2019 PTG CONVENTION & TECHNICAL INSTITUTE

Featured International Instructors

Piano Maker Paul McNulty

Paul McNulty is the most highly respected builder working today. His instruments, modeled after the best instruments of Classical and Romantic era's, are the result of meticulous research of the originals. He has built more than 250 fortepianos after Stein, Walter, Hofmann, Fritz, Graf, Pleyel, Boisselot and Streicher, which feature in many recordings and are owned by prominent players and leading music institutions such as Nikolaus Harnoncourt, Paul Badura-Skoda, Ronald Brautigam, Warsaw Chopin Institute, Klassik Stiftung Weimar and Glyndebourne Festival. Paul McNulty's recent accomplishment is a copy of "Chopin's Warsaw piano" Buchholtz 1826, the first in modern times.

Pianist Viviana Sofronitsky

Viviana Sofronitsky explores the rich, complete world of sound available to Classic and Romantic composers with their then-new pianos!

Viviana Sofronitsky has followed in the footsteps of her father, Vladimir Sofronitsky, a distinguished Russian pianist. Her current projects include recording Chopin and Liszt on Romantic fortepiano. Russian-Canadian citizen Viviana Sofronitsky is based in Prague, from which she travels Europe to perform with her fortepianos.

Comparison of Replicas from 1805 and 1812
Paul McNulty, Viviana Sofronitsky & Charles Metz, Czech Republic
This class explores the instrument and its use, with an emphasis on how piano development between 1805 and 1812 mirrors compositional style and texture over the same period. Our second class will demonstrate soup-to-nuts setup and regulation of the Viennese mechanism.

Favorite Pianos of Great Composers
Paul McNulty & Viviana Sofronitsky, Czech Republic
You will hear a description and concert-demonstration of two different fortepianos illustrating the music appropriate to each and performed by Viviana Sofronitsky. The effects these instruments can produce were familiar to the composers who wrote for them but have been absent from any piano made after 1850.

Maintenance for the Fortepiano
Paul McNulty, Czech Republic
We'll do a maintenance survey particular to the Viennese design. The class will also feature advice and demonstration on tuning, temperaments, voicing, strings, leather, felt, repairs, etc.

Grand Action Rebuilding - Making the Right Choices

Nick Gravange, RPT

Rick Baldassin, RPT

In this all-day class, Nick and Rick's three Stations of Application will guide the action rebuilder in making the right choices for a successful, no-surprises job. Beginning with Station 1, the "Drawing Board", measurements and geometry kick things off. In Station 2, "Mock-up", critical choices are tried out before committing wholesale. Station 3, "Workbench" focuses mainly on efficient key weigh-off (no guessing!).

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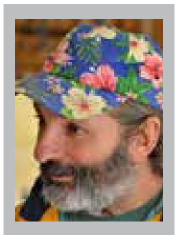
Action Spread...What's all the Hubbub?



By Jim Ialeggio, RPT
Boston MA Chapter

The following article is a companion piece to a class I will be teaching at the national convention in Tucson. Both the class and this article share the same title: "Action Spread...What's all the Hubbub?" The class will teach how one can "ask" a grand piano shank and wippen where they want their centers to be located within an action frame, using only a piece of poster board, a grade-school compass, a protractor and a ruler. The technique works for any chosen shank and wippen, of any manufacturer or combination of manufacturers, in any piano, vintage or modern. I call it the *Poster Board Trick*.

This article provides an in-depth look at the concepts behind the Poster Board Trick. By reading here before taking the class, one has a serious chance of internalizing the subject. It will simplify setting up your action rebuilds and allow you to plan for success with less uncertainty and fear.

Background

I took on Steinway action frame rebuilding a while ago as a sub-specialty. In taking these frames on, I knew rebuilding the arcane, soldered-brass action frames would be challenging, because shank and wippen center placements must be located in very particular locations, then held precisely in position while soldering the brass rails to the frame. Without an adequate fixture to hold and locate the rails, the task can be frustrating unto impossible. Consequently, my first task would be to create shop fixtures to precisely locate action centers within the action frame.

So, I set about creating shop fixtures. It was indeed challenging, requiring serious design time and R&D. In the end, though, it was well within my skill set. With the fixtures completed, I now had the capability to place action centers precisely within a Steinway action frame.

However, immediately upon finishing the fixtures and taking on my first action frame rebuild jobs, I was faced with a real puzzle. Looking at an ailing, disembodied action frame, I thought to myself, *OK, smarty-pants, you have the ability to place the action centers wherever you want them. So, where are you going to put them?*

I was stumped.

Even though I and several other technicians had been treated to an extensive course by Bruce Clark on action design, levers, ratios, etc., the interior of the action frame itself still remained somewhat of a mystery to me. I knew we had talked about "spread being somewhere close to 112 millimeters," but I didn't know why that number might be important. I also did not know how I could determine optimal center positions without having the entire action or all relevant action cavity dimensions at in my disposal. All I had was a disembodied, ailing action frame.

The old frames were not of any real help in answering this question, because the old failed rails placed parts at random locations, and the frames were often factory-assembled with bowed rails and inconsistent center locations. In addition, the frames might have been set up for obsolete parts, which might or might not have had the same flange offsets as modern parts. In short, the old frames did not offer the reliable information I needed. Wanting to provide a product that would help trusting techs achieve a successful rebuild, I started to slowly develop answers to the question posed in this article's title.

Interestingly, as the interior of the action frame became less of a black hole to me, my mastery of the entire action design thought process took a quantum leap. Getting the stack right eliminates a whole raft of variables and gives one a secure, proven, dimensionally consistent foundation on which build an action with confidence.

In reading the rest of this article, you might consider mentally prioritizing the pictures over the words. I personally find the pictures much easier to follow than the words.

The Big Picture

The big picture is: *Spread is about jack functionality*.

Spread ensures:

1. The jack center addresses the shank's knuckle core at an advantageous angle.

2. There is sufficient room in the repetition lever window for the jack to accomplish its full motion through aftertouch, without jamming against the repetition lever jack cushion.

3. The parts are set up so there is clearance between the moving parts and the hammer rail. We don't want the repetition lever crashing into the hammer rail.

Note! Spread changes will <u>not</u> correct overall action leverage problems. Spread's task is to assure adequate jack functionality. If you have leverage issues, look elsewhere to solve them. Look to the capstan, knuckle distance from the shank center, hammer weight and location of the key's balance point.

Our job in setting up the action frame is to ask the shank and wippen we have chosen where they want us to locate their centers. We need to ask the shank and wippen what center placements will allow the jack to function correctly. Interestingly, any shank and any wippen can be used in any action frame. Any shank and wippen can allow the jack to function correctly, as long as you know how to ask the parts to tell you where their centers need to be.

Said another way, there are internal levers built into the wippen you choose to use. These internal levers, i.e., the repetition lever and the jack lever, are levers we cannot change. These internal levers dictate where the action centers must be placed in order for the jack to function adequately.[1,2]

Oops

Oops. The title of this article is seriously incomplete... Sorry about that. The title should have read "Spread *and* Shank/Wippen Center Height Differential...What's All the Hubbub?" However, that title would have been too long-winded, and I needed a flashy "hook." So, let's correct that little incompleteness now.

Action spread as an isolated single entity does not contain enough information to be practically useful. We need more information. Here's why: Look at Figure 1. There are three shank and wippen center placements. I've eliminated the shank and the wippen body for clarity. Only the flanges and their respective centers are shown. The green circle is a 112-mm radius spread circle drawn around the shank center. Note that all three circles have the same exact spread (112 mm).

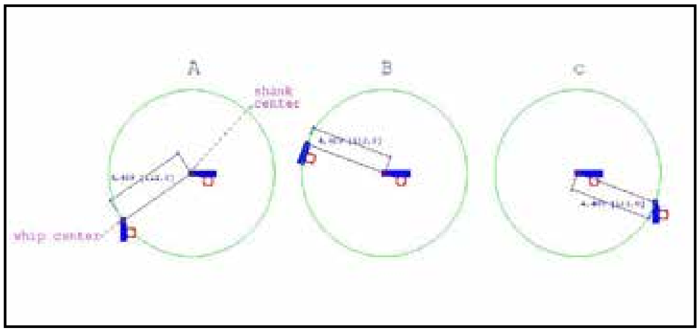


Figure 1: Spread describes a radius of a circle.

They all have the same spread, but only one of them shows a wippen center location that could even be remotely correct: circle A. On the other hand, proving the point by exaggeration, circles B and C show ridiculously impossible locations for the wippen center. The wippen center could not physically be located in positions B or C.

However, although B and C are impossibly wrong, they have the same identical 112-mm spread as A, the correct center placement. So, as an isolated entity, spread can locate the wippen center in an infinite number of positions on the green spread circle. Some locations could be correct, but the vast majority would be incorrect. As such, by itself, spread does not communicate actionable information. We need more data.

The additional data we need is provided by the differential. Differential is the difference in height between shank and wippen center, measured vertically off a table or other horizontal.

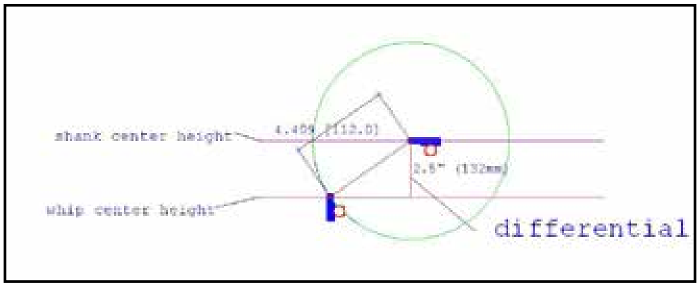


Figure 2: Always consider spread and differential together.

In Figure 2, the differential, 2.5" (132 mm), is the vertical leg of a right triangle. The spread line represents the hypotenuse of that same right triangle. So, by knowing both the spread and the differential, the geometry locates for us exactly where on that green spread circle the wippen center is to be located.

Spread and differential are partners. One needs to consider them both, together, as a pair.

Jack Function, Point #1: Advantageous Angle

Let's look at point #1 of jack functionality. The jack center must address the shank's knuckle core at an advantageous angle. Note that I am referring to the jack center, and not the jack tip contacting the knuckle.

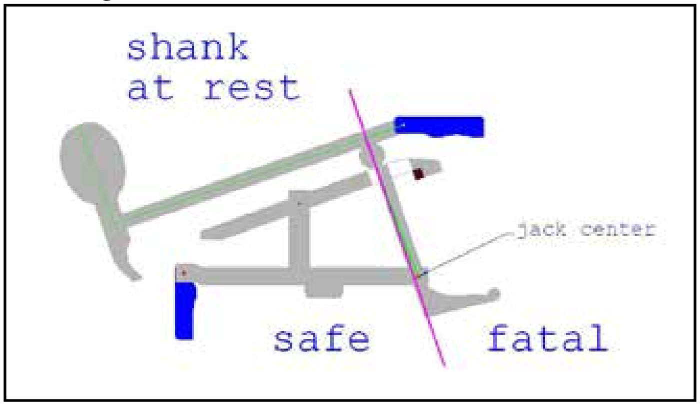


Figure 3: The all-important Purple Line.

Look at the purple line in Figure 3. The shank is at rest before the start of the stroke. That purple line is the most important thing to remember in this article. The purple line is a line drawn perpendicular to the shank, through the middle of the knuckle core. It projects down from the knuckle, past the jack center. I'll just refer to it as the "purple line from" now on. The purple line's relationship to the jack center is extremely important, so focus on this relationship... purple line to jack center.

