At Large

Mastering Friction With The Balance Weight System

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Patent Pending

My article in the October 1990 *Journal* describes how the Stanwood Action creates a high degree of touch uniformity through individual treatment of balance weight and friction. These touchweight components are derived from the following formulas:

balance weight = downweight + upweight ÷ 2

friction = downweight - upweight ÷ 2

My approach for creating uniform touch is to weigh-off to a uniform balance weight, then to set the final touch weight values by adjusting the friction level in each key. In the Stanwood Action this is done with the aid of adjustable friction hammer flanges.

The success of the Stanwood Action would not be possible without the ability to weigh-off the keys to a uniform balance weight. Creating a uniform balance weight during the process of key balancing is a confusing and tedious task without a systematic approach to the process. I have devised a system which eliminates the need for calculation. I call it *The Balance Weight System*. Even if you don't have the option of the adjustable friction hammer flange, there are advantages to creating a uniform balance weight:
Specifically:

1. The balance weight value remains unaffected by friction, whereas upweight and downweight change daily and seasonally with friction. Therefore, balance weight is the logical point of reference when balancing keys.

TABLE A

Upweight/downweight pairs at various balance weight and friction levels.

Friction

BALANCE WEIGHT	20	19	18	17	16	15	14	13	12	11	10	9	8
44	24 64	25 63	26 62	27 61	28 60	29 59	30 58	31 57	32 56	33 55	34 54	35 53	36 52
43	23 63	24 62	25 61	26 60	27 59	28 58	29 57	30 56	31 55	32 54	33 53	34 52	35 51
42	22 62	23 61	24 60	25 59	26 58	27 57	28 56	29 55	30 54	31 53	32 52	33 51	34 50
41	21 61	22 60	23 59	24 58	25 57	26 56	27 55	28 54	29 53	30 52	31 51	32 50	33 49
40	20 60	21 59	22 58	23 57	24 56	25 55	26 54	27 53	28 52	29 51	30 50	31 49	32 48
39	19 59	20 58	21 57	22 56	23 55	24 54	25 53	26 52	27 51	28 50	29 49	30 48	31 47
38	18 58	19 57	20 56	21 55	22 54	23 53	24 52	25 51	26 50	27 49	28 48	29 47	30 46
37	17 57	18 56	19 55	20 54	21 53	22 52	23 51	24 50	25 49	26 48	27 47	28 46	29 45
36	16 56	17 55	18 54	19 53	20 52	21 51	22 50	23 49	24 48	25 47	26 46	27 45	28 44
35	15 55	16 54	17 53	18 52	19 51	20 50	21 49	22 48	23 47	24 46	25 45	26 44	27 43
34		15 53	16 52	17 51	18 50	19 49	20 48	21 47	22 46	23 45	24 44	25 43	26 42
33			15 51	16 50	17 49	18 48	19 47	20 46	21 45	22 44	23 43	24 42	25 41

2. An action with uniform balance weight has optimal uniformity of the inertial component of touch. Since inertia magnifies weight factors in the action, inconsistencies in the balance weight will be magnified when the key is struck, therefore, it is desirable to have a uniform balance weight. (There are many aspects concerning the subject of inertia which I do not have space to cover in this paper.)

3. Keys with uniform balance weight will have more uniform upweight and downweight values than if balance weight were allowed to vary (compare touchweight analysis figures before and after balancing to uniform balance weight in my previous article on the Stanwood Action).

4. When balance weight is uniform, upweight and downweight become true indicators of static friction levels in the action. In other words, the technician can quickly tell how much friction is in the key without calculation by looking at either upweight or downweight alone.

Before I describe the balance weight system, let's discuss the relationships balance weight and friction have to upweight and downweight. Table A shows pairs of upweight and downweight figures at different levels of friction and balance weight. Note that the pairs of figures in the horizontal rows all calculate the same balance weight value and that the vertical columns all calculate the same friction value.

