Temperament history is a topic that many musicians and piano technicians find hopelessly complex and frustrating to understand. It doesn't have to be that way. In this series of articles, I will try to present the material in a clear and straightforward manner, so that anyone with at least a basic tuning background, and a willingness to make a bit of effort, will be able to learn. I have based these articles on considerable study of the available scholarly research, much of which has taken place during the past thirty years, and on direct reference to basic original sources in their original languages. My aim is to draw a reasonably accurate picture of how musicians tuned keyboard instruments, based on the evidence and without any particular preconceptions.

Modern interest in historic temperaments was inspired by the publication in 1951 of Murray Barbour’s book, Tuning and Temperament - A Historical Survey. This book was an expansion of his doctoral dissertation, which traced the “evolution” of western tuning systems towards equal temperament. The book documents theoretical writings about temperament from a wide range of sources, and includes calculations of all the cited theoretical temperaments in cents.

This book was both intriguing and frustrating to those who read it, many of whom were interested in recreating the tunings of the past. The cents calculations were essentially useless in that time before the proliferation of electronic tuning devices. What were needed were aural instructions for those tunings. Owen Jorgensen filled that need with his publication, in 1977, of Tuning the Historical Temperaments by Ear. It is on the basis of these two books (and Jorgensen’s later parallel book on “equal beating temperaments), that many piano technicians and musicians have learned about historical tunings.

There are several reasons not to rely on these sources for information about historical tuning practice. First, Barbour was writing about the theoretical development of equal temperament, not about the history of how people tuned. Hence, he included virtually every published temperament without reference to whether there was reason to believe it was actually in practical and common use. It must be pointed out that the creation of temperaments as an intellectual exercise was a part of the education system from the middle ages, when music was one of the seven liberal arts. It was classified with mathematics, and had nothing to do with singing, performing, or composition. It was the study of ratios, and understanding the relationships between them. The basic problem, which has remained the same to this day, was to come up with a way to resolve ratios of 2:1 (octave), 3:2 (fifth), 4:3 (fourth), 5:4 (major third) and other whole number ratios to form a musical scale. Inevitable conflicts arise, which lead to the need for mathematical compromises.

Music theoreticians of the time commonly worked with “monochords.” These were both physical instruments and paper plans. On paper, a straight line would be divided using straightedge and compass, following the geometry of Euclid. Numerical calculations were also made, so that the theoretical temperament would be expressed as a series of numbers corresponding to string lengths. Commonly the octave to be divided would be
given the values of 1000 and 2000 for its upper and lower notes, with the other notes lying between, often calculated to a much higher degree of refinement (for example, to two decimal points). The result could be transferred for demonstration purposes to a physical monochord, which was a one-string instrument with a movable bridge. The bridge could be moved to points measured in accordance to the calculations. It was conceivable that a monochord could be used to tune an instrument, and this probably occurred with organs to some extent, but this was not really practical for every day tuning of a harpsichord or clavichord. The moveable bridge was not really very precise for tuning purposes, and the process would be quite cumbersome, plucking a string and trying to match its pitch, then moving the bridge and repeating. Performing musicians certainly did not tune on a regular basis using a monochord.

![Elaborate monochord engraving published by Salinas in 1577. The numbers refer to lengths of strings; the various arcs show types of intervals.](image)

So most of these theoretical temperaments can be dismissed as irrelevant to the way most musicians actually tuned, at least in their precise details. Musicians would be far more likely to tune according to practical instructions, and a number of examples of instructions survive. There are also many contemporary descriptions of how instruments were actually tuned, supplementing the practical instructions in giving us a realistic picture of common practice.

In the nearly sixty years since Barbour wrote there has been an enormous output of scholarly research, looking at obscure sources including private correspondence, manuscripts, obscure published works, examining surviving organs for traces of their
tuning patterns, covering considerably more material than was available to Barbour. Unfortunately, most of this research is published in scholarly journals, much of it in languages other than English, so it is not very accessible to the average piano technician or musician.

Jorgensen’s aural instructions were in keeping with the common practice of the second half of the 20th century, when tuners were taught to try to achieve extraordinary precision by reproducing beat rates, often given at a theoretical accuracy of tenths of a beat per second. Jorgensen’s instructions are filled with tables of beat rates, to ensure that every single interval is precisely placed according to theory. This method is at odds with the way people tuned in the historical period we will be dealing with. Though they certainly listened to beats, they did not calculate rates, and their instructions were far less precise and exacting. Jorgensen’s instructions, while generally quite accurate, are far more complex than they need to be. We must remember that until the late 1700s, most stringed keyboard instruments were tuned by their owners, people without specialized training.

Another confusing aspect of Jorgensen’s work was his decision to assign complex names to each of the temperaments he deals with. These names are often filled with theoretical jargon that is incomprehensible to non-specialists. Further, he tended to devote an entire chapter to each small variant of a single style of tuning, rather than simply pointing out that one system was virtually the same as another except for perhaps one or two notes, or a minor proportional change. As a result, many piano technicians received the impression that there were an almost infinite variety of “named” temperaments in the historical period, and that one needs to learn all these named temperaments to become an expert in historical tuning.

In fact, things are not nearly so complicated. There are certain principles and patterns that can be applied to make the whole field of historical temperament very accessible without years of tedious study. For purposes of tuning stringed keyboard instruments (harpsichords, clavichords and pianos), there are really only four or five broad patterns that were used, with easily understood variants and deviations. I will be focusing on what these patterns are, and on some historic source materials that provide examples of each.

The underlying problems

Throughout the history of western music the octave has been divided based almost entirely on the relationships of three intervals with one another. Those three intervals are the octave, the fifth, and the major third.¹ Most piano technicians are well acquainted with how these intervals are related to the partial series, and with the coincident partials that come into play when tuning them.² These three intervals are the most prominent of the “natural” intervals, as they involve the lower partials: 2:1 for the octave, 3:2 for the 5th, 5:4 for the major third.

¹ Other intervals are occasionally considered, but usually they “come along for the ride.” The 4th is treated as the inversion of the 5th, and 6th and minor 3rds are, for the most part, allowed to fall where they may, or considered as inversions.
² For purposes of this series of articles, we will deal with these intervals in their simplest form, and without taking inharmonicity into account. And we will use only the lowest pair of coincident partials for each interval.
Any tuner or designer of a temperament must face the unchangeable and inescapable fact that these intervals are not compatible with one another when we divide the octave into twelve semitones. Since the keyboard had essentially settled into its current design by 1500, tuners have been facing the same challenges for over 500 years.

The relationship of the major third and the octave presents the biggest challenge. Any group of three contiguous thirds stacked on top of one another, like F–A, A–C# and C#–F, comes far short of an octave. It is easy to hear how large this difference is by simply retuning three strings on a piano or harpsichord. With a strip mute in place, lower the pitch of A until F–A sounds pure and beatless; then lower C# until A–C# sounds beatless; and finally lower the upper F until C#–F sounds beatless. Play the F–F octave. It will be very narrow and will beat wildly.

Now raise the upper F to form a beatless octave with the lower F. The distance you have just moved the F is called the diesis in writings about temperament, and is equal to about 41 cents.

In our standard twelve note division of the octave, there are four sets of three contiguous major thirds (the other three are F#–A#, A#–D, D–F#; G–B, B–D#, D#–G; and G#–C, C–E, E–G#). In each of these sets, the three major thirds must be widened by a total of 41 cents, or an average of about 14 cents each, in order to add up to an octave. This average of 14 cents wide corresponds to equal temperament. Tunings in which some major thirds are made closer to just must do so at the expense of other major thirds being made wider. In order that any individual major third should be just, the two other major thirds paired with it must share a widening of 41 cents. If two contiguous major thirds are just, the third contiguous major third must itself be 41 cents wider than just, so that it really loses its identity as a major third.

The second incompatibility is between the fifth and the third. If we tune a series of four fifths (and tune down an octave twice, or alternate fourths and fifths), we come to a note a third away from the note we started on. However, if our fifths are just, that third will be quite wide. By tuning five strings you can hear how wide. With a strip mute installed in a piano, or simply using one register of a harpsichord, tune a series of four just fifths starting at F–F–C, C–G, G–D, D–A - and then tune down two octaves A–A (alternatively you can tune down a G–G octave after tuning C–G, and then an A–A octave after tuning D–A, which is how this would commonly have been done in historical times; or you can omit the octaves by tuning C–G and D–A as fourths down instead of fifths up, as has typically been done since the beginning of the 20th century). Play the third F–A. It will be quite wide and will beat very fast. Now lower the A until F–A is beatless. The distance you have just moved A is called the syntonic comma in temperament writings, commonly referred to simply as “the comma,” and is about 21.5 cents.

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3 In this series of articles, the word “just” will be treated as equivalent to “beatless” or “pure.” These labels are inexact, especially when the inharmonicity of the piano comes into play. However, in dealing with historical tuning practice, that is what the tuner would hear, and what would be practical for us to emulate.
The incompatibility of major thirds and fifths is perhaps the most important problem from the point of view of understanding the history of temperament. Most temperament schemes are based on tuning a sequence of fifths in order to balance the sizes of major thirds and fifths. Since every third is “made up” of a series of four fifths, the sum of the sizes of those four fifths determines the size of the third. As we have just seen, a series of four just fifths produces a very wide third. Narrow fifths will produce thirds closer to just. So in order to make thirds “better,” it is necessary to make fifths “worse.”

The simplest and easiest incompatibility to deal with is the one between the fifth and the octave. A series of twelve fifths (with octaves down as needed to stay in range) exceeds an octave by 23.5 cents, the Pythagorean comma (sometimes referred to as the ditonic comma). This difference can be resolved by simply making each fifth narrow by about two cents, in the equal temperament solution familiar to us all. Fifths narrow by two cents are hardly noticeable in a musical context, and that small change is difficult for most people, including musicians, to hear. However, it is a significant difference when considering all twelve fifths together, and we must keep in mind that the sum of the sizes of the twelve fifths must always add up to 23.5 cents narrow in total (assuming a just octave).

Temperament is the process of altering fifths and thirds in order to balance these differences while maintaining the octave untouched. Over the course of the history of western music, which we will take as being from about 1500 to the present (the time relevant to the tuning of stringed keyboard instruments), a seemingly endless number of temperament schemes have been designed and promoted. Disputes between the advocates of various schemes were often extraordinarily heated, and it is clear that more than one style of tuning was used during many eras, though it is usually possible to determine which was most prevalent.

To get our feet wet, let us look at a temperament that is not really relevant to the tuning of stringed keyboard instruments, but which has historical importance and is useful for understanding the principles involved. The Pythagorean temperament was likely the first system used in western music to divide the octave into 12 semitones, as a practical tuning scheme. It is very simple in execution. One simply tunes a series of 11 just fifths around the circle of fifths (with intervening octaves to stay within range). The final remaining fifth will be narrow so as to complete the circle. That final fifth must be narrower than just by 23.5 cents, the entire Pythagorean comma.

This tuning was commonly used in medieval times for organs, which accompanied choirs in churches. Pythagorean tuning has several interesting features. First, most of the major thirds are quite wide. They are, as we understand from the relationship between fifths and major thirds, about 21.5 cents wide (wide by one syntonic comma. This compares to equal temperament major thirds of about 14 cents wide, so they are about half again as wide). Major thirds of this width are commonly referred to as “Pythagorean thirds.” However, there are four major thirds in this tuning that are considerably narrower.

One of the fifths is narrow by 23.5 cents. Hence each major third that “includes” this fifth in the series of fifths that comprises it, will be narrow of just by two cents, quite close to a just major third (it will be narrower than a “Pythagorean third,” which is 21.5 cents wide, by the Pythagorean comma, 23.5 cents).
Let us examine how this works a little more closely, as the principles involved are very important for a clear understanding of the mechanics of temperament, expressed as sizes of fifth and resultant sizes of major thirds or vice versa. The narrow or “wolf” fifth was often placed between B and F#. Though this would theoretically be spelled B–Gflat, we will give it a spelling more familiar to piano technicians. Four major thirds “include” this fifth: D–F#, A–C#, E–G#, and B–D#.

D–F# “includes” the fifths D–A, A–E, E–B, and B–F#. B–F# is the wolf fifth, 23.5 cents narrow. The other three are just fifths. So the total difference in the 5ths is 23.5 cents narrow. The other three major thirds are derived the same way: A–C# includes A–E, E–B, B–F#, and F–C# (B–F# being the wolf, the others being just); E–G# includes E–B, B–F#, F–C#, C–G# (B–F# being the wolf, the others being just); and B–D# includes B–F#, F–C#, C–G#, G–C# (B–F# being the wolf, the others being just).

So the Pythagorean temperament contains four “nearly just” (slightly narrow) major thirds, and eight “Pythagorean thirds.” The nearly just major thirds are not very useful, being in the less-used areas of the scale. However, their sound is strikingly different from the other major thirds in the Pythagorean tuning, and this may well have been a seed of the very important tuning system known as ¼ comma meantone, which will be the topic of the next article in this series.

Additional reading:
Probably the best brief scholarly account of the history of temperament in English is to be found in the article “Temperaments” by Paul Poletti, in the New Grove Dictionary of Music, Oxford University Press, 2014.

For a much more detailed account of historical tuning and temperament, including a far more complete mathematical analysis, and a great deal of practical material concerning the relationship of temperament to various instruments, see Claudio Di Veroli’s Unequal Temperaments, available as an e-book via http://temper.braybaroque.ie/


For those who read French, Le Tempérament Musical by Dominique Devie provides the best overview of the practical history of tuning. It was published originally in 1990, and was reprinted in 2008, available from http://musicreprints.fr.fln/

Considerable detailed information about the history of tuning and temperament can be found in Enharmonic Instruments and Music 1470-1900, Patricio Barbieri, Il Levante Libreria Editrice, 2008. This is available from the publisher by emailing

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4 This position of the wolf corresponds to the so-called “Gothic” tuning. To be precise, in much of the earliest Pythagorean tuning, the only non-diatomic notes were B flat and later F#. Later versions added the other sharp or flat keys.
illevantesas@libero.it (cost Euro 60 plus 30 shipping, about $130). Many of Barbieri’s articles are available on his web site, but most are in Italian.

