1. What is the equatorium for? How does its design fit its purpose?
2. What is simplified? How does it compare with other models?
3. How does each part work? Sun, Moon, Mercury, Cauda/Caput Draconis, Venus, superior planets, trepidation
4. How precise is description? How good is ms as explanation? What's clear, excessively clear, insufficiently clear?

Despite the astronomical sophistication underlying equatoria, this model is a relatively simple device to build and operate. This is demonstrated by the fact that it occupies a mere eight manuscript folios. On each of these fourteen sides of manuscript are thirty to forty lines of explanatory prose, except where space is occupied by one of the three carefully sketched diagrams. The first six sides contain instructions for the instrument's construction, while the remaining eight explain almost all its possible functions in considerable detail.

While the earliest and latest equatoria [**about which much more needs to be said!**] were close to direct representations of Ptolemaic theory, the instruments produced in the late medieval period underwent considerable simplification, which had the effect of making them easier to produce and use for computing purposes. This reflects their practical purpose, while making them less useful as demonstration tools.

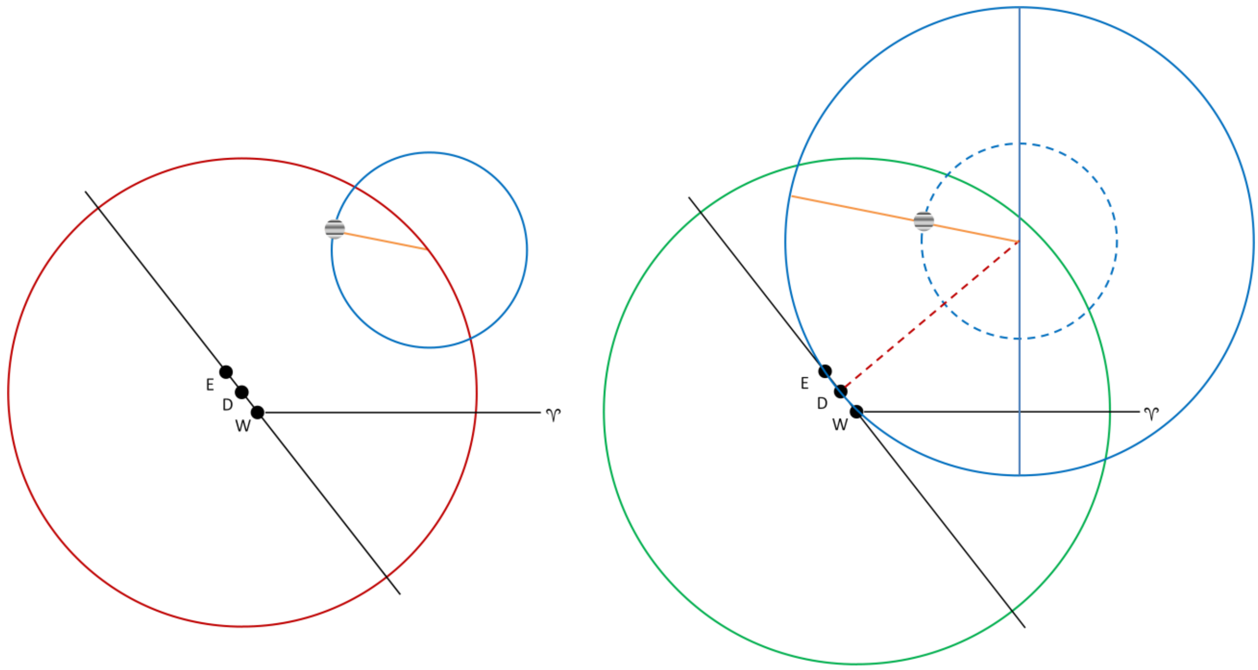
The equatorium described in Peterhouse MS 75.I bears similarities to models produced both in England and in continental Europe. [**more about Richard of Wallingford and "epicycle tail" model**] However, its precise design is unique to this manuscript, and represents a triumph of simplification without excessive limitation on function. It consists simply of a large wooden face, a circular epicycle, and a pointer which is fixed at the centre of the epicycle. Much of the complexity of earlier models, such as that described in Campanus of Novara's influential *Theorica planetarum*, has been dispensed with. The face represents a common ecliptic plane, while the deferent and equant circles of all the planets have been reduced to points marked on the planets' lines of apsides.

The equant circle itself is potentially dispensable, but the deferent circle certainly is not: because Ptolemaic theory represents planetary motion by a combination of circular motion on the deferent and epicycle, the relative size of these last two circles is crucial. Earlier equatorium makers, including Richard of Wallingford,[1] had reduced the deferent to a radial bar that turned about a fixed deferent centre, with its other end fixed at the centre of the epicycle (the so-called

[1] North (2005), 359.

