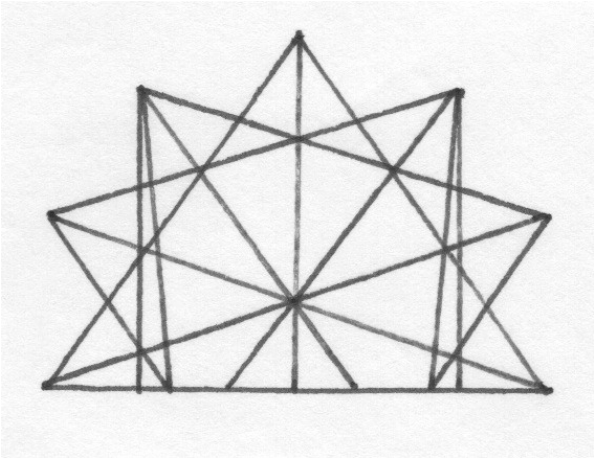
On the Circle-of-Fifths Rotor



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ABSTRACT

The author introduces a device that enables the rapid analysis of harmonic functions and related chores. He explains how the idea developed over time in his pursuit of ergonomics, as well as some essential features of the device.

A RAMBLING HISTORY

The four photos accompaning my article sample rotors made for 12, 19, 31, and 53 equal temperaments. The device has three rings or layers that can be independently calibrated to set any harmonic pattern within any pitch and function. One first calibrates function and pitch (sets the key), then happily wanders around with the pattern wheel. Here one finds many chords and scalar types housed within its geometric layout.

The best way to introduce these tools is to follow the development of the initial insight. During the late '60's while attending university I was taken by a problem in set theory. How many different chords and scales inhabit our standard tuning? For a while I played with algebraic solutions, but a much more elegant and useful approach came to me while travelling in Mexico during the winter of '71. Use a *geometric model* based on the clock face.

Every chord has a corresponding geometrical *pattern* or polygon. It turns out that 12-et has only two to the twelfth power (4096) unordered sets including the empty set (silence) and the full set (the chromatic scale). This may seem like a big number but it is quite manageable, since the patterns also form natural sub-groupings. For example, twelve of the triads belong to the family or *class* that we call 'major triad.' When we arrange the patterns in this way, we find only 352 types or classes in the whole system. Moreover, this material can be further organized by complexity—there are only 19 classes of triads, 43 of tetrads, 66 of pentads and so forth. The elegance of the system compelled me to assemble a *Dictionary of Harmonic Functions for 12-et* consisting of 352 tabbed pages. Then one can easily look up any pattern, once one understands how the address system works.

The usefulness of the *circular model* went far beyond the numbers problem. It lays bare the whole morphology of the harmonies. One can see that some patterns (a minority) are symmetrical while the rest form complimentary pairs. An investigation of this morphology influenced my decisions over the address system. The geometrical analog makes structural aspects of harmony vastly more accessible.

The circle-of-fifths rotor design is a direct evolution from the geometrical model. However, this evolution did not come about until the late '80's. What happened? In 1970 I took up the north Indian sitar and quickly fell in love with its tuning culture—drone based open systems of just intonation and its closed system associate 53-et. In the beginning I was mainly interested in exploring the alternative scale possibilities in the

pitch wheels. For various practical reasons it's best to put the pitch wheel in the middle with function on the outside. But by far the most important difference between the two devices is the absence of the inner *pattern wheel* in the earlier version. Instead I just chose a few sundry chord types and slotted them into what is essentially a transposition machine. I have a whole collection of past rejects or steps along the way, but decided to include only this one in this article. For it shows the essential feature of the advanced device—a pattern wheel in the middle that allows many harmony types to wander freely.

In order to understand what brought me back to the geometric model I must briefly review what happened during the '80's. In 1981 I was introduced to refretted guitars and other 'experimental' musical instruments that increasingly took me away from the sitar. I built various electro-acoustic stringed instruments, mostly applications of the monochord principle. I became increasingly obsessed by a practical problem: a practical color-code for microtonal (31-et) fretboards that makes the guitar easier to play. During the '80's I used a rainbow colored sequence in various contexts and tried out several possibilities, but the most ergonomic solution came to me in the early '90's. Now I only need four colors for the fretboards: black, while, and two shades of grey. Thus I managed to jettison the rainbow sequence altogether—it was too 'busy.' Another focus for me during the '80's was an optimum design for microtonal keyboards that allows alternative systems without the need to change fingerings. As with the fretboards, these musings didn't come to a satisfactory conclusion until the early '90's. The same can be said for a third focus that forms a trajectory from the schisma resolution (a favorite of mine)—an interest in the fascinating morphology of irregular temperaments (well-temperaments). By the early '90's I understood how to sculpt them into personalized characteristics.

