Mainsprings in American Clocks

This essay offers updated information to my previous essays about weights and mainsprings, both from 1999. Before describing my experiment with American clocks, let me first describe what led to this experiment. Modern German grandfather clocks have consistently high build quality and excellent escapement design, resulting in a very narrow pendulum swing. This means that my Hermle clock could be made to run with a very narrow swing, like a Vienna regulator. To find the minimum weight for the clock to run requires that the beat of the pendulum be correctly adjusted, as exactly as possible. If the adjustment is slightly off, the clock will not run.

The following clocks ran with less than two pounds (only 26 ounces):

1968 Kieninger grandfather clock, 114 cm. pendulum, Westminster chime, chain driven, Graham escapement, chimes turned on.

1975 Jauch grandmother clock, 94 cm. pendulum, Westminster chime, chain driven, Graham escapement, chimes turned on.

1975 Jauch grandmother clock, 94 cm. pendulum, Westminster chime, chain driven, recoil escapement, chimes turned on.

1980 Hermle grandmother clock (451), 114 cm. pendulum, Westminster chime, chain driven, Graham escapement, chimes turned on.

1985 Hermle grandmother clock (451), 94 cm. pendulum, Westminster chime, chain driven, Graham escapement, chimes turned on.

2001 Kieninger grandfather clock, 114 cm. pendulum, triple chimes, cable driven, Graham escapement, chimes turned on.

2004 Romba wall clock, Swiss mechanism, about 50 cm. pendulum, Westminster chime, chain driven, Graham escapement, chimes turned on.

A clock with an inefficient escapement, large and heavy escapement parts (escape wheel and pallet assembly), and an unusually large and heavy pendulum required more weight:

1820 British grandfather clock, recoil escapement, large escapement parts, required a 5 pound weight.

1825 British grandfather clock, recoil escapement, large escapement parts, less efficient escapement, required a 6.5 pound weight.

1830 British grandfather clock, recoil escapement, large escapement parts, less efficient escapement, required a 7 pound weight.

1922 Herschede #1 grandfather clock with 9 tubular bells, Graham escapement, large lyre pendulum, large escapement parts, required at least an 8 pound weight.

1980 Urgos 03 series grandfather clock with 9 tubular bells, Graham escapement, large pendulum, required at least 4 pounds.

1992 Hermle 1161 grandfather clock, 114 cm. pendulum, large pendulum, required 2 pounds, 8 ounces.

The purpose of conducting this experiment on as many clocks as possible was what I found with my 1980 Hermle clock: with 26 ounces, the clocks in the first group kept very accurate time, not like quartz, but as you would expect from a Vienna regulator clock. The clocks that required more weight also showed considerably improved timekeeping, particularly my Herschede above.

Another clock which caught my attention was a Japanese battery clock from about 1980. It had an electric motor to power the strike mechanism, simultaneously winding the clock mainspring. Even though this clock had the cheapest-looking pendulum, which looked like it belonged to a quartz clock, this clock kept exceptionally accurate time, with an error of about two minutes per month. Its accuracy could not be attributed to its cheap pin-pallet escapement, nor to its compensated pendulum, which it did not have. This clock presented a mystery, offering more accurate timekeeping than many of the finest mechanical clocks.

