Piano/Model_____ Serial #_____ Date_____

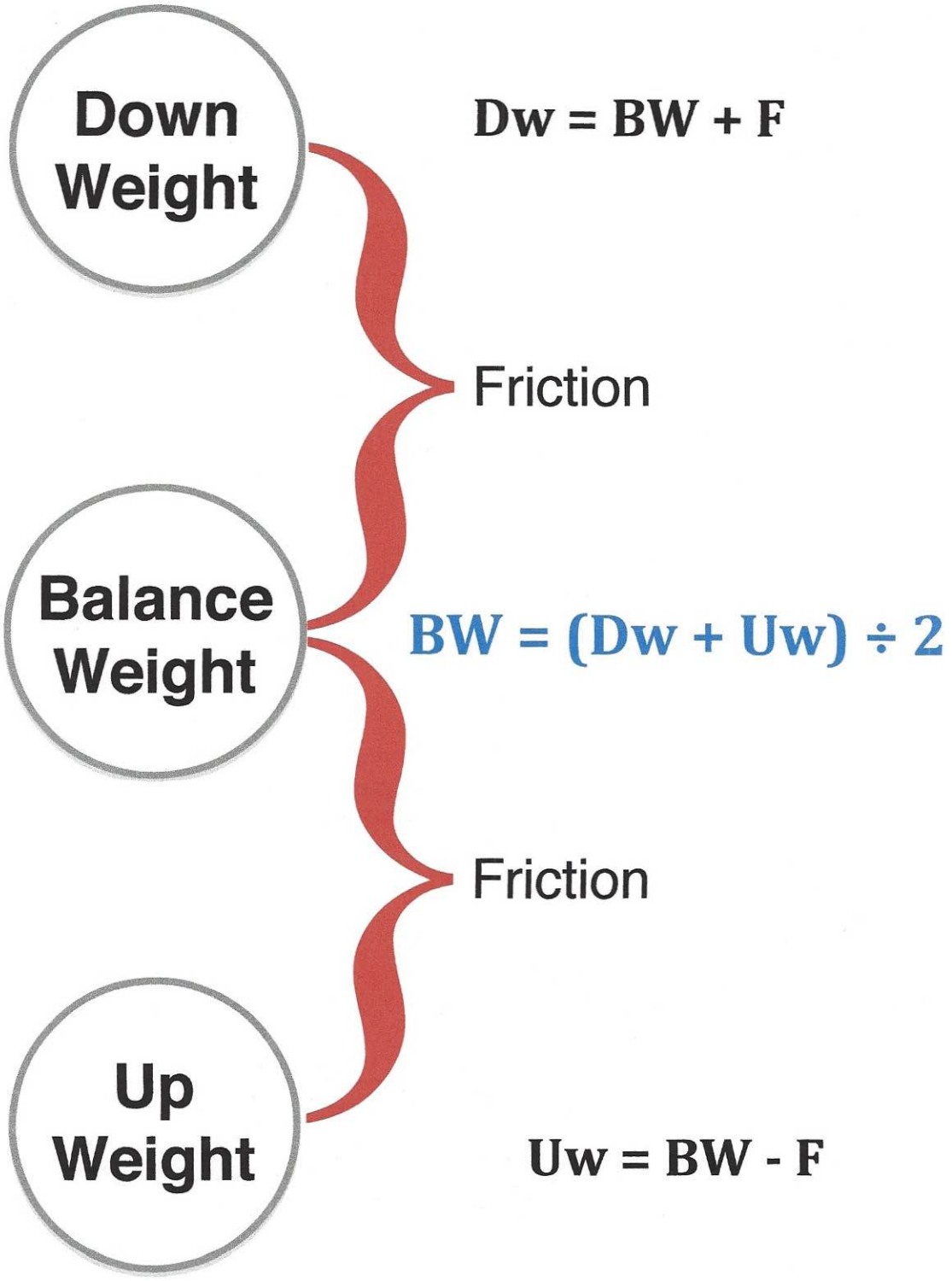
Owner Info: (Name)_____

The Split Weight/Balancing Weight Measuring System Using Spurlock or WN&G Weights

#/# = (Split Weights, i.e. 28/23 = F 14g BW 37g) **F = (Friction)** **BW = (Balance Weight)**

