

THE "EVERY-WHICH-WAY" TEMPERAMENT SEQUENCE

A mechanical algorithm for aurally tuning a piano in equal temperament,
including additional material useful in learning the art of piano tuning.

(An algorithm is a procedure for solving a mathematical problem in a finite number of steps
that frequently involves repetition of an operation.)

by Kent Swafford, RPT

The most recent version of this document may be found at:

www.kentswafford.com/EWW/ewwt.pdf

Introduction

If one learns nothing else from this paper, one should learn the importance of using fourths and fifths “against” one another in a refinement procedure to improve a temperament after tuning through a temperament sequence.

The single, distinguishing characteristic of equal temperament is that chromatically ascending and/or descending intervals have smoothly progressing beat rates. The procedure for aurally tuning a piano in equal temperament “lays the bearings” for the tuning within a single octave in the middle of the piano, in this case, F3 to F4. The procedure for tuning the temperament octave in equal temperament starts with tuning each note to approximations of its proper beat rates, and then may be followed by a *separate* refinement procedure to tweak the approximations to achieve the smoothest possible progression of beat rates. The two-step procedure is useful because the exact beat rates necessary to achieve the smoothest possible progression of beat rates of “parallel intervals” will vary a bit from piano to piano due to the variability of inharmonicity. Inharmonicity varies both from piano to piano and through the scale of individual pianos.

How does one evaluate whether a piano is in tune or out of tune? Assuming that the piano was tuned in equal temperament, the definition of equal temperament provides a way of evaluating a tuning — play intervals chromatically up and down the scale and listen for changes in the sound of intervals, evidence of unequal temperament. What intervals? I might suggest octaves and fifths. It is not possible for *both* octaves *and* fifths to be clean-sounding if the piano is out of tune. One or the other might sound clean if the piano is out of tune but not both. Play octaves up down the scale by half-steps; the octaves should sound both clean *and* the same as each other. Similarly, play fifths up and down the scale in half-steps; the fifths should sound both clean *and* the same as all the other fifths. This procedure checks temperament *and* unisons. If an octave or fifth does not sound clean, then check the unisons of both notes of the offending interval. (“Clean” means that the interval has a beatless effect even if aural beat rate checks show the interval to be stretched.)

Preliminaries

The piano tech must have enough familiarity with the intervals of equal temperament that certain knowledge can be recalled immediately:

In equal temperament, all perfect fifths are “contracted”, while all perfect fourths are “expanded”.

Minor thirds are contracted, while major thirds are expanded. Major thirds are expanded, while minor thirds are contracted.

The piano tech must have knowledge of the approximate beat rates of the intervals of equal temperament in the temperament octave:

The beat rate of perfect fourths within the temperament octave may be about 1 beat per second.

The beat rate of perfect fifths within the temperament octave may be about 1/2 beat per second.

The beat rate of F3-A3 major third is about 7 beats per second and that of higher thirds are faster.

The piano tech must have general knowledge of the effect of changing the tuning of one note of an interval:

Raising the lower note of a properly expanded perfect fourth will slow the beat rate of the interval.

Raising the lower note of a properly contracted perfect fifth will increase the beat rate of the interval.

The piano tech must have general knowledge of the beat rates of intervals relative to the beat rates of other intervals: Assuming the octaves are stretched, fourths beat faster than fifths in the temperament octave and the beat rates of fourths and fifths can be inversely proportional. That is, if there is a fast fifth then there is likely a slow fourth somewhere or vice versa. This is the basis for an extremely powerful set of checks. If a properly expanded perfect fourth and a properly contracted perfect fifth have a common top or bottom note, and if you change the tuning of the common note, the width of both intervals will be changed; widening the intervals will speed up the beat rate of the fourth and at the same time will slow down the beat rate of the fifth; narrowing the intervals will slow down the beat rate of the fourth and speed up the beat rate of the fifth. This inverse relationship is one of the most powerful checks available in the tuning of equal temperament. The successful piano tuner will have learned to use these checks well. Check the relative beat rates of the fourth and fifth on one side of a note being checked. Example: to check the tuning of D4 within the temperament octave, play A3-D4 and G3-D4. The fourth should beat faster than the fifth. If the fifth is too fast and the fourth too pure perhaps the D4 is flat; if the fourth and fifth beat at the same rate, perhaps the D4 is flat; if the fourth beats too fast and the fifth is too pure, perhaps the D4 is sharp. Do not fail to learn to use 4ths and 5ths in this way.

