

# British Horology Times

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British Horology Chapter 159 of the National Association of Watch and Clock Collectors, Inc


## All Aspects of a Transitional Pre-Hairspring to Hairspring Timepiece circa 1675 – 1682

*By David Cooper, CO*

*Figure 1: Star of David Travel Clock*

**Introduction**: Frozen in time like an archaeological discovery this piece is a perfect slice of a unique time period marking the most important transition ever to occur in portable time pieces and the invention of the hairspring that suddenly meant watches were capable of keeping time in minutes instead of hours. Resultantly, watches were elevated from elegant works of art and extraordinary status symbols of great value to become functionally accurate timepieces as pendulum clocks had become. They remained, to a lesser degree, status symbols only available to the very wealthy. This example is an extravagantly detailed travel clock; very likely the first travel clock ever made with a hairspring.

Up to this point all watch tooling and design were tailored to watches that only had an hour hand. This hand was driven by the fusee arbor along with a three-wheel train with the appropriate tooth count running from the fusee arbor pinion. For the previous 100 years or so all watches were very specific to this design.

Think of the task confronting the industry. Now, tooling and accessories handed down for generations had to be changed or remade, a time consuming and arduous task by itself, not to mention the substantial change of the whole thought and design process as how to accomplish these changes such that the watch would function with a minute hand.

Certainly, all these changes occurred over a number of years and in different time periods according to location with the shops in major cities taking the lead. With all that in mind, the construction of this piece certainly occurred over several years in a step-by-step process starting in the pre-hairspring era and finally arriving at the latest and best timekeeping design of the hairspring balance. The consequence being the Star of David clock is most likely the first travel clock made with a hairspring.

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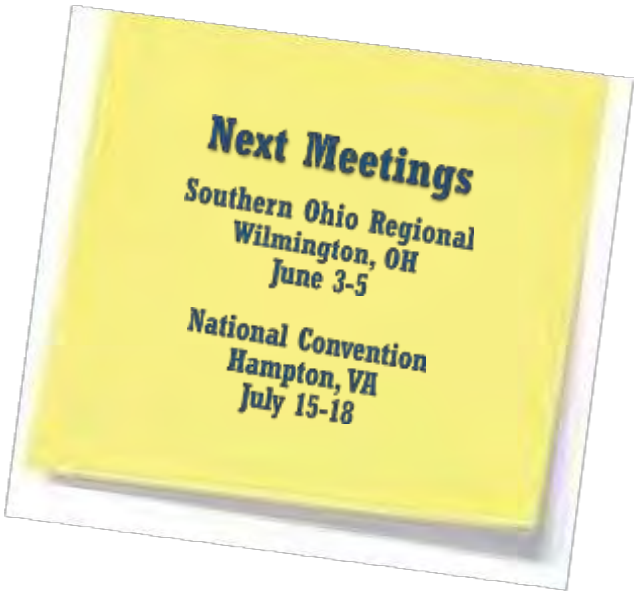
**In This Issue…**



*British ship of the line watch paper once within a watch owned by William Beekman of N.Y. dated 1745.*



## President's Message:

Again, as I write this message, we are hopeful that we can soon meet in person. We have scheduled meetings of our Chapter at both the Southern Ohio Regional in June and the National Convention in July. At our June meeting, Safwat Wahba will make a presentation based on his acquisition of a Joseph Windmills' tall case clock. Windmills was a contemporary of Thomas Tompion and I am certain that Safwat's presentation is one that you will not want to miss.

At our meeting in July at the National Convention, Craig White will talk on an unusual clock by James Ferguson. Ferguson was arguably the most respected scientist of the 18th Century in England. His principles were essential in creating meaningful mechanical models of the solar system. Craig's research has led him to an understanding of the contributions of Ferguson to astronomy and particularly to horology. Please join us in Virginia for this presentation.

We are extremely fortunate that David Cooper has chosen to share with us his description of the unique Star of David timepiece. David is a watchmaker and clock maker par excellence, whose understanding of early timepieces and his skill in restoration are fully demonstrated in his article. It is a truly fascinating study of a transitional timepiece and the pictures that illustrate his article well document and support his text. The article is, probably, one of the longest we have published in this journal. Members may have questions about his analysis and findings and I'm sure that David would be happy to discuss those with you. Please direct your questions to britishhorology@gmail.com and we will forward them on. I believe that this article deserves a special place in your reference library. Thank you, David.

Our Chapter is a co-host of the Regional Convention in Wilmington, Ohio as well as the National Convention in Hampton Roads, Virginia. If you are planning to attend either event, please consider helping us with the event administration. There is always a need for volunteers to assist with various aspects so that the Convention can run smoothly. Even if you can only spare an hour or two, your help will be very appreciated. Please let us know at britishhorology@gmail.com if you are able to volunteer.

Unfortunately, due to border restrictions and the response to the pandemic, I regret that I will be unable to attend either of our forthcoming meetings. I will be there in spirit. Until we can meet again, I wish you the very best.

Cheerio
Bob

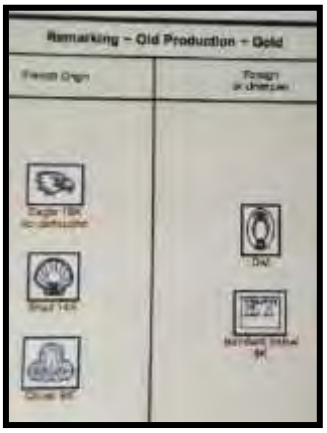
*(Continued from page 1)*

It is my express desire in this article to detail all aspects of a completely original piece of this period. I hope to provide to the collector and, more importantly, the restorer a comprehensive baseline of all the mechanical and artistic aspects of such a piece of both hairspring and pre-hairspring eras. In doing so it has been very informative for me as well.

**The Case** is made of solid gold, 3 inches or 7.5 millimeters from point to point. This stunning case represents the pinnacle of soft-soldered craftsmanship. It has exceptional high relief engraving at a level basically lost after the 1690s. High relief engraving is a particularly difficult and time-consuming process requiring the material around the engraving to be removed for the high relief to occur. All the surrounding material is removed in several stages of engraving depending on the relief desired. This material would have to be removed very carefully in several successive stages without damaging the pattern.

