The Whole truth?

The title was given to me. The Whole Truth about what? The whole truth about the half inch it has turned out to be. Only a small facet.

So many sayings, so many literary quotes from the Sophists through the New Testament to the Twentieth Century emphasize that the more you know, the more you know how little you know. And the more you realize how little use that “more” is. We use this knowledge to categorize and explain the world around us and only now are we learning that many of these explanations are special cases, valid only from our particular human vantage point. Often enough, this lets us assume the special case to be generally valid. Our schooling, the course of our western civilization since the Enlightenment causes us, like laboratory mice, to produce a certain reaction for a given excitation. This is a natural course of learning and generally keeps us from being run over by a car, for instance. At a higher level, this type of automatic thinking makes analogously automatic assumptions about the underlying levels. When there are sufficient meta-levels, the assumptions about the basic levels become unconscious. Filtered. At a meeting like this, we can all think of examples inherent to our respective native languages that do not correlate. Tout droit in French, straight ahead or gerade aus of course, but the words themselves don’t mean that. They mean all right, all is right, alles rechtens, and while going straight may be rechtens, it is not necessarily alright. Maybe too simplistic an example; let it suffice.

Modern instrument making - this is intended to mean to period from the middle of the 19th.c. - and teaching have led to a stress on standardization. I don’t wish to disparage this at all; it is not bad in itself. It is what we do with it, or perhaps what it does with us. Both building and teaching approach the keyboard as the interface between the player and the action. This it is, but this approach has given the keyboard dimensions a tactile dimension. The spacing has come to be regarded as a parameter decided upon for ease of playing. This was a natural result of piano development at the turn of the century. Octave spacing and even keydip became standardized, so much so that even organbuilding norms would like to enforce the parameters of the concert grand.

The historic revival has drawn attention to the different keyspacings. These were viewed as conscious choices made by the builder for ease of playing or complying with a regional playing style. This was a natural assumption based on the conditioning of 100 years of piano making and the treatment these parameters have come to be given. Octave spacings were measured and recorded as a characteristic of a certain shop or region. Eventually, the practice of measuring three octaves, suggested by Friedrich Ernst, has come to be standard. While it is true that octave spacings tend to be standard within a given shop, and thus, such records do give some clue to a certain builder, the whole situation has actually removed us even farther from the historic situation and cemented this type of categorization. I would like to begin with this example.

The octave spacing at the back of the keyboard was the conscious decision. After 30 years of so-called research, I am convinced that this is the case. The conscious choice was a stringband or action spacing of 1/2”. This could be easily marked off with any yardstick. Many keyboards do have the same spacing front and back. The famous Dom Bedos plate and the accompanying text describe accurately how to do this. Organ keyboards, at least single-lever keyboards are almost invariably parallel. Many organbuilders also made harpsichords and later pianos. This is the famous case. Unfortunately, the prominence of the source, so often reproduced, has further helped to cement the categorization and to obscure the fact that the action spacing determined the keywidth, both.action and keyhead being at the front.

Compass was also a conscious decision. It was the starting point of the instrument; from it everything else was determined. The projected number of notes, i.e. the number of half inches determined the basic necessary width to which the cheeks, any room necessary for trap work as well as internal walls in pianos, and case itself were added to arrive at the bottom width if the instrument was on top of the bottom and less the case if built around the bottom.

Generally, an odd number of spacings was used to arrive at a centerline as part of the spacing; 45, 49... 61 notes. This centerline generated a two to one rectangle(√5)- adjacent squares(√2) on either side of the centerline. Not always, but very often. With that, the keywell was defined. A five octave instrument has normally 61 notes. This results in 6o half inches for the width of the stringband center to center. In many cases, the requisite 61 half inches are also the width of the keysheet. This was the builders parameter. The octave span was not measured at all; the distance between the cheeks was simply divided by the number of naturals. This means that the octave spacing would be narrower than the action spacing and this can often be observed.

