

175

A SURVEY OF TUNING AND TEMPERAMENT IN THE 18th CENTURY
AND THE ATTITUDES REGARDING ITS IMPLEMENTATION

by

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
I. EXPLANATION OF TUNING SYSTEMS	2
II. APPLICATION OF TUNING SYSTEMS IN THE 18th CENTURY	7
GLOSSARY	22
SCALE VALUES IN CENTS	24
LIST OF WORKS CITED	25

A SURVEY OF TUNING AND TEMPERAMENT IN THE 18th CENTURY
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Today's standardized tuning practices make a working knowledge of temperament unnecessary. The modern musician has heard of the Well-tempered Clavier and knows that the piano is tuned in equal temperament. Terms such as "Pythagorean", "just", or "meantone" tuning may be recognized from a history or theory class, but their definitions have probably become mixed and hazy through disuse. During the 18th Century, the period just prior to the adoption of equal temperament, a knowledge of the vocabulary and mechanics of tuning were essential to every accomplished musician. If an 18th-Century musician played several instruments he could easily encounter two or three different tuning systems in the course of a day's work. This paper will explain these various tuning systems and examine the attitudes of the musicians who used them and the relationship between the tunings systems and instrument construction and technique.

I

When two pitches with frequencies varying by simple whole number ratios of 2:1, 3:2, 4:3, and 5:4 are sounded together the resulting sound will be pure and without beats.¹ Since these ratios correspond respectively to the octave, fifth, fourth, and third of Western music, the laws of nature and man would appear to be in significant and advantageous harmony. When Pythagoras discovered this in the 6th century B. C., the natural order of nature seemed confirmed. Unfortunately for Pythagoras and all subsequent theorists, a flaw soon appeared in this nicely ordered scheme. The system works well for a single-note diatonic melody or melody with a tonic drone, but problems arise in polyphonic music of any complexity. Any attempt to play other than a tonic chord or to change the key center will quickly result in harsh and dissonant sounds, since all the ratios are related to the tonic. In order to have a system of small-integer, or "just", ratios that could be played without beats in different keys, a separate set of intervals would be needed for each step of the original scale. If the original scale had 12 pitches to the octave, the final result would have 132 separate pitches and some of these would be theoretically out of tune if used in a modulatory section. Obviously, perfect mathematical intonation is impossible in real music and a compromise must be sought. From among the many theories concerning the proper division of the octave, four have emerged as the most important to Western music. These are Pythagorean, just intonation, equal temperament, and meantone tuning.

¹ Arthur H. Benade, Horns, Strings & Harmony (Garden City, New York: Anchor Books, 1960), p. 77. Beats result when two tones of nearly the same pitch or with a common harmonic are sounded together. As the pulses of the slower frequency gradually fall behind the other, the amplitude of the sound is alternately cancelled and reinforced as the sound waves move in and out of phase. The beat pulse is the same as the difference in the two frequencies.

When discussing the various tunings and temperaments, we must consider the cents system associated with modern equal temperament. In this system the octave is divided into 1200 equal parts producing half-steps of 100 cents each. For example, the equal temperament fifth of seven half-steps would have a cents value of 700.

Pythagoras derived his system from the octave, 2:1, and the just fifth, 3:2, along with its inversion the fourth, 4:3. The just third was not considered in this system. One possible explanation is that the third was simply not an important interval to the Greeks, just as it was not considered a consonance during most of the Middle Ages. Another is that Pythagoras was as concerned with the philosophy of the system as with the actual music and a system based solely on two of the smallest whole integer ratios was too profound to be unnecessarily cluttered. A diatonic scale derived from this system has whole steps which are slightly larger than an equally tempered scale and half-steps which are 10 cents smaller. The Pythagorean third is 22 cents higher than a just third (5:4). The difference between the Pythagorean third and the just third is known as the Syntonic Comma. If the process of tuning by fifths is extended beyond twelve notes, Pythagorean sharps will be 24 cents higher than their enharmonic flats. This interval of 24 cents is known as the Ditonic Comma.² Since the difference of 2 cents between the syntonic and ditonic is at the threshold of perception, there is generally no need to make a distinction. A comma is usually considered 1/9 of a whole-tone.

Just intonation refers to any system having both pure fifths and pure major thirds. The ratio 5:4 is used for a just major third and

²J. Murray Barbour, Tuning and Temperament: A Historical Survey (East Lansing, Mich.: Michigan State College Press, 1951), p. ix.