Tips

Fast-beating Checks of the Slow-Beating Intervals

Do not proceed until you understand these most important facts about these checks:

The difference in beat rates between the M3rd and the M6th (in the M3-M6 test of the 4:3 P4th) is the beat rate of the fourth.

The difference in beat rates between the M6th and the M10th (in the M6-M10 test of the 3:2 P5th) is the beat rate of the fifth.

The difference in beat rates between the M10th and the M17th (in the M10-M17 test of the 2:1 octave) is the beat rate of the 2:1 octave.

The difference in beat rates between the M3rd and the M10th (in the M3-M10 test of the 4:2 octave) is the beat rate of the 4:2 octave.

The difference in beat rates between the M3rd and the M17th (in the M3-M17 test of the 4:1 double-octave) is the beat rate of the 4:1 double-octave.

Strip Muting

Strip mute the piano so that one string per note may sound.

Tuning Levers

In order to tune accurately and with stability, the successful piano tuner will wield a tuning lever with confidence. The skill with a tuning lever must be advanced enough to reliably make small changes in the tuning of individual strings, about half a cent or so.

Recommendation: a high-quality, light-weight lever from Charles Faulk, RPT

<http://www.faulkpiano.com/>
cfaulk2@Juno.com

Very short 20 degree head available from Jim Coleman, Jr., RPT.

<http://www.colemantools.com/>

A short head is light in weight, and because of the high angle, the handle will still clear struts. Try it before rejecting this idea!

Light weight wooden handle with 2" ball end. Ball allows variation in placement of hand on lever, promoting comfort; long wooden handle on the shaft promotes stiffness of the lever.

Titanium shaft, larger diameter provides sufficient stiffness while weighing significantly less than conventional steel.

Why should a hammer be light in weight? Light overall weight allows long hours of use with less fatigue and allows movement of hammer from pin to pin on a grand without moving hand away from the ball.

Hammer Technique

Ideally, one should place the lever on the pin so as to be parallel with string segment that runs between the tuning pin and front termination of the speaking length.

Ideally, one should push and pull on the lever handle only perpendicular to the handle. If you push or pull on the lever at any other angle than 90 degrees, effort will be wasted.

Ideally, one should push and pull on the lever only in a plane parallel to that of the plate. In order to accomplish this, you will need to place your elbow at the same height over the plate as your hand.

Grip the handle in such a way that your joints (fingers, wrist, and elbow) all are free to flex and provide shock absorption.

In pitch raising verticals, grab the handle and before pulling, lean with your whole body to provide some of the force necessary to turn the hammer.

Learn the "slow pull" lever technique for pianos that need it, such as older Steinway and Mason & Hamlin grands.

A lever technique that allows one to make small changes in the pitch of a string is essential. One technique that works on many pianos is to manipulate the lever back and forth (flat and sharp) in fast oscillations, exerting a bit more force with each oscillation until the pin moves; this allows one to exert just enough force to move the pin and make very small changes in the in the pitch of the string.

Protecting Hands

A glove may be useful for the hand that manipulates the tuning lever. A baseball batting glove with fingers cut off can provide a bit of support for the wrist and impede the formation of calluses on the tuning lever hand.

