Controlling the Touchweight of the Upright Action

Part 1: Analysis and Theory

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The Character of the Upright Piano Compared with a Grand Piano

Upright pianos haven't often been the focus of advanced technical topics such as touchweight, regulation, voicing, etc.

The action of the upright piano is limited compared with the grand action. The Touch in an upright can't be adjusted as well or as accurately as a grand. Even if you adjust the upright action extremely well, it doesn't respond very sensitively. Does this sound familiar?

I would like to offer a different view. Upright piano owners don't normally expect fantastic playability and evenness of touch. The majority of good pianists start with an upright, use it for practicing or use it without knowing what they can get from the instrument with serious input from a technician. The cost of additional work may discourage some customers from advanced work on their pianos.

Some clients, however, may ask you to make the touch lighter or heavier. If so, you can adjust the regulation, fix sticky action centers and so on, and yet I've not seen a comprehensive assessment of what we can do to an upright piano to change its touchweight. The majority of piano technicians deal with upright pianos every day, but we haven't given much thought to adjusting the touch of uprights for the reasons above.

There are many upright pianos on the market with a corresponding variety of quality. One rough indicator of the quality of pianos is their price. Generally speaking, we see lesser quality in a cheaper piano. Lesser quality instruments may have minor or major problems. For example I met a customer who asked me to lighten the piano's touch. The piano had a very heavy touch because the damper springs were far too strong. As soon as the damper spoons touched the damper levers the customer could not play *pianissimo*.

This article will focus on touchweight control of the upright, moving from general points to advanced techniques. I haven't included any discussion of the alteration of touch through nuances of tuning and voicing.

Areas Where We Can Check and Adjust for Touchweight Problems

1. Friction of action parts and keys
2. Strength of action springs
3. Regulation
4. Key leading
5. Hammer strike weight
6. Capstan – whippen heel connection
7. Key balance punching cloth
8. Butt felt

Numbers 1 to 3 are general problems the majority of technicians can deal with. Fixing sticky flange centers, easing tight key bushings and regulating the action correctly may be all that is required to have the piano at a good standard and to satisfy your customer. There are many pianos in poor condition which will acceptable to the customer after this basic work is correctly done. This work must be done first in all cases.

1, Friction, Action Parts and Keys

The piano action should have correct friction at flanges, capstans and keys. Too little friction makes controlling the action difficult. Too much friction gives a sluggish feeling in an action, making it difficult to control, and in worst cases it won't work at all. Many articles, books and convention classes are available on this topic.

2, Strength of Action Springs

Hammer butt springs, jack springs and damper springs become weak or break with age. Sometimes too a strong spring is used by manufacturer or a previous repairer.

The hammer butt spring forces the hammer back to its rest position. Its force is therefore a component of touchweight. For example, touchweight decreases about seven grams when the butt spring is unhooked in an action.

Weaker butt springs impart less return force to the hammer so that hammer won't be caught by the catcher. In the worst case, the hammer will double strike if the butt spring is too weak or broken. It is possible to make the touch lighter by weakening the butt springs (provided it doesn't cause double striking). However, this is not recommended, because adjusting all butt springs takes time and it is not easy to adjust them very evenly.

Some pianos have overly strong damper spring. Strong damper springs can completely stop finger movement, especially with *pianissimo* playing or playing by a small child or elderly person.

You can measure the strength of the damper spring at the key by determining the difference between two down weight measurements. For the first measurement, the hammer moves from rest until the damper spoon touches the damper lever. The second measurement is after the spoon starts pushing the damper lever. This damper spring force might measure 30 g in treble, about 40-50 g in tenor and 70-80 g in bass. Excessively strong damper spring force measured at the key will cause problems when the piano is played.

Damper springs can be adjusted by using a spring adjuster the same way you would with a grand repetition spring. Massage near the coil gently to make them weaker. You can increase their strength in the same way, but be careful not to bend the spring. If dampers start leaking, they are obviously too weak.

