Articulation & Bowed-string Synthesis

Synth Secrets

- Synthesizers > Synth Secrets, Synthesis / Sound Design

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The skilful articulation of a synthesized string patch can improve it no end, even one created using very basic building blocks, as we saw at the end of last month. But we can take this approach much further...

Nowadays, when people talk about synthesizers and synthesis, they invariably talk about keyboard instruments. They may ask each other what type of synths they're using, but this will usually be a question about the nature of the sound generator... is it analogue, PCM- or sample-based, FM, additive, 'virtual' analogue, physically modelled, or a host of lesser variants. Alternatively, the question may refer to whether the instrument is monophonic or polyphonic, or it may be an enquiry about the manufacturer or model. But, with the exception of a handful of modules designed for use with wind controllers or guitar pitch-to-MIDI converters, synthesizers are almost always keyboards or modules controlled via CV and Gate signals or MIDI from a keyboard. Consequently, the vast majority of synths play discrete notes, with exactly 12 of them per octave, each tuned in accordance with the strict set of frequency relationships that comprise 'equal temperament'. Of course, you can often control electronic instruments using computers and/or sequencers, and some newer models offer control over aspects of the sound using innovations such as Roland's D-Beam, but the musical philosophy and the temperament of the notes remain the same.

The Tyranny Of Discrete Notes

It wasn't always like this. You only have to travel back 30 years or so to find bands such as Roxy Music and Hawkwind using synths to create new sounds that were part of the music, but were in no way played chromatically. You could argue that this was making a virtue of necessity — the EMS VCS3 that both bands used was the least likely to stay in tune of all the early synths — but this would be a simplistic argument. Brian Eno and Del Detmar could just as easily have bought a Moog or ARP and played widdly melodies as most of their contemporaries were doing. But, for a couple of years, a-melodic synthesis was not only acceptable, it was an exciting area of musical exploration.

Unfortunately, far from being the dawn of a new age of music, the 1970s proved to be the end of this fascinating era of synthesis. Despite numerous turns in the cycle of musical fashion, from electro-pop to industrial electronica, from New Age to dance, the music of the past 30 years has been firmly rooted in the 12-note chromatic, equal-tempered scale fully explored by Johann Sebastian Bach in the 18th century. Sure, Sound On Sound's readers generally make more use of rhythm instruments than did the Baroque composers of Bach's era, and — for the most part — we make less use of melody and counterpoint, but 200 year-old central European music scholars would probably find no difficulty comprehending the form of today's popular music. Like my mother, they would undoubtedly hate it — but they would understand it.

This is stranger than it might seem. Whereas pianos and organs can only play discrete notes locked to a chosen scale, many traditional instruments are less constrained. All non-fretted

string instruments allow you to play any pitch within their ranges, and many brass and woodwind instruments allow you to slide between the semitones defined by their holes or valves. And then there's the trombone, but I'm not sure that we should mention this in polite company.

So how did Western music become so firmly locked into forms of music limited by notes of discrete durations and specific pitches, all of which conform to the well-tempered scale? It didn't happen in India, nor in Bali... countries whose wonderful music sounds so 'wrong' to most Western ears. In all likelihood, it's the result of exposure to one musical form from birth, resulting in our stunted appreciation of what constitutes a note, what constitutes a musical interval, and what frequencies are acceptable in a melody. All of which brings us back to the synthesizer — an instrument that is in principle so flexible that it can emulate all the musical forms known, and be the inspiration for quite a few new ones, were it not for the limited imaginations of those who use them, myself included.

Now, you could point out that many modern synths offer alternative temperaments such as Pure Major, Pure Minor, Just, and Werckmeister III, but these are different ways of tuning the 12 keys that comprise each octave. The underlying philosophy remains unchanged.

To find an instrument that breaks this mould, you might turn (as did I) to the experimental synthesizers developed during the first six decades of the 20th century. Some of these eschewed keyboards in favour of other mechanical systems for determining pitch, tone, duration and loudness but, if you inspect them closely, you'll find that many used paper tape with punched holes to play notes according to... conventional scales and temperament. In other words, a set of electronic sensors replaced the musician's fingers, but the musical philosophy was again unchanged.

