sultan of the Rasulid dynasty which succeeded the Ayyubid dynasty in Yemen, Arabia.

A brass astrolabe with pierced decoration on the somewhat massive bracket. The degrees of the rim are doubly numbered by fives and by tens in Arabic script. Ankabut of early type, with dagger star-pointers. The tablets are sexpartite. The alidade sights are connected by a tube.

Though the greater part of metal-work with silver inlaid decorations, bearing names of the Rasulid Sultans, was probably made in Egypt,[1] this astrolabe, with its simple decoration, is probably a local product of Yemen.

The Quadrant of Ali ben ash-Shihab A.D. 1334.

W. H. Morley, *Description of an Arabic Quadrant*, 1859.

As the maker of this dated quadrant may also have been an astrolabist, its inscriptions, as translated by Morley, are worth recording.

Constructed for the use of the Sheik Shams ed-Din Ben Sa'id, the chief of the Muazzins in the Jami al-Umawi in the year 735 *by Ali ben ash-Shihab.*

Engraved by Mohammad ben al-Ghazuli.

The mosque, sometimes called the Jami Bani Umayyah, is the most remarkable of all the mosques in Damascus. In the centre is a tomb containing the head of the martyr St. John, son of Zachariah.

[1] Information from H. Gillingham.

110. EARLY ARABIAN ASTROLABE *Undated.*

British Museum. Left with Panizzi when Keeper of Printed Books, but nothing is known of it until it was handed over by Winter Jones in 1873 to A. W. Franks.

Diameter $4\frac{7}{8}$ inches.

Bracket small, 3-lobed. Rim with degrees numbered by fives.

The Ankabut has a primitive appearance, with EW bar counterchanged once only. The star-pointers are dagger-shaped, for 14+10=24 stars. Two knobs for rotation on the EW bar. The zodiac circle is engraved with the names of the signs and of the months in roman and in arabic characters.

AR TAV CAN LEO VIR LIBR SCORPIO IƆVS [*worn*] AQVAR PISCE

Tablets are two in number, and the *umm* carries a projection for lat. 35°.

The alidade is graduated and bears sight-vanes which are unique in having their second, smaller perforations in the corners.

FIG. 117.

111. The Astrolabe of Ahmed ibn al-Khidr — A.D. 1376.

In possession of Messrs. Moradoff & Sons in 1929.

Diameter about 6 inches. Stated to be inscribed:

Made by Ahmed ibn al-Khidr of Nejd in the year 778 of the Hedjra, which would date it A.D. 1376. The vendor of the instrument had considered it far older, as having been made during the reign of the Abbassides in the year 378 = A.D. 960, but to judge from the appearance of the metal, the instrument is not of such antiquity. The inclusion of a small critical mark, easily overlooked, would add 400 to the date, and that is what my friend, Professor Margoliouth, has advised.

The bracket is of an interesting design, two heads surrounded by scrolls.

Fig. 118. Bracket and copy of Inscription.

The ankabut is for 12 + 10 = 22 stars. The star-pointers are mostly of the dagger type, as shown on the accompanying rough sketch.

There are 5 plates.

Fig. 119. Part of Ankabut.

112. Tajuddin Jan Ali's Arabian Astrolabe — A.D. 1485.

Purchased in 1864 by the British Museum.

Diameter 5⅙ inches.

'*Made by Auhad Muhammad al-Auhadi for Tajuddin Jan Ali.* A.H. [ ].'

The tablets are 4 in number.

1*a*. Lat. 30° . . hours 14. 54.
b. Tablet of horizons.
2*a*. Lat. 32° . . hours
b. " 34° . . "
3*a*. Lat. 36° . . hours
b. " 42° . . "
4*a*. and *b*. are not numbered.

The *umm* is inscribed with the names of 33 towns with their longitude, latitude, and inhiraf.

On the Back are shadow scales both circular and rectangular. The right upper quadrant contains the unequal hours, the left upper quadrant is ruled for each 5°.

113. Arabic-Turkish Astrolabe — A.D. 1629–30.

Mensing Collection, No. 38.

3½ inches in diameter.

A small 'Arabic-Turkish' astrolabe bearing date 1039 A.H. The bracket is imperforate, but with moulded sides. The ankabut is simple in character for few star-pointers, three of which are implanted on a portion of the equatorial band traversing the zodiac. The meridional bar (countercharged) does not reach as far as the Capricorn band.

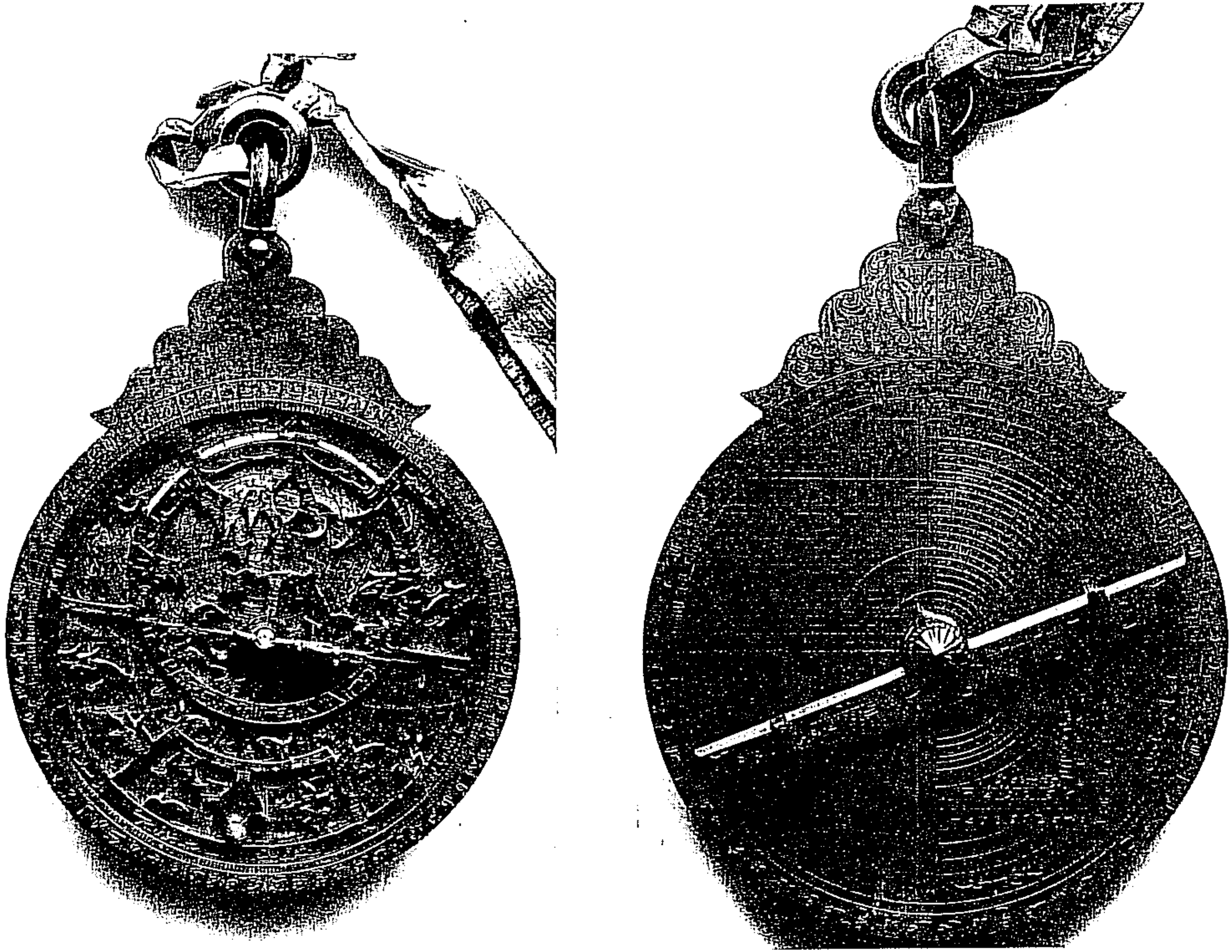
114. Laud's Astrolabe. Pl. LVIII. — *Undated:* anterior to A.D. 1636.

Gift of Laud to the Bodleian Library in 1636.

6⅜ inches in diameter.

The general character of the instrument that bears the arms of William Laud, as Archbishop of Canterbury, is sufficiently well indicated in the figures and description in *Early Science in Oxford*, vol. ii, p. 196, to need further notice here. The workmanship is poor and unfinished. Laud is known to have been fond of consulting the stars, but if he ever used an astrolabe in his astrological practice it is probable that he would have secured a better instrument than this one: moreover none of the tablets, which are for lats. 22° and 27°, 26°, and for 28° and 40°, would have been of use to him. There is no reason for believing the date to be much earlier than

LVIII



LAUD'S ARABIAN ASTROLABE

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

1636, when Laud gave it to the Library, where it is now regarded as a manuscript rather than as a scientific instrument.

The gazetteer includes towns of Syria, Persia, and India.

115. Franco-Turkish Astrolabe *Undated.*

Mensing Collection, No. 37.

3¼ inches in diameter.

The bracket is three-shouldered and contains a small magnetic compass. The design of the ankabut is peculiar in that the usual east-west and meridional bars are absent, their place, as supports, being taken by 6 ties between the Capricorn band and the Zodiac, and by a triangular arrangement of bars within the zodiac.

The 5 plates are inscribed for lats. 18°, 30°, 33°, 39°, 42°.

The Back is engraved as a calendar.

Dr. Engelmann has referred it to the sixteenth century.

102 A. Damascan Astrolabe by Sarraj A.D. 1228.

Described and figured by Padmākara, 1928, to whose paper my attention was drawn by Sir Richard Burn, who has amended the reading of the date.

Diameter 5.4 inches.

Inscribed:

Made at Damascus by Sarráj in 626 A.H.

Ring and shackle of ◇-section. Bracket with two round perforations. Ankabut devoid of tracery, with two handles. Star-pointers dagger-shaped, 26 in number. A list of the stars is printed in Padmākara's paper.

Tablets:

I*a*.	Latitude	21°;	hours	13. 21.	'Mecca'.
b.	,,	32°;	,,	14. 8.	'Baitul Mugaddas' (Jerusalem).
II*a*.	,,	27°;	,,	13. 44.	
b.	,,	30°;	,,	13. 58.	'Misra' (Cairo).
III*a*.	,,	35°;	,,	14. 25	Inscribed in kufic.
b.	,,	36°;	,,	14. 30	
IV*a*.	,,	34°;	,,	14. 19	Inscribed in naskhi like Nos. I and II.
b.	,,	41°;	,,	15. 1	

The *umm* is also engraved for latitude 24°, and the almucantars are numbered in kufic.

The Back shows:

i. Circle of degrees.
ii. ,, Manzils.
iii. ,, Signs.
iv. Circle of Months.
v. Graphic table of sines.
vi. Squares of the Shadows.

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.

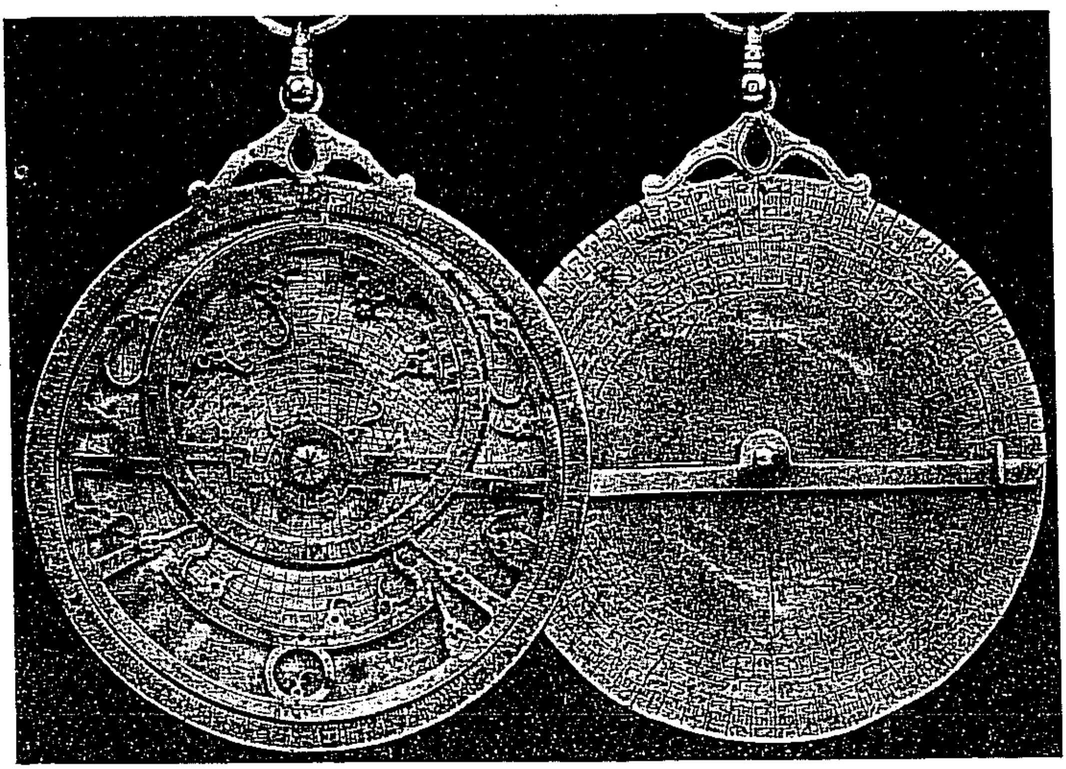


Fig. 120. Dr. Knuthsen's Moorish Astrolabe.

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.

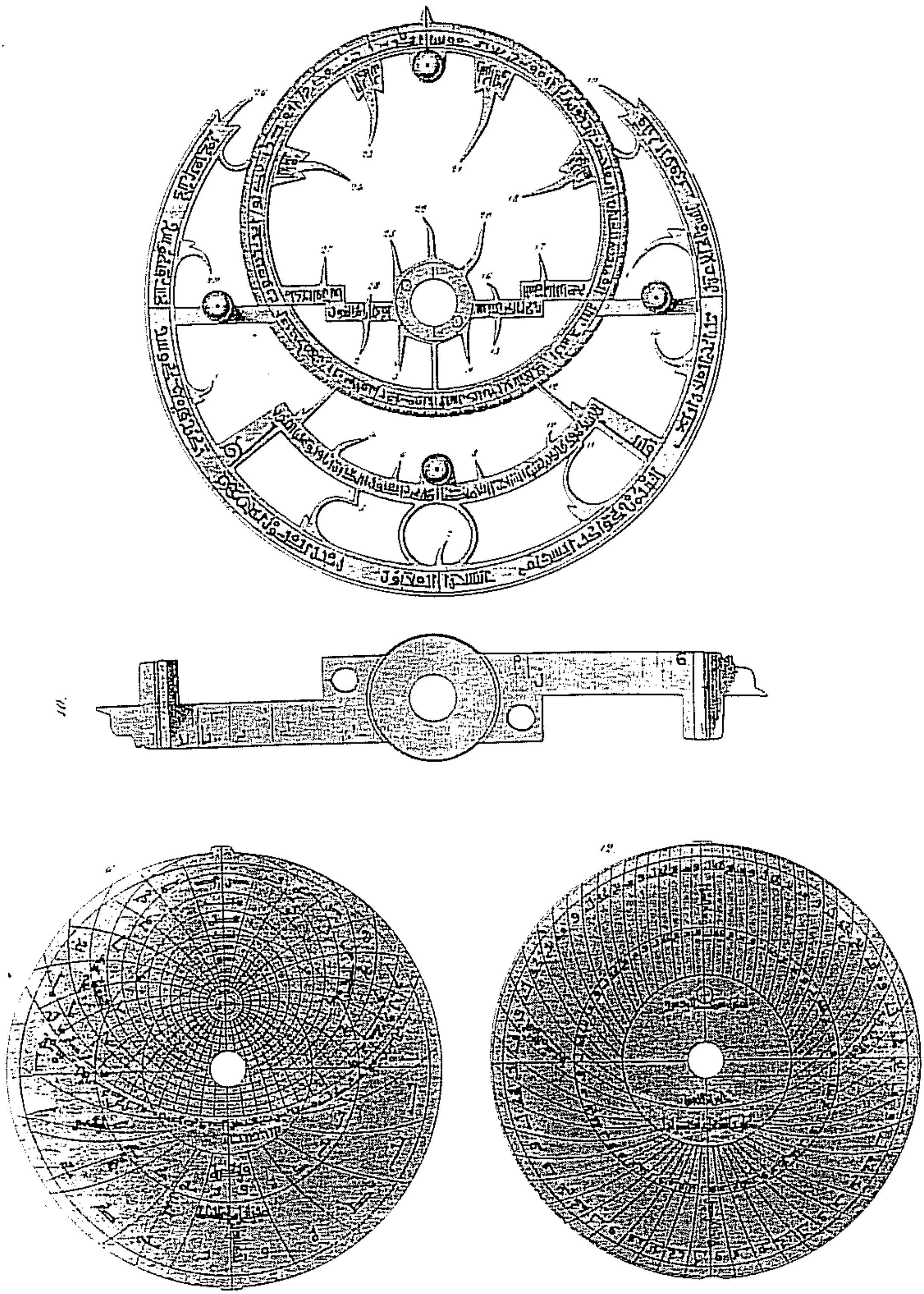
From the same Arabian stock came the Moslem invaders of Spain. By their unexpected gift for civilization, architecture, and science, they raised that south-west corner of Europe to a cultural level that was far above the capability of any northern race of their time, or, one might almost say, of the 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 foot-prints 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.

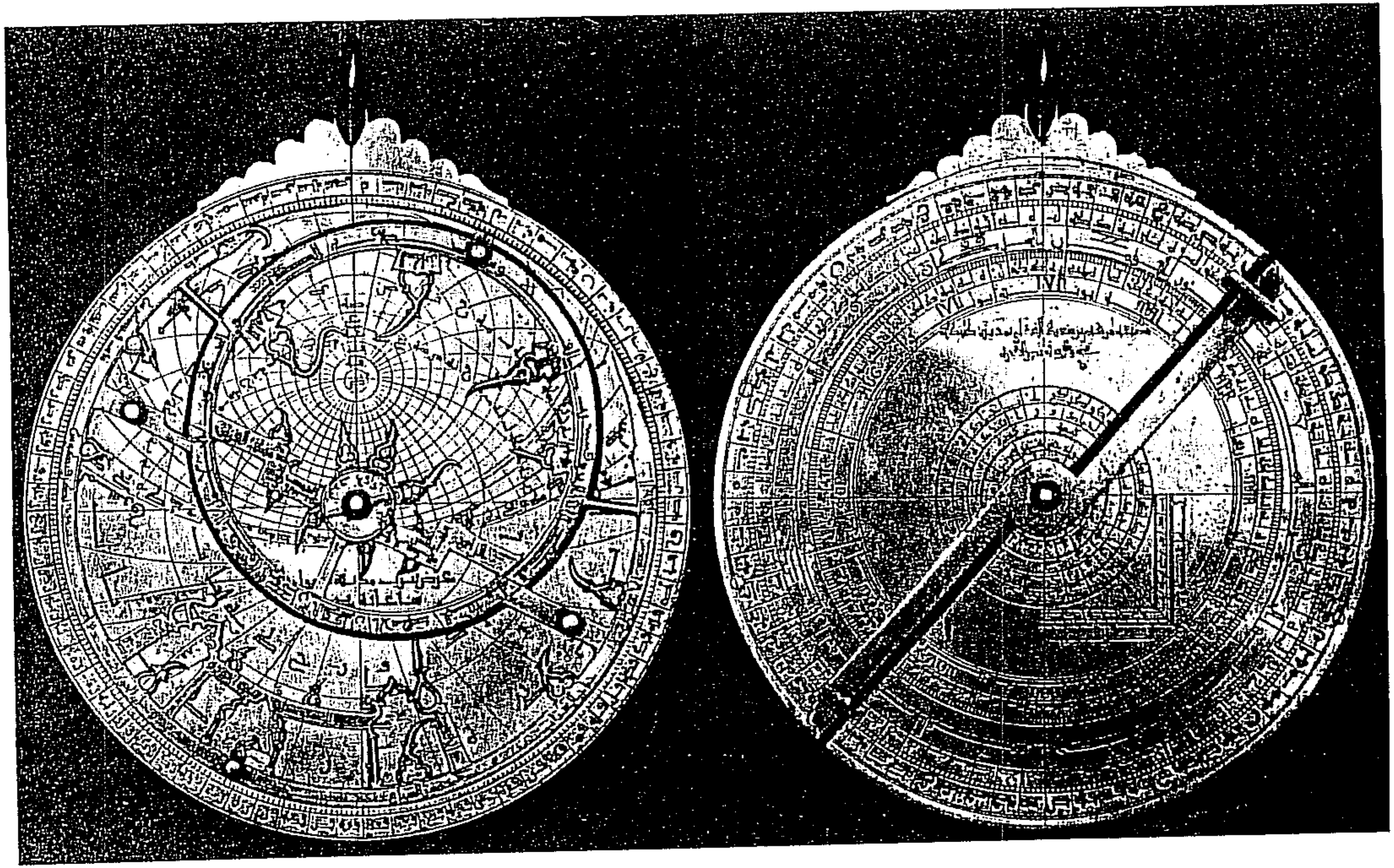
The tablets are 5 in number. Three are inscribed '25', '22', and '40' respectively.

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.

6⅝ 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 ¼ 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*. Mosul; 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.

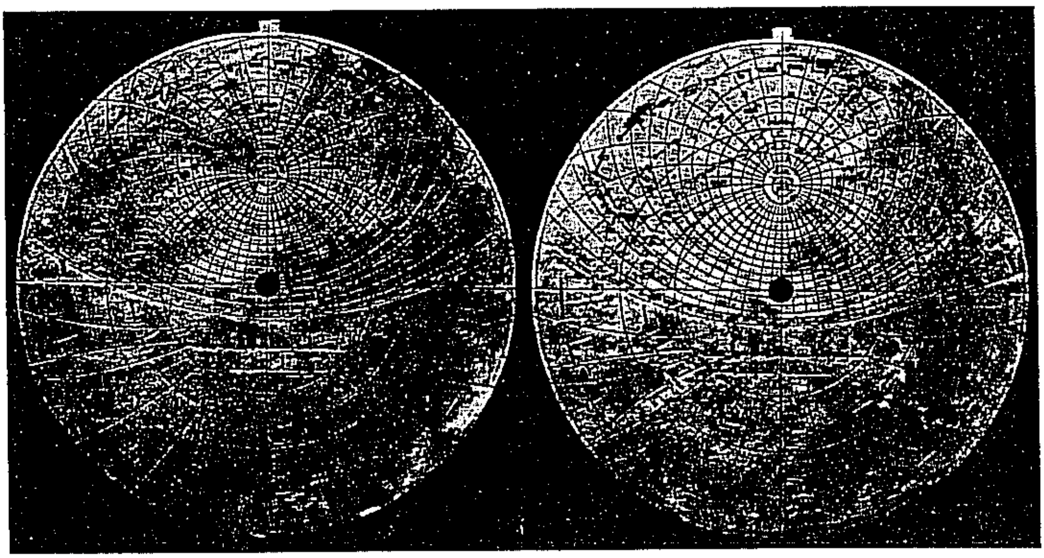


FIG. 121. TABLETS FOR LATS. 21° AND 25°. A.D. 1067–8.

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 *asr* ' (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 Zarquāli 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-'Abbādīyah* in honour of al-Mu'tamid 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-zarqāliya*) 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*.

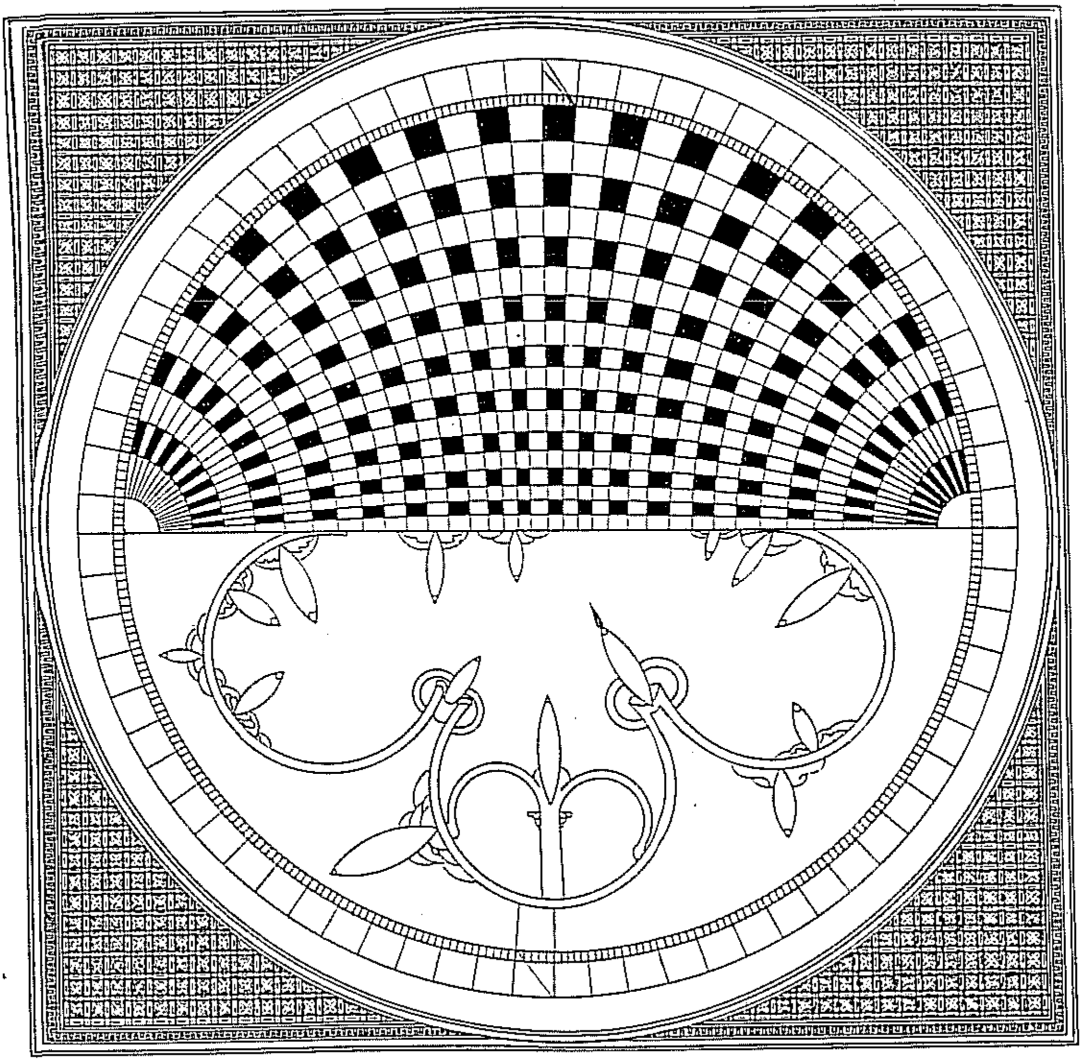


FIG. 122. RETE OF THE UNIVERSAL LAMINA. A.D. 1070–5.
From Alfonso X, *Libros del Saber*, 1864.

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 '.

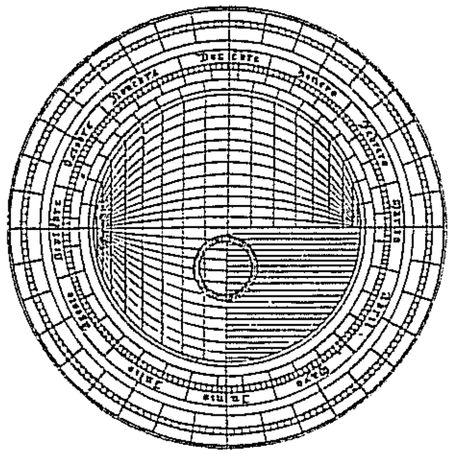


Fig. 123. Back of the Saphea of Arzachel.

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) circumducas; 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 ej us 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.

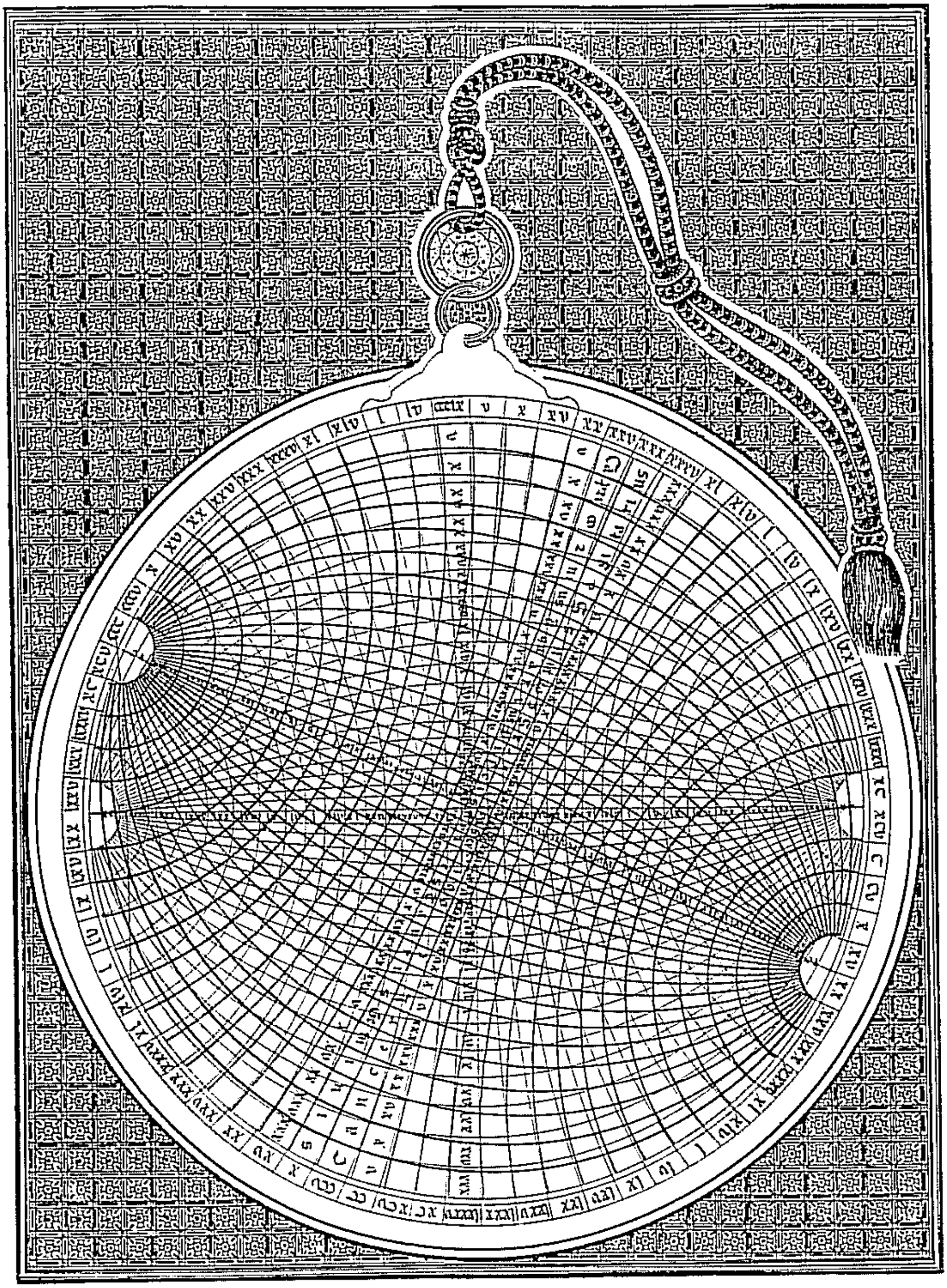


FIG. 124. FACE OF THE SAPHEA OF ARZACHEL. A.D. 1078–80.
From Alfonso X, *Libros del Saber*, 1864.

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 $6\frac{1}{16}$ 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	XXV	XXX	XXXII	XXXVII	XXX	XXXVIII	LXVI
XIX	XXXII	XXXVIII	XXXV	XXXIX	XL	XLI	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 $6\frac{1}{4}$ 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.

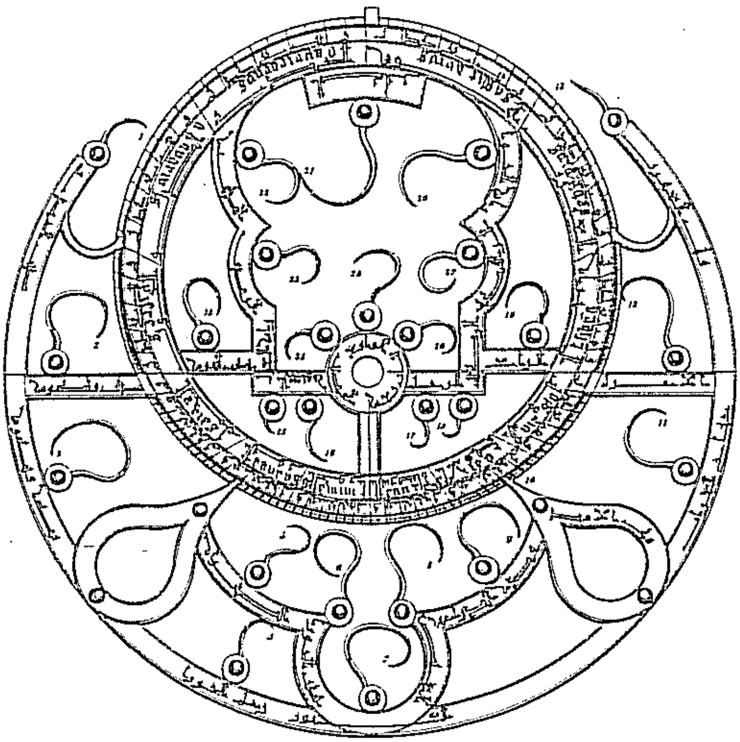


FIG. 125. ABU BEKR'S ANKABUT. A.D. 1208.

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 *'asr* 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'.

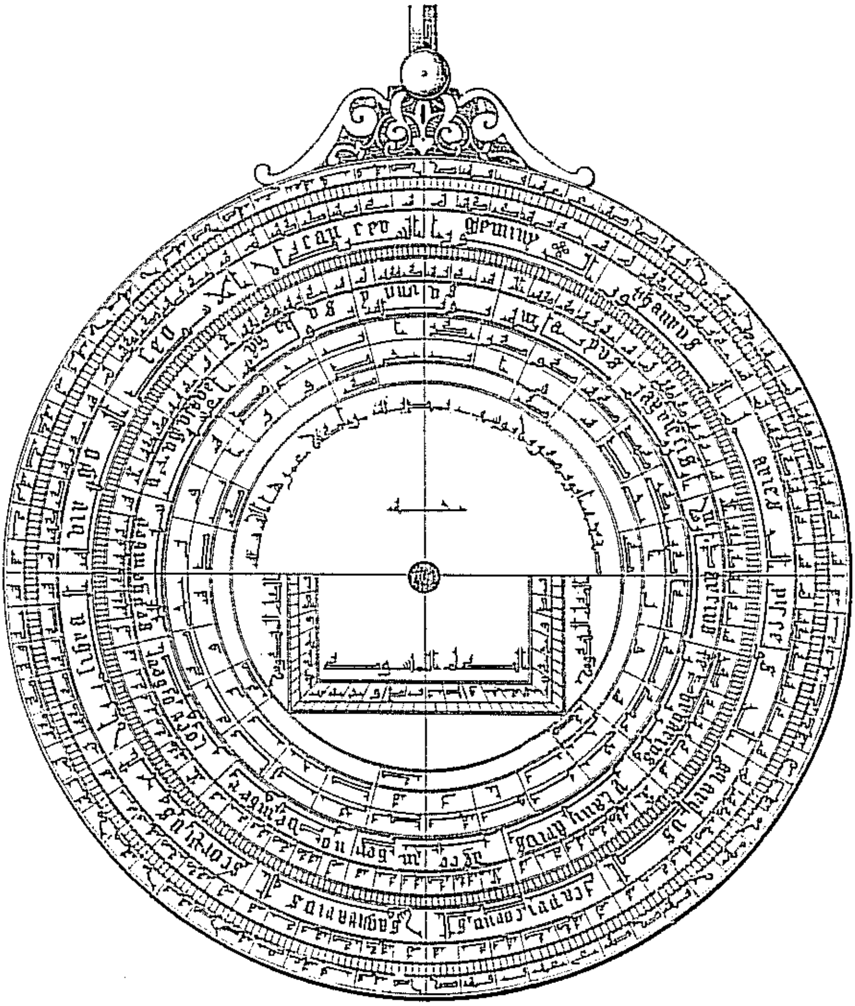
The *umm* is engraved with a most elaborate circular table, the use of which is explained by the innermost inscription, which has been translated by Sarrus: '*I have defined in the tables the limits, the dignities, the faces and the triplicities, the characters of the planets by means of the last letters 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., ix. } Limits according to Ptolemy.
x., xi. } Limits according to the Egyptians.

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.



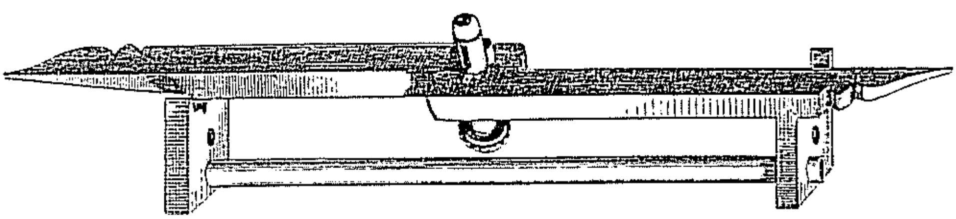


FIG. 126. ABU BEKR'S ASTROLABE AND ALIDADE. A.D. 1208.

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

6¼ 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 '.

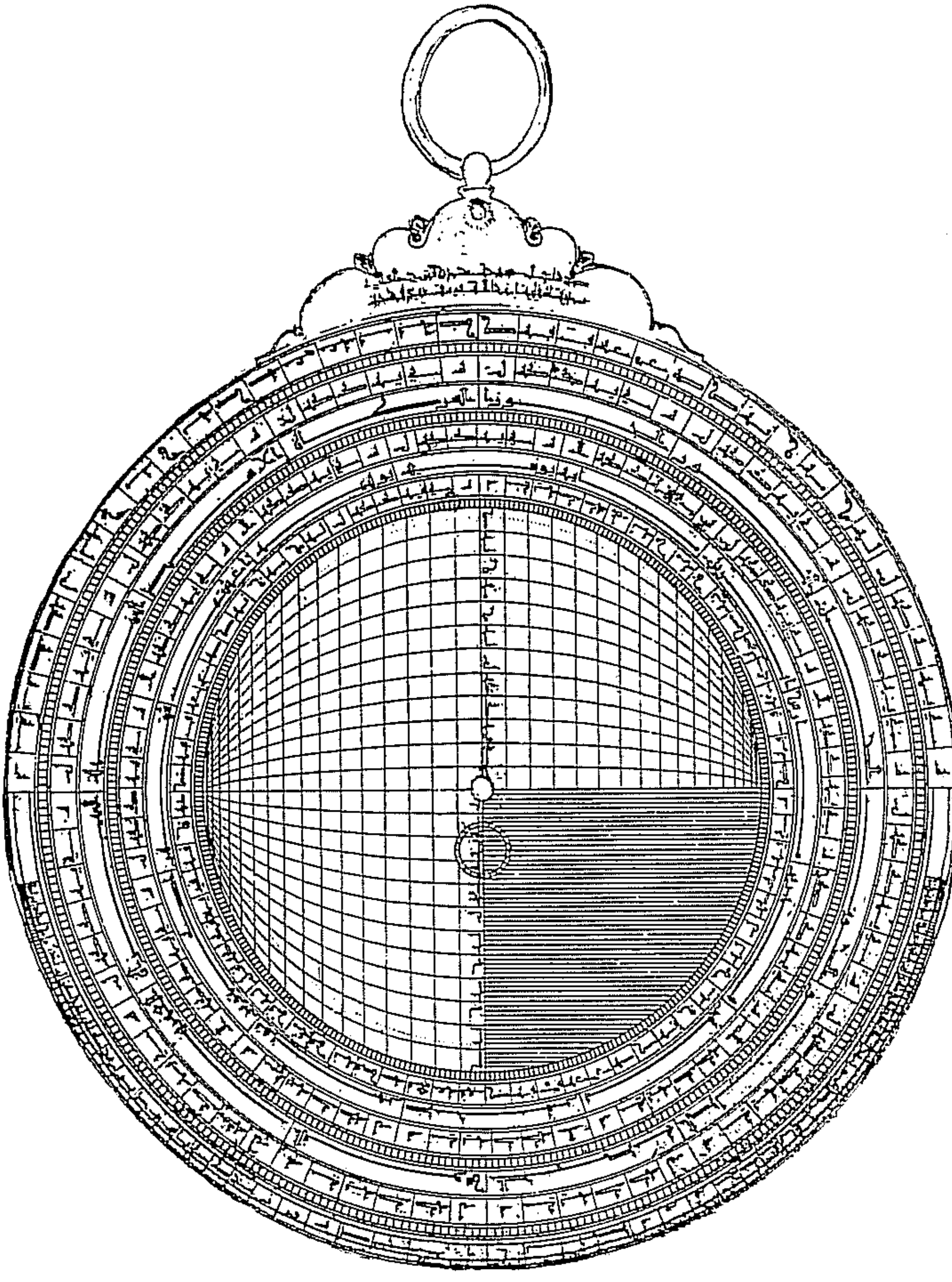


FIG. 127. THE VALDAGNO SAPHEA. A.D. 1216.
After Schio.

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 Andróm.
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.

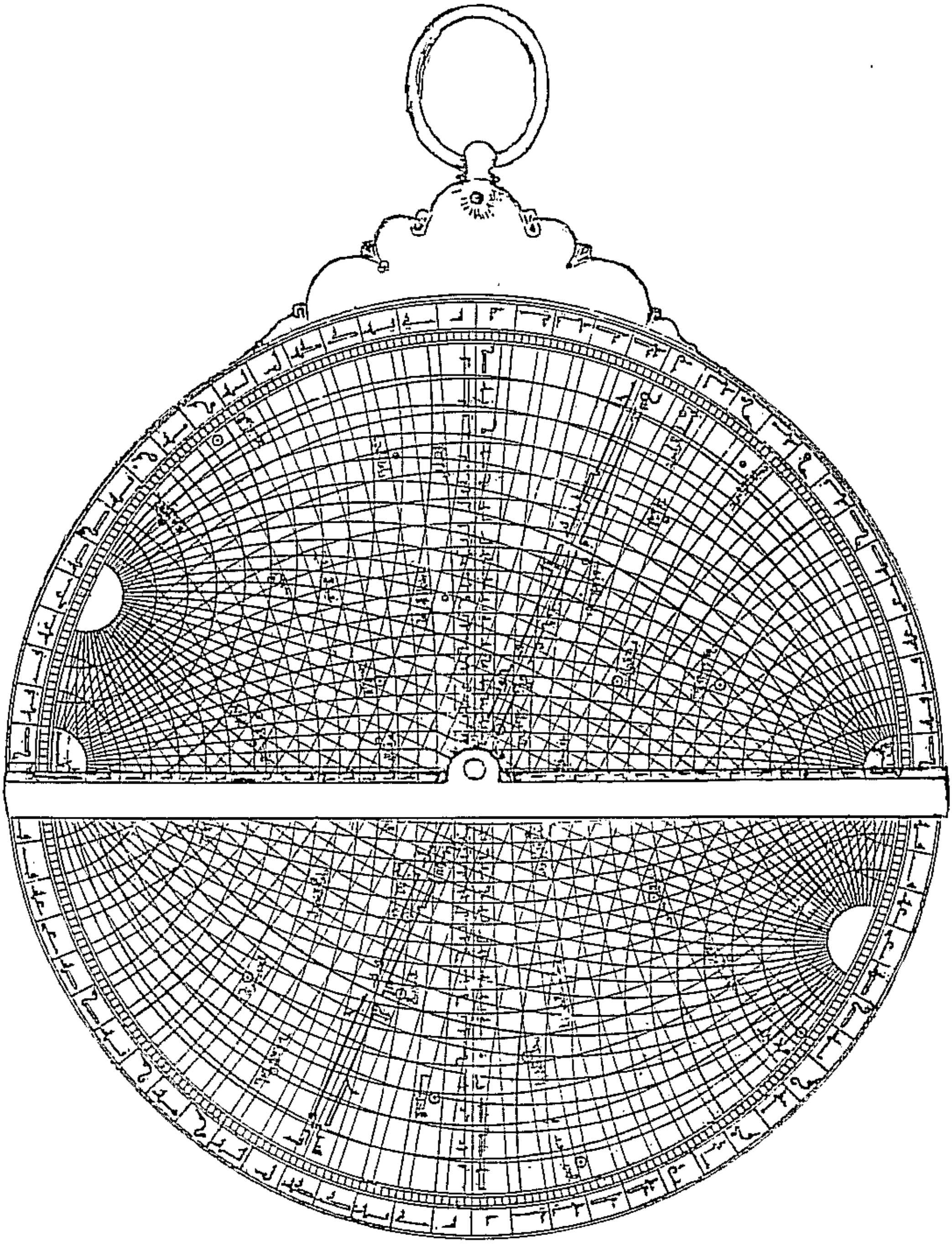


FIG. 128. THE ARZACHEL OF THE VALDAGNO SAPHEA. A.D. 1216.
After Schio.

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.

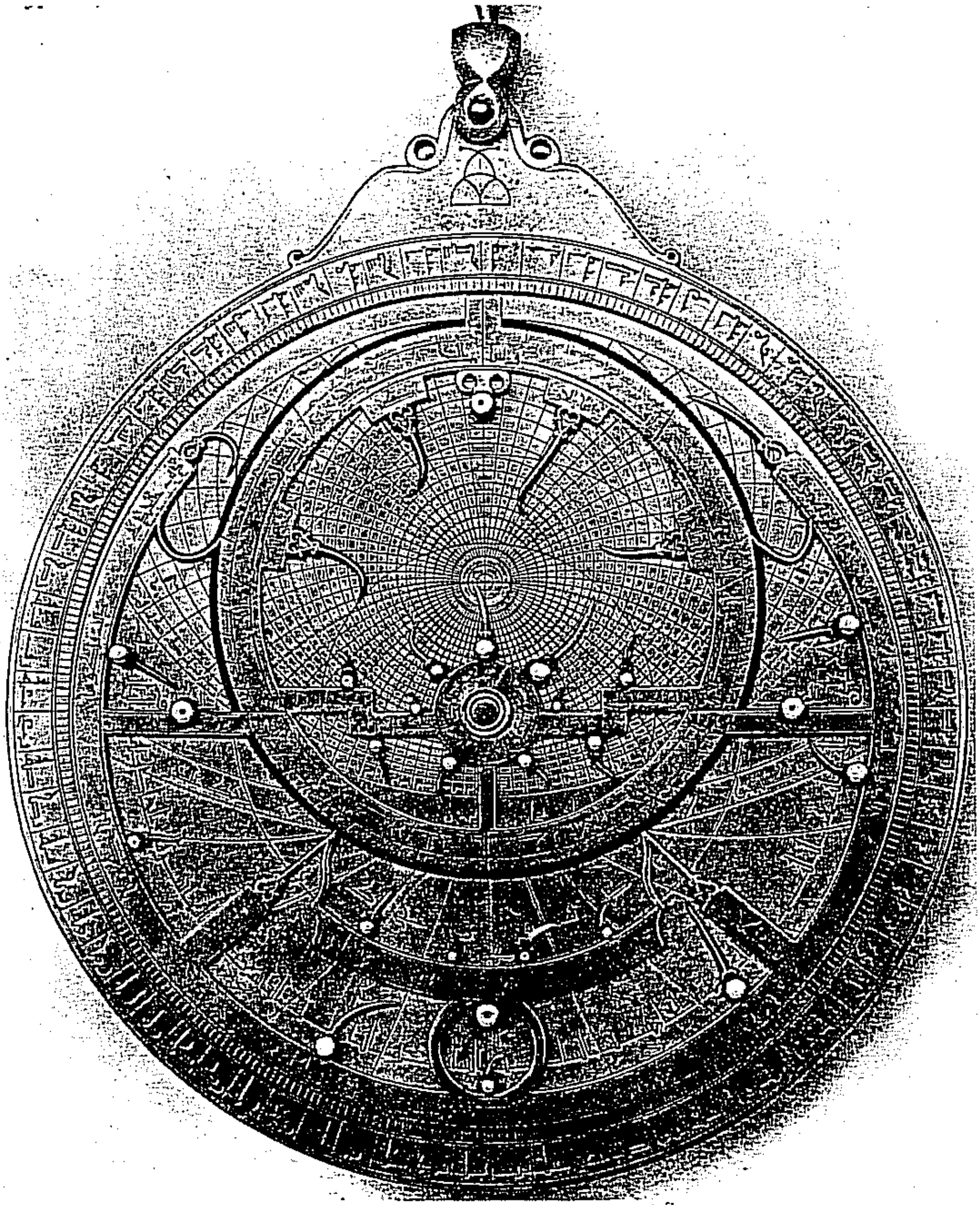
This instrument gives the names of 32 stars, 27 marked with asterisks are listed on p. 272. And in addition there are:

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

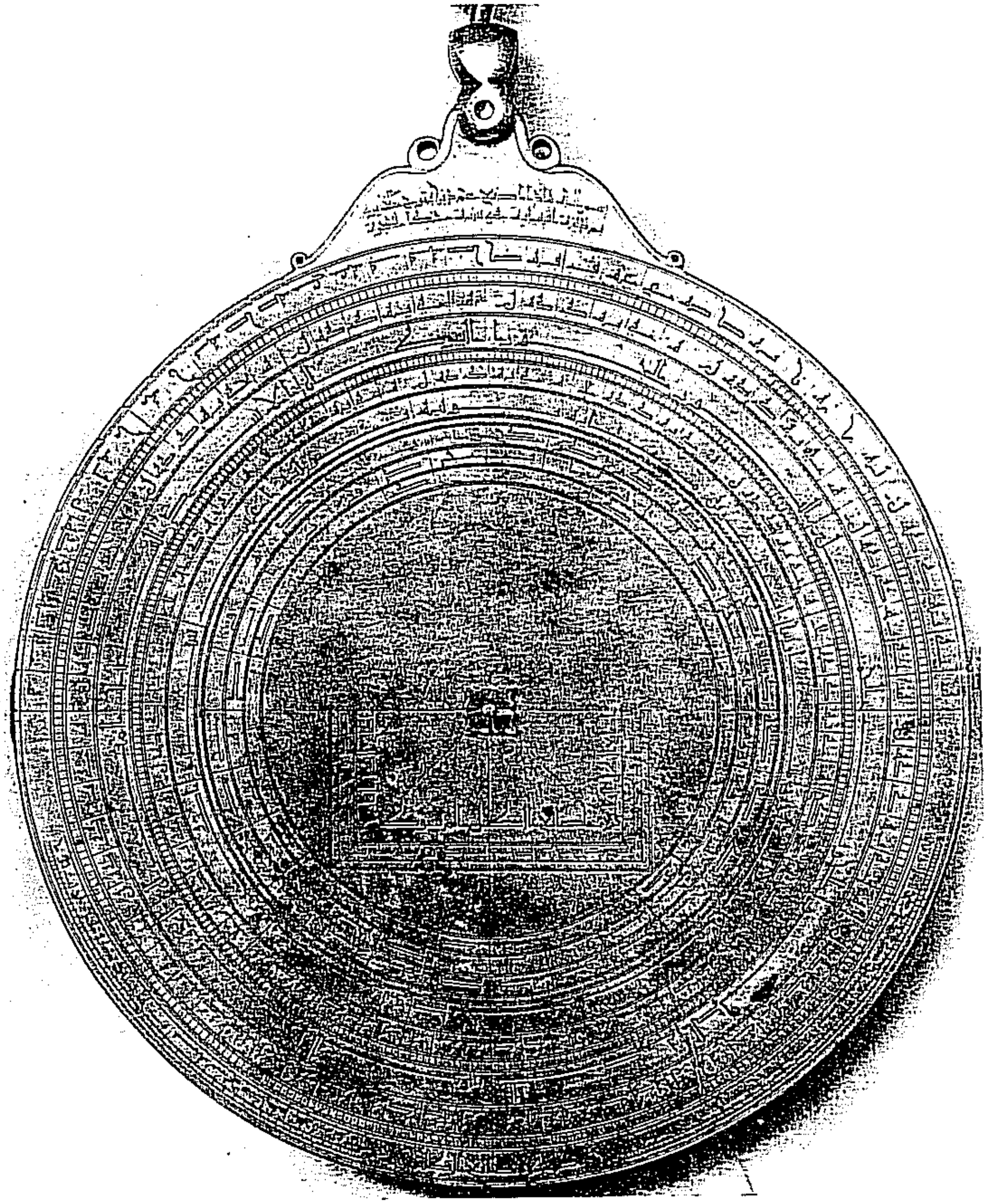
On the Back:

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.