The whimsical Adam and Eve scene on the back (Figure 6) depicts a couple sitting streamside, most likely the original owners and they are captured in stunning detail. Upon careful examination, several buildings can be seen in the background, most likely their estate. The woman's left hand pointing upward seems to be indicating the buildings but I have never been able to determine what is indicated by their right hands. Turned in remarkable detail are the six riveted solid gold feet, placed at each point on the star. Three of the feet are decorative and three are functional.

An auction house sold this piece several years ago as a Renaissance copy which was based on the assay stamps interpreted as hall marks. The fatal flaw was that, from that incorrect observation point on, everything about the clock was processed to fit the initial premise of it being a later Renaissance Revival piece and as such it was bought as a work of art rather than a timepiece of any real historical importance.
Three faint assay stamps in cartouches (two owls and a swan appear on the bottom inside cover).





*Figures 3 & 4: Assay Stamps. Figure 5 (right): Greatly magnified are the two owls and swan assay stamps in the back of the case, the owls signify gold and the swan stamp for the silver dial. There are no karat designation lines.*

These stamps may have been added at a far later date than when the timepiece was manufactured as it is unclear when they came into use. Prior to 1798, they were used solely for remarking old production or foreign goods brought into the Paris assay office and after 1838 their significance changed to denote whether the item was silver or gold and its level of purity (above or below 50 percent) designated by the lines alongside the owl and swan; therefore, even then they did not serve as hallmarks and cannot be considered reliable indicators of the date of manufacture.

**General Information**: For it to be a travel clock it had to be constructed with a balance which is basically a watch format. Most travel clocks really did not travel a lot whereas watches were constantly subject to wear caused by coarse vestments, shock, the elements, and worst of all, being dropped. Watches consequently required numerous repairs such as badly worn outer cases being replaced, new bows, worn out pendants not to mention mechanical damage.

Since this was not a piece to be worn and because it did not keep time, its importance as a clock would have greatly diminished by the early- to mid-1700s, at which time its survival would have most certainly depended on its artistic merits which was how it was sold and purchased at auction. The preservation of other stunning examples of early pre-hairspring and pre-pendulum timepieces in most cases has been primarily for the artistic value of the piece. They might tick a bit here and there but were certainly not expected to keep time of any sort. Art for art's sake.

One of the most interesting aspects of the Star Clock is that being a transitional piece it provides a unique perspective on earlier timepieces incorporating elements of earlier watch-making design and combining those with the latest technical innovations of the hairspring era throughout the process of manufacture. These unusual design characteristics appear in the early use of a fusee chain, the minute ring, minute hand, and the hairspring with Barrow regulator, all of which indicate that the owner wanted his piece to be on the cutting edge of design. In this transitional timepiece both the new and previous style of construction are very neatly combined and were unaltered in later times. There is no question that the Star Clock initially started out as a pre-hairspring balance, gut cord, single hand timepiece and by the time it was finished (which could have been several years) it had a hairspring and fusee chain. So, it follows that it was made by someone that had never made a hairspring timepiece.

From my observation, I believe that the ebauche was made in France and very possibly the case and movement were finished in the Netherlands. There is no question of the very English influence in many areas of the mechanical design leading me to believe that the maker of the movement, at the least, apprenticed in London if not lived there.

It is also very possible that a wealthy Jewish merchant in the Netherlands may have commissioned the piece as, at that time, the Jewish merchants wielded considerable influence in Rotterdam and Amsterdam due to their role in transforming Holland into a colonial empire. Because they established the first diamond exchange in Europe, procuring the requisite quartz panels, each one of which is a slightly different size, would not have presented a challenge.

Ahasueras Fromanteel brought the technology of the clock pendulum (a very significant advancement in timekeeping invented by Christiaan Huygens) to London and he began producing some of the finest and most advanced watches and clocks around the same time. It is possible that he may have made or contributed to the making of the Star of David Clock.

The meticulous and marvelous craftsmanship of this extravagantly expensive piece was rivaled only by its technical mastery. The Star of David Clock represents one of the pre-eminent timepieces of its day regarding accuracy of timekeeping, an unusual feat considering that the vast majority of its predecessors were constructed almost exclusively for aesthetic appeal and held little value as timekeepers (nearly all watches made up to this point used an hour hand only).

**Origin of Design**: The Star of David Clock, like its predecessor, after which it was patterned, David Ramsay's Star Watch of early 17th century London, exhibits a combination of thematic and design elements that set it apart from all other timepieces of the age. The only significant difference between the two is that Ramsay's watch was designed primarily as a piece of religious art and secondarily as a timekeeper while the Star Clock represented a revolution in timekeeping for portable timepieces, featuring a hairspring, a unique expanding gold minute hand and silver oval minute ring.

- Shape: The nearly identical star patterns (Figures 5 and 6) demonstrate a clear relationship between the two pieces.
- Engraving: The engraved border decoration around the front cover of the Ramsay watch and the back side of the Star Clock are typical of the period and feature a beautifully executed classical high relief style exhibiting rabbits, squirrels, cherubs, and fruit.

- Movement: The movements of both the Ramsay watch and the Star Clock are hung in the case by four tangs. The Star Clock is secured by latches that are typical of the period.
- Hands and Feet: Both pieces are equipped with gold hands, which are very uncommon for the time period and both have balance cock feet that are nearly as large as the balance cock itself.

*Figure 5 (left): A detailed look at the style and decorations of the border of the front cover of the Ramsay watch, (Clock Makers guild, London).*

*Figure 6 (right): Both pieces are reflective of the superb examples of the engraver's art of the period which ended by the 1680s.*

*Figure 7 (left): It is abundantly clear the dial was patterned after the Henricus Jones watch of London of same date within a few years.*

*Figure 8 (right): Beautifully blended together is the Jones oval dial and the splendid decoration of the Ramsay watch.*

**The Movement:** As a whole, the finish and decoration are of the highest levels of craftsmanship of the time. All screws (there is an excessive number of them) were made with a screw plate and are beautifully turned as are all the arbors. The entire piece is larger than a watch but built in the format of a watch. The movement is fitted to the case perfectly.

- The columns are nicely turned and are typical of the period.
- Soft solder was used in numerous places including the balance and staff, the raised plate bushing for a third short wheel arbor, the barrel bottom cover, and on the contrate wheel hub.
- Screws were made with a screw plate with hand-filed slots.
- There are no oil sinks for any of the pivots which is common for the period.
- Under the dial are several train layout semicircles which do not coincide with the current wheel layout indicating that they were originally for a pre-hairspring train.

