Chapter 1

The Sydney Conservatorium Tuning Style

This fast accurate aural tuning discipline was introduced by Dr. Yoji Suzuki at the Sydney Conservatorium of Music in the 70s. It combines the best of German and American tuning styles with the results of Japanese engineering research and time-and-motion studies.

Dr. Suzuki selected 3 talented graduates of the Tuning School to take the Tuning Teacher Training course at the Yamaha Academy:

- Wayne Stuart returned and took over from Dr. Suzuki as Head of the Tuning School. Wayne moved to Prestons TAFE in Victoria and continued teaching and research.
- Trevor Foulcher, who became the Conservatorium Tuner had practical engineering experience, and an academic mind. Trevor is responsible for adapting Dr Suzuki's notes into a textbook.
- Ara Vartoukian was a very energetic Head of the School. His Armenian background may be behind his amazing teaching method – he would ”re-mind” you of something you didn't know, a technique perhaps deriving from Plato's theory of knowledge.

Local conditions vary from the situation in Japan. The stock of pianos is different, the climate is different, and musical expectations are different. Sydney also had at the time, a history of piano manufacture and a tradition of tuning and service. All these conditions shaped the local tuning style.

The existing piano servicing had the upright piano as its focus, grand pianos having been rarer till recently. The local tuning style was much simpler, involving less ”checks”. It would be safe to say that Yamaha imported their own more accurate tuning discipline in order to help promote their pianos. Grand regulation procedure was virtually unkown till then, so the Yamaha course ensured that its graduates would be able to maintain the new wave of Japanese grands in good playing condition.

It was appropriate that the Tuning School was part of the Conservatorium, as the feedback from performers and teachers encouraged the acceptance of the ”Triple Octave Tuning” here, while Japanese audiences favoured a safer ”Double Octave Tuning”.

A very important feature of the course was that a brand new piano was provided for each student. Over the training year, each piano was tuned for up to 4 hours each morning, 5 or 6 days a week. This way the graduate tuners were quite at home with new pianos, and their condition after the year was like the condition of a five year old piano.

This is in stark contrast with many other courses, where new tuners are expected to learn on old unsalable pianos.

The Conservatorium has over 150 good quality pianos. During the last semester they tuned all the instruments there including the Steinway, Bechstein, Bosendorfer and Yamaha concert grands.

Since the early eighties, with increased communications and interaction, tuning schools are becoming closer. There are still major differences though. The simpler style involving a rough temperament and octave tuning has been replaced by more sophisticated techniques, and the development of Electronic Tuning Devices has given rise to another major division among tuners.

1.1 Overview of Tuning Procedures

In practice you come across pianos is various states of out-of-tuneness. Pianos which haven’t been tuned for many years, pianos recently tuned but with a set of new bass-strings, pianos recently tuned but with the middle section collapsed due to weather changes. The ideal piano to tune is one which is tuned regularly, perhaps monthly, or every term. For teaching purposes we use a pattern similar to the ideal tuning: the piano is tuned up by 5 cents two or three times, and then down to the starting point, or 5 cents below. With a standardised tuning the learner is able to observe the reaction of the piano to the tuning and to perfect his technique.

The Japanese teaching method involved a system of discovery and reward for the individual, and an environment of cooperative competition among the class. The minimum amount of information was given for a new procedure, and if the student had a question, then it seems that the answer would have more meaning if he felt the need to ask the question.

Some of the procedures got to be boring after several attempts, and the carrot on the stick was that you would be able to go on to the next step once you mastered the current one. When a student got the trick, he would be pressured to share it with the others.

The stages to be mastered were:

- Temperament, F33-F45
- Extended Temperament, F♯46-A49.
- A49 - F57, ‘Double Octave’.
- F57 - F69, ‘Triple Octave’.

- Triple octave to C88.
- Bass, top section: E32 - C16
- Low Bass.

Once the student was doing full tunings, they were scoped if the time taken was less than 1½hours. The aim was to get the time down to 1 hour, or less. Graphs were done of the tunings, and it was shown that the faster the tuning, the more accurate.

