Vertical Regulation

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Action regulation procedures are readily available in most manufacturers' service manuals and books on piano repair, but are usually presented simply as a list of adjustments to be made in a certain order. Given a piano in like-new condition with all parts within specifications, such a list of adjustments will usually give good results. However, over time, parts wear and change dimension. Even a brand-new piano may not be built to original design specs. All these variables affect how an action functions, and therefore regulating "by the book" may not give the best result in all cases.

The technician who understands how an action works and can visualize the operation of each action part in relation to others is in the best position to diagnose problems, regulate for best results, and provide the most efficient service to the piano owner. We should all be familiar with manufacturers' specs, but we should also have a thorough understanding of action operation so we can regulate for best results. In this article I will present procedures that emphasize regulating for proper action function.

Regulation is the process of adjusting the action parts to give the most power, repetition speed, and evenness in touch and tone from note to note. However, the results will only be as good as the condition of the action parts will allow. It is usually not appropriate to spend hours precisely regulating a very worn action; little benefit will be realized from having the let-off set exactly to 1/8" on each note if each hammer has a different tone and each hammer butt leather is worn to a different shape. In such cases the customer might be given the option of a quick touch-up regulation using wholesale methods to improve symptoms or else an action rebuild followed by a thorough regulation. Regulation cannot overcome the affect of deteriorated parts, nor of poor piano design, so the technician must not promise the client more than the piano can deliver.

Preliminary Steps

Before regulating, put the action in good mechanical condition by the following steps:

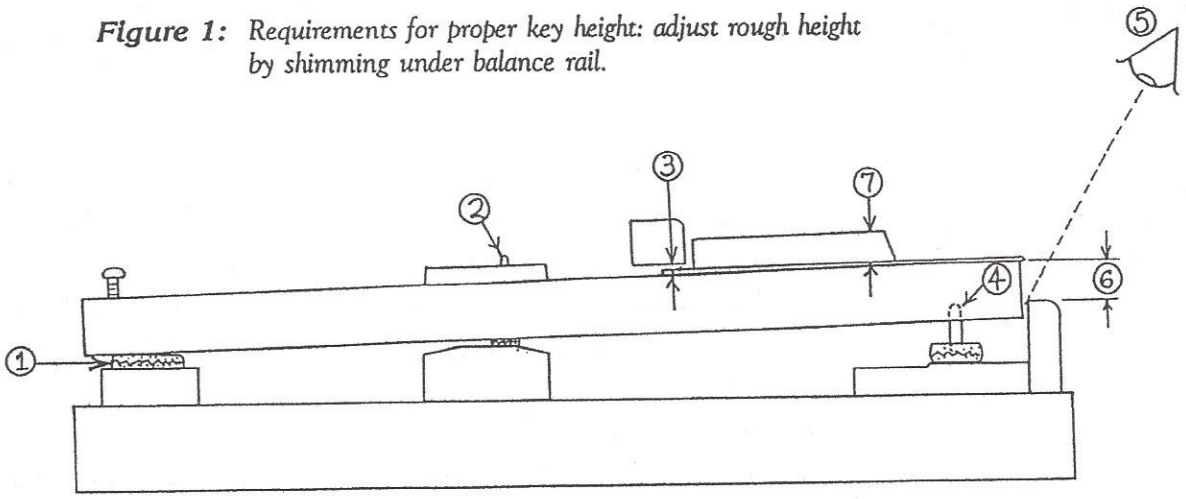
- Tighten all screws (tighten the action bracket-to-rail screws before removing the action, to lock the action frame in correct alignment.)
- Check that action felt and leather are usable (not worn to the point of dysfunction.)
- Re-shape hammers if needed.
- Check that action centers are free but not wobbly.
- Correct any interference or rubbing between action parts.
- Check hammer travelling; use brown gummed tape strips or Avery correction tape.

Parts Alignment

The first regulation step should be to align all parts, starting by positioning the action correctly in relation to the strings:

- Confirm proper striking point for the highest treble notes—hammer #88 should strike approx. 1/8" below the V-bar. Test for best height and adjust the action support posts so the action rests evenly on all supports.
- Next, adjust the top posts by bending up or down so that each bracket is snug under its mounting stud; this ensures stable lost-motion adjustments and damper alignment.
- With the action properly located, action parts can be spaced starting with hammer-to-string alignment. Loosen flange screws and shift flanges sideways on the rail; or warp the shanks by holding to one side, heating with a heat gun or small flame, and holding in position until cool.
- Next, set the rough key height. Use service manual specs if available, confirm using guidelines in Fig 1. Shim under the balance rail at its mounting points until keys are close to or slightly below the desired level.

