Making a Gold Passing Spring for an English Box Chronometer

An Integral Part of the Detent Escapement

Peter Toot

The dominance of the lever escapement and the development of new technologies that made the marine chronometer obsolete have dramatically reduced the number of detent escapements that need service. As a result, many horologists are perhaps unfamiliar with their function, adjustment and repair. One possible issue watchmakers might need to address in servicing a detent escapement is a damaged or missing passing spring. This article will outline the steps involved in making a gold passing spring for a detent in an English box chronometer and its adjustment once installed in the movement. This method will also apply to pocket chronometers and carriage clocks with spring or pivoted detents though the dimensions and shape of each passing spring will be specific to its detent.

James Poole & Co., a well-known London maker, produced the chronometer for which this passing spring was made, **Figure 1**. Its serial number 5679 dates production to circa 1876.[1] The chronometer is of typical English design with fusee and chain, four pillars and a white metal balance spring. It also features Poole's auxiliary compensation balance. English chronometer design had become highly standardised by the time Poole & Co. made this piece.[2] Rough movements were typically made in Lancashire and then sent to London makers who completed the chronometers. Though highly standardised, there can be subtle differences from detent to detent that will affect the dimensions of the passing spring and a one-size-fits-all passing spring is not possible.

Poole & Co. no. 5679 was purchased at auction in Florida, USA in 2019. It is not clear when it had last been serviced or run. An inscription on the back of the dial reads 'Therezo – Brasil 12-10-1970' and it seemed possible from the general condition of the chronometer that this marked the last time it had been serviced. The chronometer contained a detent with a passing spring made of copper. It was assumed that the passing spring was not original to the chronometer, based on its coarse finish and the fact that it was made of this metal. Passing springs had typically been made of gold since early in the development of chronometers. While it can be challenging to understand the thought process behind previous repairs, a paper shim had been placed under the front of the detent foot apparently to allow the oversized replacement passing spring to clear the impulse roller. By removing the copper passing spring from the detent and reshaping it, the impulse roller cleared the top edge of the spring without the paper shim under the detent. The escapement was functional in this state but there were also two small kinks in the spring that led to doubts about its continued functionality. Marvin E. Whitney suggests that the tip of a copper spring will wear quickly.[3] Based on those facts and the desire to use historically accurate material, it was decided that a replacement gold spring should be made.

Figure 1. James Poole & Co, no. 5679, from 1876.

The first step in making the replacement passing spring is to purchase a piece of 32-gauge 10 carat gold. A piece measuring 3 mm × 76 mm should cost about USD 27. The 32-gauge metal will measure about 0.25 mm thick. The gold must be reduced in thickness to less than 0.06 mm at its point of flexure so as not to draw too much energy from the balance on the dummy pass. The gold should first be thinned to 0.09 mm with a rolling mill. At this thickness the springiness should be felt in the hand. Going further on the mill risks work hardening and cracking. Thinning to this thickness will have stretched the gold significantly and the excess should serve to make at least six more passing springs, meaning that the cost of material for each spring is small.

Once the gold has been thinned, a drawing with the dimensions of the finished spring should be made. To be able to make both this drawing and the spring itself correctly, it is important to have a complete understanding of how a detent escapement works and to be able to visualise the interaction of its pieces during function. There are several essential books that cover detent escapements well, including Whitney's *The*

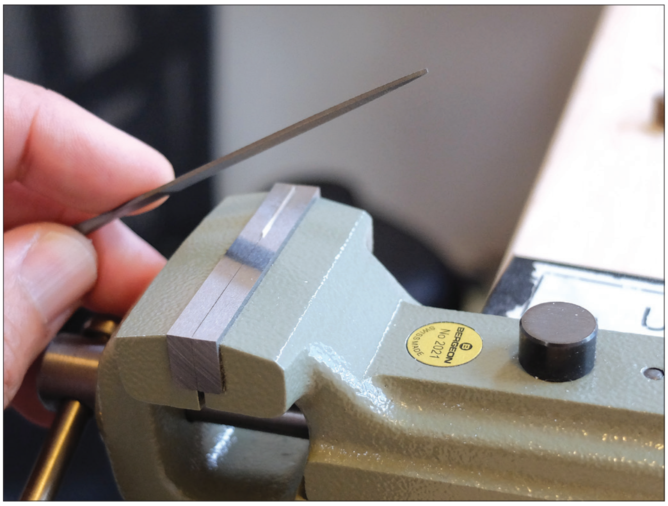


Figure 2. Using a file to shape the gold spring clamped in a vice.

