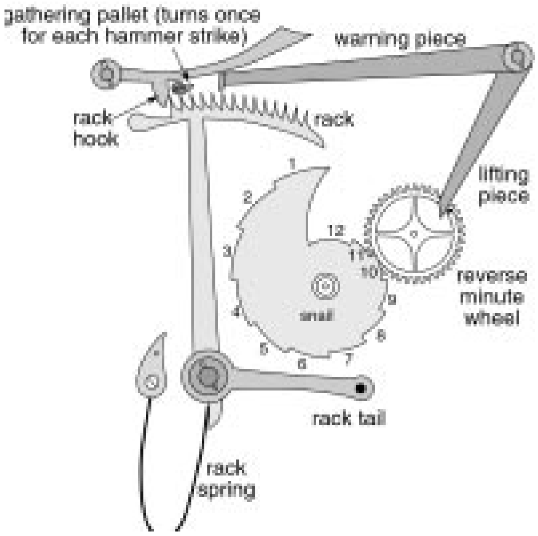
Adjusting the Rack Tail

John Robey showshow to deal with this part of the strike system



1. The usual arrangement of rack-and-snail striking.

THE CORRECT operation of rack-and-snail striking depends on the rack tail moving through the same angle (governed by which step of the snail it falls onto) as the rack, so that the pallet can gather the correct number of teeth. The arrangement as usually found on British domestic clocks (longcase and bracket) is shown in **1**. The basic geometry is shown in **2a**, where the rack tail is shown as being of the correct length, so that when it contacts the highest step of the snail the rack hook is in the first space between the rack teeth, ready to strike one hammer blow. When the tail falls onto the lowest step it has moved through a distance of eleven steps on the snail, and the rack falls a further eleven teeth. It is desirable, but not essential, that the contact pin on the tip of the rack tail should pass through the centre of the snail.

When the geometry is correct, because the movement of the rack arm and the rack tail are sectors of equal angle (almost congruent triangles), the ratio of the pitch of the rack teeth and the height of each step on the snail is equal to the ratio of the lengths of the rack arm and the rack tail, **2a**. This is the theory, but very small deviations from the ideal can cause miscounting and a faulty strike. Clockmakers did not involve geometry when making their racks and snails, but used one component to determine the size of another on the actual movement, not on the drawing board. Rack tails can become damaged or broken and then replaced by someone not fully acquainted with the principles. Faced with this problem the restorer can spend many happy hours altering the rack tail to produce a reliable striking system, but if the basic principles are understood this can be reduced to a few minutes.

Most faults with rack striking arise from an incorrect rack tail, and modifications to the rack teeth or steps of the snail should only be a last resort once the rack tail has been shown to be of the correct length.

This article describes several methods that have been used to make rack-and-tail striking systems, how to use geometric principles to determine if the length of the tail is too long or too short, and a simple jig to make life simple when making the final adjustment.