The graph had a line representing the ideal tuning for the model of piano — a Yamaha U1 — and the cents by which the pitch of each note deviated from this ideal were added up. A total cents deviation of 70 was considered unbeatable, and 150 ”lost points” acceptable. Most good tunings were between 80 and 100 cents.

These days electronic tuning devices can calculate an ideal tuning for individual pianos, so in the most recent Conservatorium tuning course a different scoring system was used.

1.2 Equal Temperament Tuning

Just Tuning. Very early keyboard instruments were tuned using a Just or Pure series of fifths.

Meantone and Well-Tempered tunings. Meantone tunings allowed for more keys to be used. So if a series of pure 5ths were tuned from C, C — G — D — A — E, the major third E in the C-chord would beat around 16.3 times a second. which is too fast to be pleasant, compared with the beat speed in today’s ET - 10.38 beats per second.

The name meantone derives from the process of tempering the third by flattening it to beat equally with the tonic and the fifth. Different thirds were tempered in this way, to suit the requirement of the music being played.

Where a just tuning was almost useless, this meantone tuning allowed musicians to use more chords. If there was a change in key between pieces the musician at the keyboard would retune the instrument to suit. Numerous tuning methods were developed, with thirds ranging from pure or very slow-beating, to faster but acceptable, to too fast and unusable

Perhaps the culmination of these tuning temperaments was the Werkmeister II Well-Temperament, where the beat speeds of the thirds progress through a regular cycle of keys, with C-E beating slowest, then the thirds progressively speeding up through the keys G - D - A etc, in one direction, or through F - B♭ - E♭ in the other, with the key of C♯/D♭ being the fastest.

The mood or character of the keys also progresses from serene, to energetic to disturbed. Bach’s Well-Tempered Klavier is thought by some to be a showpiece demonstrating the effectiveness of this or a very similar tuning.

By contrast, Equal Temperament, which progresses in beat speed by semitones, ranges from energetic to ... more energetic. It you transpose a piece and keep playing it higher, you may well speed up as you go. It is thought that the tempo of some Romantic music is tied in with the beat speed of the tonic third.

1.3 Temperament Design

Meantone and well-tempering gradually evolved into the modern Equal Temperament, and just as with the earlier system, there was a proliferation of methods and schools, with a very conservative rate of progress.

The Yamaha or Japanese style adopted by the Sydney Conservatorium was developed in a research setting, unconstricted by loyalties and traditions. The academics who developed it looked at as many traditions as they could to establish the most efficient and accurate techniques.

The Design of the temperament has these goals: **Accuracy, Stability and Speed.** They are inter-related. As an example, if a piano can be completely tuned in less than an hour, starting with the temperament in the middle and tuning to the top and then from the temperament towards the low end, then it can be expected to be stable.

This is because the iron-frame and cabinet take some time to react to the change in stress. The bass strings are positioned at an angle, with the lower part of the strings more towards the middle of the piano than the top part. Putting extra tension on the bass end can make the top end increase in tension by way of a see-saw effect centred aroung the middle.

- A temperament obviously encompasses an octave. Any more than one octave introduces uncertainty, unnecessary retuning within the procedure,
- On many pianos, the tenor strings change from plain-wire to copper-wound in the low tenor, and a large number make this change at F33, with E32 being the last copper-wound string. Copper-wound strings have a lower inharmonicity, and including a wound string in the temperament complicates tuning the temperament.
- For this reason the temperament is set between F33 and F45. This octave is in the most audible range, centred around middle C. The beat speeds are easy to count here.
  If the temperament area were shifted down a semitone or two, the beat speeds to be counted would be slower and would take more time to judge. Similarly, taking the temperament area up would mean that more notes would be in the uncountable area, and in the same area (above F45) the inharmonicity increases making for uncertainty.
- In general, strings increase in inharmonicity from the lowest plain wire upwards, and from the highest wound string downwards. Tuning the temperament in this octave allows for a smooth rise in pitch, and even if the lowest note or two increase in inharmonicity, the pitch-curve of the octave harmonics will be smooth, making it possible to have a neat tuning curve across the piano.

