Understanding Piano String Scales

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July 13, 2012

Convention

TEST #5

A longer tail on a bass string (or any string) allows more flexibility for the bridge to vibrate, providing a much longer sustain. A very short tail stiffens the bridge and sounds dull.

Campbell bought a failing piano company in 1911. He had bee na general manager of a large retail piano store and part of his job was to interview people who had bought pianos. He figured that if a small grand piano could be built at a reasonable price, they would be expensive. His goal was for every working man in America to be able to afford a grand piano. He set about to design how an affordable grand piano could be built. He approached a key manufacturer and asked for bids on supplying 2000 sets of keys. Most manufacturers had never been asked for bids of more than a dozen sets at a time. His brand was called the Brambach. Nowadays, these pianos do not hold up well. The reason? They weren't made to last more than a generation or two, because they were cheap. What he did was to figure out how to manufacture a grand piano on a large scale. By 1919 his company was about five years ahead of the other companies in manufacturing, by his estimate.

Albert B. Mann, *Piano Scale Making* described how to make a 5' grand.
"Variations on a Tension Scheme" shows some of the extremes
Chart of Examples: Scale & Note, Length, Diameter, Tension, Inharmonicity

There is not much difference between the C's in the upper region. There is not much difference in length between a long-scale and a short-scale piano. However, in the lower area there is a lot of difference in string tension and string length.

Most short pianos are saddled with a short scale because there are not many options. Rather than having power, they have more high tension scales, more massive hammers and a heavier soundboard.

When we explain why we are hearing what we are hearing, then we can better explain to our customers what is going on. We then have the knowledge to know why or why not something will work.

TEST #5

Back-scales, the string tension & soundboard panels are the same. The only difference is the speaking length.
The longer string has stronger fundamental and more upper harmonics. The pitch of the short string sounds significantly lower, even though both strings are tuned to the same note. The

String Scale Basics

$T = 1.55 \times 2^{(n/6)} \times L^2 \times d^2$

$T = 1.55 \times 2^{(n/6)} \times L^2 \times (089D^2\ 0.11d^2)$

String inharmonicity

We do not hear inharmonicity, which is just a number indicating how stiff a string is due to the function of the density of the string, the diameter of the =string carried to the fourth power and inversely related to the tension and the length.
The longer the string, the lower the inharmonicity.
The larger the diameter the higher. Keep the diameter of the core as small as possible.
The upper partials of a note are actually closer to the note just above it, and the pitch of the note becomes indistinct. When you raise the diameter a little bit, the inharmonicity goes sky-high. Length does not matter as much.

$B = (330 \times d)^4 / T \times L^2$

$B = 6.17 \times 10^{12} \times d^4 / D^2\ F^2\ L^4$ (formula for wrapped strings)

Developing the Scale

Older technique:
Give the length of every C, then the first and last of each section.
Take a stick of wood and bend it.
Put a duck (lead weight with a finger to hold it against the table) on the stick.
Take a pencil and draw the line.
The problem with this technique is that not all the pieces of the wood are uniformly stiff.

Wolfendon was the first to lay out scales logarithmically, which is how it is done today.

Del added a transition bridge at the low end of the tenor to blend the shift into the bass.
Early transition bridges were almost always scaled with wound trichords. The problem with this is basically mechanical since such small-diameter copper wire is required. Theoretically this would work, but in the real world this is impractical. The copper wire must be kept above .2mm.

The Low Tenor Scale

The hockey-stick hook

- Steinway did it that way. But why?
- Origins buried in history == brass wired bvereaks easily
- Wolfenden quote: With the bass/tenor crossover as low in the scale was typical in ;"must be forshortened in a manner that is appropriate"
- What is appropriate?

Practice probably developed to dump energy and compensate for low end-of-bridge impedance problems.

The tensions nosedive at this transition. This hook is always audible.

- Plate cross-over point & scale transitions need not be the same
- Tri-chord wrapped unisons are never a good thing
- Bi-chord wrapped string in tenor section should be placed on a separate transition bridge
- Reasonably uniform unison tensions should be maintained across all plate & scale transitions

TEST #6:
Same string length, same back-scale, same diameter, same tune.
Double-wrap vs. single-wrap. (Double sounds higher.)
The calculated inharmonicity is the same, but not the measured inharmonicity.
The spectrum is quite different.

Why do strings go dead? Possibly due to the contact of the winding to the core. Copper does corrode. A bass guitar player boils his strings and they sound better when put back on. Strings go dead after many years of exposure.

The Bass Section

- There is no ideal number. Generally there are more mono-chords in short scales, fewer in long scales. Determining factors: overall diameter and available space between strings of lowest bi-chords, and tension limits on core wire of highest mono-chord. The physical limits are how much space there is before strings will rattle against each other. All piano change decisions effect some other aspect of the piano. There should be an even number in the bass and an odd number in the tenor of bi-chords.
- The point at which a log progression of speaking length and a reasonable back scale length can no longer be achieved
    - Varies with
        - Overall piano length
        - String flare angles – physical placement of bass bridge, etc.
        - String tension schedule (short & thick, long & thin)
- To design longer bass strings:
    - Spreading out the fan of the strings makes the piano wider. The farther apart the ends of the bridges, the more difficult it becomes to blend them acoustically.
    - The other way to lengthen the bass strings would be to make a longer narrower piano, which would keep the end of the tenor bridge closer to the start of the bass bridge.
- Tenor-bass transition
    - The ultimate goal is to make the transition indistinguishable not only to the player but also to the technician
    - The only way to change the transition is to re-scale
    - The obvious advantage of flat-strung pianos is that there is no transition between bass and tenor.

    - Some transitions cannot possibly be voiced because of the design.
- The speaking length
    - Longer is not necessarily better
    - Remember the back scale
    - In most pianos A1 speaking length is usually too long
    - A sales feature that limits good bass tone production