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Haydn in Plain Sight

by David Weisbart, FNAWCC (CA)

Editor's note: David Weisbart's skeleton clock won first place in Class 5—Experimental Timepiece Designs and the People's Choice Award at the 2015 Crafts Competition during the 71st Annual National Convention in Chattanooga, TN. This article describes how he constructed this award-winning clock.

Figure 1. Full front view of the entire lyre clock.

While I have always enjoyed clockwork music as a novelty, one thing has always annoyed me about music played on bells. During the performance, the bells are struck at the correct times, but nothing stops the bells from vibrating when their sound becomes musically inappropriate. They ring and ring, eventually muddying the sound so the melody is lost.

Being a classical musician as well as a clockmaker, I am accustomed to articulation. Each of the musical notes in a composition has a pitch and a duration, such as a quarter note or an eighth note. In a properly executed musical performance, each note is sounded and then the sound is stopped at the end of its assigned duration. This is the basis of articulation.[1] In a piano, on which notes are created by a felt hammer hitting a set of strings, felt dampers also mute the string when it should be silenced. A damper is typically engaged when the performer lets up on the key, or if the sustain pedal is used, when the performer's foot is lifted off the pedal.

While music boxes with combs do include what are called dampers, their function is unrelated to articulation. The dampers are automatically engaged immediately before a note is struck, using the same pin that activates the comb tooth. This stops the comb tooth from vibrating from a previous activation so the tooth is in the correct, resting position for the next activation. Some clockwork instruments have featured a leather-covered dampening bar that simultaneously stops all bells from sounding.

My idea was to create a musical movement that would incorporate individually controllable dampers for each note, allowing for relatively precise articulation, and a crisper, more musically pleasing result (Figure 1).

As you read on, keep in mind that I had never made a complete clock, much less a complicated musical clock. While I've worked on other people's clocks for well over a decade

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Figure 2. Energy chimes that inspired the clock's creation.

Figure 3. Lyre-shaped Steinway piano logo.

since graduating from the NAWCC School of Horology, I was faced with inventing—or reinventing—quite a number of procedures and techniques completely new to me.

Design Concepts

My first idea was spawned by a little novelty gizmo I have, commonly referred to as energy chimes (Figure 2). It consists of a wooden frame onto which three tuned aluminum chime rods are tightly tied. Striking the rods, which are tuned to a major triad or chord, creates a pleasing sound with extraordinary sustain. Percussion instruments referred to as bar chimes use similar but thinner rods to achieve a "sound wash."[2]

Thinking about a rack of these chime rods on a skeleton clock conjured in my mind the image of the ancient musical instrument, the lyre. Even though it's pretty hard to find a lyre today, the shape is iconic in the musical community. It's used in everything from clocks to furniture design to the logo for Steinway & Sons pianos (Figure 3). So I sat down with CorelDRAW and created the first concept drawing (Figure 4).

I then set out to determine how I could make my own tuned chime rods. After several failed attempts to learn the exact aluminum alloy of my energy chimes through musical instrument manufacturers and distributors, I thought about alternatives to the chime rods. One of the most traditional is, of course, a rack of tuned, nested cup bells. With that in mind, I came up with another concept drawing (Figure 5). It was not as aesthetically pleasing, and an Internet research showed that high-quality tuned bells were expensive. I did purchase a bell tree from a musical instrument dealer who promised chromatic bells.[3] Unfortunately, the bell tree wasn't even close to chromatic. Fortunately, I got my money back.

I returned to my original concept and once again thought about how I could determine the alloy of my energy chimes. It dawned on me that a scrap metal dealer was in the same complex as my clock shop. I took the energy chimes to him, he touched a thermal-detection device to the rod, and a second later he said, "Oh, that's 6061 aluminum, the most common alloy there is." Sure enough, the local metal supply store had in stock all the 6061 aluminum rods I could want.

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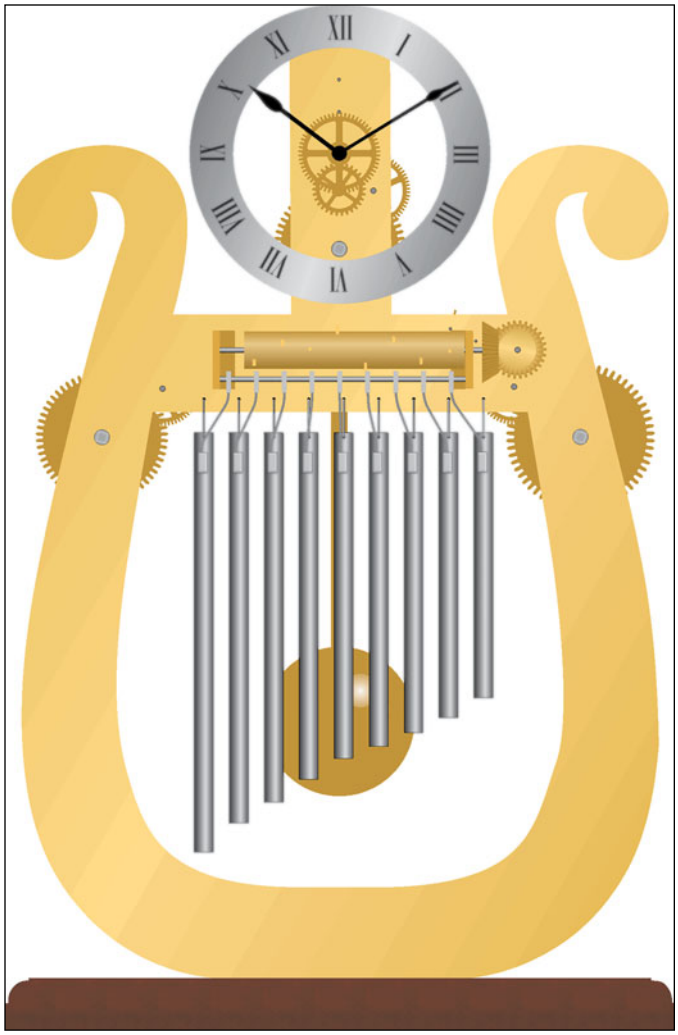

Figure 4. Original concept drawing for the lyre clock.