*Figure 9 (left): Dial side down. Figure 10 (right): Dial side up.*


*Figure 11: The backside showing the Barrow regulator below and upper mainspring setup worm with a silver indicator dial. Upper left and lower right the nice case latches are seen. The lovely symmetry of the back plate is very much a Breguet style with a balance of mechanical and artistic design and may be the reason the mainspring setup was present even though it was not needed and may account for the choice of the Barrow regulator instead of the Tompion regulator ending up with the lovely artistic visual balanced symmetry.*

The Barrow regulator, lower, which dates around 1676 to 1682, was invented in England regulating the timekeeping faster or slower by changing the active length of the hairspring thus changing the rate of oscillation of the balance. The amount of change is reflected by the numerals below which visually shows how much change is made to the hairspring and of themselves the numbers are no indication as to the actual change in minutes in timekeeping as is so with the Tompion regulator index wheel.

Above the balance cock with silver indicator dial is the mainspring setup worm which also regulates the timekeeping by virtue of increasing or decreasing the amount of force applied by the mainspring to the escapement thereby increasing or decreasing the amplitude of the balance resulting in a rate of gain or loss.

In the upper left and lower right are the nice case latches securing the movement to the case predating case screws by quite some time. The lovely symmetry of the back plate is very much a Breguet style balance of mechanical and artistic design and may be a reason the mainspring setup was left in even though it was not needed. It also may well account for the choice of the Barrow regulator instead of the Tompion regulator. This is the perfect balance of functional mechanics and artistic balance of design, so very Breguet before Breguet. Figures 12 & 13 are two other transitional watches of the period, one by Daniel Quare and the other by ThomasTompion. Both include Tompion regulators as well as the mainspring adjustment worms for regulating the timekeeping as does the Star Clock. It should be remembered that the transition period for mechanical change as dramatic as this could occur over extended periods of time, easily a decade or more as machines and trades were setup to make things in a certain way. It is not uncommon for major innovations to meet resistance from many quarters. (I like the way they used to do it. It is good enough for me.)


*Figure 12 (left): A Daniel Quare of the same period with mainspring setup and Tompion regulators.*

*Figure 13 (right): Another early surviving watch by Thos. Tompion also with the same two methods of regulating the timekeeping.*

**The Dial and Hands**: The dial is composed of three parts: first, the silver dial plate features very fine engraving with inhabited foliage; second, is an applied round hour ring containing half-hour marks; third, an applied oval minute ring. The hands are beautifully cast gold, and the spring-loaded steel arrow portion of the minute hand telescopes in and out to follow the oval minute ring by way of a roller extended under the arrow that follows the inner side of the minute ring. A pin is visible on both sides of the gold minute hand that simultaneously holds the steel hand upright and limits the outward travel of the steel arrow to the closest third of the dial on either side (the three and nine positions). If the hand extends further the tracking angle is such that it will stop the clock. The additional experimental pin hole to the right of the pin allowed the hand to extend too far. Thus, the minute hand would jam in the extremities of the minute ring and stop the clock.

*Figure 14 (below): Movement dial side down, notice lovely dial feet, screws, and turnings.*

*Figure 15 (left): A side view of the tracking minute hand with what appears to be replacement spring, the tracking hand is very sensitive to the spring pressure applied to the tracking roller. Note the hand tracking roller, the replacement extension spring, and the experimental pin hole.*

*Figure 16 (right): A detail of the set of lovely cast gold hands.*

**The Barrel**: Both the barrel and the fusee were originally made for a gut cord which was used prior to the invention of the fusee chain, generally considered to be in the 1660s. The original large, round hole angled for a gut cord was drilled into the side of the barrel with a decorative cutout in the lid to accommodate the knot which must be flush with the top of the barrel. Additionally, the mainspring is somewhat narrower than the barrel to make room for the knot of the gut cord (this is not at all necessary for a fusee chain hook because it does not penetrate the inside of the barrel). The barrel is signed Desaunay and marked 43 4. The bottom lid is expertly soft soldered on, and the mainspring is clearly handmade. From my observation, it is unquestionably original or of the same period because it fits the barrel perfectly and is the correct strength.

*Figure 17: The name Desaunay is scratched on the barrel, most likely the maker of the ebauche.*

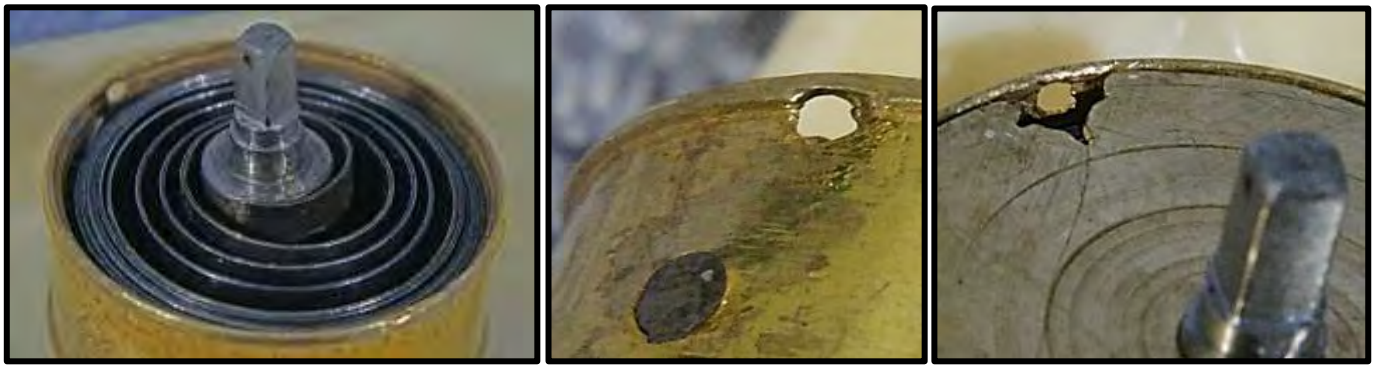


*Figure 18 (left): From my observation, and most unusual, this is certainly the original mainspring. Figure 19 (middle): The sizable round hole in the barrel is clearly intended for a gut fusee cord and necessarily is located above the mainspring. Figure 20 (right): The large decorative cutout in the barrel lid allowing sufficient space for the gut cord knot, very typical for the period.*

**The Fusee** was cast from a single piece of brass including the stop at the top, which is normally a separate piece, usually steel. As originally cast, the finished fusee snail spirals were shallow and rounded and meant for a gut cord but to provide the correct spiral for a thick chain the fusee was modified to a deep flat bottom channel with narrow sides and was most likely filed by hand. A fusee engine was not used as evidenced by the fact that the channels are at different depths in relation to each other and, in later times, a great many gut cord watches and clocks were retrofitted with fusee chains and the fusee was recut accordingly with flat bottom spirals.