A plot of upweight and downweight against different friction levels demonstrates that balance weight is unaffected by changes in friction (figure 1). Conversely, plotting upweight and downweight against different balance weight levels shows how changing the balance of the key effects upweight, balance weight, and downweight equally (figure 2).

There are three basic rules which govern downweight, balance weight, and upweight:

1. The spread between upweight and downweight varies as a function of the total action friction.
2. Changing balance weight does not change the spread between upweight and downweight.
3. Changing friction effects the spread between upweight and downweight without changing the balance weight.

For example: If we add lead to the key so as to lower the balance weight by five grams, downweight and upweight will both drop by five grams. Whereas if we change friction in the action so downweight drops by five grams, upweight will rise by five grams and balance weight will remain the same.

Consider the following set of figures: The pairs of touchweight figures in each vertical column both have the same calculated friction shown at the top of the column. Note that the first horizontal row of paired figures have a common upweight of 20 grams. The second horizontal row of paired figures all have the same balance weight of 38 grams.

Work Table For 38-gram Balance Weight

Test downweight	56	54	52	50	48	46	44	42	40	38	36
Corrected upweight	20	21	22	23	24	25	26	27	28	29	30
Corrected downweight	56	55	54	53	52	51	50	49	48	47	46

Vertical columns have constant levels of friction.

18	17	16	15	14	13	12	11	10	9	8
20	20	20	20	20	20	20	20	20	20	20
56	54	52	50	48	46	44	42	40	38	36
20	21	22	23	24	25	26	27	28	29	30
56	55	54	53	52	51	50	49	48	47	46

Let's remove the friction values at the top and the 20-gram upweight values. This creates a new table which we can use to create a 38-gram balance weight in each key during the process of key balancing. (See Work Table For 38-gram Balance Weight)

This table makes it possible to test and correct for friction when weighing-off they keyboard:

Let's say that I'm weighing-off a keyboard to a uniform balance weight value of 38 grams. I first check that the key bushings are free. If there is lead in the keys from a previous weigh-off I remove enough lead from each key so they all need some lead added in order to make the balance weight specification. I then determine how much lead to put back in each key by first testing for friction and then weighing-off the key to upweight/downweight values taken from the appropriate column in the work table.

First I test the key for friction (without regard for the balance weight). This is achieved by placing a 20-gram weight on the key and arranging any number of lead weights on top of the key so the key shows a "test" upweight of 20 grams (the actual position of the leads at this point do not relate to the final lead positioning). Once I have made the upweight 20 grams I determine the "test" downweight to the nearest even

TABLE B

Working figures for weighing off at various balance weight levels

Balance Weight	Friction 20	19	18	17	16	15	14	13	12	11	10	9	8	
	60	58	56	54	52	50	48	46	44	42	40	38	36	TestDown (20up)
44	24	25	26	27	28	29	30	31	32	33	34	35	36	Upweight
	64	63	62	61	60	59	58	57	56	55	54	53	52	Downwt
	60	58	56	54	52	50	48	46	44	42	40	38	36	
43	23	24	25	26	27	28	29	30	31	32	33	34	35	
	63	62	61	60	59	58	57	56	55	54	53	52	51	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
42	22	23	24	25	26	27	28	29	30	31	32	33	34	
	62	61	60	59	58	57	56	55	54	53	52	51	50	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
41	21	22	23	24	25	26	27	28	29	30	31	32	33	
	61	60	59	58	57	56	55	54	53	52	51	50	49	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
40	20	21	22	23	24	25	26	27	28	29	30	31	32	
	60	59	58	57	56	55	54	53	52	51	50	49	48	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
39	19	20	21	22	23	24	25	26	27	28	29	30	31	
	59	58	57	56	55	54	53	52	51	50	49	48	47	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
38	18	19	20	21	22	23	24	25	26	27	28	29	30	
	58	57	56	55	54	53	52	51	50	49	48	47	46	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
37	17	18	19	20	21	22	23	24	25	26	27	28	29	
	57	56	55	54	53	52	51	50	49	48	47	46	45	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
36	16	17	18	19	20	21	22	23	24	25	26	27	28	
	56	55	54	53	52	51	50	49	48	47	46	45	44	
	60	58	56	54	52	50	48	46	44	42	40	38	36	
35	15	16	17	18	19	20	21	22	23	24	25	26	27	
	55	54	53	52	51	50	49	48	47	46	45	44	43	
		58	56	54	52	50	48	46	44	42	40	38	36	
34		15	16	17	18	19	20	21	22	23	24	25	26	
		53	52	51	50	49	48	47	46	45	44	43	42	
			56	54	52	50	48	46	44	42	40	38	36	
33			15	16	17	18	19	20	21	22	23	24	25	
			51	50	49	48	47	46	45	44	43	42	41	

