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Writing the clock: the reconstruction of time in the late Middle Ages

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For most of the Middle Ages, diurnal timekeeping depended on sundials, water-clocks, and occasionally flame-clocks. However, towards the end of the thirteenth century, the mechanical clock, weight driven and regulated by a verge escapement and foliot mechanism, was developed. The earliest mechanical clocks appeared in Northern Italy but rapidly spread throughout Europe. In Jacques le Goff's words, 'Henceforth the clock became the measure of all things'. Early clocks were neither particularly accurate nor reliable, but the machine, because it was better than anything that had preceded it, acquired the reputation for perfect regularity and dependability. This paper seeks to show how the clock came to be regarded as a model and a reference point, invoked by writers in relation to the ordering of the universe, the nature of a well-regulated society, and as an image of proper moral behaviour.

In Chapter XX of the first part of his *Repressor of Overmuch Blaming of the Clergy*, written in 1449, Reginald Pecock, Bishop of Chichester, sought to demonstrate that the Bible was not an infallible guide to everything – a position assumed by some of the more extreme followers of the heretic John Wyclif whom he was seeking to refute. Many things, Pecock says, are not mentioned in the scriptures, yet it is, nevertheless, legitimate to use them in the service of God, and among the examples he cites is the interesting one of the mechanical clock:

> … for though in eeldist daies, and though in Scripture mensioun is maad of orologis, schewing the houris of the dai bi schadew maad bi the sunne in a cercle, certis neuere save in late daics was eny clok telling the houris of the dai and nyght bi peise and bi stroke.[1]

With his customary exactness Pecock tells the reader how clocks work, by means of a weight (*peise*) and a striking mechanism, that they coexisted with, and partly replaced, sundials, which showed the hours by means of a gnomon that produced a shadow on a graduated circle, and what the advantages of the clock were:

sundials showed only the hours of the day, clocks indicated the hours of the day and night. Even the choice of verbs denotes a distinction. A sundial works by showing the hours, that is, one needs to be able to see it to use it, a clock by counting (telling) the hours by striking. One can, therefore, calculate the time if one hears the clock – a reference to the fact that most early clocks did not have dials, only bells. Most notable of all, though, is Pecock's recognition that, though the calculation of time is an ancient practice, the use of mechanical clocks is recent: it is a product invented 'in late daies'.

Quite what Pecock means by 'in late daies' is not exactly clear, though it is apparent that he knows that the development of the mechanical timekeeper is something relatively new and that clocks were still recognized as unusual things, though familiar enough to serve as an example. Society in the middle of the fifteenth century was, in many ways, highly mechanized and people were used to machines. Windmills and watermills were familiar features of the landscape and were often highly sophisticated mechanically; the building industry used a variety of mechanical devices, such as pulleys and hoists, to make some of the more burdensome tasks less laborious; and clothmakers used an astonishingly wide range of spinning wheels and looms. So the development of the mechanical clock in the late thirteenth century did not represent a particularly major breakthrough in technology – escapement mechanisms, gears, counterweights and so on were not unfamiliar things – although David S. Landes has warmly supported the idea that the use of oscillatory motion to divide time into 'countable beats' was a stroke of genius and the 'great invention' which set the development of the mechanical timekeeper on its course.[2] The development of the mechanical clock, however, also represented a significant cultural breakthrough, for the ability to measure time easily and fairly accurately altered many social concepts. For Jean Gimpel, the mechanical clock was the most important machine of the late Middle Ages.[3] Speaking of a shift of culture he perceived in the late fourteenth century, Jacques Le Goff, parodying Protagoras's famous humanist maxim, says 'Henceforth the clock was to be the measure of all things'.[4] Lewis Mumford went further: 'The clock, not the steam engine, is the key-machine of the modem industrial age … In its relationship to determinable quantities of energy, to standardization, to automatic action, and finally to its own special product, accurate timing, the clock has been the foremost machine in modern technics; and at each period it has remained in the lead … [5] However, in the Middle Ages, the clock made its impact slowly; neither the older methods of calculating time, nor the concepts associated with these methods changed immediately, but the change did come and when it came it was irreversible.

Although there was much debate about issues such as the date at which each year should start, the larger structures of time in the Middle Ages were handled with considerable sophistication. Calendars were produced in great numbers,

articulating the shape of the year with great precision, particularly in relation to the signs of the zodiac, to major church festivals, saints' days and the like, and to schemes such as the 'labours of the months' which defined the ordering of the agricultural year.[6]

Units of time smaller than the day, however, were more difficult to define, unless one had access to one of the many measuring devices – which most people lacked. During the day it was theoretically possible to make an estimate on the basis of observing the sun, but, as Chaucer demonstrates when he has Harry Bailly attempt this, one needed to use a lot of resource:

Oure Hooste saugh wel that the brighte sonne
The ark of his artificial day hath ronne
The ferthe part, and half an houre and moore,
And though he were nat depe ystert in bore,
He wiste it was the eightetethe day
Of Aprill, that is messager to May;
And saugh wel that the shadwe of every tree
Was as in lengthe the same quantitee
That was the body erect that caused it.
And therfore by the shadwe he took his wit
That Phebus, which that shoon so clere and brighte,
Degrees was fyve and fourty clombe on highte,
And for that day, as in that latitude,
It was ten of the clokke, he gan conclude … (II [B1],l-14)[7]

