A Modern Flat-strung Piano

One of the illustrations shown in last month's article (Figure 5) was a sketch of a flat-strung (FS) version of the contemporary, if rather generic, 173 cm cross-strung (CS) grand shown in Figure 1 of that article. Very few changes were made to the overall design during the transformation from a CS design to a FS design. The same string scale was used as was the center-to-center spacing along the hammer strike line. The shape of the rim was changed a bit to better accommodate the special characteristics of the FS architecture. Other than this things stayed pretty much the same.

The performance of these two pianos would be, while not identical, quite similar with the obvious exception that the bass-to-tenor transition of the FS design would be inherently smoother. It does not otherwise take full advantage of what can be done with FS string architecture. This month I want to further explore some of the advantages that can be had with a modern approach to FS string architecture. (It's not all peaches and cream—there are a few disadvantages, as well, and I'll also discuss those.)

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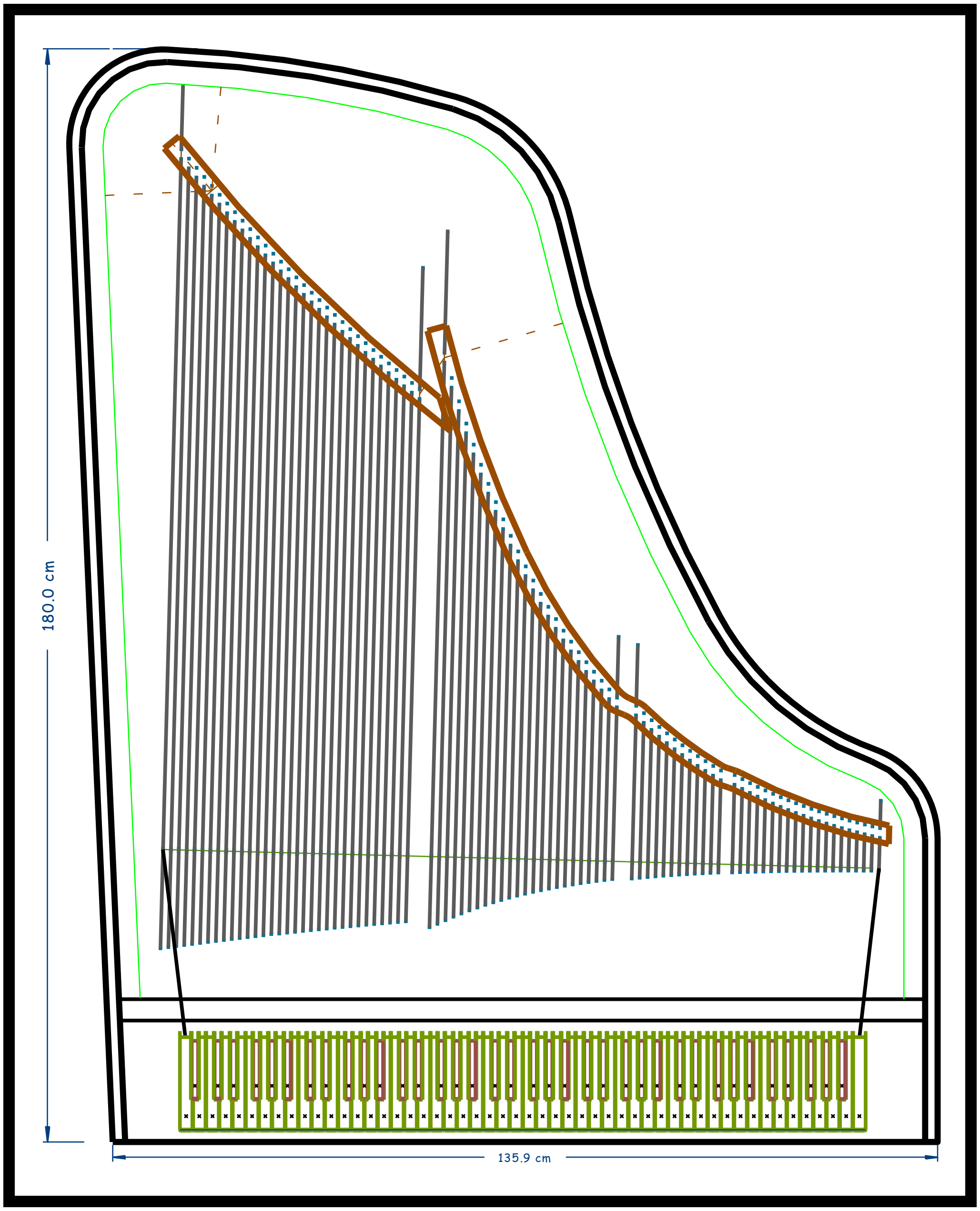

