SUNDIALS IN CETIUS FAVENTINUS

In her *Greek and Roman Sundials* (New Haven and London, 1976),[1] Sharon Gibbs discusses (pp.105–17) with success the identification of the archaeological finds of ancient sundials with the description of the types given briefly by Vitruvius (*De Architectura*, IX.8.1). There is, however, an important piece of evidence from another ancient literary source which, though it does not alter her conclusions, ought to be added and clarified.

In chapter 29 of his *De Diversis Fabricis Architectonicae*,[2] Cetius Faventinus writes as follows: 'Multa variaque genera sunt horologiorum, sed pelecini et hemicyclii magis aperta et sequenda ratio videtur.' 'There are many different types of sundial, but the principle of the pelecinum and hemicyclium seem clearer and easier to follow.' Both *pelecinum* and *hemicyclium* are found in Vitruvius, who, however, says only:

hemicyclium excavatum ex quadrato ad enclimaque succisum Berosus Chaldaeus dicitur invenisse . . . Patrocles pelecinum.

Berosus the Chaldaean[3] is said to have invented the *hemicyclium* hollowed from a square block of stone and cut according to latitude . . . Patrocles[4] is said to have invented the *pelecinum*.

From this evidence it might be thought that Faventinus, writing perhaps in the early third century A.D.,[5] is following the Augustan writer, Vitruvius. As Soubiran[6] and Plommer[7] point out this is not possible, and another source must be postulated. However, the poor technical quality of Faventinus' description shows that he was in fact describing two actual timekeepers, whose construction and calibration he did not really understand.

(i) The Pelecinum
There is no doubt that by the first dial[8] described by Faventinus, he and Vitruvius must mean one whose appearance is that of a double-axe ($\pi\acute{\epsilon}\lambda\epsilon\kappa\upsilon\varsigma$), identified[9] as the horizontal dial calculated to show the ancient seasonal hours, where the grid of lines formed by the hour lines and curves of declination is indeed of this shape, the handle of the axe being the meridian line. Faventinus' description of this dial is completely consistent with this explanation, though what he says has caused concern to previous writers.[10]

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[1] Reviewed by the present writer in *CR* 28 (1978), 336–9.

[2] Edition of V. Rose (Leipzig, 1867) = H. Plommer, *Vitruvius and Later Roman Building Manuals* (Cambridge, 1973), pp.80 f.

[3] See Gibbs, op. cit., p.60.

[4] Ibid., p.61.

[5] Plommer, op. cit., p.2.

[6] J. Soubiran, *Vitruve, De l'Architecture, Livre IX* (Paris, 1969), pp.258–60.

[7] Op. cit., p.109 and introduction, *passim*.

[8] I use the word dial in its time-honoured sense of sun-dial of whatever form (cf. L. L. *dialis* – from *dies*, German *Uhr*, French *cadran*, cf. *O.E.D.*). Thought the word used in common parlance today tends to suggest a flat disc, this is not its technical meaning.

[9] Cf. Gibbs, op. cit., p.61, H. Diels, *Antike Technik* (reprint, Osnabrück, 1965), pp.179–85. For an early attempt at identification see Bernardus Baldus Urbinas, *Lexicon Vitruvianum* pp.80–1 in an appendix to the edition of C. Salmasius (Amsterdam, 1649).

[10] e.g. Soubiran, loc. cit.

Faventinus elaborates on the *pelecinum* thus:

pelecinum	1
enim horologium dicitur quod ex duabus tabulis marmoreis	
vel lapideis superiore parte latioribus inferiore angustioribus	
componitur, sed haec tabulae aequali mensura fiunt et quinis	
lineis directis notantur, ut angulum faciant qui sextam horam	5
signabit. semis ergo ante primam et semis post undecimam	
supplebunt XII numeros horarum. sed iunctis aequaliter ante	
et extensis tabulis, in angulo summo iuncturae circinum	
figes et angulo proximo circulum facies, a quo primum	
lineae horarum partitae aequaliter notantur. item alium	10
maiorem circulum ab eodem puncto angulari facies, qui	
prope oram tabularum attingat, ad quem aestivis temporibus	
gnomonis umbra,pervenit. subtilitas ergo disparis mensurae	
de spatio horarum expectanda non est, quando aliud maius	
et aliud. minus horologium poni solitum videatur, et non	15
amplius paene ab omnibus nisi quota sit solum inquiri	
festinetur. gnomon itaque in angulo summo iuncturae	
paululum inclinis ponitur, qui umbra sua horas designet.	
constitues autem horologii partem qua decimam horam	
notabit contra orientem aequinoctialem, sicut de exemplis	20
multifariam cognoscitur.	

