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Living with Longcase Clocks in the Modern Home

Automatic Winder 'Sloth' For a 30-Hour Clock

Richard Thomas

Introduction

This article, after offering some of the virtues of 30-hour clocks, describes the design and execution of a device that automatically winds such clocks with a climbing weight, without altering or adding to the original movement or case (if already chain wound).

30-Hour Clocks

It is often said that 30-hour clocks have a greater chance of originality than eight-day ones, and more closely follow both contemporary fashions and the personal techniques of their makers (as they are more likely to have been created by the local clockmaker).

I am lucky to own one such clock by Richard Swain/e, a nineteenth-century clockmaker working in Stratford-upon-Avon, **Figure 1**, and it is chain rather than rope driven. There is a Richard Swain in the 1851 census who was born in 1799 and describes himself as a clockmaker, upholsterer and furniture broker.[1+2] I have not, however, been able to examine any of his other clocks so I cannot identify any features of the movement that are attributable to him in particular.

I have also been lucky to work on a couple of clocks by Thomas Sharpe, who was a gunsmith as well as a clockmaker and was in business from 1759–1795, **Figure 2**.[3+4] **Figures 3 and 4** show the dial and the clock's front plate with casting defects, hammer marks from planishing and the train wheel circles as an aid to planting. Another had been fitted with barrel extensions to give it an eight-day duration, **Figure 5**. I have seen several brass dial clocks with Sharpe's name engraved on brass arcs; **Figure 6** is this clock's dial. While I know a little about Sharpe (he sold artefacts made from a mulberry tree that had grown in the garden of a house in which William Shakespeare once lived); once again I do not have sufficient knowledge to identify any aspect of the movement that could be attributed to him in particular.[5]

Figure 1. Clock by Richard Swaine Stratford-upon-Avon.

Figure 2. Clock by Thomas Sharpe Stratford-upon-Avon.

Figure 3. Dial of Thomas Sharpe clock.

Figure 4. Front plate of Thomas Sharpe clock shown in Figures 2 and 3.

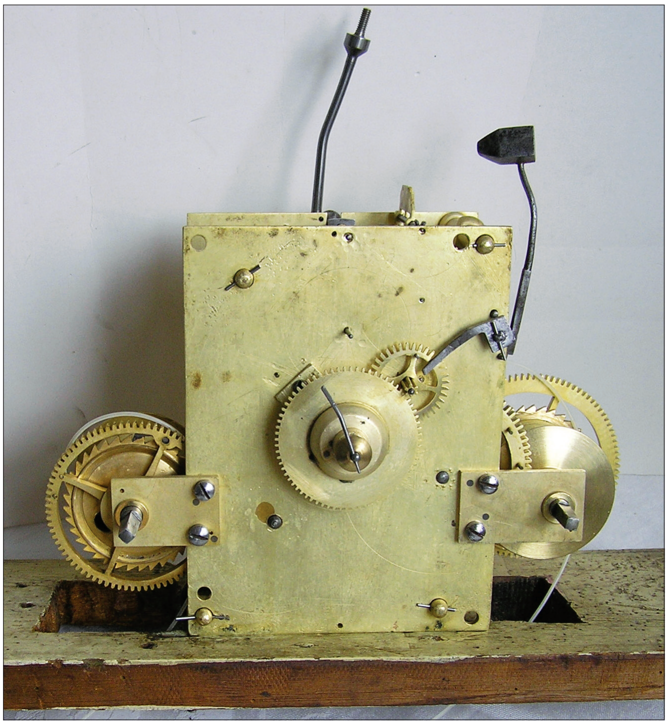

Figure 5. Another Thomas Sharpe movement with extensions for added duration.

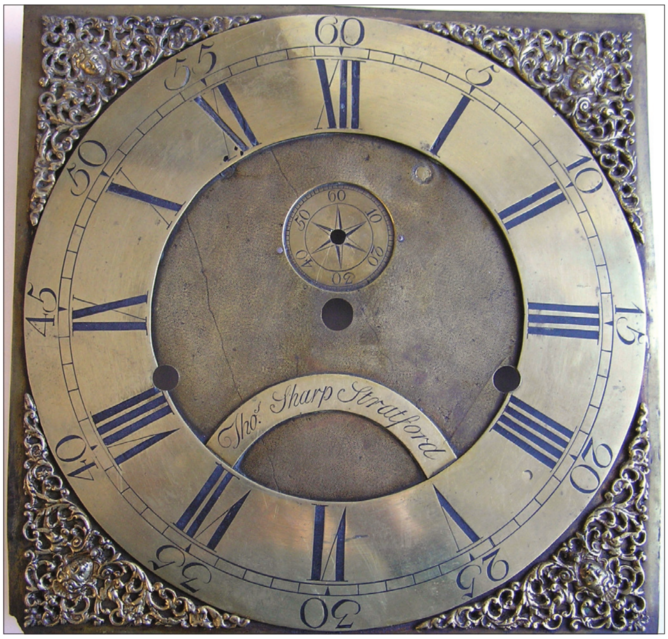

Figure 6. Dial of clock in **Figure 5**.

