

Complete Grand Regulation

By Roger Jolly (with Eugenia Carter, RPT)

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Table of Contents

Foreward

Introduction

1. Keyframe and Balance Rail
2. Key Height and Leveling
3. Hammershanks
4. The Hammer Line
5. Let-Off
6. Touchweight
7. Springs
8. Drop and Aftertouch
9. Trap System Basics
10. Dampers, Underlevers, and Guide Rails
11. Damper Felts, Heads, and Wires
12. Damper Timing
13. Damper Upstop Rail and Sostenuto
14. Damper Tools
15. Voicing

Appendix

Chapter 1

Keyframe and Balance Rail

Have you ever wondered why a hammer line doesn't remain stable? Have you ever wondered why it takes so many attempts to make it stable? . During the course of this wondering and spending many frustrating hours stabbing in the dark. It became very apparent that for high performance regulation, the action needs to be regulated several times to refine all the adjustments. Why is this necessary?

A new phrase for many is "action saturation." This can roughly be defined as the point where any increase in force at the end of the key will no longer produce an increase in hammer acceleration or impact power. When the action is in premium condition and properly regulated, the hammer will strike the string with maximum power. Under this condition most of the energy expended to strike the key propels the hammer. When the action is not regulated to its maximum capability, or has badly worn parts, tonal power is diminished as some of the energy is lost in the loosely coupled components, rather than being used to propel the hammer. The primary areas over which we have control of these losses are frame bedding, action alignment, jack height, let-off, and center pinning. Sounds rather interactive, doesn't it?

This book will outline the procedures that are needed to produce a regulation that optimizes the use of that energy, and results in a regulation that will satisfy the most discriminating musician. Throughout you will be shown how the various adjustments interact with each other for a better understanding of the whole. This way you can begin to unravel the cause-and-effect of the processes that are used to reach your goals, ergo interactive grand regulation.

Where to start? Any well-built house has a solid foundation, nothing new in this. In Europe you will find homes that are over 700 years old and still standing. They have one thing in common: a solid foundation. Like the longevity of those homes, no regulation will work properly unless the foundation is rock solid.

Since the keyframe can be likened to the foundation of a house, we will begin with the procedures in this very critical area. Just look at some of the variables that can cause problems: badly worn fittings or mis-positioned dags, badly worn or incorrectly tensioned una corda pins or clamps, incorrect cheek block hardware fittings, three rails that have to be bedded firmly to the keybed. All of these are sources of action instability, inefficiency, and can create undesirable loss of power and mobility. When any of these are not solid, hammer line and tone will be affected.

The first step is to ensure a solid and correct action position, the foundation on which the rest of the process is built. The reason to ensure the correct fit before attempting any other step is that hammers can *not* be spaced to the strings unless the action is absolutely in its correct position and will return to the same position. (Badly worn parts will create problems, confusion, and must be fixed before proceeding. Parts replacement or major repairs are beyond the scope of this work)

The first variables are the dags and how the action frame fits, secondly the correct fit of cheek block hardware, and how the action slides.

Step 1. Position the action for optimum tone quality, making sure that the top treble hammers have sufficient clearance from the belly rail. Check with the top treble notes by repetitively playing a note and pushing the action in and out, testing at least three or four positions for optimum tonal sound. Repeat the previous repetitive playing test at note #66 or #67 to verify the position. Note: while hammer angle will be covered later, this is a good time to check those treble hammers for any setting at more than two to three degrees off to a side. It is recommend

taking them off now and regluing at the proper angle. Repeat the tone test after making the correction.

Step 2. Fit the cheek blocks, checking for zero movement of the frame. Adjust the cheek block slide adjustments so that optimum tone is maintained without front to rear movement using the same procedure as above. Yes, you will have to take the cheek blocks in and out several times. Tip: make pencil lines on the keybed to observe movement.

Step 3. Reinstall keyslip, cheek blocks and fallboard. Now check the operation of pedals for no binding, squeaking or groaning; if there is, adjust or repair now. Make sure that rapid return is happening with the use of the unacorda pedal. Next, make sure that there is ample clearance between the depressed keys and keyslip. Using a business card is a definite “no-no” as a key slip fix. Identify where the keyslip is binding. One fix is to install a small set screw in the keybed between the keyframe and to the side and just a tad back of the center line of the keyslip pin or dowel at the binding point. On pianos without keyslip pins or dowels, glue thin strips of veneer to the front of the cheek blocks equally on both sides. These methods will give you clearance without introducing friction to the keyframe.

Step 4. Next, make sure that the sharps do not click against the fallboard. Remembering that keys may bounce somewhat with vigorous playing, set it for at least a credit card’s thickness of clearance between the tail of the sharp and the fallboard.

Step 5. Once again, remove keyslip and fallboard; cheek blocks remain or are reinserted into position.

Step 6a.. (Note this step does not completely apply to pianos where the cheek blocks determine the action position. See Step 6 b.) Now check the dag/frame fitting. Mark the keybed with the cheek blocks in their current place for frame position. If after removing the blocks you can push the action inward, some adjustment is required. Some pianos are fitted with dag screws. Adjust so the rear of the frame is just in contact with the screws and there is no movement of the frame when the cheek blocks are reinstalled. For pianos without dag adjustment screws, it is quite simple and easy to install them and it’s easier than gluing a strip of veneer and sanding. Clean the keybed and lubricate the friction points.

Step 6 b. For those pianos where the cheek blocks are a major factor in determining the action position, the dag/frame fitting is done in a similar method. Mark the keybed with the cheek blocks in their current place. Remove the blocks and check for tonal quality as in Step 1. The adjustment for action position is done on the cheek blocks hardware. Loosen the screws and move the position as needed. Clean keybed and lubricate the friction points.

When these steps are completed, you can slide the action in and out as many times as required throughout the regulation process, knowing that hammer-to-string alignment will be consistent when the action is firmly pushed to the rear.

Did you notice the interaction between the dags, and how the action frame fits, and how the cheek blocks fit, and how the action slides, and most importantly how they all affect the action position?

Moving on to bedding the rails. Power is lost and absorbed within the action for many reasons including key flex, hammer shank flex, loose pinning, etc. One of the biggest culprits for energy loss is poor keyframe bedding, which results not only in loss of power but can also create a “woody” sound. Many a piano has been voiced (its tone color altered) and its dynamics increased by correctly bedding the frame.

Most textbooks show this being done with the keys removed and the action stack mounted, using the “paper slip” technique. This technique works quite well with hardwood rails but can be

less effective with many of today's flexible action frames. The addition of the keys adds a considerable amount of weight to the frame and does not necessarily add it evenly. Just think of the amount of lead in the bass keys and you will get the picture.

There are two basic types of keyframe, 1, rigid hardwood, and 2, flexible softwood. We will treat each type of frame separately when we deal with the balance rail.

Begin by raising all of the balance rail glide bolts so they do not contact the keybed. Be sure to check for blind bolts. For example, Yamaha pianos generally have one or two blind glide bolts (compensates for the extra key leads) that have to be adjusted from below the rail. Make sure the bed and frame are clean.

You should always do the back rail first, like everyone else (smile). Using a long, thin-blade screwdriver, slide it down at the end dampers of each section and tap down on the keyframe (see photo 1). If the frame and bed produce an audible knock, mark the *front* of the keyframe with chalk. Sometimes you can get lucky by loosening all the action bracket screws and re-tightening them in a different sequence. Tighten the screws furthest away from the knock first, reinstall action and recheck. This quite often works on Asian keyframes with flexible softwood.

If you are unlucky, take some powdered chalk or talcum powder and scatter some along the length of the keybed at the back rail contact area. Insert the action a couple of times. When you now remove the action, the high spots of the frame will be marked by the chalk. Using a sanding block with 220-grit paper that is at least as wide as the rail, sand the high spots on the *frame*, not the keybed. Keep repeating until the bed and back frame are fitted. Caution: remove a little at a time. Remember, you can take it off, but you can't put it back.

Next, the front rail. Hold down a note without compressing the front-rail punching and tap on the key. Repeat for all As and Es. This will give you samples across the entire keyboard. Mark the front rail with chalk in the areas where there is an audible knock. Slide a piece of 220-grit sandpaper, grit side up, between the front rail and the keybed and sand the high spots of the frame by pulling the sandpaper out (see photo 2). As with the back rail, keep repeating until it is fitted. Once all is well, go back and recheck the back rail. Another reason never to sand the keybed is that this could cause the knock to reappear when the pedal is used.

A special note for later-model Baldwin frames. These frames are very rigid maple and have both front-rail glide bolts as well as balance-rail glide bolts. When bedding this kind of frame, always set the front rail first for the quickest and the best results. The front rail is absolutely flat with no traditional front lip and it floats on top of the keybed glides. The six to eight front-rail glide bolts are adjusted from the underside of the keybed. The clearance from the rail to the keybed should be .020." This is the thickness of the usual 6" machinist rule. Before doing the tapping aural check, insert the machinist rule four inches under the frame and slide from bolt to bolt. If it moves smoothly, you have clearance at the front and at the rear of the rail. If not, adjust the bolts with a slotted screwdriver. The .020" clearance is critical. Without the correct amount of clearance, it's possible to end up with no knocking on the naturals but have knocking on the sharps. This can be tested by tapping heavily on the sharps. If the clearance is not correct, the rear of the front rail may slap against the keybed. With proper clearance, though, even the most percussive playing will not flex the frame enough to knock, even on the sharps.

Balance Rail - Hardwood (Rigid) Frames

Remove only enough keys to do the standard paper slip adjustment of the glide bolts. The fact that the action is weighted with the majority of keys will give you a more accurate bedding. Some hardwood frames have slotted blind glides that adjust from the top. You will have to

remove a key to adjust them—a real pain, but sorry, no shortcuts. Begin with the second glide bolt from the left. Try lifting up at the hammer rail and tapping downward on the balance rail with the heel of your hand to detect a knock (see photo 3). Adjust the glide until the knock disappears. Continue to the next one on the right. The outer glides are the last to do. Go back and check the previous one each time as you move across the rail. Listen at each glide for a knocking sound. Readjust if there are differences. Repeat until no knock sounds anywhere across the rail.

Recheck both the front and back rails. If you have screwed the bolts down too far the outer rails will start to knock. Back off the glides and readjust.

Balance Rail - Softwood (Flexible) Frames

It isn't necessary to remove the keys. Just thumping down on the balance rail with the bolts up will produce quite a racket. Screw down the center glide to make contact, then work your way outward until they all sound solid, rechecking the previous one as you go. Lift upward on the hammer rail and fine tune the tone until all knocks disappear. As above, recheck the other rails.

Did we mention interactive regulation? You can now begin to visualize how one facet of the regulation affects another and why it is necessary to regulate more than once. This need becomes more and more apparent as we move through the process.

Chapter 2

Key Height and Leveling

The last chapter covered mating the keyframe with the keybed and how important each facet interacts with its next as well as its previous step. When that part of grand regulation has been correctly regulated, it should not be necessary to re-visit that area. Moving forward, we continue now with key height.

Key height is fundamental to any piano being able to perform properly. For us as technicians, it demonstrates a point that should be remembered: *any change to the key affects the entire regulation*. A solid, well-regulated key is essential to the process of producing the desired musical outcome. The steps involved in achieving this are just as interactive with each other as they were with keybed and keyframe. When we tune, we establish a constant, $A=440$, and tune everything else relative to that constant. Once key height is set, it becomes the constant on which the rest of the regulation centers. All the remaining steps in the process will regulate relatively to that one constant, key height.

Even though this series deals only with the regulation process, we want to remind you that sometimes repairs are necessary before a proper regulation can be accomplished. One of the things you will have checked before starting the regulating process is the status of the key bushings. It is impossible to do a good key-height/leveling job with badly worn bushings.

A band-aid fix that can help sell a key-bushing job is to show the customer the problem first. Demonstrate how rebushing will be effective by springing the balance-rail pin forward a little with an awl to get the pin out of the worn bushing cup. There should be .002" of play at the balance rail bushing. Lift the front-rail punchings and turn the front rail pins to have .005" of play. You will notice that most of the tilted keys will have disappeared, the spacing will improve and the hammer line has changed a little. This demonstration should be rather dramatic for the customer.

Another essential thing to check prior to establishing key height is the balance rail hole. It should allow the key to function freely as a fulcrum yet simultaneously hold it in a stable position. To check for correct sizing, lightly hold the tail of the key while raising the front a tad. The key should slide slowly, but not too slowly, back to rest. If it doesn't, then the balance hole is too tight. If it drops with a thump, the balance hole is too loose. If the hole is too tight, carefully ease with the Yamaha-style grand key-easing tool. *Always ease from the top, through the bushings as shown in Photo 1, never from the bottom of the key*. If the balance hole is too loose, steam or glue-size the bottom of the key. If you glue-size, we recommend white glue as it is elastic (one part white glue to three parts water). We do not recommend CA glue since, over time, it hardens quite rigidly and can become a noise source.

On many manufacturers' specification sheets, key height is stated as being "nominal," a nice little word to drive you crazy. To interpret that word "nominal" and for those of you who absolutely must have an approximate measurement, key height for the naturals will generally be in the vicinity of 2 1/2" or 64 mm. Is that specific enough? In our work, we must remember not to adhere to specific measurements each and every time. These manufacturers' specifications are intended as relative guides, not absolutes. Besides, variety is the spice of life!

Because every piano is different, we encounter many variables including key height. This may vary for many reasons. For example, during manufacturing, key height may frequently be altered due to a case part fitting problem; or the technician before you may have altered the height in a previous regulation. Just remember not to put yourself into a bind that may come back to haunt you later.

Now, to determine the key height – nominal, of course. We begin with the naturals first. Set sample keys 1, 88 and the five notes middle C to middle E, in our general vicinity of 2 1/2". The samples on notes 1 and 88 will match the length of a 48" straightedge. Quickly do a rough but complete regulation on these sample keys. If you can regulate these samples, your key height will be correct. If you can't, add or remove balance rail punchings as needed to allow you to regulate the samples.

If, after adding or removing punchings, these sample notes will still not regulate, perform the following checks. With .015" to .020" of aftertouch on the naturals, check to see that the dip is between .325" and .420". If dip and aftertouch are outside of this range, check that the hammer height is between 1 3/4" to 1 7/8". If dip, aftertouch and hammer height are all within these ranges and these notes still will not regulate, the problem is most likely an action geometry problem and is outside the scope of this article.

Since our samples did regulate, we've determined that key height is correct. Now we are ready to level the remainder of the naturals to that height. Our objective is to obtain a straight line at the correct height across the keyboard. *Tip:* Before continuing to set the key height for the rest of the keyboard do a simple check. With the action and case parts in their proper places, the fronts of the samples you just set should form an approximate square relative to the keyslip. Next, check that there is a clearance of 1/16" to 1/8" between the top of these and the fallboard. These checks will avoid the mishap of finishing a complete key level and then finding that when the case parts are put back, the keys push down, or the keyslip is too close to the keys, or some other goof-up has occurred.

When starting from scratch or when the keyboard obviously is uneven, we recommend setting key numbers 1 and 88 and working from only these two samples. Remember to use some kind of support under the keys to ensure the samples stay at the height you just determined and that the weight of the straightedge does not depress the keys. An easy method is to remove the felt punchings and replace them with the heavy cardboard punchings; then tape the sample keys to the keyframe as shown in photo 2. Quickly rough into the ballpark range by putting on the first set of balance rail punchings. Once in that ballpark range, bring out your 48" straightedge and begin the finite process. (*Tip:* Using the pre-shrunk felt punchings or ironing the regular punchings gives a nice, solid feel and they seem not to compress as much later on.)

Holding the straightedge at one end, raise the other end just slightly and let it drop down. (Sometimes a shorter straightedge works easier for this test.) The drop of the straightedge will cause the keys that are too high to move. An alternate method is to depress the key and listen for a clunk against the straightedge on its return. If the key is too high, you will hear it. Repeat several times to make sure you catch all high ones. Using chalk or light pencil – anything that you can later remove all markings – make a mark on the front rail for each one that needs to be adjusted. (*Tip:* Color-code your chalk marks to match the color of punchings to be removed or added.) Remove balance rail punchings to achieve the desired height. We are assuming that you already know how to add and remove paper punchings and that you do carry them in your tool case. (*Tip:* Gina swears by the surgical forceps; Roger swears by the 4" surgical tweezers; both are available from medical supply houses.) A cautionary reminder: when adding or removing punchings with the keys in place, protect the stretcher so that you don't make scratch marks with the drop screws.

Once you have eliminated all the too-high keys, next address the too-low ones. With the straightedge in place, look for spaces between it and the key. If there is a space, the key is too low. For assurance, attempt to raise each key – tap, tap up and listen; glissando down and listen;

if you hear any sounds the key isn't level. Mark the too-low keys with your color-coded chalk and add punchings until the desired height is achieved. (*Tip:* Another method is to place the punchings on the balance rail pin as you check each note; this eliminates the need to chalk.) For a final check to ensure all the naturals are level, shine a flashlight from the sharp side of the 48" straightedge. This will show up the smallest imperfections with height or tilting.

