The Athos clock strike locking system

Part 1: Introduction and description of the locking mechanism

Spiridion Azzopardi*

The author first visited Mount Athos in Greece in the year 2000 with a quest to explore its horological past. Since then, he has engaged in the restoration and conservation of many crown wheel and verge lantern clocks with short pendulums, as well as verge and foliot tower clocks. These projects offered an opportunity to study, document and research these clocks. This paper describes two discoveries and their significance. The first is an unknown and novel clock strike locking mechanism that was discovered on verge and foliot tower clocks at five monasteries. The other was that comparisons drawn between these five

Introduction

In northern Greece lies the Chalkidhiki peninsula, sometimes referred to as Poseidon's fork as three fingers extend southwards from the mainland. The eastern finger is the Mount Athos peninsula, on which twenty Orthodox monasteries are sited, mainly around its coast (Fig. 1). Mount Athos is a monastic state that is self-governing by a council that represents each of the twenty monasteries: seventeen Greek Orthodox, one Serbian, one Bulgarian and one Russian. The majority were founded in around the tenth century, whilst the youngest date to about the fourteenth century.

There are other secondary monasteries called Sketes that are dependent and supported by the main ruling monasteries but exist as separate entities.

Mount Athos is deemed a holy place due to its association with the Virgin Mary, who took refuge on the peninsula from a storm at sea whilst on her way to visit Lazarus in Cyprus with John the Evangelist. The peninsula has since been known as the garden of the Virgin Mary.

In honour of the Virgin Mary, Athos is a male preserve where no women are allowed to reside or even enter. Domestic animals must be male but obviously this rule does not apply to wild animals.

One has to be careful when specifying dates and time on Mount Athos as the Julian calendar is used throughout the Holy Mountain, whilst the civil services use the Gregorian calendar. Therefore, Athos lags by thirteen days behind the rest of the world. Time on Athos can also be confusing as the Byzantine time system is used, in which the twelfth hour must coincide with the setting of the sun by which a new day begins and the hours are counted. So, if the sun sets at 8pm the clocks on Athos are set at 12pm, a four- hour difference. Iviron monastery is the exception, which follows the Chaldean system where a new day begins at sunrise. Every Saturday the time is adjusted to the correct sunrise and sunset time.

The horological history of Mount Athos

Folklore tradition suggests that a tower clock was donated to Vatopedi monastery on Mount

* The author (spiridion.blueleopard@outlook.com) was born on the Greek island of Corfu and arrived in Britain at the age of six with his parents and settled in South Wales. He has studied mechanical engineering and spent most of his working life in research and development in an engineering laboratory environment until his retirement. The acquisition of his first antique clock was the start of a lifelong interest in restoration and conserving period clocks, which in turn fuelled a desire to research their history. As one of the founding members of the Wales and Marches Horological Society, he has held the position of secretary and then chairman. He has researched and restored monastic clocks on the Greek peninsula of Mount Athos for the last two decades, and continues documenting, recording, photographing, and making detailed studies of Athonite horology.

Fig. 1. Map of the Mount Athos peninsula, showing the twenty principal monasteries. with in yellow the five whose tower clocks were found to be fitted with the Athos strike locking system.

Athos by the emperor Ioannis Cantacuzenus in the fourteenth century. A simple small foliot tower clock with a 24-hour count wheel, nags head strike and capstan winding that could possibly be of that period exists at the monastery today; although as with many foliot tower clocks that survived through to the seventeenth century, it has been converted to pendulum.

In 1404 we have the earliest recorded clockmaker of Mount Athos: Monk Lazar the Serb.[1] He lived in the town of Prizren in Serbia where he studied and practised his skills as a clockmaker. Lazar is thought to have come to Mount Athos from the Holy Archangels monastery near Prizren and to have joined the brotherhood of the Serbian monastery Chilandar.

The close ties between Chilandar and the Russian monastery of St. Panteleimon that had strong connections with Moscow, led to Lazar being commissioned in 1404 by the Grand Duke Vasily Dimitryevich to design and build the first striking tower clock for the Kremlin in Moscow as a monument to mark his reign.

Today, Chilandar monastery has the remnants of an early foliot clock that has been converted to pendulum using modern material such as plastics, roller bearings and wooden cross bars attached to the original iron frame. Very little of the original clock remains. There are a few of the arbors with gears and part of the heavy frame that remain from the old tower clock. There may be an association between Lazar and this clock, but I have not found any evidence to support this. However, Lazar's visit to Mount Athos at a time where the popularity of tower clocks in Europe was flourishing, begs the question why a trained and capable clock maker would make such a long journey just to join another monastic order? Or was he a travelling clockmaker, a practice that was common in that period where these skills were rare. Therefore, was the purpose of his visit to Athos to build a tower clock at the monastery of which he became a member? Did he establish a tower clock-making industry by training other monks in this art, who continued to make clocks after Lazar left Mount Athos?

The first makers of iron clocks were established craftsmen who were already skilled in working with iron and producing iron goods. These evolved into specialist iron workers unlike the local blacksmiths who were generally engaged in making or repairing day-to-day utility products but may also have been called upon to repair broken iron clock parts.

There were also those of high-ranking social standing who would have been more engaged in the design and development rather than hands-on involvement and might have employed metal workers or blacksmiths to make these clocks under their direction.

These iron workers had the necessary set of skills for making large iron clocks, they may have evolved from the metal-working disciplines that existed on Mount Athos such as blacksmiths, locksmiths, coppersmiths and silversmiths. Even today evidence of these trades can still be seen in the metal-working workshops of the monasteries where remnants of the old forge and large ancient bellows are preserved.

The work of the iron workers could be considered as crude, since the components used in the construction of these early tower clocks were not finished to any high standard and had a rather rustic appearance, with evidence of hammer blows imprinted on the metal, file marks, chisel indentations and the visible folds embedded in the wrought iron. In addition, the gauge of duplicate parts such as the vertical posts for the frame were generally uneven and accurate symmetry was rare, however there was a certain degree of precision in the layout of gear wheels where concentricity, true centres and parallelism was necessary for the smooth running of the mechanism. In comparison, the art of the clockmaker of early chamber type clocks is perceived as having a higher degree of exactness where some components were filed to obtain flat surfaces and mating parts were made to tighter tolerances, for as clocks evolved and became smaller so did the tolerance in proportion to their size. Smaller parts were easier to finish and less time-consuming in comparison to the large tower clocks

1. Serge A. Zenkovsky (ed.), *The Nikonian Chronicle Vol. 4: From the Years 1382–1424* (Pennington: The Darwin Press, 1988), p. 143.

Fig. 2 An example of a medieval Greek lock that demonstrates the similarities found on the Athos strike locking system, that is, a sliding bolt secured to the backplate by two U brackets riveted on the backplate.

The clock strike locking mechanism

A unique design of a clock strike locking mechanism has been found on verge and foliot tower clocks at five monasteries on Mount Athos (see location on the map Fig.1), This mechanism resembles parts found in medieval mechanical locks such as those used on doors, trunks etc. (Fig. 2). This suggests that this design may have been influenced by someone versed in the art of lock making, a trade that was well-established on Mount Athos and by blacksmiths / locksmiths throughout Europe as locks are universal.

The Athos Z dual detent strike locking mechanism discovered on verge and foliot tower clocks on Mount Athos is a unique system used for controlling multiple strike sequence on tower clocks.

It comprises: a sliding flat iron bar with a detent on either end that is retained by two close fitting U brackets (Figs 8 and 9). Tight tolerance sliding mechanisms are unusual features to find on early large clocks due to the higher degree precision that is necessary for the system to function and may be considered as advanced engineering, a system that was ahead of its time.