Perhaps the only well known exceptions to the tyranny of the 12-note octave were the instruments made by Don Buchla in the 1960s and 1970s. His 'System 100' incorporated a sub-divided touch pad that made no concessions to the standard keyboard geometry, and allowed you to tune each division independently. Nevertheless, this still forced the player to think in terms of discrete notes with fixed divisions of pitch, with pitch-bend or slew to generate frequencies that lay between the notes.

As far as I am aware, there were — and remain — only two electronic instruments that challenge the domination of sub-divided pitch and discrete articulation of the notes. Both were developed in the early part of the last century, and both have found favour within all musical genres including classical music, experimental, jazz and avant-garde music, plus pop and rock. They are the Theremin and the Ondes Martenot.

Of the two, the Theremin is by far the better known, and over the past few years there have been many models produced. These range from small, basic, single-antenna boxes that cost a few pounds, to the popular 'Etherwave', through to Bob Moog's expensive recreations of the original, floor-standing instruments. Nevertheless, we're not going to discuss the Theremin this month. Instead, we're going to concentrate on the Ondes Martenot, and show how an obscure musical controller invented three-quarters of a century ago might improve many aspects of your synthesis technique in 2003, particularly with regard to our bowed-string patches.

Another Way To Play Synths

The Ondes Martenot, unveiled by Maurice Martenot in 1928, is a fascinating instrument, and if you're not familiar with it, it's really worth investigating. One of the best Internet-based resources for obscure 20th-century electronic instruments is www.obsolete.com/120_years/, and you'll find a page devoted to this unique device at www.obsolete.com/120_years/machines/martenot/ (see left). Those unfamiliar with it might well ask what is so different about it — it is, after all, another keyboard-based instrument. But the Martenot has two pitch-control mechanisms. The first of these is its conventional keyboard, but we'll ignore this from now on. The second is a little ring attached to a wire that runs along the front of the instrument. This makes the Ondes Martenot almost unique among electronic instruments because, if you slip your finger through the ring and move it to the right, the

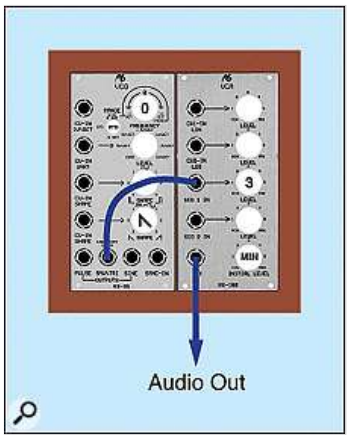

Figure 1.

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pitch of the instrument rises without quantised steps; if you move it to the left, the pitch falls without quantised steps. The keyboard then becomes no more than a reference, letting you see where you are vis-à-vis the conventional scale, but you are no longer constrained by its discrete divisions: you can move the ring to any position you choose. This, of course, is the electronic equivalent of a fretless stringed instrument.

OK... so the wire and ring let you control the pitch, but how do you get a sound out of an Ondes Martenot? Or, more pertinently, having done so, how do you shut the thing up? The secret lies in a second control found to the left of the keyboard/ring/wire assembly; a large, wooden button that controls the loudness of the sound. When this is 'out' (ie. when you're not pressing it) the Ondes Martenot produces no sound. As you press the button in, the sound becomes louder until, when the button is fully depressed, the sound is at its loudest.

With careful use of the two controls, you can pitch and articulate notes in ways that are impossible on a conventional synth. Sure, we got close last month by using a joystick to control the loudness, but it's not quite the same, believe me.

All of which brings us neatly back to the string sounds we were discussing in the last couple of instalments of Synth Secrets, and the point at which I left you last month.

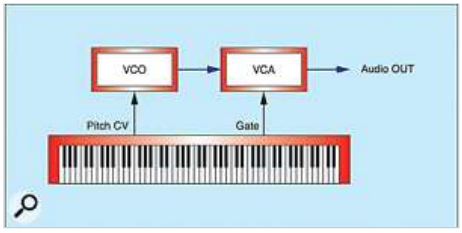

Figure 2.