An amazing on line bibliography of temperament history and related topics can be found at the Huygens-Fokker Foundation site, http://www.huygens-fokker.org/docs/bibliography.html
In the previous article, we talked about the Pythagorean temperament, with its eight wide “Pythagorean” major thirds as well as four nearly just major thirds. The Pythagorean tuning was well suited for medieval music, as at that time the major third was considered a dissonant interval, to be resolved to the fifth. Those wide major thirds sounded quite wild when played on the most prominent keyboard instrument of the time, the church organ. Moving from a major third to a fifth, with the upper note ascending and the lower note descending, gave a very clear sense of movement from tension to rest.

By the Renaissance, however, musical style had changed considerably. The major third, along with the related major sixth, had become very prominent, and was now considered consonant. The Pythagorean major third no longer sounded right. We should bear in mind that most music was not centered on the keyboard, but rather on the voice and on instruments on which pitch could be “bent” to sound more in tune. The new styles evolved in vocal music and in music for instrumental consorts. And they presumably “blended” the sound of major thirds so that they were “in tune” (that is, they did what modern vocal, string and wind groups do today, making major thirds sound relatively pure and beatless, at least in slower and sustained passages). When keyboard instruments were used to play or accompany this music, it was apparent that the tuning was not appropriate. And in solo keyboard music, which was beginning to be an important genre at this time, the wide thirds sounded unacceptable.

In the early 1500s, a new system for tuning was described by a number of authors. It came to be known as quarter comma mean tone. The basis for this tuning system was the just major third. The first detailed practical description of this tuning method was published by Pietro Aron in 1523, as part of a treatise on music. He tells us to begin with C “tuned however you like” (the idea of standard pitch was far in the future), and then tune E to C as purely and justly as possible (he uses descriptive terms that ask for the two notes to be as sonorous, just and united as possible). Then the fifths are filled in between C and E: C–G is tuned “a bit flat”; G–D in a similar way; D–D octave is tuned pure; A is now tuned so that both D–A and A–E are equally narrow. The descriptive language used is rather awkward and confusing, but it is reasonably clear what is meant: the syntonic comma is to be divided equally among four fifths, so as to produce a just major third. In other words, the fifths that “make up” the major third are all to be narrow enough that the third will be just, considerably narrower than fifths in equal temperament.

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1 It should be noted here, for the sake of being complete, that various tuning systems labeled “Just” were developed between the Pythagorean and Mean Tone systems. They are, however, not relevant to people tuning stringed keyboard instruments except in very specialized circumstances.
2 Beatless, for our purposes.
3 Pietro Aron, Toscanello, Venice, 1523. The excerpt concerning tuning is described and translated in Claudio Di Veroli’s Unequal Temperament, pp 391-393.
The title page of Pietro Aron’s Treatise of 1523.
The additional instructions are somewhat garbled, but it seems clear that the additional fifths are to be tuned to the “same degree of flatness” (equally narrow), and, while the details are left to the reader to work out, the intent is that the system of narrow fifths should be extended upward to G# and downward to Eflat. Like most practical tuning instructions of the time, these are brief and somewhat lacking in detail. They take up less than a page in a lengthy treatise that deals with music theory, counterpoint, and other musical matters.

This style of tuning is mentioned frequently in the writings (both published works and private correspondence) of musicians and theorists over the next two and even three and more centuries. It was clearly very widespread, and accepted as the most commonly used tuning method from 1500 to 1700 and beyond (along with mean tone in the range of 1/5 to 1/6 comma, which we will deal with in the next article).

Among the several surviving instructions for completing this tuning is an interesting one published by Galeazzo Sabbatini in 1657: “Reliable Rules for Tuning by Ear Organs, Harpsichords and Other Similar Keyboard Instruments According to Modern Usage.”

He tells us to start on G, and to tune a just third up (to B) and a just third down (Eflat). Each of these thirds is to be divided into its component fifths, with all fifths equally narrow. In the course of the division of G–B, E is tuned. From E, another just third is tuned (G#), and is divided into component fifths. So the tuning instructions can be summarized as dividing the just thirds Eflat–G, G–B, and E–G# into component fifths. He notes that in this tuning, only the octave, the major third, and the minor sixth are “perfect.”

In France at about this same time - in 1643 with a later, expanded edition in 1650 - there appeared the Treatise on Harpsichord Tuning by Jean Denis. Denis was a builder of harpsichords and other musical instruments, and also a church organist, and wrote proudly that he was a very practical musician, not like theoreticians who had never tuned an instrument. He casts scorn on those who try to tune using pure fifths (he seems to refer to Pythagorean and “Just” tuning systems). He contrasts these older systems to his own “harmonic tuning,” which he says is so difficult to do well that many harpsichordists and organists are unable to accomplish it.

Denis’ language is somewhat convoluted, and his writing is filled with anecdotes and opinions, but he is very clear that all fifths, from Eflat to G#, should be equally narrowed. He rails against equal temperament, promoted by some contemporary theoreticians, and says that his own tuning is closer to vocal music. His tuning instructions are relatively detailed, and he states clearly that the tuning is to be checked by listening to the thirds:

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4 This publication is transcribed in Acustica Accordatura e Temperamento nell’Illuminismo Veneto, Patrizio Barbieri, Edizioni Torre d’Orfeo Rome, 1987, pp 243-245. It is also quoted and described and quoted in Il Temperamento Equabile nel Periodo Frescobaldiano (Equal Temperament in the Frescobaldian Period) by Patrizio Barbieri, a paper given in 1983 at a conference honoring the 400th anniversary of Frescobaldi’s death, and published in a volume connected with that conference. The article is available on Barbieri’s web site, http://www.patriziobarbieri.it/

“the tuning is proven only by the thirds.” In his method, though, one is asked to tune a series of fifths (with intervening octaves), and then check the thirds that have been produced. The thirds are to be “good.” This word “good” is somewhat ambiguous, and can be interpreted possibly to mean that a somewhat imperfect third is being called for. This is unfortunately the nature of much historical writing about tuning, and in trying to recreate the sounds of the past we must be aware of this ambiguity. However, much of the evidence points to Denis’ tuning being ¼ comma, including his association with Mersenne, a theoretical writer who unequivocally advocated for ¼ comma as the way to tune both organs and harpsichords.

The German writer Michael Praetorius, in 1619, published instructions similar to those of Denis, in that he prescribes a method that centers on first tempering the fifths, and then checking by listening to major thirds. This type of method was described by many others, and seems to be based on the fact that it can be very easy to “divide a major third into fifths” inaccurately, so that the fifths are not precisely the same. Both Denis and Praetorius lay a great deal of emphasis on the precise tempering of the fifths, as the basis for fine tuning.

Let us look at ¼ comma mean tone in a theoretical way. We tune each series of four fifths so that it makes a just third. As we learned in the first article in this series, the difference between a series of four just fifths and a just major third is the syntonic comma, about 21.5 cents. So if we narrow each fifth by one quarter of this amount - about 5.4 cents - our major thirds will be just. Hence, each fifth is tuned nearly three times as narrow as in equal temperament (5.4 cents narrow compared to 2 cents narrow in equal temperament).

A total of eleven fifths are tuned this way, all of them equal to one another. This leaves a twelfth fifth that is different in size. How much different? Well, 11 times 5.4 is 59.4 (the accumulation of the narrowness of the eleven fifths), so we will have narrowed by a total of about 59.4 cents. The Pythagorean comma (the amount by which 12 fifths exceeds an octave) is about 23.5 cents. So we have “over-narrowed” by about 36 cents, meaning that our last fifth will need to be about 36 cents wide in order to close the octave. This is a very wide fifth, and is called a “wolf” because it “howls.”

We will remember from the last article how the Pythagorean wolf fifth was “included” in four major thirds. The same thing happens with respect to the wolf fifth in mean tone tuning. Since the wolf is in a different place, between Eflat and G# (instead of B and F# as in the Pythagorean), different thirds are altered. By how much are they altered? Each

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7 The easiest way to tune ¼ comma mean tone is to begin by tuning and dividing a major third, then tune the remaining notes as major thirds from notes already tuned. This method is not, however, prescribed in historical documents. The precision with which the fifths are equally tempered is very important for the sizes of the minor seconds, and their relative sizes were a prominent feature in melodic writing. In ¼ comma mean tone, the two sizes of semitone are 117 and 76 cents (seven at 117 cents, five at 76 cents), quite different from the equal temperament 100 cents.

8 We have been using approximations, which have accumulated errors. A more accurate figure is 35.68 cents wide. We will call it approximately 35.5 cents in the next two paragraphs.
of them will be made of three ¼ comma fifths (narrow by 5.5 cents each) and one wolf fifth (wide by 35.5 cents). This will make the fifths wide by a total of about 19 cents (subtract the narrowing total of 16.5 cents from the widening of 35.5). Since a major third comprised of four just fifths is 21.5 cents wide (the syntonic comma), these thirds will be 21.5 plus 19 cents wide, or 40.5 cents wide: the same as the diesis. This makes perfect sense, as the difference between three contiguous major thirds and an octave is equal to the diesis, 41 cents.

So the tuning has eleven fifths all the same size (5.5 cents narrow), and eight just major thirds. And it has one wolf fifth (35.5 cents wide) and four very wide major thirds: so wide that they are called diminished fourths. Those diminished fourths are spelled B–Eflat, F#–Bflat, C#–F, and G#–C. Another way of looking at it is through sets of contiguous thirds: C–E, E–G# (both just) and G#–C (diminished fourth); C#–F (diminished fourth), F–A, A–C# (both just); D–F# (just), F#–Bflat (diminished fourth), Bflat–D (just); and Eflat–G, G–B (both just), B–Eflat (diminished fourth).

In the next article we will look at “dirty” mean tone: mean tone tuning in which the thirds are somewhat wide of just, but with the same basic pattern of 11 equally narrow fifths and one wide wolf fifth.

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9 Again, the accumulation of errors from approximation accounts for the discrepancy between 40.5 and the 41 cents we gave earlier as the value of the diesis.
A Clear and Practical Introduction to Temperament History
Part 3: Mean Tone Temperament with “Dirty” Thirds
By Fred Sturm
Published in the Piano Technicians Journal, July, 2010

The clean major thirds of ¼ comma mean tone were very compelling, as they mirrored the sound that other musicians produced when blending their pitches. Indeed, common performance practice today calls for clean major thirds where possible, in both vocal and instrumental ensembles (with instruments that are able to bend pitch enough to achieve this). So the just major third remained an ideal for keyboard tuning for many musicians and theorists, partly as it mirrored the ideals of flexible pitched instruments – the majority of instruments.

However, the clean major third came at a price: fifths had to be rather “dirty.” The triad was quite prominent in renaissance and baroque music, and the pure sound of the third was somewhat offset by the beats of the fifths and fourths. So from the very beginnings of mean tone temperament, other sizes of fifths were used in addition to the ¼ syntonic comma fifth, usually making the fifth less narrow, and widening the third beyond pure. Practical tunings instructions tended to be rather vague: “The fifths should be as narrow as the ear can bear, and the thirds should be as wide as the ear can bear.” This is a very subjective prescription, one that could almost apply to equal temperament if one’s ear were very sensitive to the fifth and quite tolerant of beats in the third.

The predominant “practical” theoretical alternatives to ¼ comma were in the range of approximately 1/5 to 1/6 comma. 1/5 comma was very appealing intellectually, as it meant that the fifths were proportionally tempered exactly the same as the thirds: fifths were 4.3 cents narrow, while thirds were 4.3 cents wide (these cent values were expressed as fractions or ratios during the historical period). The 1/6 comma was similarly neat and proportional, with the thirds twice as wide as the fifths were narrow: fifths were 3.6 cents narrow while thirds were 7.2 cents wide.

Many additional mathematical models were proposed, using all sorts of fractions, including 1/3, 2/7, 2/9, 3/10, 3/11, 3/14, 3/17 and many others. One of the features common to these schemes was their circularity: if continued beyond the 12 notes of the common division of the octave, they eventually came back (or close) to the starting point. 1/3 comma created a 19-note division of the octave. ¼ comma was close to a 31-note division. Other systems led to 53, 55, and various other theoretical approximate circles of fifths (actually more like spirals that came back to close to the beginning point). Another purpose behind these strange-seeming fractions was an attempt to find the best compromise between the sizes of fifths, and that of thirds and sixths both major and minor, with much of the speculation arising around 1750 in France.
“Vito Trasuntino’s ‘Clavemusicum omnitonum’” with 31 keys per octave. This instrument was built in Venice in 1606. A few instruments were built with similar designs, mostly used as theoretical models more than for actual performance, though a few pieces were written specifically for such instruments. Photo courtesy of Patrizio Barbieri.