There are other approaches like that of the Ruckers. The Ruckers placed the lower guide by nailing onto the cheeks at a time when there was yet no soundboard, no bottom, and possibly not even a wrestplank. Diapasons must have been used, but a certain amount of inaccuracy is inevitable. This is not important to the final product. For this reason, and because the keyboard itself has no cheeks, they chose not 45 half inches but 47. This also gave some welcome space at either end of the bridge on the soundboard. 47 half inches is the width between the cheeks glued to the case walls. Add to this 5/8" for each cheek and 1/2" for each case wall and you have the outside width of the bottom. The keyframe is 23 1/2" wide or 47 divisions, an odd number pointing to a centerline of some sort. The keys at the back would just be marked to that guide exactly as they are on virginals. I do the same thing, and sometimes my ideal centerline and reality are not quite the same. The balance pin lines are exactly 1/2" apart, and the front row is 5" from the front of the keylevers. The gap seems to result in a ratio of 5:8. Whether that is the result of Fibonacci numbers or the lower bellyrail placement remains to be seen. While we are at it, the scribed line on the baseboard that marks the continuation of the front edge of the angled upper bellyrail is 14" from the front edge of the bottom boards. The front edge of upper bellyrail at the soundboard height is 13.5" from the front edge of bottom boards. Front lower bellyrail is another two inches back from the 14" line. The rear angled bellyrail(so-called toolbox brace) is 4" back in treble, 9 back in bass, to front surface from 14" line. The gap is 1 1/4" wide and wrestplank is 7" wide. Distance of front edge of bottom boards to the scarf joint is 7 1/2". All these dimensions are as accurate as 350 year old wood will allow for the Nuremberg Ruckers. Front edge to cheek block is 1" and keys are 1/2" thick. The utility of that 14" line is easy to see if you lay the spine on the bench to mark out. Measure back 14" from the front of the spine at the bottom edge, and 13 1/2" at the soundboard height and draw your line for the front edge of the angled mortice, 1/2" back for the back edge. It couldn't be simpler.

Two things should be noted here:

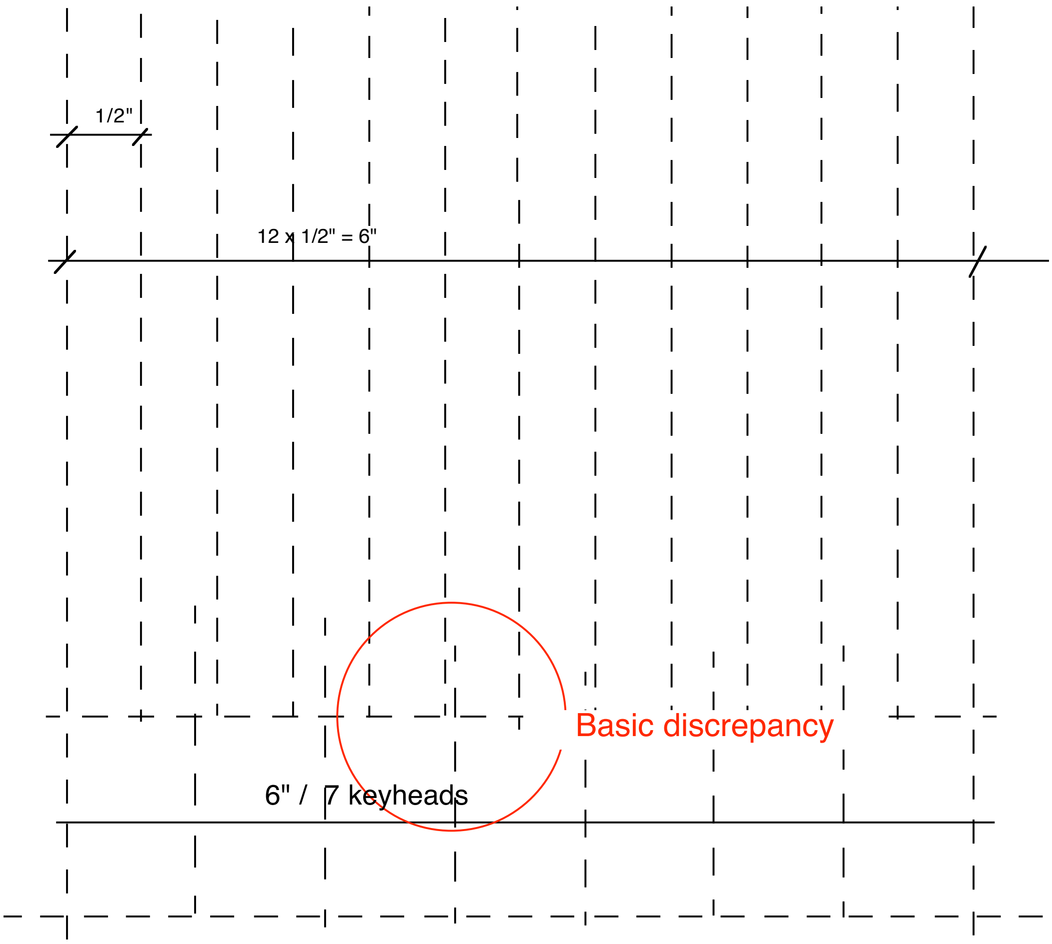
1. The entire layout of the front end was done with nothing more than a yardstick,

2. The octave span is again just the result of fitting the naturals between the keycheeks. They covered after sawing, and I have the feeling that they finished the covers before gluing them on. Thus, the space between the cheeks is at 23 1/2" very slightly more than the observed octave spacing, just enough for the top and bottom notes to move.