For pounding, fingertip protectors may be useful. For those techs who play test blows with their fingers, in dry climates calluses can build up, dry out and split open. This can all be avoided with the use of rubber fingertip protectors from the office supply store. They come in several sizes. The protectors provide enough cushioning to keep calluses from forming, keep the fingertips moist so they don't dry out, and in general can aid greatly in keeping the tech comfortable day in and day out while tuning. I use Acco Swingline Rubber Fingertips purchased from Office Depot.

<http://tinyurl.com/4xrys>

Different Temperament Sequences

There are many "bearing plans" or "temperament sequences" to tune equal temperament. It may be necessary to try many of them to find one that fits your particular aptitudes. There are many temperament sequences because a given tech may be unable to make a given sequence work correctly. The Every-Which-Way plan makes use of many checks early in the sequence. Sequences that use fewer checks may allow the tech to accumulate tuning errors as the sequence progresses. The beauty of the Every-Which-Way plan is that you can use more and more checks as one progresses through the sequence and tune each new note as a "best compromise" with all the previous notes, that is, each new note will not depend only on the last note tuned, so there will be more of a chance that errors will not accumulate in the later notes tuned. The last notes to be tuned in the sequence are tuned from many other previously tuned notes, that is, from "every which way."

The Every-Which-Way temperament incorporates aspects of other temperament sequences, including the Sanderson-Baldassin 2-Octave Temperament.

Stretch

The interval of the perfect fourth and the interval of the perfect fifth are inverted forms of the same interval. (That is, take the bottom note of a fifth and move it up an octave, and you now have a fourth.) In the mathematical model of equal temperament, perfect fourths and perfect fifths beat at much the same rate. But in the tuning of real pianos, fourths beat faster. Why? It is because of stretch. There exists the P4-P5 test of the 4:2 octave; that is, there is a check of the 4:2 octave that uses as a reference the note that is a perfect 4th above the lower note and the perfect 5th below the upper note. In this check, if the 4th and 5th beat exactly the same then the 4:2 octave is beatless or "just". But we generally do not tune octaves this way. When tuning octaves up the scale we generally raise the top note and slow the fifth down. As Alan Crane puts it, "Stretch happens." *If the fourths beat faster than the fifths, then there is sufficient stretch.*

Study Guides

Coleman Beat Locator

An excellent tool to learn about intervals, their partial relationships, and their beat rates is the Coleman Beat locator, now readily available from Jim Coleman Jr.

<http://www.colemantools.com/>

A modification of the Coleman Beat Locator morphs it into the "Swafford" Check Finder: <grin>

<http://www.kentswafford.com/EWW/CheckFinder.pdf>

Electronic Tuning Devices

An electronic tuning device can be a very powerful aid to learning aural tuning. Briefly, immediate feedback is available from an electronic tuning device if one tunes a note aurally, then steps to that note on the ETD and measures how close one actually came to a correct tuning of that note. (It is important that one tunes each note aurally without looking at a spinner or tuning display. It may help to cover the display with a device, perhaps a handkerchief, known as “the shroud of tunin’.” <groan>

The four professional quality electronic tuning devices are Reyburn CyberTuner, Verituner, the Sanderson Accutuner, and TuneLab. I highly recommend Reyburn Cybertuner.

www.reyburn.com
www.veritune.com
www.accu-tuner.com
www.tunelab-world.com

I have written a Piano Technicians Journal article on Reyburn Cybertuner:

<http://www.reyburn.com/innovations.html>

Carry Every-Which-Way Everywhere

Link to a PDF file which can be printed out, folded in half, or perhaps laminated, and carried as a field study guide.

www.kentswafford.com/EWW/EveryWhichWay.pdf

More Good Checks

A PDF file of a Piano Technicians Journal article entitled, “Temperament to the Top - Temperament to the Bottom”. The article contains a description of the “Walk Through the Neighborhood” and the “Chord of Nature”

<http://www.kentswafford.com/KESPTJ/TemperamentTopBottom.pdf>

Is it Double-Speak or is it Wisdom? (Zen and the Art of Piano Tuning)

“The secret to perfection in tunings is to give up trying for perfection.”

