Taking the Upright Piano Seriously: Comprehensive Upright Service
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Upright pianos are often given little serious attention. We tend to take the upright piano as the manufacturer or dealer may have delivered it, and accept that as the base line. We tighten screws, raise capstans, maybe do a little more regulation, but rarely get into the sort of detailed prep work we may provide for a grand. When you consider the fact that for most people, an upright piano is the only piano they will possess and the primary one they will play, this attitude doesn't make sense. An upright can be made into a relatively refined musical instrument by using focused and organized techniques.

The methods that will be presented were developed over many years in a university environment, dealing with both old and new instrument, supplemented by preparation techniques I learned during two weeks I spent at the Sauter Piano factory in Spaichingen, Germany. I will present these methods under two headings: tone production and touch.

When it comes to tone quality, the same principles apply to both uprights and grands, though we don't usually split as many hairs with uprights. In fact, many factories and technicians omit the basic steps of traveling and squaring the hammer to the string (burning shanks), not to mention mating hammers to strings and needling hammers. These steps can and must be done to achieve the best results. The techniques are quite similar to those used on grands, but must take into account the fact that the damper action is in the way, and that the hammer flange screw is less accessible. We will go through some of these techniques in detail.

Regulation is something most of us know quite a bit about, but there are refinements and techniques that can produce "factory results," with parts that are all evenly spaced and lined up, together with producing a very even and responsive touch. The interplay between check distance, key dip, and a perfectly straight line of back checks provides an opportunity to cross check and hone in to a remarkable degree. When this is done on top of the work described previously, the results are consistent and predictable: a musical instrument that is a joy to play. I will open the section on regulation with a short segment on steam-sizing key bushings, as the touch of a piano is affected considerably by the way the keys feel.

Part 1: Tone production
Voicing and related procedures

Before voicing, we must assume basic action reconditioning has been done, if needed. I won't go into those procedures here. We are assuming the hammerheads are tightly glued, other glue joints (catchers, shanks to butts) are solid, butt and catcher leather is in reasonably good condition, and centerpinning is firm and free. These things should be taken care of before the following procedures.

Traveling

For uprights, traveling is best done by using a broad straight edge to push the hammers from rest position to strike position, and then allow them to fall back to rest position. This should be done fairly rapidly so that any lateral motion of the hammer is readily seen. (I use a plastic "square" of the sort sold for school geometry classes – it fits in the gap between the hammer rail and the hammer, and provides an easy grip for the hand).

Mark the moving hammers on the side from which they are moving (the side to which you will apply travel paper in order to correct it). Use a code to indicate how much they are moving: a double line for two layers of travel paper, short or long line to indicate the length of the travel paper, and placement close to the edge or farther in to indicate placement of the paper. Mark the hammers of either a whole section or the entire action, detaching the bridles of the hammers as you mark them. Remove each marked hammer in turn, apply the amount of travel paper indicated to the side of the flange corresponding to the mark, replace. Generally two or three passes per section will suffice to achieve pretty refined travel. Since upright butts are relatively difficult to remove and replace, it is wise to be careful in marking the relative amount of travel paper to be applied, and to check your work as you go to calibrate your judgment. I try to remove any given hammer only once, and usually succeed for most of them.

A comment on removal and replacement of butts where spring rails are present: It is a good idea to get the spring of the given butt out of the way during the process of removal and replacement, so it will not be caught and misshapen. It can be placed temporarily in the spring groove of one of the neighboring butts for this purpose. I will also comment that I like to use a "grabber" tool to remove and replace the flange screw, so as to be nearly certain not to drop it and have to retrieve it. The pointed ends of each of the four grabbing prongs need to be filed to make this work, as otherwise there is not enough space to open up the grabbers enough within the available space.

Squaring hammers (burning shanks)

Hammers must strike the strings squarely, and their mass must be evenly distributed on each side of the hammer shank to the extent possible. Ideally, the hammers were hung originally at the correct angle, but shanks twist to some extent in response to humidity change, and even the best hammer hanging job needs to be refined to some extent by twisting shanks. Failure to do this will lead to hammers

that vibrate from side to side on their way to the string, losing power and focus, and causing wear to the hammer felt, to the action centers, and to checks and catchers.