"epicycle tail" model);[2] however, the author of the Peterhouse manuscript was able to eradicate even this, by using the radius of a uniform-size epicycle as a deferent radius.

This uniform-size epicycle had been discussed by Campanus (who called it 'epiciclus oportune circulationis'), but it appears [**check**] that the author of the Peterhouse manuscript was the first equatorium maker to realise that the same method, that allowed all planets' epicycles to be represented by a single device, could also obviate the need for a deferent circle or radius. As in all equatoria that use a uniform epicycle, a further device is needed to show the relative sizes of the epicycle and deferent. Like Richard of Wallingford, the author of the Peterhouse manuscript used a movable pointer or "label", which turns about the epicycle centre to mark the mean or true argument of each planet, and which is calibrated with the epicycle radii of all the planets.



The diagram above illustrates how the equatorium models the Ptolemaic theory of planetary motion for a single planet. The basic theory is shown on the left: W, D and E are respectively the Earth, a planet's deferent centre, and the equant point; ♈ is the vernal equinox, or head of Aries, from which celestial longitude is usually measured. In Ptolemy's theory, a planet moves around the epicycle (here denoted by a blue circle); the centre of the epicycle itself moves around the deferent circle (here denoted by a red circle), at a speed which is constant relative to the equant point. Five pieces of information are therefore required to ascertain a planet's longitude

[2] Poulle (1980), 158.

in this model: the direction of the line of apsides, the size of the planet's eccentricity; the relative sizes of its deferent and epicycle; the arc of the motion of the epicycle centre around the deferent from a given starting point (*mean motus*); and the arc of the motion of the planet around the epicycle (*mean argument*, shown in the diagram by an orange line).

The diagram on the right shows how the Peterhouse equatorium manages and processes this information. It will be seen that there is no deferent; instead, the instrument is based on the ecliptic circle (shown in green), which is centred on the Earth. The size of the ecliptic circle is not important in the theory (in the Peterhouse equatorium, it is 72 inches in diameter, compared with 68 inches for the deferent and *epiciclus oportune circulationis*); it is only important in that the eccentricity of the deferent centre is measured and marked relative to the size of the ecliptic disc.

There is no deferent circle, nor indeed the radial bar of the "epicycle tail" model; instead, the *epiciclus oportune circulationis* does the work of both deferent radius and epicycle. With a reference point on the epicycle fixed over the deferent centre, and the epicycle's centre positioned according to the mean motus, the label (denoted by the orange line) marks the *mean argument* and its markings indicate the size of the true epicycle. When it is considered that this simple arrangement is able, with no further modification, to model the movement of Venus, Mars, Jupiter and Saturn, which might otherwise each require individual instruments, its advantages are obvious.

By contrast, its disadvantages are few. The first is caused by the lack of an equant circle. As noted above, the equant circle is dispensable, by virtue of the fact that position of the epicycle is found using the *mean motus* (measured from the vernal equinox) rather than the *mean centre* (measured from the line of apsides). Use of the *mean motus* does obviate the need for equant circles for each planet, but in turn it necessitates a device to translate that arc, which is measured at the earth, to the equant point. As in other equatoria, this is accomplished using two threads held parallel. This solution is simple, but in practice it is rather fiddly and is perhaps the greatest source of imprecision in the instrument.

The second disadvantage, which is unique to this system, was noted by Emmanuel Poulle. He pointed out that if the *epiciclus oportune circulationis* were to function as both deferent radius and epicycle, with a reference point to be held in place over the deferent centre on the face of the instrument, the epicycle could not be graduated for the argument. This is, in principle, true, but

Poulle perhaps exaggerates the extent of this disadvantage. It is true that if the epicycle is fixed in place on the face, as the author of the Peterhouse manuscript instructs, it cannot be turned so that the argument can be counted from a "zero" reference point. But the epicycle can still be graduated and numbered; the argument will have to be counted off from a *mean aux* that may be at any number on the epicycle, but this disadvantage is clearly outweighed by the advantage of dispensing with a separate deferent circle or radius. The fact that the author instructs us to write the names of the signs on the epicycle indicates that he did not fully understand this: graduations and numbering clearly still serve a purpose, but the names of the signs are clearly useless if the epicycle is immobilised as per the instructions.

How the equatorium is built

In practical terms, construction of the equatorium is remarkably simple: far more so than an astrolabe, even though the astronomy underpinning equatoria is arguably more complex. The main complexities of production arise from the scale and precision measurement suggested by the manuscript's author. For instance, to begin with the face, this is intended to be a metal plate or board 72 inches in diameter, smoothed, level and evenly polished.[3] It is clear that to hammer out a metal such as brass to this size would present considerable, perhaps insurmountable, technical difficulties. Wood would be easier, but even then it would be hard to find a single piece of wood that could be cut into this shape; it is possible to join two or more pieces of wood, but it would be more difficult to make the disc smooth and level.