Quite a different sphere is Stein. Without a gapspacer, there is a natural middle in a 61 note compass. With a gapspacer and blindchoir, there are 62 divisions, an even number. In his phase three, there are 31 keys from "F1" to "b"; gapspacer; 30 from "c1" to "f3" the gapspacer choir is however the middle line, so there must be 31 choirs on either side: "F1" to "b" and "c1" to "f3", the empty slot at the top. The explanation of the additional Kanzelle itself is obvious. The "necessary" 63 note width to be centerline symmetrical (rule of thumb) comfortably allows for the 36 keyheads of the 31" actual size. So that is 31" plus 2x1" cheeks plus 2x1" inside walls plus the leeway which is for the levers and what little bit of fussing around that extra Kanzelle really needs, certainly not the nominal 1/2". What is left is necessary to get the action in and out. Another reason to measure the entire keyboard width between the cheeks, the action spacing, and not just the octave spacing. Here, again, the octave spacing is the result of fitting the naturals between the cheeks: keypanel front width is 31", so the octave spacing on keys is ±31÷36x7x26mm=157+mm/octave. Compare the Streicher data for # 1060: the stringband has 75 choirs = 74 spaces at per space giving 37".

The keypanel has 75 keytails at 1/2" per tail giving 37 1/2", the front width is 37 1/2" initially, then trimmed to 37 1/4" (keypanel depth = 20" bass, 19" treble), so the octave spacing on keys is 37.25÷43x7x26mm=157.7mm per octave. You can see here that the space between the cheeks was defined by Stichmaß. This is the beginning of standardization. Nanette used the same inch her father used, even in Vienna and that inch is the basis of design, the action spacing. The additional gapspacer rules out the traditional method, so she decided on an octave spacing compromising between her father's and the Vienna foot, i.e. slightly larger than her father's. Nonetheless, the spacing at the strike line is the defining factor.

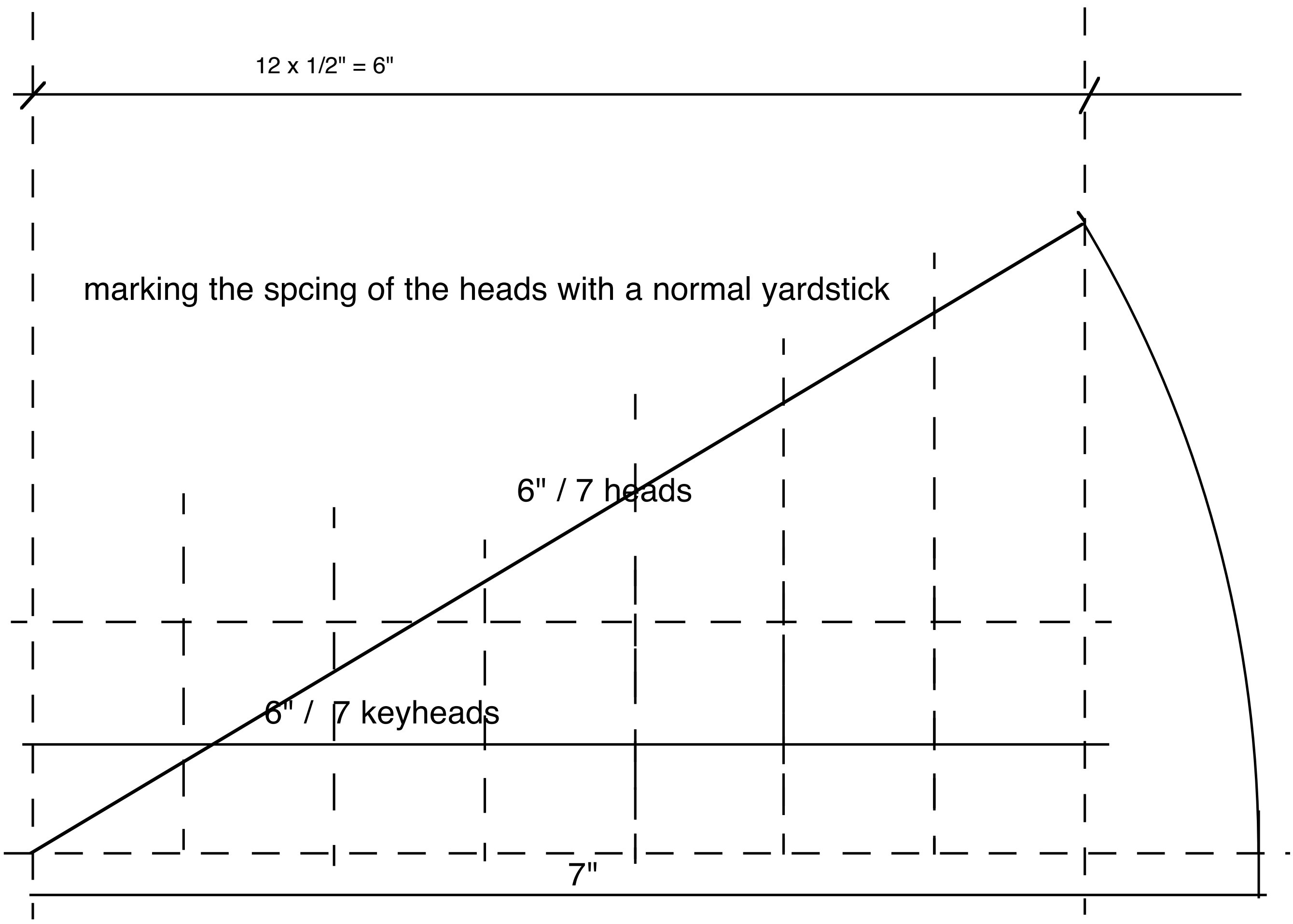
Walter demonstrates an interesting anomaly: It has been suggested that he "carried" his wide "d"s to the back. I tend to disagree, so I would like first to explain keyboard layouts There are two basic methods; the problem at the base is that the octave doesn't divide nicely: three heads for 5 tails, then 4 heads for 7 tails. If the tails are all equal and rectilinear, "c-e" is narrower than "f-b". This can actually be observed with some organbuilders. A close look at the Arnaut Ms. will nicely show this , and the fact that no attempt was in fact made to reconcile this. Keytails are in 12 even spacings of 1/2", and heads fit this spacing but are evenly divided into 7 parts.