MOHAMMAD IBN FOUTOUH OF SEVILLE, A.D. 1224



MOHAMMAD IBN FOUTOUH OF SEVILLE, A.D. 1224

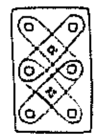
129. MOHAMMAD IBN FOUTOUH'S SEVILLE ASTROLABE A.D. 1221.

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.

7⅜ inches diameter × ⅜ 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.

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 6¼ 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 (1⅛ 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 6⅛ 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:

1*a*. 'For every place the latitude of which is 21° 40′.'
b. " " " 25° 30′.
2*a*. 'For every city the latitude of which is 30°.
b. " " " 31° 30′.
3*a*. " " " 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.*)

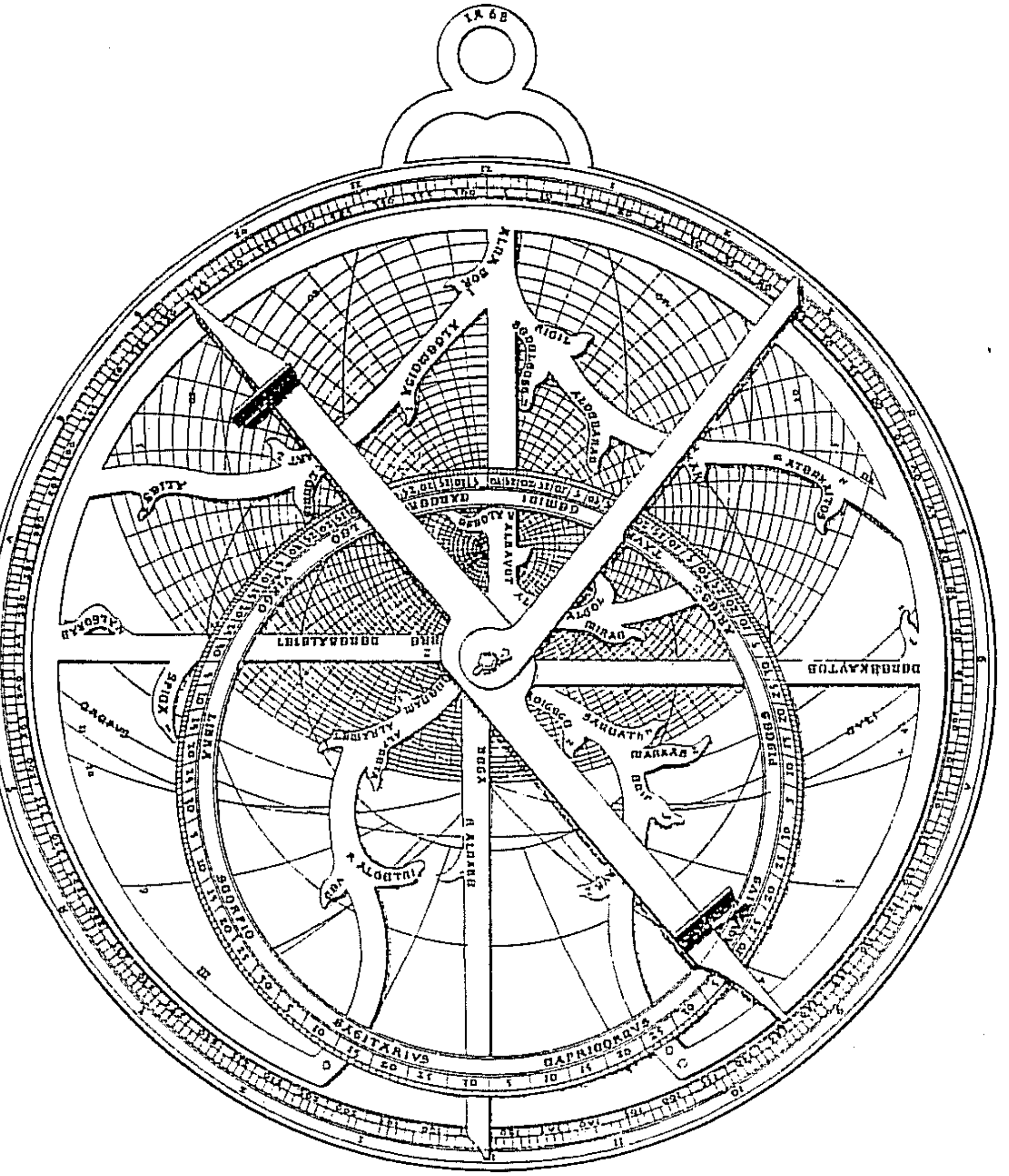


FIG. 129. ASTROLABE OF REGIOMONTANUS. 'A.D. 1468.'

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.

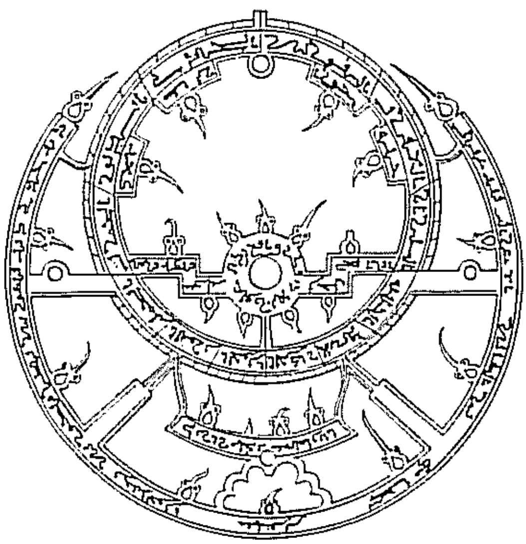
The inscriptions were in Cufic characters.
The ankabut was figured as showing 26 stars:

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.



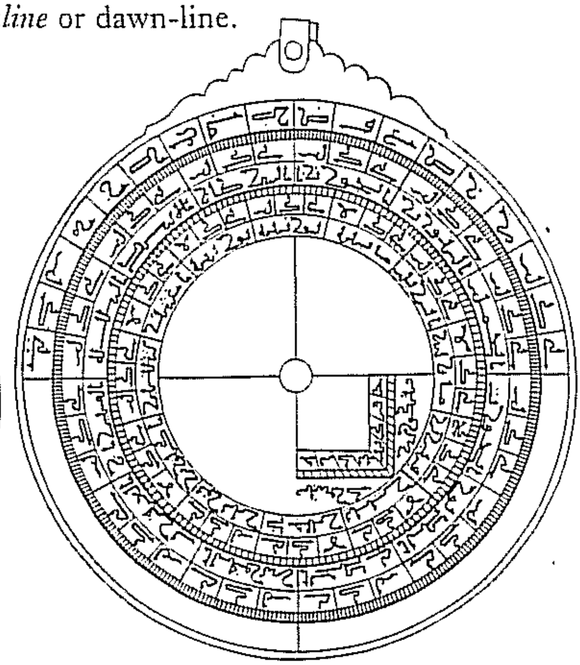


FIG. 131. MARCEL'S ASTROLABE. FIG. 132.
From Napoleon's *Description de l'Égypte*.

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.

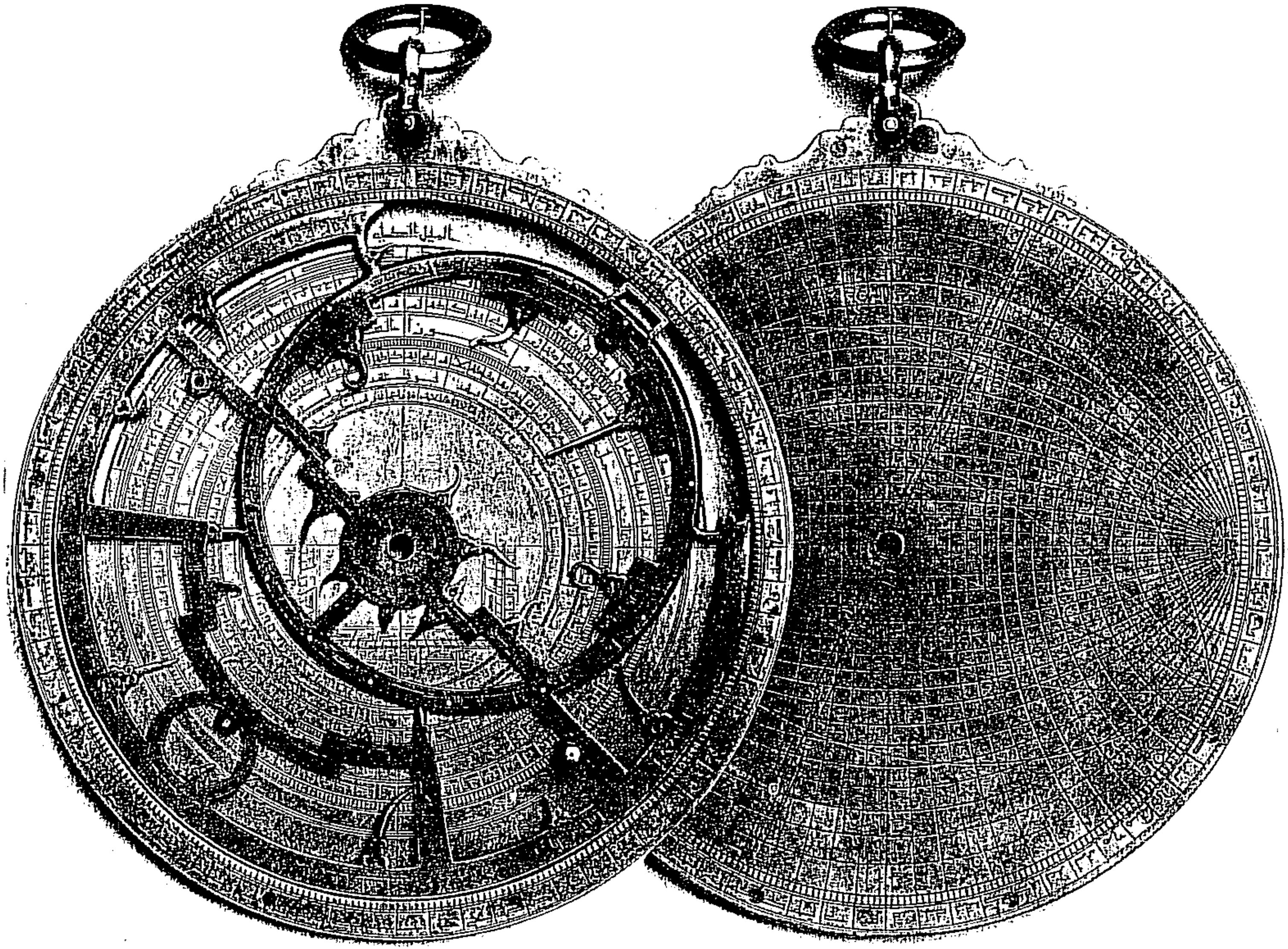
The ankabut is for 15+15=30 stars. The pointers have trifoliate perforate bases.

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 *mudirs*, 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.



MR. BARNETT'S ASTROLABE

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.

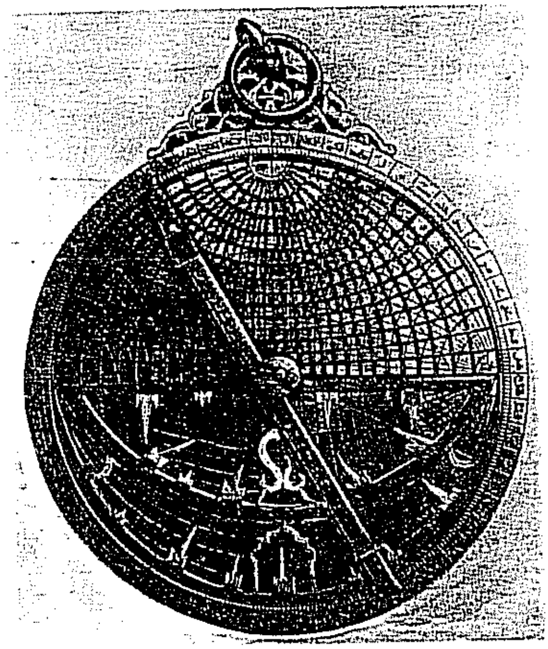


FIG. 133. ? A.D. 1329.

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

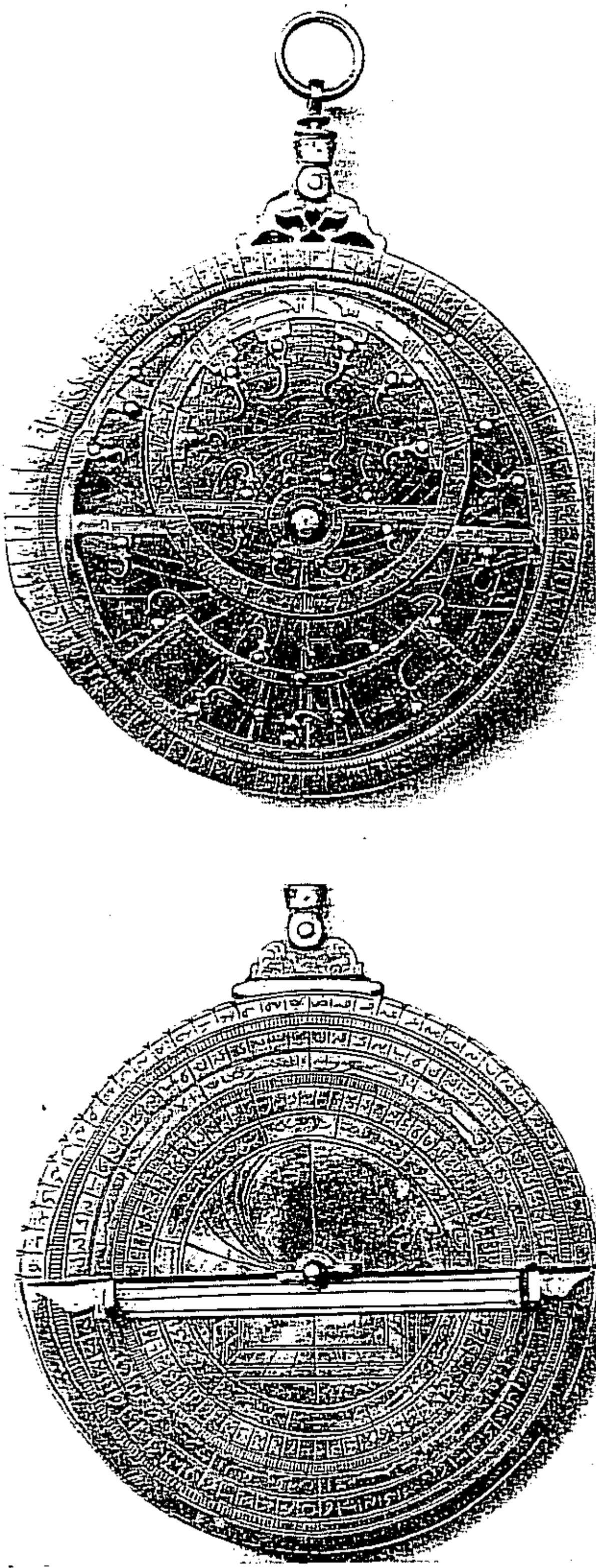
1*a*.	Lat. 21°.	3*a*.	Lat. 33°.
b.	„ 24°.	*b*.	„ 36°.
2*a*.	„ 30°.	4*a*.	„ 42°.
b.	„ 33°.	*b*.	„ 45°.

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.

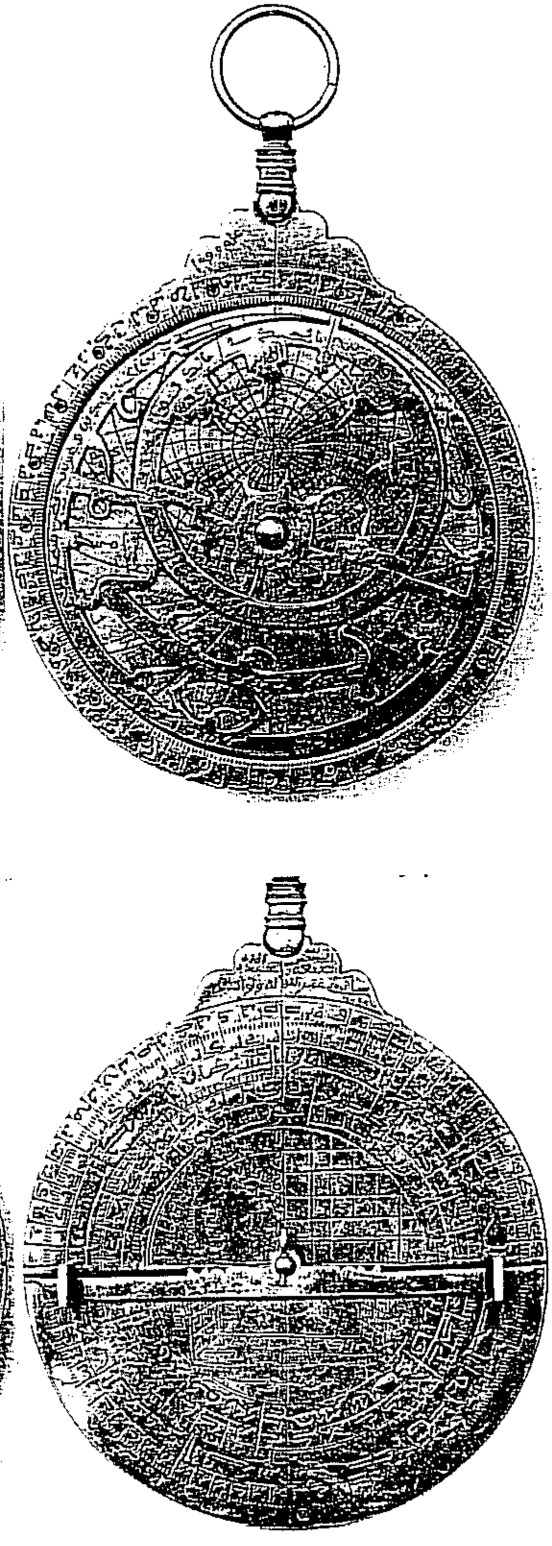
The Back shows:

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.

4⅞ inches in diameter; about $\frac{3}{16}$ inch thick; total length including ring 7¼ 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 ᴑ୨ᘔᑫ ьш = '*In the year 1099*', A.D. 1687. But this is probably not the date of its manufacture, which Dr. Evans put at c. 1400.

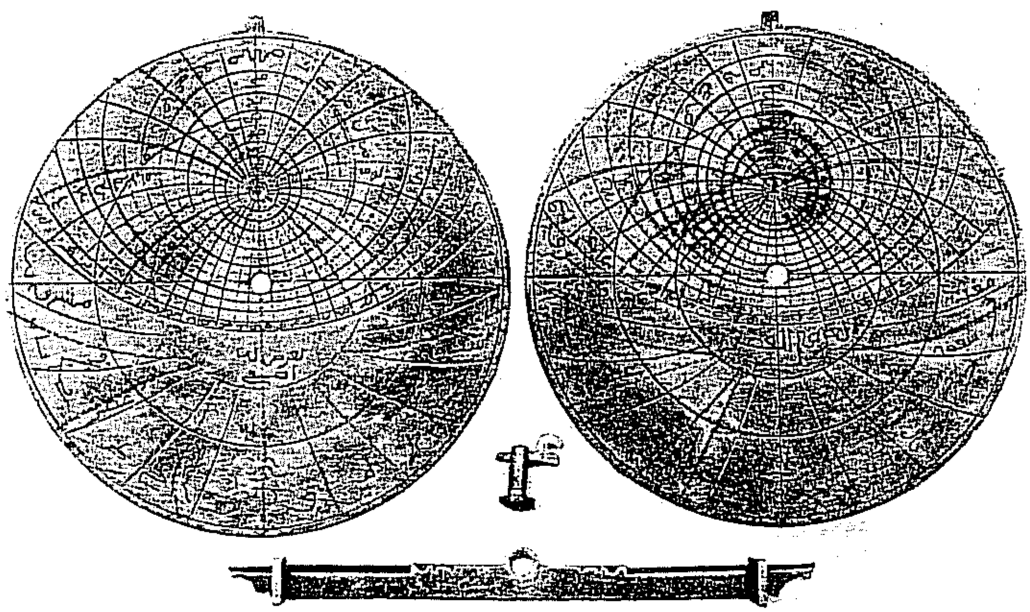


Fig. 134. Tablets for Abdullah son of Sasi's Astrolabe.
For Lats. 32° and 35°.

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 7¾ 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 = 9½ 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.

$6\frac{3}{4}$ 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.

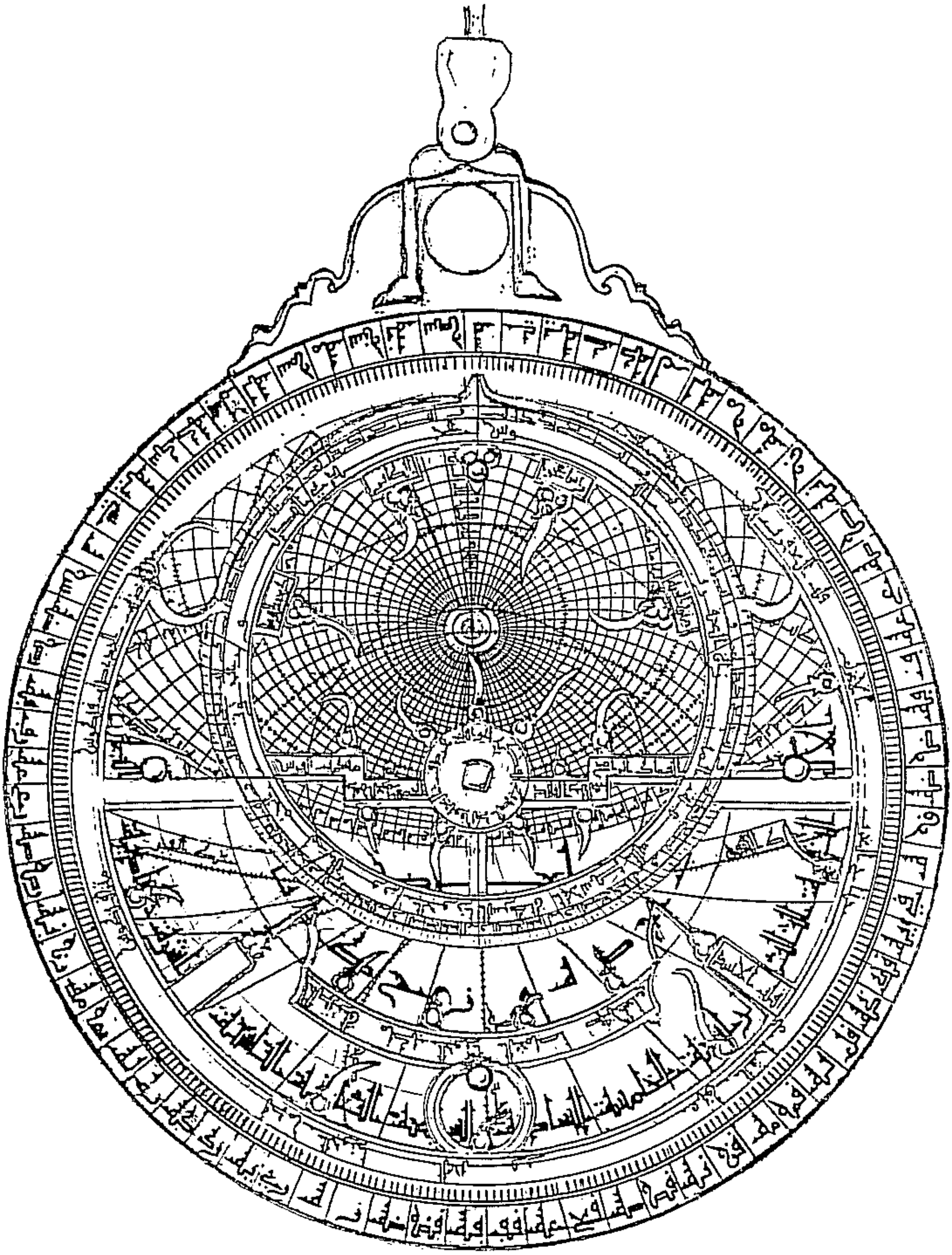


FIG. 135. ASTROLABE OF ABUL HASSAN ALI AND ABD-ALLA MOHAMMAD. A.D. 1543.

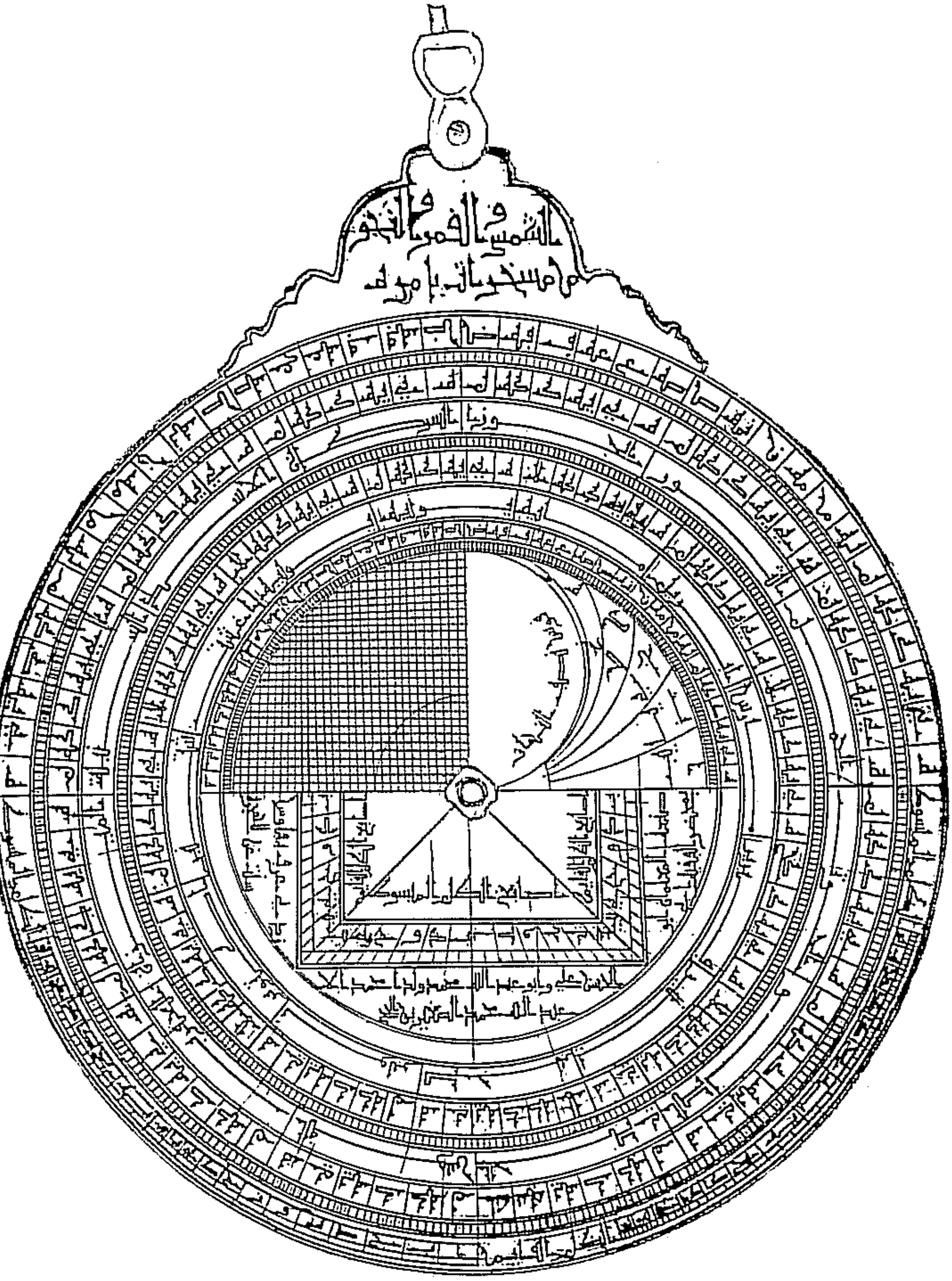


FIG. 136. ASTROLABE OF ABUL HASSAN ALI AND ABD-ALLA MOHAMMAD. A.D. 1543.
After Schio.

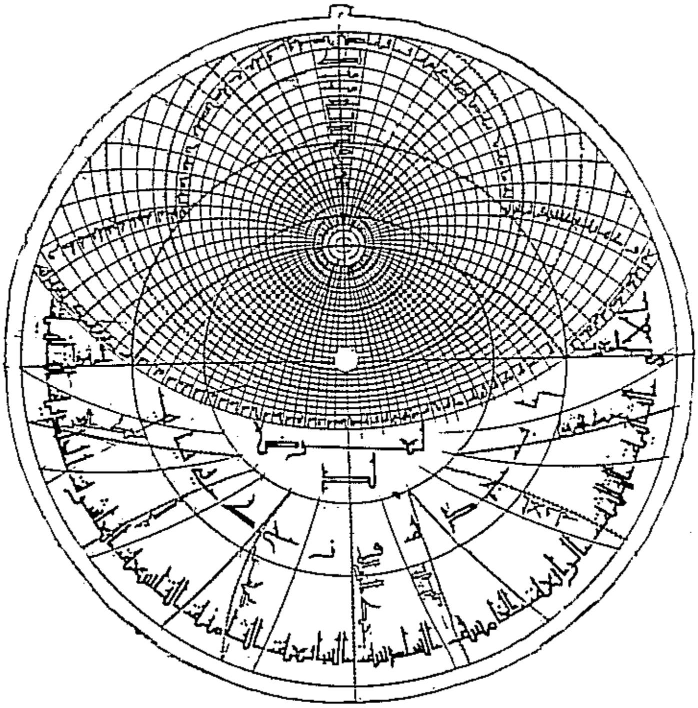


FIG. 137. PLATE FOR LATITUDE 34°.
After Schio.

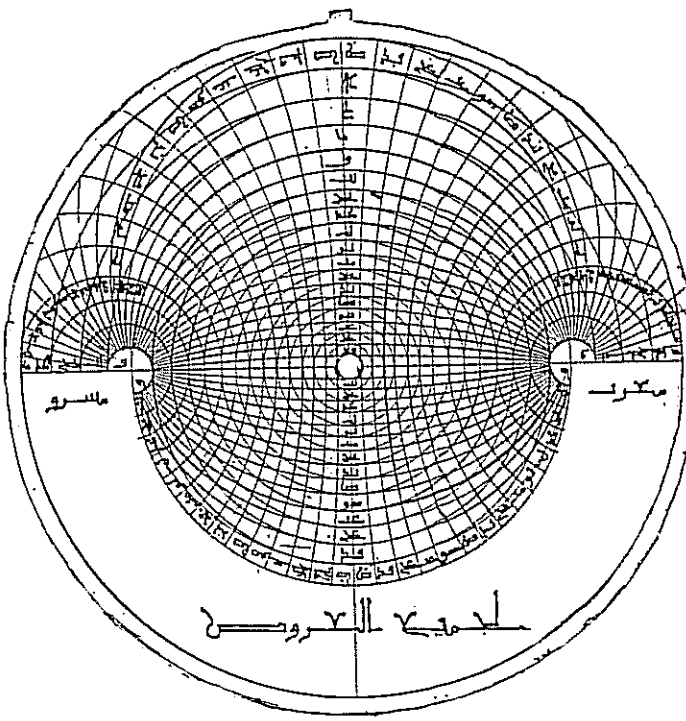


FIG. 138. TABLET OF HORIZONS FOR ALL LATITUDES.
After Schio.

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.

7¼ 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-'ayyûq	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

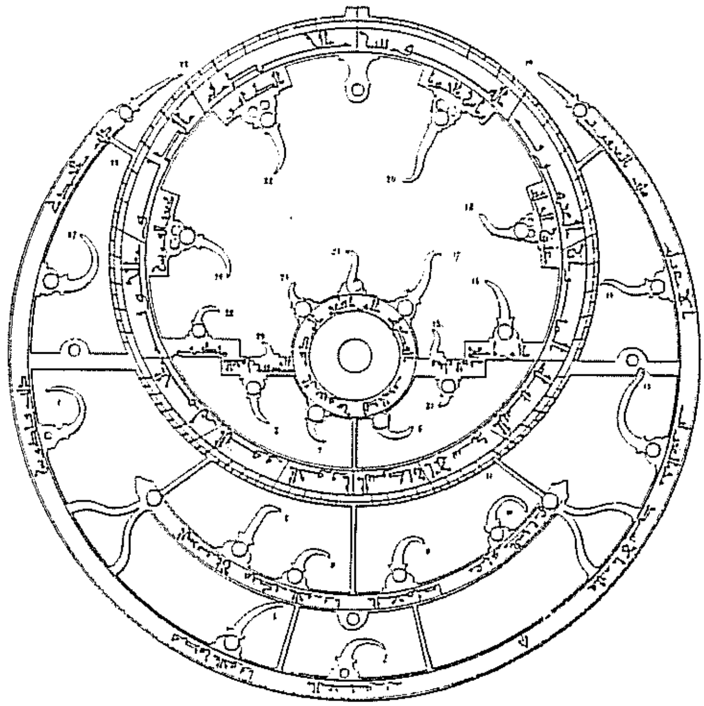


FIG. 139. ASTROLABIO NEGROTTO. *c.* A.D. 1650.
After Remondini.

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 '.

K k

'*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 7½ 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.

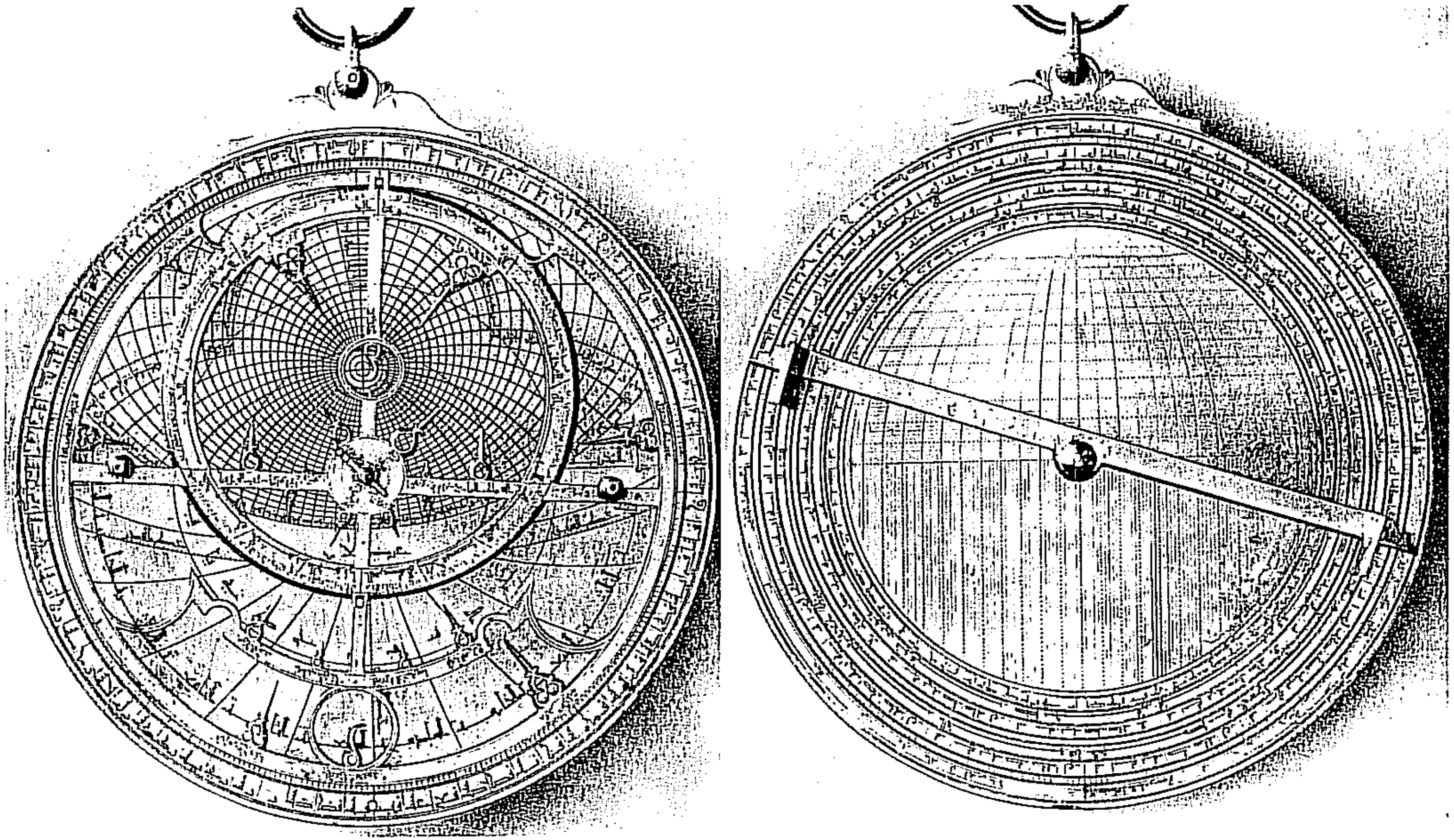
On the Back, inside the usual circular calendar-scales and a circle of the 28 mansils, is a square of the shadows which also carries the maker's inscription.

155. Modern North African Astrolabe. Pl. LXVIII *c.* A.D. 1780.

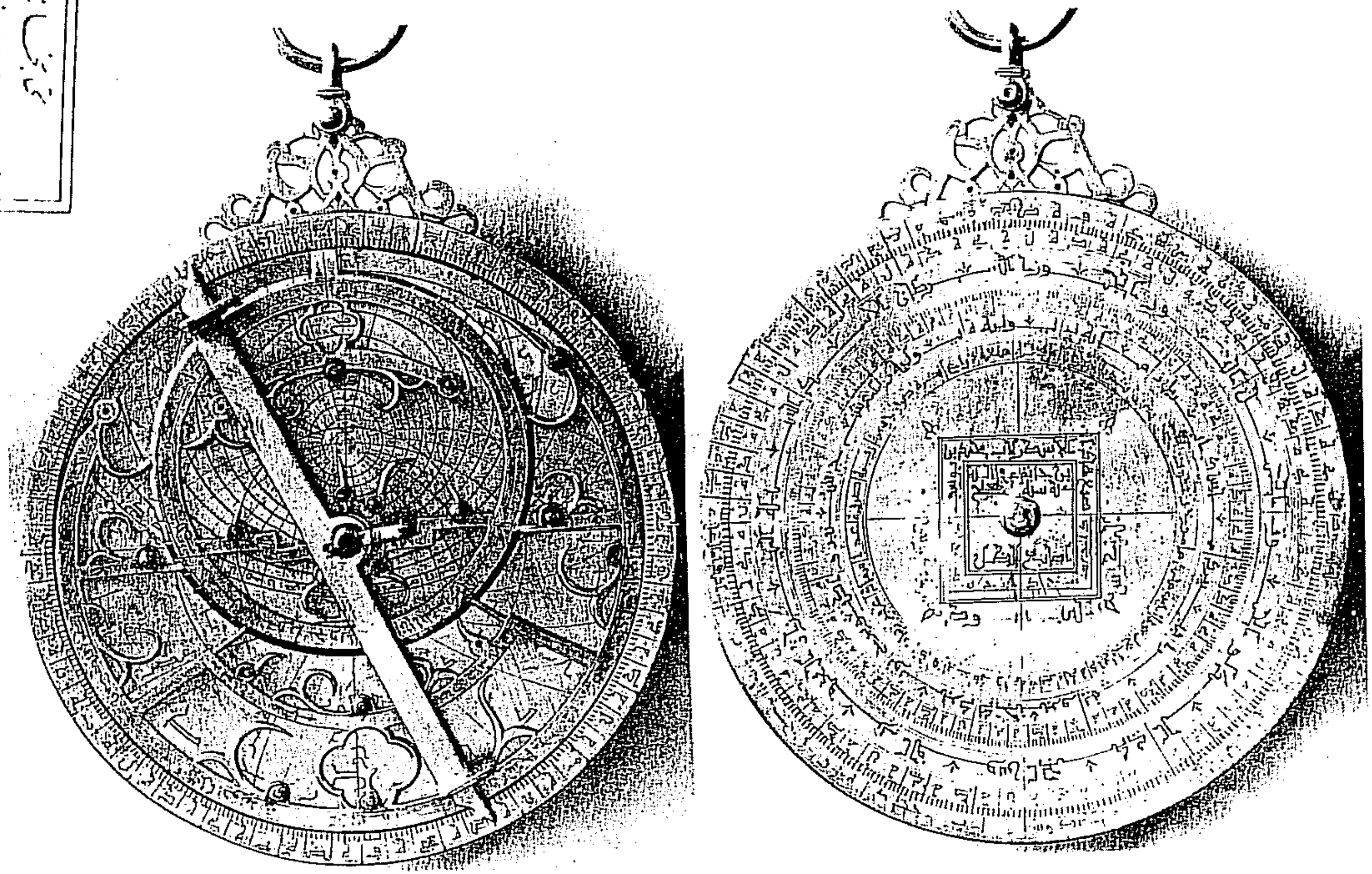
$4\frac{13}{16}$ inches diameter; ¼ inch thick, with a thin back plate soldered to a thicker rim; total length including ring 8½ inches.

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 KHAMĀ'IRI, A.D. 1743



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.

1a. 21° 40′. Mecca and ———.
b. 26°. Country of the Sudan.
2a. 29° 20′. Medina e mushaffar (= the honoured).
b. 39°. ———
3a. 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 = 6½ 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 *K'li N'hosheth* 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.
כסא or כורסיא kursi = the Throne.
אם = the Mother.
חיק hujrah = the Border.
{ בריח regula = Rule.
{ מעצד al-'idadah = Alhidade.
רישת al-'anḳabut = 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.

158. SPANISH JEWISH ASTROLABE ? *XIV Cent.*

British Museum from the Spitzer Collection.

Diameter 3⅝ inches.

Inscription in Hebrew characters.

Tablets 5 in number, without lettering except the latitudes in Hebrew characters, for 33° to 43°.

The *umm* and back are both engraved as calendars (?) and the latter has the unequal hours in duplicate in the upper hemisphere of the centre.

159. JEWISH ASTROLABE *c.* A.D. 1520

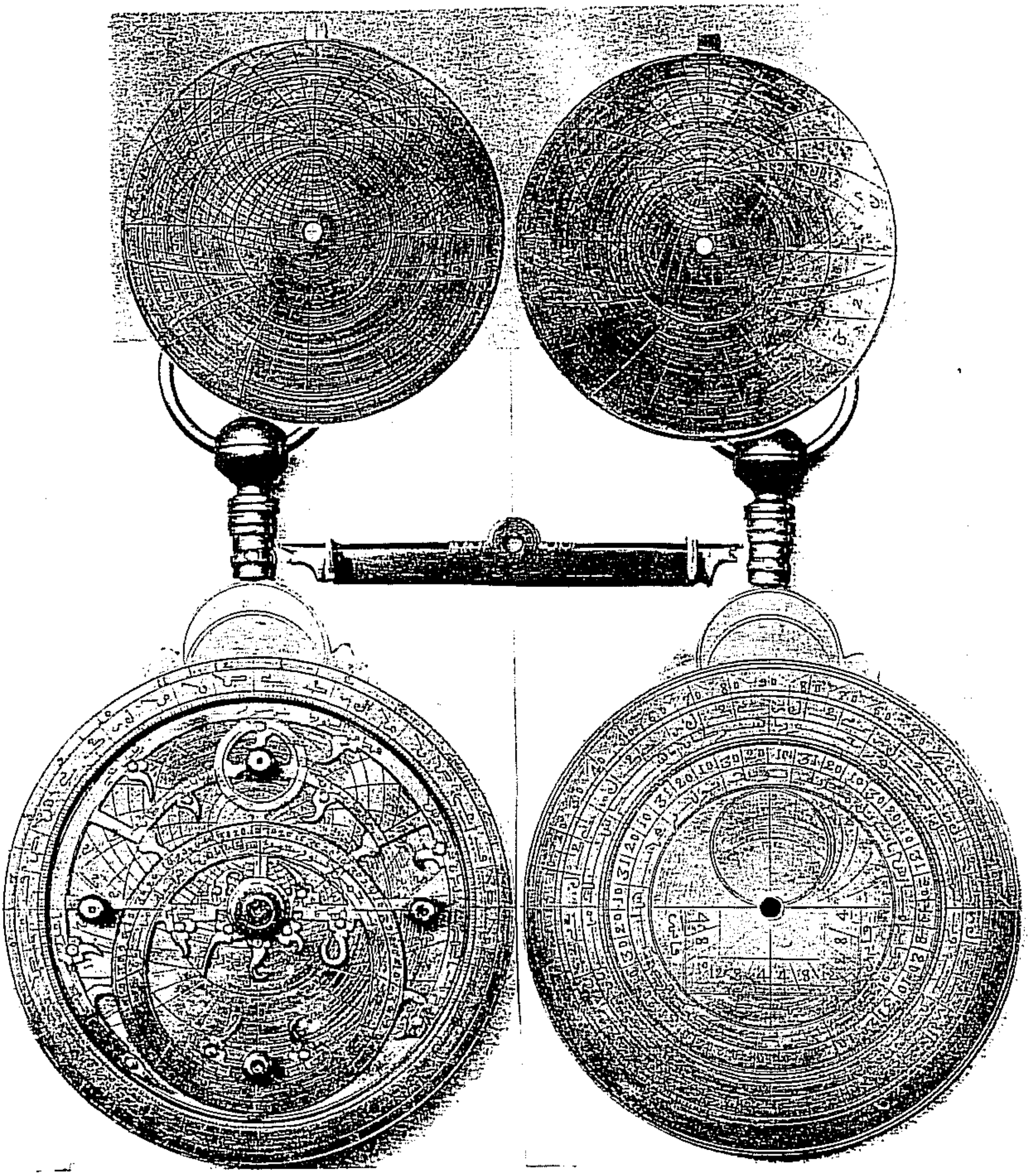
Mensing Collection, No. 20.

4¼ inches in diameter.

Engelmann in the catalogue of the Mensing Collection has drawn attention to the inscription on this brass instrument as being in Hebrew. The design of the bracket suggests the transition period between Gothic and Renaissance with flower and animal decoration. The tracery of the rete owes its character to a large quatrefoil within, and to two half-quatrefoils without the zodiac circle. An important feature in the design is the relatively large size of the star-pointers, several of which are two-pronged or what we have termed the 'boat-hook' type. The east-west bar is 4 times counterchanged. The face is traversed by a label. On the Back are calendar scales. Four tablets.

The dating is presumably the opinion of Dr. Engelmann.

Another astrolabe that evidently belonged to a Jew is described on page 469.



NORTH AFRICAN ASTROLABE, *c.* A.D. 1780

SOME INDIAN ASTROLABE-MAKERS

Some time back I received a letter from Dr. H. Van Kluber, Asrophysikliches Observatorium, Einstein Institute, Potsdam, in which he asked me to throw some light on Zîa'u'd-dîn Muhammad, the maker of an astronomical instrument dated 107 A.H. which is in the Berlin Museum. I have been able to glean some details about Zîa'u'd-dîn Muhammad which I give below, but I shall be grateful to the readers of " Islamic Culture " if they will give me further information on the subject.

The full name of Zîa'u'd-dîn Muhammad is Zîa'u'd-din Muhammad Astrolâbî Humâyûnî Lahôrî. A little digression will explain the significance of the long name.

The most famous instruments of astronomy used in Arabic educational institutions are the globe and the astrolabe. The globe is an instrument not of daily use, but is used only for educational purposes. The astrolabe is used in measuring the height of the sun and other stars, so it is in daily use by astrologers, astronomers, and connoisseurs of the art. It is therefore that a manufacturer of astronomical instruments was called in later times Astrolâbî (اصطرلابی). He could not be appropriately called کروی from کره (a globe), because کروی (spherical) is one of the terms of astronomy. اصطرلابی is not a scientific term of the art. The manufacturer of the astronomical instruments was so called in reference to this instrument.

" *Humâyûnî* is with reference to Humâyûn, who was the successor of Bâbur, the Timurid conqueror of India. The Timurid Sultans always took an interest in astronomy. The grandson of Timur, Mirza Ulugh Beg (who died in 853 A.H.) established a famous observatory at Samarqand, where the renowned astronomers of the period, such as Qâzizâda Rûmî, Ghiyâsu'd-dîn Jamshed and 'Alî bin Muhammad Qaushjî made researches, and the almanac prepared there was named after Ulugh Beg. Bâbur has mentioned the ruins of the observatory in his Tuzk.

