Dealing With Escape Wheel Problems

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One of the most worrisome conditions to find in any movement is an escape wheel with damaged teeth. For most of us, it is the first thing we look for when handling a movement since restoring a mangled escape wheel can be nearly impossible. There are times, in fact, when the task appears so daunting that a new wheel seems to be the only solution. Experience has taught us the movement is virtually guaranteed to exhibit time keeping problems if the condition isn't properly dealt with. But replacing an escape wheel should be considered a last resort since there are techniques which can restore even badly damaged escape wheels to their optimum performance. Practicing these techniques turns a nearly impossible task into routine.

The Pliers

A proper pair of pliers will make all the difference when making repairs to slender escape wheel teeth. The jaws will need to be smooth and the tips narrow. Serrated jawed pliers will mar the teeth, causing further damage, and a jaw tip which is too thick won't allow the necessary range of motion. A good pair of pliers can be made from those readily available with only slight modifications. Figures 1 through 3 show an example.

Fig. 1: A pair of pliers which will work well for straightening escape wheel teeth.

Fig. 2: A readily available pair of pliers (left) can be easily modified for escape wheel repair.

Fig. 3: A pair of flat-nosed pliers showing the areas to be relieved.

Finish the modified surfaces of the pliers to match the rest of the plier body. This is more for aesthetics and professionalism than it is for function. This pair of pliers will quickly become your favorite tool and a rough, ugly finish on the jaws will be a major distraction.

Examine the Wheel

The first step is to determine whether the escape wheel will need any attention. Problems with out-of-round or slightly short teeth can be very difficult to identify. Bent or damaged teeth are easier to see, especially using an eye loupe. This type of damage will often show up as a discoloration on the tooth; either as a bright spot, where the tooth has been nicked, or as a dark area where a bend is creating shadow. (fig. 4)

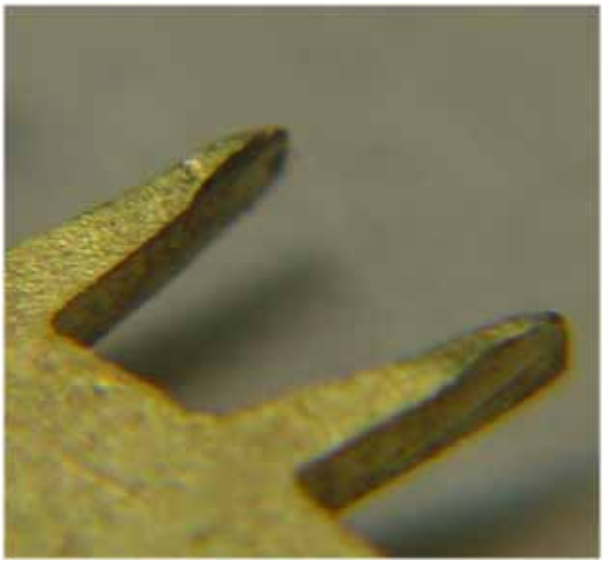

Fig. 4: Two escape wheel teeth showing slight damage. Note the irregular line along the tooth face, which can be easily seen with an eye loupe.

It is often easier to *feel* subtle problems rather than see them. Just before polishing the pivots, while spinning the wheel in the lathe, lightly rest a finger on the spinning escape wheel. (fig. 5) Feel for:

Roughness: Indicates a bent, damaged, or short tooth and can also indicate poor indexing
A bump: Indicates a damaged or short tooth
Pulsing: Indicates an out-of-round escape wheel

A light touch on the escape wheel should produce a soft, smooth feel. If any of the above is present, examine the escape wheel under magnification and determine where the problems are. This should be done after any truing of the shaft, of course, since a bent shaft will produce a similar result. Postpone polishing the escape wheel pivots until all of the problems with escape wheel teeth have been addressed.

Fig. 5: A light touch on the edge of the spinning escape wheel, just prior to polishing the pivots, will allow you to feel a problem.

Examine the escape wheel from the side as well as on edge, paying particular attention to the tips of the escape wheel teeth. If there is a tooth out of alignment, it can be straightened easily at this point, while the wheel is in the lathe. This will give better control and leverage while straightening the tooth. (figs. 6 & 7)

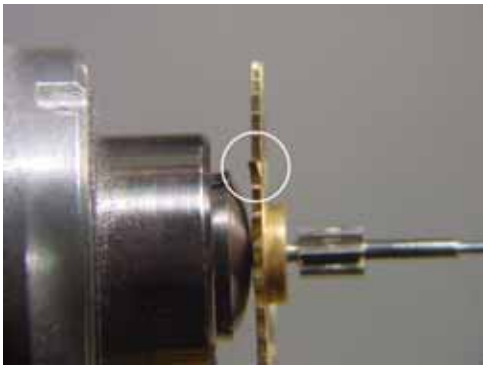

Fig. 6: Tooth bent out of alignment.

