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Ecclesiastical Timekeeping with Special Reference to the Mogiła Monastery*

Introduction: The Importance of Timekeeping

The Benedictines are usually credited with formulating standard rules of timekeeping within religious houses. The order, associated with Saint Benedict of Nursia, was based on the Rules of Saint Benedict (*Regula Benedicti*) which became a base for many religious orders. Although probably not written as one document the rules clearly lay down the times of day, for not only religious services, but also other duties within a monastic order. Although not the first set or rules used in Monastic Houses it gradually became common usage by the 9th century probably with some adaption to the circumstances of each Monastic house. Although there has been much discussion about the interpretation of the surviving text originally written in *lingua vulgaris*.[1] The widespread adoption of the rules was probably the result of Charlemagne who

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1 A sufficiently good manual edition was published by Dom Edmund Schmidt of Metten, at Ratisbon in 1892, presenting in substance the text of St. Gall manuscript, with the Low Latin element eliminated. The number of commentators on the rule is enormous. Calmet gives a list of over a hundred and thirty such writers, and Ziegelbauer gives a similar list.

had the rules copied and distributed throughout western Europe for religious houses to follow as a standard.

Chapters XV and XVI are occupied with the regulation of the Divine Office, and the Canonical Hours, seven of the day and one of the night[2] and the variations required according to the time of the Christian year, e.g.,

Chapter XV: At What Times "Alleluia" is to Be Said

18th February–19th June–19th October
From holy Easter until Pentecost without interruption
let "Alleluia" be said
both in the Psalms and in the responsories.
From Pentecost to the beginning of Lent
let it be said every night
with the last six Psalms of the Night Office only.
On every Sunday, however, outside of Lent,
the canticles, the Morning Office, Prime, Terce, Sext and None
shall be said with "Alleluia,"
but Vespers with antiphons.
The responses are never to be said with "Alleluia"
except from Easter to Pentecost.

Chapter XVI: How the Work of God is to Be Performed During the Day

19th February–20th June–20th October
"Seven times in the day," says the Prophet,
"I have rendered praise to You" (Ps. 118[119]:164).
Now that sacred number of seven will be fulfilled by us
if we perform the Offices of our service
at the time of the Morning Office,
of Prime, of Terce, of Sext, of None,
of Vespers and of Compline,
since it was of these day Hours that he said,
"Seven times in the day I have rendered praise to You" (Ps. 118[119]:164).

[2] The Rule of Saint Benedict, Analysis of the Rule Chapters 9–19.

For as to the Night Office the same Prophet says,
"In the middle of the night I arose to glorify You" (Ps. 118[119]:62).
Let us therefore bring our tribute of praise to our Creator
"for the judgments of His justice"
at these times: he Morning Office, Prime, Terce, Sext, None,
Vespers and Compline;
and in the night let us arise to glorify Him (Ps. 118[119]:164,62).[3]

It is clear that in order to satisfy these requirements strict attention to forms of timekeeping were required.

It is known that sundials and water clocks, often of the type called *clepsydra* (from the Greek for 'water thief'), were in use in pre Christian times. Examples of sundials include the vertical sundial of Rameses III (1279–1213 BCE)[4] and the Roman sundials in Side Turkey. No early examples of water clocks exist but there are numerous references in the literature.[5]

Candle Clocks

Candle clocks were probably also in use from early times. The is the story of Alfred the Great of England who experimented with candle clocks, either with graduations marked on the side of a candle, or used candles of different sizes to compare rates of burning. In some later candle clocks, pins were stuck in the side which fell out onto a metal tray as the candle burned down. This created a sound acting like an

[3] Sections are from *Saint Benedict's Rule for Monasteries*, trans. by L.J. Doyle, Collegeville 1948. Adapted for use from the first edition that was republished in 2001 to mark the 75th anniversary of Liturgical Press.

[4] The dial found in 2013 was reconstructed by Larisa N. Vodolazhskaya of the Department of Space Physics, Southern Federal University (SFU), Rostov-on-Don, Russian Federation. See: https://arxiv.org/ftp/arxiv/papers/1408/1408.0987.pdf.

