

Chapter 5

Regulating

“We are Sancho Panzas to pianistic Don Quixotes.”
—Benjamin McKlveen, RPT

In pianos, the term *regulation* applies to adjusting the functioning of the mechanism, which consists of the action, keyboard, damper system, and pedals. The mechanism is regulated by repositioning, aligning, or shimming parts, by turning their regulating screws or buttons, and/or by altering the thickness of various felts and leathers.

Every piano should be regulated periodically. In moderately used pianos, the action should be regulated every few years, and the keyboard as part of every other action regulation. Regulate the pedals as part of every tuning. The damper mechanism remains in regulation for a long time, but should be regulated if the initial regulation was poor or when the damper system is rebuilt. If the piano is used heavily or is exposed to adverse climate conditions, check its regulation as part of each tuning.

Although this chapter is presented in sections that focus on one subsystem at a time (keyboard, action, dampers, pedals), I suggest reading the entire chapter first to get a sense of how these systems interact with each other. For specifications and procedures specific to the piano you are regulating, consult the manufacturer’s service manual.

Protection

When you work in a customer’s home, be careful with the furniture, rugs, and carpets, and make sure you do not damage the piano case. Never put your tools or parts on a finished surface without padding it with cloth, felt, or a mover’s blanket. Always put a sheet or mover’s blanket under the keyboard or action on the floor (the lubricants on the bottom of the key frame could transfer to the floor and get contaminated). Remove all fragile objects from the

Recommendations

- **Condition:** Parts must be in good condition or the regulation will not hold.
 - **Clean and lubricate** all contact points.
 - **Do not realign** worn action parts unless they rub against each other.
 - **Light:** Use a dispersed, strong source of light for general work; shine a pointed light at an angle when shadows help you determine distances; e.g., when regulating let off in the piano.
 - Use **visual** and **tactile** checks.
- If you need to remove any parts:
- **Mark the numbering** and label the parts (with masking tape, for example) before removing them.
 - **Take notes** and photos that will help you realign the parts later.
 - **Don’t mix wood screws**, even when they appear to be the same—small imperfections and burrs can wear out the wood.

piano and near it, and be sure you have enough space to comfortably remove the keyboard and action. Put a mover’s blanket under the piano bench to protect the floor. If you need to perform any repairs during the regulation, turn to Chapter 7, “Repairs.”

I suggest wearing thin cotton inspection gloves for most piano work. The gloves not only protect your skin, but also protect delicate parts in the action, keyboard, and dampers from the oily acids and moisture on your skin. Tip: When the gloves get dirty, and only if they are not contaminated with chemicals, turn them inside out to double their use time. Avoid touching uncoated metal parts, such as strings and springs, with bare hands.²³³

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Christopher Brown, RPT, available from TPR Tools LLC (www.tprtools.com). Not only does this device allow you to reproduce the curvature of the key bed, it is also a comprehensive jig for regulating the action, hanging hammers, adjusting shank travel, and more (see Figure 263).

Guide Notes

Guide notes are the notes you measure and regulate first to get a quick idea of the regulation in different sections of the piano. Usually the end notes in each section and a middle note in long sections, these notes provide references for observing and regulating the notes between them. For example, if you first set the blow distance (hammer height at rest) on guide hammers in a grand action, you can visually adjust the hammers to form a line between them. Guide notes are also useful in rebuilding: guide hammers (hammers on guide notes), for example, act as templates for gluing the rest of the hammers (Figure 594 on page 392).

Guide notes allow you to quickly test multiple interrelated regulation steps in several areas of the keyboard. In verticals, for example, regulating the key dip, let off, blow distance, and jack gap of a few guide notes may reveal discrepancies in aftertouch between the bass and treble in just minutes.

If guide notes require excessive turning of regulating screws and buttons or you run out of range of adjustment, check to ensure that the action rails have not moved, the brackets are intact and fastened down firmly, and the action geometry is satisfactory (see Chapter 9, “Touch, Geometry, Playability” on page 273). In a grand piano, if hammers block on strings or drop screws bind on the pin-block, suspect expanding action brackets (page 149).

Friction

Since every part of the piano mechanism is affected by friction, this is one of the most important—and most overlooked—aspects of piano regulation. The main sources of friction in the mechanism are:

- **Metal and felt** parts (e.g., between center pins or key pins and their bushings)
- **Metal and wood** (e.g., between key frame glides and key bed)
- **Wood and felt or leather** (e.g., between jacks and knuckles; key end felts and damper underlevers)
- **Wood and wood** (e.g., between key frame and key bed).

Addressing friction between strings and their bearings is discussed in “Lubricating String Bearings” on page 113.

Friction is a huge factor in the performance of the action, keyboard, and dampers. **Excessive friction** causes premature wear and noises throughout the piano, and negatively affects touchweight and the piano’s overall playability. **Too little friction**, on the other hand, makes the action feel bouncy, and may cause the hammers to bobble (double and triple repeat) on hard blows (see sidebar, “Myth/Truth.”).

Inconsistent friction makes the action feel uneven. Evening it out is a prerequisite for adjusting touchweight and improving playability.