As you are leveling the keys pay close attention to any keys, naturals and sharps, that may be tilted. Using a blunt screwdriver or the end of the short straightedge, tap the top of the balance rail pin left or right as needed to straighten the key.

Next, determine the sharp height. Just as the naturals are in the vicinity of 2 1/2", the top of the sharps will be in the vicinity of 1/2" above the naturals. Almost all of the steps used in setting the height and level of the naturals apply to setting the height and level of the sharps. The major difference is that we use the top of the natural itself rather than the keybed to set the height of the sharp. Proceed as you did in setting the naturals. Remember to support the straightedge; 1/4" wooden blocks with heavy cardboard punching added as needed then taped together work well. When you have finished leveling the sharps, the wood of the key will usually be slightly higher than the adjacent naturals. This is most noticeable just to the rear of the keytop material and is quite normal.

Here is a tip for Steinway actions that have balance-rail bearings. With the stack and keys off, make a fresh pencil mark across the fronts of the bearings. Then loosen the front felt that holds them in place on the frame. This will allow you to insert balance rail punchings from under the keyframe. *Caution:* When the key leveling process is completed, *always* re-fasten the felt and make certain that the bearings are aligned in their correct positions.

The last step in regulating the keys is spacing them. Beginning with the naturals set the keys so that there is equal space between each. If the spacing is not even, insert the key spacing tool *beneath* the punchings of the front rail pin to avoid nicking the pin and/or creating other problems. Carefully bend the pin in the correct direction to even out the spacing. Once all naturals are spaced, repeat the process with the sharps.

All the keys are now set at the correct height, leveled, squared and spaced. Using a block of wood (your straightedge will work), press down on each rail with as much body weight as you comfortably can. This will pre-compress the punchings, giving an effect much like many hours of playing will do. Don't overdo it and break a key. Recheck the key level for any changes that may have occurred and touch up as necessary.

Through each step of achieving a correctly regulated key, one step affected another. Without the previous step correctly regulated, the next would be impossible to regulate correctly – another reinforcement of how these steps interact with each other.

Most manuals cover dip as the next process. We're not. At this point we set rough dip at around .400" – just enough to allow adequate aftertouch and ensure that the sharps don't bury below the naturals.

Chapter 3

Hammershanks

So far, we've mated the keyframe to the keybed and regulated the keys. Next, we work with the hammershanks to ensure that as they move from the rest rail to the strings there is the same amount of space between each and that the hammer strikes the string squarely. Our objective is for the shank to travel from its rest point, in a straight line, parallel to the others, so that each hammer forms a 90-degree tangent as it strikes the string.

(Note: If you are at a job site with no workbench, as we usually are when doing fine concert regulation, an ideal solution is to use the action cavity. Place the action into the cavity, keys-first. Flip the hammers upward so the crowns of the hammers are resting on the stretcher. You now have a perfect work table. Sometimes a full surface is necessary. In those cases, lower the piano lid, place a protective cover on it and use it as a workbench.)

Before we travel the shanks, it is necessary to make sure that the action centers in the hammer flanges and in the wippen assemblies work properly. Specifically, we are talking about the hammershank flange and the three wippen centers: jack, repetition lever and flange. All must be free enough to allow for smooth up-and-down movement, yet have enough friction not to allow side-to-side movement. Test each. No center should have more than three to four grams of friction. More than that will impede repetition. Reminder: when checking the jack center and the repetition lever center, remember to disengage the spring before testing. Both should move freely with no binding.

A simple method of checking for sluggish flange centers is to remove the stack and gently swing it so that all the shanks move. Sluggish hammer flanges will immediately be obvious. You can use this same method for testing sluggish wippen flanges, although it requires closer observation. Another standard test is to put the flange screw into the flange; the flange should drop gently downward of its own accord. This test works equally well for both flanges.

The hammer swing test: The hammer should swing from four to six times, although we strongly recommend a maximum of five, especially in the fifth octave. The most important aspect is to have the pinning as consistent and even as possible in every center throughout the action.

The reason for the range in the swing test is simple: relative humidity. In the South, humidity ranges much higher, sometimes as much as 100 percent, causing bushings and the wood around them to swell and contract. In central Canada, the drier climate may not affect the bushings as much but certainly can have as much adverse effect on the wood itself. It is important to remember that wood absorbs moisture much more rapidly than it loses it and allowances must be made for these changes. We point this out since many times pianos, especially concert instruments, can begin in one part of the continent and wind up in a completely different part. Humidity is a factor that must be considered. Later in the series we will see how changes in relative humidity affect other aspects of concert regulation.

If any of the centers, both hammer flange and wippen, are too loose, repin with the next larger size. (We assume you are adept at re-pinning and will not elaborate.)

If any of the centers are too tight, we recommend using a shrinking solution if time permits. Gina prefers denatured alcohol and water; Roger, being more economical (aka cheap), uses plain rubbing alcohol and water. We both use a 50:50 solution and both of us use this method when we know that we have 24 hours after application for the solution to dry naturally. We do not recommend accelerated hot-air drying as this can overshrink the cloth and potentially cause premature expansion of the wood, resulting in loose pinning problems. Lacking this 24-hour time

frame and in a pinch situation, Protek works well; but, more often than not, this probably will be a temporary fix.

Warning note: some Asian models have experienced plating and/or chemical reaction problems with their center pins. Complete reaming and re-pinning is the only solution and this includes the damper underlevers as well.

Tip: With practice you can learn to hear loose centers quite clearly. We are not talking about the obvious, audible clicks related to other malfunctions, but a weakness in tone color. Play very evenly fingered chromatic scales slowly and softly. Listen carefully to the decay. Loose pinning will decay much faster but sound more on the attack. Once mastered, this will be a technique and very valuable tool that you will use every time you voice. It's especially effective and helpful in the "killer" octave range.

If neither of the liquid solutions solve the problem, remove the center pin, ream the bushing and repin. If the entire action is sluggish, sorry, but we've not found any fast, reliable fixes. This is one of those items that should be carefully checked before beginning the regulation process, as the only reliable and long-term repair is usually replacement of these parts.

Once all the centers are functioning correctly, we address the shanks. Slide a straightedge under a section of shanks, slowly lift and observe for any side-to-side movement (see Photo 1).

Tip: take a piece of hardwood approximately 1" x 10", mark vertical lines across its width. Clamp the end of the straightedge to each end shank of the section you are working on; this will enable you to see the slightest movement and easily judge how much correction is required.

When any movement is detected, place a piece of traveling paper between the flange and the rail on the same side of the flange toward which the movement occurs. The amount of correction can be adjusted by the length and thickness of the travel paper. For more movement correction, insert the travel paper further under the flange. Always attach the travel paper to the flange, not the rail. We recommend using plain gummed brown tape cut into strips. We do not recommend sandpaper for travel paper as it usually falls out the next time the flange is removed. Continue until all hammer flanges are absolutely stable, with no movement of the hammer shanks as they are lifted from their rest point to their let-off point. If any movement is allowed to remain, the hammer will not strike the string at the 90-degree angle. This will cause tonal/voicing problems, loss of power and early wear and tear of the centers.

Once the shanks are traveled completely, check the hammer angle. Observe the spaces between the hammers, both at top and bottom. With the hammer shanks at rest, visually inspect for hammers that look skewed. If any are more than a couple of degrees off from square, remove and reglue. For those others that are not absolutely square, using a heat source (we recommend a heat gun like the Unger or similar) apply the heat up and down the shank. Once it is heated, twist the hammer in the direction needed for correction. As you are twisting the hammer, slightly over-twist it, remove the heat source, hold the hammer in this position for a few seconds more, then release. Visually check to see if the new position is correct. If not, repeat. Be careful not to overheat and burn the shank; likewise, take care not to twist an unheated shank as it is very susceptible to breakage and this could also damage the flange. It's much better to do this procedure in small increments to prevent over-angling in the other direction. The end result should be a hammer that will strike all its respective strings at the same time.

Hammer alignment to strings: our objective is to place the hammer in a position that will give the most power and the maximum use of the tonal range of the una corda pedal. Set the hammer so that the left string is just slightly to the right of the left side of the hammer and make sure that, as the hammer strikes the strings, there is full contact allowing for this maximum range of tonal

color. Take care not to set the hammer so far to the right that, when the una corda pedal is used, the hammer strikes the left string of the adjacent note.

Several methods can be used to adjust this step. One of the easiest is: with the action on your lap, place a soft cloth (the key cover strip that comes with many Asian pianos works extremely well) over the tops of the wippen assemblies. Cut a strip about 1 1/2" wide and long enough to do a section. Place the strip on top of the jacks and drop the hammer shanks back into position (see Photo 2). When you place the action back in, by slowly depressing the keys you will find that the hammers will block much more easily since they will almost be touching the strings! This will allow you to check two things in one operation: first, the hammer position with respect to the string; second, since the damper is now lifted, you can also pluck the strings and check hammer shape and string level. A sharp pencil can be used to lightly mark the strike point of the hammers that will need moving. Using the string as a guide to make the mark will show you how far to move each hammer. This method can save on the number of times you will need to move the action in and out of the drawer.

Now slide the action back in. With your finger on the jack, finish raising each hammer completely to the string. Simultaneously as you are checking for correct alignment of the hammer to the string, also check that the strings are evenly spaced as well. Chalk mark those found to be incorrect. Note: if all the hammer spacing is incorrect in only one direction, make the correction at the keyframe stop block. If the hammers need to be moved farther to the right, remove the stop block and place a strip of paper the thickness of the amount of correction needed behind the block; replace the block. Recheck. If they need to be moved to the left, remove the first strip that is usually already there; replace the block, recheck. If there are no paper strips, it is possible to sand the stop block very slightly. Use caution! We do not recommend that you sand until you've gained some experience in this process. With practice, you will quickly learn to judge the thickness required for correction.

Remove the action. Working with only those you have marked, loosen the flange screw and with the screwdriver between the flange and its neighbor, move/pivot the flange to the new position, then re-tighten the screw. Replace the action and recheck. Space and level any strings noted to be incorrect at this time as well. Repeat until all hammers and strings are properly spaced. Sometimes moving the flange is not enough to correct the spacing. It may be necessary to paper it at the back side of the flange (this is not the same area used to correct hammer travel). For those pianos that use the cheek blocks to position the action, of course you must put them in each time you put the action back in. For those pianos that don't, remember to check with the cheek blocks screwed in as a final step. When finished, don't forget to erase all chalk marks.

On some instruments, you will find that after correctly spacing and traveling the hammers, some of the knuckles will be rubbing against each other. You have two choices; either break the knuckle glue joint and reposition, or trim the side of the knuckle with a very sharp razor or X-acto knife. Either way, this must be corrected. If not, performance will definitely be adversely affected.

If the hammer line seems to vary with different intensities of touch, the probable cause will be badly worn knuckles or ones that have been treated with some type of greasy lubricant. With the latter, using a brass brush, clean the goop off with naphtha then apply Teflon powder (available from Bill Spurlock). Badly worn knuckles should be replaced since a fine-tuned regulation will be impossible to achieve with them.

If the knuckles had grooves and some of the hammers have been repositioned, the jack or repetition lever window may now be lifting the knuckle on a very small surface of virgin leather.

This will wear very quickly; be prepared that your regulation may not last long. If the knuckles are in good condition, we recommend brushing them with a brass brush and then applying the Teflon powder. If the knuckles are slightly worn and have off-center grooves from their old position along the repetition lever window and jack, lightly reshape the knuckles with a 3/8"-wide strip of 220-grit sand paper. Just lightly draw the paper around the contour of the knuckles and Teflon powder the now-raised nap of the leather. A stable hammer line cannot be achieved without a knuckle that has the proper shape and proper alignment.

The wippens now need to be spaced and traveled and jacks need to be centered in the repetition lever window slot. We center the wippen cloth with the capstan, the jack tender with the let-off button and the knuckle on the repetition lever.

Raise the shanks and observe the wippen assemblies. Remove any wippens that have jacks rubbing or too close in the slot. Before bending the jack center pin, hold the bottom of the wippen firmly in your hand and check for any movement in the glue joint of the repetition lever flange post. Looking from the top of the repetition lever downward, compare its alignment with the lower section of the wippen; the two edges should be parallel. If by twisting on the post you can center the jack, carefully break the joint and reglue. Almost half of the time this is the cause of rubbing jacks, so this check is essential for proper alignment.

If the two edges are parallel, but the jack is still rubbing or too far off-center, repin. If repinning does not correct the alignment, bend the center pin. An easy method is to place the wippen assembly on the edge of the stack so that the jack is supported on the side which needs to be adjusted. Gently tap on the top of the jack with a small rubber hammer or similar tool until the jack is centered. Remember, small increments. The objective is to achieve the correction but not damage the birdseye.

Lower each shank individually and check each shank and wippen assembly for correct alignment. Chalk all incorrect ones. Addressing each individually, first loosen the screw and move/rotate the wippen to the new position, re-tighten and observe if this corrects the alignment. If not, paper the flange between the rail and flange to center the lower part of the wippen to capstan. This will usually center the jack heel with the let-off button. Note that sometimes a double adjustment of rotation and papering is necessary to correct the alignment of the jack to the let-off button (see Figure 1).

Mating the repetition lever to the knuckle is achieved by loosening the flange screw and twisting the wippen from the front. In some cases you will need to shim between the lip of the rail and the bottom of the flange. This will not be the same place you shimmed for the jack to let-off alignment. (Now you can better understand why we recommend gummed travel paper rather than sandpaper.) Papering the flange and twisting the wippen is quite interactive so be careful. This is another job that calls for small increments.

All of the steps covered so far show how important that screwdriver is as a regulating tool. Now that we've come this far, Phew! Joking aside, a top-quality regulation will not be achieved unless all components are correctly aligned and mated. Any misalignment can be a source of energy loss. We hope you are seeing now just how important it is to have made all these prior adjustments. They are as much a part of the regulation process as is setting let-off and drop. They are essential because the success of the rest of the process is dependent upon them. Interactive regulating!

Chapter 4

The Hammer Line

In our last chapter we aligned the hammers to the shanks and the shanks to the wippens. Before proceeding further there is one last, important step in this alignment of parts. Remember to re-tighten all screws in the action: hammer flange, wippen flange and action bracket screws. Tighten the screws firmly but not too tight, snug but not so snug that it might damage the flange or strip a screw hole. Afterwards recheck to see if tightening these screws moved anything in the hammer or wippen assembly. If so, readjust.

Now that we have mated the keybed to the frame, regulated the keys, aligned the shanks to the wippens, the hammer line will be all over the place since every one of these adjustments has affected it in some way. When you observe an uneven hammer line, think of it as a symptom rather than the cause of some malady. Think: what is happening that causes that line to be uneven and what needs to be done to correct it?

Next is to begin making that hammer line even. What specifications do we use? Once again, we will not be using specific dimensions for regulation; rather we will use general ones. This is not only because different manufacturers have different specifications but, primarily, because we are trying to stimulate you into thinking about the cause and effect of every adjustment to lead to a greater understanding of the action. Just keep in mind that every aspect of regulation will always be within general ranges like we discovered with key height. Remember, in our work there are no absolutes. Our objective is always to find which ranges work for the piano we are currently regulating.

Set a very quick hammer line; it doesn't matter how much blow distance there is at this point. The thickness of the shank off the rest rail is a good general rule, as this will place the hammer very near its ideal spot. Next, check every note to see if it has drop; the amount does not matter at this time only that it has drop. Third, check every note for some spring tension. Again, it doesn't matter how much, just that the spring has enough tension to produce lift after checking. If hammer distance is close and you have drop and spring on each note, you can proceed with the regulation. If not, first see if increasing the tension of the spring will allow the hammer to check. If that doesn't work, then some problem exists that was overlooked during the previous work. It is impossible to regulate a note that does not have drop and spring. Determine the cause and fix it now.

Here is a quick check for repetition springs, especially butterfly springs: Sometimes you will find that someone previously adjusted the lower side of the repetition spring. If this has been done, the force from the spring is not divided evenly. Depending on the geometry of the spring and friction of the center pin coil, the result can be a strong repetition kick but a weak jack. Look down from one end of the action to see that all the lower sections of the springs are reasonably in line; adjust the obvious bad ones (see Photo 1).

Test each jack with your finger for spring tension and a quick return. With the action on your lap, raise the hammer and depress the key between the balance rail and the capstan with one hand. This frees the wippen assembly from the force of the key and removes all pressure from the heel of the jack and the let-off button. Move the jack back and forth with the other hand, feel for spring tension and watch for the jack to return quickly.