Fig. 7: Straightening a misaligned tooth.

The escape wheel should also run true in the flat, without any wobble. Large variations may require using pliers to straighten, but most can be done with the fingers. A pinching or twisting action works best. (fig. 8)

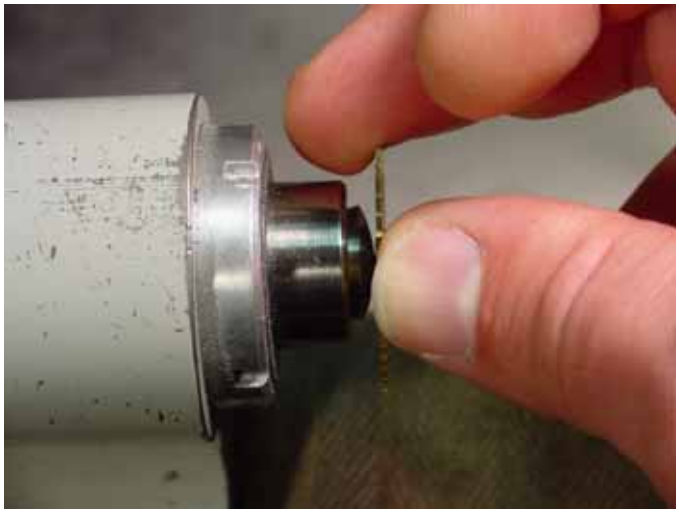

Fig. 8: Bringing the escape wheel back to true.

Drawing Escape Wheel Teeth

Bent teeth and tooth tip damage can be corrected with a process which involves pulling the teeth straight. This process, called *drawing*, is done by gripping the tooth with the plier jaws and pulling the pliers off of the tooth while simultaniously gently squeezing the pliers. (fig. 9)

The amount of pressure applied to the tooth while drawing is as important as the attitude and direction of the pull. Too much jaw pressure against the tooth will raise a burr on the

outer edge causing significant thinning and weakening of the tooth. Too little pressure and the tooth won't straighten. This process will also stretch the tooth slightly, which is advantageous in the case of a short tooth. Holding the pliers in a somewhat less than square attitude will cause a twist in the tooth, visible at its tip. The direction of the pull should be parallel to the flat face of the escape wheel tooth. Note that this direction isn't always radial!

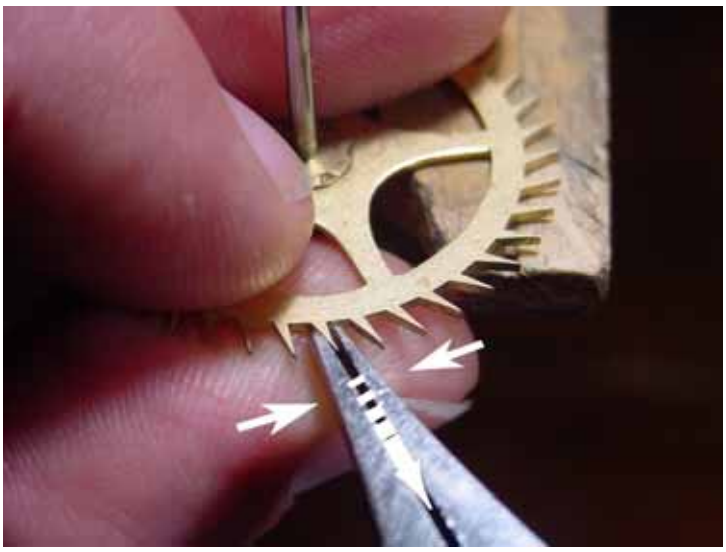

Fig. 9: Drawing escape wheel teeth to straighten. Note--The work is being well supported.

This technique will work best if done with plenty of support and in a consistent manner. Very good results will be realized when drawing all of the teeth but this must be balanced with the need to do so. If only one tooth requires attention, it is not an advantage to draw all of the teeth. Conversely, if there are very few teeth which don't need attention, better results will be had by getting in a rhythm and drawing them all.