6:5 for a minor third. Thus, a major triad can be expressed by the superparticular ratio of 4:5:6.³ This mathematical neatness is the major attribute of just intonation. Various theorists have championed just intonation since the Renaissance and continue to do so from time to time even today. It is seen as the way things ought to work. Unfortunately, it doesn't work very well in practice and has been the least used of any of the major tuning systems. When the derivation of a just scale proceeds beyond the first pure intervals of the octave, fifth, and third problems quickly develop. In a justly tuned scale the fifths of the triad built on II and VI are unusably sharp, there are two sizes of whole-tones, and four sizes of semi-tones making modulation impossible. If just intonation is taken beyond 12 pitches per octave, enharmonic sharps will be lower than their corresponding flats.

As the interval of the third became more important after the Middle Ages, the sharp third of the Pythagorean tuning became a problem. One solution, which was applied primarily to keyboard instruments, is meantone temperament. In meantone temperament, the third is tuned pure, 5:4, and the fifths are lowered. The system's name relates to the size of the whole-step, C-D, which is exactly half--the mean--of the major third C-E. It was first set down by Aron in 1523. In his system the fifths are tuned flat by 1/4 comma, or about 5 cents. Starting from C, by this method, and going up four flatted fifths and then dropping back two octaves will produce E a just third from C. When

³Barbour, Tuning and Temperament, p. 2. Superparticular ratios refer to whole integer ratios in which the numerator is one greater than the denominator. Certain early theorists, notably Ptolemy in the 2nd century, felt that scales derived from this type ratio were of a superior quality.

meantone tuning is extended to include enharmonic notes, the sharps are lower than their corresponding flats. In the case of G# and Ab the difference is 42 cents or nearly a half of semi-tone. On a keyboard instrument without enharmonic capabilities, meantone tuning gives equally distorted but quite usable triads in all the common keys. But if keys having more than three sharps or two flats are used, the large enharmonic difference mentioned above comes into play producing a very wide, unusable fifth between G# (Ab) and Eb. This interval is known as the wolf-tone, and has a value of 739 cents which is 42 cents higher than a regular meantone fifth.⁴ Various modifications to meantone tuning have been created which attempt to spread the wolf-tone error between several fifths thereby providing more usable keys. Systems such as this, which use more than one size fifth, are known as "irregular temperaments" and have been very important in the history of tuning.

Equal temperament is generally thought of as a modern development which became standardized in the 19th century; in fact, it has been in existence, at least theoretically, as long as any of the other major systems. Aristoxenus suggested it in the 3rd century B.C. It was commonly used for fretted instruments from about 1500 and was becoming common for clavier (non-organ keyboard instruments) after 1700. In an equally tempered scale all the fifths are slightly flatter and thirds are sharper than in just intonation. All half-steps are the same size and there is no difference in enharmonic notes. All intervals in all keys are equally distorted and all are usable. While an equally tempered scale always behaves in the same way, various methods have been

⁴ John Backus, The Acoustical Foundations of Music (New York: Norton, 1969), p.124.

used to derive it. The standard method today is to divide the octave into 12 proportional parts in which each part equals the $\sqrt[12]{2}$. Previous to the use of logarithms, various mechanical and geometric procedures were used to find the necessary mean proportionals. Lute and Viol makers often used (in some cases still use) the simple but not quite accurate method of placing each fret according to the ratio 18:17, which gave a half-step of 99 cents and could be adjusted to keep the error from accumulating.

II

After its introduction in the 16th century, meantone temperament became accepted as the standard method for tuning keyboard instruments. It remained the basis for keyboard tuning and general theory for the next three centuries. It is very important, however, to note that it was the basis of understanding and not a steadfast rule. The basic tenets of meantone temperament, that the fifths must be lowered and that sharps are lower than flats, were accepted as basic truths long after strict $1/4$ comma meantone tuning had been abandoned for more versatile variations, including what amounted to equal temperament. It should also be noted that throughout its period of influence, meantone temperament existed side by side with equal temperament, which was recognized as the correct method of tuning fretted instruments. Although of lesser importance, Pythagorean and just tunings were also of some influence at least theoretically in certain areas, violin playing and vocal technique in particular. This simultaneous use of different tuning systems is a curious and difficult-to-explain fact of the period prior to the general use of equal temperament. Obviously, one important point to remember when dealing with tuning practice in the 18th century is that no one discovered equal temperament: it already had an established place. The adoption of equal temperament was a gradual evolutionary process controlled by the demands of the music, the peculiarities of the instruments, and the weight of past conventions.