The normal methods are:

1) All heads are equal; "f-b" divided for equal tails and sharps. This means each sort is equally wide, not necessarily that sharps and tails are the same. With"this method, "e" - "f" and "b" - "c" are marked to equal widths such that "g" and "a" are pretty much the same, too. The remainder is "d" which is wider. In practice as said, the sharps can be marked out with a slotted template (a dedicated square) following the equal "b" -"c" and "e" - "f" simply by using these lines as one edge of the slot; "d" does not of its own get marked out. "G#" is simply centered between the heads "g" and "a", so both "g" and "a" tails don't get marked as such either.

In other words, one plays with the dividers to arrive at a "b" - "c", 'e" - "f"tail with which gives reasonably similar "g" and "a" as remaining physical keys, then records this setting on the sharp marking square. "D" is obviously the space between its sharps.



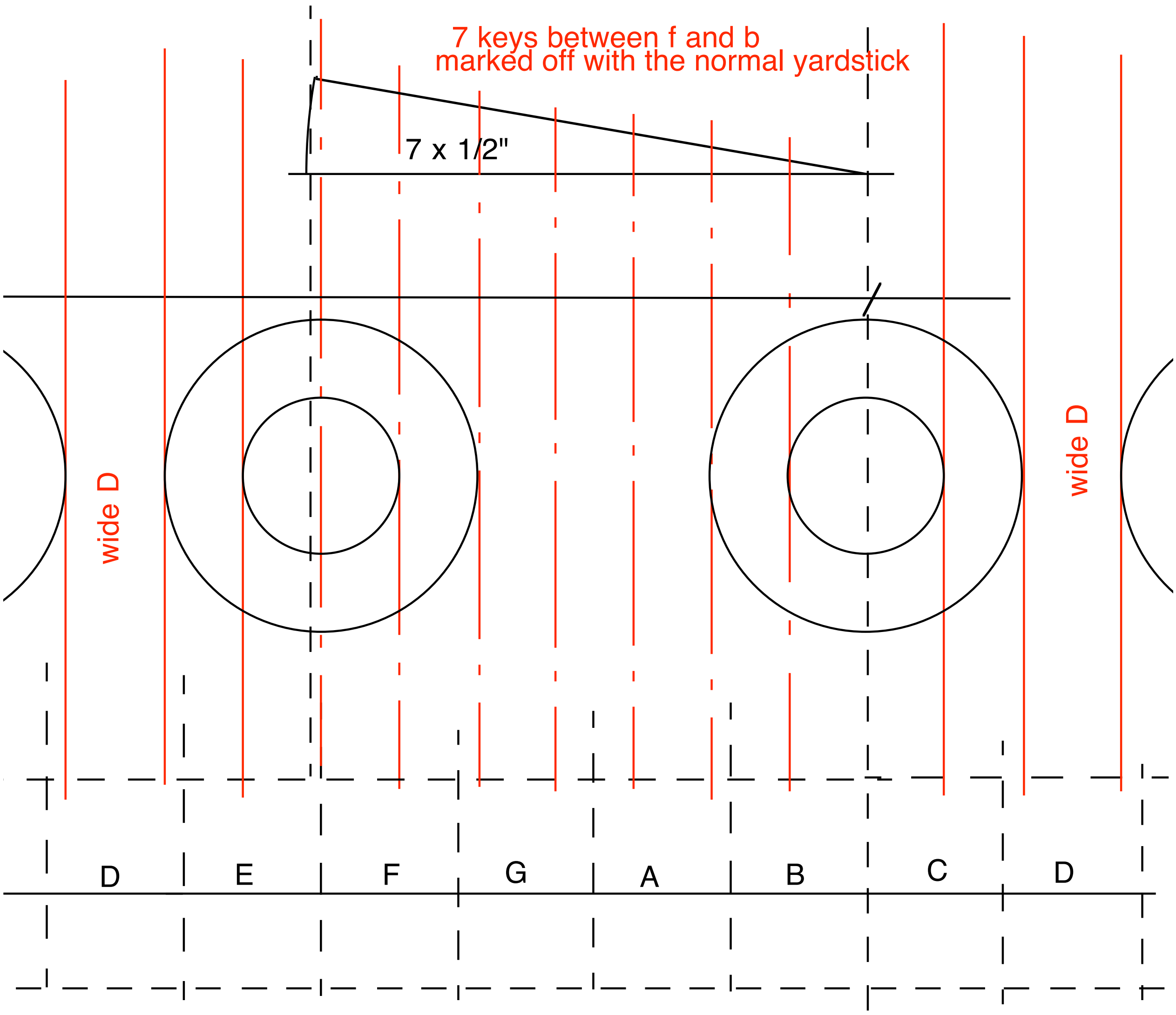
When actually working, the keysheet is covered with n number of individual keyheads to give the correct width prior to any marking out.

