

THE INVENTION OF THE MECHANICAL CLOCK AND  
PERCEPTIONS OF TIME IN THE 13TH–15TH CENTURIES

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After the invention of the mechanical clock in Europe in the 12th century, the device spread so quickly that by the 14th century no place could be considered a proper town if it did not have a public clock in its town center.<sup>1</sup> The first mention of a mechanical clock in medieval literature is often regarded to be in Dante's *Divine Comedy*, in the early 1300s,<sup>2</sup> and from this point on we see more and more references to clocks in literature and paintings.<sup>3</sup> Soon, we see not just towns installing public clocks for all of their inhabitants, but also people owning their own clocks. The term "public clock" was used by Petrarch as early as 1353 to describe the first public clock in Milan, which not only displayed the time of day for everyone to see, but also rang the hours with bell signals.<sup>4</sup> Soon, public clocks caught on in the rest of Europe, so much that cities would often compete to have the most extravagant clocks, complete with astronomical models and automatons. Still, despite the fact that the clock had become an essential part of everyday life, the church was initially opposed to their spread because of the way that public clocks not only changed the way that people measured time, but also people's perception of time itself.

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Before the 13th century, monasteries had been in charge of timekeeping, not only for themselves, but also for entire towns and villages. Since St. Benedict's rule in 530, monks had been interested in keeping time as a way of ordering their days, which were divided up into masses, or periods of prayer, also called the canonical hours, which were used to tell monks not only when to pray, but also when to work, eat and sleep.<sup>5</sup> The canonical hours were used not only by the monks but also by everyone else, from kings to peasants, and eventually, with the growth of cities and towns and the general urbanization of Europe, by merchants as well as laborers in cities. For most of early medieval history, monasteries were an essential part of medieval communities because of their stability in a time when most of Europe was in a state of political chaos. Later, towns were built around them and depended on them for many civic services, including signaling the hours.<sup>6</sup> These bell signals announced the hours of prayer for religious laymen, but they were also used as the main method for telling people when to start and stop work on the fields or in the marketplace, and how to schedule their daily lives.<sup>7</sup> Similarly, merchants in 12th century Genoa recorded the times of important business transactions, as well as times of birth and death, using the canonical hours.<sup>8</sup> In fact, even those rich enough to afford their own sundials or water clocks would calibrate them to the canonical hours, because it had been the traditional way of telling time for so long.

Unlike our modern hours, the canonical hours were actually a very fluid way of measuring time, far from regular, and were hardly fixed points in time at all. Firstly, the canonical hours were tied to the events of *ora et labora*, and were designed to schedule a sequence of tasks, so the length of the hours was allowed to move to accommodate them.<sup>9</sup> Similarly, the day and night were divided into hours separately because they were characterized by different activities, and they differed with the length of the day, season to season, especially in the more northern parts of Europe.<sup>10</sup> On top of that, since the hours were signaled by manual bell ringing rather than an automatic machine, masses could drift even farther apart, since an hour was really determined by whenever a monk

remembered to look at the sundial and decide that it was about the right time. The devices used to measure time in monasteries, the sundial during the day, and the astrolabe to calculate the positions of the stars at night, or occasionally a temporary water clock, encouraged this fluidity of time. The sundial, for example, is perfect for measuring hours with lengths relative to the length of the day, since it tells time based on the position of the sun. Even the water clock could not run long without being reset with a sundial, and even then it was keeping time by the flow of water, a process which is by definition fluid.<sup>11</sup> By the 12th century, different monasteries would often have completely different ideas about when an hour was supposed to take place.<sup>12</sup> This fluid, sequential division of time worked for monasteries keeping track of the masses, which may have been part of the reason that the system went uncorrected for so long, but it also meant that timekeeping in other spheres of life was not very reliable.

