Designing a Mechanical Organ

Looking at kits for model sailing ships, steam engines, and steam-powered road vehicles, I would often wonder why there were no street organ kits. Yes, there are kits for "professional" organs (that start at $1,000 and do not stop there), but I was thinking of a smaller model, affordably priced and not overly complex, that DIYers with the street organ bug could put together at home in their spare time.

As time went by, that idea took hold of me. I wanted to be the one to create just that kind of uncomplicated but still authentic mechanical organ. I wanted to craft a kit that even a not very adept amateur would be comfortable assembling and would be easy to play. Maybe I could even come up with a technique for producing home-made music rolls.

What I had in mind was, to coin a phrase, "a street organ for everyone." And today, 16 months of hard work later, I can modestly say that I have done what I set out to do. My new organ is called the MINI-14.

The MINI-14 project kept me busy for around a year and a half. The principal challenge, though, was not the time it took – it was all too fascinating for that to matter – but the fact that from start to finish I was, to all intents and purposes fashioning a fundamentally new mechanical instrument, with numerous innovations, original design solutions, and gadgetry.

The rest of this article describes the process that resulted in this not entirely run-of-the-mill instrument. I hope you find it an interesting read.

The MINI-14's Family Tree

My beginning premise was that the instrument should be maximally compact and simple in design. That would make it less intimidating, more "warm and fuzzy," and easier to assemble, while also cutting the cost of materials.

I went on a quest for historical

Fig. 2: The C pipes, marked in black, and the G pipes, marked in red, can be tuned up a semitone

prototypes and pretty quickly identified two instruments that became the MINI-14's closest relatives – its parents, if you will. Their names are Serinette and Organette. Let me tell you something about them, to give you a better understanding of the MINI-14 and its historical roots.

The bird organ or serinette, whose name derives from serin (the French word for "canary") is a rather rare version of the small mechanical organ. A miniature organ with only nine or 11 pipes, it was used to train canaries to sing popular tunes.

This was the instrument that first encouraged my idea of developing a kit for a small organ. First of all, I was quite infatuated by its compact design, small dimensions, and limited number of pipes. But I couldn't base my instrument-to-be entirely on the serinette because, original and elegant as it was, it still had some serious shortcomings. Its principal flaw was that it was programmed to make music by way of metal pins driven into a wooden cylinder (as in an "old-time" street organ). That was a very complex and expensive system, and it greatly limited the serinette's musical repertoire.

But there was also at the time a simpler system for recording music, which used strips of perforated paper known as music rolls. That system was found in the very popular instruments called organettes.

The sound in an organette was made not by pipes but by reeds, which are thin metal "tongues" that vibrated and produced a clearly audible sound when air passed over them. Reeds like that are still used to this day in accordions and harmonicas. Aside from reeds, an organette had bellows worked with a crank, a receiver (that pressurized the air flowing over the reeds), and, of course, a mechanism to move the music roll. The organette's rolls were very easy to switch out,

The MINI-14's musical scale

C(C#)	D	E	F	G(G#)	A	A#	B	c(c#)	d	e	f	g(g#)	a
1	2	3	4	5	6	7	8	9	10	11	12	13	14

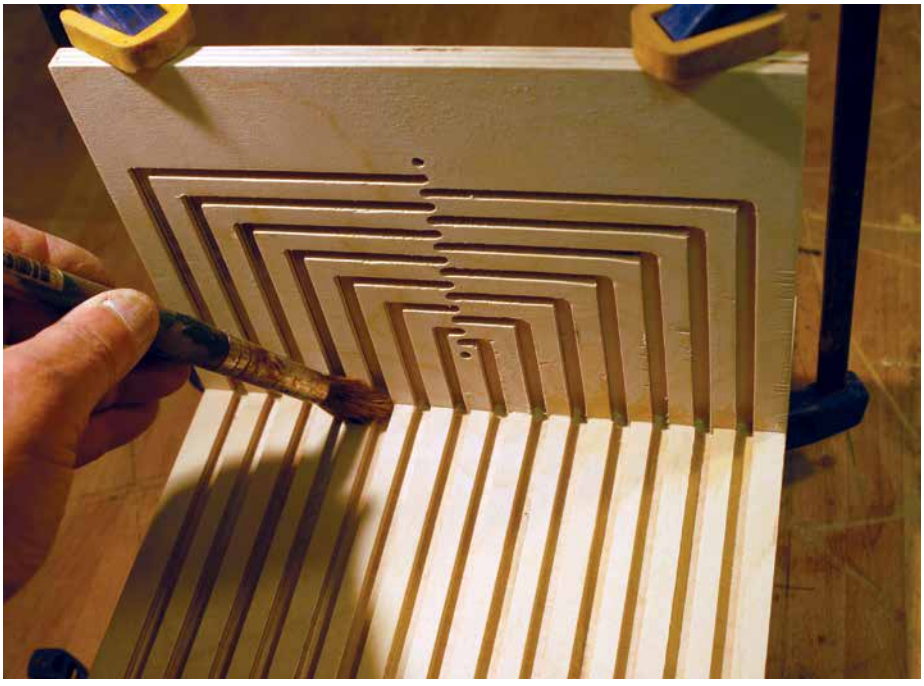

Fig. 3: A "labyrinth" inside the cabinet wall feeds the air to the pipes

which kept the interruptions in the performance to a minimum.

If I had to name one disadvantage of the organette, it would be the quality of the sound made by the reeds. In my opinion, pipes are easier on the ear.

And so, from a combination of the virtues and design features of the organette and the serinette, the MINI-14 was born.

Flexible Scale vs. Diatonic Scale

Since an organ's musical quality and dimensions are primarily defined by the musical scale it uses and size of its pipes, the first thing I had to do was define those parameters. I settled on the widely accepted 14-note interval scale that was used in the old organettes. That scale has been around for 200 years, during which time it has conclusively proven its potential to handle a varied repertoire. But I wanted to expand on that potential, because the standard 14-note scale cannot produce certain tonalities (the harmonic minor, for example). And so, after consultation with a friend of mine who is a musician and music arranger, I made it possible to retune four of the pipes (the C/c and the G/g, to be precise) a semitone higher. The pipe array is installed on the outside of the organ's front wall, making it readily accessible to the performer, so that the retuning is the work of a moment. All it involves is a slight adjustment in the placement of the plugs in those pipes (see Fig. 2).

The pitch of the pipes will obviously be an octave higher than that produced by the organette's reeds. Given the MINI-14's dimensions, the longest pipe is the one that produces a C, producing a scale that looks like this:

"Labyrinth" vs. Tubing

As an organ-maker, I know that flexible tubing connecting the pipes to the tracker bar takes up a lot of space inside the instrument. To free up much of that space, I decided to use pretty much no tubing at all. Instead, I made a network of passages in the upper and front panels that route the pressurized air to the pipes. That "labyrinth" can be seen in Fig. 3, which shows the organ cabinet under construction.

Rocker vs. Cranks

Now I had plenty of room to fit two modestly sized yet high-capacity bellows inside the cabinet. I have to say that the final design for the bellows did not come to me quickly; it was preceded by a lot of experimentation with all kinds of different bellows (see Fig. 4).

The overall air volume from those

Fig. 4: Several variants of the bellows intended for the MINI-14

two bellows proved sufficient to make four or five pipes sound simultaneously. This was a huge victory for me: I would have been willing to compromise on even three pipes sounding at once.

But this brought up yet another problem. A bellows with that much travel needs crankshafts to open and close it, which would sharply increase the organ's dimensions. And a dual crankshaft is not an inexpensive proposition.

The hint I needed to find my way out of this dilemma came from an illustration in Mechanical Music showing the design for a rocker pivoting on an axle to move two small bellows in a 17th century clockwork mechanism. That design was ideal for the MINI-14 (see Fig. 5).

Single Axle vs. Double Shafts

The organ's operating mechanism is very simple and inexpensive. In a standard organ, the speed at which the take-up spool rotates is significantly slower (approximately three times slower) than the crankshaft rotation speed, because the bellows have to open and close several times to pump enough air into the receiver to play a music roll 70 to 100 mm in length. And for this reason, one or more 1:3-ratio gears have to be installed between the shaft of the handle and the shaft of the take-up roll.

One turn of the MINI-14's handle will move the roll at the desired speed and also bring in enough air to play that roll: the crankshaft and the take-up spool share an axle (Fig. 6).

The hand crank is, of course, also installed on the same axle. For comfort and a steady, even rotation, the handle arm is much longer than you might expect.

Music Rolls

Without a music roll, a mechanical organ is just very large wooden paperweight. So the big question with any mechanical organ is: Are music rolls it needs available in a wide enough variety?

Since the MINI-14 requires a unique kind of music roll, my project

Fig. 5: A view from behind. The rocker that moves two bellows.

Fig. 6: Spool and crank on a single shaft.

Fig. 7: A pneumatic punch for MINI-14 rolls.

had to include a way of perforating those rolls. For myself I had built a pneumatic punch with its own MIDI decoder that does not require a computer to operate (the MIDI is on a flash drive that is inserted directly into the reader). I have been able to achieve a pretty high perforation speed, producing one minute of music per 7.5 minutes of punch time (see Fig. 7).

But I also decided to present an alternative, because shouldn't someone who is up to putting an organ together also be given the opportunity to make his or her own music rolls? It occurred to me that a home hobbyist would find that every bit as interesting as the organ assembly itself.

And so I developed a technique, and then the equipment, to do that. I called it the MINI-14 music-roll cutting board. It too comes as a kit.

The last stage of my project involved writing an 81-page large-format booklet that comprehensively covers the creation, assembly, and use of the MINI-14. The number of illustrations alone speaks to the level of detail achieved here; by my count, it has 150-plus. The booklet (see Fig. 8) comes as part of the MINI-14 kit, which contains some 150 parts made of wood, metal, natural leather, and other materials.

Fig. 8: The MINI-14. A Street Organ for everyone.

See the MINI-14 in action

Go to www.youtube.com and search "MINI-14 organ" to see a page of video examples or use your smart phone to scan the QR codes to the right and go directly to three videos made by the author.