Then the tails (over-sized) are glued on: “b” - “c” and “e” - “f” obviously on the lines, then a wider “d” centered and “g” and “a” equidistant between “f” and “b” . With the dividers, “b” - “c” and “e” - “f” are marked, then with the sharp marking square or the dividers set to this constant width, the 5 sharps are marked, i.e, the slots for them are marked. The sheet is fitted between the cheeks and the back action spacing marked and the points front and back are connected.

2) All heads are equal. “f” - “b” divided into 7 EQUAL parts, then this applied to “c#” - ”d” - “d#”. “C” and “e” do not get marked; they are wider than “f” and “b”. All included tails are equal, i.e., the the tails between sharps, and equal to the sharps as well. This is what Ruckers did as well as a few other early Flemings, French and Dutch organbuilders.

I have not seen it in Germany. Indeed, almost all instruments have wide “d”s, though this is only sometimes apparent because of the width of the sharps and the octave spacing. Wide spacings such as found in Italy and south Germany make wide “d”s visible, extremely narrow octaves obscure this and if the sharps are wide enough, it is not visible at all. On the other hand, narrow sharps such as those found on fortepianos makes it painfully obvious.

3) There are many of combinations of these possible and very occasionally, one sees “c”- ”e” equally divided into 5 and “e” - “f” equally divided into 7, making each sector different. As said, some organbuilders like Cavaillé Coll divided the front in 5/12 and 7/12 giving 12 equal tails and different keyheads. They then sawed on the left of the “b” - “c” line and the right of the “e” - “f” line making a gradual change in width that is not really apparent, the “d” head being the narrowest and the “g” and “a” heads the widest. (Modern emulators are apparently too dull to figure this one out and they saw right on, making the difference painfully obvious and ugly, especially with Steinway-like head lengths.)