The seriousness of this passage is difficult to determine. It has been shown that Chaucer in all likelihood used the *Kalendrium* of Nicholas of Lynn for the calculations here, where it is in one place shown that the shadow of a man six feet tall would on, 18 April at 10 am, measure exactly six feet – a passage he uses again in the Parson's Prologue X [1] 1–12 – so on one level, Harry Bailly's estimate is astonishingly accurate. What is interesting here is that though Harry Bailly measures his estimate in terms of the 'clokke' he evidently has no access to any time-keeping instrument, so he has to know the date (which was easy) and the latitude (which was difficult) and has to make estimates about the length of the artificial day (the time the sun is above the horizon), as well as having some fairly accurate sense of size and angle. On his date, according to Nicholas of Lynn, the length of the artificial day was 14 hours 26 minutes, the sun having risen at 4.47 am – so at 10 am the proportion of the artificial day that had passed was more like a third part rather than the 'ferthe part' he specifies. But this is the only inaccuracy, the only reason one might conclude that he was not very deeply learned in the knowledge of this subject. Otherwise his skill is wondrous to an incredible degree, particularly since Chaucer implies that the estimates were made

without reference to any aids – instruments or books – of any description. A further dimension to this passage is the knowledge that could be expected of Chaucer's audience. The poet himself had written A *Treatise on the Astrolabe*, based in part on Johannes de Sacrobosco's famous work *De Sphaera*, which had addressed some of the questions involved here, particularly that of calculating latitude, but how general this knowledge was is hard to determine. It may have seemed to most readers or hearers of this tale that Harry Bailly had been invested, along with the other dimensions of his authority, with an unusual degree of giftedness in the instinctive calculation of time.

When instruments were used in the calculation of time, the sundial had authority: the movement of the celestial bodies (the sun, the moon and the fixed stars) was the standard against which the calculation of time made by means of instruments had to be judged. In a manner anticipatory of the arguments between Nevil Maskelyne and John Harrison in the eighteenth century,[8] a sundial motto contrasts the different claims:

Je marque le temps vrai
L'horloge marque le temps moyen.
[I indicate true time; the clock indicates mean time.][9]

Most sundials, like most instruments for calculating time in the Middle Ages, were used by those who needed them for their daily routine: churches, religious houses, governments. At first, in Anglo-Saxon England and elsewhere, these dials were scratched on the southern walls of churches, and at other times they were inscribed on separate blocks. The daylight divisions were often marked in four 'tides', corresponding to one system of division of the day; others were more elaborate. From St Gregory's Minster, Kirkdale (Yorkshire) in about 1055 comes a sundial table recording the rebuilding of the minster, which acknowledges the patronage of Edward the Confessor and the earl Tostig, and the passage and memorializing of time, though here the 'tides' are subdivided:

This is dæges solmerca
æt ilcum tide
& Hawarth me wrohte & Brand p*reosts*
[This is the day's sun-marker at every tide, and the priests Hawarth and Brand made me.][10]

It is particularly significant that this timekeeper was constructed by the clergy. Sundials were the principal means of calculating the time of the services of the church during the hours of daylight, but at night or indoors other devices were used – the sand-clock, which has a long history stretching to the modem hour-glass, the flame-clock, a graduated candle, and the clepsydra or water-clock, which was very popular in monasteries and other religious houses, especially if

it was accompanied by a striking mechanism and an alarm system.[11] In the Cistercian Rule of the early twelfth century, item CXIV specified that the sacristan was to set the clock each night so that it would sound on weekdays in winter before lauds unless it was daylight. He was to use it as an alarm to get him up so that he could light the lamps and candles. Other monastic rules contained similar instructions.[12] Before the fourteenth century, monastic life was largely regulated by means of water clocks. A clock of this sort, according to Jocelin of Brakelond, proved useful for more than timekeeping at the Benedictine monastery of Bury St Edmunds on the morning of 22 June 1198 when a fire started on a platform which held two candles close to the shrine of the saint:

Eadem enim hora cecidit horologium ante horas matutinas, surgensque magister vestiarii, hec percipiens et intuens, cuccurit quamtocius et, percussa tabuls tamquam pro mortuo, sublimi voce clamuit dicens feretrum esse combustum. Nos autem omnes accurrentes flammam invenimus incredibiliter sevientem, et totum feretrum amplectentem, et non longe a trabibus ecclesie ascendentem. Iuvenes ergo nostri propter aquam currentes, quidam ad puteum, quidam ad horologium, quidam cucullis suis impetum ignis cum magna dificultate extinxerunt, et sanctuaria quedam prius diripuerunt.
[Around the same time the clock struck for Matins, and the vestry master, on getting up, saw the fire, and ran as fast as he could, and beat upon the board as if someone was dead, and shouted in a loud voice that the shrine was on fire. We all rushed up, and met the incredibly fierce flames that were engulfing the whole shrine and almost reaching up to the beams of the church. Our young monks ran for water, some to the rain-water tank, some to the clock, and some, with great difficulty, when they had snatched up the reliquaries, put out the flames with their hoods.][13]