Benefits of an Auto Winder in Modern Homes

As homes get smaller, finding room for longcase clocks becomes more of a challenge, and daily winding of 30-hour clocks can be a chore. (My own, 'Elizabeth', definitely needed the strike to be disabled. It is inches from my head when I am watching TV and was rendering the first minutes of the ten o'clock news inaudible.) If winding is not carried out on busy mornings, the strike may go out of synchronisation. As Elizabeth's striking is disabled, she needs winding only every other day, so it was even easier to lose track of when to do it.

Perhaps, I mused, this was an opportunity to build an automatic winder, especially as there is only one side to wind. As well as relieving the 'chore' of winding, it could exert less force than the usual cast iron weight, half of which (as the weight is split between the two trains on the Huygens principle) is needed to be sufficient to start and run the strike train, more power being needed than the continuously running going train. A reduction in driving weight should reduce the wear and tear on the going train. Further, as the clock could in theory be running continuously, undisturbed under a constant weight for months between the GMT and BST changes, its likely excellent timekeeping could become apparent.

These arguments have of course been made by the makers of other auto-winders and indeed designs have been available for years.[6–8] Perhaps, though, there is a possibility of improvement if only from an increased availability of materials and parts, which can be found through the internet.

Genesis of the Climbing Weight

It is hard to accept, but my workshop notebook suggests I began this project in 2015 as I started to 'wind down' (sorry) towards retirement. I had to hand a Como electric motor from another project; it had a 3000:1 gearbox and initial trials demonstrated that driving a 38 mm pulley it could lift a 5 lb clock weight at four inches per minute using a 4.5 volt 0.5 A power supply. It could therefore lift the weight up the 54 inch drop in the clock case in less than 15 minutes, requiring a mere 2.5 watts, **Figure 7**.

This was a static motor lifting a weight, but such an arrangement is likely to require some modifications to the clock and case. An early decision was therefore made to investigate a weight climbing up the chain, as others had done.

Many questions needed addressing:

- How much weight was required to drive the clock?
- How often and how fast would a winder have to run?
- How much electrical power would be needed?
- Could electrical mains be eliminated by employing on-board batteries?
- Could switching also be on-board to eliminate more wires or any modifications to the clock?
- Could that switching be mechanical and latching (and surely not beyond the wit and skill of a professed clockmaker)?
- Could it all fit inside a weight-shaped enclosure? The chain must run through the centre of it so that it remains upright.
- Was there a wide range of electric motors and gearboxes available at reasonable cost?

First, however, data on the clock were needed.

Weight

I wished that I had been noting the weights in the 30-hour clocks that I had serviced for my customers, but I hadn't, so I could not be sure whether the weight in this clock was typical.

It was of similar size to others and of cast iron rather than lead as encountered in many longcase clocks. It weighed, with the pulley, just over 5 lbs. It is about 2 ¼ inch diameter. That is 2300 gm and 57 mm. Half of the 2300 gm is, of course, acting on each train.

In trials, Elizabeth's going side needed only a driving weight of about 650 gm. This was an early confirmation that much less weight may be needed to drive the going train of these clocks rather than the theoretical 'half the original weight' ie 1150 gm.

However, the strike train required about one kilogram to strike at the familiar rate. Therefore, to allow for other going trains needing less than 650 gm and greater for strike trains, the design should weigh no more, and preferably less, than 600 gm — but with the ability to increase the weight and cater for at least an additional 500 gm for strike trains.

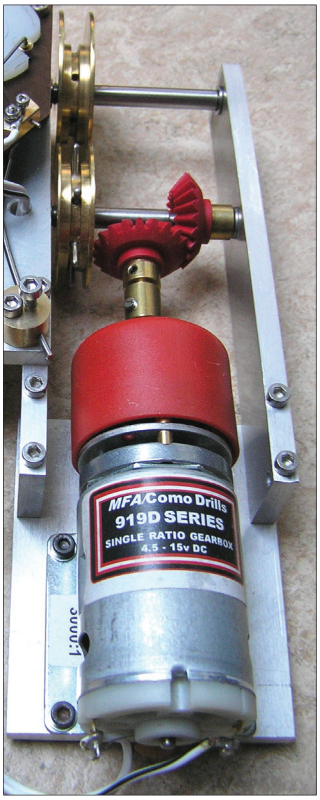

Figure 7. Motor and gears to test lifting requirements.