While these numerical speculations were very compelling to many writers, and a number of musicians expressed opinions based on them, the fact remains that tuners needed a way to tune by ear, not by mathematics. The mathematics often gave very little information that would be useful to a tuner. In trying to recreate what tuners were likely to tune, one plausible model would relate the beats of the thirds and the fifths. Since they knew that in 1/5 comma mean tone the fifth was proportionally as narrow as the third was wide, it might make sense to think that the beat rates would be the same. Similarly for 1/6 comma, since the thirds were known to be twice as wide as the fifths were narrow, it would make sense that they should beat twice as fast. As it happens, this is not the case: 1/5 comma thirds beat nearly twice as fast as fifths, and 1/6 comma thirds beat nearly three times as fast. But in trying to reproduce what tuners of the time might have done, this is at least a somewhat plausible model to follow.¹

What do these mean tone tunings with wider thirds and less narrow fifths sound like? Essentially the same characteristics that were described for ¼ comma mean tone still apply: eleven narrow fifths the same size, and a wide wolf fifth, the wolf fifth being somewhat less wide than in ¼ comma, but still very definitely a wolf; eight major thirds that are “good,” though not pure and beatless as in ¼ comma, and four diminished fourths that are unusable as thirds. The differences in half steps are still there, though not quite as obvious: 84 and 112 cents for 1/5 comma, 89 and 108 cents for 1/6 (compared to 76 and ¹ 2/9 comma mean tone, a system that was also proposed during the period, does have fifths and thirds with nearly equal beat rates. Hence, the idea of matching the beat rates has a slender historical basis beyond mere speculation about what a tuner might have done.
117 for ¼ comma). The same limitations apply, even with a closer approach to equal temperament: these are definitely not circulating temperaments.

It should be noted that mean tone tunings do not have what is referred to as “key color.” That is to say, triads do not have a range of sizes leading to a gradation of sounds for tonic triads. All eight triads sound alike, and all four “wolf” triads (with diminished fourths in place of major thirds) sound alike. The only real difference between one key and another lies in the size of the half step between leading tone and the tonic, and in the placement of the wolf tones relative to the key center.

Mean tone with somewhat wide thirds was far less common than ¼ comma during the period from about 1500 to somewhere between 1700 and 1750, at which point discussions of tunings with somewhat wide thirds appear very often in both printed sources and correspondence of the time. Based on theoretical writings and contemporary accounts, there is some reason to suppose that in France the just third was somewhat more generally preferred, while in Italy and Germany, wider thirds were tolerated more, but this is by no means certain.

From the beginning there was an understanding that mean tone tuning was a compromise, and that the limitations were troublesome. In a practical sense, particularly when playing church organs, there was a need to be able to move to other key centers beyond those allowed for by the E-flat to G# scheme. Organists needed to be able to transpose the choral portions of the mass (sung in the church modes) to match the range of the choir, and A-flat and D# were needed for cadential formulae. Jean Denis wrote at some length in his 1650 treatise about ways to avoid making the G# sound bad when used as an A-flat, or the E-flat sound bad when used as a D# (with techniques that included playing those notes very briefly, or covering them up with ornaments).

One solution was to add keys to the keyboard. Split sharps, especially the E-flat and the G#, were quite common in Italy on both organs and harpsichords. They were less common in Germany, and quite rare in France. Knowledge of this fact is important in deciding what tuning to use: Italian composers who used both A-flat and G#, and E-flat and D# (and other pairs of “enharmonic” notes) might intend a mean tone tuning with extra keys. Not so for French composers. It should be noted that some composers took advantage of wolf intervals and used them for expressive effect. There is documentary evidence that this was done consciously.

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2 There are two sizes of semitone, so seven tonics have a large one and five have a small one – the larger half steps occurring as leading tones of the more common keys like C major.
3 One part of the split key would play a string (or organ pipe) tuned to the flat, the other part would play a separate string tuned to the corresponding sharp.
Another approach involved altering one or more notes in the temperament, usually the G# and either the C# or Eflat. There are several accounts by both musicians and theorists suggesting that G# be tuned as a compromise between G# and Aflat. Practically speaking, this meant making the fifths C#–G# and Aflat–Eflat equal. The results were not described as satisfactory, and, indeed, the sound of the two wolf fifths is quite wild. But clearly there were some who tuned this way on occasion – usually on organs.

It is fairly common for modern musicians to think that mean tone tunings would be retuned to match the music, changing one or more of the sharps to flats or vice versa. There is very little evidence that this was done in historical practice. There are perhaps one or two mentions of the possibility, while almost all written evidence assumes the standard range of Eflat to G#, so that G# was perhaps occasionally retuned to Aflat, but this would be quite rare.

It is interesting to note that in mean tone, the enharmonic versions of what is the same note in equal temperament would differ in pitch in a way a modern musician would not expect: the sharp version of a “sharp key” would be lower in pitch than the flat version.
In other words, G# would be lower than Aflat, D# lower than Eflat, significantly lower.\textsuperscript{4} This is precisely the opposite of later tendencies in the intonation of unfretted string instruments (violins in particular), where the recommendation would be to make sharps sharper and flats flatter.\textsuperscript{5} This is one of the many contradictions that occur in the history of tuning and temperament.

In any case, there was a constant pressure to expand the harmonic range of the keyboard instrument, both for the practical reasons cited above (relative to church organs), and for stylistic reasons. By the end of the 17\textsuperscript{th} century, composers were writing in a harmonic style that moved from one key center to another as an expressive devise. The limitations of the tuning, and the way in which it confined certain harmonies to certain ranges of the instrument, were seen very definitely as defects, and other compromises of temperament were explored in order to attain circularity – to be able to modulate around the circle of fifths. In the next article, we will look at the early French approach to this problem, as well as some Italian developments.

\begin{itemize}
\item[4] In \(\frac{1}{4}\) comma, the difference is the same as the diesis, 41 cents, almost a quarter step. It is somewhat smaller in 1/5 and 1/6 comma.
\item[5] These recommendations are based originally on a later adaptation of Pythagorean intonation, largely based on the open fifth tuning of violins and related instruments. These strings were most commonly tuned as just fifths (as they are today), and so the resultant major thirds would end up sharp. Additional impetus came from a desire to accentuate the leading function of a leading tone, making it closer to the tonic (a smaller semi-tone). The corresponding melodic function of a flat would be to lead downward, so eventually a number of string pedagogues called for extra flattening of all flats and sharpening of all sharps. This is precisely the opposite of what happens in mean tone tuning.
\end{itemize}
By the early 18th century, French musicians had developed a style of tuning that was somewhat circular: it allowed for all key centers to be used at least somewhat, and all the accidental keys could be used as either sharps or flats. The most widely known evidence we have for this style of temperament comes primarily from three sources: Rameau, d’Alembert, and Rousseau (though there are also descriptions in various other historical documents).

The first source is from Jean-Philippe Rameau’s *New System of Music Theory*, published in 1726. Rameau was very prominent as a composer and harpsichordist, and became an extraordinarily important music theorist as well. His writings formed the basis for the modern study of music theory, with its key centers, dominant and subdominant, standard consonant and dissonant intervals, triads in various inversions, and so forth. These ideas are the basis for music education today, to the point that they are taken for granted. It was Rameau who first formulated, refined, and published them.

Rameau’s description of this temperament system is neither precise nor consistent, but it contains enough detail to give a good idea of the style of tuning. He is quite clear that one should start with just thirds, and that to accomplish this, many of the fifths are narrowed by one quarter comma, just as in ¼ comma mean tone. This pattern is to be observed from Bflat through B, meaning that there are seven fifths narrowed by ¼ comma each, producing four just thirds: Bflat–D, F–A, C–E, and G–B.

From the note B point on, he is rather vague. The principle is clear: the circle of fifths must be closed, and there must not be a wolf. However, there is a lot of ground to be covered by the five remaining fifths. He states that some of those fifths should still be narrow (though not as much as ¼ comma). Since the first seven fifths have already been narrowed by 37.8 cents, they have exceeded the Pythagorean comma by 14.3 cents. So if three of the five remaining fifths were just, the last two would need to be over 7 cents wide each, already pretty wolfish. Making two or three of the five somewhat narrow, as he suggests, would necessarily increase the width of the last two or three.

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2 It should be noted here that he is not in the least vague about the mathematics, as he sets out precisely the proportions involved. He is only vague in the aural instructions.
Rameau’s Treatise on Harmony of 1722 is still a strong basis for music theory today. D’Alembert\(^3\) gives us some additional clues to how French musicians were tuning, in his articles on Music Theory for the *Encyclopédie*, in 1752. By this time Rameau had decided that equal temperament was a better choice, and d’Alembert expounds Rameau’s later ideas in the main body of his text. In a footnote, however, he states that this equal

\(^3\) Jean-le-Rond d’Alembert was a scholar and mathematician who served as co-editor with Diderot of the famous *Encyclopédie*, which was an attempt to gather all knowledge into one organized collection of articles.

temperament advocated by Rameau is different from what musicians usually do, and he sets out a description of the “ordinary”\textsuperscript{5} temperament a little differently from Rameau in 1726 (but, unfortunately, still in a problematic way). In his description, one again starts with \(\frac{1}{4}\) comma fifths, from C to E (forming a just third), but in contrast to Rameau, he then asks us to narrow the next four ascending fifths (B–F#–C#–G#) to a lesser degree. He says that G# should form a nearly just third with E, which means that those fifths must not be much wider than \(\frac{1}{4}\) comma.

He now starts again at C, and tunes fifths downward (F–Bflat–Eflat), each of which is to be gradually wider. And he says one should continue in this direction until you end up with the fifth from Dflat to the G# already tuned, which he says must be nearly just. This was obviously an error, as the Dflat had already been tuned as C# in an earlier step. And, indeed, this error was corrected in the next edition, Dflat being replaced with Eflat\textsuperscript{6}. In any case, clearly the Eflat–G# “fifth” would have to be quite wide based on the remainder of the pattern. We must assume either that he got it wrong, or that the word “just” is being used in an imprecise way, implying “tolerable.” However, it seems clear enough that the pattern described by d’Alembert is one that has one just major third, CE, and in which the fifths are tempered less and less narrowly moving outwards, with the most expanded fifths in the flat direction, until they meet at the G#–Eflat fifth: the wolf in mean tone, and probably the widest fifth in ordinaire.

Jean-Jacques Rousseau provided a third important bit of evidence, in an article on temperament in his own Dictionary of Music.\textsuperscript{7} Rousseau is known today mostly as a philosopher, but he was fairly involved in music as well. He made his living for a few years as a young man copying music by hand, and composed a few musical works. He wrote many articles on music for the Encyclopédie, and later compiled and revised them, and added others, to produce his Dictionary, which was widely known and influential throughout Europe.

Rousseau’s description is a little more thorough and detailed than Rameau’s or d’Alembert’s, though it also contains gaps and contradictions. He states that one should, starting on C, tune four fifths narrow so as to produce a just C–E third (as the others also began their descriptions). From here, he says that one should tune fifths upward into the sharp direction, making them somewhat wider, “from which the thirds will suffer” (they will become wide). This should continue up to G#, and its “proof” is that the third E–G# should be “just, or at least tolerable.”

Now we return to C and tune in the flat direction, making the fifths gradually wider, until we get to D-flat. And here we have the same major contradiction we had in the first edition of d’Alembert, as that note was previously tuned as C# in the sharp direction. It seems pretty clear that Rousseau plagiarized d’Alembert to a large extent (much of the additional language is also identical). In Rousseau’s case, the “proof” is that Dflat–G# forms “a fifth” (he does not describe it as just as d’Alembert did, and one may assume

\begin{itemize}
  \item \textsuperscript{5} D’Alembert’s description of this temperament method as “ordinaire” is the source of the name by which the style known today.
  \item \textsuperscript{6} We will see the significance of this in the discussion of Rousseau to follow.
  \item \textsuperscript{7} Rousseau, Jean Jacques. “Tempérament” in his Dictionnaire de Musique. Paris, 1765. On line http://www.chmtl.indiana.edu/tfm/18th/ROUDIC4_TEXT.html
\end{itemize}
that he means that it is recognizable as a fifth rather than a wolf). He notes that the last few fifths as well as major thirds are “a little wide” which makes the keys of Bflat and Eflat “dark and a little harsh,” but that it will be tolerable if the tuning was well done.

I have gone into some detail here to try to give a taste of the difficulty we experience in trying to recreate tunings of the past. It seems clear from considerable evidence that what has been described here was the standard style of tuning in France for several decades. There is contemporary evidence that tuning of this style was practiced near the beginning of the 18th century, as an organ is described as having been tuned similarly in Rouen in 1712, and other evidence that describes similar tuning throughout the century until at least the 1780s. This is by no means a style of tuning that matches a theoretical model, nor is it possible to define it with precision based on the available evidence. Still, the pattern is fairly clear: we start with at least one just third, C–E, derived from four narrow fifths (as in ¼ comma mean tone). Rameau extends this pattern to seven ¼ comma fifths and four just thirds, while Rousseau and d’Alembert have only four ¼ comma fifths and one just third. Perhaps this indicates an evolution over the years between their publications, but we should note that d’Alembert and Rousseau describe the next three ascending fifths as only somewhat wider than ¼ comma.

So far we have followed a mean tone pattern, but for the remainder of the temperament, we will modify the pattern, widening the fifths so as to “fill in the gap,” to complete the circle of fifths in such a way that all intervals will be “tolerable.” We will not have a wolf fifth, nor wolf thirds, at least not to the degree these are found in ¼ comma mean tone. There will be a large range of sizes of third, from just to quite wide (the widest being as wide, or nearly as wide, as a ¼ comma mean tone “diminished fourth”), and some number of the fifths will be significantly wide, while others will be narrow, and one or two may be just.

In Italy, during the same period (starting somewhat later, but overlapping), there was a similar push towards making temperament circular. The writings of d’Alembert in particular were known to several Italians, but his method of making a circular temperament was rejected as producing some thirds and fifths that would be unacceptably wide. Instead, those Italians who advocated for circular temperament started with what I have called “dirty mean tone,” something along the lines of 1/5 to 1/6 comma. The diatonic thirds are not just, but instead are a little wide, as much as half as wide as in equal temperament. What this means is that the gap that needs to be filled by the remaining fifths and thirds is not as great, and so they can be more moderate than in the French design.