More technically difficult than cutting a precise, smooth disc out of wood would be making the epicycle, which the author suggests should be made of metal. A metal ring 72 inches in diameter and 2 inches wide would [**check**] surely have been impossible to hammer out of a single piece, so it is likely that it would have been made by welding smaller sections together, a potential source of inaccuracy. Likewise, the manuscript calls for two strips of metal one inch wide and 68 and 72 inches long: the first to be attached across the epicycle, and the second to function as a label, fixed at the centre of the first strip but free to rotate. These would have required considerable skill to make to the 'suffisaunt thyknesse' demanded so that they would be rigid, but not so thick that they would become unwieldy.[4]

[3] F. 71v

[4] Price (68) believes it would have been impossible, and takes this as evidence that the instrument was never built as described.

The key dimension of the epicycle is the diameter of the interior circle, which is to be 68 inches. This must precisely match the diameter of the circle which forms the boundary between the womb and limb on the face of the equatorium (the author calls this circle 'the closere of the signes').[5] The reason this correspondence is so important is that the distance between the centre (which the author sometimes calls 'aryn', referring to the point thought in medieval times to be the geographical centre of the earth[6]) on the face and the encloser of the signs is used as a reference with respect to which the eccentricities and epicycle radii of the planets are calibrated; and the interior circle of the epicycle of course serves as the deferent radius, as described above. The author of the manuscript is at pains to stress the importance of making the epicycle the correct size, yet equally aware that this was a formidable task. He writes that if 'thyn epicicle is fals' by not being the same size as the encloser of the signs, a remedy is at hand: 'knokke thi centre defferent innere or owtre til it stonde [stand] precise.' The notional 'comune centre defferent', a hole which the user is instructed to make in the interior circle of the epicycle, can thus be knocked into place; it does not matter if this distorts the epicycle as a whole (after all, it is only an *epiciclus oportune circulationis*) as long as the distance between the epicycle centre and the centre deferent matches the distance between centre 'aryn' and the encloser of the signs.

A final piece of metal is to be a round plate, sixteen inches in diameter, which is to be nailed on to the middle of the large disc. This will be pierced with holes to mark the deferent and equant centres for each planet and the Moon. The reason for using a metal plate here is twofold: first, implicit in the text, is that since holes will be pierced in it, it will be easier to fix in place the threads that are to be used for measurement. Secondly, and more fundamentally, it can be turned to account for [precession and?] trepidation. If the markings were made directly onto the face, the equatorium would quickly become out of date through these movements; the plate can be turned so that 'thus may thin instrument laste perpetuel.'[7] As we shall see, this is not quite true, since some markings will still be made directly on to the main disc, but it would certainly save effort in updating the equatorium.

Once the basic structure is complete, it is necessary to calibrate it for use. First, the author suggests dividing the limb of the face into signs, degrees and minutes. The instruction that 'everi degre shal be devided in 60 mi' is quite explicit, but it could not possibly have been carried out: a diameter of 72 inches gives a circumference of 18' 10", which means that 95 minute-marks

[5] F. 72r.
[6] Price, 64-5.
[7] F. 71v.

would have to be fitted into every inch around the circumference. Even disregarding the need for minutes, it is probably the case that dividing and graduating the limb of the face is the most difficult stage in the manufacture of this instrument.

Once the limb is calibrated, the author suggests marking the deferent circle of the Sun. This is to be marked directly onto the face, along with the line of apsides for each of the planets (the author is quite explicit in his instruction that this line should be drawn right up to the limb).[8] As mentioned above, this means that his instrument is not quite perpetual, as he hoped: the lines of apsides and the Sun's eccentricity are of course subject to change. Of course, it would not be possible to account for this without using a brass plate large enough to cover almost the entire face of the equatorium, since the prescribed deferent circle of the Sun has a radius of fifteen sixteenths of the "womb" (the part inside the limb, 68 inches in diameter) of the equatorium. Indeed this may be what the author is getting at when he writes that 'the eccentrik of the sonne is compaced [drawn] on the bord of the instrument and nat on the lymbe for sparing of metal.'[9] [**how could it have been on the limb?**] The deferent circle is eccentric to the earth; its centre is displaced by 1/30 of its radius, which is an excellent approximation. Its size on the face has evidently been chosen to allow it to come close to the limb (at its apogee it is about one inch away) without quite touching it.