This must have been an elaborate clock with a very large water-tank. Of course, water-clocks were also used outside religious houses. A guild of makers of water-clocks existed in Cologne as early as 1183, and by 1220 there were enough of them working in one place to cause a street – Urlogingasse – to be named after them.[14]

Time, before the development of the mechanical clock, was very much dominated by the church. There is evidence that the organization of daily life, particularly in towns, centred on the sound of bells in churches and monasteries, which were regulated by their clocks.[15] Dante, in *Paradiso* XV, into the mouth of his great-great-grandfather Cacciaguida, puts an idealizing description of Florence in the twelfth century, within its 'old walls', regulated, as it still was in his own day, by the sound of the bell of the Badia, the church of the Benedictine Abbey founded in 978, as it rang for terce and nones:

Fiorenza dentro dalla cerchia antica,
ond'ella toglie ancora e terza e nona.
si stava in pace, sobria e pudica. (97–99)
[Florence, inside her old walls, from which she still takes terce and nones, was in peace, sober and chaste.][16]

And this continued throughout the Middle Ages. François Villon describes how, on a cold December night in 1456, he came to end his poem *Le Lais*, because he heard the bell of the Sorbonne sounding nine:

Finablement, en escripvant,
Ce soir, seulet, estant en bonne,
Dictant ce laiz et descripvant,
J'ouis la cloche de Serbonne,
Qui tousjours a neuf heures sonne
Le salut que l'ange predit;
Si suspendis et y mis bonne
Pour prier comme le cuer dit. (273–280)
[Finally, as I was writing this evening, in a good mood, describing this legacy and writing it down, I heard the bell of the Sorbonne, which always strikes the Angelus at nine, so I set myself to pray as the heart tells me to.][17]

Records show that the bell he refers to was made by a certain 'Galterus' and was called 'Marie' because it struck the Angelus. In calm weather it could be heard all over Paris. It sounded the curfew inside the precincts of the University of Paris, and at this point Villon gives up writing and prays. He dozes, and 'dame Memoire' fills his mind with thoughts of scholastic philosophy so that, on awakening, he finds he can write no more of his poem: the ink had frozen; the candle had gone out. And since there is no other light by which to continue writing he puts on his mittens and sleeps through the chilly night. Effectively, his working day, because he was a scholar, had been defined by the time of the church – though it is clear he did not wish to stop work quite when he did. Just how instinctive it was to measure diurnal time by the services of the church is apparent from the following extract from a letter dated 13 May 1482 from Richard Cely, in London, to his elder brother George, who was in Calais. The details of dealing in wool and woolfells in the Cotswolds are suddenly interrupted by a passage on a prospective marriage, which is also construed as a matter of some financial moment. William Midwinter, a wool merchant, tries to interest Richard in marrying a rich heiress, Elizabeth, the daughter of Thomas Limrick or Lymeryke of Cirencester, MP for Gloucestershire and a JP who was coming to Northleach to preside at a sitting of a court:

Syr, I whryte to yow a process: I pray God sende therof a good heynd. The same

day that I come to Norlache, on a Sonday befor mattens frome Burforde, Wylliam Mydwynter wylcwmyd me, and in howr comynycacyon he askyd me hefe I wher in any whay of maryayge. I towlde hyme nay, and he informeyd me that ther whos a yeunge genttyllwhoman hos father ys name ys Lemryke, and her mother ys deyd, and sche schawll dyspend be her moter xl li. a yer, as thay say in that contre, and her father ys the gretteste rewlar and rycheste mane in that conttre, and ther hawhe bene grete gentyllmen to se hyr and wholde hawhe hyr, etc. And hewyr matens wher done, Wylliam Mydwynter had meved thys mater to the gretteste mane abot the gentyllman Lemeryke, and he yeyd and informyd the forsayd of aull the matter, and the yewng gentyllwomane bothe.[18]

Whether any of the people involved in this story actually attended matins at St Peter and St Paul, Northleach, the big perpendicular church which graces the town, is uncertain, but the time frame of the story is dominated by the church service: it is its consistent temporal reference point. And in the hours of darkness the sound of bells was even more important. It seems that small chamber clocks had been developed in the fourteenth century, but very few people possessed them.[19] In the countryside, away from urban or monastic centres, there was no alternative to listening to church bells. John of Garland, at the beginning of the thirteenth century, offers the following bizarre but significant etymology: 'Campane dicuntur a rusticis qui habitant in campo, qui nesciant judicare horas nisi per campanas' [Bells are named because of rustics who live in the country, who may not know how to calculate the time except by bells].[20]

It is not known precisely when the first mechanical clock was developed, or who developed it. And there are differences of opinion among historians of horology over whether the escapement mechanism, which was critical to the development of mechanical clocks, was imitated from Chinese technology or whether it was developed in Europe.[21] But it is plain that as early as the second half of the thirteenth century engineers were looking at the problem. This is clear from the lecture notes of Robertus Anglicus, in his commentary on Sacrobosco's *De Sphaera* dating from 1271:

> Nor is it possible for any clock to follow the judgment of astronomy with complete accuracy. Yet clockmakers are trying to make a wheel which will make one complete revolution for every one of the equinoctial circle, but they cannot quite perfect their work. But if they could it would be a really accurate clock and worth more than the astrolabe or other astronomical instruments for reckoning the hours, if one knew how to do this according to the method aforesaid.[22]

And he goes on to describe a mechanism powered by a falling weight which would turn a dial through one complete revolution between sunrise and sunset. Not long after this, the first mechanical clocks begin to appear. They were weight-driven and worked with a fairly rudimentary verge and foliot escapement mechanism –

although early on the balance wheel is found instead of the foliot. Most early clocks were public ones: they were built for churches, monasteries and towns. A clock made of iron was set up in 1309 in the church of St Eustorgio in Milan. Before 1324, the cathedral at Beauvais probably had a clock with a bell for sounding the hours. According to one Italian source, the church of St Gothard in Milan in 1335 had 'a wonderful clock, with a very large clapper which strikes a bell twenty four times according to the twenty four hours of the day and night, and thus at the first hour of the night gives one sound, at the second two … and so distinguishes one hour from another which is the greatest use to men of every degree.' From this time onwards, mechanical clocks spread rapidly: the monastery of Cluny had one by 1340, and Chartres Cathedral two by 1359. In 1353, in Genoa, a public clock was installed which struck the hours, another in Bologna in 1356, and another in Ferrara in 1362. King Charles V of France had one installed on one of the towers of his Royal palace in 1362 and two others in the Chateau de Vincennes and the Hotel Saint-Paul.[23] Most early clocks were Italian, French or German and most clockmakers came from these countries. A record survives of a grant of protection and safe-conduct by Edward III to three Dutchmen, '*orlogiers* coming into the realm to practice their art'.[24] The earliest clockmakers were non-specialist metalworkers, often blacksmiths, locksmiths or gunmakers.[25] The objects they produced were often heavy and crude. Quickly, however, highly skilled clockmakers emerged – John of Wallingford in England, Jean Fusoris in France, and Giovanni de' Dondi in Italy – the last of whom produced the celebrated astrarium, a wonder of its age, between 1348 and 1364. And, as the technology developed, clocks got smaller: in 1377, according to an inventory made at his death, Charles V of France had an '*orloge portative*' in his oratory. In 1430 Philip le Bel possessed what appears to have been a spring-powered chamber clock, and in 1459 Charles VII of France purchased a '*demi orloge dore defin or sans contrepoix*' [a small clock gilded with fine gold without counterweights].[26] In the early part of the sixteenth century, what may be described as the earliest watches developed, and it became possible, for the better-off, to possess a personal timekeeper.

Many of the earliest clocks were simply utilitarian timekeepers. But others were more elaborate and, along with the calculation of diurnal time, had more complex but related agendas. The large mechanical clock constructed at Norwich Cathedral between 1321 and 1325 appears to have been set up with monastic rituals in mind: besides an astronomical dial with models of the sun and moon, it had automata in the form of a procession of monks.[27] The clock constructed by Richard of Wallingford at St Albans at about the same time had not only planetary trains and a moon dial, but also a tidal dial – a partly utilitarian feature which appears on later clocks also, but in part a demonstration of the logic of the universe. Much the same was Giovanni de' Dondi's clock. It impressed Philippe de Mezières when

he went to look at it in part because it was so skilfully made so that 'all goes by one weight', but also because it exposed and demonstrated the workings of the universe: it '… shows all the movements of the signs and the planets with their circles and epicycles, and differences, and each planet is shown separately with its own movement in such a way that at any time of the day or night one can see in which sign and to which degree the planets and the great stars appear in the sky …'[29] It also had a 24 hour dial, a dial for the times of the rising and setting of the sun, a dial for the nodes or intersections of the orbit of the moon, and separate dials for the fixed and movable feasts of the church year – this last item locking it firmly into an ecclesiatical agenda.[30]

Medieval clocks became complex before they became accurate. Early on it became customary, especially on the bigger clocks, to have figures – 'jacquemarts' or 'jacks' – which struck the bells, and these were sometimes affectionately given names: 'Jack Blandiver' struck the bell on the clock at Wells Cathedral, and 'Jack the Smiter' performed a similar office at Southwold.[31] These figures provided entertainment. The use of automata in early mechanical clocks was, in fact, fairly common. They are little regarded by historians of horology, but better than anything else they articulated the meaning that time had for the constructors and the commissioners of medieval clocks. They are, however, not always easy to interpret. In addition to two bands marking the hours and the minutes of the day and night, each with an indicator with a gilt star, and a device for showing the phases of the moon, all of which, according to a barely legible inscription shows the wonders of the universe, the Wells clock has four equestrian knights, two white, two black, equipped for a tournament, who joust against each other, figuring, presumably, the alternation of light and darkness, day and night. The show in about 1340 at Cluny was, according to Viollet le Duc, much more complicated. In addition to indications of the movement of the sun and the phases of the moon, and a cock which crowed twice at every hour, marionettes enacted various scenes – the Annunciation, where an angel greeted Mary, the Holy Ghost descended on her head, and God the Father gave his benediction; death; the mystery of the Resurrection. When the carillon chimed all the figures retreated back into the clock. Something of the same sort appeared on the first Strasbourg clock, begun in 1352 and completed two years later. An astrolabe was in the middle, whose pointers showed the movements of the sun, moon, and hours. There was a calendar and an indication of the movable feasts. Then, in an upper compartment, the magi bowed before the Virgin Mary. The whole thing was topped by a crowing cock, which also moved its beak and flapped its wings. Whether this last feature was there as a reminder of the most celebrated of timekeepers from the natural kingdom, or whether as an antitype of sloth, or a type of Christ, is difficult to tell.[32] In some later clocks this essentially religious agenda was modified to incorporate more secular subjects. The astronomical clock