Size

In order to retain the diameter of the original weight (for appearance's sake) and to avoid fouling a strike train weight, the free side of the chain and the pendulum, the maximum diameter of the proposed device should be about 60 mm. The height is not critical: a taller weight would just have a slightly shorter interval between winds. Later, I learned that there was not quite enough clearance between the going and strike weights hanging directly from the barrels.

Motor Torque and Speed

How much torque is required to lift the weights? In trials, the going weight was lifted by the chain operating on a 30 mm diameter sprocket so the force being exerted was 650 × 15 mm radius = 975: say 1000 gm/cms, about 0.1 Nm. For the strike, 0.2 Nm.

At what speed must the weights be lifted? With each train drop being measured with the weight hanging off that barrel only (i.e. without the Huygens loop), the going weight dropped about 40 mm in an hour, about 1200 mm in 30 hours.

The strike weight of 1200 gm, however, dropped 360 mm/minute — only during the act of striking of course. The weight dropped 6 mm for each blow. 213 strikes (the most required in 30 hours if wound at, say, 6 pm) would need a drop of 1278 mm.

If one 'sloth' (slow, climbing thing) design were to be usable for both trains it would need to have a rate of climb exceeding 360 mm a minute for a worst-case scenario when the weight touched the floor as striking commenced.

The availability of a suitable motor and gearbox was the key to the whole project and a candidate quickly emerged.

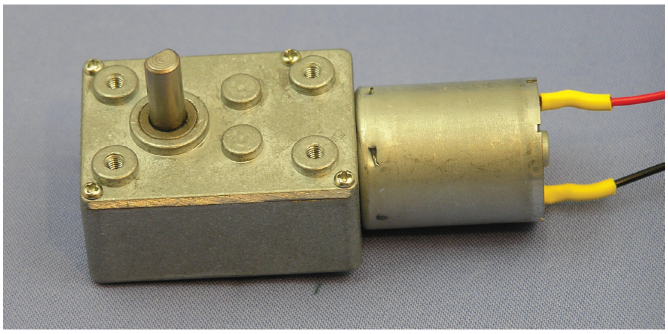
Figure 8. Motor/gearbox used in Sloth.

Chosen Motor

It was a 12 v motor with a worm gearbox, **Figure 8**, about the right size to fit in a 60 mm tube. The drive arbor was at right angles to the motor/gearbox axis, in such a way that a chain drive sprocket could be attached directly to the arbor. The worm drive ensures that the weight cannot reverse the motor.

With a 12 volt supply the motor/gearbox specification was:

Arbor speed: 7 rpm
Torque: 0.84 Nm
Current consumption: 0.14 Ampere at maximum efficiency
Stall torque: 4 Nm

At that rpm a 30 mm sprocket would shift more than 600 mm of chain in a minute, well above the 350 mm/min needed for the strike train. The stall torque is many times above the needed torque. Other motors in the range were too slow or too fast and there were no other candidates from other suppliers that were less than £20.

Next question: could it run on batteries? Even average quality rechargeable AAA cells are rated at 750 mAh. Calculations suggested that 1000 mAh would be used in 12 months, ie four minutes at 80 mA every two days or about 12 hours a year (12 × 80 = 960 mAh). Changing batteries every six months at GMT/BST should, therefore, leave room for errors in my measurements and some cell deterioration.

In early trials with four fresh 1.2 v cells, it took three minutes to lift a 740 gm 1300 mm weight on the 30 mm diameter sprocket, 420 mm in a minute.

There was still a long way to go. However, after checking that 60 mm diameter tube would just accommodate the motor, gearbox, sprocket and on-board power, it seemed the rest of the design would soon follow.

Materials

Tube and Internal Structure

Aluminium is often my preferred material: light, relatively inexpensive, easy to machine and not subject to corrosion. The tube and internal structure (ie the spine) of the 'sloth' were therefore to be made of it, and 60 mm aluminium tube was available.

Aluminium can however build up on lathe tooling so, depending on its composition, sometimes cutting fluids are needed and it does not perform for bearing duty. For the load-bearing sprocket shaft I used flanged 3 mm ID ball races between the aluminium spine and the steel shaft, **Figure 9**. Steel posts for non-load bearing tasks seem more practicable

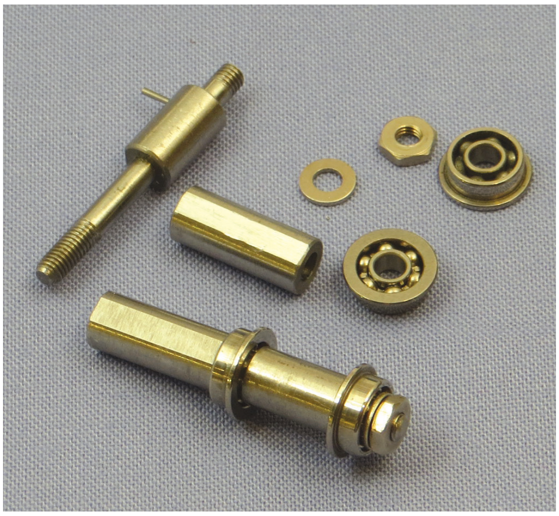

Figure 9. Sprocket shaft and bearings.