It is perhaps worth noting that the author does not specify a starting point for the marking of signs and numbers on the limb, nor does he state explicitly that such markings should be made anticlockwise. This may be an inadvertent omission, or an assumption of some expertise on the part of his reader. The first reference to the position of any of the signs is an interlinear addition on the second folio, in Latin: 'versus finem Geminorum',[10] indicating that one of the four perpendicular radii, which has previously been marked, and to which he again draws our attention, points to the cusp of Gemini and Cancer. This reference comes immediately before we are instructed to draw the Sun's deferent, with its centre on this radius (which he calls *alhudda*). This would place the true aux at 0° Cancer, which is not far from its position, as indicated by the tables in the manuscript, at almost 0° 9' in December 1392.[11] However, it is surprising that the author is so vague about this, and it might be remarked that he was fortunate that the Sun's true aux was so near to the beginning of a sign at the time he was writing.

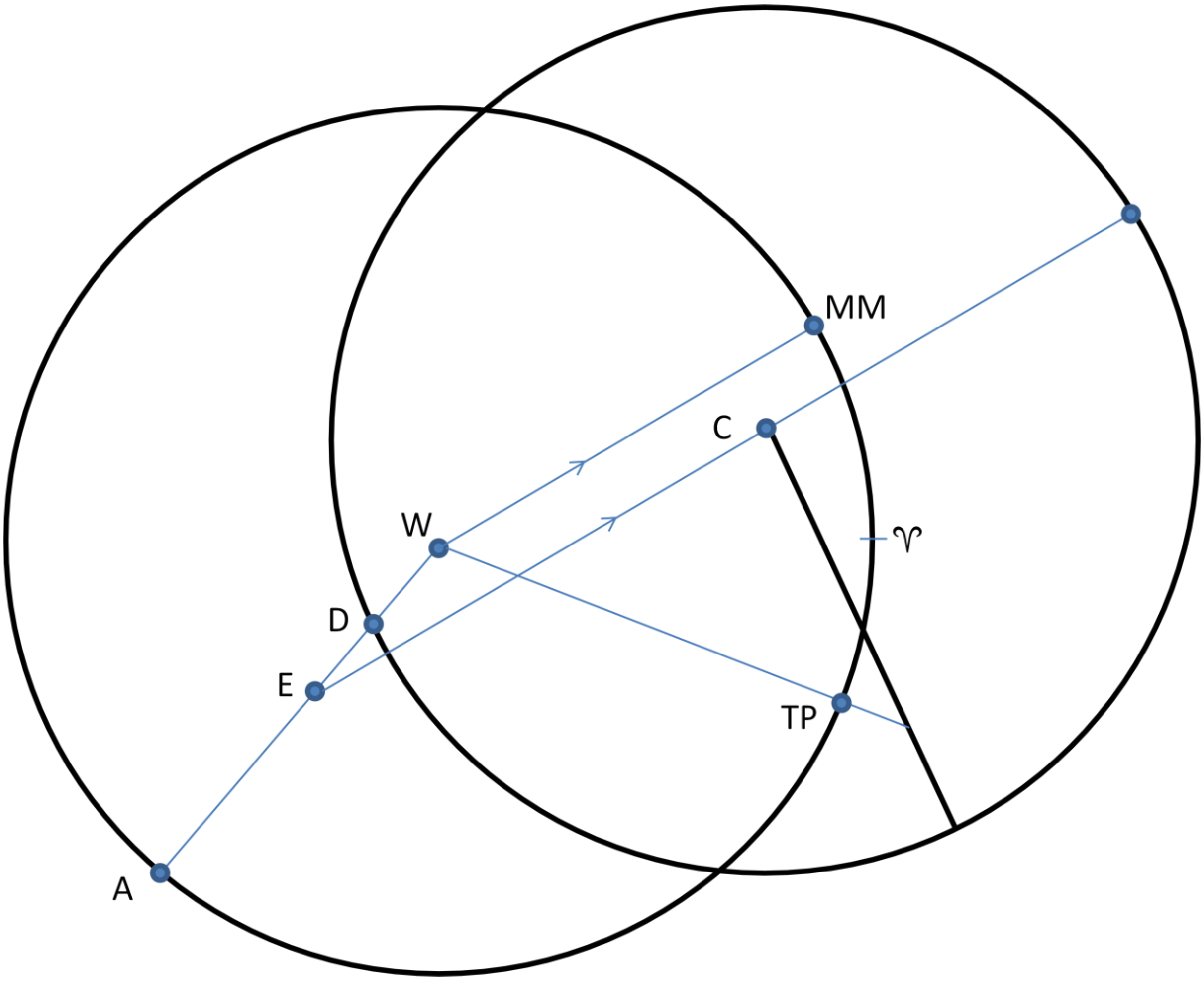
[8] F. 72r.
[9] F. 73v.
[10] F. 72r.
[11] F. 6v.