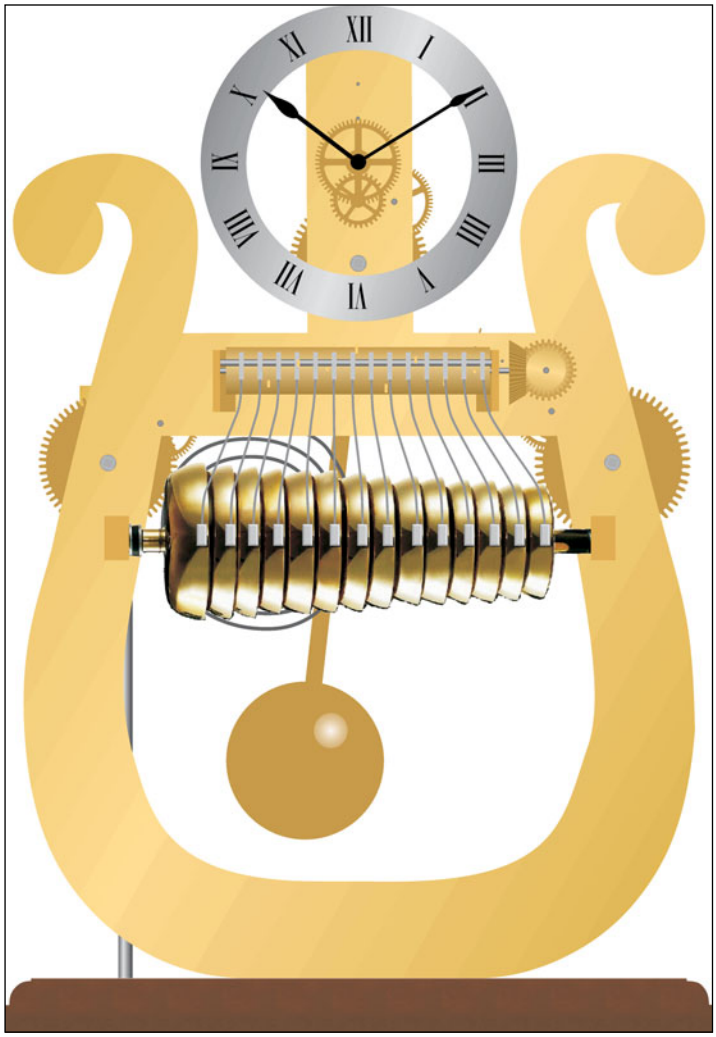

Figure 5. Second concept drawing of the lyre clock using cup bells.

Chime Rods

Holding one end of an aluminum rod and hitting it with a little hammer produces only an awful "clunk" sound. How do you get a chime rod to sing? I found several interesting articles on wind chimes online. It turns out that chime rods like these do not vibrate like guitar strings, end-to-end; they vibrate around nodal points that exist at two specific locations. A nodal point, in this instance, is a place where no vibration takes place. According to the articles I read, these nodal points are 22.42 percent of the length of rod from each end. The vibrations occur on either side of the nodal point (Figure 6).

I discovered a handy software utility that lets me enter the length of a good chime rod and the cycles per second (hertz) it produces, and then the utility computes roughly the rod length for other hertz values I want to use. It also gives me the correct location of the nodal points. When the rod is supported only at the nodal points, it yields the pleasing sound and great sustain of the energy chimes. Now all I had to do was decide on my music.

Music

I wanted a piece of music that would illustrate the musical benefits of the articulation provided by my dampers. Ideally, it would have legato, or connected, notes and staccato, or clipped, notes. I suspected I would be best off with something from the baroque or early classical periods. I scoured my own classical guitar repertoire and could not come up with anything suitable. I then started looking through my CD collection. That's when the Haydn symphony came to my attention.

Haydn's symphonies were given their nicknames not by the composer, but by his publisher. His Symphony No. 101, the *Clock Symphony*, got its name from the slow second movement, which features a repetitive ostinato under the main melody that seems to mimic the tick tock of a clock movement. While this is a very pretty movement, the melodic line is rather long and lacked the variety of articulation I was looking for. The fourth movement, however, seemed suitable, lending itself to a nice arrangement with a limited number of available notes. So I set about writing an arrangement that would use as