Figure 1: *Requirements for proper key height: adjust rough height by shimming under balance rail.*



1. Backrail cloth thickness must be such that capstan can be adjusted to correct height.
2. Balance rail pin should extend above key button to allow key squaring.
3. There must be enough clearance between keys and fallstrip or fallboard so keys can be lifted at least 1/16" at front. Fallstrip can be shimmed up if necessary.
4. Front key pin should extend at least 3/16" into front bushing.
5. Naturals should not be so high that bottom edges of keys are easily visible.
6. Naturals must be high enough that they are still well above keyslip when depressed.
7. Sharps should be approximately 1/2" above naturals. Sharps must be low enough that joint between sharp top and key wood is not visible above naturals, but high enough that they are still above naturals when depressed.

Figure 2: *Squaring keys by bending balance rail pin*

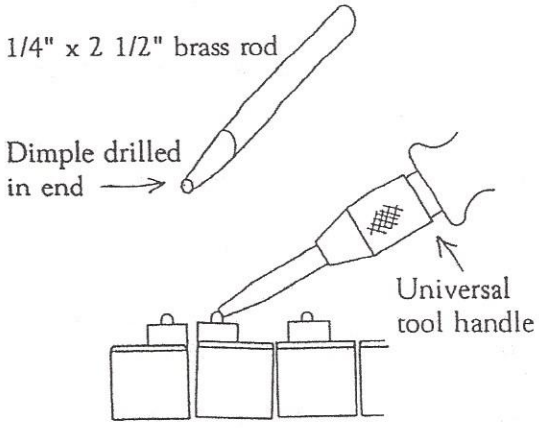
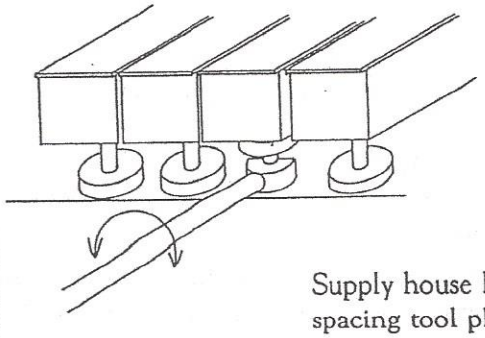
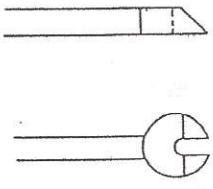


Figure 3: *Spacing keys*



Supply house key spacing tool placed *under* front punching



Tool modified by grinding bevel on end to easily slide under punching

- Square and space all keys, as shown in Fig 2 & 3. Rest a straightedge across the keys to judge squaring.
- With the hammer butts and keys spaced, we can then space the wippens to center the jacks to the hammer butts and (on direct blow console & studio actions) align the wippen cushions to capstans. Shift wippen flanges, papering flanges if necessary. For dowel capstan actions, bend the capstan wires to align capstans to wippens. For sticker actions, paper the sticker flanges.
- With the wippens spaced, we can then space the backchecks laterally to the catchers. CAUTION: To prevent damage to wippen flanges, use *only wire bending pliers* when spacing backchecks side-to-side.
- Make sure that the bridle straps are slack enough that the wippens can drop down enough to allow the jacks to get under the hammer butts.

Choosing Hammer Blow/ Key Dip Dimensions

At this point we need to decide what our hammer blow distance and key dip should be to result in correct jack escapement (the amount that the jack rotates away from the hammer butt as it is tripped by the let-off button.) It is the *proportion* of key dip to hammer blow that determines the degree of jack escapement. See Fig 4 below.

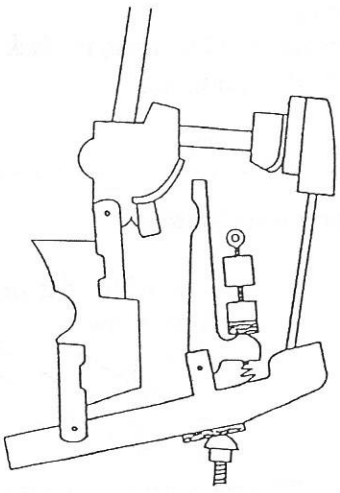
- A lower blow/dip ratio results in more jack escapement. If escapement is excessive, repetition is slowed because the key must be released farther in order for the jack to return under the hammer butt and play a repeat blow.
- A higher blow/dip ratio results in less jack escapement. If escapement is too little, the jack top interferes with checking and causes "blubbering" hammers, and the keys lack "aftertouch" (key travel remaining after escapement.) This makes the touch feel too shallow.

Figure 4: *How hammer blow/key dip ratio affects jack escapement*

All three notes have 3/8" key dip, 1/8" let-off, and 5/8" checking. Action parts are shown with keys depressed and hammers in check.

Example 1:
blow distance 1-1/2"

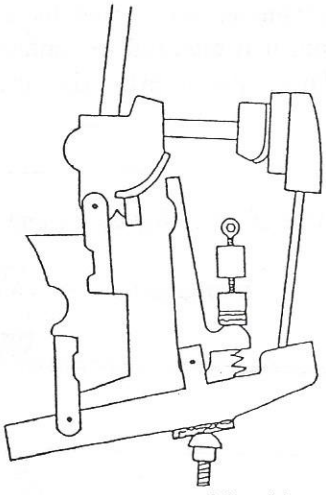
Jack has rotated far from hammer butt



Poor repetition, blow distance is too short

Example 2:
blow distance 1-3/4"

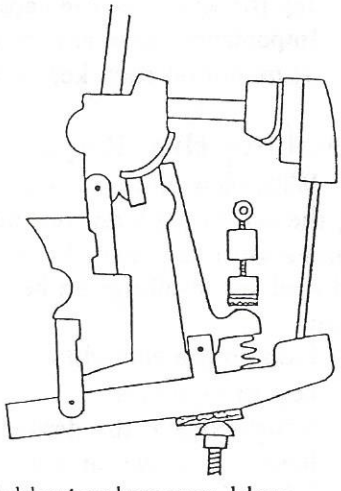
Jack top is approx. 1/16" from butt



Better repetition, blow/dip ratio is correct

Example 3:
blow distance 2"

Jack top interferes with butt as hammer comes back into check



Blubbering hammer, blow distance is too great

Choose dip and blow dimensions as follows:

1) Regulate *2 or 3 sample notes* across the keyboard by setting their let-off to 1/8", and their key dip to a reasonable figure (start with manufacturers' specs if available; or set key dip to 7/16" for most spinets, 3/8"+ for consoles or larger, 10.5mm for most Asian pianos.)
2) Adjust the hammer rail to set your experimental blow distance to 1-5/8" for spinets or 1-3/4" or more for consoles and larger.
3) Adjust capstans for slight lost motion.
4) Set checking to 5/8".
5) Then, test your experimental blow distance by playing the sample keys with a medium blow, holding each key down and observing the jack position. If the jack is resting against the butt leather there is insufficient escapement, so your blow distance is too great. If the jack top is more than 1/8" from the butt leather there is more than enough escapement and you could increase the blow distance. I normally like to have 1/16" to 1/8" jack clearance, knowing that as key dip diminishes and lost motion develops, jack escapement will decrease. Starting out with no clearance may result in blubbering hammers when slight wear occurs in the action.
6) Vary the blow distance by adjusting the hammer rail and resetting lost motion until jack escapement is correct. Re-check checking distance and confirm correct escapement. You have now determined the correct blow/dip settings for the particular piano.

Adjusting Lost Motion

Once the hammer rail is set to give the correct hammer blow, you can adjust lost motion using the following guidelines:

- Some lost motion (space between the jack top and hammer butt leather at rest) is needed to allow the jack to return fully under the hammer butt when the key is released very slowly.
- Excessive lost motion, beyond that required to allow the jack to return reliably, can accelerate wear of the butt leather and makes the keys feel sloppy and loose.
- The correct amount of lost motion is the least that will allow the jack to return fully when the key is released *very* slowly after a hard blow, with the sustain pedal depressed.
- Often new pianos are found to have the hammer rail resting too far back due to settling of the rail rest felts during shipping. Adding a piece of bushing cloth or a cardboard balance rail punching to each rest felt will quickly restore lost motion.
- If lost motion is excessive and due to wear of the butt leather, wippen cushions and backrail cloth, reduce it by raising capstans, rather than by lowering the hammer rail.

Common wholesale checks for lost motion are:

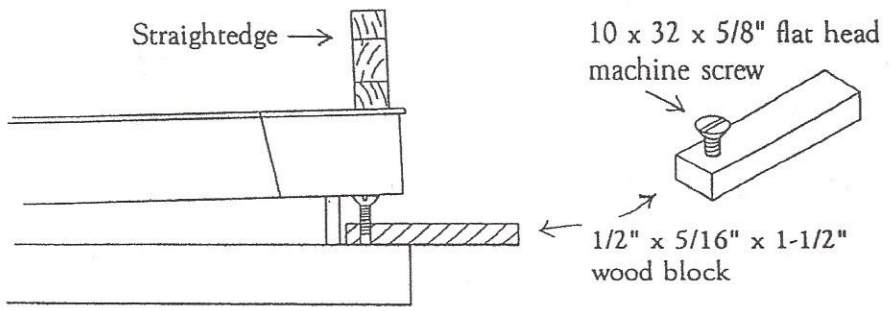
- Pull back on the hammer rest rail to see if the hammers follow the rail back about 1/16"; those that don't have no lost motion, those that follow farther may have excessive lost motion.
- Tap the keys near the capstans; if any hammers wink, they have no lost motion.
- ▸ **Important:** These checks are useful, but it is essential to confirm the correct lost motion *using the jack return test* on each key as a final regulation step to avoid that call-back for the "sticking key."

Levelling the Keys

With blow and lost motion set, the action parts rest on the capstans with consistent force and final key levelling can be done:

- Prop up the end white keys to support a straightedge at the desired height, as shown at right.
- Lift and tap the straightedge to reveal any that are too high; remove

Figure 5: Propping up the end keys to support a straightedge



paper punchings or sand the bottoms of these keys to lower.

- Lay out paper punchings in front of all white keys, estimating punching thickness to be half the gap between straightedge and key.
- Remove the straightedge, insert punchings, and repeat until keys are level.
- Prop up the end sharp keys and level all sharps.
- The more accurate the key levelling job, the more consistent will be the key dip adjustment, since white key dip will be judged by the relationship of the dip block to the height of neighboring keys.

Setting White Key Dip

I prefer the dip block modified with a cross piece as shown at right. It is much faster and easier to use, as follows:

- This block is adjustable for different dip settings by shimming under the cross piece with paper front rail punchings. Set it to match your chosen dip.
- Move from key to key, trying to use a consistent pressure.
- If the cross piece barely clicks on neighboring keys, the dip is correct. If it clicks loudly and depresses the neighboring keys, the dip is excessive. And if it does not contact the adjacent keys, the dip is too shallow.
- This tool eliminates the guesswork of comparing the height of dip block and adjacent keys by feel.

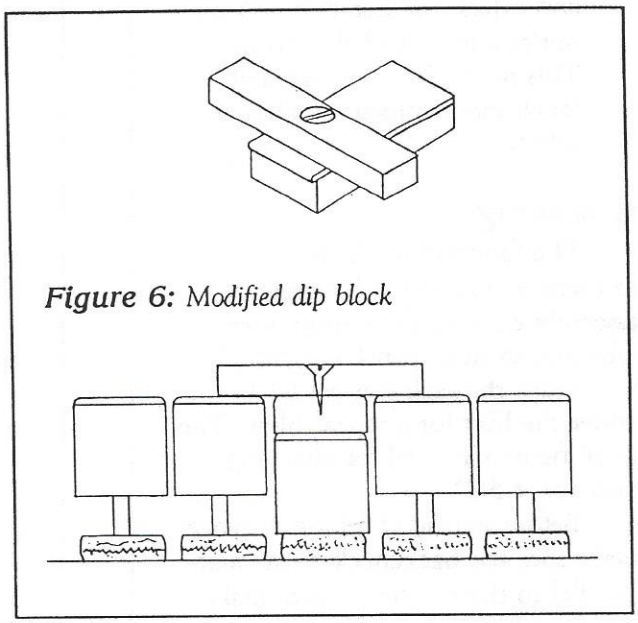


Figure 6: *Modified dip block*

Having set white key dip, we can then go on to set sharp dip in two ways: either by looking at the motion of the sharp key itself, or by looking for equal motion in the action parts between sharp and natural notes.

Setting sharp dip by measuring the motion of the sharp at the playing end of the key is useless since we're really after equal capstan rise for each key. Thus once white key dip is set, we can look for equal capstan rise between sharps and naturals as follows:

- With keys at rest, feel the wood of adjacent sharp and natural keys right next to the capstans (space permitting) or visually fix on the wood surfaces. Then, play the two keys and see if the surfaces feel (or look) the same level as before. Since the keys pivot at different points, this test is only valid right up next to the capstans. (On compact direct blow actions it is easier to watch the top surfaces of the wippens near the base of the bridle wire.)

▸ The method recommended by most manufacturers, and the one I prefer, is to judge equal capstan lift by looking for equal backcheck motion (checking distance.) This method is discussed later under "Checking."

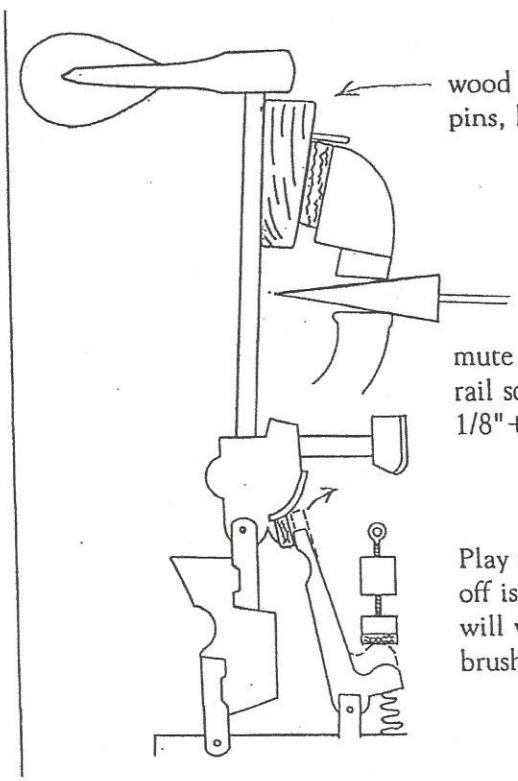
Setting Let-Off

Let-off is unaffected by capstan setting, key height, dip, blow distance or checking. The only things that can affect let-off are changes in hammer size from wear or filing, wear of the hammer butt leather, re-spacing of wippens or butts, or wear or movement of the regulating buttons. Therefore let-off can be set at any point in the sequence after the hammers and wippens have been aligned.

- Before setting let-off, double check that the regulating rail screws are tight and that the rail is located the correct distance from the main action rail. Normally, the jack tenders should contact the regulating buttons in their centers (looking at the in & out position of the rail.) Sometimes the regulating rail also serves as a jack stop rail, and its in & out position is set as described later under "Setting Jack Stop Rail."
- For maximum power and best control during soft playing, let-off should be set as close as is practically possible to the strings. Normally, 1/8" is a good measurement to use. Closer settings often cause "blocking" on hard blows due to deflection of the let-off rail or compression of the let-off button felt.
- My favorite method of setting let-off is as shown in Fig 7. Here, a wood block (preferably tapered as shown) is hung on the hammer rail between the shanks and the rail felt. Then, the rail is propped forward

until these hammers are slightly more than 1/8" from the strings. As these keys are played, their jacks will contact the let-off buttons and trip. If let-off is 1/8", a jack will just brush the butt leather, causing that hammer to wink and lightly knock against the wood block. If greater than 1/8", the hammer will not wink; and if less, the hammer will jump noticeably toward the strings. This method is very fast and much more consistent than any other.

Figure 7: Setting let-off



Checking

The function of the backcheck is to catch and hold the hammer assembly close to the strings after rebound, so that with less than full key return the jack can get back under the butt for a repeat blow. The usual figure specified for checking distance is 5/8".

Before setting checking distance make sure the backcheck heads mate parallel to the catchers. Also, make sure that lost motion adjustments are close, since any later capstan adjustment will change the checking distance that you are about to set.

