Worcester Cathedral
Guild of Bellringers

# CREATING A WELL BALANCED RING
## Part 1 – Bell Swing Times

At Worcester Cathedral over the last 3 ½ years we have been tackling a range of steeplekeeping issues. The 12 bells (total weight 10 tons) plus 4 semitones are hung on mainly 1928 fittings in a wooden 1870 frame 'perched' on a unique wooden structure inside a rather weak tower. Over the last decade those of us who have rung quite a lot of peals here have been very aware of the difficulties of ringing them well. Whilst tower movement is an issue, it did look as though some aspects of the installation could almost certainly be made better, and making a series of small improvements would eventually add up to serious positive change.

For the first two years we concentrated on some basic stuff –

**ROPES** – Getting a decent set of ropes sounds simple but isn't. It took a great deal of work to arrive at today's position of having reasonably good (and appropriately specified) ropes on all the bells, some adequate spares, and a rolling plan of repair and replacement

**PULLEYS & CHUTES** – A vast amount of effort was put into ensuring that all the pulleys employed (over 40) were working well, that not too many were used and that the drawing of any non-vertical ropes was done with as little friction as possible. This produced a vast improvement in the perceived 'go' of the bells.

**SLIDERS** – Wood running across wood is another source of friction, so we reduced it as much as possible using sandpaper and silicon polish. This had quite a noticeable effect on the front bells, which are rung to the balance in a heavy twelve. We replaced the sliderways of treble and 5$^{th}$. There is more work to do on this.

**HANDSTROKE PULL** – Quite a number of the bells had incorrect handstroke:backstroke ratios, making them more difficult to ring than necessary. 9 of the 16 were altered, with very positive results, especially for the middle bells.

Whilst doing all this we were often asked when we were going to tackle the **ODDSTRUCKNESS.** As the actual discrepancies between handstrokes and backstrokes were not large it seemed to us that what needed examining was the whole balance of the ring and whether or not anything could be done to improve it. Ringers often use the term 'oddstruckness' to describe a problem which is much greater than bells' uneven clappering.

There are potentially three problem areas within a ring which can make the bells uncomfortable and cause striking problems -

**SWING TIMES** - Bells which swing too fast or slow for their position in the ring are very awkward to ring, and for other ringers to ring round, and this problem gets harder for the ringer to work with the bigger the bells are. Perhaps at Worcester we are more aware than most because we have 'subsidiary' rings such as the Harmonic Minor Ten and the Clare Ten which highlight the awkwardness of ringing with non-optimal swing times. The thing that was most obvious in the new (2018) Clare Ten was that the 9# was really uncomfortable even after its actual oddstruckness had been eliminated. Experimenting with that bell proved it was possible to slow down bells quite easily and made us determined to get the Twelve correct, or at least better. (A bell's swing time is how one swing takes when it has been moved a short distance from rest – it can be measured using a stopwatch or using the Bagley OSM).

**CLAPPER TIMES** – the clapper may swing too fast or too slow for the bell. It is obviously worth checking that the pivot is well-lubricated, but the main factor is the position of the staple inside the bell – moving it further out (down) accelerates the clapper. A large amount of re-positioning requires some change in the length of the clapper, and also, we found, a longer staple bolt in most cases. We did not attempt any re-design of the clappers, just tried to make them work properly.

**ODDSTRUCKNESS** – this term should be reserved for where the clapper takes longer to contact one side than the other, so that to strike it correctly the ringer has to shorten one of the pulls. The clapper needs to be moved slightly by the use of tapered washers or shims. On more modern fittings it can be moved by altering the 'twiddle pins'. It can be difficult to achieve the size of difference you want and sometimes the clapper itself isn't true. Another approach is to add a weight to one side of the wheel but this will affect the bell's swing time too.