- By fortunate coincidence, when starting on A37 the first interval tuned is a fourth above, (D42), and the beat speed for A-D is 1 per second. The first third chord which is checked is F33-A37, and the beat speed here is exactly 7 beats per second. (This is all at A=440hz). Other tuning methods starting on C or F do not have such a neat reference so near the beginning of the process.
- Historically discussion of Equal Temperament referred to a ”flattening of the fifth” as the characteristic, the fifth interval being seen as important. In practice, the inversion — sharpening of the fourth, is faster to achieve. Hammer/pin technique requires each tuning event to involve taking the string over the intended pitch, and striking the key hard enough to force the string down to the intended position. This is known as *setting the pins*. So if while tuning from A37 to D40, you are intending to hear 1 beat per second pull the D up so that (for instance), there are 2bps. It will take no more than 1 second to hear the two beats, possibly less. Then after the hard blow on the key, it will take no more than a second to recognise 1 beat.
- Going the other way, dropping a fifth from, say, zero beats down to 1bps, might involve 2 to 3 seconds listening to ascertain that the interval is beatless, another 2 or 3 to hear that there is only, say, 1 beat every 2 seconds, and finally 1 second to hear the intended speed of 1bps. Obviously not the way to do it.

Inharmonicity

In the time of the harpsichord and early pianos, strings were very light. A series of octaves – octave, double octave, triple octave could be tuned such that any pair of the four strings would be in tune.

As piano manufacturers started producing louder more stable instruments by fitting heavier gauge strings, the inconsistency within a series of octaves was noticed.

In the mid 19th Century, a French writer on tuning, declared that “modern manufacturers have made more augmented semitones”. This was understood by a rival French writer on tuning [1] as “It is as if he were saying that one could alter the boundaries of the octave which contain the twelve semitones”.

The phenomenon - **inharmonicity** was measurable after the development of the Stroboconn - the earliest Electronic Tuning Device, and in 1943, Schuck and Young, commissioned by the American Piano Wire Company established that the combination of the length, diametre and frequency of a tuned string resulted in stiffness, and that the sharpness of any partial (or harmonic) could be roughly predicted by multiplying the Stiffness Coeffient of a particular string by the square of the harmonic number minus one. The harmonic series within a stiff piano-string then, is sharper than predicted. The double octave, or fourth harmonic is sharper than the octave or second harmonic. The unit of the stiffness coefficient is octave cents. So if a string has Stiffness of 0.1¢, the

[1] Claude Montal, The Art of Tuning one’s own Piano, p.11

2nd harmonic will be 0.3¢ sharp, and the fourth harmonic will be, according to this rule of thumb, 1.5¢ sharp.

Schuck and Young's inharmonicity rule of thumb is handy and can be used in a spreadsheet to calculate to some degree of reliable approximation the inharmonicity of the second and third harmonics. 'Paper' tunings can be calculated from the results. The earliest incarnation of the Reyburn CyberTuner used this method, and is still included with the RCT' as a curiosity.

Nowadays fast fourier transform calculation can be done on a small handheld device, and the actual cents deviation calculated instantaneously. Schuck and Young's equation gives exaggerated results in the higher harmonics, probably because the lower harmonics are already flexing the wire [2] and reducing the stiffness. This is evident in the lower even "octave" series of partials (2 - 4 - 8) and the lower third partial, or "fifth" series, (3 - 6 -12).

The inharmonicity of some partials of some strings is also affected by the hardness of the hammers, the amount of the hammer surface which impacts the string, the point on the strings where the hammer strikes, and the elasticity of the strings, as well as the firmness of the contact of the string on the bridge.

Tuning procedures were quite hit and miss when the theoretical speeds were used. It was noticed that the calculated beat speeds, which in the temperament area (around middle C) range from approximately 4 beats in 7 seconds, to approximately 8 beats in seven seconds in the fourths, could be given a second tempering – (by making all the fifths beat at 3 times in 7 seconds, and all the fourths beat at 5 times in 7 seconds.

This '3/5' method is still in use in America among some aural tuners. Further minor adjustment is still necessary if the tuner wishes to make the series of thirds and major sixths progress evenly in speed.

Other American schools, even today teach another century old method where the tuner introduces some flatness into the fifths, or some sharpness in the fourths. These rougher counting methods require some juggling to get the thirds and sixths to run, and in many cases the intervals are left as they are.

