ACOUSTICS GUIDE · EXPANDED EDITION

Bach's Secret Manuscript

The hidden code of 1722, the tuning recipe, and why C♯ is not D ♭.

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BEFORE YOU START · The Myth of Equal Temperament

It is often repeated that Bach wrote *The Well-Tempered Clavier* (Köthen, 1722) to champion the equal temperament of modern pianos. Yet "well-tempered" (*wohltemperirt*) does not mean "equal": it means tuned in such a way that you can play in every key, with each key keeping its own distinct color.

What we know: The 1722 autograph manuscript is preserved in the Berlin State Library (*Mus. ms. Bach P 415*). Across the top of its title page runs a calligraphic flourish of 11 loops of three distinct shapes: simple, double, and spiral.

What is hypothesis: That this flourish is a tuning instruction. Andreas Sparschuh drew attention to the drawing in 1999, and harpsichordist Bradley Lehman published his reading in *Early Music* in 2005. Other scholars propose alternative interpretations, and there is no final consensus. This guide explains Lehman's reading, which is the most widely known.

Four Ways to Distribute the Comma

SYSTEM	HOW IT WORKS & HOW IT SOUNDS
Pythagorean	Pure fifths. Very wide major thirds (≈ 408¢). Sounds bright, and leaves behind a "wolf" fifth.
Meantone	Pure thirds (386¢), but an unusable wolf fifth. Only a handful of keys are playable.
Equal	Every fifth at 700¢ and every major third at 400¢. Works everywhere, but erases key color.
Well-Tempered	Unequal fifths. All keys are playable, and each one sounds subtly distinct.

YEAR	HISTORICAL TIMELINE
1722	Bach dates the title page in Köthen.
1802	Forkel writes that Bach tuned his keyboards himself, in 15 minutes.
1999	Sparschuh highlights the significance of the decorative flourish.
2005	Lehman publishes his reading of the code in *Early Music*.

THE CODE · The Eleven-Loop Flourish

Above the title, Bach drew a sinuous flourish that generations dismissed as mere ornament. According to Lehman, it is drawn "upside down" relative to its reading and serves as a pocket reminder: a chain of fifths, each marked by its own type of loop.

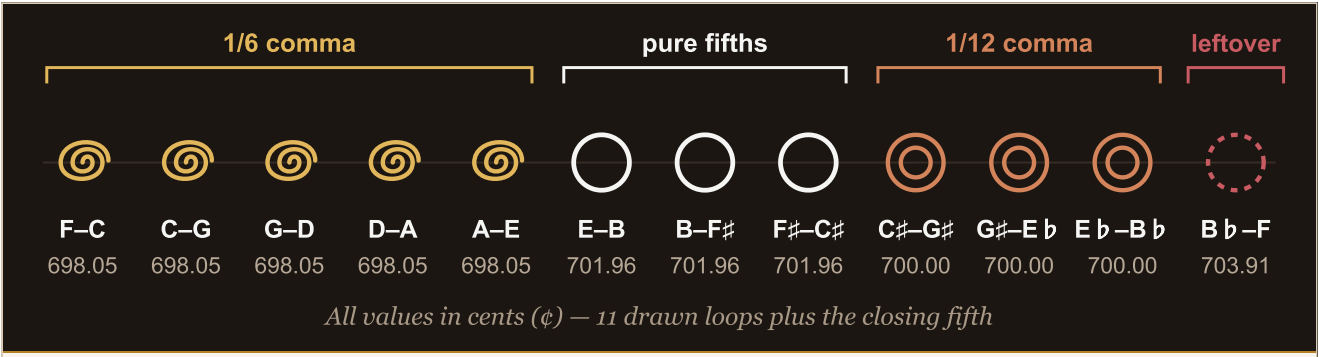


FIG. 1 · THE ELEVEN-LOOP FLOURISH. From left to right, the 11 loops drawn across Bach's 1722 title page and the 12th fifth left over when closing the circle.