If both natural *and* sharp key dip are already set, you can proceed to set checking for all notes now. However, to set sharp dip by the equal-checking method, proceed as follows:

- First, adjust checking for all *natural* keys by pushing or pulling the backcheck in or out until these hammers all check at 5/8" from the strings when played with a consistent, moderate blow.
- Then, using a straightedge against the backcheck heads, adjust the backchecks of all *sharps* until they are in line with all *natural* backchecks.
- Now, if all capstans rise the same amount, all hammers should check an equal distance from the strings. Therefore you can test sharp dip by playing adjacent sharp and natural keys simultaneously and watching where the hammers check. If a sharp hammer checks closer, its capstan is rising farther and therefore its dip is too great. If it checks farther from the string, its dip is too shallow. Adjust sharp dip until checking matches that of naturals.

Setting the Jack Stop Rail

When the key is struck with a hard blow the jack momentarily flies back away from the hammer butt further than the regulating button would normally push it. To avoid noise and improve repetition speed by keeping the jack close to the hammer butt, all actions have some type of cushion or travel-limiting device. When the jack-stop device is a felted regulating rail or a separate jack stop rail, it should be adjusted to slightly clear the jacks at full key dip. Check by holding keys down firmly after a hard blow; make sure the jacks are not jamming into the rail felt.

Adjusting Bridle Wires

The bridle straps function to keep the wippens from dropping so low that the jacks would fall below the butt felt when keys or action are removed. At the same time, bridle straps must not be so taut that wippens are

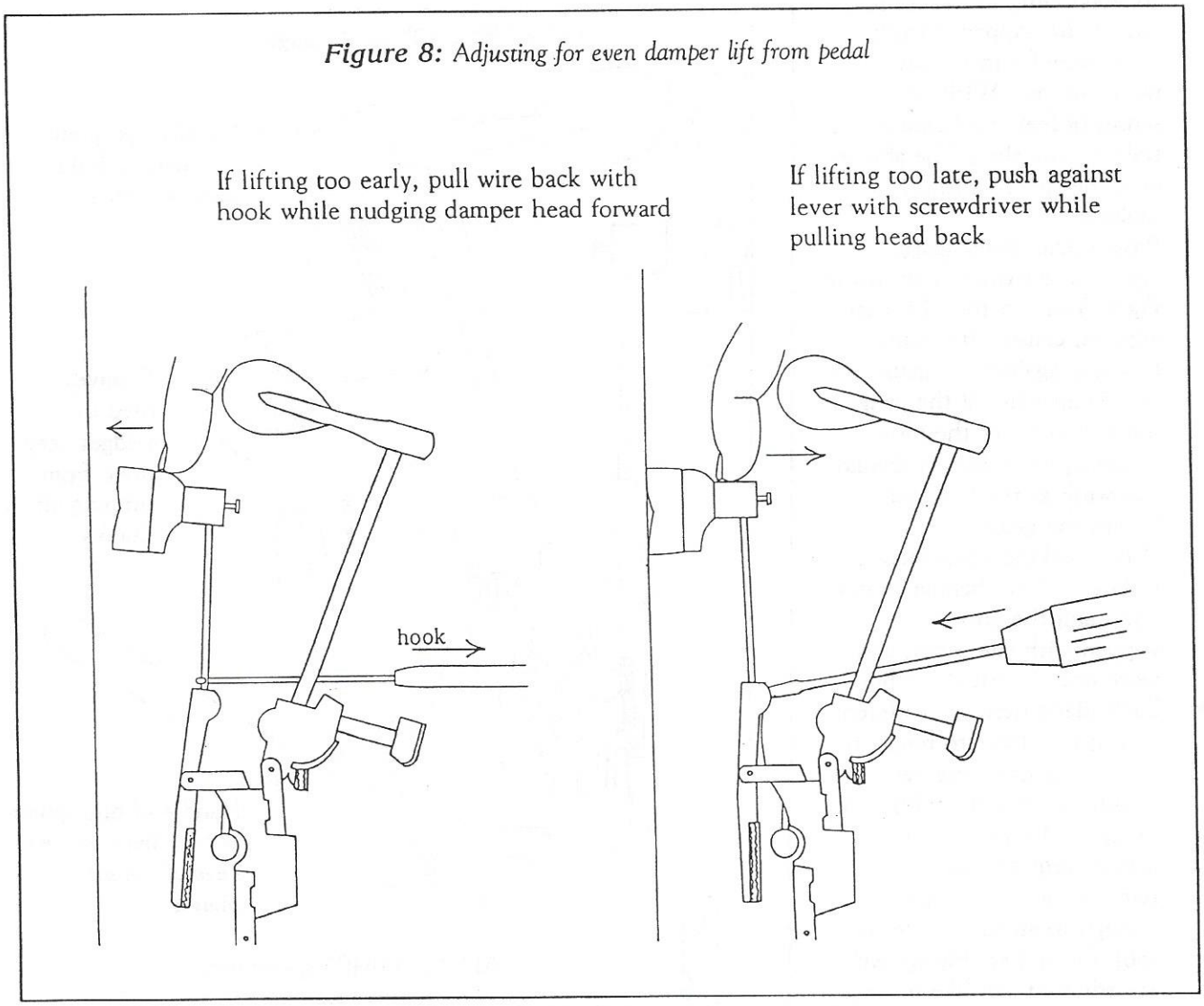
lifted (causing keys to go out of level) when the soft pedal moves the hammers halfway to the strings. Test by pushing groups of hammers all the way against the strings by hand to make sure no jacks fall beneath the butt felts. Then step on the soft pedal to move all hammers halfway to the strings while watching for wippens that wink.