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8 My major source for the following material on Italy is Acustica Accordatura e Temperamento nell’Illuminismo Veneto, Patrizio Barbieri, Edizioni Torre d’Orfeo Rome, 1987, together with an article by Patrizio Barbieri (a copy was graciously provided me by the author): Persistenza dei Temperamenti Inequabili nell’Ottocento Italiano (Persistence of Unequal Temperaments in 19th Century Italy), published in l’Organo in 1982.

9 They mention him specifically.
A number of schemes were outlined and proposed, some with a still fairly wide Eflat–G# fifth (as much as half a comma - 10 cents - or more), but there were others that tried to minimize the use of wide fifths. The system that did so most elegantly was that of Vallotti, who came up with the idea of six fifths that were each 1/6 comma narrow on the natural keys (F–C–G–D–A–E–B), and six just fifths on the sharp keys (B–F#–C#–G#–D#–A#–F). So Vallotti’s temperament, very well known and widely used today, was arrived at as a modified mean tone tuning.\(^{10}\) A number of patterns described by other Italian authors of the late 18\(^{th}\) century vary from Vallotti’s only in minor details: they also share the principle of no wide fifths, or only one or two that are barely wide. Several are variants that have two sizes of fifth: one size of narrow fifth (1/5 to 1/8 comma) and the remainder just.

Vallotti’s pattern creates a very symmetrical pattern of sizes of thirds. There are three of the smallest size (F–A, C–E, G–B), which are equivalent to 1/6 comma thirds (because each is derived from four 1/6 comma fifths); and three of the largest (F#–A#, C#–E#, G#–B#), which are Pythagorean in size (because each is derived from four just fifths). And there are three pairs of in between sizes, as the different sized fifths join symmetrically to create thirds (three narrow fifths and one just, two narrow fifths and two just, one narrow fifth and three just).

There is no evidence that Vallotti’s temperament and similar ones were in common and widespread use in Italy during this period, mean tone (and particularly ¼ comma) continuing to be the most common tuning there until the 1800s. While Vallotti’s method was known to a few prominent Italian authors and musicians of his time, his written instructions remained in an unpublished manuscript (the second volume of a theoretical work, that failed to be printed) until it was uncovered in 1950. However, there was clearly a move in this direction by a number of musicians of the time. The Italian way of creating a circulating temperament, avoiding the need for wide fifths by moderating the narrowness of the diatonic thirds, is similar to the patterns developed in Germany in the early 18\(^{th}\) century, but was arrived at by a different path, as we will see in the next article.

\(^{10}\) To be precise, he was clear that his temperament was based on 1/6 syntonic comma, and that that meant the difference between syntonic and Pythagorean, the schisma (about two cents) would be “left over.” He said the B-flat–F fifth should be narrow by that amount.
One of the earliest surviving practical accounts of setting a temperament, probably the very first, comes in Arnolt Schlick’s book about organs, published in Germany in 1511. Schlick was an organist who was involved in the design and evaluation of organs, and he wrote his book to try to establish standards for organ building. The book is extraordinarily practical: it gives measurements for all sorts of things, from length of pipes to the correct size for keys. At the time, standard units of measurement didn’t exist, so Schlick had several different, precisely measured lines printed on appropriate pages, and would write things like “the lowest C pipe should be 16 times the length of the line on this page” or “two times this line is the span of an octave on the keyboard.”

Schlick also expressed very strong and detailed opinions about tuning. He was aware of mean tone tuning, and rejected it because of the wolf intervals. He was aware of keyboards with extra keys, and rejected those. Instead, he advised a circular temperament, and described how to produce it. He begins with a series of six fifths from F to B (F–C–G–D–A–E–B) with intervening octaves to stay in range. He is very descriptive in talking about the fifths, saying the upper note should be as low as the ear can stand, and that the fifth will sound unsteady, wavering: unacceptable to the ear if held, but tolerable. He notes that this tuning makes the thirds too wide (so that his fifths must definitely be wider than ¼ comma), and says that the thirds C–E, G–B, and F–A (tuned in this initial sequence) should be made somewhat better than the other thirds (which will be tuned later on), because they are used more frequently. He notes that the better they are, the worse G#–E and G#–B will be, but he says that this is not as important, as intervals with G# are not used as much.

For the accidental keys, he begins again on F and tunes downward. The first two fifths (F–Bflat and Bflat–Eflat) are to be tuned narrow, but the Eflat–Aflat/G# fifth is to be tuned wide. He notes that this G# will make bad intervals of various sorts with other notes, which he claims that a good organist can cover up by means of flourishes, pauses, and other devises, when the note is needed in cadences. He now approaches the other sharps from B, tuning upward both B–F# and F#–C# somewhat narrow, noting that C#–G# will end up being somewhat wide. He includes considerable discussion of how this tuning will affect various intervals, and why it is better to tune his way – the other way seeming to be a version of mean tone, whether ¼ comma or with wider thirds.

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1 Schlick, Arnolt, Spiegel der Orgelmacher und Organisten, Mainz 1511. English translation together with facsimile and transcription, Frits Knuf, 1980, Buren, Netherlands. Translated by Elizabeth Berry Barber.
2 It should be noted that Michael Praetorius wrote about modifying the tuning of G# and C# to make the wolf smaller, but this cannot really be called a circulating temperament.
Das Achte Capitell.

Das acht Capitell ist von Stymmen der orgelt vnnd zu welcher zeit es zu thun / wie ein igtlicher cho/ der pfeif sen hoch oder nieder in der Stym sein sott/ species ez corronden dan es zu machen / das ist vnisonus quinta octava quarta septa tertia. durch westlich alt music menschlicher Stym/ oder instrumenta musique vollbracht wirt/ wie aber ez gedachten species geteilt und genent werd / perfect oder imperfect ist ez on not sie zu ez darzien/ sonst durch einen aufrom die music yr vilt noch leng erhrt ez. Erz ein wiwer. die offizierten species igtlich in yr selbs vollkommen vn ganzhe ghert un gezogen es sein. Auch am besten also zu Hzzen ist/ so sie anders allein ghbracht wirt ez wollen doch ez wo mit einander corrordem/ so igtlich in yr selbs gut ist. Als ein ganzhe quint chaut und gsoleut. fof dann die tert ez was darzwischen elami/ gut zu dem gsoleue sein. Als ein tertz imperfect oder tertia minor semidominus/ so
In sum, we have six probably equally narrow fifths on the natural keys, pairs of somewhat less narrow fifths expanding out in each direction, and finally two wide fifths to “span the gap.” Clearly Schlick was tuning something roughly similar in shape and sound to the much later French and Italian styles of modified mean tone, at a time before Pietro Aron first provided a written prescription for ¼ comma mean tone. While it would be dangerous to draw broad conclusions from this one example, it is intriguing evidence that there were traditions of tuning that were “derived from practical experience” rather than theoretically contrived, and that the principles of modified mean tone are as old as mean tone. On the other hand, there is ample evidence that, in fact, most organs of Germany were tuned in some style of mean tone, either ¼ comma or, less commonly, with somewhat wide thirds, during the 16th and 17th centuries.

The next important German tuning instructions that deal with circulating temperaments come from Andreas Werckmeister, organist, composer and theoretician of the late 17th and early 18th century.² His name is mostly known today in connection with one of his theoretical temperaments, the so-called “Werckmeister III,” but he also wrote a very practical tuning method as part of his treatise on the realization of basso continuo, published in 1698.³ This method is very much in the tradition of Schlick, and is similarly filled with practical comments about how it will affect certain chords and keys, and why other systems are inferior. It is noteworthy that this particular treatise is the one book by Werckmeister that J. S. Bach is known to have owned a copy of.

Werckmeister begins on C, and asks us to tune a series of ascending fifths, all a little narrow, “hovering” – a term he defines as meaning that it produces a wavering of tone. Octaves are tuned down as needed, and whenever a major third has been produced, we are asked to listen to it, and judge whether it is “tolerable.” We do this first for C–E, then again specifically for each successive third. We follow the same pattern up to C#, and Werckmeister makes no distinction between the widths of the first four thirds produced so far (C–E, G–B, D–F#, A–C#). Then we change course a bit: C#–G# should be tuned “almost pure,” which will make E–G# “somewhat strident.” G#–D# and D#–A# are to be tuned wide, so that both B–D# and D#–G (Eflat–G), and also A#–D (Bflat–D), are acceptable. F more or less fills in the gap that remains, and he says that Bflat–F may be wide if necessary.

The shape of this tuning is very much like a mild form of what we described as Italian modified mean tone in the last article. Werckmeister says that the fifths in his instructions should be between 1/8 and 1/12 comma in size (1/12 comma is approximately equal temperament, depending which comma is intended). If that were true, there would be no need for any wide fifths, as a series of eight 1/8 comma fifths take up the entire Pythagorean comma. Thus, the last four fifths could be just, which would be a mild form

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² It should be noted that Michael Praetorius wrote about modifying the tuning of G# and C# to make the wolf smaller, but this cannot really be called a circulating temperament.
³ Werckmeister, Andreas. Die Nothwendigsten Anmerckungen und Regeln, wie der Bassus continuus oder General-Bass wol könne tractiret werden. Struntz, Aschersleben 1698. An English translation of the appendix on tuning, by Paul Poletti, can be found at http://www.polettipiano.com/Pages/paglengpaul.html
⁴ The same German word was used in the same way by Schlick.
of a Vallotti-style temperament. So we can take it that the wide fifths are at any rate not
taller than the narrow fifths are narrow. In any case, one of the most telling features of
these instructions is the acceptance of small error. Werckmeister is not concerned with a
refined splitting of hairs, but with a practical process of getting a harpsichord tuned. The
basic shape is important, but the precision of the details is not so terribly important.

There are other interesting materials in Werckmeister’s treatise. While some 20th century
writers have said that the phenomenon of beats was not understood, nor listened to prior
to the 19th century, he is very clear in his understanding of beats, describing them in
detail. Furthermore, he is aware of the fact that they double in speed for every octave
shift up. It is quite clear from many of Werckmeister’s statements that, for example,
several of the assertions made by Owen Jorgensen in the opening chapters of his 1991
book are mistaken (Jorgensen was not aware of the contents of this document, as it had
not been translated into English, and he did not read German).

Werckmeister states that it would be quite possible to tune all the fifths to 1/12 comma,
which would mean that one could play all pieces in all keys. In such a system, he says
that major thirds would be 2/3 comma wide and minor ones 3/4 comma narrow. He is
very matter of fact in making that statement, seeming to imply that equal temperament
would be just fine with him. However, he says, he will give instructions for a method
where the intervals most used are the most pure.

In his theoretical writings, Werckmeister was the first to use the term “good
temperament,” a term that was altered grammatically (the adjective “good” changed to
the adverb “well”) in the title of Bach’s Well-Tempered Clavier. His use of this adjective
was in contrast to “bad” temperaments, by which he meant non-circulating ones, and 3/4
mean tone in particular. Werckmeister was very outspoken in his promotion of circular
temperaments and in his criticism of any tuning that included wolf intervals. In his 1698
work, he described the 3/4 comma fifth as follows: “especially when they are played alone
without the assistance of the thirds and if they are tuned a little bit too low, [they] cause a
dissonance which is so hideous and lame that no healthy ear can possibly approve of it.”
This is an interesting comment, considering that his theoretical temperament known as
Werckmeister III contains four 4/3 comma fifths on the natural keys.

18th Century German Temperaments, Theoretical and Practical

In the 18th century, several German writers followed the lead of Werckmeister in writing
about circulating (in contrast to mean tone) temperaments. We should begin by looking at
Werckmeister’s more theoretical writings, in which the famous “Werckmeister III” (W
III) temperament was described. This temperament description was far different from that
of his 1698 treatise, in that there were no practical instructions, but merely a theoretical

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5 Tuning, Containing the Perfection of Eighteenth-Century Temperament, the Lost Art of
Nineteenth-Century Temperament, and The Science of Equal Temperament Complete
with Instructions for Aural and Electronic Tuning

6 2/3 of the syntonic comma’s 21.5 cents is 14.1 cents; 3/4 of the syntonic comma’s 21.5
cents is 16.1 cents; these each are within half a cent of precise figures for equal
temperament.
model. He set out a group of six temperaments, and the one called W III was described as
a good way to convert an organ tuned in $\frac{1}{4}$ comma mean tone to a circulating temperament. Four pipes in every octave can remain the same, two are altered only a
little, so most of the work is concentrated on half of the pipes – a considerable saving in
time and effort. (Retuning an organ at that time was the work of many weeks, involving
cutting and trimming the pipes. Tuning slides had not yet been developed).

Early enthusiasts of unequal temperaments seized upon this temperament as a model for
the “well temperament” that “Bach must have used.” In fact, it seems pretty unlikely that
it was used for harpsichords, though it may have been used for organs. It has four $\frac{1}{4}$
comma fifths – CG, GD, DA, and EB – with the remainder being just fifths. But in this
case the comma must be the Pythagorean. Tuning it precisely by aural means is quite
difficult, and though a rough version is certainly possible, it is awkward. It seems far
more probable that practical musicians would follow a system like the one Werckmeister
set out in his 1698 treatise.

Later German writers
followed Werckmeister’s
lead in several ways. In the
first place, they were clear
for the most part that
temperament should be
circular, with no wolf
fifth. While French and
Italian authors and
musicians tuned outward
toward the limits of G# and
Eflat, leaving that “fifth” to
hold the remains of the
circle of fifths, the
Germans simply made the
circle of fifths circular. A
large number of fairly
complex temperaments
were proposed in a
theoretical way.

