I noticed that one of his cymbals had three little holes drilled in it, seemingly in random locations, and wondered if they had to do with attempts to perfect its tone. Was there a nasty little zing to the sound that a skilled craftsman could eliminate by drilling a hole? And as he played on that cymbal I noticed how different the tone was at the center than at the edge. If he did a light roll starting in the middle and moving to the perimeter he produced a subtle kaleidoscope of tone.

The bassist gave a great account of himself—always rhythmic, always exploiting and driving the direction of the harmonies, often filling in intervals with colorful ruffles of notes, sometimes stepping forward to play and improvise on the melody. He would lean forward, seemingly embracing the instrument, to reach high notes and put his pizzi-fingers closer to the bridge. He would stand straight, throwing his head back to let free the full sound of instrument. And the three of them were in constant contact with each other, celebrating a sneaky unexpected move with a grin or a wink or showing a moment of disbelief as one took off toward new horizons.

All this talk of color reminds me of a brief scene in my favorite story, the twenty-one volume epic tale of Captain Jack Aubrey of the Royal Navy and his friend, ship's surgeon and secret agent Stephen Maturin, written by Patrick O'Brian, a story that spans more than twenty years of the Napoleonic Wars. Jack plays the violin, Stephen the cello, and as they sail the oceans of the world they play their own versions of the great works of chamber music. In *Post Captain*, the second novel of the series, Jack has been injured in a battle and Stephen has prescribed some nasty medications. It was a stunning battle in which Jack's ship roundly defeated a French squadron, and as a result Jack was promoted from Commander to Post Captain. Jack and Stephen had attended a party at the home of an Admiral whose wife (known to Jack as "Queenie," a sort of nanny from his youth) was showing off a recently acquiring breezy, somewhat salacious painting of an "as of yet unrepented" Mary Magdalene:

> [Jack] had gone to bed at nine, as soon as he had swallowed his bolus and his tankard of porter, and he had slept the clock round, a sleep full of diffused happiness and a longing to impart it—a longing too oppressed by languor to have any effect. Some exquisite dreams: the Magdalene in Queenie's picture saying, "Why do not you tune your fiddle to orange-tawny, yellow, green, and this blue, instead of those old common notes?" It was so obvious: he and Stephen set to their tuning, the 'cello brown and full crimson, and they dashed away in colour alone—such colour![2]

What a lovely image—perhaps for Jack the result of too much marsala, but for organists an inspiration to exploit the depths of the instrument. You will fill the seats at your recitals if the audience knows they can expect the unexpected. A little musical wink as a humorous note or two gets soloed out, a zig when it might have been a zag, a hint of the pompous, the shy, the frightened, the regal. Your scholarship is the foundation of your music-making, not its principal purpose. Organbuilders are on a constant quest to create the sounds, to squirt the paint from the tubes onto the palette—the organists draw those squirts of paint together, blending the colors, scooping them out of the organ case or chamber, and applying them to the canvas, which is the acoustics of the room and the ears of the listeners. Make the most of it. ■

Notes

1. Perfect parabola.
2. Patrick O'Brian, *Post Captain*, W. W. Norton, 1990, page 421.

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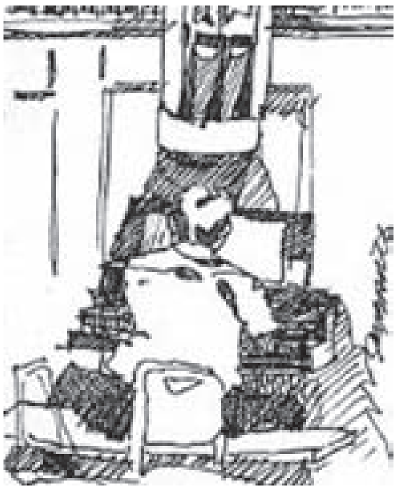
On Teaching
by Gavin Black



Intervals, tuning, and temperament, part 2

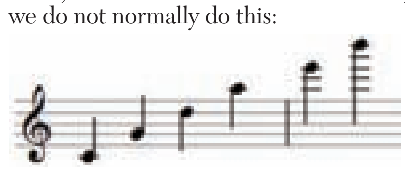
Last month I wrote about some of the fundamentals underlying the art of keyboard temperament: aspects of the nature of musical sound and of intervals, the overtone series, and the so-called circle of fifths. This month I want to discuss keyboard temperament itself, using last month's column as a foundation. I will talk about why temperament is necessary, what the major approaches to temperament have been over the centuries, some of what the different systems of temperament set out to accomplish, and about how different temperaments relate to different historical eras. Next month I will also discuss the practicalities of tuning and a few miscellaneous matters related to tuning and temperament.