Figure 1. A design cartoon depicting a modern 180 cm flat-strung design.

Figure 1 shows a design cartoon I've drawn to illustrate what I think of when I discuss a modern FS grand.[1] This piano would be expected to compete more-or-less equally with the Generic 173 illustrated last month. Indeed, it would be expected to compete with any and all CS strung pianos of similar size. The scaling is similar, although not identical, to that of the Generic 173. The speaking lengths of C88 (54 mm) are identical. As are the speaking lengths of F33 (930 mm) and A1 (1300 mm). The tenor bridge is not foreshortened. The lengths of most of the wrapped strings in the bass section are some See Figure 2.

Because this is still a relatively short piano I've chosen to give it a bass section having 32 notes all of which are wrapped strings. (The Generic 173 had 26 notes in the bass section and four notes using wrapped strings in the tenor section.) Hence the strings of notes A1 – E32 lie on the bass bridge while those of notes F33 – C88 all lie on the tenor bridge. None of the notes in the tenor section use wrapped wires. I did not attempt to use a continuous bridge so there is a small separation between the end of the tenor bridge and the start of the bass bridge—about 75 mm—but this is minimal when compared to the 380 cm separation in the CS design. If the wire diameters are well chosen the bass-to-tenor transition will be musically transparent.

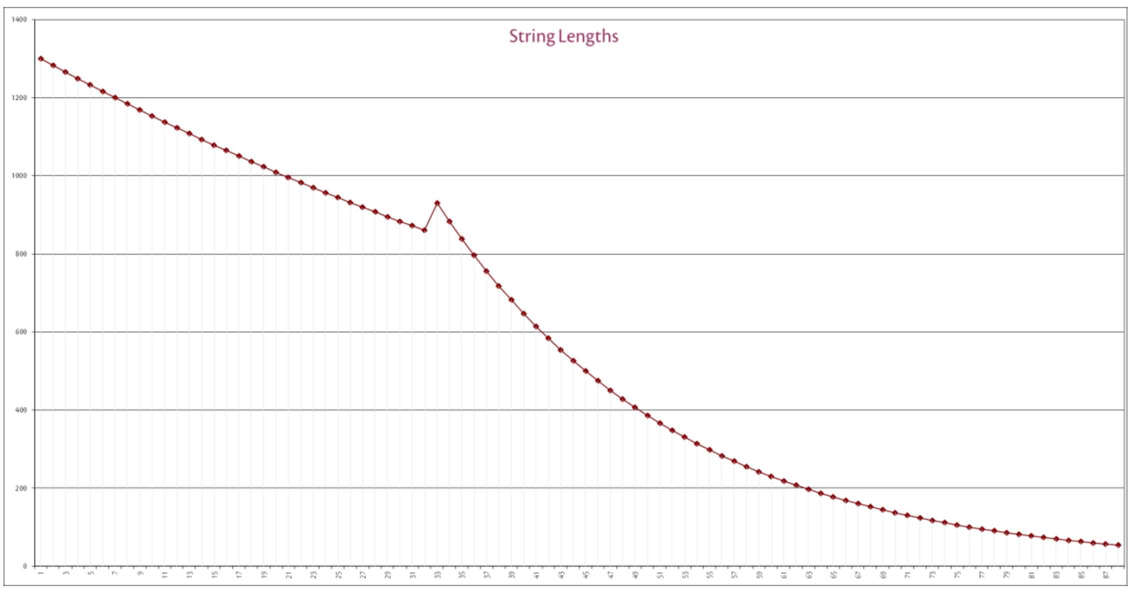

Figure 2. A chart showing the speaking lengths of the 180 cm flat-strung design.

As noted, this piano will be slightly longer than its CS counterpart. Ah ha! You say. See, the FS piano has to be "bigger" to accommodate the same bass string lengths as its CS sibling. Well, yes and no. This really depends on our definition of "bigger." To be sure the FS design is longer but it is not nearly as wide. See Figure 3 where the two rim shapes are compared. In terms of floorspace occupied the 180 cm FS design is actually significantly smaller than the 173 cm CS design. The 173 cm CS design occupies 2.03 m2 of floorspace while the 180 cm FS design takes up just 1.91 m2. Quite a difference. And yet, unlike some of the early attempts to make smaller—really smaller, not just shorter—cross-strung grands like the Chickering Quarter-Grand, this design will present no manufacturing or servicing challenges.

How is this achieved? By their nature FS scales can use tighter center-to-center spacing along the hammer strike line. As well, the gap between the bass section and the tenor section does not have to be as wide.