This sample temperament of Neidhardt is typical: it is given in proportions for
monochord, with great precision. But there are no practical instruction.

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7 Silbermann is the notable exception, using $\frac{1}{6}$ comma mean tone, at least on his organs.
One of the major temperament writers, Neidhardt, described some 21 different temperaments in 1732, but a close scrutiny of them makes clear that these are really more of an intellectual exercise than a source of practical tuning instructions. They are filled with complex proportions, relative string lengths for a monochord, and learned discourse about theoretical matters. There is no guidance for recreating these designs by aural means, no practical procedure. The only way for a contemporary of Neidhardt’s to use one of these tunings would be to match pitches with a monochord, an extraordinarily slow and inexact process.

Along with Neidhardt, other important German writers on temperament included Sorge and Marpurg, who offered somewhat similar theoretical models, most of which were impractical to achieve by aural means. While Sorge, in particular, offered practical tuning instructions as well, I have been unable to study them, as the sources are not readily available (access requires travel to Germany). The scholars who have studied these authors tend to focus on the theoretical portions, and only mention bits and pieces about the practical instructions. One characteristic that was common to all was the absence of any wide fifths (Werckmeister’s instructions of 1698 are the only exception in German literature). In any case, during the first half of the 18th century, Neidhardt, Marpurg and Sorge all advocated for equal temperament as either a good solution or as the best solution. In 1756, Marpurg noted that the best unequal temperament in use was one which he described as having the fifths in the sequence F–C–G–D–A–E–B–F# somewhat more narrow than the remaining fifths F#–C#–G#–D#–A#–F. This describes a very mild system quite similar to Vallotti, except that the wider fifths are said to be slightly narrow, not just.

Taking the evidence together, it seems likely that most unequal circulating temperaments in Germany, from about 1700 on, were relatively close to equal temperament, considerably more so than the circulating temperaments of France and Italy. And the movement toward equal temperament was becoming quite strong by the 1750s. Daniel Gottlieb Türk noted in his 1789 Klavierschule, a method book about teaching and playing keyboard instruments which had a short section on tuning, that equal temperament was the most usual tuning style at that time.

However, unequal temperament had not yet entirely lost favor. In the second half of the 18th century, Kirnberger led a movement in favor of unequal temperament, arguing vociferously that equal temperament would destroy key color, echoing the writing of Rousseau on the same topic. Kirnberger derived some prestige from his early

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8 Claudio Di Veroli comments that “All things considered, it is difficult to pinpoint even a single temperament by Neidhardt that is worth a modern revival.” C. Di Veroli: Unequal Temperaments: Theory, History and Practice. 2nd ed. (Bray, Ireland, 2009), p. 420.
9 Since I wrote the article, many more sources have become available online.
11 Kirnberger and his followers engaged in a heated exchange with Marpurg on this subject.
association with J. S. Bach (as a student of Bach’s for a few years as a youth), and he had access to important parts of the musical press at the time, so his theories were very widespread throughout Europe.

Kirnberger’s temperament prescription, however, is a different matter. He was very eccentric in his beliefs, being convinced that no interval should be tempered, so he advocated for a scheme whereby only pure intervals would be tuned. His first proposal for temperament, made in 1766, was a Pythagorean tuning, with eleven just fifths and a wolf fifth. This was universally derided as a coarse and unmusical (it has eight wide, “Pythagorean” thirds in the most prominent part of the temperament). His next proposal, published in 1771 (labeled today as Kirnberger II), had ten just fifths, and so the entire Pythagorean comma was divided between two fifths, D–A and A–E (he avoided “tempering” these fifths by tuning a just major third, CE, in the midst of his sequence, and then tuning fifths from C and from E, the final step being to balance the A between the D and the E). This temperament, with its two wolfish fifths in very commonly used keys (they are each over ten cents narrow), together with seven Pythagorean thirds, three just thirds (CE, GB, and DF#), and two intermediate-sized thirds (FA and EG#), was hardly to be taken seriously by any practical musician, and it was roundly ridiculed by many musicians at the time. Nevertheless, Kirnberger’s prestige served to perpetuate it in the literature, often as the only alternative to equal temperament to be mentioned, and it became very well known throughout Europe.

A few others were also resistant to the move towards equal temperament, and proposed more reasonable alternatives than Kirnberger’s. One of these was Johann Lambert, who proposed in 1774 two temperament schemes very much analogous to Vallotti’s. One used a combination of five 1/6 comma and two 1/12 comma fifths, the remainder of the fifths being just. The other used seven 1/7 comma fifths, with the remaining five being just. In each scheme, the narrower fifths were in a sequence from F to F#, the just fifths being in the remoter area of the circle of fifths, as would be expected. While the prevalence of equal temperament had been pretty well established in Germany by this time, and these theoretical temperament schemes would not really be possible to execute precisely by aural means available at the time, Lambert’s proposals show that a temperament style quite similar to Vallotti’s was present in Germany as well as in Italy during this time, so we can see a considerable degree of convergence of ideas.  

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12 He said it was impossible to tune a tempered interval accurately by ear.
13 There is another temperament commonly referred to as Kirnberger III. It was described in a letter by Kirnberger to Forkel, and was only published in the late 19th century. Kirnberger II was widely known throughout Europe during the late 18th and early 19th centuries, and it was this temperament that was connected with his theories.
14 In this case, the comma is the Pythagorean one.
15 It is interesting to note that one of Lambert’s proposed temperaments was what 20th century temperament enthusiasts have described as “reverse well temperament”: he has just fifths on the diatonic keys, 1/6 comma fifths on the sharps. This temperament scheme also received a certain amount of publicity.
What can we say today about tuning styles in Germany between 1700 and 1800? The evidence points to four main styles. The first is mean tone, which would be the standard tuning for most church organs, and would persist for considerable time, if only because of the high cost of re-tuning all the pipes. This tuning would probably also be used to some extent on harpsichords. Second is modified mean tone, in the style described by Werckmeister in his 1698 treatise, with two or three somewhat wide fifths, but considerably milder than the French or Italian versions. The third would be gradations of temperament with narrower fifths on the diatonic keys and just (or closer to just) fifths on the chromatic keys (no wide fifths). And fourth is a fairly close approach to equal temperament, whether consciously somewhat unequal or attempting to achieve a “real” equality. These last three styles are closely related, and it might be assumed that there was a gradation of tuning practice, where degrees of narrowness and justness, and occasional presence of one or more slightly wide fifth, might vary from tuning to tuning, depending on the skill and attention of the tuner. A fifth style must be mentioned – Kirnberger II – because it was very broadly known, and must have been tuned by some musicians. It was very much an anomaly, very different from the patterns proposed by other writers of the time.

It should not be forgotten that equal temperament is also a “historical” temperament, and that it had its advocates and practitioners at least as early as the 16th century. In the next article, we will look at the history of equal temperament up until about 1800.
Through 1800

The concept of equal temperament was understood by music theorists throughout the period we are studying. In Italy, Vincenzo Galilei (father of Galileo) laid some of the first practical groundwork in favor of equal temperament during the late 1500s, particularly with respect to the lute and other instruments with fixed frets. Unequal distances between frets, in an attempt to duplicate temperaments for keyboard instruments, were not very practical on the lute, as each fret had an effect on all the strings. What worked for one string would not work for another tuned a fourth or some other interval apart, at least not for all notes, and split frets were troublesome. Thus, equal temperament was accepted as the norm for instruments with fixed frets, as a practical matter. Vincenzo established that the ratio of 17:18 produced a fretting pattern that was, for all practical purposes, the equivalent of equal temperament, and he wrote in some detail in favor of this tuning system, especially for voice. Among other things, he pointed out that when vocalists and choirs try to sing melodically using only just intervals, they will inevitably shift in pitch during the course of a piece of music. This idea was discussed by a number of musicians, without resolution. The important composer Claudio Monteverdi was said to have expressed the opinion that choirs should sing in equal temperament, and others expressed similar opinions. However, there seems little if any evidence that any keyboard instruments were tuned according to this pattern at the time.

Zarlino’s diagram, from 1588, showing how to lay out frets on a lute in equal temperament, using Euclidean geometry.
During the period around 1640 to 1660, specifically in Rome, there was a brief flowering of equal temperament. A number of composers of the time were involved, of whom the most famous today were Frescobaldi and Froberger. Froberger later spent time in various musical centers in Europe, and it seems he took his tuning predilection with him, presumably making it better known (whether or not he “converted” many listeners).

A practical method for tuning equal temperament has survived from that time, as a very brief mention by Galeazzo Sabbatini, in his instructions for tuning ¼ comma mean tone (noted in an earlier article). He suggests that, for equal temperament, first the octave should be divided into three contiguous major thirds (presumably “equal” in width, whether proportionally or by some judgment of sound). Then each of the thirds should be divided into its component four fifths, each equally tempered, as in his method for tuning ¼ comma mean tone. This method was to be “re-discovered” during the next century in Germany. After about 1660, equal temperament essentially disappeared from the scene in Italy until the 19th century.

In northern Europe one of the first serious considerations of equal temperament came from the Dutchman Simon Stevin, who was responsible for some of the earliest calculations and theoretical writings in favor of this pattern. He did not provide practical tuning instructions, though he did design a monochord for the purpose. While his work doesn’t seem to have had much practical effect in Holland at his time, it became known to others, particularly in France to the very important writer Mersenne, and in Belgium to Jean Gallé.

Gallé became a strong proponent of equal temperament, from the point of view of solving the problem of transposition of the church modes on the organ. He seems to have designed a transposing keyboard, which would certainly not work with a mean tone temperament, and there are records of his unsuccessful attempt to have a church organ tuned in equal temperament. Most of what we know about him comes from criticism by others, like Jean Denis, who found his experiments discordant and contrary to good harmony. But while it seems clear that most musicians of that time had a negative opinion of equal temperament, the content of the discussions makes clear that there were at least some who were trying it out in practice.

Mersenne wrote about equal temperament, somewhat sympathetically, and thereafter most other French theoreticians also at least talked about it, sometimes saying that it was theoretically a good idea, but that musicians disliked the wide thirds. The very important composer Couperin was reported to have tried it, and discarded it. And then, in 1737, Rameau came out solidly in favor of equal temperament in his book *Génération Harmonique*, where he said that it was the only method of tuning that was in keeping with his harmonic theories. He said that the most important and fundamental intervals should be the most just, the octave being most important, followed by the fifth and the third. Thus, the octave should be just, and the fifth should have precedence over the third. In ¼ comma mean tone, the predominant tuning of his time and place, the third was given

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1 It should be pointed out that Frescobaldi’s reported conversion to equal temperament took place after he had written and published all his extant keyboard works.
precedence, the fifth being tempered considerably to accommodate a just third. He advocated for reversing that priority, making the fifth as close to just as possible, and allowing the third to suffer in consequence.

Rameau’s prestige and influence meant that the idea of equal temperament was thereafter treated with a great deal more respect and acceptance, but it seems to have continued to be rejected by the large majority of musicians in France for much of the remainder of the 18th century. Rameau did provide practical instructions, but they were very scanty. He said all fifths should be tuned almost imperceptibly narrow, and that one simply should tune a circle of fifths, with the “proof” being that the final fifth closing the circle was also a tiny bit narrow.

As the end of the 18th century approached, French instructions for tuning and descriptions of how keyboard instruments were tuned came closer to an approximation of equal temperament, in adaptations of the Ordinaire pattern, but it wasn’t until around the beginning of the 19th century that equal temperament really began to take hold in France.

In Germany/Austria, by contrast, there was next to no mention of equal temperament until Werckmeister in the 1690s. But thereafter, equal temperament was enthusiastically accepted as the best tuning solution by a succession of very influential musicians and writers. Neidhardt in 1706, Mattheson in 1722, Sorge in 1744, and Marpurg in 1756, all endorsed equal temperament. Neidhardt noted the possibility of tuning equal temperament by dividing the octave into contiguous thirds, and then dividing the thirds into their constituent fifths.² Both Sorge and Marpurg published tuning schemes using this procedure, Marpurg’s appearing in French (he published his works in that then more scholarly language, and they were widely read in France).

Practical methods in more accessible pamphlets and books for musicians and music lovers were more likely to provide a method for setting equal temperament using a circle of fifths, with descriptions of “proving” the temperament by listening to the thirds (they should beat “at the speed of eighth notes in common time” according to the instructions of Fritze, which were published in 1756 and then re-issued in subsequent editions until the 1790s). But one very widespread and long-lived set of instructions, by George Löhlein (1779 and subsequent editions) followed the pattern of beginning with contiguous thirds, and proceeding by fifths with various checks during the process.

While it is impossible to say with certainty, it seems fairly probable that equal temperament was the predominant tuning method in Germany/Austria by the 1760s, as long as we accept a range of error in achieving it. There continued to be a good deal of controversy, with Kirnberger and his followers saying that an unequal temperament was better for preserving key color. But in a practical sense, there was no real alternative offered except for Kirnberger’s own pattern, which even Kirnberger himself, acknowledged was not a good one.

Although there was a plethora of “well temperament” proposals written by various German authors of the early to mid 18th century, none of them appeared in print as

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² This method is considerably more precise in establishing equal temperament than a mere circle of fifths, the other most common method.
practical tuning instructions. In 1989, Thomas McGeary published an article surveying the sources of practical tuning instructions he was able to find for the period of 1770-1840 in Germany and Austria, twenty-two in all. Among them, equal temperament and “Kirnberger #2” were the overwhelming favorites, with equal temperament predominating. There were only two alternatives offered, along with a variant of Kirnberger. One was a “reverse well temperament” by Heinrich Laag (1774), in which the diatonic fifths were to be tuned just and the chromatic ones tempered, so that the key colors were the reverse of what would be normal (in Vallotti, for instance, or Werckmeister III). The other was a very idiosyncratic, confusing procedure, offered by Abbé Vogler in 1802, which bears little resemblance to any other pattern (Vogler had earlier offered a method for tuning equal temperament).