The next stage in the manufacture of the equatorium is the marking of the central brass plate. According to the instructions, the auges are first to be marked as lines of apsides from the centre of the face to the limb, according to 'the table of auges folwynge,'[12] which can be duly found on f. 6v. Here too the author's use of "signs" causes some confusion, as the word is used to mean segments of either thirty (as per zodiac signs) or sixty (as used in the Alfonsine Tables) degrees. Next the practitioner is instructed to mark the deferent and equant centres on the lines of apsides; these, we are told, can be found 'in thi table of centris.'[13] However, there is no table of centres in the tables that accompany the manuscript. This would have been a very small table, as the values are unchanging, so it is possible that it was not thought worthy of inclusion [**more on this in tables chapter?**]. There are two indications of the values used by the author: first, in the text of his building instructions he gives the distances of the equant centre and deferent centre of Saturn as 6° 50' and 3° 25' respectively (the latter is always half the former for Venus, Mars, Jupiter and Saturn). These correspond closely with values used by Ptolemy and other authors such as John of Linières. On the other hand, he states that the equant centre of Mars will be outside the circle on which the deferent centre of the Moon moves.[14] Since he has placed the latter at 12° 28', he here disagrees with most ancient and medieval authorities, who tended to place Mars' equant at 12° (e.g. Ptolemy) or 11° 24' (e.g. Alfonsine Tables); but he may still be in agreement with John of Linières, who used a value of 13°.

Finally, the label must be marked with the radii of the epicycles of each of the planets and the Moon. This comes last in the instructions, and it may have been forgotten by the author until then as he is required to mark out a new scale to measure the radii with respect to the radius of the common deferent. This could have been done using the sixty-degree scale into which he had divided the *alhudda* line for the purpose of measuring out the planets' centres as described above, but the author has already erased this scale in favour of a five-degree scale to be used for the latitude of the Moon. He is thus forced to create a new sixty-degree scale, 'be it on a long rewle or elles be it on a long percemyn.'[15] Once this scale is created, it can be used with the radii of the planets' epicycles (which again are absent from the tables in the manuscript) to calibrate the label that is attached to the instrument's 'epiciclus oportune circulationis.' The infelicitous order of presentation here may support the suggestion that this manuscript was a draft.

[12] F. 72r.
[13] F. 72v.
[14] F. 73v.
[15] F. 73r.

How the equatorium is used



The diagram above illustrates the basic function of the equatorium in finding the longitude, or *true place*, of Venus or a superior planet. Ptolemy's theories, following those of Apollonius,[16] distinguished Venus (and Mercury) from Mars, Jupiter and Saturn in order to account for the inferior planets' remaining close to the Sun at all times, but this did not affect his theory of longitudes, which is identical for Venus and the superior planets. This was clearly understood by the author of the Peterhouse manuscript, who explicitly groups these four planets together in the first stage of his instructions for the use of the instrument.[17]

As described above, the radius of the equatorium's large *epiciclus oportune circulationis* fulfils the function of a planet's deferent, while the movement of the label traces out the circle of its

[16] Evans, 338.
[17] F. 75r.

epicycle. It is therefore necessary to correctly place the centre of the *epiciclus* (I use the Latin to distinguish it from the theoretical Ptolemaic epicycle) using the mean motus, adjusted for the magnitude and direction of the planet's eccentricity, before applying the mean argument to find the planet's true place.

The user is first instructed to affix two threads, one black and one white, respectively at the earth (centre 'aryn') and the equant centre for the desired planet. The other end of each thread is to be free to move across the face. The black thread is then moved so that it crosses the limb of the face at the point equivalent to the mean motus of that planet; the white thread is in turn moved so that it is parallel to the black thread. The author recognises the difficulty of making these threads truly parallel, instructing the user to 'proeue by a compas þ^{t} thy thredes lyen equedistant'. Once they are set, the *epiciclus*, which has already been partially fixed in place by putting a needle through both its common centre deferent and the deferent centre on the face, can then be pivoted so that its centre lies under the white thread (the author's insistence that the *epiciclus* be under the threads makes this rather a fiddly exercise if the threads are to be kept parallel). With one end of its radius at the planet's deferent centre and the other end on the line from the equant centre that is parallel with the mean motus, the *epiciclus* is thus set up to function as the radius of the planet's deferent.

Before passing to simulate the planet's motion on its epicycle, we are instructed to move the black thread so that it no longer marks the mean motus but instead passes over the centre of the *epiciclus* to its far edge. As the author correctly notes, this indicates the true motus of the epicycle (at the point where it crosses the limb), as well as what he calls the 'verrey aux' of the planet, which is simply the starting point for counting the planet's true argument anticlockwise on the *epiciclus*. However, it is not necessary to know this since we are to use the planet's mean argument to calculate its movement on the epicycle. This secondary movement of the black thread therefore seems a superfluous part of the process. [**why does he include this?**]

It is in fact the white thread whose position is crucial at this point: the place where it crosses the far edge of the *epiciclus* is what the author calls the 'mene aux'. The angle between this mean aux and the true aux mentioned above is the equation of centre.[18] From the mean aux, the label is to

[18] Price incorrectly identified this as the equation of argument (Price, 108). In fact the equation of argument would be the angle between the true aux and the planet's true place, as measured on the limb of the instrument (f. 75v.).

be turned anticlockwise the number of degrees corresponding to the planet's mean argument.[19] As the planet's mark on the label turns, it traces out the true epicycle within the *epiciclus oportune circulationis*. When the label has been turned to represent the mean argument, the planet's mark on the label will be at the planet's true place for the desired time, as observed from the centre of the face. Following the author's instructions, this is easily measured by stretching out the black thread once more, this time to the planet's mark on the label. The longitude can be read off where the thread crosses the limb, as shown in the diagram above.