More On String Synthesis

Let's start by considering the patch in Figure 1 above. This must rank among the simplest of all possible patches, with two modules — in this case, a voltage-controlled oscillator and a voltage-controlled amplifier — connected by a single cord. At this point, there's no keyboard attached, so there seems to be no way to determine the pitch of the note, nor to determine its start and end times. However, if you turn the amplifier's Initial Level knob away from its minimum, you will obtain a note whose tone is determined by the oscillator's Shape knob, and whose pitch is determined by the Frequency knob above it.

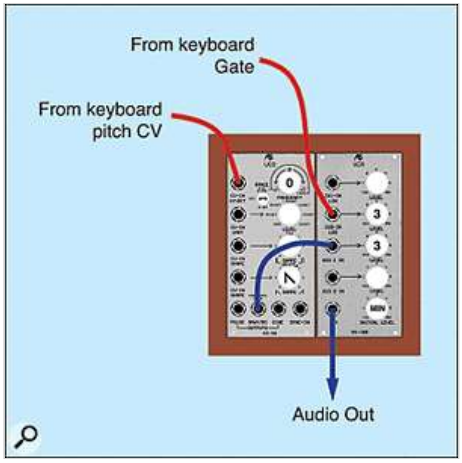

Figure 3.

On the most basic level, these three knobs provide everything you need to create musical performances. If you could twist them quickly enough and accurately enough, you could make precise changes in pitch and tone, and articulate the resulting sounds as you pleased, just as if you were using envelope generators, pitch controllers, modulation generators, and all the other bits and pieces that comprise an integrated analogue synthesizer.

Unfortunately, this is not simple. In fact, it's all but impossible, so we add a controlling mechanism to do most of the work for us. And, as discussed above, this mechanism is almost invariably a keyboard; perhaps with modulation and pitch-bend wheels that help us to inject some humanity into the performance, but a keyboard nonetheless. So we end up with the architecture shown in Figure 2, and the connections shown in Figure 3. Note that I have connected the keyboard Gate directly to control the amplifier. This is an acceptable practice because synthesizers with +5V Gates usually have +5V or +10V CV inputs on their VCAs, so you will do no damage. Sure, you lose the shaping capabilities you obtain when you use the Gate to trigger a contour generator and then use the resulting envelope to control the VCA, but the square 'organ-like' notes produced

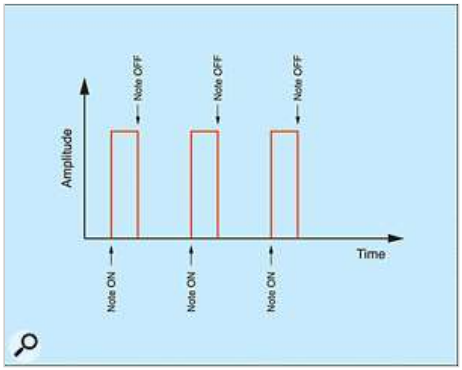

Figure 4a. Gate contour.

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by the Gate itself are acceptable because they are, well... like playing an organ (see Figures 4a and 4b).

If we play the patch in Figures 2 and 3, we obtain notes with sawtooth waveforms and the predicted organ-like articulation. It's perfectly useable, and no doubt would have graced many 1970s prog-rock recordings, but despite being based on the appropriate waveform, it sounds nothing like a bowed, stringed instrument.

So let's replace the keyboard with a version of the Ondes Martenot that has been developed specifically for use as a controller of analogue synths. There is only one such beastie in production — the French Connection from Analogue Systems, shown below — and this offers the ring/wire controller and the amplitude button of the original instrument, as well as an X/Y joystick controller (for more on the French Connection, as well as much more on the Ondes Martenot on which it is based, take a look at the review back in SOS February 2002, or head for

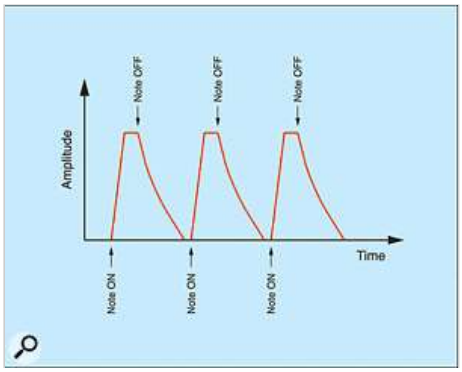

Figure 4b. ADSR contour.

