Worcester Cathedral
Guild of Bellringers

Restoring the Clock’s Quarter Chimes

After being declared unsafe in Oct 2018 the quarter chimes have been silent, and the cathedral clock’s only function has been to chime the hours. Renovation of the quarter chimes was approved in 2020 by Chapter (4 June) and the FAC (15 July) as part of a package of works, which also included removal of the redundant carillon hammers and the rehanging of the 5# and 6b semitone bells in new locations.

The original intention was that the Cumbria Clock Company would restore the quarter chimes but absence of funds meant that our steeplekeeping team has undertaken the work at no charge. The offer was made in October 2020 and taken up in Feb 2021. Work started once yet further Covid restrictions began to ease. As with the 2020 work we were restricted to short days, 9am – 3pm, at the request of Chapter.

The work

All of the hammers, quadrants and wires were removed in 2020, leaving the area free for the Cumbria Clock Company to install new kit to restore the chimes. As events transpired we ended up doing the work ourselves and rather regretted having been so efficient in our clear-up efforts - we re-used a number of heavy items, all of which we had lowered from belfry to clock-room, and all of which had to be lifted back up again!

HAMMERS

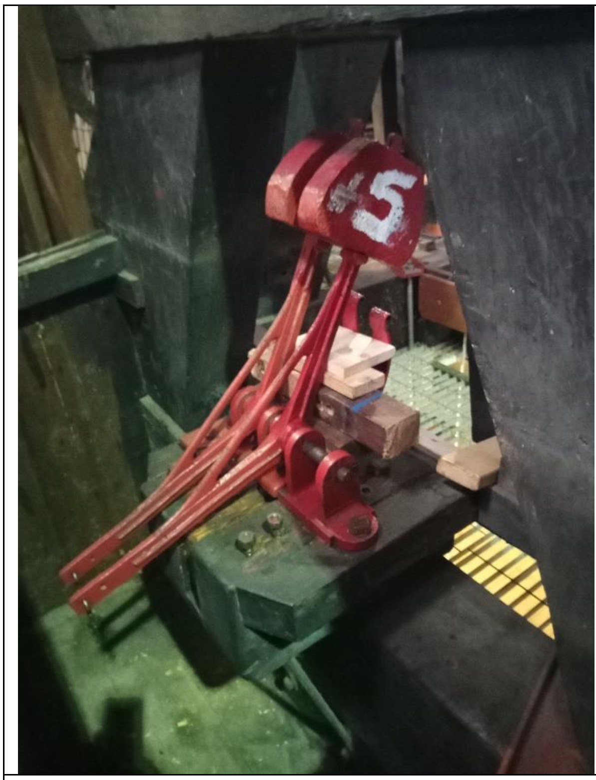
We started **9 March 2021** with the first task, selecting and installing five hammers.

We found 5 appropriate size hammers plus support springs from the carillon and clock hammers removed in 2020, weight and lever distance being the key considerations. Although we had removed 5 clock hammers and 28 carillon hammers the choice was quite limited since many were not on mounts and a significant number were too large.(For the record the 6b has the old 7th clock hammer, the 9th has the 5th pair of carillon hammers, and the 4th and 5th have two single carillon hammers. We also saved a pair for spare.) Those we chose had to be degreased and cleaned. A feature of the Worcester hammer installation was the enormous amount of grease liberally plastered over everywhere which had of course attracted all the airborne dust possible. Our working hypothesis was that rather less is actually needed.

For the 9th and the 5th there were suitable wooden platforms next to the bells on which to fix the hammers, but for the 4th and the flat 6th we had to build them. They have to be rigid and strong to absorb the force of a striking hammer. Whilst the 9th and Flat 6th had plenty of space to work in, the other two caused us to be awkwardly placed in the bell- frame. Each hammer had to be carefully positioned so that it struck the thickest part of the bell's soundbow.

A key part of the mechanism is the spring which needs to be able to hold the hammer away from the bell after striking but not impede its downward movement before striking. For each location this proved to be the trickiest part to install.