Friction affects not only the performance of action parts but also their **wear**. Keeping friction within its normal range increases the life span of key pins, bushings, knuckles, key end felts, key frame glides, and trapwork leathers. Friction increases as parts wear out and felts and leathers harden. The increase is especially pronounced between the jack and the knuckle, which need to be lubricated periodically. Center pins tend to bind in their felt bushings due to the oxidation of the pins and the swelling of the felt, especially in high-humidity climates. Lowering friction is discussed below. If ends of center pins are green, see “Verdigris” on page 246.

Myth:

All action centers should have as little friction as possible without looseness.

Truth:

Until recently this view has been widely held, even among physicists (see, for example, W.V. McFerrin, *The Piano: Its Acoustics*, p. 153), but friction in fact acts as a shock absorber, and provides the needed amount of mechanical damping that reduces the unwanted movement of action parts. Without friction, shanks and wippens would continue bouncing for a prolonged period of time, during which repetition would be unpredictable and the hammer might hit the strings several times.

Center pin friction decreases during the heating season due to low humidity.²³⁹ This may be accompanied by clicking noises caused by loose center pins or key pins. These are separate problems that should be addressed before the piano is regulated.

Assessing Friction

To assess the overall friction, quickly measure downweight and upweight on a few keys, and calculate friction (see “Static Touchweight (TW)” on page 276). If the friction is outside the ranges in the “Touchweight Worksheet” on page 277, you will need to reduce or increase it. Both cases are discussed below.

If the piano is in a humid climate and has not been played for a long time, playing it will tend to somewhat reduce friction. Move the shanks and wippens through their range of motion a few times before measuring friction.

²³⁸ The Grandwork™ Regulation Station is protected under U.S. patent no. 8,227,674 (2012).

²³⁹ In low humidity the bushing holes actually shrink somewhat, and tighten around the bushing cloth; as the wood shrinks, the bushing holes become elliptical, shrinking in diameter across the grain.

Traditional center pins are made of German silver and are not plated. The plated center pins used in newer Asian pianos exhibit a reverse trend: Moving the parts causes center pin friction to *increase*, sometimes so much that the parts seize up. The solution is to repin or rebush the parts (page 244).

Measuring Center Pin Friction

Center pins contribute significantly to the overall friction in the action—for an action to feel “fast,” their friction should be toward the low end of the ranges listed in Table 5. Center pin friction also contributes to the evenness of action response, and should be measured precisely when diagnosing friction issues and repinning or rebushing action parts.

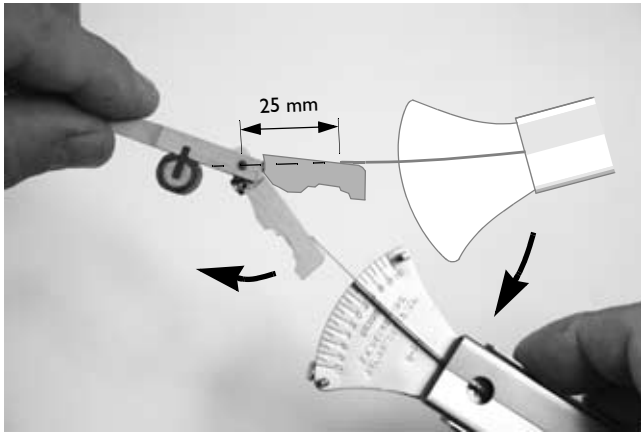


Figure 264 Measuring center pin friction of a shank flange with a 10 gram tension gauge. The photograph is taken from above.

The most precise way to measure center pin friction is with a 10-gram spring tension gauge (for less formal methods, see sidebar, “Other Ways to Test Center Pin Friction”). Hold the part (e.g., a hammer shank or wippen) so the center pin is vertical, to eliminate the effects of gravity. Push the part you are measuring (e.g., the flange) with the tip of the gram gauge probe at a spot that is as far from the center pin as indicated in Table 5. Hold the gauge lightly and follow the rotation of the part with it (see Figure 264). To avoid a false high reading, keep the probe pointed at the center pin.²⁴⁰ Don’t slide the probe, and don’t let it bind on grooves or ridges—temporarily affix a piece of tape to the flange, if necessary. Read the highest value displayed and compare it with the values in Table 5.

Because you’re measuring the force needed to overcome the resistance to circular motion, you really are measuring torque. The advantage of expressing center pin friction as torque is that you can compare measurements taken at different distances from the center pin. WNG, for example, measures flanges at 20 mm,²⁴¹ while Steinway’s

²⁴⁰ Gregory Graham provides instructions for building a jig that maintains the angle between the gauge and the part. Search <http://my.ptg.org> for “Gram Gage Jig Instructions.”

Table 5: Acceptable Friction Values for Center Pins

Part	Distance from center pin	Friction (g)	Torque (mm-g)
Hammer shank flange	25 mm	1.5–4.0	37–100
Repetition lever (spring disengaged)	Buckskin at drop screw (58 mm)	2.0–6.0	120–360
Wippen flange	25 mm	1.5–4.0	37–100
Underlever flange	25 mm	1.0–4.0	25–100
Underlever top flange	25 mm	1.0–4.0	25–100
Sostenuto tab (spring disengaged)	Tip (15 mm)	1.0–6.0	15–90
Jack (spring disengaged)	Tip of tender (25 mm)	0.5–4.0	12–100
Vertical damper lever	(ca. 50 mm)	1.0–8.0	50–400

specifications assume approximately 32 mm. To calculate torque, use the following formula:

$$31 \quad \text{Torque} = \text{Force} \times \text{Distance}$$

At the radius of 25 mm, for example, a measurement of 4 grams indicates a torque of 100 mm-grams:

$$32 \quad 25 \times 4 = 100$$

The Torque column in Table 5 allows you to compare friction values for different distances.