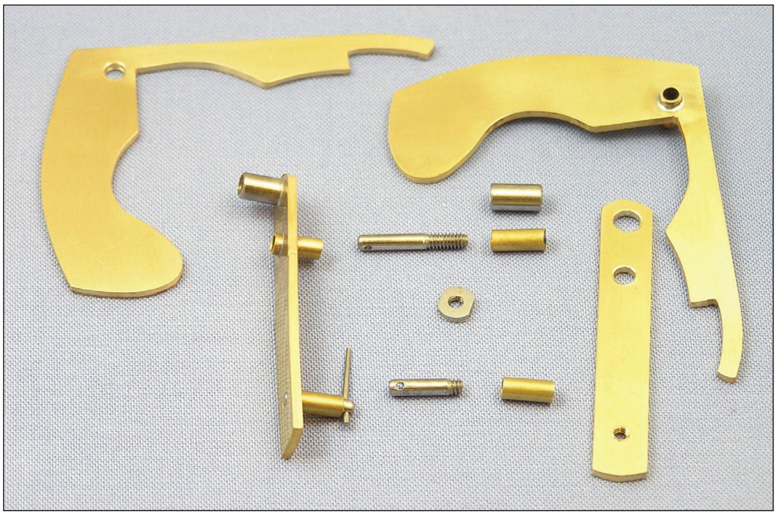

Figure 10. Parts of levers and posts.

and compact than having arbors pivoted between plates. Posts for levers were to be fabricated rather than turned from solid, from $^{3}/_{32}$ inch diameter silver steel threaded $^{3}/_{32}$ inch BSW with feet from 5.5 mm diameter silver steel also threaded and secured to the post with Loctite 603, **Figure 10**. For the pipes of the arms, $^{3}/_{32}$ inch, I soldered brass tube to the arm.

Switching

Early thoughts of using electronic sensing and switching were overcome not only by the probable requirement for something attached to the clock case to transmit to the sensors, but the familiarity we have for levers, detents and springs, **Figure 10**.

Evolution of Chain Drive

A number of considerations needed to be accommodated:

1. The path of the chain, on its way to the sprocket.
2. Ensuring that it is wrapped round enough of the sprocket circumference so that when the weight was disturbed (for instance if the chain dropped suddenly if not disengaging smoothly from the clock's sprocket), it would not come off the sprocket.
3. Positive and smooth engagement with the sprocket pins.

Gearing

The first design employed an offset spine, as in **Figure 11**. However, placing the chain route on the motor side of the spine allowed a chain route straight from the centre entry point via idlers to the sprocket, now on the same side as the motor, as in **Figure 12**. This required a transfer of drive so that the sprocket cleared

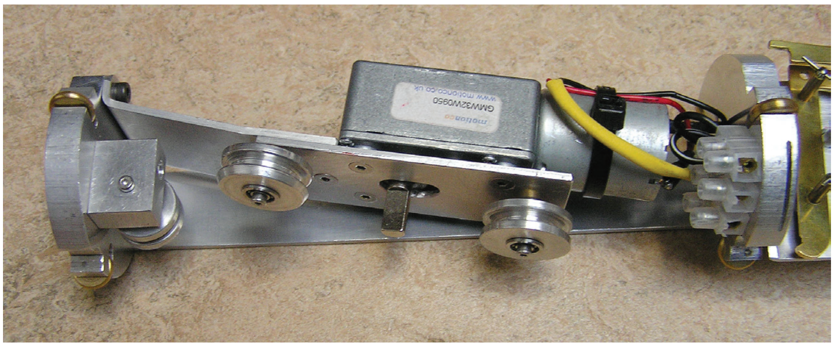

Figure 11. First idler design.