The Z duals detent system incorporates a 'warning' arrangement by the addition of a detent on the fly shaft that engages with the warning piece during the lifting period. This allows the strike train to run momentarily to prevent the detent from dropping back into the notch of the count wheel by resting on the rim of a gapped flange (over-lift cam wheel), a bit like a hoop wheel where the hoop has been taken off the wheel. This is not a nag's head system but an alternative method of locking.

Method of operation (see Figs 3–6)

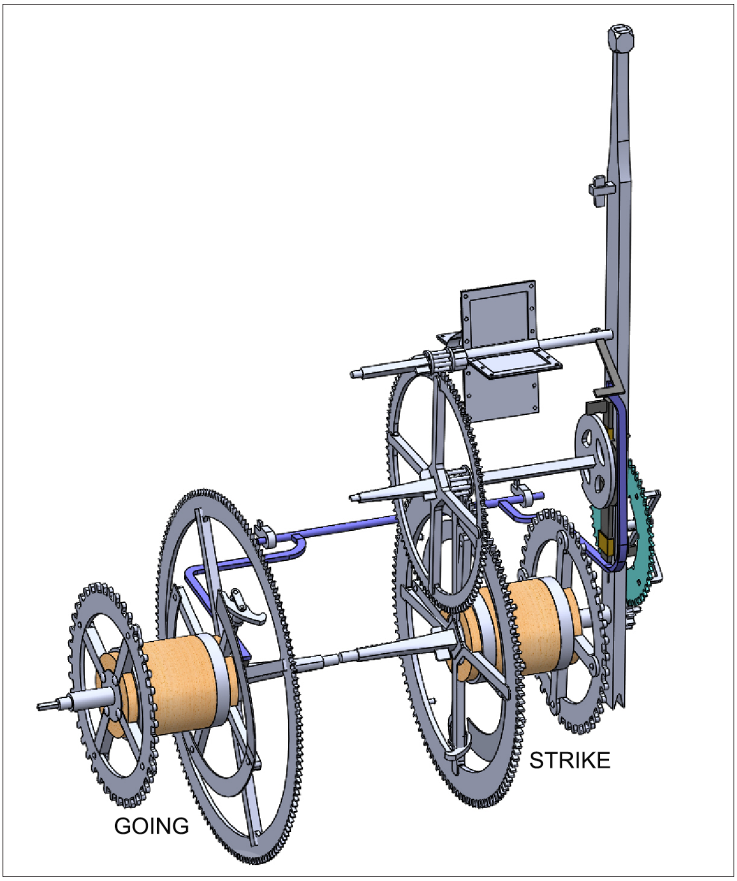
1. The going great wheel, barrel and its shaft rotate once every hour. The shaft that carries the barrel has a locking wedge which secures the great wheel to the shaft (Fig. 7), whilst the barrel is free to rotate in one direction. This wedge also acts as the lifting cam although on other clocks an iron pin on the great wheel is most commonly used to initiate the strike sequence.

2. The wedge or iron peg cam engages with the 'going' lifting lever that transmits the upward motion to the 'strike' lifting lever which engages with the bottom detent of the Z dual detent which is then slowly raised.

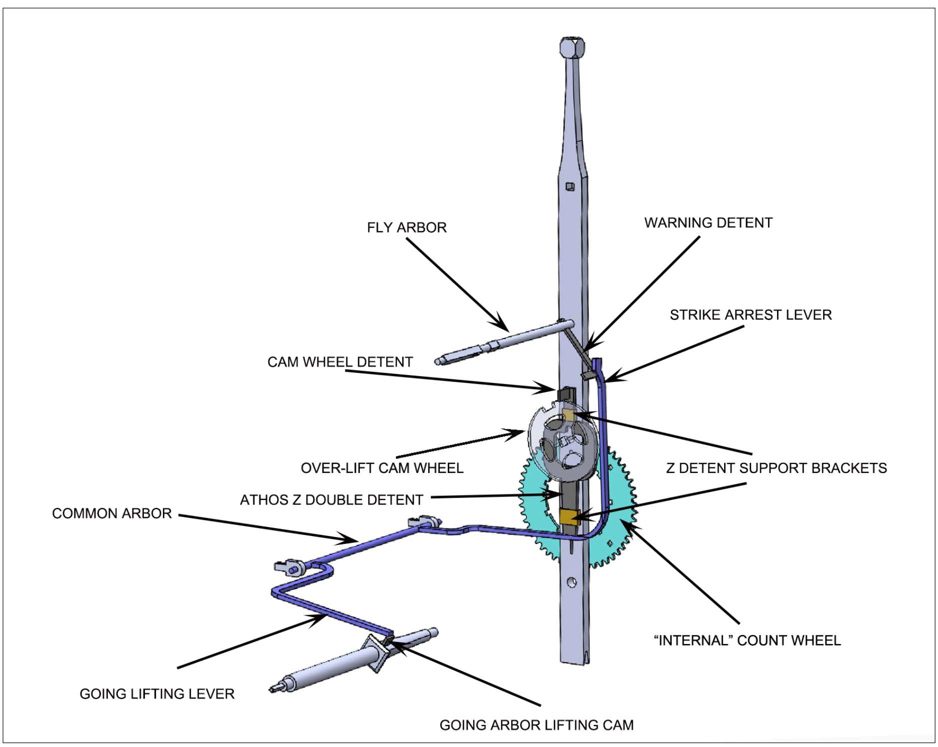
3. The Z dual detent continues to be raised and the lower detent is lifted out of the count wheel slot, whilst the upper detent is simultaneously lifted out of the over-lift cam wheel

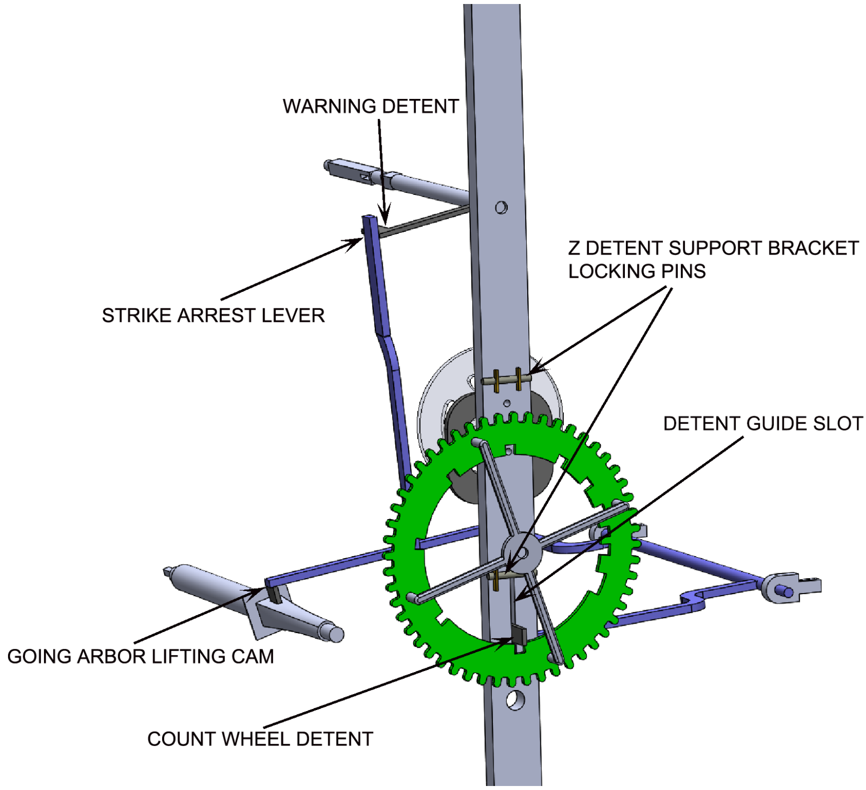
4. or locking cam slot that unlocks the strike which is briefly set free to rotate a fraction of a turn, sufficient for the over-lift cam wheel to advance so that the top detent is no longer over the locking slot and now rests on its rim.