Bâbur's son Humâyûn, whose name is mentioned in connection with astrolabe was a past master in astronomy and astrology. Mullâ Badaûnî writes of Humâyûn in his *Muntakhab-u't-Tawârîkh* dated 1004 A.H.—

"He was matchless in the science of astronomy, astrology and all other strange arts."[1]

Ferishta says:—

"He had much proficiency in mathematics, always associated with scholars and the learned, and constant discussion on learned topics took place in his presence."[2]

The king learnt the art of astronomy from Ilyâs Ardbelî, who was a mastermind in all branches of this science.[3]

During his stay in 'Irâq and Persia the king was accompanied by two famous scholars: one was this very Ilyâs Ardbelî, and the other was Abu'l-Qasim Girjânî. The king was wandering in the wilderness after he had lost the throne of India, still he took lessons from these two scholars of Qutub Shîrâzi's (died 710 A.H.) recondite book Durratu't-Taj (درة التاج) which is a compendium in Persian of scientific theory and practice.[4]

An interesting anecdote is mentioned in the *Akbar-Nâmah*. When Humâyûn reached Tabrîz during his journey in Persia, he ordered his slave Pîk Muhammad Akhtâ Begi to search for a globe (کره) in that old city. کره means colt in Persian. The intelligent slave obeyed the orders by bringing a number of colts to the royal presence. The king laughed when he saw the multitude of colts before him. Abu'l-Fazal begins this anecdote with the following words:[5]

چون به تبریز نزول فرمودند ازآنجا که توجه اقدس با اصطرلاب وکره
و سائر آلات رصدی درجه‌کمال داشت ....

(When he reached Tabrîz, there he, who had extraordinary

(1) Vol. I, p. 467, Calcutta.

(2) Vol. I, p. 243, Nawalkishore.

(3) Badaûnî has given his description in his *Muntakhab-u't-Tawârîkh*, vol. III, p. 131, Calcutta Edition.

(4) *Ma'âthir-i-Rahîmî*, p. 612, vol. 1, Calcutta and *Akbar-Nâmah*, vol. I, p. 642, Nawalkishore.

(5) *Akbar-Nâmah*, p. 241, Nawalkishore Press.

excellence in the astrolabe, globe and other instruments of observatory........).

The king himself gave lessons in astronomy and mathematics like learned teachers. The king's chief associate Nûru'd-dîn Turkhân Sufîdinî (died in 994 A.H.) who was well up in the art, was tutored by the king. Badaûnî says—

" Mullâ Nûru'd-dîn Turkhân Nûrî Sufidinî, the jagirdar of Sufidun in Sindh was a celebrated scholar of arithmetic, mathematics, astronomy and astrology and was one of the confidants and attendants of the lamented king."[1]

Nûru'd-dîn Khân Turkhân is described in *Ma'âthiru'l-Umara* thus:

" The maulâna was noted for his accomplishments, chivalry, and charity. He was fond of astronomy, arithmetic, and the astrolabe. He had a regular association with the Resident of Paradise (Humâyûn). He was one of the many associates and courtiers of Humâyûn. The king was sometimes benefited by his learning but more often than not he derived advantages in mathematics and particularly in the astrolabe from the king who was well versed in these arts."[2]

That the king had an extraordinary liking for astronomy and celestial sciences may be corroborated by the statement of the Turkish naval commander who describes Humâyûn's fondness for these arts in his *Mirâ'atu'l-Mamâlik*. This naval commander was sent by Sultân Suleymân Khân to drive out the Portuguese from the ports of Gujarat, but his naval expedition ended in destruction and he had to return to his country by land through India, Persia and 'Irâq. Humâyûn wanted this Turkish naval officer, who knew astronomy profoundly, not to go away from him. But the latter persisted in going back to his country, and the king at last permitted him on the condition that he should go after three months of the rainy season when roads were very difficult to pass. In the meantime he must make calculations of solar and lunar eclipses, and help the astronomers of the place in learning the intricate details of the movements of the sun and the axis. He engaged himself in the work and completed the astronomical observations.[3]

(1) Vol. III, p. 197.

(2) *Ma'athiru'l-Umara*, vol. I, p. 478, Calcutta.

(3) Prof. Wembri *Mirâ'atu'l-Mamâlik*, Urdu version, chapter VIII.

Humâyûn's sister Gulbadan Begum, the authoress of the *Humâyûn-Nâmah* tells on one occasion how Humâyûn himself once fixed the auspicious date for a marriage by making astral calculations. She writes:

"In short, after forty days in the month of Jamâdi-ul-Awwal, 948 A.H. at Yatur on Monday noon, His Majesty the King took the astrolabe in his hand and fixed the fateful hour."[1]

Humâyûn had such an ardent love of mathematics and mathematical instruments that his friend Commander Beiram Khân Khânkhâna composed a Qasîdah in his honour, in which the astrolabe is fully described.

آن چرخ چیست کا مده برخورش مدار — آن بدر کز میان شهابش کند گذار
با آنکه می کند به مه وخور برابری — آمد بجان زحلقه بگوشان شهریار
نارد بچشم کوکبه آفتاب را — چون مهچه لوای شهنشاه نامدار
پیوسته آسمان و زمین زیرحکم اوست — همچون نگین خاتم شاه جم اقتدار
برکف نهاده خوان زری پرزاشرفی — تابر قدوم اشرف شاهان کند نثار
شاه بلند قدر همایون که از شرف — بردرگهش سپهر نهد روی افتقار

(بدا یونی ، جلد سوم صفحه ۱۹۲ کلکته)

In this Qasîdah چرخ (Sky) محور (Axis) مدار (Circumference) بدر (Full Moon) شهاب (Meteor) خور (Sun). حلقه (Halo), آفتاب (Sun) آسمان (Sky), زمین (Earth), شرف (Height), سپهر (Sky), are various astronomical terms.

It is generally known that Humâyûn died of a fall from the stairs of his library. But the truth is that in old Delhi Shêr Shâh had built a very high three-storeyed building which was known as Shêr Mandal. On the third storey was a bastion which was higher than all the buildings.[2] The king had converted it into a library, because its height served the purpose of an observatory. In the evening of the day when he fell, he believed that the planet Venus would appear. The king was busy there in discussion with some mathematicians and was awaiting the appearance of the planet when the evening prayer call was heard. He was going hurriedly when

(1) p. 53, London.

(2) Sir Syed's *Atharu's-Sanâdîd*, p. 51, Cawnpore.

he slipped off. He, fell down and was hurt. The injury was fatal.

The author of the *Akbar-Nâmah* writes:

"On the last day he went upstairs to his library...... He called for a group of mathematicians. That night the planet Venus was to make its appearance and he wanted to see it."[1]

All the work of the king was performed on astronomical principles. The different functions of the court on various days were divided on an astrological basis. Ghiyâthu'd-dîn, in his *Humâyûn Nâmah* and Abu'l-Fazal in his *Akbar-Nâmah* have given full details[2] of these days which were apportioned astronomically. The organization of the court, the camp and the orchard was also made on these scientific principles. He had erected pavilions for the court in which the nine skies of the Greek astrology and the different stars of each sky were emblematically represented.

Humâyûn took immense interest in such innovations. He had made a بساط نشاط , where all the celestial circles and spherical elements (كرات عناصر) were to be seen. The first which was ascribed to the unspotted sky was white. The second was blue (كبود). The third, which was proper to Saturn was black. The fourth was sandal-like with reference to Jupiter. The fifth was red as Mars. The sixth was golden like the Sun. The seventh was green in relation to Venus. The eighth was bluish as Mercury. The ninth was white like the moon. After this there were figures of the four elements. Of these there were maps of the seven realms in the terrestrial globe. The colour of the public Court-hall changed each day according to the colour of the daily star as fixed by astrologers. He had likewise made a pavilion with the twelve signs of the Zodiac. He had made up his mind to build observatories at many places and had prepared various instruments for the purpose.[3] Among these various instruments there was the astrolabe.

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(1) *Akbar-Nâmah*, Nawalkishore, p. 399 and *Ma'âthir-i-Rahîmî*, vol. I, p. 609, Calcutta.

(2) *Akbar-Nâmah*, Nawalkishore, p. 399.

(3) Elliot's *History of India*, vol. V, p. 116.

In March and May 1909—i.e., some twenty-five years ago—I wrote an article in *Al-Nadwa,*[1] Lucknow, on "Muslims and Astronomy." I had for the first time made mention of Zîa'u'd-din Humâyûnî Astrolâbî. I wrote in that connection:—

"It was Humâyûn who made the astrolabe in vogue in India. Humâyûn was a mastermind in astronomy. He had invented a special kind of astrolabe, which was called Humâyûn's astrolabe (اصطرلاب همایونی). In the library of the Nadwa there is an old astrolabe which bears the following inscriptions.

عمل ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الهداد اصطرلابی همایونی لاهوری سنه ۱۰۵۹ ه

(The work of Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allah Dâd, Humâyûnî Astrolâbî, Lahôrî, 1059 A.H.)

I am sorry to say that this statement of my article finds no corroboration in any book, although from that time onward I have been making earnest researches for it. The learned Maulâna Ghulâm Huseyn of Jaunpur (1250 A.H.) writes in his *Jam'-e-Bahâdur Khânî*: "the *mechanics of the later period*[2] made these changes." It would be no wonder if the *later period* might refer to this very Humâyûn's astrolabe.

The mechanics who manufactured astronomical instruments, maps and globes for Humâyûn are not mentioned in any history. Only Maulânâ Maqsûd Herwaî is mentioned in *'Aîn-i-Akbarî*:—

"He was one of the lovers of the Resident of Paradise (جنت آشیانی)........ He manufactured astrolabes, globes and other instruments which took the people who saw them by surprise."

I have not been able to find any description of Zîa'u'd-dîn and his family in any history or biography. It is however clear from the name and genealogy inscribed in the globes and astrolabes manufactured by Zîa'u'd-dîn and his father Qâ'im Muḥammad that Zîa'u'd-dîn's great-grandfather Allah Dâd was a mechanic of Humâyûn's reign who manufactured globes and astrolabes after Humâyûn's fashion (همایونی طریق).

(1) *Al Nadwa*, March 1909. p. 24.
(2) *Jam'-i-Bahâdur Khânî*, p. 501, Calcutta.

Accordingly in the library of Nawab Sir Salar Jung Bahadur (Hyderabad), there is an astrolabe, which bears the following inscriptions

صنعت استاذالهداد اصطرلابی لاهوری فی سنه ۹۷۵ ه

(Work of Master Allah-Dâd, the Astrolabe-maker of Lahôre, dated 975 A.H.).

I have discovered the following manufactures of Zîa'u'd-dîn and of his father Qâ'im Muḥammad.

There is one astrolabe made by Qâ'im Muḥammad in Calcutta which belongs to Qâzi Obeidu'l-Bârî.* It bears the following inscription.

عمل قائم محمد بن عیسی بن الهداد اصطرلابی همایونی ۱۰۳۴ھ

(The work of Qâ'im Muḥammad, son of 'Isâ, son of Allah-Dâd, Astrolābî, Humâyûnî, 1034 A.H.). On the other corner of this astrolabe is written the "21st year of Jahângîr's accession."

An astronomical globe of his is found in the Oriental Library, Bankipore, which reads thus

صنعة اقل العباد قائم محمد ابن عیسی ابن الهداد اصطرلابی لاهوری همایونی
سنه ۱۰۴۷ھ

(The work of the humblest creature, Qâ'im Muḥammad, son of 'Isâ, son of Allah-Dâd, Astrolâbî, Lahôrî, Humâyûnî 1047 A.H.).

On the other side of the globe is the following inscription.

تمت این کره مکمل مشتمل بیك هزار وبست ودو کواکب که جمیع از ان
چهل وهشت صورت مرصوده نموده اند ـ اهل (؟) علماء وحکماء تنجیم چنانچه
مرصوده در رصد مرزا الغ بیگ است و بر تقویم هر کوکب ثابته سه درجه زیاده
کرده ایم بحساب حکماء وعلماء این فن تا این تاریخ سنه ۱۰۴۷ ه

This globe is made of pure brass metal. There is a silver nail near each star and all Zodiac signs are made therein.

Vol. I, p. 31, Nawalkishore.

*He comes of an old family of Calcutta. I am indebted to Prof. Maḥfuzu'l Haqq of the Presidency College, Calcutta, for my information concerning this astrolabe.

I have come to know of the following globes and astrolabes of Qâ'im Muhammad's son, Zîa'u'd-dîn, which I mention here in chronological order.

1. His oldest manufactured astronomical globe is to be found with Maulvi Yusuf Sahib of Phulvari District, Patna. It is of pure brass. There is a silver nail near each star. It weighs $1\frac{1}{4}$ lb. This family is in possession of this globe since 1238 A.H. The globe bears the following inscription:

عمل ضیاء الدین محمد بن قائم محمد بن ملا عیسی ابن ملا الہداد اصطرلابی
همایونی لاهوری فی سنه ۱۰۵۸ھ

(The work of Zîa'u'd-dîn Muhammad, son of Qâ'im Muhammad, son of Mullâ 'Isâ, son of Sheykh Allah-Dâd, Astrolâbî, Humâyûnî, Lahôrî, 1058 A.H.)

2. After this comes his astrolabe which is preserved in the library of the Nadwatu'l-'Ulamâ, Lucknow. It bears the name and date:—

عمل ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الہداد اصطرلابی
همایونی لاهوری سنه ۱۰۵۹ھ

(The work of Zîa'u'd-dîn Muhammad, son of Qâ'im Muhammad, son of Mullâ 'Isâ, son of Sheykh Allah-Dâd, Astrolâbî, Humâyûnî, Lahôrî, 1059 A.H.)

3. Another astrolabe of his is in the Library of Nawab Sadar Yar Jung, Maulâna Habîbu'r-Rahmân Khân Sherwânî (Habib Ganj, District Aligarh). The date and inscriptions are thus:—

عمل اقل العباد ضیاء الدین محمد ابن قائم محمد ابن ملا عیسی ابن شیخ الہداد
اصطرلابی همایونی لاهوری فی سنه ۱۰۶۴ھ

(The work of the humblest creature Zîa'u'd-dîn Muhammad, son of Qâ'im Muhammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, in 1064 A.H.)

4. A globe made by him in the same year was in the possession of a physician of Rampur, but is now in the Tibbîyah College, Aligarh. It bears the following inscription:

عمل اقل العباد ضیاء الدین محمد بن قائم محمد بن ملا عیسی ابن شیخ الہداد اصطرلابی
همایونی لاهوری فی سنه ۱۰۶۴ھ

(The work of the humblest creature Zîa'u'd-dîn Muhammad, son of Qâ'im Muhammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, dated 1064 A.H.)

5. The fifth existing work of his is the globe which is mentioned by Dr. Kluber, a photo of which he has sent me. This is in the Berlin Museum. It reads thus:—

عمل اقل العباد ضیاء الدین محمد ابن قائم محمد ابن ملا عیسی ابن شیخ الهداد اصطرلابی
همایونی لاهوری فی سنه ۱۰۷۱ ه

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, dated 1071 A.H.)

In addition we know of four other astrolabes made by him, which are all dated 1074 A.H. and are to be found in Europe and India.

6. One of them is with Maulâna Abu Bakar of Jaunpur (Chairman of Theology, Muslim University, Aligarh). It is comparatively smaller and bears the following legend:—

عمل اقل العباد ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الهداد اصطرلابی
همایونی لاهوری فی سنه ۱۰۷۴ ه

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, dated 1074 A.H.)

7. Another is in the official library of Rampur. Its inscription has become a little disfigured but is legible:—

عمل اقل العباد ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الهداد ....
سنه ۱۰۷۴ ه

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd,........dated 1074 A.H.)

8. The third astrolabe of the same date was exhibited in the Persian Arts Exhibition held in London in 1931 A.D. Its descriptions may be found on page 193 of the printed catalogue of the Exhibition—It has the following inscription:—

عمل اقل العباد ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الهداد اصطرلابی
همایونی لاهوری فی سنه ۱۰۷۴ ه

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, dated 1074 A.H.)

The compiler of the catalogue has made a mistake in reading the name of Allâh-Dâd. The name of the Indian which is a combination of Allâh (الله) and Dâd (داد) and which means 'Gift of God' has erroneously been read (الحداد) (Al-haddâd) which means in Arabic 'blacksmith.' Al-ḥaddâd was thought right because of the mechanism of the brass, but this is altogether wrong.

9. The fourth astrolabe of the same date is in Bankipore Library. It is very big. It bears the following inscription:—

عمل اقل العباد ضیاء الدین محمد بن قائم محمد بن ملا عیسی بن شیخ الهداد اصطرلابی

همایونی لاهوری فی سنه ۱۰۷۴ھ

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî, Humâyûnî, Lahôrî, dated 1074 A.H.)

From the above information and the inscriptions we come to the following conclusions:—

That they belonged to Lahore (Punjab). Genealogically, Zîa'u'd-dîn's grandfather was Mullâ 'Isâ, whose father was Sheykh Allah-Dâd. From the word Mullâ (ملا), it is obvious that they were men of education. Badaûnî describes one Sheykh Allâh-Dâd Langer Khânî Lahôrî in the following words:—

"A ward of the city is named after him (Muhallah Langer Khân is still a part of the city of Lahôre). He was well-versed and efficient in various branches of learning...... He gave lessons and never went to the houses of the rich nor solicited help from kings, nor begged favour of anyone for his livelihood. His age is about eighty years."

Badaûnî wrote his book in 1004 A.H. So the birth of Sheykh Allâh-Dâd may be believed to have taken place in 924 A.H. Accordingly this man may have been a young man of twenty-five or thirty in Humâyûn's reign. This man, however, cannot be positively said to be Zîa'u'd-dîn's great-grandfather Sheykh Allâh-Dâd.

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Zîa'u'd-dîn and his ancestors may be chronologically placed with the Muslim kings of India thus:—

1. Sheykh Allâh-Dâd	1. Humâyûn		937– 963 A.H. / 1530–1555 A.D.
2. Mullâ 'Isâ	2. Akbar		963–1014 A.H. / 1555–1605 A.D.
3. Qâ'im Muhammad	3.	Jahângîr	1014–1036 A.H. / 1605–1626 A.D.
4. Zîa'u'd-dîn Muhammad	4.	Shâh Jahân	1036–1068 A.H. / 1626–1665 A.D.
		'Alamgîr	1068–1118 A.H. / 1675–1706 A.D.

Of these we have got the dates of only two, and the two are right according to this approximation. Qâ'im Muḥammad's first astrolabe is dated 1034 A.H. (the 21st year of Jâhangîr's accession). His second globe is dated 1047 A.H. This proves that he lived in the reigns both of Jahângîr and Shâh Jahân.

Zîa'u'd-dîn's first globe is dated 1058 A.H. and his last is dated 1074 A.H., which shows that the period of his activity as a craftsman lasted for at least seventeen years.

That they made instruments in such abundance proves that they were not amateurs in astronomical arts nor learned professors of any institution but were professional manufacturers. They manufactured at least four astrolabes in one and the same year, e.g., one astrolabe and one globe are dated 1064 and four astrolabes are dated 1074 A.H.

Dr. Kluber writes in the course of his letter that Zîa'u'd-dîn or his globe might probably have some connection with Raja Jai Singh Sawai's observatory, but this is not historically true. That observatory was constructed by the order of Muḥammad Shâh by Jai Singh, the Chief of Jaipur and Subedar of Agra and Malwa in 1137 A.H. (1724 A.D.), that is, sixty years after the Berlin globe, and seventy-nine years after the first-made globe which is now in Phulwari District, Patna.

SYED SULAIMAN NADVI.

ON THE MARGIN

INDIAN ASTROLABE MAKERS

(The following note has been written in response to Syed Sulaymán Nadvi's request for further information on Ḍiyá' ad-Din Muḥammad, Astrolábi, Humáyúni, Láhóri, as made in his article, Some Indian Astrolabe Makers, *which appeared in the October 1935 number of ISLAMIC CULTURE)*

I HAVE, through the kind agency of Professor Sprengling of the University of Chicago, recently come to know of two astrolabes made by the members of the Ilâhdâd family of Lahore. The instruments are now in the care of Dr Philip Fox, Director of the Adler Planetarium and Astronomical Museum, Chicago, U. S. A. They are of brass, 12 cm., and 11.7 cm., respectively in diameter, and show excellent workmanship. The first and earlier of the two bears the following inscription: سنعة اضعف العباد عيسى ولد[1] الهداد سنة ١٠١٣ ("The work of the weakest of creatures, 'Isâ, son of Ilâhdâd, year 1013").

The second astrolabe has the following: عمل ضياء الدين محمد ابن قائم محمد ابن ملا عيسى ابن ملا الهداد اسطرلابي همايونى لاهورى فى سنة ١٠٥٧ هجرى ("The work of Ḍiyâ' ad-Din Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Isâ, son of Mullâ Ilâhdâd, Astrolâbi, Humâyûni, Lâhôri, in the year 1057 A.H.").

Dr Fox has kindly drawn my attention to several other globes and astrolabes made by members of this family and described in Gunther's *Astrolabes of the World*, Oxford, 1932, Vol. I, pp. 187 ff., Nos. 68 ff. Unfortunately, these latter have not been uniformly edited, so that there is clearly much confusion of names, and a possible misreading of some of the inscriptions—difficulties not easily overcome by those who do not know Arabic or have no reproductions before them.

The first of the Adler Planetarium astrolabes together with No. 68 in Gunther's, establish 'Isâ also as an astrolabe maker, giving us a family of astrolabe makers for four unbroken generations: Ilâhdâd, 'Isâ, Qâ'im Muḥammad, and Ḍiyâ' ad-Din Muḥammad. We learn further from Gunther, No. 69, that 'Isâ had two sons though their names are not mentioned on that particular astrolabe. The inscription on Gunther, No. 72 (plate XLVII) reads: سنعة اضعف العباد محمد مقيم بن عيسى بن الهداد اسطرلابي همايونى لاهورى سنة ١٠٥٣ ("The work of the weakest of servants, Muḥammad Muqim, son of 'Isâ, son of Ilâhdâd, Astrolâbi, Humâyûni, Lâhôri, year 1053"). From this, we may infer that Muḥammad Muqim, who is mentioned again in Gunther, No. 78, is the other son of 'Isâ, unless we assume that Qâ'im and Muqim are applied indifferently to one and the same person, Muḥammad son of 'Isâ, who again appears apparently without either of these terms, if the reading is indeed complete, as the maker of the astrolabe listed as No. 71 by Gunther. If we accept this assumption, we have still to discover the name of 'Isâ's second son. The inscription in Gunther, No. 77 (p. 208), is made to give us a Qâsim Muḥammad, son of Mullâ 'Isâ, while a second one (p. 210) described by G. R. Kaye,[1] gives us a Mullâ Qâsim Muḥammad, son of Ḥâfiẓ 'Isâ; and from these we may here infer that Qâsim Muḥammad was 'Isâ's second son. However,

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1. For another instance of the use of *walad* instead of the usual *ibn*, *cf.* Al-Badâûnî, *Muntakhab at-Tawârîkh*, tr. Ranking. Calcutta, 1898. Vol. I. 546. Note 1.

1. *Memoirs of the Archæological Survey of India*, No. 6. Calcutta. 1920.

I cannot help but be suspicious of the reading of both of these inscriptions; I am inclined to think Qâsim a misreading of Qâ'im (easily enough made if the *hamzah* stroke of Qâ'im is somewhat extended: قائم). If Qâsim is to be accepted, then we have on our hands not one but two men named Ḍiyâ' ad-Dîn Muḥammad, one the son of Qâ'im, and the other the son of Qâsim; and while it is not impossible for two cousins to bear the same name, it is difficult to assert this without a more careful check on the inscriptions. Furthermore, the order of the names in No. 77 is peculiar and if it is to be accepted as correct, it would lead to further complications, for, the inscription is translated as, "The work of the humblest of the servants, Diya al-Din Mohammad, the son of Sheik al-Haddad, the Royal Astrolabe maker, the son of Kasim Mohammad, son of Mulla Isa of Lahore in the year 1069 A.H." Again my guess would be we have here none other than Ḍiyâ' ad-Dîn Muḥammad, son of Qâ'im (or Qâsim?) Muḥammad, son of Mulla 'Îsâ, son of Shaikh Ilâhdâd.

It is interesting to note the appellations and titles of each of the four generations of astrolabe makers, as they appear on their individual instruments. Ilâhdâd himself is characterized simply as a master-craftsman *(ustâdh)* and is in no way associated with the astrological activities of Humâyûn. His son 'Îsâ, not only does not claim the craftsmanship of his father, but is satisfied at first to be known simply as the son of Ilâhdâd, though later, according to Gunther, No. 68, he adds Astrolâbî, Humâyûnî, Lâhôrî to his name. The date of this Astrolâbî is given in round figures about A.D. 1600. I would place it not only later than his astrolabe now in the Adler Planetarium dated A.H. 1013/1604 A.D., but also later than No. 69 dated 1018/1609 whose inscription reads (Gunther, I, 189, Fig. 90): صنعته تمت بأيدى اضعفى العباد ابن عيسى ابن الهداد سنة ١٠١٨ فى مدينة دارالخلافة لهارر [sic] ("Its making was completed by the hands of the weakest of servants, the two sons of 'Îsâ, son of Ilâhdâd, in the year 1018, in the capital city of the Khalifate, Lâhôr.) I would thus place the date of No. 68 in the period between 1018-34/1609-1624/5, the last being the first date when Qâ'im Muḥammad adds the terms Astrolâbî, Humâyûnî to his name. (ISLAMIC CULTURE, Vol. IX, Oct., 1935, p. 627). It is left for Ilâhdâd's great grandson, Ḍiyâ' ad-Dîn Muḥammad, to supply his ancestors with the titles Mulla and Shaykh. His instruments refer to both Ilâhdâd and 'Îsâ as Mullas up to the year 1058 A.H., after which Ilâhdâd is further dignified by the title of Shaykh, while 'Îsâ continues to be referred to as Mulla, up to 1087, when he has the title Ḥâfiẓ (Gunther, p. 210).

I have before me Haig's translation of Badâoni's reference to Ilâhdâd of Lahore. It differs significantly from that given by Syed Sulaymân Nadvî (ISLAMIC CULTURE, Vol. IX, Oct., 1935, p. 630), and runs as follows: "Maulânâ Ilâhdâd-i-Langarkhânî. He comes from a quarter in Lâhôr. He is well versed in all such branches of knowledge as are included in the ordinary curriculum, and is a profound scholar. He employs his time in teaching. He has never visited the houses of worldly and unpolished men and has never asked assistance from the great ones of the earth, nor accepted the usual subsistence allowance made to religious teachers. He is nearly eighty years of age."[1]

From this version, it would seem that Ilâhdâd was identified by the quarter of the city in which he lived, and not that a quarter or ward *(maḥallah)* of the city of Lahore was named after him; that is, Langarkhânî must be given the same interpretation as Lâhôrî. His age, as Syed Sulaymân Nadvî has already pointed out, makes him a contemporary of Humâyûn. The rest of the description points to a self-respecting independent character, who valued professional excellence above worldly advancements. Such a person is very apt to inscribe himself as "master-craftsman" *(ustâdh)*. His descendants, however, especially if they themselves were more ambitious for recognition and honour, would not be content to refer to him as such. So

2. Vol. III. 215. Calcutta 1925.

perhaps after all, this Ilâhdâd Langarkhânî is our astrolabe maker and the founder of this family of progressive astrolabe makers, for at least four generations, covering a known period of more than a century, from 975 to 1087 A.H., the dates of the earliest and latest astrolabes, now known, made by the family.

From what has preceded, it is clear that Ilâhdâd, though contemporary with Humâyûn, was not that Emperor's official astrolabe maker. Neither could 'Îsâ have filled that position since the term *Humâyûnî* is not applied to him until nearly three-quarters of a century after the death of that monarch. Syed Nadvi's suggestion that *Humâyûnî* here meant that the family manufactured their astrolabes after a model improved by Humâyûn, still remains to be substantiated, as he himself points out. In fact, the professional prominence of the family, especially of the third and fourth generation, as reflected in the number and size of their instruments, would suggest that the descendants of Ilâhdâd became the official instrument makers to the successors of Humâyûn. *Humâyûnî* then must be interpreted here, as in other cases, to mean *royal*, and as such it has been correctly translated in several of Gunther's numbers.

Though established at Lahore, it is difficult to tell if the family was of Indian, Persian or Arab origin. The names Allâh-dâd and Ilâh-dâd might be borne by Indian and Persian alike. (The later form is preferred in this instance because it is truer to the Arabic as it appears on the astrolabes.) There is, however, a bare possibility that the name is not an Arabic-Persian combination of *ilâh* and *dâd*, but a regular Arabic name, since it might be the old Arab name of al-Hadâd[1] or al-Haddâd.[2]

—*Nabia Abbott*

1. *cf.* Ibn Doreid, *Genealogisch-Etymologisches Handbuch* (ed. Wüstenfeld, Göttingen, 1854), pp. 284-85.

2. *cf. e.g.*, Yâqût, *Geographical Dictionary* (ed. Wüstenfeld), IV, 996.

ON THE MARGIN

INDIAN ASTROLABE-MAKERS

IN my article, *Some Indian Astrolabe-Makers*, I had requested for further information on Ḍiyâ' ad-Din Asṭrolâbi Humâyûni. I am highly obliged to Mr. Nabia Abbott of the Chicago University, who, in response to my request, wrote an interesting note in ISLAMIC CULTURE of January, 1937, through which I came to know the names of two more astrolabe-makers of this family, namely, Mullâ 'Îsâ and Muḥammad Muqîm. At the same time, my attention was drawn to Gunther's *Astrolabes of the World*, which had been referred to by the above writer.

The learned writer has quite correctly read Muḥammad Qâ'im instead of Muḥammad Qâsim. In the State Library of Rampur, in an inscription on an astrolabe made by Ḍiyâ' ad-Din, which runs thus: عمل ضياء الدين ابن قائم محمد—the word قائم is written in such a way as to be misread قاسم. It is fairly common in such inscriptions deliberately to extend a letter which occurs near a hole, so as to save it from being mutilated; and thus the mis-reading becomes possible (see *Ma'ârif*, Azamgarh, September 1933, p. 220). Otherwise it is quite obvious that one Ḍiyâ' ad-Din Muḥammad, the grandson of Mullâ' Îsâ, cannot possibly have been a son of two persons, Qâsim Muḥammad and Qâ'im Muḥammad. The name of Ḍiyâ' ad-Din's father, Qâ'im Muḥammad, is correctly written on several other astrolabes. Besides the mis-reading of this name, there have occurred several other mistakes in reading the inscription of Gunther's No. 77. The correct reading is thus: عمل اضعف العباد ضياء الدين محمد ابن ملا عيسى ابن شيخ الهداد اسطرلابی همایونی لاهوری ۱۰۶۹ ھ ("The work of the humblest of the servants, Ḍiyâ' ad-Din Muḥammad, son of Qâ'im Muḥammad, son of Mullâ 'Îsâ, son of Shaykh Ilâhdâd, Asṭrolâbi Humâyûni Lâhôri, 1069 A.H.").

Similarly, in the astrolabe of Gunther's No. 71, the name in the inscription has been read as محمد ابن عيسى ابن الهداد اسطرلابی لاهوری همایونی and translated "Mohammad ibn Isa ibn El-Haddad Asturlabi Lahori Humayuni (the Royal Astrolabist of Lahore)". I quite agree with my friend in believing that this name is, correctly speaking, either Qâ'im Muḥammad or Muḥammad Muqîm. The other mistake consists in writing Humâyûni after Lâhôri, which is decidedly wrong.

The meaning of Ilâhdâd Langar-Khâni, which occurs in my article and is based on a reference of Badâyûni, is the same as interpreted by the learned writer. In my original article (in Urdu) I had merely copied the Persian version without translating it (*cf. Ma'ârif*, August, 1934, p. 94); and I had written in Urdu within brackets: (*Maḥallah Langar Khân* is a ward of Lahore). The translator of my article has committed a mistake, and Mr. Abbott has rightly pointed this out.

I my article, I suggested that the term *Humâyûni* refers to Humâyûn, son of Bâbar. Mr. Abbott, however, hesitates to accept this, and would interpret *Humâyûni* as *royal*, as has been previously done by Gunther. I disagree with this view.

Humâyûn is a Persian word which means "auspicious". In Persian it is never used in the sense of "king". Similarly, the یاء نسبی of *Humâyûni* (همایونی) is never used in this combination; if it were a یاء مصدری it would mean "auspiciousness". In Osmanli Turkish, to be sure, the word *Humâyûni* was used metaphorically in the sense of "royal", hence we find فرمان همایونی or خط همایونی (Royal Charter or Royal Proclamation) often mentioned in Turkish histories. It was through the

Osmanli Turkish that the word in the above sense was introduced into Syrian and Egyptian Arabic. But the original (Persian) meaning is "auspicious", and —at least so far as the Mughal Persian is concerned—it has never been used in India or anywhere else in the sense of "royal": and so it is impossible to interpret *Astrolâbi Humâyûni* as "Royal Astrolabe-maker". And, moreover, had this word been used in the sense of "royal", why was it that they used this one word only, and never at any time another word having the same meaning? Again, so far as we know, there are no traces of any contact whatever between another astrolabe-maker with a king of any other period. It is therefore quite obvious that *Humâyûni* has not been used in the sense of "royal", but refers to King Humâyûn.

In the Persian histories of the Mughals, the word *Humâyûn* has ever been used in the sense of "auspicious", *e.g.*, فرمان همایون ("auspicious proclamation"): *Akbar-Nâmah* (Nawal Kishore edition), p. 225, جلوس همایون ("auspicious [year of] accession): see *Tuzuk-i-Jahângiri*, edited by Sir Syed Ahmad Khan, p. 65, 79, 114, and موکب همایون ("auspicious procession"): see *Iqbâl-Nâmah Jahângiri*, Calcutta, p. 117. We do not find anywhere موکب همایونی or جلوس همایونی or فرمان همایونی.

In the biography (in *Ma'âthir al-Umarâ'* I, 479) of Maulana Nûr ad-Dîn Tarkhân, who took lessons from Humâyûn in astronomy and astrology, we read that Humâyûn was deeply interested in mathematics and astronomy and possessed considerable knowledge on the subject of astrolabes.

In the *Qaṣidah*, which Bayram Khân composed for Humâyûn, he used various terms referring to astrolabes in metaphors and similes, which again shows the great interest of Humâyûn in astrolabes (Badâyûni, Calcutta, vol. III, 192). Humâyûn's sister Gulbadan Bêgam writes that the Emperor used astrolabes with his own hands (*Humâyûn-Nâmah*, London, p.53). Abu'l-Faḍl writes (*Akbar-Nâmah*, Nawal Kishore ed., vol. I, 241): "He had an extraordinary interest and proficience in the [use of the] astrolabe, the globe and other instruments of the observatory."

One of the artisans of Humâyûn was one Maulana Maqṣûd Hirawi, who is thus mentioned in *Â'în-i-Akbari*:

"He was one of the devotees of the Resident of the Paradise [Humâyûn]... He manufactured astrolabes, globes, in such a manner that the observers of his works were wonderstruck" (*Â'în-i-Akbari*, Nawal Kishore ed., vol. I, 31).

These facts abundantly show that Humâyûn had a great love for astrolabes.

Now, the learned writer has questioned most properly: If the above dynasty of astrolabe-makers was associated with Humâyûn, why was it that on the astrolabe of the first astrolabist, Ilâhdâd, who was, in my opinion, a contemporary of Humâyûn, the word *Humâyûni* was not written? This word does not occur in one of the inscriptions of his son also, although this addition is to be found in the latter's other astrolabes (Gunther, No. 68).

Let us first make clear the point that the astrolabe of Ilâhdâd, which I saw in the library of Nawab Sir Salar Jung, Hyderabad, and which has been referred to in my article, is dated, as the inscriptions show, 975 A.H. Now, Humâyûn was born in 913 A.H., ascended the throne in 927 A.H. (1530 A.C.), and died in 963 A.H. (1555 A.C.).

Ilâhdâd's son 'Îsâ's astrolabe is dated 1013 A.H. According to Mr. Abbot it is preserved in the Adler Planetarium and Astronomical Museum of Chicago. And the date of astrolabes made by 'Îsâ's two sons is 1018 A.H., a description of these astrolabes is to be found in Gunther, p. 187, No. 69, Figs. 90 and 91. This proves that about thirteen years after the death of Humâyûn, that is, in 975 A.H., Ilâhdâd made an astrolabe. He must have been an astrolabe-maker in the very life-time of Humâyûn, because 43 years later his two grandsons, who were astrolabe-makers, were already of ripe age. We have, therefore, to admit that Ilâhdâd must have been a contemporary of Humâyûn, while 'Îsâ and his two sons were contemporaries of Akbar.

Now the question is, why does the word *Humâyûni* not occur in the inscription of Ilâhdâd, as well as the early astrolabes of 'Îsâ and in the astrolabes of 'Îsâ's two sons, which is dated 1018 A.H.?

The answer is that the fashion of naming nobles, officials, dates and eras with reference to contemporary rulers began amongst the Mughals after Akbar, hence the expressions : *Jahângîrî*, *Shâh-Jahânî* and *'Âlamgîrî*, which so frequently occur in historical works written after the time of Akbar. As Ilâhdâd probably had enjoyed the patronage of Humâyûn, so his son, Mullâ 'Îsâ, added in the later part of Jahângîr's or Shâh-Jahân's period the appelation of *Humâyûnî* to his father's name, which grew subsequently and became a part of his "dynastic" designation.

I just happened to read a passage from the manuscript of *Sîrat-i-Fêrôz-Shâhî*, (No. 547, catalogue of the Arabic and Persian Manuscripts in the Oriental Public Library at Bankipore, vol. VII, Indian History), which corroborates the above two assertions of mine. Like Humâyûn, Fêrôz Shâh Tughlak had a great liking for astrolabes and astronomy. The name of a treatise on astrolabes or of an astrolabe invented by the Emperor himself, was *Asṭurlâb-i-Ferôz-Shâhî*. In this connection we find the word *Humâyûn* (not *Humâyûnî*) in two places ; it clearly means "auspicious" and not "royal."

Now a word about the name Ilâhdâd, which also might be read al-Haddâd. The learned writer has preferred the former reading, but contends at the same time that it might be the old Arab name of al-Ḥaddâd or al-Ḥadâd. If this had been written in Roman script, there would have been this possibility. But in the Arabic script there is no possibility of mistaking *h* (ه) for *ḥ* (ح). Thus the name is undoubtedly Ilâhdâd.

—*Sayyid Sulayman Nadvi*

MUSLIM OBSERVATORIES[1]

THE beginning of Muslim observatories is traced back to al-Mā'mūn's days in the third century A.H. But before we deal with them, let us say a few words about the various astronomical instruments used by the Muslims. The Muslims learnt the art of manufacturing astronomical instrument from the Ṣābeans, whose famous city Ḥarrān, where these instruments were made abundantly, had been brought under the sway of Muslim conquerors. In the 'Abbāssid period, the art of manufacturing astronomical instruments also prospered along with the promotion of other learning and literature. When al-Mā'mūn established an observatory in Baghdād, Ibn-Khalaf Marwarūzī invented an instrument called Dhāt-ul-Ḥalaq (Armillary Sphere) which was used by the scholars of Baghdād till the fourth century A.H.[2]

Ibn-Nadīm, who flourished in the fourth century A.H., has given the following names of the mechanics of the astronomical instruments. Ibn-Khalaf Marwarūzī, al-Fazārī, 'Alī bin 'Īsā (a slave of Ibn-Khalaf), Aḥmad bin Khalaf, and Muḥammad bin Khalaf, (slaves of 'Alī bin 'Īsa), Aḥmad bin Isḥāq Ḥarrānī, Qatustulus, and 'Alī bin Aḥmad (slaves of Rabī' bin Faras Ḥarrānī) Muḥammad bin Shaddād al-Balādī, 'Alī bin Ṣard Harrānī, Shujā' and 'Ajlī (slaves of Batilulus), 'Ajliya, daughter of 'Ajlī, Jābir bin Sanān Ḥarrānī, Sanān bin Jābir Ḥarrānī, Faras bin Ḥasan Ḥarrānī, Ḥamīd bin 'Alī (slave of 'Alī bin Aḥmad), Ibn-Najbah and Ḥusain-ul-Būqī. This long list of names shows clearly that in the early centuries A.H. the Muslims were much addicted to the art of astronomy, which was cultivated equally by men, women, masters and slaves. The descendants of Shākir were great manufacturers of astronomical instruments. Abū-Ḥāmid Saghānī (died 379 A.H.) had great skill in making these instruments. Khāzin Mozānī, whose full name was Abū Ja'far al-Khurāsānī, was another expert mechanic of astronomical instruments. He lived for a long time in Egypt and Spain. He made investigation into the knowledge of Light (علم نور) and wrote a manual

1. In translating this article from the Urdu version, the translator has taken much help from *the Encyclopaedia of Islam*.

2. *Kitāb-ul-Fihrist*, pp. 284, 285.

called كتاب آلات العجيبه الرصديه,[1] which gives a description of marvellous instruments of observations. It also deals with instruments for measuring the altitude of the Sun. One of Khāzin's works is also كتاب زيج الصفائح (*The Book of Tables of Planes*). In it there is most probably an explanation of the progressive and retrograde movement of spheres. Khāzin's other book is named كتاب المنازل القدسيه.[2] Mazonī also dealt with astrology. He died in 430 A.H. Abu'l-Ḥasan 'Alī ibn-Rājil was another renowned manufacturer, who flourished in the thirteenth century A.H. His book[3] dealing with the manufacture of astronomical instruments was translated into French by Sidellot in 1835 A.D. and published in two volumes at Paris. Ibn an-Nabdī, who lived in the 11th century A.H., was another famous mechanic. When the books of the Imperial Library of Egypt were being catalogued, he was offered by the Egyptian minister, Abu'l-Qāsim 'Alī. the task of cataloguing the books on astronomy as well as astronomical instruments. Ibn an-Nabdī lived in Egypt till 1040 A.H. In the days of Caliph Mustarshid, Badī', the astrolaber, was an illustrious manufacturer, who had amassed a large amount of wealth by selling astronomical instruments. He died in 534 A.H.[4] The Muslims in Spain had also made considerable improvement in astronomy, but with the extinction of their rule in Spain, their achievements in the domain of art and learning were buried in oblivion, and so we regret to say that we know very little of astronomical instruments invented and observatories founded during the palmy days of Muslim rule in Spain. In the latter part of the 11th century A.D. az-Zarqalī (Anzachel) was a famous mechanic of astronomical instruments in Spain. He constructed an astrolabe for Mā'mūn, the ruler of Ṭalīṭala, and compiled in Ashbīliya (Seville) for Ibn-i-'Abbād a book dealing with astronomical instruments and named it *'Abbādiya* (عباديه). He made some new researches into astronomy.

Big Friday mosques had a Muwaqqit (time-keeper) who was appointed from amongst learned astronomers. The Muwaqqit told the Mu'azzin the correct time of the five prayers. The Muwaqqit of the Friday mosque of Granada was Ibn-i-Baza Salma. He constructed beautiful and durable astronomical instruments, which were purchased at handsome prices. Ibn-i-Baza Salma learnt this art from his father Ḥasan.[5] In Constantinople, Ghurs-ud-Dīn was a renowned manufacturer who prepared all the instruments personally. He also participated in the battle which took place between the Sulṭān of Egypt and the Charakasa.[6] In India Tafaḍḍul-Ḥusain Khān (died 1215 A.H.) and his pupil Dabīr-ud-

1. *Kashf-uẓ-Ẓanūn*, Vol. II, p. 264.
2. *Akhbār-ul-Ḥukamā*, p. 259.
3. اكتفاء القنوع p. 445.
4. ثمرات الاوراق Vol. II, p. 390.
5. الاحاطه باخبار غرناطه, p. 85.
6. الشقائق النعمانيه, Vol. II, p. 136.

Daulah Khwāja Farīd-ud-Dīn (died 1244 A.H.) were great scholars in astronomy and highly skilled in making astronomical instruments. Dabīr-ud-Daulah's youngest son Nawāb Zain-ul-'Ābedīn constructed very beautiful globes (كرات), astrolabes (اصطرلاب), Dhāt-ul-Ḥalaqatain (ذات الحلقتين), Rub' Mujīb (ربع مجيب) and Ḥaladhūn (حلزون). His studio, where these instruments were placed, looked like an observatory.[1]

Besides the above noteworthy persons, Naṣīr Ṭūsī, 'Alī Barjandī, Ibn-i-Shāṭir, Taqī-ud-Dīn, Ghiyāth-ud-Dīn Jamshēd and Ghulām Ḥusain of Jaunpore were great masters in manufacturing astronomical instruments, which are no longer found but are referred to either in historical books or in their own literary works.

Let us now describe the instruments which were invented by the Muslims. They are: (1) لبنہ (Libna): This was invented by Naṣīr-ud-Dīn Ṭūsī (died 672 A.H.). The distances of latitude, stars, and obliquity of the ecliptic were read with the help of it. This was for the first time used[2] in the observatory of Marāgha. (2) Dhāt-ul-Autār (ذات الاوتار) was invented by Taqī-ud-Dīn of Syria, who was Sulṭān Murād's contemporary. This instrument was so contrived and arranged as to ascertain the time at different latitudes. One of the works of Taqī-ud-Dīn is سدرة منتهى الافكار, which deals with astronomy and astronomical instruments. (3) Dhāt-us-Simt wa'l-Irtifā' (ذات السمت والارتفاع) [3] is a semi-circular ring, which was helpful in finding the contraction of altitude and azimuth. Taqī-ud-Dīn writes in his سدرة منتهى الافكار that this instrument also was invented by the Muslims. (4) Mushabbah bi'l-Manāṭiq (مشبه بالمناطق) was also one of the inventions of Taqī-ud-Dīn. It was utilized in calculating the distance between two stars. (5) Rub' Tām (ربع تام) was invented by Ibn-i-Shāṭir (died 777 A.H.), who was a Muwaqqit (time-keeper) of Damascus. In his treatise النفع العام which gives a description of Ruba' Tām, he writes that "he found most of the astronomical instruments defective, so he constructed Rub' Tām. This is the most perfect of all instruments. From this instrument alone, every kind of astronomical observation can be easily made."[4] (6) Sudas Fakhri (سدس فخرى) is a ring made of bronze. It is used in finding out the obliquity of the ecliptic and the latitude. This was invented in the days of Fakhr-ud-Daulah, hence it is called Sudas Fakhrī.[5] It is said to be the fore-runner of the sextant. (7) Asa'ṭ-Ṭūsī, or linear astrolabe. According to old astronomy, each star had a circular movement. It was for this reason that the orbits and the circular movements of stars were represented in a circular globe.

1. *Sirat-i-Farīdiya*, pp. 7, 9, 42.
2. *Jāmi'-Bahādur Khānī*, p. 506.
3. Al-azimuth of modern days.
4. *Kashf-uz-Zanūn*, Vol. I, pp. 136, 137.
5. *Jāmi'-Bahādur Khānī*, p. 506.

Ptolemy introduced a flat astrolabe, which served the above purpose fully well. The word 'astrolabe' is derived from a Greek word اسطر (Astēr), meaning 'Star,' and astronomy is from this اسطر. This instrument was used for measuring the altitude of stars, as well as of the sun and the moon. The use of this instrument began amongst the Muslims from Caliph Mā'mūn's days. The first astrolabe was constructed by Ibrāhīm bin Jaib Fazārī.[1] In the latter part of the fifth century A.H. Shaikh Sharf-ud-Dīn Ṭūsī introduced a linear astrolabe, resembling in form a calculating rod. It was greatly improved by Sharf-ud-Dīn Ṭūsī's pupil, Kamāl-ud-Dīn[2] (died in 639 A. H.). In India Fīrūz Shāh Tughluq invented a special kind of astrolabe, which was constructed by his order and placed on the Mināra of Fīrūzābād.[3] The Mughal emperor, Humāyūn also had manufactured a particular model of astrolabe, called Usṭurlāb-i-Humāyūnī.[4]

Now let us consider the Muslim observatories founded in different parts of the world. The first series of regular observations with the aid of fairly accurate instruments appears to have been made at Jundi-Shāhpūr (a town in Khuzistān, S.W. Īran), in the first years of the 9th century A.D., by Aḥmad an-Nahāwandī who prepared an almanac entitled *Zīj al-Mushtamil*.[5] But the most remarkable period of Muslim astronomy commenced during the caliphate of al-Mā'mūn, whose capital city of Baghdād was a rendezvous of eminent scholars and men of letters. When Ptolemy's *Almagest* was translated into Arabic, al-Mā'mūn ordered the establishment of an observatory at Baghdād in the quarter called ash-Shammāsiya. It was completed in 214 A.H. (829 A.D.). Yaḥya bin Abī Manṣūr[6] was its director, under whom worked 'Abbās bin Sa'īd Johrī, Hind bin 'Alī, Haish bin 'Abdallāh Marwarūzī and 'Umar bin Muḥammad Marwarūzī, etc.[7] Some of the researches made in this observatory were: (*i*) The angle formed by the intersection of Equation (معدل) and the Zodiac (منطقة البروج) is called obliquity of Zodiac اعوجاج منطقة البروج. It was observed that the obliquity of the Zodiac lies at 23° 33′ and 52″. This comes near to modern investigation, which is 23° 27′. (*ii*) The points which are the intersections of the Celestial Equator (معدل النهار) and the Zodiac are called equinoxes (نقاط اعتدال) through which the number of days of the solar year was calculated almost precisely. It was supposed

1. *Kitāb-ul-Fihrist*, p. 273.
2. *Ibn-i-Khallikān*, Vol. II, p. 185.
3. *Catalogue of the Arabic and Persian Manuscripts in the Oriental Public Library at Bankipore*, Vol. VI, p. 32. I have not been able to see the book *Sirat-i-Fīrūz Shāhī*. Its author gives a description of the various astronomical instruments invented by Fīrūz Shāh Tughluq.
4. *Vide* my article *Some Indian Astrolabe-Makers* in *Islamic Culture*, Oct. 1935.
5. The translator has taken the liberty to supplement this information from the *Encyclopædia of Islam* (article "Astronomy"), although '*Zīj-al-Mushtamil*' is not referred to in *Kashf-uz-Ẓanūn*.
6. مختصر الدول ابو الفرج ملطى, p. 248.
7. *Kitāb-ul-Fihrist*, pp. 272, 275, 276.

that the equinoctial point was fixed in one place, but it was found out that it moves fifty seconds ahead every year. This movement is termed Precession of Equinoxes (استقبال اعتدالین), which was also an object of research in the above observatory. The Apogee of the Sun, the Degree of Inclination (مقدار میل) and Eccentricity (خروج مرکز) were also investigated here, and some new information regarding the planets and fixed stars was also obtained.[1]

In order to corroborate the astronomical investigations and researches, different observatories were erected in different places. So al-Mā'mūn built another observatory on Mount Qasiyun,[2] at a distance of two or two and a half miles from Damascus.[3] The data thus collected in these observatories were compiled in a *Zīj* by Abū-Ja'far Muḥammad bin Mūsa Khwārazmī. This Table (*Zīj*) became highly popular. In this, the mean (اوساط) of the sun, the moon, etc. were maintained according to the Indian almanac, the researches ragarding the equinoxes were according to the Persian investigation, and the observations of the obliquity of the sun were according to Ptolemy's.[4] Another astronomer of al-Mā'mūn's, Ḥabsh Ḥasib Marwarūzī, also prepared three Tables.[5]

In the third century A.H. Abū Ḥanīfa Aḥmad bin Dā'ūd Dīnāwarī was a highly eminent scholar of literature, history, arithmetic, algebra, and astronomy. His historical book *Kitāb-ul-Akhbār aṭ-Ṭiwāl* is of great value. He is the author of many books in literature and arithmetic. In 235 A.H. he founded an observatory in Ispahan,[6] and recorded his observation in *Kitāb-ar-Raṣad*. It has been mentioned by some historians that Abū Ḥanīfa wrote this book for Rukn-ud-Daulah, but this is simply an error, for the rule of the Dailimites commences from 320 A.H., and Abū-Ḥanīfa died forty years before this, in 281 A.H.

Abū 'Abdullāh Muḥammad bin Jābir Banī, (died in 317 A.H.; the Albatengi or Albategnius of European authors), was regarded as one of those twenty astronomers who made inestimable contributions to astronomy. In his days there were two great observatories, one at ar-Rakka and the other at Antioch. Baṭṭānī worked in these two observatories for forty-two years, *i.e.*, from 264 A.H. to 306 A.H. He compiled his

1. *Kashf-uẓ-Ẓanūn*, p. 12.

2. مختصر الدول ملطی p. 248.

3. Caliph al-Mā'mūn also carried out one of the most difficult and delicate geodetic operations, the measuring of an arc of meridian, in the regions between Tadmur (Palmyra) and ar-Rakka in the plains of Mesopotamia. The mean result gave $56\frac{2}{3}$ Arabic miles as the length of a degree of meridian, a remarkably accurate value, for the Arabic mile being 6473 ft. This value is equal to 366, 842 ft., a number which only exceeds by about 2,877 ft. the real length of degree between 38° and 36° N. lat. *Encyclopaedia of Islam* 'Astronomy.'

4. *Jam'ul-Qaṣaṣ-ul-Hindiya*, printed in France, 1838 A.D., p. 100.

5. *Kashf-uẓ-Ẓanūn*, Description of زیج حبش الحاسب .

6. *Ibid.*, Description of رصد

observations in *az-Zīj*, wich was translated into Latin by Robertus Retinenses or Ketensis (died at Pamplona in Spain after 1143 A.D.) and by Plato Tibastinus in the first half of the 12th century (an edition of the text without the mathematical tables was published at Nuremberg in 1537 and at Bologna in 1645). Alphonso X of Castile (1252 A.D.) had it translated from Arabic into Spanish, and an incomplete manuscript of this version is in the National Library of Paris. Baṭṭānī was also the author of the following books :—
(1) كتاب معرفة مطالع البروج في ما بين ارباع الافلاك which deals with ascensions of the points of the ecliptic as well as the mathematical solution of astrological problems ; (2) رسالة في تحقيق اقدار الاتصالات dealing with the rigorous trigonometrical solution of the astrological problem of prorectio radiorum when the stars in question lie outside the ecliptic ; (3) شرح المقالات الاربعة في بطليموس is a commentary on Ptolemy's *Tetrabiblon*. Baṭṭānī's main researches are : (*i*) He proved that the moon has also equinoxes just as Ptolemy showed that the sun has equinoxes. (*ii*) The points of the orbits which are nearest and remotest to the sun are called نقطة الراس (Perihelion) and نقطة الذنب (Aphelion) respectively. Baṭṭānī demonstrated that these points are not stationary but are subject to changes. (*iii*) He also corrected the degree of the Precession of the equinoxes. (*iv*) He fixed the precise degree of the inclination between the Celestial Equator and the Zodiac. (*v*) According to him the solar year covered 365 days, 5 hours and 40 minutes.[1]

Abu'l-Wafā', whose full name is Muḥammad bin Aḥmad bin Yaḥya bin Ismā'īl bin al-'Abbās al-Buzjānī, is regarded as the most renowned Muslim astronomer. He hailed from Buzjān, which was a small town lying between Herat and Nishapore. He was born in 328 A.H. and died in 376 A.H. He made vigorous astronomical researches along with his colleagues for a pretty long time in an observatory, the place of which has not been identified, Kātib Chalpī says" *Zīj ash-Shāmil* is the book of Shaikh Abu'l-Wafā Muḥammad bin Aḥmad Buzjānī, who compiled and corrected it after numerous researches and observations, made by him and his colleagues in an observatory founded after al-Mā'mūn's observatory."[2] A commentary on this Zīj was written by Sayyid 'Alā'-ud-Dīn Qoshi, who died in 800 A.H. This commentary is in the library of Khadieviah, Cairo. Buzjānī had many useful and valuable instruments in his observatory. He found out the Obliquity of the Zodiac (اعوجاج منطقة البروج) with the help of an instrument having the shape of a quarter circle, the half diameter of which was seven yards. The equation of the equinoxes, which causes the acceleration and the retrogression in the motion of the moon, was also discovered in this observatory.

'Alī bin Ḥassān, popularly known as Ibn-A'lam, was an erudite mathematician attached to the court of 'Izz-ud-Daulah of the Dailimite dynasty.

1. *Barjundī*, p. 189.
2. *Kashf-uz-Ẓanūn*, Vol. II, p. 15.

He received no favour from 'Izz-ud-Daulah's successor, so he broke his connection with the court and died in 272 A.H. while returning from a pilgrimage to Mecca. He had his observatory in Baghdād, where he proved, contrary to Ptolemy, that planets travel one degree in seven solar years. Ptolemy asserted that the time taken by planets to travel one degree was one hundred solar years. Ibn-A'lam prepared an almanac of Mercury, which was regarded as the best and the most reliable almanac.[1]

The Dailimites were great patrons of astronomy, and Ibn A'lam, 'Abdur-Raḥmān Ṣūfī, Aḥmad Ṣāghānī and Wigin Kohi were some of the illustrious astronomers who basked in the sunshine of the favours of the Dailimite rulers. 'Izz-ud-Daulah prided himself on having learnt the art of astronomy from 'Abd-ur-Raḥmān Ṣūfī. In 379 A.H. Sharf-ud-Daulah fitted up an observatory in Baghdād in the garden of his palace, and carried out there observation of seven planets. Wigin Kohi was the superintendent of this observatory and his colleagues were Aḥmad Ṣāghānī (died in 379 A.H.) and Ibrāhīm bin Hilāl Ṣāghānī (died in 381 A.H.). Aḥmad Ṣāghānī attempted some corrections regarding the coming of the sun into the Zodiacs.[2]

Al-Ḥākim bi-Amrillāh, the sixth Fāṭimid Caliph of Egypt, established a very big observatory on the summit of al-Muqaṭṭam, and placed it in charge of Ibn Yūnus, who was a great scholar in astronomy and mathematics. Ibn-Yūnus compiled his observations and researches in الزيج الكبير الحاكمي which is referred to in most of the astronomical works. Professor Caussin translated and published in 1840 A.D. a few chapters from these tables in the *Notice et extraits des manuscripts de la Bibliotheque nationale*, Vol. VII. Ibn Yūnus made lunar and solar observations also, which he recorded in a table. Another almanac of his consisting of the ephemeries of the sun and the moon is entitled التعديل الحاكمي. These two books are preserved in the Khadiviah library, Cairo. He also showed great skill in the solution of several difficult exercises in spherical astronomy with the help of orthogonal projection of the celestial sphere on the horizon and the plane of the meridian.

Jalāl-ud-Dīn Malik Shāh of the Seljūq dynasty built an observatory in Ispahan at a great cost. Here 'Umar bin Ibrāhīm Khayyām, Muḥammad Baihaqī, Abu'l-Muẓaffar bin al-Asfarāzī, and Maimūn bin an-Najīb Wāsṭi worked together. Prior to 485 A.H. New Year's Day began when the sun crossed half of the Pisces, but for the correct determination of the year, New Year's Day was fixed on the day when the sun entered into Aries.[3] This change was adopted by all calendar makers. In this same observatory, Khayyām introduced the rule of the intercalary

1. *Sharḥ Chugmanī*, p. 13.

2. مختصر الدول p. 325.

3. Ibn-i-Athīr, Vol. X, p. 537. The names of Ispahan and Muḥammad Baihaqī have been taken from *Tārīkh-ul-Ḥukamā* by Shahzorī.

year in the Persian era, which was thenceforward regulated according to the revolution of the sun. This reformed era was termed Jalālī era after the name of Jalāl-ud-Dīn Malik Shāh. The details of this reform may be summed up thus.[1] The sun travels all the celestial spheres in 365 days and some hours, but in order to facilitate calculation, a year has been determined into 365 days, and the fraction of hours is glossed over. But after some years the fraction of hours causes considerable differences between the solar years and the revolution of the sun. In order to avoid this difference Khayyām made a new regulation. He took that day as the first day of the year when the sun enters into Aries before coming to the meridian. He fixed thirty days for each month of a year, adding five days in the month of Isfandar, and six days after every third or fourth year. This regulation was made current in Europe six hundred years afterwards by Gregory. According to the Gregorian principle, one day is added to the month of February every fourth year. But Khayyām's regulation is better than the Gregorian one, for according to the latter, the differences between the solar year and solar revolution within the period of the thousand years amounts to three days, while according to Khayyām it amounts to two days only.

Abū Raiḥān Muḥammad bin Aḥmad Bērūnī founded his own observatory in the fifth century A.H. Bērūnī was the author of many works, each of which abounds in profuse references to astronomical matters. His most renowned book is *Qānūn-i-Mas'ūdī*, which he wrote in 421 A.H. at the instance of Sulṭān Mas'ūd, son of Sulṭān Maḥmūd of Ghazni. Bērūnī's *al-Hind* is an exhaustive study of the art of astronomy and astrology, which was cultivated by the Hindus. His other books are *al-Āthār-ul-Bāqiyah*, *Kitāb-ul-Irshād*, *al-Jamāhir fi'l-Jawāhir*, *al-'Ajā'ib-uṭ-Ṭabī'āt*, *Maqālīd-ul-Ḥayāt* and *at-Tafhīm fī Ṣanā'at-it-Tanjīm*, all of which deal authoritatively with one or another aspect of astronomy or astrology, as well as geography, history and philosophy. We are sorry not to be able to throw much light on Bērūnī's observatory. Kātib Chalpī writes succinctly that 'Bērūnī had establishd an observatory.' Bērūnī was attached to the court of the Ghaznivide rulers, amongst whom Sulṭān Mas'ūd had a great love for astronomy.[2] It is just possible that Bērūnī's observatory was located somewhere between Ghazna and Herat. Bērūnī's most valuable contribution was that he prepared a list of the longitudes and latitudes of all the existing big cities of the world.

'Alā'-ud-Daulah Kākiviyah of Ispahan also founded an observatory with the help of Avicenna, who had accepted the post of minister under the former after forsaking in disgust the service of Shams-ud-Daulah of Hamadan. This observatory, which was equipped with necessary instruments, was established to correct the defects and anomalies of the old almanac. It was placed under the care of Avicenna's learned pupil Abū

1. *Vide* the details in my book *Khayyām*, pp. 111-138 (Ma'ārif Press, A'ẓamgarh).
2. *Tārīkh-ul-Ḥukamā'*, Shahzorī, Description of Bērūnī.

'Ubaid. Avicenna worked here for eight years and found out numerous mistakes of the former astronomers.[1] There was a difference of opinion as regards the celestial order of the Sun, Mercury, and Venus. Avicenna observed Venus and Mercury as two black moles on the face of the Sun[2] which prove the following things: (i) Venus and Mercury are located beneath the Sun; (ii) there is no light in Venus and Mercury, otherwise they would not have looked black; (iii) just as the moon grows into the New Moon, Full Moon, and then is absent in the last three days of a lunar month, so Venus and Mercury undergo the same process. For darkness must have been coming into them gradually. It is not possible to describe here fully the various astronomical contributions made by Avicenna. It will be sufficient to say in the words of Shahzorī that Avicenna knew a large number of astronomical details which were not known to earlier astronomers.

Koshyār bin Labbān flourished in the fifth century A.H. In 459 A.H. he made observations which he recorded in two books. One of these is entitled *Zīj Koshyār*, which was written originally in Arabic but was translated into Persian by Muḥammad bin Abū Ṭalib Tabrēzī. The name of his other work is زيج الجامع والبالغ in which the movements of stars and spheres are determined according to mathematical calculations. We do not know much of Koshyār. The above meagre references have

1. *Tārikh-ul-Ḥukamā'*, Shahzorī, Description of Ibn-i-Sinā.

2. Vide *Sharḥ-i-Chaghmenī* p. 13 (Alvi Press edition, Lucknow) Maḥmūd bin Muḥammad bin 'Umar al-Chaghmenī al-Khwarizimī, who was a distinguished scholar, wrote الملخص فى الهيئة in. 618 A.H. (1221 A.D.) A commentary on this book namely *Sharḥ-i-Chagmenī* was written by Ṣalāḥ-ud-Dīn Mūsa Qāḍi Zādah bin Maḥmūd, who lived at the court of Ulugh Bēg in Samarqand and died some time after 803 A.H. (1424 A.D.) Qāḍi Zīdah writes in *Sharḥ Chaghmēnī*, p. 13:

وقد تأكد عندهم بما حكى عن جماعة منهم الشيخ الرئيس انهم رأوا الزهرة كشامة على وجه الشمس و
اياها مع عطارد كشامتين على وجهها

And their opinion was strengthened by the fact that a group of (astronomers) amongst whom was also Shaikh-ur-Ra'īs (i.e. Avicenna) observed Venus like a mole on the face of the sun. They saw it along with Mercury also as two moles on the face of the sun. This observation was also made by Ibn Bāja of Spain (died 533 A.H./1138 A.D.). 'Abdul-'Alī Barjandī writing the marginal notes on *Sharḥ-i-Chaghmenī*, (p. 83), quotes the following version from Qutb-ud-Dīn Shīrāzī's نهاية الادراك فى دراية الافلاك composed some time before 683 A.H. (1284 A.D.).

قال صاحب نهاية الادراك ذكر ابن باجة الاندلسى فى بعض كتبه انى كنت ذات يوم على سطح دارى
وقت طلوع الشمس فرايت فيها كشامتين فاستخرجت تقويمى الزهرة و عطارد من الزيج ذالك الوقت
فوجدتهما مايقرب من تقديم الشمس فعلمت ان الشامتين كانتاهما

(Ibn Bāja relates in one of his books: I was on the roof of my house when the sun was about to rise. I saw two moles in the sun. Just at that time I calculated the almanac (تقويم) with the help of a Calendar (زيج) and found their almanac close to that of the sun. From this I knew that the two moles are Venus and Mercury).

These astronomers made investigations about the stars with the help of an instrument which was called ذات الشعبتين (*vide* المقدمه فى بيان اقسام الاجسام على الاجمال in *Sharḥ-i-Chaghmenī*).

been made by Kātib Chalpī in connection with Zīj. Ibn-i-Khallikān has mentioned Koshyār thus :—کوشیار بن لبان بن باشهری الجیلی مصنف زیج (Vol. II, p. 185).

Ibn Zarqal (Arzachel) was a great mathematician of Spain. He constructed an astrolabe called Mā'mūniya for Mā'mūn, the ruler of Ṭalīṭala. After leaving Ṭalīṭala he came to Seville and enjoyed the patronage of Mu'tamad bin 'Abbād. Here he compiled a book *al-'Abbādiya* in which he gave details of the astronomical instruments manufactured and introduced by him. One of his new instruments was named Zarqala, which helped to determine celestial movements.[1] Ibn Zarqal made appreciable contributions to astronomical observations. In order to know the apogee of the sun, he made four hundred and two series of observations. It was he who first discovered that the annual precession of the celestial equator amounts to fifty seconds and this is correct according to modern calculation and researches. Zarqal used his own manufactured instruments during the course of his observations. His observatory was probably in Ṭalīṭala.

Afḍal Shahinshāh bin Amīr-ul-Jāyūsh (died 515 A.H.) the Vazīr of the Fāṭimide Caliph Āmar bi-Aḥkāmillāh, erected an observatory in Cairo. According to the common practice amongst the Muslim rulers, an annual calendar was prepared by astronomers in the beginning of each year. At the commencement of 500 A.H. Afḍal Shahinshāh had about five hundred almanacs. But the Egyptian calendars differed greatly from Syrian ones. The main cause of this was that the Syrian almanacs were prepared according to the observations made in an observatory which was founded at Baghdād by Mā'mūn, while the Egyptian calendars were based on the observations of Ḥākim's observatory at al-Muqaṭṭam. Afḍal Shahinshāh, therefore, felt the need of fitting out a new observatory, which, after being constructed, was placed in charge of Abū-Sa'īd bin Qarqā. The latter was also the superintendent of the royal armoury as well as of industrial manufactures. He was also highly skilled in constructing observatories. The erection of the above observatory was begun in 513 A.H. and it was attached to the mosque Qiblat-ul-Kabīr, which was built at the cost of six thousand dinars. Valuable and highly useful astronomical instruments and pretty compasses were made here. The structure (قالب) of the Ḥalqat-ul-Kabīr (حلقة الكبير) which was prepared here was ten hands in diameter and thirty hands in circumference. The observatory could not be completed owing to Afḍal Shahinshāh's murder in 515 A.H. After him Mā'mūn Bataihi was appointed the minister of Egypt, and he undertook to complete the unfinished building of the observatory, although his death in 519 A.H. checked its further progress. Prominent engineers, astronomers, and manufacturers who worked in this observatory were Shaikh Abū-Ja'far bin Hasandanī, Qāḍī Ibn-Abi'l-

1. *Kashf-uẓ-Ẓanūn*, Vol. II, p. 17.

'Aysh, Khatīb Abu'l-Ḥasan 'Alī, Shaikh Abu'n-Naja Sa'ati, Abū Muḥammad 'Abd-ul-Karīm of Sicily, Ibn-Ḥalabī, Ibn Haithamī, Abū Naṣr, Ibn-Dhayāb, Qala'ī.[1]

An observatory was founded at Baghdād in the days of the 'Abbāsid Caliph Mustarshid-bi'Allāh, who ruled till 529 A.H. The construction of this observatory, which was located in the palaces of the Seljukids, was commenced in 524 A.H. It was supervised by Badī' the astrolaber (died 534 A.H.) whom we have described earlier. He was a highly skilled engineer. This leads us to believe that the observatory under him must have been excellently planned, but we regret to find that this was not completed.[2]

Farīd-ud-Dīn Abu'l-Ḥasan 'Alī bin 'Abdul-Karīm Shērwānī, who is popularly known as Fahad, erected an observatory which was named Rasad-i-Fahad Shērwānī.[3] He was a renowned scholar of astronomy and observed the movements of stars with the help of ذات الشبين for thirty years, and had compiled a large number of *Zīj* based on his personal observations and researches. Five of his *Zīj* are *āl-Mughnī*, *āl-Muḥkam*, *āl-Mushtanfī*; *āl-Ma'dūl* and *āl-'Alāī*. These books have been regarded as trustworthy and authoritative by later scholars. Muḥammad bin 'Abī Bakr of Persia, who wrote a *Zīj* after the name of Malik Muẓaffar Yūsuf bin 'Umar, the ruler of Yemen, has relied mostly on Fahad Shērwānī's researches. The period of the latter's astronomical investigation is dated 541 Yezdgardi era, which is much nearer to the Hijri era, because the difference between the two is one of 3,625 days only.

The most notable observatory was at Marāgha. Its foundation is attributed to Hulāgū, but properly speaking it owed its construction mainly to the illustrious astronomer-scholar Naṣīr-ud-Dīn Ṭūsī. This was manned by a large staff of observers, who were mostly Muslims. Moreover, Hulāgū, according to some Muslim historians, had adopted Islam in the last days of his life, so we can conveniently include the observatory of Marāgha in the list of Muslim observatories. This was begun in 657 A.H. and scholars from distant lands were invited to supervise its construction. Mu'id-ud-Dīn, Najm-ud-Dīn Dabīrān, Fakhr-ud-Dīn, Marāghī, Fakhr-ud-Dīn Akhlaṭī came from Damascus, Qazwīn, Mosul and Thiyphilus respectively. Books for this observatory were procured from Baghdād, Syria and Mosul. 'Abdallāh bin Faḍlallāh Shīrāzī, the author of *Tārīkh-i-Waṣṣāf*, describes this observatory in the following words :—

" چون هلاکو از فتوحات فارغ شد، طوسی برائے بنائے رصدے تحریك کرد
هلاکو حکم داد هر چند که کافی مصارف باشد از خزانه داده شود بحکم فرمان موید الدین
از دمشق و فخر الدین اخلاطی از تهیفلیس احضار کرده و در مراغه از طرف شمالی بر سر پشتهٔ
رفیع رصد خانه بنافرمود و درکمال آراستگی در سنه ٦٥٦ هجری .... و تماثیل مثلات

1. *Maqrīzī*, Vol. I, p. 126.
2. *Ibn-i-Athir*, Vol. X, p. 254.
3. The name of the place where the observatory was located is unknown.

D—7

افلاك وتدویرات وحوامل ودوائر متوهمه ومعرفت اسطرلاب وتقاویم منقورهٔ ومنازل
ماه ومراتب بروج دوازده گانه برهیاتے ساخته شد که هر روز عند الطلوع پرتو نیر اعظم از
ثقبه قبه برسطح عتبه می افتاد وبرج ودقایق حرکت آفتاب وکیفیت ارتفاع درفصول اربعه
درساعات از آنجا معلوم می شد وشکل کرهٔ زمین وجزائر وبحار واقالیم سبع وطول ایام و
عرض وارتفاع قطب شمالی وصورت ووضع اسامی بلدان چنان روشن نمود که گوئی کتابیست
درممالك ومسالك وزیج خان (طوسی) بنام بادشاه تصنیف کرد وچند جدول ونکات حسابی
که در دیگر زیجات متقدمین چون کوشیار وعلائی وشاهی وغیره نبود افزود "

Some of the researches made in this observatory by Naṣīr-ud-Dīn Ṭūsī, Mu'id-ud-Dīn 'Aṣdī, Fakhr-ud-Dīn and others are as follows: (*i*) They supported Ibn A'lam's view that the fixed stars travel one degree in seventy solar years. (*ii*) The solar year covers 365 days, 5 hours and 49 minutes.

Abū 'Abbās Aḥmad bin Isḥāq Tamīmī, who is popularly known as Ibn-Kamad, was a renowned engineer of Tunis. According to Kātib Chalpī, he also made a series of observations. He made corrections in Khayām Ashbīlī's *Zīj*. These corrections refer also to the calendars of the year 679 A.H., which shows evidently that Ibn-Kamad lived till the latter part of the 7th century A.H.

'Alī bin Ibrāhīm, who is better known as Ibn-Shāṭir in historical books, acquired much fame by his achievements in the field of Astronomy. He hailed from Damascus and died in 777 A.H. His observatory was in Syria (the name of the actual place could not be traced). His great merit was that he made astronomical researches without being subservient to Ptolemy's theories. He had his own laws and principles, which contradicted many of Ptolemy's regulations. He compiled a manual dealing with the positions of stars. His *Zīj*, prepared from his own researches in his observatory, was very popular, and served as a guide to eminent scholars.

Taqī-ud-Dīn bin Ma'rūf Shāmī whom we have mentioned earlier was another renowned engineer, attached to the court of the Osmanli ruler Sa'd-ud-Dīn Affendi Sulṭān Murād. He compiled his famous book, سدرة منتهی الا فکار at the latter's instance. He also had an observatory, which he probably built at Sa'd-ud-Dīn Affendī's orders, we have not been able to discover the place where it was located.

Another noteworthy Muslim astronomer was Shams-ud-Dīn Muḥammad Yamili Khwaja Walkanvi, who made a series of observations for forty years with the help of many reformed instruments. He compiled a small *Zīj* on his observatory. He has referred to Ṭūsī's *Zīj*, which proves that he did not flourish prior to the 7th century A.H.[1]

1. These observatories are mentioned in *Kashf-uẓ-Ẓunūn*, Description of رصد.

7*

A most celebrated observatory was that of Ulugh Bēg, the son of Shāh Rukh Mīrzā and grandson of Amīr Tīmūr. He learnt astronomy from Qāḍīzāda Rūmī and developed a highly admirable taste in this art. In 853 A.H. he founded at Samarkand an observatory under the supervision of Maulānā Ghiyāth-ud-Dīn Jamshēd. After the latter's premature death, Qāḍīzāda undertook the task of completing the erection of an observatory and after his death he was succeeded by 'Alī bin Muḥammad Qoshjī. The remaining work of the observatory was accomplished by the latter.[1] Ulugh Bēg got for this observatory innumerable and highly serviceable instruments. The quarter-circle of this observatory was so high that half of its diameter was equal to the well-known mosque of Aya Sofia. The ruins of this observatory existed till the days of Bābur, who, in the course of describing the various buildings of Samarkand, writes: "Another of Ulugh Bēg Mīrzā's fine buildings is an observatory, that is, an instrument[2] for writing astronomical tables. This stands three storeys high on the skirts of the Kohik upland. By its means the Mīrzā worked out the Kurkani Tables, now used all over the world. Little work is done with any others. Before these were made, people used the Īlkhānī tables, put together at Marāgha by Khwāja Naṣīr Ṭūsī in the time of Hulāgū Khān."[3] From this statement of Bābur's we learn that the astronomical table prepared in Ulugh Bēg's observatory was such a perfect and reliable one that it threw Naṣīr Ṭūsī's *Zīj* into the background. I have also studied a commentary on Mīrzā Ulugh Bēg's *Zīj* and can say definitely that this is the best compendium of Muslim astronomy. Some of the researches in the observatory were:—(i) The time covered by the lunar month is 29 days, 31 minutes, 50 seconds, 4 Thalitha (thirds), 40 Raba' (fourths), and 30 Khamsa (fifths).[4] (ii) The extreme equation غايت تعديل of Mercury is 23 degrees, 26 minutes, and 3 seconds. (iii) The obliquity of the Ecliptic is 23 degrees, 30 minutes and 17 seconds.[5] (iv) The Persian astrologers believed that the origin of life in the organic matter of the world was in the Canary Islands (Khalidat), while the Indian astrologers were of opinion that it originated from Ceylon. But Ulugh Bēg advanced the theory that the earth was round, so that the origin of life in organic matter can be traced to any spot.[6]

Amongst the rulers of India, Fīrūz Shāh of the Bahmanī dynasty is highly conscious for his love of learning and literature. He was well versed in many sciences. He was a great lover of astronomy also and began the erection of an observatory on the summit of the pass near Daulatābād under the supervision of Ḥakīm 'Alī Ḥasan, Sayyid Muḥammad Kāzrūnī and other eminent scholars. But Ḥakīm 'Alī Ḥasan's death

1. شقائق نعمانيه, p. 19.

2. A. S. Beveridge writes in *the Babur-Nama* in English, Vol. I, p. 79, "As ancient observatories were themselves the instruments of astronomical observations, Babur's wording is correct."

3. *Ibid.*, p. 79.

4. *Jama' Bahādur Khānī*, p. 585.

5. *Ibid.*, p. 596.

6. *Ibid.*, p. 668.

put a stop to its completion.[1]

The second Mughal Emperor Humāyūn had an extraordinary liking for astronomy and celestial sciences. He learnt the art from Ilyās Ardbēlī, who was a master-mind in different branches of science. The king himself gave lessons in astronomy and mathematics like learned teachers. Nūr-ud-Dīn Turkhān Sufidīnī, who was well up in astronomy and arithmetic, was tutored by Humāyūn. The author of *Maāthir-ul-Umarā* writes that Nūr-ud-Dīn Turkhān " derived advantages in mathematics and particularly in the astrolabe from Humāyūn, who was well versed in these arts."[2] The king also utilized the services of Sayyid 'Alī, the Turkish naval commander, to make calculations of solar and lunar eclipses and help the Indian astronomers in learning the intricate details of the celestial sciences. Accordingly the Turkish naval commander set to work and completed the astronomical observations. Humāyūn's organisation of the court, the camp, and the orchard was also made on astronomical principles.

Humāyūn had made up his mind to build observatories, in many places and had prepared various intsruments for the purpose. Among these various instruments there was the astrolabe called Uṣṭurlāb-i-Humāyūnī, whose chief mechanic was Shaikh Allāh Dād.[3]

Humāyūn died while he was trying to observe Venus. He had converted the third storey of Shēr Shāh's Shēr Mandal, situated in the fortress of Old Delhi, into a library, because its height served the purpose of an observatory. On the day of his death he had fixed an assembly, when a number of officers were to get promotions. This Darbar was to be held with the appearance of Venus in the evening, and the emperor had sent for a group of mathematicians to observe the planet along with him. He was busy in discussion when the evening prayer-call was heard. Out of respect to the call, he wished to sit down where he was, but he slipped, and was fatally injured.[4]

We do not find the archæological remains of any observatory built by Shāh Jahān, although he had court-astronomers, who calculated his horoscope. Again, the Vazīr Āṣaf Khān proposed to make the year of Shāh Jahān's accession the beginning of a new era, called Tārīkh-ī-Ilāhī Shāh Jahānī, similar to Tārīkh-i-Jalālī. Accordingly a royal command was issued to Mullā Farīd Ibrāhīm Dehlavi to prepare a new Zīj. Mullā Farīd did not get sufficient time for fresh observations, so he based his Zīj, entitled کارنامہ صاحب قران ثانی زیج شاهجهانی on the tables of Ulugh Bēg, which, however, received many corrections and improvements.[5] From the preface to *Tajallī-i-Nūr* (history of Jaunpore) we learn that Maulānā Maḥmūd of Jaunpore received instructions to build an observa-

1. *Raudat-ul- Awliyā*, by Ghulām 'Alī Āzād Bilgrami, p. 22.
2. *Ma'āthir-ul-Umara*, Vol. I, p. 478, Calcutta edition.
3. *Vide* my article *Some Indian Astrolabe-Makers*, in *Islamic Culture*, Oct. 1935.
4. *Akbar Nāma*, Vol. I, p. 363 ; also H. Beveridge's translation, Vol. I, p. 363.
5. *Catalogue of the Persian Manuscripts* in the British Museum, Vol. II, pp. 459, 460.

tory, and he selected a plot of land for the same, but could not build it owing to the heavy expenses.

Raja Jai Singh Kachhwāha of Ambar, who was a distinguished military officer in the time of Aurangzēb and his successors, and the Governor of Agra and Malwa in Muḥammad Shāh's reign, was a learned scholar in Arabic and ardent lover of astronomy. He did not feel satisfied with the current almanacs, which were based on the tables of Ulugh Bēg, *Taḥṣīlāt* of Mullā Chānd Akbarī, and *Zīj Shāh Jehānī* of Mullā Farīd. So he got orders from the Emperor Muḥammad Shāh to call for the Muslim, the Brahmin, and the Christian astronomers of the country and lay the foundation of a new observatory in Delhi in 1137 A.H. In this observatory there were some instruments such as were used in Ulugh Bēg's observatory in Samarkand, and some were quite new, invented by the Rāja himself. He built similar observatories in Jaipur, Muttra, Benares and Ujjain to corroborate the observations made simultaneously in different places. These observatories were erected under the guidance of Mīrzā Khair Allāh. Bindraban writes in his *Safīna-i-Khushgo*, the manuscript of which is preserved in the Oriental Public Library, Patna, " Now-a-days his (Imām-ud-Dīn's) brother Mullā Abul Khair popularly known as Khair Allāh is unrivalled in astronomy, engineering, and other branches of learning. Rajadhiraj Jai Singh Sawai had just then in view the construction of several observatories. On these he spent twenty lakhs of rupees in twenty years under the supervision of Abul Khair,who is really a unique man of his age." Hindu, Muslim and European scholars worked in these observatories for seven years, after which some were sent to Europe under Padre Monoel's guidance for further researches. When they returned they compared the eastern method with the western and supported the latter. The researches made in these laboratories were embodied in *Zīj Muḥammad Shāh*, which consists of three sections: (*a*) current eras, (*b*) regulation of time, and (*c*) motions of the planets, stars and their positions. Some of the astronomical investigations made in these observatories are : (i) The period of the lunar month covers 29 days, 39 minutes, 34 seconds, 4 Thālitha (thirds), 24 Ruba '(fourths), and 34 Khamsa (fifths, (ii) Venus and Mercury have no light of their own but draw it from the sun. (iii) Saturn is not globular but elliptic. (iv) There are four moons (satellites) round Jupiter. (v) Some of the stars which we have believed to be fixed are really planets. (vi) The spots of the sun (which were found out for the first time by Ibn-Rushd) move. (vii) The orbit of the sun and all small celestial circles are eccentrically oval.[1]

SAYYID SULAIMAN NADVI.

1. For all these details vide *Jamā Bahādur Khani*, pp. 579, 586 and 628. As regards the spots of the sun we find the following version in *Sharaḥ-ī-Chaghmani* also (p. 13).

وزعم بعض الناس ان فی وجه الشمس نقطة سوداء فوق مرکزها بقلیل کالمحو فی وجه القمر.

(Some are of opinion that on the face of the sun, a little above its centre, there is a black spot, just as the moon has spots).

محو has been explained thus: کالمحو فی وجه القمر هو اختلاف اجزاء سطحه فی قبول النور

8

Description d'un Astrolabe persan construit par Muhammad-Mehdi.

L'auteur remercie vivement M. le professeur Armand ABEL, qui a bien voulu déchiffrer pour lui les textes persans et qui a apporté à leur traduction sa connaissance de la paléographie et des sciences orientales.

De tous les instruments scientifiques dont s'occupent les archéologues, les littérateurs et les artistes, l'astrolabe est peut-être celui qu'ils nomment le plus volontiers lorsqu'ils veulent évoquer les arcanes les plus mystérieux de la science. Quant aux mathématiciens et aux amateurs de sciences exactes, ils éprouvent également un respect admiratif pour le « joyau mathématique », l'ancêtre de tous les instruments astronomiques. Pourtant, les uns et les autres sont, en général, assez en défaut lorsqu'il s'agit d'expliquer le maniement de l'astrolabe.

Ce n'est pas que nous manquions de littérature à ce sujet! J'ai rappelé, dans un précédent article, les centaines d'ouvrages mentionnés dans la bibliographie de Houzeau et Lancaster. Mais malheureusement les livres anciens sont rarissimes, les modernes peu connus, et les uns comme les autres d'une lecture assez rebutante.

Il serait donc utile de refaire la description d'un astrolabe typique, et j'ai choisi à cet effet un instrument persan du XVII^e siècle, dont l'exécution remarquable est bien caractéristique.

Cet astrolabe (fig. 1) est un disque de bronze, de 92,5 mm. de diamètre et 5,7 mm. d'épaisseur. Ce disque porte, dans les astrolabes arabes, une expansion nommée le *trône* (kursi) (*) à laquelle s'attache un *étrier* (ansa, urwa) où passe l'*anneau* de suspension (armilla suspensoria, halqa) lui-même muni d'un *cordon* (ilâqa).

Une des faces du disque est plate : c'est le *dos* (dorsum, zahr) (fig. 2); l'autre (facies) comporte un évidement circulaire de 79,5 mm. de diamètre, la *mère* (mater, umm) (fig. 3) et un limbe extérieur (limbus, hajra); dans la mère se logent plusieurs disques ou *tympans* (tabulae, safâ'ih) (fig. 4, B et C).

Le centre est traversé par un *pivot* (clavus, khutût) (fig. 4, E) muni d'une *clavette* qui dans certains astrolabes anciens, figure une tête de cheval et en prend le nom (equus, faras) (fig. 4, F).

Sur les tympans repose un disque très découpé, du même diamètre, qui figure un réseau (rete) que l'on nomme plus souvent *araignée* (aranea, ankabût) (fig. 4, A).

Une *alidade* à pinnules (dioptra, murî') se place sur le dos de l'instrument et pivote autour de l'axe commun; parfois un second *index* (ostensor) pivote comme un rayon sur la face antérieure, mais ce dispositif ne semble pas exister dans les astrolabes orientaux.

Toutes ces pièces portent de nombreuses indications, qui, sur l'astrolabe que je décris, sont gravées pour la plupart en relief, par un procédé qui consiste à ciseler les fonds, en réservant les caractères. Par endroits, le fond est encore recouvert d'une nielle noire, qui accentue la ciselure et lui confère une singulière élégance.

Face.

Le limbe porte une graduation de 360°, qui débute à l'aplomb de l'anneau de suspension et tourne vers la droite.

(*) A défaut des caractères spéciaux exigés pour la transcription des termes arabes, l'orthographe adoptée pour ceux-ci ne peut être qu'approximative.

Le fond de la mère porte, dans une série de cercles concentriques divisés par des arcs rayonnants, les noms des diverses villes suivantes, avec leurs latitudes, leurs longitudes, et une troisième indication qui est probablement l'azimut de la Qibla (la Mecque).

Du sud vers la droite.

Cercle extérieur :

Damghân — Samnân — Astarâbâd — Tâlaqân — Qum — Kâsân — Isfahân — Garfâdafân — Qazwîn — Hamadân — Yazd — Shirâz — Kâzûn — Shustar — Basrah — Bagdâd — Kûfa — Surra-man-Ra'a — Ardabil — Tabrîz — Marâgah — Naghjwan — Mausil — Halab — Dimishq — Bait-Al-Maqdis — Lahsâ — Sana'â — Masr — Madîna — Makka — Balad.

Cercle intérieur :

Al-Balâd — Qâin — Multan — Quandahâr — Samarkand — Bahâzâ — Bad-Khashân — Akra — Kâbul — Marv — Zustar — Tûn — Tûs — Nishabur — Sirfân — Bistâm.

Dos.

Il est divisé en deux par un diamètre horizontal, la *ligne est-ouest* (l'est étant à gauche et l'ouest à droite). La moitié supérieure est à son tour divisée en deux quartiers par un rayon vertical, qui va du centre au Sud et s'appelle en conséquence *ligne du milieu du ciel.*

Chaque quartier porte à sa périphérie une graduation de 0 à 90°, les zéros étant à l'est et à l'ouest et le degré 90 au sud, à l'aplomb de l'anneau.

Dans le quadrant supérieur gauche (quadrant S.-E.) on voit 60 lignes horizontales équidistantes, divisant le rayon vertical en autant de parties égales. On mesure ainsi directement les sinus des angles indiqués sur le quart de cercle extérieur.

Ce quadrant porte en outre 6 arcs de cercle, dont le centre est sur la « ligne du milieu du ciel » et dont les diamètres vont en croissant; ces arcs constituent un quadrant astronomique horaire indiquant les *heures inégales.* On sait qu'on nommait ainsi les heures résultant de la division en 12 heures *égales*, de l'espace de temps entre le lever et le coucher du Soleil. Ces heures ne sont donc pas, à proprement parler, inégales entre elles; elles diffèrent simplement de durée d'un jour à l'autre.

Nous décrirons plus loin l'usage de ce cadran solaire.

Dans le quadrant supérieur de droite (quadrant S.-O.) nous trouvons une série de cercles concentriques, à distances inégales l'un de l'autre. Le long du rayon vertical et du rayon horizontal s'échelonnent les signes du zodiaque, dont chacun occupe un espace proportionnel à la projection de son arc sur le plan du colure des équinoxes. Nous trouvons, du centre à la périphérie, le long du rayon vertical: le Cancer, le Lion, la Vierge, la Balance, le Scorpion, le Sagittaire, et le long du rayon horizontal : les Gémeaux, le Taureau, le Bélier, les Poissons, le Verseau, le Capricorne.

L'espace réservé à chaque signe est subdivisé en 5 parties par des cercles concentriques. Chacun de ceux-ci correspond donc à une période de 6 degrés de l'écliptique. L'astrolabe que nous décrivons est dit de ce chef *sudsi*, ou du 6e ordre.

Deux séries de 5 arcs recoupent ces échelles.

Les 5 arcs équidistants qui se dirigent vers le Sud indiquent, chacun pour une latitude déterminée, la hauteur du Soleil à midi, aux jours marqués par leurs intersections avec les cercles zodiacaux.

Dans l'espace compris entre le cercle du Capricorne et le bord de l'instrument, une inscription définit ces arcs: « *Les lignes du midi dans les lieux inscrits à leurs extrémités* ».

Les 5 arcs qui se dirigent vers l'Ouest donnent, chacun pour une ville déterminée, l'altitude du Soleil au moment où il traverse le cercle azimutal de la *Qibla*, c'est-à-dire la direction de la Mecque.

Dans l'espace compris entre le cercle du Cancer et le centre de l'instrument, une inscription définit ces arcs : « *les lignes de l'azimut de la Qibla, dans les villes dont les noms sont indiqués à leurs extrémités, au moment où le Soleil est en culmination occidentale* » (c'est-à-dire commence à décliner) et on lit d'autre part à l'extrémité des arcs vers l'ouest, les noms de : Kûfâ, Bagdâd, Isfahân, Yazd et Tûs.

Le demi-cercle inférieur porte les graduations suivantes, de la périphérie vers le centre :

a) une échelle des cotangentes correspondant aux angles indiqués sur le demi-cercle supérieur, au point diamétralement opposé. A gauche, en pieds; à droite, en pouces. Ces cotangentes expriment la longueur des ombres pour une hauteur du Soleil égale à l'angle considéré. C'est pourquoi le demi-cercle en question se nomme l'*arc des ombres.*

b) une subdivision de la graduation précédente en 5 parties.

Les graduations suivantes sont du domaine astrologique (1) :

c) le cercle des *planètes,* portant les noms des 5 planètes : Saturne, Zujal — Mars, Mirikh — Mercure, Utârid — Jupiter, Al Mushtari — Venus, Zuhra — etc., répétés à raison de 5 par signe du zodiaque, dans l'ordre de leurs termes ou limites.

d) le cercle des *limites,* c'est-à-dire le nombre des degrés dans chaque signe, attribués aux planètes précitées.

e) le cercle du *zodiaque,* à partir du Bélier, à gauche.

f) les *faces* des planètes, indiquant les planètes dominantes au jour considéré.

g) les *maisons* lunaires, c'est-à-dire les 28 stations de la Lune dans le ciel stellaire.

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(1) Chaque signe du zodiaque est en corrélation avec les planètes, et la position de celles-ci dans le signe leur confère un pouvoir ou « *dignité* » de plus ou moins grande importance.

La première dignité est la *maison*, c'est-à-dire la consécration directe d'un signe à une planète.

La seconde est l'*exaltation* ou *domination:* c'est un instant déterminé dans certains signes, où chaque planète a son pouvoir maximum.

La troisième est la *triplicité*, c'est-à-dire la combinaison de trois signes ayant les mêmes influences sur les éléments. Chaque triplicité est sous l'influence d'une planète maîtresse.

La quatrième est le *terme* ou *limite:* c'est une subdivision de chaque signe zodiacal en 5 parties inégales, consacrées chacune et dans un certain ordre, à une planète.

La cinquième dignité, et la moins importante, est la *face*, d'origine égyptienne. C'est la consécration d'un espace de 10° c'est-à-dire à peu près dix jours, à une planète déterminée.

Enfin, au centre, un carré géométrique, ou carré des ombres, divisé à gauche en 7 (pieds) à droite en 12 (pouces) et donnant pour les diverses élévations du Soleil les longueurs des ombres, ou inversement les hauteurs des objets portant ombre.

L'intérieur de ce carré est divisé en 5 bandes horizontales. La plus élevée en indique l'usage : « *la nature des triplicités, ainsi que les maîtres de jour et de nuit* ». Les autres bandes sont divisées chacune en 10 loges, dont les dernières à droite contiennent les signes des 4 éléments: Nâri = Igné — Bara'î = Terreux — Hawâ'î = Aérien — Ma'âi = Aqueux; les 3 suivantes les Triplicités zodiacales, et les 6 de gauche les planètes dominantes dans ces triplicités.

Araignée.

L'araignée représente la projection stéréographique de la sphère céleste sur un plan parallèle à l'équateur; le centre de projection est au pôle antarctique; le cercle extérieur correspond au tropique du Capricorne.

La circonférence porte diverses inscriptions qui seront expliquées plus loin.

Elle est traversée diamétralement par la projection du colure des équinoxes, sous forme d'une barre rectiligne, la *traverse équinoxiale*.

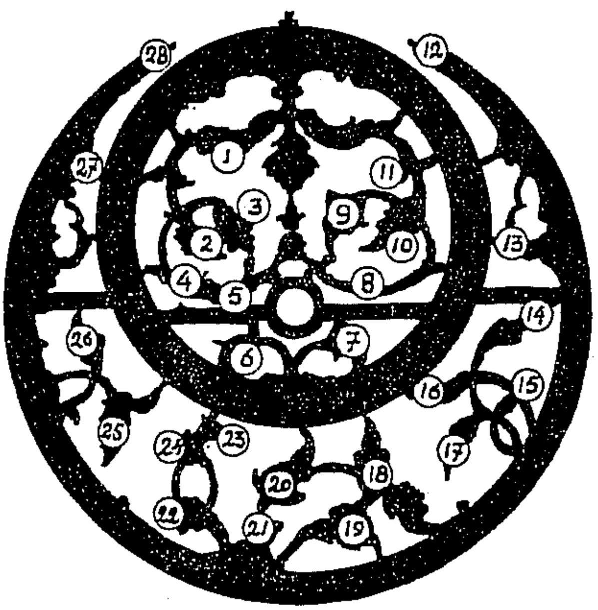
Le petit cercle excentrique est la projection de l'écliptique; il porte les 12 signes du zodiaque, que la traverse coupe aux débuts du Bélier et de la Balance. Au point initial du Capricorne correspond un petit index, le *murî'*, que la rotation de l'araignée déplace devant les graduations du limbe extérieur.

L'espace réservé à chaque signe du zodiaque est divisé, dans l'astrolabe qui nous occupe, en 5 parties, dont chacune correspond à 6 degrés de l'écliptique (astrolabe *sudsi*). Dans les instruments de plus grandes dimensions, les subdivisions vont jusqu'à 30 parties par signe (astrolabes *tamm* ou parfaits).

Le reste de l'espace occupé par l'araignée est découpé en une série d'index, en forme de feuilles entrelacées, dont les pointes correspondent chacune à la projection stéréographique d'une étoile importante.

Dans l'astrolabe qui nous occupe, nous relevons les 28 étoiles suivantes :

1. Al Nasr-al-Tâ'ir.	L'Aigle volant.	Altaïr.
2. Fum-al-Faras.	La bouche du Cheval.	ε Pegasi.
3. Minqar-al-Dajâja.	Le bec de la Poule.	β Cygni.
4. Mankib-al-Faras.	L'épaule du Cheval.	β Pegasi.
5. Kaff-al-Khadîb.	La main posée (?).	β Cassiop.
6. Al-Gûl.	Le Monstre.	Algol.
7. Zahr-al-Dubb.	Le dos de l'Ours.	α Urs. Maj.
8. Qâ'id.	Le Conducteur.	η Urs. Maj.
9. Nayyar-al-Fakka.	La lumière de la Couronne.	α Cor. Bor.
10. Al Samâk-al-Râmih.	Le Porte-lance.	Arcturus.
11. 'Unuk-al-Hayya.	Le cou du Serpent.	α Serp.



12. Qalb-al-Aqrab.	Le cœur du Scorpion.	Antares.
13. Al Samâk-al-Azal.	L'Homme sans armes.	Spic. Virg.
14. Janâh-al-Gurâb.	L'aile du Corbeau.	γ Corvi.
15. Qâida-al-Bâtiya.	Le pied de la Coupe.	β Crat.
16. Qalb-al-Asad.	Le cœur du Lion.	Regulus.
17. Fard-al-Shajâa.	La solitaire de l'Hydre.	Cor Hydrae.
18. Shaari-al-Shamiya.	Le Chien de gauche.	Procyon.
19. Shaari-al-Yamâniya.	Le Chien de droite.	Sirius.
20. Yad-[al-Juza]-al-Yumna.	La main droite du Géant.	Betelgeuse.
21. Rigel-[al-Juza]-al-Yumna.	Le pied droit du Géant.	κ Orion.
22. Nâbi-Masâfât-al-Nahr.	Le coude de la Rivière.	η Eridan.
23. Aïn-al-Thaur.	L'œil du Taureau.	Aldebaran.
24. Fum-al-Qaïtus.	La bouche de la Baleine.	γ Ceti.
25. Sadr-al-Qaïtus.	La poitrine de la Baleine.	π Ceti.
26. Danab-al-Qaïtus.	La queue de la Baleine.	ι Ceti.
27. Danab-al-Jad.	La queue du Chevreau.	δ Capric.
28. Manque.		

Tympans.

L'astrolabe contient 5 tympans élégamment gravés sur leurs deux faces. Neuf de ces diagrammes sont des projections stéréographiques de la sphère, établies chacune pour une latitude déterminée. Le point autour duquel rayonnent les arcs de cercle est la projection du point d'observation (zénith) situé à la latitude choisie.

Les arcs rayonnants sont les projections des azimuts issus de ce point.

Ils sont au nombre de 36, soit un par 10°.

Les cercles de diamètres croissants qui entourent le point d'observation sont les projections des almucantarats, c'est-à-dire les hauteurs successives au-dessus de l'horizon du point. On voit que notre astrolabe porte 15 de ces cercles, soit un par 6°, comme il convient à un astrolabe *sudsi* ou du 6e ordre.

Le plus grand des almucantarats est la projection de l'horizon.

Sur chaque tympan, sous la ligne d'horizon, est inscrite à droite la latitude pour laquelle il est construit; à gauche la durée du plus long jour en cet endroit; au milieu la ville ou les villes principales situées à cette latitude.

Certains instruments portent encore, sous la ligne d'horizon, un dernier arc figurant le parallèle où se trouve réellement le Soleil au moment de son lever ou de son coucher apparent (*ligne du crépuscule*).

Dans la moitié inférieure, l'espace compris sous l'horizon est divisé en 12 parties par des arcs de cercle qui représentent les lignes horaires divisant en 12 parts égales l'espace de temps entre le lever et le coucher du Soleil (heures inégales).

Sur 6 des tympans, on observe encore, dans la même partie, d'autres arcs, qui correspondent aux 24 heures régulières ou équinoxiales, comprises entre deux midi successifs (heures égales).

Pour distinguer les heures inégales des heures égales, les arcs des premières sont tracés en traits barbelés.

Autour du centre du tympan, 3 cercles représentent les projections du tropique du Cancer, de l'Equateur et du tropique du Capricorne. Une ligne diamétrale passe par les intersections de l'équateur et de l'horizon: c'est la *ligne des équinoxes*, projection du colure des équinoxes. Une autre, perpendiculaire, est la projection méridienne ou « *ligne du milieu du ciel* ». Elle se nomme, dans sa partie supérieure, *ligne de midi;* dans sa partie située sous l'horizon, *ligne de minuit,* ou encore l'*axe de la Terre*, dont elle est la projection.

Le 10e diagramme, dit Tympan des horizons, porte dans chacun de ses 4 quartiers, la projection des cercles d'horizon pour 5 latitudes diverses, sauf dans un des quadrants où il n'y en a que 4. On a ainsi 19 horizons différents en supplément aux 9 premiers diagrammes.

Ce tympan porte en outre les cercles habituels du Cancer, de l'Equateur et du Capricorne, entre lesquels 4 échelles donnent tous les degrés d'obliquité de l'écliptique, groupés de 4° en 4° sur un même rayon, de manière à former une graduation complète, clairement répartie sur 4 échelles distinctes.

Alidade.

L'alidade est constituée par une traverse, de longueur approximativement égale au diamètre de l'astrolabe, et dont un des côtés coupe diamétralement le dos de l'instrument.

L'alidade tourne librement autour du pivot. Ses extrémités, découpées en index, se déplacent devant les graduations du limbe. Deux pinnules à peu près carrées portent chacune deux trous superposés. Les trous inférieurs sont coniques, et leur orifice étroit, dirigé vers le pivot, n'a qu'une fraction de millimètre. Ces trous servent à orienter l'alidade vers le soleil, de manière qu'un rayon lumineux traversant la première pinnule, vienne se projeter sur le trou correspondant de la seconde. Les deux trous supérieurs, cylindriques et plus grands, servent à viser une étoile.

L'arête diamétrale, taillée en biseau, porte diverses graduations.

L'alidade étant orientée de l'est à l'ouest, en dessous du pivot, on voit sur sa moitié de gauche 6 traits inégalement distants, dont chacun correspond à deux des signes du zodiaque: en lisant du centre à la périphérie, le premier trait est utilisé quand le soleil est au solstice d'hiver (Capricorne), les suivants correspondent au Verseau, aux Poissons, au Bélier, au Taureau, aux Gémeaux; le trait extérieur marque le solstice d'été (Cancer), puis en revenant vers le centre, les mêmes intervalles correspondent au Lion, à la Vierge, à la Balance, au Scorpion, au Sagittaire.

Quand on oriente cette partie de l'alidade vers le Soleil, dans le quadrant supérieur gauche, le trait correspondant au signe du jour où l'on opère marque l'heure par son intersection avec une des lignes des heures inégales.

L'autre moitié de l'alidade porte du côté de l'arête douze divisions égales, partagées chacune en 5 par des subdivisions gravées sur l'arête.

Ces 60 degrés permettent la mesure des sinus.

Sur cette même moitié, du côté opposé à l'arête, se trouvent encore six traits inégalement distants, dont je n'ai pu encore trouver la destination.

Inscriptions.

Sur le trône se trouve une longue inscription qui reproduit intégralement la sourate koranique du trône (Chap. II, verset 256).

« Dieu est le seul dieu: il n'y a point d'autre dieu que lui, le
» Vivant, l'Immuable. Ni l'assoupissement, ni le sommeil n'ont
» de prise sur lui. Tout ce qui est dans les cieux et sur la terre
» lui appartient. Qui peut intercéder auprès de lui sans sa permission? Il connaît ce qui est devant eux et ce qui est der-
» rière eux, et les hommes n'embrassent de sa science que ce
» qu'il a voulu leur apprendre. Son trône s'étend sur les cieux
» et sur la terre, et leur garde ne lui coûte aucune peine. Il est
» le très-Haut, le Grand. »

(Trad. Kasimirski.)

Ce verset, dont le titre et le texte s'adaptent particulièrement bien aux instruments astronomiques, est fréquemment gravé en tout ou en partie sur le kursi des astrolabes persans (cf. coll. Lewis-Evans, Gunther n° 8).

Autour de la tranche extérieure se déroule l'inscription suivante :

« Dieu, accorde ton salut à Ali le pur, à Muhammad qui s'est
» attiré ta bienveillance et à la vierge Fatima et (fais le des-

» cendre) sur les deux généreux : Al-Hassan et Al-Hosein; et
» accorde ton salut au noble parmi tes serviteurs, Ali et
» Al-Baqir Muhammad, et le véridique Jafar et le silencieux
» Mousa et celui qui a mérité ta satisfaction : Ali; et au chari-
» table, au généreux guerrier Hassan; et écoute la prière de
» Muhammad et d'Ali, et oriente dans la direction du pèleri-
» nage éternel Muhammad-al-Mehdi, seigneur du temps. »

(Trad. Abel.)

Cette inscription qui, selon M. Abel, serait une litanie schiite en l'honneur des saints patrons de l'auteur (cf. coll. Lewis Evans, Gunther n° 8) pourrait être, également, un cryptogramme contenant les noms de divers célèbres constructeurs d'astrolabes persans, et pourrait également cacher la date de l'ouvrage, selon le chronogramme d'Abjad, fréquemment employé par Muhammad-Mehdi.

Enfin, l'écusson placé sous le carré géométrique contient, comme d'usage, la signature de l'auteur : Muhammad-Mehdi-al-Khâdam-al-Yazdî.

Il est souvent difficile d'identifier les constructeurs d'astrolabes persans, tout d'abord à cause des erreurs faciles de lecture, ensuite par la répétition fréquente des mêmes noms à des époques très différentes.

Le nom de Muhammad-Mehdi se retrouve sur divers astrolabes, dont la facture ressemble assez au présent instrument : Dans le catalogue de Gunther, je relève :

n° 8 = Mehdi de Yazd — AD. 1450 (?);
n° 18 = Muhammad de Yazd — AD. 1647;
n° 20 = Muhammad-Mehdi-al-Khâdam — AD. 1659;
n° 25 = Muhammad-Mehdi-ben-Muhammad Amin-Alradi — AD. 1667;
n° 44 = Muhammad-Mehdi (s.d.).

Tous ces instruments ont une parenté indubitable. Du même style sont ceux de Muhammad-Amin, de Muhammad-Tahir, son père, d'Abd-al-Ali, fils de Muhammad Rafi, ou Muhammad Shafi, et de son frère Muhammad-Baqir. Il doit s'agir là d'une famille d'astrolabistes célèbres du XVII^e siècle.

Sur de nombreux instruments de cette famille, on lit également une seconde signature, celle d'Abd-al-A'immah, qui s'intitule auteur de la gravure. Nous retrouvons en Orient la collaboration que j'ai déjà signalée pour les instruments européens, entre deux auteurs bien distincts : le calculateur et l'artiste exécutant.

Les anomalies de certaines dates peuvent s'expliquer par les difficultés de la paléographie, les cryptogrammes et les retouches (1). Ajoutons-y la transmission du nom du grand-père au petit-fils.

Gunther mentionne 1450 et 1469 pour trois instruments de Mehdi de Yazd, Abd-al-Alî et Abd-al-A'immah alors que les mêmes noms se retrouvent avec une exactitude plus probable entre 1659 et 1730.

La similitude presque complète entre notre astrolabe et celui d'Abd-al-Alî au British Museum (décrit par Morley dans son ouvrage célèbre), astrolabe qui date indubitablement des premières années du XVIII[e] siècle, me semble en préciser l'époque.

Usage de l'Astrolabe.

Je me garderai bien d'exposer en détail tous les problèmes que l'astrolabe résout élégamment; on m'en voudrait de reprendre les 25 questions de Severus Sabokt (AD. 650), les 43 d'Al-Khwarizmi (+ 840), les 21 de Hermannus Contractus (+ 1054), les 64 de Blundeville (1613) pour ne point parler des 103 problèmes de Clavius et des 1.000 de Jabîr-al-Sûfî! Je rappellerai qu'il existe à peu près 300 auteurs de Traités de l'Astrolabe, et je doute qu'ils aient eu beaucoup plus de lecteurs.

Pour ne point partager leur sort, je ne donnerai donc que quelques exemples très simples, à titre indicatif.

La première opération à faire au moyen de l'astrolabe consiste à prendre la hauteur d'une étoile au-dessus de l'horizon. Il suffit d'une visée au moyen de l'alidade. Connaissant ainsi l'almucantarat de l'étoile considérée, il est facile de choisir, sur l'araignée, l'index correspondant à cette étoile et de l'amener, par rotation de l'araignée, sur le cercle de l'almucantarat observé. Bien entendu, on se servira du quartier est, si l'obser-

(1) Je rappelle à ce sujet l'astrolabe d'Arsenius, au musée de Cluny, qui porte la date de 1661, alors qu'Arsenius avait disparu dès 1575.

vation a été faite avant le passage de l'étoile au méridien, ou du quartier ouest après cette heure.

Dès ce moment, l'instrument est en position de travail : toutes les autres étoiles se trouvent également sur leurs almucantarats respectifs.

Au lieu d'observer une étoile, on peut évidemment observer le Soleil: c'est alors le signe zodiacal correspondant au jour de l'observation que l'on amènera sur l'almucantarat relevé.

L'*heure astronomique* est aussitôt indiquée par la position du petit index (murî') sur le limbe.

L'*heure civile* est donnée par la position du point du cercle zodiacal diamétralement opposé au signe zodiacal du jour de l'observation ; ce point touche l'une des lignes horaires gravées sur le tympan, et indique en conséquence l'heure inégale ou l'heure régulière selon que l'on fait la lecture sur l'un ou l'autre système de lignes horaires (1).

La *durée du jour civil* est donnée par l'angle que doit décrire l'araignée pour que le point zodiacal du jour considéré passe de l'horizon est à l'horizon ouest.

Le *moment des principales prières* se lit aisément d'une manière analogue ; certains instruments portent, en sus des courbes horaires, des lignes spéciales à cet effet (lignes du crépuscule, ligne de la prière d'après-midi, etc.).

Un point très important au point de vue astrologique est la détermination du *Tâli* (horoscope), c'est-à-dire de l'étoile qui se lève au moment d'un phénomène quelconque, par exemple une naissance. Il suffit pour cela de connaître la hauteur du Soleil et sa position dans le zodiaque au moment de l'événement. Cette indication est généralement donnée par les tables astrologiques. En plaçant le signe en question sur son almucantarat, on voit immédiatement quel est à ce moment *l'ascendens*, l'*horoscope*, par la simple lecture du signe zodiacal qui se trouve sur la ligne d'horizon est. Cette détermination est le point de départ de toute l'astrologie divinatoire. C'est dire son importance pour nos ancêtres.

Le lecteur comprendra qu'il est tout aussi facile de trouver,

(1) Je passe les détails relatifs à la lecture des fractions d'heure.

par une simple lecture, l'heure et la direction du lever d'une étoile quelconque, et notamment du lever du Soleil.

Au moyen des tables planétaires et lunaires, l'instant d'apparition, sur l'horizon est, d'une planète ou de la Lune se précisent aussi aisément.

Enfin, par une simple lecture, les ascensions droites des astres et leurs déclinaisons se déterminent immédiatement. Ces changements de coordonnées sont indispensables dans les calculs astrologiques.

Les nombreuses abaques tracées sur l'instrument permettent en outre la solution de tous les problèmes usuels de topographie, de gnomonique et de trigonométrie.

Quant aux tracés astrologiques, je me bornerai à les évoquer respectueusement. Rappelons qu'il s'agit en général de déterminer, en premier lieu, les points de la sphère céleste qu'une étoile influence par sa position — sextile, quadratique ou trine — selon que l'angle entre l'étoile, l'observateur et le point concerné est de 60°, 90° ou 120°. Ce problème délicat des « aspects » se résout par un seul déplacement de l'araignée.

En résumé, l'astrolabe n'est qu'une règle à calcul circulaire; les problèmes que la trigonométrie sphérique ou la géométrie descriptive ne résolvent que péniblement y trouvent une solution instantanée, grâce aux heureuses propriétés des projections stéréographiques.

On reste confondu d'une telle ingéniosité dans un instrument dont l'invention remonte aux temps des invasions barbares. Sans disposer d'aucune méthode de calcul, sans algèbre, sans analytique, sans descriptive, par une simple intuition géniale et l'observation attentive des sphères armillaires, Synesius et ses successeurs ont établi le plus merveilleux des instruments de mathématiques, guide infaillible des astronomes de tous les temps.

HENRI MICHEL,
Ingénieur A. I. Br.

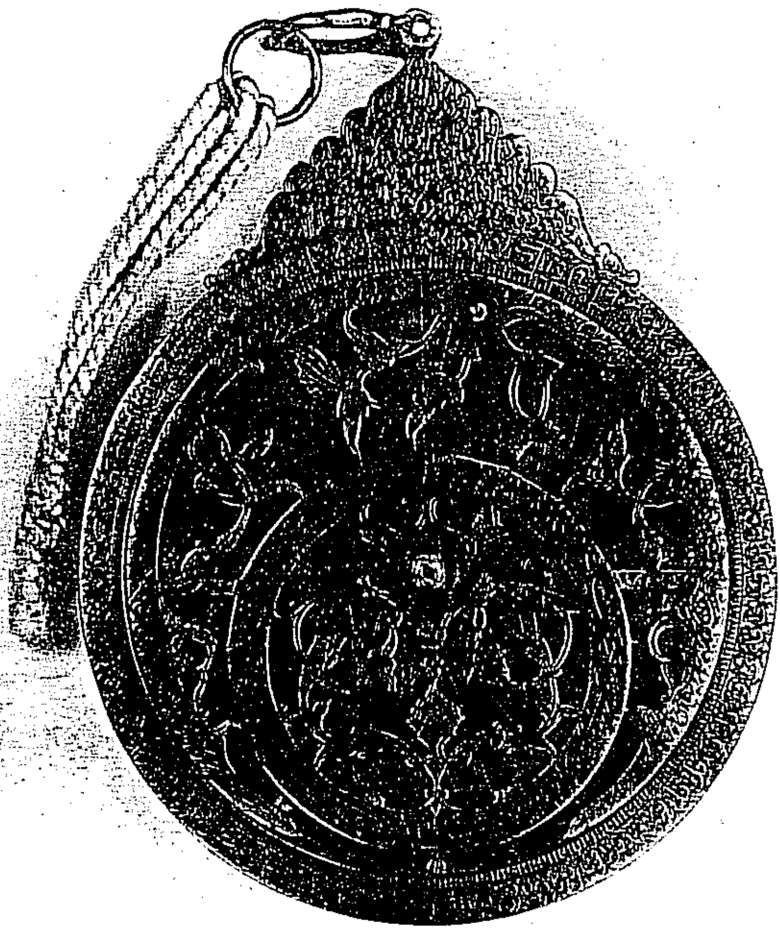


Fig. 1. — Astrolabe de Muhammad-Mehdi (Face).
Gr. 1/1 Coll. de l'auteur.

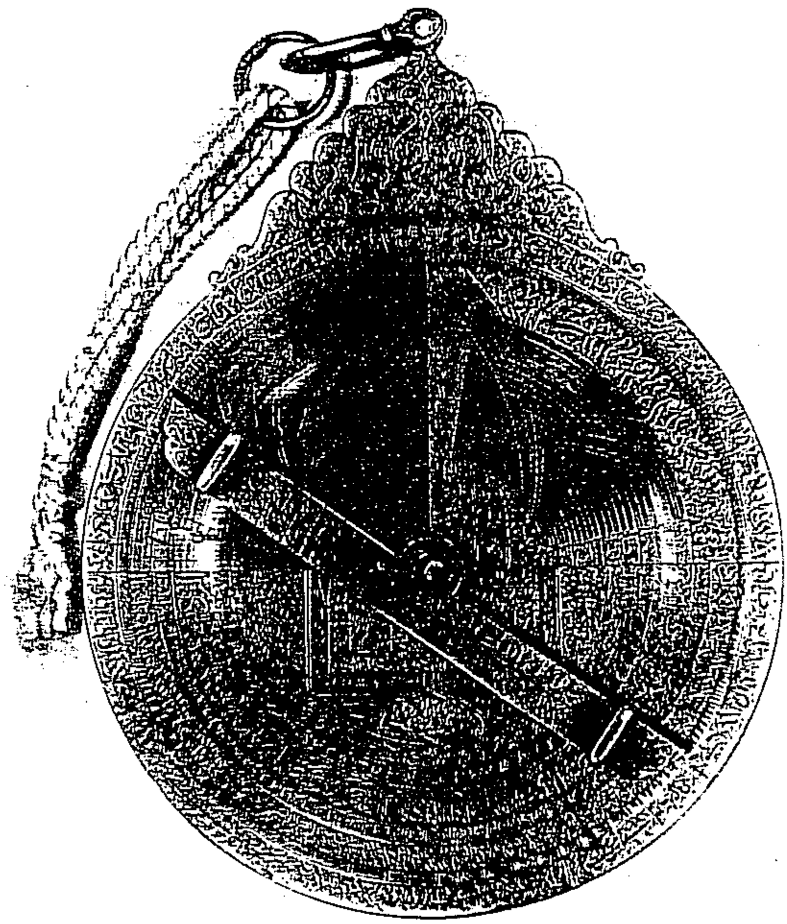


Fig. 2. — Astrolabe de Muhammad-Mehdi (Dos).

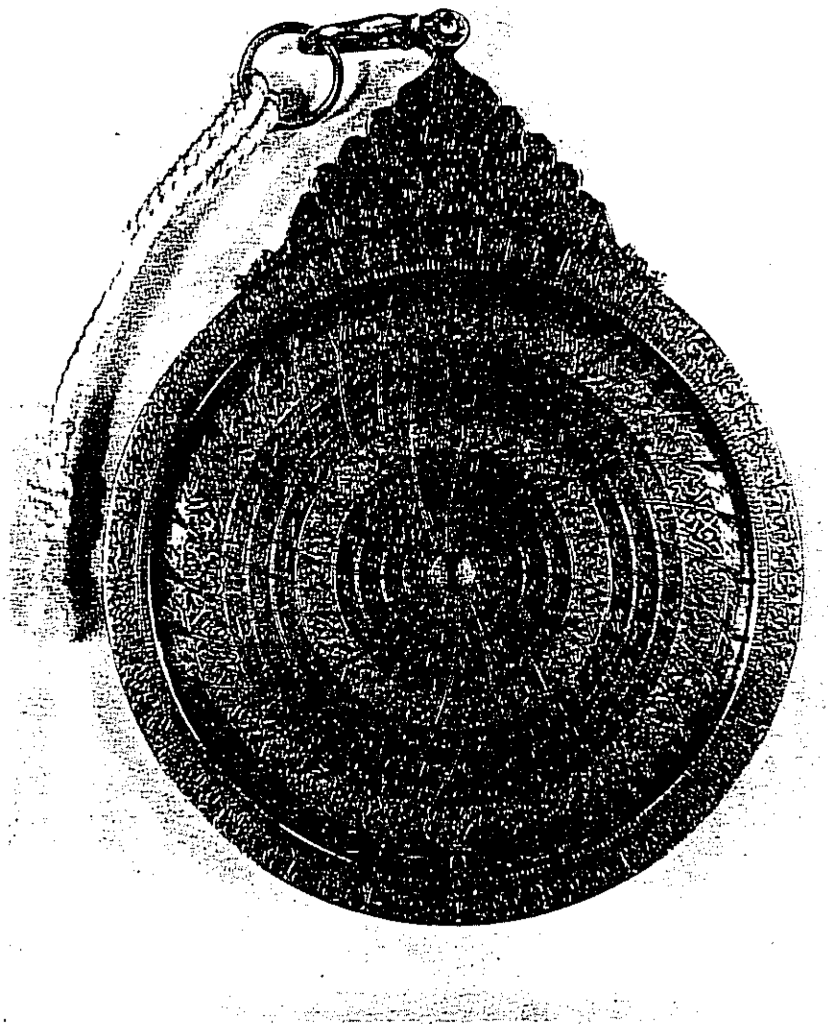


Fig. 3. — Mère de l'Astrolabe.

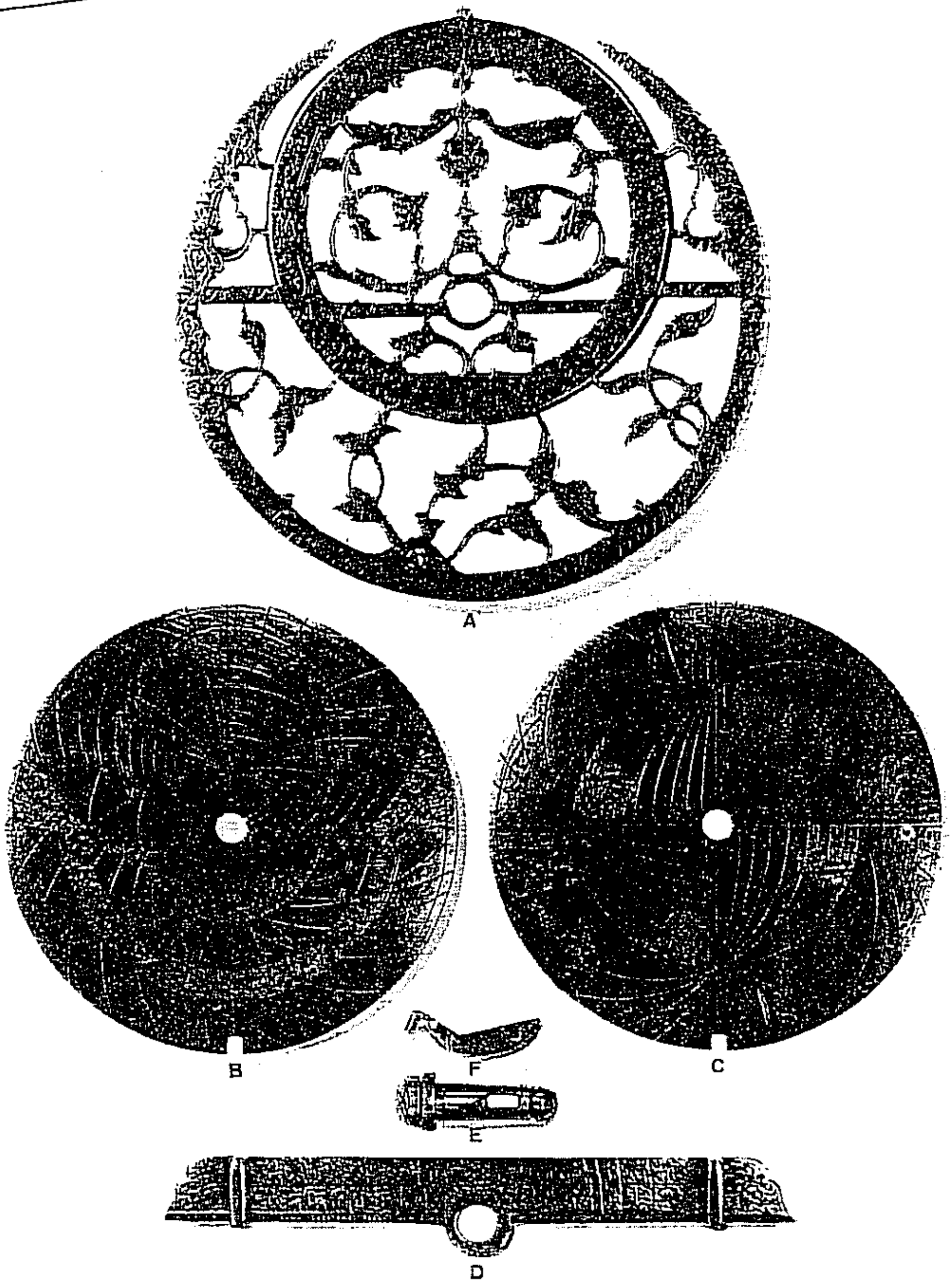


Fig. 4. A : Araignée. – B, C : Tympans (Réduits aux 3/4).
D : Alidade. E : Pivot. – F : Clavette.

Méthodes de tracé et d'exécution des Astrolabes persans.

Dans un ouvrage qui semble bien éloigné de nos sources habituelles, on rencontre une contribution intéressante à l'histoire des sciences astronomiques. Le journal des *Voyages de M. le Chevalier Chardin en Perse et autres lieux de l'Orient* contient, en effet, un chapitre remarquable et très détaillé, où l'auteur décrit les procédés graphiques et techniques employés par les astronomes persans pour le tracé de leurs astrolabes.

Cette partie du journal de Chardin a été rédigée en 1674, alors que l'auteur résidait à Ispahan, sous le règne éclatant de Shah Abbas II. De cette époque datent les plus beaux instruments de nos collections (1). Les astronomes qui ont documenté Chardin, Muhammad-Amin et Hassan-Ali, sont connus parmi les plus brillants constructeurs d'astrolabes. Nous recueillons ainsi des indications précieuses sur des méthodes dont la perfection n'a jamais été dépassée.

Rappelons que Jean Chardin, né à Paris en 1643, fils d'un joaillier protestant, fit de 1665 à 1670 un premier séjour en Perse, pour y acheter des diamants. Nommé *marchand royal* par l'empereur Abbas II, il revint en France pour y faire monter quelques bijoux destinés au Shah, et retourna aussitôt en Perse pour un nouveau séjour de plusieurs années. Ses fonctions et une certaine connaissance de la langue lui permirent d'approfondir l'étude des mœurs et des sciences persanes. Il eut l'esprit de noter soigneusement ses moindres observations, et sut s'entourer, comme on le verra, de collaborateurs compétents.

A son retour en Europe, Chardin dut se retirer en Angleterre, à la suite de la Révocation de l'Edit de Nantes. Il y fut fait chevalier par Charles II, et c'est de là qu'il publia, en 1686, à Londres d'abord, à Amsterdam et à Lyon ensuite, la première partie de son journal de voyages. Ces éditions ne contiennent pas le passage que nous reproduirons plus loin. Ce n'est que

(1) Des photographies d'astrolabes persans d'Abd-al-Ali (vers 1700) et Muhammad-Mehdi (1649) ont été reproduites dans *Ciel et Terre*, sept. 1933 et août 1936.

dans la quatrième édition (Amsterdam, 1711), et dans la cinquième (Paris, 1723) que nous le trouverons pour la première fois.

Malheureusement l'épure qui accompagne le texte, dans ces deux éditions, semble avoir été tracée, par Chardin ou par un de ses collaborateurs, avec une fantaisie étrange. Elle fourmille d'erreurs et le texte, qui déjà manque parfois de clarté, en devient absolument inintelligible.

Je me suis donc permis de l'annoter, et de *traduire* l'auteur d'une manière que je crois plus conforme à la langue moderne de la géométrie. Ce petit travail m'a permis de reconstituer l'épure exacte. J'ai décomposé celle-ci en quatre parties pour la rendre plus claire et je me suis aussi abstenu de reproduire le dessin original, qui ne nous apporte que de la confusion.

Avant d'aborder la reproduction et le commentaire du texte de Chardin, je crois utile de rappeler sommairement les principes du tracé de l'astrolabe. Cet instrument, si souvent cité, n'est en effet connu que de rares spécialistes.

Une brève description de l'astrolabe a été publiée dans cette revue (2) et l'explication détaillée d'un astrolabe persan y a également paru il y a quelques années (3). Je ne reviendrai donc ici que sur le tracé de ses éléments principaux : le *tympan* et l'*araignée*.

Le tympan n'est qu'une carte du globe terrestre. On y indique principalement l'équateur, les tropiques, les azimuts et les almucantarats pour une latitude déterminée. Il y a un tympan pour chaque latitude.

L'araignée est une carte du ciel. On y indique le zodiaque et les principales étoiles.

L'araignée étant mobile par rapport au tympan, on peut reproduire à volonté toutes les positions relatives du ciel par rapport à la Terre. On en déduit facilement les observations que j'ai sommairement exposées dans les notes précitées.

Le tracé des deux cartes susmentionnées s'obtient par projection stéréographique. Rappelons que cette projection est une

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(2) H. Michel, Les Anciens Instruments de Mathématiques. *Ciel et Terre*, septembre 1933.

(3) H. Michel, Description d'un Astrolabe persan construit par Muhammad-Mehdi. *Ciel et Terre*, août-septembre et octobre 1936.

projection polaire, issue du Pôle Sud, sur un plan de projection qui se confond avec le plan de l'Equateur (fig. 1).

Rappelons encore les deux propriétés les plus remarquables de ce mode de projection :

La projection stéréographique d'un cercle de la sphère, petit ou grand, est un cercle.

L'angle de deux lignes tracées sur la sphère se projette en vraie grandeur.

Dans l'extrait qui va suivre (*), j'ai copié scrupuleusement le texte de l'édition de 1723 (vol. V; pp. 89 et ss.). J'en ai respecté la forme et l'orthographe. Chardin, qui n'était pas mathématicien, est excusable de n'avoir pas été plus clair. Il faut, au contraire, rendre hommage à ce joaillier qui sut nous transmettre une documentation précieuse sur un sujet fort aride.

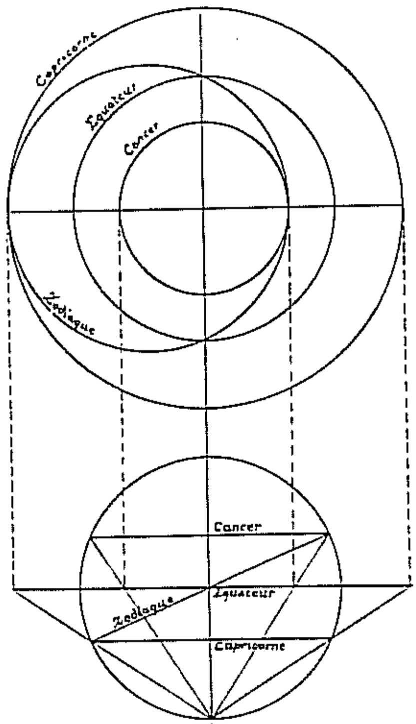

Fig. 1. — Principe de la projection stéréographique (projection sur le plan de l'Equateur).

Si tous les voyageurs nous avaient laissé des notes aussi complètes sur l'avancement des sciences et de la technique dans les contrées qu'ils ont visitées, l'étude de l'astronomie chinoise, précolombienne ou océanienne en serait singulièrement facilitée, et les ouvrages qui en traitent seraient débarrassés de nombreuses considérations purement hypothétiques ou conventionnelles.

(*) M. Djalaleddine Teherany, qui a bien voulu examiner le texte ci-après, y a trouvé matière à d'intéressantes notes que nous reproduisons. Les notes de M. Teherany sont suivies du signe (T) pour les distinguer des notes de M. Michel. (N. d. l. r.)

Extrait
des
Voyages de Chardin.

Comme l'Astrolabe est presque l'unique instrument Astronomique des Persans (4), on peut dire aussi qu'ils l'ont le mieux fait & le plus exact de tout le monde. Les lignes & les cercles sont tirez plus net & juste que le meilleur trait de plume, sans faute de trait, ni variation de Compas : ils passent en cela les meilleurs ouvriers que nous ayons : on peut l'assurer fort positivement, & qu'on ne voit cet Instrument nulle part si curieusement fait, & avec tant d'exactitude & de délicatesse, ni gardé avec plus de soin & de propreté; car les Persans le tiennent toûjours dans des étuis & des sacs, quoique l'air de Perse n'enrouille, ni ne salisse & ne ronge pas le corps, comme il fait dans nos Païs Septentrionaux : parmi le commun peuple même chacun garde son Astrolabe comme un bijou. Ce qui fait que les Astrolabes sont si bien travaillez, c'est que pour l'ordinaire ils sont faits par les Astronomes même; ce n'est pas qu'il n'y ait des Artisans de profession pour les Instruments de Mathématique : mais c'est qu'on n'estime pas tant ceux qu'ils font, que ceux qui sont faits par les Mathématiciens, qui ne sont pas si sujets à se méprendre aux nombres, & qui marquent plus juste les chiffres & les figures.

Il faut ajoûter à cela qu'un Astronome n'est point mis au rang des Savans, s'il ne sait faire tous les Instrumens lui-même, & s'il n'y travaille mieux qu'un habille Artisan. Lors que j'étois à Ispahan, l'Astrologue le plus fameux pour la fabrique des Astrolabes, s'appelloit *Akound Mahomed Emin*, homme aussi Savant qu'il étoit excellent Artiste : c'étoit le fils d'un autre savant Astrologue, nommé *Molla Hassen Aly*. Outre qu'il possédoit la Science à fonds, il avoit la main la plus adroite qu'on puisse voir pour la composition des Instrumens de Mathématique. Le Supérieur des Capucins d'Ispahan, chez qui je logeois d'abord, homme fort versé dans les Mathématiques, m'avoit donné sa connaissance : il m'y menoit souvent, & m'apprenoit à entendre ce que je voyois faire. C'est à cet habile *Mahomed*

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(4) Il est certain que Chardin n'a pas vu les collections d'instruments persans lorsqu'il écrit que l'astrolabe est presque l'unique instrument de ce pays. (T).

Emin que j'ai vû faire tout ce que je vai raporter sur l'Art des Astronomes Persans, pour la composition des Astrolabes. après que j'aurai fait quelques observations sur les termes dont les Persans se servent dans la Science Astronomique.

. . . .

Je viens à l'Astrolabe, & je dirai d'abord que ce nom vient d'*Asterleb* (5), terme Persan, qui veut dire levres des Etoiles; parce que c'est par cet Instrument que les Etoiles se font entendre. D'autres disent, qu'il faut prononcer *Astir lab*, c'est à dire, connoissance des Etoiles, & c'est comme les Persans apellent d'ordinaire cet Instrument-là; mais dans leurs livres & dans leurs leçons ils l'apellent *Veza Kouré*, mot abrégé de *Veza el Kouré* (6), qui signifie position de la Sphère, parce que cet Instrument & la projection des cercles de la Sphère est un plan. C'est sans doute de ce terme *Veza el Kouré* qu'est venu le terme barbare de *Valzagore*, qui se trouve dans *Regiomontanus*, & dans les auteurs qui l'ont devancé, pour signifier l'Astrolabe.

Les Persans ont cet Instrument de quatre sortes, qu'ils apellent, entier, demi, d'un tiers, d'un sixième : c'est comme ils les distinguent. L'entier est ainsi nommé, parce que les Cercles parallèles à l'horizon sont marquez dessus de degré en degré : il est de neuf à dix pouces de diamètre, & ce sont les plus grands qui se fassent. Le *demi* est ainsi dit, parce que ces Cercles sont marquez de deux en deux degrez, & sa grandeur ordinaire est de six pouces. Les Astrolabes d'un tiers n'ont ces cercles marquez que de trois en trois degrez, & ne sont grands que de quatre pouces : & ceux d'un sixième, qui ne sont grands que de trois pouces, sont marquez de six en six degrez. On ne croiroit pas qu'ils fissent des Astrolabes plus petits que de trois pouces, mais il s'en voit qui n'en ont que deux.

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(5) Chardin ne connaissait certes pas le persan littéraire : le mot *Asterleb* est de pure invention. En fait, le mot arabe exact est : *Astorlâbe* et l'origine de ce mot est grecque. L'étymologie est *Astron lambanein*, c'est-à-dire instrument qui prend la mesure de l'astre. Al-birauny, vers 1020-1030, dit que le mot *Astorlâbe* signifie « miroir des étoiles », de *assthr* (étoile) et *lakhoûn* (miroir). (T).

(6) Exactement : *Vazé el-Koréh*, c'est-à-dire position du globe. Mais ce terme ne se rapporte pas à l'astrolabe. (T).

Les outils des Persans pour la construction de leurs Astrolabes sont de fer & d'acier. La Règle est d'acier, large de trois doigts, mince & déliée comme du parchemin. Le compas est de fer, & fort matériel, les pièces en sont grosses d'un doigt pour l'ordinaire, & carrées, les bouts sont percez en long d'un trou carré, profond d'un pouce, pour enchasser les pointes, qui sont d'acier très fin, de la grosseur d'un burin commun, pas plus longues qu'un pouce & demi, taillées l'une en poinçon menu & aigu. l'autre en burin, & la vis qui tient ces pointes, est d'une circonvolution fort pressée, bien limée, très juste, & ferme dans son écrou : la tête plate, brute, rivée comme les ciseaux de tailleur. c'est-à-dire, que le clou deborde, pour tenir l'Instrument plus ferme. L'arc qui tient le compas en état, est aussi de fer, large d'un doigt, soudé à une jambe, & passant par l'autre, avec une vis pour arrêter l'ouverture, comme à nos Compas ordinaires. Mais ce qu'il y a encore de different, c'est que cet arc est ataché à l'extremité du pied du compas, à l'endroit où la pointe d'acier y entre. Les Persans raportent à la force & à la fermeté du compas, dont les pieds ne branlent, ni ne vacillent le moins du monde, la netteté & uniformité des traits, ou lignes courbes de leurs Astrolabes, qui est assurément admirable; ils la raportent, dis-je, à cela, autant qu'à l'art de celui qui tire les lignes. Tel est le Compas ordinaire des Astronomes Persans. Ils en ont un d'autre sorte pour tirer les arcs des grands Cercles, comme les *Azymuths,* qui est fait comme je vais le dire. C'est une verge de fer carrée, grosse d'un doigt, à un des bouts de laquelle est arrêtée une pointe de fer carrée, hormis à l'extremité, où elle est ronde & fort aigue. Le long de la verge il y a un pied mobile à angle droit, qui s'arrête & se serre avec une vis, dont le bout porte une pointe carrée à l'extremité, comme un burin de graveur. En quelque ouverture que vous mettiez ce Compas, il est toujours à angle droit, & il fait un trait fort délié, égal & uniforme en ses bords, ce qu'un autre Compas dont les pointes sont toûjours à angle aigu ne sauroit faire, particulierement lorsque vous le faites passer au-delà du soixantième degré.

Mais le principal Instrument qu'ils ayent, pour la construction juste & exacte de leurs Astrolabes, & qui est une pièce dont je crois qu'ils se servent seuls, à l'exclusion des Europeans, c'est une platine, qu'ils apellent *destour* (7), ou régle, qui est un nom commun chez eux à toutes les méthodes d'operer : cette platine est de laton, de l'épaisseur d'un écu, de la longueur d'un pied, bien pôlie & claire. J'en donne la figure à côté, & je vais y ajoûter la manière dont ils la composent, & celle dont ils se servent.

A un quart de la platine, c'est-à-dire, à trois pouces de hauteur, ils prennent le centre, marqué A, où ils tirent un demi cercle, dont le semi diamètre est coupé par une ligne, qui tire à angles droits sur son diamètre, qui est, comme vous voyez, A. E. M. par laquelle la figure se trouve divisée en deux quarts de nonante, l'un grand de neuf pouces, qui est le supérieur, & l'autre petit, qui est apellé ici quart inférieur, & n'est que de trois pouces. Le quart supérieur est divisé en cent huitante parties égales ou degrez dont les lignes, tirées du centre à la circonférence, se terminent aux extremitez de la platine, ne restant de place, que pour marquer les nombres par parties dixainaires, à commencer du semi diamètre susdit, marqué A. E. M. Le quart inférieur est aussi divisible en cent huitante parties égales, comme le quart supérieur, mais ils ne marquent les lignes ou degrez que de la moitié, comme l'on voit, & laissent la partie des autres nonante degrez vuide, & sans y rien tirer, comme ne leur servant de rien, ... (8).

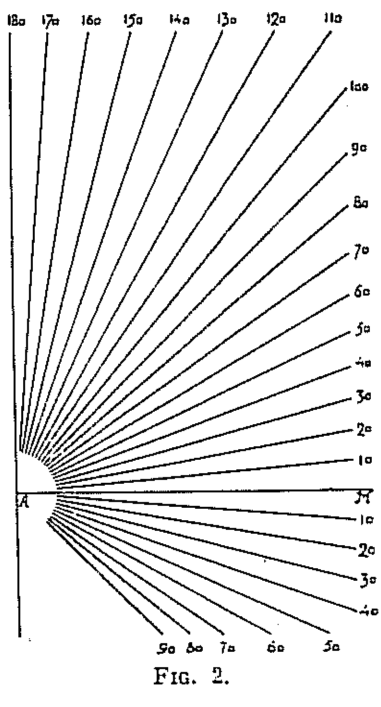

FIG. 2.

(7) Ou plus exactement *Dastoure*, c.-à-d. le rapporteur, qui sert aussi à d'autres usages. (T).

(8) Ce paragraphe peut se résumer comme suit :

Du point A, et de part et d'autre de la ligne A. M., tracer des rayons de 5 en 5 degrés, et cela sur un secteur d'un quart de cercle au-dessus de A. M., et d'un demi-quart au-dessous (figure 2).

Ces rayons, que j'appellerai dorénavant *lignes angulaires*, Voilà la source où ils puisent la justesse & la briéveté, avec quoi ils composent leurs Astrolabes, & voici comme ils se prennent à les faire. L'Astrologue tourne premièrement au tour le modelle de l'Astrolabe qu'il veut avoir, & puis il fait jetter son Astrolabe en moule : le fondeur le lui rend brute, & l'Astrologue le travaille, et forme lui-même, tant à la lime, qu'au tour, tant la mère de l'Astrolabe que les feuilles ou *Tampans,* qui sont d'ordinaire au nombre de cinq ou six pour les élevations des lieux, où la Cour a coûtume d'aller : après il pôlit ces feüilles, jusqu'à ce qu'elles soient liées et pôlies au possible, puis il les perce, se met à graver toutes les piéces de son Instrument, tant les mobiles que les immobiles, & puis il se met à tirer les lignes, se servant de l'étau à main ou à vis pour tenir les feüilles fermes. Les Persans apellent les *Tampans* d'Astrolabe *Sapheh,* c'est-à-dire feüille d'écriture, & la Mere d'Astrolabe, *Am asterleb* qui veut dire aussi Mere d'Astrolabe (9).

L'Astrologue prend ensuite son compas, qu'il accommode selon la grandeur de son Astrolabe, c'est-à-dire selon la grandeur de l'Equateur qu'il veut lui donner : il détermine par exemple A. E. pour être le semi diametre, puis il tire par E. perpendiculaire à A aux point marquez depuis E jusqu'à H pour prendre sa distance, laquelle il prend comme il veut entre A.E. ou E.B. l'une & l'autre étant égale, & ayant pris cette distance pour semi diametre, il tire le cercle entier de l'Equateur; les Persans apellent ce perpendiculaire E.H. *Kretel eslac* c'est-à-dire la ligne des Tangentes (10) : après il compte depuis E. jusqu'au haut nonante degrez, puis vingt trois degrez & demi de E terminez en C. il prend l'espace E.C. & avec cet espace pris du centre de l'Astrolabe, il décrit le Cercle ou Tropique du Capricorne :

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seront numérotés de 0, sur la ligne A. M., à 180 dans le quadrant supérieur, et de 0 à 90 dans le demi-quadrant inférieur.

Remarque : Cette platine sert une fois pour toutes et dispense de faire des épures de construction sur l'astrolabe lui-même.

Quel que soit le diamètre de l'astrolabe, toutes les mesures peuvent être prises commodément et exactement sur la platine seule. C'est donc de l'exactitude de celle-ci que tout dépend ; en revanche, elle peut être tracée avec un soin tout spécial.

(9) Exactement : *Saphîhah,* et *Omme-Astorlâbe.* (T).

(10) Exactement : *Khatt-al-azlâle,* ligne des tangentes. (T).

après continuant de même il compte nonante degrez, tirant de E vers D, il prend cet espace E.D. avec le compas & décrit le Cercle qu'on apelle le Tropique du Cancer, avec quoi il se trouve avoir décrit les principaux Cercles entiers & paralleles de l'Astrolabe qui reglent tous les autres, de sorte que pour tirer tous les Cercles paralleles à l'Equateur, il n'y a plus qu'à prendre les distances sur l'échelle E. L. des Tangentes (11).

Cela fait l'Astrologue tire sur son *Tampan* deux lignes droites, qui se coupant à angles droits dans le Centre, représentent, l'une, la ligne de douze heures ou de Midi, & l'autre la ligne de six heures, qu'on apelle autrement l'horizon droit. Après il se met à tirer l'horizon oblique avec tous ses Cercles paralleles,

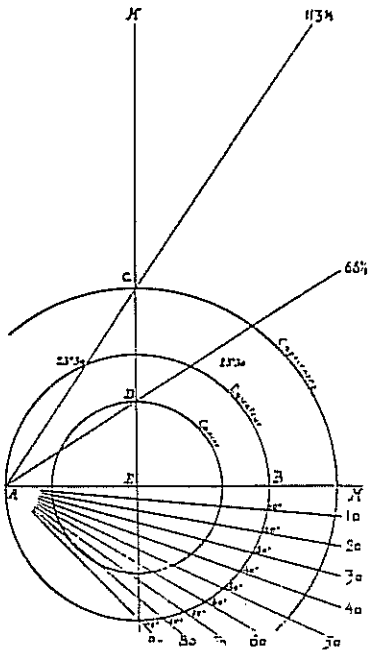

Fig. 3.

(11) Ce paragraphe peut se résumer comme suit :

Ayant choisi « ad libitum » le rayon de l'astrolabe à construire, soit A. E., le constructeur tire en E sur A. E. la perpendiculaire E. H., que Chardin appelle *ligne des Tangentes* (Figure 3).

Le cercle tracé de E comme centre avec le rayon E. A. est la projection de l'Equateur.

La ligne angulaire (90+23½) = 113½, A. C. coupe la ligne des Tangentes en C. Le cercle tracé de E comme centre avec le rayon E. C. est la projection du Tropique du Capricorne.

La ligne angulaire (90—23½) = 66½, A. D. coupe la ligne des Tangentes en D. Le cercle tracé de E comme centre avec le rayon E. D. est la projection du Tropique du Cancer.

On voit que cette construction est identique à la construction classique : le point A correspond à l'origine des projections (Pôle Sud) ; E. H. est la trace du plan de projection (plan de l'Equateur). (Comparer avec la fig. 1.)

Les angles de 5° que font entre elles les lignes angulaires issues du point A délimitent des angles inscrits dans le cercle de centre E et de rayon E. A. ; les segments qu'ils définissent sont de 10° ; c'est pourquoi les lignes angulaires sont numérotées comme nous l'avons dit plus haut : 0, 10, 20, etc., bien que n'étant séparées que par des angles moitié moindres.

Cette propriété est indépendante du diamètre du cercle E. A., du lesquels les Persans apellent *Moukan tareh* (12), c'est-à-dire arche de pont, terme que nos Astronomes ont changé en celui d'*Almicantaras*, qu'ils donnent à ces Cercles : l'Astrologue compte sur cette ligne des Tangentes, dans le quart superieur, ou inferieur, la latitude du païs, pour lequel il fait le *Tampan* : ainsi par exemple pour trente degrez de latitude, il se met à compter cette latitude de trente degrez, tirant de M. vers R. ou de K. vers L. c'est-à-dire de haut en bas, ou de bas en haut, & observant où ces deux lignes vont couper la ligne des Tangentes, ce qui arrive dans les points F. & H. il prend avec son compas cette distance, qui est assurément le diamètre de l'horizon oblique (13).

Après il prend la moitié de l'horizon oblique pour avoir le semi diametre & mettant une des pointes du compas sur l'une des sections de l'Equateur circulaire ou ligne de six heures : il fait avec l'autre pointe la section de la ligne Méridienne, avec quoi il se trouve avoir le centre de l'horizon oblique pour trente degrez de latitude, & puis resserrant son compas sur les deux

moment qu'il passe par A et que son centre est sur la ligne A. E. La construction est donc valable pour tout diamètre d'instrument à construire.

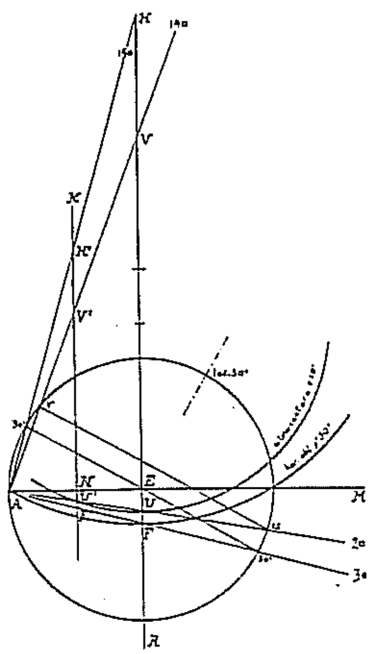

FIG. 4.

(12) Exactement : *al-Moghantarah*. (T).

(13) Ces deux paragraphes peuvent se résumer comme suit:
Soit à construire par exemple le tympan pour la latitude de 30° N.
Comptant 30° à partir de M sous A. M., on a la ligne angulaire 30, A. F., qui coupe la ligne des Tangentes en F. (Fig. 4).
Comptant 30° à partir de A vers le haut, on a la ligne angulaire 150, A. H., qui coupe la ligne des Tangentes en H.
Ces deux points déterminent le diamètre F. H. du cercle représentant l'horizon oblique pour la latitude de 30°. Le centre de ce cercle est à mi-distance de F. H.
C'est encore la construction classique.

degrez suivants, il en prend la moitié qui est le second *Almicantaras*. Les gens du Mêtier croiroient que l'Astrologue continueroit cette mechanique, jusqu'à nonante degrez, mais les Astronomes Persans, voyant que de couper ainsi les distances, en deux parties égales, celà consumeroit trop de tems, & donneroit aussi trop de peine, ils ont trouvé par démonstration de Géometrie, le moyen d'abreger ce long & ennuyeux calcul, en tirant la ligne N.Z. parallele à E.H. laquelle divise celle qui est marquée A.E. en deux parties égales, de sorte qu'il se trouve que les distances de N.Z. ne sont que les moitiez de E.H. & ainsi de suite par distances et moitiez de distances, avec quoi ils abregent cette laborieuse mechanique, & c'est comme ils tirent les Almicantaras, en double proportion (14).

L'Astrologue vient ensuite aux Cercles verticaux que nous apellons *Azymuths* du mot Arabe *Azimé*, c'est-à-dire grand, ou de celui d'*Elzemuth*, c'est-à-dire le sommet, & pour les tirer, il compte sur l'échelle E.H. le double de la latitude : ainsi par exemple pour celle de trente degrez il compte soixante degrez, puis marque par Y la secante, ou ligne traverse marquée A.Y. mise en A.D. & par D. il tire la ligne marquée D. T. avec quoi il a une ligne ou Echelle, dont les distances, ou Tangentes, lui donnent les centres des *Azymuths* (15), (16).

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(14) L'almucantarat à 10° au-dessus de cet horizon (u. v.) (figure 4) est délimité par les lignes angulaires 20 et 140 qui coupent la ligne des Tangentes en U et V. Le diamètre de l'almucantarat cherché est U. V.

Pour tracer au compas ces cercles, il faut en prendre le demi-diamètre. Au lieu de diviser péniblement en deux les distances F. H., U. V., etc., il est plus simple de tracer en N une parallèle N. K. à la ligne des Tangentes E. H. Si N est à mi-distance entre A et E, les sections F' H', U' V', etc., de la ligne auxiliaire N. K. comprises entre les lignes angulaires précitées donnent immédiatement les rayons des almucantarats successifs.

Connaissant ces rayons, et un seul point (F, ou U, etc.) des almucantarats correspondants, on peut tracer ceux-ci, en évitant la recherche des points extrêmes H, V, etc., et on simplifie considérablement l'épure.

(15) Exactement : *Azimah-al samte*, le grand cercle de direction. (T).

(16) Ce paragraphe est très obscur, et l'épure que donne Chardin le rend tout à fait inintelligible. Voyons d'abord le procédé classique tel que le donne Stöffler, dans son *Elucidatio fabricae ususque Astrolabii* (1513) :

Par même Calcul il fait les cercles des douze maisons, les tirant avec le semi diamètre de l'horizon oblique, qui est le premier cercle des douze maisons : ensuite il décrit les heures babyloniques et la ligne Crepusculine. Pour ce qui est des Heures Planetaires, comme leurs arcs, si on les examine à la rigueur de la Perspective, ou la Géometrie, ne sont point des arcs ou cercles parfaits, mais bien des lignes courbes irrégu-

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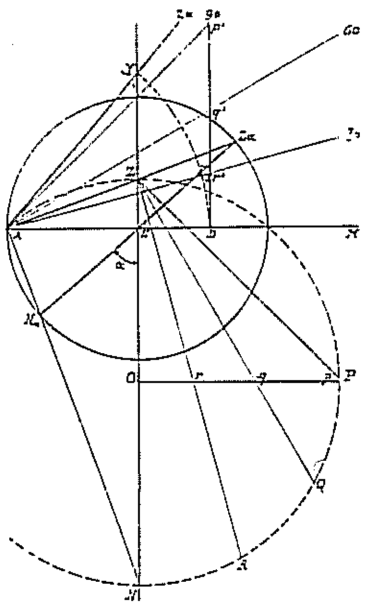

Fig. 5.

Tracé des Azimuts pour la latitude α (Fig. 5) :

De A, centre de projection, joindre le point Zα, zénith du lieu. Sa projection sur le plan de l'Equateur sera Z.

De A, joindre le point Nα, nadir du lieu. Sa projection sera N.

Le centre de la projection du premier azimut sera O, sur la méridienne Z. N. à mi-distance de Z et N, et le diamètre de ce cercle sera Z. N.

Tous les azimuts pour la latitude α passent par Z et N. Le lieu géométrique de leurs centres sera donc O. P.

Ayant divisé le cercle Z. P. N. en autant de parties qu'on veut tracer d'azimuts, par exemple de 30 en 30 degrés, on joint Z aux divers points P, Q, R, etc. L'intersection des lignes Z. P., Z. Q., Z. R. avec le lieu O. P. donne les centres p, q, r des azimuts successifs.

Le rayon de ceux-ci est évidemment Z. p., Z. q., Z. r., etc.

L'inconvénient du mode de construction classique est que pour les points situés entre Z et P, l'épure prend des dimensions excessives, et il est difficile de la tracer exactement sur le tympan lui-même. Stöffler conseille de coller celui-ci sur une longue planche, dont le fond doit d'ailleurs être relevé pour le mettre au niveau du tympan.

Méthode persane :

On suit la ligne angulaire issue de A qui fait avec A. E. un angle *vrai* de α. C'est donc la ligne numérotée 2α.

Cette ligne coupe la ligne des Tangentes en un point Y.

On porte sur A. E. une distance égale à A. Y. et on obtient un point D (fig. 5). A. D. = A. Y.

Par ce point D, on mène une parallèle à E. Z. Cette parallèle est lieres, l'Astrologue Persan, les tire comme nous, par trois points donnez, ce qu'il fait mécaniquement, sa platine, ou régle, ni toute la Science n'arrivant pas à fournir d'autre méthode. comme chacun le sait (17).

Quant à la *Volvele,* ou *Rete* que les Persans apellent *Enkebout,* c'est-à-dire araignée, qui est le nom que nous lui donnons aussi. comme ce n'est qu'un tampan pour le complément de la grande déclinaison, elle est faite sur un tampan divisé pour 66 & demi degrez de latitude : l'Astrologue y pose les Etoiles, suivant leurs longitudes & latitudes tirées de leurs livres, & entr'autres

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une ligne auxiliaire qui va nous donner directement les positions des centres de tous les azimuts pour la latitude α.

En effet, la distance Z. O. est égale à A. Y., car :

$$Z.O. = \tfrac{1}{2}\, Z.N. = \tfrac{1}{2}\,(Z.E. + E.N.), \text{ et si nous posons } AE = 1 :$$

$$Z.E. = \operatorname{tg} \frac{90^\circ - \alpha}{2} = \frac{1 - \cos(90^\circ - \alpha)}{\sin(90^\circ - \alpha)} = \frac{1 - \sin\alpha}{\cos\alpha}$$

$$E.N. = \operatorname{tg} \frac{90^\circ + \alpha}{2} = \frac{1 - \cos(90^\circ + \alpha)}{\sin(90^\circ + \alpha)} = \frac{1 + \sin\alpha}{\cos\alpha}$$

$$Z.N. = \frac{2}{\cos\alpha} = 2 \text{ séc. } \alpha = 2 \text{ A.Y.}$$

D'autre part, D. r' est égal à O. r. ; D. q' est égal à O. q. ; D. p' est égal à O. p, etc., puisque les angles inscrits que font entre elles les lignes angulaires A. D. ; A. r' ; A. q' ; A. p', etc., sont égaux à ceux que font les lignes Z. O. ; Z. r. ; Z. q. ; Z. p. ; etc., et que Z. O. = A. D.

En bref, la construction A. D. r' q' p' est identique à la construction Z O rqp ; elle donne immédiatement, sans tracé sur le tympan, la position du point O et les distances des centres des projections des azimuts depuis le point O.

(17) Ici, on a l'impression que Chardin escamote un peu la difficulté. Toutefois, les tracés dont il est question dans ce paragraphe sont faciles.

Les douze maisons sont des fuseaux qui ont leur pôle au point d'intersection de l'horizon oblique avec la ligne méridienne. Les cercles qui les délimitent passent par douze points de l'Equateur équidistants entre eux. Il suffit donc de diviser la projection de l'Equateur en douze parties égales à partir de la ligne méridienne. Par ces points pris deux à deux et l'intersection F de l'horizon avec le méridien (Fig. 4), il est facile de faire passer des cercles. Ce tracé doit évidemment se faire sur le tympan lui-même.

Le tracé des heures babyloniques se fait en général, pour la clarté des lectures, en dessous de la ligne d'horizon. Il suffit de diviser en douze parties égales les segments de l'Equateur et des deux Tropiques compris sous la ligne d'horizon, et de joindre en-de celui qui est intitulé *Samer Abdul Rahmen,* dont j'ai parlé ci-dessus (18).

Voilà la Théorie de cette platine Persane, pour la construction des Astrolabes, avec laquelle les Astrologues du païs font leurs instrumens, exacts & précis, sans beaucoup calculer & suputer, comme on fait ailleurs. Le docte Capucin, dont j'ai parlé, qui en admiroit la méthode, & qui me porta & m'aida à la mettre dans mes Mémoires, me disoit qu'il l'avoit long-temps comparée par les principes Geometriques, avec la méthode laissée par Steflerin, & Regiomontanus, pour la fabrique des Astrolabes, & qu'aiant bien considéré d'un côté les angles des soustendantes et tangentes & les autres régles de cette platine Persane, & de l'autre les divisions & partitions actuelles de ces deux Auteurs, dont on se sert en Europe pour la construction ordinaire des Astrolabes; il trouvoit que les deux méthodes se ressembloient fort & même qu'on pouvoit dire que l'une étoit l'abregé de l'autre, mais que la méthode Persane étoit bien meilleure que l'autre, plus sûre & plus courte. Il faut juger de ces méthodes, disoit-il, ou voies d'operer par comparaison à deux Horlogers qui feroient leurs rouës, l'un en se servant de sa platine pour en diviser & partager les dents, & l'autre en les divisant actuellement au compas avant de les refendre : si celui-ci manque en ses divisions comme il est difficile qu'il ne le fasse pas, il manque de beaucoup, à cause de la petitesse de la circonférence de sa rouë, mais quand l'autre qui se sert de la platine, viendroit à manquer en ses divisions, ce qui n'est pas si sujet à faire, son manquement est comme insensible en son opération ou sur sa rouë; mais la grande raison de préférence, est en ce que celui

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suite ces points trois à trois par des arcs de cercles, qui sont d'autant plus faciles à tracer qu'ils ont tous le même diamètre.

La ligne crépusculine n'est qu'un almucantarat à 18° sous la ligne d'horizon. Elle se trace comme il est dit à la note 7.

(18) En ce qui concerne le tracé de l'araignée, le procédé persan est encore une fois bien plus simple que celui que Stöffler et les auteurs contemporains indiquent : il suffit de construire un tympan pour la latitude de 66°30' comme il est dit aux notes 7 et 8. Pour cette latitude, les azimuts et les almucantarats se confondent évidemment avec les longitudes et les latitudes célestes. Grâce à l'emploi de la platine persane, le tracé d'un élément d'azimut ou d'almucantarat pour chaque étoile est très facile ; par exemple : pour une étoile telle qu'Aldebaran, dont la longitude est 2°18' et la latitude 5°10' (d'après les tables citées) il suffit de tracer un petit fragment de l'azimut 2°18' et de l'almucantarat 5°10' ; l'intersection donne immédiatement la position de l'étoile sur l'araignée.

qui se sert de la platine Persane, fait en un moment de tems & sans peine; ce que l'autre ne sauroit faire qu'avec beaucoup de tems & de peine; sans compter que son ouvrage est toûjours bien moins net, étant comme impossible qu'il ne marque bien des rayes & des points inutiles sur sa rouë. Il ajoûtoit que si l'on prenoit garde aux Tangentes, & Secantes, qui se forment des degrez de cette planche, avec ces lignes des Tangentes, mises pour *Sinus total :* on concevroit aisément combien l'usage de cette platine abregeoit & facilitoit la construction de l'Astrolabe & la précision exacte dont il le rendoit.

Quant à la division de la Mere de l'Astrolabe, les Astronomes Persans la font avec un très-grand Bassin de cuivre, ou de Laton, à fonds plat, & à bords larges & bien unis & polis, divisé du centre à la circonférence en 360 degrez, chaque degré marqué par dixaines de minutes : ils mettent au fonds du Bassin, quatre petits morceaux de bois, poissez aux bouts de poix noire, de hauteur à élever leur Mere d'Astrolabe, jusqu'au plan ou niveau des bords du Bassin, ce qu'ils nivellent avec le tranchant de leur régle, afin que la Mere d'Astrolabe & les bords du Bassin soient en un même plan. Celà fait ils prennent deux fils de soye la plus déliée & ils les bandent en croix sur les quatre divisions de leur Bassin afin de faire ainsi angle droit au centre du Bassin, et puis ils le prennent doucement, & sans que rien remuë, et le posent sur un rechaud de feu qui échauffe et fond cette poix, après quoi ils poussent & repoussent peu à peu leur Mere d'Astrolabe, tant que la section de cette soye croisée tombe sur le Centre de la Mere d'Astrolabe, avec quoi ils sont assurez que leur division sera juste : alors ils ôtent la machine de dessus le feu, & laissent refroidir ce mastic; & leur Mere d'Astrolabe étant ferme & en duë position, ils prennent la régle, & en portent les bouts sur les bords du Bassin, divisez comme ils sont, ils sectionnent très également le limbe de leur Mere d'Astrolabe. J'oubliois de dire qu'afin de tourner aisément leur piéce, ils attachent sur le bord un Centre fixe, avec un clou rond & rivé au centre de la Mere d'Astrolabe. Ils font de même leurs échelles altymetres, qu'ils apellent échelles de douze pouces, avec quantité d'autres lignes traversales, lesquelles ils adaptent à leurs jours & heures planetaires, & leurs dominations ou arbitres, pour tout ce qui doit arriver suivant la Théorie de leur Negromance ; car il faut ainsi apeller leurs pronostics. J'ajoûterai que la mécanique de ces instrumens est admirable en son genre, autant que la méthode; car les cercles sont tirez d'un trait égal, net, délié & profond comme il faut, si hardiment, & si uniformément, que la meilleure vûë n'y sauroit remarquer d'entrecoupure, ni dentelure & raye aucune, en un mot aucun chancellement de compas, mais la gravure des nombres n'est pas si fine & si belle, à cause qu'ils ne savent pas cet art de graver, aussi bien que les Européans à beaucoup près (19).

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J'ai cru devoir reproduire intégralement le texte de Chardin, parce qu'il constitue un document peu connu, dont l'intérêt échappe évidemment à ceux que l'histoire des sciences ne préoccupe pas. Au surplus, le cinquième volume des *Voyages* contient nombre d'autres renseignements curieux sur les idées scientifiques qui régnaient en Perse au XVII[e] siècle.

En ce qui concerne la construction de l'astrolabe, les notes de Chardin jettent un jour tout spécial sur l'esprit de rationalisme qui existait dans les écoles persanes. Si l'on compare la simplicité, la clarté du procédé exposé ici, au dogmatisme obscur des traités de Stöffler et de Regiomontanus, on ne peut qu'admirer une fois de plus les mathématiciens arabes. Il ne faut jamais oublier que ce qui nous parait aujourd'hui élémentaire, résulte de notre longue habitude de la géométrie descriptive qui est devenue, à la fin, presque intuitive pour un grand nombre d'entre nous.

Henri MICHEL,
ingénieur.

Bruxelles, juin 1941.

(19) Ici, Chardin est injuste pour certains graveurs persans ; il suffit de voir les astrolabes persans dont la reproduction a été donnée dans cette revue (voir note 1) pour constater que la gravure des astrolabes de la fin du XVII[e] siècle est incomparable. Mais j'observe que ces instruments portent en général deux signatures : ainsi l'astrolabe n° 32 décrit par Günther est signé comme suit :

Dessiné par Muhammad-Amîn-ibn-Muhammad Tahîr
et gravé par Abd-el-A' immah.

L'astrolabe n° 21 décrit par le même auteur :

L'œuvre de Muhammad-Tahîr terminée par Abd-el-A' immah.

Un astrolabe de ma propre collection :

Construit par Ibn-Hassan-Alî-Muhammad-Djalile
Gravé par Ibn-Abd-el-Hossein-Abd-el-A' immah.

Ces instruments sont précisément construits par les astronomes que Chardin cite ; mais cet auteur ne fait pas mention du graveur Abd-el-A' immah. Au reste, ce dernier nom n'apparait que sur des instruments légèrement postérieurs à l'année où Chardin écrivait. J'y vois une nouvelle preuve de ce que j'ai pressenti, à savoir que le graveur Abd-el-A' immah a repris des astrolabes plus ou moins anciens, et les a enrichis de gravures que les instruments originaux ne comportaient pas.

522.41

L'astrolabe linéaire d'al-Tûsi.

Les nombreux ouvrages, anciens et modernes, consacrés à l'étude de l'astrolabe ne traitent généralement que du seul astrolabe planisphérique.

Il existe cependant d'autres types d'astrolabes.

On sait que cet instrument se compose en substance de deux parties : l'une qui représente la sphère terrestre, l'autre, la sphère céleste. Ces deux parties, mobiles l'une par rapport à l'autre, peuvent être disposées de façon à reproduire la position relative des deux sphères à un moment quelconque. On peut déterminer ainsi l'heure, la durée du jour, etc.

La sphère armillaire est, en fait, le plus simple des astrolabes. C'est d'ailleurs sous le nom d'*astrolabos* que Ptolémée désigne cet instrument.

L'*astrolabe sphérique* en dérive directement : le globe terrestre, au lieu d'être entouré de simples anneaux *(armillae)*, est coiffé d'une calotte qui représente le ciel boréal. Il est aisé de disposer les deux parties de l'instrument dans la situation relative voulue, et de prendre alors les mesures cherchées. Il ne nous reste, de l'astrolabe sphérique, aucun exemplaire complet ; mais nous possédons de ce rare instrument une description suffisante (1). Il connut un certain succès dans les écoles arabes, du IX[e] au XIII[e] siècle.

L'*astrolabe planisphérique* est le plus connu. Les sphères y sont figurées par leurs projections planes, soit stéréographiques, soit orthogonales. Le plus souvent, on se sert d'une projection stéréographique issue d'un centre de projection situé au Pôle Sud. C'est l'astrolabe dit *septentrional*, parce que l'œil, situé au Pôle Sud, regarde l'hémisphère Nord. Le centre de projection peut aussi être situé au Pôle Nord (astrolabe *méridional*) ou au point vernal (astrolabe d'Arzachel et de Gemma Frisius). La projection orthogonale (sur le plan du Colure des Solstices) constitue l'astrolabe de Roias.

Mais il existe un troisième type d'astrolabe, beaucoup moins connu : l'*astrolabe linéaire* d'al-Tûsi.

La plupart des auteurs ont négligé de parler de cet instrument. Gunther, dans son grand ouvrage général (2) ne le mentionne que pour dire qu'il n'en traitera pas.

L. A. Sédillot (3), complétant le travail de son père (4), cite la « baguette de Nasir-Eddin-Thousi » sans la décrire; son intention de traiter ultérieurement de cet instrument est restée lettre morte. Devant cette carence, l'éminent orientaliste Carra de Vaux publia, en 1895, le texte intégral de la partie du manuscrit d'Abu'l-Hasan qui se rapporte à l'astrolabe linéaire, et la traduisit littéralement (5).

Malheureusement, comme l'avoue lui-même le B[on] Carra de Vaux, ce texte « n'est pas facile à comprendre ». Le traité d'Abu'l-Hasan reproduit incomplètement celui d'al-Tûsi. Les figures et certaines tables manquent. De

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(1) Voir notamment les *Libros del Saber de Astronomia del Rey D. Alfonso X de Castilla*, dont une excellente reproduction a été publiée à Madrid en 1873; et l'étude de SEEMAN et MITTELBERGER : *Das Kugelförmige Astrolab.* Erlangen, 1925.

(2) R. T. GUNTHER : *The Astrolabes of the World.* Oxford, 1932.

(3) L. A. SÉDILLOT : *Mémoire sur les Instruments astronomiques des Arabes.* Paris, 1841 ; p. 191.

(4) J. J. SÉDILLOT : *Le Traité des Instruments astronomiques des Arabes, d'Aboûl-Hhassan-Ali.* Paris, 1834.

(5) B[on] CARRA DE VAUX : L'Astrolabe linéaire ou Bâton d'Et-Tousi. Paris, *Journal Asiatique*, mai-juin 1895.

plus, comme tous les textes anciens, il est sèchement dogmatique, et ne s'appuie sur aucune démonstration qui permette une meilleure intelligence des principes exposés. A l'époque où écrivaient les deux auteurs arabes, en Orient comme en Occident, le « magister dixit » était une raison suffisante ; l'élève appliquait aveuglément les règles sans chercher à en pénétrer l'esprit.

La traduction de Carra de Vaux souffre d'autre part d'une trop grande fidélité au texte. Des termes équivalents dans la pensée de l'auteur (p. ex. : *rétenteur, axe, centre, origine;* ou encore : *ligne, arc, quadrant)* sont indifféremment employés, avec une inévitable confusion. Nous pensons qu'il aurait convenu, dans de pareils cas, de suivre le sens plus que la lettre (6). Très probablement, si le B^on^ Carra de Vaux avait essayé de reconstituer l'instrument, il aurait senti la nécessité de « traduire sa traduction », et d'expliquer en langage moderne ce que son texte a d'obscurément scrupuleux.

Il ne l'a pas fait, et ceci l'amène à conclure par le résumé suivant :

« L'astrolabe linéaire est un véritable astrolabe : il dérive de l'astrolabe planisphère ; comme celui-ci est en principe un plan sur lequel on a projeté la sphère et ses différents cercles, il est une droite de ce plan sur laquelle on a projeté cette projection ».

Cette définition, que d'autres ont copiée sur la foi de l'autorité de Carra de Vaux (7), est malheureusement tout à fait inexacte.

L'objet de la présente note n'est pas de critiquer le précieux travail de l'éminent orientaliste ; nous voulons uniquement faire connaître et comprendre un instrument très curieux. Nous en décrivons donc la construction et l'usage en toute indépendance, sans chercher à suivre ni le texte, ni les méthodes d'Abu'l-Hasan, et sans signaler ici les difficultés d'interprétation que comporte la traduction de Carra de Vaux.

TRACE DE L'ASTROLABE D'AL-TUSI (8).

Si nous examinons le tympan d'un astrolabe ordinaire (fig. 1), nous y remarquons d'abord un diamètre vertical MM', qui est la projection du méridien du lieu d'observation (9).

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(6) D'autant plus que si l'auteur emploie des termes techniques que le traducteur ignore, il se produira fatalement des confusions. Un savant érudit — il faut l'être pour se permettre de telles boutades — disait un jour : Si dans mille ans un profane déchiffre la phrase : « Je projette ma figure sur un plan horizontal », et s'il traduit mot à mot, il est capable d'exprimer la pensée : « Je me suis jeté le visage par terre ».

(7) Dans l'*Encyclopédie de l'Islam*, l'éminent orientaliste et professeur d'Histoire des Sciences C. A. Nallino écrit : « La projection de l'astrolabe planisphère commun a été projetée sur une droite de son plan même ». Il est vrai qu'il ajoute : « L'instrument représente donc l'intersection du plan du méridien avec le plan de projection de l'astrolabe planisphère », ce qui se rapproche plus de la vérité, mais n'est pas encore absolument exact.

(8) L'astrolabe linéaire a été inventé par Scharaf-al-Dîn-al-Muzaffar-ibn-Muzaffar-al-Tûsi, un astronome persan, originaire de Tûs comme son nom l'indique, et qui vécut vers la fin du XII^e^ siècle. Il ne faut pas le confondre, comme l'a fait Sédillot, avec Nasir-al-Dîn-Abu-Dja'far-Muhammad-ibn-Muhammad-al-Hasan-al-Tûsi, également originaire de Tûs, également astronome, qui construisit l'observatoire de Marâgha, écrivit un traité de l'astrolabe et vécut environ 60 ans plus tard.

(9) Voir, pour plus de détails : *Ciel et Terre*, n^os^ 8-9 et 10 ; 1936. H. MICHEL : Description d'un Astrolabe Persan.

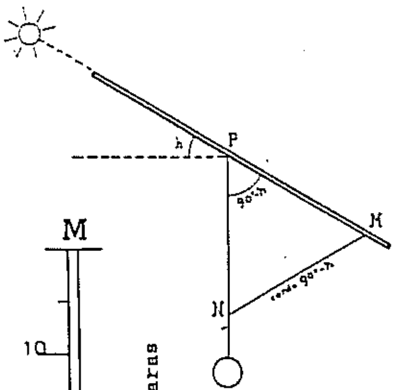

Fig. 3.

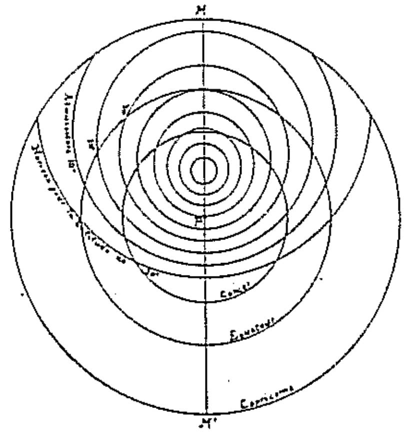

Fig. 1.

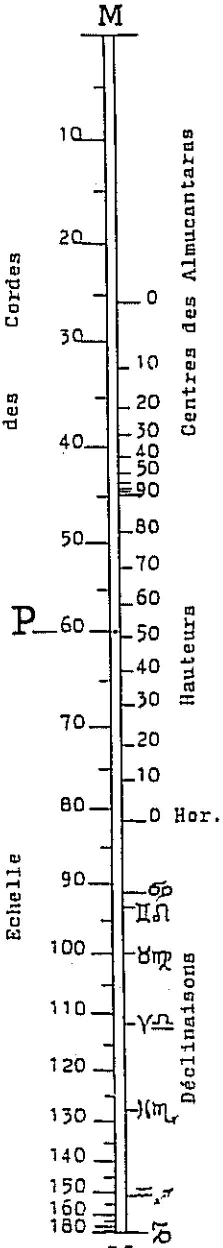

Fig. 2.

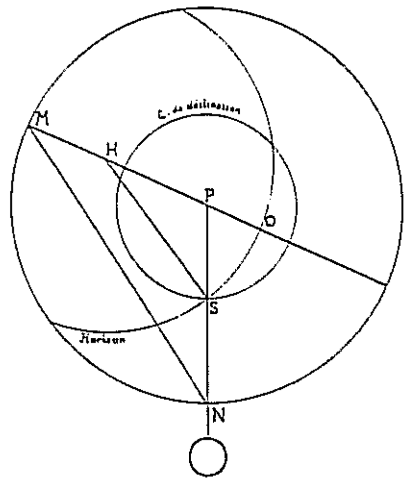

Fig. 4.

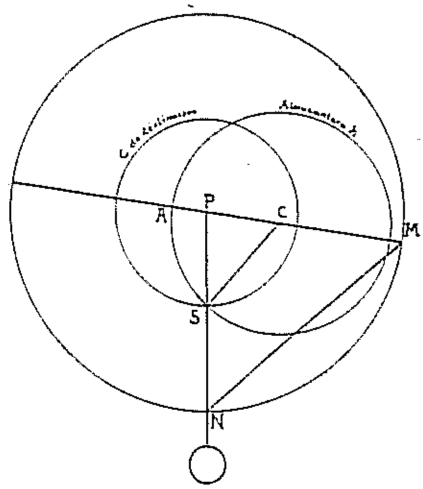

Fig. 5.

Nous voyons ensuite un certain nombre de cercles qui ont leurs centres sur cette ligne méridienne :

Les trois cercles qui ont leur centre commun au centre P du tympan sont les projections du Tropique du Cancer, de l'Equateur et du Tropique du Capricorne. Leur centre est la projection du Pôle Nord.

Ces trois cercles sont des cercles de déclinaison. Rien ne nous empêche d'en établir toute une série, pour toutes les déclinaisons successives du Soleil au cours de l'année.

Les arcs de cercle et les cercles complets qui occupent la partie supérieure du tympan sont les projections de l'Horizon du lieu d'observation, et des cercles de hauteur successifs ou *almucantaras*.

Du moment que nous connaîtrons les centres de tous ces cercles, et un point de leur circonférence, ils seront parfaitement définis.

Si donc on nous donnait le tracé de la ligne méridienne, en y indiquant le centre P, projection du Pôle, les centres successifs des almucantaras, et les points d'intersection des cercles de déclinaison et des cercles de hauteur avec la ligne méridienne, nous aurions tous les éléments nécessaires à la construction de la fig. 1.

Tout point de la surface d'un astrolabe est déterminé par l'intersection de deux arcs de cercle. Avec les données que nous venons d'évoquer, nous pouvons résoudre tous les problèmes qui résultent de l'intersection d'un cercle de déclinaison avec un cercle de hauteur, notamment : la mesure de la hauteur des astres ; la mesure des arcs diurnes ; l'observation de l'heure ; la détermination de l'heure du lever et du coucher du Soleil ou d'une étoile ; enfin, quelques problèmes d'astrologie.

Les centres des projections des azimuts ne se trouvent pas sur la ligne méridienne. Nous ne pourrons pas résoudre, au moyen de l'astrolabe linéaire, les problèmes qui se rapportent aux azimuts.

L'astrolabe linéaire n'est en effet rien d'autre que la ligne méridienne d'un astrolabe ordinaire, où l'on a marqué les centres et les points d'intersection des cercles de déclinaison et des cercles de hauteur.

Le tracé de ces éléments peut se faire au moyen de tables, et le traité d'Abu'l-Hasan donne à ce sujet quelques chiffres très difficiles à bien comprendre. Mais il est beaucoup plus facile de procéder graphiquement, par la méthode que nous avons décrite antérieurement dans cette Revue (10). La détermination des points cherchés est un travail d'une heure au plus.

Il ne nous manque plus maintenant, pour que tout soit déterminé, qu'un moyen de mesurer les angles, comme on le fait sur l'astrolabe ordinaire avec l'alidade et le limbe gradué. Inscrivons, le long du diamètre MM', les longueurs des cordes successives, de 0 à 180°, pour le cercle de rayon MP. Ces longueurs se trouvent dans des tables.

A titre d'exemple, la fig. 2 constitue le graphique d'un astrolabe linéaire pour la latitude de 50° 50' (Bruxelles). Allant du point M, que nous appellerons dorénavant l'*origine*, vers le Pôle P, nous voyons à droite de l'échelle les positions des centres successifs des almucantaras, depuis la hauteur de 0° (Horizon) jusqu'à 90° (Zénith). Après le Zénith, nous voyons les points

(10) H. Michel : Méthodes de tracé des Astrolabes Persans. *Ciel et Terre*, 1941, n° 12.

d'intersection du méridien avec les cercles de hauteur, de 90° jusqu'à l'Horizon.

Viennent ensuite, portant l'indication des signes du Zodiaque, les intersections du méridien avec les cercles de déclinaison successifs du Soleil, à l'entrée de l'astre dans chaque signe.

A gauche de l'échelle, une graduation dont le 0 est à l'origine M et le 180 à l'extrémité M' donne les longueurs des cordes de 5 en 5° pour un cercle de rayon MP.

Nous pouvons évidemment, selon les dimensions du graphique et le degré de précision voulu, pousser plus loin la subdivision de ces échelles.

Nous pouvons aussi ajouter aux cercles de déclinaison du Soleil, quelques-uns des cercles de déclinaison pour les principales étoiles fixes : ceci pour utiliser l'astrolabe de nuit.

Il ne nous reste qu'à nous procurer un bâton quelconque sur lequel nous transposerons ce graphique, et trois bouts de ficelle : nous aurons ainsi construit un astrolabe qui nous rendra les mêmes services que le plus coûteux instrument.

Remarque : Le traité d'al-Tûsi indique encore quelques échelles supplémentaires, qui peuvent être utiles et dont nous indiquerons succinctement le tracé.

Une double échelle indique les ascensions droites du Soleil au début de chaque signe du Zodiaque ; elle peut aussi indiquer les ascensions droites des principales étoiles. Ces données sont nécessaires pour déterminer l'heure de nuit, en appliquant la formule bien connue :

$$t_v = H_{\text{ét.}} + (\alpha_{\text{ét.}} - \alpha_{\text{sol.}})$$

Une autre échelle, dite « des coascendants, sur l'Horizon, des signes du Zodiaque », sert principalement à l'astrologie et nous n'en parlerons pas ici.

Enfin une « échelle des ombres » donne la longueur de l'ombre d'un style orienté parallèlement à l'axe de la Terre, sur un plan parallèle à l'Equateur, aux divers moments de l'année (11). Cette échelle sert principalement à l'établissement d'un cadran solaire.

Les trois échelles accessoires susmentionnées peuvent être tracées sur une face latérale du bâton.

USAGE DE L'ASTROLABE LINEAIRE.

Les explications que nous allons donner peuvent sembler complexes au premier abord. En fait, rien n'est plus aisé que de se servir de l'astrolabe d'al-Tûsi.

Voici le principe des opérations. Pour trouver un point astronomique, qui est, comme nous l'avons dit, à l'intersection de deux cercles, on matérialise ces deux cercles comme suit : leurs deux centres étant marqués sur le bâton, on attache un fil à chacun de ces centres. Sur chaque fil, on marque la longueur du rayon du cercle correspondant. On tend les deux fils et on les croise, de manière que les deux marques se touchent. On réalise ainsi un triangle dont la base est le bâton, les fils les deux autres côtés. Le sommet

(11) Le traducteur emploie ici à tort le terme « gnomon » qui désigne un style vertical. Le chapitre, déjà fort obscur, en devient à peu près inintelligible.

du triangle, constitué par le croisement des fils, situe par rapport aux deux centres le point cherché.

Appliquons, à titre d'exemple, cette méthode à quelques problèmes fondamentaux.

I) Mesure de la hauteur du Soleil (Fig. 3) :

On attache au Pôle P un fil à plomb. On marque sur ce fil, par un nœud, un point N à la distance PN = PM. On attache un second fil à l'origine M.

On vise le Soleil avec le bâton. Dans cette position, on tend le second fil de M vers N, et on marque sur lui l'emplacement de l'intersection N.

Portant alors le second fil le long de l'échelle des cordes, on note la division où aboutit la longueur MN. Cette division indique la distance zénithale du Soleil.

Démonstration : La fig. 3 est suffisamment explicite : PM et PN sont, par définition, égaux au rayon de la projection du Tropique du Capricorne. MN est donc une corde de cette projection, et soustend un arc égal au complément de la hauteur du Soleil.

Remarque : On opérera exactement de même pour mesurer la hauteur d'une étoile.

II) Mesure de l'arc diurne (Fig. 4) :

L'arc diurne est la portion du cercle de déclinaison du Soleil comprise au-dessus de l'Horizon.

L'arc semi-diurne est la moitié de l'arc susdit, comprise entre l'Horizon et le méridien.

On attache au Pôle P un fil à plomb. On marque sur ce fil, par un nœud, un point N à la distance PN = PM. On attache au même fil, par un nœud coulant, un second fil. Amenant le fil à plomb le long de l'échelle des déclinaisons, on fait glisser le nœud coulant jusqu'au degré S de l'Ecliptique où se trouve le Soleil au jour de l'opération. On serre ce nœud en S, et on porte le nœud S sur l'échelle des hauteurs au point O correspondant à l'Horizon (almucantara zéro). On tend alors ce deuxième fil jusqu'au centre H de ce même Horizon, où on l'attache. (On peut aussi se borner à l'y retenir du doigt).

On relâche alors le fil à plomb. La règle et les deux fils forment un triangle (fig. 4) qu'on incline de sorte que le côté PS soit vertical.

Prenant alors un troisième fil attaché à l'origine M, on mesure la distance entre M et le nœud fixe N du fil à plomb. On reporte cette distance MN sur l'échelle des cordes et on lit, en face de N, l'angle qui exprime l'arc semi-diurne, moitié de la durée du jour.

Démonstration : La fig. 4, qui représente cette construction superposée au tympan d'un astrolabe ordinaire, est explicite : PS est le rayon du cercle de déclinaison du Soleil. HS = HO est le rayon de l'Horizon. S est donc le point où le Soleil se lève.

PM et PN sont deux rayons du Tropique du Capricorne. MN est donc la corde de ce Tropique qui soustend l'arc semi-diurne. Sa mesure, sur l'échelle des cordes, donne la mesure de cet arc.

III) Détermination de l'heure (Fig. 5) :

L'heure (à partir de midi) est donnée par la portion de l'arc diurne comprise entre le méridien et l'endroit où se trouve le Soleil au moment de l'observation.

On procède exactement comme ci-dessus, mais en opérant sur l'almucantara du Soleil au lieu d'opérer sur l'Horizon. Répétons en détail :

On commence évidemment par relever la hauteur h du Soleil (problème I).

On attache au Pôle P un fil à plomb. On marque sur ce fil, par un nœud, un point N à la distance PN = PM. On attache au même fil, par un nœud coulant, un second fil. Amenant le fil à plomb le long de l'échelle des déclinaisons, on fait glisser le nœud coulant jusqu'au degré S de l'Ecliptique où se trouve le Soleil au jour de l'opération. On serre ce nœud en S, et on porte le nœud S sur l'échelle des hauteurs au point A, correspondant à l'almucantara h. On tend alors ce deuxième fil jusqu'au centre C de ce même almucantara, où on l'attache.

On relâche alors le fil à plomb. La règle et les deux fils forment un triangle (fig. 5) qu'on incline de sorte que le côté PS soit vertical.

Prenant alors un troisième fil attaché à l'origine M, on mesure la distance entre M et le nœud fixe N du fil à plomb. On reporte cette distance MN sur l'échelle des cordes et on lit, en face de N, l'angle qui exprime l'arc parcouru depuis midi par le Soleil.

Cet angle peut être converti en heures égales ou en heures temporaires : l'heure égale est définie par la 24e partie du jour, soit un angle de 15°. L'heure temporaire est la 12e partie de l'arc diurne, que nous avons déterminé selon le Problème II. Cette heure se comptait, en Orient, à partir du lever du Soleil.

Démonstration : Dans la fig. 5, PS est le rayon du cercle de déclinaison du Soleil. CS = CA est le rayon de l'almucantara h à l'heure cherchée. S est donc le point où le Soleil se trouvait au moment de l'observation. MN mesure, sur le Cercle du Capricorne, l'arc parcouru par le Soleil sur son cercle de déclinaison, à partir de midi.

Remarque : Le lecteur modifiera aisément lui-même ce qui précède s'il s'agit d'heures avant midi.

Il adaptera aussi sans difficulté la méthode à l'observation de l'heure de nuit, en mesurant l'angle horaire d'une étoile et en appliquant la formule que nous avons donnée plus haut.

CONCLUSION.

Ces exemples suffisent à faire comprendre le principe de l'astrolabe d'al-Tûsi. On voit qu'il ne s'agit nullement de la « projection sur une droite » des tracés de l'astrolabe ordinaire. L'astrolabe linéaire est plutôt, s'il faut en donner une définition, le squelette d'un astrolabe stéréographique, rabattu sur le plan vertical.

Il est très facile de reconstituer cet instrument et de s'en servir. Il est peu encombrant, peu coûteux, et permet de remplacer un astrolabe de grand diamètre par un simple bâton. On doit regretter qu'aucun échantillon ne soit représenté dans nos collections.

Vraisemblablement, ces bâtons gradués ne disaient rien aux collectionneurs et n'ont pas justifié l'honneur de leurs vitrines. Ils ne nous ont pas été conservés. C'est le sort des instruments trop modestes.

Henri Michel,
Ingénieur.

CHAPTER 57

THE PRINCIPLE AND USE OF THE ASTROLABE

By WILLY HARTNER*

THE astrolabe (Pls. 1397–1402) is an instrument, usually made of bronze or brass, designed to measure the altitude of the stars, moon, or sun, and to determine all kinds of astronomical and topographical relations, without any mathematical formulae or calculations. Astronomical observations are made with the astrolabe in much the same way as with the simple quadrant or sextant; but in addition, the astrolabe contains various diagrams, tables, and scales which make it possible to determine immediately the positions of the fixed stars in relation to the horizon, the position of the sun, moon, and planets relative to the fixed stars, and any other astronomical (or astrological) relations of interest. One of its chief uses has been to tell time. In like manner it may also be applied to terrestial measurements, such as estimating the distance of a visible objective, or determining the height of a mountain or the depth of a well. The astrolabe was the most important astronomical instrument of the Middle Ages.

The name astrolabe is derived from the Greek word ἀστρόλαβος (or ἀστρόλαβον ὄργανον), which is generally rendered in Arabic and Persian *asṭurlāb* or *aṣṭurlāb*.[1] The term is applied to three principal classes of instruments:

(1) The spherical astrolabe (Arabic: *asṭurlāb kurī*), which is called *astrolabio redondo* in the *Libros del Saber de Astronomía* of King Alphonso X of Castile, consists of a celestial globe with a 'spider' surrounding it, and various arrangements for measuring stellar distances, determining time, and also solving many types of problems in spherical astronomy.

(2) The linear astrolabe (Arabic: *asṭurlāb khaṭṭī*), also called the *Staff of Ṭūsī* (*'Aṣā aṭ-Ṭūsī*), after the inventor, al-Muẓaffar ibn Muḥammad ibn al-Muẓaffar Sharaf ad-dīn aṭ-Ṭūsī (d. *c.* 1213 (*c.* 610 H.)), was not so widely used because it is less accurate. The dome of the sky is projected in a straight line.

(3) The astrolabe in the narrower sense, the flat astrolabe (Arabic: *asṭurlāb saṭḥī* or *musaṭṭaḥ*), called in medieval Latin *astrolabium planisphaerium*, is the commonest type and was the most important instrument of observational astronomy in the Middle Ages. It was employed both in the Orient and in Europe up to the beginning of the eighteenth century and was highly prized because it was so convenient, had so many uses, and, not least of all, because of its beauty. None but this type will concern us here, and only outstanding examples can be cited.[2]

* Translated by PHYLLIS ACKERMAN.

[1] The true Arabic name for the astrolabe is *Waḍ'at al-Kura*, but this is seldom used. It means 'position of the globe', or more accurately 'projection of the globe', and very probably represents a literal translation of the Ptolemaic term ἅπλωσις ἐπιφανείας σφαίρας (see p. 2532, n. 1), the 'spreading out of the surface of the sphere', that is to say, the stereographical projection, which was rendered by the Latin *planisphaerium*. The Arabic term is found in medieval Latin texts as *walzacora*, *walzachora*, *walzagora*, *wazzalcora*, or *waztalcora*.

[2] In Greek the term ἀστρόλαβος, which has only the general significance of 'a means of comprehending the stars', can be applied theoretically to any astronomical

THE PRINCIPLE AND USE OF THE ASTROLABE

The planispherical astrolabe has two definitive features: the manner in which the heavens are represented, the so-called stereographic projection; and the arrangement of the rotating spider or *rete*. The former is found also on the linear astrolabe, the latter on the spherical.

HISTORY OF THE ASTROLABE

Unfortunately we have no trustworthy information about the original inventor of the astrolabe. The statement of Vitruvius,[1] often cited, that Eudoxus of Cnidos (*c.* 408–355 B.C.) or Apollonius (*c.* 265–170 B.C.) invented the spider (*arachne*) has nothing to do with the astrolabe, but refers rather to a specific improvement of the sun dial, which is discussed in the passage in question. Inasmuch as the stereographic projection, without which the planispherical astrolabe is inconceivable, was worked out, in all probability, by Hipparchus of Nicaea (*c.* 150 B.C.), the astrolabe can hardly antedate him. For the same reason it is impossible to accept the theory of a Babylonian origin, which has recently appeared occasionally,[2] but without any scientific evidence to support it.

The oldest astrolabes extant are relatively late, for they date only from the Islamic medieval renaissance, but the first examples are so highly evolved that we must assume that a long technical development preceded them, and Greek and Syriac writers of the first Christian millennium give evidence of the existence of the instrument in the pre-Islamic period.[3] Synesius of Cyrene (d. *c.* 415), a pupil of Hypatia of Alexandria,

instrument used for observations of the firmament. The term, however, assumed a more specific scientific meaning under the influence of Ptolemy's Almagestus, I. 5, where it is used for an improved variant of the armillary spheres, which may go back to Hipparchus. These 'Ptolemaic astrolabes', which served especially for direct observations of the ecliptical longitudes and latitudes of the heavenly bodies, formed a separate class of instruments, and they have nothing in common but the name with the astrolabes described here. They, too, were used throughout the Middle Ages in Byzantium, Islam, and the West, and are sometimes confused with either the spherical or the planispherical astrolabe.

[1] Architectura, IX. 8. See H. Diels, Antike Technik, Leipzig—Berlin, 1920, p. 160, note 4, and p. 168.

[2] R. T. Gunther, The astrolabes of the world, Oxford, 1932, I, pp. 51–2. Neither the accepted facts that some late Babylonian astronomers such as Naburianos and Cidenas 'are entitled to places among the greatest of astronomers' and that 'the Greeks took and used Chaldaean science', nor the existence of fragments of Babylonian clay tablets, apparently astronomical, showing concentric circles, straight lines, and stars, constitute a serious argument for the existence of Babylonian *astrolabes*.

[3] A bronze instrument recovered in 1902, with a number of other objects of art, from the sea near Antikythera has been called the 'astrolabe of Antikythera'. Though badly damaged there is still visible on it an astronomical inscription in Greek, and it included a very complicated system of cog-wheels, technically fully developed (first published by P. Radiades, Der Astrolabos von Antikythera, *in* J. N. Svoronos, Das Athener Nationalmuseum, Athens, 1908, pp. 43–51). Svoronos recognized some similarities in the inscription to the text of Johannes Philoponus' treatise on the astrolabe, but these are not very significant. That, however, this is an astronomical instrument is certain, so that it can be called an astrolabe in the wider Greek sense, and as a unique example of the type it deserves careful consideration. According to J. Theophanidis, Sur l'instrument en cuivre dont des fragments se trouvent au Musée Archéologique d'Athènes et qui fut retiré du fond de la mer d'Anticythère en 1902, Πρακτικὰ τῆς Ἀκαδημίας Ἀθηνῶν, IX (1934), pp. 140–9, the instrument gives the direct reading of the ecliptical and equatorial co-ordinates of the sun, the moon and four of the five planets then known (ibid., p. 143). But the most important fact, for the present study, established by Theophanidis is that the construction was clearly based on the stereographic projection of the orbits of the planets on the northern tropic. Yet apart from this the principle of the instrument is entirely different from that of the planispherical astrolabe. So far as has been noted only one Persian astrolabe shows an interesting parallel to the Antikythera instrument, that of Muḥammad ibn Abī Bakr ibn Muḥammad ar-Rāshidī al-Ibarī of Iṣfahān, of 1224 (621 H.) (Pl. 1398, and Gunther, op. cit. I, Pls. XXV, XXVI), where also cog-wheels are used to represent the courses of the sun and the moon, the moon phases, and other similar phenomena. Yet one could hardly claim any relation between the two instruments.

There is a divergence of opinion on the date of the mentions a silver planisphere of which he claims to have perfected the theory, having derived the principle from an outline by Hipparchus, which had been disregarded by the famous Ptolemy and his great successors.[1] Johannes Philoponus of Alexandria wrote an extensive account in Greek on the construction and use of the astrolabe in the sixth century,[2] and about the middle of the seventh century Severus Sebokht of Nisibis, Bishop of Kennesrīn in Syria, wrote a description of the instrument in Syriac.[3]

The oldest surviving astrolabe, which is in the Lewis Evans Collection in the Old Ashmolean Museum, Oxford, is Persian, made by two brothers, Aḥmad and Muḥammad of Iṣfahān, sons of Ibrāhīm, in 984 (374 H.) (Pl. 1397 A, B).[4] It is an outstanding example, and its historical interest can scarcely be over-estimated. Relatively few astrolabes of the next centuries have come down to us, either originals or even copies, yet a great many must have been made, for there are quite a number of references to craftsmen who bore the soubriquet *Asṭurlābī*,[5] and we also know that the art of making astrolabes was highly

Antikythera instrument. It is usually attributed to the third century A.D. (e.g. GUNTHER, op. cit., I, p. 55); but V. STAÏS, Τὰ ἐξ Ἀντικυθήρων εὑρήματα, Athens, 1905, p. 26 *et passim*, claims that the shipwreck from which this treasure came must have occurred in the first century B.C.; and K. MALTÉZOS, Εἰσηγητικὴ ἀνακοίνωσις περὶ τοῦ εὑρήματος τῶν Ἀντικυθήρων καὶ τῶν ἀνακοινωσέων τοῦ κυρίου Θεοφανίδου, *in* Πρακτικὰ τῆς Ἀκαδημίας Ἀθηνῶν, IX (1934), pp. 130–2, considers that this is absolutely certain. This would mean that the instrument dated from the time of Hipparchus or immediately thereafter.

[1] The passage in the letter of Synesius to his friend Paeonius reads: 'The very ancient Hipparchus alluded to it obscurely, and he was the first to apply himself to the consideration of the problem. We, however, have carried the study out to its conclusion, for in the very long interval that has elapsed, the question has been neglected, since the great Ptolemy and his remarkable band of followers were content with its practical application, which was sufficient for the purposes of determining the time at night by the sixteen stars that were placed on the instrument by Hipparchus.' See Συνεσίου ἐπισκόπου Κυρήνης ἅπαντα τὰ εὑρισκόμενα, interpreted by D. PETAVIUS, Ὑπὲρ τοῦ δώρου λόγος, Paris, 1631, p. 301, reprinted in J. P. MIGNE, *Patrologia Graeca*, LXVI (1864), columns 1583–4. Suidas says that Ptolemy wrote a treatise on the 'spreading out of the surface of the sphere', ἅπλωσις ἐπιφανείας σφαίρας: i.e. projection (see p. 2530, n. 1). The original text has been lost, and an Arabic version by Maslama ibn Aḥmad al-Majrīṭī (d. *c.* 1007 (*c.* 397 H.)) is also lost; but fortunately a Latin translation of the latter, made in 1143 by Hermannus Dalmata, called *Planisphaerium*, exists in a number of manuscripts, and this is the earliest extant treatise on the principle of the stereographic projection. There is, however, no mention here of its application to the astrolabe. The Latin text of this treatise was published in J. L. HEIBERG, Claudii Ptolomaei opera quae extant omnia, Leipzig, 1907, II, pp. 227–59. The first German translation was made by DRECKER, Das Planisphaerium des Claudius Ptolomaeus, *Isis*, IX (1927), pp. 255–78. In Tetrabiblos, III, Chapter 2, however, Ptolemy says that the astrolabe is the only useful instrument for determining the hour of birth, and here the term ἀστρόλαβος seems really to refer to the planispherical astrolabe.

[2] H. HASE (Ed.), Περὶ τῆς τοῦ ἀστρολάβου χρήσεως καὶ κατασκευῆς, *Rheinisches Museum*, VI (1839), pp. 127–56. For a complete English translation, see GUNTHER, op. cit., I, pp. 61–81. In a German translation with introduction by DRECKER, Des Johannes Philoponos Schrift über das Astrolab, *Isis*, XI (1928), pp. 15–44, Drecker's statements (ibid., p. 15) that Johannes Philoponus and Johannes Alexandrinus Grammaticus were two distinct persons, and that the latter must have lived about 640, are erroneous. M. MEYERHOF, Joannes Grammatikos (Philoponos) von Alexandrien und die arabische Medizin, *Mitteilungen des deutschen Instituts für ägyptische Altertumskunde in Kairo*, II (1931), pp. 1–21, proved that there was only one person, the Johannes Philoponus of the first half of the sixth century. See also Meyerhof's conclusions quoted in *Isis*, XVIII (1932/3), pp. 447–8. GUNTHER, op. cit., I, p. 59, was also in error in attributing the treatise in question to the seventh century.

[3] For a complete English translation, see GUNTHER, op. cit., I, pp. 82–103.

[4] W. H. MORLEY, Description of a planispheric astrolabe constructed for Sháh Sultán Husain Safawí, London, 1856, p. 4 (reprinted in GUNTHER, op. cit., I, pp. 1–50), claims that the earliest extant astrolabe is one which he dated *c.* 905 (*c.* 293 H.), made by Aḥmad ibn Khalaf for the Caliph Ja'far (906–87 (294–377 H.)), son of the Caliph al-Muktafī Billāh; and DRECKER in *Isis*, XI, p. 19, also considers this the earliest, though he dates it *c.* 950 (*c.* 339 H.); but A. da Schio believes this to be only a twelfth or thirteenth century copy of an early original: see GUNTHER, op. cit., I, p. 113.

[5] H. SUTER, Die Mathematiker und Astronomen der Araber und ihre Werke, *Zeitschrift für Mathematik und Physik*, Supplement, XLV (1900), mentions among

esteemed at the time of the first 'Abbāsid Caliphs, especially in the reign of al-Ma'mūn (786–827 (170–212 H.)), and often the profession passed down through several generations from father to son.

The earliest known Arabic treatise on the subject is a long discussion composed prior to 815 (200 H.) by Messahalla (*Māshā'allāh*), an Egyptian Jew whose correct name was Manasse. The original has never been found, but we have a Latin version dating from 1276. The oldest Arabic description still extant in the original was written by 'Alī ibn 'Īsā, a pupil of Ibn Khalaf al-Marwarrūdhī, who in 829/30 (214 H.) and 832/3 (217 H.) participated in the astronomical observations made at Baghdād and Damascus under al-Ma'mūn.[1] This account includes also instructions for the use of the instrument. Thereafter some of the outstanding Arabic scholars, including such notable Persians as al-Bīrūnī (973–1048 (363–440 H.)) and Naṣīr ad-dīn aṭ-Ṭūsī (1201–74 (598–673 H.)), wrote systematic and detailed discussions of the astrolabe.

By the beginning of the thirteenth century the astrolabe was known throughout the East from India to Islamic Spain, where, incidentally, it seems to have been in use surprisingly early, for various examples made in Toledo are dated in the eleventh century. In the Christian West it did not come into general use until the thirteenth or fourteenth century, Europeans adopting it at the same time that they took up Graeco-Arabic mathematics and astronomy; but in certain learned circles, which probably derived their knowledge through the Venetians, it was known earlier, as is shown by the writings of Count Hermann Contractus of Vehringen (d. 1054), a pupil of the monastery school of Reichenau.[2] In the later Middle Ages Count Hermann was famous as a great scholar, and because he was known to have written the first European treatise on the astrolabe, he was often credited with being its inventor.[3] After an

others 'Alī ibn 'Īsā (see p. 2533), Fatḥ ibn Najīya (d. *c.* 941 (*c.* 330 H.)), Hibatallāh ibn al-Ḥusayn (d. 1139 (534 H.)), and Muḥammad ibn Sa'īd al-Saraqusṭī, who is thought to have died in the middle of the twelfth century.