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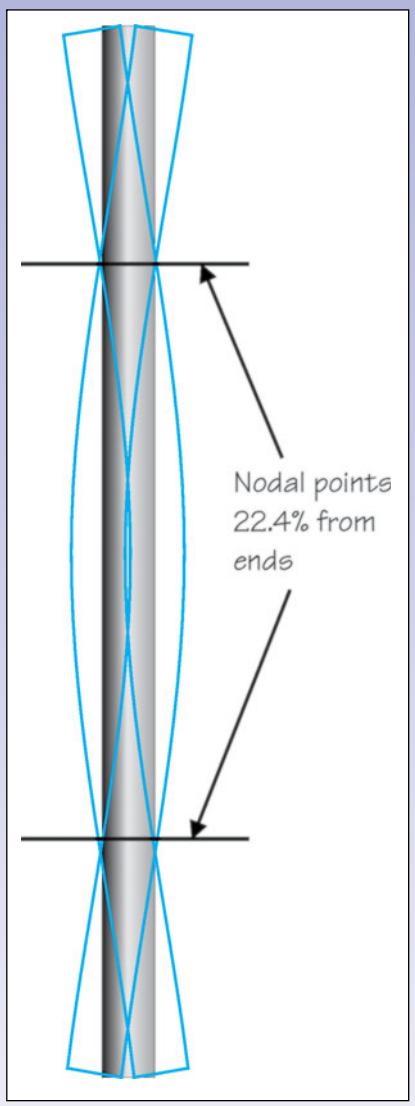

Figure 6. Illustration of how a chime rod vibrates.

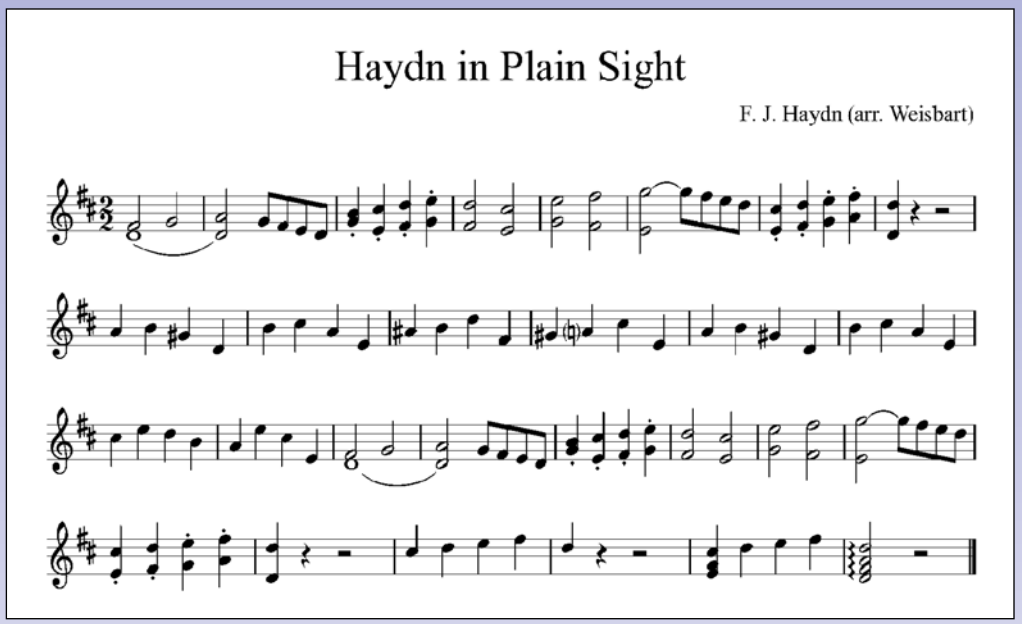

Figure 7. My musical arrangement for 14 chime rods.

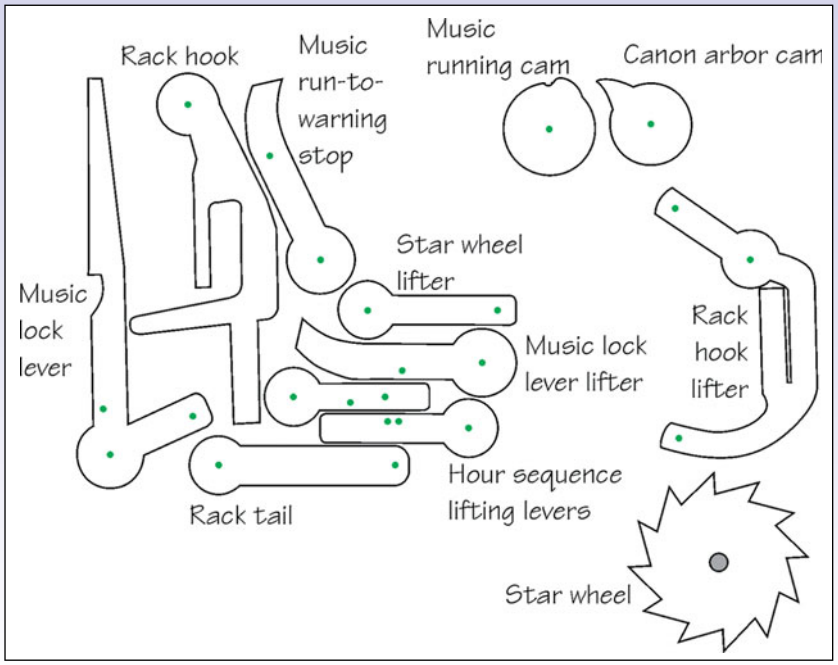

Figure 8. Designs for various levers.

few notes as possible, and would last approximately 35 seconds (Figure 7).

Gears

Why 35 seconds? In building this clock, I never intended it to be an exercise in gear cutting or, for that matter, designing gear trains from scratch. I decided to simply recycle the gears from a reliable movement. I chose a Hermle 1051-020 movement for my gears.