Since adjusting the jack to the knuckle will affect hammer line, set this now. Setting the jack position is crucial for control of the hammer shank's upward movement and should be done before setting jack height. Set the jack so that it will give the most power and the fastest return for maximum repetition speed. Lift all the hammers and work from one end to the other. Keeping

your eye on the same level, drop one shank, depress the repetition lever and look where the jack rests. Release the repetition lever. Adjust the jack position by turning the screw on the front of the jack so that the rear edge of the knuckle core aligns with the rear edge of the jack as in Figure 1.

In this position the jack will remain in a tangent to the knuckle throughout its entire forward movement ensuring the most power and speed. If the jack is too far forward, it may escape too early and lose control especially on a *fff* blow. If it is too far to the rear, it will have excess friction from its longer return under the knuckle and repetition will suffer. After all has been adjusted, check each by holding the hammer in its rest position and strike the note with a firm blow. If correctly set, the jack should remain under the knuckle.

After setting all 88 jacks, raise the hammer shanks. The jacks should be in an almost straight line. If any are not, recheck. Sometimes the knuckle will be out of alignment causing the jack-to-knuckle setting to appear differently than its neighbors. Ignore this. As long as the jack is set in its correct core position, looks don't matter. What is important is for each jack to be set at that same core position.

Note: Gina sets all 88 individually. Roger sets #1 and #88, then uses a straightedge or Taut Line Regulation Guide (TLRG available from Pianotek) to set the jack line and then adjusts any of the misplaced knuckles individually as shown in Photo 2.

Sometimes, in a concert situation where we are given the time to regulate to the most infinite possibility, we may set the jack just slightly forward. This will increase repetition speed but runs the risk of catching and not returning. It is frightfully embarrassing if it does happen so we do not recommend it to those who are leery. Naturally when we do this, we triple check every note before the concert pianist rehearses on it (and then pray).

Next is to set the height of the jack in the repetition lever window. This acute adjustment effects the speed of the repetition and should be given very careful attention. We set the height of the jack so that it is just slightly below the top of the repetition lever. The objective is to set it so that the jack will return under the knuckle as quickly as possible with no lost motion. Lost motion in this very critical area greatly diminishes power and causes the touch to be inconsistent. A correct hammer line will be almost impossible to establish because of the varying amount of compression of the repetition springs, especially when touch varies. Depending on the force of the blow, the touch varies even more and the inconsistencies become more pronounced. Remember, when the hammer returns to rest, the load should be shared equally between the top of the jack and the top of the repetition lever. Too much lost motion will cause the spring to compress and friction will not allow the repetition lever to return to the same position every time.

With all the shanks raised, adjust the height of the repetition lever by raising or lowering the screw at the back of the lever. Slightly lift the tool when turning the screw so that the change being made is not affected by the felt under the screw button. Use very small increments. The jack should be set to have no interference as it moves forward but have a very slight, almost imperceptible brake on its return under the knuckle just as it meets the spoon.

Caution: Sometimes the top of the repetition lever may be slightly warped causing the jack to be lower on one side of the repetition lever than the other side. Always adjust from the lower side of the lever to give the jack ample clearance in its forward movement.

Several tests work to check for correct placement of the jack:

1. With the hammer at rest, lightly depress the jack tender with your finger. You should see the hammer drop slightly. This "wink" shows that the jack has escaped the knuckle.

2. With the hammers raised, lightly run your finger across the top of the jack to the lever. You should be able to feel the change where the jack stops and the repetition lever begins. The lever should be slightly higher than the jack.

3. With its neighbor hammer raised, put the hammer you are working on through let-off and drop, but hold it at its drop position. Depress the repetition lever of the neighbor hammer allowing you see the jack you're working on. Looking through the repetition lever yoke, very slowly release the key and watch as the jack returns under the knuckle. Its return should be smooth, quick but not jerky, and come to rest at its original starting point.

Developing a sensitive touch is an essential skill for us to learn and applies very directly to setting the jack. We recommend using all three tests until you are certain jack height is set correctly, especially #3 as a final one. These ensure that this adjustment allows correct escapement and return. Sometimes the jack can wink but the return will not be a smooth and even one. The "feel the top of the jack" test can be difficult to regulate evenly until you've gained much experience. Using the last test gives visual and tactile assurance that the height is set correctly.

Although this series specifically addresses concert regulation and is intended to help learn/practice those steps for the highest level of regulation, let's get real. In the ideal world, we would never have to regulate with worn or inferior parts, and especially with knuckles that should be replaced. So what do we do when no alternative exists but to regulate the best possible with what we have, even in a concert situation? Simple, we do what we must do. Sometimes we just have to set the jack height so that it works. Sometimes that means we even might set the jack so that its height is actually above the top of the repetition lever. Never lose sight of what we're trying to accomplish: making that piano perform to its maximum capacity. If that means you have to fudge, do it with competence and understanding!

Now we will set the hammer blow, the distance from the top of the hammer to the bottom of its respective string. This distance will almost always fall between 1 3/4" and 1 7/8" especially for concert instruments. The correct blow distance will be that which allows the most power, the fastest repetition and the smoothest return. The longer the distance, the more power you will have. We recommend setting samples with the maximum blow distance first. Quickly regulate a sample to see if you can achieve let-off, drop, spring and checking at this distance. It doesn't have to be precise, only that it will regulate. If you can make it work at this distance, proceed. If you can't, try a tad less. Continue decreasing the blow distance until you find the distance that will allow you to regulate samples. Remember to set both sharp and natural samples in each range.

Having different blow gauges, varying from 1 3/4" to 1 7/8", is helpful. Insert the gauge from the top of the strings so that the top of the gauge is level with the bottom of the string. Adjust the capstan so that the hammer touches the bottom of the gauge. Slide the gauge back and flick the capstan wrench upward while still in the capstan. Slide the gauge forward and re-measure, re-adjust and repeat. This should insure static friction or repetition spring compression is not giving you an error. Measure every six or so notes. Plates and string lines are not always parallel to the action and there is a difference in the bass as the windings get thicker. In the high treble, be sure to keep the gauge in a vertical position; otherwise errors may occur. With some capo bars it is helpful to turn the gauge at 45 degrees. Because of the differences in string height from section to section, we set samples for each section, usually the ones at each end, but making sure that the final guides are naturals.

Once you are satisfied with your samples, set the remainder of the hammer line to those samples. While this will be the first major hammer line, we assure you it certainly will not be the final one. Pull the action forward so that the hammers clear the stretcher. If you have one of those neat gadgets that screws into the underside of the keybed and extends outward as a support for the front of the action, now is a good time to get it out. (It's called a Keybed Action Support and is available from Spurlock Specialty Tools or Pianotek.) If not, balance the action on your lap. Using either the Taut Line Regulation Guide or using the stretcher to eyeball it set the hammer line. (Note: Using the TLRG for this setting gives you a quick, reliable, visual guide right at the piano.)

We've now set jack-to-knuckle, height of the repetition lever to the jack, and hammer line. Glissando all the keys in the section a couple of times. Did that hammer line remain stable? Probably not. Inevitably change occurs. Why? Because these three adjustments actively interact with each other, it's almost impossible to regulate all three in one pass. It definitely requires checking them twice, sometimes more. Isolate those hammers that changed. Recheck jack-to-knuckle position and repetition lever height since, more than likely, one of these will have caused the change in blow distance. Make the necessary adjustments. Glissando the section again, readjust and repeat; glissando, readjust and repeat, until that hammer line stays put.

Once the hammer line is firmly set, pull the action toward you far enough so that the hammers clear the stretcher. Quickly check that each hammer will check. At this point we are not setting the height of the backcheck; just insuring that the hammer will go into check. If any do not, determine why and fix it now. We will address the relationship of the backcheck and the repetitions springs later.

As Cristofori's first piano, almost 300 years ago, provided for what we today call let-off. Let's try to understand what is happening. Actually, it's not let-off; it's really escapement, i.e., when the jack fully escapes the knuckle allowing the hammer to strike the string and return, so that it can repeat the process without lifting the finger off the key. Setting what we call let-off at its best place is crucial to allow the pianist to use every shade of tone and every bit of power this instrument can produce.

Chapter 5

Let-off

The function that makes the grand piano unique is its capability of double escapement. Let-off is the first of these two escapements. Simply put, let-off is the point at which the jack is completely free of the knuckle; it is indicated by the hammer not rising to the string. Let's visualize what happens. The key is depressed; the capstan raises the jack; the jack slides out from under the knuckle. The force created through this movement propels the hammer toward the string. When the jack tender meets the let-off button, this energy converts from momentum to mass thus creating the point of let-off. Kinetic energy then continues the movement of the hammer to the string causing the note to sound. So, what else do we need to know about let-off?

From the musician's perspective, let-off must be set so that the pianist will be able to play soft, loud and all the ranges in between. It must be set at the same distance for each note in the section; otherwise, the touch will be uneven. A good pianist *will* feel the smallest differences and may voice concern.

The contact between the jack and the knuckle should be as long as possible but simultaneously as smooth as possible. Why? Because the longer the jack is pushing the knuckle upward, the more force the shank will have to propel the hammer to the string. The more the force, the wider the range of sound. The jack, however, must be set to disengage before the hammer reaches the string; otherwise, the hammer will block itself against the string and an obnoxious sound will be produced.

Reminder: worn knuckles will not only impede the process but will make it almost impossible to regulate at concert level. The out-of-round knuckle adds unwanted friction, delaying its forward movement and will almost always require let-off to be set too wide. Let-off that is too wide causes most of the complaints about uneven touch. If it is set too far from the string, the hammer escapes too early not only decreasing power, but also making control over soft playing more difficult and making it almost impossible to achieve a real pianissimo.

We technicians go through this regulation process almost in slow motion with each note for we must feel as well as observe visually and aurally what happens throughout the cycle to regulate it properly. Pianists will never play the key that slowly because their objective is to produce a musical sound. Keep in mind that the key is the most intimate interaction between the pianist and the music. The pianist doesn't care how we achieve the regulation; the pianist just wants it to "be even." So how do we make it even?

Basic reminder here, folks. While much of what we are covering in these articles applies to grand regulation in general, our main focus addresses concert regulation. In most cases the regulation process in this area is much more stringent and exacting than in-home regulating because the pianist's expectations and needs of the instrument's capability are much more demanding. The primary reason we are stressing the term pianissimo is simply that this is the most difficult sound for the pianist to achieve. Almost anyone can bang out a loud forte, but achieving a musical, beautiful *ppp* passage requires all the skill the pianist possesses and every nuance the piano is capable of producing. It's our job to make that piano capable of producing this sound the pianist needs. If the piano can produce this *ppp*, it certainly will produce any other range wanted or needed.

Let's review how most of us first learned to set let-off: An easy and close-to-accurate method of setting let-off was to use a let-off gauge, usually one (or more) that allows for measuring 1/32", 1/16", and 1/8". The rule of thumb was to set let-off at 1/16" to 1/8" for pianos in

customer's homes and closer to 1/8" for those that would be subjected to high humidity swings. This would usually provide a built-in safety factor to prevent blocking hammers. For performance pianos the measurement was closer, more to 1/16" to 1/32" for this range increases power and control, especially with a *ppp* blow.

We adjusted every six or so hammers to the gauge, so the hammer just started to block against the gauge. The gauge should have been angled at 45 degrees under the string to ensure that it was not slightly in front or to the rear of the strike point (see Photo 1).

The remainder of the notes were set by depressing the measured note and its adjacent neighbor simultaneously and adjusting for identical let off. While this method got us in the ballpark, it rarely, if ever, evenly set it as close to the string without blocking as possible.

So, how do we set this critical step so that it feels right and is set as close as possible? Before we begin, let's think about why it is essential to set let-off in the piano. Remember back to the first article when we mated the keyframe to the keybed? That process showed that not all keybeds are equal; in fact, every one is different. These differences become obvious when you reach the finite regulating processes. This is why bench regulating will usually get you in the ballpark, but when you put the action back into the piano it doesn't function at concert level. There's no place like the keybed with the action in its correct position and cheek blocks installed to set let-off as it should be set.

The three basic tools for adjusting let-off are:

1. The standard capstan tool. Roger favors the Renner tool for its thinner spike and thicker non-slip handle; Gina prefers the Yamaha tool since it works so well on almost all pianos.
2. The regulating pliers, ideal because you can use them while looking at the hammers without bending down to reinsert the tip. They grasp the dowel and allow you to concentrate on looking at the movement of the hammer rather than moving back and forth to find the hole in the dowel.
3. Steinway-style wrench (also known as the Mason-Hamlin screw stringer wrench) which, obviously, works best on the regulating screws like Steinway uses.

So, let's proceed. With the action in the piano turn the let-off dowel/screw so that the hammer just blocks against the string; then back it off just a bit (see Photo 2). Play the note and listen for a clear, ringing tone that is not muted in any way and at the same time observe that let-off is as close to the string as it can be without blocking. Hint: It may be helpful in adjusting let-off if you place your thumb under the bottom of the key and block the key before it completes its drop cycle. This will allow you to observe the point of let-off much better. In the top damper section, sometimes it is easier to see if you place a mirror behind the dampers.

Note: When let-off is being regulated, if the point of let-off cannot be set evenly and smoothly (in other words if let-off seems to be jerky), then something has been incorrectly set before now or else there is a problem within the wippen assembly and/or the hammer shank assembly. You have no choice but to go backward, find the problem and fix it.

Until one gains experience at setting let-off in the piano it may be faster to set samples and do a very quick setting outside the action cavity. With the action in the piano, set samples in each section using the first and last notes respectively. Using the Keybed Action Support™, pull the action out just far enough that the hammers clear the stretcher. Set up the TLRG at the let-off point on each section; set let-off on each note to the samples. Another method is to pull the action out from under the dampers so that you can see exactly where the let-off point will be. When you complete all sections, put the action back into the piano.

If you use either of these outside-the-action-cavity methods, you must still refine each note as stated earlier with the action in its proper place, properly set. With a firm, mezzo blow, carefully

listen for that clear sound. Critically observe that each hammer comes as close to the string as possible but does not block. Remember that because of the larger diameter of the bass strings and their wider physical movement, this section will need more space. Re-adjust any that do not meet the criteria.

If you were measuring, the range for concert regulation rarely will be more than between 1/16" and 1/32" and it may be even less, depending on which section you are regulating. The actual distance is not the important factor. What is important is to achieve the maximum range this piano will allow and that means setting the let-off as close to the string as possible and as evenly as possible throughout. And one final reminder, let-off cannot be set in one pass. You must go over it again and maybe even a third time. Better safe now than have it bite you later. Even after all this, it will still be necessary to check it one more time after we regulate the springs – guaranteed. Do you recall that interactive stuff? Just one more example.

Caution, remember that we talked about the effects of humidity on regulating earlier in this series? Let-off too can be affected by humidity. In a dry climate humidity probably will not affect this setting. However, in a climate where the humidity levels can range from 20 percent to 100 percent relative humidity in one day, the possibility of minute swelling of the felts can and probably will affect the let-off distance. Unless you can be at the piano and be able to test each note just before the concert, be sure to provide a safety factor into this setting. Allow enough room so that any swelling of the felt will not cause the hammer to block against the string or impede the sound by touching it in any manner.

At this point quickly check each note again to see if drop still is there. Again, it does not matter how much, only that there is some. Drop will be set accurately later in the process. Check your hammer line; by this time it probably needs another pass so set it one more, but surely not the last time.

Now we will refine the dip that we roughed in after we set key height and level, naturals first then sharps.

What is dip? It is the full distance the key travels downward to the point it stops on the front rail punching. What is aftertouch? It is the amount that the key travels after the point of let-off to when the key bottoms out. These two, dip and aftertouch, are not one and the same. Each has a different function, but both are equally important. Dip will be affected by many factors, e.g., length of the shank, height of the jack, arc of the hammer. Aftertouch is affected by dip. To achieve concert quality you must be able to have the same relative pressure on all 88 notes and all have the same feel of aftertouch. Dip itself may not be the same on all notes; aftertouch must be.

Dip is one more of those measurements that fall within a general range, usually around .400", give or take a few thousandths here or there. On a piano whose blow distance is closer to 1 3/4", the dip will be closer to .370" to .380"; on one whose blow distance is closer to 1 7/8", the dip will be around .390" to .415". Keep in mind that too shallow key dip results in lost power as it limits the amount of thrust; too deep dip results in reduced repetition and performance since it increases the length of time for the cycle to complete. As a general rule of thumb the longer the blow distance, the smaller the amount of aftertouch needed.

Dip is set by limiting the downward motion of the key by placing punchings under the front of the key. This is one time we do use a specific measurement; it is the measurement of whatever dip block turns out to make the process work properly. Sometimes using a block of a different depth helps. Dip blocks are available in different depths and it may even be helpful to add a cardboard punching to the bottom of one for measuring the amount of depth desired. Test to see

which works best. Using the dip block gets us in the ball park range but doesn't refine the process completely.