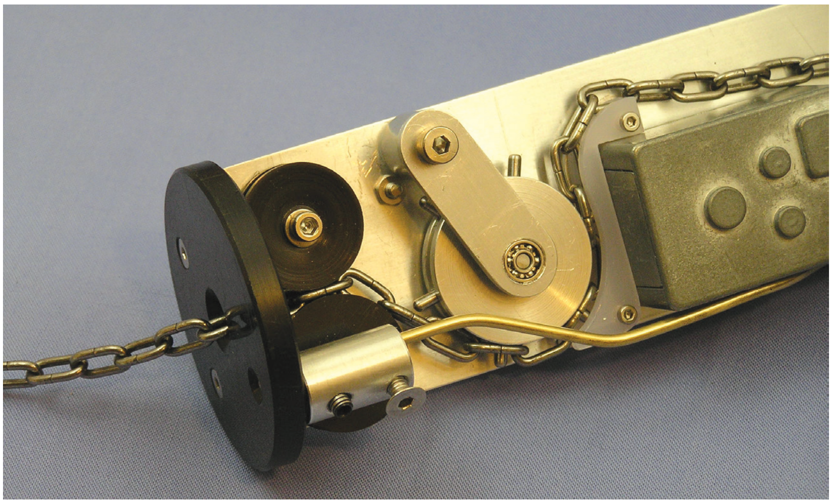

Figure 12. Final idler design.

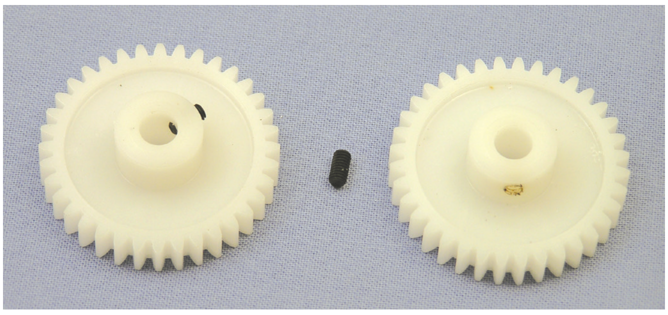

Figure 13. Plastic gears purchased.


Figure 14. Aluminium chain idler.

the motor. I chose to utilise purchased plastic gears, **Figure 13**, rather than cut brass ones.

Idlers and Guide

Many arrangements of one or two idlers were tried before the final design was found. This aspect was probably the most challenging to make reliable. Early efforts were two aluminium idlers with ball bearings, **Figures 14 and 15**, then one idler, **Figure 16**, and finally two plastic idlers, tensioned together to hold and guide the chain as it entered. The spring behind the spine was acting on a brass lever to which the idler post was attached, **Figure 17**. Now there was an aluminium sprocket on the spine centre line and a chain guide to keep the chain on the sprocket pins as gravity takes over. The guide was made from acetal, as this material is quite 'slippery'. The chain now engaged smoothly with the sprocket pins, avoiding current surges and no

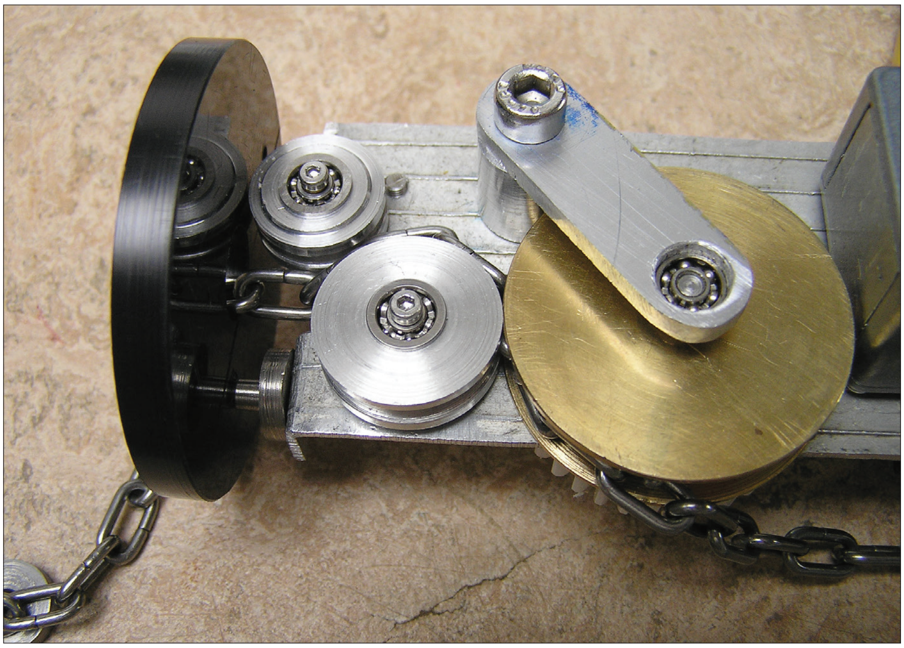
Figure 15. Second idler design.