The chime train on this movement, when allowed to play all ten measures of an hour's worth of chimes, runs about 35 seconds. My clock only plays on the hour, so it uses the same running duration as the original Westminster chime configuration. I did, however, replace the chime train spring barrel with a larger barrel—with the correct modulus—that I happened to have in stock so I could use a larger, more powerful spring to drive my music box.

Levers

As I got into designing the layout, I realized that the three gear trains—time, music, and strike—were quite distant from one another. While the original, compact Hermle movement had short levers that communicated from one train to the other, such levers were not an option here. So I designed small levers with linkages to bridge the large gaps between the trains (Figure 8).

The lever that's actuated by the cam on the canon ar-

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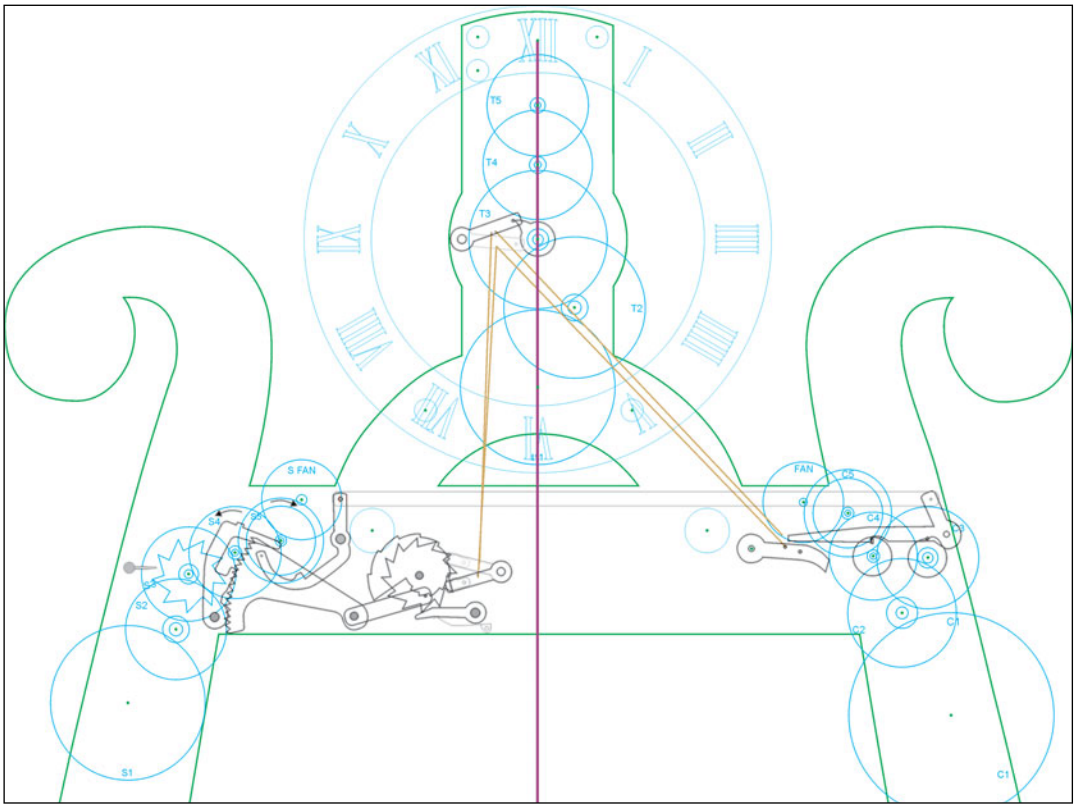

Figure 9. Mechanical drawing in colored layers.

bor is linked to two other levers: one puts the music train into warning and the other advances the hour snail for the strike train. Toward the end of the music train's running cycle, a purpose-built cam raises a lever that puts the hour strike train into warning. When the lever drops, it stops the music train and allows the strike train to run (Figure 9).

Mainspring Ratchets

I did not want ratchets to detract from the front of my clock. Instead I fabricated new mainspring barrel arbors (Figure 10) so I could mount the ratchet wheels and pawls on the back plate.

Tuning

With my musical arrangement done, I needed to create the set of tuned rods using the notes I had written. I did not transpose Haydn's work—it is performed in the same key signature as the original. I ended up needing 14 chime rods, up from the eight rods of my original concept design.

I used the computer program to determine the lengths of rod I would need—I cut them slightly longer than needed—and tuned them using an electronic tuning device. A rod that's too long will sound flat—below desired pitch—so by filing off bits of the rod I could bring each one up to the correct pitch. The result is that these chimes will not offend a musician with perfect pitch!

Figure 10. New barrel arbors with a square on the back for the ratchet wheel.

Damper Design

I had originally envisioned the hammers and dampers being driven from the same pin barrel, with the lifting mechanisms 180° apart—the hammers in front and the dampers in back (Figure 11). The dampers need to land on the chime rods anywhere but on a nodal point. The ideal location is dead center, which is also the most effective place for the hammer to strike.

