7.2.3 The Buzz-Feiten-system

In his US-patent no. 6642442 (uspto.gov), Howard B. Feiten describes a system for a tempered tuning of fretted musical instruments. Supposedly, an *extraordinarily pleasing intonation* is achieved by applying small deviations from the traditional tuning. *"One very important aspect of acoustic guitars that has been overlooked is proper intonation"* – i.e. according to Mr. Feiten, luthiers have – until the year 2002 – studiously overlooked that guitars indeed need to be correctly tuned. Without a doubt, old-world luthiers will beg to differ, insisting that correct tuning was an objective since long before building guitars became fashionable west of the Canary Islands. Anyway, not every guitarist is always happy with the result of his strive for balanced tuning. Enter Howard "Buzz" Feiten.

In the description of his patent, Mr. Feiten explains that guitars have their frets positioned according to the *Pythagorean Scale*. One is tempted to object with a "well in that case …" and to add – depending on ones disposition – a sarcastic "yeah, maybe the axes made stateside"; but let's hold our horses for a minute. To begin with, and in order to avoid misunderstandings, the term "Pythagorean" is explained: "*The Pythagorean Scale is based upon the fourth, the fifth, and the octave interval ratios*." Without a doubt: that's Pythagorean. However, what's that got to do with the guitar? In Europe, especially in Old Europe♣, tuning is accomplished since the 1700's using equal temperament, not Pythagorean. But let us allow Mr. F. to continue his explanation: "*To determine fret positions, guitar builders use a mathematical formula based on the work of Pythagoras, called the rule of 18 (the number used is actually 17.817). This is the distance from the nut to the first fret.*" May the present work be charmed against that many errors in a single paragraph – that's what one instinctively thinks as the author of the book you are reading … Anyway: the rule of 18 generates a geometric sequence for fret positions: equal temperament; but he latter does not trace back to Pythagoras whose intonation is based on fifths, fourths and octaves, as Mr. F. elucidates himself. What Mr. F. seeks to express with "*this is the distance*" remains shrouded in Greek history, too. The subsequent explanations in the patent (not cited here) then do reasonably and correctly clarify what the rule of 18 purports. Let's note: H. B. F. sees the reason for the inadequate precision of tuning in the use of the Pythagorean (fifths-) tuning as it is contained in the rule of 18. That is incorrect but apparently did not phase the patent examiner (the one at the *US Patent Office*).

To cite Mr. F. some more: *"Prior to the mid 1600's, pianos had evolved from a 'just' intonation to 'equal temperment'; i.e., tuning the instrument so that all the notes were mathematically equidistant from each other. ... It was only partially successful and resulted in the entire keyboard sounding slightly out of tune, especially in the upper and lower registers. In the mid-1600's, an enormous breakthrough occurred in piano technology. The 'well tempered' keyboard was conceived*." Let us ask J. M. Barbour to comment about just intonation: *"There is no such thing as just intonation, but rather many different just intonations; of these, the best is that which comes closest to the Pythagorean tuning"*. So indeed: in the Middle Ages there was need for action, and "equal temperament", i.e. an intonation causing equal beats within the scale and allowing for modulations across the whole circle of fifths was considerable progress. However, "equal temperament" must not be confused with the "well tempered intonation" proposed by H. B. Feiten! The latter in fact distinguishes between "equal temperament" and "well tempered". "Well tempered" is a specially modified tuning derived from the uniformly-beating equal temperament.