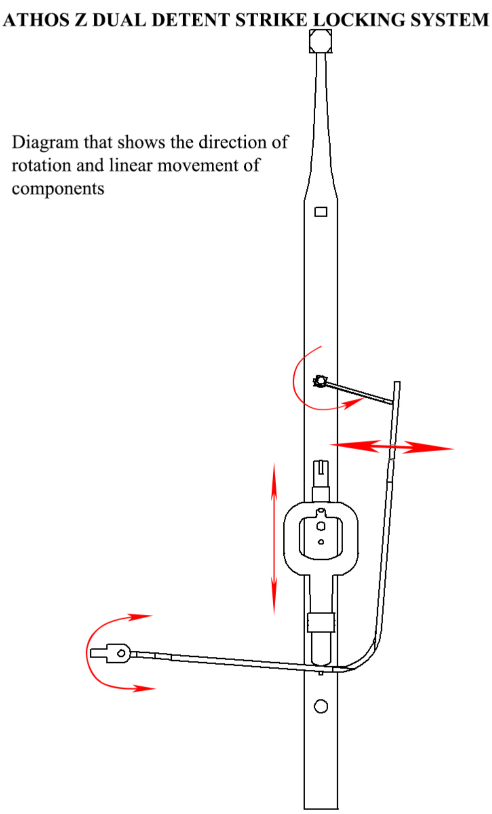
5. The fly detent warning arm is attached to one end of the fly shaft. It engages with the end of the lifting lever which also raises the Z dual detent. It holds the fly and the strike train in check until the 'going' lever falls off the edge of the cam which then releases the fly detent initiating strike sequence.



Figs 3 and 4. The Athos Z dual detent strike locking system of the Pantocrator monastery tower clock.







Figs 5 and 6. The Athos Z dual detent strike locking system of the Pantocrator monastery tower clock.

6. Close observation of the strike system in a clock in Xenophontos monastery revealed that the Z dual detent was carefully designed so that only the lower detent was in contact with the slow rotating inner rim of the internal count wheel, whilst the upper detent was just off the over-lift cam wheel rim that rotates at greater speed. This feature avoids frictional wear of the over-lift cam wheel rim and the braking effect due to friction. This is an ingenious design feature that can be easily overlooked.

7. The strike sequence is ended when the lower detent of the Z dual detent is aligned with the count wheel hour locking slot, and the upper detent drops into the over-lift cam wheel locking slot, that has a small step with a gradient that lowers both detents to their final resting position, to complete the locking sequence.

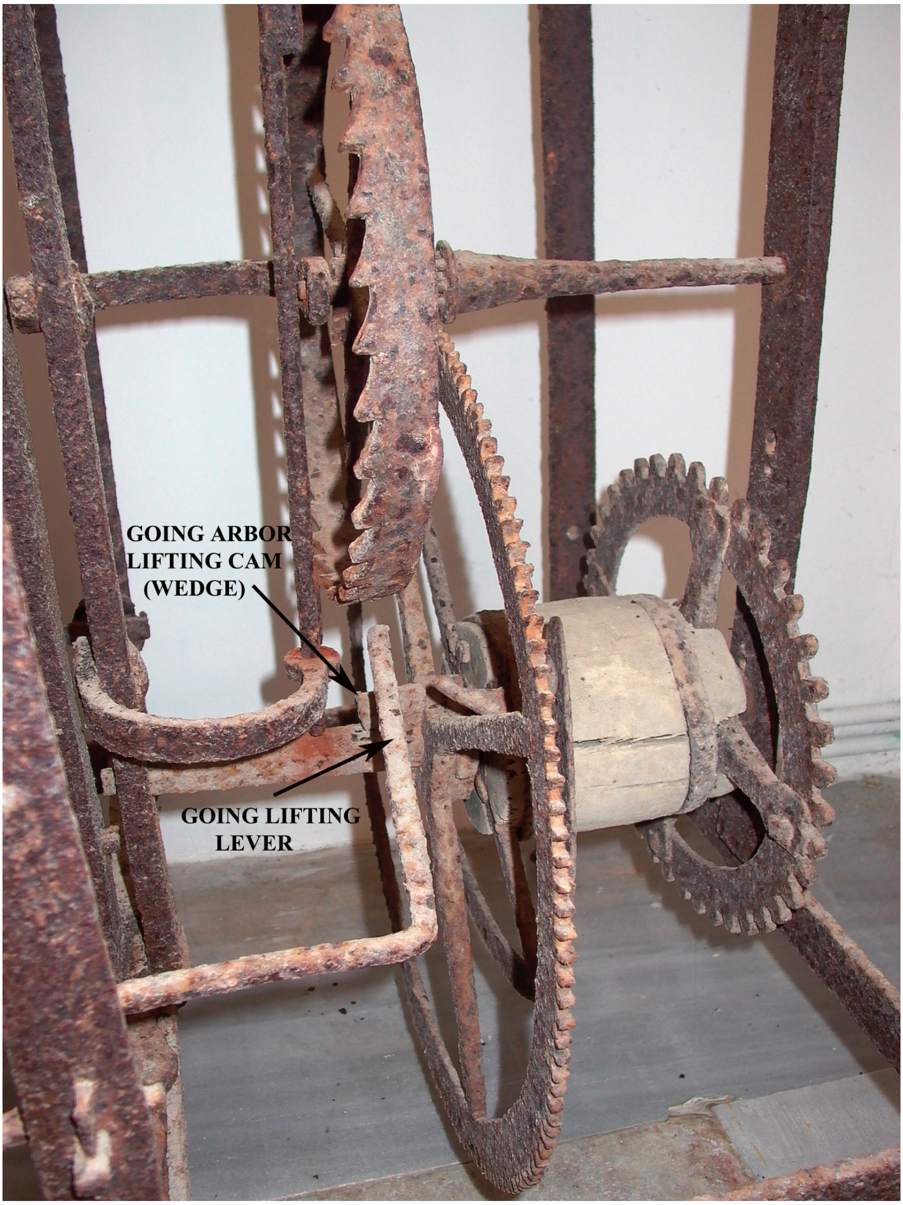


Fig. 7. The Pantocrator monastery tower clock showing the strike cam and lifting lever on the going train. The cam system may be considered somewhat unorthodox as a locking wedge is used to lift the unlocking lever. There was no evidence of the conventional lifting pins on the crossings of the great gear wheel, therefore it appears that this system was the intended design.

The Lavra monastery tower clock had the same wedge cam features as the Pantocrator clock and the absence of lifting pins on the great wheel crossings. However, both the Iviron and the Xenophontos tower clock strike systems used the conventional pin cam method to actuate the lifting lever.

These design variations of the wedge and the pin cams may give an indication of the sequence in design. Lavra being the first and most important of the twenty principal monasteries established on Mount Athos and first in the hierarchy makes it more probable that the clocks with the wedge system preceded those with the pin and the earliest being the clock at Lavra.

Fig. 8. Z bracket.

Fig. 9. Z slider

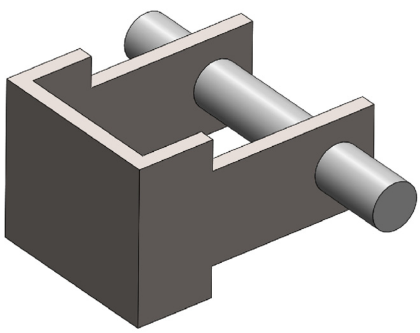


Fig. 10. U bracket

The main component of the Athos strike locking mechanism is the Z sliding dual detent, which has an aperture at its centre that straddles the arbour of the second wheel which carries the over-lift cam wheel (Figs 8 and 9).