Fitting was time-consuming and it wasn't until 6 April that all of them were in position. The installation of the 4th hammer was accompanied by renovation and re-positioning of the slider way.

	
NINTH – the pair of carillon hammers from the 5th	FLAT SIXTH – the old 7th clock hammer in glorious red primer

	
FIFTH – installed on south side, operated from pit of 6th	FOURTH – installed on west side, operated from under the treble

QUADRANTS

The clock has a barrel-driven pull-down and release mechanism to operate the chiming hammers, which connected, via long wires, to five quadrants in the NE corner under the bell-frame. These we have termed the **'clock quadrants' (CQ)** (they are also known as 'cranks') and they convert the vertical pull to a horizontal one. Because the hammers are now on different bells (4-5-6b-9 and not 7-8-9-T) these CQ's had to be re-oriented to face in the right directions, which necessitated the removal of the wooden 'cupboard' around them. Like everything else they also had to be degreased and cleaned.

In terms of awkwardness this was work akin to mining, never standing up straight and always being positioned uncomfortably.

Under each hammer we had to install a **hammer quadrant (HQ)** to reverse the process, aligning them with those in the NE corner. In the case of the 9th we dismantled two of the quadrants to create a double one, as this bell has two hammers. Attaching these to the underside of the frame was heavy work.

We lined them up and connected them using washing line because that was easy to adjust and we wanted to get all the hardware in just the right places before doing a proper linkage with wire rope.

QUADRANTS

The floor quadrants (CQ's) in the NE corner which convert the vertical pull from the clock below to horizontal pull across the belfry.

Photo looking north

The two tenor HQ's side-by-side under the bell-frame, which operated before Oct 2018.

The largest bell and therefore lowest note of the four quarters always needs two hammers because in two of the sequences it is struck twice in succession. The pickup and release takes too long to do this at a satisfactory speed using just one hammer.

The 9th is now the lowest note of the quarters and has a pair similar to these.

Photo looking west

LINKING THE PARTS

Using strong washing line, by 12 May we had made the three linkages needed for each chime - Hammer to HQ, HQ to CQ, and CQ to Clock – and then tested that it all worked. However, the clock's quarter chime mechanism, the release lever, refused to play ball. It wasn't until the next week we worked out that the clock was actually 12 hours[1] out, so it was on night-time during the day. Its mechanical night silencer fixed to the geared-down hour strike stops the quarter chimes operating between 10pm and 7am and so we were trying to get them working when they were locked off! Winding the hour strike round 12 hours was the solution.

So on **19 May**, we were able to get the clock's release lever working well enough for the hammers to be operated manually. Getting the tension just right on the setup was the hardest part – too loose and the hammer is not picked up enough, too tight and the hammer does not drop enough! We also had to ensure that the hammers in the raised 'off' position were clear enough of the bells for them to be safe to ring.

Once we were happy with this, all the line was replaced by 4mm galvanised steel wire rope, each end of which had to be made into a loop, a total of 30 ends. The adjusters at the clock end were used to get the tension right in each case. For each chime there is about 13m of vertical wire to the clock quadrants, 5-10m horizontal distance to the hammer quadrants and another metre up to the hammer. Overall we used about 120m of wire. On **16 June** this was completed - a video of the chimes working is on Facebook.

SORTING OUT THE CLOCK

At this point it was obvious there was a problem with the clock itself. The strike mechanism would only work manually and was slightly misaligned so that the last bell of each quarter failed to strike. This was extremely frustrating. In addition the belt drive used on the motor for raising the weights which drive the strike was missing and we had to create a makeshift one from cable ties.

On **4 Aug** Keith Scobie-Youngs visited and fixed the strike mechanism. He made the observation that the mechanism is very worn, not surprising after 152 years, and will need some attention soon. The temporary fix we had applied to the weight motor broke just after, so a new belt was installed on **9 Aug**. We made a small repair to the release lever's brake on **12 Aug,** adding some weld to replace the worn part.