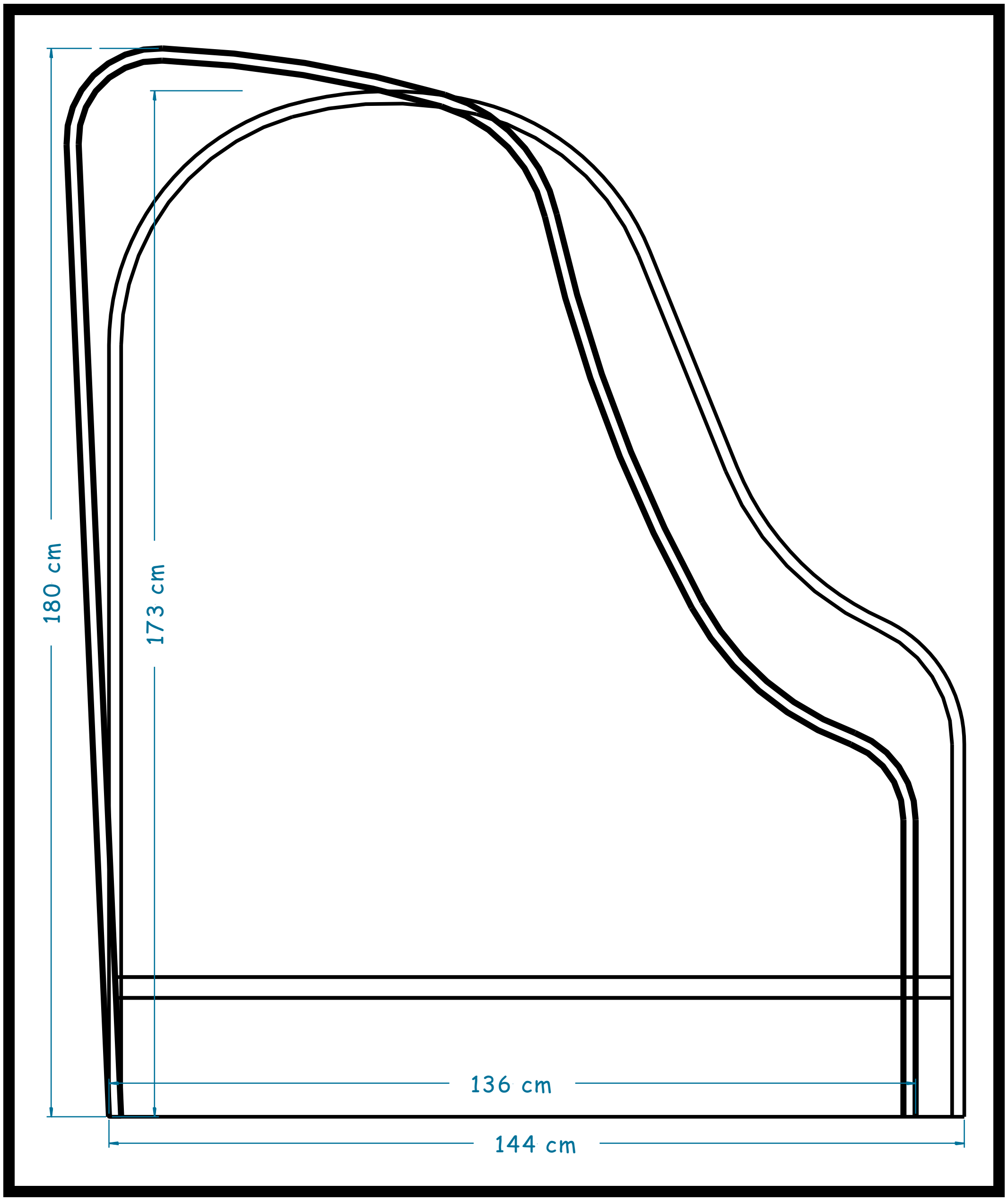

Figure 3. A comparison of two rims. The wider rim depicts the conventional 173 cm grand we've been discussing. The narrower rim depicts the flat-strung design. The CS rim occupies 2.03 m2 of floorspace. By comparison the 180 cm FS rim occupies just 1.91 m2.

In this design I've made the note-to-note spacing a modest 13.0 mm through the bass and tenor sections. From there it gradually decreases to 12.5 mm at C88. This piano, being a modern *pianoforte*, would use relatively narrow hammers in the upper tenor and treble so this represents generous spacing. It could be even tighter—even using WN&G parts a spacing of 12.5 mm throughout would be practical—but this gets me to my goal.

I envision this piano having a relatively low-tensioned string scale. I would put it at 70 – 72 kgf through the tenor. Given that the string's tensile stress is all in one direction with no torsional stress coming from cross-stringing, the frame struts can be lighter than we're used to seeing. (Indeed, the entire structure can be made lighter.) I've chosen to make this a three-section design using just one break in the tenor/treble scale to accommodate a string frame strut. I've allowed 32.0 mm for this break and this is more than adequate.

I've allowed a bit more for the bass-to-tenor break—39.2 mm—in part because of the split bridge. This gives me a little more room to deal with the ends of the bridges.

I've even inserted an extra 10.0 mm gap for an action rail stiffener if such is desired.

Even though the centerlines of the string groups are parallel—they do not spread as is common with CS designs—this note-to-note spacing still provides adequate spacing on the bridge so I can use a fairly standard bridge pin field and yet the bridge pins will not be running into each other. One of the difficulties encountered in some of the early FS grands is their string group centerlines converged—presumably to get the bass bridge away from the rim—and this crowded bridge pin fields. Chickering, for example, laid out some of his FS designs with the string group centerlines converging. This placed the bridge pins very close together. So close, in fact, that bridge cap failure—at least in those I've encountered—was common. Not so with this design.

Nor will the strings of the adjacent notes be rattling against each other. At least not in a piano of this length. This would not likely be a problem even with converging strings on a piano of this length but why push our luck?

With this spacing the overall width of the scalestick—the distance from the centerline of A1 to the centerline of C88 is just 1170 mm. This compares with the 1220 – 1260 mm found on typical modern CS designs. This is important for several reasons and I'll come back to this point next month.