This can be translated[1] and classified as follows:

(1) *Description*

Now the *pelecinum* is so called because it is composed of two slabs of marble or stone, broader at the top and narrower at the bottom. These slabs are of equal size and are each marked with five straight lines so that the point where they join will mark the sixth hour. Then the half-space before the first and the half-space after the eleventh hour will make up the number of twelve hours.

(2) *Construction*

When the slabs have been joined evenly and set out, put your compasses at the top angle of the join and make a circle nearest the join. From here the hour lines begin, evenly marked. Likewise make another larger circle from the same point on the join. This is almost to touch the rim of the blocks and is reached by the shadow of the gnomon in summer. No precision in the unequal measurements of the spaces between the hours is to be expected since it seems that dials are marked with grids of varying size and further almost everyone is in too much of a hurry to want to know more than what hour it is.

(3) *Setting*

The gnomon is then set at the top of the join, sloping slightly inwards to mark the hours with its shadow. You shall set the part of the dial on which it marks the tenth hour facing due east.[2] This can be observed everywhere from examples.

Muddled though he sounds, Faventinus has described a dial the shape of which is not seriously in doubt. It is obviously not one of spherical or conical section (implied by the two slabs and by the description of a *hemicyclium* which follows), but a plane one. This could be either vertical or horizontal (dials on inclined

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[1] I apologize for an occasional echo of Plommer's translation (loc. cit.), which is almost unavoidable if one wishes to be idiomatic.

[2] *contra orientem <solem> aequino-* *ctialem* 'facing the sunrise at the equinox'. In any latitude the sun rises exactly 90 degrees east along the horizon from the meridian point when its declination is 0°.

planes were probably a rarity—only one is cited by Gibbs[1]). If vertical, it could
be such that the two slabs were joined in a single vertical plane, in which case a
symmetrical grid of five lines to each side of the sixth (noon) line can only
imply a direct south vertical dial, or it could be that the slabs made an angle with
each other either convexly or concavely, with the gnomon above the join facing
south, as in the *Dials of Phaedrus* in the British Museum.[2] Either hypothesis for
a vertical dial presents a problem. Faventinus says that the half-space (*semis*)
before the first hour line and that after the eleventh complete the dial. If the
dial he was looking at had been vertical, the spacing between hour lines would,
for most appropriate declinations, have tended to be more even and so not have
led him to speak of *semis* but rather of clear full hours. On the other hand, if we
understand him to be describing a particular horizontal dial (cf. Fig. 1), in which
the stone was cut off any distance outside the first and last hour marks which was
less than that between either the hours 1 and 2 or 10 and 11, he would have been
likely to think that there was only half an hour shown. On any horizontal dial the
distance from the first or eleventh hour lines to 0 and 12 respectively is infinity.
Additional evidence that the slabs were horizontal is perhaps found in the phrase
'sed iunctis aequaliter et extensis tabulis', where 'extensis' probably means that
the slabs are laid out horizontally. Further, the absence of any instruction to set
the slabs vertically may be taken as an *ex silentio* argument for the same arrange-
ment.

It is in the setting of the dial that the possibility of its being any type but
horizontal is completely removed. A vertical dial cannot be said to be set up so
that any particular *hour*, tenth or otherwise, is facing a direction, because the
hour lines tend to the horizontal the further they are from noon and it would
be far more apt to speak of the whole *dial* facing a direction. On the other hand,
in a horizontal dial there are hour lines (1 and 11) at each end of a horizontal
surface. These can loosely be said to face a direction. If we make a simple
emendation of the text of *decimam* to *undecimam* (cf. above, line 19),
Faventinus is now telling us that the easternmost line of the horizontal dial
(see Fig. 1), which the shadow reaches in late afternoon, at the eleventh hour,
should be set facing east. This is a very rough and only general indication of the
correct orientation. None of the lines other than noon is at right angles to the
point due east, and all the afternoon hours if produced beyond the summer
solstitial curve would in theory reach the horizon between north and east. Only
on the equator would a horizontal dial showing the seasonal hours have its hour
lines symmetrical about even the equinoctial line. The hour lines other than
that for noon on a grid showing the seasonal hours are never, in fact, straight
lines,[3] but arcs of great circles of the celestial sphere, though they were habitu-
ally made straight or notionally straight lines by the ancients. In all latitudes
north of the equator, the pattern of the hour lines will be similar to that shown
in Figure 1; the nearer the equator, the more nearly the fore- and after-noon
hours will run in a north—south direction.