Regulating Dampers for Even Pedal Lift

Here I will assume that the damper felt and other components are in good repair, and that all dampers are working well. Of course all damper heads should be properly spaced (side-to-side) and rotated square (as viewed from above) to the strings. However, existing damper felt that has always been misaligned should be left that way as long as it damps well because it has formed to the strings; re-spacing the heads would cause ringing dampers.

Dampers must first be regulated to lift evenly with the pedal, *then* the spoons should be adjusted to give even lift with the keys. At the same time all damper felt must seat squarely on the strings with even pressure top and bottom. Usually, unless some poor damper replacement has been done, the wire bending required to achieve even pedal lift is very minor, and not enough to upset the parallel mating of felt to strings. In such cases I find it easiest to just use my fingers and a hook or screwdriver, as shown in Fig 8 below, rather than conventional damper wire bending tools. Use your foot to just barely wink the pedal to identify the early-lifting dampers. Correct these, then find and correct the late-lifters.

Figure 8: *Adjusting for even damper lift from pedal*



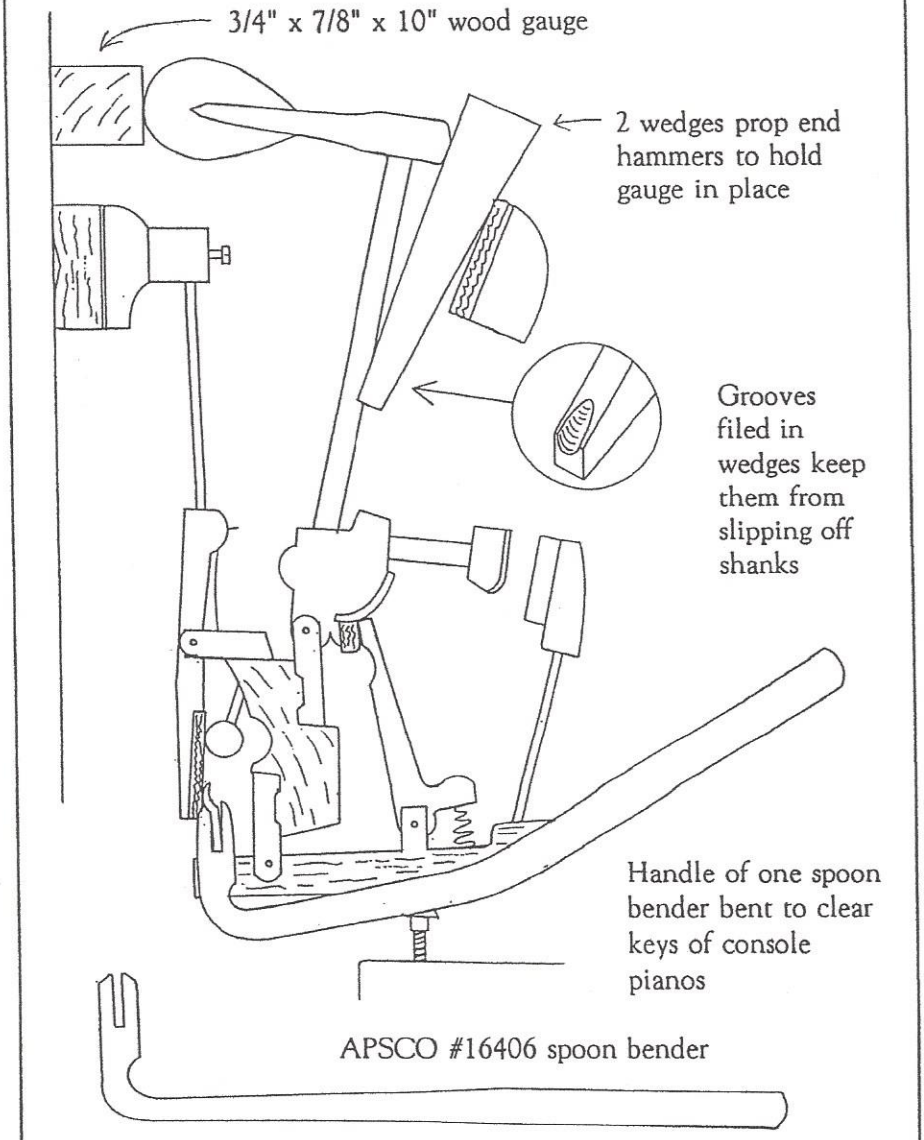
Regulating Damper Lift With the Keys

Dampers *must* lift evenly with the pedal before adjusting spoons. Damper lift with the spoons greatly affects the touch resistance of a piano, so it is important that spoon adjustments be as uniform as possible. Although there are methods of adjusting spoons with the action on the bench, they are not as accurate or as fast as using a well-designed spoon bending tool with the action in the piano. The first requirement is *the proper spoon bender*. Fig 9 shows a particular model that I favor (APSCO #16406). I suggest getting two and bending the handle of one as shown for use on compact console actions.

Unlike most adjustments, spoon bending is done blind, so first we must teach our fingers what the tool feels like as it slips onto the spoon. I suggest the following procedure:

- Remove the action nuts, tip the action back toward you, look down in and put the tool on a spoon. Notice that the tool must lean to the side, toward the spoon.