Today the term "meantone temperament" is rather loosely applied to that group of tunings which are related to Aron's $1/4$ comma system. In the 17th and 18th centuries "meantone temperament" would have meant no more to a musician than the terms "Baroque" and "Classical". Tunings

were either equal, just, or tempered. Most systems were tempered but in a great many ways and to varying degrees. It was generally recognized that in practice the octave would have 19 pitches, and that the sharps would be lower than the flats. This would be true for both just and tempered based systems. The 19-tone octave poses an immediate problem for the 12 tone keyboard. Forced to pick between enharmonic accidentals, the standard practice was to use C#, Eb, F#, G#, and Bb. With these choices the most consonant keys would be those with the fewest accidentals. Barbour⁵ notes that it was not uncommon for players to re-tune several notes, in effect transposing the temperament so that more distant keys would be playable. For example, changing Eb to D# would make G major the most consonant and E major possible. This would be a workable solution since the majority of pieces were within a twelve note compass. It would, however, be quite impractical in certain performance situations, such as opera, and impossible on organ. The need for more flexible systems spurred the theorists to create many temperaments which would provide a greater choice of keys, and more importantly, greater chromatic freedom within the common keys.

One solution was to simply split the black keys across the middle and add extra notes. Keyboards, especially organs, were built with split keys from the 15th century through the 18th, but were never considered standard practice. The obvious explanation is that the complications of construction and performance involved with the additional mechanism were not worth a few additional notes. Donald Hall⁶ insists

⁵J. Murray Barbour, "Bach and the Art of Temperament", Musical Quarterly, Fall, 1947, p. 73.

⁶Donald Hall, "The Objective Measurement of Goodness-of-fit for Tunings and Temperaments," Journal of Music Theory, XVII/2 (Fall, 1973), 287.

that an additional Ab or D# wouldn't significantly help the distant keys of a meantone system even if they were available. According to his system of statistical measurement of "goodness-of-fit", connecting distantly related keys in a meantone system results in an accumulated error of a syntonic comma which is not greatly affected by one or two accidentals.

The more obvious solution is to tune the clavier strings in such a way that the bad intervals sound better and the good intervals still sound good. Many musicians and theorists sought a solution to this dilemma, and while all efforts had to end in compromise, many "good" temperaments did result. A "good" temperament was one which could be played in all keys. The common keys would sound best but all keys would be passable. These are also known as circulating temperaments since one can circulate around the circle of fifths. A keyboard tuned to a good temperament would be "well-tuned". This is not the same as equal temperament. The Germans had a very good word for equal temperament--"die gleichschwebende Temperatur, "the equally beating temperament",⁷--Bach was careful not to use it. Most of the good temperaments were irregular in nature. That is, they had fifths of different sizes. A good example is one of Thomas Young's⁸ temperaments in which six fifths are tuned pure and six are tempered by 1/6 comma. This is a practical system which could be realised by a competent tuner. Many of the systems proposed by Young, Neidhardt, Werkmeister, Marpurg, and others were such subtle mathematical exercises that they had little practical value.

⁷ Barbour, Tuning and Temperament, p. 194.

⁸ Barbour, Tuning and Temperament, p. 181.

The mathematicians were often more concerned with a symmetrical division of the syntonic comma than with how a tuning would sound, much less how it could be accomplished. In Barbour's words, these temperaments often represent "having fun with numbers".⁹

The irregular temperaments can be seen as a sizable and varied middleground between the traditional meantone varieties and the more equally tempered systems which were gaining prominence. The conservative 18th-century position is best represented by the temperament advocated by the famous organ builder Silbermann in which all fifths are lowered $1/6$ comma. Silbermann's fifths are not so flat as regular meantone, but the wolf is nearly as vicious. $1/6$ comma meantone was recommended by such important musicians as Quantz, Tosi, Telemann, and Leopold Mozart.¹⁰ These are very good references for any system, but it should be noted that most of these men were not keyboard players and thus had some enharmonic freedom.

The more progressive attitude is best exemplified by J. S. Bach. Bach did not support the rigorous theory and mathematics of true equal temperament, but in reality his keyboards were as equally tempered as most pianos today. By Barbour's¹¹ count only $1/3$ of Bach's clavier pieces would be playable on a meantone instrument, even considering the possibility of variable tuning. Only one in ten of his organ pieces would be playable in meantone. Bach probably knew Neidhardt's and

⁹ Barbour, Tuning and Temperament, p. 181.