Unfortunately that wasn't quite the end of it. After a period the chimes stopped working and it became clear we had at least two more issues. First, that the 'lugs' on the

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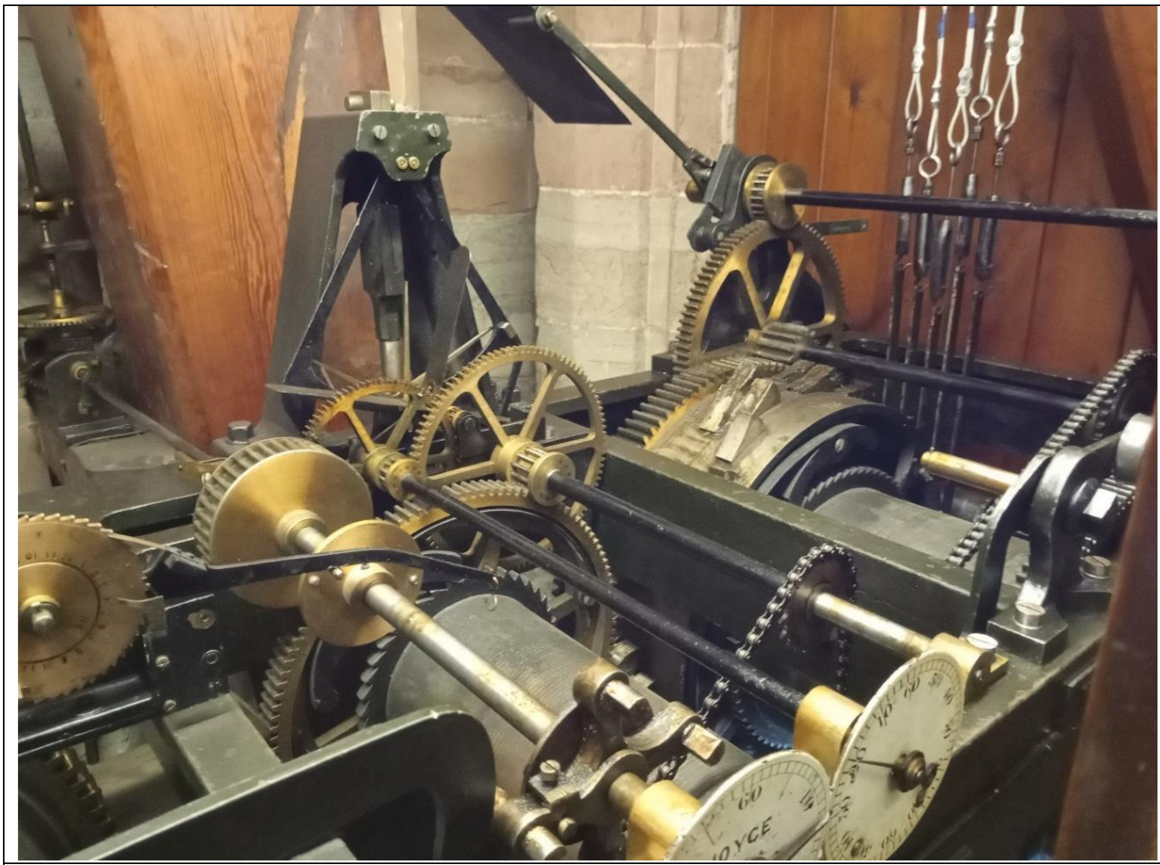
[1] Likely to have been caused by winding the hour strike forward 11 hours at the autumn time change (rather than stopping it then restarting after an hour), and then winding it another hour forward the following spring. With no quarter chimes in action this error would not be obvious.

rotating wheel which interact with the release lever were not all acting the same way, creating a situation where the some of the quarters worked, but not all, and once one had failed they all stopped because the release lever would be in the wrong position. Second, the brake on the release lever was not engaging correctly with the count wheel with much the same result. So after a whole day's work on **31 Aug** we were getting a little despondent.

Keith paid another visit on 8 Sep with some good advice and on **13 Sep** we were able to do a day of focused work, involving some reshaping of the end of the release lever, and gentle re-profiling of the recalcitrant lug so that it performed in the same way as the others. We also pinned the brake to the lever as it was prone to slipping. That day we also replaced the belt drive on the hour bell's weight motor, not before time as the old one broke as we took it off. There was also time to clear out the bottom of the clock case, which generated two bags of rubbish.