in the town square in Prague, perhaps dating from as early as 1410, has a lower roundel which shows the signs of the zodiac and the labours of the months while, above, the marionette performance begins with a skeleton who shakes an hour-glass and rings a bell. Various other figures appear, including a miser who rattles his purse and a vain man who looks at himself in a mirror. The agenda seems to be cautionary: death and time preside over the sinful world of men. Others were apparently advisory: according to Bartolomeo Manfredi in 1473 the cosmological indications of a clock in Mantua showed ' … the proper time for phlebotomy, for surgery, for making dresses, for tilling the soil, for undertaking journeys, and for other things very useful in this world'.[33] Early clocks were not simply timekeepers: they claimed to be able to suggest how people might organize their lives in the religious, moral and social spheres.

Early clocks were neither accurate nor reliable: they had to be reset frequently by reference to sundials; and they needed constant repairing. When Chaucer's Nun's Priest says of Chaunticleer

Wel sikerer was his crowyng in his logge
Than is a clokke or an abbey orlogge (VII [B] 2853–4)

he is comically preferring the reliability of the natural timekeeper to that of machines that were man-made. There was a rhyme current in Paris in the late fourteenth century, which referred to the inaccuracy of the clock that had been installed by Charles V:

l'horloge du palais
Elle va comme il lui plait.[34]
[The clock of the palace goes as it pleases.]

In 1387, King John of Aragon decided he would employ two men to strike the bells of his clock in Perpignan because the striking mechanism could not be made to work perfectly – an ironic reversal in that the 'jacquemarts' became human again.[35] At his death Giovanni de' Dondi's clock fell into disrepair because nobody knew how to maintain it. It was eventually put in the library of the Visconti castle in Pavia and fell to pieces through neglect.[36] Despite all this, mechanical clocks became associated with precision, reliability, and perpetual motion – partly, no doubt, because they brought a new orderliness into timekeeping through using equinoctial hours, partly because they did not need so much attention as clepsydrae, which needed frequent resetting, and partly because they were a constant reminder, day and night, of the passing of the hours. The mechanical clock, with its division of time into regular pulses, became an image of the logical arrangement of things, of unerroneous constancy, of temperance, and gave writers an instrument that served as a religious, moral and social measure.

Whether the diurnal mechanical timekeeper developed more or less as a

by-product of the need to provide a mechanical image of the workings of the universe, or whether it developed in response to mundane necessities is a hotly debated issue: there are arguments, incomplete because of the paucity of the evidence, which support either position. But what is not in doubt is the fact that the comparison between the workings of the universe and the workings of a clock emerged at an early stage. The view that the comparison emerged conterminously with the mechanistic philosophy of the early seventeenth century is not sustainable. Who first compared the cosmos to a clock is in doubt. It could be argued that any clock that attempted to account for the turning of the heavens, the movements of the stars and the planets, the sun and moon, the circuit of the seasons, the logical alternation of day and night, the division of the day into ever smaller particles, could be said to be a universal model. And there is early evidence that medieval thinkers entertained the possibility that the clock mirrored the universe. The German mystic Heinrich Suso (died 1366), in his *Horologium Sapientiae*, described a vision, dated 1334, in which he had been privileged to see Christ in the form of an elaborate contemporary clock chiming the hours: God's eternal time, he thought, provided a model for the soul which needed to operate in consonance with it.[37] In 1377 Nicole Oresme, in his *Livre du Ciel et du Monde*, compared the universe to a clock (*horloge*) which worked whatever the season, by day and by night, was never fast or slow, and never stopped.

> Et selon verite, nulle intelligence n'est simplement immobile et ne convient pas que chascune soit par tout le ciel que elle meut ne en chascune partie de tel ciel, pose que les cielz soient meuz par intelligences, car par aventure, quant Dieu les crea, il mist en eulz qualitez et vertus motivez aussi comme il mist pesanteur es choses terrestres, et mist en eulz resistences contre les vertus motivez. Et sont les vertus et ces resistences d'autre nature et d'autre matiere que quelcunque chose sensible ou qualite qui soit ici bas. E sont ces vertus contre ces resistences telement moderees, attempres et acordees que les mouvemens sont faiz sanz violence; et excepte la violence, c'est aucunement semblable quant un homme a fait un horloge et il le lesse aler et estre meu par soy. Ainsi lessa Dieu les cielz estre meuz continuelment selon les proporcions que les vertus motivez ont aus resistences et selon l'ordenance etablie.[38]
>
> [Actually, no intelligence is absolutely immobile, and, if we assume the heavens to be moved by intelligences, it is unnecessary that each one should be everywhere within or in every part of the particular heaven it moves; for, when God created the heavens, He put into them motive qualities and powers just as he put weight and resistance against those motive powers in earthly things. These powers and resistances are different in nature and in substance from any sensible thing or quality here below. The powers against the resistances are moderated in such a way, so tempered, and so harmonized that the movements are made without violence; thus, violence excepted, the situation is much like that of a man making a clock and letting it run and continue its own motion by itself. In this manner did God allow the heavens to be moved continually according to the

proportions of the motive powers to the resistances and according to the established order.]

