

# The Rosetta Revisited

Bach's Very Ordinary Temperament

Dominic Eckersley, Berlin 2012

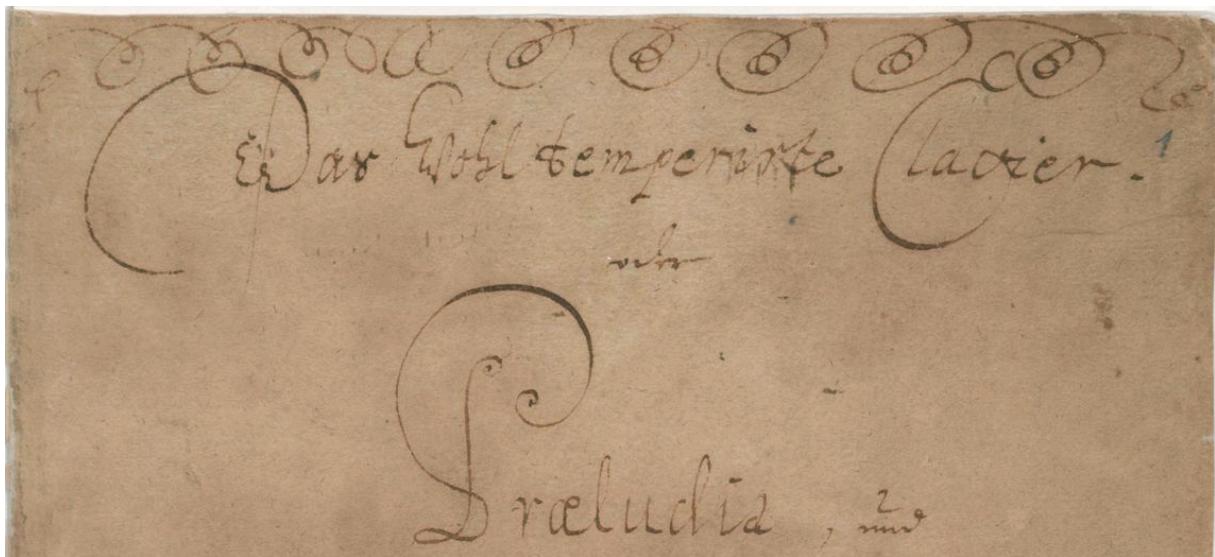


Plate. I Top portion of the title page of J. S. Bach's *Das Wohltemperirte Clavier* 1722. (Staatsbibliothek zu Berlin – PK Musikabteilung mit Mendelssohn-Archiv, D B Mus. ms. Bach P 415.)

Did Bach indeed leave a record of how he tuned his keyboard instruments as Bradley Lehman's 2005 article, *Bach's extraordinary temperament: our Rosetta Stone* would have us believe?<sup>1</sup> With a bit of cloak and dagger work, can we get to the bottom of this Da Vinci Code of tuning secrets? Has a Bach temperament solution miraculously appeared by way of a tantalising hint Bach may have left for us at the top of the title page of *The Well-Tempered Clavier*?<sup>2</sup> in the form of a cursive calligraphic flourish, a secret codified message, a memory jogging reminder; or was it even just a doodle?

Sadly, Lehman's "Bach temperament" is not only incomplete, but misleading, suggesting something which is neither probable, nor representative of the tuning traditions of Bach's time and likely vastly different from that which Bach knew, or used, or would have found acceptable. That the calligraphic scrolling glyph on the title page of *The Well-Tempered Clavier* is indeed a diagram of a temperament can be supported in that it can be broken down into structural elements which compare in structure and placement with intrinsic values of temperament intervals found elsewhere in the literature of the period.<sup>3</sup> So how did he really tune his harpsichord?

"Lehman I", as we might call it, is a fine temperament made up of "five  $\frac{1}{6}$  comma narrowed 5ths, F-C, C-G, G-D, D-A and A-E, three pure 5ths E-B, B-F#, F#-C#, and finally three  $\frac{1}{12}$  comma [narrowed] 5ths C#-G#, G#-D#, D#-A#" with a wide fifth, A#-F, which is "probably [a]  $\frac{1}{12}$  comma wide 5th." It works well, is sweet, playable in all keys, and provides interesting and palatable, yet subtle differences to the various keys. Lehman claims that this is the tuning system used by Bach and is the tuning system intended for playing The Well-Tempered Clavier. Yet, this temperament demonstrates the absence of actual tuning norms of the period, specifically of what today we like to call "*tempérément ordinaire*". Most importantly, a crucial attribute of Bach's spirals was completely overlooked by Lehman rendering his temperament meaningless;<sup>4</sup> there is a reasonable amount of information in Bach's spirals, none of which should be ignored or overlooked; only by properly analysing these spirals can we hope to get to the bottom of the matter.