Proportional Second Tempering

The genius of the method introduced by Dr. Suzuki is that the speeds of the series of fourths, which range from 4bp7s to 8bp7s is still counted but by counting one at the moment the chord is struck, one beat is subtracted over the period of 7 seconds. So in the lower fourths where 4 beats in 7 seconds is the theoretical speed, one beat is subtracted by this counting method, meaning that the speed is reduced by a quarter. Higher up the temperament area, where one counts to 8 over 7 seconds, one beat is subtracted, giving a reduction, or secondary tempering of one eighth.

[2] That the harmonic is somehow driving or flexing the string is a handy way of visualising the situation. There *is* a correlation between amplitude and flexing, and higher amplitude is more likely in lower partials.

This is a refinement of the notion that the lower fourths need more compromise than the higher fourths, as attempted in the '3/5' tuning style, where three beats are counted over seven seconds for the downward fourths, and five beats for the upward fourths. Another method in use is the ' 0/1' style, counted per second, where all downward fourths are beatless, and the upward fourths all have one beat per second, the counting starting with 0 at impact, and 1 after 1 second.

All these alternative methods, as well as Dr. Suzuki's, involved some further compromise. Dr. Suzuki's 'proportional compromise' works well on better quality large grands.

Further Tempering

On smaller pianos, both uprights and grands, the string scaling may be so poor that the tuner has to resort to slowing the beat speeds even more. As the habit of counting the speeds is reinforced by practice, the tuner can count the speeds, but instead of fitting them into 7 seconds, you can make them fit into the time that the chord sustains on the instrument, possibly 9 or 10 seconds.

Temperament Steps

The temperament octave is set with a cycle of fourths within the F33-F45 octave. (The downward fourths look like fifths). There are 3 stages.

* The first stage is the series
A37 ⟶ D42 ⟶ G35 ⟶ C40 ⟶ F33

* The second stage is the same a semitone higher:
A♯38 ⟶ D♯43 ⟶ G♯35 ⟶ C♯41 ⟶ F♯34

* Finally two short stages
B 39 ⟶ E♯44, and
C 40 ⟶ F 45

Step 1:
Tune: A37 to a Tuning Fork.
Test: F33 - A37 = F33 - Fork

NOTE—I. The two notes used are within the temperament octave. F33 may be adjusted to beat 6 or 7 times a second to be within the usual speed range, before being properly tuned as a fifth from C40.
NOTE—II. The Randy Potter method uses F21 here, as the American PTG use this interval and the pitch of A49 in their examinations. In practice the results are usually the same. The third F33-A37 will beat faster than the seventeenth F21-A49, allowing for an easier and faster assessment of the speed.
NOTE—III. Although the tuning fork's fundamental frequency is A-440, its second harmonic vibrates at 880 cycles, and this is the harmonic which is aligned with the 4th harmonic in A37 when F33 is used to provide the interference.

Step 2:
Tune: A37 ⟶ **D42** . Count 7 in 7 seconds, with count one on impact. The effect will be in fact 6 beats in 7 seconds, which is a compromise needed for inharmonicity.
Test: If F33 has been roughly set, compare F33-A37 and F33-D42. Play the third until you have counted 7 (with the count of one being on impact) and play the sixth for the same time, checking that it is almost 1 beat faster.

Step 3:
Tune: D42 ⟶ **G35**. Count 4.5 beats per 7 seconds, with count one on impact.
NOTE—. Counting this way will actually give 3.5 beats in 7 seconds. Because of inharmonicity, on most pianos you may have to compromis even further, perhaps down to 2 beats in 7 seconds.

Test: No official test.
You can however check that G is on the sharp side of D by listening to the tenth A♯26—D42 and the sixth A♯26—G35. This is not part of the orthodox temperament method, but is a handy check if A♯26 is not too far from pitch. The sixth should beat slightly faster than the tenth.

Step 4:

Tune: G35 ⟶ **C40**. Count 6 in 7 seconds, with count one on impact.

Test: Listen to A37-C40. It should be at least 12pbs, slightly too fast to count.