¹⁰ John Hind Chesnut, "Mozart's Teaching of Intonation", JAMS, XXX, No. 2 (Summer, 1977), 287.

¹¹ Barbour, "Bach and....Temperament", p. 88.

Werckmeister's temperaments which approximated equal temperament, but in all likelihood he did his own tuning by counting beats as Mersenne suggested and as is done today. It was said that he could tune a harpsichord in 15 minutes.

In order to obtain correctly proportional fret placement on an instrument in equal temperament it is necessary to find the value of the $\sqrt[12]{2}$. To do this one must first find the cube root of two, $\sqrt[3]{2}$. This is the classic problem of two mean proportionals, $\frac{a}{b} = \frac{b}{c} = \frac{c}{d}$. Once $\sqrt[3]{2}$, which equals the major third, is obtained the other intervals can be obtained by simpler proportional operations using the square root.¹² The problem for instrument makers was to find the cube root without the aid of logarithms or the complex arithmetic extraction procedure. As previously mentioned, most makers used the simple ratio of 17:18 to place the first fret and either repeated the process for the other frets (while allowing for a slight error) or found the rest by simple proportions. Both of these methods can be quite accurate, since the original error between 17:18 and $\sqrt[12]{2}$ is much less than the width of a gut fret. The extraction of the cube is impossible using basic geometry, but other more complex geometrical solutions are possible. There was considerable interest in these methods in the 16th century. While these very complicated procedures were theoretically accurate, they were limited by the accuracy obtainable with pen and ruler. The one constant in the theoretical interest in equal temperament is the obsession with accuracy. The first numerical values for equal temperament appeared around 1600. Over the next 200 years many mathematicians searched for the most precise division of the octave. Their computations were usually carried

¹²Dr. Brock Dale of the Kansas State Univ. Physics Dept. was most helpful in clarifying the technical aspects of mean proportionals and equal temperament.

out to nine to eleven decimal places. This obsession with numbers, which seemed useless and confusing to most musicians, was probably the reason Bach and others were unwilling to accept true equal temperament.

A more philosophical objection to equal temperament was that the different keys would no longer have distinctive characters. It is true that meantone temperament does sound different than equal temperament. The lower fifths would be most obvious to modern ears and the just third would give a chord a certain smoothness. An increase in harshness can be heard as one moves from C and G to the region of D and A. These are subtle changes. A light, pleasant Couperin harpsichord piece might gain a certain nuance when played in its original temperament (if we knew what that was) but it is still light and pleasant in equal temperament. The notion that composers used the enharmonic dissonances of the less common keys for dramatic effect has little support. An occasional piece can be found which extends into the more dissonant regions of meantone temperament, but these pieces seem more experimental than dramatic. The vast majority of pieces stayed safely within a twelve note compass. The harmonic quality of meantone temperament deteriorates very quickly when the normal compass is exceeded. Also, as Barbour notes,¹³ the tuning practice was so varied that a predictable excursion into enharmonic intervals would be impossible.

The relationship between meantone and equal temperament is the main issue in tuning in the 18th century, but the older systems, Pythagorean and just intonation, were also of some influence and had their supporters, especially among some theorists and mathematicians. The common attribute of Pythagorean and just intonation is the pure fifth. The influence of

¹³Barbour, "Bach and...Temperament", p. 73.

the pure fifth is most obvious in violin and vocal practice.

Tuning by fifths is a necessity on the violin, both because the strings are a fifth apart and because the lack of fretts precludes tuning unisons. The natural tendency is to tune the fifths pure as is the practice today. Pure fifths will work for equal temperament since the equally tempered fifth is only 2 cents lower than just. If meantone intonation is attempted the error will become more apparent. Rameau said that "able masters" lowered their fifths¹⁴ (to conform to meantone intonation). It seems likely that the "able masters" would also tune to pure fifths when playing with keyboards which were often very close to equal temperament. In fact many 18th-century irregular systems contained more pure fifths than impure; this would put a justly tuned violin precisely on the mark. Although meantone intonation was probably the ideal and equal temperament quite common, one should be aware of what Rameau's statement implies--with the exception of the "able masters" most players probably tuned justly and hoped for the best no matter what the performance situation. It is of interest to note that the best players of the 18th century used the violin's flexibility to play their sharps lower than their flats. This was true even in Mozart's day.¹⁵ The first mention of the modern practice of raised sharps, which would conform to a Pythagorean influenced system, was in a treatise by Campagnoli in 1797.¹⁶

¹⁴J. Murray Barbour, "Violin Intonation in the 18th Century", JAMS, 5, No. 3 (Fall, 1952), 234.