But what is all the fuss about anyway? Simply put, tuning the notes of the scale by way of twelve consecutive pure fifths produces a slightly higher ending pitch than produced by seven consecutive pure octaves. We call this difference a pythagorean comma. Similarly, in tuning four consecutive pure fifths the resulting final note would not quite match the resulting final note had we tuned using

two pure octaves and one pure third. This difference we call the syntonic comma and it is only very slightly different in size from the pythagorean comma.<sup>5</sup> In practice, a compromise must be made between good fifths or good thirds.  $\frac{1}{4}$  comma meantone, the most prevalent Renaissance tuning, simply required narrowing eleven of the twelve fifths, each by  $\frac{1}{4}$  of the syntonic comma, leaving the last fifth, G#-D  $\flat$ , the "wolf",  $\pm 1\frac{3}{4}$  commas wide: The idea was to get as many as possible of the commonly used major thirds pure; eight in this case.  $\frac{1}{4}$  comma meantone, allowing for so few pleasant keys, grew to be too limiting with time. A plethora of other tunings arose, many being adjusted meantone tunings, where attempts were made to 'temper' the "wolf", spreading it out over more than just one interval. This, then, is the birth of temperament in the true sense. One such solution was to divide the pythagorean comma between all the fifths, creating "equal temperament." The intention being to tune all the fifths almost pure but at the expense of producing very wide thirds. Of greatest importance was the quality of sound of various temperaments resulting from these varied inter-relationships: Rousseau, writing of Rameau's new equal tuning, as presented in Rameau's *Génération harmonique*, says that "in regard to the builders, they find that a harpsichord tuned in this manner is not as well tuned as Mr Rameau assures. The major thirds appear to them to be hard and shocking."<sup>6,7</sup> Rousseau mentions that equal temperament had long been described by Mersenne and that "this method Mr Rameau proposes to us today, has already been proposed and was rejected by the famous Couperin."<sup>8,9</sup> Kirnberger stresses the need to know and understand equal temperament *theoretically* for the placing of frets: "Equal temperament is absolutely terrible, only being useful in the case of properly positioning the frets of a theorbo, lute or other such similar instrument such as a psaltry, zither etc., as a temperament of another type does not do each string justice."<sup>10</sup> Another example of *adjusted meantone* can be found in Werckmeister's fourth temperament, where we are directed to narrow five fifths by a total of  $2\frac{1}{3}$  comma with two wide fifths each of  $\frac{2}{3}$  comma to compensate (see Plate. 2).<sup>11</sup> Other tunings, such as those suggested by

Kirnberger<sup>12</sup> or, for example the now famous "Werckmeister III" tuning, involved a completely different approach of dividing the pythagorean comma in four, thereby narrowing only four fifths each by the same amount of a pythagorean comma with the remaining fifths being pure (see Plate 2). To what extent such tunings were actually used, however, is hard to know.

(78)

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Die erste Art Num. 3.		Die andere N. 4.		Viertheil eines commatis.	
G	schwebet gegen C herunter $\frac{1}{3}$ com.	G	schwebet gegen C herunter $\frac{1}{3}$ com.		E
d	bet gegen G herunter $\frac{1}{4}$ Com.	—	G ist rein	F	Cis - 4
A	gen. D herunter $\frac{1}{3}$	—	A ist rein	Fis	D 2
e	—	H	E ist rein	G	Dis 3
H	—	—	—	Gis	E 3 1
fis	gegen H herunter $\frac{1}{4}$ Comm.	—	—	A	Fis 4
cis	—	Fis ist rein	—	B	G 2
Gis	—	Cis ist rein.	—	H	Gis 4
dis	—	Gis ist rein	—	c	A 3
B	—	Dis ist rein	—	cis	B 2
f	—	B ist rein	—	d	H 3
c	—	F ist rein.	—	dis	


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Die erste Art Num. 3.		Die andere N. 4.		Dritttheil eines commatis.	
G	schwebet gegen C herunter $\frac{1}{3}$ com.	G	schwebet gegen C herunter $\frac{1}{3}$ com.		E
d	—	G ist rein	—	F	Cis 4
A	schwebet gegen D herunter $\frac{1}{3}$ com.	A ist rein	—	Fis	D 1
e	—	—	H	G	Dis 2
H	schwebet gegen E herunter $\frac{1}{3}$ com.	—	—	E	E 1
fis	—	H ist rein	—	F	Fis 4
cis	schwebet gegen Fis herunter $\frac{1}{3}$ com.	—	Cis ist rein	G	G 1
Gis	—	—	—	Gis	Gis 4
dis	schwebet gegen Gis herauf	B schwebet gegen Dis herauf $\frac{1}{3}$ com	—	A	A 1
B	—	—	—	B	B 1
f	schwebet gegen B herunter $\frac{1}{3}$	F ist rein	—	H	H 3
c	—	—	—		

Plate. 2 Werckmeister's third and fourth temperaments: A. Werckmeister *Musicalische Temperatur 1691* (Frankfurt and Leipzig, 1691) pp. 78.  
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Diese folgende Manier kan auch wol passiret werden.