Conventional wooden parts shrink and swell, and your readings will differ somewhat from season to season. To reduce sideplay, friction may need to be higher in parts with softer bushings, and lower in parts with firmer bushings. Consult the manufacturer’s specifications, if available. Steinway & Sons, for example, recommends torque on the low end of the ranges in Table 5.²⁴²

Repeat the measurement in the opposite direction. If the resistance is off by more than 50 mm-grams, check for debris and microscopic splinters between parts. Just sliding a piece of paper a few times between the parts may help. If it doesn’t, remove the center pin and smooth the bird’s eye (a circular protrusion around the center pin hole) on both sides of the part with a few *light*, circular passes with 1000-grit or finer sandpaper. If the wood is smooth, the center pin itself may turn more smoothly in one direction than the other. Install a new center pin, one half size thicker, as explained in “Repinning Action Parts” on page 244.

Shank Center Pin Friction Affects Tone

High friction in hammer shanks dulls the tone by increasing the amount of time the hammer remains in contact with the strings. Reducing shank friction, aside from making the action perform better, can open up the tone appreciably.

²⁴¹ http://www.wesselnickelndgross.com/media/pdfs/gram_gauge_usage.pdf.

²⁴² Steinway & Sons, *Worldwide Technical Reference Guide*, “Grand Preparation,” p. 21.



Figure 282 Brushing the knuckles with a soft suede brush.

Photo by Allen Wright, RPT



Figure 283 Applying powder lubricant with a cosmetics brush.



Figure 284 Rubbing a powder lubricant onto the knuckles with the top stack tilted forward.

(page 145). This is easiest to do with the top stack removed and tipped forward 90° (Figure 284). Cover the surface under the knuckles with paper towels to catch excess lubricant. Apply the lubricant with a small brush (Figure 283), a pipe cleaner, or by dabbing it on with your finger, wearing cotton gloves (Figure 284). Work it in with the finger or a felt block. If you are in a hurry, use a technique taught by André Oorebeek: work the lubricant into a felt block, support the hammers so the knuckles form a line, and rub the knuckles with the block from one end to the other in each section. Burnish the lubricant with a small spatula or a metal shank (e.g., a screwdriver). Carefully remove and dispose of the paper towels. Combined with the lubrication of other friction points, a powder lubricant will reduce the overall action friction to very low levels (6 to 8 g). For an even greater reduction, you could mask everything but the graphited areas of the repetition levers, and spray them with a dry-film lubricant. Some pianists will then complain that the action doesn't provide enough feedback.

Caution: Wash your hands thoroughly before playing the piano, to avoid spreading the lubricant on the key tops. If the keys get slippery, wash them with alcohol. If the owner or performer still complains, protect the fallboard and the rest of the piano, and mist them with a very small amount of hair spray (don't spray directly).

45 Sluggish or loose wippens: Tilt the top stack forward, as depicted in Figure 284, so that the wippens hang loosely or barely sit on the wippen rail. Move the wippens in groups toward the shanks, and let go. Repeat in the opposite direction. If any wippens return slowly, remove them and measure center pin torque on their flanges. If the torque is high, lubricate them (page 148). Also measure the torque on jack and repetition lever center pins—when one center is sluggish, usually all of them are. Next, grasp each jack tender and gently move it left/right a few times. If you feel any looseness, repin the jack and/or the wippen flange. Check the repetition lever pinning for looseness.

46 Wippen heel felts: Turn the top stack upside down and lightly brush wippen heel felts with a brass bristle brush. If they are dented, steam them lightly (though not so much as to compromise the glue), then iron them at low temperature with circular motions. Rub a powder lubricant into the felt (Figure 285) and burnish it with a metal shank. Vacuum excess lubricant.

47 Lubricate repetition spring/repetition lever notch: This applies to Steinway and similar designs. Remove the top stack from the key frame and turn it upside down. Dislodge all repetition spring hooks and, reaching between the wippens, scrape the old, caked lubricant from repetition lever notches with a thin, pointed hardwood dowel (Figure 273 on page 151). If there is a lot of lubricant in the notches or the lubricant is still greasy, wipe the notches with cotton swabs dipped in a 90% alcohol. Allow to dry,



Figure 285 Applying and rubbing powder lubricant into wippen heel felts with a cotton glove.

Lubricate Spring Notches with Film or Grease?