How to Read Each Loop

SYMBOL	TUNING INSTRUCTION (LEHMAN'S READING)
Spiral	Fifth narrowed by 1/6 of a Pythagorean comma (≈ 3.9 cents). According to Lehman, this was the customary amount for tempering a fifth in Bach's era.
Double loop	Fifth narrowed by 1/12 of a comma (≈ 2.0 cents)—the exact same size as the fifths on a modern piano.
Simple loop	Pure, untempered fifth: 701.96 cents, completely beatless.

Why a Drawing Instead of a Table?

It seems unusual today, but in the 18th century tuning a harpsichord was the performer's own job. Forkel recounts that Bach tuned his keyboard instruments himself with such ease that a quarter of an hour was all he needed. A compact visual reminder on the cover of the very book that required tuning fits that craft naturally.

> **Fun fact:** According to Lehman, the "C" hanging down from the word *Clavier* marks where the note C sits within the chain—a clue hidden inside the clue.

THE RECIPE · The Twelve Fifths, One by One

The 11 loops describe 11 fifths. The twelfth is never drawn: it is simply what remains when closing the circle. Here is the complete table of Lehman's reading:

#	FIFTH	SYMBOL & TEMPERING	SIZE
1	**F – C**	Spiral · 1/6 comma narrow	**698.05¢**
2	**C – G**	Spiral · 1/6 comma narrow	**698.05¢**
3	**G – D**	Spiral · 1/6 comma narrow	**698.05¢**
4	**D – A**	Spiral · 1/6 comma narrow	**698.05¢**
5	**A – E**	Spiral · 1/6 comma narrow	**698.05¢**
6	**E – B**	Simple loop · pure	**701.96¢**
7	**B – F♯**	Simple loop · pure	**701.96¢**
8	**F♯ – C♯**	Simple loop · pure	**701.96¢**
9	**C♯ – G♯**	Double loop · 1/12 comma narrow	**700.00¢**
10	**G♯ – E♭**	Double loop · 1/12 comma narrow	**700.00¢**
11	**E♭ – B♭**	Double loop · 1/12 comma narrow	**700.00¢**
12	**B♭ – F**	Remainder · 1/12 comma wide	**703.91¢**

The arithmetic proof: If you add up the sizes of all 12 fifths in the table, the total is exactly **8,400 cents = 7 octaves**. The circle closes without leaving any unusable "wolf" fifth. That is the great virtue of this recipe.

The result—a map of colors: Because the fifths are not all equal, neither are the keys. F and C major end up with the sweetest major thirds, since they sit closest to a regular 1/6-comma system. D and E♭ major have a middle quality, similar to equal temperament. E major sits closest to pure Pythagorean tuning, giving it a brighter, tenser edge.

In Lehman's system, every major third is slightly wider than pure. What changes from key to key is by how much.