It might be argued that since only one line on the dial, that for noon, does
'face' due east ('contra orientem aequinoctialem'), *sextam* should be read for
decimam. Of course, the corruption of numerals (·X· / ·XI· / ·VI·) is notorious in
the transmission of many texts, especially those of technical authors. However,

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[1] Catalogue, 5022G.   5002G, cf. 5020, p.361.
[2] Ibid., pp.346–7, catalogue number   [3] Cf. Gibbs, p.97 n.2.

the sixth or noon line is not likely to be described as facing due east or for that
matter due west, which it also does, but more probably as pointing to the sun
at noon. On the other hand, the eleventh hour stands at the eastern end of the
dial. Faventinus was probably aware that the equinoctial line pointed due east
as it crossed the eleventh hour line and this may have been his careless way of
saying so.

   Consequently it is clear that Faventinus is speaking of a horizontal dial when
describing the *pelecinum.* In this case his remark that the gnomon *slopes (inclinis)*
is illustrative of Gibbs's suggestion[1] that this is how it was set in this type of dial.
Faventinus' description does not inspire confidence that he knew much about
this particular subject and the whole section is indicative of his working from a
specimen he had seen.

   His constructional details do not redeem him. By interpreting the description
as of a horizontal dial, we can see the loose way in which Faventinus is using the
notions of top and bottom. In the case of the slabs, *top* is the part at the join, the
sixth hour, *bottom* the extremities, but in the construction he is speaking of
positions at right angles to this, *on* the join. The small circle centred at the top
of the join (point X in Figure 1) from which he seems to believe the hour lines
diverge is probably an ornamental line he had seen on his specimen.[2] The hour
lines do not usefully extend further south than the summer solstitial line (AB).
The 'larger circle' is his crude description of the diurnal shadow track at the
summer solstice, which is correctly a hyperbolic curve. He makes no mention of
the equinoctial line (CD) or winter solstitial (EF). His remark 'subtilitas ergo . . .
expectanda non est etc.', is intended to cover for his ignorance. The geometric
method used by the ancients to delineate this type of dial (and the plane
vertical dials), as set out by Vitruvius and Ptolemy, is much more informative and
quite different.[3]

(ii) *The Hemicyclium*
Of his second dial, the *hemicyclium*, he speaks as follows:

                             horologium autem quod hemi-   1
cyclion appellatur simili modo de lapide vel de marmore
uno, quattuor partibus sursum latioribus infra angustioribus
componatur, ita ut ab ante et a tergo latiores partes habeat,
sed frons aliquantum promineat atque umbram faciat maio-   5
rem. sub hac fronte rotunditas ad circinum notatur, quae
cavata introrsus hemicyclium faciat schema. in hac cavatura
tres circuli fiunt, unus prope summitatem horologii, alius
per mediam cavaturam, tertius prope oram signetur. a
minore ergo circulo usque ad maiorem circulum horalem   10
una et x lineae directae aequali partitione ducantur, quae
horas demonstrent. per medium vero hemicyclium supra
minorem circulum planitia aequalis subtiliori crassitudine
fiat, ut aperta rotunditate digitali facilius solis radius infusus
per numeros linearum horas demonstret. hiemis ergo tem-   15

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[1] Ibid., pp.41–2 and 79.
[2] Some dials of this type were com-
bined with a wind rose (cf. Gibbs, pp.86–7)
—a variation of this with vertical dials is
found on the Tower of the Winds at Athens.
[3] See Gibbs, op. cit., pp.105–17, esp.
p.107. For details on how the constructions
were applied to dials see Gustav Bilfinger,
Die Zeitmesser der Antiken Völker
(Stuttgart, 1886), pp.28–37, cf.
O. Neugebauer, *A History of Ancient
Mathematical Astronomy* (Berlin etc.,
1975), Part II (Book V), pp.843–56.

