A balance vibrating tool – 10

by Guy Gibbons

Preliminary timing

One thing that will be useful to know is the effect of the length of the balance spring on the number of beats per hour. Initially I suggest you install the balance spring cropped with one full turn; if you do you will find that the number of beats per hour is quite low (around 16,000 bph), so it will need cutting to an even shorter length in order to achieve 18,000 bph. Of course you may wish to achieve 14,400 bph suitable for a marine chronometer in which case the longer, $11^1/_2$ turn spring is more suitable.

For the 10-turn 18 mm outside diameter balance spring suggested we can calculate the very approximate effect of a length reduction on the increased number of beats per hour (bph) and this is tabulated below.

removal of one complete turn	percentage increase in bph	o/dia. of balance spring (mm)
(none)	0%	18
turn 1 (outer turn)	7%	16.7
turns 1 & 2	13%	15.4
turns 1 to 3	19%	14.1
turns 1 to 4	24%	12.8

Example: 1.4 mm thick steel balance wheel, mass 1.8 grams fitted with an uncropped 10 turn balance spring 18 mm dia.

Required bph = 18,000, timed bph 15,120

Therefore the percentage increase required =

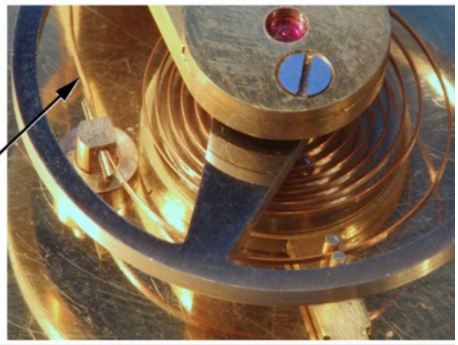
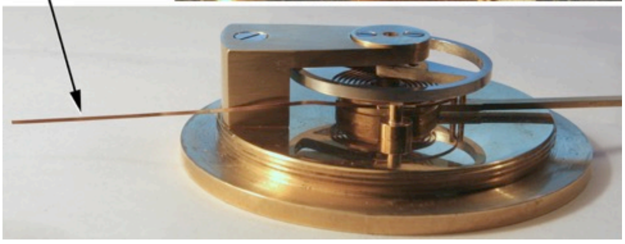
= 100 x (18,000 – 15,120)/18,000 = 16%

From the above table, this suggests about $2^1/_2$ turns in total need to be cut off the balance spring.

Ideally the balance spring is about half the diameter of the balance wheel or slightly larger, so if you need to remove more than four turns you should consider reducing the thickness (and hence the mass) of the balance wheel or (if possible) selecting a stiffer spring.

You do not need to make the joggle at this stage or whether it 'breathes' particularly evenly as it oscillates, but do make sure that the coil one turn in from the outside of the balance spring does not touch either the innermost surface of the inner curb pin or the inside of the stud when set oscillating; not only will this affect the period of oscillation but the friction caused by the spring coil dragging on the touching surface will quickly bring the balance to rest. Some careful manipulation of the balance spring may be necessary to make sure this doesn't happen, and if you have set your curb pins to the dimensions shown on the drawing, probably the best way to do this is to remove one complete coil (turn) from the balance spring before even starting.

With the balance spring fitted to the balance staff and the tool fully assembled, thread the outer end of the balance spring through the stud and pin with the D-shaped taper pin. Once you are satisfied the balance spring is clear of all obstructions, give the balance an initial twist of half a turn (turn the spoke through 180 degrees) and let it go. The balance amplitude should not fall below ('decay' to) 90 degrees (i.e. half its original amplitude) for at least 60 complete oscillations (120 'beats'). If it does, then either there is excessive friction in the balance staff pivots or the balance spring is rubbing on something. Going on further is pointless until this has been corrected.

preliminary timing: after each rate check, the excess length of balance spring is pulled through the stud

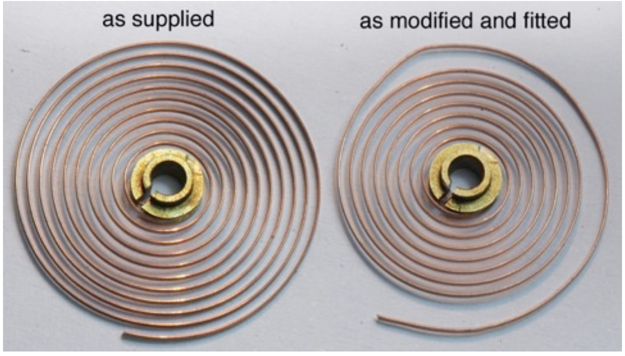
An optical timing machine such as the one shown is now set up; if you do not have one, timing will be very difficult. An acoustic pick-up is not useful as there is no escapement to tick. Set the timing machine to average ten counts, and set it up as shown and set it going. Now give the balance a 180 degree turn and let it go, and after ten oscillations a reading will appear and then be refreshed every ten counts thereafter. It would be very surprising if the count were anywhere near the desired 18,000 bph so you must now loosen the D-shaped pin and pull a length of the balance spring through the stud. Re-pin the balance spring. The spring will again probably need some manipulation to get it approximately concentric and clear of any obstructions, which can be done with tweezers.