As I said last month, my main point is to help students become comfortable with tuning and temperament and to develop a real if basic understanding of them, regardless of whether they are planning to do any tuning themselves. Before describing some of the essential details of several tuning systems, I want to review how we discuss tuning and how our thinking about tuning is organized, so that the descriptions of different temperaments will be easy to grasp.

1) For purposes of talking about tuning, **octaves are considered exactly equivalent**. (This of course is no surprise, but it is worth mentioning.) The practical point of this is that if I say, for example, that "by tuning up by a fifth, six times in a row, I get from C to F#" I do not need to say that I also have to drop the resulting F# down by three octaves to get the simple tritone (rather than the augmented twenty-fifth); that is assumed. To put it another way, simple intervals, say the perfect fifth, and the corresponding compound intervals, say the twelfth or the nineteenth, are treated as being identical to one another.

2) **Intervals fall into pairs that are inversions of one another**: fifth/fourth; major third/minor sixth; minor third/major sixth; whole tone/minor seventh; semitone/major seventh. For purposes of tuning, the members of these pairs are interchangeable, if we keep direction in mind. For example, tuning up by a fifth is equivalent to tuning down by a fourth. If you are starting at C and want to tune G, it is possible either to tune the G above as a fifth or the G below as a fourth. It is always important to keep track of which of these you are doing or have just done, but they are essentially the same.

3) When, in tuning a keyboard instrument, we tune around the circle of fifths, we do not normally do this:



but rather something like this:

going up by fifths and down by fourths—sometimes up by fourths and down by

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fifths—in such a way as to **tune the middle of the keyboard first**, thus creating chords and scales that can be tested.

4) **In tuning keyboard instruments we purposely make some intervals impure**: that is, not perfectly (theoretically) in tune. When an interval is not pure it is either *narrow* or *wide*. An interval is wide when the ratio between the higher note and the lower note is greater than that ratio would be for the pure interval; it is narrow when the ratio is smaller. For example, the ratio between the notes of a pure perfect fifth is 3:2, that is, the frequency of the higher note is 1½ times the frequency of the lower note. In a narrow fifth, that ratio is smaller (perhaps 2.97:2), in a wide fifth it is larger (perhaps 3.05:2). Here's the important point—one that students do not always realize until they have had it pointed out: making an interval *wide* does not necessarily mean making some note *sharp*, and making an interval *narrow* does not necessarily mean making some note *flat*. If you are changing the higher note in an interval, then raising that note will indeed make the interval wider and lowering it will make the interval narrower. However, if you are changing the lower note, then raising the note will make the interval narrower and lowering it will make the interval wider.

5) **Tuning by fifths (or the equivalent fourths) is the theoretically complete way to conceive of a tuning or temperament system.** This is because only fifths and fourths can actually generate all of the notes. That is, if you start from any note and tune around the circle of fifths in either direction, you will only return to your starting note after having passed through all of the other notes. If you start on any given note and go up or down by any other interval, you will get back to your starting note without having passed through all of the other notes.[1] For example, if you start on c and tune up by major thirds you will return to c having only tuned e and g#/a♭. There is no way, starting on c and tuning by thirds, to tune the notes c#, d, d#, f, f#, g, a, b♭, or b. Tuning is sometimes done by thirds, but only as an adjunct to tuning by fifths and fourths. Any tuning system can be fully described by how it tunes all of the fifths.