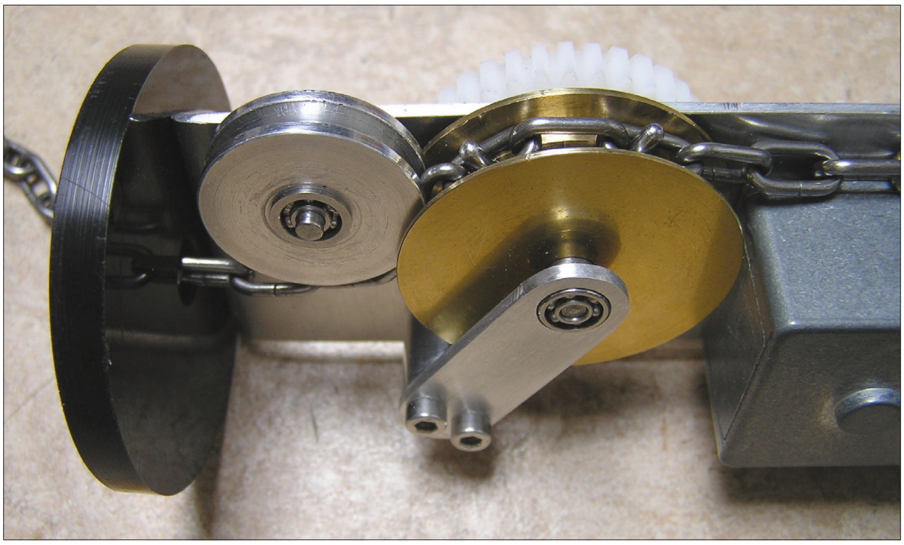
Figure 16. Third idler design.

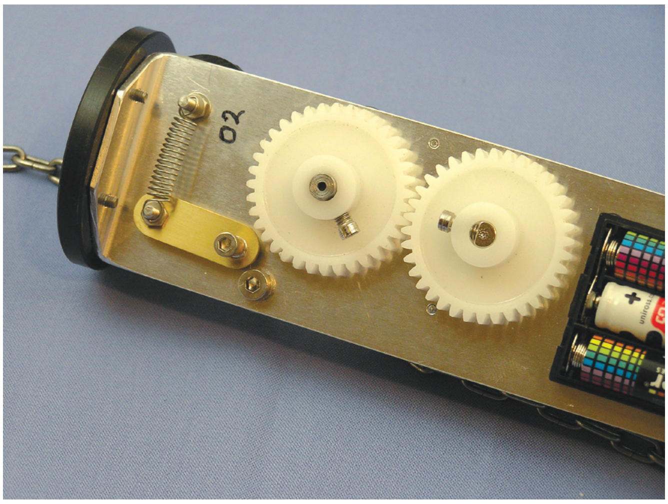

Figure 17. Final idler design behind spine.

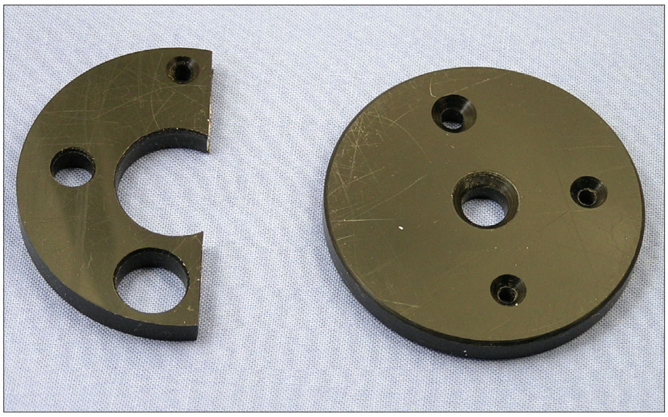
Figure 18. Acetal discs.

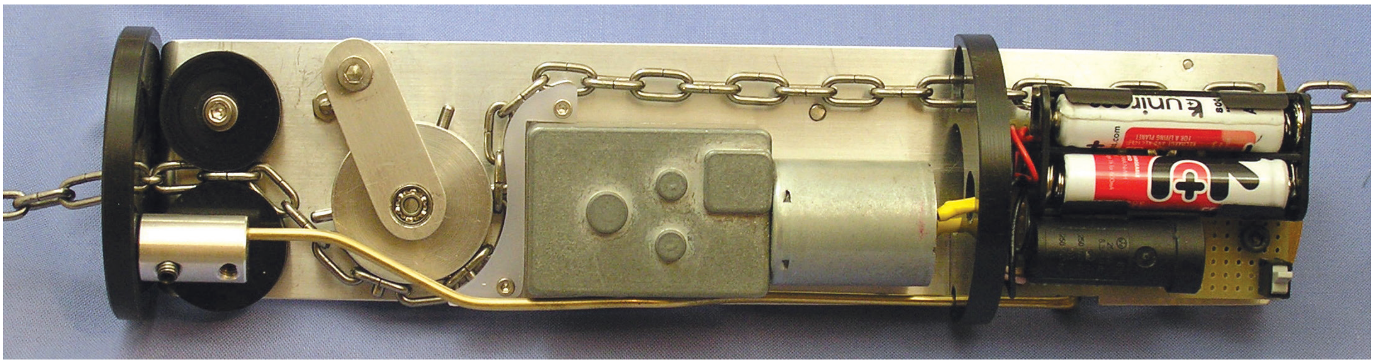

Figure 19. Final Sloth.