#	#/#	F	BW	#	#/#	F	BW	#	#/#	F	BW	#	#/#	F	BW
1	/			23	/			45	/			67	/		
2	/			24	/			46	/			68	/		
3	/			25	/			47	/			69	/		
4	/			26	/			48	/			70	/		
5	/			27	/			49	/			71	/		
6	/			28	/			50	/			72	/		
7	/			29	/			51	/			73	/		
8	/			30	/			52	/			74	/		
9	/			31	/			53	/			75	/		
10	/			32	/			54	/			76	/		
11	/			33	/			55	/			77	/		
12	/			34	/			56	/			78	/		
13	/			35	/			57	/			79	/		
14	/			36	/			58	/			80	/		
15	/			37	/			59	/			81	/		
16	/			38	/			60	/			82	/		
17	/			39	/			61	/			83	/		
18	/			40	/			62	/			84	/		
19	/			41	/			63	/			85	/		
20	/			42	/			64	/			86	/		
21	/			43	/			65	/			87	/		
22	/			44	/			66	/			88	/		

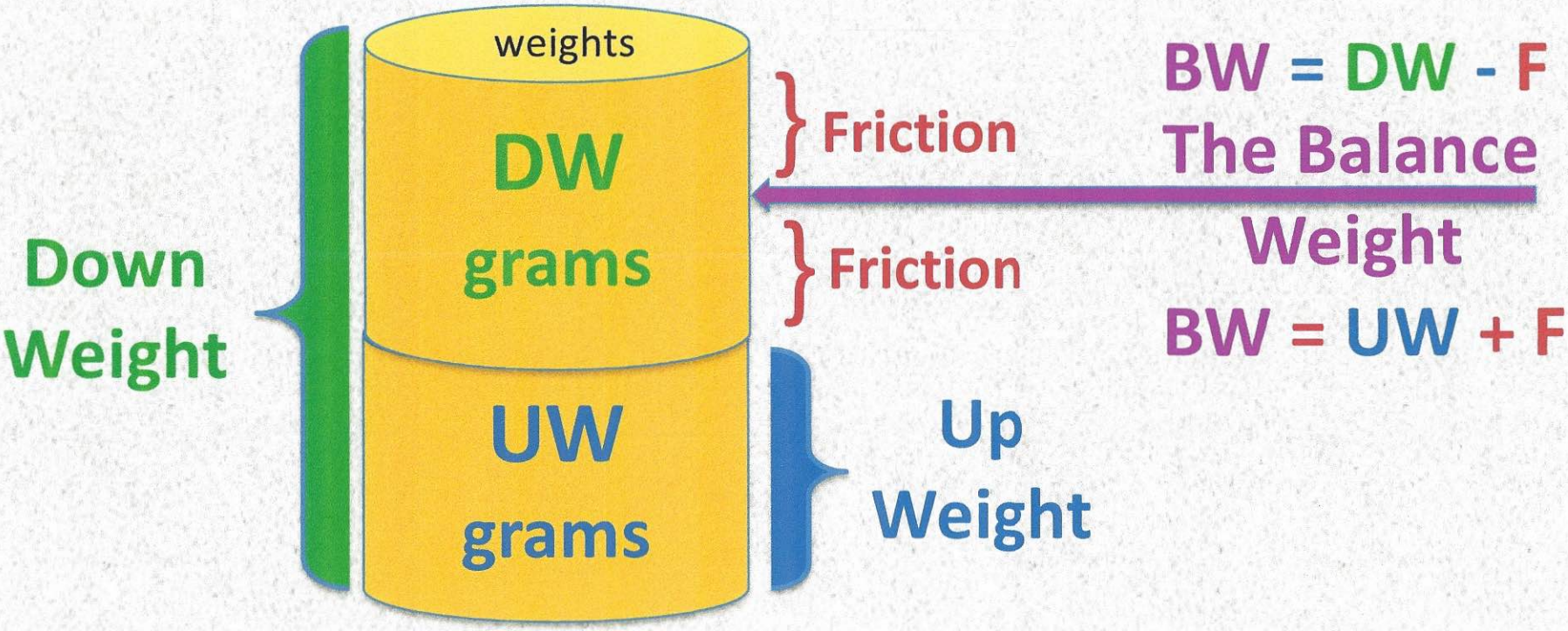
Downweight = Balance Weight + Friction
Upweight = Balance Weight - Friction
Friction = (Downweight - Upweight) ÷ 2
Balance Weight = (Downweight + Upweight) ÷ 2



Balance Weight Is Half The Distance Between Down Weight and Up Weight

Dw	47	48	49	50	51	52	53	54
f	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Bw	38	38	38	38	38	38	38	38
f	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Uw	29	28	27	26	25	24	23	22