What I did not count on was that in order for the hammers and dampers to hover close to the rods when not in use, the return springs needed to exert a fair amount of

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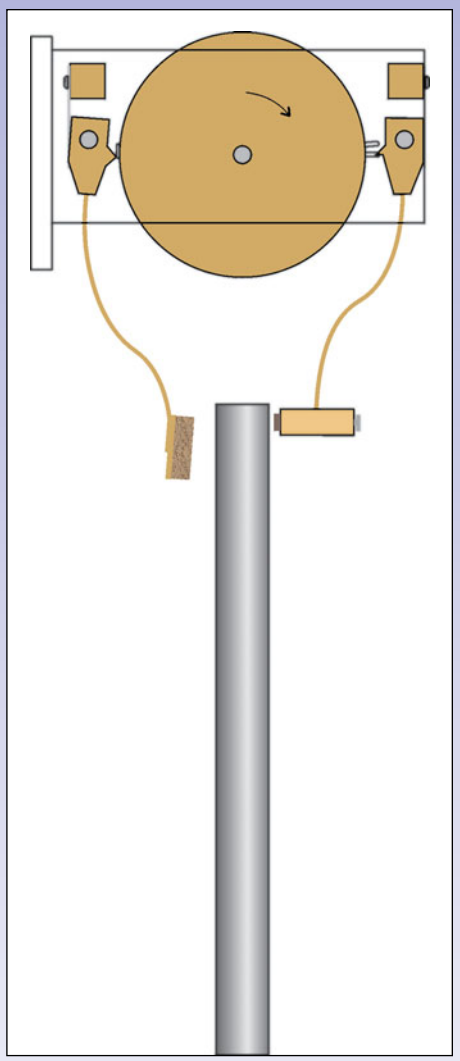

Figure 12. Second version of dampers installed.

Figure 11. Original failed design for hammer and damper locations.

tension because the rods were centered under the large pin barrel. While the gear train could power the hammers alone without any problem, when the dampers were added, the extra tension caused the train to stall.

In the final version the dampers operate by resting on the top of the chime rods (Figure 12). This has three advantages: (1) Because only gravity is used to dampen a note, there is very little drag on the movement; (2) the hammers can hang straight down, so there is almost no starting tension on the return springs; and (3) the whole pin barrel assembly doesn't have to stick out so far. This did require that I refabricate the pin barrel mounting brackets and realign the damper lifting pins to 110° from the hammer pins instead of 180°.

Pin Barrel

Before taking on this project, I had never given any thought to designing a music box pin barrel. Its function is pretty simple—arranging notes in linear time—but I was also adding the extra layer of the dampers. Once again, I used CorelDRAW software to design a guide that would allow me to drill the holes as precisely as I could. I set a snap-to function, so my cursor would automatically move between the exact locations of possible notes, using spacing that represented the shortest note duration, an eighth note. I then drew a large grid in which each vertical line represented a bar line in the music—a measure of eight eighth notes—and for the horizontal lines I used alternating black and red lines to line up with the lifters for the hammers and dampers. From there it was only a matter of transcribing the musical notation into its graphical representation on the grid: black points for the hammers to strike and red bars to represent how long each note should last. I put the points and bars on separate layers in the drawing program. This allowed me to shift the bars the requisite 110° when I was done (Figure 13).

The final step in the preparation of my drilling guide was to shrink my grid horizontally to the circumference of my pin barrel. I printed it out and taped it to the barrel. I was then ready to drill (Figure 14).

I had originally intended to use a brass tube for the pin barrel. I did, in fact, fabricate this barrel and its end caps. I made a jig for a mill vise that would hold the tube. However, because I had never done this before and didn't know how well it would work or what problems I might encounter, I decided to create a pin barrel out of wood

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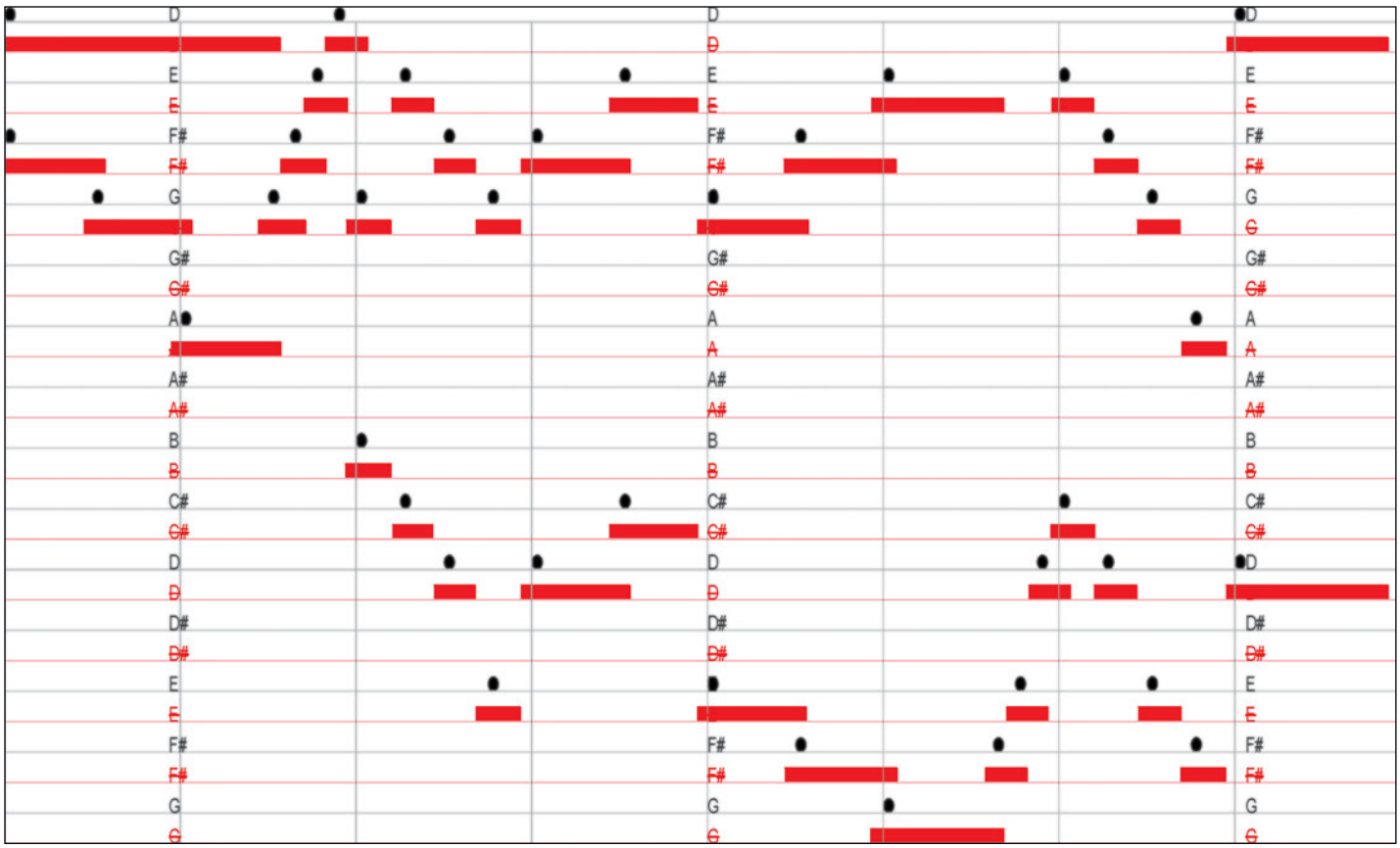