[1]To be clear, it is actually possible to make small changes in leverage by moving the wippen center towards or away from the balance point. But moving just the wippen center would affect spread. Changing spread might jeopardize jack functionality. Since one's attention in setting up the action frame must be first and foremost to assure adequate jack functionality, moving the wippen center relative to the shank center to change leverage is putting the cart before the horse. It just adds unnecessary complications and variables to what should be a simple picture. It is also ineffective as a leverage adjusting mechanism. Other parameters other than spread offer much more effective ways to control leverage. Leave spread to do its primary task of assuring adequate jack functionality.

[2]Regarding the placement of the wippen heel: Though the heel is part of the wippen, it is not part of the wippen that controls jack functionality. So, though part of the wippen, I think of the heel as outside the internal, jack-related levers of the wippen. As such, the heels on universal wippens and Wessel, Nickel & Gross's modular wippens can be a useful variable to manipulate when adjusting leverage.

Look at how the purple line passes slightly to the left of the jack center. I've notated this left side of the jack center as the "safe" side. It does not pass through the jack center, but slightly to the left, safe side of the center (at rest). This offset from the jack center is essential and very purposely done. It is a safety margin.

Safety margin? What safety margin?

Parts designers want that purple line to avoid intersecting the jack center, staying slightly to the safe side (hammer side of the jack center at rest). Although the purple line would be in the most advantageous mechanical position if it did pass directly through the jack center, this offset's goal is a small compromise which seeks to avoid a serious, nasty, fatal badness that would make the action unplayable.

Notice the word "fatal" on the right side of Figure 3, more precisely on the right side of the jack center. If the purple line were allowed to project to the right side (player's side) of the jack center at rest, the first millisecond of the keystroke, the point where static friction is greatest, would have a static downweight (DW) 20-30 grams higher than it would during the rest of the stroke. So, the start of the stroke artificially elevates static DW by 20-30 grams for milliseconds. Then, after those first scant milliseconds, as the purple line passes through the jack center, the DW drops precipitously, instantly, by 20 – 30 grams.

In this scenario. the player would have been duped into applying way too much effort to start the keystroke. Then, as the purple line passed to the safe side of the center, the key would slip out from under the player's finger, as if feet had slipped uncontrollably on ice... no traction, no connection, too much resistance followed instantly by complete lack of control. Very bad! See Figure 4.

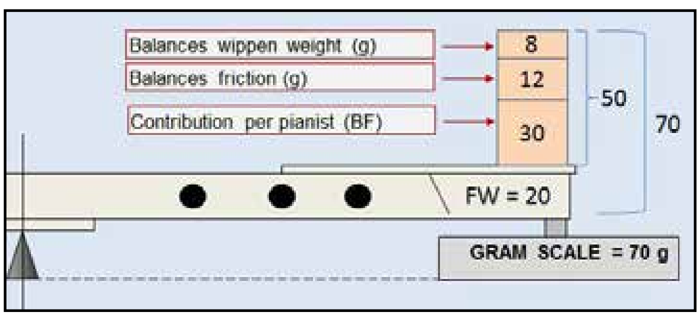


Figure 4:The Purple Line setup for failure!

I have achieved this badness in the shop, once by mistake and once on purpose, just to see what happened. It is as I described. It is a fatal mistake to be avoided and corrected.

Most current parts designers aim for two degrees or so offset from the jack center to the safe side. In some exceptional instances, like setting up Boston Chickerings with new parts, the flared actions require a wippen center location that pushes the purple line 15 degrees or more to the safe side of the jack center, at rest. Those redesigned actions do not suffer from this generous angle; they are some of my nicest playing actions.

The forced Chickering exception confirms that there is a wide margin of normal functionality when the purple line is on the safe side of the jack center at rest. Conversely, there is absolutely no margin at all on the fatal side. Running the purple line directly through the jack center is asking for trouble. Passing through the jack center, the purple line can migrate to the fatal side if the hammers sink a bit as the piano is allowed to stray from regulation specs. So, Figure 3 exhibits an essential safety margin.

Another reason to avoid running the purple line through the jack center is that most actions are not fabricated with absolute dimensional consistency. If the purple line is not allowed a safety margin, a sample note set up with the purple line perfectly intersecting the jack center at one end of the action could easily see the purple line in a very different position somewhere else on the keyboard.

The Dimensional Inaccuracy Challenge

Dimensional inaccuracies are practically unavoidable in piano actions, in either factory or rebuild work. As a practical reality, positioning anything in three dimensions is a difficult task. In addition, a rebuilder comes to an as-built piano as a forensic sleuth. The piano's string heights often wander from spec, the distance between strike line and the front of the piano can be unintentionally skewed, knocking the strike line off-kilter relative to the front of the keys, etc. Forensically reading an action cavity's as-built conditions is not only a difficult task, it is also easy to misread evidence. Then, further complicating things, an element like Steinway's arcane action frame can contain more hard-to-quantify but very present inaccuracies. Even with more modern action frames, it is still difficult to create consistency. This is not to impugn any manufacturer's or rebuilder's skills. Rather, controlling action center locations in three dimensions, in a three-dimensional action cavity, in a structure that contains few straight lines, is simply extremely difficult to pull off with absolute consistency. So, a safety margin in placement of the purple line is not only warranted, it is required.

The Purpose of Differential

So, what controls the angle of the purple line relative to the jack center?

That is the job of the differential. The differential controls the angle of the purple line relative to the jack center. In Figure 5, the left "fatal" diagram has a differential which places the purple line on the fatal side of the jack center.

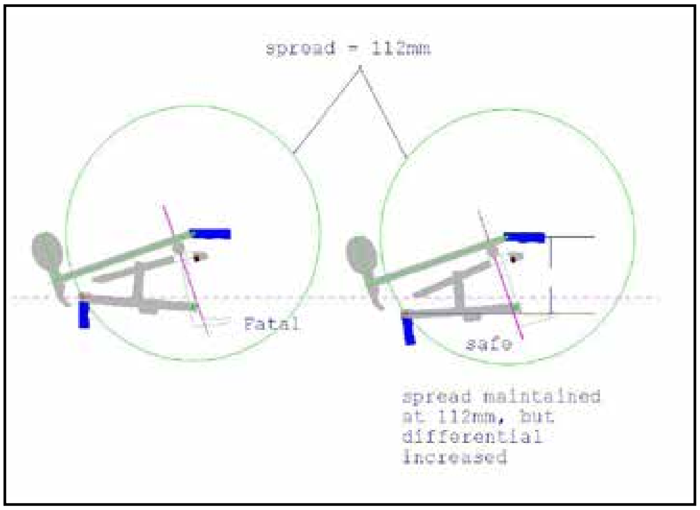


Figure 5: Fatal (left) and safe differential.

By swinging the wippen center down the green 112-mm spread circle's perimeter, the differential is increased. Spread is still maintained at 112 mm, because the wippen center is merely rotating around the perimeter of the green spread circle. However, increasing the differential rotates the entire wippen such that the purple line is now on the safe side of the jack center.

In order to change differential, one elevates or lowers either the front or back feet of the action brackets, in effect rotating the action frame. Rotating the frame increases or decreases differential, leaving spread constant.

Some manufacturers build the full differential into their action frames, and some do not. Wessel, Nickel & Gross builds full 2.5" differential into their action frames. Their frames usually do not need to be rotated, so a simple flat shim can be used in elevating them. Steinway does not build the full differential into their action frames. They depend on angled cleats mounted to the keyframe to rotate the action frame. This rotation fine-tunes the differential. (Note: The shims [cleats], angled or flat, also "elevate" the shank centers to accommodate as-built string height requirements. That is a second important function of elevating the action frame, but it must be left for a different article.)

One might ask, "Why do I need to worry about setting the differential correctly if my action parts manufacturer designed the full differential into their action frame?"

Even if a full-differential action frame like WN&G's is used (depending on as-built leverage), significantly increasing hammer blow in order to satisfy regulation requirements may swing the purple line to the fatal side of the jack center. Also, the purple line may swing to the fatal side if hammer bore or shank center height are not appropriate to match the as-built action cavity and string height of that particular piano. Figure 6 shows how this can happen.

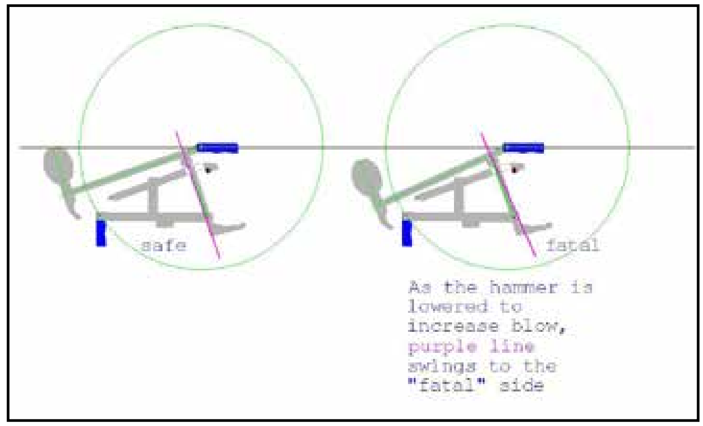


Figure 6: Changes in blow distance change the Purple Line angle.

Both scenarios in Figure 6 have the same shank/wippen center locations. Only the hammer blow has increased, to satisfy regulation requirements. Increasing hammer blow has the potential to swing the purple line to the fatal zone if the safety margin is not set correctly. Increasing blow will not always create this condition, but vigilance is prudent.

Jack Function #2: Determining Spread

Where does the actual spread number come from? The correct spread number for your action will allow the following parameters to be met:

1. There must be room in the repetition lever window for the jack to progress through aftertouch without jamming on the repetition lever's jack cushion.

2. The knuckle core must be placed so the purple line can pass to the safe side of the jack center.

3. There must be clearance between the moving parts so that parts do not collide. Care must be taken to make sure the drop screw contact end of the repetition lever does not collide with either the hammer rail or the hammer flange.

Item 1 is easy. The manufacturer has given us a hash mark to indicate where the jack would have ample room to progress through aftertouch without jamming on the rest cushion, given current normal ranges of leverage. Stay reasonably close to that hash mark when setting the jack position, and it will be safe. If the jack is set more than 1 mm from the hash mark toward the jack stop cushion, you may run into a problem depending on overall action leverage. So, stay close to the knife mark.

Item 2 restates what we discussed earlier. At rest, the purple line must pass to the safe side of the jack center.

Notice that #1 above refers to the jack tip, and #2 refers to the jack center.

Item 3 is self-explanatory, but I will illustrate.

Suppose I'm feeling ornery and don't want to set my spread close to 112 mm. Could a 115.2-mm spread work? Let's take a previous example's setup that worked fine at 112 mm, and see what happens at 115.2 mm. See Figure 7.