THE CIRCLE · Bach's Circle of Fifths

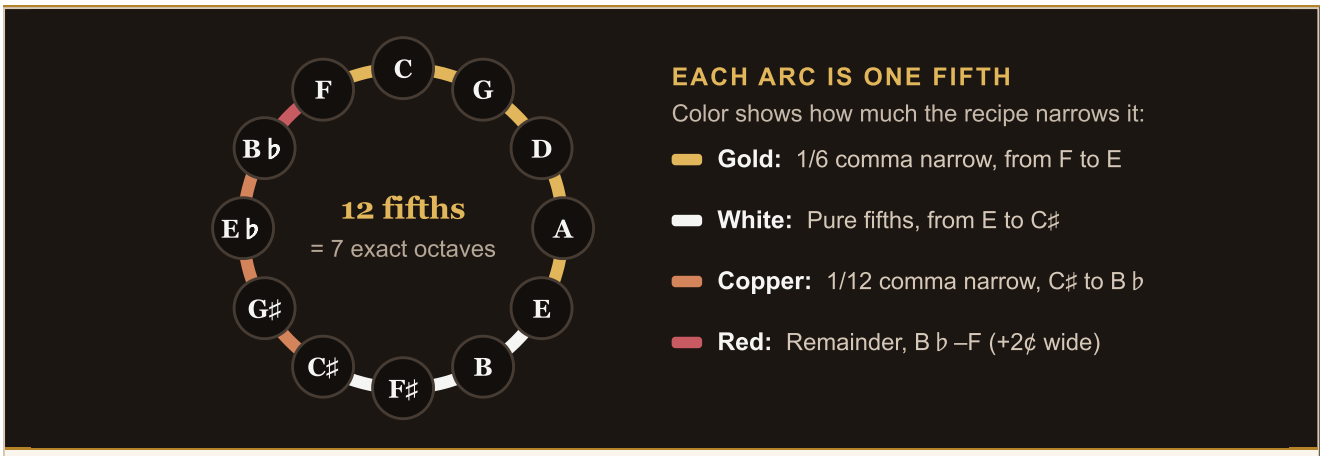


FIG. 2 · BACH'S CIRCLE OF FIFTHS. Five 1/6-comma fifths, three pure fifths, three 1/12-comma fifths, and one closing fifth barely 2 cents wider than pure.

Why a Comma Must Be Distributed

If you stack 12 pure fifths, you do not land on 7 exact octaves: you overshoot by about **23.46 cents**—the *Pythagorean comma*. It is a tiny gap, yet large enough to prevent the circle from closing. Every temperament is simply a decision about where to hide that comma.

EQUAL TEMPERAMENT	WELL-TEMPERED (BACH, PER LEHMAN)
Spreads the comma equally across all 12 fifths. Every key sounds virtually identical.	Distributes the comma unequally. Every key retains its own character, and none is unusable.

PHYSICS OF SOUND · Why Are C♯ and D♭ Not Identical?

On a modern piano, C♯ and D♭ share the exact same key and frequency: 100 cents above C. On the violin there are no frets—and physics tells a different story.

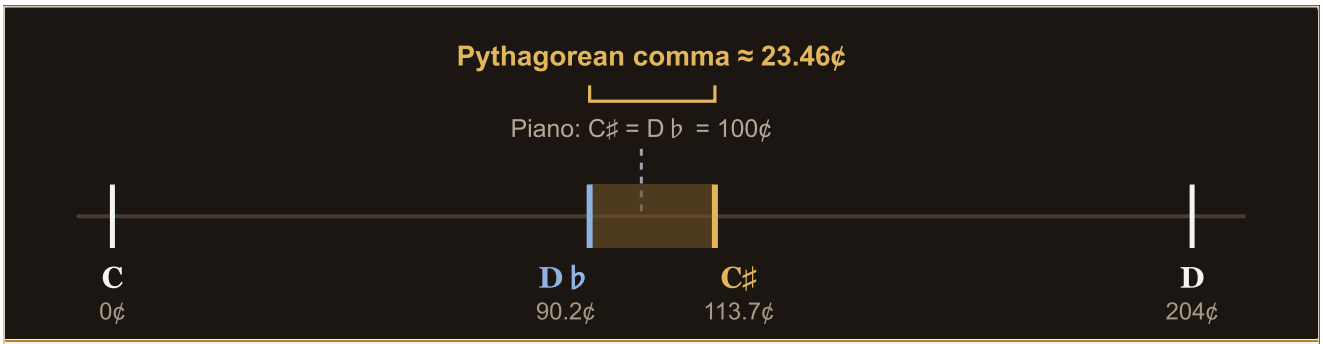


FIG. 3 · PYTHAGOREAN SPLIT. In pure fifths, C♯ sits 23.46 cents higher than D♭; the modern piano splits the difference at 100 cents.

C♯: 7 FIFTHS UP	D♭: 5 FIFTHS DOWN
Climb 7 pure fifths and drop 4 octaves. **Result: 113.7 cents above C.**	Drop 5 pure fifths and climb 3 octaves. **Result: 90.2 cents above C.**

The gap between the two is, once again, the Pythagorean comma: 23.46 cents. In Pythagorean tuning, the sharp sits higher than the flat. The piano averages them and merges them into one key. The violinist, on the other hand, gets to choose.

Try It on Your Violin (3 Minutes)

- Play the open D string as a drone, and over it play a high C♯ acting as a leading tone pulling upward into D.
- Now play a C as a drone, and over it play a low D♭ leaning downward into C.
- Compare: it is the exact same "note" on the piano, yet your fingers land in two different spots. Your ear already knew this.