The fluidity of monastic timekeeping was also even more largely connected to Christian philosophy about the nature of time, which was also influenced by the available devices for measuring time. Even in the 4th century, Christians were already thinking about the metaphysical question of God's relation to time. In the *Confessions*, St. Augustine argues that there was no time before creation because God created the world and time as one, and that they are thus eternally linked to each other, settling a theological debate about the nature of time before Creation.<sup>13</sup> And even apart from St. Augustine, there was a belief that time and the natural order are linked, and that the cycles of nature, the seasons, the movement of the sun, and the heavenly bodies, were given to us by God to measure time.<sup>14</sup> This philosophy is obvious from illustrations in copies of the 'books of hours' from the Early and Central Middle Ages that often depict plants, animals and other images of nature that belong with the time of year and day.<sup>15</sup> Before the invention of the mechanical clock, devices for measuring time depended on observing nature. The sundial tells time by measuring the position of the sun, the astrolabe by heavenly bodies, and even the water clock can hardly be called

independent from nature, since it has to be reset every morning with a sundial, and the fact that all of these devices really act as a way of measuring nature, promotes the idea of time as part of the natural world.<sup>16</sup> In this philosophy there is no difference between the natural cycles and time, and timekeeping devices do not really determine the hours, they just tell you where in the fluid cycles of nature you are. This fundamental idea of time as part of nature and therefore God's creation is the basis for the monastic hours and their non-rigidity.

The escapement itself was actually invented completely independently from the realm of mechanical clocks, which may be the reason why it was so different from previous timekeeping methods. The initial 12th century search for more refined clocks, mostly led by astronomers looking for more accurate instruments to observe the planets, was looking for an entirely different sort of device: a sort of disk that would rotate along with the earth.<sup>17</sup> This is yet another piece of evidence for the belief in time as linked to nature since even scientific researchers were seeking to model time on nature, and even after the escapement began to be widely used for the mechanical clock, most early clocks were really astronomical models with a timekeeping device added on to them. The escapement, however was invented entirely independently from the astronomer's line of inquiry, some time in the early 1200s, in a Benedictine monastery, although there is debate as to the actual date and place. There is also debate about what the original purpose of the escapement was, but the unifying characteristic of most theories was that it was not at all intended to be a machine to change timekeeping, and it was not until a while after the invention of the escapement that people realized that this was the device for creating the regular circular motion that they had been looking for all along, but once they did, the escapement revolutionized the world of timekeeping.

The escapement is a rather counterintuitive solution to the problem of creating regular circular motion, since it relies on the downward force of gravity, and oscillation rather than rotation. An escapement is the term for any machine that breaks

circular motion up into regular ticks, and there are a number of types, which mostly differ based on their power source, from the weight-driven verge and foliot, to the spring-powered escapement (developed much later, and useful in powering small, portable clocks and watches).<sup>19</sup> The former is the type used in the earliest mechanical clocks, and it takes the form of a toothed wheel, or “crown wheel,” the foliot, a weighed bar suspended so it can turn, and the verge, a stick that connected to the foliot and a few paddles which rested on the teeth of the wheel. As the wheel turns, the teeth catch on the paddles, turning the verge and foliot in little “ticks” of motion that become the “ticks” of a clock.<sup>20</sup> The escapement can keep very regular time, and with the development of the mechanical clock, the escapement was further refined. Even though early mechanical clocks were still unreliable by our current standards (it was considered an achievement if a clock did not lose a few minutes every day), they were much more precise than any device for keeping time that the medieval world had seen before.<sup>21</sup>

The mechanical clock did more than just change the mechanism that people used to measure time; it changed the system of time measurement. Because of the mechanical clock’s regular motion, it was ill-suited to measuring hours of unequal length, and so it needed a system of equal hours.<sup>22</sup> Originally, private clocks were used to divide up the day at the convenience of whoever owned them with no real convention; for instance, kings commissioning clocks that rang a number of hours based on tasks that they planned to do.<sup>23</sup> However, with the rise of public clocks in the late 1300s came the need for a universal standard of time measurement, and so the system of the 24-hour-day originated in Italy with some of the first town clocks, and eventually became the model for all town clocks in Western Europe. The 24 hours divided into 60 minutes (and eventually 60 seconds) goes back to time measuring systems that were in place before the canonical hours, such as those used by the ancient Greeks or Persians,<sup>24</sup> although they still used unequal hours tied to natural cycles. The numbers 24 and 60 were probably chosen for their divisibility and ability to be split up evenly a number of ways.<sup>25</sup> So, with the proliferation of the public clock came a switch from the canonical hours to what

is known as the “equinoctial hours” or “modern hour reckoning,” i.e., measuring time in hours of equal length.