¹⁵Chesnut, p. 260.

¹⁶David D. Boyden, The History of Violin Playing from Its Origins to 1761, (London: Oxford Univ. Press, 1965), p. 371.

As mentioned previously, just intonation was the darling of many theorists and mathematicians. The violin and the voice, with their inherent flexibility, were often held up by this group as examples of the rightness of just intonation. It seemed logical to these men, Zarlino included, that given a flexible instrument and left to their own devices musicians would naturally play just intervals. While three violins could probably play a reasonably just triad on command, the possibility of a choir performing an entire piece in just intonation is highly unlikely. A just major third is not an especially easy interval to hear, but supposing a choir could all hit it accurately they would then have to be able to vary it by a syntonic comma depending on its usage in the music.¹⁷ It has been shown that pitch stability in the human voice is not consistent enough for this even if vibrato is not considered.

The 18th-century music instruction book The Modern Music Master (1731) by Peter Prelleur contains a violin fingering chart which is both evidence of the influence of just intonation and an example of the gap between theory and practice. This chart has been exhaustively examined by J. Murray Barbour¹⁸ and David D. Boyden,¹⁹ who both conclude that it was intended for some form of just intonation. Unfortunately, what first appears to be a possible key to 18th-century performance practice turns out to be the work of a careful mathematician following his theories in the face of the haphazard approach of the

¹⁷ Barbour, Tuning and Temperament, p. 198.

¹⁸ Barbour, "Violin Intonation", p. 224-234.

¹⁹ David D. Boyden, "Prelleur, Geminiani, and Just Intonation", JAMS, 4, No. 3 (Fall, 1951), 202-219.

practicing musician. The chart makes a careful distinction between sharps and flats. Barbour estimates that all of divisions on the chart are within 3 or 4 cents of the correct mathematical value, and that many are within 2 cents which is as close as one can get with a pen and ruler (2 cents is equivalent in length to 12 parts in 10,000). By contrast, the violin instructions in the text describe the method of obtaining sharps as sliding the finger up the fingerboard "about half an inch farther than it was before".²⁰ Obviously the writer is not concerned with accuracy to within 12 parts in 10,000. Barbour also points out that had a student pasted this chart onto his fingerboard and learned to follow it carefully, his attempt to play with a harpsichord tuned to either meantone or equal temperament would have been a sad realization of just intonation's limitations. The purity and logic of just intonation has repeatedly seduced theorists over the years, but the hard fact remains that it will not work without many more than 12 notes to the octave.

The question of woodwind intonation is very complicated. In addition to the gap between the ideals of the finest players and the reality of the common musician, the characteristics of the instruments limited the flexibility of the performer. The principle woodwind instruments, oboe, bassoon, and transverse flute, were developed in the second half of the 17th-century. Within the next 40-50 years they were firmly established with widely available instruction books and well-known virtuosi.

The case of the transverse or German flute is perhaps the best documented of the principle woodwinds. Early in the 17th-century the transverse flute was a very simple consort instrument, a cylinder with a mouth

²⁰Barbour, "Violin Intonation", p. 232.

hole and six finger holes. This instrument has a pleasing tone but intonation is difficult. Praetorius (1620)²¹ and Mersenne (1636)²² give fingering charts for the transverse flute as well as other woodwinds. These charts make no distinction between sharps and flats. This would seem to indicate equal temperament; Mersenne does, in fact, advocate equal temperament for the wind instruments. Despite Mersenne's support, equal temperament was not common at this time except for fretted instruments. It would seem more likely that the lack of subtlety in the fingering charts reflects the lack of precision in the intonation of the instruments and the less refined demands of consort playing.

During the last half of the 17th-century the transverse flute was evolving into an important solo instrument, especially in France where it underwent considerable modification. It was divided into three sections with a separate head and foot joint. The bore was changed to an inverted conical shape and a key was added which permitted D# (the half-step above the lowest note) to be played. These changes produced an instrument which was more responsive and permitted the player more control of pitch and nuance. One of the best known players of this instrument was Jacques Hotteterre. His treatise Principes de la Flute Traversiere, de la Flute a Bec, et du Haut-bois (Principles of the Flute, Recorder and Oboe), 1707,²³ was the principle flute method during the first

²¹Nicholas Bessaraboff, Ancient European Musical Instruments (Cambridge: Harvard Univ. Press, 1941), appendix A.