The most precise and efficient way I have found to do this begins by pressing an individual hammer forward to about the letoff point. While holding the hammer in this position, center the hammer molding, at the point corresponding to the middle of the hammershank, between the neighboring hammers: make the spaces equal on each side by spacing the hammer with a flange spacer or by loosening the screw and shifting it. Now let the hammer return to the hammer rail. Note the spacing of the crown of the hammer between the crowns of the neighboring hammers. If the spaces are not precisely equal when the hammer is returned to rest position, heat the shank and twist it until they are. Check your work by moving the hammer forward and back again. Precise judgment of spacing is the key here.

Why does this work? Essentially we are relying on the job we did previously, traveling the hammer. We have established that the shank moves in a direct arc from the rest point to the point where let off will occur, so we can use that arc as a reference. When we center the shank between the two neighboring hammers in the forward position, we are using those neighboring hammers only as random reference points. When the hammer is returned to the rest position, if we center the middle of the crown between the same two reference points, we are sure that the hammer crown is centered on the direct arc, that it is directly ahead of the center of the shank.

The angled sections are somewhat more challenging. The eye (use one eye only) should be positioned so that it is sighting at the same angle as the hammers, and is precisely in the middle between the two adjacent hammers. If you can see a bit of the inside of each of the adjacent hammers, you are in the right spot. It is important that the gaps you are making even in the forward position are precisely at the shank, so I like to scribe a pencil line on the moldings just at that point as a reference.

Angled hammers are sometimes leaned slightly – tenor hammers toward treble, bass hammers toward bass – but only a very small amount, on the order of one to two degrees. I am not sure whether the small difference is significant. (It compensates for the natural flex of the hammershank caused by the weight distribution of the angled hammer, and allows a little more clearance.) Squaring by the method I have described will result in angled hammers appearing to "scoop" toward the string, but spacing between adjacent hammers will be close to optimum, with respect to avoiding rubbing.

The most efficient way to do this is by sections, doing every other hammer: "Thread" a strip of wood between every other shank: that is, insert the wood while pushing every other shank forward in turn (I do this in threes), so that the strip is supporting half the hammers in the section. The strip should be of a size that will push those hammers to let off distance when slid down toward the butt, about 1/2 – 5/8". Then center every other hammer between its neighbors as described above. Remove the strip of wood, let the hammers go back to rest position, a burn shanks so that the crowns are evenly spaced. Then repeat the operation for the other half of the hammers (all even hammers, alternating with all odd hammers – number the hammers so it is easy to keep track). This goes quite a bit more quickly than doing

them individually, and the process is likely to be more precise. At the end of the process, all hammers should be parallel with their neighbors. If any are not, investigate and adjust as needed.

Bench voicing

Upright hammers need voicing just as grand hammers do to produce the best tone quality. The same principles that are used for grand hammers apply equally to uprights. Essentially, the first step is to open up the shoulders with deep needling: pre-voicing. This establishes the conditions that produce a gradient of tone color. (Note that on an older instrument, with deeply grooved hammers that are in need of a full voicing treatment, the hammers should first be reshaped roughly to the correct shape. They will need to be filed again in a more refined way after voicing).

Deep needling requires that the hammers be well supported, which is best done by laying the action on its back on a bench with dampers and hammers up, checks and bridles down. In a few models of pianos, the action brackets are designed so that this can be done without the wippens and checks bearing on the bench. If not, a couple blocks may be needed under the "feet" of the brackets, and often by the hammer rail as well, to hold the action high enough that there is a bit of space beneath the bridle wires and checks. I have designed a simple jig consisting of a length of 1 x 2 about a foot long, and a short (2.5") piece of 1 x 2 that can sit on top of it. The short piece has a dowel protruding, and the long piece has holes into which the dowel can be inserted.