A Single Weight Stack Instead of 2 Separate Weights For Measuring DW & UW



DW = BW + F

F = (DW - UW) ÷ 2

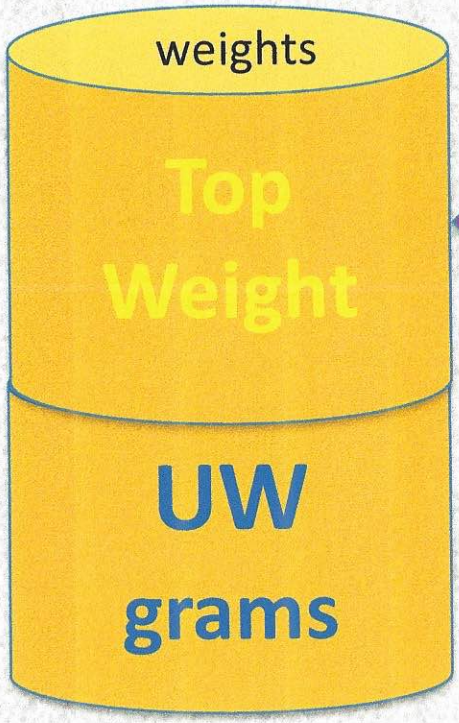
UW = BW – F

BW = (DW + UW) ÷ 2

What/Where Is The Balance Weight?

(The "Slow" Key/Action Motion From Total "Stack" Weight vs. Up Weight Is Equal/Even In Both Directions)

Then Apply Top Weight To Match Motion Of UW



Friction

Friction

The Balance Weight

Up Weight

Measure UW First

F = Top Weight ÷ 2

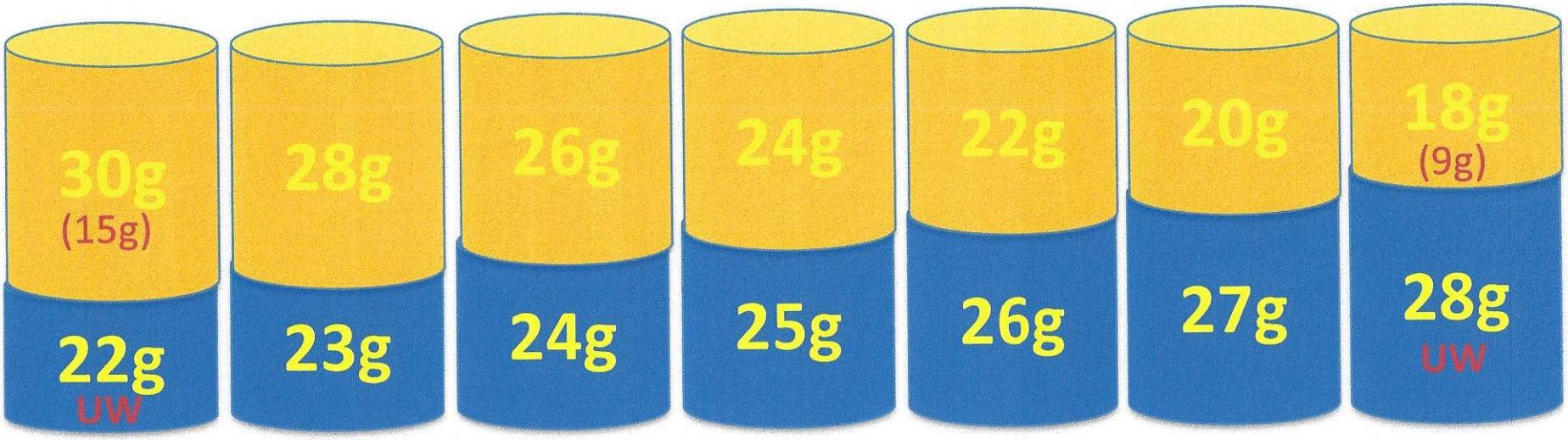
BW = UW + F

2 Essential Equations To Calculate Balance Weight

Stacks Arranged for 37g BW

Friction = Top Weight ÷ 2

BW = Upweight + Friction (½ Top Weight)



The Key Is Balanced When The "Slow" Key/Action Motion From The Total Stack Weight (DW) Is The Same As Upweight (UW)

Stacked Weight Pairs For Desired Balance Weight

Establish BW & Choose A Weight Stack For Slowest, Even DW & UW

[Friction]	16g	15g	14g	13g	12g	11g	10g	9g	8g
Balance Weight 36g	32g	30	28	26	24	22	20	18	**16g**
	20g	21	22	23	24	25	26	27	**28g**
Balance Weight 37g	32g	30	28	26	24	22	20	18	16g
	21g	22	23	24	25	26	27	28	29g
Balance Weight 38g	32g	30	28	26	24	22	20	18	16g
	22g	23	24	25	26	27	28	29	30g
Balance Weight 39g	32g	30	28	26	24	22	20	18	16g
	23g	24	25	26	27	28	29	30	31g
Balance Weight 40g	32g	30	28	26	24	22	20	18	16g
	24g	25	26	27	28	29	30	31	32g