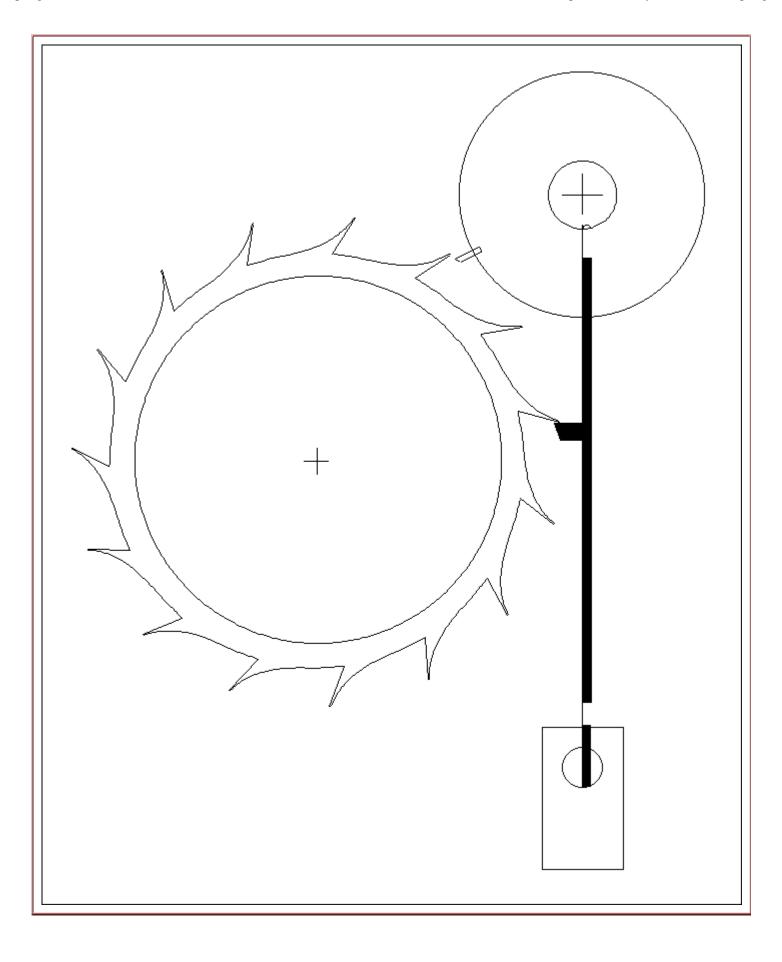
The explanation commonly offered is that the variations in timekeeping are caused by circular error. With weight-driven clocks the force is constant, so the amplitude of pendulum swing remains constant, and therefore the circular error is zero. One clock, however, offers an important clue: a French Morbier clock from about 1870, with a crown wheel escapement (think of this as an early recoil escapement),



requires an unusually wide pendulum swing because it has no suspension spring, so it needs an 11 pound weight to keep it running, yet it keeps time about as accurately as my Vienna regulator clock. I believe the answer lies in the escapement since this Morbier has very little contact between the pallets and the escape wheel because of the way the parts move (think about the way the roller jewel and the escape wheel move together in the Marine Chronometer escapement, which has rolling action instead of sliding action), so there is very little friction in the escapement of this Morbier, despite the heavy weight used.



Chronometer Escapement



The friction in the escapements could be brought to a minimum in other clocks, particularly clocks with recoil escapements, by lowering the weight to a minimum. I believe this is why erratic timekeeping is lowered to a minimum and shows us how to improve the timekeeping in any mechanical clock with an ordinary pendulum, no high-grade pendulum required.

American Clocks

The typical American 8-day clock, like the Seth Thomas 89, the Sessions, and the Ansonia on the preceding page, are massively over-powered and offer some of the least accurate timekeeping of any mechanical clock with a pendulum. I have always been told that the correct mainspring for these clocks is 3/4" wide, 0.018" thick, and 96 inches long. This mainspring is so powerful that it sometimes causes damage to the teeth of the great wheel.



The question to ask is why a French clock can run on a mainspring 0.009" thick, whereas many German clocks have mainsprings that are 0.014 to 0.016" thick, and British and American clocks have to be the most massively over-powered? Why could an American clock not be made to run on the same mainspring as a French clock?

The thinnest 3/4" mainspring available from timesavers.com that could be used on an American clock was 0.012" thick and only 72" long (part #16879), and would have 30% of the strength of the 0.018" thick spring normally recommended. The only way to find out if it worked was to try it. An Ansonia with the Brocot escapement became the first patient for this experiment, since it had the wrong time mainspring anyway, which needed to be 5/8" wide and not 3/4", a mistake commonly made by repairmen. The thinnest 5/8" mainspring available from timesavers.com that could be used on an American clock was 0.013" thick and only 69" long (part #16876), calculated to have a strength of 31% of the 3/4" mainspring it replaced. After overhauling the mechanism, I installed the new mainsprings (time: #16876 and strike: #16879). Despite the shorter mainsprings, this Ansonia clock ran for 11 days, striking correctly and keeping accurate time (after

adjusting the pendulum). The error was about a minute in total during the first five days, after which it began to lose time (typical for spring-driven clocks).