Spring ends and repetition lever spring notches traditionally have been lubricated with mutton tallow. Manufacturers chose this heavy grease to act as a brake to slow the motion of the repetition lever. Combined with the friction of the repetition lever center pins, the grease allowed stronger adjustment of the springs, thus improving the reliability of repetition (see “Increasing Friction” on page 148). Unfortunately, this lubricant quickly caked up and oxidized the springs, rendering the action sluggish or unplayable. We cringe today as we clean it from the springs and notches of almost every grand made in America before WW II. Modern, synthetic grease lubricants are much better: they are stable and noncorrosive, and promise great longevity. However, before you use one for this application, consider that, over time, every grease lubricant loses effectiveness as it traps dust, lint, and wool fibers. A dry-film lubricant doesn’t suffer from that problem. Unless the friction of the repetition lever center pins is exceedingly low and hammers are particularly heavy, the benefits of a grease lubricant may be outweighed by the long-term effectiveness of a dry-film lubricant.

then apply a dry-film or grease lubricant to the notches with a folded pipe cleaner (see sidebar, “Lubricate Spring Notches with Film or Grease?”). Turn the top stack back up, and clean old lubricant from the spring hooks with very fine steel wool (#0000) dipped in alcohol or lacquer thinner, then polish them with a rotary tool and a small buffing wheel (use a chrome buffing compound or tripoli). Wipe the buffing compound from the springs, lubricate them with dry-film lubricant, and reposition them in the notches. Squeeze each repetition lever. If you feel increased resistance at the start of the travel, the springs have dented the notches—if the dents are deep, replace the wippens.

48 Let off button cloth: If the cloths on let off buttons are dimpled, *lightly* brush the cloths with a brass-bristle

brush, sand them lightly, then iron them at low temperature. This will improve the stability of let off regulation. Rub a small amount of powder lubricant into each cloth and burnish with a metal shank.

49 Lubricate jack tenders: Lubricating let off buttons is usually sufficient lubrication for jack tenders, but if they feel rough or were treated with a greasy lubricant, clean them with alcohol and apply liquid dry-film lubricant to them with a bottle brush.

50 Vacuum excess powder lubricant.

51 Reinstall the shank rest rail (if you removed it earlier) and, if you don’t intend to regulate the keyboard, fasten the top stack onto the key frame.

Regulating Keyboard (Grands and Verticals)

Functionally, the keyboard is part of the action and should be regulated with it. I treat the two as separate units because the keyboard tends to stay in regulation longer than the action top stack. If you’re pressed for time, focusing on the action will generally yield greater improvement for the player than perfecting key level and key dip or adjusting key spacing. For ultimate results, however, the keyboard, action, and damper system should be regulated together. For example, if the aftertouch is shallow after you regulate the let off and hammer-blow distance, you will have to decide whether to reduce blow distance (action) or increase key dip (keyboard). You can’t adjust the damper stop rail before you define key dip, and even the damper lift timing depends on the hammer-blow distance and key dip. Please note that, for purposes of regulation, I treat back-checks as part of the action, not the keyboard.

Since the regulation of the keyboard is mostly the same in grands and verticals, it is described for both designs under this heading. Procedures that are unique to either design are explained as necessary.

The regulation of the keyboard involves the following procedures, in this order:

- Bedding the key frame
- Spacing the keys
- De-slanting the keys
- Squaring the keys
- Setting white key level
- Setting black key level
- Setting key dip (white and black keys)

In vertical pianos, the key frame is affixed to the key bed with screws, and the regulating is quite straightforward. In most grands, though, the key frame shifts sideways with the soft (una corda) pedal, and bedding it to the key bed is critical. Poor contact between the two causes knocking or rattling noises, and the accumulation of dust

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Figure 315
Regulating
the drop
(Steinway).

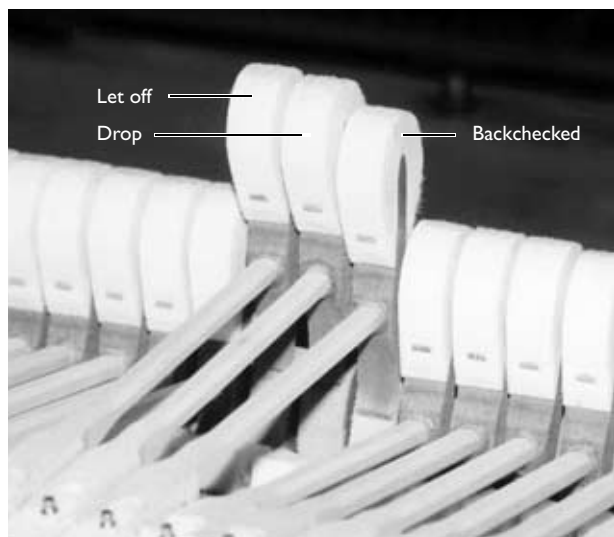


Figure 316 Regulating the backchecking against the drop of the neighboring hammer.

sistance that the pianist has to overcome toward the bottom of key travel as the tip of the repetition lever pushes against the drop screw.

How: To adjust the drop, pull out the action and work either with the keyboard halfway on your lap (see “Tip” below), or place the keyboard and action on top of the (padded) front lid. Depress the key slowly, controlling its movement, and look for the vertical distance between the hammer at let off and the position to which it drops *just after* let off. This distance is the “drop.” Ignore the hammer’s rise as the key continues moving toward the bottom of the key travel. The rise may be substantial if aftertouch is excessive, but if the hammer doesn’t drop at all, reduce the blow distance to increase aftertouch (see step 4). Adjust the drop by comparing it to the neighboring hammer, as shown in Figure 316. It should be ca. $\frac{1}{16}$ ” [1.5 mm] below let off.