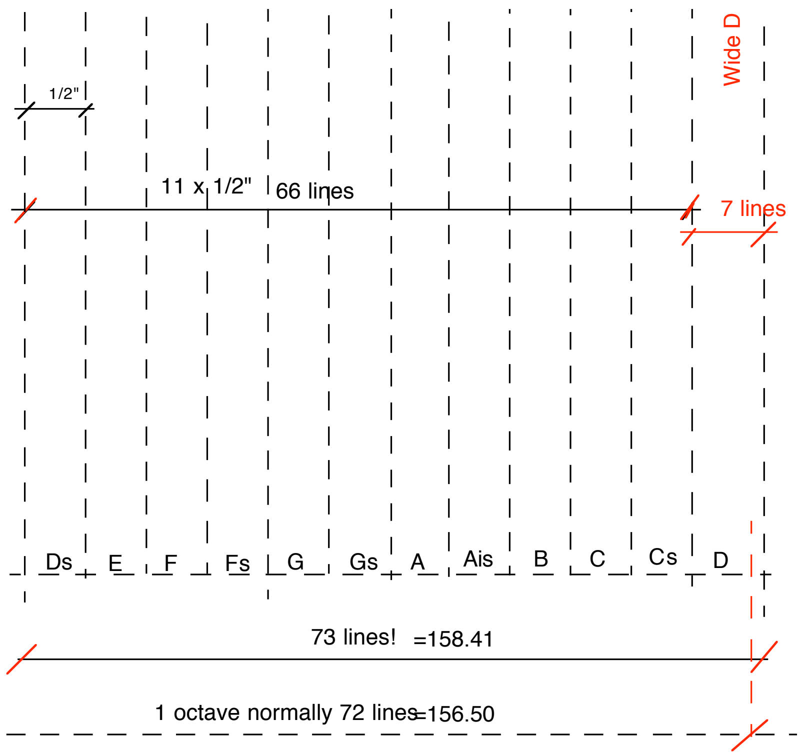


Nº. 1 can be applied to Walter: If the octave span at the front is 6", then a naturally wider "d" is the result if the equally wide tails of all notes but "d" were sawn straight back, but the choir centers would not be 1/2", though the octaves would seem to imply this. Turned around: 11x1/2" for "d#" - "c#"; "d" is 7 '''= and octave of 73 lines results instead of 72, a larger octave spacing with 1/2" octaves picked up and moved by one line for each consecutive "d".

The keyboard would still look right, but has little basis in traditional wood working and cannot be seen as "carrying the wide "d"s to the back." In its own right, it would be like Stein, using the action spacing to arrive at the keysheet width. It is just that this width cannot be a multiple of 1/2" : it would necessarily be 1 line less:

63x(6 lines)=378'''+5''' for the 5 "d"s =383''' = 840.37mm keysheet.

32" x 26.33= 842.56.

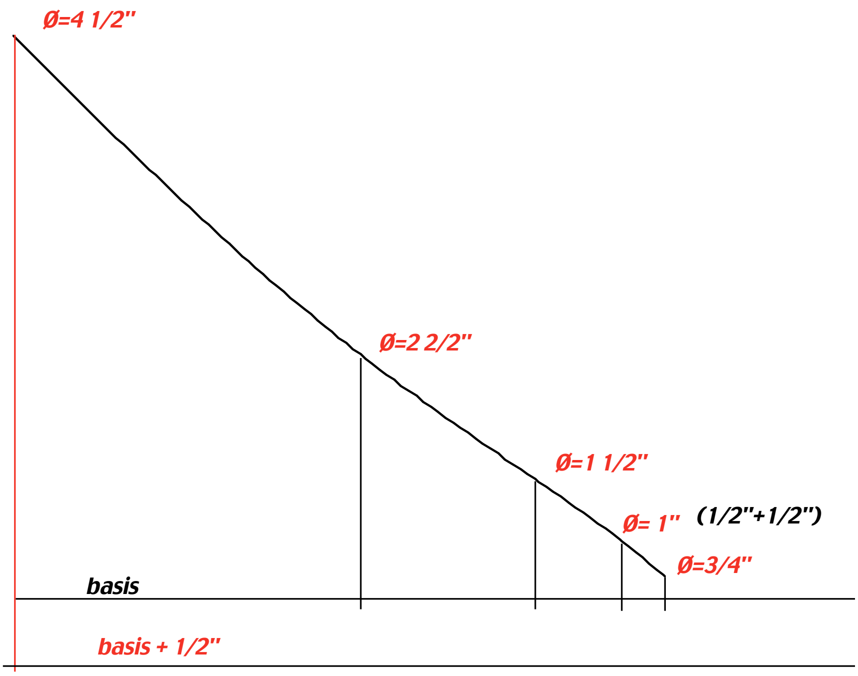


Two mm is close enough for me, having made a few keyboards myself. It is normal to cover the top and bottom notes wider that the rest when fitting between the cheeks so that the sheet can be tightly fit. Enough is planed off for the key to move in the end. With broken sharps, this is absolutely normal and these top and bottom notes are often actually wider than the others because the back and front have so little to do with each other. Like Walter. As you can see, the problem can be reconciled: string spacing and sizes and dimensions and scaling seem in this case to equal 26.33, keyboard doesn't. The 32" result from this 26.33 inch.

The half inch was the basis of design. The ratio 1:2 was the basis of design and that ratio has always fascinated, as in the ancient Greek paradox of halving a distance and halving it again ad infinitum (tortoise and hare) and never reaching the end because the remainder can always be halved again. The octave ratio is 1:2 giving Pythagorean scaling and natural pipe lengths as well.

Our schooling and so-called scientific convention has resulted in a organ pipe scaling procedure that can used for any progression or method. Scales are given, starting with the lowest note, as a progression or as a complex curve, deviations from the fixed progression or standard scale of 4√8. Usually this is done on graph paper, but there are a dedicated slide rule and computer programs for the purpose. Compared to this, ancient methods are simple. The most common one was to use the length diapason to mark the width as well. Thus, a division was sought that gave the circumference of the one foot pipe of π x 1". This was, like the length, a ratio of 1:2 and resulted, with a 28mm "c2", in a 14mm "c3 ", a 56mm "c1 ", a 112mm "c" and an immense theoretical 224mm "C", a note they did not have. Such extreme scales were restricted to narrow compasses and with larger compasses, a variant was soon found to be able to continue using the standard method. The one inch "c2" was divided by two, and1/2" was assigned the Ø function to progress at the normal ratio of 1:2, while the other 1/2" was added to each diameter as a constant.