The switch to modern hour reckoning was not just a technicality of the way people measured time, because of the importance of the ringing of the hours in medieval towns. As mentioned before, when monasteries signaled the hours, they were used by the townspeople for determining times of prayer, but also for the other aspects of daily life.<sup>26</sup> But in the 1300s, people began recording times in “o’clock,” rather than canonical hours, not only in business documents,<sup>27</sup> but also for recording times of birth and death,<sup>28</sup> and the hours of work for certain trades also switched to the equinoctial hours. As the ringing of the canonical hours by monasteries was replaced by the ringing of the equinoctial hours by public clocks, the timing of secular life began to switch from the canonical hours to the equinoctial hours.<sup>29</sup> Eventually, although not until much later, even the hours of prayer became tied to certain secular hours.<sup>30</sup>

In addition to public clocks making modern hour reckoning more readily available to the public, the switch to modern hour-reckoning was also driven by the merchant class, because it was so well suited to the world of business.<sup>31</sup> We can see that there was an obvious benefit to merchants because they were the first behind the push for public clocks, and often made large contributions for their installation.<sup>32</sup> As cities like Venice and Genoa got more and more involved in trade, the lives of businessmen seemed to become more and more scheduled and ordered.<sup>33</sup> And so, although the canonical hours were acceptable, an arbitrary, rational system for timekeeping appealed to them,<sup>34</sup> since it was not only more geared towards the scheduling of secular life and a larger variety of activities, but also allowed merchants to be independent from the church. For example, guilds were able to schedule regular hours of work that they controlled.<sup>35</sup> It is no coincidence that the first public clocks were all in Italy, which was famous for its trade and rich merchants.<sup>36</sup> In some ways, the switch from canonical hours to equinoctial hours represented the power of the merchant class in the 14th and 15th century, since

their movement for a new system of hour reckoning was behind the change in the way all Europe measured time.

The fact that modern hour reckoning took time out of the sphere of the church and into the hands of the merchant class may account for part of why the church was opposed to the clock and to modern hour reckoning, but the full scope of their objections is even more complex, and to understand them we must investigate the way that the mechanical clock not only changed the way that people measured time, but the way that they thought about it. The switch to the mechanical clock and modern hour reckoning led to an entirely new metaphysical idea about time: time as abstract and rational, completely separate from nature. Unlike previous devices for measuring hours, like the sundial and the astrolabe, which observed nature, the clock actually defines time itself as completely separate from nature.<sup>37</sup> By removing time from nature and its cycles, the clock started to use divisions of time that were rational and arbitrary, since they were based solely on the length, not natural events or the activities of *ora et labora*.<sup>38</sup> Time became something that you used to measure events and activities rather than being defined as a sequence of them, and the natural order became yet another sequence of events that fit into time and could be measured by the abstract divisions of the clock.

The idea of time as abstract also led to a greater sense of the scarcity of time, since it made people start to think of their allotted time, and of using all their time well. This development is evident from the number of clocks that were marked with *memento mori*, or reminders of the shortness of life.<sup>39</sup> Phrases like “wasting time,” “time is short,” and “time is money” sprung from this idea that time is a valuable resource that belongs to people, and people began to schedule their days a lot more, as we can see from the planners of merchants, who began to schedule their time down to the hour rather than the day.<sup>40</sup> This scheduling brought with it a greater anxiety about the passage of time. For example Madame Louvigny, a noblewoman in Paris, refused to stay in a house with a clock that rang the hours because she felt that it “cut her life into too many little pieces.”<sup>41</sup> All of this came from the idea that

time is a resource that belongs to people and needed to be put to good use, an idea which came into conflict with the church's beliefs about time as God's possession and a part of nature.