36g BW = 16/28

Friction:
Top Stack ÷ 2
16 ÷ 2 = 8g

Down Weight:
Top Number
Of Stack
+
Bottom Number
Of Stack
16+28=44

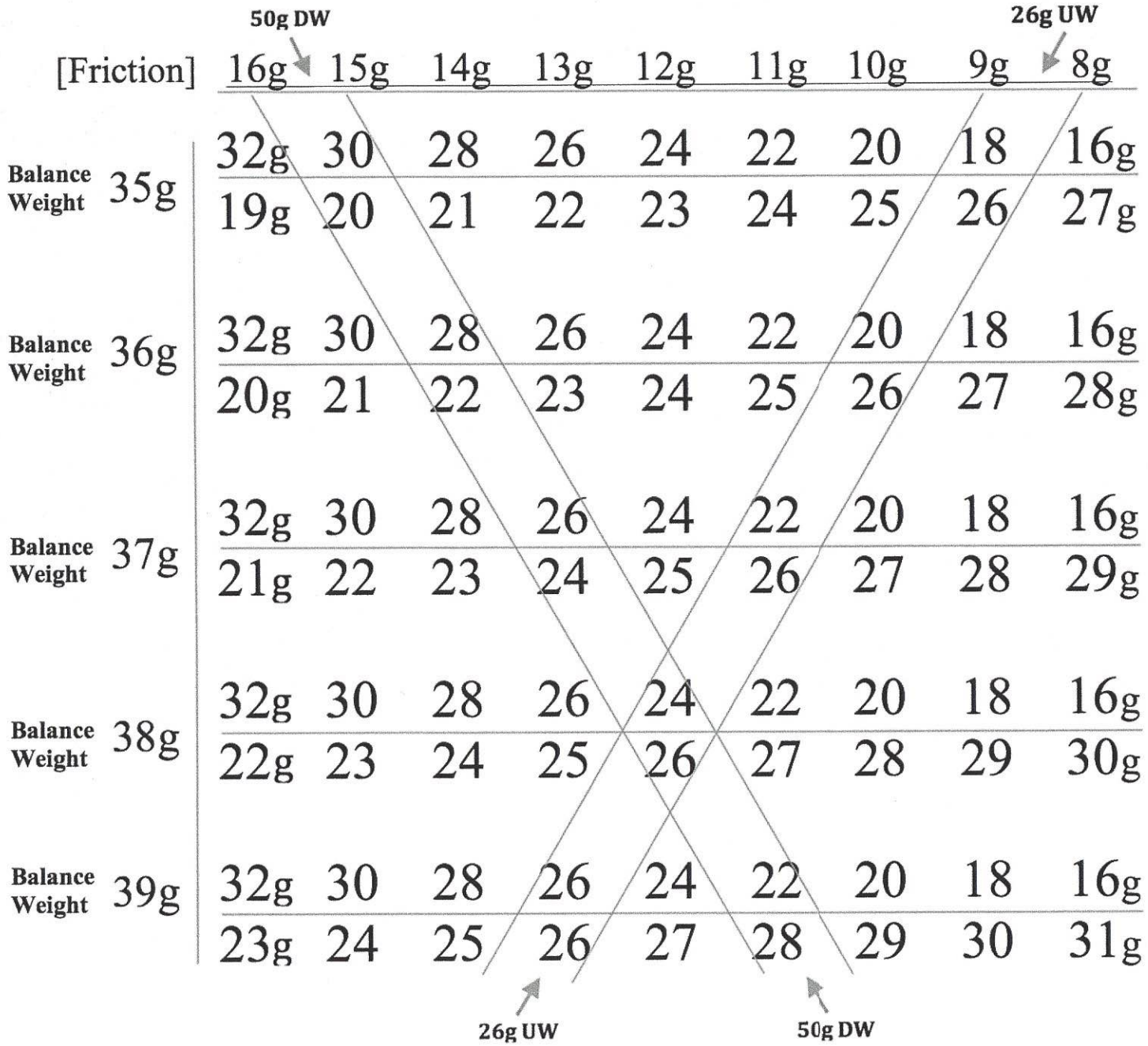
Up Weight:
Bottom Number
Of Stack
28

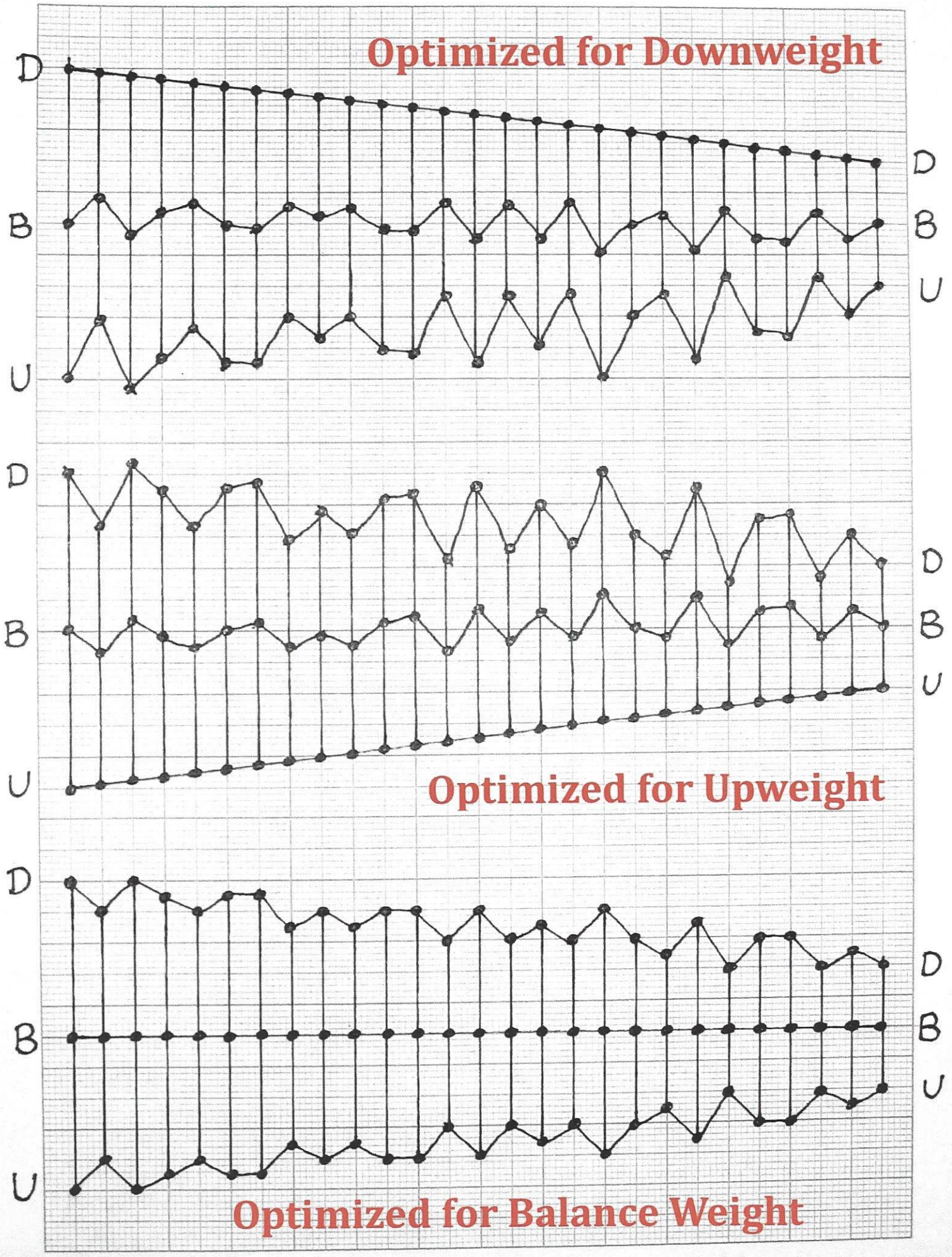
Balance Weight
[DW+UW÷2]
or
Top Stack ÷ 2
+ UW=BW

Friction
DW-UW÷2

Favoring DownWeight - Upweight Will Change By 2g as Friction Changes by 1g Note-to-Note

Favoring Upweight: Downweight Will Change by 2g as Friction Changes by 1g Note-to-Note




Optimized for Downweight
D
B
U
D
B
U
D
B
U
Optimized for Upweight
D
B
U
D
B
U
D
B
U
Optimized for Balance Weight

Theoretical Downweight Target

Downweight	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**
Balance Weight	34	35	36	37	38	39	40	41	42

Stepped Downweight Target

Downweight	**52**	**52**	**52**	**50**	**50**	**50**	**48**	**48**	**48**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**20**	**22**	**24**	**24**	**26**	**28**	**28**	**30**	**32**
Balance Weight	36	37	38	37	38	39	38	39	40