Figure 13. First phrase showing note striking and duration.

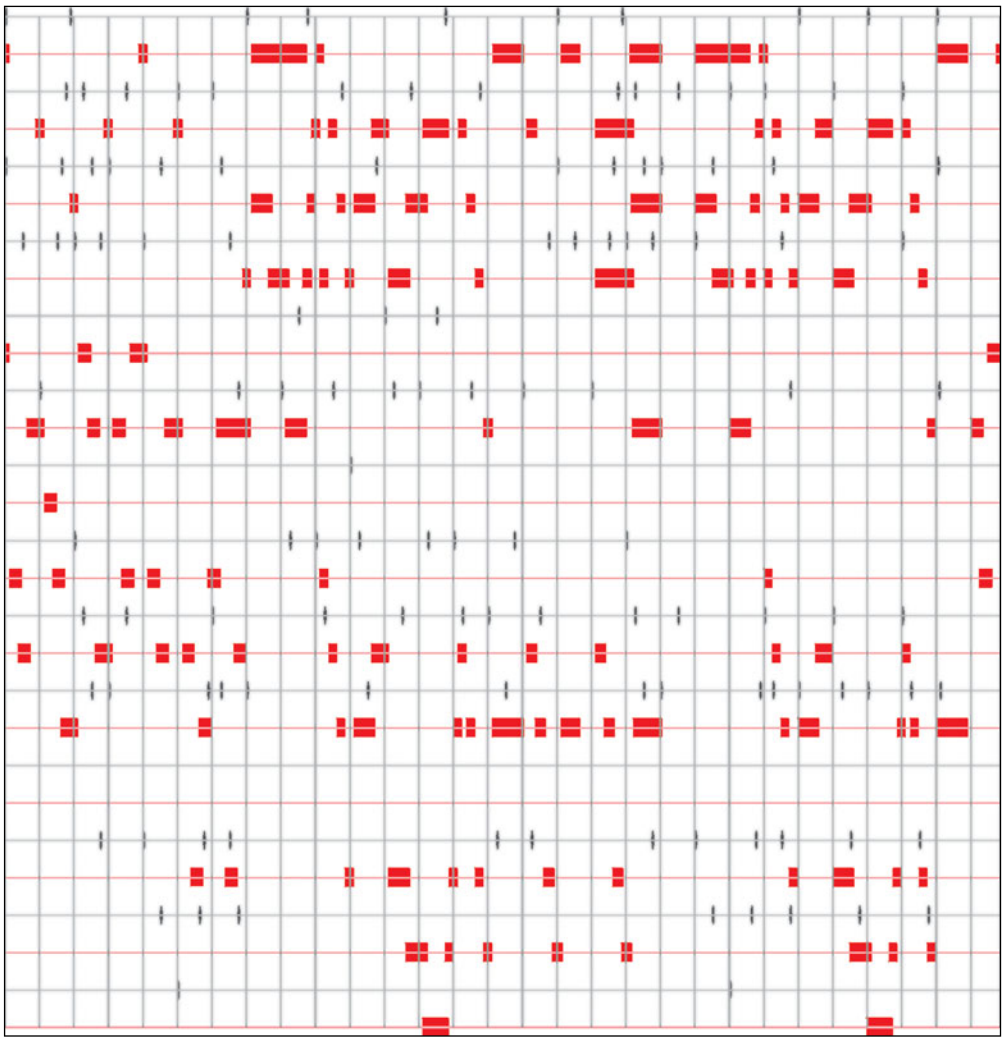

Figure 14. Final pin barrel template with dampers rotated 110 degrees.

first. I acquired a solid maple dowel of the correct diameter and a long drill bit to drill the center hole for the shaft. After working with the wooden barrel for a while, I came to like the look of it more than the brass. The maple is hard enough that it seemed to hold the pins well, so I stained it to more or less match the base and used it in the final product.