The bottom of the fusee cone was originally drilled at an angle for a gut cord which would fit in a hollow in the fusee, in this case not completed as a chain was to be used. When the finish cut for the ratchet wheel at the bottom of the fusee had been made, the cord hole was revealed indicating that it had to have been drilled prior to the fusee being recut to accommodate a fusee chain.

*Figure 21 (left): Originally intended for a gut fusee this hole was drilled in the fusee prior to its modification for a fusee to accommodate a chain.*

*Figure 22 (right): The remains of the gut cord hole in the slot cut for the fusee. chain hook.*

At the time of finishing a very long slot for the chain hook was cut through the original gut cord hole made for the chain hook. The drilled hole all but disappeared and the only evidence of it being there are the slightly rounded sides at the top and bottom of the far end of the slot.

The Star of David Clock represents a very early example of the use of a fusee chain in a timekeeper. This is not a conversion after the fact but rather an upgrade installed during the making. To further this point, the ratchet wheel and teeth were cut not on the outside of the fusee as was customary in later timepieces, but rather on the inside of the fusee wheel, a very early example of that design.

*Figure 23: Edward East pre-hairspring calendar watch Ca. 1645 showing the fusee wheel four leaf pinion driving the hour wheel.*

Due to their poor timekeeping, pre-hairspring fusees were a unique design. There was only an hour hand which was mounted to an hour wheel on the dial side, and it was driven by an appropriate pinion attached only to the fusee wheel. By this means, the fusee cone was on a separate shaft from the fusee wheel so when the watch was wound the hour hand would not travel backwards. The fusee only engages the fusee wheel by means of the click and disengages upon winding as the fusee wheel is part of the gear train. Also, as part of this design, the fusee was held together by the top and bottom plates. In hairspring watches, the fusee and fusee wheel was held together by a pinned washer at the bottom of the fusee wheel. This design change would not allow the fusee wheel to drive the motion work which was then carried out by the center wheel and cannon pinion.

The pre-hairspring construction of the fusee in the Star of David Clock could allow it to run the hour hand of a single-handed timepiece as the fusee wheel attached steel bushing could have extended through the top plate with a pinion to drive an hour wheel.

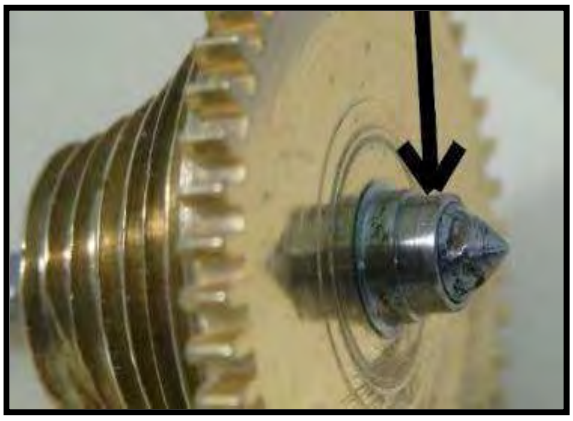


*Figure 24 (left): The steel bushing attached to the fusee wheel which if it were extended through the top plate would accommodate a pinion for an hour hand only timepiece.*

*Figure 25 (right): The fusee cord knot hollow persisted even after gut cord was long abandoned in favor of a chain and this style of fusee cannot be used to drive an hour hand as it travels in two directions.*

*Figure 26: The fusee and external click of Edward East #3, Ca. 1678.*

The movement shown above has an English style of external ratchet fusee wheel and click. This was a poor design as it left practically no material for the root of the teeth and a very thin section for riveting the click. As a result, often the teeth next to the click are frequently damaged or broken. Also, because of the very thin section, the click rivet hole can become, with wear, easily enlarged and the click loosened to the point where it fails. With so little material there it is a very difficult repair. This problem most often appeared in the later verge fusee watches when the watches became thinner and smaller.

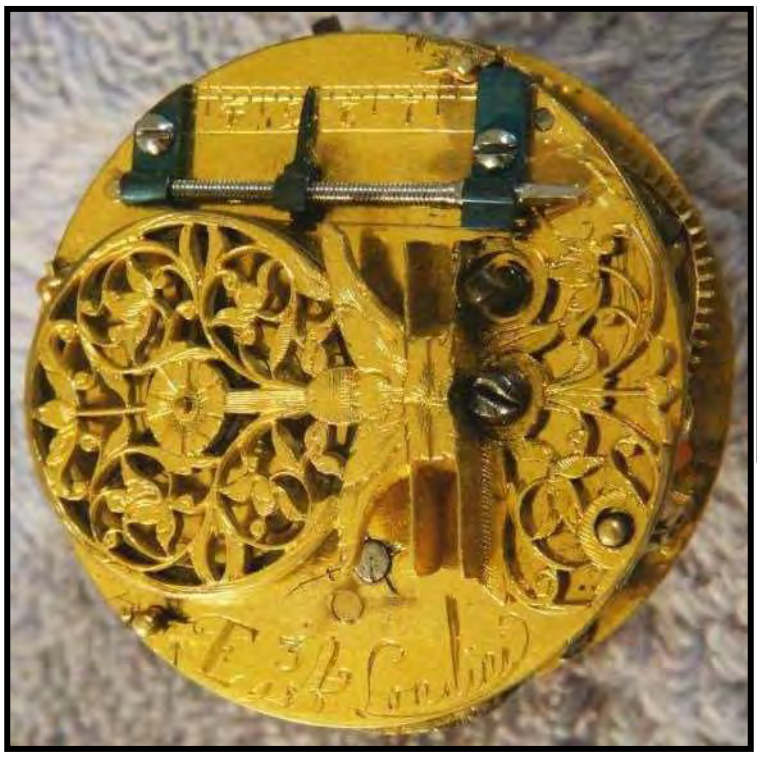


*Figure 27 (left): Edward East #3, Ca.1678, with a Barrow regulator is almost certainly his third hairspring watch. The original Barrow regulator was completely missing. The replacement was made by the author. Figure 28 (above): A most elegant fusee iron with a very unusual step design of the Star watch.*

It is almost certain that this is the third hairspring watch made by Edward East. The original Barrow regulator was completely missing. The period style regulator was made by the author using a period screw plate for the screws as well as the long, threaded regulator indicator arbor and screws. The free form balance cock foot also denotes the time period of the of this watch.