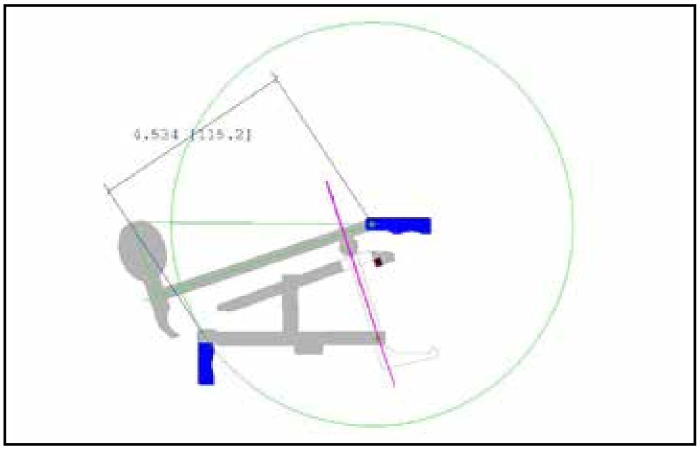


Figure 7: 115.2-mm spread?

In Figure 7, increasing the spread to 115.2 mm, the shank center and knuckle do not move, so the purple line does not move. However, the wippen center and thus the jack center move laterally to the left, away from the shank center. So, the purple line stays put, and the jack center moves laterally left. The result is that the purple line is now on the fatal side of the jack center.

We could increase differential to fix that. However, there is another problem. We moved the wippen center, wippen body and jack toward the left, away from the shank center, but the knuckle remained where it was originally. In order for the jack tip to be properly aligned with the knuckle core, the jack tip now has to be advanced 3 mm. It needs to be adjusted away from the knife hash mark, to the diagram right, towards repetition lever's jack cushion felt. We have just stolen 3 mm of travel from the jack before it hits the jack cushion felt. This 3-mm move greatly reduces room for the repetition lever to move, increasing the probability that the jack will jam on the cushion.

So, increasing the spread has challenged two parameters of jack functionality. It probably could be made to work with Herculean modifications, but why bother? Now maybe if we went with a knuckle distance of 20 mm, we could fix those problems, but then key dip would probably end up around 5/8". The wippen clearly is asking for a spread other than 115.2 mm. I'll give this example a no-go.

How about reducing spread to 110 mm? Would that work? Well, almost, but not quite. See Figure 8.

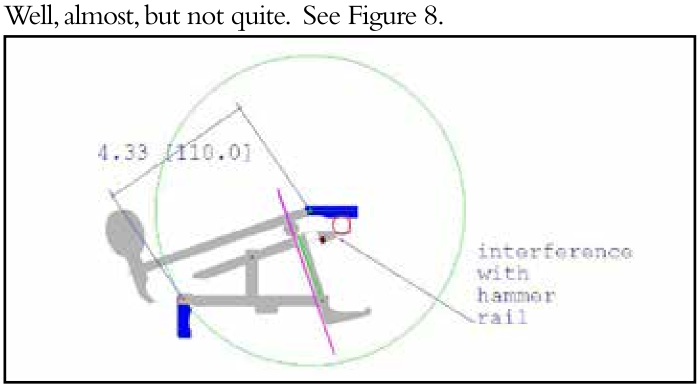


Figure 8: 110-mm Spread? Almost.

In reducing spread, as in the previous example, the shank center and knuckle do not move, so the purple line stays put. The 112-mm spread is decreased by moving the wippen center and jack center laterally to the right. This moves the jack center well to the safe side of the purple line, so that's acceptable. Since the wippen moves to the right and the jack moves to the right with it, the jack tip must be adjusted to the left towards the knuckle. This allows more room for the jack to swing before encountering the jack rest cushion. There may be some argument that the jack tip is now too far from the jack rest cushion at the end of the stroke, but at least this scenario looks basically functional. So that's acceptable too. So, what doesn't work?

There is a "gotcha" that kills this scenario. Look at Figure 8. At 110 mm, the end of the repetition lever is now so close to the hammer rail that repetition lever and hammer rail collide. I'll have to give this example a no-go, too.

Not shown in Figure 8 is another possible collision. At spread reduced by only 1 mm (to 111 mm), the repetition lever could collide with the bottom of the shank flange at the relief cut for the drop screw. At best, this would make it impossible to adjust drop and at worst, make it impossible to finish the stroke. Additionally, even if there were adequate clearances, the drop screw might run off the repetition lever buckskin and into the jack window.

So, reducing spread too much creates interference problems.

Different manufacturers' hammer rails and shank flanges have different shapes. These shapes will determine how much available clearance there is between repetition lever and hammer rail or repetition lever and shank flange bottom. If the parts are asking for a spread slightly less than 112 mm, one needs to model the action parts to make sure there will be adequate clearance. WN&G part and rails will have very minimal clearance to reduce spread much less than 112 mm. Steinway's rails have a smaller profile, so there is a little more room for reduced spread if the parts call for that, but not much. I can't speak to Renner's frames, as my experience is with WN&G and Steinway. So, if the parts are asking for a spread reduced much from 112 mm, one must model all the parts and rails of the action to prove adequate clearance.

For modern parts, action spread will work out to somewhere between 111.5 mm and 113 mm. However, please note that this stated range does not suggest that one can just pick a number randomly in that range. There is a technique to determine the appropriate spread for the parts you have in hand. I call the technique the Poster Board Trick.

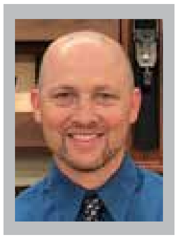
The Poster Board Trick

The Poster Board Trick is the technique I use to visually model action center locations within the action frame. The Poster Board Trick makes it easy to determine spread, differential and action frame elevation appropriate to the parts you have and the specific piano the parts are going into.

It is a visual technique, for visual learners. It allows one to draw out the actual as-built dimensions of an action cavity, complete with unique out-of-spec conditions many pianos exhibit, and then actually place the chosen shank and wippen on the poster board, located correctly, for that unique piano. It allows one to prove, in real time, that the actual parts in hand will be placed in locations that meet all the parameters I have just discussed. In addition, if the parts laid out on the poster board do not conform the required parameters in the initial attempt, it is easy to redraw and relocate the shank and wippen so that they will be placed in successful locations.

The Poster Board Trick is more easily demonstrated than described, as it is a visual and hands-on experience. I look forward to helping you master this aspect of action design in Tucson. ▢

***Jim Ialeggio's** lifelong exploration of the intersection of engineering and aesthetics brings him to piano design, restoration and tone building. With his son Dave, he creates highly worked, redesigned, restored pianos in his Shirley, MA shop. Jim has a particular interest in refined designs of highly musical, venue-appropriate, home-sized grands. Earlier in his career he reproduced sash and millwork for historic buildings. He is also a composer, pianist, and early-music tenor.*



Core Competencies in Piano Repair

Replacing Flange Bushings in Action Parts

By William R. Monroe, RPT
Journal Contributing Editor

Action center bushings require maintenance to keep them functioning well. Periodically, a bushing can become so loose, worn or contaminated that it requires replacement. Tools and supplies needed to replace bushings in action parts are shown in Photo 1.

Before beginning the replacement process, determine whether the action parts can be used as they are or if remedial steps are needed to prepare the parts for bushing replacement. The parts must be structurally sound, exhibiting no cracks or damage to the delicate pivot area. Occasionally a birdseye has become enlarged enough to justify resizing or replacement (Photo 2). Resizing a birdseye hole can be done, but it is tedious work with little room for error. It is most often more cost effective, more long-lasting and more precise to replace the part rather than attempt to repair it.

1. Remove the center pin connecting the flange to its corresponding action part with a pinning tool (Photo 3) or center pin punch.

2. Examine the birdseye of the part for problems and find an appropriate-size replacement pin. This is done by inserting pins into the birdseye by hand, starting too small, until one fits tightly enough that it cannot be pushed through by hand. A proper-size pin will be the smallest pin that fits tightly in the birdseye. Do not to force a too-large pin into the birdseye with a pinning tool; doing so risks breaking parts.

3. On the flange, remove the old bushing with the pinning tool or the center pin punch by pressing into the bushing cloth around the perimeter of the bushing.

4. Drill out any glue or cloth residue in the flange by hand with a #37 drill bit held in a pin vise (Photo 4). Be cautious not to remove wood and avoid drilling at an angle or otherwise deforming the hole.

5. Select a high-quality bushing cloth. Bushing cloth is available in precut strips as well as in bulk. Both will produce a good result with proper attention to detail. If you choose to use precut strips, have some bulk cloth available as well. The precut strips will not always deliver a proper fit, and it may be necessary to make a custom width of felt. Do so by tearing the cloth along the bias of the fabric. Once a bulk sheet of bushing cloth has been torn, the bias will be obvious, and usually it will not be in line with the factory-cut edges of the large sheet of cloth (Photo 5). Only after the first tear is made can the cloth be marked and torn off in strips of consistent widths. It is easiest to tear a few strips of slightly different widths to ease the process of finding exactly the right width of cloth for the flange.

6. Cut one end of the bushing cloth into a long, thin taper to ease insertion into the flange (Photo 6).

7. Feed the cloth into the flange, pulling it through both sides to flush (Photo 7).

Photo 1: Tools of the Trade (from top left): flange bushing cloth, sized reamers/burnishers, tapered reamers, pin vise with #37 drill bit, razor knife, side-cutting center pin nippers, wood glue, center-pinning tool, bushing cloth sizing tool, center pin case and pin assortment.

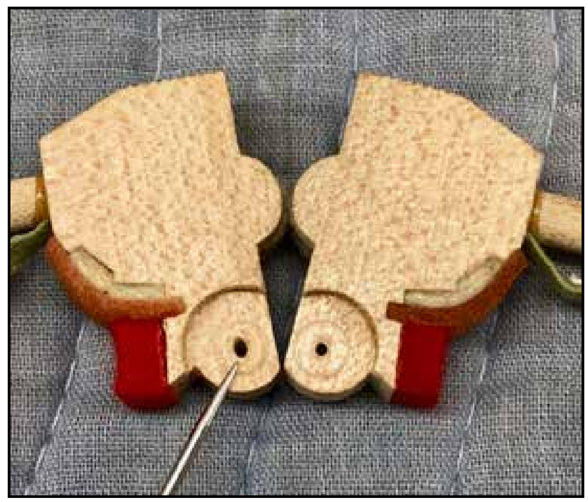


Photo 2: An obviously misshapen birdseye.

Photo 3: Removing the center pin with a pinning tool.

8. Check the fit of the cloth in the flange. Make sure that the strip of cloth is wide enough that the two edges of the cloth come together comfortably, but not so strongly as to create buckling or bunching of the cloth.

9. If you are unsure of the fit of the cloth in the action part, it is helpful to pull the cloth almost all the way through the part and then cut the trailing end flush with a razor blade or knife, exposing the end of the cloth as it sits in the hole. This provides a clean look at the fit of the cloth in the action part. Once satisfied, pull the cloth through completely, re-insert and pull through to within 3/16" of the trailing end (Photo 8).

10. Check the fit of the cloth in the flange with the new center pin. Insert the pin into a pin vise and push the pin into the bushing cloth. It should feel firm but not overly tight (Photo 9).

If the pin fits too tightly, double check that the width of cloth is not too great and therefore responsible for causing this binding. If the cloth strips are too wide, reduce the width of the cloth and re-install. If the width is proper but the fit of the pin is still too tight, it may be that the holes in the flange were not cleaned well enough during the removal process. Clean the flange holes of any remaining residue and then check the fit of the cloth again. If more material was removed, the strip of cloth may need to be wider now, to accommodate the larger diameter hole.