Traditionally, players are taught to play sharps slightly high and flats slightly low. In practice, exact intonation always depends on harmonic context.

THE DOCTRINE OF THE AFFECTIONS · The Emotional Colors of Each Key

Because thirds are not identical across all keys, 18th-century theorists—including Mattheson (1713) and Schubart (c. 1784)—assigned a specific *Affekt* (emotional character) to each one. Bach arranged Book I of *The Well-Tempered Clavier* chromatically, alternating major and minor, to journey through all 24 colors.

Major keys (left) · Minor keys (right). These descriptions are historical interpretations, and 18th-century writers did not always agree with one another.

MAJOR KEYS (C TO F)	MINOR KEYS (C TO F)
I **C Major** Purity, innocence, noble simplicity, clear light.	II **C minor** Tragic love, solemn lament, passionate confession.
III **C♯ Major** Ecstatic joy, mystical brilliance (an unusual key).	IV **C♯ minor** Anguished penitence, painful dialogue with God.
V **D Major** Triumph, victory, festive jubilation, and majesty.	VI **D minor** Severe tragedy, devout solemnity, dignified melancholy.
VII **E♭ Major** Solemn devotion, spiritual dignity.	VIII **E♭ minor** The dark night of the soul, deep despair.

MAJOR KEYS (C TO F)	MINOR KEYS (C TO F)
IX **E Major** Joyful laughter, jubilation, sunlit brilliance without shadows.	X **E minor** Deep lament, solitary affliction, tender complaint of love.
XI **F Major** Pastoral calm, inner peace, tenderness.	XII **F minor** Somber anguish, mourning, groaning in the face of misfortune.

THE DOCTRINE OF THE AFFECTIONS · From F♯ Major to B Minor

MAJOR KEYS (F♯ TO B)	MINOR KEYS (F♯ TO B)
XIII **F♯ Major** Triumph over difficulty, relief after overcoming an obstacle.	XIV **F♯ minor** Heartrending melancholy, tormented passion.
XV **G Major** Serene gratitude, rustic joy, luminous balance.	XVI **G minor** Bitter discontent, restlessness, inner struggle.
XVII **A♭ Major** Extreme delicacy, sigh of the soul.	XVIII **G♯ minor** Bitter complaint, stifled weeping without consolation.
XIX **A Major** Sincere love, youthful contentment, trust.	XX **A minor** Pious sadness, dignified resignation, temperance.
XXI **B♭ Major** Cheerful love, steady hope, serene faith.	XXII **B♭ minor** Deepest night, remorse, hopelessness.
XXIII **B Major** Ardent passion, pride, vivid colors.	XXIV **B minor** Resignation to fate, sober contemplation.

On the Violin, Color Is Also Physical

Even though keyboard temperament does not restrict you (the violin has no fixed keys), every key sounds different for another reason: the **open strings** (G, D, A, E) vibrate sympathetically whenever you play related notes. That is why D, A, and G major sound open and resonant, while keys like B♭ or A♭ sound more veiled.

KEY TAKEAWAYS · The Essentials in Five Ideas

- **"Well-tempered" is not "equal."** It is a system where every key is playable, yet each retains its own distinct character.
- **The 1722 title-page flourish may be a tuning recipe.** It is a serious hypothesis (Lehman, 2005), though still actively debated.
- **A comma of 23.46 cents must be hidden somewhere.** Every temperament decides where to place it.
- **C♯ and D♭ are two different notes**, separated by that exact same comma. The piano fuses them; the violin distinguishes them.
- **Key "colors" have a physical basis**, even though the emotional labels belong to their historical era.

Sources

- B. Lehman, "Bach's extraordinary temperament: our Rosetta Stone," *Early Music* 33/1 (February 2005), pp. 3–23.
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- J. N. Forkel, *Über Johann Sebastian Bachs Leben, Kunst und Kunstwerke* (1802).
- J. Mattheson, *Das neu-eröffnete Orchestre* (1713); C. F. D. Schubart, *Ideen zu einer Ästhetik der Tonkunst* (c. 1784, published 1806).
- Autograph manuscript: Staatsbibliothek zu Berlin, Mus. ms. Bach P 415.

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