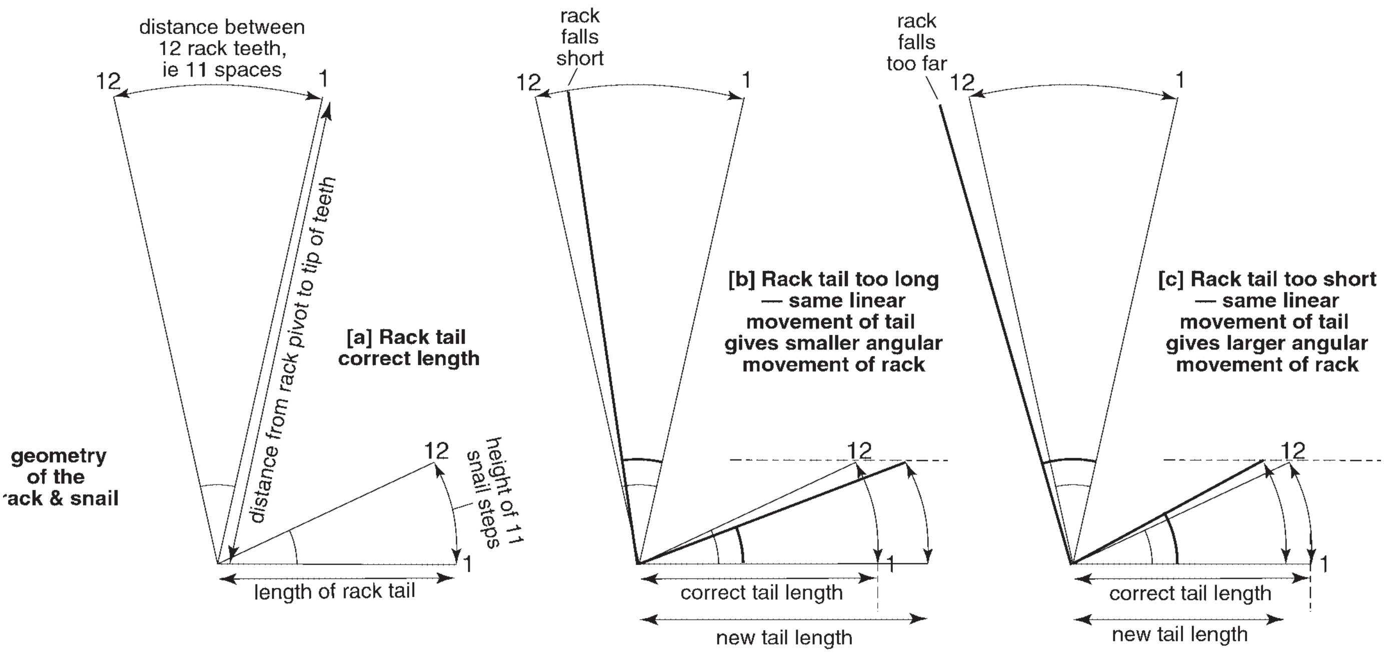
Methods of Making the Rack and Snail

Clockmakers in the eighteenth and nineteenth centuries could mark out the steps on the snail from the rack teeth, or vice-versa, using hand tools, while today's clockmakers rely on machine tools rather than the file.

Marking the Snail from the Rack

Daniel Burnap, a Connecticut clockmaker trained by Thomas Harland, an Englishman, described in 1779[1] how to mark out the

1 Hoopes, Penrose R., Shop Records of Daniel Burnap, *Clockmaker*, 1958, p112-13.



2 The basic geometry of rack-and-snail striking.

striking work of an eight-day longcase clock. This is the only contemporary description known to the author of how the job was actually done. The position of the tips of teeth of the rack were marked out using a double pointed punch to give an even spacing, but as no dimensions are given it is clear that the clockmaker would have had some idea of their pitch, taught to him during his apprenticeship and from his subsequent experience. The spaces between the teeth were filed by hand and the rack, with its collet and tail, were fitted to its stud on the front plate of the movement, along with the rack hook. A screw with a sharp point was fitted to the tail 'just as far from the end as the centre pinion'. The hook was put into the first gap (he actually says "the second tooth") and the snail, fitted to the hourwheel pipe, rotated so as to scribe the first step. This was repeated for every tooth of the rack, to mark all the steps on the snail.

The snail was divided into twelve hours by using the 72-tooth hour wheel as a dividing plate, with a piece of brass clamped to the plate acting as a detent to count off every six teeth, and the sharp point rotated about the rack post to define the edges of the snail steps. The rough snail casting would be taken off the hourwheel pipe and the steps filed to the scribed lines. The pointed screw was the replaced by a stout pin with a sloping end, to assist the tail to ride up past the large step between one and twelve, and so avoid the clock stopping if the rack was not fully gathered at 12 o'clock.

Marking the rack from the snail

By the early years of the nineteenth century, and probably much earlier, sets of clock parts were readily available with all the components cast and forged accurately to size, with only minor filing or turning required to bring them to their final dimensions.

These 'suits of clockwork' were supplied by wholesalers such as Peter Stubs of Warrington, to local hardwaremen, merchants and clockmakers, and one such set (actually almost enough parts for two clocks, and including an unopened packet of slit pinion forgings) from probably the 1820s, survives[2]. Included is a snail with the steps cast in place so accurately that only a few strokes of a file would be needed to take off any rough edges to complete the component.

There are no contemporary descriptions of how the striking work was laid out using such parts, but it is a reasonable assumption that it was the reverse of the method described by Daniel Burnap. The normal contact pin on the rack tail would contact each step of the snail in turn and using the hook or another fixed marker the position of each tooth would be scribed on the rack blank. This is the preferred method if a replacement rack needs to be made to suit an existing snail.

Modern methods

Nowadays clockmakers, particularly ex-engineers, tend to employ machine tools wherever possible, and making the rack and snail is no exception.