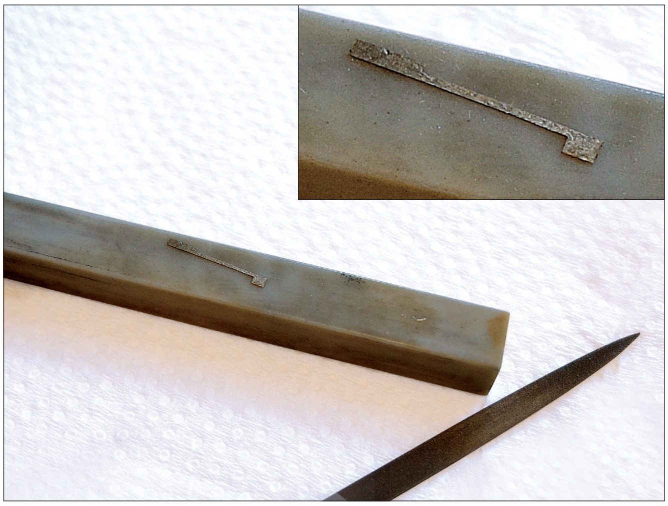


Figure 3. Deburring the spring on an Arkansas stone.

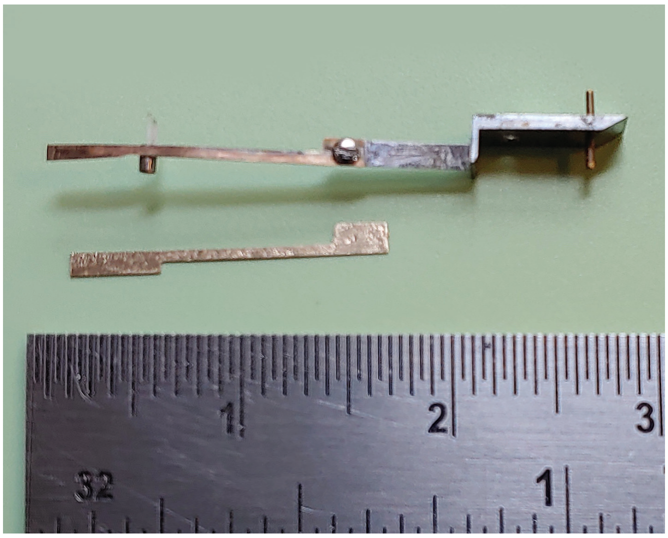


Figure 4. The unfinished gold spring next to the detent with the existing, reshaped copper spring in place.

Ship's Chronometer and *Mercer Chronometers: History, Repair and Maintenance* by Tony Mercer.

With a thorough understanding of the escapement, remember the following when making the drawing of the spring:

1. The detent pipe must be able to return to the banking screw and briefly rest flat against it for correct lock. This means that the passing spring should not touch the banking screw at any point.
2. The passing spring will be curved so that it only contacts the detent where it is screwed to it and at the tip of the detent horn. Allow at least one additional millimetre of length in the design to account for this curve.

Metal snips can be used to cut the gold to rough dimensions. Some snips slightly bend the edge of the gold. A razor blade may also be used to cut the gold: draw the blade over the top while the gold is clamped in a small vice.[4] Make a trial cut to see if this is the case and if so, account for it in the dimensions as the bent edges will have to be removed. The gold may then be cut into a rectangle of the approximate overall dimensions of the spring as per the design, leaving about 1 mm extra overall in width and length, which is in addition to the extra 1 mm minimum for the curvature of the spring. A razor blade may also be used to cut the gold while it is clamped in a small vice. The razor blade is drawn over the top of the vice jaws, cutting off the excess. This will curve the piece being removed but avoids bending the rectangle from which the spring will be formed and allows for cutting closer to the final dimensions. Drawing the blade along the jaws can pull the gold out of the vice. The vice must be closed tightly on the gold strip to be able to cut accurately and the vice jaws must be clean and unmarred so as not to scratch or damage the gold.