The treatise does not move directly on to consider Mercury, but since it is very similar to the process just described, it is convenient for us to cover it next. Mercury requires a non-circular deferent in order to account successfully for observations, and this is achieved in the same way by most equatorium-makers: the use of a movable deferent centre. [**more detail on this?**] Instead of the deferent being fixed halfway between the Earth and the equant point, it moves on a circle whose centre is on the line of apsides at a distance from the Earth double that of the equant point, and whose circumference passes through the equant point. When constructing the equatorium, the author assumes significant prior knowledge in his reader, asking us to 'sette the fix point of thy compas in the lyne of the aux of mercurie euene by twixe [i.e. at the midpoint of] the centre E and centre D of mercurius' before drawing a circle that touches both the 'centre E' and 'centre D'.[20] He thus assumes that his reader will understand not only that by this 'centre D' he is referring to the furthest possible position of the movable deferent centre from Earth, at three times the distance of the equant point, but also the more fundamental fact of the relative distances of these points, which he nowhere specifies. He then asks the user to pierce evenly spaced holes in the circle just drawn: 'in 360 holes yif it be possible or in 180 or in 90 atte leste.'[21] Here we have a glimpse of the practical concerns involved in making the instrument. If the author was following Ptolemy and John of Linières in ascribing to Mercury's equant an eccentricity of 3°, the radius of the little circle would also be 3°, or 1/20th of the internal diameter of the face. On the idealised six-foot equatorium, this would give a little circle with a circumference of 10.68 inches. At this scale, it might be possible to make 180 holes (at a little more than sixteen to the inch), but certainly not 360. The fact that the author later admits that his instrument 'hath but 24 holes' shows that he was working with a much smaller model than he recommends, perhaps one a foot in diameter.[22]

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19 Here too, Price seems confused, labelling a diagram to suggest that the mean argument should be counted from the true aux (Price, 54).
20 F. 72v.
21 F. 72v.
22 F. 76r.

This circle of holes is used to find the location of Mercury's deferent centre, after which the technique of calculation is the same as for the other planets. The base variable is still the mean motus, but in this case the mean centre is also needed; without naming it, the author instructs us to calculate it by subtracting the value for the planet's aux from the mean motus, adding 12 signs to the result if it is negative. The mean centre is then counted round the little circle to find the location of the deferent centre. There is an error here, possibly two: first, he instructs us to count the mean centre anticlockwise around the little circle, when in fact the theory requires us to proceed clockwise in this case. In addition, he may be suggesting that the equant too moves round the circle, which it does not (though it does in the case of the Moon). It is possible that the author realised his mistake, as he has written 'this canon is fals' at the top of the page, and drawn a series of lines across the text. As Price previously noted, this seems something of an overreaction, because none of the errors on this folio is so significant as to be uncorrectable.[23] However, it is possible that the author did not himself realise what the specific error was, only noting that his calculations of Mercury did not match observed positions without realising why.

Ironically, the folio that contains the most significant errors has not been marked as false by the author.[24] The errors come in the section of the manuscript dealing with the longitude of the Moon. According to Ptolemaic theory the motion of the Moon could also be described in terms of a deferent and epicycle, and the use of the equatorium is in some ways similar to the method for the planets. However, like Mercury, the Moon has a movable deferent centre; and unlike all the planets, the Moon has no equant, since its motion as seen from the Earth is much more regular. As in the case of Mercury, the deferent centre moves around a circle, though unlike Mercury this circle is centred on the Earth. As with Mercury, we have previously been instructed to pierce this circle with holes, 360 this time, which on the ideal six-foot equatorium would work out at about eight holes to the inch on the circumference. This would be difficult to do with precision, which is presumably why the author advises us to draw lines inwards from the limb of the face in order to locate the holes.[25] Opposite the deferent centre on this circle is another important point, sometimes known as the *centrum oppositum*;[26] the author of the Peterhouse manuscript named this the Moon's equant centre, though it does not function in the same way as the planets' equant centres do; this was perhaps the source of his later confusion.