Die dritte Manier.	C - Grein	C - E	2	Vierthel einescom- matis.
	G - d rein	Cis - F	4	
	D - A unterw. $\frac{1}{4}$ c.	D - Fis	2	
	A - e unterw. $\frac{1}{4}$ c.	Dis - G	3	
	E - H rein	E - Gis	2	
	H - fis rein	F - A	2	
	Fis - Cis unterw. $\frac{1}{4}$ c.	Fis - B	3	
	Cis Gis unterw. $\frac{1}{4}$ c.	G - H	2	
	Gis - dis Aufw. $\frac{1}{4}$ c.	Gis - c	4	
	Dis - B rein	A - cis	2	
	B - f rein	B - d	3	
	F - c unterw. $\frac{1}{4}$ c.	H - dis	3	

Plate. 3 Werckmeister's fifth temperament. Notice his use of "unterw." ("unterwärts" or "down") for narrow and "Aufw." ("Aufwärts" or "up") for wide. A. Werckmeister *Musicalische Temperatur* 1691 (Frankfurt and Leipzig, 1691) pp. 79. Reproduced by kind permission of Sächsische Landesbibliothek - Staats- und Universitätsbibliothek Dresden. © SLUB Dresden/Digitale Sammlungen, MB. 8.414

Lehman states that the calligraphic flourish at the top of the title page of *The Well-Tempered Clavier* "completely describe[s] the distinctive character [Bach] expected for every key", but that "[u]ntil now music history had lost three crucial pieces of information: (1) that Bach ever wrote down any required keyboard-tuning method at all; (2) that this drawing is his precise schematic; and (3) the proper derivation of a set of instructions, arising from normal 17th-century *temperament ordinaire* practice." He describes the "sinuous spiral" saying, "[t]he diagram has three loops with one knot in them, then three empty loops, then five loops with double knots. the letter C orients the home base, middle C: second from the right." For this to indicate a temperament it would need eleven loops for the eleven different notes to be tuned and that the loops describe how each of the eleven intervals must be tempered, the twelfth interval being that which remains after the others have been tuned. Indeed, there are eleven loops. Eight appear to be 'altered', the remaining three 'unaltered'. A

temperament with eight tempered fifths seems quite plausible. The letter C in the spiral must indicate middle C.<sup>13</sup> Looking at the spiral, it is immediately obvious that something is seriously wrong. The starting note C appears at the right of the diagram rather than the left, as we would expect. Would Bach write it upside down, or even backwards? Lehman argues, unconvincingly, that a student wishing to copy the diagram would simply turn the page upside down, which, he says, was common practice. Looking at the spiral upside down and backwards it does look like it was drawn with the page inverted:

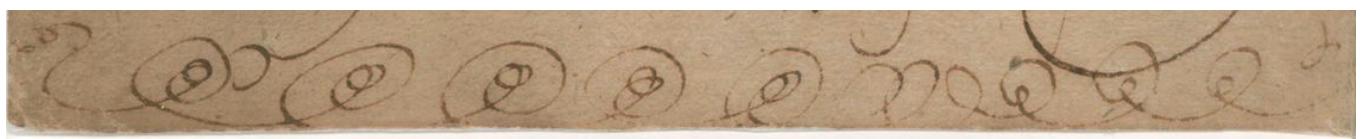


Plate. 4 Bach glyph upside down and then back to front

Might Bach have chosen to put the answer upside down simply to make it less obvious like modern puzzle solutions in magazines and comics? Or had he written it backwards, as Da Vinci wrote backwards, as some kind of coded secrecy, disguising it as a calligraphic ornament? I doubt we will ever know. But, accepting that this glyph is a temperament and is also upside down or backwards, can we make sense of it as a tuning system? Lehman appropriates the "knots" and loops as representing five narrowed intervals of  $\frac{1}{6}$  comma, followed by three pure intervals, and then in turn by three more intervals each narrowed by  $\frac{1}{12}$  comma, given that the first five have double knots, the last three only have single knots, i.e. half as many pen rotations equates to half the amount of

narrowing. The small addition by a separate pen-stroke of three small curves at the left of the inverted glyph, he most remarkably attributes to an indication of the frequency of three beats per second for the major third F-A, justifying  $\frac{1}{6}$  comma narrowed fifths. Bach counted beats per second in 1722? I am sure he felt a beating rate which he had learned to reproduce, more or less, but beats per second would be *extremely* doubtful. Lehman's last interval, B  $\flat$ -F, is of unnamed, and presumably  $\frac{1}{12}$  comma wide nature. He seems to think that a wide interval, even by so little as  $\frac{1}{12}$  comma, is bad: "[W]e need only ensure that the resulting 5th B  $\flat$ -F is not obtrusively poor." Yet the 18th century musician was quite comfortable with wide intervals. Lehman mentions also a small loop after B  $\flat$  which is "probably representing its  $\frac{1}{12}$  comma wide 5th." It is probably false to assume that the  $\frac{1}{6}$  comma narrowed fifth was in such common use at the time of Bach, as Lehman claims, much less so the  $\frac{1}{12}$  comma fifth--wide or narrow. Quite the contrary, the common size for a narrowed fifth was  $\frac{2}{7}$ ,  $\frac{1}{4}$  or  $\frac{1}{3}$  syntonic comma; something inherited from earlier meantone tunings as witnessed by the writings of Zarlino and temperaments of Kirnberger, Werckmeister and Rousseau.