Elaboration — More correctly one might say that the secret to accomplishing the most nearly perfect tunings is NOT to try to get the beat rate checks to work out completely perfectly. The final refinement of a tuning is a fundamentally different type of activity than tuning through a temperament sequence in the first place. When tuning a temperament sequence, one must impose absolute beat rates, for example, 7 beats per second expanded in the F3-A3 major 3rd. However, no temperament sequence produces perfect results. At some point it is necessary to refine a temperament and breakaway from the absolute beat rates of a temperament sequence. The distinguishing characteristic of equal temperament is the smooth progression of beat rates. The refinement process should include extensive playing of parallel intervals while listening for inconsistencies in the progression of beat rates. Play intervals one at a time (all the major 10ths or all the double-octaves, for example) chromatically up and/or down the piano and listen for ones that sound different from the others, that is, listen for a M17th that doesn't like all the other M17ths. When an inconsistency is heard, the next step is to determine what are the fewest, smallest changes that may be made to improve the smoothness of the beat rate progression. Make no changes until it has been determined which individual note is flat or sharp. Determine which interval is too fast or too slow to fit into the progression, and then check the tuning of the two notes in the offending interval and determine which note is mistuned. Make changes to the tuning only to make an improvement in the tuning, not to create perfection. *Do not eliminate the good by seeking only the perfect.* Continue the process until the mistunings that are discovered are too small to bother with and/or until conflicting checks do not show mistunings but rather display the inconsistency in inharmonicity in the piano's scaling. When changes make no overall improvement in the tuning, then you are done. Make your best compromise. Absolute perfection will be impossible, but by tuning to the best compromise, close-to-perfection tunings will result. *Don't make it perfect; make it better. There is no perfection, only smaller and smaller imperfections.*

“Stretch is over-rated.”

Elaboration – As noted above, if the fourths beat faster than the fifths, then there is sufficient stretch. That's all.

“Zero in on perfect stretch by making clean, stretched octaves.”

Elaboration — If octaves are stretched, then they beat, that is, the checks will not show perfectly beatless relationships of the coincident partials. However, when the two notes of an octave are played together the overall effect should be a clean-sounding, beatless octave. Because there are multiple sets of coincident partials in the octave, there is a range of widths in tuning the octave that will yield a clean effect. Tune octaves so that the beat rate checks like the M3rd-M10th test of the 4:2 octave demonstrate that the interval is clearly stretched, but not stretched so far that the octave beats noticeably. In other words, stretch the octaves as much as possible as demonstrated by the beat rates checks without causing a noticeable beat in the octave itself.

“Temperament Sequences, including the Every Which Way Sequence, are over-rated.”

Elaboration — Great tuning can happen without the ability get a great temperament with a temperament sequence. The secret is to learn great refinement techniques to make an existing temperament better. Do the best temperament you can with a temperament sequence and then start your tuning refinement procedures. Refinement will help the successful tuner find and fix errors in the temperament. As Gregory Graham, RPT puts it, “If one is looking for the one-pass, bullet-proof, set-it-in-stone temperament sequence, then one is on a wild goose chase, wasting time, and asking the wrong question.”

“There are an infinite number of equal temperaments.”

It is much more important to stretch consistently than it is to stretch a lot or a little. Remember that the distinguishing characteristic of equal temperament is the smooth progression of beat rates. If one stretches a lot and the beat rates progress smoothly, then the tuning is equal temperament; if one stretches very little and the beat rates progress smoothly, then the tuning is equal temperament. This means that there are an infinite number of different tunings that can be called equal temperament. Although there is a mathematical model of equal temperament in which the fundamental frequencies increase evenly by a factor of the “twelfth root of two”, in the real world there is more than one equal temperament. Think of an expanding cup-holder as a model of equal temperament.

“If one must choose between tunings that feel right and tunings that check out right, go with the objective checks every time.”