If the cloth is fitted to the flange properly but the pin still fits too tightly, a thinner cloth can be used. Select a thinner cloth and repeat the fitting procedure. It is also possible to thin the existing cloth by using a specialized flange bushing cloth calibration tool (Photo 10). The cloth is drawn through a metal plate with different diameter holes in it, removing material from the outer side of the cloth. The more times the cloth is drawn through, or the smaller-diameter hole that is chosen, the more material will be removed, thinning the bushing cloth. Repeat the fitting procedure with the thinned cloth until the fit is correct.

11. Now that the cloth is the right width and the correct thickness, pull the bushing cloth into the flange, again leaving 3/16" exposed on the trailing end.

12 Apply a small amount of hot hide glue or wood glue to the outer surface of the bushing cloth where it is about to be pulled into the flange (Photo 11).

13. Pull the cloth into the flange, leaving a small amount exposed at the tail. This will help avoid pushing the cloth out in step 14 (Photo 12).

14. Insert a center pin of the appropriate size into the newly bushed part to serve as a clamp while the glue dries (Photo 13).

15. Once the glue has dried, remove the center pin.

16 Cut the bushing cloth flush with the forks of the part using a sharp razor (Photo 14), paying particular attention to the inside of the forks. Any excess material on the inside of the forks can cause binding of parts once they are reassembled.

Photo 4: Using a #37 drill bit in a pin vise to clean the hole in the flange, preparing it to receive new bushing cloth.

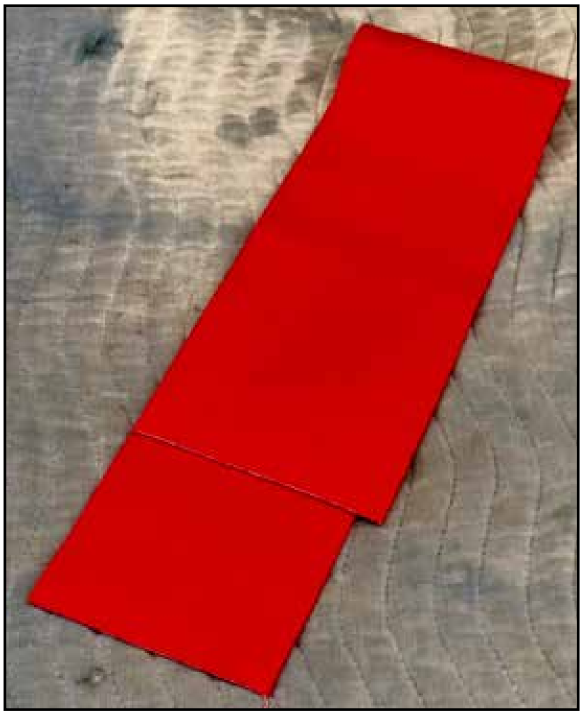


Photo 5: The left side of this sheet is a factory-cut edge, the right side is torn. Note how the sheet tapers now because of the torn edge, which follows the bias of the cloth

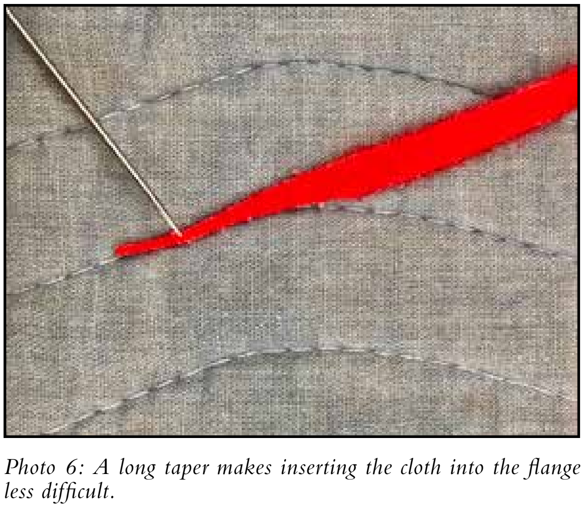


Photo 6: A long taper makes inserting the cloth into the flange less difficult.

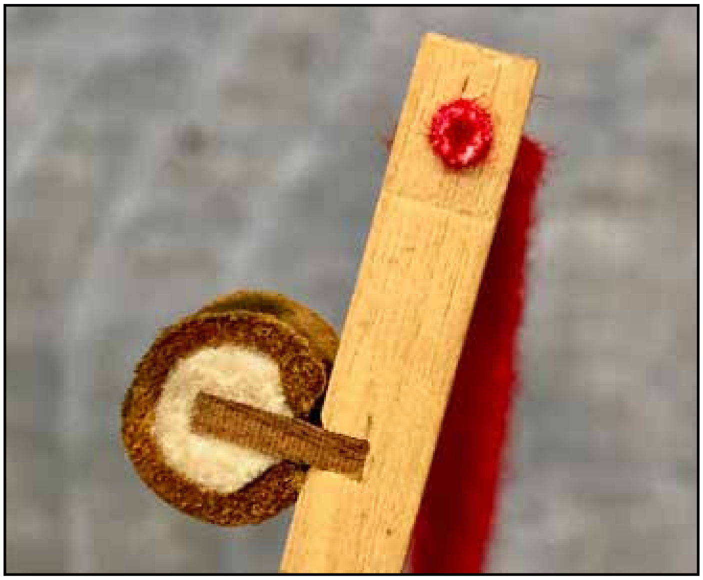


Photo 7: Bushing cloth pulled flush on one side. This facilitates assessing the width of the cloth.

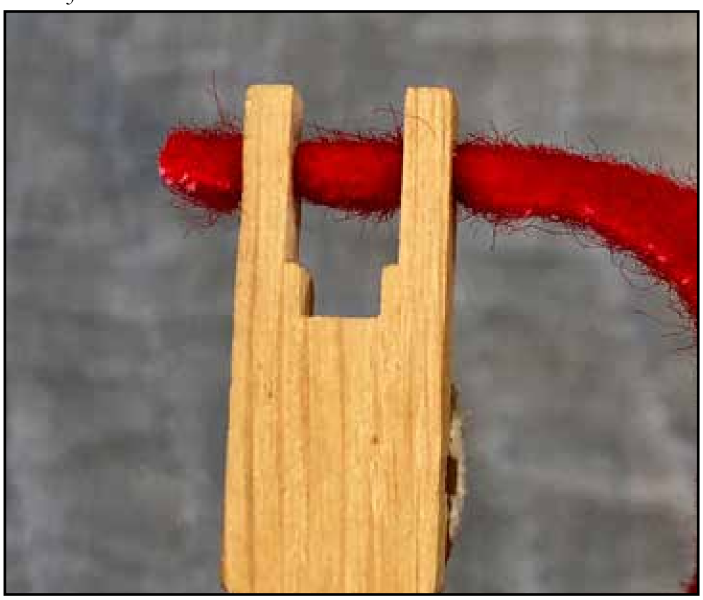


Photo 8: Bushing cloth inserted into the action part, 3/16" short of flush.

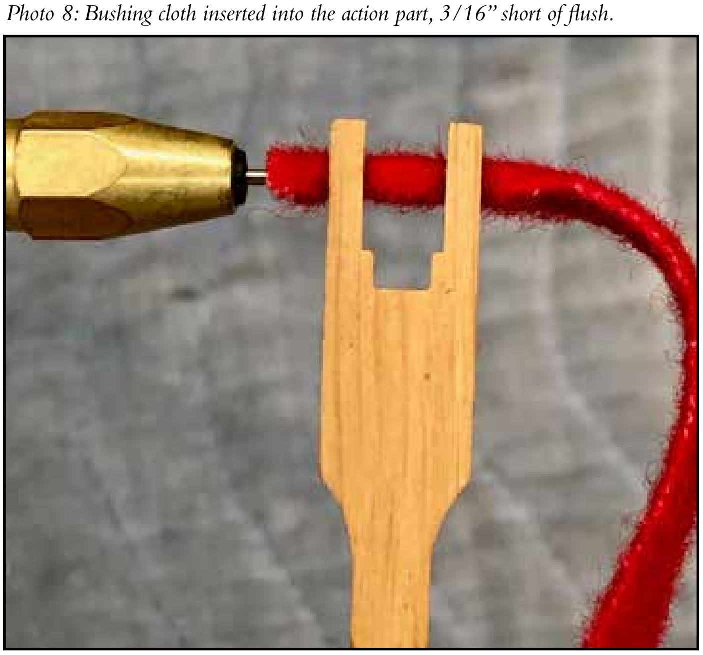


Photo 9: Assess the fit of the cloth to its center pin.

Photo 10: Bushing cloth sizing tool.

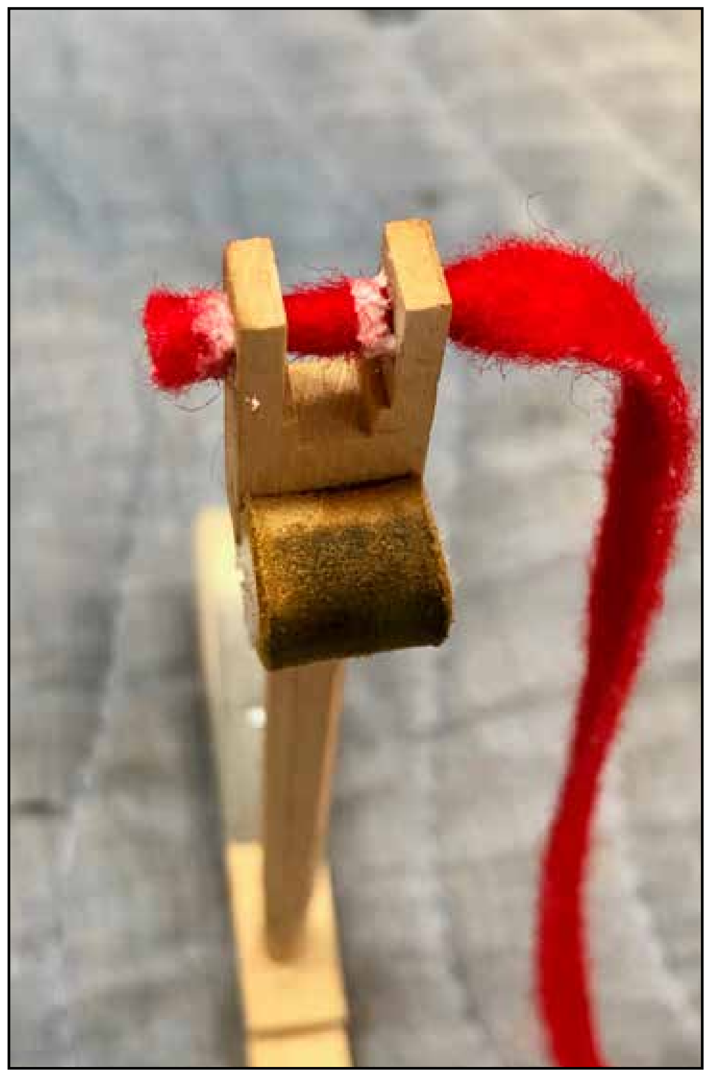


Photo 11: Apply glue to the bushing cloth.