The Z detent is attached to the clock frame vertical post by two U-shaped clamps with shoulders which rest on the post face and is secured by a tapered pin that tightens the clamp to the post, whilst allowing free movement of the detent to slide up or down, guided by the two clamps and a cut out slot in the post. (Fig. 10)

The other interacting components of the Athos strike locking system shown in Figs 3, 4 and 5, are:

1. Lifting leavers.
2. Athos Z sliding dual detent.
3. Fly detent.
4. Over-lift cam wheel.
5. Internal count wheel.
6. Going cam.

The count wheel

The count wheel, also known as the locking-plate, was the earliest method of synchronizing the order of striking the hours on a bell. It appeared around the second half of the fourteenth century and the concept remained un-altered for over 600 years. There are two significant variations in its design. (Fig. 11a and Fig. 11b.) The more familiar design has

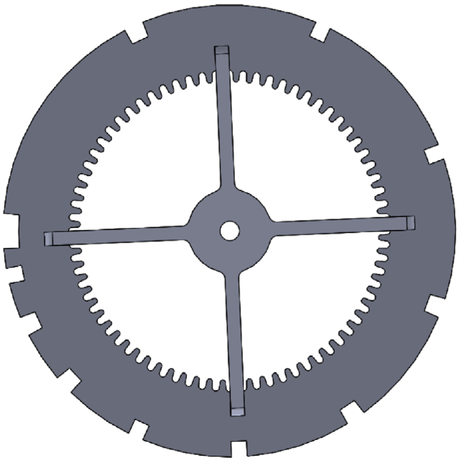


Fig. 11a. External notch count wheel.

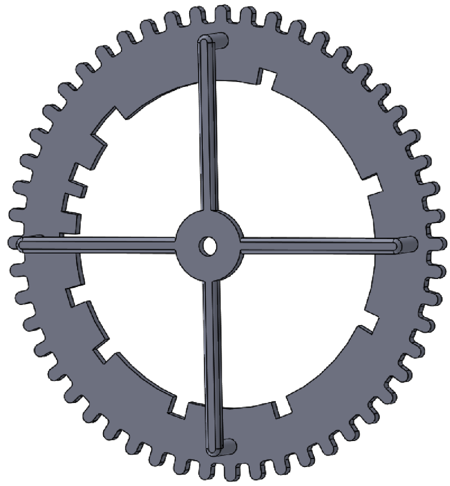


Fig. 11b. Internal notch count wheel.

the hour notches situated on the outer rim of the wheel and the other has the hour notches on the inner rim of the annulus. This design was used on some Italian tower clocks.

The internal notched count wheel Fig. 11b is the design used with the Athos Z sliding dual detent locking system. This count wheel design was also used on early English tower clocks of the two-iron posted frame and wooden frame type3 which use the 'flail-locking system' that comprised of a pivoted arm that carried the locking detent as opposed to the Athos sliding locking system. The internal notch count wheel was also used in other forms of strike including the standard hoop wheel locking system.

The next part of this article will contain a detailed and richly illustrated discussion of the five tower clocks that were found to be fitted with the Athos strike locking system.

ANTIQUARIAN HOROLOGY

AHS | THE STORY OF TIME

NUMBER FOUR VOLUME FORTY-THREE DECEMBER 2022

The Athos clock strike locking system

Part 2: The five tower clocks found to be fitted with the system

Spiridion Azzopardi

[continued from *Antiquarian Horology* September 2022, 336–344]

Pantocrator Monastery tower clock

The monastery of Pantocrator lies on the wind-swept north-eastern side of the Athos peninsula and was founded in the second half of the fourteenth century by Alexios the Stratopedarch[4] and John the Primikerios.[5]

The first time I came across the Athos Z strike locking mechanism was in 2008 during a conservation project of a complete verge and foliot tower clock at the Greek Orthodox monastery of Pantocrator. The clock that was housed in the bell tower was exposed to the elements, as these rooms are generally open to the outside so that the sound of the bells is not constricted. The clock had accumulated 1 to 2 mm of rust over most of its surface. At first, I was apprehensive as to how much of the clock could be saved as I had never seen a clock with so much corrosion. However, I was amazed at the results of a non-intrusive, rust removal process of electrolysis that I used for the first time, which was very effective. This is a safe method, where no caustic chemicals are used and is self-limiting, in that the electrolysis stops when all the rust has been removed irrespective of how long the process is allowed to run. Working in these remote monasteries, equipment and material supplies are scarce so one must manage with what is available and improvise. A large wine vat was emptied, and on the side walls were placed sheets of steel that formed the anode of the electrolysis circuit, Fig. 12. The frame of the clock was placed in the centre, out of contact with the steel sheets. The vat was filled with water and a few handfuls of baking soda (sodium carbonate, Na_2CO_3), borrowed from the monastery bakery, were mixed into the water. I used a 30 ampere car battery charger that I found in the workshop and connected the positive terminal to the steel anode and the negative terminal to the clock frame. This was run overnight at a current input of about 15 to 20 amperes. It is difficult to control the process as it is dependent on many factors, such as the surface area to be cleaned, the amount of soda in the mix, the distance between the anode and the cathode and input voltage.

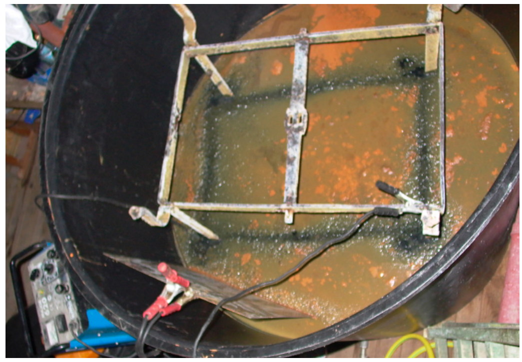


Fig. 12. The frame - electrolysis.

The process converts the red rust to a black iron oxide that can easily be removed with a wire brush after the part is allowed to dry. The clean iron is then treated immediately as it is vulnerable to oxidisation. I use a synthetic micro-crystalline black wax of my own formulation that I have developed specifically for wrought-iron tower clock to treat the iron. It is available under the name Athonite Black Wax (Fig. 13). The wax contains a colour pigment that patinates clean bright iron to an aged appearance.

Dating the clock was difficult as I have not been able to find early records with reference to this or other tower clocks that I have restored of this period. The scarce written documents that exist are of the late eighteenth and early nineteenth centuries.

4. Stratopedarch, Greek στρατοπεδάρχης, was a term used to refer to high-ranking military commanders.

5. Primikerios, Greek πριμικήριος, was a title applied in the Byzantine Empire to the heads of administrative departments.

Fig. 13. Athonite black wax tin.

Fig. 14. Pantocrator clock tower with 24-hour dial and date painted on outside wall of the tower. Photograph: Pantocrator Monastery.

The monastery held an image of the clock dial painted on the outside wall of the clock tower (Fig. 14) that shows a date of 1815, just under the outer circumference of the dial. The Arabic numerals indicated a 24-hour dial, which can be an indicator in dating the clock. If the dial was painted in 1815 as the date suggests it is feasible to speculate that the clock was working at that period. It is not uncommon on Mount Athos to find foliot tower clocks still in use well into the late nineteenth century. Evidence of this will be

Fig. 15. The Athos Z detent system before restoration.