This resulted, starting again with the 28mm "c2" in:
a "c3 " of (14÷2)+14=21mm,
a "c1" of (14x2)+14=42mm.
a "c"   of (14x4)+14=70mm, and
a "C" of (14x8)+14=126 mm.



Graphically, this shows a complex curve. By increasing the constant, the treble becomes wider and by increasing the fixed Ø the bass becomes wider while the absolute diameter of the starting note remains the same. This was important to them. "c2" falls in the most sensitive range of human hearing and they realized that - not by chance? - the one foot pipe, the unit one was also that scale, that diameter they could easily leave unaltered, regardless of acoustical variations from building to building. With some organbuilders, you will find this one foot pipe to be absolutely standard, virtually interchangeable, even between organs although the scaling on a whole is not.

Our scalings also use 1:2 as a basis, more or less. And again our propensity for looking at things on a matrix have brought us to see the string band as a diagram and indeed, some even call it that. Of course, scalings are easy to document and this fact, together with the modern pianomaker's preoccupation with scaling (not to mention the organbuilder's) has led to a emphasis far beyond the actual importance.

Ten years ago, I wrote, „Is looking Seeing“ in which I discussed an Italian harpsichord of about 1600. Besides explaining the restoration, I attempted to take a closer look at some special features of this particular instrument. Assuming, for the moment, that an octave equals 6″, then one division would equal 1/2″. The measure (nach Ernst) of the keyboard is 488mm and of the wrestplank markings is 487mm, practically identical and this shows that, in this case, the spacing front and back are the same. We get a spacing of 13.53mm. That would give an inch of 27,06mm: I round this off to 27mm. How does this fit? The instrument is 30″ wide: 816:30 = 27.2mm. The distance from the bottom to the soundboard surface is 4 1/2″: 121:27 = 4.48. The distance from the front edge to the end of the bridge is 60″, from the front edge to the soundboard on the spine is 12″, the cutoffbar is exactly 30″ long. The longer "c2" string is 269mm, almost 270 or 10″ long. In that case, "c1" should be 540 or 20″ long but it is only 517. Unused bridgepinnings show that the 2′ scale indeed was intended, but for some reason, the bridge was placed - misplaced? - farther from the bentside.

How to arrive at a plan. One possibility is to mark off the centerlines of, say, the "c" and "f" keys along the length of the bottom, adding to this the keywell borders which are defined by the keyboard, as well as the pluckingpoint and a line for the nut (these are actually present on our instrument). From this the string lengths can be measured for the scribed notes giving points along a curve defining the bridge and from this the bentside curve, at an appropriate distance from the bridge is drawn. This is nothing but a simple graph or coordinate system- it is the method most of us use. We can consider this to be working from the inside out. But the key centers are missing on the bottom of our instrument although they are present on the wrestplank.

There is also the possibility of working the other way around. It is well known that, for instance, luthiers made their instruments according to so-called divine proportions: Fibonacci numbers, Golden Section, primes.

I will try to apply the Fibonacci row 1,2,3,5,8, 13,21,34,55...to our instrument. It is 30″ wide which equals 5 octaves: let this be our Fibonacci No. 5, then 1 would be 6“ or one unit (unit measure). The length would have to be one of the next numbers, perhaps the sum of the next two: 5+8 = 13. 13x6″-78″ but the length is only 67″. Try again. 67.5÷6≈11, a prime and incidentally the sum of the first four numbers of the row: 1+2+3+5=11. The point on the line of the spine 78″ from the front is the intersection of the straight continuation of the long bridge, so that number does have some relevance. It is very common in the 15th. and early 16th. centuries for the cheek to be 1/2 of the width and here, also:30÷2=15″. The width of the tail is about 6″ or 1 unit. What about the curve? It is equally common for the width to be 1/2 at 1/2 of the length, but in this case it is not. However, at unit 5 of the length it is about 1/2 of the width and at unit 8 it is 8″ wide. We have used the numbers from 1 to 13, if we divide 13 by 21 we get .619, very close to the Golden Section .618 (the same is true if we divide 21 by 34, 34 by 55, 55 by 83...). At the minor of the length, the instrument is 1/4 of the length wide and here is the first knee an the spine. The center knee on the bentside is at 1/2 of the length, and all knees are roughly equally spaced at about 13″. The front edge of the soundboard is 12″ or 2 units from the front, the end of the nut about 6″ or 1 unit from the front. The treble end of the nut is about 9″ or 1 1/2 units and the treble end of the bridge is quite close to 12“ from the front. The ends of the bridge are about 3″ from the bentside and if our master had kept this distance constant along the length, the scale of "c1" would have been correct.