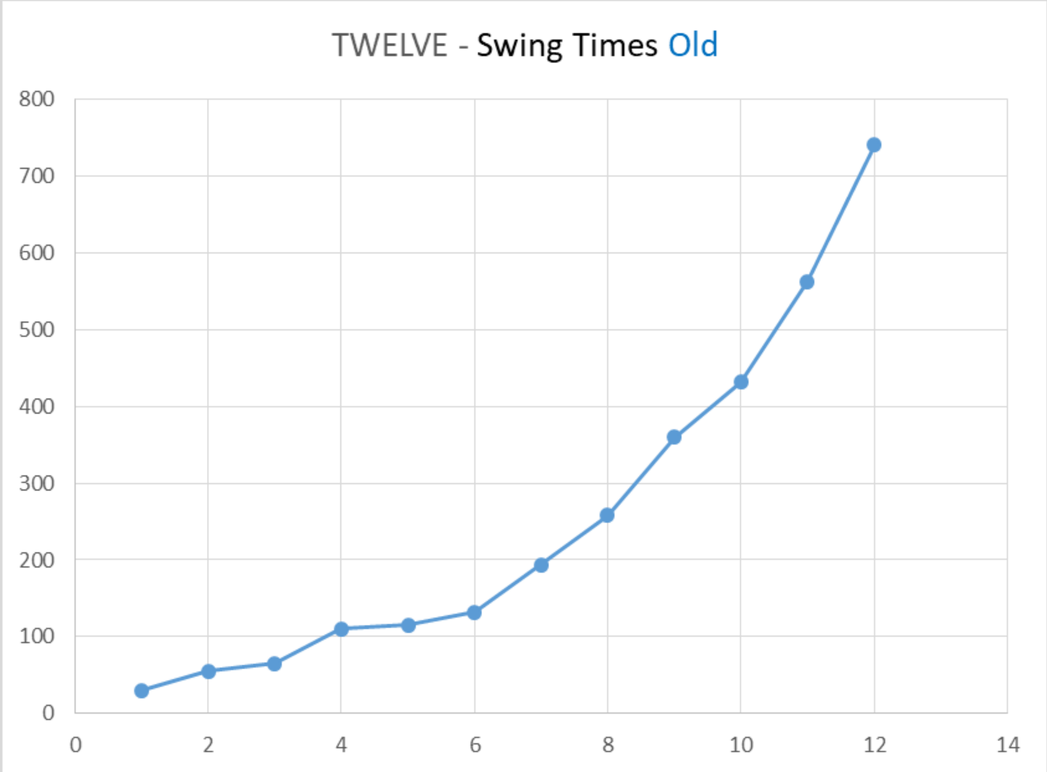
In our experience the swing times have the biggest impact on the ability to produce good ringing, so getting them right is the most important. This is especially true with larger bells where the ringer does not want to be 'fighting' the bell to get it into the correct position.

These aspects are covered in three papers. This first one is about Swing Times. The second deals with Clappering and the third with Oddstruckness..

# SWING TIMES – the Twelve

The swing times were measured in July 2019 and are shown graphically below, *(the y-axis is milliseconds less 1600).* They depend mostly on bell weight but the proportion of each bell above the pivot line of the bearings (the amount of 'tucking up') is crucial to the exact number.

We are confident in these numbers as the swing times had been measured previously, both manually and electronically, with results which pretty much matched these measurements.




$2^{nd}$, $4^{th}$ & $9^{th}$ too slow?

or

$3^{rd}$, $5^{th}$, $6^{th}$, $10^{th}$ & $11^{th}$ too quick?

Ideally this should be a smooth line – it is clear that adjustments were required. One way of viewing this is to see the $4^{th}$ and $9^{th}$ bells and to a lesser degree, the $2^{nd}$, as too slow. But as it is close to impossible to speed bells up (at least not without rehanging) the other way to perceive the line is that the key fixed points are the $4^{th}$, $7^{th}$, $8^{th}$, $9^{th}$ and tenor, meaning that other bells should be <u>slowed down</u>.

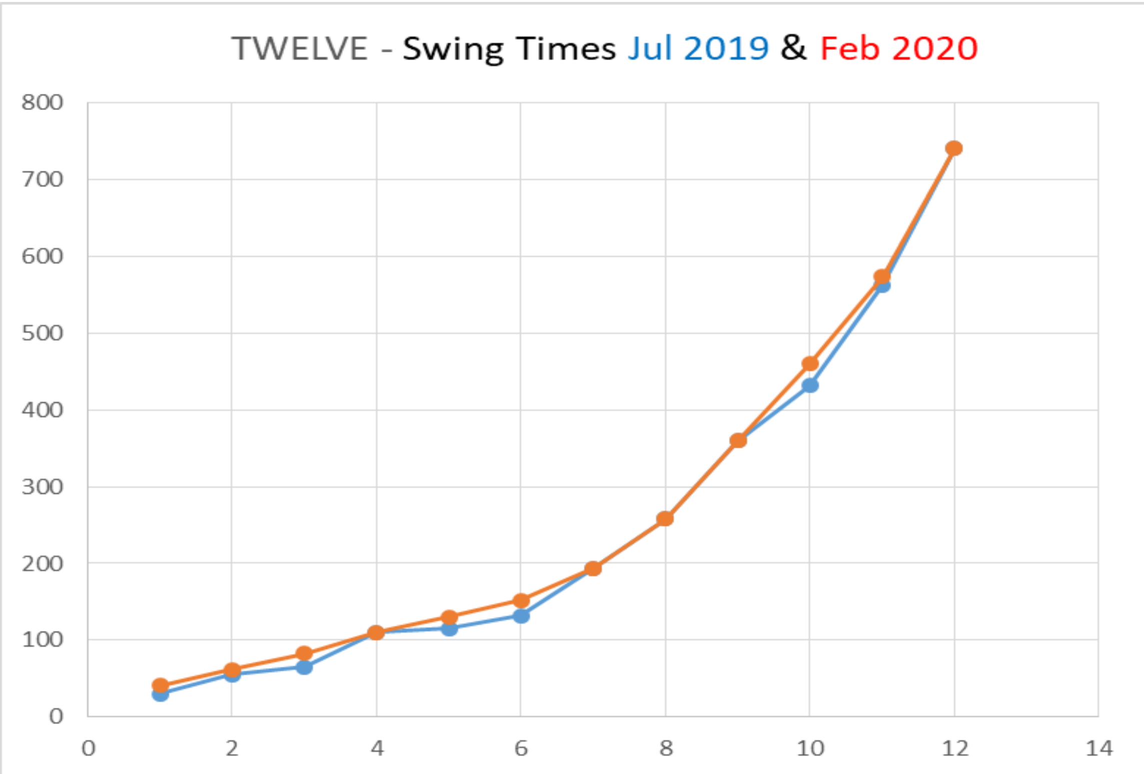
In terms of importance getting the 'rhythm-setting' larger bells[1] consistent with each other was key, so the first work done was to **adjust the $10^{th}$ and $11^{th}$** to fit in with 7-8-9-12. Weights safely bolted to the wheels slowed the swing times (by over 30ms in the case of the $10^{th}$) and the difference in ease of ringing was immediately apparent. There were many favourable comments after the peal on 10 Aug 2019.

[1] Worcester actually has the heaviest back end of any of the Top Ten big rings of bells. The total weight of the $9^{th}$ $10^{th}$ and $11^{th}$ bells as a percentage of the tenor weight is 167%. The complete twelves tend to be closer to this figure than the mixed-founder ones.

We could have stopped there but there seemed no good reason not to get the front end right as well. Whilst these bells are rung up to the balance rather than below it like the back bells, their swing times are still important in terms of how comfortable they feel to the person on the end of the rope. Using our experience of adjusting the 9# and the back bells we were able to assess what weights were needed and had steel plates manufactured at NDS Engineering. This avoided the need to drill steel on-site which had wrecked most of our drill bits doing the work on the 10th and 11th!

By early Sep 2019 the **front six bells** (apart from the 4th obviously) had been slowed which had a very favourable effect on the ringing experience. It should be noted that at this point <u>no work had been done on the strike times of the clappers</u>, validating the original premise that the swing times have the biggest impact on the ringers' ability to ring rhythmically with ease. To put it another way, it seemed to be easier to ring bells with the correct swing times and incorrect clappering than to ring bells with the right clappering and the wrong swing times.

The work on adjusting swing times is now complete, with 7 of the 12 bells having some alteration. The next graph shows the original times plotted in blue and the new times in red/orange. The blue plot is hidden where the swing time has not been changed (4th, 7th, 8th, 9th, tenor)




With the twelve adjusted work then moved on to adjusting the semitone bells.

## SWING TIMES – the semitone bells

Worcester is unusual in having four semitone bells which are used in four distinctive rings. The major ten employs three semitones, the minor ten two, and the two octaves one each. Generally such 'sub-sets' of a twelve always feel slightly more 'awkward' than the same size bells hung as a single ring but in Worcester's case they always felt particularly difficult.

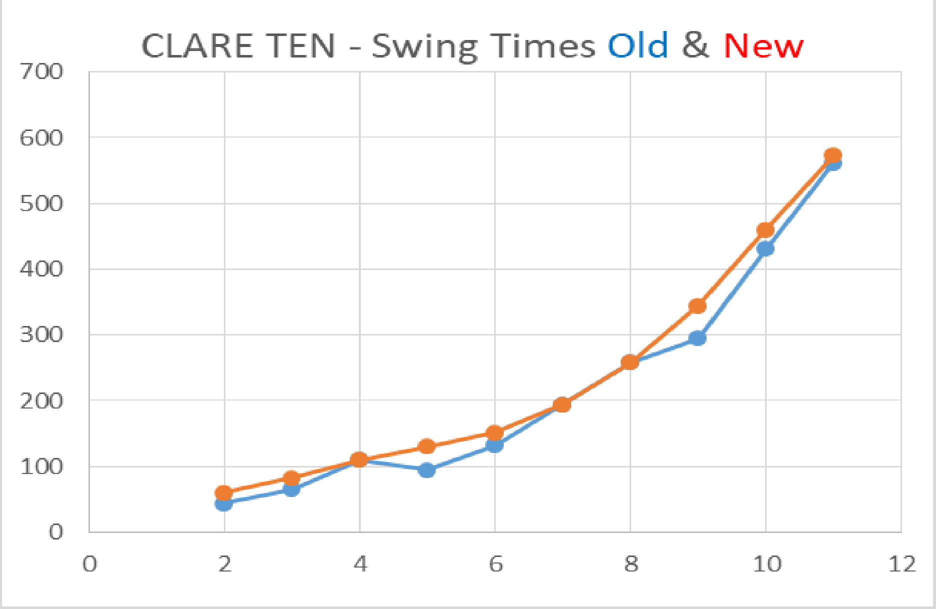
Given that the swing times for each of the main bells should be set up optimally for ringing the twelve, we reasoned that one curable problem with the 'sub-sets' was that each semitone performed rather differently from the bell it replaced. The most obvious case was the 9# which spun much faster the 9th, mainly because it is so much smaller – 833kg vs 1019kg[2]. In fact, trying to adjust this bell was our first experiment and its success encouraged us to tackle the twelve.

As the adjustments made to the 5# and 9# were the largest that needed to be made to any of the bells one has to wonder why they were hung so poorly. Possibly because the semitones within the previous ring (the 'Grimthorpe' twelve cast 1869 and recast in 1928) were only used by the carillon machine, their replacements were not expected to do much more. So although hung for ringing they were not used much, the first peal on any of the semitones (6b) not being until 1960.

The changes to each ring are plotted below. In some cases the work already done within the Twelve had the largest impact but for the Tens it was the changes to the semitone swing times which were key. The 6b was not altered because it did not require slowing down – in fact speeding it up would have been desirable but was not possible.

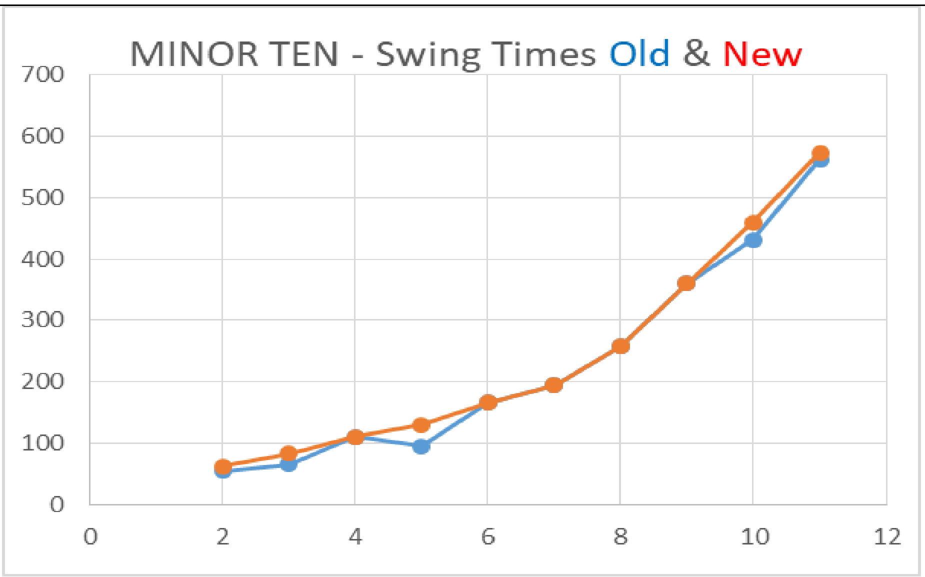
[2] Not only is the 9# light but the 9th is quite heavy, at over a ton. The only bigger 9th bells are in larger twelves. At 42% of the tenor weight it is in line with those of the big complete twelves but larger than the 9th bell of mixed rings such as Exeter, Redcliffe and Southwark.

## CLARE TEN – 2#, 3, 4, 5#, 6, 7, 8, 9#, 0, E



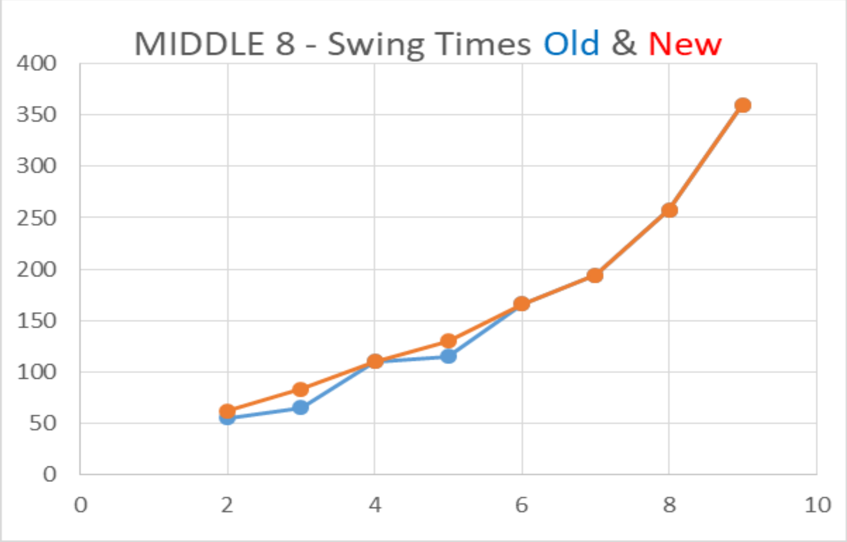

The large changes to the 5# and 9# bells are very evident. The smaller change to the 10th is also important.

## HARMONIC MINOR TEN - 2, 3, 4, 5#, 6b, 7, 8, 9, 0, E



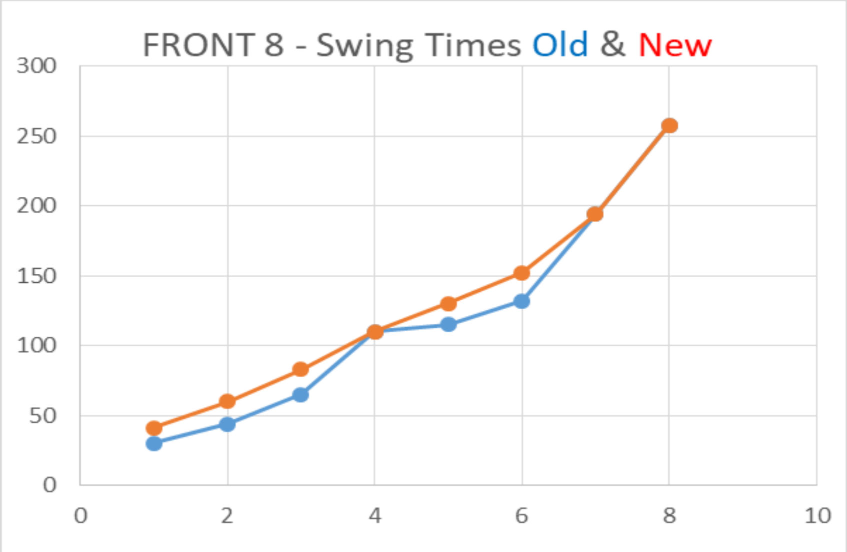

The alteration to the 5# and 10th are the key changes.

## MIDDLE EIGHT – 2, 3, 4, 5, 6b, 7, 8, 9




The slowing down of the 3rd and 5th when altering the Twelve made the most difference here as the semitone (6b) was left untouched.

## FRONT EIGHT – 1, 2#, 3, 4, 5, 6, 7, 8




The work done slowing down most of the front six obviously made the most difference to this octave.

With the swing times sorted we next turned to the clappering. This proved quite a task for various reasons and is the subject of the next paper.