Tip: When regulating the action with the keyboard on your lap, the front rail of the key frame bends upward and the key dip decreases. Keys may reach the bottom of their travel before the hammers reach the let off, let alone drop. To increase the key dip, move your leg sideways, away from the area you’re working on.

4 Aftertouch is the amount of key travel measured at the front of the key from the highest point in hammer travel (let off) to the bottom of the key travel with moderate pressure. It is a function of let off, hammer-blow distance, and key dip, and should be adjusted to around 0.040” [1.0 mm]. Excessive aftertouch wastes energy, makes repetition sluggish, and can cause the hammers to get jammed by the backchecks. Insufficient aftertouch, on the other hand, causes inadvertent double-repeating when you play softly—the hammer and shank bounce between the string(s) and the jack because the jack does not escape sufficiently from under the knuckle.

Dependencies: Since let off is tied to the position of the strings, aftertouch is adjusted by altering key dip and/or blow distance. In a precisely regulated action those two distances should be consistent throughout, but in reality they vary slightly from note to note and can be compromised to a certain degree. Many technicians give priority to blow distance because it affects the hammer line (horizontal alignment of hammers at rest), and a straight hammer line makes the action *look* regulated. Blow distance also affects the acceleration of the hammers and the amount of force they deliver to strings, which is one more reason to keep the blow distance consistent.

Measuring: Aftertouch is very sensitive to the curvature of the key bed/bench, and should be adjusted inside the piano. Although you can measure aftertouch by comparing the key height at let off and at the bottom of key travel, I prefer adjusting it by feel. This way you will automatically compensate for variations in the size and curvature of the knuckle and other discrepancies in action parts. Press the key slowly to the point of let off and, while observing the hammer, press the key to the bottom of its travel. The hammer should drop, then rise *a little*, and you should feel a short, accelerating motion with a well-defined “bottom” and with very little free play after the drop. Measured at the front of the key, this will be achieved within 0.030 to 0.060” [0.8 to 1.5 mm] after let off.

Adjusting: Adjust the aftertouch by changing the key dip (step 7 on page 164) or making small adjustments to blow distance (step 1 on page 170). Maintain a reasonably straight and even hammer line. Don’t alter let off or drop to adjust the aftertouch.

Testing: Test the let off, drop, and aftertouch as explained in the sidebar on page 174.

Note: When adjusting blow distance, bounce the key a few times—you may notice that the hammer stops at a slightly different height each time. This is because hammer height at rest is affected by the tension of the repetition spring, its friction

Testing Let Off, Drop, and Aftertouch by Feel

The following tests supplement visual checks and are optional. They require good finger control and a refined sense of touch. The room should be quiet, but *you* will make a lot of noise—let the owner know what you are doing.

Playing off the jacks: Playing with control in *ppp* dynamics requires let off and drop to be close to the strings and to be *extremely consistent*. The following tactile check, known as “playing off the jacks,” allows you to refine the results. Perform the following tests with the damper pedal depressed.

Depress a key until you feel increased resistance, then depress it to the bottom of its travel with moderate force (Figure 317). Reduce the force until the note barely sounds. Repeat this test with the same amount of force on all white, then black keys. Each note should sound. If a note doesn't, its let off and drop are likely too low—adjust and retest until the note sounds. The more quietly you can play off the jacks, the softer you will be able to play the piano with control.

If you feel markedly greater resistance on any of the notes, those hammers may be blocking against the strings—increase the let off and drop distances. Slight discrepancies in resistance may be caused by the jack position at rest (step 7 on page 176). Adjusting the jack slightly toward the player will reduce the resistance, and vice versa. Resistance also can be caused by wear and lack of lubrication on the knuckles, lubrication of the repetition spring, condition of let off button felts, lubrication of the jack tender, inconsistent force of the repetition spring on the jack, even a sluggish center pin.

Dropping the weight: Assemble touchweight-measurement weights to the total weight of approx. 100 g. Depress the pedal, block the key with one hand and place the weights on a key with the other, then let go of the key. You should hear a faint sound. Repeat on several adjacent keys, reducing the weight until notes start missing, then add a few grams. Test all keys. It's normal to have to add some weight toward the bass and reduce weight toward the high treble.



Figure 317 Testing the consistency of let off by playing off the jack.



Figure 318 Testing whether the start of the bump on adjacent keys is level.

This test checks not only the consistency of let off and drop, but also of touchweight, friction, and hammer inertia. It is even more effective at revealing inequalities in *ppp* response than playing off the jacks.

Too close to the strings? Depress the damper pedal and pound each note twice in rapid succession (clear the pedal between the notes). If let off is too close to the strings, the sound will be harsh and distorted either on both strikes or on the second strike. In either case, set the let off a little lower (turn the button clockwise) and repeat the test. If you are not sure what the note should sound like, set the let off practically at the string and compare the sound with the let off set to 3 mm (the latter will sound cleaner).

Strings have greater excursion in the tenor and bass sections; there, you should test whether the hammer touches them at let off. Hold the damper pedal depressed and loudly play several quickly repeated octaves or big chords that include the note you are testing, then quickly bring the hammer up, but take it through let off very slowly. If you feel string vibrations on the key or hear a “zing,” indicating that the hammer is touching the string, lower the let off a little (turn the let off button clockwise) and repeat until the hammer no longer touches the string.