The next patient was a Sessions clock, with a mechanism like one you would find in a parlor clock or a kitchen clock. With the new mainsprings, #16879 for both time and strike, this clock lost 5 minutes in the first 24 hours, so the pendulum needed to be adjusted up a little. This brings the issue of the two types of error. Constant error is easily corrected by adjusting the length of the pendulum: screw it up to speed it up and screw it down to slow it down. Variable error is not as easily adjusted. Timekeeping will vary with changes in temperature. Colder temperatures cause clocks to runs slightly faster, and vice versa. A pendulum with temperature compensation, such as the mercury pendulum, can reduce this error. Timekeeping will vary with changes in power. Spring-driven clocks will run faster at the beginning of the week and slower towards the end of the week, especially after the fifth day. Weight-driven clocks will run faster when the weight is increased, and vice-versa. Where the experiment becomes interesting is in observing how the variable error is decreased when the weight is reduced to a lower amount, as seen in the grandfather clocks above, and similarly when using a thinner mainspring. Once the pendulum was adjusted, the clock kept more consistent time, running and striking correctly for 9 days.

While the 0.012" thick mainspring I used in this experiment had 73% more power than a comparable 0.009" thick mainspring for a French clock, the 0.012" mainspring offered a considerable improvement as an alternative mainspring to consider to replace the massively powerful 0.018" thick mainsprings in American clocks.

The strike mechanism in this Sessions clock only strikes the hours, not the half-hour. The half-hour is simply the lift-and-drop method by the centershaft. This requires more power in the time train than lifting the strike lever. I believe this is why the Sessions ran for 9 days, whereas the Ansonia, which uses the strike mechanism to strike the hours and the half-hour, ran for 11 days. Both clocks kept more accurate time than before and lost less time after the fifth day. After adjusting the spring for the strike hammer, so that the hammer would strike the gong less than half as hard as before, the Sessions ran for 13 days.

There are three advantages to using a less powerful mainspring: more accurate timekeeping, longer durability, and less damage if the mainspring breaks. Furthermore, the clock will probably not run when the oil becomes gummy, which is good because the clock will wear faster if used after the oil no longer lubricates. A disadvantage is that a clock running on minimum power must be set up correctly and adjusted precisely for it to run.

The third patient was a Seth Thomas, similar to the #89, with a gong strike for the hour and a brass bell for the half hour. The escapement was a half-deadbeat. With the new 0.012" mainsprings, the clock ran very well, though the pendulum needed to be adjusted. In this clock, it was necessary to consider the other springs. It had a thick suspension spring, which I decided to replace with a thinner one. The spring for the strike hammer was very strong, so I decided to use another spring wire, in which I could adjust the tension easily by bending the wire. The springs for the strike count lever and the left lever were very strong, as I have found in many similar American clocks, so I decided to use another spring wire, which I could adjust for the minimum tension needed to obtain proper performance. This Seth Thomas clock was running and striking correctly for 13 days, losing time after 5 days. The point here is that these clocks are running for more than 8 days with the thinner mainsprings, as they should, not whether they run for 11 or even 14 days.

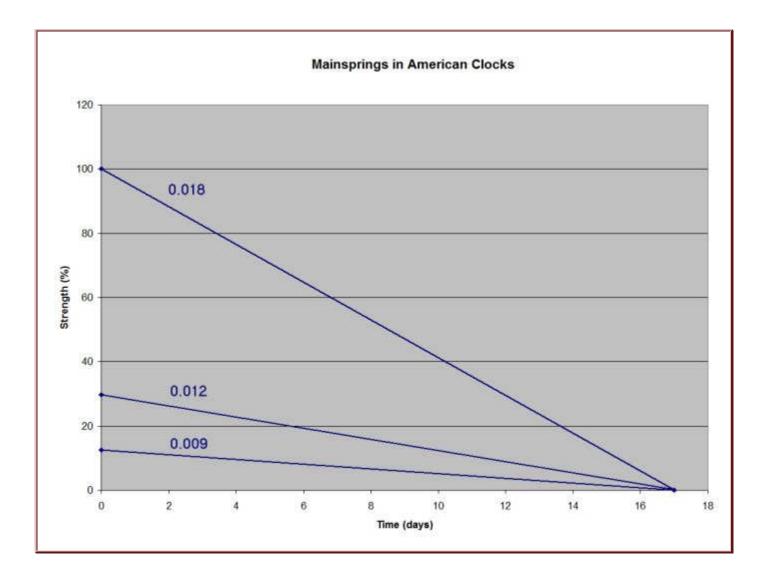
The fourth patient was a Gilbert with two mainsprings. All the clocks in this experiment were made around 1900 to 1910. Even though it had a strippallet recoil escapement, this clock was different in that the action of the pallets was visibly more symmetrical and correct than the others. Despite that, I was surprised to see this clock run and strike correctly for $15\frac{1}{2}$ days with two 0.012" mainsprings.