Once the rectangle has been cut, begin shaping the spring according to the dimensions of the drawing by clamping the gold in the vice and using small files. No more than 1.5 mm of the gold must be visible above the vice jaws, **Figure 2**. If more is left free, the spring at this thickness is inclined to bend from the cutting motion of the file. The filing may begin on the top or bottom of the rectangle. An oiled India stone passed over the gold in the vice can help level out lengths and also smooth the finish on the edge of the work. It is important to deburr the piece frequently by passing it over an oiled Arkansas stone, **Figure 3**. This prevents clamping problems and damage to the gold due to burrs.

Once the shape of the top and bottom of the spring has been formed, the slot which will fit under the passing spring screw can be made using a needle file. This slot permits the passing spring to be moved forward or backward along the detent to increase or decrease the engagement of the passing spring with the unlocking stone. Clamp the gold into the vice vertically and proceed using the same method outlined above, clamping and filing and then repositioning the spring in the vice and filling again.

It is advisable to remove the spring from the vice frequently to check progress. Most of the work will not be visible while filing and it is easy to file too far or out of square. Also be sure that the work is always well-clamped, especially when horizontal. If not, filing an unclamped tip can push it down in the vice and bend the gold along its length.

When the slot has been cut, deburr the entire spring by rubbing both sides of the spring on an oiled Arkansas stone. Fit the passing spring to the detent without fully tightening its screw, to check overall dimensions. The spring should

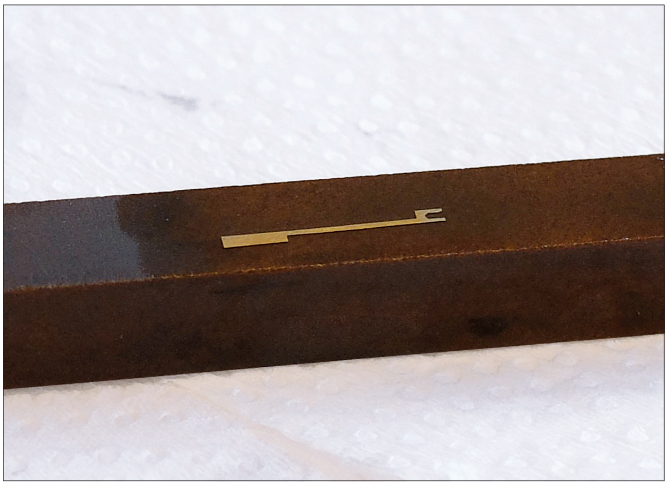


Figure 5. Thinning of the spring on an India stone.

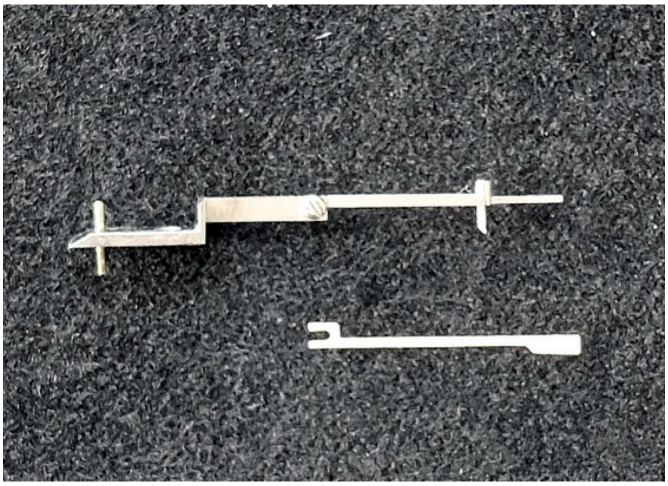


Figure 6. Finished replacement spring next to the detent.

protrude about 2 mm beyond the detent horn. This protruding tip should have been filed only to square as the last step in the filing, removing as little as possible while leaving the spring long. The length can be adjusted by where the screw sits in the passing spring slot and it can also be filed back slightly if necessary as the last step in fitting.

Once the spring meets the final dimensions with the length just slightly long and the fork shaped, it is time to thin the spring to functional thickness. Begin the thinning with an India stone, **Figure 5**. Rub the spring on the oiled stone using the tip of your finger, being careful that the tip of the spring does not get caught on the stone. Although springy, the gold at this thickness is now easily bent. If kinked, the piece must be discarded.