I went through some kind of mutation during the '80's. By the end of the decade I had shifted my allegiance away from 53-et and toward 31-et. The reasons for this shift are too complex to relate here. The idea for the *circle-of-fifths rotor* came from this period of the late '80's. I longed for a complete 31-et dictionary, but it's just as impossible as a 53-et version. While reflecting on this old problem the breakthrough occurred. The pattern wheel on the inside opens the whole system to easy scrutiny. Instead of laboriously flipping though the pages of a dictionary in order to find some function, I have the information at my fingertips all at once. The optimal design was born.

SOME ESSENTIAL FEATURES

First of all, why a circle of fifths and not some other interval? In my old 12-et dictionary I used two circles: fifths (called the Harmony Wheel) and semitones (called the Melody Wheel), since they form the only possibilities, given the multiple symmetry of the system. However, with prime numbered divisions like 31-et and 53-et one can make a circle from *any* interval in the system. One can reasonably argue that 31-et is better modeled as a circle of major thirds, given its orientation on the matrix. I experimented with possibilities but finally concluded that the circle of fifths has certain

special harmonic properties—important harmonies tend to be compact structures. So I abandoned the alternatives.

Another issue is the 'alphabet' for function. Different countries use different names but I decided to adapt the standard international jazz terminology. '1 2 3' means 'doh re mi' or some other equivalent. This system is convenient for meantone-related temperaments of which 12, 19, and 31-et are prominent members. 53-et comes from a very different family—one of several that are not meantone-related. Here we need an additional sign for comma shift. Its notation has peculiar properties that create what I have called a 'four beat rhythm' on the circle of fifths. I won't defend the notation here, only note that this regionalism of the system is prominent on the rotor for 53-et. My terminology for function is a direct extension of the jazz terminology. The notations for 12, 19, and 31-et are much more like each other—sharps clockwise, flats counterclockwise. They only need some tailoring around the antipodes, a different twist for each division. 12, 19 and 31-et form a tight family.

On the colors. I have always striven to make my devices pleasing to look at without compromising functionality. For the 12-et dictionary I decided to apply the rainbow sequence to the order of consonances. Thus the unison and octave became white or 'shining' (I used mylar on my fretboards), fifths and fourths red, major thirds and minor sixths orange, minor thirds and major sixths yellow, wholesteps and minor sevenths green, semitones and major sevenths blue, and tritones purple. The correspondence is well suited to 12-et but the shift to 31-et needs a lot more shades. It becomes too busy. Nevertheless, I tried to make it work all through the '80's, aiming to adapt it to microtonal fretboards.

The two rotors for 12-et and 19-et use colors for function derived from the old schema, but the 31-et rotor I am displaying here is an ergonomically improved model. During the '90's I finally discarded the rainbow reference, replacing it on the rotor with a much more practical schema. It uses *axis symmetry* and highlights the diminished tetrad. By the mid '90's I realized that axis symmetry is structurally more significant than point symmetry. Alas, the rainbow sequence schema has point symmetry. Notice how much easier the 31-et color schema is to use than the old approach displayed on the older 12 and 19-et rotors.

A truly modern rotor for 12-et and 19-et should also emphasize axis symmetry in a related color schema. However, I have photographed these two as illustrations of how I tried to adapt to fretboard problems during the '80's. Fretboards work on the principle of juxtaposition: one wants a bright (foreground) colored fret beside an uncolored (background) fret. Consequently, roughly half of the frets need bright colors, the other half not. In the case of 12-et we need seven brights for the foreground, five for the background. Consequently I only used the colors shiny, red, green, and yellow. Using the same approach I needed some more colors for the 19-et version. My 31-et version has an even wider assortment of shades—I didn't photograph it for this article. With the new axis-based schema I have finally liberated the rotor from its shackles to fretboard realities. The rainbow schema looks pretty but is just not suited to the rotor. It