This is a remarkable passage, not least since when the language of philosophical discourse becomes punctuated by the image of the clock and its maker, it is clear that Oresme knows precisely what he is about: orderly movement depending on power and resistance are at the heart of the mechanics that account for clockwork. So God became a sort of divine clockmaker: having constructed the 'horloge' and set it in motion he could leave it to move by itself.

Whether Dante knew about mechanical clocks is much argued about, but the likelihood is that he did. *Paradiso X*, which deals perhaps significantly with the circle of the sun, begins with a cosmological description of the universe and ends with a monastic clock signalling the time for matins by means of a striking mechanism:

Indi, come orologio che ne chiami
nell'ora che la sposa di Dio surge
a mattinar lo sposo perchè l'ami,
che l'una parte l'altra tira e urge,
tin tin sonando con si dolce nota,
che '1 ben disposto spirto d'amor turge;
cosi vid' io la gloriosa rota
muoversi e render voce a voce in tempra
ed in dolezza ch' esser non pò nota
se non colà dove gioir s' insempra. (139–148)

[Then, like a clock which calls us at the hour when the bride of God rises to sing matins to the Bridegroom that he may love her, when one part draws or drives another, sounding the chime with notes so sweet that the well-ordered spirit swells with love, so I saw the glorious wheel move and render voice to voice in harmony and sweetness that cannot be known but there where joy becomes everlasting]

Dante uses the word 'orologio' which could indicate a clepsydra or a mechanical clock, though whatever sort of timekeeper he is thinking of here, it was clearly intricate. The circling of the Fellowship of the Lamb in *Paradiso* XXIV (the canto number is possibly significant because of the number of hours in the day) is also compared to a clock, and here the description is more precise:

… e quelle anime liete
si fero spere sopra fissi poli,
fiammando forte, a guisa di comete.
E come cerchi in tempra d'orioli
si giran si, che 'l primo a chi pon mente

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quieto pare, e l'ultimo che voli;
così quelle carole, differente-
mente danzando, della sua ricchezza
mi facieno stimar, veloci e lente. (10–18)

[… and those happy spirits formed themselves in circles on fixed poles, flaming brightly like comets. And as wheels in the structure of a clock revolve so that, to one watching them closely, the first seems to rest and the last to fly, so those choirs, dancing severally fast and slow, made me gauge their bliss.]

On this particular passage David Landes writes: '… it takes excessive ingenuity to see here anything but the wheel train with reduction gearing characteristic of the mechanical escapement clock'[39] The orderliness of this heavenly dance is like the orderliness of a mechanical clock, and, because of the language of astronomy (*spere, fissi poli, comete*) it is further suggested that the universe moves in the same logical way – so Dante may have been thinking of a clock that was also an astrarium.

Two other points are important in relation to these passages. One is that in hell there are no timekeepers: clocks appear only in heaven, where they are seen as images of orderliness and constancy.[40] The second has to do with the phrase 'in tempra', meaning something like 'in measure' or 'in harmony', which here has important etymological overtones and other semantic nuances, some of them musical: orderly movement and orderly sound are features of both passages, and both are associated, like Nicole Oresme's word 'attempres', with the clock.

The development of a mechanical method of calculating time also provided an incentive and an opportunity for the imposition of greater political and social orderliness In 1370, Charles V of France tried to organize time according to his own standard: he decreed that all the clocks in Paris should be regulated by the one he was installing in his palace. The churches were to ring their bells when his clock struck the hour. The control of time had passed from the church into secular hands.[41] That the regulation of time belonged to the king may be the implication of the early sixteenth-century clock in the tower of the church of St Mary Steps, Exeter. In an alcove over a dial, ornamented with the four seasons appears a seated figure of Henry VIII, flanked by two soldiers in military dress each holding a javelin and a long-handled hammer, with which they strike the quarters. When the clock strikes the hour the seated figure of the king nods his head at every stroke, as if in approval.[42] However, those with the greatest interest in using the new precise timekeeper were those responsible for organizing the day to day life of urban populations, particularly with respect to the working day. On 24 April 1335, for example, Philip V granted a request from the mayor and aldermen of Amiens that they could

… faire une ordenance quand les ouvriers de ladicte ville et banlieue d'icelle

> iroient chascun jour ouvrable a leurs ouvrages au matin, quand ils deveroient aler mengier et quand ils deverioent repairier a leurs ouvrages apres mengier et aussi au soir quand ils deveroient laissier oevre pour la journee; et que par la dite ordenance que il feroient, il peussent sonner une cloche que il on fait pendre au Beffroi de ladicte ville, laquelle se differe des autre cloches[43] …
> [… issue an ordinance about when the workers of the said town and its suburbs should go each working day to their work in the morning, when they should go to eat and when they should return to work after eating and also in the evening when they should leave work for the day; and by the ordinance that they had made they might sound a bell which might be hung in the Belfry of the said town, which differs from the other bells …]

Similar arrangements were instituted in other towns and cities, particularly in those associated with the clothmaking trades. Since urban authorities tended to be dominated by the employers, these workbells were frequently resented by the labourers. In Thérouanne in 1367, the dean and chapter of the cathedral promised 'to silence forever the worker's bell' after public pressure, but this was a rare occurrence.[44] The working day ceased to be open-ended, and became defined by the clock.