²²Marin Mersenne, Harmonie Universelle: The Books on Instruments, trans. by Roger E. Chapman (The Hague: Martinus Nijhoff, 1957), p. 313.

²³Jacques Hotteterre le Romain, Principes de la Flute Traversiere de la Flute a Bec, et du Haut-bois, trans. by David Lasocki (New York: Frederick A. Praeger, 1968).

half of the 18th century. Most other flute methods from this period, including The Modern Music Master already mentioned, either borrowed heavily from Hotteterre's text, or were outright copies. Hotteterre's attitude toward temperament is rather inconsistent. The enharmonic notes F#-Gb, D#-Eb, and the high C#-Db are given separate fingerings. The player is told to make a distinction between other enharmonic notes by rolling the flute in and out, and by using certain trill fingerings. Other notes, A#-Bb, "are the same".²⁴ The beginner is told not to attempt these small pitch variations. But it is stated that they are necessary "for perfection".²⁵ The presence of the enharmonic notes indicates an extended meantone temperament to be the desired result. Hotteterre obviously differentiated between sharps and flats but he doesn't seem to expect everyone to do likewise. This casual attitude became less prevalent in the next 25 years, at least in print. The fingering chart in The Modern Music Master (1731) gives separate fingerings for all the sharps and flats.

After Hotteterre, the most important source of woodwind information and musical performance information in general is J. J. Quantz's²⁶ Versuch einer Anweisung die Flöte traversiere zu spielen (On Playing the Flute), 1752. Quantz was a virtuoso musician in the court of Frederick the Great of Prussia. All of Quantz's work shows meticulous care about

²⁴Hotteterre, p. 52.

²⁵Hotteterre, p. 53.

²⁶J. J. Quantz, Versuch einer Anweisung die Flöte traversiere zu spielen, trans. by Edward R. Reilly (New York: Free Press, 1966).

details. His fingering charts²⁷ give separate fingerings for all enharmonic notes and provide suggestions to help the more difficult notes. Quantz's devotion to meantone temperament is clearly demonstrated by the addition he made to his own instrument--a second key to provide Eb in addition to D#. Another feature which was common to all flutes of Quantz's day was an additional joint in the body. By substituting different sections one could compensate for the great variety of pitch encountered in keyboard instruments. In the hands of a master like Quantz the one-keyed (in Quantz's case two-keyed) flute could be played as well in tune as a violin. But since "only a minority of flute players"²⁸ observed his rules it was probably often played rather out of tune, also like the violin. In simple wind instruments the placement and number of tone holes is largely determined by the availability of fingers to cover them. Because of this the scale beginning with the lowest note of the instrument (D on flute, F on recorder) can be tuned fairly accurately but the more chromatic keys can only be played by using various forked fingerings and embouchure techniques which compromise both tone and intonation.²⁹ From 1650 to 1750 the development of woodwind technique advanced much further than the physical development of instruments. Because of this only the very best players obtained the degree of pitch accuracy available to the player of a modern instrument. Quantz's performance standards were as high as any today but only a very few of his

²⁷Quantz, p. 43.

²⁸Quantz, p. 55.

²⁹Trevor Robinson, The Amateur Wind Instrument Maker (Boston: Univ. of Mass. Press, 1973), p. 7.

fellow musicians were able to obtain them.

It is important to consider what the tuner had to work with and what results he was likely to achieve, amid the myriad of tuning systems subtly shifting a $1/6$ comma this way and $2/7$ that way. The standard instrument of tuning practice was the monochord, a single string on a resonator box with two moveable bridges which could be set to mathematically determined string lengths. Selection of a reference pitch was very arbitrary. Tuning forks were available but not common. Small, roughly calibrated tuning whistles were also available.³⁰ To tune a harpsichord with a monochord the middle octave is tuned to the monochord values and the rest of the keyboard is tuned by octaves. This is a workable method, but the monochord values must be set very carefully and once the monochord is changed the original pitch is lost. There is also the problem of tension variation in the monochord string. With the organ it is very difficult to accurately tune a pipe to a string because of the great difference in tone color and volume.³¹ Because of the limitations and inconvenience of the monochord, most tuning was done by counting the beats of the fifths. The beating fifth is the key to realizing any tuning system, even $1/4$ comma meantone which is based on the just third. Although the major third can be tuned so that it will not beat, it is so difficult to hear accurately that it is safer to tune by a series of equally distorted fifths. The language and theory of tuning and temperament was much more familiar to the 18th-century musician than it is to us with our standardized equal temperament. There is no

³⁰ Barbour, Tuning and Temperament, p. 85.