## CONCLUSION

The adjustments necessary to balance the swing times of this magnificent ring of twelve were not huge, being neither difficult to calculate[3] nor tricky to implement. What did seem odd was that they were needed at all – this is a ring all cast together and hung at the same time. Even though they were hung in the old 1869 frame it should not have placed a restriction on the choice of their hangs and all bar the tenor had new headstocks.

That was all nearly a century ago but the intriguing question is this – if we asked the industry to rehang them now (in the same frame), what would be different? What swing time numbers would they come up with? Would they be prepared to share their thoughts on this? We've adjusted what we've got to make it better but what would be the answers if we started from scratch?

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*Bernard Taylor, Steeplekeeper*

*24 Mar 2020*

*A slightly altered version of this appeared in the 'Ringing World' issue of 17 Apr 2020 pp 388-91, unfortunately in black & white which rather spoilt the graphs. However the digital version was in colour.*

[3] The Bagley OSM has been very useful and an Excel spreadsheet very handy but all of this can be done with paper and pencil.

# APPENDIX 1 – Swing Time data

Bell Swing Times, in milliseconds (ms), measured using the Bagley OSM.

| | 30 Jul 19 Swing Time | **25 Feb 20 Swing Time** | Adjustment made |
|---|---|---|---|
| 1 | 1630 | **1640** | 10 |
| 2 | 1655 | **1662** | 7 |
| 3 | 1665 | **1683** | 18 |
| 4 | 1710 | **1710** | --- |
| 5 | 1715 | **1730** | 15 |
| 6 | 1732 | **1752** | 20 |
| 7 | 1794 | **1794** | --- |
| 8 | 1858 | **1858** | --- |
| 9 | 1960 | **1960** | --- |
| 10 | 2031 | **2060** | 29 |
| 11 | 2162 | **2173** | 11 |
| 12 | 2340 | **2340** | --- |
| 2# | 1644 | **1664** | 20 |
| 5# | 1695 | **1730** | 35 |
| 6b | 1766 | **1766** | --- |
| 9# | 1895 | **1945** | 50 |

## APPENDIX 2 - Wheel Weights

The weights bolted to the wheels are steel **plates 10mm thick and 8" long**, cut from either 3" or 4" wide steel 'strip', painted and pre-drilled. Usefully a pair of 3" plates weigh 3kg, a pair of 4" plate 4kg. The plates are bolted to each other, clamping them against the double spoke of the wheel above the headstock, this being the most obviously strong point.

| Bell | | | % of bell | | Bell | | | % of bell |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 x 3" | 3 kg | 0.8 | | 9 | --- | | |
| 2 | 2 x 3" | 3 kg | 0.7 | | 10 | 3 x 3", 1 x 4" | 6.5 kg | 0.5 |
| 3 | 2 x 4" | 4 kg | 1.0 | | 11 | 2 x 3" | 3 kg | 0.2 |
| 4 | ---- | | | | 12 | --- | | |
| 5 | 2 x 3" | 3 kg | 0.6 | | 2# | 2 x 4" | 4 kg | 0.9 |
| 6 | 2 x 4" | 4 kg | 0.8 | | 5# | 4 x 3" | 6 kg | 1.4 |
| 7 | --- | | | | 6b | ---- | | |
| 8 | --- | | | | 9# | 8 x 3" | 12kg | 1.4 |

To put this in context, the additional weight these additions are making to the bell is 1% or less in most cases. The most extreme adjustments were those of 5# and 9# where the goal was to make each swing like the bell they replace.

For the 9# this meant getting an 833kg bell to feel like a 1019kg bell. Interestingly, this has made the bell clapper correctly. It was actually looking at why this bell was so awkward to ring within the C# eight and ten that led us to consider what was possible for the other bells. We figured that if this one could be altered then the adjustments needed elsewhere would be minor by comparison.

One of the good aspects of this work is that it is all reversible – if our successors want the authentic 1928 experience they can get out the spanners and take these weights off.

## APPENDIX 3 - Measurement

Swing Times were measured using The Bagley Odd Struck Meter (OSM). It employs a photo-head (sensor) and yellow reflective tape (YRT) together with a microphone. It can measure the swing time when the bell is down and swung through a small arc, and the clapper strike time of handstroke and backstroke when the bell is rung.

More detail is on David's website www.ringing.demon.uk/osm/osm.htm