From my personal experience I know that *feeling* good about a tuning does not guarantee that the tuning is actually good. Tunings that are a struggle and unsatisfying when they are over may be very good indeed. Emotions are a poor guide. Learn this for yourself by checking many tunings the day after or as soon as you can after the fact when the mood is different. *Pianos are not necessarily in tune because you have performed a tuning procedure on them; they are in tune when you have tuned them AND the tuning checks still work out when you go back to check your work.*

Using a Visual Tuning Device in Learning Aural Tuning

Above I say, “Continue the process until the mistunings that are discovered are too small to bother with and/or until conflicting checks do not show mistunings but rather display the inconsistency in inharmonicity in the piano’s scaling.” Student can have difficulty determining how big or small mistakes they can hear really are. It makes a difference. If the mistakes are large, then the only way to fix them may be another repetition of an aural temperament sequence. If the mistakes are small, then the way to fix them is with the final refinement techniques. This is where a visual tuning device can help. At the most basic level, the way to use a visual tuning device in learning aural tuning is to tune one note at a time aurally, then check the tuning of that note with the VTD before continuing. The more advanced way of using a VTD is to tune all the way through an aural tuning sequence and then check all of the temperament notes with a VTD; if most mistakes are less than 1.5 cents with few or no mistakes more than 2 cents, then the temperament is ready for refinements techniques. If there are multiple errors above 2 cents, then fifths might be expanded (although they are supposed to be contracted) and fourths might be contracted (although they are supposed to be expanded), and another repetition of an aural temperament sequence may be needed in order to get all of the fourths and fifths “on the right side”. Refinement techniques do depend upon fourths and fifths being “on the right side,” that is, fourths being expanded and fifths contracted.

One Last Reminder Before Beginning to Tune a Temperament

The successful piano tuner will understand the difference between the first attempt at laying the bearings and the subsequent refinement of that initial temperament. The objective while tuning through a temperament sequence is not perfect results the first time through. The tuning resulting from the first (or second or even third) pass through the temperament sequence only needs to be good enough to allow the refinement procedures to proceed. *The purpose of tuning through a temperament sequence is to provide a temperament that can be refined in the separate refinement procedures. Get through the temperament sequence without belaboring it and move on to temperament refinement. The temperament refinement procedures are where one can achieve close-to-perfection tunings. A temperament sequence is only the preparation for fine tuning; it is not fine tuning itself. Great tuning is accomplished during the refinement procedures, not during the temperament sequence.*

Every Which Way Temperament Sequence, The Algorithm

Tune the piano's A4 beatless to an A=440 pitch source, then test using note F2.

Tune the piano A4 beatless with the pitch reference A4. Do not skip this first step! Tune A4 beatless to the pitch source and get it close before checking its beat with F2. (Although unlikely, it would be possible for the F2-A4 beat rate to be the correct speed, but with the interval contracted instead of expanded. This possibility is avoided by first tuning the piano's A4 beatless to the pitch source A4.)

Rough tune F2 to form a 4 bps expanded interval with A4.

Make the beat rate of the F2-A4 M17th on the piano exactly equal to the beat rate of the M17th between the piano F2 and the pitch reference A4.

(An alternate test note would be B1, since its 7th partial is coincident with A4. Make the beat rate of the B1-A4 double-octave minor 7th on the piano exactly equal to the beat rate of the double-octave minor 7th between the piano B1 and the pitch reference A4. The alternate test note can be used to enlarge the piano tech's bag of tricks, and might be useful if for some reason there is difficulty hearing the beat rate formed by F2-A4.)

Tune A3 to A4, using test note F3.

Tune A3-A4 octave to be clean-sounding and make the F3-A3 M3rd beat the same as or slower than the F3-A4 M10th.

Tune F3 to A3, approximating 7 bps expanded.

Rough tune the F2-F3 octave to sound clean.

Rough tune A2 to A3 and A4 using test note F2, making F2-A2 M3rd beat the same or slower than F2-A3 M10th and F2-A4 M17th.