The last patient was a Gilbert calendar clock with one mainspring. While I wanted to concentrate on American clocks with "H" plates, which look like the Seth Thomas 89, I thought this Gilbert was essentially of the same design as the other clocks on the time side. Before proceeding with the experiment, it was necessary to repair the escapement in this clock, even though it looked like the escapement in the other Gilbert. The problem was that the escape wheel did not rotate as the tooth slid across the exit pallet. Work done is equal to force times displacement. If there is no angular displacement, then no work has been done, which means that the pendulum received no kinetic energy via the exit pallet. Half the energy is lost in the escapement because of this problem. This is a surprisingly common problem in American clocks, suggesting that many repairmen do not know how to repair escapements, and make up for the loss by using brutally powerful mainsprings. After repairing the escapement so that the rotation of the escape wheel would be equal on both sides, so that the lock and drop were also equal on both sides, and so that the amplitude of oscillation of the pendulum were reduced to a lower level, this Gilbert clock ran nicely and kept good time for 151/2 days with a 0.012" mainspring. It kept better time than the other clocks in this experiment, particularly after day 5, because it had a longer pendulum of 17 inches long instead of 9.

Since the other clocks in this experiment had ticking sounds which were considerably louder than in my French clocks, I decided to try a 0.009" thick mainspring, available only with a hole end, so I added a loop from another mainspring and installed this 0.009" mainspring in the Gilbert calendar clock. It ran nicely and kept good time for $13\frac{1}{2}$ days. Note that the 0.009" thick mainspring has only 14% of the strength of the brutally powerful 0.018" thick mainspring, all other factors being equal.

The last step in this experiment was to go back to the Sessions and install two 0.009" thick mainsprings in it. The Sessions ran for $10\frac{1}{2}$ days, striking correctly. Then I installed a piece to wire to keep the warning lever out of the way, and a piece of cardboard to keep the strike hammer out of the way, to observe how this Sessions would run as a time-only clock. It ran for another $1\frac{1}{2}$ days, for a total of 12 days. I thought that the Sessions was the most important part of this experiment because it exemplified the typical American clock more closely, when considering all the American clocks I have repaired over the decades. It had the design imperfections I expected to find in this type of clock, the asymmetrical pallets, and the escape wheel which was ever so slightly out of true.

To explain the reason why these clocks lose time after day five, consider how the strength of the mainspring decreases as the clock runs. According to Robert Hooke's Law (1678), which states that "the force F needed to extend or compress a spring by some distance X is proportional to that distance," we get a graph with straight lines. If we express the mainspring strength as a percentage and we assume that all the mainsprings have no strength after 17 days, we get a graph like the one below. You can see that the stronger spring has a much greater difference in strength after 7 days, compared to the weaker spring. By comparison, the line for the weaker spring appears to be almost horizontal by comparison, so the clock with the weaker spring will keep more consistent time, especially if it has a recoil escapement.



It is worth mentioning that the Timesavers catalog has a $3/4 \times 0.015 \times 170$ inch mainspring for Japanese and Korean 31 day clocks from the 1970s and 80s, because some of their mechanisms look like copies of American clocks from the early 1900s. A 0.015" mainspring, when installed in a Seth Thomas 89, should have a calculated length of 169", and it would have 58% of the strength of a 0.018" mainspring. They were obviously onto something there.

This simple experiment is replicable and could therefore be subjected to "peer review." My sample of only five clocks is not enough to generate statistically significant data, though it does confirm that most American clocks of the type in this sample are massively overpowered and could run well with much less power. While not all American clocks will work well, such as some of those made before 1890, suffering from lower manufacturing standards, and those with escapement problems, which need to be corrected first, I believe that almost all American clocks of this type could be repaired to enable them to run with thinner mainsprings. The purpose of this experiment is to find how to do the best possible repair for the most durability and the best timekeeping. Could my Sessions clock ever keep

time as accurately as a Vienna regulator? No, because it is not weight driven, nor does it have a Graham escapement. However, installing the thinnest mainspring possible would reduce the recoil action to a minimum and offer a terrific improvement in timekeeping.

Now for the disclaimer to keep me out of trouble: experiment at your own risk! Avoid irreversible modifications. Clocks with escapements which are badly worn or defective, with escape wheels which are out of round or have irregular teeth, would need more power to overcome such problems. A high-beat clock with a very short pendulum, like many Ingraham tambour clocks from the 1920s, will probably require more power. A clock with an unusually large and heavy pendulum may require more power, etc.

Mark Headrick

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