Strength of the jack spring is measured at the key. You can measure the strength of the jack spring at the key by the difference between two downweight measurements, taken with all the dampers lifted to remove them from the measurement. The first measurement is taken before the jack tender touches the let off button; the second downweight measurement is while the jack is letting off. This force difference might be 10-20 g. In principle this should be same for the whole piano, because all jack springs in a piano should be at the same tension. However, it can vary because friction between the jack and butt leather may be inconsistent, and the measurement in bass may be higher.

A customer may complain of double striking because the jack spring is far too strong so the player’s finger stops on reaching the letoff point. You can replace the spring with a shorter or weaker one if it is too strong. Check the actual strength in an action. The same length of coil spring may not mean the same force is applied, due to variations in material and thickness.

3, Regulation

We know regulation is very important, but in reality only few upright pianos have been very well or very accurately regulated; only rarely do owners of upright pianos require the level of finesse this article deals with.

When regulation is poor, the action is not efficient. Then the player feels the touch as “not good” or “heavy”. Regulation directly affects touchweight and the "feel" of the action. If the hammer blow, key depth, aftertouch and letoff are very different from standard, the touch may be described by the player as weird, odd, funny or heavy.

Examples of regulation which directly affects the touch would be the bridle wire for-aft adjustment and damper spoon. If the bridle tape is too tight, the touch feels heavier; if the damper spoon contacts the damper lever too early, the touch feels heavy. They need correct adjustment.

Fixing Touchweight Problems

If you have dealt with the general treatments above but the customer is still not happy, you may need to look at points 4 to 8 above. They are related to static balancing and kinetic resistance of the action i.e. Moment of Inertia (MoI).

I won't go into analysis and theory in this article but rather will deal with important points about these concepts and show how to apply them in a practical way.

Finding the Strike Ratio of the Upright Action

Strike ratio shows how 1 g of hammer strike weight (HSW) feels at the key. A 5.0 ratio means that 1 g of HSW is felt as 5 g at the key. (All weight is measured at “weighting position” or “measuring position” where is 13 mm from the edge of the key.)

The Stanwood equation can be applied to an upright action. However I add in butt spring force.

BW + FW = WW x KR + HSW x HSR + BSF

with balance weight as *BW*, front weight as *FW*, wippen weight as *WW*, key ratio as *KR*, hammer strike weight as *HSW*, strike ratio as *SR* and butt spring force as *BSF*.

Please follow Stanwood's protocols when taking measurement of each item. (I measure *HSW* differently from Stanwood’s protocol, which I will explain in part 2 of this series.) Butt spring force (*BSF*) can be obtained by subtracting balance weight with the butt spring unhooked.

The Stanwood equation shows how the action balances at a specific balance weight and strike ratio. However, it takes considerable time to get all the data necessary to make these calculations.

I suggest an alternative way to find the strike ratio using normal touchweight measurement such as downweight and upweight. We can then adjust touchweight by *HSW*, strike ratio and balance weight, as described later.

Here is the alternative method to get the strike ratio for an upright action. Calculate it by comparing two balance weight values; the value as it is, and with additional weight on the hammer as in Photo 1.

BW_1 and HSW_1 are as-is values. BW_2 and HSW_2 are values when an additional weight was put on the hammer. *FW*, *WBW* (Wippen Balance Weight) and *SR* do not change by adding weight to the hammer. If we apply Stanwood's equation to these two situations, we get the two equations below.

$$BW_1 + FW = WBW + HSW_1 \times SR + BSF$$

$$BW_2 + FW = WBW + HSW_2 \times SR + BSF$$

If we subtract the upper equation from the lower equation, we get:

$$BW_2 - BW_1 = (HSW_2 - HSW_1) \times SR$$

So we can calculate the strike ratio by:

$$SR = (BW_2 - BW_1) / (HSW_2 - HSW_1)$$

I normally use 2.0-g weight as shown Photo 1, so this can be re-written:

$$SR = (BW_2 - BW_1) / 2.0$$

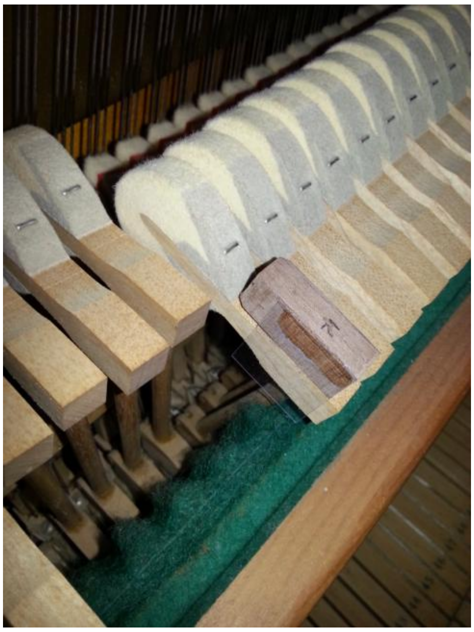

Photo 1: A 2.0-g weight is attached to the hammer to determine strike ratio.

On actual trials, the strike ratio of upright actions was somewhere between 1.5 and 3.0. These are quite different values from grand piano values, which are normally 5.0 to 6.5.

This is because the hammer in an upright travels nearly horizontally and the hammer assembly rotates about the hammer center. Gravity has less effect on the hammer assembly in an upright than it does in a grand.

In an upright the HSW effect on the wippen and key decreases during its travel, as if hammer weight is reducing. The lower strike ratio in an upright means the HSW affects the touchweight much less than it does in a grand action.

Effect of Moment of Inertia

The MoI of action parts was discussed in my previous article, "Practical Application of Moment of Inertia". My method of finding MoI can also be applied to the upright action.

In a grand action, hammer weight is responsible for about 80% of the Moment of Inertia at the key. This was reinforced in some recent articles.

What about MoI in an upright action? It is also a major factor, actually even more so than in a grand action. We can calculate a value for MoI at the key as follows.

The MoI of hammer assembly: multiply hammer strike weight with the squared distance between center pin and center of the hammer moulding (Photo 2). My sample was C4 of a Yamaha U1, which had 9.6 g of HSW and 12.8 cm distance from center pin to center of the hammer moulding. It calculated at 1,573 gcm^2. Calculating it using segmented parts (as in theory) gave a value of 1,422 gcm^2. There is about 10% different between these figures. As I stated before, we can use this method to approximate MoI, as in practice we can't segment piano mechanisms.

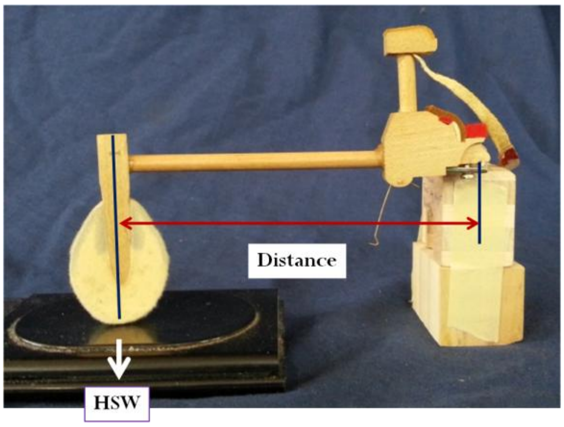

Photo 2: Measure HSW and distance to calculate the MoI of the hammer assembly.

The MoI of the wippen: I segmented an actual wippen into many parts (Photo 3), then added them up as I did on a grand wippen. From the calculation of the sample wippen, the MoI of the wippen was 622 gcm^2.