[5] For example the Egyptian clepsydra found at Karnak. See G. Dohrn-van Rossum, *History of the Hour. Clocks and Modern Temporal Orders*, Chicago–London 1996, p. 43. Also see M.J. Czajkowski, T. Węcławowicz, *Chronotopos monasticus. The Medieval Clock and the Rhythm of Monastic Life at the Mogiła Abbey near Krakow / Średniowieczny zegar i rytm życia monastycznego w klasztorze w Mogile koło Krakowa*, Kraków 2016, for general discussion.

alarm clock. The burning down of a candle was also used in auctions in England in the 17th and 18th century. The last bid just before the flame went out was accepted one.[6] The earliest reference known is from China from 520 AD[7] but it is likely that they were universally known and simple method for recording the passage of time during the hours of darkness. In 1209 Al-Jazari described a sophisticated candle clock where the candle is constantly pushed upwards with a device to ensure steady burning.[8]

Sundials in Britain

In Europe it is the Mass dial, sometimes called the Scratch or Tid (Tyde) sundial, which is associated with ecclesiastical buildings. Over 1 500 have been recorded in mainland Europe and over 3 000 have been recorded in Britain, usually near the south door of parish churches, though many have been moved when the blocks on which they are inscribed have been used in subsequent building work.[9] Their greater survival in Britain is probably due to the British Reformation when

6 In the diary of Samuel Pepys, written from 1660–1669, Pepys records two occasions when the Admiralty (his employer) sold surplus ships "by an inch of candle" (in November 1660 and September 1662). Pepys also relates a hint from a highly successful bidder, who had observed that, just before expiring, a candle-wick always flares up slightly: on seeing this, he would shout his final – and winning – bid. Various editions of Pepys Diary exist. Pepys worked for the British Admiralty and covered events and also personal happenings.

7 A candle clock is referred to in a poem written by the Chinese thinker You Jiangu in 520 AD.

8 See D. Routledge Hill, *Mechanical Engineering in the Medieval Near East*, „Scientific American", May 1991, pp. 64–69 in which he describes Al-Jazari's candle clock: "The candle, whose rate of burning was known, bore against the underside of the cap, and its wick passed through the hole. Wax collected in the indentation and could be removed periodically so that it did not interfere with steady burning. The bottom of the candle rested in a shallow dish that had a ring on its side connected through pulleys to a counterweight. As the candle burned away, the weight pushed it upward at a constant speed. The automata were operated from the dish at the bottom of the candle. No other candle clocks of this sophistication are known".

9 P. Rumley, *Medieval Mass Dials Decoded*, see: http://www.buildingconservation.com/articles/mass-dials/mass-dials.htm.

King Henry VIII's reforms and destruction of the monasteries halted church architectural development. The dials are cut into a wall and have a central hole in which a horizontal peg was inserted to act as a temporary gnomon. The hole is usually less than 1.8 m from the ground, the higher ones having cemented in iron pegs. Grooves then radiate away from the hole indicate the "hour." There would be five major divisions relating to the Canonical hours of *Prime*, *Terce*, *Sext*, *Nones*, and *Vespers*, and sometimes minor grooves for the twelve daylight hours (fig. 1). However, some dials only have a few lines to indicate midday (*Sext*), *Terce* and *Nones*. We can assume the reason for this was either obstructions preventing the shadow from being cast or that *Prime* and *Vespers* were self explanatory.

The oldest Tyde dial known, is in Britain on the Anglo-Saxon church of on St Andrews's church, Bishopstone, East Sussex, which contains the name 'Eadric', a 7th century king of Kent. An interesting example is the remains of the Brewcastle Cross, in Cumbria, a pedestal of an early 8th century cross, carved with Anglo-Saxon runes, Christian figures, and interlaced animals and foliage. The dial is a half moon mass dial (fig. 2). a later example from Kirkdale, North Yorkshire, can be exactly dated between 1055–1065AD, due to an inscription on both sides which confines the dates:

+ ORM GAMAL / SVNA BOHTE SCS / GREGORIVS MIN / STER ÐONNE HI / T ÞFS ÆL TOBRO // CAN 7 TOFALAN 7 HE / HIT LET MACAN NEÞAN FROM / GRVNDE XPE 7 SCS GREGORI / VS IN EADÞARD DAGVM CNG / 7 [I]N TOSTI DAGVM EORL +;

"Orm son of Gamal bought St Gregory's Minster when it was all ruined and collapsed and he caused it to be made new from the ground for Christ and St Gregory in the days of Edward the king and in the days of Tosti the eorl";

and the name of the maker (fig. 3).