Once the action is lying securely on the bench, the hammerheads must be supported. This can be done using a length or two of 2 x 4 plus a length of 1 x 4 cut to an appropriate length, set in place under the hammers. It needs to be thick enough to raise the hammers to about let off position, clearing the dampers. The dampers should be pressed back with their lift rod, using something like a tuning wedge to hold them in that position, to give access to more of the under surface of the hammer. Sometimes it makes sense to remove the spring rail or the rail limiting damper travel to gain more space, when that is particularly close to the damper wires.

It will now be possible to stand over the hammers and lean the voicing needles into the hammers, using body weight to press them into the felt. The workbench should be at an appropriate level to make this comfortable, somewhat low (or one can stand on a low stool if the available bench is too high).

Hammers are occasionally too hard to press a three-needle voicing tool deeply into the felt. The needles should penetrate about 10 mm each insertion. If it isn't possible, or is too difficult, to do this with three needles, remove one needle from one side of the tool and use two needles for the pre-voicing of the shoulders. In extreme cases a single needle can be used.

With three needles, insertions should start a little above 9/3 o'clock on the shoulder, and the first insertion should be more or less parallel to the lower shoulder of the hammer, about 3 mm from the outside of the hammer. The next insertions will move up the hammer by about 2 mm, staggering left and right to make a diamond pattern. There should be about 5 – 6 insertions more or less parallel to the first insertion, so that they are each penetrating a little closer to the

core of the hammer. When you arrive at a bit above 10/2 o'clock, the angle should be changed gradually as you approach the middle of the crown, and an additional 3 – 4 insertions are actually angled out from the crown toward the shoulders, leaving an untouched triangular point under the crown of the hammer. The last insertion should be fairly close to the crown, and the last two insertions should be shallower, about 6 mm and 4 mm.

This pattern will usually have 8 – 10 needle insertions per side of the hammer, depending on what you are feeling, how much resistance there is. There should be fewer insertions and less depth as you move into the top 2 1/2 octaves.

With two needles, the pattern to follow is to make two rows of two-needle insertions - a row up each half of the width of each hammer - so you end up with four evenly spaced needle insertions across the whole width of the hammer, done multiple times. Generally speaking, ten insertions in each row (from the shoulder up towards the crown) will be a good starting point, so there will be 20 insertions per side of each hammer (40 total individual needle insertions per side).

The area to be needled starts midway in the hammer felt (where it bulges the most) and extends up to about 4 mm from the center of the crown. This takes me usually 1.5 - 2 hrs, and opens up the shoulders enough to allow for three-needle voicing if additional shoulder work is needed.

Filing

After traveling and squaring, the hammers must be filed, because the grooves (if any) will have moved relative to the strings, and in order to produce a smooth and straight surface to the strings. Upright filing presents the problem of the dampers being in the way. I prefer to file with individual strips of sanding film (polyester film with precision sized abrasive particles, available from Pianoforte Supply, and from Rio Grande Supply, http://www.riogrande.com/: 3M microfinishing film, in grits described in microns. 100 is the coarsest, with 60 and 30 being the commonly used finish grits). Regular sandpaper backed with tape can be substituted, but is less stiff, harder to control, wears more quickly, and can tear. The bottom side of the hammers can be filed with the dampers and hammers in rest position, and the stiff film makes it easier to get the strip to go back and forth, a finger pressing on the strip to control its pressure on the pull stroke. For the tops of the hammers, the dampers should be raised using the lift rod (shim out with a rubber wedge or something similar). To get more room and allow for supporting the hammer better, remove the damper restricting rail (sometimes also functioning as the hammer spring rail). Even if it is a spring rail, it is not too hard to remove and replace. This also gives access for lower shoulder voicing if needed.

Always check your work with a straight edge, and adjust as necessary. The hammer line across the crowns must be perfectly straight, every hammer perfectly square, so that the hammer will strike the strings squarely.