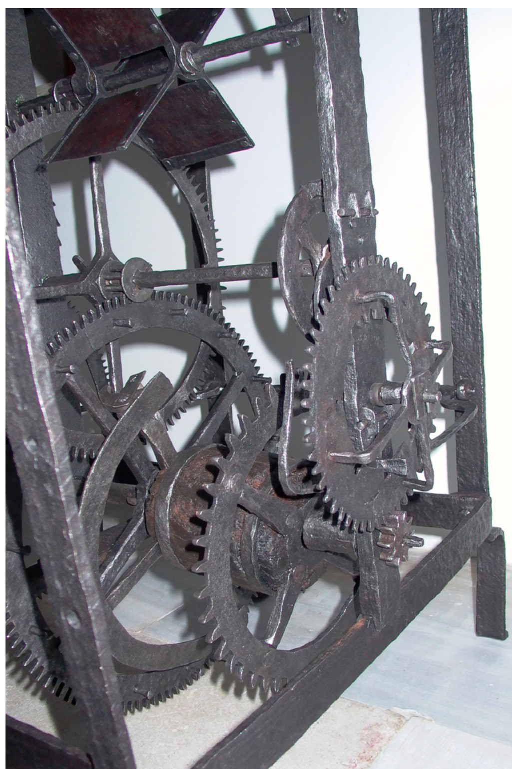


Fig. 16. The restored locking system.

Fig. 17. The Pantocrator verge and foliot tower clock after restoration.

presented later when we investigate a clock at Iviron monastery.

Although the dial shows 24-hours, the clock mechanism has a 12-hour count wheel. My attention has been drawn to a practice that exists in Venice that may explain this anomaly, where clock dials with 24-hours indication were modified to a 12-hour strike system in the mid-sixteenth century for ease of counting.

Thus, it may be construed that a 24-hour dial system was still in use at Pantocrator monastery after 1815 as 24-hour dial systems were a common sight on Mount Athos around this period, although the transition from 24 to 12-hours was already in progress.

The 24-hour dial system began to decline during the early part of the seventeenth century throughout many countries in Europe, in favour of what was emerging as the preferred standard, 12-hour system,[6] but on Mount Athos the local traditional 24-hour system lingered on probably due to its remote geographical location, on the edge of Europe. Another option was to replace the 24-hour count wheel with a 12-hour count wheel, as was the case with the Dohiariou Monastery tower clock, which had a replacement 12-hour count wheel crudely fitted whilst the original 24-hour count wheel was found nearby (Fig. 34).

Fig. 15 shows the Athos Z detent system prior to restoration. The whole system was encrusted with rust which made it difficult to distinguish between parts. The Z detent was seized to the post with rust, so a measured approach was applied in freeing and dismantling the component parts without causing damage. This was achieved by repeatedly heating the parts and cooling with penetrant oil, then using a hammer and soft metal punch to loosen the bond.

Fig. 16 shows the restored locking system assembly in working order. I had not previously encountered this locking device and initially it made little impression on me as I was too busy with the conservation / restoration of the clock (Fig. 17). It was only when I had seen the same locking system on several other tower clocks, that its significance became apparent. This was a locking system that I had never encountered on any other clock, but it dawned on me that the unique Z locking system was a common factor that connected all of these clocks, with the notion that they were likely to have been made in the same workshop.

Xenophontos Monastery tower clock

The monastery of Xenophontos is situated on the sheltered west coast of the Athos peninsula and was founded by Saint Xenophon in the tenth century.

In 2011, I was invited to examine the unfortunate foliot tower clock of Xenophontos. In 1995 the monastery had gone through a period of restoration, that included the bell / clock tower. The clock had been removed from its original location and placed on the floor in the room whilst the work continued. When the work was completed the workmen were asked to clear the room and dispose of any rubbish. This instruction was misinterpreted, and it was assumed the rubbish included the old rusty clock mechanism which was found to be too cumbersome to manoeuvre down the six-storey building so it was thrown from the top of the tower! (Figs 18 and 25)

Fig. 18. The Xenophontos tower clock after it had dropped down six storeys.

I found the clock mangled, bent and broken and hardly any of the clock components escaped the devastating damage. I must admit at first, I found the offer of restoring the clock frightening and I initially declined the offer, but as I am now sitting in my cell at the same monastery writing this article, I am pleased to report that the same clock is now ticking away nicely at a two-second beat interval. Figures 18 and 19 are a testimony to the durability of wrought iron.

6. F. Beeson, *English Church Clocks, 1280–1850* (1971).

Fig. 19. The Xenophontos tower clock after restoration.

My approach to restoring this clock was to first remove every part out of the frame and focus on straightening out the damaged frame. The frame was separated into individual

Fig. 20. A former for making rivets.

Fig. 21. A new rivet joining the frame.

components by removing the rivets. I worked the bent parts by heating on a forge and beating on an anvil to realign them back to their original form. Some of the vertical frame posts had broken in two parts and I used TIG welding to join the parts and artistically dress the weld so that the joint was difficult to distinguish. This was the only process in the restoration where a modern technology was used, and the remainder of the restoration was performed using traditional blacksmithing methods. Even the rivets that were replaced were all individually made and riveted by hand (Figs 20 and 21).

The Xenophontos clock was very similar to the clock at Pantocrator in many respects. However, it seems that it was in the process of being converted from verge and foliot to pendulum, as the original foliot, verge and crown wheel were missing and instead a number of rogue parts from another clock were found nearby. These parts included a verge crown wheel escapement and pinion (Fig. 22), ready to be adapted into the clock but they never were. The close similarities of the Pantocrator clock provided a reference to work from, in restoring the clock back to its original verge and foliot design.

Fig. 22. A verge crown wheel escapement and pinion found nearby the clock.

Fig. 23. The Xenophontos clock Z dual detent.

Fig. 24. The new dial of the Xenophontos clock.

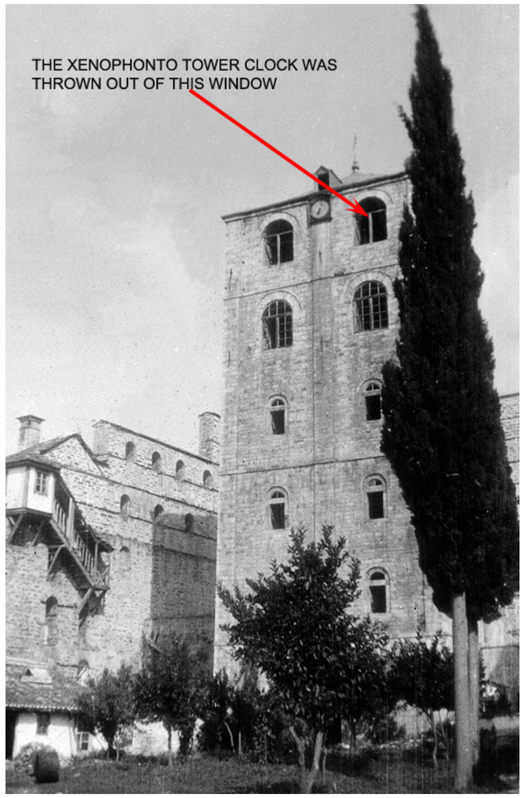


Fig. 25. Xenophontos clock tower and dial. Photograph: Xenophontos Monastery.

My main interest in this clock was that it had the Athos Z locking system (Fig. 23) like the Pantocrator clock, and many other similar characteristic features.

The early design features of the clock predate the clock tower that was built in 1864. The dial shown in the old photograph Fig. 25 was missing and was reconstructed with the aid of this photograph. The new dial was installed in 2020 (Fig. 24). It is ironic that the clock after restoration entered the tower through the same window from which it had been thrown down in 1995.