This is an unofficial test, not strictly needed. It will give you an indication that the fourths tuned so far have been correctly set on the sharp side of pure. If A-C sounds slow, then one or more of the fourths is flat.

Step 5:

Tune: C40 ⟶ **F33**. Count 4 in 7 seconds, with count one on impact.

Test: F33-A37, theoretically 7bps, or 35 beats in 5 seconds.

This is the first real check. The success of the temperament depends on the placement of the preceding notes. In the Yamaha teaching method, this was a 'milestone'. When the student could correctly tune F-A he would be eligible to proceed to the next interval.

Step 6:

Tune: F33 ⟶ **A♯38**. Count 5 in 7 seconds, with count one on impact.

Test: A♯38–D42, 9bps.

Compare: F33—A37 (~7bps), F33—D42 (~8 bps), and A♯38—D42 (~9 bps).

The third beating at 9bps may be too fast to count, but it should be faster than the other set third, F33-A37. You might try counting 45 in 5 seconds while learning, but eventually you want to tune the temperament within 2½ minutes, so this would be considered a waste of time.

Step 7:

Tune: A♯38 ⟶ **D♯43**. Count 7 in 7 seconds, with count one on impact.

Test: None yet. This note is 'insecure' until the next four notes are tuned.

Step 8:

Tune: D♯43 ⟶ **G♯36**. Tune: **D♯43** ⟶ **G♯36**. Count 5 in 7 seconds, with count one on impact.

Test: G♯36-C40, theoretically 8.24 beats per second, in practice 8bps or slower. It should fit between the previously set thirds, F33-A37 and A♯38-D42.

Compare: F33–A37 (∼7bps), G♯36–C40 (∼8 bps), and A♯38–D42 (∼9 bps).

While learning to recognise the progression in speeds over these three thirds, you can time them, counting 35, 40 and 45 beats over 5 seconds, (with the first count on impact). Experienced tuners count the 7 beats of the F–A, then play the G♯–C till the count of seven[3]*, which should take less time, and the same with A♯–D. The progression in beat speeds is reflected in the shorter playing time of the 2nd and 3rd chords, resulting in a speeding up, or accelerando.*

Step 9:

Tune: G♯36 ⟶ **C♯41**. Count 7 in 7 seconds, with count one on impact.

Test: A37–C♯41, theoretically 8.7 beats per second, or 43 in 5 seconds.

Compare: G♯36–C40 (∼8 bps), A37–C♯41 (∼8½bps), and A♯38–D42 (∼9 bps).

The A cannot change, as that is the starting note. If C♯ needs to go up or down to fit, then G♯ and D♯ may need to be adjusted to suit. As the 4th A37–D42 is fundamental to the tuning, try to make the adjoining 4th, G♯–C♯ match it by adjusting G♯, and perhaps C to make the G♯–C third fit.

[3] To save time, you can count to 3 and note the accelerando.

Step 10:

Tune: C♯41 ⟶ **F♯34**. Count 4½ in 7 seconds, with count one on impact.
Test: F♯34–A♯38 should fit between F33–A37 and G35–C40.
A second test would be the sixths F33-D42 and F♯34-D♯43.

Step 11:

Tune: F♯34 ⟶ **B39**. Count 6 in 7 seconds, with count one on impact.
Test: B can be tested as a third G35–B39, and as a third B39–D♯. D♯ is most likely to need adjustment as it was not tested when first set.

Step 12:

Tune: B39 ⟶ **E44**. Count 7 in 7 seconds, with count one on impact.
Test: C40–E44 should progress from the preceding thirds, and should also run as a sixth. Listen for the 'accelerando' effect.

Step 13:

Tune: C40 ⟶ **F45**. Count 7 in 7 seconds, with count one on impact.
Test: C♯41–F45 should run as a third and as a sixth, and of course will make an octave with F33.

It can be useful to start setting F45 by playing it as a fifth with A♯36, close to pure, then lowering it down to 7½ in 7 seconds as a fourth. This technique is often applied in the next section, where the temperament is extended up to A49.

1.4 Extended Temperament, F♯46 – A49

The inharmonicity is greater here than in the lower part of the temperament area, so set speeds are irrelevant. Instead one relies on hearing a progression of speeds in the sixths, while keeping the pitch of a note not sharper than pure as a fifth, and certainly never slower than 1bps as a fourth.