Addressing the naturals first, test two or three sample notes. Remember that we originally roughed-in dip in the general vicinity of .400". Immediately test these notes to see if let-off, checking and some aftertouch are present. (Don't worry about the height of the checking at this time; this, too, will be refined later in the process.) If these aren't, add or subtract punchings until these three are present.

When these samples work and feel correct, proceed setting the rest of the naturals at the same depth of the samples, using the dip block that worked to set them. Remember to place the dip block in exactly the same position on the key. It takes some practice, but, holding your thumb on the key lip, depress the dip block and key simultaneously with your index finger, taking care not to overly compress the front rail punchings. Make sure you keep the block forward and against your thumb. Check the level by sliding your finger across the block and its adjacent natural. Be consistent with the amount of touch; a firm but not too heavy touch works best (see Photo 3). Add or subtract punchings as needed for a consistent depth. (Do we need to remind you to place the paper/cardboard punchings under the felt ones?)

Next is where the acute refinement takes place. Play each note with the same touch, not too hard nor too soft. Listen to the sound each note makes, then duplicate that sound for every note. We're not talking about voicing at this point; just that the sound, specifically its loudness, be produced consistently across the keyboard. Add or subtract punchings as needed.

Because final sharp key dip is set by comparing the aftertouch of the adjacent naturals and duplicating it on the sharps, we need to check for aftertouch now. The amount of aftertouch will vary from piano to piano, but it is usually within 1/16" to 3/64". There are basically two ways to adjust aftertouch:

1. By changing the amount of key dip.
2. By changing the blow distance.

How important is aftertouch? Roger tells the story of a concert artist who was in his store to select one of two concert grands. She preferred the sound of one, but the feel of another. The one she wanted was the one with the tone that she liked, but it felt "sloppy." When he checked the regulation Roger found that there was .007" difference in dip between the two. After he added a pink punching to the "sloppy, but beautiful tone" one, touched up the backchecks, and adjusted the aftertouch from the decrease in dip, he had her play it again. She then delightedly chose the one whose tonal qualities she preferred. Consistency in touch is all important for it allows the pianist to concentrate on making music, not fight with an uneven action.

Before setting sharp dip, just as was done with the naturals test two or three sample sharps to ensure let-off, checking and some aftertouch are present. While the backcheck height is not set at this time, now is a good time for a fast test of all the backchecks. If any are unusually low or high now, investigate why and fix.

Key dip on the sharps is set the same as the naturals, by adding or removing punchings. As with the naturals, sharp key dip was basically established after we leveled the keys. At this point we are once again refining what we set previously. The controlling factor is to ensure that the sharp key does not bury itself when played against a natural. A quick check is to place a nickel on an adjacent natural, depress the sharp. When fully depressed, the sharp should be slightly above the nickel or even a smidgen more, but definitely not buried below the natural (see Figure 1). We cannot stress strongly enough that the thickness of the nickel compared against firmly depressing the sharp is the minimum requirement of depth. Anticipate the most vigorous playing;

set the depth to ensure no possibility that repeated firm blows will compress the punchings and cause the sharp to bury. It may even be necessary to re-adjust the sharp height to provide that safety factor.

With sharp key dip, the compression of the felt punchings may have more impact on setting aftertouch than it does on the naturals simply because of the difference in the width of the key. Since the width of the sharp key is narrower than the felt punching, it tends to compress the punching unevenly. When paper punchings are added or subtracted, this gives the added factor of slightly altering the original position of the punching. This movement could create an uneven contact with the bottom of the key. Either and/or both of these can adversely impact aftertouch. Remember that we are dealing in the .000" range. A simple, precautionary method is to turn the felt punching over and use the other side as a nice, flat, fresh surface from which to work.

Once depth is established, set aftertouch to closely equate that of the naturals. Slowly depress the sharp and feel the amount of aftertouch between it and the adjacent natural. Duplicate this same feel by adding or subtracting punchings to achieve the same amount of aftertouch on the sharps as with the naturals. At this point, it is a good idea to regulate completely four or five notes in each section, middle, top treble and bass. Sort of insurance to make sure all is well.

Have you noticed how frequently we are alternating between one step and another? Beginning with let-off and continuing until the regulation is finished, the interactive relationships effect the process the most. When you adjust one thing, it affects another. That's why it is so necessary to check and recheck. More importantly, it shows that a true, concert-level regulation can only be achieved by these back and forth inspections and adjustments.

Chapter 6

Touchweight

In fine performance regulation we strive for checking as close to the string as possible on a *ppp* blow and simultaneously have the repetition spring set strong enough to attain the fastest repetition possible. Correct adjustment of the repetition spring and correct backchecking can be one of the most interactive and, seemingly, most complex adjustments in the regulation process. How can we be on our toes, identify where problems lie, separate the causes and correct them?

We will not go into an in-depth discussion of touchweight and geometry, since it has been covered by others; we recommend that readers make a careful study of the subject as a complement to our series. We believe this awareness will greatly add to your arsenal of diagnostic tools.

Two areas of touchweight analysis that can be used as diagnostic tools for fast troubleshooting are hammer weight and the downweight/upweight spread. Without getting into specific details, a few very general rules of thumb may help separate regulation problems from action geometry/touchweight problems.

1. Every gram of hammer mass removed will produce a reduction of around four to five grams at the key front.
2. When the upweight falls much below 50 percent of the downweight, the action will not feel as responsive. (Be on your guard as this will most likely be a friction problem.)
3. Weight over 12 grams for the #1 bass hammer can be a good indicator of possible problems not related to the regulation. Actual individual hammer weight (when the hammer is separate from the shank) of over 10 grams is a good indicator for further investigation.

When these following conditions exist, fine regulation becomes all but impossible to achieve:

1. Excessive hammer mass.
2. Hammer tails not at 90 degrees to the hammer shank.
3. Tail arc and length incorrect.
4. Backcheck rake and height incorrect.

To diagnose and solve these problems, you will need some or all of the following tools.

1. A set of gram weights to measure “down” and “up” touchweights. This is useful to determine friction problems. Don’t confuse this with your earlier checks (key easing, etc.).
2. A hammer tailing jig (see Photo 1) for two uses: a.) for mass removal and b.) for improving checking geometry. (Bill Spurlock’s is highly recommended.)
3. A hammer tapering jig (see Photo 2). (Again, Bill Spurlock has a reasonably priced one.)
4. A 100-gram digital scale.

Stop a moment and think: What we are trying to achieve with checking? We are trying to stop the hammer as high and as positively as possible, thus allowing the upward motion of the repetition lever to free the jack so it can reset as quickly as possible for another cycle. To achieve this, we trap the hammer’s wooden tail with a piece of padded leather. If the hammer tail is parallel with the center pin of the hammer flange, the tail traps with the greatest efficiency. If the tail is angled, it has a tendency to slide across the backcheck since it is not being trapped firmly towards the center pin. In turn, side pressure will create excessive wear on the center pin bushing. Over time, the resulting loose pinning will add to the problem of inconsistent checking.

Did we mention interaction? When checking at *ppp*, you may notice some hammers jumping a little higher than others. Remember how earlier in this series we stressed center pinning? Well, here is an easy check for any you may have missed. Hammers that want to travel higher may have less friction on the center pins. While this could also be the result of unevenness of drop,

unevenness of let-off and/or unevenness of spring tension, now is a good time to recheck the center pin friction. Repin if necessary. It won't take long to learn how to identify what must be corrected how. Practice will give you the experience to know what you can live with.

Let's look at three normal operations that can alter the weight of the hammer:

1. Coving, a method of weight reduction done on the inside of hammer tails below the hammer shanks (see Figure 1).
2. Tailing/tapering, an operation to remove excess wood and/or felt from the sides of the tail and hammer in order to improve clearances and reduce weight (see Figure 2).
3. Arcing, the shaping of hammer tails to a given radius to promote good backchecking (see Figure 3).

The tail should have an arc from the bore to the bottom of the tail of approximately half the radius of the center pin to tail radius. A good rule of thumb is 2 1/2". The tail length below the bore should be no longer than 1". Ideal tail arcing is about 1/2 the radius of the center pin to the rear of the molding. Hammers on most pianos fall in the 5" to 5 1/4" range, so tailing between 2 1/2" and 2 5/8" radius will work very well. To check this parameter, use a pair of compasses and set them at 2 1/2". Set the pencil lead at the tail adjacent to the bore and the point into the center line of the hammer shank. Scribe a radius on the molding and check the shape of the tailing. Correct if required (see Photo 3).

Next, let's move to backcheck height and rake. Rake should be approximately 22 degrees (from vertical). It should be set so that the hammer tail has ample clearance as you slowly depress the key. At no point should distance between the backcheck and the tail of the hammer be less than approximately 1/16" from the check or the tail may clip the backcheck on its way upward on a forte blow (see Figure 4). Remember, this also depends on hammer weight, strength and flexibility of shank, arc of tail and angle of backcheck. Any one of these can change the parameters; that's what makes it interactive.

First quick check: Look along the backcheck line and chalk mark any obviously low, high or badly raked checks. If the check is too low (using a pair of Vise Grips™ and a small block of wood), grip the backcheck wire with the vice grips and using the wood block as a fulcrum, lever the wire upward. If the backcheck is the screw type, twist upward.

If the backcheck is too high, gently tap the top of the backcheck down using a scrap piece of wood and a hammer. Or, if it is the screw-adjusting type, turn it down until it is level with its neighbors. Remember to give the back of the key firm support.

Obviously, badly raked checks should be corrected so that they align with their neighbors. If the note still doesn't check properly after alignment is corrected, it's probably an arcing or regulation problem.

Correctly arced and raked, the hammer tail should now slide into the upper bulbous cushion part of the backcheck to give positive, high, *ppp* checking. This being done, it will be easy to obtain correct and consistent checking distance later in the regulation procedure.

Using the above information for analysis, let's try some hypothetical situations:

Scenario #1: Hammer tails' arced surfaces are about 15 degrees off from the ideal of 90 degrees to the hammer shank. The backchecks have all been angled to mate with the tails, but checking is inconsistent.

Solution: Re-arc the hammer tails, realign and reset the rake of the backchecks, reset the spring tension. This will improve the checking capabilities quite dramatically. The mass removal may have caused the repetition springs to become too strong in relation to the new hammer weight. Most piano brands that we know of with these production/design problems seem to have heavy-

touch problems as well, so this treatment actually addresses two birds with one stone. See how interactive?

Scenario #2: Action is very heavy, with downweight in the 60-gram-plus range. Although there can be many causes for this malady, one of the most common is excessive hammer mass. With untapered and poorly tailed hammers, it is not uncommon to be able to reduce the hammer mass by as much as 1.5 grams resulting in as much as a reduction of 7.5 grams at the key tip. Excessive mass makes backchecking difficult and necessitates high spring tension to raise the hammer out of check. This in turn leads to a “jumpy” and/or non-responsive feel to the action.

To verify, remove some sample hammers and measure the strike weight. Propping the hammer up on the end of the flange as shown (see Figure 5) and measuring the weight at the tail can make an approximation of David Stanwood’s technique. Bear in mind that you are adding center-pin friction. Anything over 13 grams will need further investigation. This is a quick troubleshooting technique and is not to be confused with a definitive part of touchweight analysis. Important: make sure that the flange center pin friction is within that manufacturer’s specifications.

If heavier hammers are used, lightly checker the bass hammers with no more than one 45-degree pass of a coarse file over the lower part of the tail. Checkering from the tenor upward is neither needed nor desirable, as it will only increase wear.

Solution: Taper the hammer from about 1/8" to 1/4" beneath the strike point, and taper the sides from 10 mm back to 5 mm. Removing felt will give the greatest amount of mass reduction. Note that the tapering jig will get the job done with the shanks installed (see photo X).

With the hammer line set, the height of the check and the center line of the shank should align at approximately the top third of the backcheck at rest (see Figure 6). All the backchecks should line up like toy soldiers. This alignment reinforces the interactive nature of all the regulation parameters.

Next, with the hammer line set and with shank clearance on the rest felt, lightly tap down on the hammer. The rake should be set so that the hammer tail has ample clearance as you slowly depress the key. Again, at no point should it be less than approximately 1/16" from the check.

Taking these extra moments to examine the situation before you attempt to regulate backchecks and spring tension may make that seemingly complex portion a little less so. Additionally, this gives another opportunity to check your work: check for even friction, consistent center pinning, accurate arcing, consistent key dip and aftertouch.

Chapter 7

Springs

The relationship between the repetition spring tension and the backcheck is one of the most interactive of all. A change in one will most likely affect the other.

What does the repetition spring actually do? It supports the knuckle, allowing the jack to return as fast as possible, thereby enabling fast repetition. (We are assuming the butterfly spring style at this time; other types of repetition springs are addressed later in this article.)

The direction of compression on the spring coil directs the force. The tension in the coil determines the amount of force, so if the coil is opened, more tension is stored. Adjustment of the coil adjusts both arms of spring. The spring needs to slide along the spring slot in the repetition lever with as little friction as possible. Too steep an angle may bind, causing a jumpy feel. If spring tension isn't smooth, drop lags.

Sidenote: While checking drop earlier in the regulating process, if the quality of drop seemed slow or unresponsive, it probably was due to some problem within the repetition spring itself: it was gunky or bent, or had too much or too little tension. It is possible to have correct tension for the correct rise, but drop still may not be smooth because of excess friction in the spring slot. The assistance of the jack in the let-off process may mask a repetition spring inadequacy. Correcting those problems now will make the final adjustment of the drop a whole lot easier.

The repetition spring will not function correctly if there is a problem in any of several areas: binding at the coil, excessive friction in the spring slot or poor center pin quality at either the repetition lever post or the hammer flange center. If incorrect friction exists in the spring, the repetition lever will not always return to the same position; hence the hammer line will become uneven.

Remember that in an earlier article we made the statement that an uneven hammer line was a symptom and not the cause of problems. In our opinion, an incorrectly tensioned repetition spring is one of the most common causes of unstable hammerlines. Addressing the spring slot is very often overlooked and sometimes even neglected during service. When the problem is hidden within the slot, the solution is too often sought by increasing the tension on the spring. Thus, the problem becomes worse rather than fixed.

When working with repetition lever springs, remember: spring tension is adjusted only by opening or closing the tension of the coil. It should not be adjusted by bending the arm of the spring. When the springs are correctly tensioned, all should line up like toy soldiers, right straight in a row. When setting tension on the spring, think how a safety pin works: with the safety pin opened, spreading it apart makes it stronger; pressing it together makes it weaker. This is the basic principle of how the repetition lever spring works.

Before starting any adjustments, look down through the wippen assemblies and make sure all the springs line up evenly. If any are bent out of alignment, examine and determine what is wrong. Usually the cause will be that some previous tech bent the spring incorrectly. If that is the case, bend it back to match the rest. Sometimes you may have to work both sides of the spring to make the correct alignment. After all are correctly aligned re-check the winking of the jack for correct jack alignment.

Unhook several springs in each section and check for cleanliness of the curved end that sits in the repetition spring slot. If verdigris or hard greasy graphite is present, repetition speed will definitely be adversely affected since this gunk increases friction in this area. This is one area where we can safely say that friction is undesirable. Clean both the slot and the end of the spring.

To clean the slots, use a vertical hammer shank sharpened to a point and burnish the slot until all the old material is removed (see Figure 1). The slot can now be lubricated with a #2 pencil lead or a light coat of Protek MPL-1™. Clean the end of the spring with naphtha or with the white Scotch Brite™ pads. An alternate tool for cleaning the slot is a rubber mute handle with a hook on the end, with the end dulled appropriately, to clean out the gunk.

Cleaning the slots and springs will give the appearance of increased spring tension, but remember the tension was always there. Lots of energy was stored there that just couldn't get out. It was being wasted overcoming the friction from the gunk inside the spring slot.

Now check for spring strength. Play the key with a mezzo-forte blow and allow the hammer to go into check. Slowly release the key. The hammer should rise away from the backcheck toward the strings until the drop screw stops the rise of the repetition lever. This motion should be a smooth, steady rise. If the movement is too fast or is jumpy, the spring has too much tension. If hammer rise is very slow or almost non-existent, not enough tension is present.

To increase tension use your spring tool to disengage the spring from the slot and pull it to the side so that it is free from the repetition lever (see Figure 2). Place the hook of your spring tool in the arc at the tip of the spring. Gently pull the spring upward so that you are gently unwinding the coil of the spring. Slide the spring back into its slot and test the rise.

To ease spring tension use your spring tool in the center of the curved part of the upper portion of the spring and gently push downward (see Figure 3). This will have the effect of tightening the coil and reducing the amount of Keep testing and flexing the spring until you end up with the desired lift. This is another of those times when one pass doesn't get the job done. Be patient and persistent. Becoming proficient at this operation takes some practice; we call it paying your dues. After the tension of the springs is set correctly, go back and wink the jacks. This will be a check to make sure the jack position was not misaligned because spring tension was incorrect.