pore per minorem circulum horarum numeros servabit,
aequinoctiali tempore medium circulum sequetur, aestivo
tempore per maioris circuli spatia gradietur. sed ne error in
construendo horologio cuiquam videatur, libero loco alto
vel plano sic ponatur ut angulus huius qui occiduas horas   20
notabit contra aequinoctialem vernum spectet, unde sol nono
kal. apriles oriatur. fit etiam in uno horologio duplex
elegantiae subtilitas. nam dextra ac sinistra extrinsecus in
lateribus eius quinae lineae directae notantur, et ternae
partes circulorum aequali intervallo sic fiunt ut una proxima   25
sit angulis posterioribus, ubi stili ponentur qui umbra sua
horas designent, altera mediam planitiem detineat, tertia
prope oram contingat. has enim partes circulorum hieme
vere et aestate sic ut interius gnomonis umbra sequitur. in
angulis ergo posterioribus stilos modice obliquos figes, qui   30
umbra sua horas designent. oriens enim sol in primo latere
sex horas notabit, occidens alias sex in sinistro latere per-
curret. legitur etiam horas sic comparari debere, primam
sextam septimam et duodecimam uno spatio mensuraque
disponendas, secundam quintam octavam et undecimam pari   35
aequalitate ordinandas, tertiam quartam nonam et decimam
simili ratione edendas. est et alia de modo et mensuris
horarum comparatio, quam prolixitatis causa praetereundam
aestimavi, quoniam haec diligentia ad paucos prudentes
pertinet. nam omnes fere, sicut supra memoratum est, quota   40
sit solum requirunt.

Again this can be translated and analysed as follows:

Description

The dial which is called the *hemicyclion* is made from a single block of stone or marble in a similar way. Its four sides are broader at the top than at the base and its front and back are the wider faces. Its front juts out a little so as to make a larger shadow.

1. *Main Dial*

(a) *Construction*

Below the jutting front a circular area is marked with the compasses. When this is hollowed out it is to provide the hemispherical figure inside the stone. In the cavity there are three circles; one should be marked near the top of the dial, one in the middle of the excavation, and a third near the edge. From the smaller circle to the larger circle which is marked with the numbers[1] eleven equidistant straight lines should be drawn. These are to show the hours. Right in the middle of the hemispherical cavity, above the smaller circle, let there be a thin flat plate of fine thickness with a round hole of finger's breadth, such that when the sun's rays pour in through the hole they can easily indicate the hours by the numbers on the lines. You will find that the sun will mark the numbers of the hours on the smaller circle in the winter, at the equinox it will follow the middle circle, and in the summer proceed along the intervals of the larger circle.

(b) *Setting:*

So that no one thinks you have made a mistake in constructing the dial, set it up in an open place, either at a height or on ground level such that the corner which is going to mark the hours near sunset faces the vernal equinox,[2] or the point of sunrise on 25 March.[3]

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[1] On the meaning of *horalis* see below, p.210.
[2] Strictly he should say 'the heliacal rising of the vernal equinox'.
[3] The old date of the vernal equinox, until the Gregorian calendar set it at 21 March in and after 1582 (see *Explanatory Supplement to the Astronomical Ephemeris etc.* (London, 1961), p.412).

2. *Subsidiary Dials*

(a) *Descriptions:*

The elegance of this single timepiece is enhanced by a second refinement. On the outer left and right sides five straight lines are marked, along with three equidistant arcs of circles. The latter are set in such a way that the first is close to the rear corners, where rods, whose shadows indicate the hours, are placed, the second occupies the middle of the surface and the third comes near the edge. The shadow of the gnomon follows these arcs in winter, spring and summer in the same way as happens inside the cavity. So at the rear corners you should fix, with a slight tilt, the rods the shadows of which indicate the hours. The morning sun will mark six hours on the one side, and the afternoon sun will cover the other six on the other, left, face.

(b) *Construction:*

A book tells me that the hours should be set out as follows. The first and sixth must be the same distance and spacing apart as the seventh and twelfth, the second and fifth, and eighth and eleventh must be arranged in similar proportions, likewise the third and fourth and ninth and tenth. There is another way of comparing the relationship and spacing of the hours, but since it is lengthy I have decided to pass it over. Few sensible men bother about such attention to details, for almost everyone, as I said above, only wants to know what hour it is.