Sundials in Poland

In contrast the mass dials recorded in Lesser Poland are fewer in number. This is probably due to continual church alteration and reconstruction after various destructions during catechistic events.

The church in Stróżyska, Świętokrzyskie Voi., contains two dials on a south facing buttress east of the tower (fig. 4). The church was rebuilt in 1378 and the tower in the beginning of 14th century. It is not known if the dials are from the earlier church but 1378 seems a late date for these rather crude dials. Since there are two dials we might speculate that one was from the earlier church, then reset but found to be inaccurate requiring a second dial. However, a series of at least 12 dials are found on the tower of St Peter's church, Hanwell, Oxfordshire, England for no apparent reason, so this may be other unknown causes.

The dial on the side of the church at Wiślica, Świętokrzyskie Voi., is on a buttress on the south side of the chancel near the east end (fig. 5). The church is 14th century and the style of the dial with its roman numerals, corresponding to holes on the dial, suggests it is later than the Stróżyska dials or has been altered and the numerals added to reflect the numbering used on mechanical clocks in the 15th century.

Possible Clock Movements at Mogiła

The earliest know surviving clock dial in use is the astronomical clock on the Torre dell'Orologio, Palazzo del Capitanio, Padua, Italy originally constructed in 1344, but was reconstructed to its original design in 1428 after the destruction of Milanese forces in 1390.

The clock dial in the cloister of the Mogiła Monastery, Kraków (fig. 6) was built into the wall during its construction and dates from about 1280 AD.[10] It was restored by *Renowacja*, Aleksandra and Eugeniusz Grochal, supervised by Prof. Władysław Zalewski, *Akademia Sztuk Pięknych im. Jana Matejki w Krakowie*, in 2008. Although not immediately recognised as a clock dial by the conservators its proper function was recognised by Prof. Tomasz Węcławowicz.[11] The author recognized at least two sets of numbering on the dial chapter ring (fig. 7).

This suggested that the earliest dial, (c. 1280–1300 AD) had the number 'I' at the bottom (assuming the hand moved in a clockwise direction) and apart from rings delineating the chapter ring, the dial

[10] M.J. Czajkowski, T. Węcławowicz, *Chronotopos monasticus*, p. 32 and associated text.

[11] Ibidem, p. 31.

was probably plain in line with the requirements of the Cistercian order (fig. 8).

The original dial must have been used with some kind of water clock possibly a *clepsydra*. This is because there is no record of a clock work using an iron mechanical escapement before 1300 AD and the first rather vague reference known is from 1308–1309.[12] This being the case, the water clock must have been large to have the power to drive the hand and lunar work. Water clocks in monasteries are not unknown and were probably relatively common, though expensive compared to candle clocks. There is a record of a fire in the Abbey of Bury St Edmonds, England which was extinguished with the help of water from the clock suggesting a reasonably large water container used for that clock.[13]

Although no water clocks survive from Medieval times the illustration of a *clepsydra* on a 13th century manuscript in the *Arxiv de la Corona*, Barcelona, Spain (fig. 9), allows a reconstruction of a possible *clepsydra* used at Mogiła. a disc with a series of holes around the edge which revolves as the water is released from the cistern via a hole in the bottom. a peg can be inserted into any of the holes which will then, at the allotted time, trip a previously wound up weight driven alarm system (fig. 10).

The bell would not need to be large, the sound just sufficient to wake the custodian so he could ring a larger bell with the appropriate number of strikes for the Canonical hour in question.