This, in turn, sharpened the distinction between when it was proper to work and when it was not. Not to work when one was meant to work was, naturally, frowned upon. But, equally, to work outside the permitted hours was something to be disapproved of, particularly if one worked at night – which was meant for rest. It is this feeling that appears to lie behind the Middle English alliterative poem, dating from the first half of the fifteenth century, which is usually called *Blacksmiths*:

Swarte smekyd smethes smateryd wyth smoke,
Dryve me to deth wyth den of here dyntes!
Swech noys on nyghtes ne herd men never:
What knavene cry, & clateryng of knockes!
The cammede kongons cryen after 'Col! Col!'
& blowen here bellewys that al here brayn brestes.
'Huf, puf!' seyth that on; 'Haf, paf!' that other.
Thei spytten & spraulyn & spellyn many spelles,
Thei gnauen and gnacchen, thei gronys togydere,
And holdyn hem hote wyth here hard hamers.
Of a bole hyde ben here barm-fellys,
Here schankes ben schakled for the fere-flunderys;
Hevy hamerys thei han that hard ben handled,
Stark strokys thei stryken on a stelyd stokke.
'Lus, bus! Las, das!' rowtyn be rowe –
Sweche dolful a dreme the devyl it todryve.[45]

There were sometimes good reasons for smiths to work at night: equipment, particularly farm equipment, had to be repaired quickly. But the setting here looks urban and the workshop seems to be quite large, since a number of people work in it, and the poet may intend the smiths to be armourers (see *clothemeres*, 21). It is in the context of complaints about night work by metalworkers and about legislation to regulate it that this poem needs to be seen.[46] In the articles of 1345 it was argued that work done at night was often inferior in its craftsmanship, 'for no man can work so neatly by night as by day', and that it often led to the deceptive use of inferior materials. Usually, however, complaints centred on the dangers created by metalworkers' forges and the anti-social noise they made as they fashioned their materials:

> many … are wandering about all day, without working at their trade; and then, when they have become drunk and frantic they take to their work to the great annoyance of the sick and of all the neighbourhood … And then they blow up their fires so vigourously that their forges begin at once to blaze, to the great peril of themselves an of all the neighbourhood around …

This complaint concerns the London smiths. In 1394, their trade became subject to regulation in terms of working hours: they could work only between sunrise and 9 pm, or between 6 am and 8 pm between All Hallows and Candlemas (1 November to 2 February).[47] And other regulations were in force elsewhere. The manuscript in which this poem is preserved (London, British Library MS Arundel 292) once belonged to Norwich Cathedral Priory, and it may be that the author of the poem was a cleric: the slightly envious disapproval of the somewhat gross physicality of the blacksmiths is characteristic of the non-manual worker. But whoever he is, the complaint is made in the usual terms: the flames, and particularly the noise, offend him, as does the crucial fact that the work takes place 'on nyghtes'. Later in the poem the speaker complains that because of those who burn water (*brenwateres*) nobody can 'on night han his rest'. What he sees in the night-working blacksmiths shop is a vision of hell. Working at night is not just anti-social, but diabolical too: 'the devel it todryve'.

The possibility of the quantification of time, which the mechanical clock promised, appears to have increased the sense of its value.

Tempus donum dei est
Inde vendi non potest
[Time is the gift of God, so it cannot be sold]

– so ran an anti-usury jingle.[48] But as early as the first half of the fourteenth century Domenico Calva of Pisa, in his *Disciplina degli Spirituali* compared wasted time to the unused talent of the biblical parable, so, in a sense, even for someone in orders, time was money.[49] And for those engaged in commerce or trade this sense

quickly became highly developed. In the Merchant Tailors' records for the years 1488–93 comes a complaint by a tailor against one of his apprentices because he has fallen in love. Indentures between masters and apprentices frequently stipulate that the apprentice shall not commit fornication: yet the complaint is not brought on those grounds, but on the grounds that the apprentice is wasting time because he ' … used the company of a woman which was to his (the tailor's) grete losse and hynderyng for asmoch as he was so affectionate and resorted daily unto hyr.[50] How time was spent came to be something of importance in the later Middle Ages. '& therfore take good keep into tyme', advises the author of *The Cloud of Unknowing*, 'how that thou dispendist it. For nothing is more precious than tyme. In oo litel tyme, as litil as it is, may heuen be wonne & lost.' And, he continues, God will want to know what a person did with his time 'in the dome & at the yeuyng of acompte of dispendyng of tyme' – where the vocabulary of commerce suggests that the spiritual was being invaded by this secular sense.[51]

Time and its proper use became important moral matters too, and the clock became an image for the well-regulated behaviour of people. As early as 1369 Jean Froissart explored the possibilities of the comparison in *L 'Orloge Amoureus*, a long allegorical poem. It opens with some lines in praise of mechanical clocks:

L'orloge est, au vrai considerer,
Un instrument tres bel et tres notable,
Et s'est aussy plaisant et pourfitable,
Car nuict et iour les heures nous aprent
Par la soubtilite qu'elle comprent
En l'absence meisme dou soleil … (1–6)[52]
[The clock is, if considered rightly, a very beautiful and remarkable machine, and it is also pleasant and useful, because night and day it tells us the hours by the intricacy of its mechanism, even when there is no sun …]

The man who invented the clock was 'vaillant' and 'sage', says Froissart, and then launches into an allegorical anatomy of a lover's emotions in terms of the parts of a clock. The housing of the mechanism– the clockcase – is appropriately the 'coer loyal'. Then he moves to the mechanism itself: the largest cog is 'le vrai desir'; the weight which drives the clock is 'la beaute'; and the cord by which the cogwheel and the weight are attached is 'plaisance'. All of which means that the force of beauty moves part of the lover's heart to thoughts of pleasure, which in turn sets in motion his true desire. But this passion is controlled by reason: 'attemprance' (temperance, moderation) is the escapement mechanism, which determines the speed of the clock. Some of the comparisons are truly ingenious, as when the foliot – the oscillating bar which regulates the escapement – is made to stand for 'paours' [fear]:

Car tout ensi que le foliot branle,
Doit coers loyaus estre tous jours en branle,
Et regarder, puis avant, puis arriere …(251–3)
[For just as the foliot moves loyal hearts must every day be in agitation, and look, sometimes before, sometimes behind …]

The other parts of the clock are mentioned as the poem develops–he clock face is 'doulc penser', the 24 hours each correspond to a virtue, and so on. The 'orlogier' or 'governor' of the clock, by whom it is kept in good working order is 'souvenirs'– the lover's memory of the lady. The principal virtue that the whole allegory demonstrates is the fairly predictable one of constancy: just as a good clock runs incessantly day and night, so the loyal heart of the lover should always be moved by thoughts of the lady – which is proposed as an appropriate way of spending time. But for those who wasted time, the clock became a potently menacing image. As he languishes in prison, Shakespeare's Richard II meditates on the subject:

I wasted time and now doth time waste me;
For now hath time made me his numb'ring clock … (V. v. 49–50)

He allegorizes himself, his sighs and his groans in terms of a clock, concluding that he has lost control of his own time and now moves only to Bolingbroke's measure 'while I stand fooling here, his Jack of the clock' (60). Like a marionette or an automaton, he marks the passing of time but has forfeited his capacity to use it.

The development of the mechanical timekeeper altered the culture of Western Europe. It brought with it a heightened sense of time and privileged virtues such as regularity, constancy, punctuality, exactness. It enhanced the sense – on a spiritual, social and personal level – of the value of time. It suggested ways in which one might organize one's life by dividing it up into compartments – so much time for work, so much time for study, so much time for recreation and rest. And writers reflect about, and meditate upon, these issues, absorbing the new machine into their literary consciousness.

But the new machine was not universally welcomed: its equinoctial hours, its disregard of the seasons, its imperviousness to day and night, its automatic movement whatever the circumstances, proved irritatingly intrusive. It is a clock which interrupts Dafydd ap Gwilym's dream of a beautiful girl:

Och i'r cloc yn ochr y clawdd
Du ei ffriw a'm deffroawdd.
Difwyn fo'i ben a'i dafod
A'i ddwy raff iddo a'i rod,
A'i bwysau, pelennau pwl,

A'i fuarthau a'i fwrthwl,
A'i hwyaid yn tybiaid dydd,
A'i felinau aflonydd.
Cloc anfwyn mal clec ynfyd[53]
[Alas, the clock beside the dyke black-countenanced, which awakened me; let its mouth and tongue be vain with its two ropes and its wheel, the stupid balls which are its weights, its four-square case (?) and hammer, with its ducks who think it day, and its restless mill-wheels. Churlish clock with foolish chatter …]

This must have been written before about 1380 when Dafydd is thought to have died. This is clearly meant to be a mechanical clock, apparently with automata, but none is mentioned in Wales in the fourteenth century. It may have been a monastery clock. But what emerges clearly from this poem is the feeling that it is somehow out of place in what is presented as a rural setting. The sense that the new mechanical timekeeper separates people from the older, more natural rhythm of things – so powerful in the seventeenth century – here gets stated early, and in memorable fashion. According to the author of *The Cloud of Unknowing*, echoing St Augustine, 'tyme is maad for man, & not man for tyme'[54] But after the development of the mechanical clock this proposition became somewhat problematic.

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39. See D. S. Landes, *Revolution in Time*, p. 57
40. I owe this point to my colleague Corinna Salvadori Lonergan, to whom I am also generally indebted for much advice on Dante.
41. On this point see particularly J. le Goff, *Time, Work and Culture in the Middle Ages*, pp. 49–50. He says: 'The new time thus became the time of the state'.
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