Tune D4

... to F3, approximating 8+ bps expanded.

... to A3, approximating 1+ bps expanded.

... to A4, approximating 1/2 bps contracted.

Make the A3-D4 P4th beat as fast or faster than the D4-A4 P5th and the F3-D4 M6th beat faster than the F3-A4 M10th, and the F3-A4 M10th beat the same as or faster than the F3-A3 M3rd.

Tune A#3

... to D4, approximating 9+ bps expanded.

... to F3, approximating 1+ bps expanded.

Tune F4

... to F3, using test note C#3.

... to A#3, approximating 1/2 bps contracted.

Tune a clean-sounding F3-F4 octave and make the C#3-F4 M10th beat the same as or faster than the C#3-F3 M3rd.

Rough tune C#3 to A2 and F3,

forming progressing beat rates in A2-C#3 and C#3-F3 M3rds.

Make the F3-A3 M3rd, the F3-D4 M6th, and the D4-A#3 M3rd progress (approximating 7,8+,9+ bps) and make the F3-A#3 P4th beat as fast or faster than the A#3-F4 P5th.

Tune C#4

... to **A3**, slightly slower than the beat rate of the A#3-D4 M3rd.

... to **F4**, to beat faster (5:4 ratio) than the A3-C#4 M3rd.

Make the F3-F4 octave is as wide as "clean-sounding" allows.

Make the contiguous major thirds F2-A2, A2-C#3, C#3-F3, F3-A3, A3-C#4, C#4-F4, F4-A4 progress smoothly (4:5 ratio), and

make the F2-F3, A2-A3, C#3-C#4, F3-F4, and A3-A4 octaves clean-sounding, and

make the F2-F4 and A2-A4 double-octaves clean-sounding.

Tune F#3

... to **A#3**, slightly faster than the beat rate of the F3-A3 M3rd.

... to **C#4**, "almost-clean" P5th, about 1/2 bps contracted.

Tune D#4

... to **F#3**, slightly faster than the beat rate of the F3-D4 M6th.

... to **A#3**, same beat rate as the A3-D4 P4th.

Tune B3

... to **D#4**, slightly faster than the beat rate of the A#3-D4 M3rd.

... to **F#3**, same beat rate as the F3-A#3 P4th.

Tune G3

... to **B3**, slightly faster than the beat rate of the F#3-A#3 M3rd.

... to **D4**, same beat rate as the "almost-clean" F#3-C#4 P5th.

Make the G3-B3 M3rd duplicate the beat rate of the F3-D4 M6th.

Tune E4

... to **G3**, slightly faster than the beat rate of the F#3-D#4 M6th.

... to **A3**, same beat rate as the G3-D4 P5th.

... to **B3**, same beat rate as the A#3-D#4 P4th.

Make G3-E4 M6th duplicate the beat rate of the A3-C#4 M3rd.

Tune C4

... to **E4**, slightly faster than the beat rate of the B3-D#4 M3rd.

... to **G3**, same beat rate as the F#3-B3 P4th.

... to **F3**, same beat rate as the F#3-C#4 P5th.

... to **F4**, same beat rate as the B3-E4 P4th.

Tune G#3

... to **C4**, slightly faster than the beat rate of the G3-B3 M3rd.

... to **D#4**, same beat rate as the "almost-clean" G3-D4 P5th.

... to **C#4**, same beat rate as the A3-D4 P4th.

... to **F4**, slightly faster than the beat rate of the G3-E4 M6th.

Make G#3-F4 M6th duplicate the beat rate of the A#3-D4 M3rd.

Make G#3-C4 M3rd duplicate the beat rate of the F#3-D#4 M6th.

If you tune through the sequence again, use all available checks from the beginning.

For example, check F3 against A#3, C4, D4, and F4.

Temperament Refinement

Just as a whole piano is not necessarily in tune because you have made one or two tuning passes on it, a temperament is not necessarily the best it can be after tuning through a temperament sequence. Refinement is a separate procedure and the improvements possible can be substantial.