Planish the Teeth

Another technique, which can be used in conjunction with drawing, is called *planishing*. (fig. 10) Lightly hammering on the sides of the teeth with a glancing blow will harden, flatten, and stretch the teeth as well as smooth out any burrs caused by the drawing process. This should be done with a brass hammer so as not to leave marks on the rim of the wheel or tooth. Good technique and support is as important for planishing as it is for drawing. The direction and force of the blow must be carefully controlled so as not to cause damage to the wheel or teeth. Blows which are too aggressive will cause the wheel to become severely out-of-round, so be light handed. Watch for the changes in the surface of the teeth rather than just blindly bashing. Care should be taken to use the flat face of the hammer and not catch an edge which will leave a dent in the wheel.

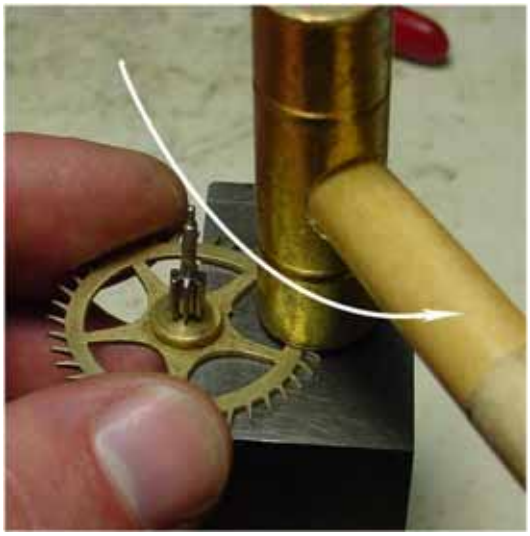

Fig. 10: Planishing the escape wheel teeth. Light, glancing blows will flatten, harden, and slightly stretch the teeth.

The blows of the hammer should be glancing and in a direction parallel to the flat face of the tooth. This will keep the tooth straight and minimize indexing errors. Support the wheel on a bench block and get in a rhythm as the wheel is rotated. As with drawing, planishing the whole wheel will produce the best results. Sometimes it is necessary to flip the wheel and planish the other side as well, but too much will distort the wheel.

Indexing the Teeth

The evenness of tooth spacing is difficult to visualize without something to use as a reference. Teeth that are grossly bent out of position will be fairly evident, but those that are bent gradually or at the root may be more difficult to identify. An easy and quick method to visually identify teeth that are poorly indexed is by using Rodoco, a clay-like material, to make an impression of a good area of teeth. (fig. 11) This impression can then be used as a reference for the rest of the wheel. (fig. 12) Examine the teeth under magnification and true any which are poorly indexed.

Fig. 11: Make an impression in the Rodoco of a section of good teeth to use as an indexing reference.

Fig. 12: Use the impression to compare the spacing of the teeth on the rest of the escape wheel.

Tip Escape Wheel Teeth to True

With all of the drawing, planishing, bending, and straightening of the teeth it is very likely they are now different lengths. In order to bring the escape wheel back to true following these processes, or round up a slightly oblong wheel, it will be necessary to accurately tip the teeth. This should be done before the pivots are polished since you must chuck up on the pivots for accuracy. (fig. 13) *Note: If a wheel is extremely out-of-round, it may be better to remount it. Also, it may be necessary once the wheel has been rounded up, to file back the thicker tooth tips so they are consistent.*

Fig. 13: Turning the escape wheel on the pivots will offer the highest degree of accuracy when tipping the escape wheel teeth.

There are several different methods of tipping the escape wheel teeth depending on the tools available—but in all cases, support is the key. The following are just a few examples:

1. File and T-rest method—(fig. 14) This method doesn't require expensive tooling but it does require a careful touch. Even a slight slip of the hand could cause severe damage to the escape wheel teeth. It involves resting the file on the T-rest and rocking it into the escape wheel teeth. A careful adjustment of the T-rest is important so as to offer as much support as possible. There are a number of disadvantages to this method but an inability to accurately limit the amount of material removed from the teeth is the biggest drawback.

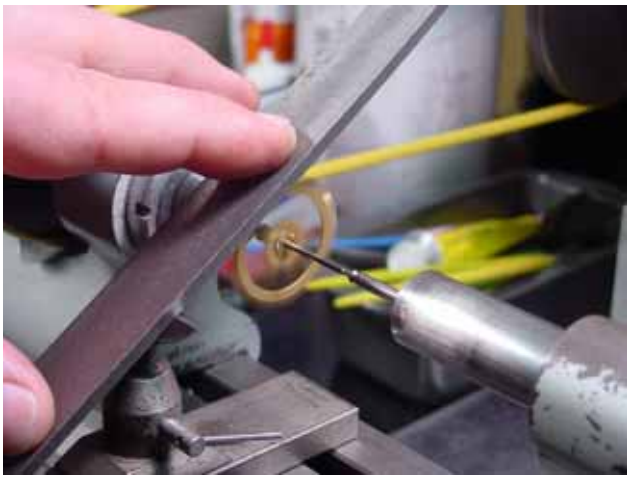

Fig. 14: Using a file and T-rest to machine the escape wheel to true. (There are better ways.)