³¹ Barbour, Tuning and Temperament, p. 85.

reason to doubt that the musicians and tuners of the day had very specific intentions and goals in mind when they began a tuning job, but whatever tuning or irregular temperament was attempted, the final fine adjustment was accomplished by the tuner's sense of what sounded good, not by a set of mathematician's monochord values.

The one consistent thing in 18th-century tuning and temperament is its inconsistency. When faced with the great variety of tuning possibilities, one's natural reaction is to develop some criteria to sort out the good from the bad. Barbour compared all the systems to equal temperament. The closer a system came to equal divisions the better it was. This can give the reader some idea of the nature of a system, but it is not historically valid. As long as a composer writes in the common keys within a twelve-note compass, meantone will work quite as well as equal temperament. Deviation from equal temperament merely shows a system to be different, not better or worse.

Donald Hall has devised a computer program which considers all eleven intervals above each chromatic note (producing 132 intervals) within a given system. Deviation numbers are assigned to these intervals by comparing them to "intune" values based on small integer ratios (5th=3:2, 4th=4:3, Maj.3rd=5:4, etc.). When the deviation values are taken times the number of corresponding intervals in a piece or group of pieces a total deviation number is produced which shows the relationship between a particular piece and a specific scale. The lowest total number is the best fit. This system has some faults. The most obvious is the question of deciding what is consonant and what is not. For example, the sharp Pythagorean thirds in a medieval piece inflates its error figure even though they were the standard practice of the day. Despite some problems, Hall's system makes some valid and very interesting

observations. The main points are that equal temperament works best for chromatic harmony and meantone works best for 17th and early 18th century music. It's nice to know that all those composers were on the right track.

Various temperaments of Kirnberger, Silbermann, and their contemporaries are currently in vogue with organ builders wishing to achieve authenticity. The question of which one is best is actually moot. The best one is the one which produces the sound which the builder likes, just as it has always been. As far as authenticity is concerned, a good tuner given a pitch pipe and the instructions to tune the organ to equal temperament would be just as authentic and perhaps closer to the truth.

The problem of two different systems working together, a solo flute with accompaniment for example, was approached in several ways. Sorge, an organist, felt the soloist should conform to the temperament of the accompanying instrument.³² Quantz, a flute soloist, naturally disagreed. He felt the accompanist should be aware of notes that were in disagreement and either leave them out or hide them in the middle of a chord. Quantz does note that these subtle differences cannot be heard in a large group and are therefore not a problem.³³ This observation by Quantz suggests a parallel: the general adoption of equal temperament coincides with the rise of the piano with its multiple strings and rich sonority which can cloud the subtleties of intonation. An overview of the 18th-century tuning situation finds the keyboard becoming more and more equally tempered even though its practitioners were resistant to the complex formulas of true equal temperament. The non-keyboard soloists adhered to an extended system based on meantone theory, and the second violins in the back of the section got by any way they could.

³²Chesnut, p. 250.

³³Quantz, p. 261.

GLOSSARY

Cent*--The unit of interval measure. The hundredth part of an equal semitone, with ratio $1200\sqrt[12]{2}$.

Circulating Temperaments--Temperaments in which all keys are playable, but in which keys with few sharps or flats are favored.

Comma--A tuning error, such as the interval B#-C in the Pythagorean tuning. See Ditonic Comma and Syntonic Comma.

Ditonic Comma--The interval between two enharmonically equivalent notes, as B# and C, in the Pythagorean tuning. Its ratio is 531441:524288 or approximately 74:73, and it is conventionally taken as 24 cents.

Duplication of the Cube--A problem of antiquity, equivalent to finding two geometrical means between two quantities one of which is twice as large as the other, or to finding the cube root of 2.

Equal Temperament--The division of the octave into an equal number of parts specifically into 12 semitones, each of which has the ratio of $12\sqrt[12]{2}$.

Good Temperament--See Circulating Temperaments.

Irregular System--Any tuning system with more than one odd-sized fifth, with the exception of just intonation.