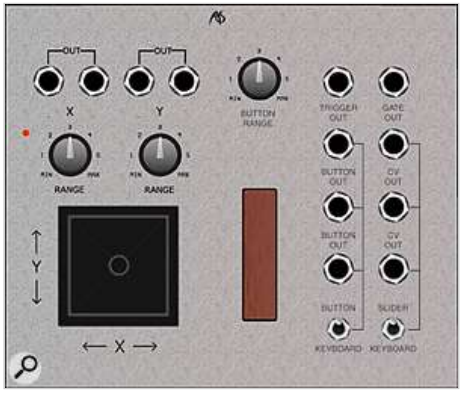

Figure 5.

www.soundonsound.com/sos/feb02/articles/frenchconnection.asp).

Figure 5 (above) shows the French Connection's control panel. As you can see, there are two switches to the lower right of this, and if we were to flip both of these to 'Keyboard' and connect CV and Gate cables to the appropriate sockets, there's nothing stopping us from using the instrument as a conventional CV/Gate keyboard. I've shown the resulting patch in Figure 6, and you can see that this is identical to that shown in Figure 3, so it will come as no surprise to you that it produces the organ-like sound already discussed.

However, if we now flip the switches to Button and Slider, playing the keyboard produces no sound whatsoever (see Figure 7). We must re-patch the cord in the Gate Out and insert it into one of the Button Outs. If we then press the button, we produce a variable voltage that controls the VCA Gain, and therefore the loudness of the sound. Likewise, playing the keyboard no longer controls the pitch. That duty is now undertaken by the wire, with the position of the ring determining the pitch at any given moment.

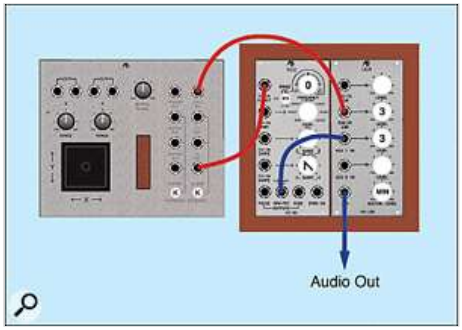

Figure 6.

If we now play, the result is remarkable. With a little practice, the performance is no longer that of a soulless single-oscillator, unmodulated sawtooth buzz. You can add vibrato by wiggling your 'ring' finger from side to side, controlling both the speed and depth in a way that feels and sounds completely natural. Glide is merely a matter of pressing the button as you move to the next note. Moreover, judicious use of variable pressure on the button allows you to articulate notes in human ways, making each note unique in a fashion that is not possible when triggering envelope generators.

So, how does it sound? As you probably have guessed, the unquantised nature of the pitch controller, and the fluid way in which you can articulate sounds, means that the Ondes Martenot lends itself to imitations of unfretted string instruments. With just an oscillator and an amplifier, higher pitches sound remarkably like a violin, while lower pitches sound much like a contrabass or cello, although probably not one that the late, great Jacqueline du Pré would have cherished unduly.

The modern French Connection lacks the amazing resonant sound reproduction system of the original Ondes Martenot, but it nevertheless allows you to articulate and add expression to the almost limitless range of sounds available from any synthesizer that provides a pitch CV input and a VCA Gain input. Unfortunately, this precludes most common analogue (and digital) instruments, but if you own a modular or semi-modular synth, you're in business.

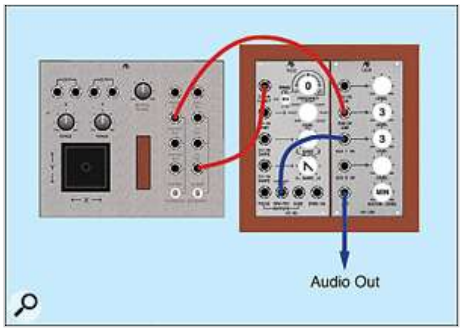

Figure 7.

Of course, we need not stop here, and there's nothing preventing us from using the 'feel' of the French Connection with more complex patches. Figure 8 shows a small extension to Figure 7 in which we control the waveform using the 'X' direction of the joystick. We achieve this by connecting a cable from one of the 'X' outputs to the sawtooth CV-In Shape input on the oscillator, so that left-to-right movements of the joystick change the wave from a sawtooth, to a triangle, to a ramp wave, and back again.