The general notation for striking the Canonical hours by the 13th century was:

Prime = 3 strikes	Nones = 2 strikes
Terce = 2 strikes	Vespers = 3 strikes
Sext = 1 strike	Compline = 4 strike

It is possible that another form of water clock was used at Mogiła. There is an illustration from a French 13th century Bible showing a water clock in connection with the legend of King Hezekiah (fig. 11). The

[12] Ibidem, p. 39.

[13] Ibidem, p. 42. The *Chronica Jocelini de Brakelonda* records a fire partly extinguished by water from the *clepsydra*.

illustration appears to show a water wheel type clock, although there is no general agreement as to how it worked.

At sometime, probably in the 14th century the numbering on the dial was changed (fig. 12).[14] The framing of the numbers seem to coincide with the style seen on 14th century Italian clocks showing a 24 hour dial with 'I' at the modern 9 o'clock position similar to the Padua astronomical clock, constructed in 1344 AD mentioned above (fig. 13). This probably indicates when an iron clock movement with an iron escapement was installed at Mogiła, the water clock now worn out and increasingly difficult to maintain. It is clear from the rapid appearance of tower clocks after 1350 that the technology of iron escapement used in iron mechanical clocks became rapidly known and its reliability appreciated. It is also know that Mogiła had strong connections with Italy.

Enhancement of dial details in areas left by the conservators also show that there was decoration within the dial area. It is impossible to make out the details of the decoration though there may be more than one decorative scheme here, and it is uncertain whether the first was contemporary with the dial repainting or whether it might be the work of Father Samostrzelnik (c. 1480–1541) who painted the crucifixion scene on the north wall of the cloister (fig. 14) and much other decoration. We might speculate that if contemporary with the second dial it might include some representation of an earthly paradise involving foliage as depicted in late Romanesque carvings[15] to complement a starry background that might have been present with the lunar dial to complement a starry background often associated with the lunar dial (fig. 15).

A clepsydra type water clock would have to be reset and filled each day. Under the early medieval timekeeping system, based on ideas instigated by Julius Caesar in 46 BC, the day would have started at dusk.[16] This tradition is still being maintained on Christmas Eve in

[14] Ibidem, pp. 14–17 and figs. 5–9 and 11, for a full discussion on the Mogiła dial description.

[15] See R. Wood, *Paradise*, York 2017 for a detailed discussion of Romanesque carvings and their interpretation. It is likely that Romanesque painted decoration had a similar function.

[16] The *hora italica* of twenty-four hours, starting at sunset, was originally proposed by Julius Caesar since it was observed that when a seed was planted it spent some time in the ground before sprouting. Consequently night should proceed day when marking the start of the day. Since clock dials were often placed on

Poland and is illustrated as "Ancient Czech Time" on the astronomical clock in the town square in Prague, Czech Republic. Consequently the dial at Mogiła using a *clepsydra* would not need to be calibrated beyond resetting the pointer to the end of the 24th hour as dusk, and the pegs in the wheel behind the dial repositioned so that the alarm would be set off at the hours of church services. It is not known if small tide dials were also used at Mogiła though their occurrence elsewhere in Lesser Poland, as discussed above, suggests it was likely.

The change to a more reliable mechanical clock with an iron escapement that would show continual timekeeping would have required some form of regulation to maintain *hora Italica*. It is likely the clock would be reset at dusk despite the fact that the equal hours recorded would not equate with solar time. The alarm system would have been activated in the same way as for a *clepsydra*. This may be explained by the remains of a large sundial found engraved on the south wall of the nave of the church when it was rebuilt in brick in about 1350. The dial, seen on the drawing in Ewa Łużyniecka's book of 2002[17] (fig. 15) is now behind a later wall built to construct a room over the north Cloister. The dial is interrupted by the remains of flying buttresses, which are clearly later than the sundial but were mentioned by Jan Długosz in his Chronicles written between 1455–1480. Długosz assumed that the flying buttresses were original to the construction but clearly their construction would impede the workings of the sundial and it is suggested by Węcławowicz that these buttresses may be a response by the monks of Mogiła to buttresses built at Wawel Cathedral after a crack appeared in the south wall on the Cathedral's nave in about 1400 AD.

a south facing wall and the clock hand followed the path of the sun at a time when the Earth was considered geocentric in the Solar System, the dial would show the start of the day when the Sun would move below an east–west horizon. It is clear that many cultures within the Roman world used different times of the day as a starting point and although Julius Caesar instigated his system with reference to Rome the idea was gradually adopted throughout most of the Roman Empire. There was often much confusion between church time for prayers and secular time used in courts and markets. For a full discussion see G. Dohrn-Van Rossum, *History of the Hour*, ch. 2–3.