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23 Price, 70-71. Worth noting that Price's model is also mistaken in locations of E and D?
24 Price, too, failed to note these errors.
25 Price (66) felt that the demand for 360 holes was impracticable, but a spacing of eight per inch is hardly more demanding than other requirements of this insturment's production.
26 E.g. Poulle (12).

The location of the Moon's deferent centre is found using its 'mean elongation', that is, its mean motus minus that of the Sun; the mean elongation, which the author of the Peterhouse manuscript calls the 'remenaunt' [remnant or remainder], is counted clockwise around the pierced circle, starting at the mean motus of the Sun. As with the planets, the Moon's mean motus is then drawn out from the Earth using the black thread, and the common centre deferent on the *epiciclus* is fixed in place on the Moon's deferent centre we have just found. However, since there is no equant, the 'pool' [pole, i.e. centre] of the *epiciclus* is moved to sit under the black thread.[27] The white thread is then stretched out from the *centrum oppositum* so that it too lies over the pole. As with the planets, it stretches over to the far side of the *epiciclus*, where it is used as a starting point ('mene aux') from which to count off the Moon's mean argument with the label, but unlike the planets, this is counted clockwise. The black thread is then stretched out to the Moon's mark on the label in order to find the Moon's true place. Finally, the author adds, rather as an afterthought, that if the mean motus of the Sun is greater than that of the Moon, 12 signs (360°) are to be added; this ensures that the mean elongation will be positive.

The process is explained in reasonable detail in the manuscript, but there is some confusion. The author is clearly aware that the point he calls the 'centre equant' does not function in quite the same way as the planets' equants, since he emphasizes that 'the pool of the Epicicle ne shal nat ben leyd [shall not be laid] vnder the blake thred of non [any] other planete saue only of the mone [except the moon].'[28] This instruction is a little unclear, since as we have seen, he includes a superfluous instruction to the user to move the black thread over the pole to see a planet's true aux on the *epiciclus*. Nonetheless, his intent can be discerned: the pole of the *epiciclus* is normally set in place over the white thread, but not in this case. However, he confuses himself and his readers by writing that the white thread should be laid 'equedistant' [parallel] to the black thread. This is obviously incorrect, since the black and white thread, starting respectively from centre 'aryn' and the *centrum oppositum*, both pass over the pole of the *epiciclus*.

The explanation of the Moon's longitude concludes with a rather confusing statement: 'the centre of hir (lune) epicicle (‸ in voluella) moeuyth equaly aboute the centre of the zodiac þ^t^ is to sein aboute the pol of the epicicle þ^t^ is thy riet.' The analogy at the end between the *epiciclus* and the rete of an astrolabe is clear enough, but the author's identification of the pole of the *epiciclus*

[27] F. 76v.
[28] F. 76v.

with the centre of the zodiac cannot be correct, and how the centre of the Moon's epicycle is supposed to move uniformly around this pole is unclear, since the centre of the Moon's epicycle is surely itself at the centre of the *epiciclus*! However, in the Ptolemaic model, the motion of the epicycle centre is uniform with respect to the Earth, at the centre of the equatorium;[29] this explains the first part of the above quotation, and suggests that the 'volvelle' mentioned does not refer, as Price thought, to the *epiciclus*,[30] but rather to the sixteen-inch metal plate on which are inscribed the centres for each planet and which was intended to be rotated to account for equinoctial precession. It remains unclear how the centre of the zodiac has been identified with the pole of the *epiciclus*, but perhaps this error accounts for the fact that the author has again written 'this canon is fals' at the top of the page, and drawn two lines diagonally across the first twenty lines.[31]

After discussing the longitude of the Moon, the treatise then passes to explaining how to find its latitude. The five-degree scale that we are instructed to mark on the *alhudda* line which runs from the centre 'aryn' to the encloser of the signs at the cusp of Gemini and Cancer is used in a simple process, involving a calculation using the lunar nodes Caput and Cauda Draconis, followed by stretching a thread across the face, perpendicular to the *alhudda* line. Where the thread crosses that line gives the Moon's latitude.[32] [**Do I need to explain this in more detail?**] This system permits a latitude of ±5°, which are the values used by Ptolemy and close to modern values. Although the process of calculating the latitude is, to modern eyes, rather simple, even self-explanatory, it is explained in unparalleled detail in this manuscript. The explanation, replete with emphatic repetitions and three worked examples, runs over three-and-a-half pages of the manuscript. The question must be asked why the author felt it necessary to include so much worked detail. Perhaps it was a method with which he himself was unfamiliar; or perhaps the inclusion of a latitude scale was a departure from his source text, and he thus felt free to include more detail. [**more detail on this – not discussed by Price**] The suggestion that the author was unfamiliar with this method is supported by a basic error which occurs in the last sentence