Just--Pure: A term applied to intervals, as the just major third.

Meantone Temperament--Strictly, a system of tuning with flattened fifths and pure major thirds.

Monochord--A string stretched over a wooden base upon which are indicated the string-lengths for some tuning system; a diagram containing these lengths; directions for constructing such a diagram.

Monopipe--A variable open pipe, with indicated lengths for a scale in a particular tuning system, thus fulfilling a function similar to that of a monochord.

Multiple Division--The division of the octave into more than 12 parts, equal or unequal.

Pythagorean Tuning--A system of tuning based on the octave (2:1) and the pure fifth (3:2).

Regular Temperament--A temperament in which all the fifths save one are of the same size, such as the Pythagorean tuning or the meantone temperament. (Equal temperament, with all fifths equal, is also a regular temperament, and so are the closed systems of multiple division.)

Split Keys--Separate keys on a keyboard instrument for such a pair of notes as C# and Ab.

GLOSSARY

Syntonic Comma--The interval between a just major third (5:4) and a Pythagorean third (81:64). Its ratio is 81:80 and it is conventionally taken as 22 cents.

Temper--To vary the pitch slightly. A tempered fifth is specifically a flattened fifth.

Temperament--A system, some or all of whose intervals cannot be expressed in rational numbers.

A Tuning--A system all of whose intervals can be expressed in rational numbers.

Unequal Temperament--Any temperament other than equal temperament, particularly the meantone temperament or some variety thereof.

Varieties of Meantone Temperament--Regular temperaments formed on the same principle as the meantone temperament, with flattened fifths and (usually) sharp thirds.

Wolf Fifth--The dissonant fifth, usually G#-Eb (notated as a diminished sixth), in any unequal temperament, such as the meantone wolf fifth of 737 cents.

*All definitions are from J. Murray Barbour's Tuning and Temperament.

SCALE VALUES IN CENTS

Equal Temperament

C	C#	D	E ^b	E	F	F#	G	G#	A	B ^b	B	C
0	100	200	300	400	500	600	700	800	900	1000	1100	1200

Pythagorean Tuning

C	C#	D	E ^b	E	F	F#	G	G#	A	B ^b	B	C
0	114	204	294	408	498	612	702 *	816	906	996	1110	1200

Just Intonation

C	C#	D	E ^b	E	F	F#	G	G#	A	B ^b	B	C
0	70	204	316	386	498	590	702	772	884	1018	1088	1200

Meantone Tuning
(Fifth is 1/4 comma flat)

C	C#	D	E ^b	E	F	F#	G	G#	A	B ^b	B	C
0	76	193	310	386	503	579	697	773	890	1007	1083	1200

Meantone Tuning

(Fifth is 1/6 comma flat, with enharmonic equivalents)

C	C#	D	E ^b	E	F	F#	G	G#	A	B ^b	B	C
0	89	197	305	394	502	590	698	787	895	1003	1092	1200
	D ^b	D#		F ^b	E#	G ^b		A ^b	A#		G ^b	B#
	108	286		413	483	609		806	984		1111	1182

* _____ = pure interval

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A SURVEY OF TUNING AND TEMPERAMENT IN THE 18th CENTURY
AND THE ATTITUDES REGARDING ITS IMPLEMENTATION

by

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A SURVEY OF TUNING AND TEMPERAMENT IN THE 18th CENTURY
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An Abstract

The report describes the four basic systems of tuning and temperament which have been important in Western music. These are Pythagorean tuning, just tuning, meantone temperament, and equal temperament. These basic systems are then examined further in terms of their use and influence in the 18th century. Pythagorean tuning and just tuning were of minor importance. They were of interest to theorists and had some influence on violin and vocal technique. Meantone temperament was the accepted theoretical basis of intonation. Its extended form was the ideal of the better string and wind players such as Leopold Mozart and J. J. Quantz. Many variations on meantone temperament were applied to the keyboard. In practice many of these were closer to equal temperament than to original meantone temperament. Equal temperament was the accepted system for fretted instruments and of great interest to theorists. Its rigorous mathematical base hampered its acceptance by the practicing musician. Tuning practice was generally very inconsistent with different tunings being used simultaneously. Performance standards varied from excellent very poor. Consequently, the subtler aspects of temperament were not always present in performance. The gradual acceptance of equal temperament in the 18th century was an evolutionary development of meantone-related practice and not a sudden acceptance of the established equal temperament theories.