♣ The ethnologist Donald Rumsfeld specified this term (otherwise to be understood more as a geographic distinction) via his subjective, differential diagnostic observations that were complemented by the philosopher Joschka Fischer by an evaluation of the origin of European and US-American culture (*translator's note: you better read this observing a STRONG twinkle in the author's eye ...*)

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Mr. F. continues: *"the universally accepted method for intonating guitars represents a form of "equal temperment" ... a method that was abandoned in the 1600's by piano tuners"*. Hold it, Buzz, didn't you say a moment ago that guitars are tuned pythagoreically? *"Based upon the fourth, the fifth, and the octave interval ratios."* Ye gods and little fishes! Hopefully we all still know after reading the patent how in the end any tuning and intonation is achieved. At this point, why don't we digress a little into contemporary literature, to show what kind of wide appeal a topical – if error-prone – patent can have:

Musik Produktiv, one of the giants in German music commerce, state regarding the matter: *with this modification of the scale, Buzz Feiten achieves a "well-tempered" tuning for the guitar*. Um … the term "well-tempered" is a bit misleading here because Mr. Feiten expressly seeks to avoid this piano-tuning. Musik Produktiv continue: *a piano tuner explained to Buzz Feiten that an electronic tuner cannot generate a well-tempered tuning*. We may disregard the nitpicky rationale that – as a measuring instrument – an electronic tuner can never by itself generate a tuning, but we cannot help recognize another considerable discrepancy: the piano tuner sought to achieve a stretched tuning (according to the Railsback curve). That is – at least according to conventional terminology – something rather different than a well-tempered tuning that is directly connected to Bach/Werckmeister (supposedly equally beating).

Musik-Thomann, the huge mail-order shop, writes: *For calculating the scale and adjusting the intonation, people relied on old, traditional formula. These heirlooms were based on a method that piano tuners developed already in the 16th century: the equal-temperament tuning. The commonly used formula to position the frets had already been developed by Pythagoras. There is, however, an error due to the stiffness of the string that generates too strong a disturbance.* In this comment in its German language form, "equal temperment" has been translated into the German expression for "equal temperament" – not as intended, but with some good will we can arrive at the intended interpretation. Again, Pythagoras is brought in. And finally: *All over the world, more and more guitarists have their darlings modified by authorized retrofitters.* Right, a lot of offers are said to exist across the Internet. Guitar players may need that kind of thing. Cave inflammtio!

Here's what **Proguitar** (not yet a giant) contributes: *The formula for positioning the frets was already developed by Pythagoras.* Mr. P. must have been a very early fan of the Strat.

Maybe we can clarify this jumble a bit: Pythagoras is readily cited with his insight that given constant string tension, frequency and length of the string are reciprocal (monochord = single string instrument). Still: already before Pythagoras, the Egyptians, Sumerians, Chinese, Indians, and presumably many other peoples in the ancient world knew about physical and mathematical interrelations. However, the Pythagorean school had the greater impact onto Western civilization, and in particular it left written documents early on (Euklid, Didymos, Ptolemäus, and many more). This Pythagorean school spawned a tonal system based on fifths and octaves that to this day is designated the **Pythagorean tonal system** (Chapter 8.1). It is applied, in its pure form, by the canons regular up to the 16th century, and in a modified form by the harmonists [Simbriger/Zehelein, Barbour]. When, from the 16th century, keys with more and more chromatic signs appeared, the subjectively perceived dissonances of the Pythagorean system were increasingly felt (or rather heard). Two improvements were devised as a remedy:

1. Increasing of the number of steps within an octave, and
2. Tempering, i.e. the fine-tuning of individual notes.

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The temperament may feature equal or different beating between notes. Simbringer/Zehelein date the first introduction of temperament back to 1482: *Bartolomeo de Ramis demands that the difference between the third (5:4 = 1,2500) and the fifth no. 4 (81:64 = 1,2656) be balanced out by temperament.* Barbour assumes the date to be 1496, and lists 17 different temperaments, designating them "meantone temperament" and "comma temperament". Around 1533, Lanfranco lays the foundation for the equal-beating intonation (equal temperament), and subsequently Vincenzo Galilei and Marine Mersenne (1636) concern themselves with the question how to calculate the 12^{th}-order-root of 2 (or an approximation as precise as possible, at least), without having a pocket calculator at hand. Then, the works of Neidhardt and **Werckmeister** – carried out around 1700 – become very popular. Almost 200 years later, Alexander Ellis reports that even "the best British piano tuners" could not produce an acceptable tuning with equal beating, and in 1948 and 1943, **Railsback** and Schuck/Young publish in the Journal of the Acoustical Society of America (JASA) the **stretched** intonation found in pianos: high notes are tuned slightly sharp, and low notes slightly flat.