Theoretical Upweight Target

Downweight	**58**	**56**	**54**	**52**	**50**	**48**	**46**	**44**	**42**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**26**	**26**	**26**	**26**	**26**	**26**	**26**	**26**	**26**
Balance Weight	42	41	40	39	38	37	36	35	34

Stepped Upweight Target

Downweight	**56**	**54**	**52**	**52**	**50**	**48**	**48**	**46**	**44**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**24**	**24**	**24**	**26**	**26**	**26**	**28**	**28**	**28**
Balance Weight	40	39	38	39	38	37	38	37	36

A Balance Weight Target

Downweight	**53**	**52**	**51**	**50**	**49**	**48**	**47**	**46**	**45**
Friction	16	15	14	13	12	11	10	9	8
Balance Weight	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**

The Stacked Weight Balance Weight Method for Grand Action Weigh-Off

Action Weigh-Off /Key Leading Prerequisites

Before any action weigh-off can be done, the following must be addressed:

Hammer shank pinning is as even as possible, capstans and key pins are polished, and repetition and jack tops are smooth and well burnished. Space action parts and bench regulate the action. If the piano is available, install the action and pound in a tuning to settle the new action parts, then re-regulate.

Eliminate any obvious sources of friction:

- *Key bushings must have slight play. Lubricate key pins with dry PTFE spray or McLube 1725.*
- *Wool fibers on closely spaced action parts can rub, causing surprising amounts of friction. Using an electric burn-in knife or flame-heated knife, iron down the fuzz on the sides of hammers, knuckles, repetition lever cushions, and key end felts to eliminate all contact between neighboring parts. Don't even bother taking measurements until you have done this step.*
- *Lubricate the knuckles; talc is OK but our Micro-Fine PTFE Powder is far better (see web site). Avoid touching knuckles with your fingers—a little moisture or oil from the skin can temporarily add 2gm of friction to a note. If the action has not been played at all, burnish the knuckles against the repetitions by rocking the key and hammer together, as if you were checking backcheck to hammer tail clearance.*
- *Re-check parts spacing, key height, repetition lever height, and capstan height. (Dip, let-off, drop, etc. have no effect upon touch weight measurements and so do not need to be exact at this time.)* (Bill Spurlock)

Action Balancing / Balance Weight (Weigh-Off Method discovered by David Stanwood, RPT)

"Understanding and employing Balance Weight as the standard for establishing the static touch weight of the action is not simply one method, it is the essential and most efficient method. The Balance Weight value of a key/action assembly is the mid-point between Upweight and Downweight." Read all PTG Journal articles by David Stanwood on this subject.

The balance weight and friction of a key/action assembly are calculated by the following equations:

Balance Weight = (Down Weight + Up Weight) ÷ 2

Friction = (Down Weight – Up Weight) ÷ 2

Example: A key with a Downweight of 50g and a Upweight of 26g will have a 38g Balance Weight and Friction of 12g

"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. An action with uniform balance weight has optimal uniformity of the inertial component of touch."

"Keys with uniform balance weight will have more uniform upweight and downweight values than if balance weight were allowed to vary."

"When balance weight is uniform, upweight and downweight become true indicators of static friction levels in the action." (David Stanwood, R.P.T)

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) "Changes in friction affects the spread between upweight and downweight without changing the balance weight."

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."* (David Stanwood, R.P.T.)

Stacked-Weight Balance Weight Weigh-Off Method & Instructions

This method discovered by Steve Schell, RPT (using Stanwood BW calculations) presents the easiest and most efficient way to establish the Balance Weight in the weigh-off process. Using WN&G Gram Weights, (brass weights of 10g, 14g, 16g, 18-30g in 1g increments + an additional 24g & 26g) stacks of the weights are arranged that represent/establish the desired Balance Weight and will be arranged for increments of friction that will likely be present in the action note-to-note, i.e. 37g Balance Weight of a given note with 10g of friction is represented by a stack of 20g on top and 27g on the bottom – DW is 47, UW is 27. **F = (Dw – Uw) ÷ 2. BW = (Dw + Uw) ÷2**

The **Normal friction** in an action with correct geometry and hammer weight **should range from 12g-14g in the Bass to 8g-9g in the high treble**.
A 37g-38g Balance Weight seems to be ideal for most actions.

Assemble Stacks of Weights to Desired Balance Weight of 37 or 38

The "assembled stacks" (see chart) represent the gram weights used for a 37g BW or 38g BW; the total grams of the two parts of the "stack" represents Down Weight, the bottom number represents Up Weight, ½ of the top number represents Friction. ½ of the top stack + the bottom stack = the Balance Weight.

As you can see from the Stacks, it is very easy to track Friction and Balance Weight from note to note with virtually no calculations except to mentally note that ½ of the top stack is the friction as you observe the slowest and most complete and equal movement of the key down to the point of let-off and returning to its rest position.

