A Many-Colored Jungle Of Exotic Tunings

By Dominic Milano

FOR YEARS, WENDY CARLOS HAD TO content herself with the exploration of timbre synthesis. During those years of butterfly collecting in the timbre domain, she managed to come as close as anyone to exhausting the possibilities of her chosen instrument. While the rest of us have been crawling around with nets looking for the next hot timbre, Wendy has been asking, What's next? What new vistas are there to explore that go beyond timbre? For her, the answer is emphatic: *Tuning!* Exotic, non-equal-tempered tunings have become a passion for her ever since 1984, when Stoney Stockell, the engineer responsible for getting the Synergy/GDS up and running, gave Wendy access to the instrument's tuning tables, allowing her to control the pitch of every note. Using a ten-year-old Hewlett-Packard computer to store tuning tables, Carlos has been able to probe alternatives to equal temperament. The initial collection of results can be found on *Beauty In The Beast.* As Wendy is quick to point out, this groundbreaking material is only the tip of an iceberg.

Wendy with some of the tools of her trade (L, top to bottom): one-octave keyboard used to remotely control Hewlett-Packard computer, volume and tone controls, Aphex Aural Exciter Type B, T.C. Electronics parametric equalizers, Phase Linear Autocorrelator, Moog 904 lowpass filter. Two Synergy synthesizers stand to the rear. Note custom switch used to control which Synergy is affected by Hewlett-Packard tuning tables.

She feels lucky that she hasn't been forced to construct instruments in order to investigate alternate tuning schemes the way Harry Partch was. "He devised a nice 43-note scale," she explains. "Unfortunately, he built instruments that had bad overtones for doing harmonies. Xylophones, metal and bamboo marimbas, and glass bell trees all have overtones that don't lend themselves to harmonies. Also, because they are so percussive and because there is so much quick movement in the music, you don't get a chance to notice that the tuning isn't equal-tempered."

One listen to a track like "That's Just It," and you'll notice that Wendy has succeeded in making you aware that you're not hearing equal-tempered tunings. Nor is she limiting herself to only one non-standard tuning. Two Balinese scales, her own "perfect" tuning, two custom scales called alpha and beta, and a scale based on Tibetan traditions are among those used on *Beauty In The Beast.*

The Balinese scales in "Poem For Bali" and the Tibetan scale of "Incantation" were 'found.' That is, Wendy played along with recordings, effectively making herself a part of the ensemble. She was then able to tell what notes were sharp or flat, make adjustments in their tuning, and arrive at a scale that was, in her words, "accurate within five cents. That's pretty good for ethnic tunings, because the [original] instruments don't have much more tolerance for holding tunings than that."

The Balinesian pelog scales used in all but one section of "Poem" are a sort of variant of the pentatonic scale—they actually have seven notes, but one aspect of the music is that players are limited to five of the seven notes at any one time. The scale has a minor second, major third, minor second, major third structure; however, Wendy used at least four different versions of the pelog scale, some with major feels, others with minor feels. One of these pelogs is the first thing heard on the Soundpage.

"The slendro scale," she says, "is a little less passionate than the pelog, which I found to be much more interesting melodically. Slendro is the older of the two scales, but the varieties of melody available in pelog are more stimulating. [Track two on the Soundpage illustrates this point.] You could never think of these melodies in equal temperament."

The scale used on "That's Just It" (the final excerpt on the Soundpage) is a sort of super just intonation Wendy has dubbed the harmonic scale or perfect intonation. Unlike just intonation, transpositions *are* possible in the harmonic scale, although they require the assistance of Wendy's Hewlett-Packard. But we're getting a little ahead of ourselves. The harmonic scale is a scale related to one fundamental. So a one-octave C major scale in the harmonic scale of C would be constructed several octaves above a low fundamental. The first C in this octave would be the 16th harmonic. The octave above that would be the 32nd harmonic. C# becomes the 17th harmonic, *D* the 18th, *E♭* the 19th (which isn't a real *E♭*), *E♮* becomes the 20th harmonic (the perfect major third), *F* is the 21st harmonic (the natural seventh above G, but not a very good interval above C). Then *F#* becomes the 22nd harmonic. The 24th harmonic produces the G to get the perfect fifth. The 26th harmonic is *A♭*. The 27th harmonic, *A*, produces a perfect fifth above the *D*, and the *B♭* is the 28th harmonic. The *B♮* is produced by tuning to the 30th harmonic. Finally, the octave C is produced by tuning to the 32nd harmonic.

"As you can see, I've left some harmonics out," Wendy points out. "But I have enough to deal with within the confines of the standard 12-note per octave keyboard we're forced to use until we can scrape up the funds to build a multiphonic generalized keyboard."

A little thought will show that if that were all there was to it, transposition wouldn't work, since the intervals are all tuned relative to a fundamental of C. The solution? Store a different tuning table using each of the twelve notes in an octave as the fundamental. When you're playing in C major, you use that tuning table. To play in *F*, change the tuning table and play away. For you mathematical types, that's 144 notes per octave.