Unfortunately, C. P. E. Bach in his essay *Versuch über die wahre Art das Clavier zu Spielen* (literally; Essay on The True Manner of Playing the Clavier) of 1753,<sup>14</sup> doesn't help much when he states that "in tuning the fifths and the fourths, while checking the thirds, major and minor, and full chords, so much must be taken from their absolute purity, particularly from most of the fifths, that the ear can barely notice it and one can use all twenty-four keys well." We learn from Emanuel that *most* of the fifths should have something taken from their absolute purity. To take from the absolute purity of *most* of the fifths can only mean some fifths *must* be left pure. He says also that with the 'old tuning' a few tonalities were purer than those of many instruments "today", informing us that

the new temperament is not as pure in some keys as was the old temperament. The new tuning cannot be *equal temperament* or *¼ meantone*, which both require all fifths to have something taken from their purity. The old tuning is likely to have been a meantone tuning. He doesn't mention specific intervals, specific adjustments,<sup>15</sup> but says that if keyboard instruments "are tuned this way, one may rightfully take them for the purest of all by way of this practice, as some instruments may be more purely tuned but less purely played." Perhaps he expected his reader to already know how to tune a harpsichord to make it play in all keys, or to have someone, to tune it for them.<sup>16</sup> His vague discussion of tunings implies that this new temperament was known but not yet standard practice in Berlin at the time of writing his *Versuch*. Emanuel Bach, Rousseau and Werckmeister all complain that there still are those who continue to use the old tuning.

In his dictionary of 1775, Rousseau describes a temperament in great detail and claims that "[t]he organists and builders regard this temperament as the most perfect which one could employ." He writes: "Hence 1° One starts at C in the middle of the keyboard, and weakens the first fifths in succession, until the fourth E produces a very pure major third with the first tone, C. This is called the first part. 2° One continues to tune by fifths, as soon as one has arrived at the sharps one reinforces the fifths a little, such that the thirds suffer, and once one has arrived at G#, one stops. This G# should form with the E a third which is "just" or at least tolerable; this is the second part. 3° One returns to C and tunes the flat fifths; i.e. F, B♭, etc. weak initially; then widening them by degrees, that is to say, lowering<sup>17</sup> the tones until one has returned to D♭ which, taken as C#, must be found in tune and forming a fifth with G#, at which one had stopped previously; this is the third part. The last fifths will be found to be a little strong, just as the major thirds; this will cause B♭ major and E♭ major to be sombre and a little hard." Rousseau describes narrow fifths, a pure third

and wide fifths. He refers to it as the temperament in "*l'usage actuel*" ("current use", "common use") and the "*tempérément étabil*" ("established temperament"). So, a detailed description of *tempérément ordinaire* does exist in the literature after all? Indeed, Diderot actually calls it "*tempérément ordinaire*" when reproducing, exactly, Rousseau's temperament in his own Encyclopédie.<sup>18</sup> Rousseau, like Emanuel Bach, doesn't find it necessary to mention actual portions of the comma by which fifths are to be adjusted; keyboard players clearly didn't think in such terms. Perhaps, even, both Rousseau and Emanuel Bach thought the whole practice of talking of fractions of commas too precarious both in respect to physics and tuning practice. By saying the third C-E must be "*bien juste*" (very pure) and presuming the first four fifths are tuned to much the same size as each other, we know that Rousseau's fifths C-G-D-A-E are to be tuned  $\frac{1}{4}$  syntonic comma narrow each (as well as the ear can do so consistently). The pure third C-E enables us to place these four first intervals with acceptable accuracy. In part two Rousseau tells us to continue tuning in the same manner, but having arrived at the sharps (F#) the fifths are widened a little until one reaches G# which should be make a "just" third with E or, at worst, one that is at least tolerable. To tune such that G# remains pure with E, yet to have widened these fifths (to whatever degree greater than  $\frac{1}{4}$  syntonic comma narrow) creates a contradiction. We have to be satisfied with an E-G# third which is acceptable, "*juste ou du moins souffrable*" ("just or at least sufferable"), rather than very pure ("*bien juste*"). In other words, we could tune the fifth E-B likewise  $\frac{1}{4}$  comma narrow ("[o]ne continues to tune by fifths") producing yet another desirable pure major third, G-B. Having arrived at the sharps, namely F#, the fifths B-F#, F#-C#, C#-G# are to be tuned slightly wider, probably pure or possibly wide of pure. Rousseau warns, the thirds suffer a little by their being slightly wider than pure. Rousseau's temperament appears thus far to be very comfortable to tune: If the fifths B-F#, F#-C# and C#-G# are tuned pure, then all intervals could be checked either to be pure or acceptable using another pure interval such as the thirds C-E and G-B. As Rousseau does not