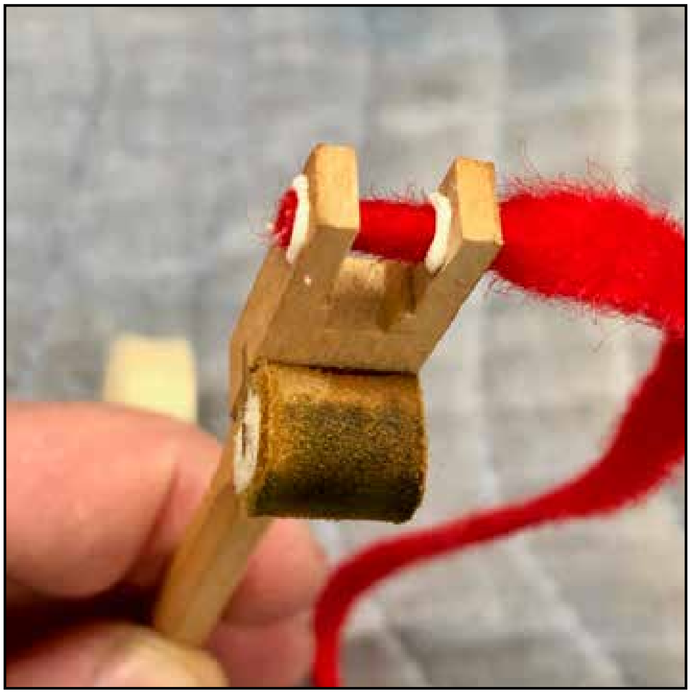


Photo 12: *Draw the bushing cloth into the action part.*

Photo 13: *Bushing installed with a center pin to act as a clamp.*

Photo 14: *After trimming the bushing cloth, the flange is ready for pinning.*

In next month's article, the focus will turn toward achieving a proper fit of the flange to the pin and pinning the parts together.

What skills do you think should be covered in this series? Send your suggestions to billmonroe@ptg.org.

The Maximum Allowable Strike Weight
Installment 6 of a Series

By Nick Gravagne, RPT
Phoenix AZ Chapter

The pursuit of effective action design requires awareness of the prospective hammer weights offered by suppliers. It also requires a readout of theoretical hammer weights that will work for a given or modified action geometry. This fact pushes the limits of our surveys. Modern hammers may be too heavy to install on some old, outdated action setups, particularly on vintage Steinways that came equipped with lightweight hammers along with high action ratios. The goal of this article is to advise the technician as to when strike weights and hammer heads are too heavy for or are pushing the limits of a given and calculated mass action ratio.

To maintain consistency and free the text from excessive wordiness and parenthesizing, the following terms are abbreviated. As you read the article, you may need to refer back to these. If you are unfamiliar with any terms, the text explains them at appropriate places.

SW – Strike weight: The "weight" or "mass" that strikes the piano string and thus includes a portion of the hammer shank itself.

SW_{max} – Maximum SW: Maximum (or natural) SW related to a mass action ratio that will balance front key leads and the pianist's touch.

SW_{lev} – *SW* as leveraged through the action ratio and experienced by the pianist as resistance to touch (SW x MAR).

WW – Wippen Weight: Weight of the wippen as it sits upon the capstan.

EWW – Effective Wippen Weight (a subclass of WW): Key ratio x WW experienced by the pianist as resistance to touch.

F – Friction (Will be abbreviated or spelled out depending on context.)

FW – Front weight: The effective mass of key leads as weighed at the front end of the key.

DW – Downweight: Weight or force applied at front of key required to overcome SW, action leverage, EWW and friction. Also referred to herein as *gross DW.*

BW – Balance weight: a.k.a. DW minus friction.

BF – Balance force: Slightly different from BW, unique to this article and refers to the pianist's touch (or our test weight).

MAR – Mass action ratio (fully covered in previous articles): The MAR relates to perpendicular force vectors as these convey from key to hammer head.

The Strike Weight (SW)

The term *strike weight* references David Stanwood's extensive published work as well as widely disseminated feedback from piano technicians. SW is essentially the "weight" or "mass" that strikes the piano string, and thus includes a portion of the hammer shank itself. SW can be easily weighed on a gram scale as per Figure 1. SW is a resisting force.

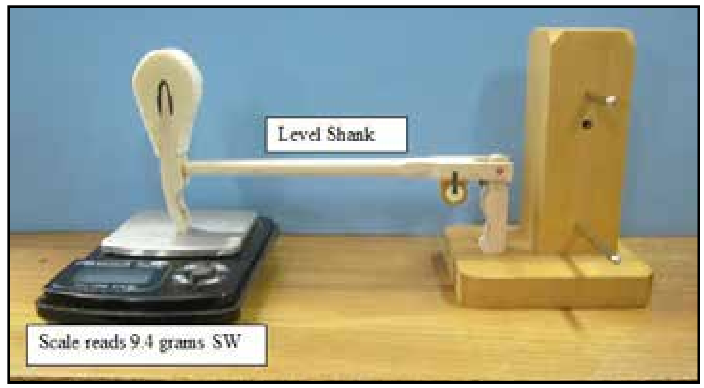


Figure 1: Setup for measuring SW. The shank should be level to the bench surface and the flange needs to be set vertical. The shank portion of the SW is ~1.5 grams. Find this inexpensive and low-profile gage online. Be sure that your gage can read to 10ths of a gram.

Wippen Weight (WW)

Figure 2 demonstrates the procedure for obtaining the weight of the wippen as it sits upon the capstan. Typically, the digital scale reading is ~17 grams. The *effective wippen weight*, that proportion of the WW felt at the playing end of the key, computes as follows:

EWW = Key Ratio x WW, (0.50 x 17 = 8.5 grams). This is a resisting force. Clearly, as the key ratio is not the same on all actions, the effective wippen weight will vary, but not by a significant amount.

Figure 2: Wippen radius weight (WW), typically 15 to 18 grams, while 17 grams is common for new wippens.

Friction (F)

The key-hammer system produces friction, which calculates as: (DW – UW) / 2, (50 – 26) / 2 = 12 grams of friction. Friction is a resisting force. DW refers to the force required to balance the key-hammer system by overcoming all resisting forces including friction, the EFF and SW_{lev} *Upweight* refers to the heaviest test weight that the key can lift as the hammer returns very slowly to rest. Gross DW is a compliance force.

Front Weight (FW)

The term *front weight* also references Stanwood's work, and for the sake of simplicity, the FW of a key is synonymous with the effective mass of the key leads as weighed at the front end of the key[i] (Figure 3). Heavier hammers require more key leads to balance the key system, and lighter hammers fewer leads. FW is a compliance force.

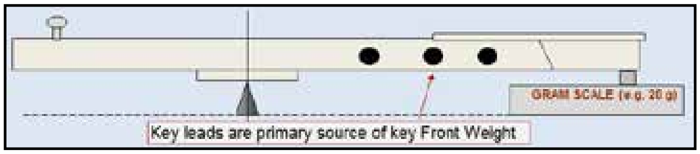


Figure 3: FW consists primarily of key leads.

Pertinent to FW's, David Stanwood writes in the Journal, March 2000:

The question "is there too much lead in the keys?" may be partly answered by measuring Front Weight because its value is determined mainly by the number and displacement of key leads in the key. Table VI gives a proposed set of values for maximum recommended Front Weight. If Front Weight is above these values it may be considered excessive. At this stage this may serve as a frame of reference called "Front Weight Ceiling."

Having a table of maximum FWs supplies us with useful information. Stanwood published a table of suggested FW ceiling maximums in the aforementioned Journal article, and you can find it online.[ii] I have worked out a set of FW maximums, and my numbers compare very closely to David's (see Table 4 below). Tables aside, and as will be covered in a future article, every set of hammers yields its own readout of unique FW's.

A Case in Point

Beginning here and continuing in upcoming articles, we start fusing the practical and theoretical.

A summarized case in point runs like this: A circa 1915 Steinway B action, fitted out with a 15.5-mm knuckle location along with a 0.52 key ratio (262 mm front and 136 mm rear), suggests the presence of lightweight hammers. The MAR is relatively high at 6.3, and as explained in past articles, a high MAR action requires light hammers. This action sits in my shop as I write this, and does indeed come equipped with suitably light original Steinway hammers — an almost unheard-of 5.5-gram hammer (7.0 gram SW) along with only two key leads at note E44.

For a Steinway B, a typical modern, prepped hammer[iii] from reputable suppliers weighs ~7.5 grams for note E44, a full two grams heavier than the original. Given the high MAR, a two-gram addition to the hammer weight would require two additional 13-gram leads in the key to maintain a 50-gram DW, amounting to a grand total of four large leads at this note. Although this arrangement could actually work, it is inadvisable. The reworked key FW (now at ~28 grams), along with the resultant increased inertia, push the limits of tolerability (Table 1). Some pianists, those with a strong touch, could absorb this; others would likely have issues, claiming the action was too hard to play (meaning *inertially* hard) and tiring.

SW	FW	Leads	Inertia
7.0	14.1	2	Low
9.0	28.0	4	High

Table 1: SW's, FW's, leads and inertia compared at note E44.

What does all this mean? Where do we go from here? Leaving inertia aside for the moment, previous articles in this series have touched on SW and FW. The interplay of these factors warrants deeper examination, since SW always balances the combination of FW and gross DW. This balancing act may not be a happy one for the pianist, but it always exists. What, then, may we consider the high-end limits of SW's?

A Most-Simple Strike Weight Calculation

Referring to previous articles in this series, there exists a further and revealing use of the 5.74 MAR as was calculated in those pages. Recall that the *MAR as a ratio is completely unrelated to the weights of anything* — not the key and its leads, not the wippen as it sits on the capstan and not the weight of the hammer head. The MAR is unrelated to friction as well. Thus, the MAR stands alone and is reliable as to the use we will put it to as follows.

Some New Terms

(Note to reader: the following section, included here as logical support, need not be fully grasped in order to benefit from this article. Find the condensed form at Equations 3 and 4 below, as well as in the "Steps to finding the SW_{max} for any or all hammers" appearing near the end of this article.)

Let's consider a couple of terms:

1. Activating Force (AF) – The force exerted by the pianist's touch (or test weights) that, in combination with the FW of any key, will balance the SW. Thus, the AF includes two forces, but as yet not parsed out. Friction is not involved and no wippen exists.

2. *SW_{max}* – The maximum, or natural, SW related to a given AF and MAR. We do not choose the SWmax as a target, it is a computed result based on AF and the MAR. So AF *is* a target, but the MAR has already been worked out and relates to all scale notes.

$SW_{max} = AF / MAR$ (*Equation 1*)

So, where the AF = 50 grams and the computed MAR = 5.74 we have

$SW_{max} = AF / MAR = 50 / 5.74 = 8.7$ grams

Note that SW_{max} is an ideal equation in that the MAR of 5.74 knows nothing of friction or wippen weight. Therefore, we imagine a completely frictionless system, along with the complete absence of a wippen, and that this ideal system employs a 50-gram force to activate and balance a SW of 8.7 grams. Inertia is implied, but casts only a shadow at this stage.

Now, let us work with note 62. Most of the FW in a key is due to lead weights, and, referencing Table 4, it so happens that the FW ceiling of 20 grams occurs at note 62. Assuming a 50-gram DW target at note 62, we can easily calculate the maximum strike weight (SW_{max}) for that note. We begin by rearranging Stanwood's equation for calculating a SW, and plugging in targets for DW and FW along with average constants for friction and EFF.