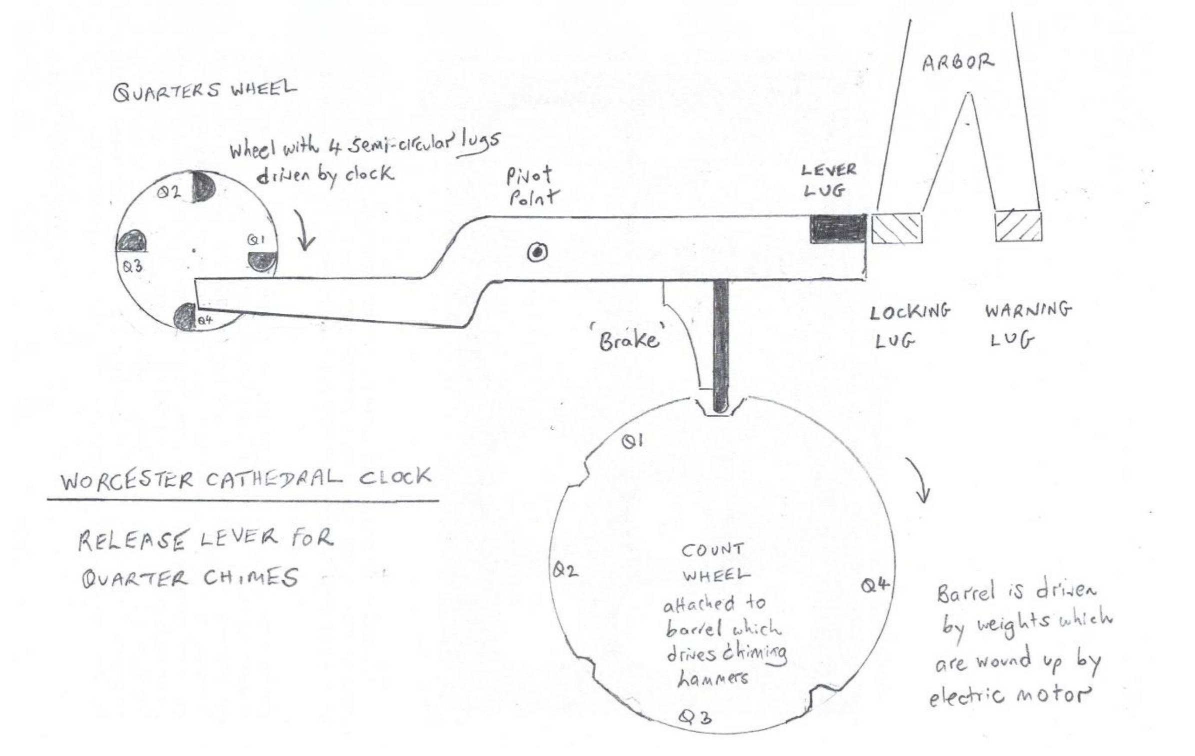
The chimes were still operating that evening before and after the ringing practice, so perhaps, finally, we have got the quarters working! Overall it has taken 6 months.

There is still work to do on making the chimes a bit louder, on lighting the clock properly and generally showcasing this magnificent 1869 machine as it should be.