I am quite ready to accept his working from the outside in and, as can be seen, following his “divine” numbers, he could have arrived at a just scale without even considering the string lengths. The fact, of course, that the scale is measured in the same units as the keyboard and the entire design is the key to this.

Bridge was also located from the nut, unlike the above. This seems reasonable. There is the possibility of simple fractions of the scale for the PP: from the top down to the center as can be found often in southern Europe. Or there is also the possibility of simply measuring back from the wrestplank edge: 1”, 2”, 3” etc. From here, the distance was simply measured in whole inches between the bridge and the nut, not the distance from pin to pin and this was often measured along the center of the spacing, not at the string itself

Thus, one can observe on Mine 109 that Walter’s nut was located with the usual few inch-measured points from the back of the wrestplank. Then the ruler was shoved against the nut for each “a” and “d” to locate the “front” edge of the bridge. The 26.33 mm inch actually fits and those “a”s and “d”s are exactly 4.5, 6, 9, 12, 18, 24, and 36 inches measured nut back to bridge front (the long strings). After the 36 inch measurement, the bridge continues to follow 6 inches from the edge of the bentside exactly, until the tail hook starts.

One can observe a foreshortening of the scale and, again, we tend to see it as the modern compensation. On pianos, the gapspacer(s) cause a shift and in Walter’s special case, every “d” causes a shift , but these are in the wrong direction. The thought of tension compensation did not cross their minds except where the change from iron to brass was concerned. On clavichords, this was done with a subtraction constant similar to the organbuilders: take for instance the standard scale of 12”(1’) for “c2” to be doubled for each octave and subtract from that a progressive constant based on 1”, also doubled for each octave:

“c3” =(12+1)÷2=6.5”
“c2” = 12”
“c1” =(12-1)x2=22”
“c” =(22-1)x2=40”

You have a progressive scale resulting a brass length at “c” without any diagrams or tricks or logarithms; it can be done easily with a yardstick and a little mental calculation.

Purposefully, I have only mentioned a few examples for the basic importance of the half inch and the connection to layout and scaling. I have tried to show that Stichmaß is not a very meaningful parameter, not taken by itself. Above all, what I hope to have pointed out is the connection between basic measure and layout and scale. For the “old guys” this was understood, there was no contadiction. We are unfortunately in a different position.

Octave spans are requested because they are “comfortable” to play or, worse, because the other instrument has the same span. Pitchs are chosen among the fixed standards today and transposing keyboards augment the situation. We can’t turn back the wheel, but we can endeavor to understand what they were doing, how they arrived at the design. To do that we must try to rid ourselves of our blinders and see what is really there. And why it is important. Or not. What purpose can there be in making a copy of a Ruckers exactly as it is with upperbraces exactly where they were put if the upperbraces are not inserted the way they did it, using force after the soundboard was installed, nailed but not glued. Of course the braces have a “proper place,” but the tension is what is important, not the exact place. The same can be said for Stichmaß or scale, for any parameter which is copied or recorded without context.

For restorers, it is paramount to find out what the context is, to understand what was done. What you have before you as an artifact can be interpreted in many ways. Perhaps even more than one way is correct. Restorer's judgement of what to do, what to record must be guided by this understanding. It is not enough just to record data out of context because all of the data is never recorded, regardless of how often or thoroughly it is done; something is always missing. Often enough, it is the most important thing like action spacing or keysheet width. The practice of "objectively" recording data, so often considered to be scientific, can be just as subjective as a wordy description with flowery adjectives because it is based on what the recorder considers important or what "academia" considers to be valid parameters. The example of Stichmaß shows this to be highly questionable.

For builders it is important understand the working proccess and the tools involved. To find out why the soundboard of a particular model, not a specific instrument, has a characteristic thicknessing and why different examples have slight deviations and why that is so. Maybe the wood just wasn't any thicker. Maybe too stiff? Maybe too soft. It is paramont to put the cart before the horse. Replicating a particular molding while putting it on with Titebond is self-delusion. Planing a soundboard to exactly the thicknesses of the original without having the original wood or at least having felt what that is like is self-delusion. Counting rings per inch is self-delusion. What kind of rings are they? They can be narrow and heavy , wide and light. Could it be that that is not important at all? What about bearing? Is Stichmaß important? Scale? Having really understood what is being done, you are free to say, "what do I care how they did it?" And to take the blame for what you do. More probably, you'll kick yourself for not having looked earlier and saved yourself so much effort.

The whole truth is that they as group were fast and secure, faster than we are for all our machines. Secure because they worked within a world view, a traditional system in use since the middle ages in which everything had to fit together. It was not questioned. Instead of questioning the system, we should first question ourselves...

Lauffen am Neckar,
im September,
Wm. Jurgenson