DW_{tar} = 50 g DW target
FW_{max} = 20 g (Taken from Table 4, max ceiling for note 62)
F_{const} = 12 g (Friction constant)
EFF_{const} = 8 g (Constant)
WW = 16 g (As weighed per Figure 2)
BW rearranged as (DW – F)[iv]
KR = 0.50
AR = 5.74 (Same as MAR)
SW = Strike weight to solve for

SW = [(BW + FW) - (WW x KR)] / AR
(Stanwood Equation 2)[v]
SW = [(DW - F + FW) - (WW x KR)] / AR
(Rearranged equation)
SW = (50 – 12 + 20 – 8) / AR
SW_{note62} = 50 / 5.74 = 8.74 grams

So, we have the same answer as in equation 1 above, but herein identifying discrete DW and FW variables along with the elimination of gram values for friction and EFF (red letters). Lastly, and for the sake of simplicity, we use constant values for friction and EFF. The average values for these constants, 12 g and 8 g respectively, are useful and defensible.

Parsing the 50-Grams DW into Two Parts

Simplifying the equation, we may combine the constant negatives for friction (-12 g) and EWW (-8 g), which will always = -20 g.

So, where:

DW_{tar} = 50 g (DW target as chosen by tech as a constant)
FW = 20 g (per FW Table 4 for note 62)
n = -20 (combined friction and EWW as a constant)

SW_{max} = (DW + FW + n) / MAR (Equation 3)
SW_{max} = (50 + 20 – 20) / MAR
SW_{max} = 50 / MAR
SW_{max} = 8.7 grams

We may further simplify by combining the constants of DW = 50 g and n = -20 g into a net constant of 30 grams, which we may refer to as BF.

SW_{max} = (BF + FW) / MAR
SW_{max} = (30 + 20) / MAR
SW_{max} = 50 / MAR
SW_{max} = 8.74 grams

Figure 4 demonstrates the contributions to gross DW of 50 grams. Net key rotation includes FW contribution of 20 grams, yielding 70 grams total compliance. Balancing this compliance, we delineate 70 grams resistance as such:

SW_{lev} = SW x MAR = 8.74 x 5.74 = ~50 g
F = 12 g
EWW = 8 g

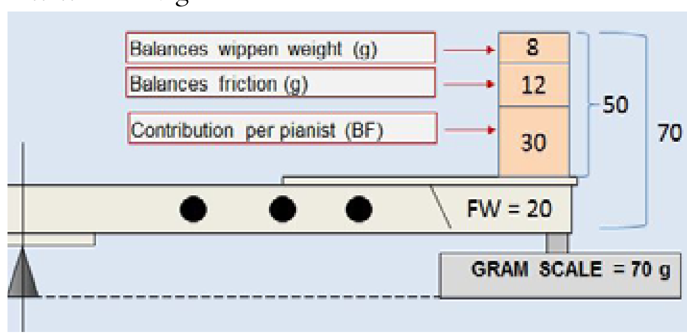


Figure 4: 50-gram gross DW stacks up as 8 grams wippen weight, 12 grams friction, 30 grams BF from pianist. Total key compliance of 70 grams stacks up as 50 grams DW plus 20 grams FW.

So long as the chosen DW = 50 grams, we may use this BF value of 30 grams as a constant in all following SW iteration workups for each note in the scale[vi]. Also, note that the grams stack-up in Figure 4 remains the same on all keys. Such itemization isolates and connects in a direct way the balancing act of SW_{lev} to the BF and FW combo.

Thus, here is our SWmax equation for any note in the scale:

SW_{max} = (FWmax + BF) / MAR (Equation 4)

Let's consider another FW ceiling maximum for note A49. The suggested FW max is 26.1 grams. Remember, the BF factor is always 30 grams.

Plugging this into equation 4, we have:

SW_{max} = (FW_{max} + BF) / MAR
SW_{max} = (26.1 + 30) / 5.74
SW_{max} = 56.1 / 5.74 = ~9.8 grams

And subtracting the estimated 1.5-gram shank portion, we have a maximum hammer-head weight for A49 of 8.3 grams.

Simple and useful, and this can be done for all notes in the scale. Table 2 shows the SW_{max} and its related hammer max for several notes as calculated per Equation 4. A step-by-step procedure appears at the end of this article.

Note	SW_{max}	Ham_{max}	Ham_{typ} S&S B
A1	12.6	11.1	9.6
E20	11.7	10.2	8.9
F21	11.6	10.1	8.8
B27	11.3	9.8	8.6
C40	10.5	9.0	8.1
E44	10.2	8.7	7.8
A49	9.8	8.3	7.5
A#62	8.8	7.3	6.4
C64	8.6	7.1	6.3
C76	7.3	5.8	5.2
C88	5.9	4.4	4.1

Table 2: Worst-case SW_{max} as calculated from Equation 4. To estimate hammer weight (Ham_{max}), subtract 1.5 grams from the SW. The column Ham_{typ} indicates typical modern weights of prepped hammers for a 7' piano.

Don't take this to mean that these SW's and hammer weights indicate *targets*, per se. What the table proposes is that — operating from a computed MAR, and from a target DW of your choosing, and finally consulting from a table for your FW maximum ceiling weights — these SW and hammer weights indicate the heaviest allowed, or else excessive key leading will be required to statically balance each key. Still, these SW's represent the worst-case scenario, the highest end of the acceptable zone.

If your existing hammers or proposed replacement hammers weigh *less* than these, then you are in safe territory in not over-leading the keysticks. Of course, lighter hammers will naturally correlate with actual lighter FWs given your target DW of 50 grams. Also, as stated elsewhere in this series, hammer weights impact not only touchweight, but tone as well. In broad strokes, hammer weights should suit the belly system and piano size too.

The experienced action rebuilder will notice that the SW maximums in Table 2 typically correspond to concert grands with longer keys, and not to shorter 7-foot and 6-foot grands with shorter keys. Maximum SWs along with corresponding maximum FWs indicate maximum key leads, and these all working together indicate maximum inertia. Fortunately, typical modern replacement hammer sets for a Steinway B weigh less than the maximum hammers in Table 2. Moving forward, we will examine and refine these details more closely.

Downweight Variations on a Theme

Table 3 contains BF constants for other DW choices. Choosing a DW amounts to choosing a BF, and we recommend a declining taper of the DW's in each ascending octave. Thus, beginning with Octave 1 (A1 to G♯12), use a 53-gram DW, and in the highest section (A73 to C88) use the 47-gram DW. Reason: a 50-gram target in the bass is unnecessarily low, requiring more key lead and thus higher key inertia. A 53-gram DW lowers key leading and inertia for a given hammer weight, or else allows for a heavier hammer with the same key lead. Steinway NY recommends such a scheme (plus or minus), as do other manufacturers along with many experienced rebuilders.

DW	BF	Octave
53	33	1
52	32	2
51	31	3
50	30	4
49	29	5
48	28	6
47	27	7+

Table 3: DW and BF choices for each octave.

Equations 1, 3 and 4 are shortcuts requiring little time, only necessitating measuring the action components to produce a MAR and accepting useful averages for friction and EWW. This simple protocol, as stated previously, expedites the discovery of closely approximated maximum allowable hammerhead weights relatable to maximum allowable FWs.

Steps to Finding the SW_{max} for Any or All Hammers

1. Compute the MAR per preceding articles; say the MAR = 6.1
2. From Table 3, choose a DW target and select its related BF constant (e.g., DW of 50 grams relates to BF = 30 for middle of the scale).
3. From Table 4, find the suggested FW_{max} (e.g., C40 would be 29.8 grams).
4. Run Equation 4: $SW_{max} = (FW_{max} + BF) / MAR$
   a. Example: $SW_{max} = (29.8 + 30) / 6.1 = 9.8$
   b. Estimated hammer weight is 9.8 – 1.5 = 8.3
5. Do this for each note in the scale. SW_{max} based on 50 g DW for note 1 would be:
   a. $SW_{max} = (41.7 + 30) / 6.1 = \sim 11.8$
   b. Estimated hammer weight is 11.8 – 1.5 = 10.3

6. But if we allow for DW tapering, we would choose a 53-g DW, along with a 33-g BF
    a. SW_{max} = (41.7 + 33) / 6.1 = ~ 12.3
    b. Estimated hammer weight is 12.3 – 1.5 = 10.8
    c. Notice the allowance for a heavier SW / Hammer

If your proposed new hammers or existing hammers on an action *weigh more* than the SW_{max} estimates, then you have a red flag. It may be that lowering the MAR via a capstan move (closer to key balance) or knuckle change (15.5 mm to 16.2 mm) is the answer. If your proposed new hammers or existing hammers on an action *weigh the same as or less* than the SW_{max} estimates, you are most likely good to go. Expect much more on these types of analyses as we go forward.

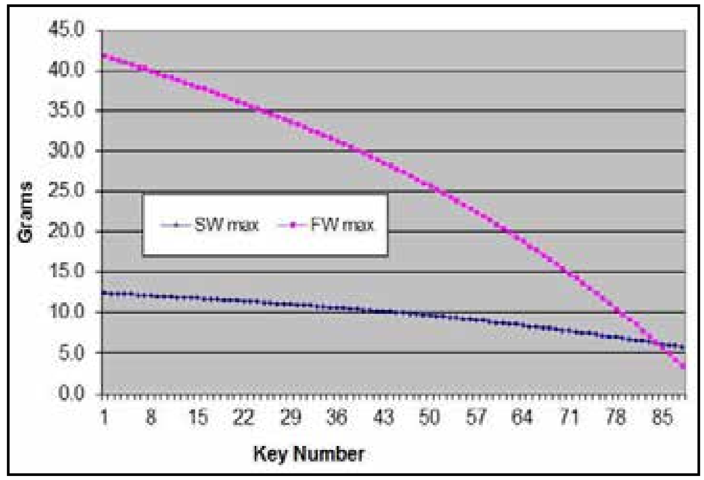
Conclusions and Takeaways

The usefulness of computing a mass action ratio is to uncover the balancing relationship of a gross activating force at the key end (DW) to a responding force-mass at the hammer (SW). Simple math supplies us with a full range of estimated maximum allowable hammer weights. These we compare to either existing hammer weights or proposed replacement weights.[vii] Hammers and SWs that are heavier than a given MAR allows indicate that excess key leads will be required to obtain a reasonable static and acceptable (expected) DW of ~50 grams in the center of the keyboard. Inertia may or may not be problematic depending on other variables. Friction must be controlled — adding leads to overcome excessive friction is against the rules.

Key Front Weight (FW) Ceiling Maximum Suggestions

Note	FW	Note	FW	Note	FW	Note	FW
1	**41.7**	23	**35.6**	45	**27.8**	67	**17.3**
2	**41.5**	24	**35.3**	46	**27.4**	68	**16.7**
3	**41.2**	25	**35.0**	47	**27.0**	69	**16.1**
4	**41.0**	26	**34.7**	48	**26.6**	70	**15.5**
5	**40.7**	27	**34.4**	49	**26.1**	71	**14.9**
6	**40.4**	28	**34.0**	50	**25.7**	72	**14.3**
7	**40.2**	29	**33.7**	51	**25.3**	73	**13.7**
8	**39.9**	30	**33.4**	52	**24.8**	74	**13.1**
9	**39.6**	31	**33.0**	53	**24.4**	75	**12.5**
10	**39.4**	32	**32.7**	54	**23.9**	76	**11.9**
11	**39.1**	33	**32.4**	55	**23.4**	77	**11.2**
12	**38.8**	34	**32.0**	56	**23.0**	78	**10.6**
13	**38.5**	35	**31.6**	57	**22.5**	79	**9.9**
14	**38.3**	36	**31.3**	58	**22.0**	80	**9.3**
15	**38.0**	37	**30.9**	59	**21.5**	81	**8.6**
16	**37.7**	38	**30.6**	60	**21.0**	82	**7.9**
17	**37.4**	39	**30.2**	61	**20.5**	83	**7.2**
18	**37.1**	40	**29.8**	62	**20.0**	84	**6.5**
19	**36.8**	41	**29.4**	63	**19.4**	85	**5.8**
20	**36.5**	42	**29.0**	64	**18.9**	86	**5.0**
21	**36.2**	43	**28.6**	65	**18.4**	87	**4.3**
22	**35.9**	44	**28.2**	66	**17.8**	88	**3.6**

Table 4: Suggested FW maximums.