Each tuning table was originally called up using the HP's function keys, but later Wendy got the idea of using a one-octave music keyboard to trigger the function keys remotely. When she needs to transpose, her left hand plays the appropriate note on the one-octave keyboard which tells the HP to change the Synergy's tuning table. "This scale lets you have your cake and eat it too," she says. "You can modulate anywhere and be in perfect tuning at all times. Of course, if you play like a bat out of hell, you really don't notice the perfect aspect of the tuning. But if you play slow passages, you hear the lack of beating between intervals right away. Some of the wilder harmonies using the eleventh partial, which is a perfect quarter-tone, could never be used before." The arpeggio on the Soundpage illustrates this point.

One interesting side effect of the perfect scale is that if you hold down a cluster, you will hear one note sticking out below the others. This note is the fundamental, which is being reinforced and implied by all the other notes, which of course are harmonics of it. This phenomenon can be observed in the high cluster chord played on the Soundpage.

Are there drawbacks to perfect tuning? "Chord progressions are hard to work out. They're hard to find," Wendy answers. "The notes just don't fit that easily next to one another. With 144 notes in an octave, there are just too many possibilities to experiment with. It took me four hours to compose four measures of four-voice music. Quarter-notes, nothing complex. [See page 54 for those four bars.] So there's a very high price of admission for doing this kind of work. It's extremely time-consuming. But it's fun because you're exploring virgin territory.

"This tuning goes so much further than regular just intonation. It makes me impatient with the people who are trying to get just intonation established. You get perfectly in-tune thirds and fifths, and maybe if you're lucky perfect sevenths. But then you have to worry about where you put the commas. If you really want to get something sweeter than equal temperament, you should be using mean-tone, which has nothing to recommend against it except the wolf intervals, which really only occur in the remote keys. I suggest strongly that we go back to mean-tone, using computers to keep re-centering the pitch so you avoid the wolf tones. You still get small beats, but they're like chorusing tones. It's a much sweeter-sounding scale than the equal-tempered scale."

Despite her enthusiasm for mean-tone intonation, Wendy didn't do any pieces with it on *Beauty In The Beast*, because, as she puts it, she "was having too much fun with the more bizarre tunings."

Three scales of Wendy's own invention certainly fall under category of 'bizarre tunings.' They're called alpha, beta, and gamma. Alpha and beta were used on the title track from *Beauty In The Beast*. The alpha scale consists of 78-cent steps, creating 15.3 notes per octave, which means octave transposition is impossible. The idea was to split a minor third into two equal parts. Then that was divided again. The scale produces wonderful triads. Wendy also says, "For harmonization, this tuning is a blessing. But 78 cents is an odd melodic interval. Hearing it for the first time is like eating sushi for the first time. It's exotic."

Beta tuning developed out of splitting a fourth in half. It's close to being 18.8 equally spaced (63.8-cent) steps in the octave. According to Carlos, beta has almost the same properties as the alpha scale, except that the sevenths are slightly more in tune. The alpha and beta scales are heard in the Soundpage's third example.

The gamma scale, which wasn't used on the album, features 35.2-cent steps, making for a little more than 34 notes per octave. "It's the one that I've never seen anyone refer to before," Wendy explains. "Yet it produces nearly perfect triads. I don't want to use it until we can raise the money to have that generalized keyboard built. I just don't want to deal with a 35-cent step on a standard 12-note-per octave keyboard.

"Gamma is as far as I think I want to go with these exotic scales," Wendy continues, "because you don't have any octaves. You have to use 16', 8', and 4' stops, or figure out some way to derive the octaves synthetically, to get them. And that can drive you crazy."

Instrument sounds sometimes dictate tuning, and vice-versa. For example, getting the Western orchestra to accompany the gamelan orchestra in "Poem For Bali" required that Wendy make adjustments in the overtones of the instruments to better accommodate the pelog-meets-equal-tempered scale. It's also true that certain instrument types are more suited to certain scales. "The Bali instruments don't have the overtone structure to do octaves," Wendy says. "Their octave is about 1,212 cents." On Western instruments this octave is sharp; however, on Balinese instruments the octave sounds right on. Brass instruments are better suited to perfect tunings. Strings like violin favor Pythagorean, where the fifths are good and the thirds aren't. Woodwinds, harp, organ, and so on favor equal temperament.

Since she's still using a standard keyboard, one has to wonder what adjustments Wendy has to make to her physical technique while playing in scales that have 15.3 and 18.8 notes per octave. "Almost none at all," she explains. "You have to be obstinate enough not to be bothered when you're playing something that looks weird. You just don't think about it, because—like a centipede—if you think about the muscles, you stumble." ■

Consonance of all equal divisions of the octave from 10 to 40 steps per octave. This chart was something Wendy plotted to show her the results of dividing the octave in up to 150 equal steps (only 40 are shown here). The two curves shown here plot how close to in-tune both triads (the blue line) and triads with the flat seven added (the magenta line) are. Zero deviation (at the top) equals perfectly in tune, i.e., no beats.