In a popular instruction manual on making a longcase clock movement, the snail blank is mounted on a dividing head, marked out to calculated dimensions, and the steps cut using a milling machine and rotary table[3]. The rack teeth are shaped using a milling machine and a dividing head, set to cut 144 teeth, giving a pitch for the size of rack being made of approximately 1/8". Using the measured dimensions of the components the length of the rack tail is calculated from the geometry, **2a**. The rack and other components of the striking work are assembled on false arbors clamped in the calculated positions on the front plate, which are then moved about to give the correct action. It is admitted that "there is a good deal of 'fiddling about' to be done" to get the striking correct.

This procedure turns what is a relatively simple exercise in hand filing and fitting into a major engineering project, which will take many times longer than using traditional methods. It should also be noted that as the rack teeth and snail steps are machined independently of each other there is no guarantee that they will be correct at every hour. With the traditional methods, as each tooth is filed to suit its own particular step (or *vice-versa*) small discrepancies are automatically accounted for.

Adjusting an Existing Rack Tail or Making a New One

While the above method of shifting the position of the rack stud to achieve correct striking is a possible, although heavy-handed, method when making a new clock, it is not feasible when a new rack tail needs making, or if its incorrect length causes miscounting.

If the tail is missing or needs replacing, it is best to start with the assumption that the contact pin should pass through the centre of the snail. This point was not always appreciated by clockmakers, and the striking work was sometimes made to operate with a longer or, more usually, a shorter tail than ideal. First check that with the tail on the highest step of the snail the rack hook falls into the first space, and with the tail on the lowest step the hook falls into the twelfth space. It this is satisfactory and the tail is of the correct length, then the intermediary steps should be correct, but they need to be also checked. If the 1 o'clock and 12 o'clock positions are correct, but intermediate ones are not, then it may be necessary to file or stretch the appropriate tooth or snail step, but this should only be done as a last resort.

If the rack drops so that the hook falls into the first space when the tail is on the highest step, but it drops either too short or too far when on the lowest step, then the tail is too long or too short. Does the tail need to be made longer or shorter? A consideration of the geometry shows that if the rack falls short then the rack tail is too long, **2b**, but if it falls too far then the tail is too short, **2c**. This should be obvious by intuition, although many clockmakers seem to be confused by the geometry, but the diagram should clarify this point.

A temporary rack tail, made from scrap brass with holes drilled near the end to take a taper pin, may be used to find the correct length by trial-and-error, with observations of how far the rack falls indicating which way the pin should be moved. The temporary tail needs to be a very firm fit on the rack collet, so that its angle may be adjusted, but will not move during the trials. Once the correct length has been determined, the position of the temporary pin can be transferred to the new rack tail.

An alternative approach is make an adjustable rack pin[4] which can be positioned on the tail at will, **3**. This consists of a short piece of brass bar approximately 1/4" (6mm) square with a longitudinal slot at one end. A hole is drilled through both arms of the slotted end. A pin is fitted into one arm with soft solder or an adhesive, while the hole in the other arm is opened up and tapped to take a 4BA or similar screw, **3**, **4**. This screw is drilled axially with a hole approximately 1.5mm diameter by holding it by its threads in a collet or accurate small chuck. A flat screw head is preferable, as a slot may make the drill wander when starting the hole, but cut a screwdriver slot after drilling to aid tightening.

This attachment is held onto the rack tail by the screw and moved in the appropriate direction until the rack falls correctly at both the 1 o'clock and 12 o'clock positions. When this has been determined the hole in the screw is used as a drilling jig to give the correct position for the pin on the rack tail. Once made, this simple jig can be used time and time again

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2 Robey, John, *The Longcase Clock Reference Book*, 2001, pp64. These parts are now in the American Clock & Watch Museum, Bristol, CT.

3 Timmins, Alan, *Making an Eight Day Longcase Clock*, 1981, pp48-51, 58, 59

4 This jig was devised by Fred Hall of Derby, and is described here with his permission.

3. 4. Jig for determining the position of the contact pin on the end of the rack tail.

5 A crude replacement rack tail.

6 The jig in use on the new rack tail. Note the heavy scoring where the rigid rack tail has caused the contact pin to gouge grooves in the snail. Thinning the centre of the tail alleviates this problem.