Level strings

We want to be certain the hammers each strike all their strings simultaneously. Although strings look as if they are pretty level, when you examine them closely you will find that many of the unisons have strings that are not

precisely in the same plane as the others. It is possible to sculpt the crown surface of each hammer to match the strings, but it is more efficient to level the strings before mating. The most convenient gauge for this purpose is a weak magnet, just strong enough to hold on the strings. (It is also possible to lay the piano on its back and use a gravity level, but this is usually not very convenient to do).

With the action out of the piano, begin at the lowest trichord unison. Place the magnet about 10 – 15 mm from the v-bar, and pluck the three strings. (If it is placed farther from the v-bar, the magnet will tend to draw the strings to itself, telling you they are level when they are not). There are three possible scenarios: all strings sound equally muted (do nothing, move on); one of the outer strings is open (push in on the middle string); or the middle string is open (push in on one or both of the outer strings). The idea is simply to get the three strings into the same plane, so the surface of the hammers can be straight across when it is mated.

I usually find it takes me about 30 – 45 minutes to level a set of upright strings, a good investment of my time. As a shortcut, my first action is to see whether the magnet rocks on the unison, which would mean the middle string is high and needs to be pushed in. In that case, it isn't necessary to pluck the strings to find the problem (especially if it is a large one). If the magnet doesn't rock, I start by plucking the middle string. These are just efficiency tips.

Mating hammers to strings

Precise mating of the hammer surface to the strings is essential to good tone, and this applies to uprights as well as to grands. Perhaps we don't need to be quite as meticulous, just as with travel, but attention should definitely be paid, and the tonal results will be worth it.

This step should be done after aligning the hammers to the strings, as described in the following section, "Part 2: Fine Regulation." It is placed in this section as it has more to do with tone than with regulation.

Begin by propping the damper pedal with a wedge to hold all dampers away from the strings. Each hammer in turn should be very sensitively pressed to the string with the tip of a finger, resting on the hammer rail and pressing the shank forward. The hammer should just touch the strings, and the strings are now plucked. I find the best thing for plucking is a piece of music wire, held in a wooden sanding paddle described below. The wire gives a very moderate and high pitched (rich in upper partials) pluck, which reveals mating problems well, and can get into tight places. Pluck the strings with the hammer held against them with different pressures, from very light (allowing all the strings to bleed a little) to slightly heavy (where at least one string is fully muting its string). If any string or strings bleed more than others, the hammer needs to be filed a bit: file a little on the crown at the point where the hammer touched the string(s) that were muted (this will allow the part of the hammer that corresponds to the open string to approach its string).

A nice tool for this job is a thin strip of wood, maybe 1/8 x 1/2 x 5", tapered to a point at one end. Apply 220 paper to one side, 400 to the other. Drill a hole at the pointed end and insert a piece of music wire to pluck strings. Good mating is

essential to clarity of tone and avoidance of certain timbres that occur when the strings are struck unevenly, and vibrate out of phase with one another.

Finish voicing

Once all the hammers have been mated and the action has been regulated, finish voicing is done. A single needle is usually the most appropriate. A needle tool with a sharp angle is best for the under side, while the top is most efficiently done with an ergonomic tool used commonly in Europe (and available from Pianoforte Supply and Renner). In general, it should only be necessary to needle in the area approaching the crown at this point, at most about three insertions per side of the hammer. If more is needed, it is probably better to do it on the bench, as described earlier.

When all you want to do is reduce attack noise, in a relatively subtle way, shallow crown voicing with thin needles can be very effective. Use #10 or #12 needles (purchased as quilting needles, either from a fabric store or on line), inserted in an angled voicing tool that holds four needles (available from Schaff). The needles should protrude about 3 mm, and should be inserted directly into the string grooves.

Part 2: Fine Regulation

Alignment of parts

The first step to regulation is alignment of hammers to strings, together with refining spacing of the hammers so that it is even. While refined spacing may seem only to be cosmetic, I believe it is the professional thing to do, similar to having tight coils when restringing. And if all the action parts are very evenly spaced, it will be easy to see at a glance when something has gone awry, like a shank twisting or a loose center pin. This and some of the regulation steps can be done best with the keys removed, though that is not required.

The hammer squaring procedure outlined earlier will leave the hammers quite evenly spaced already. Since they are well traveled, if they are spaced evenly in rest position, they will be spaced the same in strike position. So the process of aligning the hammers should go fairly quickly. First, ensure that they all strike their strings squarely. Then look at them section by section for inconsistent spacing, and make small changes to even it out. Often this means moving two hammers just a tiny bit each to make the space between them consistent with the others, compromising the spacing to the strings a little bit if necessary. The string spacing may be refined as well, though sometimes it isn't possible to space all unisons evenly.

With the hammers well aligned, the checks may now be aligned to the catchers, and spaced evenly. This involves two bends, at the base of the wire next to the wippen to space, and at the top next to the check to straighten. The best tool to use is a compound wire bender with round gap so that it can reach around the bridle wire.

The first step is simply to roughly align each check to its catcher. The process of making all the checks vertical, and spacing them evenly, is more complex and

time-consuming, but with practice it can be done pretty efficiently. It is similar to making the bends in damper wires in a grand. The trick is to recognize that a top bend will also effect spacing, and to plan accordingly: make the spacing bend larger than needed to space, realizing that the top bend will space in the opposite direction.

Look at large sections, and notice uneven spacing, and whether or not adjacent checks are parallel to one another. Sight along the check and compare its angle with that of the hammershank as a reference. When refining things, it is useful to lift four or five wippens at a time, which will move the checks forward, and look at them when they are contacting their catchers. The key to really refined spacing and squaring is the ability to make very small, controlled bends in the wire

Let off

The most efficient and precise method for setting let off in uprights was developed by Bill Spurlock: the hammers are pressed forward to just before the let off point and held there, using a strip of wood between the shanks and the hammer rail. The rail itself may also be shimmed forward to get the hammers into precisely the correct position. Use a gauge between the hammers and the strings to check that the distance is correct, and move the shim accordingly. I use a 4 mm gauge, and slide it between the hammers and the strings: it should just be able to slide, touching all the hammers.

The actual let off distance will be 3 mm, but this will be achieved by having each hammer just wink off the strip of wood, by 1 mm. If the regulation is far off, it can be more efficient to go through it two times, once to get it in the ball park, a second time to refine it. Each wippen should be lifted with the finger of one hand, while the other hand turns the regulating tool. The wippen only needs to move a tiny bit, upward enough to move through let off, and down enough to reset the jack. It is more ergonomic to do this with a finger on the wippen rather than on the key.

Spoons

I will not describe regulation of dampers in detail here, but want to give a few tips. First, the dampers must be regulated to lift evenly with the pedal. With that done, and with keys removed, the spoons are regulated as follows:

- Shim the hammer rail so the hammers are at half blow distance (use a gauge to be consistent and precise, running it between the hammers and the strings).
- Raise each wippen in turn with the finger of one hand, and look to see that the damper begins to move at the same time as the hammer.
- The keys should be out, especially for studio size instruments, as this gives easy access to the bottoms of the wippens, and enough room to move the spoon bending tool downwards as well as upwards to adjust the spoon.
- To insert the spoon bending tool and find and engage the spoon, run it along the edge of the wippen to its end, then up and backward to find the spoon – by feel. It is helpful to learn to do this with your eyes closed. Feel the tool sliding along the wippen, feel the end of the wippen, etc.

- Note the angle of the spoon (which way is the damper offset from the hammer butt?), and adjust the angle of the tool accordingly, so that it will engage squarely.
- When you have engaged the spoon bender on the spoon, test that by trying to move the wippen up and down using only the tool to move the wippen.
- Hold the wippen securely while bending the spoon with the tool – often it is better to hold the tool steady and move the wippen.

Spoon bending is difficult for many to learn, but it is a skill worth learning, as it has considerable effect on the feel of the regulation.

Level keys

I won't go into detail here, but simply provide some tips. For naturals, it is best to do larger punchings first, say everything from 0.010" (blue) and up, then everything from 0.005" (green) up, and finally the small thicknesses. The level stick should always be raised and tapped downwards slightly as the first step, to find any high keys. High keys are corrected first, then punchings are added to low keys. The level stick should be placed midway between the front of the naturals and the sharps, as that is where the fingers contact the keys most often, and that will provide the best average level if the keys are warped somewhat.

As you get close to finished, squaring the keys becomes very important. This can be done using a brass slide hammer, sold as a string seating tool by Pianoforte Supply (http://www.pianofortesupply.com/ see under Voicing Tools), as it will not damage the balance pins. It can be helpful to raise keys to touch the level as a way of distinguishing between 0.003", 0.002" and 0.001" punching distances (Pianotek sells a good quality 0.001" punching). The final test is by touch: run your fingers along the keys and feel for any inconsistencies.

Sharps should be a standard height above the naturals, usually about ½" or 13 mm. This can be done precisely and efficiently using a wooden tool that straddles the two neighboring naturals, and has an undercut angled leading edge that meets the front of the sharp. The height can be gauged by feel, just as we do with a key dip block.

Dip and check

It is here that we come to the real refinement of upright regulation. The first step is simply to rough in a keydip that will work, as determined by a few test keys. Set a normal hammer blow of 46 mm as a starting point. Then start with a standard key dip block, like 3/8", 10 mm or thereabouts, set check to 5/8" (16 mm), and see whether you have sufficient aftertouch. That is a matter of judgment: when the key is in check, at a minimum the jack should be just touching the butt leather, and when the key is squeezed harder the jack should move back a bit, leaving the butt leather. That is probably ideal, but for many pianos it might be wise to have a little more for a safety factor, to account for compression of felt and leather. If the jack does not move back when you squeeze the key down, it is resting against the butt leather, and dip will need to be increased. Different shapes of butt may behave somewhat differently in practice.

Note that if the parts are fairly worn, that will mean that the leather and felt contacted initially by the jack top will be worn and compressed, and it will take a greater angle backward for the jack to clear the butt leather. So you will either need more dip, or you will need to bolster the leather, replace the leather, or replace the butts to avoid bobbling. Worn uprights need excessive dip to function reliably, which is one reason they tend to play "like trucks."

Having determined the correct key dip (approximately), all naturals should be set using a key dip block, adjusted as needed to distance needed. Then three naturals at each end of each section should have their checks regulated to 5/8" (15 mm). A gauge should be used. Do this with care, with repeated blows, trying to use equal force, a good firm blow. When you are sure that they are checking pretty consistently, use a straight edge to align all the checks of the section precisely in line. If the three end samples are not quite precisely the same, do a good compromise. Twist checks as needed to square them precisely to the straightedge.

Now dip and check should be set interactively, moving from one end of the section to the other. The sharp dip is set so that its hammer will check precisely the same as the adjacent naturals. Adding punchings will make it check farther away, while subtracting punchings will move check distance forward. While adjusting the sharps, the naturals should be fine adjusted as well. This is a bit of a puzzle, where you decide what should be done to address discrepancies. Dip can be adjusted slightly: play three naturals in a row (the two on either side of the one to be adjusted), hold them down with an even, light touch, and feel along the three keytops. Is there unevenness? Would adding or subtracting a punching to even then out make the checking more even? Put the straightedge across the checks and see whether they are precisely in line. Can one be fudged a little? Feel the keytops at rest. Are they actually precisely level at rest? Sometimes adding a .002" balance punching will make the difference.

Note that naturals that are level and square in the rest position may tilt a little at full dip. In feeling the level at dip, you will feel that the middle key is higher on one side, lower on the other, and should make that even: make the middle of the key even with the ones on the side.

This is touchy, fussy work, but it pays off. It is not always possible to make everything work out perfectly, because catcher lengths might vary a bit, catcher leather or check felt thickness might vary, etc. The interactive process means that every step is being double-checked and refined, and a very good compromise is being reached, where all factors combine to produce a result. In focusing on all the variables and coming up with the best compromise, the action will have an evenness that is very precise, and this will make it feel much more even to the pianist – especially when added on top of the other work that has been done.