It seems reasonable to suppose that traditions might have been passed down without leaving documentary evidence behind. Werckmeister’s instructions of 1698 are a likely model for the sort of unequal temperament that would actually have been used, based on the idea that diatonic fifths should be narrower than chromatic ones so as to favor the keys that were used more, those with less sharps and flats. This principle was fairly widely known, and could be adapted either subtly or more obviously as desired. But it is interesting to note that the authors who wrote most vehemently in favor of unequal temperament, because of its supposed promotion of key color, were followers of Kirnberger, and they offered no alternative to equal temperament except for Kirnberger’s far from subtle and rather raucous proposal. There were many patterns available that were far better suited to the theory of key color, but there is no evidence that any of them entered the main stream, being used commonly for the actual tuning of real instruments (as opposed to providing fodder for theoretical arguments).

After 1800

It should be noted here that at some point during the period between about 1750 and 1800, tuning of the newly dominant instrument, the pianoforte, began to be a specialized skill offered by professional piano technicians, rather than something undertaken by individual musicians. There was certainly an overlapping period when some piano owners tuned their own instruments, but more and more this became the job of a craftsman. Hence, we need to look more and more at the techniques being taught to and followed by these new professionals, at least as documentary material has survived to provide evidence.

In Germany/Austria following 1800, McGeary’s research shows near unanimity in the published tuning instructions in favor of equal temperament. There was still discussion among scholars, theorists and critics of the question of key color, and how it might relate to unequal temperament, but practically speaking there was little evidence that tuners were doing other than attempting to tune equal temperament to the best of their ability, using methods that, while some were not very precise in their instructions, were all clearly aimed at creating an equal temperament with all keys sounding alike.

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In France, there seems to have been a transition period between 1800 and 1835, with the Ordinaire temperament approaching closer to equal temperament, and with equal temperament gaining ground. Methods for tuning equal temperament began to be published early in the century, and they reached their culmination in the work of Claude Montal, who published a very detailed method for learning how to tune in this way in 1834. Montal had taught himself to tune while a teacher at the National Institute for Blind Youth of Paris, and had successfully taught public classes in tuning for two years, when he decided to publish a book. His method for learning how to hear equal tempered intervals involved a number of exercises to be practiced and mastered before undertaking the tuning of an instrument. His procedure for setting a temperament is very rigorous and exacting, with many test intervals and chords used as “proofs” at various steps along the way. He proposed to tune both forward and backward, so as to refine the tuning by working back through what amounted to a reversal of the temperament sequence.

Montal’s expanded book of 1836 also included detailed instructions for making repairs, notes on the history of the instrument, and considerable additional information. It was reprinted and constantly available for the following decades, until his revision of 1865, and seems to have been the French equivalent of Braid White’s Piano Tuning and Allied Arts in early 20th century America. The tuning method was also published in German, Czech, and Dutch, and quite probably other languages as well. In part because of this very influential book, most temperament scholars consider that equal temperament was nearly universally adopted throughout France and Germany/Austria by about 1835.

In Italy, by contrast, unequal temperament practices survived into the last decades of the 19th century, with traces still present in the early 20th century. Various systems of the Italian version of modified mean tone seem to have predominated, either with wide fifths in the Eflat–G# area, or similar to Vallotti’s scheme using some narrow fifths and some just fifths. Equal temperament was viewed with suspicion as a German innovation, and only really began to become prevalent in the mid 19th century. In more conservative areas, Naples in particular, unequal temperaments continued to be predominant until as late as the 1880s, with a Vallotti style tuning – five narrow fifths and seven just fifths, sometimes referred to as the Sievers tuning – described as the most common tuning. This tuning had been described first in 1830, and had apparently persisted for fifty years.

As late as 1870, Giambattista De Lorenzi suggested the possibility of a mild unequal temperament, in which a “half comma” was to be divided between the fifths from C to E, which would make them 1/8 comma in size, the remainder of the fifths being “nearly just.” This prescription for an unequal temperament is surely one of the very mildest to be proposed, and should be viewed as a theoretical statement rather than evidence of an actual tuning practice, except to the extent that it shows the principle of somewhat narrower fifths in the diatonic area, with somewhat wider ones in the chromatic area. Executed with the precision of the modern electronic tuning device, the CE third would be about 3 cents narrow of equal temperament, while the widest third would be perhaps

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5 De Lorenzi’s comma would be the syntonic, 21.5 cents. 1/8 of this comma is 2.7 cents.
1.5 cents wider than in equal temperament. A 1/8 comma fifth is 0.7 cents narrower than in equal temperament. These are subtle differences, indeed.

Readers may have noticed the conspicuous absence of England in the articles to date. This omission will be remedied in the next article, which will be devoted entirely to the history of temperament in England.

For further details on the history of temperaments used on the piano from its invention to the end of the 19th century, see Patrizio Barbieri’s article Temperament in The Piano – an Encyclopedia, Palmieri, Robert, ed., Routledge, New York. 2003.
A Clear and Practical Introduction to Temperament History
Part 7: Temperament in England
By Fred Sturm
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I have chosen to treat England separately from continental Europe for several reasons. In the first place, England was not an important center of musical creativity, at least in the classical world: very little of the standard concert repertory was composed by English composers. England was more of a consumer of continental music and of musicians, who went to England to make their fortunes, as England was relatively wealthy and welcoming. In a more practical sense, though, England was out of phase with the rest of Europe in its tuning history. Developments in England were generally later than those on the continent, and were significantly different.

The period of 1500 to 1700 or so is the exception. During this period, in England as in the rest of Europe, the prevalent temperament system was, by far, $\frac{1}{4}$ comma mean tone. Starting in the early 1700s, mean tone with less narrow fifths and wider thirds began to be more common, with the publication of Michael Keller’s \textit{A Compleat Method}... providing the first indication of this tuning style to appear in print. Keller’s instructions are imprecise to say the least: he tells us to tune the fifths “as flat as the ear can bear” and the thirds “as sharp as the ear can bear” and gives his instructions as proceeding outwards to EFlat and G#, which would be the standard wolf fifth. Peter Prelleur plagiarized Keller in 1731. The preponderance of the evidence points to this style of tuning being the norm in England for the entire 18th century. Most scholars consider it to be in the realm of $\frac{1}{5}$ to $\frac{1}{6}$ comma mean tone. The most common alternative during the 18th century was $\frac{1}{4}$ comma mean tone.

An interesting development occurred in 1748, with the publication of Robert Smith’s \textit{Harmonics}. In this book, Smith, a professor of mathematics at Cambridge, applied science and mathematics to tuning theory, and came up with a method of calculating beat rates for various intervals. He presented a table of beat rates for $\frac{1}{4}$ comma mean tone and for a tuning system he devised, which he called “equal harmony.” These consisted of rates for fifths, given in number of beats per 15 seconds, something that would only be useful for the tuning of organs. He calculated beat rates for six different pitches, a quarter tone apart. While his calculations were based on faulty information concerning the measurement of pitch, Smith’s beat rate calculations became a part of the English approach to tuning thereafter, leading directly to the beat counting methods of 20th century America.

By contrast, in continental Europe beat rates were considered too variable to be useful. It is clear that beats were listened to, and their rates of speed were compared, as they are described in some detail in many practical and theoretical works on tuning. But because of the lack of a fixed pitch standard, they did not consider it worthwhile to calculate precise beat rates. Instead, they relied on proportional judgment to determine whether intervals were tempered the same or differently.
Smith was a firm proponent of intervals that were as “pure” as possible, and he considered that a tuning system with 5/18 comma fifths¹ (slightly narrower than ¼ comma) was the best compromise, a tuning that divided the octave into 50 parts if it were extended in both directions. This kind of analysis echoed 16th and 17th century Italian and French theoretical writings, and served to inspire English theoreticians for the next several decades. Smith was of the opinion that, since both the flat and sharp versions of all the chromatic keys were needed to perform the music of his time, all raised keys should be divided so that they could give both pitches. As an alternative, he proposed a design that would allow for the extension of the tuning in either the flat or the sharp direction, so that, by use of an organ stop (and a similar devise on a harpsichord), G# would automatically become Aflat, C# would become Dflat, and similarly with the other raised keys.²

Though Smith could be dismissed as a theoretician with little connection to the musical life of the time (he was an amateur musician), his ideas were in keeping with attitudes of the time. In fact, keyboards with split keys began to appear in England in the mid 18th century, though they had disappeared from Italy nearly a century before.³ The use of split keys would allow for the performance of music with additional sharps and flats without resorting to a circular tuning, though at the cost of learning a specialized technique. Split keys are found on organs, harpsichords, and even some pianos of the second half of the 18th century in England (and not in the rest of Europe during this period).

Patent drawings from 1811 for a transposing piano. While this was advertised, it is unclear whether any were built and sold.

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¹ 5/18 comma mean tone, very close to the 2/7 comma of Zarlino in 17th century Italy, produced somewhat narrow thirds. Smith claimed it produced the best overall balance of tuning, based on his beat calculations among other things.

² In practice, on the harpsichord there were two sets of strings, each with its own jack, and the stop determined which jack would pluck its own string. On the organ, separated pipes would be activated or deactivated.

³ The last surviving split key Italian harpsichords were built in the 1660s.
The concept of using stops, or pedals, or some other devise to extend the tuning in either the sharp or flat direction was carried out, at least experimentally. This was most successful on several organs, and new designs continued to be devised and executed into the late 19th century. The method was less successful on at least one harpsichord, and extraordinarily complex designs were developed and patented for the grand piano between 1788 and 1809 (there is no evidence that these were ever built).

While the foregoing discussion is somewhat separate from the subject of temperament history, it gives an indication of the English mindset. In the first place, there was strong resistance to the use of tempered intervals, more than absolutely necessary. And in the second place, the English were going over ground that musicians in continental Europe had covered and abandoned many decades earlier. It was as if England was reliving the discussions and experiments of the Renaissance.

When 1800 arrived, there was still very little use of circulating temperaments in England, in contrast even to conservative Italy. As the 19th century progressed, and the newer styles of music from Germany began to be performed more and more, the need for circulating temperaments became obvious, and changes gradually took place. In 1800, scientist and mathematician Thomas Young proposed two temperaments in a paper presented to the Royal Society. One was the same as Vallotti except for being transposed by a fifth (the diatonic fifths are C to F#, while Vallotti’s are F to B), the other a more complex combination of various sizes of fifth. Young did not include any practical instructions, and his proposals did not enter into the common literature, but they are indicative of a change of perspective within the scholarly world.

In 1806, Charles Stanhope found that the two tempered fifths in Kirnberger #2 were unbearably dissonant, and he proposed an alteration to improve that temperament. He suggested that the comma be divided among three fifths instead of two (G–D–A–E instead of D–A–E). It is noteworthy that this commentary on Kirnberger came three decades after Kirnberger proposed his tuning (yet another piece of evidence that England was behind the times). Stanhope’s proposal received some positive comments in the press, but seems not to have become at all common. In that same year, Stanhope noted that, of 16 to 18 prominent musicians he consulted, only half supported the idea of equal temperament.

In 1811, John Broadwood announced that Broadwood pianos were tuned in equal temperament, the tuning he said was preferred by all the prominent classical composers, including Mozart and Haydn. This seems to have been more an attempt to appear to be up to date than an actual description of reality. It seems likely that Broadwood was not well informed about the details of temperament, and that in practical terms he was referring to circulating rather than equal temperament. Evidence suggests that the style of tuning at Broadwood during that period was a version of what is known as “semi mean tone,” in which the diatonic notes are tuned in mean tone (which would have been closer to 1/6 comma than 1/4 comma at this time), and the raised keys are tuned so as to be approximately midway between the adjacent natural keys. The tuning is circular, but without a clear pattern of sizes of thirds, especially considering the probably very approximate methods of trying to achieve it. No tuning instructions seem to have survived.
In 1830, Henry Liston reported that the most prevalent tuning practice in England was “to divide the scale of the instrument as nearly as possible into 12 equal semitones,” but the methods described in practical instructions at that time were closer to late French modified mean tone, where the final fifth, G#–Eflat, was the worst, and might most commonly be fairly wide. An example of this procedure was published in 1832 by Jean Jousse, prescribing narrow fifths from C to B, somewhat wider (perhaps just) fifths from B to G#, and wide fifths in the flat direction from C to Eflat.

In 1846, the Broadwood firm instructed A. J. Hipkins to train all its tuners in equal temperament, and it seems that it is only from this time that equal temperament began to take hold in England. It is interesting to note that Hipkins served as tuner for Chopin during his stay in England in 1848.

Colin Brown’s “Voice Harmonium,” with 41 keys per octave, tuned in just intonation, allowing for all intervals to be just (no tempered intervals).

But though equal temperament became more prevalent, traditions of unequal temperament persisted into the last decades of the century. Evidence of French Ordinaire-like procedures are present in the 1880’s, organs continued to be tuned in mean tone until about 1875, and critics continued to express opinions in opposition to equal temperament.