**The Fusee Chain:** The fusee chain itself consists of five sections of various lengths and widths, each of which were put together in later periods and subsequently joined to the original chain together with replacement later narrow hooks. Manufacturing of these early watch fusee chains was very much a new trade and as a result they could be unreliable. It is not uncommon to see these early fusee chains in early watches completely replaced by narrower chains of a later vintage.

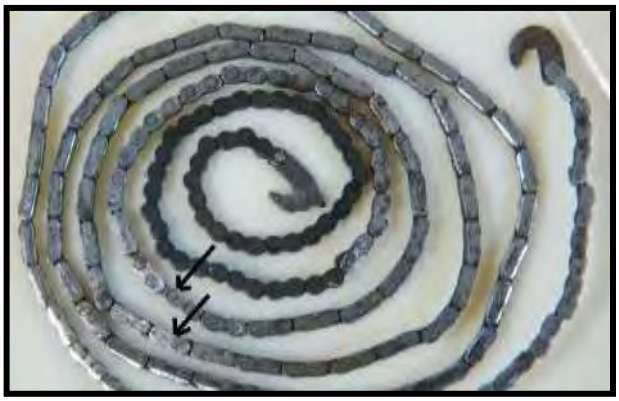


*Figure 29 (left): This is the most multi period chain I have ever seen comprised of 5 separate pieces. Actually, 7, if hooks are included. The pieces of chain below the arrows are the only possible sections of original chain.*

*Figure 30 (right): This is a correct period chain, notice the difference in these hooks that are handmade versus the much later stamped hooks in Figure 29. This chain is quite wide and cannot be used in a later timepiece with the long hook being made slightly curved to lay flat on the barrel. This appears only in earlier watches, not much later than 1680s, possibly somewhat later than that.*

One of the two portions of coil marked in Figure 29 may be the remains of the original chain. Based on the observation that the remaining portions of chain are much narrower than the grooves of the fusee, they clearly embody a different style and were manufactured later.

An original replacement chain of the correct period is currently used in the clock as evidenced by its size and shape (earlier hooks were wider and almost twice as long as later hooks) as the chain shown in Figure 30. The chain that came with the clock has had so many repairs that it could not be relied on and would be liable to break in use raising havoc in the gear train as well as the staff.

**The Gear train:** All the train wheel teeth are hand filed using a dividing engine and they are slightly beveled on each side with 45-degree deburring cuts at each corner of the roots of the wheels and are scribed with traditional circular layout lines, all very typical of this period.

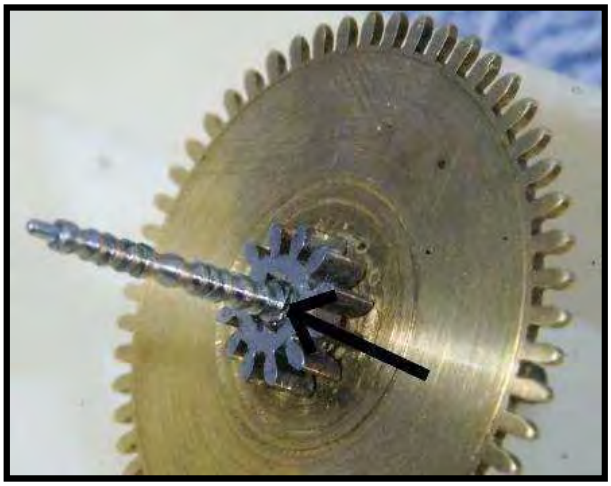


*Figure 31: The very unusual square mounting block of the arbor for the center wheel and the separate pinion along with the beautifully turned arbor is an extravagant and unique way of mounting the center wheel.*

The elegantly turned center wheel arbor and pinion are two separate pieces. Both the center wheel and pinion are mounted on a square hub of the center arbor making this design completely unique to this piece. (Pre-hairspring timepieces had no center wheel as there was no minute hand.) This became the design for watches with a minute and hour hands. A slot remains at the end of the cannon pinon, formerly a hole, that would have pinned the cannon pinion to the arbor.

The pinions are also hand filed and display the traditional teardrop profile with very narrow roots, as was typical of this period, shown in Figure 31.

*Figure 32 (left): These close-ups of the six leaf "tear drop" pinions beautifully turned arbors and collars illustrate the amazing finish details of this piece. Figure 33 (right): This hand gear cutting is typical of the period with the slightly rounded teeth, pointed addenda and the relieved roots.*

**The Escapement:** Starting with the counter potence, several highly unusual features attest to the extravagant finish work and age of the entire piece. In virtually all earlier and later pieces the escape wheel counter potence was riveted to the back plate with the early pieces having an "escape" slot through which the escape wheel could be installed or removed. However, in the case of the Star Clock, the counter potence is fastened by two nicely turned screws, leaving the "escape" slot as an unwarranted holdover from earlier watches. In this case, unlike the rest of the movement, the screws show considerable amount of use indicating that the escapement was taken apart and adjusted quite a few times. Both the potence and counter potence are of an unusual style and unique to this timepiece.

The depthing of the escape wheel to the staff is adjusted with a turned screw instead of the customary brass friction end piece typically found in English timepieces. The depthing of the escape wheel to the balance staff can dramatically affect the fast or slow rate of timekeeping and, in this case, the limited adjustment of the adjusting screw prevents any damage to the escapement as well. The screw slots for the counter potence and the adjusting screw for the escape wheel show an unusual amount of damage indicating that many unsuccessful attempts were made to try to make this escapement function correctly.

The escapement was erroneously set up for the earlier style of free balance with only two banking pins allowing for only 90 degrees or less of balance arc. This eventually resulted in a notch being created in the leading edge of the escape wheel because of a recoil action created by the bounce from the banking pins as well as the hairspring that made the leading edge of the staff pallets engage the impulse face of the escape wheel, see Figure 35. Since this problem was never resolved, the clock simply did not run for the better part of its existence. It was such a subtle and rare problem that not even the best watchmaker would look for it as it could occur only in a transitional timepiece such as this. This was an escapement problem that I had never encountered or heard of in 50 years of restoration.