2. Hand graver method—(fig. 15) Slightly better than filing, this method allows you to *see* how much material you are removing from the escape wheel teeth. It still lacks the ability to accurately regulate how much material is removed however. The hand graver should be sharp and properly supported on the T-rest. The T-rest must have a smooth surface to allow unimpeded travel of the graver and it should be properly presented to the escape wheel.

Fig. 15: Using a hand graver to tip the escape wheel to true.

3. Cross-slide method—(figs. 16 & 17) The most accurate method of tipping the escape wheel teeth is with the use of a cross-slide. Either a screw feed or a lever feed (with stops) cross-slide will allow you to see how much material is removed with the added advantage of limiting how much material is taken off. A properly shaped and sharpened tool bit is a must!

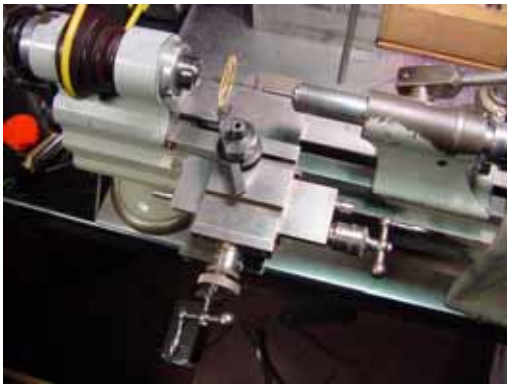

Fig. 16: Tipping the escape wheel teeth with a screw feed cross-slide.

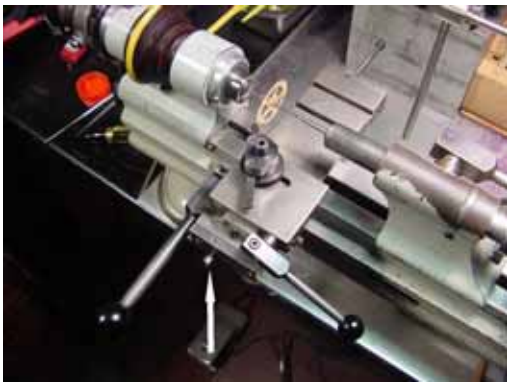

Fig. 17: Tipping with a lever feed cross-slide. Note the stop limiter at arrow which allows control of how much material is removed.

Regardless of which method is used, there are certain procedures to follow when tipping the escape wheel teeth.

The wheel should be machined in a direction such that the burr occurs on the non-working face of the escape wheel teeth. This will preserve the acting face of the tooth when the burrs are removed.

Only remove as much material as necessary. Watch for teeth that show dark tips. This will indicate a tooth which is too short and that more machining is needed. The machined teeth will show up bright and shiny at the tips, while the short teeth will be dark and dull. (fig. 18) Once every tooth shows a bright tip, the wheel is round. Not every tip must be totally machined, however. If there is only one tooth remaining which shows a slight machine line, the wheel can be considered true. (fig. 19) It is better to stop machining at this point rather than remove too much material.

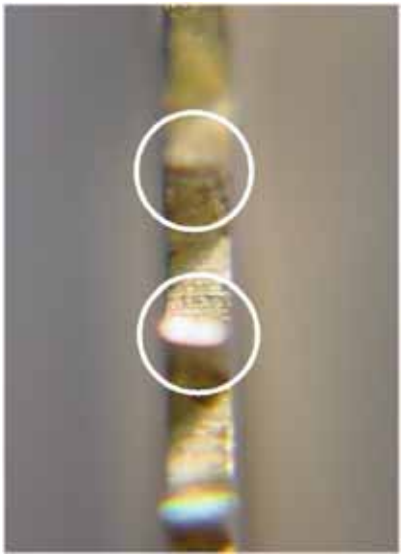

Fig. 18: Looking through a loupe, machined teeth will show a bright tooth tip (bottom) while short teeth will be dark (top). Dark teeth indicate more machining is needed.