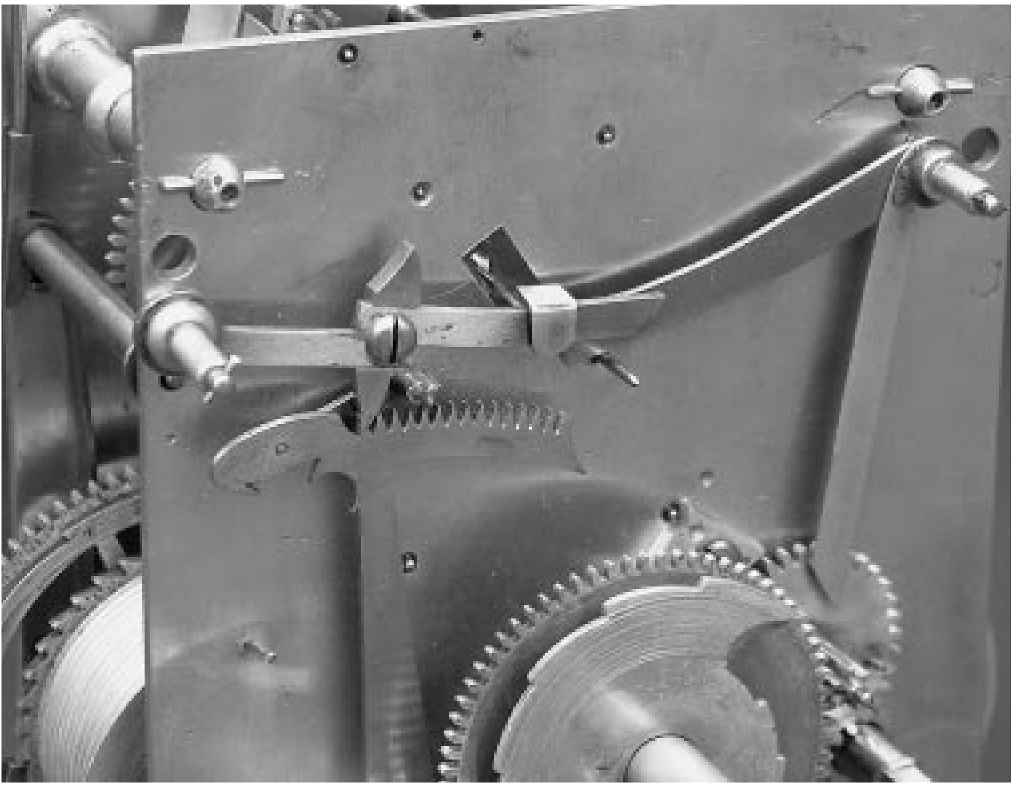
to determine the correct length of the rack tail and is far more convenient that making a temporary tail with trial holes.

There is often a stop pin in the front plate to the left of the rack to prevent to rack falling too far and jamming the mechanism. Sometimes the 12 o'clock step on the snail was made lower than necessary and the fall of the rack governed by this pin, rather than the snail. If a pin is present, check that when the rack has fallen to strike 12 o'clock the rack does not contact this pin.

If it does, make all the checks on the eleventh step, rather than the twelfth, and the above comments should be modified accordingly. Once the rack hook falls correctly at 1 o'clock and 11 o'clock, the stop pin can be 'adjusted' (the horological technical term for bending – a word which should never be uttered in the presence of a customer) so that the rack also falls correctly at 12 o'clock. If in doubt, regard the deepest step as suspect and make any adjustments to the tail when it is on the first and eleventh steps of the snail.

Once the correct length has been determined, the contact pin is fixed in place and the tail filed to its final shape, which must then be firmly riveted to the rack collet so that with the pin on the high step the hook is in the first space between the rack teeth. There must be no chance of the repeated dropping of the tail pin onto

7 The finished rack tail.



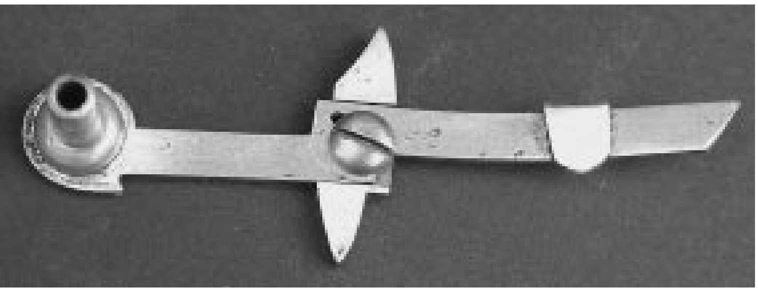
8 The strikingwork of a clock by Thomas Cooke of Derby, the movement dated 1849.