FIGURE 1

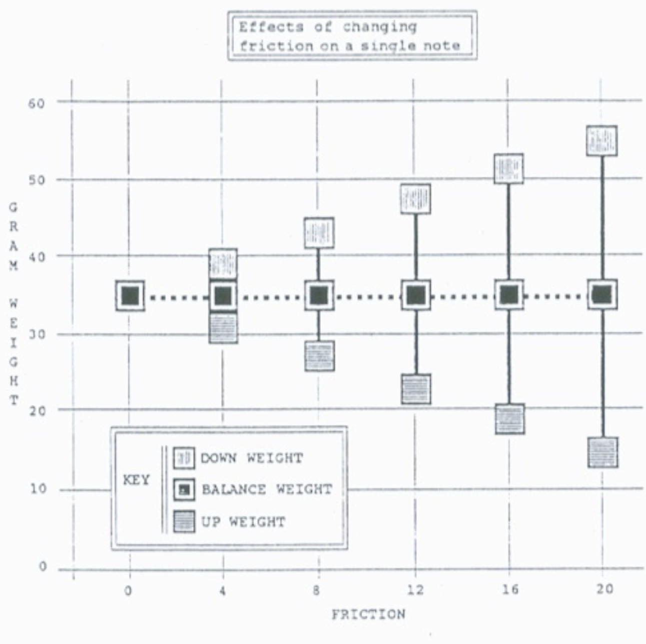

FIGURE 2

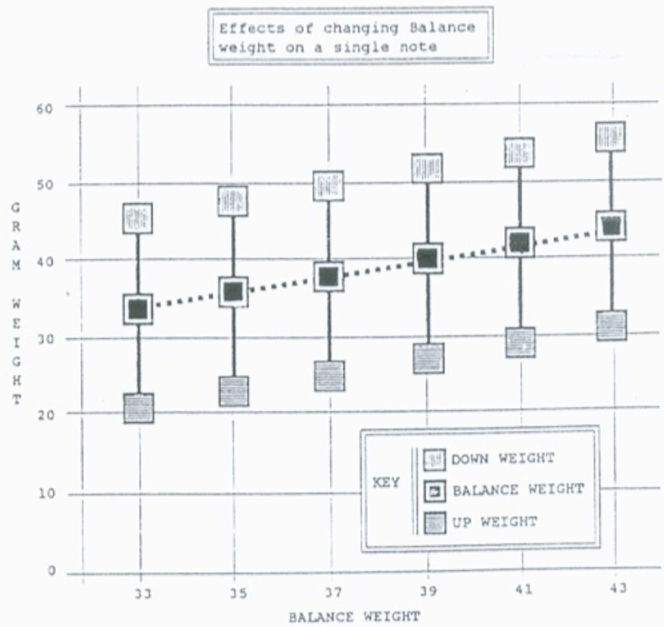

figure. The test downweight identifies the friction level in the key with a vertical column in the work table. I find the figure that matches the test downweight by looking across the top horizontal row of the table. Directly beneath this value are the appropriate upweight and downweight values for a 38-gram balance weight which correspond to the friction in that key. The key should be weighed off to these frictionally corrected values.