The finished passing spring will be curved so that it clears the locking stone pipe and only contacts the detent under the screw and at the tip of the detent horn. To help avoid catching a tip of the gold on the India stone during thinning, the spring can be lightly rolled to produce a curve along its length. This is achieved by placing the spring flat on a bench mat and rolling a cylindrical object along it under some pressure. Be sure that the cylinder and the face of the spring are parallel to each other at the point of contact so that the resulting curve is not twisted relative to the detent.

The spring should not be thinned on the India stone uniformly along its length. The thickest areas should be at the slot where it is fixed by the screw, and at the opposite tip. From those ends, the thickness should diminish to the area midway between the spring's fixing screw and the locking stone pipe, which is where the flexing should take place. In the case of the Poole chronometer, the finished replacement spring measures 0.07 mm thickness at the tip and the slot, diminishing to 0.05 mm at the point of flexure ahead of the screw.

It is important that the spring not be too stiff. This will rob amplitude from the balance during the mute or dummy pass. Roger Stevenson recommends testing the spring while screwed to the detent with hand bellows. By blowing air directed at the tip of the spring, it should separate from the detent horn as it would in the dummy pass. Once approaching final thickness, the India stone can be replaced by the Arkansas stone to provide a finer finish. Remember to deburr the spring and to clean it of oil before fitting to the detent. Any residual oil will make it more difficult for the spring to separate from the detent and impede proper function. **Figure 6** shows the finished spring and detent next to each other.

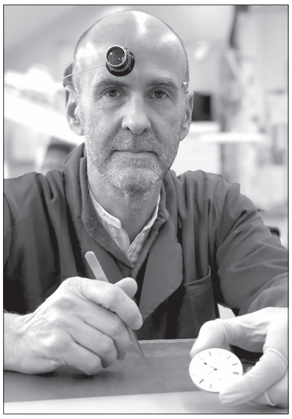
Once the spring has been fitted and screwed to the detent, check that its curve is sufficient to clear the detent. If it is not, then repeat the bending process with the cylindrical object on the bench mat, then install it in the chronometer and check that the top edge clears the impulse roller. The detent pipe should rest flat against the banking screw and no part of the passing spring should touch that screw. The passing spring should not touch the unlocking roller but its tip should engage with the unlocking stone. This depthing should be set in the following way: apply pressure to the fourth wheel to provide some power to the escapement and bring a tooth of the escape wheel in to lock on the locking jewel. Use pegwood to rotate the balance clockwise through a dummy pass, watching the passing spring separate from the detent and return to it after the unlocking jewel clears. Then move the balance in the opposite direction and note how far the unlocking jewel moves from its resting position against the banking. Whitney advises that the stone move the distance necessary to release the tooth plus half that distance again.[5] If the jewel travels too far, the passing spring needs to be shortened, either by moving it toward the detent foot by unscrewing the passing spring screw and repositioning the passing spring, or by filing the tip of the passing spring while still attached to the detent.[6] If the locking jewel is not moving enough in its arc, then the passing spring should be moved farther toward the horn of the detent. This can be done only by unscrewing the passing spring screw and repositioning the spring.

The lift of the passing spring during the dummy pass should be equal to the lift of the detent during unlocking. The correction for any imbalance in lifts is to bend the detent horn. This is a delicate process and must be performed only if the horn has been tempered.[7] There are several other adjustments to the escapement that must be made for a detent escapement to work ideally. These are not directly related to the passing spring and therefore will be left for the reader to discover in the books cited.

The making of a passing spring requires thorough understanding of the detent escapement in general and careful planning with regard to the specifics of each example. Detents have a reputation for being delicate and they certainly should be handled with care while making the passing spring, but they are remarkably sturdy for their diminutive size. The making of the passing spring for a detent is well within the reach of watchmakers with good filing skills and patience.

ENDNOTES

1. Tony Mercer, *Mercer Chronometers: History, Maintenance & Repair* (Derbyshire, Mayfield Books, 2003), p222.
2. Jonathan Betts, *Marine Chronometers at Greenwich* (New York, Oxford University Press, 2017), p102.
3. Marvin E. Whitney, *The Ship's Chronometer* (Cincinnati, American Watchmakers Institute Press, 1991) p188.
4. Technique shared by Tobias Birch, in discussion, June 2019.
5. Whitney, op cit, p152.
6. Ibid., p153.
7. Mercer, op cit, p190.



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