From about the middle of the 19th century, on the newly popular harmonium, proponents of mean tone and just tunings developed many designs with more than twelve keys to the octave, including as many as 53 (in several rows). These were tuned using either an “extended mean tone” system, where the twelve note temperament simply was continued in either direction, using the same size fifths until the two directions finally came together; or in some form of “just intonation,” where tuning was done in such a way as to make all intervals just – so that there would be an available key corresponding to the appropriate pitch. Instruments like these were sometimes used as teaching devises, but

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4 The English equivalent of the American reed organ.
5 Experimental harpsichords of this sort had been built in Italy in the 16th and 17th centuries, with up to 36 keys, and with tuning systems along the same lines for the most part.
were also intended for musical performance, though it is unlikely they were actually used very commonly, as they required a very specialized technique.\(^6\)

Tuning in the United States followed the pattern of England fairly closely. While there is considerably less documentary evidence, it is clear that mean tone tuning was dominant for a fairly long period of time. Thomas Jefferson used the tuning method of Pasquali, which is usually interpreted as close to 1/5 comma mean tone. Various methods of creating circulating temperaments were used, and equal temperament only became solidly established in the early 20\(^{th}\) century. In 1906, Cree Fisher reported that some tuners shaded their tunings to favor the flats, as much popular music of the day was written in keys with many flats. This style of tuning would be similar in shape to the “reverse well temperament” described in a previous article as a proposal of Heinrich Laag. But the publication of Braid White’s *Piano Tuning and Allied Arts* in 1911 marked the beginning of standardized acceptance of a precise equal temperament.

*Bosanquet’s 1875 “Generalized Harmonium,” which could play both a circular ¼ mean tone tuning, as well as a tuning based on a pattern developed by Helmholtz. (Despite the French-sounding name, Bosanquet was English).*

\(^6\) These experiments led indirectly to a 20\(^{th}\) century American musical movement, the microtonal school of Harry Partsch and Ben Johnston, an interesting case of a conservative, anachronistic movement turning into what became known as cutting edge modernism. Harry Partsch ordered one of these harmoniums early in his career, and was influenced by the theories behind them.
A Clear and Practical Introduction to Temperament History
Part 8: Jorgensen’s “Tuning”
By Fred Sturm
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Owen Jorgensen’s first two books were discussed briefly in the very first article of this series, but since then his work has barely been mentioned. His later book, Tuning, Containing the Perfection of Eighteenth-Century Temperament, the Lost Art of Nineteenth-Century Temperament, and The Science of Equal Temperament Complete with Instructions for Aural and Electronic Tuning\(^1\) (which I will refer to simply as “Tuning” hereafter) has been essentially absent from this account so far. It will be obvious to those who are familiar with that book, or with many of Jorgensen’s articles in the Journal, that Jorgensen’s account of the history of temperament is very different from what I have presented. It is time to explain the differences.

Jorgensen worked extraordinarily hard researching the history of tuning, travelling to England on several occasions, and unearthing a great deal of original material from English sources. Based on those original materials, he analyzed, interpreted, and calculated a great many temperament patterns, and developed precise aural procedures to reproduce them, as well as cents offset numbers for use with electronic tuning devices.

The title of Tuning implies that it covers universal European practice, but, in fact, it is based almost entirely on documents he unearthed himself in his own research. Those documents were all in English, and were published in England, or, in a few cases, in the United States. He only cited original sources from Continental Europe when they were either referred to, or translated and published, in English sources, which usually occurred some years after the original publication.

Jorgensen should be applauded for his energy in undertaking such a mammoth research project, and for his insistence on reaching his own conclusions based on his analysis of original materials, as opposed to relying on the interpretations of others. Unfortunately, as we have seen in the preceding article, the history of tuning in England was quite distinct from that of the remainder of Europe. In general, temperament developments took place in England a few decades later, and there were many trends that were unique and unconnected. Jorgensen seems to have believed that European practices were fairly homogenous, and came to his conclusions based on that belief. His belief was mistaken, and it led to a great deal of misunderstanding.

Let us take for example the tuning practices of Germany and Austria in the 18th century. This is an extraordinarily important time and place for the history of western music, as it covers composers as prominent as Bach, Haydn, Mozart, and early Beethoven.

In Germany of the 18\textsuperscript{th} century, the idea of circulating temperaments was predominant from the beginning of the century, and mean tone was disparaged by almost all important musical figures. Furthermore, the idea of equal temperament was very prominent from very early in the century, and as we have seen, one can make a good case for its acceptance by a majority of musicians by about the middle of the century (though it continued to be somewhat controversial in the musical press). By contrast, in England during this century, most of the evidence demonstrates that mean tone was used almost universally, with minor exceptions, and there was very little mention of equal temperament.

With respect to practical tuning instructions, those of 18\textsuperscript{th} century England were almost all aimed at a mean tone in the 1/5 to 1/6 comma area, with a pattern that left a wide wolf fifth at G#–Eflat. In Germany, most 18\textsuperscript{th} century instructions aimed at a circular temperament with no wide fifths (Werckmeister's instructions of 1698 are the exception with respect to somewhat wide fifths). There were several patterns published for producing equal temperament, including patterns that began by dividing the octave into contiguous major thirds. Considerable thought was given to establishing the size of the equal tempered fifth, with both Marpurg and Sorge proposing sequences of just intervals that would result in a 1/12 Pythagorean comma fifth.

Clearly a strong case can be made for equal temperament as the likely tuning for Haydn, Mozart and Beethoven, and even possibly for Bach.\textsuperscript{2} Reading Jorgensen, you would certainly not receive that impression. He ignores completely the work of Werckmeister, Neidhardt, Sorge and Marpurg (and of the other major German writers of the era), and was not familiar with any tuning instructions published at the time in Germany or Austria. He seems to have assumed that during that period people were talking about equal temperament, but that nobody actually had given thought as to how to achieve it in practice, and that English tuning instructions were representative of tuning instructions throughout Europe. While many of the surviving German/Austrian instructions are rather imprecise and lacking in detail, others make clear that there were at least some people who had developed reasonably good methods for achieving a very fair approximation of equal temperament by the last half of the 18\textsuperscript{th} century.

Jorgensen read the temperament instructions of Keller and Prelleur from the first half of the 18\textsuperscript{th} century in England, clearly written with the intention of creating a 1/5 to 1/6 comma mean tone, and tried to find in those instructions something that would correspond to the movement towards circulating temperaments that musicians on Continental Europe were talking about. Keller’s instructions from 1707 he interpreted as mean tone. While Prelleur’s instructions are obviously a literal plagiarism of Keller’s, published a couple decades later, Jorgensen created an

\textsuperscript{2} It is noteworthy that a prominent temperament scholar from the Netherlands, Rudolph Rasch, considers that the evidence shows equal temperament to be as likely for Bach as an unequal pattern. We will look more closely at that question in the next article.
interpretation that turned it into a circulating temperament – with no justification in the words used by Prelleur, nor any other solid evidence. He simply states that the later date made it obvious the Prelleur “must have” intended a circulating temperament.

Jorgensen’s treatment of the 19th century is similarly limited and skewed. Kirnberger’s temperament proposal finally reached England about 30 years after he first published it, and the Earl of Stanhope responded to it by proposing a modification (dividing the comma among three instead of two fifths). Stanhope’s modification is not terribly important for English temperament history, and was completely unknown on continental Europe, but it is duly recorded in Tuning as a temperament method of 1806, as if it were perhaps a norm for that time throughout Europe. In the same way, Jean Jousse’s prescription for a tuning in the style of French Ordinaire, published in England in 1832, is reported as if it were a standard tuning for that time. In fact, that tuning style had nearly disappeared in France by that time, and the style was never common outside France.

The late arrival of equal temperament to England, and its sketchy and often inadequate instructions in the earlier published materials led Jorgensen to believe that equal temperament was similarly late and inaccurate in Continental Europe. This conviction was reinforced by his interpretation of the tunings measured and documented by Alexander Ellis, the translator of Helmholtz’ On the Sensations of Tone. It seems that the evidence he found in these tunings provided the major underpinning for Jorgensen’s major assertion in Tuning, repeated throughout the book, that equal temperament was not practiced before the 20th century. So a close look at this evidence is in order.

Alexander Ellis provided considerable supplemental material in his “translator’s appendix” to Helmholtz’ work, including the results of research that he undertook himself. He developed and tuned a large set of tuning forks calibrated very carefully (after a pattern developed by J. H. Scheibler), capable of measuring pitch to a tolerance of about one cent through the use of precise beat counting over several seconds. He used these forks for a number of purposes, including some of the earliest research into historical standards of pitch, based on measurements of historical tuning forks, organs, and other artifacts.

One of the projects Ellis undertook using the set of forks was that of measuring a sampling of temperaments from four pianos, two harmoniums, and one organ, documentation that essentially provides our only reasonably precise concrete evidence of actual tuning practice prior to the 20th century. Jorgensen found traces of what he called a “Well Temperament style” in some of these tunings. However, his methodology in analyzing them left much to be desired, to put it mildly.

Ellis’ method required listening for several seconds and counting beats of the string against the fork. Hence, he measured the notes C3 to C4, because higher notes lacked enough sustain, and he measured the fundamental only. There are several issues that should be raised before looking seriously at the numbers Ellis obtained. First, while we have good reason to believe he was very careful in his measurements,
we do not know the margin of error using his methodology. He provided figures to the resolution of one cent, but it could well be at a margin of error of plus or minus one cent. Second, the range from C3 to C4 usually covers a portion of the piano scale that has large discrepancies of inharmonicity, including the break between wound and plain strings, so conclusions drawn from this area are not particularly reliable as a measure of temperament. We are given no information as to the size or type of piano Ellis measured, so we have no information as to scaling or position of the bass to tenor break. Thirdly, use of raw data for pitch measured at the fundamental is suspect, as those of us who have been involved with the PTG tuning test are well aware. Aural tuners listen to beats produced by upperpartials, and pitch curves for the first partial in the temperament area are rarely if ever smooth.

Jorgensen makes no allowance for error on the part of the tuners of the instruments. He assumes that they were extraordinarily skilled, and that every note was precisely where they wanted it. Except that in two of the tunings, known from Jorgensen’s writing as “Broadwood’s Best IV” and “Broadwood Ordinary Tuner,” he decided that some notes had “obviously slipped.” He made corrections, moving three notes in one, two notes in the other, in amounts ranging from two to 7.5 cents. We are asked to trust his judgment in reading the minds of the tuners, recreating what he believed were their intentions.

When all these factors are taken together, it is clear that Jorgensen’s analysis of the Ellis tunings is deeply flawed. While there may be traces of unequal temperament tradition to be found in the Ellis tunings, the “Victorian tunings” Jorgensen provided us based on the Ellis measurements should be taken with a grain of salt, as should the conclusions he drew from them.

Many piano technicians have been introduced to unequal temperaments through electronic tuning devices, most of which include many preloaded templates for alternate tunings. The labels for these temperament templates are largely based on the names used in Jorgensen’s books, and this leads to considerable misunderstanding and confusion.

One problem is that of dating. Jorgensen meticulously recorded the date of publication for each of his historical temperaments, but that date lacks context. Since they were published in England, the dates only correspond to English tuning practices, and even then serious questions could be raised as to how common or well known many of these temperaments were. And because he did not document some of the more commonly used temperaments, like Werckmeister III, they are missing from the libraries of many electronic tuning devices.

A second problem arises from Jorgensen’s very eccentric terminology, which doesn’t correspond to the common terminology used by the majority of temperament scholars and early music specialists. Thus, in his 1979 book, the very common 1/4 comma mean tone is called “Pietro Aron’s 1/4 Syntonic Comma Meantone in the Acoustic Tonality of C Major and A minor” in both “theoretically correct” and “equal beating” versions (as well as versions “whereby three notes must be retuned” and the like). In 1991, this title was expanded to “Pietro Aron’s restrictive regular
noncirculating one-fourth syntonic meantone keyboard temperament of 1523 in the theoretically correct manner."

All the extra verbiage possibly adds some precision for the temperament theoretician, but it is quite simply needlessly confusing for the rest of us. It should be noted that the equal beating versions are aural tuning sequences Jorgensen developed using intervals that beat at nearly the same rate as test intervals. He made small changes in the temperament patterns in order to make various intervals beat at precisely the same speed (assuming the tuner is skilled enough to make it so). These have become popular among some tuners in the past few decades, but they are entirely Jorgensen’s creation and have nothing to do with historical practices.

One of the major themes of Tuning is the assertion that equal temperament was not practiced before the 20th century. Early in the book, in the introductory chapters, Jorgensen sets out some of the reasons he believes this to be true. Among his claims are statements like the following: “In the past, tuning by ear meant that one judged the relationships between the two notes of an interval by listening to the two notes melodically only.” A familiarity with any of countless basic sources from continental Europe would make it obvious that this is simply not true. Arnolt Schlick in 1511, Jean Denis in 1643, and Werckmeister in 1698 are three sources that have been mentioned in earlier articles, each of whom described vividly the playing of two notes of an interval, and the beats that may be produced. Once again, reliance on English sources, and unfamiliarity with other sources, led to misinformation, and to misconceptions about the past.

Much of Jorgensen’s argument about the impossibility of equal temperament before the 20th century is based on a very narrow definition of equal temperament, where any deviation of as much as one cent in the temperament is enough to make it something different. Hence, much of the book is taken up with analysis of temperament sequences Jorgensen says can only produce “quasi-equal” temperament, based on his interpretation. He was a product of the 20th century style of tuning based on precise beat rates for every interval (given at a resolution of tenths of a beat per second), and he claimed that the lack of such beat rates and a wide range of test intervals made precision impossible.

These are matters of interpretation, looking at the 19th century with a 20th century mind set. Jorgensen assumed that minor deviations from “precise” equal temperament are significant, and that procedures other than those of the 20th century could not achieve such precision. Both assumptions are subject to question. We simply do not know how much variance from precisely defined equal temperament is necessary before it is noticed by musicians or audiences, as no rigorous testing has been done in that area. In any case, it is difficult to define “precise equal temperament” for purposes of practical application. As for what procedures work best, and whether results of a more “scientific” method differ significantly from those of more “intuitive” methods, opinions differ, as evidenced by many articles in these pages over the years.
I hope that this discussion has covered enough ground to reveal some of the major shortcomings of Jorgensen’s work. While his energy and enthusiasm were commendable, the limitations of his scholarship led to grave errors of interpretation, and to misunderstandings that will probably persist for many years to come.