specifically suggest tuning the fifths B-F#, F#-C# and C#-G# pure one could consider tuning them pure, wide or narrow (though not as narrow as  $\frac{1}{4}$  comma). However, as 18th century emphasis was on good thirds Rousseau may not feel the need to talk of pure fifths. What he means by "*renforcer un peu*" ("strengthen a little") is unclear but in practice, to widen the fifths by even the very smallest amount greater than pure results in the third E-G# being beyond the very limit of tolerable to most people's ear. Part three requires two processes. Firstly, one tunes the remaining notes by intervals, F-B $\flat$ , etc., weak initially. If E-B was tuned narrow, then in the interests of ease and symmetry F-C could be likewise "weak" by the same amount as E-B. In this case all fifths involving two white notes have been tuned narrow by the same amount,  $\frac{1}{4}$  syntonic comma, which is pleasing for its symmetry and ease of remembering and tuning, especially as F can be checked against A with which it forms a pure third. D is the only white note which cannot be checked by a pure interval with another note and must be checked by comparison to the other fifth intervals of the same size which can be. Also all major thirds containing two white notes will be pure which is, again, symmetrically pleasing and retains the very desirable purity of  $\frac{1}{4}$  comma meantone. From here on we increase the size of the intervals "by degrees, so to speak, weakening the tones" thereby widening each of the fifths from F downwards more and more until we return to D $\flat$ , which was already tuned as C#. This means that some or all of the remaining fifths working downwards, F-B $\flat$ , B $\flat$ -E $\flat$  and E $\flat$ -G#, would need to be wide of pure, to absorb the extra  $\pm\frac{1}{2}$  syntonic commas created by the six  $\frac{1}{4}$  comma narrow fifths described in the first two steps of the temperament (F-C, C-G, G-D, D-A, A-E and E-B) *and* by the schism between syntonic and pythagorean commas to complete the circle. As we can see in Werckmeister IV and V (see Plates. 2 and 3), there is precedent in both temperaments for wide fifths; G#-D# and D#-Bb in the case of IV; G#-D# in the case of V. Although the temptation to divide the remaining, surplus  $\pm\frac{1}{2}$  comma between these three intervals equally each is strong, Rousseau does say to enlarge the remaining

intervals *by degrees*. We can also fairly certainly ascertain that some of the intervals are wider than pure by Rousseau's saying the intervals should be tuned weak, i.e. narrow, *initially*. This indicates undoubtedly that subsequent intervals are not narrow but either pure or wide. Tuning F-B  $\flat$  pure or slightly narrow, would leave only two intervals, G#-E  $\flat$  and E  $\flat$ -B  $\flat$ , to absorb  $\pm\frac{1}{2}$  comma between them. It seems to make sense then that all three fifths, F-B  $\flat$ , B  $\flat$ -E  $\flat$  and E  $\flat$ -G# are tuned slightly wide of pure by increasingly larger amounts so that B  $\flat$ , E  $\flat$  and A  $\flat$ /G# create progressively larger major thirds and therefore progressively darker key tonalities. Had the previous fifths of the second part, B-F#, F#-C# and C#-G#, been tuned narrow rather than pure, the portion of the comma remaining to be absorbed by the final three fifths of the third stage, would be greater still and probably too great to be absorbed musically in the last three fifths and resulting in a third, F#-A#, too wide to be useable. Tuning the fifth E-B wider than  $\frac{1}{4}$  comma narrow would likewise have pushed the remaining thirds, sharper and worsening them in turn.

There is, however, a contradiction in Rousseau's text: In the third stage of the temperament he advises tuning the remaining intervals wider by degrees until "one has returned to D  $\flat$  which, taken as C#, must be in tune and forming a fifth with G#, at which one had stopped previously." He must have meant to stop at E  $\flat$ , which must be in tune with G#. This is probably a mistake on Rousseau's part.<sup>19</sup>

Consequently, we end up with six  $\frac{1}{4}$  syntonic comma narrow fifths, followed by three pure fifths, and three consecutively wider fifths with three pure major thirds, F-A, G-B and C-E. This temperament is playable in all keys, favouring the more common keys, as expected, while allowing for differences in size between mirrored major thirds such as B  $\flat$ -D and D-F# as also between E-

G# G#-C. As per Emanuel Bach's suggestions, we have tempered most of the fifths but not all. The reason Rousseau did not stop after narrowing the first four fifths, as *Kirnberger III* had required, is because the thirds produced just were too wide for his taste and require improving albeit at the cost of the purity of the remaining fifths. As Diderot puts it: "On ne sauroit gagner d'un côté qu'on ne perde de l'autre. Voyons de quelle maniere on combine tout cela, et comment par le *tempérament* ordinaire on met cette partie même à profit." ("One doesn't win something on the one hand without losing out on the other. Let us see how one combines all that, and how by way of *tempérament* ordinaire one puts this even to profit.") Notice however, that Diderot italicised only the word *tempérament* and not *ordinaire*, implying that the term "tempérament ordinaire" is a modern expression: "*ordinaire*" must have been understood to mean "normal" or "usual", much as Rousseau had referred to it.