6) As I mentioned last month, **tuning two or more in a row of any interval spins off at least one other interval**. For example, tuning two fifths in a row spins off a whole tone. (Starting at c and tuning c–g and then g–d spins off the interval c–d). Tuning four fifths in a row spins off a major third. (Starting at c and tuning c–g, g–d, d–a, a–e spins off the interval c–e). The tuning of the primary intervals—pure, wide, or narrow—utterly determines the tuning of the resulting (spun-off) interval. For example, tuning four *pure* perfect fifths in a row spins off a major third that is *wider* than the theoretically correct 5:4 ratio: very wide, as a matter of human listening experience. Tuning three *pure* fourths in a row (c–f, f–b♭, b♭–e♭, for example) spins off a minor third that is *narrower* than the theoretically correct 6:5.

So, what is temperament and why does it exist? **Temperament is the making of choices about which intervals on the keyboard to tune pure and which to tune wide or narrow, and about how wide or narrow to make those latter intervals.** Temperament exists, in the first instance, because of the essential problem of keyboard tuning that I mentioned last month: if you start at any given note and tune around the circle of fifths until you arrive back at the starting note, that starting note will be out of tune—sharp, as it happens—if you have tuned all of the fifths pure. The corollary of this is that **in order to tune a keyboard instrument in such a way that the unisons and octave are in tune, it is absolutely necessary to tune one or more fifths narrow**. This is a practical necessity, not an esthetic choice. However, decisions about how to address this necessity always involve esthetic choices.

There are practical solutions to this practical problem, and the simplest of them constitutes the most basic temperament. If you start at a note and tune eleven fifths, but do not attempt to tune the twelfth fifth (which would be the out-of-tune version of the starting note), then you have created a working keyboard tuning in which one fifth—the interval between the last note that you explicitly tuned and the starting note—is extremely out of tune. If you start with c and tune g, d, a, etc., until you have tuned f, then the interval between f and c (remember that you started with c and have not changed it) will be a very narrow fifth or very wide fourth. The problem with this very practical tuning is an esthetic, rather than a practical, problem: this fifth is *so* narrow that listeners will not accept it as a valid interval. Then, in turn, there is a practical solution to this esthetic problem: composers simply have to be willing to write music that avoids the use of that interval. This tuning, sometimes called Pythagorean, was certainly used in what we might call the very old days—late middle ages and early Renaissance. As an esthetic matter, it is marked by very wide thirds (called Pythagorean thirds) that are spun off by all of the pure fifths. These thirds, rather than the presence of one unusable fifth, probably are why this tuning fell out of favor early in the keyboard era.

The second-easiest way to address the central practical necessity of keyboard tuning is, probably, to divide the unavoidable out-of-tuneness of the fifths between *two* fifths, rather than piling it all onto one of them. For example, if in the example immediately above you tune the last interval, namely b♭–f, somewhat narrow rather than pure, then the resulting final interval of f–c will not be as narrow as it came out above. Perhaps it will be acceptable to listeners, perhaps not. Historical experience has suggested that it is right on the line.

In theory, what I just called the "unavoidable out-of-tuneness" (which is what theorists of tuning call the "Diatonic Comma" or "Pythagorean Comma") can be divided between or among any number of fifths, from one to all twelve, with the remaining fifths being pure. The fewer fifths are made narrow—that is, "tempered"—the narrower each of them has to be; the more fifths are left pure (which is the same thing), the easier the tuning is, since tuning pure fifths is the single easiest component of the art of tuning by ear.[2] The more fifths are tempered, the less far from pure each of them has to be; the fewer fifths are left pure, the more difficult the temperament is to carry out by ear.

Temperaments of this sort, that is, ones in which two or more fifths are made narrow and the remaining fifths are tuned pure, and all intervals and chords are usable, make up the category known as "well-tempered tuning." There exist, in theory, an infinite number of different well-tempered tunings. There are 4083 different possible ways to configure the choice of which fifths to temper, but there are an infinite number of subtly different ways to distribute the amount of out-of-tuneness over any chosen fifths. From the late seventeenth century through the mid to late nineteenth century, the most common tunings were those in which somewhere between four and ten or eleven fifths were tempered, and the rest were left pure. In general, in the earlier part of those years temperaments tended to favor more pure fifths, and later they tended to favor more tempered fifths. The temperament in which all twelve fifths are tempered and the ratio to which they are all tempered is the same (2.9966:2) is known as **equal temperament**. It became increasingly common in the mid to late nineteenth century, and essentially universal for a while in the twentieth century. It was well known as a theoretical concept long before then, but little used, at least in part because it is extremely difficult to tune by ear.