To refine a sequence, move through the temperament chromatically rather than in the order of the temperament sequence. Play all of the tuning intervals chromatically through the temperament octave, that is, play all the Major 3rds up or down the scale in half-steps, and listen for inconsistencies in the beat rates; they should progress evenly. In turn, play all the fourths, fifths, and major 6ths that lie within the octave. If you find an interval that seems to be beating too fast or too slow, individually check the tuning of both notes that form the interval. During any refinement procedure the emphasis should be on checking the tuning of one note at a time. Change the tuning of an interval only when you know for sure which note of the interval is in error. Make only the change necessary to help smooth things out and make an improvement. Just try to make things better; don't try for perfection.

The beat rates of like contiguous intervals should be more the same than different but the beat rate of the upper interval should be faster.

Neighboring (that is, parallel, continuous, or chromatically ascending/descending) intervals should have smoothly progressing beat rates; this is the single, distinguishing characteristic of equal temperament.

In the temperament area of the piano, the beat rates of the fourths should be faster than that of the fifths.

If you have a properly expanded fourth and a properly contracted fifth with a common upper note, lowering the common note will narrow both intervals, slowing down the beat rate of the fourth but speeding up the beat rate of the fifth. If the beat rates of fourths and fifths do not exhibit this inverse relationship, either a fourth has been mistakenly contracted or a fifth has been mistakenly expanded.

Here is a list of checks using fourths and fifths. These checks should let you thoroughly evaluate the tuning of all of the individual notes within a temperament octave before you begin to tune outside the temperament octave, assuming an F3-F4 temperament octave. Make the fourths beat just slightly faster than the fifths.

To evaluate the tuning of:

F3, compare F3-A#3 P4th with F3-C4 P5th;

F#3, compare F#3-B3 P4th with F#3-C#4 P5th;

G3, compare G3-C4 P4th with G3-D4 P5th;

G#3, compare G#3-C#4 P4th with G#3-D#4 P5th;

A3, compare A3-D4 P4th with A3-E4 P5th;

A#3, compare A#3-D#4 P4th with A#3-F4 P5th;

B3, compare F#3-B3 P4th with B3-E4 P4th;

C4, compare F3-C4 P5th with G3-C4 P4th;

C#4, compare F#3-C#4 P5th with G#3-C#4 P4th;

D4, compare G3-D4 P5th with A3-D4 P4th;

D#4, compare G#3-D#3 P5th with A#3-D#4 P4th;

E4, compare A3-E4 P5th with B3-E4 P4th;

F4, compare A#3-F4 P5th with C4-F4 P4th.

Final Refinement Tips

An uneven progression of beat rates of one interval will almost certainly mean an uneven progression in the beat rates of other intervals. Example: If you find an uneven progression of thirds, there is a bad fourth and/or a bad fifth somewhere too. Find the fast (or slow) fourth and then check each note of the 3rd with the associated fourths and fifths to confirm the tuning error. (In case there is any question about this, do not let anyone tell you that fourths and fifths are “bad” or less accurate than thirds and sixths. You need both the slow beating intervals *and* the fast beating intervals. Fourth and fifth can be used to find mistakes in the thirds and sixths and vice versa.)

The object of tuning refinement techniques is not “perfection”; the object is to simply make things better. After all, piano tuners get so adept at hearing tuning errors that even the smallest of insignificant errors may sometimes be heard. But beyond that, during refinement a certain amount of patience and persistence is needed; if you can’t completely eliminate a tuning error, then just make it better; perhaps the full solution will reveal itself later during a different check. Different errors may become apparent with different checks. Running parallel 4ths may tend to reveal different errors than running parallel 5ths. Parallel 3rds and parallel 6ths may reveal different errors. In other words, looking at the problem from different points of view may with patience allow enough improvements to be made to closely emulate perfection.