So what does all this have to do with Sebastian Bach or, for that matter, Bradley Lehman's temperament proposal? Let us recap briefly. From what Emanuel Bach writes in his *Versuch* we can rule out *equal temperament* and  $\frac{1}{4}$  *meantone* as Emanuel Bach's temperament, and we are informed, indirectly, that Emanuel Bach likes some fifths pure. Through Rousseau's discussion in respect to Rameau's equal tuning in Rameau's *Génération harmonique*, and from Kirnberger, we know that equal tunings were also not generally liked by musicians or instrument builders in France or Germany, even having been rejected by "the famous Couperin." Further, through Rousseau and Diderot we are able to produce a reasonably probable scheme for the temperament in common "current" use ("*l'usage actuel*"), "the established temperament" ("*tempérament établi*"),<sup>5</sup> and "*tempérament ordinaire*", at the time of his writing in France which, while being playable in all keys, retains different personalities and colours for each different key. This temperament would likely have been in "*l'usage actuel*" in the French courts and those in Germany. Both Emanuel and

Sebastian Bach likely knew of this temperament. Maybe Bach is describing nothing more in his spiral glyph than his interpretation of this temperament.

Taking a closer look at the Bach spiral we notice one crucially important matter missed by Lehman. The double knots are not only different from the single knots in the number of rotations of the pen used to create each knot, but also *importantly* in the order in which the outer loops and inner knots are drawn relative to each other for each interval.<sup>20</sup> With the spiral inverted, in each case the double inner knots are drawn with the pen before the outer loop are drawn around them. In all cases of the single knots, however, *the reverse is true*; the outer loops are drawn *before* the inner knots are added.<sup>21</sup> How could this have been overlooked? There is too little information in the spiral for any of it to be less than vital! There is no doubt that the inversion of the order of drawing loops and knots is most highly significant. It is only logical that the inversion of the loop/knot order of penning indicates an apposition; narrow fifths on the one hand and wide fifths on the other. That temperaments existed with more than one wide fifth we know through Werckmeister's *IV* and *V* temperaments (Plate. 3), and through Rousseau, of course.

The three different kinds of loop configurations describe five possible items of information or 'indicators':

*List 1*

- 1) loops without knots
- 2) loops with double knots
- 3) loops with single knots

- 4) knots-loop sequences
- 5) loop-knots sequences (in reversed order of penning)

There are five significant attributes a fifth can have and we might equally ascribe those values to the above indicators thus:

*List 2*

- 1) pure fifths
- 2) markedly deviant from pure fifths
- 3) slightly deviant from pure fifths
- 4) narrow fifths
- 5) wide fifths

It is no coincidence that there are five fifth attributes and five indicators. Using the same numerals from *List 2* above as a key we can try to apply this to Rousseau's temperament schematically from what we already know of it. For example, (4+2) indicating a narrow fifth (4) + a markedly different from pure fifth (2) while placing the letter "C" within the diagram for calibration:

(4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1) (1) (1) (3+5) (3+5) (3+5)

C

Here we see that the first six fifths of Rousseau are all narrow (4) and markedly deviant from pure (2) given that they are a full  $\frac{1}{4}$  comma narrow. Likewise, the following three are all pure (1) and the remaining three fifths are both slightly deviant from pure (3), and wide (5).

Compare this directly to the Bach glyph using *List 1* For example, (4+2) knots-loop sequences (4) + loops with double knots (2) while placing the letter "C" within the diagram for calibration:



(4+2) (4+2) (4+2) (4+2) (4+2) (1)(1)(1) (3+5) (3+5) (3+5)  
C

Here we see that the first five spirals of Bach are all knots-loop sequences (4) and loops with double knots (2). Likewise, the following three are all loops without knots (1) and the remaining three fifths are loops with single knots (3) loop-knots sequences in reversed order of penning (5).

Seen directly above one another the effect is striking:

C

Rousseau: (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1) (1) (1) (3+5) (3+5) (3+5)

Bach: (4+2) (4+2) (4+2) (4+2) (4+2) (1) (1) (1) (3+5) (3+5) (3+5)

C

But what of the missing first interval F-C in the Bach scheme, and the loose loop-less rogue double knot at the beginning of Bach's glyph? Ought we to continue with the hapless notion of a 'three-beats-per-second' calibration by Lehman? Or does the rogue double knot represent the missing fifth, a narrow fifth, markedly deviant from pure, (4+2), as was true for the double knots *within* loops? Had Bach added the rogue loop with a second pen-stroke because he started the spiral at C, where he normally started tuning, having forgotten F until the end, not wanting to separate this narrow fifth from the others by tagging it on the back of B  $\flat$ ? Let's go for it, and add it to the beginning of the 'Bach' scheme where the interval F-C was missing:

C

Rousseau: (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1) (1) (1) (3+5) (3+5) (3+5)

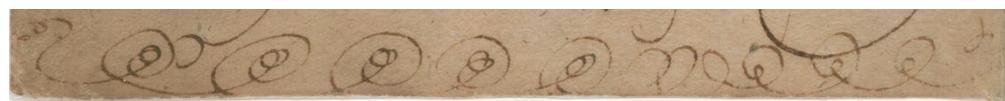
Bach: (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1) (1) (1) (3+5) (3+5) (3+5)