My initial music arrangement included some fancy ornaments in the repeat of the "A" section. Early on, however, I determined that because of the geometry of the hammers, there were defi-

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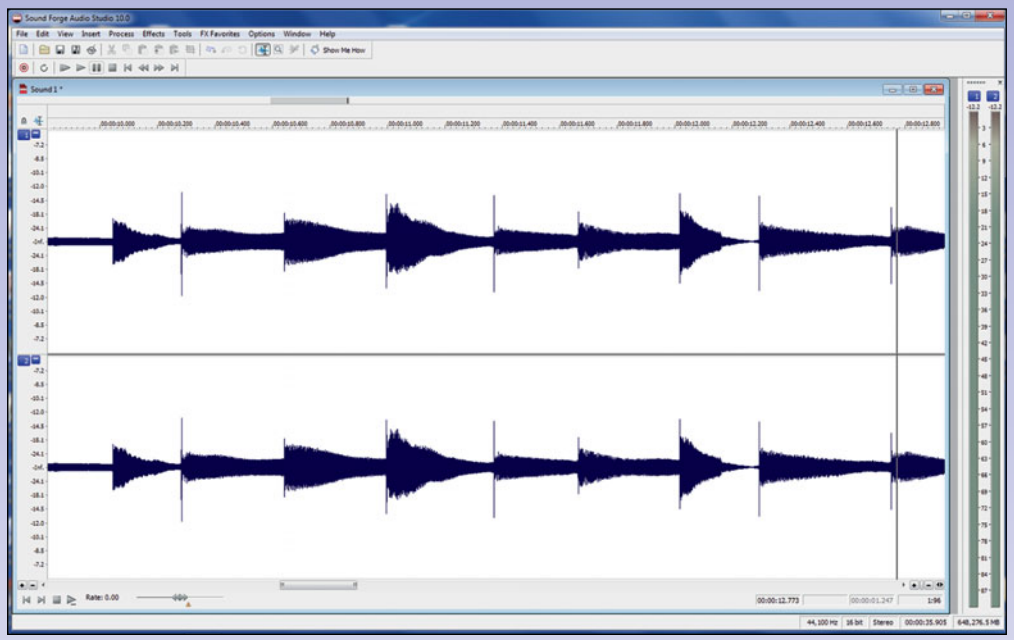

Figure 15. Uneven note durations as shown through a computer.

nite physical limitations on how quickly a given note could be repeated. This caused me to have to simplify the arrangement by removing the ornaments, which made me a bit sad for the music, but glad that I remained with the maple pin barrel.

Once the barrel was pinned, then came the rather tedious task of doing fine adjustments to the timing of the notes. While the jig held the barrel securely to the table of my drill press, all the alignment during drilling was done visually. As a result, there were tiny, unmusical deviations from the exact times that the notes were supposed to sound, mostly measured in hundredths of a second. To help locate and diagnose these, I recorded the music on the computer and used a wave form editor to visually detect when note timings were incorrect. I then bent individual pins forward or backward to modify the timing of each errant note (Figure 15).

Figure 16. Dial prepared for acid etching of numerals.

Water Jet and Dial Debacle

The large clock plates were cut using CNC water jet. I provided my computer-generated, Auto-CAD formatted files to the water jet company along with the raw brass sheets. I also had it cut the hammer lifting pieces from the same material.

I asked the company to help with the dial, too. I explained that I needed the Roman numerals to be completely hollowed out, so I could fill them with the traditional wax used on engraved clock dials. The sales engineer assured me my request could be done without any problem.

I was disappointed, however, when the dial was returned to me. Instead of hollowed-out numbers, the company had engraved outlines only, leaving the middles of the numerals high (Figure 16). I didn't want to go through the expense of making another dial, so I came up with an alternative. I covered the front and back of the dial with ordinary clear box tape. I trimmed the excess and then painted the edges with an acid-resistant enamel paint. Then I painstakingly used an X-Acto knife to cut around the outlines of all the numerals. This left only the middles of the numerals exposed. I dropped the dial into a mixture of muriatic acid and hydrogen peroxide. About 10 minutes of bubbling acid later, the dial had beautifully hollowed-out numerals (Figure 17).

After talking with a couple different clockmaker friends who had experience applying wax to engraved dials, I came up with a procedure that worked nicely for me. Using an old drill press, I positioned an alcohol lamp under one of the slots in the table, set the dial over the flame, melted the

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wax into the numerals, and while the metal was still hot, scraped off the excess wax with the edge of an old AAA card (Figure 18).

Coda (Epilogue)

During the building process I consulted with some very high-level music box experts on the following question: Has anyone created a bell-striking music box in which each note had a damper for articulation? No one had heard of such a thing, so at this point I believe my design is unique. Because I set out to do something no one had done before, I expected to have to invent some new procedures. Having never made a complete clock, I'm sure I ended up reinventing many processes to implement the more ordinary clockmaking functions. There were several procedures I did not document here, which may be nontraditional, but which helped tremendously in bringing this idea to fruition.

Part of what made this project so engaging for me was its interdisciplinary nature. I needed my clockmaking knowledge, musical training, artistic ability, computer skills, scientific bent, and procurement experience to make it happen. (Being the son of an aerospace design engineer didn't hurt, either.)