Bump and aftertouch: Hold the damper pedal depressed. Press four adjacent white keys with the same hand and feel whether the bump in each key's travel starts at the same spot in the travel. While holding the keys at the bump with the same force, slide the finger of the other hand from one key top to another (Figure 318). Slightly adjust the pressure of each finger and observe how the relationships between the keys change. If the bump of one of the keys is higher, either the let off and drop are lower, the blow distance shorter, or the action leverage higher than on other notes, due to geometry inconsistencies. That note is also likely to have greater aftertouch. Correct the regulation and retest.

against the repetition lever, the friction between the repetition lever and the knuckle, and even the friction of the repetition lever's center pin. If the variations in hammer height are large, lubricate the first three friction points and make sure that the center pin friction is not too low (see “Friction” on page 142). Increase spring tension slightly if necessary (step 6 on page 175).

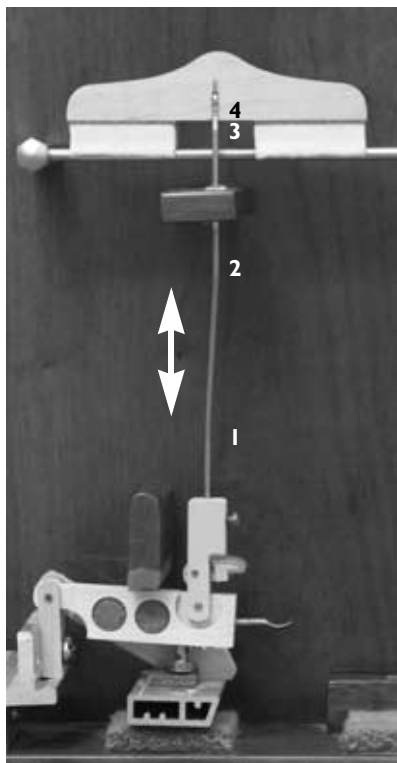
5 Backchecking height: As explained in “The Importance of Backchecking” on page 77, backchecking speeds up repetition by preventing the hammer from getting too far from the strings after strikes that involve keeping the key depressed (*legato*, *tenuto*). Typically, backchecking is adjusted to between $\frac{1}{2}$ " and $\frac{5}{8}$ " [12 to 15 mm] from the strings. The shorter this distance, the less time the hammer spends returning to the strings on restrike. Without

Adjusting Damper Wires

Viewing the damper wire from the front, the segment under bend 1 and the segment between bends 2 and 3 should be parallel to the plane on which the underlever moves up and down, which should be vertical.

Bends 1 and 2 abridge the misalignment between the underlever and the guide rail bushing. These bends should be mirror images of each other, and should allow the damper to move freely. If they are angled too much, the wire will rub against the left side of the bushing and the underlever will be pushed to the right. Conversely, if the bends are not angled sufficiently, the wire will rub against the right side of the bushing and the underlever will be pushed to the left. The wire should lightly rub against one side of the bushing, consistently within each section (see below).

a. Side view:



b. Front view:

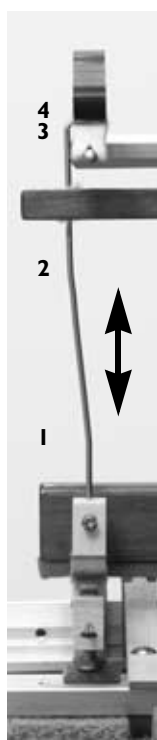


Figure 327 Side and front views of a typical grand damper assembly. Numbers indicate the bends in the wire.

Bends 3 and 4 must be adjusted so the damper head is vertical and centered to the string(s). Viewed from the side, the wire should be vertical except between bends 1 and 2, and the felts at both ends of the damper head should sit on the strings with equal force. Lifting and lowering the underlever should not change the alignment of the damper head.

Aside from observing the bends and the amount of side-bearing that damper wires exert on guide rail bushings, a good test is placing a small ruler on top of the damper heads. If they are aligned correctly, their tops will be parallel with the ruler.

To Center the Wire in the Bushing or Not?

If the damper wire bears against the bushing with significant force, the bushing will wear out prematurely. The logical conclusion is to adjust the wire to be centered perfectly in the bushing. However, the damper is actually more effective if the wire is slightly off center. Here's why.

Let's look at a single bass string. Although the hammer excites the string to vibrate in a vertical plane, the vibrations change direction, and soon the string is vibrating in all directions. When the damper falls on the string, it pushes the string down, causing the vertical vibrations to quickly subside. Vibrations around the horizontal plane, however, cause the damper head to move left-right. You can observe this when loudly playing low-bass notes—the damper head flutters horizontally (side to side) when it touches the string. By itself, the damper can't stop horizontal vibrations—that's the job of the damper bushing.

The bushing damps horizontal excursions of the string by limiting side-to-side travel of the damper head. The tighter the bushing, the more effective it is. However, the adjustment of the damper wire can make the bushing even more effective. Suppose that the string is deflected from its rest position by 1 mm to the left and 1 mm to the right. Also suppose that the damper wire is 1 mm thick and the opening in the bushing has a diameter of 3 mm, leaving 1 mm of room on each side of the wire. If the damper wire is in the middle of the bushing, the string will move it equally in both directions, for a total motion of 2 mm. But if the wire leans against, say, the right side of the bushing, the excursion to the right will cause almost no damper movement, whereas the excursion to the left will bring the wire to only the middle of the hole. The total motion will be only 1 mm, half of what it would be with the wire centered. The degree of the lean must be very gentle or the added friction will offset the benefits of this technique by making the damper less effective in the vertical plane.