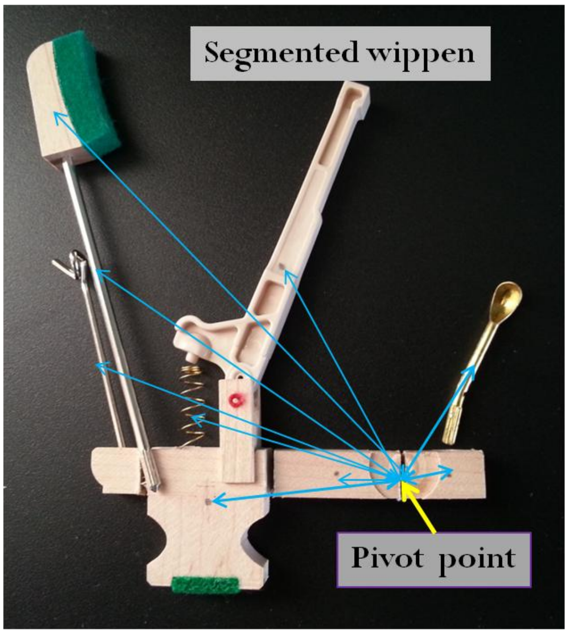

Photo 3: Segmented upright wippen; blue lines show distance between pivot and mass center of each part.

The MoI of the key calculated by my method was 10,079 gcm^2.

The MoI of the whole action at the key on upright action can then be calculated by use of the following equation:

$$MoI_{(Whole\ action\ at\ key)} = MoI_{(K)} + MoI_{(W)} \times (L_{KO}/L_{WI})^2 + MoI_{(H)} \times (L_{WO}/L_{HI} \times L_{KO}/L_{WI})^2$$

L_{KO} is the distance between the pivot of the key and the top of the capstan. L_{WI} is the distance between wippen center and capstan center. L_{WO} is the distance between wippen center and jack center and L_{HI} is the distance between butt center and jack / butt leather contact (Photo 4).

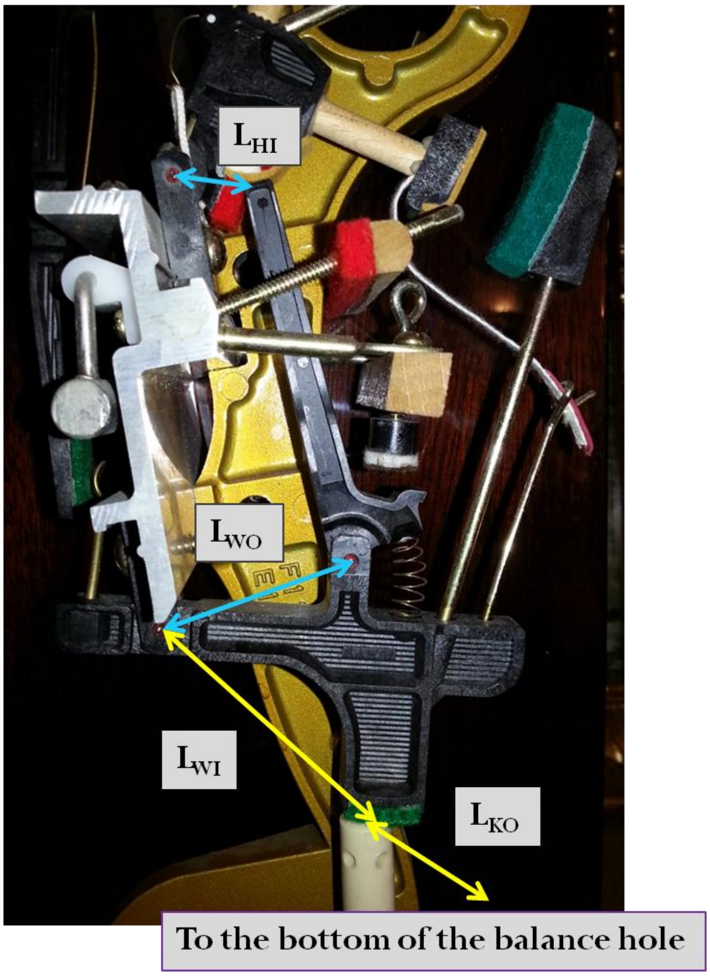

Photo 4: Gear ratio at capstan-wippen (yellow) and jack-butt (blue) for calculation of the MoI at the key.

Why can we use the distance between wippen center and jack center as output length of wippen (L_{WO}) for calculation of the gear ratio?

This is because when the wippen is moved up, the amount moved at the jack center and top of the jack are nearly same as if they were solidly connected (Photo 5). Note that slight angle difference and traveling arc may make small difference between the two lengths, but this measurement is adequate for our purpose, as we can measure it easily and accurately.