Oh, and the name "Haydn in Plain Sight"? What else would you call a skeleton clock that plays Haydn?

Notes

1. Of course, infinite subtleties are involved in actual performance articulation. This describes only the most fundamental implementation.

2. A sound wash is a sparkling, metallic percussive effect similar to a harp glissando.

3. The chromatic scale is a musical scale with 12 pitches, each a semitone above or below another. On a piano this is achieved by playing all the white and black keys in succession.

Acknowledgment

I gratefully acknowledge NAWCC member Leon Coufal, winner of the wood carving category at the 2012 National Convention, for his help in crafting the wooden chime rod brackets and the clock base.

About the Author

Dave Weisbart, FNAWCC, is past president of Orange County Chapter 69 and serves on the board of Los Angeles Chapter 56. He graduated from the NAWCC School of Horology Clock Repair program in 2002 and now runs Prestige Clock Repair in Huntington Beach, CA. He is coauthor of the NAWCC publication *Tips on Collecting Clocks and Watches*. He has played the classical guitar for over 50 years.

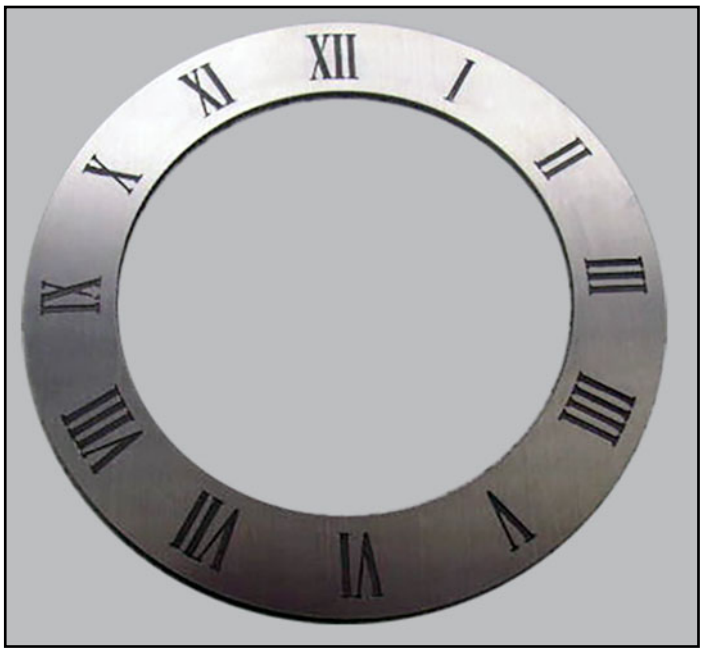

Figure 17. Dial after acid bath.
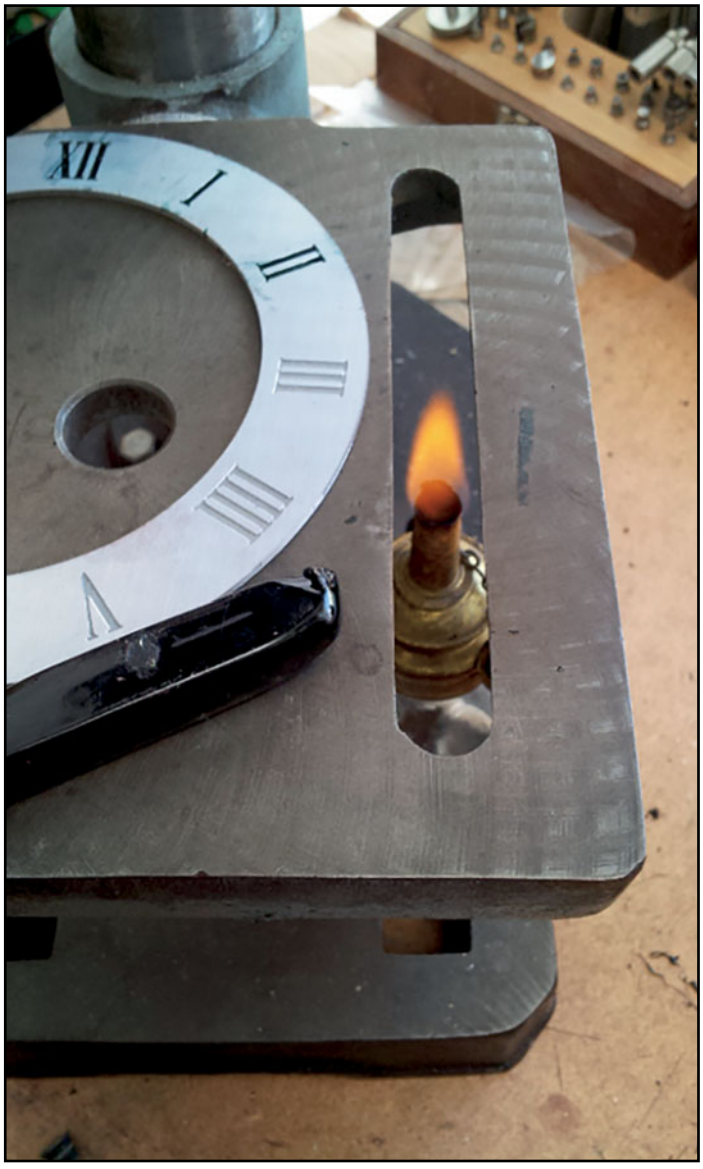
Figure 18, below. Filing the numerals with wax.