Aural Tuning

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Twelve perfect fifths don't equal the same note, nor do even thirds.
Inharmonicity is the reason we must temper the whole piano. The effect of inharmonicity is a distortion of the mathematical tone. Stiffness acts lon the restoring force on the string. A node is like a teeter-totter and has no dimension. Fat nodes are where each string creates the partial. What are anti-nodes? Nodes are defined by the vectors around them. A stiff wire

The restoring force due to the stiffness of the string is fundamental to the piano. A machine measures the phenomena of inharmonicity and averages it out.

Using a formula and an Excel spreadsheet, Jim measured and entered the string lengths and diameters.

Coincidental partials: two different notes share the same note for a particular partial.
Test coincident partials: play another note that has a partial in common with those two notes.

Read Gary Schultz's article in the 1982 Journal.
From this article, Jim made diagrams of keyboards representing a music staff.
He compared coincident partials with a fifth partial, which gives us a third. Seventh partials also help – particularly minor sevenths and major seconds.

Listen to thirds and tenths, major thirds and minor sixths, minor thirds and major sixths, octaves.
Major third above top note, minor third below lower octave note.
Double & triple octaves.
Tenths and 19ths.
It's all base 7, so divide the number by 7.
Twelfths and 19ths are 5ths.
Tune an Octave 5th and test it against major sixth below and two octaves and a third below.
19th is 2 octaves and a 5th
Major sixth below the octave 5th, then invert it and play it below, listening to an octave and a fifth above that: minor third, then double octave and major sixth.

In the Hamilton graph, the inharmonicy on note 29 is grater than it is around notes35-39. Hamiltons have thick plain-wire bi-chords and wound strings in the tenor. The piano itself is short, which immediately tells us that there will be inharmonicity issues. There is a big curve on the treble bridge. When you're done tuning, you can hear the inconsistencies. Because of the inequity in the inharmonicytty constant, when you listen to a low set of coincident partials and compare them to a higher set of coinicident partials, the difference between the two string will be different. The 2:1 partial will be slower than a 4:2 partial.

If we tuned a temperament to one key, the upper third will beat twice the speed of the lower. The 6:4 partial should be double, but on a Baldwin D it is three times. The upper partials are faster than the lower ones.

To test the fifth, play a major sixth below the lower note. Listen to the upper coincident partial to learn the condition of the fifth at a 3:2 partial. How do we know how the fifth is with a 6:4 partial? It will be an octave up. Compare those two beat rates – the sixth below, the minor third and the major third – you'll know the difference between the partials. In the Hamilton it may be zero difference in the lower range and 1.5 times as fast in the upper. If the 6:4 partial is fast, you'll have to bring it down.

Jim played a tuned Hamilton so we could hear the differences in the partials.
M6:octave + 3rd,
At the break the 6th interval beat was too slow but the partial was too fast; what do we do? We have to compromise. A 2:1 interval cannot be tuned there.

The flaw in many charts is that they are based on 12 notes to the root of 2. Pitch and tension must be taken into account. String length, diameter, inharmonicuy constants through partial 8, frequencies of each partial, etc. When tuning a piano to itself, what do we have to compare it to?

Choose a partial, tune it and see if it sounds good. Machines don't know.
Don't worry if the 4th partial is out.
What is stretching the octaves? From what? The 8th partial? The 2nd partial?
It depends on the scale of the piano which set of partials to tune to. These can't be put into a book. Each piano must be tuned differently.

Ed devised a formula for the inharmonicity constant that he got from Earl Kent, who got it from Schuck and Young's paper from Chuck Walter the engineer.