At some point we have to consider just how we're going to lay out the string architecture. In this case I wanted to retain a fairly conventional grand piano shape. I wanted it to be smaller—

both aesthetically and physically—but I still wanted it to have the look and feel of a "normal" piano. At least from the outside.

Historically we know that there are a number of design challenges but most are relatively easy to solve. There are two fundamental design challenges, however, that have to be resolved if we are going to develop a musically satisfying FS grand.

The first of these has to do with the area around the lower end of the bass bridge. It is essential that we provide for enough system mobility around the end (i.e., A1) of the bass bridge to ensure good, clean bass tone of adequate power. This means keeping the end of the bridge a reasonable distance away from the inner rim. This has long been considered to be the most significant limitation of FS grands. But, take another look at Figure 1. The center of the A1 bridge pin field is approximately 120 mm from the inner rim. In the CS Generic 173 this distance is just 50 mm. But, one notices, the bass bridge in the Generic 173 is mounted on a cantilever. True, but the end of this cantilever is itself just 100 mm from the inner rim. The bass bridge in the FS 180 grand will actually have greater mobility than that of the Generic CS 173.

How is this achieved? Look at the straight (bass) side of the rim. It is angled out—flared—by -2.5°. As well, the entire string set is angled 1.5° in the opposite direction. Not enough in either case to cause problems, but enough to provide an adequate distance between the end of the bridge and the inner rim. If more distance is desired the bass bridge can be undercut somewhat. This has essentially the same effect as a cantilever but without the energy losses inherent in the cantilever design. See Figure 4.

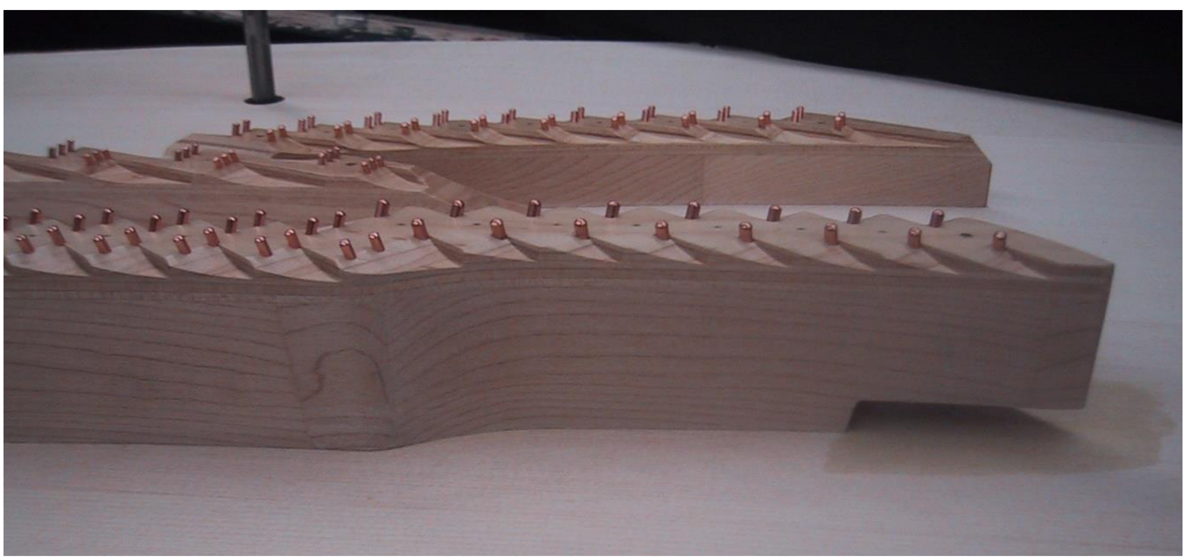

Figure 4. An "undercut" bass bridge.