By having these stacks in front of you on the bench during the action weigh-off process, it is quick and easy to use the stack that will allow for the best observation of even (and slow) key/action movement (in conjunction with the addition or removal of lead) having the confidence that each stack represents the desired Balance Weight. (If the motion is different in one direction from the other, either lead needs to be removed or added to the key)

A 37g-38g Balance Weight is ideal for most actions.

37g BW	16g 18 20 22 24 26 28 30g	**< Top Weight**
	29g 28 27 26 25 24 23 22g	**< Bottom Weight**
38g BW	16g 18 20 22 24 26 28 30g	**< Top Weight**
	30g 29 28 27 26 25 24 23g	**< Bottom Weight**

Balance Weight = (Down Weight + Up Weight) ÷ 2 **Friction = (Down Weight – Up Weight) ÷ 2**

Down Weight = Balance Weight + Friction **Up Weight = Balance Weight - Friction**

The Process

Remember, any grand action key assembly has a Balance Weight by virtue of the mass/weight on each side of the fulcrum. The process is to regulate the BW to a desired number of grams along with a goal is to see an even, slow (approx. 1 second) movment of the key and hammer in both directions only to the point of let-off/drop. (It is possible that you will need to use the upward ¾ of the hammer movement as a point of reference due to difficulty in starting the motion from the point of rest)

To determine if a key assembly is in balance, place a stack for a desired balance weight (representing 10g-12g friction) on the key at the front edge; **if there is fast downward movement of the key followed by a slow or no upward movement when the top weight is**

removed, lead needs to be removed from the key. Conversely, if there is slow or no downward movement of the key followed by fast upward movement when the top weight is removed, additional lead needs to be added to the key. When you have achieved what appears to be **even motion** in both directions, the accuracy of this process is dependent on the setting and lifting of the top weight to set the key into continuous motion: When you do this several times in a row, you will easily overcome static friction without the need to thump the action rail or work bench and you will quickly see if the motion is even in both directions.

As you add or remove lead using a given stack, you will eventually reach the point where the key & hammer motion will be even in its speed of travel. When it appears that the action movement is even, you may need to choose a weight stack that allows the slowest, most even and complete movement of the key and hammer. This will reveal the Balance Weight of the key/action assembly and an acceptable level of friction.

Remember, the greater the friction, the heaver the weight stack to evaluate the BW motion – notice that as friction increases, the spread between Upweight and Downweight increases but the Balance Weight Does Not Change!

Diagnosis of the Balance Weight and Friction on any grand action key assembly…

…is quick and easy using the stacked weight method. You must first eliminate any obvious sources of friction before taking measurements.

First, start with selecting a WN&G weight that reveals the Upweight of the key from the point of let-off that allows upward key movement as slow as possible…

…then select the top weight that causes the downward motion of the key to be as slow and even as the upward movement. Immediately lift top stack to observe Upweight motion – repeat several times. If the downward movement of the key does not match the upward movement of the key, change the top stack until it does. If the downward movement is too slow or not at all, you must increase the weight of the top stack because of higher friction present. Conversely, if the downward movement of the key is faster than the rise with the established Upweight, choose a lighter top stack weight to reflect lower friction.

Add these weight stack numbers to your action assessment sheet and calculate the Balance Weight and Friction. If all the C's or A's are measured in this manner, you will immediately know the general static touch weight and friction status of the action and will be able to then make some informed decisions as to what to do to either correct or improve situation.

IMPORTANT

The problem with the old method of focus on Down Weight weigh-off is that action friction dictated the placement of leads: Any unevenness in friction note-to-note would result in uneven leading as well as uneven Up Weight of 2g for every 1g variation in friction (Balance Weight was not a consideration!). The converse was also true if the focus was on Up Weight.