[1] For Messahalla's treatise see MS. Cambridge University Library, I, i. III. 3, fols. 61–79a; facsimile and translation in GUNTHER, Chaucer and Messahalla on the Astrolabe, in GUNTHER (Ed.), Early science in Oxford, V, Oxford, 1929, pp. 137–92. Concerning 'Alī ibn 'Īsā see SUTER, op. cit., p. 13. The Arabic text was published by P. LOUIS CHEIKHO, S.J., Kitāb al-'amal bi 'l-asṭurlāb li 'Alī ibn 'Īsā, *Revue al-Mashriq*, XVI (1913), pp. 29–46, from the three manuscripts still existing in the Bibliothèque al-Mashriq in Beirut and the Bibliothèque Royale in Damascus. The treatise was translated into German by C. Schoy, the work being posthumously published by Drecker: C. SCHOY, 'Alī ibn 'Īsā, Das Astrolab und sein Gebrauch, *Isis*, IX (1927), pp. 239–54.

[2] De mensura astrolabii, *in* B. PEZ, Thesaurus anecdotorum novissimus, III, Part II, Augsburg, 1721, columns 93–106, reprinted in MIGNE, *Patrologia Latina*, CXLIII (1853), columns 379–90; also GUNTHER, Astrolabes of the world, II, pp. 404–8. In these printed editions of Hermann's treatise it is followed by two books called 'De utilitatibus astrolabii', but these are not by him. The first is a translation from the Arabic made not later than the eleventh century. This was published by N. BUBNOV, Gerberti, postea Silvestri II papae, Opera Mathematica, Berlin, 1899, pp. 109–47 (Part II, Gerberti Opera Dubia). The second is by an unidentified writer and is also not later than the eleventh century. E. ZINNER, Geschichte der Sternkunde, Berlin, 1931, p. 330, suggests that Hermann used a translation made in Spain from an Arabic work. For the transmission of this branch of astronomy from Islamic Spain to southern Germany see L. THORNDIKE, History of magic and experimental science during the first thirteen centuries of our era, I, New York, 1923, pp. 697–718.

[3] See R. WOLF, Geschichte der Astronomie, Munich, 1877, p. 165. It should be noted that Wolf is in error in stating (op. cit., p. 76) that Walafried, called Strabo, who died as Abbot of the Reichenau Monastery in 849, learned the use of the astrolabe from his teacher Tatto about the year 825. The statement was based on the 'Autobiography' of Walafried, published in the *Jahresbericht der Schule von Einsiedeln für 1856/57*; this is not, however, an authentic document by Walafried, but a kind of religious tract written in autobiographic style, which contains many errors: see W. WATTENBACH,

interval of more than two hundred years Henri Bate wrote *Magistralis Compositio Astrolabii* (1274) in Belgium.[1]

A century later still the great poet and astronomer Geoffrey Chaucer wrote an account in English for his ten year old son Lewis, called *The Conclusions of the Astrolabie*, with the sub-title *Bread and Milk for Children*. This is the first discussion of the subject written in western Christendom that is not in Latin, and as such it is of special importance. It was, however, apparently based on a Latin translation of Messahalla's treatise. It gives, in a very instructive style that is easy to follow, information on the use of the instrument.[2]

After this, both scholarly and popular works on the astrolabe become more numerous, too numerous, indeed, to cite in detail, but three are especially important and have been repeatedly referred to: the *Elucidatio Fabricae Ususque Astrolabii* of Johannes Stoeffler, published at Oppenheim in 1512; the *Paraphrase de l'Astrolabe* of Jacques Focard, which came out in Lyons in 1546; and the *Trattato dell' Uso e della Fabbrica dell' Astrolabio* of Egnazio Danti, which appeared in Florence about 1562.

By the beginning of the modern period the astrolabe was no longer confined to the scholarly world but had been popularized, rapidly reaching an ever wider range of people. The instrument was often used by the educated public as a convenient means of telling time, sometimes in a smaller form known as a pocket astrolabe. Meanwhile, at the time of the great discoveries it became of primary importance as a navigation instrument, Columbus, Vasco da Gama, and many of the later explorers using it on their long sea voyages. However, the instrument made specifically for navigation is really an astrolabe only in external form. In order to reduce to a minimum the surface exposed to the wind, the centre of the disk is cut out in the form of a cross, so that the engraved diagrams on the *Ṣafīḥa* (see p. 2536) and the back are suppressed and the *Alidad* turns around the middle of the cross indicating the altitudes on the outer rim. This instrument was used chiefly instead of the quadrant and the sextant as a convenient means of determining the altitude of the stars. Various special types of astrolabes have also been devised for astrological purposes, but these do not come within our purview.

Aside from such peculiar types, the astrolabe has remained essentially unchanged from its first historical appearance down through the centuries. The additions or improvements that have been made from time to time have all been of minor significance, not affecting the basic principle of the instrument, a conclusive proof of the perfect adequacy of that principle. Moreover, the astrolabe is of the greatest assistance in teaching, serving to clarify all the fundamental problems of spherical astronomy, and even today it can be of the utmost value, just as it was a thousand years ago, to elementary students.

Persians played a dominant part in consolidating Islamic culture, which has commonly been called Arabic because so much of the literature was written in Arabic. Their

Deutschlands Geschichtsquellen im Mittelalter, 7. Auflage, I (1904), p. 277, note 3. The astrolabe was certainly unknown in Central Europe in Walafried's time.

[1] See GUNTHER, op. cit., II, pp. 368–76.

[2] See Gunther's edition of the text in: Chaucer and Messahalla.

work in the exact sciences was especially significant. Recent researches have brought increasing confirmation of the importance of the Persians, so that there is no longer any doubt that Arabic mathematics, astronomy, and medicine owe their foundation and development mainly to Persians. Thus among the most famous Islamic mathematicians and astronomers are Muḥammad ibn Mūsā al-Khwārazmī, 'Abd ar-Raḥmān aṣ-Ṣūfī, Abu'l-Wafā', al-Kūhī, al-Bīrūnī, and, not least, 'Umar Khayyām and Naṣīr ad-dīn aṭ-Ṭūsī, all Persians. To the theory of the astrolabe Persian scholars made important contributions, writing sometimes in Arabic, sometimes in Persian, while both in earlier and in later periods Persian masters competed successfully in the manufacture of fine instruments, which are excellent both technically and artistically.[1] As has been said, the oldest extant astrolabe, dated 984 (374 H.), is Persian, and despite its early date it bears witness to remarkable skill, while the astrolabe of Shāh Sulṭān Ḥusayn (Pl. 1402 A, B), dated 1712 (1124 H.), shows what artistic perfection the Persian craftsmen achieved in later periods, for the piece surpasses all others both in beauty and in precision.[2]

DESCRIPTION OF THE ASTROLABE

1. *THE SUSPENSORY APPARATUS*

When in use, an astrolabe must be hung, and therefore the instrument is provided with an apparatus by which to hang it, consisting of three parts: the so-called 'throne' (Arabic: *kursī*) (K in Fig. 844), a triangular piece of metal, usually richly decorated with ornament or inscriptions, which is firmly attached to the round disk that constitutes the body of the instrument; the 'handle' (Arabic: *'urwa* or *ḥabs*; Latin: *armilla reflexa*) (U in Fig. 844), a ring with a flattened end, affixed to the point of the *kursī* in such a manner that it can be turned to either side in the plane of the *kursī*; and the 'ring', specifically so-called (Arabic: *ḥalqa*; Latin: *armilla rotunda*) (H in Fig. 844), which passes through the handle at right angles to it, and moves freely. A cord (Arabic: *'ilāqā*) with which to hang the instrument is tied to this ring.

2. *THE BODY OF THE ASTROLABE*

Both the front (Arabic: *wajh*; Latin: *facies*) and the back (Arabic: *ẓahr*; Latin: *dorsum*) of the body are important. The front consists of a circular outer rim

[1] GUNTHER, Astrolabes of the world, I, which is devoted to Oriental astrolabes, includes sixty-five Persian examples, as against twenty-seven Muhammadan Indian; eight Hindu; twenty-one Arabic, including the instruments of Syrian, Egyptian, and Mesopotamian origin; forty-two Moorish (Spanish Islamic and North African); and two Jewish pieces; and this numerical preponderance cannot be explained away as an accident.

. . . .

An astrolabe in the Museo della Storia della Scienza, Florence, is inscribed: *Work of Muḥammad ibn Abi'l-Qāsim ibn Bakrān, an-Najjār, al-Iṣfahānī, aṣ-Ṣāliḥānī*, 1103 (496 H.): E. COMBE—J. SAUVAGET—G. WIET, Répertoire chronologique d'épigraphie arabe, VIII, Cairo, 1937, pp. 54–5; and another is signed: *Ḥāmid ibn Maḥmūd al-Iṣfahānī*, 1152 (547 H.): ibid., p. 263.—*Ed.*

[2] Chardin reports: 'As the astrolabe is almost the sole astronomical instrument of the Persians, so one can also say that they have made it better and more precise than anyone else in the world. . . . They surpass in this the best workmen that we have.' 'The reason that their astrolabes are so well made is that usually they are made by the astronomers themselves: It is not that there are not professional artisans for making mathematical instruments, but rather that those which these artisans make are not valued as highly as those made by the mathematicians.' E. LANGLÈS (Ed.), Voyages du Chevalier Chardin en Perse, et autres lieux de l'Orient, Paris, 1811, IV, p. 332; and ibid., pp. 336–49, there is a detailed description of the Persian astrolabe.—*Ed.*

(Arabic: *ḥajra*, meaning 'side', or *ṭawq*, meaning 'ring', or *kiffa*, meaning 'curve'; Latin: *limbus* or *margo*), which encloses the inner surface, usually depressed, called the 'mother' (Arabic: *umm*; Latin: *mater*). A number of thin disks, called in Arabic *ṣafā'iḥ* (singular *ṣafīḥa*; Latin: *tympanum* or *tabula regionum*), are fitted into the *ḥajra* over the *umm*, and on each side of every one of these is engraved a stereographic projection of the heavens (see below, *c*.) for a different geographical latitude. Either on the *umm* or on the *ḥajra* there is a projecting bit of metal (Arabic: *mumsika*), which fits into an exactly corresponding depression or hole on the edge of each disk, and thus prevents the disk from turning. A hole (Arabic: *maḥan*) is bored through the centre of every part of the body of the astrolabe, and a broad-headed pin (Arabic: *quṭb*, *watad*, or *miḥwar*; Latin: *clavus*, *axis*) passes through this, holding the parts together. The two movable parts of the astrolabe turn on this as an axis, the 'spider' (Arabic: *'ankabūt*, meaning 'spider', or *shabaka*, meaning 'net'; Latin: *aranea*, or *rete*), and, on the back, the *alidad* (from the Arabic *al-'iḍāda*; Latin: *radius* or *regula*). A long slit in the narrow end of the *quṭb* into which is fitted a wedge called the 'horse' (Arabic: *faras*; Latin: *equus*, *caballus*, or *cuneus*) prevents the pin from coming out. A small ring (Arabic: *fals*) lies between the horse and the spider to prevent the latter from being damaged.[1]

a. The *ḥajra*. The surface of the *ḥajra* carries a circle graduated from 0 to 360°, beginning at S (Fig. 844), the middle point of the *kursī*, that is to say, at the top of the body of the astrolabe.[2]

b. The *umm*. When an instrument is made for different latitudes, the *umm* may be plain or have on it a list of the cities with the geographical co-ordinates of each one, or it may function as one *ṣafīḥa*, carrying the stereographic projection of the heavens for one specific latitude. When the instrument is made for only one latitude, the *umm* is not depressed, but simply takes the place of a *ṣafīḥa*.

c. The *ṣafīḥa*. The stereographic projection of the heavens constitutes the basis for the diagram on the *ṣafīḥa*. The equator forms the plane of the projection, and the centre of the projection for a *northern* astrolabe (*asṭurlāb shamālī*) is the *South Pole* of the heavens, while for a *southern* astrolabe (*janūbī*) it is the *North Pole*. By far the larger proportion of astrolabes are *northern* astrolabes.

The stereographic projection has two outstanding characteristics: in the first place, it represents every circle on the sphere, whether great or small, as a circle on the plane of projection;[3] and in the second place, the angles are correct ('conform projection'), that is, every angle on the vault of the sky remains unchanged in the plane.

The *ṣafīḥa* for north latitude 36° 0', corresponding approximately to the latitude of

[1] European astrolabes often have on the face above the spider a ruler similar to the alidad on the back, or a hand like the hand of a watch (Latin: *index* or *ostensor*), attached at the centre and extending to the rim. This feature is never found on Oriental instruments.

[2] The *ḥajra* on European instruments often has, in addition to this, a division into twenty-four parts, corresponding to the twenty-four equal hours of the day and night ('equinoctial' hours).

[3] With the sole exception of the great circles passing through the centre of projection, which are represented as straight lines.

Raqqa in Mesopotamia, Kennesrīn in Syria, and Rayy in Persia, is shown in Figure 844. A meridian section of the vault of the heavens is represented in Figure 845, showing the principle of construction of the linear system in 844. S is the South Pole of the heavens, N the North Pole, $\Omega\omega$ the equator, produced at either end in the direction Q, q. TT′ and tt′ are the Tropic of Cancer and the Tropic of Capricorn, respectively. Hh is the horizon, the angle NCh equalling latitude φ, in this case 36° 0′. Z is the zenith, and z the nadir. The chords $A_{10}a_{10}$, $A_{20}a_{20}$, . . . $A_{80}a_{80}$ correspond to the almacantars (that is to say, the parallels of altitude or circles parallel to the horizon) of, respectively, 10°, 20° . . . 80°. The stereographic projection consists of representing all the points of the celestial sphere unambiguously on the equator, so that every point P on the sphere is regarded as connected by a straight line with S, the centre of the projection, and the point of intersection π of the straight line SP (or its production) with the plane of the equator is designated as the projection of P.

In Figure 845 all points of the meridian SωNΩ are projected in the way that has been described on the meridian line (the north–south line) $\Omega\omega$ (or its production Qq) of the equatorial plane. Evidently the equatorial points Ω and ω of the sphere coincide with the same points on the equatorial plane, while all points in the *northern* hemisphere will lie *within* the equator, all of the *southern*, *without*. It should be noted that the point of projection of the South Pole will fall at infinity. In this type of projection the centres of the equator and of all the circles parallel to it coincide at point C, which represents the North Pole. On the other hand, other parallel circles can never have a common centre in this projection.

On the meridian line Q$\Omega\omega$q, section $\Omega\omega$ represents the equator, while $\Theta\theta$ represents the northern tropic, $T\tau$ the southern. The centre common to these three circles is C. Section $\eta_0\alpha_0$ represents the horizon Hh, and sections $\eta_{10}\alpha_{10}$, $\eta_{20}\alpha_{20}$ . . . $\eta_{80}\alpha_{80}$ represent the almacantars of 10°, 20° . . . 80°. The centre points R_0, R_{10} . . . R_{80} of the horizon and the almacantars can be determined by dividing in half the corresponding sections of the line. As will be seen, these approach, with a constantly diminishing difference, point ζ of the zenith Z.

Point ξ of the nadir z lies in this diagram beyond τ, that is, outside the southern tropic. If latitude φ equals the obliquity of the ecliptic ε (angle ΩCT), ζ coincides with θ and ξ coincides with τ. If it is smaller, ζ moves out of the northern tropic, while ξ moves into the southern tropic.

In Figure 844 are described the circles, the diameters or radii and centres of which are given in Figure 845, the relative sizes being maintained.

The outer rim of the *ṣafīḥa* represents the southern tropic (Arabic: *Madār Ra's al-Jady*, the 'circle of the head of Capricorn'); the next smaller concentric circle is the equator (*Dā'irat al-i'tidāl*, 'circle of the equinoxes', or *Madār Ra's al-Ḥamal*, 'circle of the head of Aries'); the innermost circle represents the northern tropic (*Madār Ra's as-Saraṭān*, 'circle of the head of Cancer'). The common centre of these three circles, C, represents the North Pole of the heavens.

The diameter NCS represents the north-south line or the meridian (Arabic: *khaṭṭ wasaṭ as-samā'*; Latin: *linea medii coeli*, 'the line of the midst of heaven'); the section or radius CS is especially called in Arabic *khaṭṭ niṣf an-nahār*, in Latin *linea meri-*

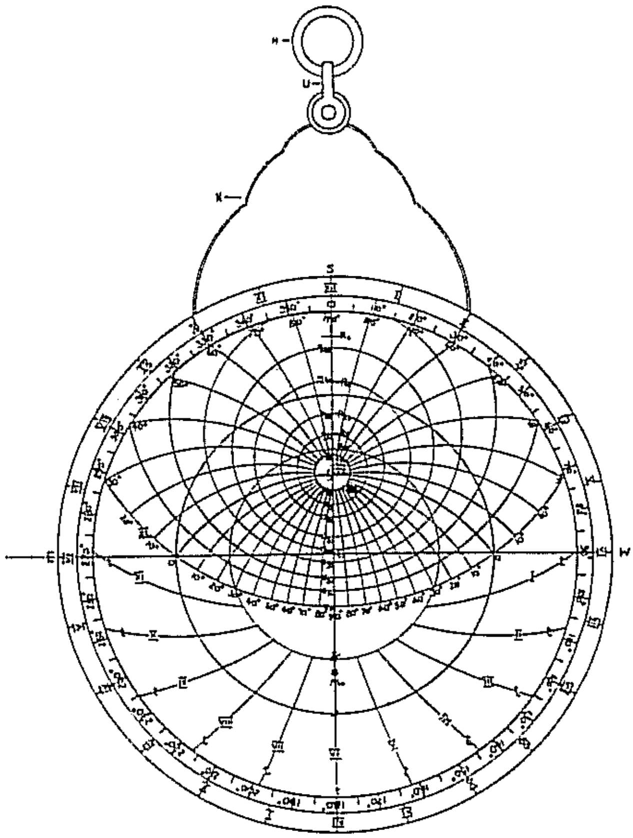

Fig. 844. Face of an astrolabe, showing the divisions of the *ṣafīḥa*.

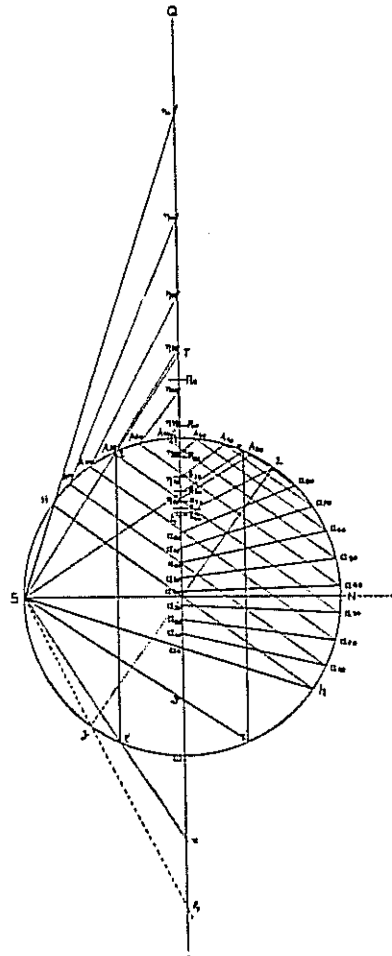

Fig. 845. Stereographic projection on the equator.

dionalis, 'line of midday', while the opposite radius CN is correspondingly called *khaṭṭ niṣf al-layl*, *linea mediae noctis*, 'line of midnight'. The diameter ECW at right angles to the meridian is called the east-west line or the 'straight or level horizon' (Arabic: *ufq al-istiwā'*; Latin: *horizon rectus*), or it is also often called the *khaṭṭ wasaṭ al-mashriq wa'l-maghrib*, 'the line of the midst of the east and the west'; the radii CE and CW bear, respectively, the names *khaṭṭ al-mashriq*, the 'east line', and *khaṭṭ al-maghrib*, the 'west line'.

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The *true* horizon (Arabic: *ufq* or *ufq al-mashriq wa'l-maghrib*; Latin: *horizon obliquus*) is represented by the circle around R_0 through α_0 and the points of intersection of the *horizon rectus* with the equator, that is, the eastern and western points of the equator, while the almacantars, a term derived from the Arabic (*al-dā'ira al-muqanṭara*, the 'complete circle'), which are in reality parallel to the horizon and *concentric*, are shown on the *ṣafīḥa* as the *eccentric* circles around R_{10}, R_{20}, . . . R_{80}, through, respectively, α_{10}, α_{20}, . . . α_{80}. Obviously only the arcs of the circles of the horizon and the almacantars which fall within the southern tropic are shown. The zenith, a word which is derived from the Arabic *samt ar-ra's*, 'direction of the head', lies according to Figure 845 within the smallest almacantar circle, at the point 3.

Astrolabes are classed according to the number of almacantar circles shown. An astrolabe is 'complete' (Arabic: *tāmm*) when ninety circles are shown from degree to degree; 'bipartite' (*niṣfī*) when there are forty-five circles indicating every second degree; 'tripartite' (*thulthī*) when there are thirty circles indicating every third degree; 'quinquepartite' (*khumsī*) when there are eighteen circles indicating every fifth degree; and 'sexpartite' (*sudsī*) when there are fifteen circles indicating every sixth degree; Nāṣir ad-dīn Aḥmad Shīrāzī speaks further of 'novempartite' (*tus'ī*) and 'decempartite' (*'ushrī*) astrolabes, with, respectively, ten circles indicating every ninth degree, and nine circles indicating every tenth degree. Figure 844 represents the last class of astrolabe. The instrument of Shāh Sulṭān Ḥusayn (Pl. 1402 A, B) is a 'complete' astrolabe. The *horizon obliquus* in each instance divides the visible part of the firmament (Arabic: *fawq al-arḍ*, 'above the earth') from the invisible (Arabic: *taḥt al-arḍ*, 'under the earth') part of the firmament.

The points where the *horizon rectus*, the *horizon obliquus*, and the equator intersect are called, respectively, the 'east point' (*nuqṭat al-mashriq*) and 'west point' (*nuqṭat al-maghrib*). The azimuth is numbered from these two points, from 0° to 90° towards the north and south (see Fig. 844).[1] The azimuths (a term derived from the Arabic plural: *as-sumūt*; singular: *as-samt*, 'direction' (compare above *samt ar-ra's*)) are the great circles through the zenith and the nadir, the 'vertical circles', and hence cut the horizon and the series of almacantars at right angles; because the stereographic projection leaves the angles unchanged, this characteristic is retained in the projection on the *ṣafīḥa*, as a glance at the diagram (Fig. 844) shows. In general, astrolabes represent only the parts of the vertical circles that lie above the horizon.

The central point of the vertical circle through the east and west points (that is, the so-called 'first vertical', Arabic: *awwal as-sumūt*) lies at point M_0, the point of intersection of the tangents to the horizon at the east and west points, with the midday line, NS. The centres of all the other vertical circles lie, as a little consideration shows, on the perpendicular to NS through M_0. The construction of these circles for the northern and southern azimuths of 0°, 30°, 60°, and 90°, and for any azimuth that may be

[1] This is in direct contrast to astronomical usage today, which numbers the azimuth from the north or south point of the horizon.

chosen of x° is shown in Figure 846. Oriental astrolabes give the azimuths either, as in Figure 843, from 10 to 10 degrees, or sometimes only from 15 to 15, or 30 to 30 degrees (for the latter see Fig. 846).

The Lines of Equal and Unequal Hours, and the Lines of Prayer Hours.

The divisions of the day in the Islamic Orient must be understood in order to interpret Islamic astrolabes. The day (that is: νυχθήμερον; in Arabic: *al-yawm bi laylatihi*, 'the day with the night that belongs to it') begins with sunset.[1] In ordinary life only the 'unequal hours' are used (Arabic: *as-sā'āt az-zamāniya*; Latin: *horae temporales seu inaequales*). These are the hours that result from dividing into twelve parts either the night, the period from sunset to sunrise, or the *light* day. Thus, an hour in the night is shorter in summer and longer in winter than one in the corresponding day, and only at the time of the equinoxes are night and day hours of the same length. The 'equal hours' (*sā'āt al-i'tidāl*; Latin: *horae aequinoctiales seu aequales*), which correspond with our modern hours, each consisting of one-twenty-fourth of the total νυχθήμερον, or day and night together, were reserved for astronomical use only. But these hours also were numbered from sunset on, not, as in the West, from midnight or midday. The lines for both the unequal and the equal hours are as a rule marked on the part of the *ṣafīḥa below* the horizon (*taḥt al-arḍ*).

To construct the lines of the unequal hours (t t t t . . . in Figs. 844 and 847*a*), the arcs of the circles of the two tropics and of the equator and of all the other concentric circles around C, below the horizon, are divided into twelve equal parts, and the corresponding points are connected with curves, which, of course, are *not* circles. The numbering begins at the west horizon. The line for six o'clock corresponds with the midnight line, and the line for twelve o'clock corresponds with the east horizon.

In order to construct the lines for the *equal* hours, the *complete* concentric circles around C are divided in the same way into twenty-four equal parts, beginning with the points of intersection with the west horizon, and again the corresponding points are connected by curves. These, as is at once obvious, are, in contrast to the curves defining the unequal hours, segments of circles, congruent with each other and with the horizon, the centres lying equidistant on the circle around C which passes through the central point R_0 on the circle of the horizon. These relations are demonstrated by the curved lines a a a a . . . (Fig. 847*a*), which represent the lines of the equal hours. In isolated cases the equal hours are given from the west horizon as well as the east, going north to the midnight line, as in the curves a a a a . . . (see Fig. 847*b*). It should be noted that the lines of the unequal and the equal hours intersect at the equator. The equal hours are often drawn in dotted lines to distinguish them more readily from the unequal hours.

The equal hours numbered, according to our system, from midday or midnight on, have to be shown by a second division of the *hajra* into twice twelve equal parts, beginning

[1] As al-Farghānī assumes, this way of numbering is connected with the circumstance that the first day of the month is determined by the *hilāl* (the new light), which can always be seen at sunset.

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منشورات
معهد تاريخ العلوم العربية والإسلامية
سلسلة الرياضيات الإسلامية والفلك الإسلامي
المجلد ٩٤

منشورات
معهد تاريخ العلوم العربية والإسلامية

يصدرها
فؤاد سزكين

الرياضيات الإسلامية والفلك الإسلامي

٩٤

نصوص ودراسات
حول الآلات الفلكية ودُور الرصد في العالم الإسلامي

القسم ١٠

جمع وإعادة طبع

١٤١٩هـ - ١٩٩٨م
معهد تاريخ العلوم العربية والإسلامية
في إطار جامعة فرانكفورت - جمهورية ألمانيا الاتحادية

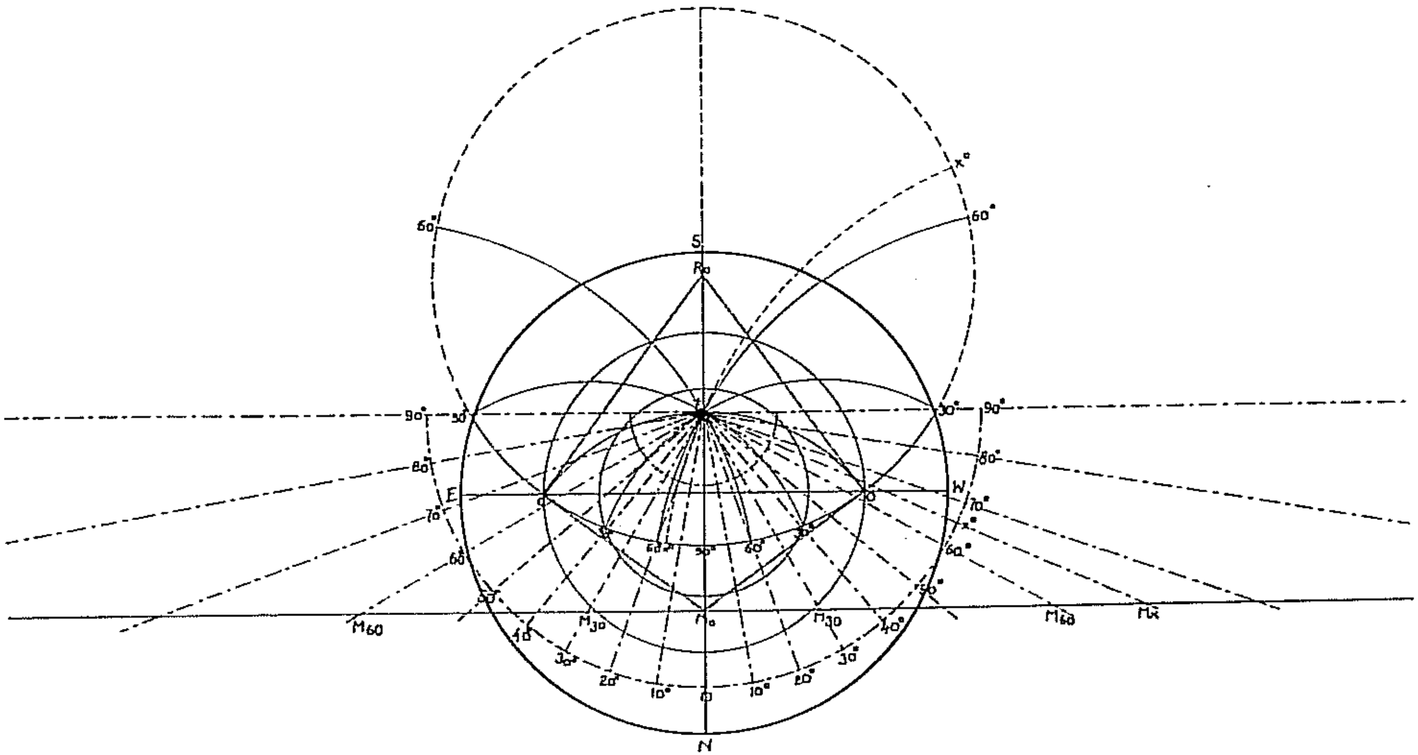

Fig. 846. Construction of the azimuth circles.

from the south and north points of the instrument (see Fig. 844, the outer rim, I–XII and I–XII), but this is not found on Oriental astrolabes.

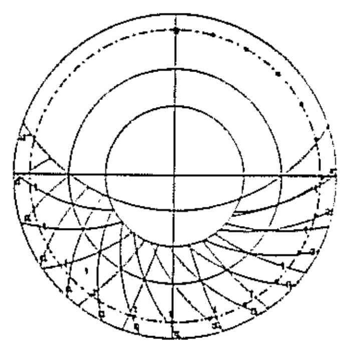

FIG. 847*a*. Lines of the unequal (*t*) and equal (*a*) hours, counted from the western horizon.

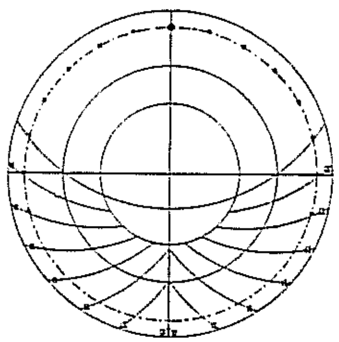

FIG. 847*b*. Lines of the equal hours (*a a a* . . .), counted from the western and eastern horizons.

In addition to this purely astronomical division, most Islamic astrolabes have also lines to mark the various times of the day that are of religious importance. These include especially the lines for the nightfall and dawn (*khaṭṭ ash-shafaq wa'l-fajr*), to indicate the times of evening and morning prayers; the line for midday prayers (*khaṭṭ aẓ-ẓuhr*), which lies somewhat to the west of the meridian; and that for afternoon prayers (*khaṭṭ al-'aṣr*). It is not necessary to consider this any further.

d. The *'ankabūt* (the 'spider'). The spider carries a stereographic projection of the sphere of the fixed stars on the plane of the equator. The construction is carried out in precisely the same way as that of the *ṣafīḥa*. Figure 849 shows again the equator and the concentric circles of the tropics around C, the North Pole of the heavens, and all the other parallel circles from 10° to 10°, as well as all the hour circles from 10° to 10° (or from forty to forty temporal minutes); the hour circles are the great circles through the two poles of the heavens and thus are portrayed as a diameter through C. In this system of equatorial co-ordinates are marked the positions of a number of conspicuous stars at a given time,[1] and also the circle of the ecliptic which cuts the circle of the equator at the vernal and autumnal points (the point of intersection of the equator with the circles of zero hour and twelve o'clock), corresponding to 0° and 180° in right ascension, and touches

[1] The craftsman making the astrolabe has quite a range of choice in selecting the fixed stars to be indicated on the spider. In general, all fixed stars of first magnitude are marked, as well as a series of other stars that are conspicuous because so clear or so isolated in the firmament. Figures 848 and 849 give the stars designated as 'astrolabe stars' in the 'Treatise on the fixed stars' of 'Abd ar-Raḥmān aṣ-Ṣūfī, the positions being reduced to the equinox of 970 (360 H.): see H. C. F. C. SCHJELLERUP, Description des étoiles fixes, composée par l'astronome persan Abd-al-Rahman al-Sûfi, St. Petersburg, 1874. The full number totals thirty-seven, including eleven stars of first magnitude (according to aṣ-Ṣūfī's own classification, which does not always agree with the modern grading), thirteen of second magnitude, twelve of third, and one of the fourth magnitude. Each star is indicated in Figure 849 by a number, the following being the list:

1.	α Bootis	1 m.	20.	α Trianguli	3 m.
2.	α Coronae borealis	2 ,,	21.	α Arietis	3 ,,
3.	α Herculis	3 ,,	22.	α Tauri	1 ,,
4.	α Lyrae	1 ,,	23.	α Geminorum	2 ,,
5.	β Cygni	3 ,,	24.	α Leonis	1 ,,
6.	α Cygni	2 ,,	25.	λ Leonis	2 ,,
7.	β Persei	2 ,,	26.	β Leonis	1 ,,
8.	α Aurigae	1 ,,	27.	α Virginis	1 ,,
9.	α Ophiuchi	3 ,,	28.	α Scorpionis	2 ,,
10.	α Serpentis	3 ,,	29.	λ Capricorni	3 ,,
11.	α Aquilae	2 ,,	30.	α Ceti	3 ,,
12.	ε Delphini	4 ,,	31.	ι Ceti	3 ,,
13.	α Andromedae	2 ,,	32.	α Orionis	1 ,,
14.	γ Pegasi	2 ,,	33.	β Orionis	1 ,,
15.	β Pegasi	2 ,,	34.	α Canis majoris	1 ,,
16.	α Pegasi	2 ,,	35.	α Canis minoris	1 ,,
17.	ε Pegasi	3 ,,	36.	α Hydrae	2 ,,
18.	β Andromedae	2 ,,	37.	γ Corvi	3 ,,
19.	γ Andromedae	3 ,,			

both tropics at 6^h (90°) and 18^h (270°). The revolution of the whole system around C demonstrates the swing of the courses of the fixed stars around the pole. Hence it will be necessary to transmit to the spider the position of the ecliptic and of the fixed stars, determined in this wise. Since the diagram on the *ṣafīḥa* under the spider must be clearly visible, the spider cannot, of course, be a solid disk, but must be a network of openings on which the fixed stars can be indicated as protuberances or pointers. It is because of this reticulated form that it has been called a 'spider', referring, of course, to the spider's web.

In designing this openwork plate practically no limits are imposed on the imagination, and almost every conceivable type is found, from the simplest continuous geometrical

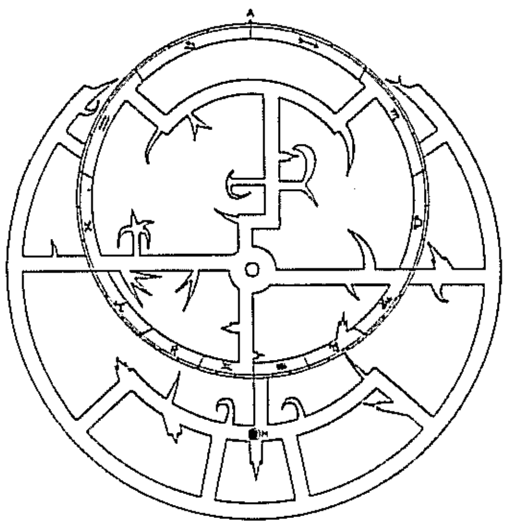

FIG. 848. Spider of an astrolabe containing the stars of Figure 849.

pattern to the most beautiful leaf and scroll designs; the same freedom and variety appear in the pointers indicating the stars, as is seen in the various astrolabes illustrated. The really remarkable instrument of Shāh Sulṭān Ḥusayn is especially interesting in this respect (Pl. 1402).

For technical reasons the outer rim of the spider usually takes the form of a circular ring (see Fig. 848), and this is at various points attached to the zodiac (Arabic: *minṭaqat al-burūj*), which also is represented as a ring. The lines of the hour circles representing zero hour and twelve o'clock are apt to be developed as major supports. The outer rim of the zodiac represents the mathematical line of the ecliptic. The circle of the zodiac is divided into twelve parts, beginning with the point of intersection with the circle representing zero hour, AC (radiating from the pole of the equator, *not* from that of the ecliptic), corresponding to the twelve signs (Arabic: *burūj*, 'castles'): Aries (*al-Ḥamal*), Taurus (*ath-Thawr*), Gemini (*al-Jawzā'*), Cancer (*as-Saraṭān*), Leo (*al-Asad*), Virgo (*as-Sunbula*, '*spica*', or *al-'Adhrā'*), Libra (*al-Mīzān*), Scorpio

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(*al-ʿAqrab*), Sagittarius (*al-Qaws*, 'bow', or *ar-Rāmī*), Capricorn (*al-Jady*), Aquarius (*ad-Dalw*, 'the bucket', or *Sākib al-Mā'*), and Pisces (*al-Ḥūt* or *as-Samakatāni*). Each sign, furthermore, is subdivided, there being on a 'complete' astrolabe (*tāmm*) thirty subdivisions to a sign, on a bipartite fifteen, a tripartite ten, and so on, each subdivision consisting of one, two, three, and so on degrees. The names of the signs are found on the rim of the zodiac, those of the fixed stars on the pointers indicating them.

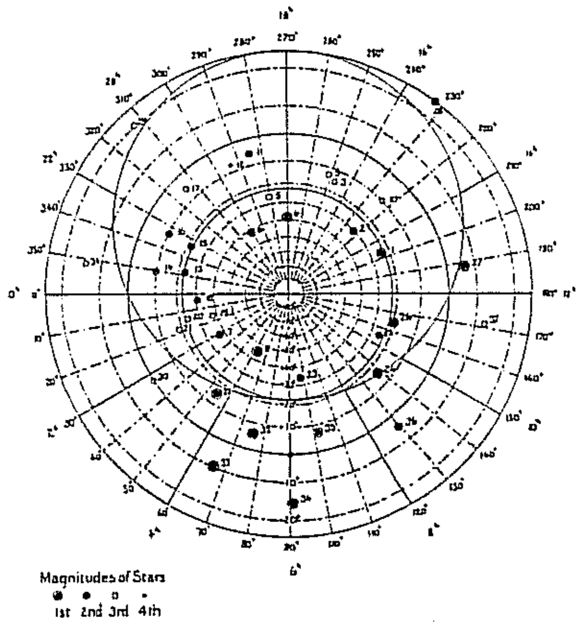

FIG. 849. Showing the positions of the thirty-seven astrolabe stars mentioned in 'Abd ar-Rahmān aṣ-Ṣūfī's *Book of the Fixed Stars* (970 (360 H.)).

At the point of contact with the southern tropic (and likewise with the *ḥajra*), at 18^h right ascension, the zodiac usually carries a little hand A (Fig. 848) (Arabic: *murī ra's al-Jady*), which serves to set it in relation to the *ḥajra*, and so to read the instrument. The spider is rotated by means of a handle consisting of one or several knobs, called, in Arabic, *mudīr* or *muḥrik*, which are usually attached to the lower part of the spider (designated as M in Fig. 848).

In the Arabic and Persian literature variant types of spiders of different construction are mentioned, the astrolabes so equipped being called accordingly, for example: a 'quince', a 'drum' (*asṭurlāb safarjalī* and *asṭurlāb muṭabbal*), a 'myrtle', or a 'crab's claw' astrolabe (*asṭurlāb āsī* and *asṭurlāb saraṭānī* or *musarṭan*);[1] but no examples of these types have been found. Probably they were only fanciful instruments, without

[1] For further information on this point see GUNTHER, Astrolabes of the world, I, p. 111; and J. FRANK, Zur Geschichte des Astrolabs, *Habilitationsschrift* (Auszug), Erlangen, 1920, pp. 9–33.

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scientific import, which were not, as a rule, used, for in all these variations the band of the ecliptic would not be a continuous circular ring, but would be divided into widely varying forms that suggested quinces, drums, myrtle, crabs' claws, and similar things, and the divisions on the *ṣafīḥa* would not be those on the usual northern astrolabes, but would consist of a rather complicated combination of the divisions used on northern and southern astrolabes.[1]

e. The *back*. The back of the astrolabe is always made of a single piece of metal.

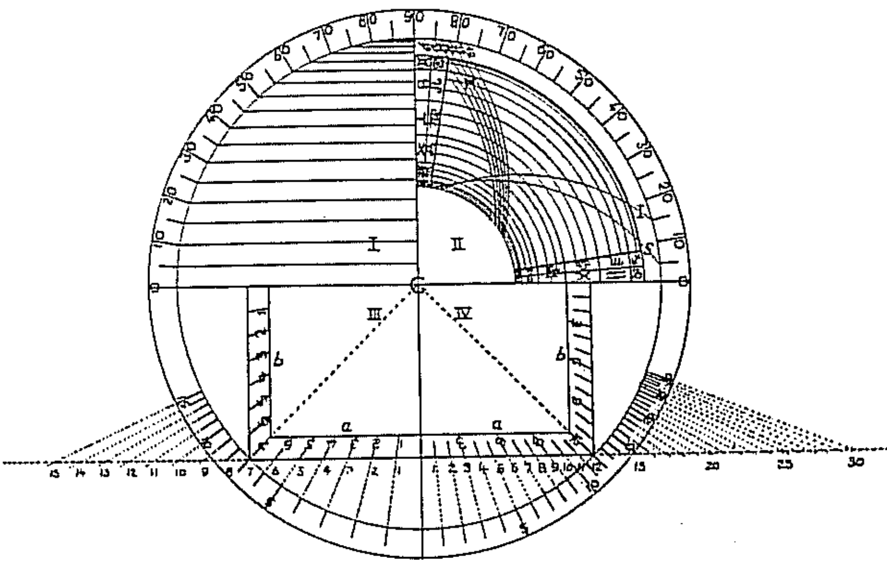


FIG. 850. Back of an astrolabe, showing the construction of the shadow divisions in Quadrants III and IV.

The hard and fast rules that pertain to the divisions on the face do not hold here; but in general, that is to say, in by far the greatest number of examples, the following principles are observed (see Fig. 850). The circular disk is divided into quadrants (Arabic: *rub'*) by a horizontal and a vertical diameter which are numbered on the diagram I, II, III, IV. Following the divisions on the *ṣafīḥa*, the horizontal diameter is called *khaṭṭ al-mashriq wa'l-maghrib* (east-west line), the vertical *khaṭṭ niṣf an-nahār* (midday line), or else it is known as *khaṭṭ al-'ilāqa* (line of the cord); the two first names, reminiscent of the divisions of the *ṣafīḥa*, have no real meaning here.

The four quadrants are called, according to a readily comprehensible convention, 'southeastern' (*ar-rub' ash-sharqī 'l-janūbī*, I; sometimes called also the 'altitude quadrant', *rub' al-irtifā'*); 'southwestern' (*ar-rub' al-gharbī 'l-janūbī*, II); 'northeastern' (*ar-rub' ash-sharqī 'sh-shamālī*, III); and 'northwestern' (*ar-rub' al-gharbī 'sh-shamālī*, IV).

[1] GUNTHER, op. cit., I, p. 111; FRANK, loc. cit., gives the constructions of the various kinds of *ṣafā'iḥ* used in these astrolabes.

Quadrants I and II usually have on the outer rim a division from 0 to 90°, terminating in the east and west points of the horizontal diameter, which serves to measure the altitude of the sun, the moon, and the other astral bodies, with the help of the alidad (see p. 2550). Inside Quadrant I are a number of horizontal and sometimes also vertical parallel lines (see Pl. 1399 B); the horizontal lines correspond to the cosines (*jayb mabsūṭ*), the vertical to the sines (*jayb mankūs*) of the related angle. On smaller instruments the vertical radius is usually divided, according to the Arabic usage, into sixty equal sections (*partes*, 'p'), and these are again subdivided into minutes, seconds, thirds, fourths, and so on.[1] The half-chords representing the cosines are constructed from the divisions of the vertical radius. The lines representing the sines are drawn in the same way, but as a rule only every fifth is marked, making twelve in all. The points of intersection of the sines with the fifth, tenth, fifteenth, and so on, lines of the cosines are often emphasized with heavy dots. Thus the length of the *sinus totus* (that is, the vertical radius itself, sine 90°) equals 60^p, that of sine 30° = 30^p, sine 45° = $42^p\ 25'\ 35''\ 3'''\ 53^{iv}$, sine 60° = $51^p\ 57'\ 41''\ 29'''\ 14^{iv}$, and so on. The division of larger instruments is different in principle, for these give the half chords from degree to degree (see the astrolabe of Shāh Sulṭān Ḥusayn and Fig. 850, where, to make the diagram clearer, only every fifth chord is drawn); in this case the chords are, of course, no longer equidistant, but the spaces between them diminish progressively with the increasing angle, so that naturally the chords of angles approaching 90° cannot be very clearly drawn.[2]

Where Quadrant I is divided into sixty parts, the adjacent Quadrant II usually has the same network of lines in distances from 5 to 5^p; moreover, this quadrant has twelve concentric quadrants of circles around the centre C, with the radii 5^p, 10^p, 15^p . . . , which are tangent to the corresponding vertical and horizontal half-chords where these intersect the two extreme radii; and also there are twelve radii spaced at angles from 5 to 5°.

Quadrant II in Plate 1401 A is, however, constructed on an entirely different system (Fig. 850). Here the concentric quadrants of circles represent the equatorial parallel circles of every fifth degree of the Zodiac (the diagram gives these circles in distances of 10°); the names of the signs are in the *horizontal* radius. The two curves S and I which cut across the system of parallel circles give the azimuth of the qibla (that is, the direction towards Mecca) for the cities of Shīrāz (S) and Iṣfahān (I). Plate 1402 A has the corresponding curves for seven additional cities. More accurately said, these curves represent the altitude of the sun at all times of the year, to be read on the rim with the help of the alidad, at the time of its passage through the azimuth of the qibla. In the same way the system of curves M, which is almost at right angles to the other set of curves, indicates the altitude of the sun at midday at all seasons of the year, for the geographical latitudes, marked on the upper rim, of 30°, 32°, 34°, 36°, 38°, and 40°. It should be

[1] Not to be confused with the minutes, seconds, &c. of degrees or hours.

[2] The division into 60^p is called for convenience *sexagesimal*, that in accordance with the degrees in the graduation on the rim, *nonagesimal*.

noted that in this case the series of signs of the zodiac is indicated in the reverse of the normal order on the *vertical* radius.

Inside Quadrants III and IV are the 'shadow squares', and the left Quadrant III refers almost always to the gnomon divided into seven parts, reckoned in 'feet' (Arabic: *qadam*; plural: *aqdām*), while the right Quadrant IV is used for the gnomon divided into twelve parts, reckoned in 'fingers' (*aṣba'*; plural: *aṣābi'*). The horizontal division *a* is related to the '*umbra recta*' (*ẓill mabsūṭ* or *mustawī*), that is, the shadow thrown by the vertical gnomon on the horizontal plane; the vertical division *b*, on the other hand, indicates the '*umbra versa*' (*ẓill ma'kūs*), that is, the shadow thrown by the horizontal gnomon on the vertical plane. The relation of the first to the whole length of the gnomon corresponds to the cotangent; the relation of the latter to the length of the gnomon corresponds to the tangent of the altitude of the astral body throwing the shadow. The division of the outer rim of these quadrants is constructed by means of a simple projection of the division *a*, which is relative to the *umbra recta* (and so of its production beyond the rim) (see Fig. 850); the centre of the projection is, as is evident, the central point C. This division gives a dependable measure, without computation, of the altitudes of the stars with the aid of the gnomon, an estimate more accurate than can be obtained with the alidad alone. If, for example, the length of the shadow is found to be 11 feet, that is $\frac{11}{7}$ of the length of the gnomon, one simply puts the alidad at division 11 on the rim of Quadrant III, and reads on the diametrically opposite altitude division of Quadrant II the altitude $A = 32\frac{1}{2}°$. Indeed, by calculation we get from cot A $= \frac{11}{7} = 1{\cdot}571$, the angle $A = 32° \ 28'$. The divisions on the rim of Quadrant IV are used in exactly the same way in combination with the gnomon divided into twelve parts.

In addition to these astronomical and trigonometrical divisions, most astrolabes have also on the back a series of purely astrological devices and diagrams relative to the calendar. The back of an astrolabe made by the Egyptian 'Abd al-Karīm al-Aṣṭurlābī in 1227/8 (625 H.)[1] shows an especially full and varied series of these. All the significant details are shown schematically in Figure 851, the usual signs of the zodiac and symbols of the planets having been used.

Thirteen concentric circles divide the disk into twelve circular rings, a, b, c . . . m (the lettering beginning in the figure at the west point). These are divided as follows:

a. The outer rim, a, carries four quadrants of circles divided from 0 to 90°, numbered from the east and west points to the south and north. The upper half, above the horizontal diameter, gives the altitudes of the stars, the lower half the 'depressions', that is to say, the altitudes below the horizon.

b, c. Zone b gives the names of the twelve signs of the zodiac,[2] while c has figural representations of the signs, together with the stars that constitute them; to each

[1] GUNTHER, op. cit., pp. 233–6, No. 103, discusses this instrument, but his description contains several grave errors.