C

And with the Bach glyph between:

C

Rousseau: (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1)(1)(1) (3+5)(3+5)(3+5)



Bach: (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (4+2) (1)(1)(1) (3+5)(3+5)(3+5)

C

There only remains the matter of a small flourish after the last loop which appears not to have a meaning and is likely only to be ornamental, or perhaps implying a return to the beginning of the circle at F, as there are no more fifths to tune. The possibility that the overwhelming similarities in the two schemes are purely coincidental is very slight, given the precedent of the use of Rousseau's *tempérément* as the temperament in common use. It is much more likely that we are dealing with one and the same temperament type.<sup>22</sup> We should also not forget that Rousseau speaks of "the temperament in current use" and Emanuel Bach speaks of "the new temperament", indicating only one temperament was generally in use in France, and one temperament in Germany, and that these temperaments were plausibly one and the same.

Bach's temperament appears far from extraordinary. Indeed, it resembles that of Rousseau so much as to be almost, if not completely, identical and can only be considered another example of the *tempérément* in common use. As Bach seems to have corrected his autograph at least four times, we do not know exactly when Bach penned the glyph onto his title page. However, that he felt it necessary to describe a temperament on the title page of his Well-Tempered Clavier indicates that this kind of *tempérément* was not universally used in Germany in 1722 by those who Bach hoped would play these pieces. Bach's temperament plays well in all keys and manages the Well-Tempered Clavier comfortably and colourfully. It is perfectly in keeping with the nature of Bach's time.

As much as I expect some who try this temperament to find it too strong in distant keys, I would only suggest they first ensure their instruments are good examples, with appropriate set-up including particularly, Nürnberg type wire, i.e. plain low-carbon iron wire, not plated or polished, at the correct tension and, well voiced with, ideally, crow or raven quills. Incorrect wire produces very

false overtones which quickly go out of tune with each other and do not sustain evenly. Also tune very carefully, using all the pure intervals as checks throughout the compass. I would add, finally, that their and Bach's idea of strong probably differ significantly, much as our notion of a good curry might differ from that of a chef in Jaipur. Indeed, coming upon an E# in the cadence of an C# minor prelude might be akin to biting down on a cardamon pod, but when you know to enjoy it, it is all the more beautiful. A dangerous trap, and perhaps that into which Lehman himself has fallen, is that of fetishising Bach into a curious recluse, running alone in some parallel-dimension musical world. Far more probably, Bach was very involved with the musical practices and norms of his time. There is probably no holy grail of temperament which Bach alone discovered and kept secret but, as I hope to have shown here, a good and solid working temperament which Bach and the other musicians who played with him (and his tempered harpsichord) understood and with which they were familiar.

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1 B. Lehman, 'Bach's extraordinary temperament: our Rosetta Stone, *Early Music*', 33(i) (2005) pp. 3-24.

2 J. S. Bach, Das Wohltemperierte Clavier, (Manuscript 1722) Frontispiece. The MSS is deteriorating quickly due to the chemistry of the ink and paper; It is hoped that these representations are legible examples of Bach's intentions.

3 *Das Wohltemperierte Klavier I*, ed. W. Dehnhard/D. Kraus (Vienna: Wiener Urtext Edition, Schott/Universal Edition, 1977), Preface, pp.VI. "Bach made his corrections bit by bit; the copies indicate the stage Bach's amendments had reached at the time the copy was made. These copies enable one to clearly identify four distinct phases in the correction of the autograph." The spirals could have been added by Bach, or someone else, perhaps a student or copyist, at some point during or after 1722.

4 Bradley Lehman's important and positive contribution to this aspect of Bachology should not be underestimated.

5 The difference between a syntonic and a pythagorean comma is very slight indeed,  $\pm 1.95$  cents, perhaps a little under 2 one-hundredths of a semi-tone. Most people think they are tuning using pythagorean comma divisions, whether they are using them or syntonic comma divisions, as in the case of meantone tunings. Pure thirds are arrived at intentionally by employing the syntonic comma and perhaps only incidentally by use of the pythagorean comma. Ultimately, there mostly remains a schism between the size of a syntonic comma and a pythagorean one such that actually ascribing definitive values to fifths, such as  $\frac{1}{4}$  or  $\frac{1}{8}$  etc. can only be approximated values.

6 J. J. Rousseau, (*Dictionnaire de Musique* 1768) Vol. 2 pp. 499-505.

7 In translating this, as with all other translated texts contained in this article, I have attempted to remain as close as possible to the original texts while being as intelligible as possible to a modern mind.

8 One ought to bear in mind that Rousseau and Rameau were known for their rivalry as attested to in Diderot's dialogue *Le neveu de Rameau*.

9 Obviously, François Couperin.

10 J. Kirnberger, Letter to Forkel, c.a. 1779, (*Allgemeine Musikalische Zeitung*, Breitkopf und Härtel, Leipzig, 1871) It must not be assumed that Kirnberger, a student of Bach, had been taught to tune by Bach or that he agreed on tempering issues with Bach.