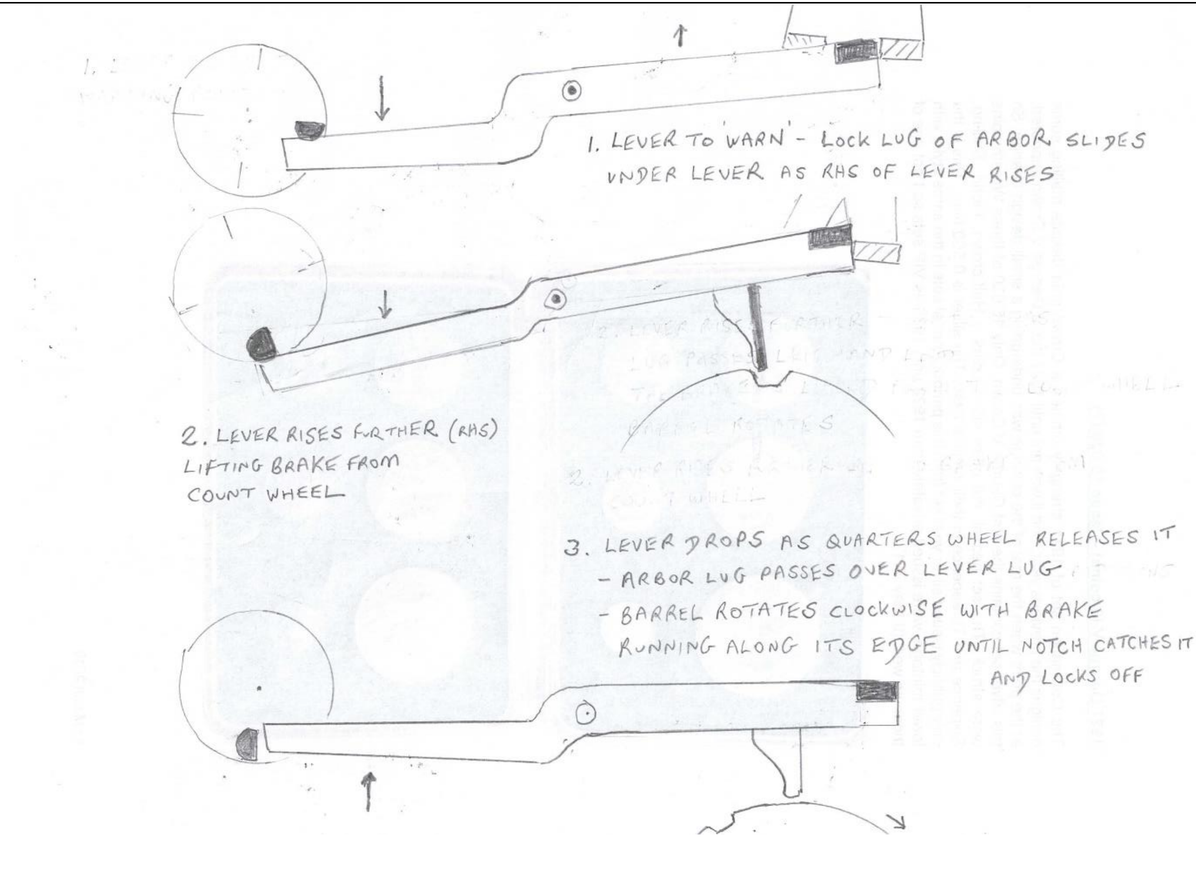


4 Aug 2021 – the new quarter chime connections in place

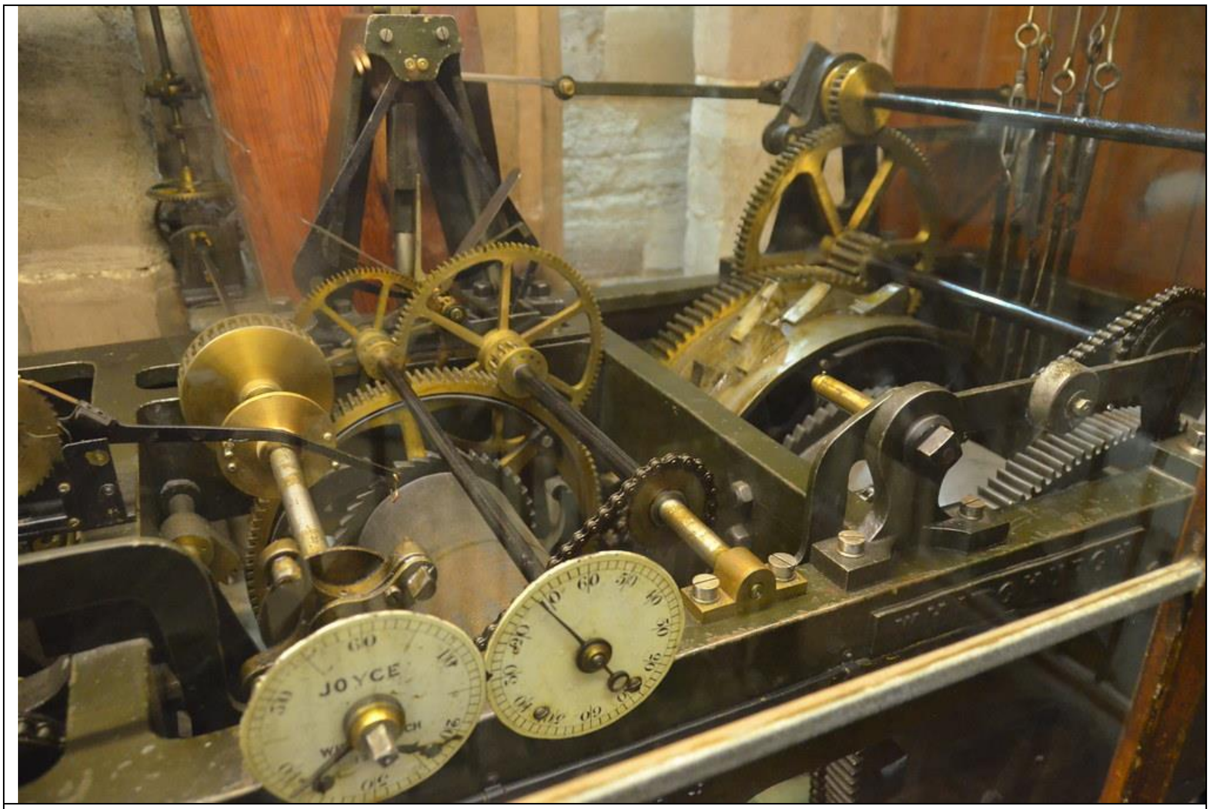
Bernard Taylor, Steeplekeeper, 15 Sep 2021



The **Release Lever** which allows the quarter chimes to operate



Historical Note – Clock



The clock in Apr 2021 – centre train which drives the clock and right hand train which drives the quarter chimes. The hour chime train is out of shot on the left. The old linkages to the hammers, about 60' above, are on the right of the picture

The **1869** clock was designed by Edmund Denison (later Lord Grimthorpe) and manufactured by **James Joyce** of Whitchurch in an early collaboration with his brother John Barnett Joyce at Bradford. At the time of its installation it was regarded as the second largest clock of its type, the Great Clock of the Palace of Westminster being the biggest. It is a flatbed movement, equipped with Denison's double three-legged gravity escapement - apparently the first made by Joyce who, up to then, had used his own form of four-legged gravity escapement. The 13-foot pendulum swings every two seconds. The clock has proved to be an excellent timekeeper. Unusually, it has no external dials - owing to the stipulation made by the Earl of Dudley as a condition of his £5,000 donation for the tower restoration - but it drives two slave dials, one in the ringing room and the other (decorated by Hardman of Birmingham) high up on the east wall of the north transept.

The clock has an **auto-winding mechanism** dating from the 1960s, with the drive weights falling just below the clock. Previously all three drive trains were hand-wound daily, and the weights travelled up and down in the NE corner.

The Joyce clock operates **six chiming hammers** by linkages of wire rope and quadrants. Five of these go up in the NE corner and operate the quarters on bells 4, 5, 6b and 9, whilst the one for the hour bell goes up the centre of the N wall.

SILENCING THE CHIMES

A **mechanical lock** was fitted in the 1960's (?) which prevents the **quarter chimes** striking at night – after 10pm and before 7am. Its timing is set by the clock itself using the hour strike count wheel. On the left-hand front of the clock a 'count' wheel for 24-hrs is geared-down from the 12-hr count wheel, on the back of which a cam forces a lever to pull a wire which places a lock on the quarter chime mechanism after the hour has struck at **10pm**. In the morning the **7am** hour strike releases this lock, so the first quarter chime of the day is at 7.15. During this period the clock cannot move the arbour, the chime barrel does not rotate and its drive-weight does not move.