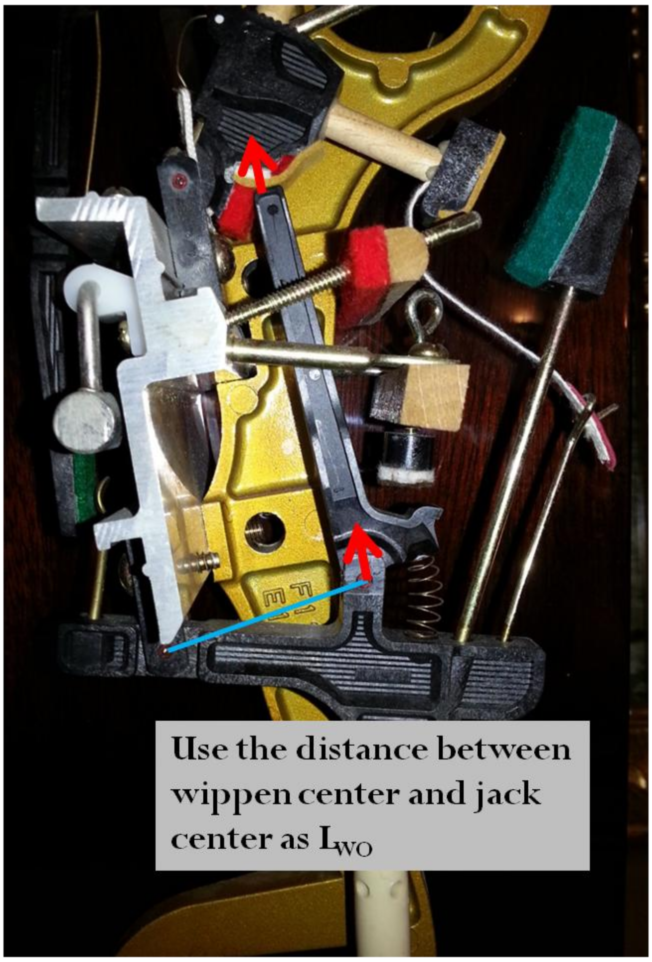

Photo 5: Determining output length of the wippen.

An example, note (C4) from Yamaha U1:

$$MoI_{\text{(Whole action at key)}} = 10{,}079 + 622 \times (160/48.5)^2 + 1{,}573 \times (36.5/14.5 \times 160/48.5)^2$$

$$= 125{,}217\ gcm^2$$

So the percentage contribution of each part of MoI of the whole action at the key is

Hammer: 86.5% (108,364 gcm^2),

Wippen: 5.4% (6,774 gcm^2),

Key: 8.0% (10,079 gcm^2).

Compare this with note C4 from a Steinway D (whole amount of the MoI at the key is 257,311 gcm^2):

Hammer 78.7% (202,577 gcm^2),

Wippen 1.7% (4,332 gcm^2),

Key 19.6% (50,463 gcm^2).

For details of this, see my previous article in the October 2014 Journal.

As you see, the hammer is the biggest contributor to the MoI at the key, the same as in a grand action. It is, however, an even bigger percentage than in a grand. The key now has a much smaller role in resistance to acceleration in the action. However, I believe the key must be included in our consideration of touch resistance. (See Igrec, Pianos Inside Out, page 299.)

Sometimes a customer wants a heavier touch on an upright piano. Possibly it is because the MoI in the key is small. The Hammer moves similarly to a grand, but the key of an upright action moves with much less resistance than it does in a grand, so a pianist may feel a disconnection between action parts. This may be corrected or improved by increasing the MoI of the key. Details of this will be discussed in part two of this series.

Note that effect of hammer weight on touchweight is smaller in an upright than in a grand because of the reduced effect of gravity on an upright action. However, the MoI of the hammer assembly is still calculated as a whole because we are measuring resistance to acceleration of the object, whichever direction it is moving, vertically or horizontally.

In the next article, I will show you how we can apply these theories to an actual action to control touch.