- Slip the tool on and off the spoon, noticing what it feels like. Notice that lifting the wippen moves the spoon away from the action rail, making it easier to slip the tool in place. Close your eyes and notice what the bender sounds like as it clicks against the spoon.
- Next, push the action forward and try to find the spoon without looking. Remember to lift the wippen slightly to make the spoon more accessible. If you're not sure where you are, pull the action back and look. You may find it helpful to place a piece of tape around the handle corresponding to the front end of the wippen, so you know how far in to reach with the tool. With your senses of feel and hearing thus trained, you should be able to grab the spoons without looking.
- Prop a damper-lift gauge against the strings as shown in Fig 9. You can then lift each wippen, causing its hammer to bump against the gauge, to test damper lift. If the gauge dimension is 1/2 the blow distance, each damper should just wink as the hammer bumps the gauge.
- When making adjustments, hold the spoon bender in one hand and the end of the wippen with the other, and work one against the other.
- Each piano design is different so you may have to repeat the initial step of tilting back the action occasionally with new designs. Many compact actions require that you remove the keys to get enough room to operate the tool. On spinets the spoons are adjusted just like on larger uprights, except that the tool is held under the keybed.

Figure 9: *Adjusting damper spoons*



Regulating the Pedals

The soft or hammer rail pedal should have no lost motion, but should not hold the hammer rail up off its supports. A piece of firm blocking felt should be glued under the pedal to limit travel to one-half the blow distance. Another block of felt can be glued between the hammer rail and the right action bracket to prevent the rail from flying forward in case of a strong stomp on the pedal.

The sustain pedal should have enough lost motion to ensure that the damper lift rod is well clear of all damper levers at rest, so that all dampers rest against the strings with their full spring force. Test by deflecting some strings inward; the dampers should follow the strings at least 1/16". The sustain pedal travel should also be limited by blocking felt, to limit damper lift to approximately the same amount as the dampers lift with the spoons.