Dealing with the Renner butterfly style spring with the additional spring tension set-screw is very similar (see Figure 4). This style wippen does not have a spring slot. Rather, the bottom of the tension set-screw (on the underside of the repetition lever) is fastened onto a Teflon™ collar. The spring is attached to the underside of this Teflon™ collar. (New wippen assemblies of this type are not pre-regulated and usually have too much rather than not enough spring tension.) Before making any adjustment to the tension set-screw, adjust the spring coil as above so that rise is smooth and even for reasonable operation. After these steps have been completed, the tension set-screw adjustment can be utilized to achieve very refined spring regulation.

Baldwin-manufactured wippens are a little different, a single spring with two coils (see Figure 5). The coil that is visible from the side of the wippen will alter jack tension and should have been adjusted when winking the jacks. (So we are human and forgot to tell you earlier – better late than never.) To adjust the jack tension, lift the spring out of the jack slot and very gently open up the coil. This will increase jack tension. The repetition spring is then adjusted with the tension set-screw.

The Schwander-style (lower straight spring, rear screw adjustment) wippen works a little differently than others in that the spring is attached to the jack with a cord loop (see Figure 6). As the wippen is compressed and the jack is moving forward the jack and the tail of the repetition lever are moving away from each other, thereby increasing the tension for a faster return of the jack. One advantage of this style of assembly is that the spring friction is a non-issue.

The same rules apply to the two-spring Schwander-style actions. The spring tension is derived from the coil; opening and closing the coil is how the adjustment is made. Fine adjustment is made with the tension set-screw.

In the Knabe/Chickering two-spring type both springs are attached to the wippen with cord loops (see Figure 7). Both the jack spring and the repetition spring are adjusted by opening and closing the coil. However, the repetition spring usually has a set-screw for fine adjustment.

Caution: In all cases where the repetition lever has a tension set-screw always remember that the spring itself is the important thing. Do not rely on the tension set-screw as the only way to adjust spring tension.

Now that we have the springs regulated, good hammer tail geometry, backcheck rake set, and the backchecks in close regulation, it's time to re-check the backchecking with the newly regulated springs. However, since the spring tension has been altered, the hammerline is probably uneven again. Reset the hammerline one more time. This will be the last time the hammerline must be adjusted for this regulation process.

With the same pressure on each key, play four naturals with one hand and four adjacent sharps with the other. If repetition lever spring tension and the backchecks have all been set correctly, the hammers should all check at the same height. Remember, they should check as high as possible. If any do not, bend the backcheck wire in or out with your finger depending on what is needed. As a final check, put the action back in the piano and re-check. Adjust any that don't check at the same height.

Chapter 8

Drop and Aftertouch

Several chapters ago we noted that the aspect that makes the grand piano unique is its capacity of double escapement. The first of these is let-off; the second is drop. Before setting the drop, let's think through what is happening.

If we depress the key very slowly, we observe a sequence of events. At the point of contact when the top of the repetition lever (or balancier) meets the drop screw on the underside of the hammer flange, further rise of the balancier at this point of contact stops. Propelled by the jack, the hammer continues to rise until let-off is reached. After let-off, the hammer will drop back from the point of let-off if, and only if, the drop screw is set so as to stop the upward motion of the balancier at a point below the let-off point. It is this distance, between let-off and balancier rail stop, that determines the drop setting. No matter how early the balancier contacts the drop screw, drop cannot happen until the jack skips out from underneath the knuckle. The balancier/drop screw adjustment may determine the height or depth of drop, but drop can only occur after the point of let-off. Ideally, the amount of space set for drop is proportional to the amount of space set for let-off. For high performance pianos, less is better.

At this time in the regulation process, drop should already be very close to its ideal setting. To recap, one of the very first things we did was to ensure that drop occurred on each note. Several times during the process we checked and adjusted the drop, each time getting it nearer and nearer to its final place. With all the previous steps correctly regulated, a properly set drop prevents the hammer from blocking against the string. One of the primary reasons for regulating drop at this point rather than earlier in the process is that so many other factors can also cause the hammer to block against the string.

Placing your thumb under the bottom of the key to block it after let-off, depress a key so that it goes through let-off but not into aftertouch. Depress an adjacent key to its highest position just before let-off. Adjust the drop on the first key by rotating the drop screw up for less drop or down for more drop.

With drop being set, all umpteen steps in the regulation process, save one, have been adjusted. The action now should be functioning the way it was designed to perform. Although this series does not include damper regulation, we remind you that properly regulated dampers are essential for maximum level performance. Be certain that the damper upstop rail functions properly. A discerning pianist will not accept the bump at the end of the key caused by an improperly set upstop rail. When the damper pedal is fully engaged, any single damper head should still be able to be lifted very slightly above the top of the line of the damper heads.

Aside: as we stated early in this series, major repairs and action geometry are beyond the scope of this series. However, we encourage all to study Bob Hohf's article in the June 2000 issue. His discussion of the "magic line" for capstan alignment will certainly help in understanding how importantly this affects the regulation process.

Before we delve into aftertouch, let's touch briefly again on those steps that affect it. Those that have the most immediate effect on the actual touch are:

Hammer travel – If the hammer blow distance is uneven from note to note, aftertouch will be affected. Compensation must be made at some point to correct the inevitable unevenness.

Key dip – If the depth the key moves down is uneven from note to note, aftertouch will again be affected and some other aspect must be changed to compensate.

Key height – Since we prefer one aspect of the regulation process to be the one static point from which we reference all others, key height is rarely changed. However, do not forget that if a change is made after the initial key height is established, this too will affect aftertouch.

Those that have the most effect on the amount of aftertouch are:

Jack position – because the amount of movement from its rest position to its being free of the knuckle will vary proportionately to its actual movement.

Balancier height – because this affects the movement of the jack.

Let-off – because the amount of let-off is dependent on how close the hammer comes to the string; the closer to the string, the less aftertouch (other things being equal) and vice versa.

Drop – because the amount of drop is dependent on let-off.

Slight adjustment of the glide bolts on soft wood frames will also affect aftertouch.

Changes in the amount of repetition spring tension and point of backchecking will also, but to a lesser degree, have a perceived effect on aftertouch because the force or momentum used to move the key and wippen assemblies would have a different touch when these are changed.

Whenever we set aftertouch, we allow for certain variables. One of the primary factors will be the needs of the performer. A concert pianist will expect the maximum range of power and the maximum range of tone. Humidity/environmental factors, condition of action parts and the vagaries of the instrument all influence the final decision for setting it. Aftertouch, whatever the amount, assures these factors will be set to enhance the pianist's ability to make music.

So, what is it and what do we do to adjust it? Aftertouch is the amount of downward movement of the key after let-off until the key stops at the keybed felt punchings. The visual demonstration that aftertouch exists is the rise of the hammer immediately after drop but before the key is physically released. The longer the distance of that rise, the more aftertouch established. At the point of drop, the forward portion of the balancier remains fixed by the drop screw. Further travel of the key causes the wippen to travel upward. Since the forward point of the balancier is in a fixed position by the drop screw and the wippen heel is being forced upward by the capstan, the momentum of this force causes the rear of the balancier to move the hammer upward. Thus, we see the visual evidence of aftertouch.

Another visual technique is to make sure the jack clears the knuckle (just a tad, but no more than 1 mm) when the key just contacts the front rail felt. With firmer pressure, as in a *mf* blow, the clearance will be more, but should not be more than 2 mm. The objective is to have minimum jack travel and ample clearance between the jack and the stop felt. The stop felt should limit travel only from the momentum of a *fff* blow.

In any given key assembly whose parts are in good working order and where all parameters have previously been established to the desired regulation, after escapement (both let-off and drop) the jack should never block against the stop felt. If aftertouch is set so that the jack blocks, jack tenders will break. Insufficient clearance produces a sponginess that the performer will not accept. Given that we have regulated let-off and drop to very close tolerances, the hammer rise needs to be minimized to prevent it rising to the point of blocking on the string. Close tolerances and wide aftertouch do not coexist.

Now that aftertouch is set, the final step is to go back and re-check everything one more time. (Bet you thought we wouldn't say do it again, didn't you!)

In these critical areas lies the art of our profession. We technicians connect the feel and tone of the instrument for the pianist; the pianist translates the music; the beauty is heard in the ears of the beholder. Rather nice, isn't it?

Chapter 9

Trap Systems Basics

Introduction

Like many technicians, I used to fear and dread working on grand dampers. In truth, I simply did not know what I was doing; “stabbing in the dark” would be a kind description of how I approached damper problems for many years. Today, damper work is one of my favorite jobs, mainly because there is a smug inner satisfaction contrasted against my previous ineptitude, and the sense of accomplishment that comes from mastering a skill.

Over a period of several years, I read everything that I could get my hands on about the subject, and often wondered what was wrong. Now, after replacing dozens of damper sets, and having the good fortune to receive factory training from both the Yamaha and Baldwin piano companies, I believe that I know a little more about what I’m doing, and can offer some insight on the subject. Besides covering the regulation of the dampers and trapwork, we will take an in depth look at general troubleshooting and repairs – from the pedals to the damper heads.

It is impossible to regulate the dampers or trapwork for consistent operation if the pedal or trapwork bushings are worn or are in poor condition. We will strive to give you all the information required to facilitate effective repairs that will last and be trouble free.

Concert musicians will be very fussy about the state of the pedals; they use them in many subtle ways to voice and tonally control a passage of music. Not in the on/off manner that most of us use to check the operation, but by using a technique known as half-pedaling. Just to define half-peddling, for those who are unfamiliar with the term: the damper pedal is depressed just enough so that the dampers will just start to bleed, making a note or passage sound a little fuller.

With *una corda* half peddling, the pianist will use the pedal to just move the strings out of the grooves, to find the soft part of the hammer. This will alter the texture and tone without the pianist having to change dynamics. Both of these techniques require a high level of pianistic skill, but a good pianist will demand high performance from these very important functions, since they are as adept with their feet as they are with their fingers.

When the pedals are correctly regulated, and are functioning at the maximum potential, they will be capable of producing a wide variety of tonal colors and special effects that will add a whole new dimension to the music being performed. It is therefore very important that when the pedal is depressed, say 1/4", the identical tonal result will take place each time on each note. This will not happen if there is side-to-side movement in the pedals and pedal rods, or if the trapwork is slopping about in between the guide/pivot blocks, or axle pins are loose. Each mm of movement with the pedal, must translate to movements within the action cavity, and not be lost in the linkage of the mechanism.

Incorrect lubricants and poor-quality materials in the pedals and trapwork are often the cause of unreliable and faulty operation. Oil and WD40 are absolute no-nos. Leave them in the garage where they belong. Poor-quality felt or leather will wear quickly, so be selective with replacement materials.

Each point in the trapwork linkage can be subjected to pressures of several hundred pounds per square inch. Therefore, it is very important to use a lubricant that will stay where you put it, and not evaporate or be pushed aside, and that replacement materials are of the highest quality.

Trap System Basics

To start with, here are some thoughts to keep fixed in your mind when working with damper systems. Think in terms of all the component parts as needing to move in clean, vertical planes, with reliable rotational movement. Any sideways motion is unacceptable, and this holds true for all components: the pedals, trapwork, underlevers, damper wires, and heads.

For secure and reproducible operation, we need several things to be carved in stone.

1. There is no side-to-side play in the pedals, yet they can move freely up and down for quick response.
2. The pedal rods are firmly and securely connected to the rear of the pedals and are held in place by the guides.
3. The pedal rod has a fixed contact point with the trapwork, but is free to slide a little on its contact surface.
4. There is no side-to-side sloppiness in the traplevers, yet the ends travel freely about their axes.

To successfully repair and refurbish pedals and trapwork, you will need:

- A supply of good quality woven bushing cloth, in a variety of thicknesses.
- A supply of firm felt to limit pedal travel inside the pedal box. I prefer hammer felt, cut to thickness on the band saw, where possible. Very firm and durable, particularly good for die stamped pedals.
- A variety of balance and front rail punchings. To be used as positioning spacers between the pedals and the pedal dowels or axle clamps.
- A variety of felt for pedal surrounds.
- A block of paraffin wax or Protek grease. My personal preference is paraffin wax.
- A selection of leather.
- Some thick leather for pedal rod contact pads. Shoe leather and an arch punch are ideal for making these 1" diameter pads.

Grand pedal systems fall into two general categories. 1. The clamped axle type. (Three pedals on a common axle) 2. The spline axle/pedal dowel type.

Clamped Axle

The clamped axle type usually has a piece of folded bushing cloth that is clamped over the axle and fits into a groove on the pedal. When the cloth wears, side play starts to develop in the pedals, while noises and squeaks increase and refined control starts to disappear.

When refurbishing this type of pedal system, I like to use high-grade woven key bushing cloth and melt paraffin wax into the area of axle contact. This will totally impregnate the felt and prevent wear, and give years of good, squeak-free lubrication. Use firm balance rail felt punchings on the axle to ensure correct centering of the pedals in the box. This will prevent the pedal from rubbing against the sides of the box and keep it centered. Inspect the axle carefully for nicks and dents and replace the axle if it's defective. This type of steel rod is readily available from good hardware stores.

The fixed axle clamps should be secure so there is no movement of the axle.

Disassembly of some Korean manufacturer's pedals having clamps held in place with a Phillips screw can often be difficult, since the screws seem frozen in place. Using a large Phillips-head screwdriver on a socket set makes the job simple.

Spline Axle

With the pedal dowel type, carefully inspect the axle for any nicks or burrs, change the spline axle if required (available from supply houses). If the dowels are worn, my preference is to make new ones from maple, using a good machinist vice and drill press to drill the holes accurately in the center of the dowel.

For a field fix, use a spare axle with a thin coat of Vaseline, and fill the sides of the worn holes with medium gap-filling CA glue, or five-minute epoxy. After curing, melt paraffin wax into the hole for lubrication. The CA repair seems to be impervious to changes in humidity and is very durable. I have had some thoughts about pre-treating newly made pedal dowels with the thin CA product.

Both of these procedures work very well and there have been no service recalls with either of these repairs to my knowledge. Just lubricating worn parts will not last. Remember when you get a call-back, you pay for the time, so think in terms of doing a lasting repair and getting paid for it.

For the rear of the pedal, there are a wide variety of arrangements for coupling the pedal rod to the pedals. For many pedal sets, I find that the Yamaha pedal rod replacement kits work well and are noise-free when used with Teflon powder. Drill out the rear of the pedal, if necessary, to receive the leather pad and rubber collar. Dust with dry Teflon powder to prevent squeaks, then reinstall the rod. Remember that petroleum-based products will degrade the rubber in a relatively short period of time.

When rebushing pedal rod guide holes, select the correct thickness of bushing cloth or leather, so that the pedal rod has minimal side play. The pedal rod sliding around on the contact points of trapwork causes many squeaks and groans. Clean out the worn bushing cloth. Steam or water is a good method for removing the old bushing cloth and glue, and you will find it much easier if the guide block is detached. Cut the felt to the desired width to completely cover the circumference of the guide hole. Remember high school? " $D \times \pi$." Just measure the hole and calculate the circumference for the desired width of bushing cloth.

Taper the end of the felt as shown, draw through the guide hole, apply a little glue to the end of the felt, and draw it through to be flush with one side of the guide rail. Let the glue dry, then trim the opposite side with a sharp razor knife; remember to be sparing with the glue. Too much glue and it will wick into the bushing cloth, and the bushing will lose much of its resilience. Often, you cannot find the correct thickness of quality bushing cloth to get the desired result. In this case, double-bush the holes with two layers of thinner cloth. Let the first bushing dry before rebushing the second layer.

The traplevers are a common source of difficult-to-detect noises. Sound travels and these noises are often frustrating to locate. At times, when trying to trace these noises, I believe that the keybed is as efficient as the soundboard. Each bearing point and contact area is a potential area for these noises and lost efficiencies.

Due to lack of tools and shop facilities, making new trapwork components is impractical for many technicians. But much can be done to make effective repairs that will be durable and trouble free. The above-mentioned CA glue repair for oversized or worn holes is just one such approach.

One of the more common faults that we encounter is an enlarged pin hole, either in the traplever itself or in the lever blocks. Sometimes we can get lucky. Just re-drill the hole and use a larger-size hinge pin, or make your own pins from 1/8" or 3/16" rod. Two drill bits are needed: one for a force fit in the lever, to prevent the pin from "walking out," the other for a clearance

hole in the blocks. The addition of a set screw on the lever will help reduce future wear and cure the walk-out problem for good.

To install a set screw, mark the center line of the lever hole with a set square, center-punch the position for the set-screw hole, and drill a hole to accept a #6 wood screw. Install the screw, to cut a thread in the lever. Remove the screw and cut the tip off. File the end of the screw clean and reinstall. This will prevent damage to the pin, plus it will give a larger contact surface with pin and screw. Yamaha trapwork pins have a clip to prevent walkout, or a small electrical cable clip. Look at the system; it will give you a few good repair ideas.