There are some problems of loose phrasing in his description. In this case *top* and *bottom* are not in dispute, though a block of stone used as a dial would have at least six faces, so by *partes* Faventinus means vertical or sloping faces. If the faces at the front and back were narrower at the base than at the top, the sides of the block would also slope inwards at the base. This is unlikely, since Faventinus says that the subsidiary dials, which are claimed to increase the elegance of the timepiece, show six hours in the morning and six in the after-noon. Unless he is being vague and means *about* six hours (i.e. five or six hours and a fraction of an hour more) this description is faulty. Only if the subsidiary dials are vertical and facing due east and due west could they show six hours, since otherwise the sun would leave the east face before noon (hour 6) and pass on to the west one at some time after crossing the meridian. There is a little ambiguity about the word *ora* (quotation, ll.9 and 28). In the first case it refers to the rim of the cavity, but in the second must be the junction of the proclined south face with the adjoining side to the left or right (cf. Fig. 2).

Faventinus is here describing a dial with an inclined front into which is cut a hemispherical cavity (cf. Fig. 2). The dial is one of those described by Gibbs[1] as 'roofed spherical', of which she cites twenty-four surviving examples. The cavity is to the south since the side within which are marked the hours towards sunset faces the point of the rising of the sun at the vernal equinox (anciently 25 March). There is no rod for a gnomon, but instead a thin metal plate with a hole through which the sun's rays are concentrated so as to leave a spot of light in the hollow which is shielded from direct light by its downward-facing position. This spot shows the time against a grid of lines on which the three curves of declination,[2] the winter solstitial right on the inside, the summer solstitial around the rim of the cavity and the equinoctial between, are intersected by eleven mutually equidistant straight lines marking the hours 'ad maiorem circulum

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[1] Ibid., pp.23–7, esp. Figs. 9 and 12, cf. Plates 23 and 24 relating to dial number 2017G (p.211).

[2] i.e. the lines marking the path of the shadow across the dial during certain days.
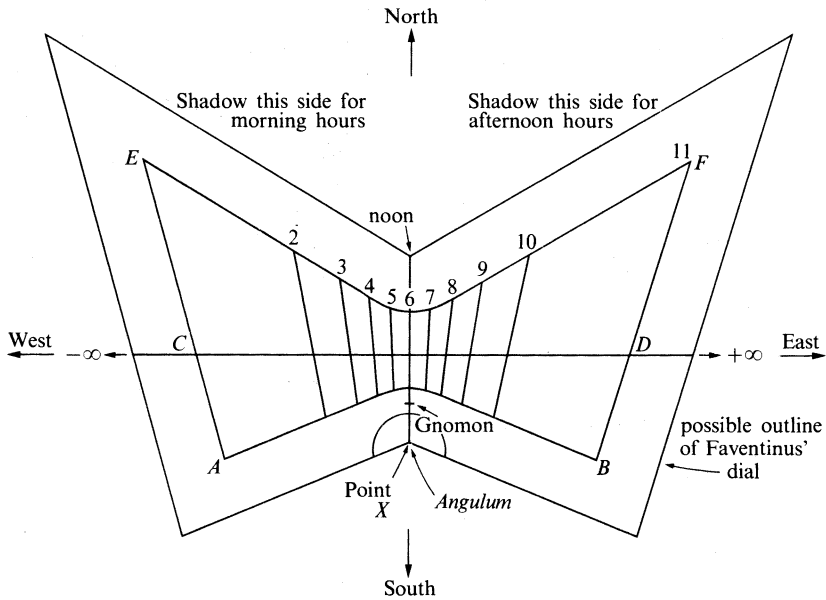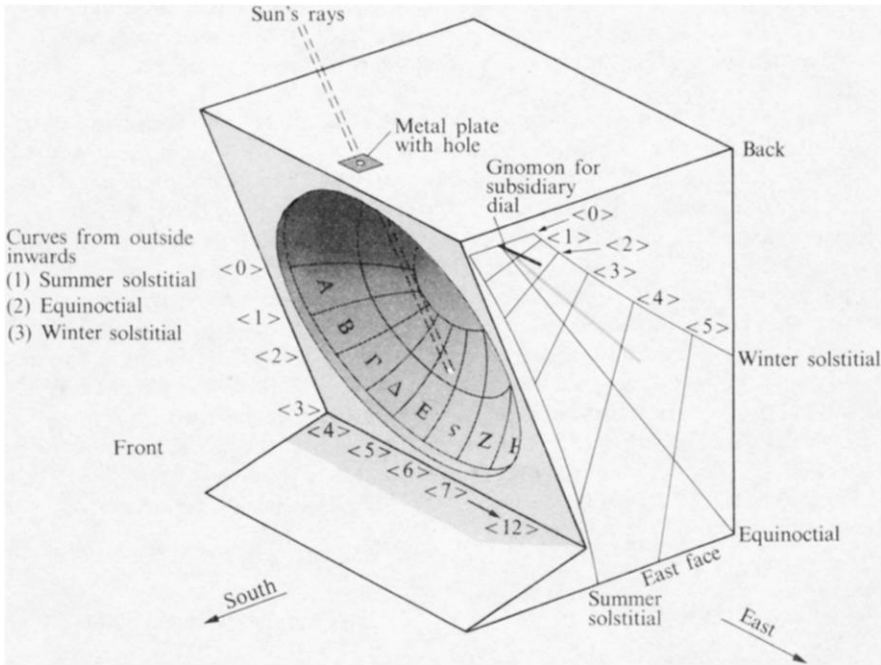
Figure 1. The *pelecinum*