The lean also makes damper movement, when lifted with the pedal, appear more precise because there is no fore/aft movement of the damper heads.

page 402). Loosen the screw in the underlever top flange, and set the underlever to rest on the tongue of the tool, and the damper to sit on the strings, then tighten the screw. If the damper head twists out of alignment with the strings, loosen the screw, twist the head slightly in the opposite direction, and tighten the screw. If that doesn't work, lift and twist the damper wire under bend 2 with a pair of linesman or similar pliers while holding the underlever top flange with parallel pliers. Lift the underlever and let the damper head return to the strings under its

own weight, then *lightly* tap down the damper head (or the underlever) a few times. You should feel resistance and see the tool tipping forward a little. If the underlever knocks more than very softly against the tool, lower it.

10 Adjust pedal lift on guide dampers: Sit at the piano and press the damper pedal slowly while observing the guide underlevers (ignore the underlevers between them). Adjust their capstans (if so equipped), or remove/add shims under the tray felt (under guide under-

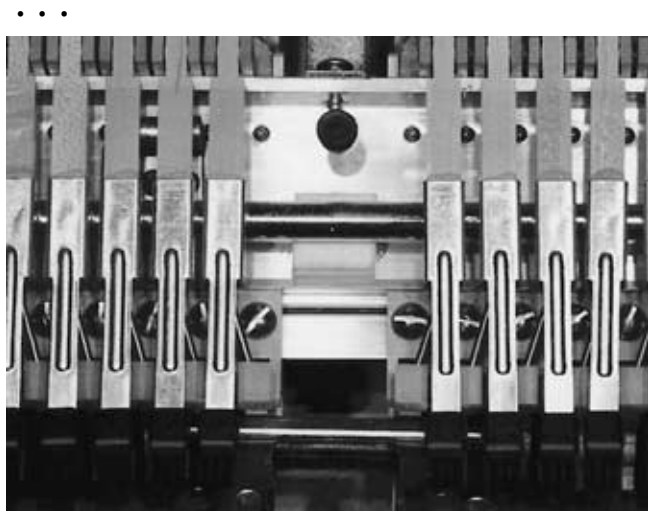


Figure 337 Wippen flange screws are usually in the back of the action (Yamaha U3).



Figure 338 The jack spring should be positioned in wippen and jack notches, and the jack base must be firmly attached to the wippen.

Jack spring notch

Jack base

Oxidation and wear will make that interface noisy and creaky. First, make sure that all springs are seated in their notches (they often get dislocated when a pencil is removed from the action). To test the lubrication and wear of the springs and notches, disconnect the bridle tape and lift the catcher very slowly. If the motion is not smooth or you hear any noise, remove the action and place it on a cradle, then disengage the butt springs. Clean bare wooden notches with a sharpened dowel and lubricate them with a dry-film lubricant. If the notches are covered with cloth punchings, rub them with powder lubricant. If worn, replace and lubricate them (see “Spring notch cloth punchings” on page 413). Polish the spring hooks (end that presses into the notch). Hammer butt springs are not noisy in Schwander actions, but make sure their spring cords are intact and that all springs are engaged.

35 Damper lift rod: Lift the end of the damper lift rod (hold the action rack with the other hand) and observe the lifting of dampers. If the lifting is uneven or tapers toward either end, inspect and repair rod hooks and hinges as necessary (see “Uneven Damper Lift” on page 253).

Noise: Lift the rod slowly. If its motion is not smooth, and you hear noises, lubricate the rod, its hinges, and damper lever felts. If in a hurry, turn the action at a right angle to the floor, apply Protek Prolube, and let it run down the rod. Apply at a few points along the rod’s length. Press the tops of the levers to keep the damper lever felts away from the rod as the liquid flows.²⁵⁴ Apply Prolube to the rod hooks and hinge bushings. You can also brush Prolube on damper spoons, unless you have a different plan for them (see step 36). If you remove the rod, clean and polish it and its bracket bushings, then apply liquid dry-film lubricant to the rod and inside hard bracket bushings (if the bushings are of cloth, swab them with a powder lubricant instead). Refresh the lever cloths by brushing them with a firm pipe cleaner or a small brass-bristle brush if you can reach without scratching the lift rod or spoons. Lubricate the lever cloths where they touch the rod and damper spoons with powder lubricant applied with a folded pipe cleaner (Figure 339). Burnish the lubricant and vacuum the area. Reinstall the rod and the brackets, if you removed them.

36 Damper spoons, when deteriorated, increase action friction, accelerate wear of damper lever felts, and can be noisy. Visually inspect the spoons. If the plating is flaking or rust is visible, replace them or they will quickly wear out the damper lever cloths. If the cloths are contaminated with rust or caked-up lubricant, brush them with a small brass-bristle brush (without touching the spoons) or with a firm, folded pipe cleaner, then rub/burnish them with a powder lubricant (or replace them). Lift and prop the damper lift rod. Clean and polish the spoons with pieces of felt or cloth, then coat them with dry-film lubricant in liquid form with a felt wedge or pipe cleaner (Figure 340). Make sure the lubricant doesn’t get on the lever cloths. A quick alternative is to apply Protek Prolube to the felts and spoons.