11 A. Werckmeister, *Musicalische Temperatur*, (Frankfurt and Leipzig, 1691) pp. 57-58, 78-79. Notice, however, that the markings " $\frac{1}{4}$  c" on his fifth temperament are written in by hand by someone who may not have been Werckmeister.

12 Kirnberger's third temperament requires tuning the four fifths, C-G, G-D, D-A and A-E only, resulting in a pure third, C-E. A contradiction appears here in that to produce a pure third the syntonic comma must be resolved. However, to narrow only four fifths, leaving the remainder pure, would require tempering these four fifths by  $\frac{1}{4}$  pythagorean comma each. Four  $\frac{1}{4}$  syntonic comma fifths are not equal to four  $\frac{1}{4}$  pythagorean comma fifths. Hence, the difference, or "schism", must be ensconced somewhere in the remaining eight fifths.

13 Although we tend to think of tuning using A from the oboe today, this is probably due to the instability of the oboe's c<sup>1</sup>. Until the advent of electronic tuning machines, modern piano tuners often started their temperament with middle C. We see also that Werckmeister in his diagram starts with C (see fig. 2).

14 C. P. E. Bach, *Versuch über die wahre Art das Clavier zu Spielen*, (Berlin, 1753) pp. 10.

15 It is of interest that although C. P. E. Bach mentions the checking of the thirds, both major and minor, he does not give any hint as to which, and for what. It is not possible to ascertain whether Bach assumed a great deal more temperament knowledge from his reader, removing the need for specifics, or if he was not too worried about the thirds. Rousseau is quite specific on the other hand about the third C-E. This third is used by Kirnberger in his third temperament, and mentioned repeatedly by Werckmeister in respect to the theory of temperament and the syntonic comma. Like Rousseau, Bach seems not worried about fractions of commas, but of getting the intervals tuned.

16 We know that John Broadwood, piano maker in London, had regular piano and harpsichord tunings booked with a number of his clients by way of the Barbara Broadwood's book, (1768- 1791) MS Eng. Misc. c529, a photocopy of which is held at Bodleian Library, Oxford.

17 Rousseau's use of the word here "affoiblissant" appears confusing in that it literally means to "weaken" and he has spoken of weakening intervals to indicate making them narrow. However, in this case it can only mean to lower the pitches.

18 Diderot et d'Alembert, Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers (1751 - 1780) Vol. 16 (Dec. 1765) p. 57 "On ne sauroit gagner d'un côté qu'on ne perde de l'autre. Voyons de quelle maniere on combine tout cela, et comment par le *tempérament* ordinaire on met cette partie même à profit."

19 This error, however, is reproduced also exactly in Diderot's Encyclopédie, which could question whether it was an error and oversight or not, given it was missed twice. However, to retune G# so as to end on D  $\flat$  /C# makes little sense, if any.

20 Werckmeister, a German speaker like Bach, in the diagram of his *Musicalische Temperatur* (See Plate. 3) refers not to wide and narrow fifths, but to fifths where a note is tuned "up" and "down". Arguably, the knot/loop sequence could be understood as "down" where the loop/knot sequence could be understood as "up" where Bach's spiral is viewed upside down. This would make sense in the context of the spiral.

21 G. Interbartolo Bach 1722, *Il temperamento di Dio Le scoperte e i significati del "Wohltemperirte Clavier"* (Edizioni Bolla, Finale Ligure 2006) pp. 136. In 2006, Graziano Interbartolo published a different interpretation of this same Bach spiral which does come close to the truth by also having recognised the apposed loop/knot format.

22 Interbartolo, rather than reading each spiral as an interval of, say "C - G", for example, seems to have read them as "*C from F*", as Werckmeister had presented his fifths in his third temperament. The result being that Interbartolo's fifths are displaced by one position. Interestingly, Werckmeister presents his three temperaments in diagrams of two similar but slightly different styles, as the presentation of his third and fifth methods demonstrate in plates 2 and 3. In the first, for his third temperament, he positions the intervals *from* one note to another, i.e. G from C, where in his V temperament he presents them more as we might today, i.e. from C to G. Werckmeister writes in the diagram of his third tuning: "G beats against C downwards  $\frac{1}{4}$  com[ma]" rather than "temper C to G  $\frac{1}{4}$  comma narrow", as we would likely say today. Rousseau, like in modern usage, tends to write "tunes the flat fifths; i.e. F, B  $\flat$ , etc. weak [...]"<sup>15</sup>. Interbartolo's temperament replaces the  $\frac{1}{4}$  comma narrow fifth E-B with a pure one, pushing the G# yet further from the E while improving slightly the thirds B  $\flat$ -F and E  $\flat$ -G. This also results in the loss of the pure major third G-B and widens (thereby worsens) the major thirds D-F#, A-C# and E-G# with a slight improvement of the third

F#-A#. Although similar to Rousseau at first glance, it is unfortunately probably just sufficiently inaccurate to be very inaccurate and can probably be ruled out as Bach's temperament.

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