From the Church's point of view, the idea of abstract time was dangerous because it challenged the idea of time as belonging to God. Recalling St. Augustine's argument about God's creation of time and nature, you can see how, to the medieval church, the idea of time as separate from nature was threatening to the idea of time as God's creation. The mechanical clock and the equinoctial hours were seen as an attack on the idea of God's power over time, because they suggested that a man-made mechanical device should be the absolute standard for measuring time, rather than the heavens, which God himself had placed there, and thus that an abstract division of hours decided on by humans was more important than God's creation.<sup>42</sup> The idea of time as a resource, especially one that can be bought and sold, was very disturbing to the church as well. A common argument against usury in an anonymous 12th century document says that usurers "sell nothing... time, they sell the day and night... they are selling eternal light and rest,"—the implication being that selling time is like selling a part of the natural order, and as God's creation it cannot be owned, bought, or sold by anyone.<sup>43</sup> But now, time was thought of as a resource belonging to people, that was theirs to use, or to sell if they so wished, an affront to the idea of time as God's possession and not any mortal's. In these ways, modern hour reckoning was not only a threat to the church because it took away their power over time through the ringing of the hours, but it also threatened to take power over time away from God.

Because it was a challenge to the church, the proliferation of public clocks and modern hour reckoning became a major part in the ongoing struggle between the papacy and the kings of Europe, and royal support is part of the reason the public clocks became so widespread. While, as previously mentioned, the merchant class often provided funding and campaigned for public clocks, many town clocks were officially commissioned by a royal charter. Not only did kings support the building of clocks, but they also gave



towns the official right to ring the hours. In a famous edict, King Charles V of France banned the church from ringing their bells at times when they would interfere with the public clock, which rang in time with the king's private clocks.<sup>44</sup> Some historians pass this off as Charles V simply trying to avoid confusion about the bell signals, but still, the fact that he chose the public clock over the church shows that the French royalty was trying to take control over timekeeping from the church.<sup>45</sup> By encouraging the building of public clocks, kings could not only forge an alliance with the rich and powerful merchant class, but could also exert power over the church by placing timekeeping in the sphere of royal powers. This explains the expansion of public clocks by royal charters in the 14th century when, in France especially, kings were trying to break away from the weak and corrupt papacy.

With the push for public clocks, led by merchants looking for a more rational system of time, and by kings looking to get a political advantage against the Church, the canonical hours eventually gave way to the equinoctial ones, and eventually the idea of time as God's creation and part of nature had to give way to rational and abstract timekeeping as a function of business and the government. For all that they fought against it, the Church of Rome eventually conceded on the question of modern hour reckoning, and even the canonical hours eventually became tied to the equivalent equinoctial hours.<sup>46</sup> On the other hand, the Greek Orthodox Church held their position on the mechanical clock, and until a few centuries ago would not allow mechanical clocks in their churches.<sup>47</sup> The reason for this difference between the East and the West, and the concession of the papacy is sometimes thought to be that the Church of Rome was on the whole more accepting towards new technology than other churches,<sup>48</sup> or it may have simply been that the clock was too convenient, and became too widely used in the West to fight against.<sup>49</sup> It is likely also related to the weakness of the Avignon papacy, and the papacy in general in the 14th century, when most of the adoption of mechanical clocks was taking place, and they simply did not have the political power (especially in relation to the French monarchy) to continue

to fight it. Maybe in a world where the papacy had not been in the middle of such political troubles, or where the clock had not spread so quickly, the Church of Rome would have refused the clock for longer too, since it is evident from the Greek Orthodox Church's reaction how serious a theological issue the mechanical clock created for the nature of time.