Iviron Monastery tower clock

My next discovery of the Athos Z dual detent lock system was at Iviron Monastery, situated on the north-east side of the Athos peninsula. The monastery was founded in the last quarter of the tenth century by two Georgian (Iberian) monks, John and Euthymios.

I first visited the monastery to view the clock in the year 2000 and fifteen years later undertook its restoration. The Iviron clock was the largest tower clock mechanism that I had encountered on Mount Athos (Fig. 26 on the following page). It had a three-train mechanism with a 24-hour count wheel. The hours were struck by a clock jack who held a bell in one hand and a hammer in the other (see Fig. 31).

Fig. 27. The quarter strike of the Iviron clock.

The quarter strike played a short melody on five dish shaped bells (Fig. 27). The going train had a verge and foliot and all three barrels arranged end-to-end.

Iviron monastery has no documented

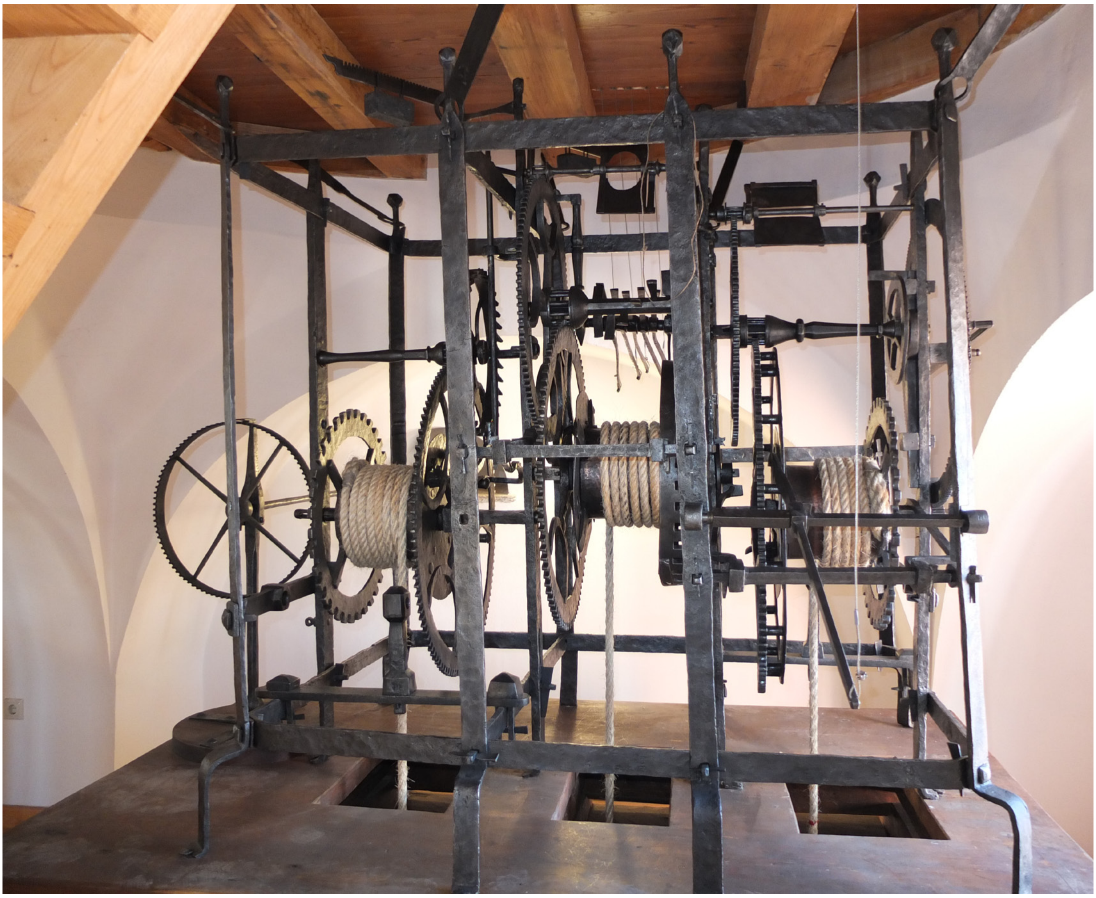


Fig. 26. The Iviron clock with all three barrels arranged end-to-end.

history on this great clock but there was an account given by visiting travellers, Athelstan Riley and his companion the Rev. A. E. B Owen, during their travels on Mount Athos in the 1880s. When they visited Iviron, they were shown the tower clock, and Riley made the following observation:

> I may here notice in passing that in the clock tower of the monastery is an ancient clock of Venetian or Genoese construction, probably one of the earliest timepieces in existence. It has no pendulum, but an escapement somewhat resembling that of a verge watch; this having been broken, was fastened to the beam above by two wires. O— [his assistant] asked one of the monks how it went, and jokingly suggested it might lose an hour in a week. 'O yes,' replied the monk, not at all astonished, 'quite that'.[7]

It is interesting to note that this makeshift repair was still evident on the beam before the recent refurbishment of the clock room. Fig. 28 shows the two large nails on the wooden beam with remains of cord still attached, that are directly over the centre of the foliot. These were used to suspend the foliot. It appears that two nails were used in order to form the cord in a triangular shape as is normally found on a foliot cord suspension arm with a serrated edge that locates the cord at the required distance. This offered a certain amount of resistance to the turning moment and was an additional means of regulating the clock. The wider the triangle, the smaller was the swing of the arc and the clock ran faster.

Riley's observation confirms that the Iviron verge and foliot clock was still working in the late nineteenth century, as was the case with other foliot clocks on Mount Athos.

7. Athelstan Riley, *Athos; or, The Mountain of the Monks* (1887), p. 143.

Fig. 28. In this photograph, taken before the refurbishment of the Iviron clock, the two nails used to suspend the foliot, which Riley had observed in the 1880s, are still in place.

I have recently been made aware that this clock was in service and working until 1952. A monk responsible for the clock resided in the clock tower, in a room beneath the clock, where he would have been on hand should a problem arise. He would have maintained the clock, and oiled it on a regular basis, and set it by a sundial or an accurate clock. This information was relayed by one of the elderly monks at Iviron who was present during that period and recalled these events.

The Z dual detent locking system was used on both the quarter and hour strike mechanisms (Fig. 29). Its design concept was identical to the systems of the other four tower clocks discovered on the Athos peninsula and is the main feature that links all of these clocks together, which strongly suggests that they were made in the same workshop.

Fig. 30 (see following page) is an early photograph of the main church and clock tower of Iviron Monastery taken in the second half of the nineteenth century. On the outside wall of the clock tower is a 24-hour painted dial with an anthropomorphic image of the

Fig. 29. The Iviron clock with the Z dual detent locking system, internal count wheel and over-lift cam wheel.

Fig. 31. The Moor jacquemart, colloquially referred to as the Arab, was removed from the clock tower for restoration.

Fig. 30. The main church and clock tower of Iviron Monastery in the second half of the nineteenth century. Photograph: Iviron Monastery.

sun at its centre and above the clock one can just about discern the Moor jacquemart that strikes the hours on a bell, which is seen in Fig. 31.

Dochiariou Monastery tower clock

The monastery of Dochiariou lies on the west side of the Mount Athos peninsula and is alleged to have been founded in the second half of the tenth century by Saint Euthymios. I visited the monastery in 2019 to examine and document the Dochiariou tower clock with a view to restoring it. Whilst in the process of documenting the clock it soon became apparent that there were striking similarities between it and the tower clock of the neighbouring monastery of Xenophontos, situated just a few miles away. The two clocks were of similar size, construction and decorative features including the Z dual detent locking system. The similarities were

Fig. 32. The Dochiariou tower clock.