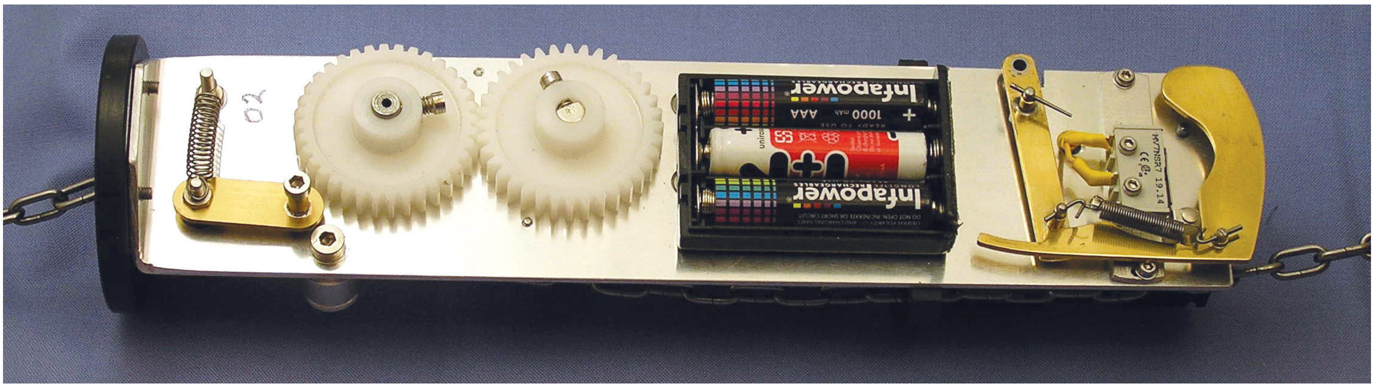

Figure 20. Final Sloth, other side.

longer being susceptible to any fouling or disengagement if the sloth dropped suddenly (from rare but potentially disruptive erratic disengagement with the original sprocket up in the movement). Constant engagement with at least three of the six sprocket pins was achieved. This could possibly allow a range of chain pitches to be accommodated.

The Path of the Chain as it Leaves the Sprocket and Guide

I tried several arrangements of tubes down which to pass the chain, to avoid it getting caught up or touching electric components. Eventually, freefall through a large opening in the ¼ inch acetal disc between motor and printed circuit board (PCB) proved to be the most reliable, although the back of the PCB had to be protected.

The Mechanical Latching Switch

Being modern, I had so far employed materials, science and techniques not encountered in nineteenth-century longcase clocks. This saved weight, made manufacture easier and cheaper and, indeed, allowed the use of electricity! This seemed pragmatic and acceptable. After all, this device may be easily removed from the clock and the original weight, chain path and striking can be reinstated.

Initially, electronic sensors and gate circuitry were considered for the switching. However, while I have some knowledge of these matters from a previous life, it seemed unlikely that it could be carried out without wires outside the unit, which had so far been successfully eliminated along with the mains power supply. Furthermore, as the unit will touch the floor to start and the seatboard to stop, surely these actions could operate levers and a microswitch? Besides, would any clockmaker turn to electronics rather than levers?

The system has to latch reliably until the unit rises to the seatboard and here there was excess motor power to re-set the switch. The position of the microswitch arm was critical, there being virtually no hysteresis between on and off positions in modern microswitches. Here the small amount of overrun of the motor after switch-off came to the rescue.

Early on, I had thoughts of using the top of the outer tube shell itself as the stop sensor. This would keep the unit upright by avoiding the possibility of a smaller sensor hitting the seatboard clamps or going through the seatboard chain holes. For this to work, the tube would need to move freely and vertically around the central interior. Initially I used aluminium discs with three rollers on their outer diameters, later superseded by plain acetal discs. **Figure 18** shows the top disc with central hole for chain entry and the fixing holes for the spine, and the lower partial disc with clearance holes for the chain and access for wiring. Both also have holes for the 'switch off' rod. **Figures 19 and 20** show both sides inside one of the completed units.

Electrics

The first battery holders were aluminium tubes but were then replaced by plastic alternatives. One mounted on a small piece of Veroboard enabled other connections to be gathered on to one site.

Accommodating several AAA cells and a small PCB seemed relatively straightforward. Initially three, then finally five, batteries were used to give sufficient speed with the extra weight for the strike train to keep a common design for both going and strike.

Towards the final arrangement, an on/off switch was added to the PCB so that when setting up or changing batteries twice a year, the triggering of the light-action 'on' position switch would not be a nuisance.