If the inside of the lever blocks has felt or leather glued to the sides, it is wise to replace it. Make sure you select the correct thickness of material to hold the lever parallel and prevent side-to-side movement. Rub or melt paraffin wax into the material for lubrication. If the sides of the levers have been roughly cut at any of the contact points, sand them smooth.

Most traplevers have a 1"-diameter, thick pad of hard leather glued to the end that makes contact with the pedal rod. If this pad is deeply dimpled, cut a new leather pad out of shoe leather with an arch punch. The tanned side of the leather should contact the pedal-rod capstan. Glue to the lever with hot hide glue or apply white glue to the leather, and CA glue to the wood or metal part of the lever, then press the two pieces together, holding for about 30 seconds. For the metal una corda levers, burnt shellac was often used to glue the leather pads. Today we have many good contact cements that will also work just as well.

Many older una corda levers have a wooden insert that the pin pivots through. Because of the heavy load of the action, a lot of stress and wear take place at this point. Drill out the old dowel and force-fit a new one. If you dry the dowel down in the oven on low heat it will shrink, making it a lot easier to install. Dry down the dowel at home and place in a Zip-lock bag until you are ready to install. On installation, drill for a force-fit of the pin; as the dowel takes on moisture the pin will be gripped very tightly.

Check the pitman and sostenuto lifter to make sure that they will not rub or bind through the keybed. If the pitman has end pins, also check to ensure that the pins are long enough to prevent them from jumping out with vigorous pedal operation. If the pins are too short or loose, remove them, fill the hole with five-minute epoxy, and re-install the pin at the desired length. Most modern aluminum lifter trays have rubber collar-type bushings for the pitman. Replace them if they are hard or worn. They are a common source of clicks and clacks.

Finally, check and lubricate all spring and pitman contact points, making sure that all spring screws are secure. In the case of coil springs, weaving key bushing cloth through the coils will often reduce creaks and groans. Many Korean pianos have 1" x 1/4" blind holes drilled into the bottom of the keybed and the tops of the traplevers, to secure a 1" coil spring, and many are not lined. Cut a thin leather pad with an arch punch for the bottom of the hole. Glue some thin key bushing cloth around the side of the hole; this will greatly reduce unwanted noises. If the lever is grooved from a leaf spring, sand out the groove and lubricate with wax.

With all this done, each mm of movement of the pedals will be efficiently transferred to the damper underlever tray, and into action movement via the pedal shift arm. Just like in fine regulation, attention to detail is the key to success.

Chapter 10

Dampers, Underlevers, & Guide Rails

If you have traveling problems with an underlever, it will start to move the damper wire to the side and cause it to start binding in the damper guide. This sideways movement can be noted at the damper head and will make it difficult to attain clean damping. With well-regulated underlevers and the ends of the damper wires straight and in a vertical plane, the underlever and lift flange (sometimes called top flange) should slide up and down freely on the damper wire, with the set screw backed off. To get to this point we need to check and service several things within the underlever assembly:

1. Centerpinning.
2. Travel.
3. Vertical position of the damper lift flange (top flange).
4. Security of underlever leads.
5. Spring and slot condition.
6. Underlever tray pivot blocks.

In the last few years I have repinned many sets of underlevers. Besides those done in the course of rebuilding, a significant number of Asian pianos have had pin plating problems. These pianos seem to be in the 15- to 20-year-old age group and exhibit extreme damper problems. Both the flange and lifter centers tend to freeze up. When you encounter an Asian piano of this age group that has frozen centerpin problems, inspect the pins carefully. If the pins seem pitted or scored, prepare the customer for a potential complete repinning job. Anything less and you will likely be plagued with recalls. Treating these centers with centerpin lubricant may help for a few weeks at best. The only professional fix is to ream the bushing clean and repin both the flange and the damper lift flange. Some technicians will advocate repinning and rebushing, which is fine, but I have had no problems with repinning two sizes over.

Don't even think of doing this job in the piano; the flange screws will drive you insane. Remove the underlever tray, and do the job on the bench or a table. This is one of those jobs where 100 percent of the pins need changing. I like to ream out for #21 pins to make sure that all debris is removed from the bushing cloth. The criteria for secure but free pinning are that the flange should just fall with the weight of the flange screw, but should not fall under its own weight. The lift flange should start to fall cleanly under its own weight, when the lever is vertical and the lifter is held horizontal. Remember, these components are located in a very difficult to reach location, so check and double-check your work before reinstallation. If you are repairing an isolated underlever, a good quality, self-grip screwdriver to hold the flange screw is a must to re-install the underlever.

To remove a Steinway underlever with the horizontal glued flange, drill two small index holes through the flange and into the tray. This will ensure that you can reglue it back in its original position. Take a wet cloth and steam the flange with a hot iron until it will release.

Do the required repairs. Make sure the surfaces of the flange and tray are completely clean. Dry fit and clamp firmly in position with a small C-clamp. Check travel and the vertical position of the lift flange before regluing. Use only hide glue to reinstall.

Next we need to travel, space, and rotate the underlevers. This traveling procedure was covered well in the "Interactive Regulation" series. The vertical lines on the edge enable you to see the traveling in the piano. Just clip the bar to the two end levers of each section, and observe and correct any sideways movement. Use a set square on the bench or in the piano, to check that

all the lifters are plumb and vertical. Rotate the flange to correct. If the lifter is out of square by a large amount, check to see that the centerpin is square through the bushing, rebush, and repin to correct, remembering to check the correct pin size within the bird's-eye. The more fastidious you are with travel, spacing, and rotation, the easier things will be later

Check the underlever leads for security. Three methods for tightening loose leads:

1. Remove the lever and use a key lead punch to spread the lead.
2. CA glue will secure the lead and stabilize the wood if there is a wood shrinkage problem.

This is a very practical field repair.

3. A custom-made set of underlever lead pliers. Fast and efficient, without having to remove the underlevers. Just squeeze the leads. The tool was designed by Yamaha.

Here's how to check for loose leads before strip-down:

- Depress the damper pedal to the point where the dampers are just starting to lift.
- Flick the underlever so it will bounce on the tray. Listen to the noise of the underlever hitting the tray and you will hear the problem.

Some underlever systems have no leads, but use springs. Some use a combination of both.

The spring slots and springs need to be clean and well lubricated.

- Sharpen a hammershank with a pencil sharpener and burnish the slot clean.
- Polish the spring tip with a White Scotch-Brite pad.
- Lubricate and burnish the slot with ProTec grease.
- When some of the old lubricants dry out, sliding friction will greatly increase and can be the cause of sluggish response.
- Re-tension the springs if required. Just enough tension to prevent damper bounce is all that is needed.
- If the underlever tray pivot blocks are worn, repair and lubricate. Make sure the felt spacer bushings are in good condition, and that the tray will not move from side to side once the blocks are secure.
- The underlever tray felt should be flat and even to ensure that the pedal will achieve even damper lift. If you replace the tray felt, make sure your glue line will only contact the rear half of the felt width.
- Replace the tray/dag stop felt, if required.
- Check and service any tray springs.
- Check and service the pitman contact surfaces, and/or bushings.
- Reassemble.

The Damper Guides

Badly worn damper guide rails are a common source of unwanted noises and rattles. A sizzle-like sound can often be heard as the damper starts to damp the strings. The momentum of the strings will cause the damper head to oscillate back and forth with the motion of the strings, greatly reducing the efficiency of damping.

Next, we will rebush and size the guide rail. Remember our vertical thinking! We have the damper underlever and lift flange moving upward in a nice vertical manner. So if we have damper guides that have vertical and correctly sized surfaces, it is going to fix the position of the upper part of the damper and wire. This will enable us to do all the wire bends in a logical and systematic matter. I like to think of this as "divide and conquer." Underlevers okay, guides okay. It's got to be the wire. Logical.

Remove the dampers and place them in order so they will not get mixed. If you do not have a damper rack, punching a series of holes in the top of a cardboard box is a simple way to store the damper heads safely. Remove the guide rails, making sure not to mix the screws. It's a personal fetish of mine to put the screws back into their respective holes until reinstallation.

There are several ways to remove the old bushings: steaming, soaking, wallpaper remover – we all have our favorites. My method is a bucket of warm water with detergent. I scrub the rails with a scrubbing brush and leave for 15 minutes. The bushings will just push out nice and clean. Rescrub to remove any residual glue, dry with some cloths, leave overnight to dry completely, and the rails will look new.

Select the correct thickness and width of bushing cloth, and rebush. Remember to tear the bushing cloth so the sides are a little ragged. This will give you a tighter butt joint. This is definitely a place for hot hide glue. Be sparing; you do not want it to wick into the bushing. This method will make it easy for the next person to do the same repair.

After the glue has dried, I prefer to size the bushings in the following manner: Wet each bushing with 50 percent alcohol, 50 percent water. Many damper wires are .0725" diameter, so if you insert a .075" bridge pin and leave overnight to dry, you will have a bushing with perfect clearance. Using a hairdryer to speed the process is an option, but it can over-size the bushings. As the bushings are drying, make sure that the bridge pins are nice and vertical; you do not want to size the holes off-plumb. Remember, we said to think in vertical lines. Once dry, use the same size bridge pin in a pin vise to burnish a little dry Teflon powder into the bushing cloth. A clean damper wire will slide nice and free, but will have little side play.

With well-traveled and well-spaced underlevers, vertical lift flanges, sized and vertical guide bushings, we have eliminated many of the variables. Bending damper wires to try and solve any of the above will usually make matters worse, not better. Reaming bushings is usually not a good idea. If the end of the damper wire runs freely through the bushing, the bushing is not the problem, but a symptom of incorrectly bent or positioned damper wires.

In the field, if I believe a bushing needs sizing, I remove the damper, heat the end of the damper wire with a disposable lighter, then burnish the bushing with the hot wire. Apply a little Teflon powder and burnish in with the damper wire. Polish the damper wires with a good quality metal polish, being careful not to damage or stain the damper felt.

Raise the damper upstop rail to its highest position and lower the damper lift tray to the lowest position. Reinstall the dampers, making sure that the screws are well backed out and that the lift flange will slide up and down the wire freely. If not, remove the damper and lightly tap the end of the wire on a hardwood block with a small hammer as you rotate the wire between your finger and thumb. This will ensure that the end of the wire is straight. If the wire is nicked, when you try to tighten the screw, the wire will keep going back to the same position. Polish the nick out with #600 wet or dry sandpaper. If the damper wire is badly out of alignment, the lift flange may not slide on the wire – more about that later. We have some interactive things that take place in this area, too.

Finally, make sure the damper guide rail screws are snug. A mobile rail is far from the easiest problem to track down.

Chapter 11

Damper Felts, Heads, & Wires

Before we get started on bending and positioning the damper wires, some comments on felt variety and quality are in order. Working with good material and tools is always more satisfying than having to improvise or fudge.

Trying to attain quiet trichord dampers with poorly cut felt is extremely difficult. In addition, misdrilled agraffes can cause strings to be badly spaced and not level, and this will lead to similar frustrations. Make sure the strings are evenly spaced and level before you start. You will need a stringing hook and a pair of parallel pliers to correct any problems in this area. The important thing is to recognize where the faults lie before diving in and bending, pushing, and poking. This will only make matters worse.

Selecting felt with the right balance of firmness, resilience, and cut is often the key in achieving a good damper replacement job. As you gain experience in working with dampers you will not only become picky about slight tonal bleed and fast shutdown, but you will start to be very conscious about the damper swish as the pedal is depressed.

Damper wedge felt can be purchased with the grain running either vertically or horizontally. There are advantages and drawbacks to both. The horizontal-grain felt tends to be firmer, and is very durable, but it will tend to swish more with the use of the pedal. It can be cut very accurately and is easy to work with. The vertical-grain variety tends to be softer, and as a result, the strings tend to cut into the felt and the indents tend to bunch up. Often this can lead to the center string in the trichords muting at a different time than the outside strings. This type of felt tends to be less durable over the long term. The main advantages are:

1. Less swishing noise with the damper pedal operation.
2. More subtle results with half-peddling. Vertical-grain felt can be useful in recording studios, where the swish can be an irritant. Generally it needs lots of trimming and fitting.

In our shop we use more Yamaha damper felt than other brands. It is resilient, accurately cut and sewn, and cuts cleanly. Renner felt is high quality and similar to Yamaha. Leading American piano makers use good-quality felt, some nicely tapered unichord damper felt, but poor-quality cutting for trichord felt. The sewn flat damper felt quality leaves a bit to be desired. Laoureux (France): A soft vertical-grain felt. The tips of the trichord and bichord wedges are excessively long, always need a lot of careful trimming to get good clearance from the strings. Ideally, the length of the tips should be flush with the bottom of the string with the damper at rest. More on that later. For the right application it is the felt of choice, but not recommended for a damper novice.

To replace the damper felt, do not try to cut or chisel the old felt off. The last thing that you want is to chip the flat surface of the damper head, so soak or steam the old felt off and use a good sharp scraper to get down to the bare wood. Just think for a moment: if the surface is uneven, how can we expect the felt to rest evenly on the strings?

Once you have the damper heads clean and dry, refit them into the piano (see Photo 1). I have found this helpful for several reasons. It is easy to see if the head is parallel with the strings, the left-to-right position of the damper head is easier to see with respect to the strings, as is the clearance of the damper wire with adjacent strings. Finally, it's easy to see if the bottom of the damper head is parallel to the strings from front to back. With the damper wire/lifter screws finger tight, there is no felt to pull the head out of position.

You can quickly get all the bends into the ballpark and this will make things a lot easier later.

As shown in Photo 2, the “tools of the trade” for damper regulation include (from left to right) an alcohol lamp, a bridge pin in a pin vise, shank-knurling pliers, parallel-jaw pliers, wire-bending pliers, a Spurlock felt-cutting jig with razor knife, and modified needle-nose pliers.

Attach a piece of pinblock stock to the stretcher as shown in Photo 2, and make your correcting bends as necessary to make the wires parallel to the sides of the heads and perpendicular to the bottoms of the heads (see Photo 3).

Previously, I mentioned the concept of “divide and conquer.” Let’s just think, for a moment, how many factors can cause the damper head to move to the left or right of center.

1. Badly traveled underlevers (already eliminated).
2. Worn guide bushings (already eliminated).
3. Incorrectly positioned damper head (wire into head should be flush and secure in the slot.) If the head and wire is loose apply a little burnt shellac. Now eliminated.
4. Incorrect wire bends above the guide rail.
5. Incorrect wire bends below the guide rail.

When replacing damper felt, cut the felt to the original dimensions, unless you are sure that changing the length of damper felt will improve the operation. As a side note, I strongly recommend the Spurlock jig in combination with a good sharp utility knife to produce consistently straight cuts, and duplicate the damper angles (see Photo 4). Take a pencil and scribe a line down one side of the rear of the felt, this will ensure you will get the two pieces in same alignment when gluing to the blocks.

Glue the precut felt to the block and be sparing with the glue. Gently tap the end of the felt with your finger so that it is flush with the damper head. Stroke the sides of the damper with your finger and thumb to ensure the felt is parallel with the head. Now press the felt firmly down onto the head. With the trichords and unichords, I like to slide a 6" machinist rule along the bottom of the V to make sure both locks are aligned.

Keep a damp cloth close at hand to keep your fingers clean of glue. I like to glue on the felt, at the piano, and drop the damper wire into the lift flange, and seat the felts into the strings as I proceed.

Now everything is working correctly. The positioning is roughed in, so we can start to work on bending the wires to get those smooth vertical lifts.

Keep these planes firmly fixed in your mind.

1. The damper head is horizontal.
2. The damper wire, going through the bushing is perfectly plumb and vertical. Now it is clear that the top bend is there to fix the position of the damper head above the strings.
3. The wire coming out of the lifter is plumb and vertical. The dogleg bends in the lower wire are there to vertically connect the damper head to the lifting mechanism.

Each time you bend the wire, you are either moving something out of the vertical, or in the case of the head, the horizontal plane. A second bend must be made to compensate to bring the system back into true. The objective is to bend the head to the left or right so that the felt contacts the strings evenly, or you are moving the two vertical planes closer or further apart to maintain unimpeded, smooth vertical lift.

Once you have a mind’s eye picture of what each bend is used for, your thinking will become very simple and clear. Since there is only .002" clearance in the guide rail bushing, (very little movement) any slowing down of the movement of the damper wire is an alarm bell warning you that one of the lower bends is out of the true vertical plane.

Chapter 12

Damper Timing

How important is damper timing, and what are the related problems? Unless there is an obviously leaky, or slow damper, do not expect too much help from the player in diagnosing touch and tone related problems that are caused by dampers; a player may be aware that something is not working properly, but be totally unable to explain the problem. It is, therefore, important for us to understand problems and causes as they influence the player.