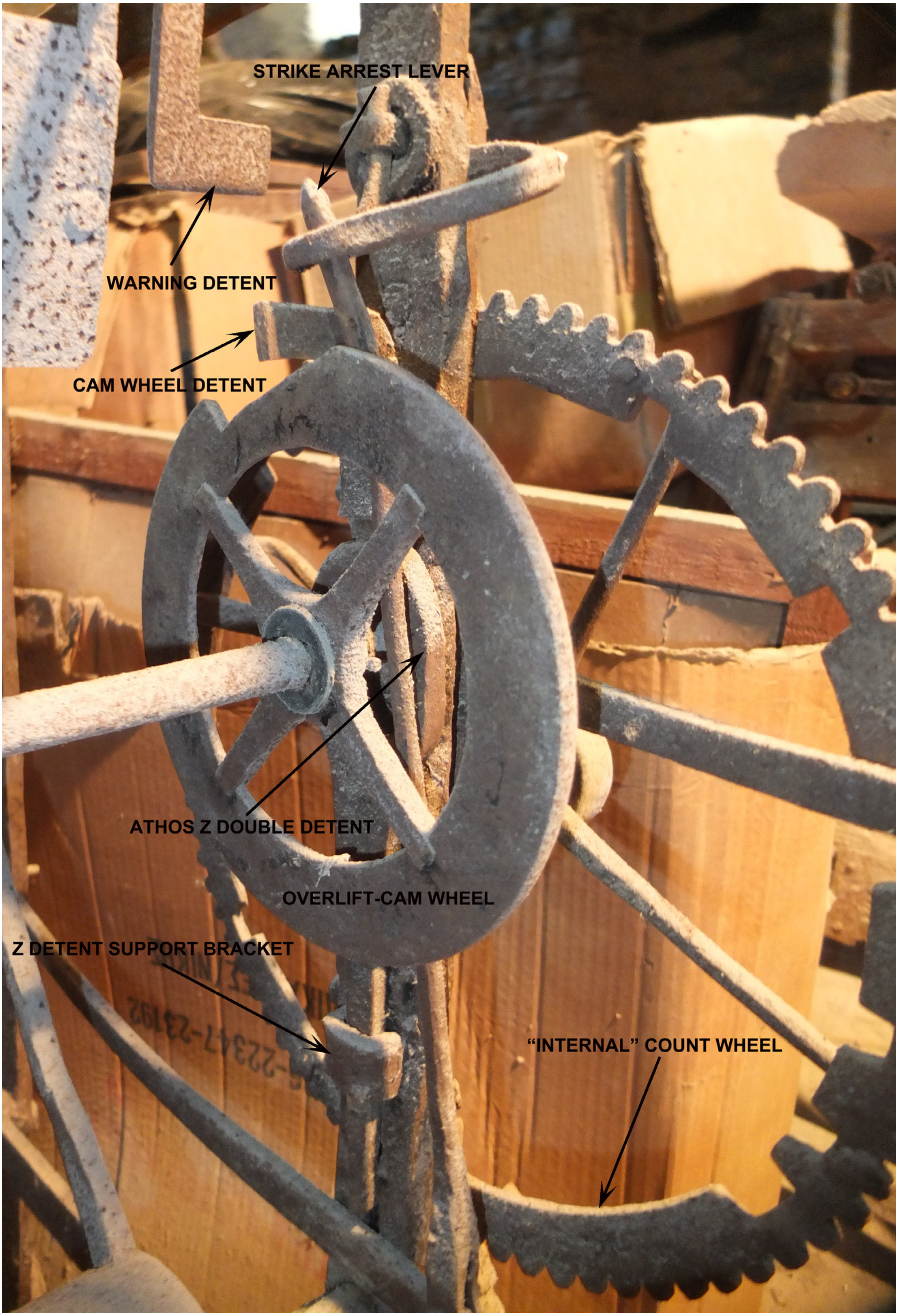


Fig. 33. The Z dual detent system of the Dochiariou tower clock.

Fig. 34. Fr. Theoktiste with the 24-hour count wheel.

Fig. 35. Copper engraving of Dochiariou Monastery by Antonios Ioannis Zoulanis dated 1819.

so compelling that there was little doubt that they had been made by the same workshop.

The Dochiariou tower clock (Fig. 32) was originally a verge and foliot with the conventional end-to-end barrels that was in the process of being converted to a verge and pendulum. It had a 12-hour internal count wheel with the Z dual detent locking system (Fig. 33). There was evidence to suggest that the count wheel was not original to the

Fig. 36. Dochiariou clock bell.

clock as it was attached to the frame with a makeshift cross bar, between it and the frame.

Near the clock was a box containing a collection of early tower clock parts. It included a 24-hour internal count wheel and a foliot crown escape wheel. The count wheel was found with a series of wire hooks attached around its periphery which suggested that it was used to hang bunches of herbs to dry. Fr. Theoktiste (Fig. 34) can be seen with the 24-hour count wheel in hand and a pair of snip cutters ready to remove the wire.

Dochiariou is the only monastery on Mount Athos that has a tower clock without a dial to visually indicate the time. No one at the monastery had any recollection of a clock dial on the tower. However, I discovered a copper engraving depiction of the monastery that shows a clock dial on the bell tower. It was engraved in Venice, which suggests a certain degree of artistic license may have been applied, and whether the dial was present is uncertain (Fig. 35).

The bell that was connected to the clock is shown in Fig. 36. It dates from the first quarter of the seventeenth century and may have been made for the clock when it was installed. The age of the clock bell is often used as an aid in dating the clock but in this analysis, it can only be considered as a possibility. This was mentioned by the monks at the monastery but unfortunatly it is hearsay and can not be substantiated. I find there are few written records at the monasteries that can be searched for this type of information, as they have either been destroyed, do not exist or have not yet been organised systematically

Fig. 37. Lavra Monastery on an early photograph. The clock tower with the dial is on the right. Photograph: Great Lavra Monastery.

to facilitate searches. Therefore much of the information is extracted from the items researched.

Lavra Monastery tower clock

Lavra is the most southerly monastery on the Athos peninsula. It was the first principal monastery established on Mount Athos (Fig. 37), founded by Saint Athanasios in 963. He laid the foundations of an orderly, organized monastic life system by writing a set of rules and guidelines that became the template for successive monasteries that followed. One of the key tools that he used in applying and implementing these rules was the seed for the roots of horology on Mount Athos, a means of noting time by the use of a water clock.

St Athanasius was born between 925 and 930, to a wealthy family in the city of Trebizond.[8] He was educated in Constantinople where he worked as a teacher. We can safely assume that time measurement devices were familiar to Athanasius who probably relied on them in his day-to-day activities. Public clocks in the heart of Constantinople were positioned at key points in the city centre including the Basilica, the entry to the imperial palace, and the Hagia Sophia.[9] These were sophisticated water clocks, as opposed to the simple clepsydra used in early antiquity. They served a useful function to society by their obvious intended use but they also inspired wonder and a sense of technical superiority.

St Athanasius was known to have practical skills as he was involved with the physical construction of the main church at Lavra Monastery. This, coupled with his educational background, would have equipped him with the necessary skills to construct a water clock.

St Athanasius refers to the monastery

8. Graham Speake, *Mount Athos, Renewal in Paradise* (2002), p. 41.

9. Benjamin Anderson, Public clocks in late antique and early medieval Constantinople, *Jahrbuch der Österreichischen Byzantinistik* 64 (2014), 23–32.

Fig. 38 (left). The Lavra clock / bell tower after the earthquake.