Graph 1: Plot curves for SW maximums and FW maximums.

A maximum allowable SW relates to the inherent mechanical advantage ratio (also MAR) of the system as you find it or as you change it with new parts or relocations of a knuckle or capstan screw. That is to say, the reasoning and computations above will always produce a balancing act of gross DW (say 50 grams) to a correlating SW — the higher the MAR, the lower the allowable maximum SW, and the lower the MAR, the higher the allowable maximum SW. But whether high or low, the computations always yield a maximum allowable SW in balance with a given DW. Of course, lighter hammers may be used providing they are not too low in mass to adequately activate the belly system. SW and FW maximums require further assessment, and that, along with additional practical aspects of action work, will comprise future installments of this series. Next month we return to the Steinway B action mentioned above.

Endnotes

[i]Unleaded keysticks are surprisingly close to being in balance, only favoring front or rear by small gram amounts, referred to as key imbalance weight (KIW) in Mario Igrec's book.

[ii]Go online to www.stanwoodpiano.com/ptgmarch00.htm and find Table VI of Stanwood's FW ceiling maximums.

[iii]A prepped hammer exhibits tail arcing, cut to length, bored, coved and side tapered (minimal molding tapering up to the bottom of the hammer felt).

[iv]Stanwood's four most quoted and used equations (for AR, SW, BW and FW) all contain a BW factor. Nowhere is friction explicitly stated. An elaborate equation that parses out F, BW and DW is forthcoming, but for now, the simple identity is that BW = DW – F.

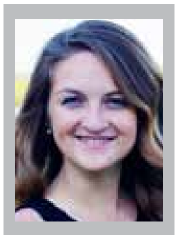
[v]Stanwood's balance equation in terms of the strike weight: SW = [(BW + FW) - (WW x KR)] / SW. Note that BW = DW – F; e.g., 50 g DW -12 g friction = 38 g. The quantity (DW – F) appears in the rearranged equation to remind us that friction is not part of mass and inertial considerations and should be removed from the SW outcome. Also removed from the SW outcome is the weight of the wippen as felt at the playing end of the key, e.g.,

(WW x KR). In the examples above, we make some reasonable and typical assumptions: The wippen radius weight sitting on the capstan is 16 grams operating on a 0.50 key ratio. Thus, the wippen contribution to touchweight as felt at the key front is 16 x 0.50 = 8 grams.

[vi]There may be objections to this line of reasoning from those familiar with or deeply steeped in Stanwood protocols. Further support will come next month. The concepts as shown in no way undermine Stanwood's transformative work or imply a methods change on the successful work performed by Stanwood practitioners. In the meantime, mull over this: In the highest octaves where friction is 12 grams and EFF is 8 grams, balancing these alone would require 40 grams of lead at the midpoint of the key front. Where are these leads?

[vii]Hammers required to balance a keyboard are not necessarily suited for best tone depending upon the many parameters of the belly system. Should heavier hammers be more suitable for a larger piano, but the MAR's dimensions won't allow them without extra offsetting key leads, then a careful assessment of knuckle relocation with new shanks or a capstan move closer to the balance pin (or both) is suggested. Another solution might be the thoughtful use of turbo wippens. In addition, today's typical modern hammer sets for a given model of piano are generally not too heavy, assuming that the MAR will allow, or you adjust it accordingly. Expecting or insisting that a supplier meet your exacting hammer weight specs is unrealistic and counterproductive. A couple of suppliers do, however, attempt to accommodate within reasonable constraints.

Nick Gravagne *has been an RPT since 1975 and has been active ever since in all aspects of piano technology. His specialty fields include soundboard manufacturing for the trade and grand piano action analyses and rebuilding. Nick has served as national service manager for Kawai USA and currently holds a position as an instructor at the Renner Academy. Formal education includes a BA in speech and communication from William Paterson University (1972) and a degree in mechanical engineering via Penn State's continuing education program (1999). Nick is also the recipient of PTG's Member of Note and Hall of Fame awards.*



NAMM 2019

By Hannah Beckett, RPT
Journal Editorial Staff

Many of us find piano technology by entering through the back door. This career does not parade itself on the stage of possibilities when we consider work that will direct the course of our lives in the same way that more obviously defined careers do. Perhaps we begin with a vague curiosity about pianos, which leads to learning about their parts and structure, which leads to connecting with other technicians, and before we know it, we are in a home working on a client's piano. The journey into the piano industry almost never looks the same person-to-person. In today's world, where most careers have a fairly cut-and-dried path — interest, degree, internship, climb the ladder until you reach your ultimate goal — piano technology almost never fails to appear upside-down.

This upside-down start means that there is not a clear sequence in our education. It may take some time to figure out how we fit into the many cogs that make up the machine of the piano industry. For me, going to the National Association of Music Merchants (NAMM) show felt like I'd finally found the front door. The once-a-year, bigger-than-life show attracts enough of the music industry to fill a 1.6 million-square-foot convention center in Anaheim, California. It's primarily a trade show, with dealers from all over the world coming to make large purchases from the companies on display. This is the lifeblood of the piano industry; the deals made at NAMM are the carriers of the pianos from their conception in factories to their resting places in the international marketplace. In the past, the piano corner of NAMM (referred to as Lounge 88) occupied a much larger space than it does today. On one hand, we could mourn the loss of elaborate displays and pianos spilling out of every corner, but on the other hand, this more minimal approach allows the pianos to speak for themselves. Less pomp and circumstance invites a more balanced critique of the many represented brands, all clamoring for the attention of thousands of spectators.

But before the public arrives, a two-day frenzy of setup and maintenance keeps Lounge 88 humming with activity and colliding partials. I found a corner to hunker down in and observed the madness for an afternoon. Besides the five pianos being tuned at any one time, the room was full of workers getting pianos on their legs, hanging banners scrupulously straight, buffing and shining glowing finishes, and unpacking boxes of benches and props. Not all the booths were a flurry of preparation, however; a pre-show setup can tell you a lot about a company's quality standards. Germany's family-owned Steingraeber featured three concert grands that were given three hours of tuning per instrument by seventh-generation Fanny Steingraeber, and the now-Chinese company Harrodser (ironically situated directly across from the PTG booth) threw their pianos out on the floor at the last minute, didn't tune a string, and set up utility lights on the plates to illuminate the bellies of their hastily assembled pianos.

The Anaheim Convention Center.

Setup day one in Lounge 88.

By some miracle, just one day later, NAMM opened its doors to about 100,000 people eager to see the latest and greatest of the music industry. Lounge 88 was full of dealers looking at new lines, and pianos from every booth were scrutinized by players and salespeople alike. This was an interesting place to be as an independent technician. While I'm not concerned with sales, a large part of my job is to educate my clients on their options when they decide to purchase new pianos. I have the gift of impartiality as a technician and the ability to play as a musician. I decided my course of action would be to play pianos from every single brand represented and chronicle my findings.

A scan of Lounge 88 revealed a surprisingly small number of brands familiar to me. The American used piano market keeps continues to circulate pianos that should be long gone by now, and while old Aeolians, Winters, and Kimballs are slowly disappearing, it may be some time before we consider any of the brands at NAMM common household names, if ever. At first glance, the displays communicate exotic European brands, but don't be deceived: China has fingerprints everywhere. Many of these Chinese companies come and go with the wind, but they take great pains to disguise their origins, especially in their choice of name.

Piano brand names are an increasingly tense topic these days. Mason & Hamlin's

Burgett brothers have been struggling to regain rights to their trademark in China after discovering that fake Mason & Hamlins were being sold at the Music China show. We're all used to seeing American names like Kohler & Campbell and Hallet & Davis on pianos coming out of China that bear no resemblance to their former name bearers. Posters and banners bearing German names advertise, "German Technology" or "German Engineering" on instruments that came straight from the factory in China to be sold in America. So, what's in a name? Increasingly less and less meaning is in the names of our pianos, particularly at a sales-based trade show such as NAMM.

Politics aside, many of the lesser Chinese brands are producing a far higher-quality piano than their American stencil-named brand ever did. Part of me wishes they didn't feel the need to hide behind a European or American name. Globalization is no secret at this point, and I appreciated the few displays that were candid about their places of manufacture. For the most part, it takes a decent amount of digging to ascertain what is actually in the names of these brands.

The following report is the result of my digging. I don't have space to include a review of every piano manufacturer at NAMM, so I'll keep my remarks limited to companies that have stood the test of time.

Seiler

Originally a German company, Seiler was purchased by Samick of Korea in 2008. It has three lines of uprights. The Johannes Seiler line is advertised as "perfect for beginners," but the action was so heavy that I struggled to play it altogether. I'm not sure what a six-year-old would be able to do with it. The Eduard Seiler has the magnetic jack return action. When I asked about possible repairs on the magnets, I was told they would never wear out. Time will tell if that is a valid statement. It also has "leadless keys." Their head technician said, "Lead will be illegal in a matter of years anyway, so we went ahead and found a solution." The keys are weighted with a highly compressed plastic. The Seiler upright piano was a beautiful German upright with a clean tone and responsive touch. However, I'm not sure it's quite worth the steep price of $28,000.

Eduard Seiler magnetic return action.

Seiler leadless keys.

Seiler's panda player piano entertained all day long with songs from Chopin to Norah Jones to Def Leppard.

Hailun

Hailun is making great improvements to their pianos. I was impressed with the way their uprights felt and sounded. This year they featured two new lines of uprights: Vienna and iPiano. The Vienna design is mostly an artistic stab at a redesigned case, but they also have aluminum keybeds and Renner actions. Their new silent piano, the iPiano, features silent capabilities and an LED display over the keys. Silent features allow acoustic pianos to be played with headphones while the instruments makes no actual noise. Students can also record their songs and send them electronically to their teachers. I investigated the technology inside to see if we need to watch out for anything when taking these iPianos apart. They did an excellent job putting all the tech under the left cheek block, and the LED key rail comes out just like any other, with only a chord attached. Their uprights also feature a controlled fallboard.

LED display rail with no wires in the way. Thanks, Hailun, for a technician-friendly design.

Yamaha

Yamaha seems content with what they've achieved in their U3's, P22's, and B series upright pianos. Their efforts continue in the direction of hybrid technology, and only two of the pianos they featured were acoustic only. The rest of the pianos had digital components including transducers, silent capabilities, and various combinations of digital and acoustic capabilities.

Yamaha grand piano display. The screen behind the piano mirrors the sound waves created by the person playing the piano.

Pearl River

Pearl River continues to mass-produce affordable upright pianos in the $5,000-$7,000 range. The price is tempting, and perhaps there is a place for them in institutions. Their Ritmüller line featuring "German technology" starts a bit higher in price, but I was hard pressed to find any significant differences between the two. Both had a frustrating lack of power and very stiff action with a heavy touch indicating too much downweight. To my knowledge, they are one of the few companies that have not yet designed a silent piano.