[2] In all twelve instances the inscription follows a stereotyped form: '*al-ḥamal* (*al-thawr*, &c.) '*alā mā yurā fi 's-samā' wa'l-kura*', that is: 'Aries (Taurus, &c.) in accordance with what is seen in the heavens and on the globe'.

sign is added, as is not unusual, its representation in reversal. In some cases the names of the principal stars are especially indicated. Between the figure and its reversed representation is the name of the 'Lord' (*rabb*), indicated above the sign in question (in the diagram it is on the lower right side of the sign of the zodiac). The sun is the Lord of Leo; the moon of Cancer; Saturn of Capricorn in the

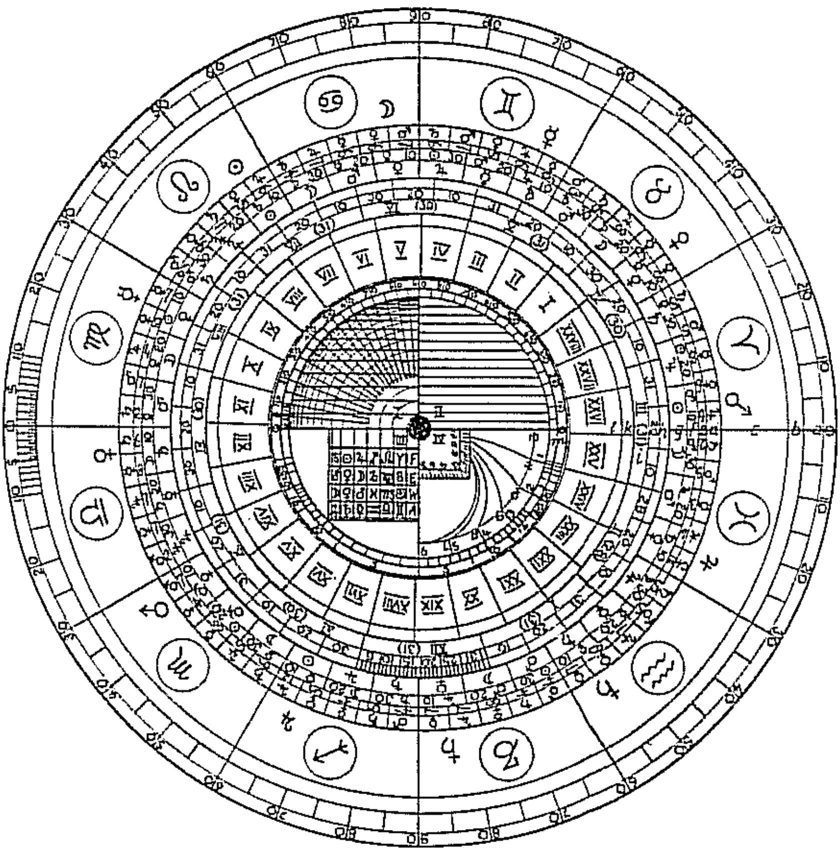


Fig. 851. Back of the astrolabe made by 'Abd al-Karīm al-Aṣṭurlābī in 1227/8 (625 H.).

daytime, and Aquarius at night; Jupiter of Sagittarius in the day, Pisces at night; Mars of Scorpio in the day, Aries at night; Venus of Libra in the day, Taurus at night; Mercury of Virgo in the day, and Gemini at night.

d, e. Zones d and e have the 'limits' (Arabic: *ḥudūd*; Latin: *fines*), in accordance with the arrangement in use in Egypt. These consist of five areas of unequal size for each sign of the zodiac, with the exception of the sun and the moon. The extent of each limit in degrees is indicated by the figures in zone e.

f. Zone f has the names of the Lords of the thirty-six 'faces' (Arabic: *wajh*; plural: *wujūh*; Latin: *facies*), which go back to ancient Egyptian prototypes.

Each of these faces includes 10°, so that each group of three corresponds to one sign of the zodiac. These faces play an important part in the horoscope.

g. Zone g is divided in relation to the so-called 'triangles' or triplicities (Arabic: *muthallatha*; Latin: *trigonum* or *triquetrum*). Each triplicity consists of three signs of the zodiac, which are grouped at a mutual angular distance of 120°, and each has a Lord of the day and a Lord of the night and also a Companion (*sharīk*). Furthermore, each triplicity corresponds to one of the elements, in the following relations:

1. The 'fiery', *muthallatha* (*nāriya*): Aries, Leo, and Sagittarius; Lord of the day, the sun; Lord of the night, Jupiter; Companion, Saturn.
2. The 'earthy', *muthallatha* (*arḍiya*): Taurus, Virgo, and Capricorn; Lord of the day, Venus; Lord of the night, the moon; Companion, Mars.
3. The 'airy', *muthallatha* (*hawā'iya*): Gemini, Libra, and Aquarius; Lord of the day, Saturn; Lord of the night, Mercury; Companion, Jupiter.
4. The 'watery', *muthallatha* (*mā'iya*): Cancer, Scorpio, and Pisces; Lord of the day, Venus; Lord of the night, Mars; Companion, the moon.

The Lords of the day occupy the first place, the Lords of the night the second, the Companions the third place, numbered with increasing longitudes.

h, i. Zones h and i give the days of the Julian year, and the names of the Syro-Arab months (*shuhūr ar-rūm*), which are equivalent to the Julian months. The inscriptions, beginning in the left lower quadrant (III), run:

Tishrīn (al-)awwal, 31 days (October, X),
Tishrīn (ath-)thānī, 30 days (November, XI),
Kānūn (al-)awwal, 31 days (December, XII),
Kānūn (ath-)thānī, 31 days (January, I),
Shubāṭ, 28 days (February, II),
Ādhār, 31 days (March, III),
Nīsān, 30 days (April, IV),
Ayyār, 31 days (May, V),
Ḥazīrān, 30 days (June, VI),
Tamūz, 31 days (July, VII),
Āb, 31 days (August, VIII),
Aylūl, 30 days (September, IX).

k, l. Zone k carries the names of the twenty-eight old Arabic Mansions of the Moon (*manzil*; plural: *manāzil*), while zone l gives figures representing these mansions, and also indicates the names of each of the chief stars.[1] The numbering begins with the lunar mansion *ash-sharaṭān* in the seventh degree of Taurus, that is, at the 37° longitude. They are arranged in such a way that each of the twenty-eight

[1] For more detailed information on the configurations of the *Manāzil* and their place in relation to the constellations of the zodiac see HARTNER, Minṭaka, *Encyclopaedia of Islam*, III (1931), pp. 501–4; and the reprint of the treatise of W. H. MORLEY, *in* GUNTHER, op. cit., I, p. 30 (see p. 2532, n. 4).

mansions stands under the day of the Syrian month on which it rises heliacally, for example, ash-Sharaṭān (I) on Nīsān (April) 21; al-Buṭayn (II) on Ayyār (May) 5, &c. This agrees almost exactly with al-Bīrūnī's dates of the heliacal risings of the lunar mansions as given in his *Chronology of Ancient Nations*[1] calculated for the year 1300 A. Alex. (A.D. 990). The slight differences between al-Bīrūnī's dates and those of 'Abd al-Karīm's astrolabe are mainly due to the effect of the precession of the equinoxes, and the change of the date of the Vernal equinox in the Julian calendar during the 237 years that had elapsed between the time of al-Bīrūnī and 'Abd al-Karīm.

m. Zone m is identical with the outer rim of Figure 850 (see p. 2545). Within zone m are the four quadrants (Fig. 850 and Pl. 1399 B), but with the following modifications: Quadrants I and II are interchanged as compared with those on Plate 1399 B. Quadrant I is divided into ninety parts; the circle of the obliquity of the ecliptic (for $\varepsilon = 23\frac{1}{2}°$) is drawn in a dotted line. Quadrant II, the quadrant of altitude, is divided into sixty parts. Quadrant III contains a rectangular diagram that has to the right of the vertical division line the twelve signs of the zodiac, divided into the four *muthallathāt*: (1) 'fiery', (2) 'earthy', (4) 'watery', (3) 'airy', designated F, E, W, A, in that order from top to bottom, while on the left side there is in the first column the Companion of the *muthallatha* in question, in the second its Lord of the day, and in the third its Lord of the night. In Quadrant IV are a small shadow square divided into twelve fingers, and the curves of the unequal hours ('temporal hours', *al-sā'āt az-zamāniya*).

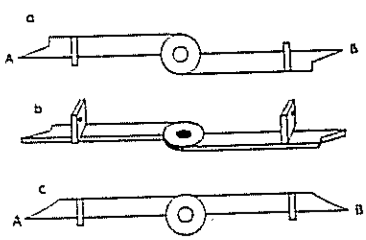


FIG. 852. Types of alidads.

f. The *alidad*. The *alidad* is a flat ruler affixed to the back of the astrolabe, which turns around the *quṭb* and serves to set and read the instrument, as has been described, in order to measure the altitude of the stars. Figure 852 *a* and *c* shows the two principal types that come into consideration, Figure 852 *b* being a drawing in perspective of 852 *a*. The straight line AB which passes through the central point and extends to the outer rim in either direction was called in medieval Latin *linea fiduciae* or *fidei*. At either end of the alidad is a rectangular plate (*libna*) standing at right angles to the plane of the alidad itself, through which a hole (*thuqba*) is bored above the *linea fiduciae*. In order to measure the altitude of the sun, the plane of the astrolabe, which must be hung vertically, is turned towards the azimuth of the sun, the alidad is turned around until sunlight falls through both holes, and the altitude of the sun can then be read on the outer rim. The altitude of stars can be read in the same way by simply sighting through the two holes.

[1] For an English translation see E. SACHAU, Chronology of ancient nations, London, 1879, table p. 352, column 3.

THE USE OF THE ASTROLABE

In the following brief survey of the most important uses of the astrolabe the treatises of 'Alī ibn 'Īsā and of Messahalla on the astrolabe and its use have, in general, been followed. Certain aspects, notably the determination of the altitudes of the stars, have already been considered, so that it would be superfluous to repeat this discussion.

INTRODUCTION

a. Since the curves of the unequal and equal hours are in most cases *below* the horizon line, the hours of the day are not read by means of the points on the zodiacal circle of the spider which correspond to sun longitudes, but on the points diametrically opposed, which thus correspond to the sun longitude increased by 180°. As a rule this point is called, in Arabic astronomy, the nadir point, *an-naẓīr*.

b. In setting the spider to the altitude circles of the *ṣafīḥa* (almacantars) one must always take into account whether the altitude has been measured before or after the passage through the meridian. In the former case the spider is set to the *left*, in the latter to the *right* of the vertical north-south line.

1. *DETERMINATION OF THE LONGITUDE OF THE SUN IN THE ECLIPTIC*

One places the alidad on the line marking the day in question (Fig. 851, zone h/i), reckoned by the Julian calendar, and reads on the rim diagram (zone a) the corresponding solar longitude in the ecliptic (hereafter always designated as L).

2. *UNEQUAL AND EQUAL HOURS*

The spider is turned, until the degree of the ecliptic corresponding to the day on which the observation is being made falls on the almacantar of the sun altitude that has been measured. Then the hour of the day can be read at the point of the nadir on the curves of the unequal or the equal hours, as desired. At night the altitude of a star is measured, the indicator representing this star is made to coincide with the almacantar in question, and L itself is used instead of the nadir, since it is night, as the indicator on the curves of the hours (see also below under No. 5).

3. *ASCENDANT, DESCENDANT, 'DEGREE OF THE MIDDLE OF THE HEAVENS', AND 'DEGREE OF THE POINT OF REVOLUTION (THAT IS, OF THE NORTH LINE) OF THE EARTH'*

When the spider is set for the time of the day or night as indicated in Number 2, the degree of the ecliptic coinciding with the east horizon is called the *ascendant*, the degree of the west horizon the *descendant*, the south line (CS in Fig. 844) indicates the 'degree of the middle of the heavens' (that is, the part of the ecliptic which is in the upper culmination), while the north line CN, the line of the 'revolution point of the earth', *khaṭṭ watad al-arḍ*, indicates the 'degree of the revolution point of the earth', that is, the degree of the ecliptic which is at the time in question in the lower culmination.

2551

All four of these points have astrological significance. The *ascendant* plays an especially important role, for from this point the zodiacal circle is schematically divided, in the direction of increasing longitudes, into twelve parts or 'houses' (Arabic: usually *buyūt*, from the singular *bayt*; Latin: *loci*).[1] These must not be confused with the twelve signs. These houses are decisive in predicting the life history of the new-born, in accordance with the medieval Latin verse:

'Vita, lucrum, fratres, genitor, nati, valetudo,
Uxor, mors, pietas, regnum, benefactaque, carcer.'

House I, which is also called the horoscope, furnishes the general conclusions as to the whole course of the child's future life. House II determines financial position; III, the brothers and sisters; IV, parents; V, children; VI, health; VII, married life; VIII, manner of death and heritage; IX, religious connexions and also journeys; X, merits and capacities, character, and residence; XI, good works and friends; XII, enemies, imprisonment, and all kinds of trouble.

The astrolabe enables one to read directly the configuration of the stars in these twelve *loci*, and saves the astrologer a complicated and tiresome calculation with formulae of spherical trigonometry.

4. *DAY AND NIGHT ARCS*

The diurnal arc of any fixed star that may be selected is equal to the number of degrees which are covered by the *murī* (indicator A on the spider, at 270° longitude; see Fig. 848), between the rising and setting of the indicator of the star in question. To determine the diurnal arc of the sun the longitudinal degree L is used in place of the star indicator. The nocturnal arc in each case is equal to 360°, minus the diurnal arc.

5. *LENGTHS OF THE UNEQUAL HOURS EXPRESSED IN DEGREES OR IN EQUAL HOURS*

If L is made to coincide with first one and then another of two immediately succeeding curves of the unequal hours, the *murī* covers the number of degrees corresponding to the length of an hour of time. The transposition into equinoctial hours ('equal' hours) is done in the usual way, dividing by fifteen. When the lines of the equal hours are not specifically indicated, the equal hours of the day and the night can be determined in analogy with this procedure: they are derived from the number of degrees which

[1] The directions for the correct division into the twelve *loci* run as follows: When the spider is in the correct position for the time of the observation, the east horizon marks the ascendant (locus I), the west horizon the descendant (the nadir point of locus I), which is identical with locus VII; the north line CN marks locus IV, the south line CS, locus X. If one puts the ascendant on the curve of the eighth hour (of the *unequal* hours), locus II lies above CN, locus VIII above CS. In the same way one determines loci III and IX by placing the *ascendant* on the curve of the tenth hour. Loci V and XI are determined by placing the *descendant* on the curve of the second hour, loci VI and XII by placing the *descendant* on the curve of the fourth hour. This complicated ancient procedure is based, as is seen, on the principle of the temporal hours. A simpler system was developed later on the principle of the equinoctial hours, and according to this the ecliptic was divided, from the ascendant on, into twelve equal parts, each of 30°.

the *murī* covers when L is moved from coincidence with the line of the horizon to coincidence with the almacantar which corresponds to the altitude measured. If the equinoctial hours are to be counted in European fashion from midday or midnight on, it is necessary to measure, in exactly the same way, the arc of the circle which is described by the *murī* when L is moved from the midday, or midnight line, as the case may be, to coincidence with the almacantar corresponding to the altitude measured; or, in the case of night hours, to coincidence of the pointer of a fixed star, which has been sighted, with the almacantar in question. On European instruments the hours can be read directly on the outer rim of the *ḥajra* (Fig. 844) by placing the ostensor on point L of the ecliptic.

6. *THE* MAṬĀLI' *(ASCENDANT) IN THE OBLIQUE AND IN THE RIGHT ASCENSION* (Ascensio obliqua *and* ascensio recta)

The exact degree of the *maṭāli'* (ascendant) is also most conveniently determined with the help of the *murī* by measuring the number of degrees of the equator, which, together with the part of the zodiacal sign in question, rises above the horizon (*ascensio obliqua*), or else passes the east-west line (*ascensio recta*).

For the former one sets the beginning of the sign of the zodiac in question on the east horizon and turns the spider until the degree desired coincides with the east horizon, and measures the arc of the circle covered by the *murī*. For the latter the eastern part of the east-west line CE takes the place of the east horizon. By dividing with fifteen one gets the time that has elapsed in equal hours.

7. *AZIMUTH*

The azimuth of the sun, or of any fixed star that may be chosen, is obtained by the position of L, or of the indicator of the star in question, in relation to the azimuthal circles (see Fig. 844). The numbering, as has been said, goes from the east and west points of the horizon towards the south and north, in each case running from 0 to 90°. Conversely, of course, time can be determined from the observed azimuth of the sun or star, as well as from the altitude.

8. *LONGITUDES OF THE MOON AND OF THE PLANETS IN THE ECLIPTIC*

To obtain these longitudes one measures at the same time the altitude of the moon, or of the planet, and of a fixed star, and sets the spider on the almacantar of the latter. The longitude of the moon or of the planet desired is then given by reading the degree of the ecliptic which lies on the almacantar corresponding to the altitude of the moon or of the planet measured. It is obvious that this will give only the approximate longitude. The estimate will be the more inaccurate the greater the ecliptical latitude of the moon, or planet. To make observations of the moon in the daytime the sun is used in place of the astrolabe star.

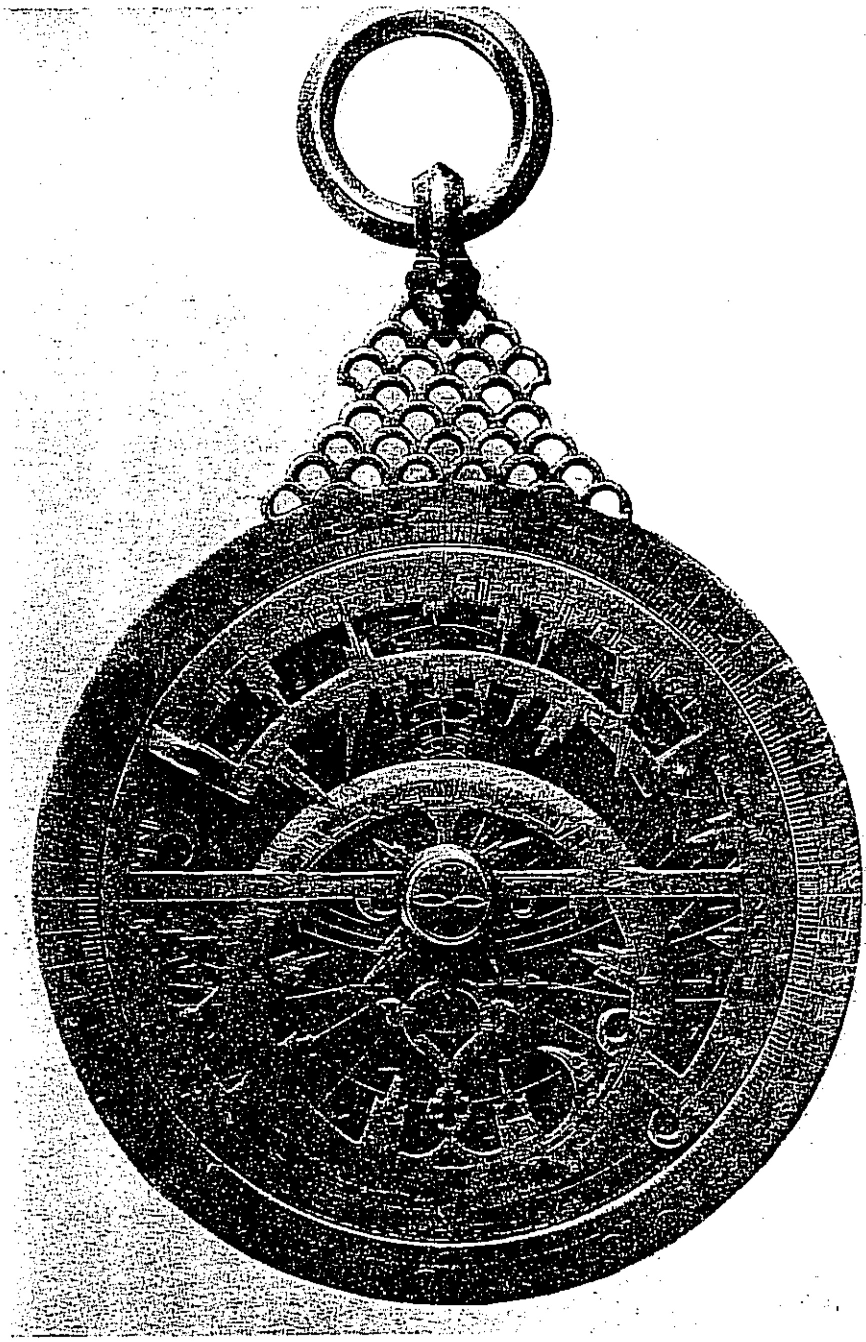
9. *ECLIPTICAL (GEOCENTRIC) LATITUDE OF THE MOON AND PLANETS*

In order to determine whether the moon or a planet stands north or south of the ecliptic, one measures its altitude in the meridian, and compares this with the altitude of the degree of the ecliptic culminating at the same time. An exact numerical determination of the latitude is not possible with the astrolabe alone.

10. *CONFIGURATIONS OF THE PLANETS*

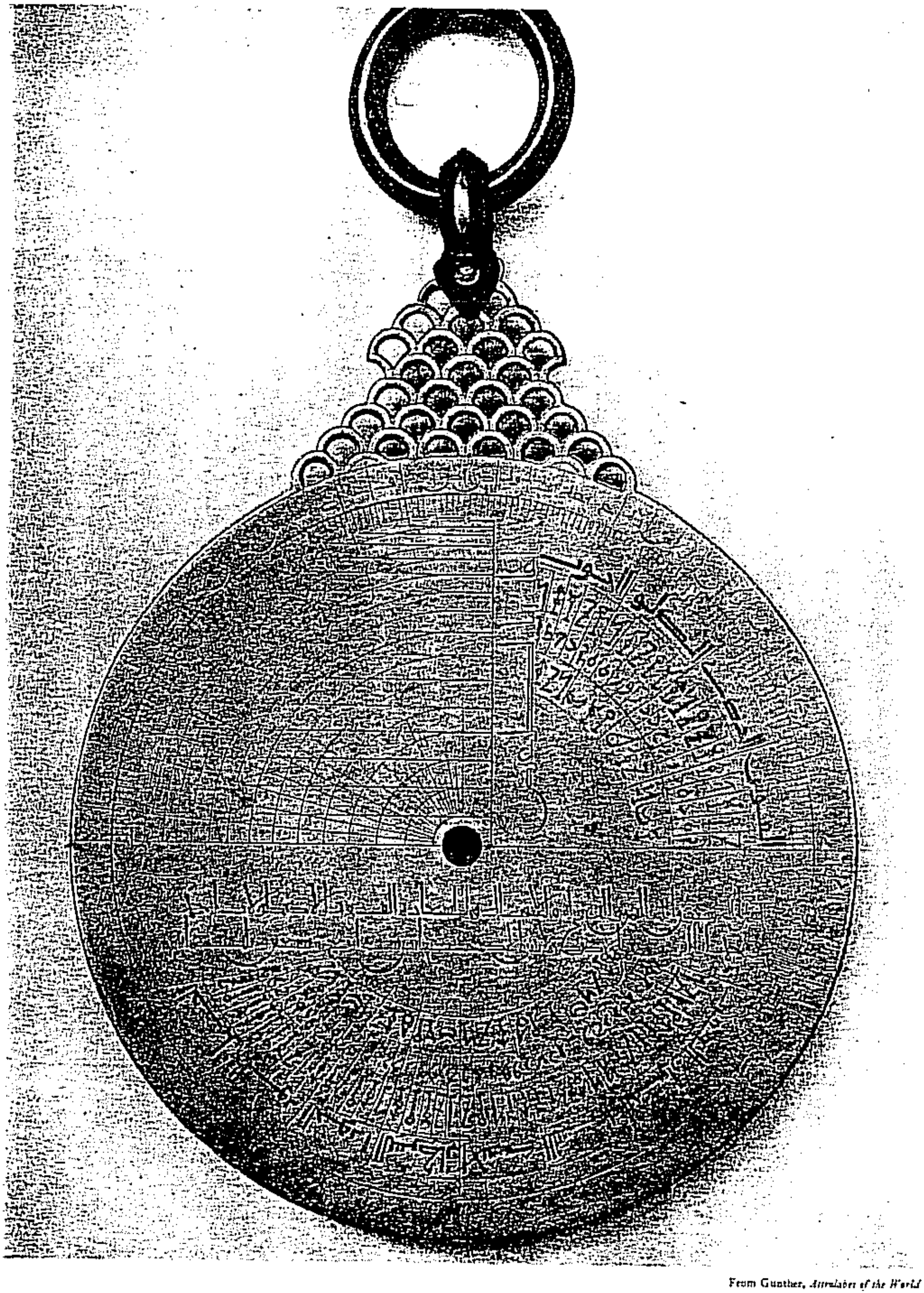
When the longitudes of two planets l_1 and l_2 have been determined in accordance with Number 8, the configuration is obtained by sighting from the central point over points l_1 and l_2 of the ecliptic, to the degrees of the *ḥajra*. If the resulting difference in right ascension comes to 60°, the two planets stand in sextile configuration; 90° difference is called quadrature, 120° trigonal configuration, 180° opposition, and finally, 0°, that is, when both longitudes are the same, conjunction. These configurations also play an important part in astrology. In using a European instrument the sighting is done with the help of the ostensor.

1397



A, B. ASTROLABE, BRASS, ENGRAVED

Signed: *the work of Aḥmad and Muḥammad Banū Ibrāhīm the astrolabe makers of Iṣfahān*, 984 (374 H.)
Old Ashmolean Museum, Oxford. D. $5\frac{3}{16}$ in. (13·2 cm.)

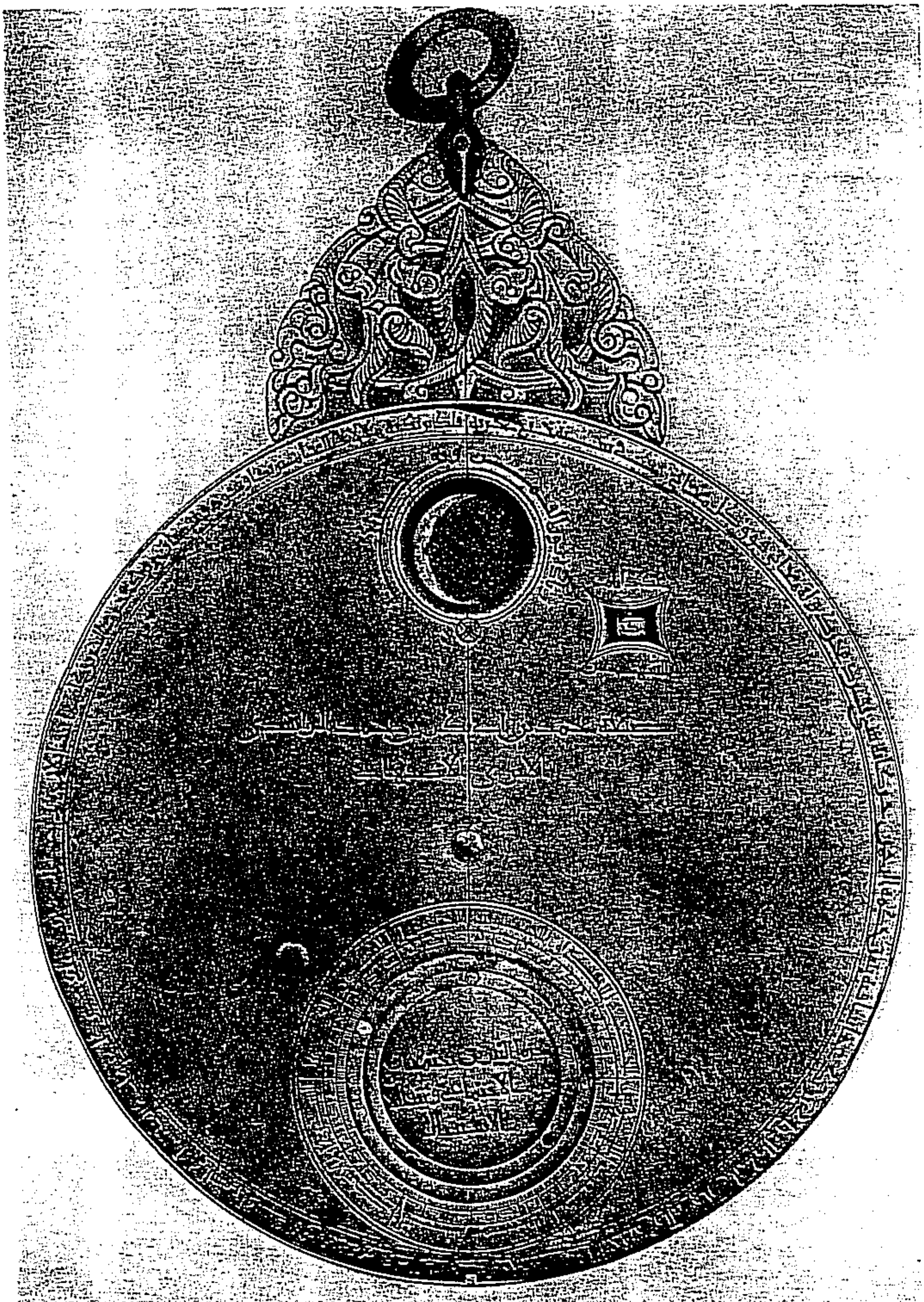


From Gunther, *Astrolabes of the World*

A, B. ASTROLABE, BRASS, ENGRAVED

Signed: *the work of Muhammad ibn Ali Bakr ibn Muhammad ar-Rashid al-Ibari of Isfahan.* 11th or 12th century
Old Ashmolean Museum, Oxford. D. 7 5/16 in. (18·5 cm) See Pl. 1312 D, E

1398

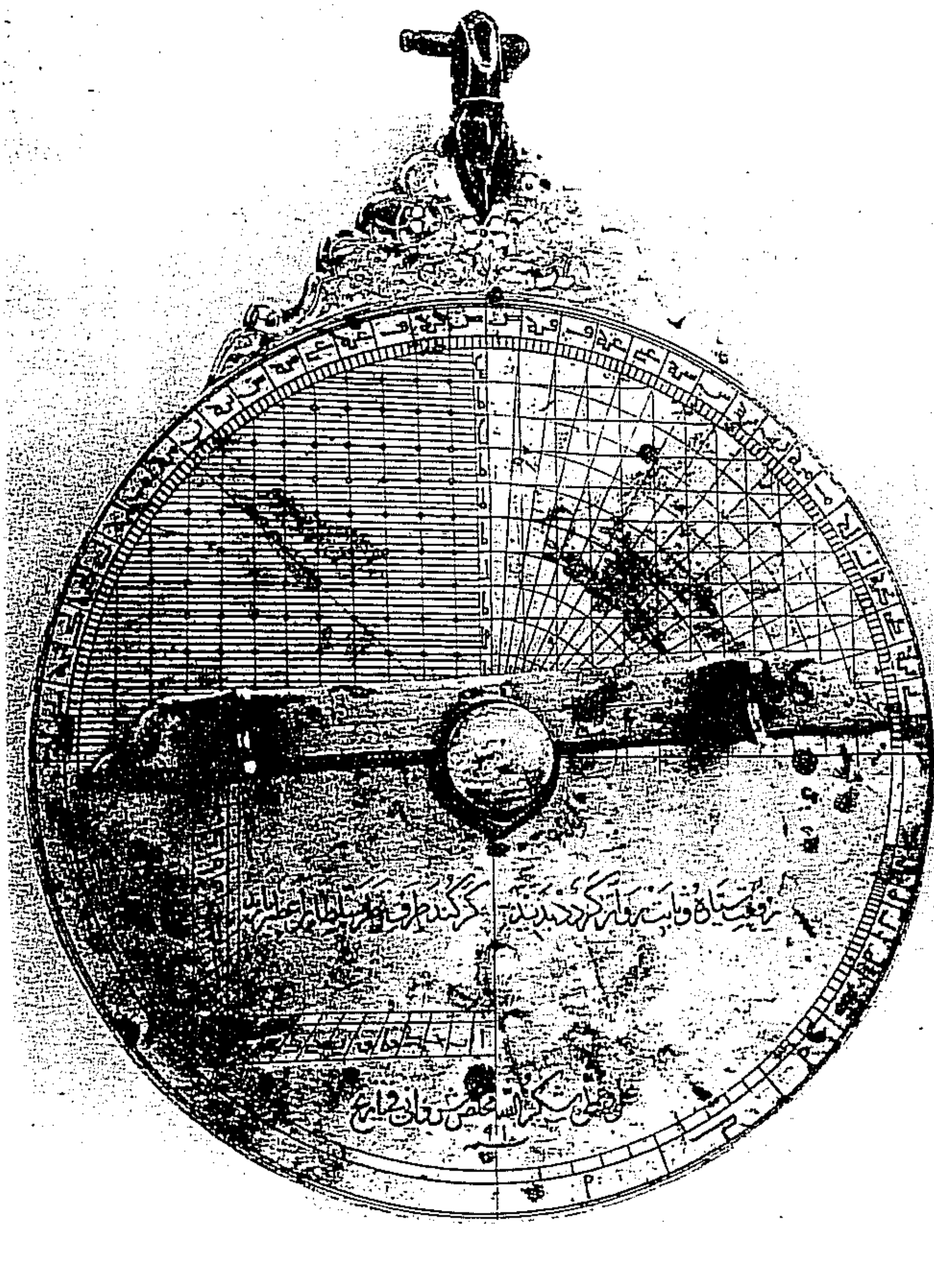


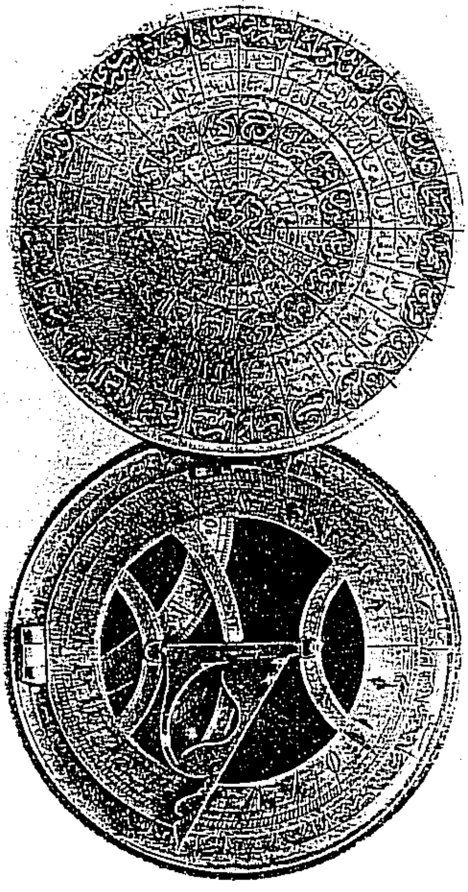
From Gunther, *Astrolabes of the World*

Lon. Ex. No. 309 c

A, B. ASTROLABE, BRASS, ENGRAVED

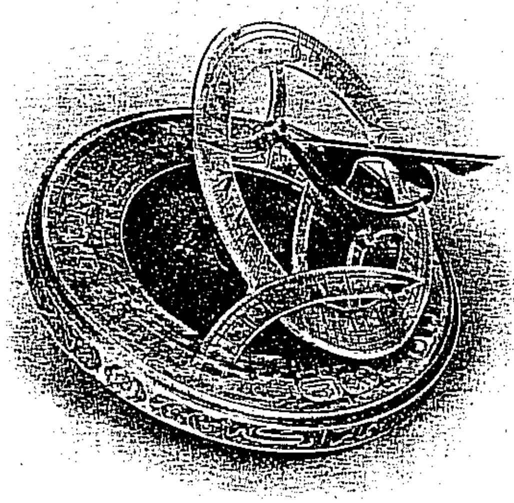
Signed: *the work of Shukr Allāh Mukhliṣ of Shirvān*, 1486 (891 H.). Collection Harari. D. 5⅞ in. (15 cm.)





Lon. Ex. No. 309 H

A. PORTABLE SUNDIAL, BRASS, ENGRAVED
17th century. Collection Captain E. McCauley
D. 3¼ in. (8 cm.)

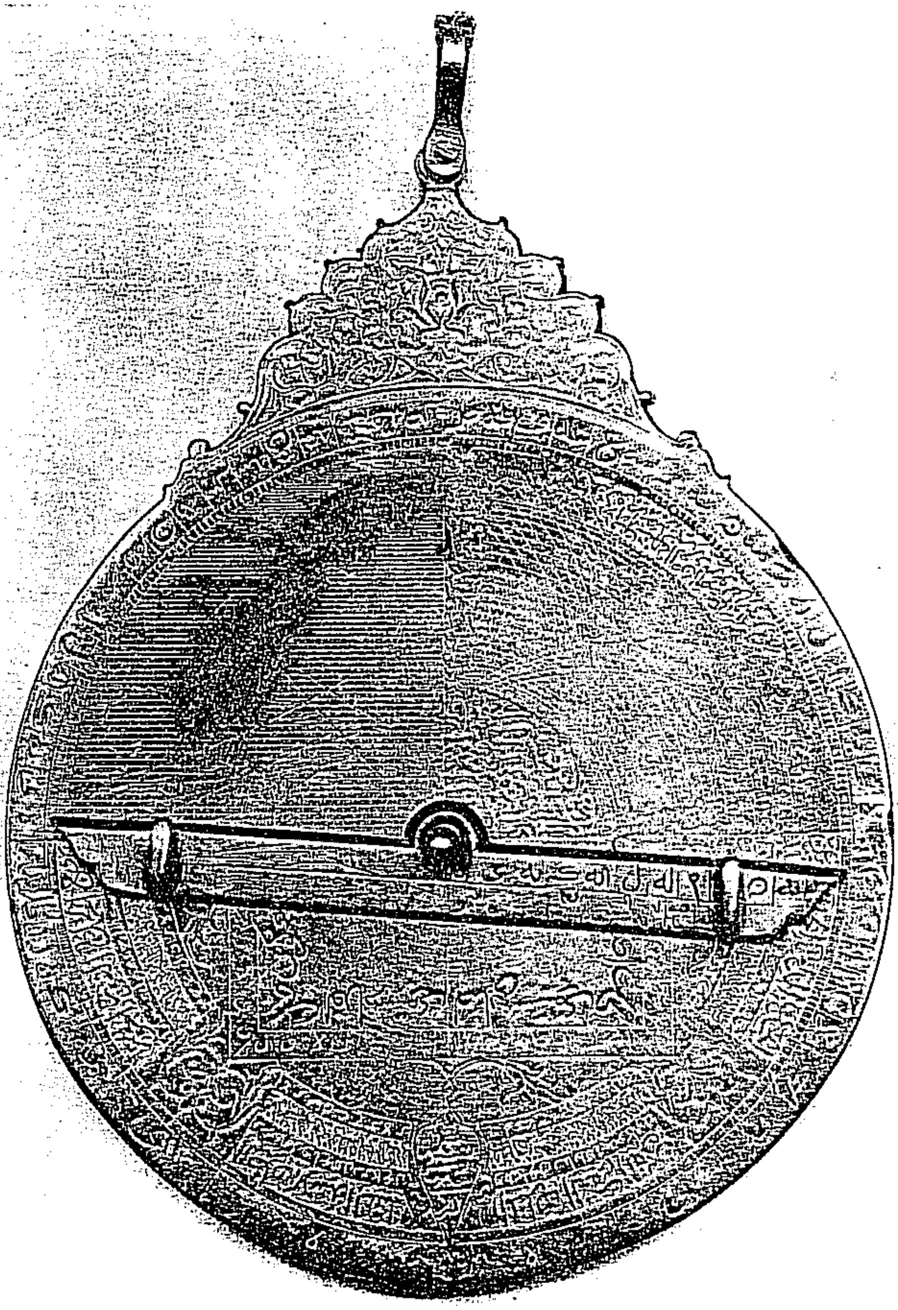


C. ANOTHER VIEW OF
SUNDIAL (A)

Lon. Ex. No. 309 G

B. ASTROLABE, BRASS, ENGRAVED
Signed: *the work of Khalil ibn Muhammad*, 1506 (912 H.)
Collection Harari. D. 3 15/16 in. (10 cm.)

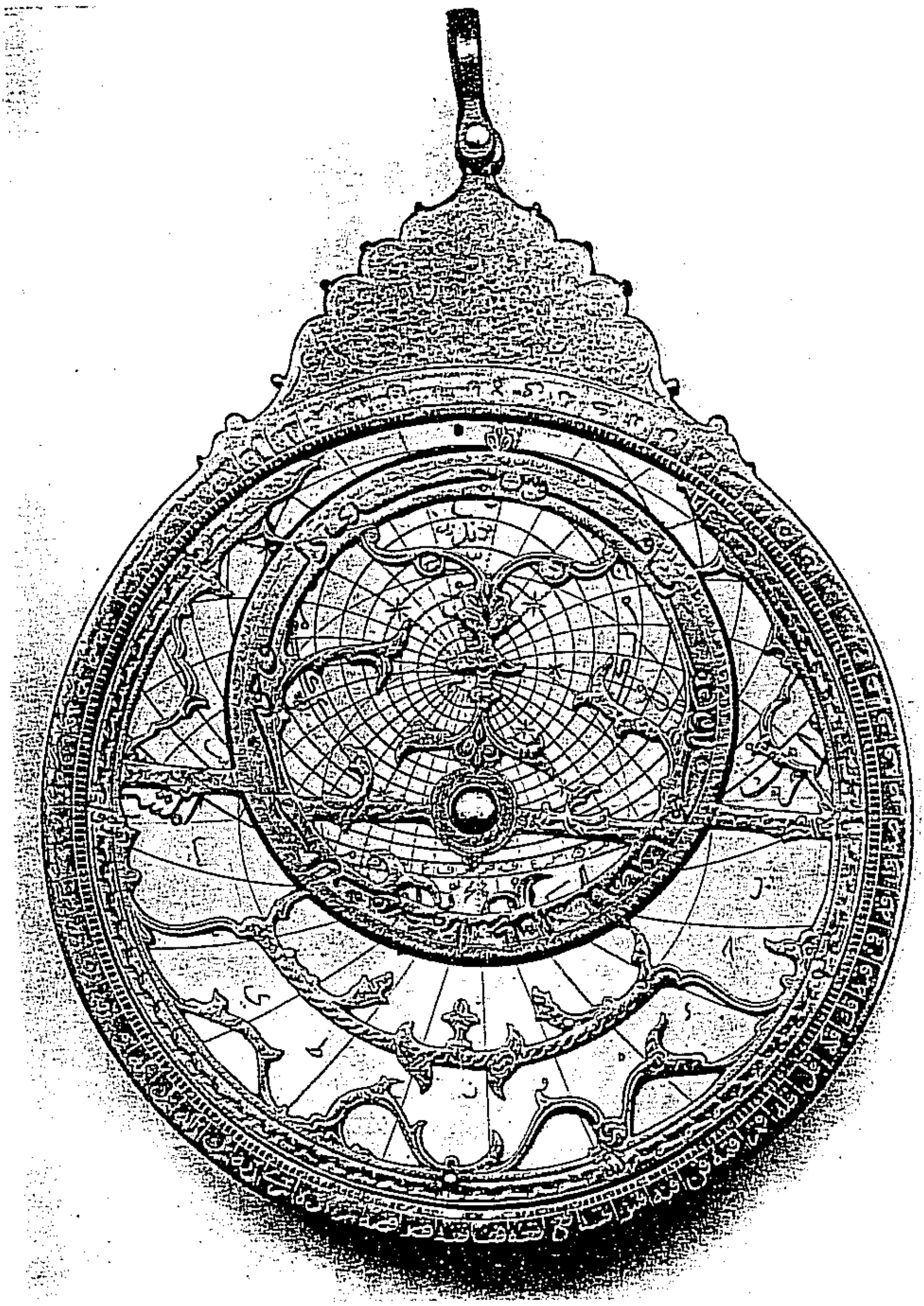
1401



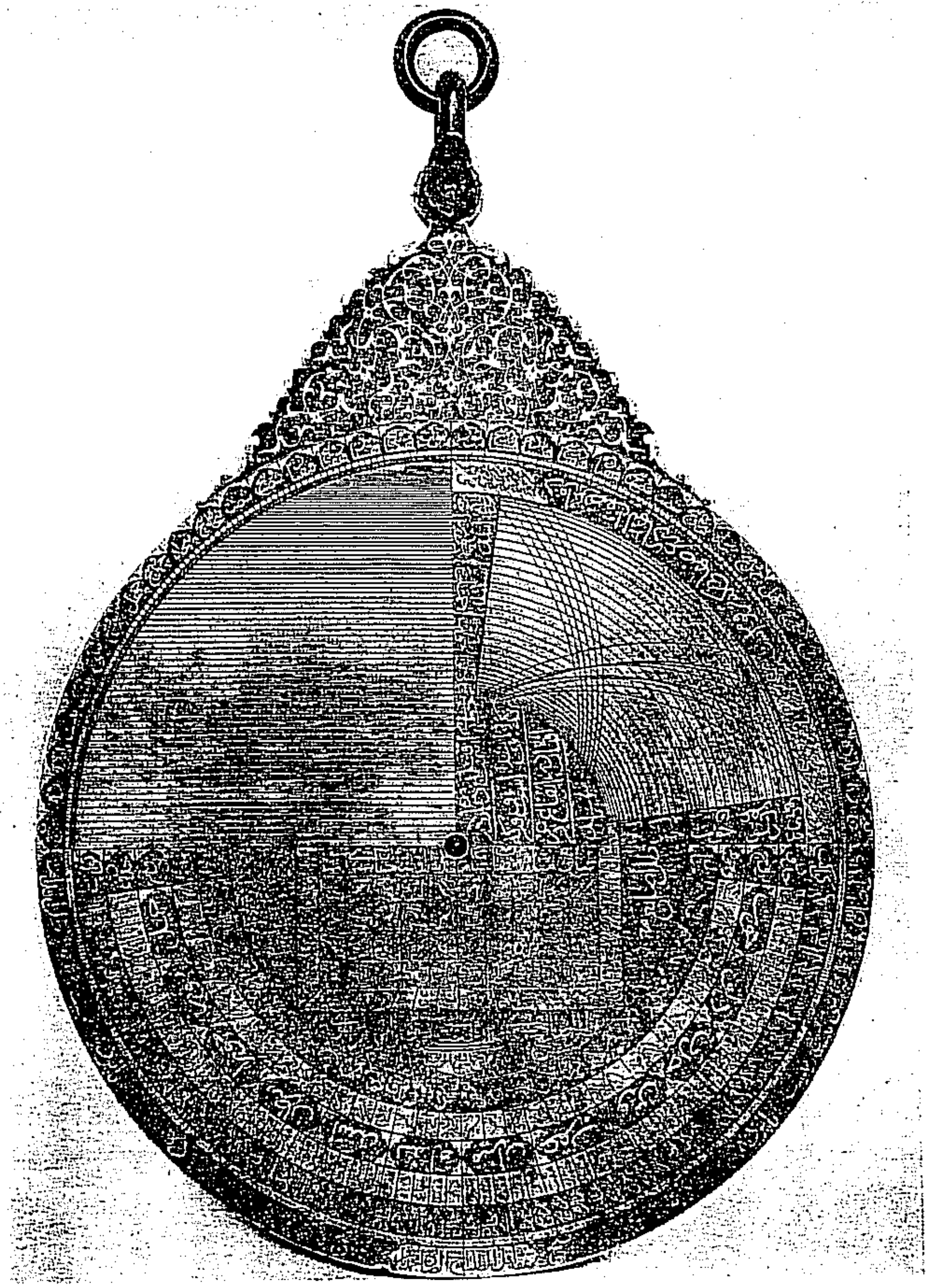
From Gunther, *Astrolabes of the World*

A, B. ASTROLABE, BRASS, ENGRAVED, GILT

Signed: *the work of Muhammad Muqim* and *Muhammad Shafi'*, engraved by *Mahdi of Yazd*, dated 1647 (1057 H.)
Old Ashmolean Museum, Oxford. D. 4⅜ in. (11·1 cm.)

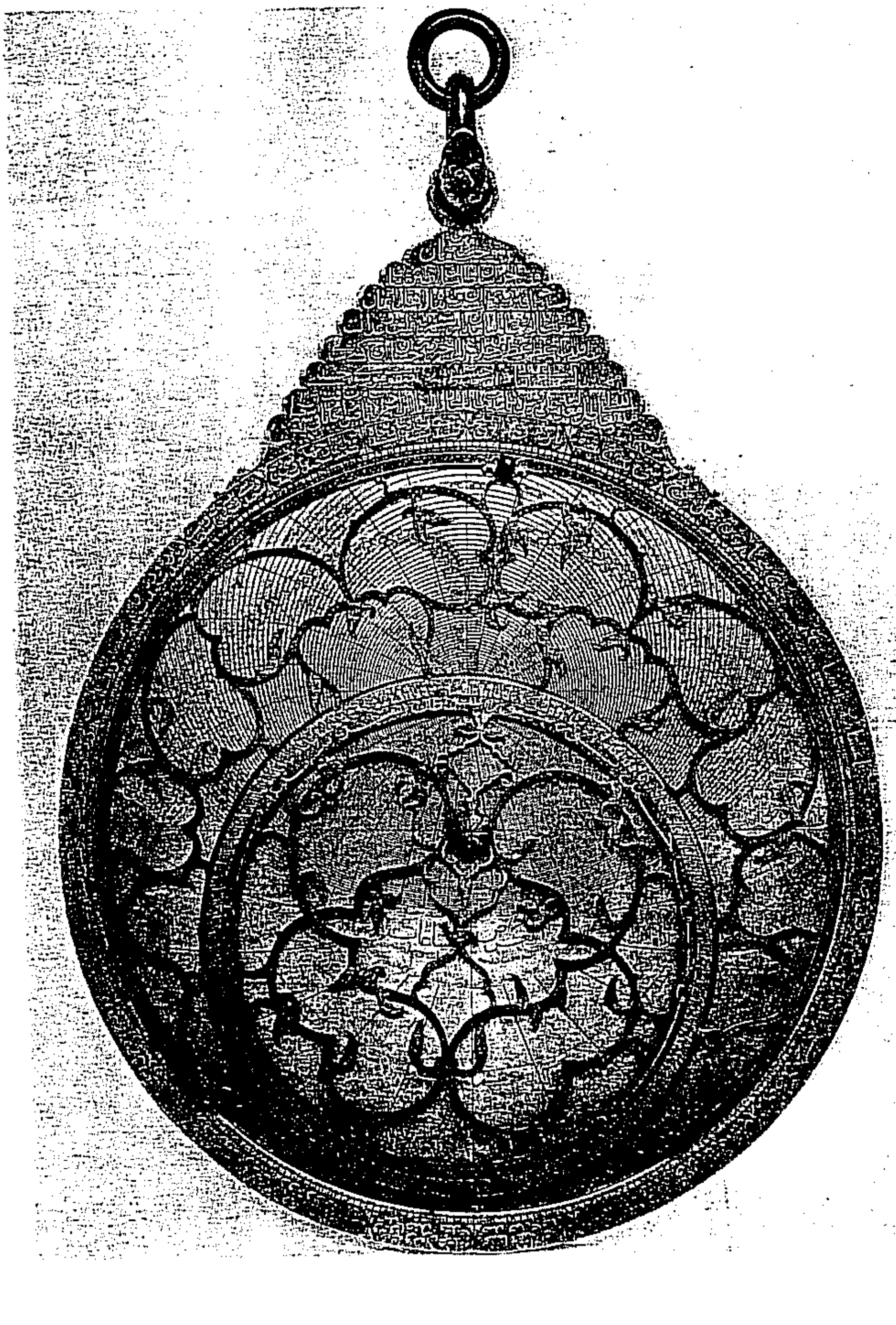


1402



ASTROLABE, BRASS, ENGRAVED

With the name of *Shāh Sulṭān Husayn*, 1712 (1124 H.). British Museum. D. 15 13/16 in. (40·2 cm.)



فهرس المحتويات

طبع في ١٠٠ نسخة

نشر بمعهد تاريخ العلوم العربية والإسلامية
بفرانكفورت - جمهورية ألمانيا الاتحادية
طبع في مطبعة شتراوس، مورلنباخ، ألمانيا الاتحادية

الرياضيات الإسلامية والفلك الإسلامي

٩٤

نصوص ودراسات
حول الآلات الفلكية ودُور الرصد
في العالم الإسلامي

القسم ١٠

جمع وإعادة طبع
فؤاد سزكين

بالتعاون مع

كارل إيرج-إيجرت، مازن عماوي، إكهارد نويباور

١٤١٩هـ - ١٩٩٨م
معهد تاريخ العلوم العربية والإسلامية
في إطار جامعة فرانكفورت - جمهورية ألمانيا الاتحادية