29 In this respect the Earth's role in lunar motion is analogous to that played by the equant point in planetary motion. This refined model is succinctly explained by Benjamin and Toomer (42-46).
30 Price, 71.
31 Price wrote 'I can find no serious error in this section.' (71) The confusion explained here (which Price did not note) is surely significant enough to warrant correction.
32 Price's edition uses two diagrams to clarify this process (58-59), but one contains an error: when the true motus of the Moon exceeds that of Cauda Draconis, one must subtract the true motus of Cauda from that of the Moon to find the point on the limb from which to stretch the thread, as explained in the manuscript (f. 77v., 78v.). Price's diagram (58) indicates that the true motus of the Moon should be subtracted from that of Cauda.

of the text: he suggests that Caput and Cauda Draconis are each confined to one half of the zodiac, when in fact they both rotate through the zodiac, always opposite each other.[33]

The Ptolemaic theory for the Sun's motion can be represented on an equatorium such as this in two ways: either by a simple eccentric model, or by an epicyclic model analogous to that used for the planets.[34] Briefly put, either the Sun's mean motus can be translated from the earth to the centre of its eccentric circle, before the true place is read off using a thread through the eccentric circle, at the limb (with no need for the *epiciclus*); or the label on the *epiciclus* could be marked with the Sun's eccentricity before the pole of the *epiciclus* is placed over the mean motus, the label aligned with the Sun's aux, and the thread used over the label to read the longitude at the limb in the usual way (with no need for the white thread). Unfortunately the author of the Peterhouse manuscript appears to have confused these two methods, arriving at an explanation that accurately conveys neither.[35] Although this is not on one of the pages that the author marked as false, it is perhaps the most significant error in the text.[36]

By instructing his reader to draw the eccentric circle of the Sun on the face of the equatorium, and writing that the 'eccentrik of the sonne shal nat be compassed in this epicicle' (which in context probably means that the Sun's eccentricity is not to be marked on the label on the *epiciclus*),[37] the author appears to favour the eccentric method for calculating the Sun's true place. Yet when it comes to explaining the method, the author instructs us to use the *epiciclus*, which is redundant in the eccentric method. He correctly explains how to use the black thread to mark the mean motus before laying the white thread parallel from the centre of the Sun's eccentricity; however, he then writes that 'wher as the white thred keruyth the grete lymbe tak ther the verrey place of the sonne' [i.e. the true place is where the white thread crosses the limb],[38] when in fact the black thread should be moved to cross where the white thread cuts the Sun's eccentric circle before the reading is taken on the limb where the black thread, not the white, crosses it. The author asks us to use the *epiciclus* in a manoeuvre that tells us nothing, but that may suggest that he was intending to explain how the epicyclic model could be used without having marked the

[33] Price, 74.
[34] The two models are explained with clear diagrams by Benjamin and Toomer, 40-42.
[35] Although Price explains the eccentric method (98) and notes that 'two quite independent schemes are given for calculating the position of the Sun' (68), he fails to note that neither scheme is correctly explained in the manuscript: they appear to have been confusingly conflated.
[36] It is not clear why Price did not note this error, when he clearly understood the theory and accurately translated the text into modern English.
[37] F. 73v.
[38] F. 75v. If 'white' is replaced by 'black' in this quotation, the confusion is mostly unravelled, though it does leave the explanation somewhat incomplete.

Sun's eccentricity on the label. (It could be done by using the parallel white thread to translate the eccentricity to the label.) If that is the case, the explanation is quite incomplete.

The final function of the equatorium is calculation of trepidation, the movement of accession and recession of the eighth sphere which was assumed to oscillate back and forth by 9° every 7000 years. This is not explained in the manuscript, though the author clearly intended the instrument to have this function as he included a nine-degree scale on the 'midnight' line (the continuation of the *alhudda* line, running from the centre to the head of Capricorn) which was surely designed for this purpose. Its use is analogous to the method for the latitude of the Moon.[39] The tables in the manuscript include a calendar for the equation of the eighth sphere; this could be read off on the limb of the disc and a thread placed perpendicular to the midnight line to read off the proportional trepidation on the 0-9° scale. The only problem is that the scale is only positive, but this is solved by a method identical to that for the Moon: if the trepidation takes us past the head of Libra, we then start counting backwards and the result is negative, until we once again reach the head of Aries.

- More on the eighth/ninth/tenth spheres
- Difference between vernal equinox and head of Aries? How does this affect position of Sun's aux? Do tables give us MM from constellation Aries or from ♈? Output will depend on what tables give us.
- Big question – were medieval astrologers more interested to find true place against background of zodiac stars, or with respect to vernal equinox? If auges move, must be vernal equinox…? Yes, otherwise star signs would move throughout the year – Aries/spring equinox always in March…? Is Aries always in the spring?
- But aux of Sun appears to move both against fixed stars AND vernal equinox – is that right? Accounted for by trepidation of eighth sphere.
- More about diagrams in MS

[39] Poulle, 163-4.