Now I take the lead weights off the top of the key and replace the 20-gram test weight with the corrected upweight value from the table. I then arrange the leads on the key so it lifts that upweight. Once I establish the proper upweight, I check to see if the downweight matches the appropriate value from the work table. The leads should now be in the positions where they will be permanently mounted in the key. I like to position leads in the old holes wherever possible. Even if it means clipping some weight off the lead, or flattening out a 3/8" lead to fit in a 1/2" hole. I mark the lead positions on the key and *remove the leads carefully to a tray with numbered slots so that the exact same leads go back into the same key.*

Let's review the procedure by weighing-off a hypothetical key to a 38-gram balance weight.

1. Place a 20-gram weight on the key and depress the key as if you were measuring upweight.

2. Set the upweight by arranging keyleads anywhere on top of the key so it just lifts 20 grams.

3. Remove the excess 20-gram weight and test the key for downweight. Let's say downweight measures out at 48 grams.

4. Go across the top horizontal row in the work table until you find the 48-gram figure.

5. Directly beneath are the frictionally corrected upweight and downweight values for this key. In this case they are: upweight — 24 grams, downweight — 52 grams.

6. Place a 24-gram weight on the key and arrange keyleads in their final position on the key so the key lifts 24 grams. Confirm that the downweight is 52 grams. If so, then you have created a key with a balance weight of 38 grams.

7. Mark the key and remove the leads to a slotted tray so they can be later mounted in the same key they came off.

This is the most practical method I have found to date for creating uniform balance weight.

In my shop we generally set balance weight at a uniform value of 38 grams. You may decide to use different balance weight values in which case you may refer to Table B which has working figures for a variety of balance weights.

Judging the motion of the hammer during measurement of touchweight is a critical aspect of key balancing. I like to judge the upweight in the normal fashion by depressing the key until the drop screw and the jack tender just touch their respective cushions, but without deflecting their springs. Upon release of the key, the hammer should move in a controlled downward motion that the eye can follow to a place just short of the rest position. For downweight I like to see the hammer move upwards in a sustained motion after rapping on the hammer rail with the fist. *The motion should mirror that seen in the upweight.*

I feel that keybushing friction tends to skew the meaning of upweight and downweight because it is not always uniform through the stroke of the key. I therefore favor keeping key bushings as free as possible. *I have found that it is difficult to achieve consistent results unless key bushing cloth surfaces have been treated with a dry lubricant (such as McLube #1725).*

It should be noted that friction, as measured in the key, is magnified during the actual playing of the instrument. The amount of magnification depends on the types of friction that are in the key. For instance: a key that has a friction of 15 grams, largely as the result of a tight hammer flange and a loose key bushing, will have a higher frictional component in the touch resistance during actual playing of the piano, than a key with a 15-gram friction — largely as a result of a tight key bushing and a loose hammer flange. This is because friction in the hammer flange results from the rubbing of the center pin against the felt bushing cloth. When the key is struck, the centerpin is driven more tightly against the cloth which increases the friction between the two surfaces. In the key bushing, the force of friction does not increase because the blow to the key does not tend to push the front pin and the bushing cloth surfaces against each other. This subject deserves more thorough study and discussion than I can offer here.

One last point: Buy or make yourself a set of gram weights graduated in one-gram increments. My set has enough weights so that I can make up a set for weighing-off which are mounted on a tray in a configuration like the figures in the work table. Then you don't have to look at numbers. Just find the appropriate test downweight and when you return it to the tray, your hand will fall right onto the corrected upweight and downweights. You can make your own weights by tamping lead into cut and deburred lengths of copper pipe.

In a future article I will discuss how to choose specifications for balance weight and how to use the balance weight system in mastering the adjustment of wippen helper springs.

See you in Philadelphia!