In the next article we will wrap up this series, trying to tie things together into a larger picture, and providing some discussion of the practical application of historical temperaments.
A Clear and Practical Introduction to Temperament History
Part 9: Practical Application
By Fred Sturm
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In the first article of this series, I said that historical temperaments could be grouped into four or five broad patterns, with some deviations and variants. We have been through each of these patterns in some detail. Let us summarize:

First, there is mean tone, which is characterized by a focus on major thirds, generated by fifths that are all the same size. The most common mean tone pattern was the one called 1/4 comma, in which all thirds are pure and beatless. Other mean tone patterns mostly had thirds that were somewhat wide, and fifths that were somewhat less narrow than 1/4 comma. Additional characteristics of mean tone include semitones and whole tones of different sizes; a pattern of fifths that move outward in both directions from A or C, ending up at E flat and G sharp; a wide wolf “fifth” between E flat and G sharp; accidental keys that are either usable as a sharp or as a flat, but not both; and many “thirds” that are badly out of tune, and should be considered as “diminished fourths.” Mean tone was not a circular temperament. It was the dominant tuning throughout Europe from 1500 to 1700, continued to be used in the 18th century, and persisted somewhat into the 19th. (If we distinguish between mean tone in which the thirds are just and those variants in which they are not, we can call mean tone “two broad patterns” – here lies the extra, fifth pattern).

Second, there are modified mean tone tunings, which begin with a series of fifths in a mean tone pattern, but then change the sizes of fifths, usually irregularly, so as to make the tuning circular. The earliest documented pattern of this sort was very early indeed, the tuning pattern recorded by Arnolt Schlick in 1511. However, the most prominent and well documented were the French patterns known as “Ordinaire,” used mostly in France during the 18th century. Other modified mean tone systems were used in Italy, including the famous Vallotti tuning. A very mild form of modified mean tone was described by Werckmeister in Germany, in 1698.

Third, there were a number of circular temperaments described by Germans of the 18th century, the Good Temperaments commonly referred to as “Well Temperaments” from their connection in many people’s minds to Bach’s Well-Tempered Clavier. The general characteristics included fifths of two or three different sizes for the most part, some of which were usually just. Narrower fifths were mostly in the areas of the natural keys, with wider fifths (as wide as just but not wider) mostly on the accidental keys. These patterns are very similar in concept and sound to that of Vallotti. A distinguishing characteristic of the Good Temperament is the use of the Pythagorean comma in place of the syntonic, a difference that had more theoretical than practical effect.

Finally, there is equal temperament, which was a concept that occurred throughout the historical period we have dealt with. A number of different approaches were invented over the years in order to put it into actual practice. Equal temperament
gradually became the dominant tuning pattern beginning in the early 1700s in Germany until about 1850 throughout Europe.

Given those patterns, how would we use them in practice? How does one go about choosing the appropriate tuning for a particular piece of music or period?

For music before 1700, the answer is rather easy. Most music of that period should probably be played in mean tone, and 1/4 comma mean tone would be a good choice as a default, with 1/5 comma a second choice. For Italian music in particular, there is the possibility that an instrument with split keys was intended, and if there are more than two flats or three sharps used in a piece of music, this should be considered. Lacking an instrument with split keys, the best compromises for such music are probably either Vallotti or a French Ordinaire tuning. It should not be assumed, however, that the extra sharp(s) or flat(s) definitely mean the use of split keys or call for a different tuning, as some composers used the dissonances produced by those wolfish intervals for dramatic effect; but this is a judgment best left to the performer.

For later periods, the answer becomes somewhat more problematic, but not insoluble. In practical terms, most musicians who play early music today choose to tune in Vallotti for almost all Baroque music. This is a good compromise, as it shares characteristics with both French Ordinaire and the German circulating temperaments of the time. Some harpsichordists use a form of Ordinaire for concerts or recordings devoted to French music, but most commonly concerts include pieces from a variety of composers and countries, so a compromise tuning is often perhaps more appropriate.

The music of 18th century Germany and Austria presents the largest number of possibilities, and the smallest degree of certainty, as it was a period of change and controversy. It was during this period that much of the standard repertoire currently performed on piano was written, so a detailed discussion is in order. Perhaps the most controversial questions and opinions surround the music of Bach, so we will begin by examining some of them.

The title and purpose of the “Well-Tempered Clavier” are the source of much dispute. Bach chose to use that title for a series of pieces that included a prelude and fugue in each of the twelve major and minor keys, organized by moving upward a half step starting at C, and he did so not once but twice. In each instance he published the set himself. For a considerable period of time, music scholars considered this music an endorsement of equal temperament, and some called Bach (mistakenly) the “inventor” of equal temperament. In the mid to late 20th century, when more detailed research had been done in the area of historical tuning practices, a contrary opinion was taken up: that Bach definitely intended an unequal temperament. Various candidates were promoted as the unequal temperament of Bach. Among these were Werckmeister III and Kirnberger II, though further research has made it clear that neither is a good candidate for the tuning used by Bach.
Many very passionate articles and books have been written, “proving” that some other pattern must have been the one Bach intended. Herbert Anton Kellner, who wrote perhaps the most prolifically on the subject, found a pattern in Bach’s seal ring that he decided was a clue to his tuning method. Based on this and on other “proofs” he found elsewhere, he came up with a tuning using five 1/5 comma fifths and seven just fifths, and promoted this method in his book, The Tuning of My Harpsichord, and in many articles. Most reputable scholars dismiss his writings, which are filled with numerological and mystical references, but his tuning continues to be used by some.

John Barnes analyzed the number of times each major third was used in the Well Tempered Clavier, and developed a pattern based on his findings, which he wrote about in an article published in Early Music. His article was intended to show that the pattern of major third usage was more consistent with an unequal temperament than with an equal one, and the temperament pattern he suggested arose out of his statistical analysis – with no claim that this must have been Bach’s temperament, but merely a statement that it would be an appropriate temperament given the data. His pattern has six 1/6 comma fifths and six just fifths, the same as Vallotti except that one of the 1/6 comma fifths is exchanged with a just fifth – E–B is just, B–F# is 1/6 comma narrow. Barnes’ methodology has been sharply questioned by a number of temperament scholars, but his method does have some supporters, including notably Claudio Di Veroli.

Bradley Lehman found a pattern in a decorative device on the title page of the WTC, which he claims to be the “Rosetta Stone” of Bach’s tuning. He published two articles on this topic in the journal Early Music, which I described in an article in the Piano Technicians Journal, November, 2006. His thesis relies on a series of leaps of faith, and it was rather thoroughly debunked by Mark Lindley and Ibo Ortgies in a responding article in Early Music. His temperament pattern has a considerable following, however, due to his tirelessly passionate and persuasive promotion of it. His pattern is also quite similar to Vallotti, with one of the 1/6 comma fifths divided into two 1/12 comma fifths (along with a couple other very minor details).

One could go on to describe other opinions, but the plain truth is that we don’t know how Bach tuned. The prominent temperament scholar Rudolf Rasch published an article entitled “Does ‘Well-Tempered’ mean ‘Equal-Tempered’?” in 1985. In this article, he surveyed the historical evidence, particularly for the use of the term “well tempered” during that period, and concluded that Bach most likely intended equal

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3 A fairly detailed historical analysis of Lehman’s proposal can be found at [http://my.ptg.org/blogs/fred-sturm/2014/10/24/lehman-bach-tuning-refuted](http://my.ptg.org/blogs/fred-sturm/2014/10/24/lehman-bach-tuning-refuted)
temperament for the Well-Tempered Clavier. Bach, himself, was silent on the question, and his son Carl Phillip Emmanuel Bach was very vague, writing only that “most” of the fifths should be narrow, and all keys should be equally “pure.”

I will state as my own opinion that it is quite likely Bach tuned in a method similar to that described by Werckmeister in 1698, a very mildly unequal temperament in which a fifth or two might be slightly wide. This opinion is based in part on the fairly well-established fact that Bach possessed that particular book of Werckmeister from an early age, and that Bach was known to be averse to the scholastic pedantry of those who wrote about temperament during his time. The preponderance of the evidence seems to suggest that Bach was focused on a tuning in which no key would sound out of tune rather than concerned that his tuning have a particular shape or color. Obviously many people disagree with my assessment. In any case, it seems clear that something along the spectrum from Vallotti to equal temperament can be considered historically appropriate.

With respect to the music of Haydn, Mozart, Beethoven, and their contemporaries, there has been much less scholarly investigation into the question of appropriate tuning. Most music scholars have assumed that equal temperament is appropriate for this period and style of music. Those who advocate for an unequal temperament for these composers usually rely heavily on an argument based on the concept of “key color,” the assumption being that each key has its own character based on the sizes of the various intervals (particularly the size of the major and minor thirds), and that composers wrote either consciously or subconsciously using these differences expressively.

There is a long tradition of using different scales and irregularities of tuning as expressive devices throughout the history of western music. The church modes (scales using only the natural keys, but beginning on different steps) were sometimes associated with certain functions and emotions, harkening back to the writings of the ancient Greeks. One or two accounts have survived recounting how the irregularities and wolf intervals of mean tone tuning might be used expressively.

In the period after 1700, Rameau and Rousseau both wrote about the expressive possibilities contained in the “ordinary” tuning of their time and place. Each gave descriptive terms to some of the various keys. For example, Rousseau described B flat major as tragic, while Rameau used the words tempest and furies. These two descriptions are somewhat similar, but in contrast a French predecessor of the two, Charpentier, described B flat as magnificent and joyful. In general, among those who wrote about keys having specific characters, there was some degree of agreement in the descriptive language used for some keys, disagreement for others, but the wording used was most often quite vague and ambiguous.

Among German writers on this subject, the first to give a fairly comprehensive account was Johann Mattheson, writing in 1713 and later. His description of B flat major: “Very diverting and sumptuous; yet, it is also somewhat modest, and thus can pass as both magnificent and dainty.” Mattheson provided some of the most lengthy and detailed descriptions of key character, and his writings on the subject were
quite influential. However, it seems quite clear that his notions of key color were not connected to temperament. He was consistently a very strong advocate of equal temperament, and he made clear that his key characteristics were tied to pitch: there were two major standard pitches at his time and place, a whole step apart, and he stated that his descriptions applied to one of those and not to the other.

Key character descriptions continued to be made through at least the end of the 19th century, and the literature on the subject has been covered exhaustively by Rita Steblin in her book *A History of Key Characteristics in the Eighteenth and Early Nineteenth Centuries*\(^5\). Steblin’s account makes it clear that there was no consensus on the major points. Some connected key character with temperament, while others did not. Some connected it directly with pitch, while others did not. Descriptions of the characteristics of each key became more standardized in the late 18th and early 19th century, but it seems obvious that this is because the writings of one author, Schubart, began to be plagiarized.

The most prominent advocate for key color connected to temperament was Kirnberger, writing in the late 18th century. But, as we have seen, his advocacy was connected to his very idiosyncratic temperament proposal, a pattern far from mainstream practices. If composers were writing based on subtle key coloration, as is suggested by those who believe unequal temperaments should be used for music of this period, it is impossible to know what pattern they based their music on, as there is no evidence directly linking the major composers with any specific temperament choice. And most of the documentary evidence points to equal temperament as the most prominent pattern during this time.

Taking all the evidence together, there is little reason to believe that major composers of mid to late 18th century Germany and Austria composed for the piano based on a temperament pattern other than equal temperament. There are some who believe music of this era sounds better in a temperament in the “German Good Temperament” tradition, and one cannot say that use of such a pattern is “inauthentic” historically. There is evidence that tunings in that tradition might have been used during that time and place, but the preponderance of the evidence points to equal temperament as the most likely tuning style.

The same conclusion holds for the music of later eras: while there is evidence that various unequal tuning traditions persisted in some areas, it is quite clear that equal temperament was the norm throughout Europe during most of the 19th century, with the exceptions noted in previous articles. While there are a few tuning styles that might be used for music of specific times and places, the most authentic tuning for the 19th century is, without question, equal temperament. One may quibble as to the precision of tuners prior to 1900, based on tuning instructions of the time, but one may quibble equally about the precision of tuners in the 20th century, based on common practices and ranges of ability. And we simply don’t know how well even

the most acute human ear distinguishes between small variances of tuning. Most scientific testing in this field suggests that variances must be quite large (from the piano technician’s perspective) to be noticeable, so the range of tuning accepted as equal temperament is probably far larger than we tend to believe, based on our intimate experience during the tuning process.

Throughout this series of articles, I have tried to present the topic as it is revealed by the historical evidence, following the data wherever it might lead me, without any preconceptions as to what tuning pattern sounds best or any preference for some theoretical standard. Musicians are practical, pragmatic people for the most part, who want to get to the business of making music, and it is from their point of view that I have written. What does the evidence suggest musicians did? What are they likely to have done? The perspective I have chosen to take has led me to emphasize the more practical aspects of the surviving evidence, in contrast to the more scholastic approach of many others, which focuses more on the theoretical arguments.

I hope that this presentation of an overview of temperament history has been clear and reasonably well balanced. No doubt some of my analyses and interpretations will prove controversial in some circles, as is inevitable with such a topic. In the final analysis, every temperament is a compromise, decided so that we can stop tuning and begin to make music. Yet for some reason temperament has always been a subject that arouses passionate disagreement. I will close with a quote from Johann Mattheson, in which he comments on those passions.

“One must take refuge in temperament when tuning claviers and harps. Many books make as much to do of this as if the welfare of the entire world depended on a single clavier.”