Here are just a few typical customer complaints that will help you to start to form a checklist as an aid to troubleshooting, both the customer and the piano:

- When the dampers are timed too early, the touch is heavy, and lacks control; the pianist will complain quite often that they cannot play the piano with control at the *ppp* dynamic. Stop and think about it. When the dampers are starting to lift as soon as the keys are depressed, the player has to overcome the inertia of the keys and the damper mechanism simultaneously. This will also make the bass section feel extremely heavy and unresponsive. Another common complaint is that the tone is muddy or unclear. Dampers timed to lift too early produce almost the same effect as half peddling, a very slight tonal bleed from many strings. The piano will lose its clarity, and will exhibit a slower shut down of the strings. This will happen because the full weight of the damper and underlever in motion will not wedge or seat the felt snugly onto the strings.
- When the damper timing is too late, the center string of the wedge trichords will be slightly muted compared to the outer strings, because the tips of the wedge will not lift high enough to clear the center strings. This can cause the center string to speak with a different voice than the outer two. Also check to make sure that the tips of the dampers are not too long, and are completely clearing the strings at full key dip. If the wedges are too long, remove the action. Then take a fine pencil and draw a line along the tips of the felt, using the under side of the string as a guide. Remove the dampers and carefully trim the tips to length. Very sharp surgical scissors are a must for this task. Trim along the center of your penciled lines. When you reinstall the dampers, the tips of the wedges should be as nearly flush with the bottom of the strings as possible.

The process of regulating dampers falls into two basic phases: adjusting the lift timing to the keys and pedal, and adjusting the travel by bending the wires. These phases are, of course, interactive. The lift timing cannot be set until the travel is has been adjusted; and the travel cannot be tested until the lift timing has been set. Sound familiar? In Parts II and III of this series, we prepared the backaction and roughly bent the damper wires before the felt was installed. In this article, I have begun by describing the procedure for setting the lift timing, but if the travel is not already close enough, you will have to skip to the second section on wire bending first.

Adjusting the Key Lift Timing

Dampers can be lifted either individually with the keys, or all together with the damper pedal. Either way, the lift should be uniform and timed properly. In order to accomplish this, we start by adjusting the key lift. Underlevers come in two styles: those with capstan adjustment and those without. Adjusting the key lift timing is the same with both types.

1. First raise the damper upstop rail as high as possible. This will enable you to travel the dampers through a greater distance, and make errors easier to spot, as well as regulating a safety margin into your work.

2. Lower the pedal rod dowel so that the underlever tray rests on the dag blocks.
3. Loosen all the damper wire screws and check that the blocks slide freely up and down on all the damper wires. (If not refer to Parts I and III.)
4. On the bench, set the underlever timing jig (see Figure 1) to the height of the key end felts (see Figure 2).
5. With the timing jig in place under the underlevers (see Figure 2), lightly tighten the screws of two end sample natural keys in each section.
6. Next adjust the pedal rod length, so that the tray at rest is 1/8" above the dag blocks. This will ensure enough tray clearance to prevent noise when peddling is aggressive. In the case where the pedal rods are not adjustable, shim the pad on the trap work lever as required, or replace the leather.
7. On the hammers of the sample notes from step 5, draw a horizontal line 7/8", or half the blow distance, down from the strike point. Insert the action in the piano. Check to see that, as the key is depressed, the damper just starts to move as the pencil line becomes parallel with the strike point of the adjacent hammer. Of course, before using this test of the lift timing, the blow distance and hammer line must be set correctly. If the damper begins to lift at the wrong time relative to the hammer lift, readjust the underlever timing jig accordingly, and go back to step 5.
8. When the jig has the proper height setting, put it in place under the underlevers and adjust them all by hand-tightening the damper wire screws. You must check that all the underlevers are firmly in contact with the jig before you start. On the ones that do not contact the jig, back off the capstans until they do.

There are several things to be aware of while performing this adjustment:

- Before tightening the damper wire screws, check to be sure that the dampers rest in their “damping” position on the strings. If some are suspended above the strings, check to make sure that the damper wires are not too long and bottom in the block, a common problem on some Korean instruments.
- Pluck each string as you proceed to make sure the damper is seating correctly on every string.
- Do not press down on the damper head as you are tightening the lifter screws, since this will lead to inaccuracy in the adjustment.
- Tightening the damper wire screws with too much pressure will flex the damper wire and also lead to errors. A damper lift jig as shown, is invaluable and very accurate for this task.
- Alternating between lifting the underlever lightly with your finger, plucking the strings, and lightly tapping down on the top of the underlever, listening for the wooden click of the underlever against the jig, will help set the height perfectly for each note.

Recheck all the keys for consistent lift timing. If all the underlevers are correct and some dampers appear to lift late, the problem will be in the key end felt; indented felt causes late damper lift. Using an Exacto™ knife, slice the lifter felt parallel to the keybed. Then glue in a thin card or paper shim to increase the lifter felt height and correct the timing.

Sometimes the depressions in the felt are caused by compression and not wear, and can be steamed out. Take a damp cloth and use the tip of a clothes iron to “pop” out the depressions caused by the underlevers. Dry iron after to remove moisture and gain stability. You will be surprised how much of the uneven lift problems will disappear.

Adjusting the Pedal Lift – Underlevers With Capstans

Adjusting damper lift so that it is uniform with all the keys is no assurance that the lift will be uniform when using the damper pedal. In damper backactions that have capstan adjustments, once the key lift is adjusted, the pedal adjustment is relatively simple:

1. Roughly adjust all of the capstans for a clearance of 1.5-2 mm between the lifter tray felt and the capstan.
2. Operate the damper peddle in a rapid fluttering motion to observe how well the damper lift is synchronized.
3. Refine the capstan adjustments to obtain an even damper lift.

In summary, the under lever height above the keybed sets the damper timing relative to the key travel; the capstan adjustment sets the evenness of pedal operation.

Adjusting the Pedal Lift – Underlevers Without Capstans

1. Please recall in Part II we discussed that the underlever lift tray felt should be glued only on the back edge.
2. While fluttering the damper pedal as above, notice which dampers lift later than the others.
3. Place paper or thin cardboard under the loose front edge of the lifter felt on the late dampers.
4. If the existing felt is well worn, this adjustment can be a chore, so consider saving yourself some time and replace the felt.

For high performance damper regulation, with or without capstans, we will repeat this whole procedure after the complete regulation of wire bending and string seating.

Bending the Wires – The Upper Bends

The bends at X1 and X2 (see Figure 3) adjust the position of the damper head to the strings. The bend at X2 moves the damper head left and right, the bend at X1 rotates the damper head. These bends are best done by holding the damper head with smooth-jawed parallel pliers while bending with a pair of ground down, long needle nose pliers. I have ground the tips of the jaws down to 1/16" thick and 1/8" wide. The long jaws will enable you to stay parallel to the damper head as you make the bends. It is important that the damper wire below the bends be parallel to the side of the damper head. The damper head can be moved to the left or right, and rotated, by increasing or decreasing the bends at X1 and X2 until the damper head is exactly centered on the strings.

Remember, each time you make one bend, an equal but opposite bend must be made to keep the flat side of the head parallel to the length of the wire. Each time you make a small correction of these bends, hold the flat side of the damper block firmly on the stretcher, and check that the lower bends are parallel with the stretcher (see Photos 2 and 3 in chapter 3). Reinstall the damper and finger tighten the screw, pluck the strings, actuate the damper and recheck several times. When all three strings sound the same when plucking, the damper head position is correctly set to the strings.

The Lower Bends

These bends (Y and Z in Figure 4) adjust the alignment of the damper wires from the holes in the underlever blocks to the damper guide rail bushings. Bend Z will have a great effect on the fit of the wire in the block, and bend Y will affect the travel of the wire through the guide rail bushing. Adjust the bend Z so that the block is free to travel up and down the damper wire when the screw is loose. Remove the damper, and adjust bend Y so that wire segments B and C are parallel. Finger tighten the screw. Now check that the wire is traveling freely through the guide

rail bushing. Fine tune bends Y and Z until there is complete freedom of operation, and the head does not travel left or right when lifted.

All four bends in the damper wire are interactive; changing any one will require readjusting the others. Fine damper regulating entails repeating the wire bending steps over and over, making finer and finer adjustments, until the function of every damper is uniform.

Now reinsert the underlever height jig, which is still set to correct timing height, and fully tighten the damper wire screws with the underlevers resting on the jig. Tightening the screws will cause many of the damper wires to rotate in the blocks, and the damper heads will twist as they lift off the strings. Using a pair of heavy pliers to grip the damper wire as it leaves the block, rotate the wire in the opposite direction of the damper head twist. Support the block with your other hand while rotating the wire to avoid stressing the underlever center pins. Keep fluttering the pedal as you proceed to make sure there is no rotational movement of the heads. Recheck pedal timing lift, and adjust as required.

Front-to-Rear Timing Lift

Now is the time to check that the front and the rear of the dampers are lifting off the strings evenly. Again, rapidly fluttering the pedal will show the slightest discrepancy. Uneven lift can be corrected in two ways:

- Holding the damper head firmly between your thumb and forefinger, raise the damper head a little and bend back or forward in line with the string. This should be done with a light rocking motion, taking great care to not tip the head to the left or the right.
- Remove the damper, and lightly place the face of the damper on the stretcher. Then spring the wire a little in the desired direction.

I prefer the second method since it gives better control of fine adjustments, but I frequently use the first method for minor adjustments on routine service calls.

When all of the above adjustments have been made, it is time to test the job. Flutter the pedal and watch the dampers move: they should all move as one. The dampers at rest on the strings should be evenly spaced. Depress the pedal fully (the upstop rail is still set high and will allow greater-than-normal damper lift). At the top of the damper lift, the damper heads should also be evenly spaced. Repeat adjustment steps as required.

Chapter 13

Damper Upstop Rail and Sostenuto

Adjusting the Damper Upstop Rail

When all the other damper adjustments are performed to your satisfaction, it's time to set the upstop rail so that there is 1/16" or less of free travel of the damper head at a firm full depression of all keys. Nothing is more annoying to a pianist than feeling the bump to the back of the key on a forte blow caused by too high an upstop rail. If the rail is too low, the action will feel "spongy." The pianist will have difficulty describing this problem to you, so be on your guard. It only takes about 10 minutes to make the damper upstop adjustment.

With the upstop rail in its raised position, measure how much excess damper travel that you have on at least two sample notes. Then mark a pencil line on the belly rail at the top of the rail for a guide behind the damper wires of the samples. Loosen the upstop rail screws, and using the marks for reference, lower the rail a little more than the measured excess travel measurement.

Tighten the screws so there is just enough friction to hold the rail in position, but so that it can be moved with slight pressure. Replace the action and firmly press down on a handful of keys in each section (body weight). This will cause the rail to slide up with the force of the keys lifting the underlevers. Remove the action and tighten screws. Recheck with the action in and adjust as necessary.

Side Note: Some older models of Baldwin grands have pins installed through the upstop rail and into the belly rail, so that the rail will not move. These pins need to be removed with a pair of needle nose pliers before the rail can be adjusted. You will need a flashlight to find them. This adjustment is probably the most neglected of all regulation adjustments, yet it has one of the most notable effects on the feel of the keyboard. I believe that it is important enough to check every time a piano is tuned. It only takes seconds to press a few keys and lift a damper to feel for the correct lost motion. This is a good habit to start.

Adjusting the Sostenuto

There are so many different sostenuto systems, each having its own quirks, that we can only discuss the adjustment procedure in general terms. The quality of materials used in the sostenuto system will also vary greatly from piano to piano. However, most sostenuto brackets have some kind of screw and slot arrangement to adjust the height of the brackets, and are easy to adjust. Adjusting the front to rear distance is another story. Some brackets, in Baldwin pianos for instance, have a setscrew adjustment underneath. If there is any doubt of the bracket type, it is worthwhile removing a bracket to check. Asian pianos usually rely on bending the bracket to make this adjustment.

Steinway has the sostenuto rod mounted on brackets attached to the action stack. This type has screws in slots to adjust the rod front to rear, but the bracket must be bent to correct the height. With this arrangement the relationship of the rod to the sostenuto tabs is not visible with the action in place, so a Steinway gauge is needed to make an accurate adjustment. Since the position of the action is not determined by the dag blocks, the cheek blocks must be in place to check the adjustment.

Another type of mounting system that is very solid has brass brackets with a post threaded directly into belly rail. This arrangement is found in such pianos as old Mason and Hamlin

grands. The only way to adjust these is to completely remove the sostenuto rod and turn the post in or out one complete revolution. The posts of these brackets usually have a machine thread, so one complete turn is one millimeter or less. The height is factory set, so if there is a problem with the underlever block height with respect to the sostenuto rod and damper timing, the thickness of the damper tray felt or key end felt will be the cause of problems. I have encountered problems with this arrangement because some previous tech has replaced the damper tray felt, the key end felt, or the keyframe backrail felt with the wrong material.

The common factors of all systems are as follows, and they should be carved in stone:

- The sostenuto rod blade must be at 45 degrees at rest. In this configuration, the tip of the blade will protrude no farther than the body of the sostenuto rod. Check this with a small machinist set square.
- The blade must be horizontal at full pedal depression.
- The full travel of the pedal should only move the rod through 45 degrees. Again you will find as many styles of pedal adjustments as manufacturers. This is a part of what makes our craft so interesting. Some pianos have a capstan screw under the trapwork to limit the pedal travel; some have capstans or shims under the sostenuto pitman. Regardless of the arrangement, the adjustment must be made to establish the 45 degrees of sostenuto rod rotation. Check the condition of the felt in the pedal box, since badly worn felt there can make the above parameters impossible to achieve.

The sostenuto pedal is normally used to hold the damper open on a single note or group of notes in a passage of music. It is imperative that all parts move freely and quickly, since it is needed to engage the tab in a fraction of a second. Special attention to trap work springs is a must.

Diagnosing Sostenuto Problems

1. Visually inspect the sostenuto operation to ensure rapid movement of the components, and the 45-degree rotation of the sostenuto rod.
2. Install the action and cheek blocks.
3. Rapidly depress the pedal and look for any movement of the damper heads. If the rod is just clipping any of the tabs you will observe a slight damper blink. Mark the offending damper heads with chalk.
4. Depress the damper pedal full travel.
5. Engage the sostenuto pedal.
6. Release the damper pedal; all dampers should stay up in an even line.
7. Slowly release the sostenuto pedal. In a perfect world all dampers will drop simultaneously when the pedal has been released half way. Attaining this perfection takes time.
8. Press the sostenuto pedal followed by the damper pedal. Then release the damper pedal only, and check that no dampers are hanging up. This checking is to ensure that all tabs are striking the under side of the rod and the tab springs are working.

Correcting Sostenuto Problems

- Check to see that all tabs are in a straight line using a straight edge. If they are not, first check to see that the underlevers are level and timed correctly; see above to correct underlever alignment.

- If the underlevers are correct and there are tabs out of line, the height of the individual tabs must be changed. To lower a tab, travel paper is inserted on the top of the tab to bring it into line. To raise the tab, use a sharp razor knife to slice a thin sliver of felt off the tab stop felt.
- If any tabs are too far forward or back, recheck the wire bending; in most cases rebending the wire will solve the problem.
- A tab that is too long can be sanded back into line; a short tab needs to be replaced.
- Bending the wire a little forward as it leaves the underlever block is a Fudge Factor 101 option, but the timing and complete damper operation has to be rechecked.

Adjust the height of the blade to be in line with the centerline of the tab tips with the damper pedal depressed. Adjust the front to rear adjustment for 1.5-2mm clearance from the tip of the blade to the tip of the tab.

Chapter 14

Damper Tools & Jigs

In previous chapters, I have mentioned several tools and jigs that facilitate the installation and regulation of grand dampers. In this chapter we will discuss these devices in more detail, so that those who wish to try the methods outlined here can do so with the proper equipment. Installing and regulating dampers so that they look and respond like a factory job is all but impossible without the aid of good tools and jigs.

Most production facilities have dedicated tools and jigs for these purposes, so that semi-skilled workers can perform difficult tasks with precision and consistency. Often these factory jigs are made to be specific for a particular make and model of piano. Our challenge is to adapt these tools so that they will produce the same results on a wide variety of pianos. With this in mind, the tools and jigs listed below are my own variants of what I have seen used in factories.

Damper Timing Jig

The purpose of this jig is to set the bottom of the underlevers in a perfect line and at the correct height to facilitate note-to-note consistency in timing as the dampers are lifted individually by the keys at the half-way point of the key dip. This jig can be made very quickly with a good table saw and drill press (see Figure 1). A small bubble level glued to the dowel with epoxy or gap-filling CA glue is a useful addition if you do a lot of damper work. The only critical dimension on the jig is the one-eighth inch thickness of the lip; since most grand key tails lift very close to one-quarter inch, the one-eighth inch thickness of the lip will automatically set the dampers to begin lifting at one-half of the key dip.

