Building an Archiphone

In 1970, my grandfather Adriaan Fokker designed an electronic organ on which one can play microtonal music. Instead of 12 notes, the octave is subdivided in 31 notes. The number 31 was chosen because Christiaan Huygens found in 1691 that the major third interval 5:4 can be approximated better by $2^{10/31}$ than by $2^{4/12}$, the perfect fifth interval 3:2 almost as good by $2^{18/31}$ as by $2^{7/12}$, and as a bonus the harmonic seventh interval 7:4 quite good by $2^{25/31}$.

Four of these organs, nicknamed Archiphone, have been built at the time, using analog electronics. The original Archiphone could play 31 notes in 5 octaves, that is 156 different notes. For easier playability, these were duplicated two or three times on the keyboard, consisting of 341 typewriter-style keys.

Alas, none of the four archiphones is in a playable state anymore. Therefore, we strived to rebuild an archiphone using modern technology. Before doing a full 341-key archiphone, three prototypes were built: a feasibility study (9 keys), a small archiphone (32 keys for 1 octave) and a medium archiphone (106 keys for 3 octaves with some duplications).

Typewriter-style keys are easily available presently, on a market aimed at people building their own computer keyboard. The keys must be mounted on a plate, which is available commercially for the *qwerty* layout, but not for the archiphone layout. We thus employed the laser cutter to create the keyboard baseplate (and while we were at it, the instrument's casing as well). This was facilitated by two online tools: keyboard-layout-editor.com for designing the layout, and swillkb.com to generate the svg-file for laser cutting.

Keyboards are conventionally read by wiring them in a grid. A microcontroller sequentially sends a signal to every row and scans the columns for response. Thus, a keyboard with n keys doesn't need n input pins on the microcontroller, but just $\sqrt{n}$ output pins and $\sqrt{n}$ input pins. A scan reveals which keys are down, and by comparing this to the previous scan, key presses and releases can be detected. An Arduino Nano microcontroller was used for the small prototype, and an Arduino Mega2560 for the medium prototype.

Music generation was done in the 1970s by analog electronics but today is easily done using a Midi synthesizer chip. In the small prototype, we employ a low-cost Dream SAM2695 chip, conveniently packed with an 1W amplifier and a mini speaker by M5Stack. The medium prototype has the more sophisticated SAM5716B chip, appearing on the Serdaco X16 sound card. Here, we have a separate 3W amplifier and two speakers. As the Midi protocol was designed for the 12-tone octave, we need some trickery to generate the microtones: before every note, a *pitch bend* command is sent to slightly change the tuning.

Two follow-up projects are inspired by this project: recreate a full 341-key archiphone with Arduino and Midi, but also delve into vintage analog electronics and bring the original archiphone from the 1970s to life.

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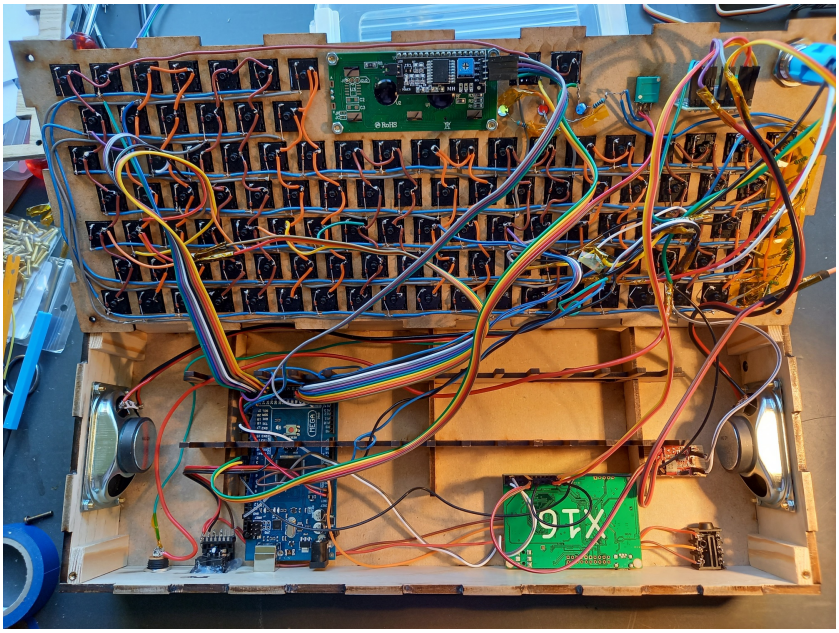
Small and medium archiphone prototypes



Wiring of the Arduino microcontroller and X16 Midi synthesizer

Laser cut base plate, with keys and key caps