Second, we have to keep the tenor bridge an adequate distance from the inner rim so its mobility is not restricted. This is not a problem through the middle section of the tenor bridge in a CS grand. It can be at the ends, however. Going back to the Generic 173 we see that the tenor/treble bridge is well off-center through much of its length. It starts off at C88 extremely close to the belly rail soundboard extension and ends up very close to the inner rim at B27.

In a FS grand we have to reach a compromise between being able to place the tenor bridge far enough out in the middle of the soundboard to give it adequate mobility and still give the piano a clean, aesthetically pleasing shape. (Yes, style counts.) In this design cartoon I've pulled the curved, treble, side of the rim in as far as is practical to reduce the aesthetic bulk of the piano. In spite of this the end of the tenor bridge is some 200 mm from the inner rim. Not much but still more than the 190 mm between the inner rim and the end of the tenor bridge of the Generic 173.

I've not yet drawn in a soundboard cutoff bar but this piano will need one. And it will need to cut off a significant portion of the soundboard area. So how can the poor little thing produce enough volume to satisfy the modern ear? The soundboard panel—preferably laminated—will need to be fairly thin and light. The ribbing would also have to fairly light. If I were building a prototype of this piano I'd give it very little crown and very light string bearing. I'd want to keep the soundboard system as light and as flexible as I could.

The danger with this, of course, is that if the soundboard assembly is too light and flexible the tone might be a little too percussive and the decay rate might be a little too abrupt. If this proved to be the case it would be a simple matter to stiffen it up some and/or add a little more mass. In either case I'd not worry about the piano not being "loud" enough to satisfy even the most jaded modern ear.

To complete the picture I'd want the piano to have an action with as little mass as is practical in today's piano manufacturing environment. None of the wippens available today are particularly light weight but I'd do want to do everything I could to reduce the rotational mass of the action. Most importantly, this would include the use of very light hammers. What we used to call "12 lb." hammers would be a good starting point.

In keeping with the overall character of the piano the action should be very light and quick. With its low mass hammers and lightweight action components it could handle an overall action ratio of around 6.0 : 1. Using standard regulating specifications the key travel would be reduced to around 9.5 mm. And it would do this without five or six leads in the keys. This, by the way, was the *de facto* standard back in the 1960s and 1970s when I was just beginning my career in piano technology.

So, is a modern FS piano practical? Yes, I believe it is. Aside from offering the consumer a refreshing alternative to the aesthetically bulky CS piano of today it also offers the potential of greatly reducing the weight of the grand piano. The modern grand in this size range varies from about 275 kgs to upwards of 300 kgs. The piano I've described here could be built to weigh much less than this. I'd target about 180 – 200 kgs. And it would at least stable as the much heavier CS grands. In fact, it would be even more stable if I could convince the manufacturer to use a modern laminated soundboard panel.

But there is one more reason why I think we should be pursuing the development of pianos like this. Early in this article I mentioned the desirability of reducing the scalestick measure as much as is practical. While this does have the benefit of allowing us to build pianos that are less bulky and more aesthetically pleasing it also enables us to fit keyboards of alternate sizes.

Throughout the history of the piano the width of the keyboard has remained more-or-less fixed at around 165 mm for the octave. This is fine if you are blessed with relatively large hands. It is a struggle, however, for many pianists who have smaller than average hands—and there seem to be many! Alternatively-sized keyboards are gradually becoming available but building them to fit conventional pianos can be challenging. The fundamental problem is the width of the scalestick. The distance between A1 and C88 is simply to great to make shorter keyboards practical. Hence they end up being very costly. Next month I'll explore this further.

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[1] A design cartoon is not a completed design. It is a sketch intended to demonstrate whether a design idea is practical or not. I only take design cartoons as far as necessary to prove—or disprove—a particular idea. In this case I've drawn only the speaking lengths of the 88 notes and wrapped a rim around them.

If I'm happy with how this looks then I continue to refine the design and start sketching in the string frame, the belly rail, belly braces, etc. A design cartoon is an organic thing. It evolves and transforms itself continuously through the design process.