Once you have got it to within ± 100 bph (i.e. between 17,900 and 18,100 bph), this is probably as close as reasonably practicable at this stage.

Now the spring is at its approximately correct length, cut it off about 5 mm to 10 mm overlong. The spring must now be brought to its final shape by manipulating it with tweezers, the aim being to ensure:

- the spring should be flat

- the radius either side of the index mid-point is constant so that adjustment of the index does not distort to the balance
- the spring is concentric with the balance staff
- the spring should 'breathe' evenly (concentrically) about the balance staff as the balance oscillates.
- The balance should oscillate at between 17,950 bph and 18,050 bph with the index centralised



Once you are satisfied strip, finish and polish any parts that still need it before a final clean. Reassemble the vibrating tool, this time lubricating the pivots with a tiny drop of oil such as Moebius 8010 placed in the centre of each endstone.

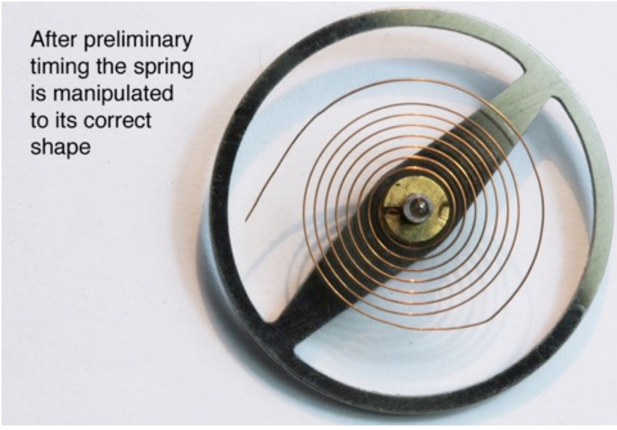
Repeat the pinning and timing as before to bring it to as close to 18,000 bph as you can, again ensuring that the decay to half the initial amplitude takes more than 120 beats (50 complete cycles). It is good practice to get as close to the required bph with the index centralised, using the index only for small final adjustments. A useful refinement that will make testing easier is to adjust the balance spring collet on the staff so that the spoke lies in line with the axis of the cock and the centralised index when it is at rest.

Isochronism

Unless you are extraordinarily lucky, you will have noted that the measured rate changes as the balance amplitude decreases; i.e. the balance is not isochronous. Correcting for the balance being anisochronous ('not isochronous') is something that is not within the scope of this practical exercise, partly because the basic spring balance is never going to be that accurate due to the use of a balance spring that may be mismatched to the mass and dimensions of the balance wheel, and partly because of the generally simplified design. Moreover, in a real watch or clock fitted with an escapement, the escapement itself introduces errors, which can to some extent be compensated for by the anisochronism of the basic spring-balance assembly.

'Springing' as it is known in the trade is a highly skilled job, and factors such as the total number of turns in the coil, the number of quarter turns above or below a whole position of the start point to the end point (number of quarter turns on the coil), the relative dimensions of the spring and balance all have an influence. Overcoils (e.g. the Breguet overcoil) and the shape of the terminal curve are all designed to reduce errors, and this includes correction of positional errors.

All of these factors conspire against us, but we can use this to our advantage as a teaching aid in that it clearly demonstrates some of the problems associated with spring-balance design and timing.



Finishing the casing

There remains only one job, and that is to finish the casing. Clean and finish the casing with 600 grade wet and dry paper before polishing to a good finish inside and out. Clock pathway students will sooner or later need to re-lacquer brass parts, so the casing is a good opportunity to practise lacquering. Use a proprietary horological lacquer applied with a soft lint-free rag (a bit of old, well-washed bed sheet or tea-towel is good). After shaking well, up-end the bottle to lightly soak a small patch of the rag and quickly wipe a very thin film all over the inside surface. If you have made a screw-on casing, try not to get any lacquer in the threads. Set aside to dry for 24 hours before repeating for the outer surface.

Set aside for several days to harden before finally pressing-in ('popping-in') the glass.