A Failsafe Operation?

Consideration was given to failsafe operation. However, when I was unable to devise a foolproof mechanical arrangement, I eventually fitted a fuse in line with the motor so that if stalled by, for instance chain jamming or the motor not switching off at top of travel, the higher stall current would blow the fuse. The sloth would then not lift when reaching the floor and the clock would stop.

Linking the Switch to the Tube

As the sloth evolved, it seemed possible that a number of them could be made for sale, perhaps to defray the costs of practising horology without an income from repairs. Making the removal and replacement of the tube easy and reliable for installation and battery changing was therefore essential.

There should be no projection beyond the tube diameter as already on one occasion an unnoticed, slightly open chain link had caught up on the top edge of the tube, tilting the sloth into the path of the pendulum. There were many versions of this switch link. Finally, the need to make dismantling easy and foolproof was achieved, as far as I can tell — it remains to be established by others.

Two Sloths: One For Each Train

If the sloth were to be usable on the strike side, it had to accommodate extra weight. This could be achieved by lengthening the space between the top plastic disc and the top of the tube so that lead discs, slotted to take the chain, could be added.

This second heavier sloth was only recently tested. The two weights were found to be a little too close. Furthermore, while the tube top edge of a sloth was designed to come against the seatboard around the hole for the chain to initiate stopping, it sometimes contacted the seatboard hook, tilting the weight. A seatboard buffer/diverter was therefore added to the going side, counterbored deep enough to accommodate the seatboard hook wingnuts, drilled for both chain entry and exit. By offsetting the hole for the going side and fitting an acetal insert, the clearance between weights was increased (and setting the going weight slightly further from the pendulum). This is held in place only with the original seatboard hooks, so it may be easily taken out when removing the chain to reinstate the original Huygens system.

This does, it seems to me, spoil the concept that fitting a pair of sloths should involve only opening two chain links, threading the chains through and closing the links again. For my use of going-only, that has been achieved, but for a pair, extra chain to fit the clock's sprockets must be obtained and this buffer/diverter board made.

Further Observations

The clock was now a timepiece.

To thread the chain (done frequently during development), I attach a piece of thin wire to the last chain link and thread it through the sloth and around the sprocket (having loosened the screw clamping the sprocket to its shaft). I then take it up through the seat board, over the clock's sprocket arbor, back down through the seat board and then use tweezers to lift the chain onto the clock's sprocket.

To detach the sloth itself, just one link needs to be opened and the sprocket loosened.

Figure 21. One of the completed Sloths.

The whole length of chain originally used for the Huygens system was employed. The excess on the floor of the clock (in this case the carpeted room floor) was not an issue, especially as having a board on the carpet kept the chain away from dust and carpet fibres. This also gives a hard surface to actuate the 'on' switch positively, rather than soft carpet.

The chain dimensions for this clock are internal length 9.2 mm, external width 6.6 mm and wire thickness 1.8 mm, ie about 33 links per foot. The sprocket is 30.5 mm diameter and 7.5 mm wide plus flanges. The deep groove is 4 mm deep by 3 mm wide.

The first weight-shaped sloth to drive the going train on battery power was tested in December 2016 and had most of the final features. It was only in December 2020 when I could be sure the design functioned, having produced four units and run two of them for at least seven months without stopping on one set of rechargeable batteries.

Conclusion

The 'sloth' does provide reliable auto-winding without mains power or any alterations to the clock or case. The batteries (I use rechargeable here and for all battery duties in the home) require replacement only at each GMT/BST change.

At this stage there has not been a long-term test with a heavier unit on a strike train. It may need the tube to be of steel for added weight and room for six cells as clocks not yet encountered may need a heavier, faster-climbing weight.

ENDNOTES

1. Joseph McKenna, *Clockmakers & Watchmakers of Central England* (Ashbourne, Derbyshire: Mayfield Books, 2002) p298.
2. Brian Loomes, *Watchmakers and Clockmakers of the World Complete 21st Century Edition* (London: N.A.G. Press, 2006) p752 .
3. McKenna, *Clockmakers & Watchmakers*, op cit, p280.
4. Loomes, *Watchmakers and Clockmakers*, op cit, p702.
5. Betty Smith, *Tales of Old Warwickshire* (Newbury Berkshire: Countryside Books, 1988) pp29–32.
6. Anthony Venn, 'Automatic Winder for Thirty-Hour Longcase Clocks', *Horological Journal*, vol. 145(April 2003), pp134–135.
7. Ted Wale, 'Antique 30-hour Movement Restoration 2', *Horological Journal* vol.151 (Oct2009), pp466–470.
8. John Wilding, *Horological Miscellanies* (Bordon, Hampshire: RiteTime Publishing, 2002) pp29–39.