Fig. 39. The Lavra tower clock.

water clock in the set of rules he formulated in the Typikon of 970 CE. It reads: 'The signal of the water clock strikes, and at this signal they immediately rise and sound the wooden semantron'.[10] The Greek word 'semantron' is reserved for a wooden instrument that is likened to a plank that is struck with a wooden mallet.[11]

Fig. 37 is an early photograph of Lavra Monastery that shows the inner court. To the far right is the clock tower and clock dial. In 1905, a severe earthquake caused the clock tower to lean towards the main church of the monastery (Fig. 38). As it was feared that the tower might topple onto the church, the clock was removed and the tower was demolished. It is not known whether the Lavra clock was still in service when the earthquake struck. If so, it may have been preserved for future use in case the tower were to be rebuilt. This however never happened; instead, a metal structure was constructed on to which the bells were hung as a substitute for the bell tower.

The tower clock at Lavra (Fig. 39) followed the general design and layout of the clocks of the other four monasteries already mentioned. This clock was the third verge and foliot clock discovered on Athos that was in near complete condition. It had a 24-hour

10. John Thomas and Angela Constantinides Hero (eds), *A Complete Translation of the Surviving Founder's Typika and Testaments. Byzantine Monastic Foundation Documents* (5 vols; Dumbarton Oaks, Washington, 2001), vol. 1, p. 221.

11. Percival Price, *Bells and Man* (OUP, 1983), p. 173.

Fig. 40. The Z dual detent locking system.

Fig. 41. Fr. Simon demonstrating the size of the single hand of the Lavra tower clock.

internal count wheel with the Z dual detent locking system (Fig. 40). The drive from the clock mechanism to a single hour hand (Fig. 41) on the 24-hour dial was through a large reduction contrate gear wheel supported by a tripod stand, which allowed the gear to be disconnected from the pinion of report, so that the single hour hand could be advanced

Fig. 42. The notches of the foliot arm of the Pantocrator clock look like the back spine of the dragon, and the end like its head.

or retarded in order to set the correct time. The hour strike would also require re-setting separately so that it would be synchronous with the time set.

The contrate gear wheel arrangement necessitated the clock mechanism to be positioned at a right angle to the dial face, as was the case with the Iviron tower clock that had an identical system.

The Lavra tower clock had one significant feature that made it stand out from the other clocks on Athos and dare I say Europe. It was adorned with some of the most exquisite structural art work, fashioned in wrought iron, that I have seen on any tower clock. The image portrayed is that of a serpent or dragon which corresponds to one of the many names attributed to the foliot over its long history. (Some early Spanish names that were in use to describe the foliot are (a) "Spirit", and for the foliot support, (b) "Dragon".[12]

An example of the latter can be seen in the foliot arms of the Pantocrator clock Fig. *42,* where the notches of the foliot arm may be interpreted as the back spine of the dragon and the modelling of a head at the end of the arms completes the image. Another example is the foliot support of the Lavra clock which is formed in the likeness of a dragon or serpent and integrated into one of the main centre posts of the going train that supports the arbors. It was extended vertically upwards

12. Information on a plaque near the 'Flemish' verge and foliot clock made for the Barcelona cathedral by Simo Nicolau and Climent Ossen in 1576, now on display in the Museum of Urban History, Barcelona. The authors may have been Marti Verges and Joaquim Agullo who directed the restoration of the clock in 1975 and contributed to the content of the plaque.

Fig. 43. The foliot on the Lavra tower clock.

Fig. 44. Close-up of the serpent-head figure on the Lavra tower clock.

and the end bent over in line with the verge to form the suspension anchor point for the verge and foliot (Fig. 43). The creation of the serpent was skilful, with intricate details highlighting the scales on its body and the head, where every tooth in the creature's mouth was perfectly formed (Fig. 44). Iron is a difficult material to form with this degree of detail. I consider this to be the best example of horological art related to tower clocks.

Conclusions

The Athos Z dual locking system design was identified on five Athonite tower clock mechanisms on the Mount Athos peninsula, including two other major features. One is the vertical frame posts with tetra-decahedron pommel style finials. The other is that, apart from the large Iviron clock, the frames were embellished with simple design art work incised into the surface of the iron frame.

Despite these unifying common design features, each of the five tower clocks were hand crafted as one-offs. They followed a standard design template but varied in size of the frame and gear trains.

These features, and similarities between these clocks that link them together, leave little doubt that they all originated from the same workshop. To bolster this idea, my research has highlighted the likelihood that at least another three of these clocks existed: at Vatopedi, Esphigmeno and Xiropotamos monasteries. These, and the relatively large number of tower clocks found, all within a geographical diameter of 23 km, leads me to the conclusion that there is a high probability that they were made on Mount Athos and not imported from other countries as was the case from the late eighteenth century onwards. The substantial number of monasteries situated in close proximity would have been a major influence in establishing a centre for the construction of monastic tower clocks on Athos.

To determine the period in which these clocks were made with some precision is difficult, as documented information relating to this subject in the fifteenth, sixteenth and seventeenth centuries is scarce on Athos. Therefore, the only tangible reference that can be interrogated are the clocks that remain from that era. There are numerous design features or characteristics on these tower clocks that have been identified by other researchers as belonging to a particular period, but even these span many decades and can be considered as approximations. So when trying to attribute a date in the absence concrete evidence, it is very much based on personal experience in appraising what remains of the clock and also taking into account the possibility that some of the components may have been replaced or modified over the life span of the clock.

We can safely make the assumption that these clocks predate the invention of the pendulum, so we can consider 1650 as the approximate latest date. However, assigning the earliest date would, at best be an educated guess.

Some of these distinguishing features that are associated with early verge and foliot clocks and are present on the Athonite tower clocks—the internally notched count wheel and the 24-hour strike count wheel—might give some credence to a speculative date of 1500 +/- 100. A wide margin of error has been applied because there are signposts directing us either side of this date. On the one hand we have the clock bell of the Dochiariou clock that dates to the first quarter of the seventeenth century, and on the other hand, the notched count wheel and the 24-hour strike count wheel. However, so far, I have not found any evidence that establishes the period with any degree of accuracy in which these tower clocks were made and therefore we can only speculate based on the information collected at present.

The earliest brass dial lantern clock that I have discovered was engraved with the date 1743, the name of the monk who made it and place, Mount Athos.

The construction of these clocks continued up until the end of the nineteenth, early twentieth century without any change in the basic style of the lantern verge clock with short pendulum. The clockmaking industry during this period is well documented,[13] but there is an absence of written records relating to these early tower clocks. Perhaps when the demand for the tower clocks was satisfied and the work dwindled, the monks diversified into making brass dial lantern alarm clocks, which kickstarted the brass clockmaking industry to meet the needs of the local community and the increasing demand of the Turkish market, whose appetite for clocks was insatiable. The discovery of these five verge and foliot tower clocks has not only highlighted a unique clock strike locking mechanism, but has also opened a window into early horological history of Mount Athos, and to new avenues for research that may not yet have been considered.

Acknowledgements

My sincere thanks to Dr John Robey and Dr William Linnard for their help and advice in preparing this article. I also wish to acknowledge the following monks of Mount Athos for their help, support and encouragement over the many years of field work and research.

Fr. Jeremiah, Iviron Monastery.
Fr. Egnantios, Fr. Phillipos, Fr. Constantinos, Fr. Timotheos, Vatopedi Monastery.
Fr. Simon, Dionysiou Monastery.

13. Πετροσ Μ Κουφοπουλοσ & Σταυρος Β Μαμαλουκος, *Αγιορειτικη Μεταλλοτεχνια απο τον 18ο στο 20ο αιωνα* [Petros M Koufopoulos and Stavros Mamaloukos, *Athonite Metalcraft from the 18th to the 20th century*] (1997), pp. 89–93.