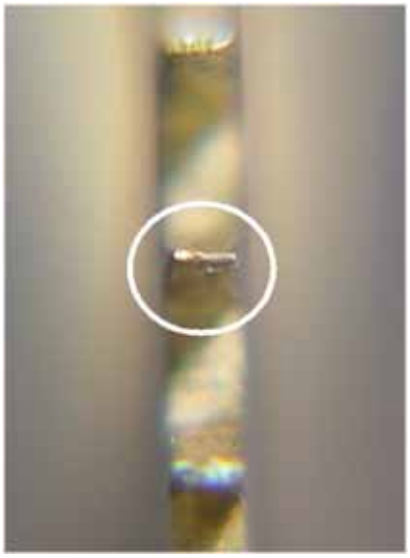

Fig. 19: The wheel can be considered true when the last dark tooth on the wheel just barely shows a bright spot.

Once the teeth have been machined true, examine the tips for twisting. (fig. 20) This is usually caused when drawing the teeth straight and is a symptom of the pliers not being held square with the teeth. This condition must be corrected for the escape wheel to function properly. Simply twist the tip of the tooth with the pliers until it is straight.

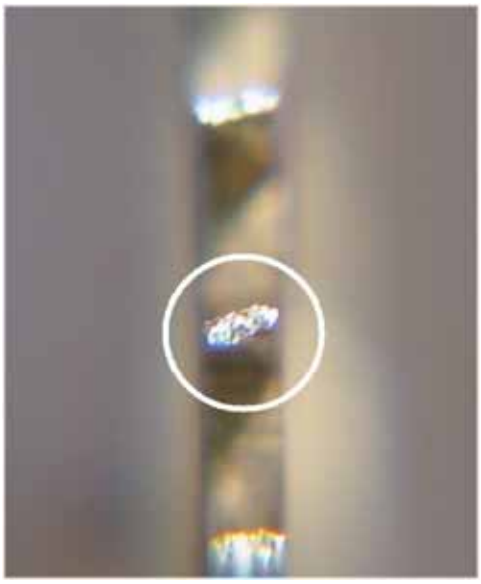

Fig. 20: A twisted tooth tip. This is probably due to faulty technique during the drawing process. Following tipping, these twisted teeth should be straightened.

De-Burring the Escape Wheel Teeth

Once the escape wheel teeth have been tipped, they will be left with a slight burr which must be removed. One of the quickest and easiest ways to do this is to spin the escape wheel on the buffer. (fig. 21) Present the side edge of the escape wheel to a brass bristle buffing wheel. A brass wheel is used so as not to damage the brass escape wheel. Let the escape wheel spin in the fingers with just enough pressure on the shaft to give slight resistance but with enough control that the escape wheel can't get away. If the buffer grabs the wheel and tears it out of our fingers…

Fig. 21: De-burring the escape wheel teeth by spinning on the buffer. Note a brass brush is used to prevent damage to the wheel.

An added benefit of spinning the wheel on the buffer is that it removes the particulates embedded in the teeth which cause ruts in the pallets. The particulates are steel (from the pallets themselves), dirt, and dried oil. Since the brass is softer than the steel particulates, the steel becomes embedded in the working surface of the teeth creating a charged lap. To reduce the amount of future wear on the pallets, the escape wheel should have these particulates removed even if not de-burring.

The burrs can also be removed with a file if a buffer isn't available or if spinning doesn't completely remove the burrs. (fig. 22) Support the wheel and use a consistent motion when filing. That may mean you have to count your filing strokes in order to be able to dress each escape wheel equally. Feel the back of the tooth with a fingernail to be sure the burr is completely gone.

Fig. 22: Removing burrs by filing. Use consistent strokes to be sure each tooth is treated the same and support, support, support.

Check the Indexing One Last Time

Check the spacing between the teeth again using Rodoco. It is possible for a tooth to be bumped during all of the handling and it is preferable to be sure everything is correct before the escape wheel is in the movement. Make any adjustments necessary.

Final Results

Polish the escape wheel pivots and then take one last look through the loupe at the escape wheel teeth. The idea is to have improved the quality of the teeth and not caused more damage. (fig. 23) Once the escape wheel is installed, be prepared to make adjustments to the escapement drops. Drawing and planishing will lengthen the teeth but not always enough to compensate for tipping. When it is all done, sit back and enjoy the results!

Fig. 23: Once all of the drawing, planishing, indexing, tipping, buffing, and filing is done, the damaged teeth should look much better.

Special thanks to Jerry Faier, CMC for his training and expertise. Most, if not all, of the techniques described in this article are from Mr. Faier's apprenticeship training. Any mistakes or inaccuracies are mine.

Dedicated to Charles Baldwin, CMC who passed away 12 October, 2004–A great man of God and a good friend. We'll miss you Charles!