A similar mechanism, employing a mercury switch, was used to silence the hour bell but it is no longer operational. Night-time silencing of the hour bell is done by the CCC electro-mechanical box – see below.

The **CCC** (2006/2013) **electro-mechanical pull-off device,** situated in the ringing room by the door, lifts the quarter and hour hammers away from the bells (plus the tolling hammer on 9#), and replaced an older manual 'pull-off'. The clock continues to operate the chimes but no sound is heard as the hammers do not reach the bells. The switches are operated manually, so that ringing can take place – it is safe to ring when a green light is displayed for the quarters (4,5,6b,9), the hour bell (bourdon) and the tolling bell (9#) when the hammers are off.

Separately the box contains a timer which is set so that the **hour hammer is pulled off** just after **10pm** and put back on just before **7am**. It is important that the timer is set to match the actual clock, (it therefore needs adjusting twice a year), and that the period chosen matches the mechanical timing of the quarters.

One piece of redundant mechanism still attached to the clock is the connection to the carillon machine (which had no timing mechanism itself) to tell it when to play. This was done on a 3-hourly basis, at 9am, noon, 3pm and 6pm. The carillon machine fell into disuse in the early 1990's.

Historical Note - Chimes

15 mins	**4 5 6^b 9**
30 mins	**6^b 4 5 9 – 6^b 5 4 6^b**
45 mins	**4 6^b 5 9 – 9^2 5 4 6^b – 4 5 6^b 9**
Hour	**6^b 4 5 9 – 6^b 5 4 6^b – 4 6^b 5 9 – 9^2 5 4 6^b**
	The lowest note, the dominant, in this case the 9^{th} bell, requires two hammers because it takes too long for the clock mechanism to strike consecutively when the fifth phrase follows the fourth. This is marked as 9^2 to distinguish it from the normal hammer, marked 9.

These are not the actual notes of the Worcester bells (which are C#, B, A and E) but of those at Westminster – however it is the relationship between the notes that matters.

The quarter chimes are a set of five phrases played twice through the hour, alternately finishing on the dominant (9^{th}) and the tonic (6^b) notes, alleged to have been derived from Handel's 'Messiah', and first used in Cambridge in 1793, but better-known from the 1851 installation at Westminster where the hour bell is the 13.5 ton 'Big Ben'.

The five phrases could be played on six combinations of the bells at Worcester – $2^\#$-3-4-7, 3-4-5-8, 4-5-6^b-9, $5^\#$-6-7-0, 6-7-8-E and 7-8-9-T. Up to 2020 the hammers were on the heaviest of these but they were not originally planned that way. When the 1869 twelve were put in a $5^\#$ was included as a 'quarter' bell, at the insistence of Edmund Denison, so that the chimes would mimic those at Westminster, designed by him 18 years earlier.

The key issue for Denison was that **the tonic note of the set should match the hour bell** which is an octave lower. In 1869 that meant using $5^\#$-6-7-0 as the quarters because the 7^{th} matched the B^b bourdon. However, and rather unusually, he was persuaded to have the heaviest quarter bells possible, 7-8-9-T, which left the $5^\#$ functionally useless until the carillon machine, along with a further two semitone bells, was installed in 1874.

In ringer's terms the quarters and the hour represent 1-2-3-6-0 of a ring of ten bells. However, across the country the chimes that have probably been most frequently installed are 1-2-3-6-6 on rings of six and 2-3-4-7-8 on rings of eight, so everyone has become quite accustomed to the hour bell bearing no direct musical relationship to the quarters.

In 1928 the bells (by recasting), and the bourdon (by retuning), both changed pitch but Denison's original plan was still possible, and installed in 2021 –

	1869 plan			2021	
Mediant	$5^{\#}$	D		4	C#
Supertonic	6	C		5	B
Tonic	7	B^{b}		6^{b}	A
Dominant	10	F		9	E
Tonic	Hour	B^{b}		Hour	A

Position of clock hammers in 2021