Beyond the Temperament Octave

Tuning up or down from the temperament octave is sometimes referred to as “tuning the octaves”, but should more properly be referred to as “extending the temperament” up and down from the temperament octave. The distinction comes from the fact that other intervals are just as important as the octave and need to be tuned and checked in addition to the octave. But how many checks are sufficient? There is a saying, because tuning checks can be so time-consuming, that “You can check yourself into the poorhouse” if you take too long to complete one’s piano tunings. Tune octaves and check them as you go with 4ths and 5ths, remembering the inverse relationship of 4ths and 5ths. *(If both the lower 4th and upper 5th inside the octave you are tuning are clean-sounding, then the octave probably isn’t far wrong. If the 4th or 5th don’t match, that is, if there is a too-busy 4th and a too-clean 5th or vice versa, then you have found a tuning error that you can correct.)*

Run some parallel 3rds, (or 10ths or 17ths) to check each section as you complete it. *Keep in reserve all the aural beat rate checks you can learn to bring out of your bag of tricks when a given piano presents an unusual or difficult tuning problem.*

Final Checks

The final tests of a good and complete tuning will include the playing of intervals with all strings unmuted. You will hear mistakes in the tunings of unisons while playing intervals that you will not hear playing individual notes. Here is why: There are tolerances in just about everything we do; piano tuning is no exception. This means that small errors may occur that cannot be heard when playing individual notes, but are errors nonetheless. Let’s say one string of one unison is tuned just slightly sharp, and one string of another unison is slightly flat. When the two notes are played together, the mistakes sum and may become hearable. Most of the mistakes you discover while playing octaves slowly up and down the keyboard may be simple mistakes in unison tuning. If your unisons are not right, your temperament is not right.

Final Thoughts

The twenty-first century is a great time to learn aural piano tuning! You may have heard the comment that the rise of sophisticated visual/electronic tuning devices has allowed new students of tuning to tune well enough visually that they could just as well forgo the study, practice, and vigilance necessary to learn aural tuning.

However, look at the resources now available to help students learn aural tuning, resources that were not available decades ago. At one time, a student had to learn aural tuning with just a tuning fork and his wits. He or she had to learn tuning hammer technique while trying at the same time to learn to tune a temperament. Now these different skills can be learned separately. One can begin tuning visually and concentrate on learning hammer technique and how to tune with stability. Later, when one has learned to tune solidly, one can harness the power of the electronic tuning device to guide one's study of aural tuning. Tune a note aurally, check and correct the tuning of the note with the ETD, and *listen* to the results, committing the aural results to memory.

In addition, the texts available now are superior. The Piano Technicians Guild has available the Tuning Exam Sourcebook, and the PACE Tuning Series, both excellent. At the PTG Annual Convention and Institute, great tuning teachers include Dan Levitan, Mitch Kiel, and Ward Guthrie.

There may be more to good piano service than a well-tuned piano -- but it's a good start!

4/16/07

Appendix 1

To assist in learning the beat rates of piano tuning, there are mp3 files on the web that demonstrate the speed of various beat rates:

<http://home.broadpark.no/~rbrekne/beats.html>

Appendix 2

The question has come up about whether one could use an mp3 player as a pitch source on the PTG RPT tuning exam. This is likely to be within the rules as long as the device has no pitch display.

There is one caution to be made, however. Even if the A440 tone was accurate to begin with and was recorded accurately, there is no guarantee that any one player will play the tone back at exactly the right pitch. Remember that in the digital realm, playback is dependent upon a given device's ability to duplicate the proper sampling frequency. We know that computers are not always pitch-calibrated correctly, and mp3 players could be just as inaccurate.

Here is an mp3 file of 10 seconds of an A=440 tone. The tone is known to be accurate. However, after the tone is installed in a player, play the tone from the mp3 player and measure its accuracy with a good ETD such as CyberTuner, Verituner, TuneLab, or Accutuner.

<http://www.kentswafford.com/EWW/A440.mp3>