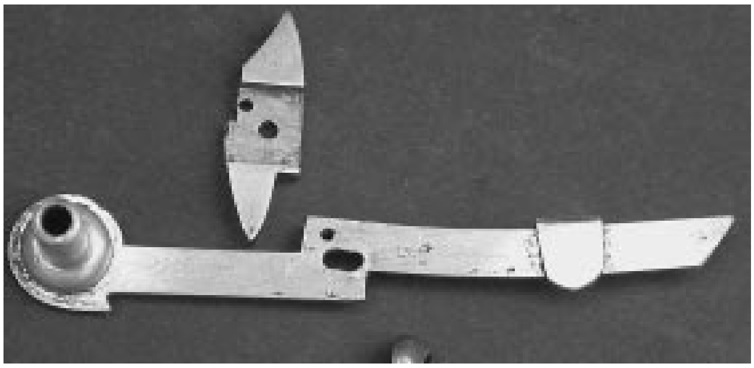
time consuming task, while the simple jig described here makes the task even easier.

An Adjustable Rack Hook

Small adjustments of the angle between the rack tail and the rack, so that the hook falls into the correct gaps between the rack teeth, can be tricky, but one longcase clock has been seen where the adjustment was made on the hook, rather than the tail. The clock has a painted dial by S. Baker of Birmingham, with very unusual Arabesque designs in red, blue, green and gold in the arch and corners, and is signed Thomas Cooke, Derby, who is recorded at four different addresses in 1843-60[6]. As well as the possibly unique dial, the movement has an adjustable rack hook, which also appears to be unique, **8**.

The hook itself is a separate piece with a slot that fits over the arm of the rack hook. The hook is fixed to the arm with a screw through an elongated hole in the arm, so that the position of the hook may be adjusted. Once the correct location of the hook had been determined the two components were locked firmly together with a taper pin, **9**, **10**. The rack hook is lifted by the warning piece via a brass tab





9, 10 The adjustable rack hook of the Cooke clock.

the snail causing the tail to move on the collet, otherwise miscounting will eventually occur. If a loose tail cannot be fixed firmly by riveting, it may be pinned with a small taper pin, or the joint fixed with a small amount of soft solder on the underside of the tail, where it is not visible.

If the contact is dirty and cannot be cleaned *in situ* to make a neat soldered joint, it is better to make a new tail than to have persistently temperamental striking. If the tail is not quite at the correct angle with respect to the rack, but cannot be moved on its collet, then gentle hammering of the rack tail near the top or bottom edges will stretch the metal and cause it to curve towards or away from the snail.

Similarly, a rack tail that is too short may be stretched by even hammering in the centre of the tail. A tail that is too long, but not long enough for the contact pin to be repositioned, must be remade.

A very poorly made replacement rack tail on a clock by James Fowlds of Kilmarnock is shown in **5**. Not only is the crude contact pin fixed with a nut, spring washer and cross pin, but the tail is also thick and inflexible. The distance from the contact pin to the pivot post is 28.5mm, whereas for it to pass through the centre of the snail it should be 36mm, but the new tail was found to be the same length as the existing one.

Other clockmakers, including the Harlows of Ashbourne, major manufacturers of longcase movements during the first half of the nineteenth century[5], used the preferred length. The jig was used on the replacement tail to find the exact position of the contact pin, **6**, while **7** shows the finished tail. The rear of the tail was thinned to half its thickness to improve flexibility, so that it rides up over the snail if 12 o'clock is not fully struck.

Having a clear understanding of rack-and-snail geometry will enable a systematic approach to be made to what can otherwise be a very frustrating and

riveted to the arm of the hook. The hook is double-ended with two different shaped points. The arrangement is experimental, nevertheless well made, but whether it is original to the movement, or a later modification, is difficult to determine. The fact that the movement has the date 1849 neatly engraved on the front plate suggests that the clockmaker wished to record it as something special, hence the adjustable rack hook may well be original to the movement.

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5 Robey, John, "Samuel Harlow of Ashbourne and his Longcase Movements", *Antiquarian Horology*, March 2002, pp527-45

6 Hughes, Roy G., & Craven, Maxwell, *Clockmakers & Watchmakers of Derbyshire*, 1998, p82