Playing this patch is surprisingly easy... use the inside of your left index finger to move the joystick while you use your thumb to press the button. Now you can articulate the note and determine its harmonic content with one hand, while playing the pitch with the other. It sounds simple, and it is, but this is something that you will find almost impossible on most synths. What's more, it's hugely expressive, because you can reduce the amplitude or even eliminate harmonics by moving the wave from a sawtooth towards a triangle as you reduce the overall loudness of the sound. This relationship between loudness and high-frequency content is — as we have discussed before in Synth Secrets — very much the behaviour of blown, bowed, strummed and struck instruments, and we're recreating it without a filter anywhere to be seen. Neat, huh?

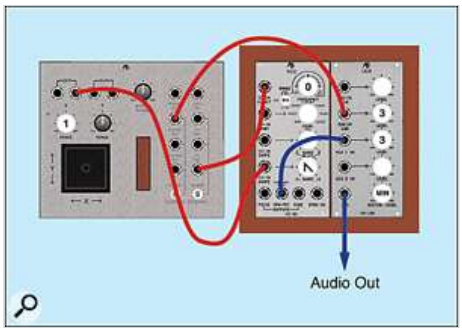

Figure 8. Wave shaping.

But hang on a moment... Haven't I spent the last couple of months telling you that you need low-pass and high-pass filters, formant filters, modulation generators, mixers, joysticks, reverb, and loads of other gubbins to create even the barest likeness of a string instrument? Well, yes, I have. However, the ability to play the synth in the manner of a stringed instrument overcomes so many of the limitations imposed by a CV/Gate keyboard that we no longer need many of these to create recognisable imitations and performances. And they're better performances, believe me.

Adding Articulation To Other Sounds

Once you've got the hang of shaping notes and pitching them using the Ondes Martenot architecture, there's no reason to confine yourself to imitations of violins and cellos. You can create stunning imitations of instruments such as flutes and, in particular, vocal 'formant' sounds (both of which will be the subject of a future Synth Secrets). As for generating new sounds and effects, the freedom afforded by the ring and button opens up completely new areas of sound design and creation.

But

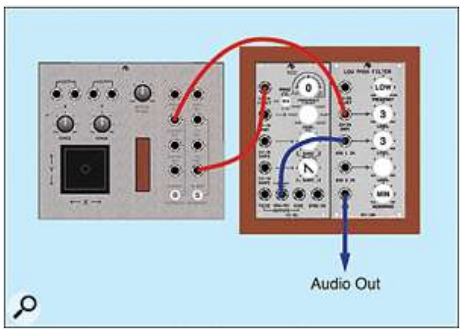

Figure 9: A simple but impressive (and, with the correct articulation controllers, expressive) brass patch.

perhaps the most fun (for today, at least) are the brass sounds that you can conjure effortlessly by replacing the VCA in Figure 7 with a low-pass VCF (see Figure 9 above).

As you can see, we're still using just two modules, and the patching is identical, but the button — instead of controlling the loudness — is now controlling the cutoff frequency of the filter, and therefore the tone of the sound. And, because the initial cutoff frequency is set to Low, all the harmonics are filtered out until you press the button, which means that silence reigns between notes. Consequently, the filter is not only shaping the tone of the sound, it's also differentiating one note from the next. This is incredibly elegant!

If you now play a note, articulate it with the button, and add suitable vibrato using the ring/wire, the result is magic, especially when played through a good digital reverb. You can play distinct notes, imitate swell, recreate the mis-pitching of certain notes that invariably occurs when playing real brass instruments, slide notes to imitate trombones... and if you detune the oscillator by a couple of octaves, you'll obtain the most realistic tubas you've ever heard from an analogue synth.

So there we have this month's Synth Secret; two modules and a more appropriate method of controlling them can be far more expressive and create more realistic bowed string and brass sounds than any number of modules and facilities controlled by a less suitable device. It's an important lesson, but because of the ubiquity of the keyboard synthesizer, it's not one that many people have had the opportunity to learn.

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