Figure 2. The *hemicyclium*, shown late in the morning at the end of February or early in October

horalem' (the summer solstice curve around the rim). The curve itself is not *horalis*—it shows no hours—but the space between this curve and the equinoctial curve is often labelled with the numbers[1] for the hour lines in surviving specimens of ancient dials (cf. Fig. 2). Faventinus' dial could well have been labelled in this way and so misled him into believing that the summer solstitial, which he thought was called *circulus horalis*, was an 'hour curve'. Ptolemy, in his exposition of the *analemma*, names one of the lines used in constructing the figure the ὡριαῖος κύκλος.[2] Though he does not in any way refer to the part of the dial labelled *circulus horalis* by Faventinus, the latter may, in his *naïveté*, have believed that he was using a technical term—which indeed he was, but wrongly. It is quite likely that the curves of declination in Faventinus' examples were also labelled[3] but he does not say so. The size of the *planitia* is not specified apart from its fineness which is necessary to ensure that the aperture is a hole and not a short tunnel. In Figure 2 it is shown similar to that indicated in Gibbs's catalogue number 2017G and Plate 24. In one respect this type of dial should be more accurate than the open hemisphere, since the spot of light should be sharper than a shadow, but more would depend on the size of the light hole and the accuracy of calibration of the lines. Faventinus' example, with its hole 1.5–2 cm wide ('finger's breadth') would therefore not have been too precise.

Both Faventinus and Vitruvius use the word ἡμικύκλιον in a loose way which allows *hemicyclium* to be applied to what is actually a half-*spherical* dial. Soubiran[4] saw the problem, rightly relating the name to the hemispherical dial. The imprecise use of the word is not therefore Faventinus' fault, but was probably the usual one. The circle of which the half is referred to must therefore be the shape of a cross-section through the dial (e.g. along the hours 0 and 12). Some confusion of nomenclature or perhaps a desire to identify a refinement now no longer clear may well underlie the two names for very similar types of dial.[5]

The specimen he is describing has two subsidiary direct vertical east and west plane dials (*pharetrae* according to Vitruvius and Gibbs[6]). The right-hand, east one shows the morning hours, the left-hand, west one the afternoon hours. The fact that Faventinus says that there are three equidistant arcs, ('ternae partes circulorum aequali intervallo'), when one, the equinoctial, must be a straight line, and also says that the gnomon is near the winter solstitial (it should be on the equinoctial at the hours 0 and 12 on the east and west dials respectively) means either that he was unobservant or that the dial worked badly. Since this type of dial is rather sophisticated, the latter seems unlikely. The gnomons are said to be set 'angulis posterioribus', but according to the other indications of front and back in his description they must be 'anterioribus', i.e. at the south end, where the sun can cast a shadow from them across the sides of the block, to be of any use. Perhaps the text should again be emended. There is no reason for the gnomons to tilt. The description of the hour lines, as it stands, make no sense;

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[1] The numbers marked were Α′ Β′ Γ′ Δ′ Ε′ ϛ′ Ζ′ Η′ Θ′ Ι′ ΙΑ′ which gave rise to the epigram in the Anthology, punning on the letters Ζ Η Θ Ι—see *Anthologia Graeca*, X. 43.

[2] Cl. Ptolemaei *Liber de Analemmate* ed. J. L. Heiberg (Leipzig, 1907), Vol. II, p.191, line 3. *horarium* and e.g. ὡριαίου κύκλου, p.205, line 17 of the Greek.