In well-tempered tunings and in fact any tunings, the choices about which fifths to temper affect the nature of the intervals other than fifths. The most important such interval is the major third. The importance of the placement of tempered fifths has always come largely from the effect of that placement on the thirds. Historically, in the period during which well-tempered tuning was the norm, the fifths around C tended to be tempered so as to make the C–E major third close to pure, in any case almost always the purest major third within the particular tuning. This seems to reflect both a sense that pure major thirds are esthetically desirable or pleasing and a sense that the key of C should be the most pleasing key, or the most restful key, on the keyboard. In general, well-tempered tunings create a keyboard on which different intervals, chords, and harmonies belonging to the same overall class are not in fact *exactly* the same as one another. There might be, for example, major triads in which the third and the fifth are both pure, alongside major triads in which the fifth is pure but the third a little bit wide, or the fifth pure but the third very wide, or the fifth a little bit narrow and the third a little bit wide. It is quite likely that one of the points of well-tempered tuning was to cause any modulation or roaming from one harmonic place to another on the keyboard to effect an actual change in color—that is, in the real ratios of the harmonies—not just a change in the name of the chord or in its perceived distance from the original tonic.

In equal temperament, all intervals of a given class are in fact identical to one another, and each instance of a chord of a given type—major triad, minor triad, and so on—is identical to every other instance of that chord except for absolute pitch. Next month I will discuss ways in which the esthetic of each of these kinds of temperament fit in with other aspects of the musical culture of their times.

The other system of tuning that was prevalent for a significant part of the history of keyboard music—from at least the mid sixteenth century through the seventeenth century and, in some places well into the eighteenth—is known nowadays as **meantone tuning**. (This term was not used at the time, and is now applied to a large number of different tunings with similar characteristics.) In a meantone tuning, there are usually several major thirds that are unusably wide and one or more fifths that are also unusable. In fact, the presence of intervals that must be avoided by composers is greater than in Pythagorean tuning. However, this is in aid of being able to create a large number of pure or nearly pure major thirds. This was, perhaps, as a reaction to the earlier Pythagorean tuning with its extremely wide thirds, considered esthetically desirable during this period. The mathematics behind the tuning of thirds tells us that, if two adjacent thirds are both pure, say c–e and e–g#, then the remaining third that is nestled within that octave (see above), in this case a♭–c, will be so wide that no ears will accept it as a valid interval. Therefore only two out of every three major thirds can be pure—that is, eight out of the twelve—and, if they are tuned pure, the remaining major thirds will become unusable. This, of course, in turn means that composers must be willing to avoid those intervals in writing music. It is striking that composers were willing to do so with remarkable consistency for something like two hundred years.

The distribution of usable and unusable thirds in meantone is flexible. For example, while it is possible to tune c–e and e–g# both pure, as mentioned above, it is also possible to tune c–e and a♭–c pure, leaving e–g# to be unusable. In the late Renaissance and early Baroque keyboard repertoire, there are, therefore, pieces that use g# and piece that use a♭, but very few pieces that use both. There are pieces that use d# and pieces that use e♭, but very few pieces that use both. There are many pieces that use b♭ and a few that use a#, but almost none that use both. There are very few keyboard pieces from before the very late seventeenth century that do not observe these restrictions. This is powerful evidence that whatever was accomplished esthetically by observing them must have been considered very important indeed. ■

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Notes

1. The semitone/major seventh will also generate all of the pitches, but it is essentially impossible to tune by ear and has never been the practical basis of a tuning system.

2. More about this next month.

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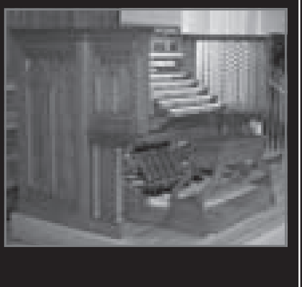

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