The sixths are used instead of thirds, because their speeds are slower, making it easier to assess the progession, or *acceleration*.

Step 14:

Tune: F♯45, G47, G♯48 as fifths and as fourths from the temperament. In the time it takes to count 2 beats on the fifth, count 3 beats with the fourth.
Test: Optionally test as octaves. With practice you can skip this.
Compare: Progression of speed in the sixths, starting with G♯36–F45 up to B39–G♯48.

With both Equal Temperament and Just Tuning, the relationship of a note to its fourth and fifth is in the ratio of 3:2. So if you hear 2 beats in the fifth, you should expect to be able to hear 3 beats in the fourth. Now we begin counting with 'one on impact' meaning that the relationship is really 2:1. The difference is minimal, and after A49 is tuned in the next step, we have the opportunity to re-asssess these three notes.

In any case, the results are going to be in accord with the goals of Equal Temperament tuning, and will certainly be more accurate when assessed aurally and when viewed on a graph than they would be if tuned merely by octaves.

Similarly, the results will satisfy more aural checks than a tuning done with an electronic tuning device.

Step 15:

Tune: A49 as a fifth from D42 and as a fourth from E44

Test: The third F33–A37 with the tenth F33–A49 should have the same speed.

A37 was set to the tuning fork in Step 1. By aligning the speed of the third and the tenth in this way, you establish a 4:2 octave between A37 and A49. Having determined that important interval, it is then possible to reassess the sixths A37–F♯46, A♯38–G47 and B39–G♯48, making sure that they accelerate to fit in with C40–A49.

These three notes will be used later as tenths to check the pitch of the top three notes of the bass section.

1.5 The Elusive Octave

Every musician can tell you that the octave of a note vibrates at twice its frequency, and since the time of Pythagoras it has been know that halving the speaking length of a string (or monochord) will result in the octave.

Less known is the fact that the *sound* of an in-tune octave depends on the co-incidence of the 2nd harmonic of the base note with the 1st harmonic of its octave, rather than the harmony of the frequency of the base note with twice that frequency in the octave above.

Even less obvious, is that the 'in-tune' sound of an octave also involves the co-incidence of the 4th harmonic of the base note with the 2nd harmonic of its octave, the 6th harmonic of the base note with the 3rd harmonic of its octave, the 8th harmonic with the 4th, the 12th harmonic with the 6th and so on.

From classical times to the late 19th century, the octave chord was thought to be fixed, having its upper note at half the length of the base note. In the mid-nineteenth century we have Earl Stanhope declaring that tuning the octave was the same as tuning a unison.

Totally unforeseen before the highly strung instruments of the late 19th century and onwards, is the fact that an octave can be *stretched* to different degrees, depending on which pairs of harmonics are aligned between them. It is up to the tuner to apply the checking techniques uniformly, to produce a consistent smooth tuning curve.

If an elementary tuner uses only octave tuning without any checking chords, and the results are graphed, the tuning curve will show a saw-tooth pattern, suggesting among other faults, an inconsistent alignment of harmonics, and a varying tonality in the octave and other chords.

The harmonic checks mentioned here are now quite widely used, but some schools have no systematic method for the highest and lowest octaves. Here the 3rd, 10th and 17th checking chords are either too fast or too slow to be useful. One tuning course on offer today advises its student that they are 'on their own' in the top octave, and in some parts of the world no-one expects the top octave to sound consistent.

Thankfully the designers of the Yamaha method discovered a set of checking chords for the treble, used in parallel with the 10th and 17ths until they become too fast to hear, involving the double octave, triple octave, twelfth and nineteenth harmonics, and the tuning can be continued to the top, with reliable precision. No more "You're on your own here, good luck!"

In the low bass, the tenths are audible, but very slow, increasing the time taken to assess them. Here the creators of the method added an interval not considered before, the seventh, separated by one or two octaves so that the seventh is in the temperament area. The speed of a seventh or extended seventh is quite countable, and the lowest notes can be pitched neatly, allowing for consistent tonality of any interval, not just the octave.