To fix the problem, the original hairspring was replaced with a tempered hairspring of four coils. While this modification allowed the clock to run, it did so only for a short period of time and its ability to keep time was highly compromised. I replaced the hairspring with a correct, annealed, period hairspring of 1½ coils which brought the clock to time.

The question of why the clock would stop and start at the slightest nudge led me to investigate viewpoints that were nearly inaccessible, and I finally discovered that the pallets were becoming caught on the leading face of the escape wheel which led me to find the notches themselves on the escape wheel teeth. I realized then that what I thought were over-banking pins were instead banking pins and they were at the root of the problem as they were acting as part of the escapement, not over-banking pins. I then adjusted the banking pins to become over-banking pins and the balance took off in a very smooth, wide range of motion of about 120 degrees.

After approximately 340 years, the timepiece had been set free. This has been one of the greatest – if not the greatest and most exciting accomplishment of my long career of restorations. In this investigative troubleshooting I was also limited by the fact that I could not make irreversible changes to the piece. As this was truly a conservation restoration, problem solving was far more difficult and my options at experimental changes were severely limited. Because of my labor, the star clock runs well and keeps excellent time to the order of a few minutes a day. It is by the most extraordinary good fortune that a previous watchmaker was not instructed to make the piece run by any means necessary, such as an escapement conversion. This would have been a historical and mechanical disaster resulting in the loss of historical integrity that exists by very good fortune.

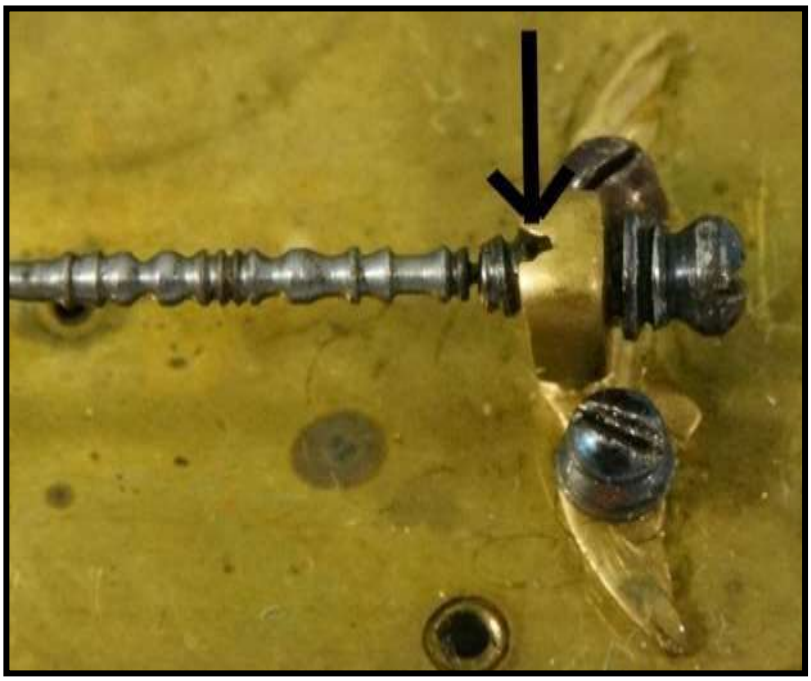


*Figure 34: The ornate, winged counter potence with the escape wheel arbor escape slot is unique to the pre-hairspring period as is the steel on steel adjusting screw. All three damaged screws resulted from numerous efforts to keep the clock running and/or bring it to time.*

*Figure 35: The potence together with the escape wheel centering slide upon close examination (arrows) reveal the two troublesome banking pins. A most elusive and subtle problem that I had never experienced before because it can only occur in a transitional balance timepiece, a period of about ten years. With verge hairspring time pieces overbanking was controlled by a single pin behind the staff opposite the escape wheel.*

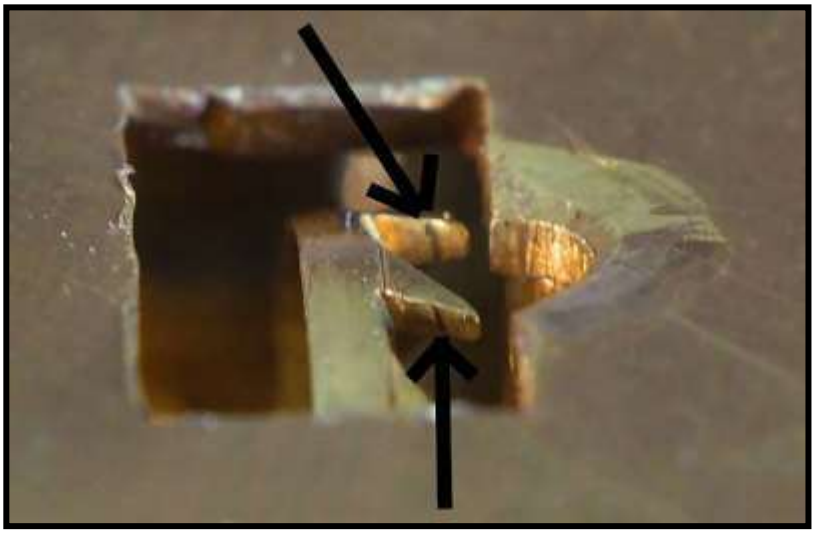


*Figure 36: The notching of the impulse faces of the escape wheel could easily escape detection as one would not be looking for such a unique problem and cannot be seen without taking the balance cock off and removing the balance.*

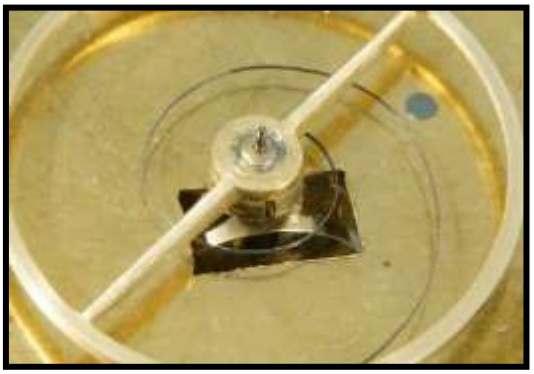


*Figure 37: An early style very unusual gold balance with only two balance beveled arms soldered and the staff with the correct period one and a half coil hairspring made up and fitted by the author.*

**The Hairspring and Balance:** The balance, made of gold (a very unusual material for this part, given the period), features two beveled arms and is soft soldered to the staff. The staff is well crafted, tapered, and blued and shows very little wear (as does the rest of the piece). The pivots are rather large, and the back side of the pallets are slightly curved, unlike English pallets, which are Flat on the back side.