[3] Winter solstice—χειμερινή [sc. τροπή] Equinoctial—ἰσημερινή Summer solstice—θερινή For a suitable example see p.211 n.3. below.

[4] Soubiran, op. cit., pp.240–1.

[5] Cf. Gibbs, op. cit., pp.59–60.
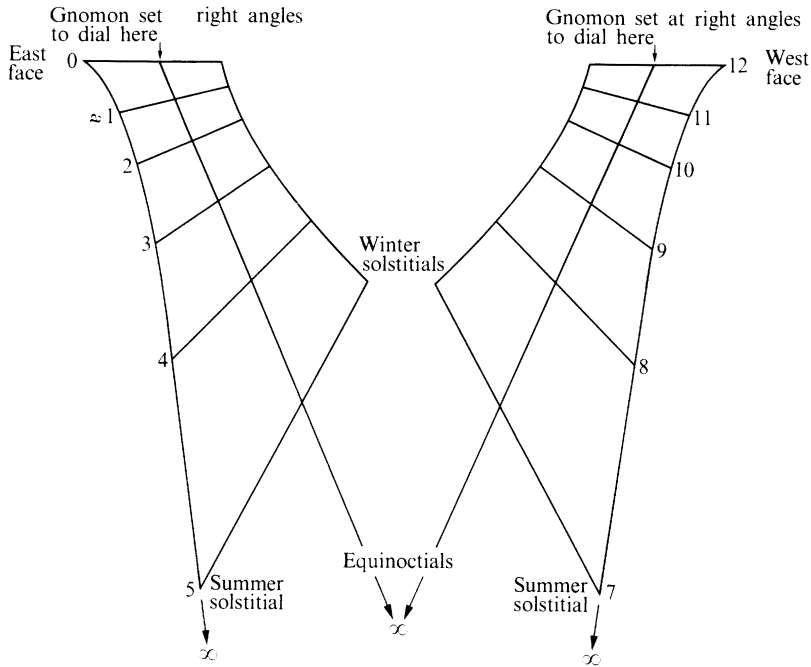
[6] See Gibbs, op. cit., p.61.

Figure 3. The subsidiary dials of the *hemicyclium*

the proportions given do not correspond. The correct computations can be seen in Figure 3. They should be that the space from the gnomon (0, east dial) to hour 1 is the same as that from the gnomon (12, west dial) to hour 11 and so on. These unhelpful instructions on how to calibrate these dials would not benefit anyone trying to do so and it would be hardly surprising in the case of either of Faventinus' dials, if such a person were to make the criticism envisaged by 'ne error in construendo horologio videatur'. The ancient methods mentioned above for the *pelecinum* should have been used.

Here, then, Plommer is right[1] in criticizing Soubiran's comment that Cetius Faventinus is relying on some source other than Vitruvius 'pour une fois'. He is not using him at all for chapter 29 and has described two types of dial which must have been common in his day, in the Middle Empire, on the evidence of two specimens which he must personally have known. In the case of the *pelecinum* the dial can only be the ordinary horizontal dial calculated to show the ancient temporary hours. The *hemicyclium* is clearly not the simple dial implied by Vitruvius in the first of his list of types. Vitruvius' hemicycle must be the very common open-topped spherical dial[2] with the front cut away according to latitude as parodied in *Anthologia Graeca* XI. 418. The fact that Faventinus uses the word *hemicyclium* to describe his dial, which very closely resembles the dial of Andronicus Cyrrhestes on Tenos,[3] a multiple 'roofed

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[1] Plommer, op. cit., p.109.
[2] Gibbs, op. cit., pp.59–60 and 14–16, esp. Figs. 2, 3, and 4.
[3] Gibbs, op. cit., pp.373–5, catalogue

number 7001G. For illustration see Soubiran, op. cit., p.245, originally *IG* XII. 5. 891.

spherical' with auxiliary east and west plane dials, shows that the word perhaps had a more general application in his day, at least to any dial of concave spherical if not merely curved, surface. It is to be regretted that the older, probably Greek, manuals on dialling read by Vitruvius ('. . . dicitur invenisse . . .'[1]) and Faventinus ('. . . legitur . . .'[2]) have not survived.

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[1] *De Arch.* IX. 8. 1; cf. the list of in the main otherwise unknown writers of architectural manuals in Vitruvius VII. praef. 14 (159–60).

[2] Above, p.207, line 33 of quotation.