[17] E. Łużyniecka, *Architektura klasztorów cysterskich, filie lubiąskie i inne cenobia śląskie*, Wrocław 2002.

The position of the sundial in relationship to the clock (fig. 16) would mean that it would be very easy to use the dial to adjust a continually rotating clock hand that would be associated with an iron mechanical movement with an iron escapement.

However, a mechanical clock with an iron escapement is considerably more accurate than a clepsydra. Consequently, its regulation requires an understanding of the seasons and variations between clock time and Solar time. This is due to the orbit of the Earth being eccentric around the Sun and the tilt of the Earth's axis producing seasons (fig. 17). The monks at Mogiła might have had some understanding of Ptolemaic astronomy for a geocentric Solar System, but by 1350 sufficient observations had been made for tables to be published showing equations of time allowing for accurate adjustments between sundials and mechanical clocks throughout the year.

The removal of the clock mechanism in the late 17th or 18th century, when the Chapter House was rebuilt suggests that either the clockwork was worn out, or other more reliable clocks were available. The dial was plastered over and the cloisters redecorated and the purpose of the chapter ring forgotten.

Possible purpose of the Clock

The unique survival of the clock dial at Mogiła allows speculation for its purpose beyond that of an alarm system. The occurrence of the stone framed hole that might have contained a lunar dial may relate to the determination of the dates of Easter. However, although the date of Easter is calculated according to the lunar cycle and the Jewish calendar,[18] it is a complicated procedure and it was more usual for tables to be calculated in Rome and then an almanac sent to the various monasteries to ensure synchronization.[19] The dial could have been an important

[18] The Computus system of calculation depends on the actual date and time of the Full Moon. This can vary according to the position of the observer on the Earth aiding confusion. Consequently the use of an almanac was simpler and guaranteed the festival being held on the same day.

[19] M.J. Czajkowski, T. Węcłowowicz, *Chronotopos monasticus*, Appendix pp. 67–70 for simplified version.

educational tool. The early church had an interest in astronomy and such a device could be used to illustrate the wonders of the heavens and God's creation. Moreover, it is known that cloisters in western monasteries were often used as a place for the instruction of novices and in richer monastic institutions in western Europe it is suggested that figures carved on colonnades show biblical stories to enable such instruction.[20] In which case the clock might have been a teaching aide to show the wonders of God's universe as well as some indication as to when Easter would be observed. The position of the dial in the cloisters rather than within the Abbey church where many important clocks are displayed, e.g., St Mary's church, Gdańsk, may reflect this.

Conclusion

It is clear that the clock dial in the cloister at Mogiła is an important discovery for understanding Monastic timekeeping. However, its understanding needs to be put in context with other forms of timekeeping then available. Although candle clocks must have been used, sundials are a more permanent example recording the required times of prayer according to Monastic convention. Examples of mass dials showing the Canonical hours are common throughout Europe and their development in the 14th century, as an aid to time regulation, can be demonstrated in conjunction with development of mechanical clocks with iron escapements. This is the case at the Mogiła Monastery where the change from a water clock originally used with this large dial to an iron mechanical clock prompted the installation of a large sundial to aid time regulation. The sundial was probably only in service for 80 years or so until building work obstructed its performance. The iron mechanical clock used with the large dial was removed at the time when the Chapter House was altered in the late 17th or early 18th century, leaving the dial chapter ring and window which housed the lunar dial. It was then plastered over and re-decorated and forgotten.

[20] For example the Capitals of the cloister colonnade in Tarragona Cathedral, Spain, show a varied selection of figures and animals associated with the Old and New Testaments and are considered to have been used as a teaching aids.

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