With the action on the workbench, I adjust the screw feet so the lower side of the lip just comes in contact with the damper lift felt at the end of the key. Then, moving the jig underneath the underlevers, I adjust the height of the two end underlevers of a section as samples. Check the samples by sliding in the action, and make any minor corrections to the jig settings if necessary. Then proceed to set the height of the rest of the underlevers in the section.

On some Korean pianos that have adjustable lifter spoons on the ends of the underlevers, I use a two-step procedure:

- Set all bottoms of the underlevers to a uniform height with the jig. The exact height is not important as long as it is within the workable range.
- Then on the bench reset the jig to the key lift felt. Finally, move the jig back into the piano under the spoons and bend the spoons to the height of the jig shelf. This will ensure that all the spoons are mating with the key end felt at a consistent angle.

Damper Wire Bending Jig

This device is easy to make out of three-eighths inch maple stock and half-inch high-density fiberboard (see Figure 2). Tape the jig to the stretcher as shown in Chapter 11. With the damper head laid flat on top of the jig and aligned with line A, lines B and C mark the positions of the two offset bends on the damper wire. Line B marks bend Y described in Part IV, Figure 4, and line C marks bend Z. With the damper head laid vertically on the top of the jig, the wire may be bent perpendicular by reference to line D.

This jig doubles as a bench hammer line jig. Just use it upside down and eyeball the hammer line with the top of the board.

Needle Nose Top Bend Pliers

These pliers are used to make the bends labeled X₁ and X₂ in Part IV, Figure 3. Starting with a pair of electronic technician's long-nose pliers, grind the tips to 3/32" thick x 1/8" wide (see Figure 3). With the damper head held firmly in smooth-jawed parallel pliers, the upper bends of the damper wire are easy to make.

Underlever Lead Crimping Pliers

Using these custom made pliers (see Figure 4), a complete set of underlever leads can be crimped within an hour. The leads can be crimped without removing the dampers or underlevers. The tool is made from a pair of Yamaha electric shank bending pliers.

Remove the elements from the stock pliers, and grind down the head of the jaws, so that you end up with two one-eighth inch thick tongues extending upward one-fourth inch, similar to the jaws of a pair of Renner grand key easing pliers. Drill a hole on the inside of each tongue to accept a 3/32" Phillips round head machine screw. The three lines scored on the top of the jaws reference the depth that the jaws must be inserted to crimp leads in three positions common to many makes of pianos.

Even when underlever leads are not actively clicking, they can contribute subtle noise to the tone of a piano that we often dismiss as "action noise." I am continually amazed at how much the tone of many pianos can be cleaned up by simply squeezing the leads. After buying the pliers, and paying the machinist, these are easily the most expensive pair of pliers that I own, but they have paid for themselves many times over.

Chapter 15

Voicing

Most texts that discuss voicing pianos open with a statement such as the following: “The piano should first be finely regulated and well tuned.” Far be it from me to argue with this truism – at least so early in this article. However, the statement is overly simplistic; there are quite a few other things that need to be checked and addressed, before the voicing tools come out of the toolbox. In fact, many of the following items should be done before tuning, since they have a great impact on the ability of the piano to accept a quality tuning. Frequently we hear complaints about isolated notes that speak with a different voice than other notes within the same register, or about a particular register that does not balance with the rest of the piano.

There are many factors other than hammer voicing that can contribute to these conditions. Power loss, and low sustain can be caused by loose bridge pins; faulty string termination can add unwanted noises, metallic rattles, false beats, and many other maladies. The key to any good performance preparation is to identify which problems are hammer related, and which are mechanically related, and rectifying the problems before proceeding.

I would like to share my collection of experiences that has evolved into a checklist, with remedies that are done prior to resorting to any voicing techniques.

Many supposed voicing problems can be traced back to several sources:

- Hammer flanges poorly pinned; hammers that are poorly fit to the strings, and/or badly shaped, causing beats from poor string phasing.
- Mechanical inefficiencies that are associated with the strings and their termination points.
- Lack of crown in the soundboard, or bridge failure resulting in weak tone and poor sustain.

It is prudent to check for crown on the board with the basic string test, and bearing over the bridge with a bearing gauge, before wasting many hours trying to achieve a performance regulation and voicing.

Double check the regulation and question how efficiently the action will transfer energy from the key to the hammers and strings. Let off and key frame bedding are high on the list as major sources of energy loss. Consistent action response from note to note is essential. Once one begins to see the interactive nature of all aspects of piano work, there is no turning back: read on and you will soon start thinking in terms of interactive regulation and voicing.

Hammer Flange Pinning

Let us start by examining poor center pinning in the hammer flange. The standard field test is to look for 4-5 swings of the hammer, or 4 gm of friction as measured with a spring gauge (see Figures 1 and 2). With practice hammer flange pinning tightness can be tested aurally. Long before the characteristic “woody” click caused by loose pinning, you can hear a loss of power and a significant drop in sustain. I feel so strongly about hammer flange pinning that on major regulation and voicing jobs, I quickly remove all treble hammer shanks and check each flange. This test usually results in lots of repinning, so do yourself a favor and get a set of Don Mannino’s reaming and burnishing tools. They will help you perform this task quickly and accurately. Table 1 shows how pinning tightness and hammer/string fit affect the amplitude and sustain of the first four partials of B5.

The results were obtained using a Reyburn CyberTuner Pianalyzer™ and an external microphone placed 2 in. from the bridge pins. A constant velocity drop weight device was used to strike the key and five samples were taken and averaged for each test. In the first test the hammer flange was loose and allowed 10 swings of the hammer. In the second test the center was repinned to allow just four swings. In the third test the four-swing hammer was correctly fit to the strings.

Table 1 shows how the tone quality of a note can be changed without using any traditional voicing techniques. In this case the fit of the hammer to the string seemed fine with the loose pinning, but repinning changed it a little. Once friction decreases beyond a certain point, the knuckle tends to bounce on the repetition lever on the upward stroke, dissipating much of its energy within the flange bushing and at the knuckle/repetition lever contact point. When the pinning is loose enough to allow more than 5 swings, the travel of the hammer and shank become much more erratic and cause a larger variation in the test results.

Here is a quick test of the tightness and consistency of the hammer flange pinning:

1. Holding the action upside down with the hammers toward the floor, rock the action frame with your knees, and observe the swinging hammers. The loose or tight ones will be obvious. If the quality of pinning is excellent, the hammers will swing very nicely in unison.
2. With the action upright, balance the keyframe at the balance rail on the front edge of the keybed. Slowly depress the keys, just firmly enough for the hammers to go into check. Observe the flight of the hammers: the same key pressure will make the loose hammer flanges travel much further in height than the correctly pinned flanges. You will also notice much more bounce as the shank returns to the rest felt. By using one hand to depress a group of naturals, and the other hand on a group of sharps, you will soon get the feel and sight of poor center pins.

Center pinning in the treble section of the piano is critical for note-to-note consistency. This register leaves very little room for errors. It is a heavily used part of the keyboard, and most melodies are played there, so problems soon become very noticeable. Unless pinning is addressed, fine voicing is all but impossible. Pianists will complain of having control difficulties when tonally shading a passage. Traditional voicing techniques will not solve the problem; in fact it will usually make matters worse.

So take my advice: check, check, and check again before proceeding. In “Interactive Grand Regulation” we stressed the importance of pinning and how it affects let off, repetition, hammer rise, and checking, and how interactive they all are. Now add interactive voicing to the list. Next time you need to repin a flange, make a point of listening carefully to the tone and the sustain before and after pinning, and compare with adjacent notes. Do not be surprised if you now feel the need to repin the good note. Take heart, as this will start you on the trek to a different kind of listening. Soon you will be able to tell the difference aurally.

After center pinning, you will need to go back and recheck all regulation parameters, especially let off, drop, and repetition spring tension. Don’t be surprised if repinning causes the hammer to block, drop disappears, or

Forward Duplex Area

Over time and with frequent tunings, a treble string can start to wear grooves in the capo and counter-bearing bars. When the grooves get deep enough, the string starts to rattle around inside these grooves causing what we affectionately call V-bar or capo noise. The sizzling sound is often accompanied by a certain amount of false beating. By placing a finger on the forward duplex section, the noise can be decreased or eliminated, but the note is deadened, and the

sustain is very short. Needling the hammer may mask some of the problem, but as far as singing tone and power are concerned, needling will make matters worse, not better. The finger test is ideal to identify the source of the problem. Take a blunt screwdriver and move the string out of the groove. If moving the string eliminates the sizzle, this will be conclusive proof that the string groove was the cause of noise and tonal loss.

There are several remedies for string noise in the forward duplex area listed in order of effectiveness:

1. Drop the tension of six strings at a time and feed plumbers emery tape with the grit side up between the strings and the capo bar, then shoe-shine the bar from the top to remove the grooves (see Figure 1). Also remove the grooves from the counter-bearing bar. Lubricate the bars with paraffin wax and re-tension the strings. The paraffin will greatly improve string rendering and make tuning much easier. On a performance piano that is tuned frequently, this should probably be done after about five to six years along with restringing the treble section. I consider this the only lasting treatment. However, many customers will not pay the price for the full treatment.
2. Move the string left and right with a blunt screwdriver, out and over the groove. This will burnish the corners off the groove and reduce the noise. Rarely have I broken a string, but be prepared because it does happen. If the customer is not willing to do the procedure above, then he/she is faced with either living with the noise or accepting the risk of string breakage. I reserve this screwdriver technique for a few isolated strings.
3. Another method to achieve the same result, is to use a string spacer, just behind the capo bar, working upward from inside the action cavity. Tap the side of the string spacer with a small hammer to push all three strings of a unison out of the grooves, first left and then right. I usually do this two or three times in each direction. It will burnish the edges off the grooves quite nicely. This can be used to quickly clean up a whole section in 10 to 15 minutes work, and be a huge improvement. Caution: do not try this on the day of a concert, it can have a big effect on tuning stability.
4. This is a relatively low-cost treatment, for a significant gain: put a little dab of white glue on the forward duplex section of a string to quiet the noise. There will be no gain in power or sustain, but it will mask the noise. Reserve this for isolated strings, or a quick temporary fix. This is a good remedy for stage pianos, since it will not destabilize the tuning.

I frequently run across pianos with the forward duplex taped off. To me this is an absolute no-no. Taping treats the symptom and not the problem. It robs the piano of much of its power, sustain, and color, and is a clear signature of an amateur technician.

Bridges, Pins & Things

This is often an area of greater losses, power, and sustain than the forward duplex. The bridge is also the primary cause of false beats, and the condition of the bridge also has a big effect on tuning stability. Loose bridge pins are the prime offenders; not just the pins with obvious cracks around them, but also pins that look perfect to the naked eye, but are loose nevertheless.

To test for loose bridge pins, find a weak and false string, take a large blunt screwdriver, press firmly down on the bridge pin, and play the note (see Figure 2). If there is a big improvement in power, sustain, and cleanliness of tone, that is a good indication that the pin is loose.

There are several possible solutions to the problem:

- Tap the bridge pin with a punch. (I have a made a special brass set punch dedicated to this task.) On most pianos, this is temporary fix at best. If the pin was loose, a few major humidity swings will cause the problem to return. On some older pianos, years of tuning can cause the string to wear a groove into the side of the bridge pin. The groove can allow the string to ride up off the bridge. Tapping the pin will drag the string down onto the bridge and move it out of the groove. With the string in contact with the bridge, falseness can clear up, and power and sustain can improve. If the pin was grooved and it moved down a little, the fix may be semi-permanent. In new pianos, where the pin was not seated at the bottom of the hole, it can also be a semi-permanent fix.
- Ideally, drop the tension and move the string out of the way. Remove the bridge pin and swab the hole with CA glue or five-minute epoxy. Heating the epoxy with a hair drier will make it run like water. Reinstall the pin and bring the string back up to tension. This is a much more permanent solution. In some circles epoxy or CA glue treatment of bridge pins is viewed with some controversy. Good judgment needs to be used to determine whether this is a proper repair for a particular piano. I personally have no problem with either of the above solutions, but I do have a problem with leaving false beats that can be easily cured or minimized. To me, it is a repairable fault just like a sticky key, and it needs attention.
- When recapping a bridge or otherwise installing new bridge pins, I am in the habit of using CA glue as a driving fluid. Early indications have shown this to improve both power and sustain. I believe the glue forms a barrier that protects the hole and pin from the ravages of humidity swings. Caution: two drops per pin from a small hypo are all it takes. Mechanical security of all the component parts of the bridge is critical, so check very carefully.

String Contamination

The strings need to be clean and free from rust and contamination. I favor two methods of cleaning. Light cleaning: Use a white Scotch-Brite™ pad and burnish the strings. For a more aggressive clean up, use a string eraser. With a sharp knife form a chisel point on one end of the eraser, and wedge it between the strings to get most of the corrosion and dirt from the sides and undersides of the strings. Use the squared off end to burnish the top side of the strings. Remember strings need to be clean to sound clean.

Lift & Seat All Strings

After all bridge work has been completed, to make sure all strings are nicely seated, I find that burnishing the strings down to the bridge with a hammer shank at the angle of the bridge pins will settle the string nicely. Not a lot of pressure is needed, so proceed with caution, and keep listening for results. On new and restrung pianos, it seems that pulling the tuning 10 cents sharp, then burnishing all lengths, will give a little extra tuning stability, and drop the strings back to pitch. It helps form a more stable curve to the strings around the bridge pins and gives a tighter mechanical connection. Lightly does it.

At the forward end, burnishing with a hammer shank from inside the action cavity gives excellent results. At the agraffe end, massage with a stringing hook, so the string is flexed upward just a little. This will give the string a solid mechanical connection to the agraffe.

Lift all strings. Lifting all strings at the forward termination points will help control the amount of leakage past the termination point. Just enough lift to flex the string is all that is needed, remember you are not trying to bend the wire. Lightly stroke back and forth a few times with the stringing hook using a little upwards pressure.

Hammer to String Mating

Being observant can yield many clues. Are the hammers evenly spaced? Are there any hammers clearly leaning to the left or right with respect to their neighbors? Are all hammers correctly traveled? In order to thoroughly evaluate piano tone, ears, eyes, and brain must all be in good operating condition.

Here is a standard checklist for hammer/string function:

1. Hammer travel. It is important that the hammer travels in a straight vertical line to transfer the maximum amount of energy to each of the strings. After traveling some hammer shanks, burn-in may be required to correct the changes. This ensures that the hammer is traveling in as straight a line as possible. If more than a few degrees of shank burn-in is needed, pull the hammer and reglue it. It will just wander back with a few humidity swings if you don't.
2. Hammer shape at the strike point. Resting a straight edge across the strike points will show the poorly shaped hammers, as will looking at the string grooves on the hammer surface. Reshape the hammers to correct. To fully check hammer-to-string fitting, I use a thick strip of cloth resting between the jacks and the knuckles, slowly pressing the note will cause the hammer to block against the strings. Since the damper is raised, the strings can be plucked to check for fitting. Use a sharp pencil to mark the muted strings of a unison, it will save a lot of time sliding the action in and out of the drawer. Then just file off your pencil lines. Simultaneously, I also check for string level, and determine if fit or level is the problem.
3. String leveling. Great care should be used with the stringing hook. Massaging the strings into position will give better results than just pulling upward, aggressive pulling on the string with a hook can make matters worse, not better. Joe Goss, of Mother Goose Tools™, makes a neat level gauge. Using the gauge to attain level strings, I remove the action, prop the damper pedal down, and massage the strings with a hammer shank from inside the action cavity as I pluck. It is a quick and effective way of doing this task.

Any of the above maladies will create phasing problems between the strings of a unison. The first struck string will sound at a much louder volume and give a completely different partial spectrum than the last.

If all of the above steps are performed correctly, less time with needles and hardeners will be necessary, and traditional voicing methods will produce better, more stable results.

Summary

Here is my fast checklist to prepare a piano for voicing:

1. Tap all bridge pins with pin punch or hammer shank. A light tap with 4-oz hammer is all it takes.
2. Massage all strings with a hammer shank on the speaking and duplex side of the bridge pins.
3. Evaluate forward duplex termination noise and correct any problems.
4. Lift all strings.
5. Level all strings.
6. Check center pinning.
7. Check keyframe bedding.
8. Check regulation – particularly the relationships between the knuckle, the repetition lever, and the jack.
9. Mate hammers to strings.

10. Fine tune, listening carefully for any signs of falseness, or strange noises. Clean up as you go.

If you follow this procedure, you will be surprised how clean the piano will sound, and how much easier the tuning will become. Let's face it: who enjoys tuning or playing a piano that is full of false tones? As an added bonus, with all termination points solid, tuning will last longer. You will also find that the amount of hammer crown voicing needed to remove unwanted noises will be reduced.