The nicely executed staff in the classical manner shows very little wear consistent with the rest of the clock. The lower and upper pivots are rather large. The hairspring, with too many coils, as well as being hardened and blued, is of considerably newer vintage and much stronger than the original. It was probably added to make the clock run.

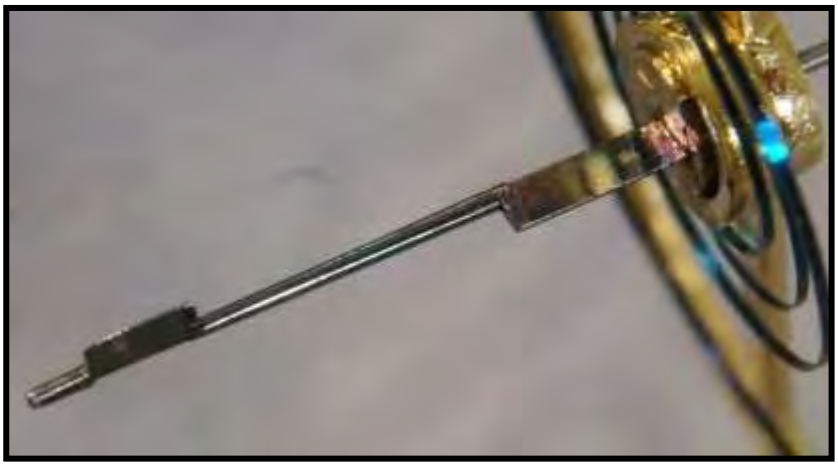


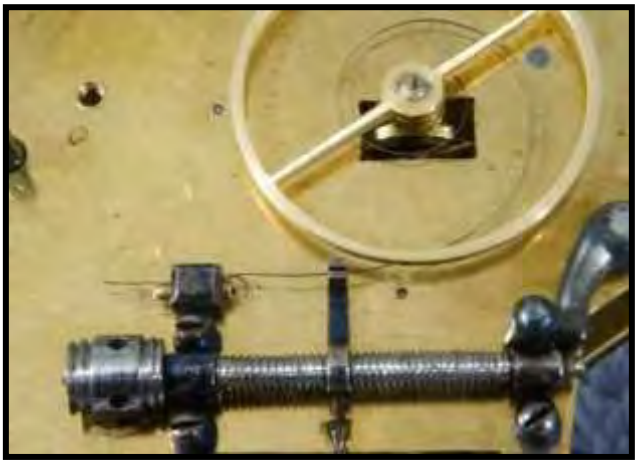
*Figure 38. The original staff has practically no wear and is very nicely executed in the classical manner. Notice the rather large upper and lower pivots shown with the very incorrect later period replacement blued and hardened hairspring of approximately four coils.*

Given that no standard method for pinning the hairspring to the collet had yet been established at such an early time, the hairspring was attached to the collet in an unconventional manner wherein the pin lies to the inside of the collet and the hairspring lies to the outside of the collet. Additionally, the hole for the pin and hairspring intersects the inside ring of the collet, so the taper pin must be flattened almost in half to make room for the collet hub on the staff.

*Figure 39: The hairspring in this case is correctly pinned to the outside of the of the collet pin, left to right, if pinned to the inside of the hairspring studding pin the hairspring runs into leading edge of the notch in the collet as well as intersecting the hole for balance hub. The studding pin is also flattened to accommodate the balance hub.*

In the case of the Star of David Clock, the taper pin for studding the hairspring tail enters the studding block hole from the inner coil side of the hairspring, as the hole is tapered from left to right contradicting the standard way of pinning the hairspring tail from right to left that was established shortly after the construction of this timepiece and has been in practice ever since.

As can clearly be seen here the active regulating length of the hairspring is fairly short (less than half the length of the regulator) as the hairspring regulating slot would intersect the balance and is another error that was overlooked at the time of finishing. This is just one of many mistakes made in the construction of this timepiece that would only be made by someone who had never built a timepiece of this design before.



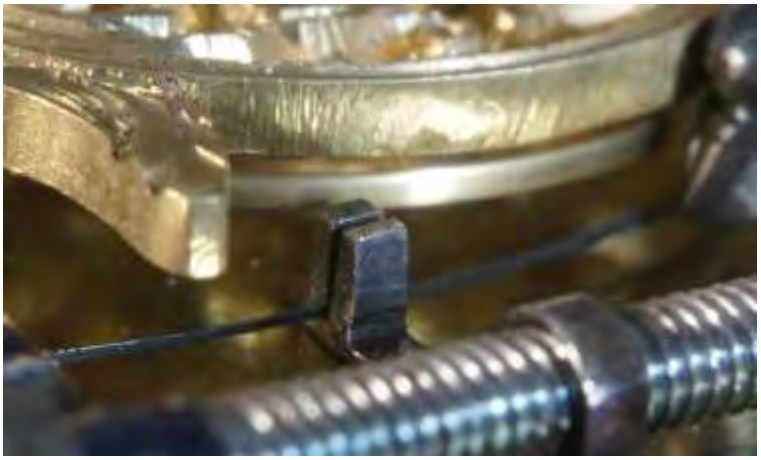


*Figure 40 (left): The finished hairspring of correct length and configuration for the active portion of the regulator is a correct period hairspring. The last adjustment made was an off set for the pinning of the tail as the hole in the studding block does not line up with the regulator slot. The longer end of the pin is the smaller end, pinned from right to left. Note that near the rim of the balance below and upper left are two pivot holes for the time train with no oil sinks.*

*Figure 41 (right): In a surprising mistake by the maker, the regulating slot is much taller than need be and it will run right into the balance in less than half the distance as provided by the regulator. If one proceeds further in that regard, it will either bend the balance rim or break the staff or both. This finishing error means that less than half of the regulator is usable. Notice how thick the balance cock is, well beyond the norm.*

**The Screws:** In early watchmaking, screws (even those without decorative turnings) were considered a luxury due to their hefty price tag based on the labor that went into their manufacture. Instead, watchmakers often used taper pins to secure the plates, fusee, motion work, and any other applicable pieces. In most cases, the original screws did not last long, as the hole threads were shallow and subject to wear and loose fit. If the piece were taken apart and reassembled numerous times, many of the original screws would have been replaced with larger plain screws of a later time period due to their propensity for deterioration in many cases due to a heavy-handed watchmaker.