Young Chang

Weber and Young Chang were both represented this year, but they were hard to evaluate because of the poor preparation the instruments received. The contact information for expanding action brackets is the same as last year: Vincent Choi can be reached at vincentchoi@pal-sound.com.

Kawai

Kawai is rapidly approaching their centennial anniversary in the piano industry. This year they had a large room with at least twenty or thirty pianos ranging from the Shigeru concert piano to hybrid pianos. Most of their pianos have some combination of composite action parts and they have a wide range of hybrid instruments. They continue to produce consistent quality in their acoustic grand and uprights lines.

Mason & Hamlin

The Mason & Hamlin booth was always bustling with people. They had several grand pianos and one upright with silent capabilities featured, along with a large Wessel, Nickel & Gross action parts display. Kirk and Gary Burgett are as enthusiastic as ever about the carbon composite parts and can easily entertain with stories of their testing procedures and latest ideas. It is refreshing to find a company that wants to make a better product for consumers and technicians alike.

The Wessel, Nickel & Gross parts display at the Mason & Hamlin booth.

Schimmel

Schimmel has three factories producing three different lines of pianos. The German factory produces their high-end uprights and concert grands referred to as the Koncert line. The uprights from this line have a shockingly clean bass and rich tone. In Poland, they produce the Wilhelm Schimmel line. These pianos are still very nice uprights, but are a bit lesser in sound compared to the Koncerts. This year, they also had Fridolin Schimmel pianos, designed by Schimmel but made by Pearl River. Their website refers to this as a "strategic alliance." They are an obvious step down from the other two lines, but a step up from other Pearl River uprights.

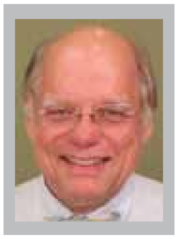
After a few days of playing dozens of pianos, they all started to run together. At this point, I found it helpful to take a step back and look at the big picture. Overall, the manufacturers making efforts to incorporate technology with acoustics are doing well in marketing their hybrid pianos. Yamaha and Kawai lead the way with producing hybrid grands and uprights. Kawai has a hybrid grand piano that features wooden keys and an "authentic" damper system. There may be a time when we will be called on to rebush the keys of the Novus NV10. Yamaha's AvantGrand pianos will eventually require regulation. It seems that silent pianos also have found a niche in the growing market of parents with young children. An acoustic upright for students that also has the capability to be made silent while six-year olds practice their Chopsticks is undeniably attractive.

While the technology side of pianos is evolving rapidly, in the world of traditional acoustic pianos, little has changed in the last century. The main ingredients have stayed the same, but each company has its own take on the recipe.

Our responsibility as technicians is to develop the taste to distinguish the good from the bad. The local PTG California chapters do this well by capitalizing on the presence of NAMM in their area. Each year they have a technical presentation from a visiting manufacturer. This year, Steingraeber's head technician, Alexander Kerstin, spent an afternoon at the Colburn School in Los Angeles, giving a lecture to a roomful of technicians, students, and faculty about the making of a Steingraeber concert piano. This is a great picture of our role in the piano industry. Steingraeber was in town for sales, but they also wanted technicians to know about maintenance specific to their pianos. After all, pianos can be limited by technicians who work on them.

Alexander Kerstin lecturing at Colburn School.

The technician of the future will be one who can distinguish what is in a piano regardless of name or place of origin. It is our job to make some of the lower quality instruments become the best they can be, and often, that is enough for our clients. We all dream of working on a Grotrian or a Fazioli, but the reality of the piano market is that the majority of our work will likely be on cheap uprights and grands. So, how good can these instruments become? Time, and the quality of our work in the grand scheme of the piano industry, will tell.



A New Approach to Piano Tuning

Lesson 4: Creating a Framework of Equally Tempered Thirds

By Ed Sutton, RPT
Journal Editorial Staff

Tuning a Stack of Contiguous Equally Tempered Thirds

In the context of piano tuning, tempering means compromising intervals to fit. Tuning equal temperament on a piano involves trial and error to discern the needed degree of compromise. There is a great advantage to beginning a temperament by fitting thirds into octaves, as you have only two notes to juggle while you look for the compromise. If we can tune dependable octaves, we can gain further advantage by fitting the thirds into two octaves. When this is done, we have a framework to create the rest of the temperament with certainty.

Illustrating the Process

A pure, beatless Major third is a much narrower interval than the Major third we hear in a familiarly tuned piano. If we tune three pure contiguous Major thirds, the top note of the stack will fall far short of a pure octave from the starting note.

Pure Octave: A2 .... A3
Pure thirds: A2 .... C♯3 .... F3 .... A3?

Try it! Hear it!

Strip-mute the piano and tune three pure Major thirds, starting with A2. You can't have three pure thirds and also a pure octave in a twelve-note octave keyboard. In the language of acoustics, this difference between the pure-thirds stack and a pure octave is about 41 cents.

If we want a tolerable octave, we must distribute 41 cents between the Major thirds, and in equal temperament, we do it equally by adding about 14 cents to each third. This is enough to give the tempered thirds a noticeable beat.

Pure Octave: A2 .... A3
Tempered thirds: A2 .... C♯3............ F3 .... A3

Some Rules of Thumb for Tuning Equally Tempered Thirds

- In equal temperament, identical fast-beating intervals double their beat rates at the octave. For example, A3 – C♯4 beats twice as fast as A2 – C♯3. The beat rates of identical intervals between the octaves increase proportionally.

- In practice, the beat rates of contiguous Major thirds have the ratio of 4 to 5.

- Further, if we know the beat rate of the top or bottom third of an octave, to complete the progression we can adjust the other two thirds, which share a common note.

- If we had sample notes at both the top and bottom of the sequence of thirds, we could compare our adjusted thirds both above and below.

- Even better, we could do this easily if we were at a place in the piano where we can assess fast-beating thirds clearly.

- And we can.

Inharmonicity and scaling irregularities may cause slight deviations from perfection, but as rules of thumb, these relationships work reasonably well.

First, the Process Illustrated Further

Octaves: A2 .... A3 .... A4
Estimate C♯3: A2 .... C♯3
Tune C♯4: A2 ...... C♯3 ...... A3 ..... C♯4 .... A4
Tune F3: A2 ...... C♯3 ...... F3 ...... A3 .... C♯4 .... A4
Tune F4: A2 ...... C♯3 ...... F3 ...... A3 .... C♯4 ..... F4 .. A3

F3 is the crucial note that proves the accuracy of our tempered thirds. The two outer thirds, A2 – C♯3 and A3 – C♯4, give a clear framework for placement of F3. If F3 cannot produce a stack of four contiguous thirds with smoothly rising beat rates, the adjustment needed can be easily determined.

Now the Real Thing

On a strip-muted piano:

1. Tune the double octaves A2 – A3 – A4.

2. Take as a hypothesis that A2 – C♯3 beats 4.3 times per second. That's 13 beats in 3 seconds, loosely 4 beats per second plus one more every third second. Ghost at C♯5 to hear the beat clearly.

Use the second hand of a watch and tune the interval to 4 bps, then just a tiny bit faster, then push it down, not quite back to 4 bps.

Get happy that A2 – C♯3 is beating about 13 times in three seconds.

3. Tune C♯4 to C♯3 as a 6/3 octave. A2 – C♯4 should beat just a little faster than A2 – C♯3.

You have created upper and lower reference thirds. Your job now is to tune F3 to create a progressing sequence. Let's take time to get to know F3, and what it can do.

4. First, lower F3 to make A2 – C♯3 and C♯3 – F3 beat equally. (This should also make F3 – A3 beat equally with A3 – C♯4.) We know this is too low for F3, and that C♯3 – F3 needs to beat just a little faster.

5. Now raise F3 until C♯3 – F3 and F3 – A3 are equal beating. Now we know that F3 is a little too high, and that C♯3 – F3 needs to beat just a little slower.

6. Nudge down F3. A little settling push should be just about right. Compare the lower two thirds. Do they beat in a 4 to 5 ratio? Listen up the stack of thirds. Do they progress evenly? If not, see below.

7. Tune F4 from F3, another 6/3 octave. This completes the stack of thirds from A2 to A4.

8. Listen to this extended sequence. Each interval should beat a little faster as you go.
   A2 – C♯3 ....A2 – C♯4... C♯3 – F3 .....C♯3 – F4............
   F3 – A3 ....F3 – A4 ...... A3 – C♯4 ....C♯4–F4. . .F4–A4

Troubleshooting the Stack of Thirds

If the thirds are not progressing:

1. Check the A2 – A3 – A4 octaves. Be sure they are 6/3 octaves. If you find an octave error, fix it and start over.

2. If the A octaves are good, check the C♯3 – C♯4 octave. If you find an octave error, fix it and check F3.

3. If the thirds still don't progress, then the problem can take two patterns:
   a. One or both of the F3 contiguous thirds are two slow, relative to the framing A – C♯ thirds. This means the A2 – C♯3 is tempered too wide. Lower C♯3 a tiny amount and retune C♯4 and F3.
   b. One or both of the F3 contiguous thirds are too fast, relative to the framing A – C♯ thirds. This means the A2 – C♯3 is tempered too narrow. Raise C♯3 a tiny amount and retune C♯4 and F3.

Graphically:

If the C♯s are too low, C♯3 – A3 is too wide:

A2 ....C♯3..............A3 .... C♯4................. A4

One or both F contiguous thirds will be too wide:

A2 ....C♯3 .... F3.............A3........... C♯4............. A4

There will be too many beats for C♯3 – F3 – A3 to share.

If the C♯s are too high, C♯3 – A3 is too narrow:

A2 ....C♯3..............A3 .... C♯4................. A4

One or both F contiguous thirds will be too narrow:

A2 ....C♯3 .... F3.............A3........... C♯4............. A4

There won't be enough beats for C♯3 – F3 – A3 to share.

Practicing This in Your Daily Work

This sequence is easier to do than it is to describe. Once you tune a note, the piano remembers it for you; it becomes a physical marker from which you can hear and place other notes. You don't have to do it all in your head.

Your ETD can be a friendly coach, sometimes taking the lead to show you what to do, sometimes helping you find the placement of a note, sometimes checking your work note-by-note, sometimes stepping in to help when things aren't going well, sometimes just giving a final look over an extended sequence.

If your ETD is programmable, enter the sequence. If not, you will want to remember it anyway, and it is not that complex.

Play with the sequence and the troubleshooting processes. Intentionally mis-tune the C♯s and listen to the problems when you tune F3.

Learn to judge the piano in front of you. Know when the piano offers an A+ learning opportunity and when to just let the ETD make the best of it. You may also begin to notice there are times when the ETD needs your help.

Twenty-first century piano tuning can be a wonderful collaboration between the barely tamed brute physics of the piano, the rapid calculating power of digital technology, and the deep biological responses of an awake human being.

Give yourself time to learn. With practice this tuning sequence will become second nature. The next article in this series will appear in June, giving you two months to master this procedure. When the two-octave stack of thirds is tuned, you have completed the most important framework for a good mid-range tuning. Tuning will proceed rapidly as you add more and more reference notes.

PTG members will find further materials at tinyurl.com/ya8nxulv.

Happy tuning!