37 Damper springs, levers, and lever notches can be responsible for oinking, creaking, or crackling noises when playing softly and when pressing the damper pedal slowly. The noises indicate excessive friction, which impedes performance and accelerates wear.

Sluggishness: Pull the bottom of the damper lever away from the damper spoon, or pull the damper away from the strings and let it go. If it doesn’t snap back, is the spring intact and engaged? Severely oxidized? Is it jamming in the worn notch in the lever (especially if the notch is covered with cloth)? Next, push the top of the damper lever toward the rail and return it a few times. If the motion feels rough or you hear a faint creaking noise, the lever spring notches (Figure 341) need to be lubricated. If in a hurry, lubricate them with Protek Prolube. For more permanent lubrication, clean/polish spring ends and clean/lubricate the notches using the techniques described in step 34. To test the friction of lever center pins, pull the spring away from the damper lever with a hook

²⁵⁴ Thanks to Fred Sturm, RPT, for this technique.

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3 Blow distance is the distance between the hammer at rest and the strings. It determines the amount of force that the hammer can deliver to the strings: the greater the distance, the greater the force. As hammers wear, blow distance typically needs to be reduced. Blow distance is directly proportional to key dip and inversely proportional to jack gap and aftertouch.

How: Measure blow distance as depicted in Figure 345. To reduce, shim the hammer rest rail (or half-blow rail) with felt, paper, or cardboard shims. In the case of a rest rail, place the shims between its felt blocks and the action brackets (Figure 346). Do not glue the shims in place yet. To increase the blow distance, remove the shims or cut the rail felt blocks (this is unusual; do this after step 5). In most studio uprights, the blow distance should be $1\frac{3}{4}$ – $1\frac{7}{8}$ " [45–47 mm]; in spinets and consoles with compressed actions, as little as $1\frac{1}{2}$ " [39 mm]. Ultimately, adjust the blow distance and gap (next step) for optimal aftertouch (step 5).

4 Jack gap is the distance between the jack and the hammer butt that ensures the jack's repositioning under the hammer butt after the key is released. This distance should be as small as possible, but sufficient for the jack to return consistently under the hammer butt. In new actions the gap is less than 0.004" [0.1 mm], whereas it may need to be double that in worn ones. The measurement, however, is unimportant—you will adjust the gap by feel. If the butts sit on the jacks (no gap), notes may bobble and miss. You must regulate jack gap whenever you alter blow distance or key level.

How: Depress each key lightly at the very top of its travel a few times, and observe when the hammer begins to lift relative to the motion of the jack and wippen. There should be a very small amount of free play in each key's movement, during which the jack rises but the hammer does not move at all. Adjust the gap by turning key capstans (Figure 347) or, in a dropped action, the screws or capstans on linkages that connect the keys to the wippens. The gap should feel the same on all keys.

5 Aftertouch is the distance that the front of the key travels after the let off. In most verticals it should be 0.040–0.060" [1.0–1.5 mm]. Insufficient aftertouch causes hammers to bobble as the hammer butts bounce off the jacks, whereas excessive aftertouch causes inconsistent back-checking, wastes finger force, and may cause the jacks to jam at the let off rail. Aftertouch is directly proportional to key dip and inversely proportional to blow distance and jack gap.

How: Depress each key and measure how far it travels after the let off occurs. To measure aftertouch more precisely, place a cardboard punching of the desired thickness (e.g., 0.040" [1.0 mm]) on the front key punching, and depress the key with moderate force (place a weight of 8 to 10 oz. [ca. 250 g] on the front end of the key—this will keep the measurements consistent from key to key). Pressing the key just slightly more should take the hammer through let off. If the hammer is already past let off,



Figure 345 Measuring blow distance.

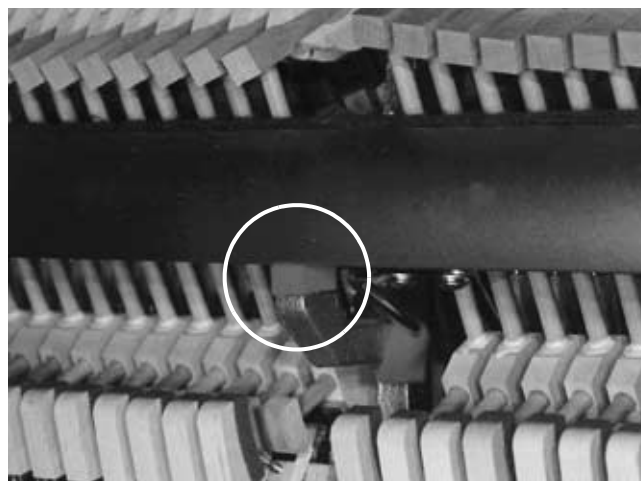


Figure 346 The hammer rail is supported by felt blocks. Place shims under or above this felt, if necessary.



Figure 347 Adjusting the jack-to-hammer-butt gap by turning key capstans.

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