The lesser screws in the Star of David Clock would take at least 2 to 3 hours to make with an electrically run lathe, carbide tooling, and high-grade threading dies due to the complexity of the process summarized by the following: 1. turn the basic screw out of larger stock; 2. turn the decorations with special gravers for the task; 3. turn the threaded section to size for the screw plate; 4. thread it (carefully); 5. polish the decorated section; 6. part off the screw; 7. finish the parted end; 8. slot the top; 9. harden it; and 10. anneal it. The longer screws would add another hour to two hours at best in the making. Threading with a screw plate is a combination of swaging and cutting the threads (hence the round bottoms) – a slow and difficult process.

The three screws (Figure 42) would have taken 9 to 10 hours to complete with modern tools, and in early times, it would have taken significantly more hours. In the Star of David Clock, all 11 screws remain intact and in place. All are ornate to a greater or lesser degree, meaning that they would have taken approximately 70 hours to manufacture (approximately 40 hours longer than with modern tools).

*Figure 42: These lovely hand-turned screws with V shaped filed slots were threaded with a screw plate having the characteristic shallow threads.*

**The Time Regulators:** There are two methods of regulating the timekeeping for the Star of David Clock; one is for regulating the timepiece by increasing or decreasing the active power of the mainspring, and the other is a Barrow regulator for adjusting the active length of the hairspring.

The worm mainspring with silver indicator dial and arrow found here was used exclusively in pre-hairspring pieces for adjusting the timekeeping, although a limited number of examples of post-hairspring watches retaining this feature do exist.


*Figure 43 (left): Lower is the Barrow hairspring regulator with the indicator numbers engraved on the back plate, upper is the mainspring setup worm with silver dial. Also seen are the case latches which are found in early English clocks for securing the back plate of the movement the case. Case screws were to be invented many years later.*

*Figure 44 (right): An elaborate worm and pinion mainspring set up mechanism for adjusting mainspring tension was used almost exclusively in pre-hairspring timepieces to bring the piece to time. In this case the adjusting barrel for the worm is fitted over the original key square barely visible at the lower end. The silver indictor dial is a very close fit with the balance cock such that the underneath of the cock had to be relieved to accommodate the silver dial. The single piece steel indicating arrow is a really neat piece of work.*

With the invention of the hairspring, the worm mainspring setup mechanism was then moved under the barrel between the plates, whereby, only a watchmaker's special shop key would be capable of setting the initial tension of the mainspring after assembly. However, if the owner possessed this key, he could also use it to adjust the mainspring accordingly. In most cases, when the initial mainspring tension was set, it was not changed. The disadvantage of this construction is that there was no indicator as to where the mainspring was currently set in relation to its previous setting.

The second time regulator is an English Barrow regulator that was commonly used between 1675 and 1682. It is only found on certain watches as it was somewhat cumbersome to use, hard to make, bulky, and resulted in a rather odd hairspring configuration. By 1682 it was surpassed by the Tompion regulator, which was more user friendly, compact, and designed to fit into the limited space around the balance and the regulating pins. When adjusting, the regulating pins followed the natural curve of the hairspring.

Both regulators were made in the conventional fashion, with square ends for adjustment using the watch key, but in the Star of David Clock, the square was inaccessible unless the movement was removed from the case. This is why the barrel ends were attached in relieved spaces in the plates. The craftsmanship for relieving the plates failed to live up to the standard of the rest of the piece, indicating that the barrels were added very late in the finishing process.

For adjusting mainspring tension the mainspring worm setup was used almost exclusively in pre-hairspring timepieces to bring the piece to time. In this case the adjusting barrel for the worm, lower, is fitted over the original square for adjustment with a key as there is no room to accommodate a key. (Figure 44).

*Figures 45 & 46: From observation, the watch cock of the Edward East watch (left) and the Starclock (right) are of identical design and style.*

For the most part, this is the final stage of the high relief watch engraving as seen on the Star clock, soon after cases were turned on a lathe and not cast; hence, they were thinner than the earlier cases which did not allow for high relief engraving. This was part of the bigger picture of watches becoming commercial, working timepieces instead of works of art.

The symmetrical engraving case is a most difficult style as the eye can readily see the slightest difference between the two sides. Eventually the high relief cases came back in to favor as repousse cases that were thin and stamped over forms and, as result, the raised sections commonly wore through with extended use.

*Figure 47 (left): Most likely one of the last of the English transitional watches, this wonderful coach watch made by Benjamin Bell that dates in the late 1680s.*

*Figure 48 (right) Together with the single hand, this type of the high relief watch engraving was in its final stages but to a lesser degree than that of the Star Clock as cases were now turned on a lathe. This was also part of the bigger picture of watches becoming commercial working timepieces instead of works of art. Eventually, the high relief cases came back in to favor as repousse cases that were thin and stamped over forms.*

*Figure 49: To drive the hour hand continuously, the fusee cone must ride independently on the shaft of the fusee wheel and hour pinion. The elegantly large barrel aperture is more than large enough to accommodate a cord knot which by now would have been out of date. Like many other customary styles started early on, the aperture in the barrel lid now was only used for removing the barrel lid as well as establishing the location of the lid on the barrel at the chain hook hole. Consequently, the aperture was much smaller and very plain.*

**Conclusion:** It is said that one never totally understands a subject until they have to teach it. In this case I have been led down the path of examining in great detail every aspect of this piece and categorizing them step by step through every aspect of a timepiece of this period. Many of the comments and questions that I have received have also helped me in devising a systematic method of examination. To the best of my abilities, I have reached conclusions which I believe are based on unbiased facts. These are taken from observation - not preconceived objectives - always letting the piece reveal to me what it is and not manipulating any information at any time to fit some a set of standards as to what the clock should or should not be. As can be seen, there are a several unique features in this piece making it even more interesting. It is a good illustration of how varied and wonderfully executed these early timepieces can be and that makes them all the more interesting. If you approach a clock or watch with a blank pallet it will render so many colors if you just let it do so.