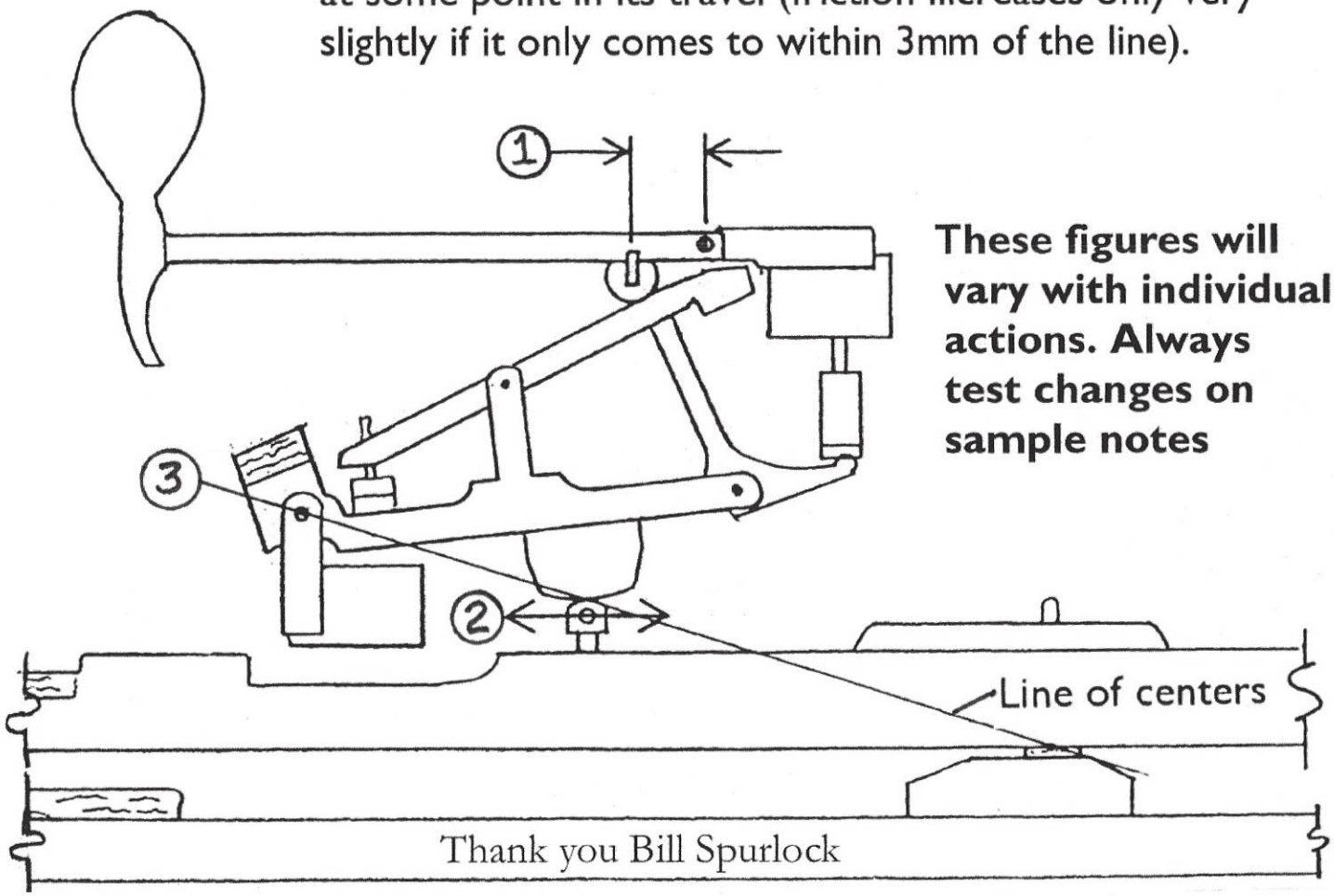
The great value of establishing the Balance Weight, is that you are truly regulating the mass of the action which results in a more even leading of the keys and is not affected by variations in friction: A specific Down Weight or Up Weight number is no longer significant because those numbers only reveal the variations in friction (IMO, 1g-2g of friction variation between notes is not significant to the pianist). With the stacked weight weigh-off method, it is easy to quickly to identify and address strange and sudden changes in friction note-to-note, i.e. tight key bushing or center pinning.

[Bruce Stevens – rev. 7/1/19]

1. Changing to shanks with a 1mm greater knuckle-to-centerpin dimension will lower R by approx. .4 and lower D by about 5gm (vice versa for a 1mm reduction in knuckle/c.p. distance.

2. Moving capstans 2mm toward balance rail will decrease R by approx. .4 and decrease D by approx 5gm (vise versa for moving capstan 2mm back).

3. Ideally the capstan top should meet the line of centers at some point in its travel (friction increases only very slightly if it only comes to within 3mm of the line).



These figures will vary with individual actions. Always test changes on sample notes

Thank you Bill Spurlock

Piano/Model _____ Serial# _____ Date: _____

Owner Info: [Name] _____

Hammer Type: [Original] _____ [New Hammer Type] _____

(For Hammer Installation) [O] Original [R] Raw [F] Final [SW] ShankWgt [HW] HammerWgt

1		23		45		67		
2		24		46		68		
3		25		47		69		
4		26		48		70		
5		27		49		71		
6		28		50		72		
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20		42		64		86		
21		43		65		87		
22		44		66		88		

NOTES: