The Sound of Minute Repeaters

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Striking Clocks

Through history, striking clocks which mark the hours were invaluable in the regulation of communities. Domestic long-case striking clocks are very familiar and often treasured.

The 17th-century repeater was an invention from necessity; how to know the time in the dark without waiting for the chimes?

In contrast to broadcasting clocks, one's relationship with a repeater is quite different and strictly personal; the time is told more precisely and on demand.

Although the primary need has gone, there is no doubt that adding this complication to a watch is a significant engineering feat. But because it is a watch and therefore smaller, the sound that results is different in both scale and quality to that of a striking clock.

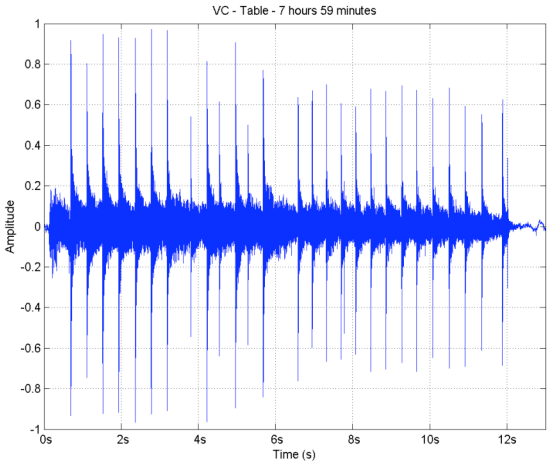
The minute-repeater sound

The watches we tested had a common feature: to 'hear' the time one slides a lever on the left side of the body. This action winds a separate spring so that the main power is not disturbed and starts a regulating mechanism which sequences through the chimes.

The scope of a minute repeater is therefore within arm's reach and because of its size, the quantity of sound generated, whilst enough at 0.5m, is not for sharing in a room. If the watch is held to the ear it is highly audible and if it is placed on a table then the sound can be much amplified, just as one hears with a tuning fork.[1]

These watches have two different gongs inside: one to strike the hours, another, higher in pitch, for the minutes, while both in rapid low–high sequence indicate the quarters.

Each gong sound has a hammer strike and a bell-like tone which gradually decays. The overall sound sequence has four more components: the regular tick, the initial sound of winding the repeater mechanism, a whirring from the chime regulator and in some, a click at the sequence end. These elements can all be seen in the picture below.



This graph shows the sound wave (left to right) for the Vacheron Constantin striking 7:59 (seven hours; three quarters and 14 additional minutes). The steady buzz between each chime is the regulator.

These mechanical devices show small irregularities between strikes, and indeed part of the charm is that the sound is different every time.

The gongs themselves are normally curved metal rods which fit around the inside of the body, as can be seen in the picture below.

This picture shows the two gong rods curling round the outside, clamped between the two hammers.

[1] Some makers provide sound-box accessories to boost the level, but we did not test these.

The dimensions and material of the gong govern the pitch of the note and the structure and decay of the overtones. The persistence of the lower – so-called 'hum tone' of the gong – is also modified by the body of the watch and whether it rests on a wrist. The sound of each gong is similar to a chime or bell and, as with all percussion instruments, the exact location and duration of the strike action affects the sound. So there is a great deal the watchmaker can do to 'tune' the sound of each chime in addition to just picking the fundamental notes. As we found in listening, some were much more elegant or musical than others.

These pictures show the recording location and (below), John Rutter checking it out.

How we tested

We settled on a combination of measurement, analysis and listening tests for all eight watches in the group.

Reflecting its use, we captured the sound of each watch on both a table-top and wrist, using a high-quality recording system at the close range of 6cm. These recordings were made in Meridian's anechoic chamber – this special room floats on a suspension and is lined so that it is totally silent when the door is closed.[2]

The recordings were then analysed by computer to estimate the apparent loudness (audibility) and reveal the harmonic structure, decay and harmonicity of each chime.

Listening panel

Measurements allow us to put some meat on the bones, but these watches are meant to be enjoyed – and that means listening.

We decided to recruit a panel whose vocation includes the creation and analysis of sound, and were delighted that John Rutter agreed to join us. John's renowned skills as composer, choral director and recording producer brought a unique perspective. Another member, Melvyn Goldsmith, is a respected UK violin-maker whose intuition on the relationship between materials and the resulting sound was invaluable. I was able to add psychoacoustic insights and the experience of designing high-quality sound systems. Together with Nick Foulkes, this panel was able to clearly articulate the nuances of each individual watch.

For the listening we used a quiet room. The recordings were first replayed at high resolution using a pair of Meridian's DSP loudspeakers, and then we listened live to each watch individually.

If you are interested to hear for yourself, these recordings and more technical results can be downloaded at http://media.meridian-audio.com/watches/.

What we found

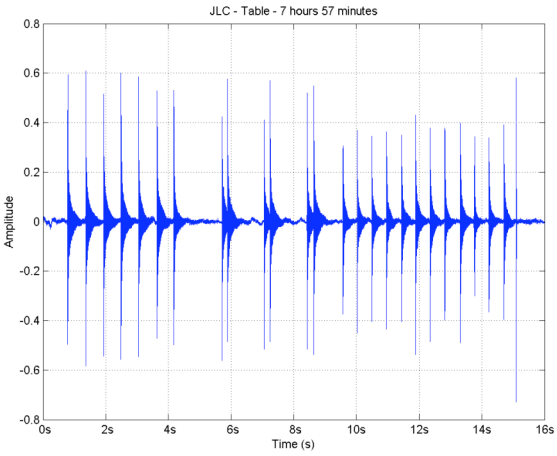
Based on measurement and listening we were able to identify six dimensions for comparison: loudness, noise, match, richness, purity and musicality.

First the watches fell into two distinct groups as far as quantity of sound (loudness) is concerned. Sheer volume of sound might be an important factor, *Vacheron Constantin* and *Jaeger le Coutre* were more than twice as loud as the quietest.

There were also two groups when it came to the background whirring noise of the repeater regulator mechanism. From a purist perspective, fewer

[2] It is so quiet that in some of the recordings you can hear Michael's heartbeat.

extraneous noises should be better. The quietest by far was the *Jaeger Le Coutre*. In the *Corum* the 'machinery noise' was described as 'like a passing train' and in the *Piaget* as 'not helpful'. By contrast, despite having a mid-rank background level, the *Audemars Piguet* was liked because it was smooth and 'evoked a spinning trout reel'. So, in this regard, both quality and quantity of the noise matters.



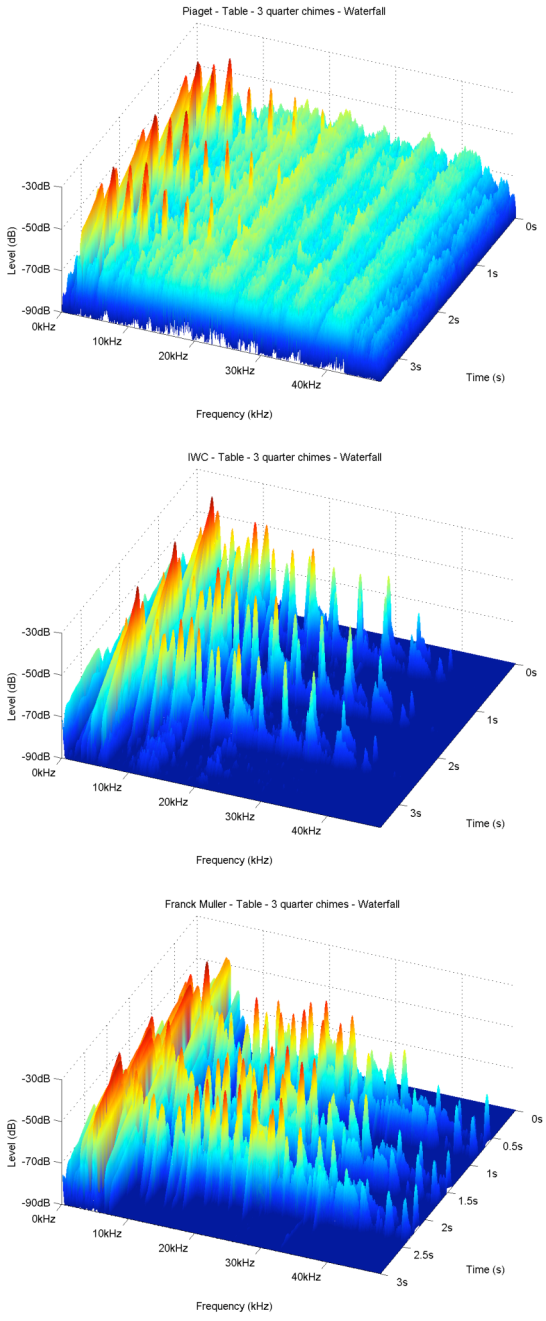
Compare the much quieter background in this Jaeger le Coultre compared to the Vacheron shown earlier.

Low noise and a good level match between the gongs seemed to be positive in the listening tests.

Richness refers to the amount of lower-pitched hum sounds in the gongs. All these watches strike quite high notes and most emit maximum energy between 4kHz and 10kHz, which is a very sensitive region for our hearing. 4kHz corresponds with the very top notes on a piano. The vintage *Piaget* was unique in 'sounding' a whole octave lower, but seemed 'dead' by comparison through lack of overtones.

The waterfall graphs allow us to visualise the strike and decay of each frequency in the sound. Some of the watches produce sounds much higher in frequency than the 20kHz humans can hear. The panel's favourites in this category were the 'self-assured' *Audemars Piguet*, *Jaeger Le Coultre's* 'good round hum with a multiplicity of pitches' and the *Franck Müller* for its 'very pleasing rainbow of pitches'.

Purity and musicality emerged as features in the listening test. By pure, we mean that each gong sound has a related or sophisticated harmonic structure – it is quite possible for a percussion instrument to produce overtones which are not all harmonically related and the result can be impure or 'rough', but occasionally inspired. Once again the *Franck Müller* was liked as a 'complex ring, carefully tuned', also *Audemars Piguet* 'sounds like bells rather than a glockenspiel'.



Waterfall plots show frequency rising from left to right and time coming towards us. The higher the peak, the more energy. These comparisons allow us to see the decays of the harmonics, to decompose the sound and estimate richness. (Top to bottom: Piaget, IWC and Frank Müller).

The *Jaeger Le Coultre* evoked 'the reassuring sound of a grandfather clock downstairs' and 'good pitch with a

clear ting'. By contrast the gong of *Vacheron Constantin* was compared to 'tapping a glass with a fork'. Almost of necessity these sound descriptions are radical, but they do convey the impression.

Musicality refers strictly to the sound sequence: its pace, timing and intervals.

The music interval of a 5th in the *IWC* seemed to 'not quite work musically'; the major 3rd of the *Bvlgari* was 'not unpleasant – like a small glockenspiel'. The sharper-than-major-3rd interval in the *Audemars Piguet* seemed 'more sophisticated'. Unusually, the *Franck Müller* had only a semi-tone between the gongs but 'sounded as though great care had been taken in its tuning'. This watch had a unique feature in that the minute chime sounded 4dB louder when used to mark the quarters, which may support this comment.

Summary

Each of the eight watches, in its own way, is a tour-de-force of engineering and design; some have more features than others and their sound is just one of many elements of differentiation.

When this project was suggested we were not sure how different the watches would sound. We were intrigued to find that in this elevated realm, where no detail should be too minor to overlook, there were clear differences and preferences as the Table shows.

Acknowledgements

Special thanks are due to the panellists who gave valuable time and braved the fens in December to participate:

John Rutter CBE: Pre-eminent English composer, choral conductor and recording producer. He was very gracious giving his special ear and insights. http://www.collegium.co.uk/

Melvyn Goldsmith: One of the UK's leading violin makers and an expert on the sound of materials. http://www.goldsmithviolins.com/

Nick Foulkes: Your intrepid editor.

Also thanks to Michael Capp who silently operated the watches during recording, supervised playback and processed the data.

Soundfiles

http://media.meridian-audio.com/watches/

References

Background on chiming clocks:

http://en.wikipedia.org/wiki/Repeater_(horology)

http://en.wikipedia.org/wiki/Striking_clock

http://en.wikipedia.org/wiki/Bell_(instrument)

Summary Table

Model	Loudness	Noise	Match	Richness	Purity	Musicality
Audemars Piguet	85dB	2%	+6dB	7	6	8
Bvlgari	83dB	38%	+5dB	4	5	4
Corum	86dB	8%	+2dB	1	1	1
Franck Müller	88dB	0.2%	0dB	6	7	7
IWC	85dB	1%	-6dB	3	2	2
Jaeger Le Coultre	95dB	0.02%	-1dB	8	8	6
Piaget	88dB	0.2%	-2dB	2	3	3
Vacheron Constantin	94dB	0.1%	-1dB	5	4	5

Key to table:
Loudness: in dB, higher numbers are louder. A 9dB increase sounds twice as loud.
Noise: As percentage of hour strike level; lower is better.
Match: Level difference Hour/Minute
Richness, Purity and Musicality are ranked from listening in descending order (8 best).

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