At this point, the Feiten-patent picks up: *"In the mid-1600's, an enormous breakthrough occurred in piano technology. The 'well tempered' keyboard was conceived, and with it a new standard for piano keyboard intonation which we still use today."* In the mid-1600's, i.e. in the 17^{th} century, Mersenne & Co. were working on that root-calculation and developed the equal temperament. Does therefore, in Mr. F.'s book, equal temperament mean "*well tempered*"? No, that can't be because he has (correctly) termed the equal temperament with "*equal tempered*". But why would he (with the apparent support of the patent examiner) then write: *"The inventors believe that the reason that guitars still sound out of tune, in spite of 'perfect' intonation, is that the universally accepted method for intonating guitars represents a form of 'equal temperment' ... a method that was abandoned in the 1600's by piano tuners!"*? Quite enigmatic, these Americans! The patent continues: *"When a piano tuner intonates a piano, he uses one string as his 'reference' note, typically, A-440 (or Middle "C"). He then 'stretches' the intonation of the octaves, plus or minus a very small amount of pitch. These units are called cents"*. Ah – here's the crux of the Buzz-ing matter. Even without further historic ado (already the ancient Greeks …) we could formulate the idea behind the patent application as follows: *similarly to pianos, guitars should be tuned using a stretched intonation.*

That justifies a quick look into JASA: Schuck/Young cite in their publication (JASA 1943) the stretched intonation found by **Railsback**. Below E_2 and above approximately E_6, a considerable effect is indeed recognizable, with the piano tuning deviating by up to as much as 30 cent. That is not a wonder: the investigated pianoforte will be challenged to conjure a whopping bass of 25,6 Hz out of a mere approx. 1 m string-length, and at the top there's about 4 kHz tickling out of some tiny 5 cm string-length – in this scenario, dispersion-induced inharmonicity will definitely play a role. In the guitar … how shall we put this without being transatlantic-ally un-accommodating … well: it's not directly possible to coax 27.5 Hz out of your regularly tuned guitar, and 4.2 kHz on an open string is more of an un-feasible wish, to put it mildly. That's not even considering that in the piano, for the medium pitch range, the different frequencies come from strings of almost equal in gauge but of different lengths, while on the guitar we have strings of the same length but differing thickness. Schuck/Young explicitly say: *"The sharpening is least in the two octaves below middle C"*. "Sharpening" relates to the partials and can be taken to be synonymous with "stretching". Middle C is on the E_4-string at the 8^{th} fret. The string-pitches of the guitar therefore fall exactly into the range where the effect is minimal on the piano. Nevertheless: 2 cent per octave may occur according to Schuck/Young and Railsback, i.e. about 0,12%. For the piano, that is – with its E_4-string being about 1 mm thick. That is about 4 times the thickness of the corresponding guitar string! And thus on the piano the build of the partials includes much more inharmonicity.

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Nevertheless, there must be something to this patent by Mr. Feiten. Doesn't Californian guitar-god **Larry Carlton** say about the Feiten-tuning: "*I've been playing the guitar since I was six years old, and finally it is in tune.*" One could of course find a number of reasons for this♣. How about: Larry C.'s nickname is Mr. 335 due to his penchant for Gibson's thin-line guitars. If, on the necks of his noble vintage pieces, the frets were placed as inaccurately as on all Gibson necks this author checked, then reworking of the necks might indeed have made for audible added value. Whether the application of the Buzz-Feiten-offsets alone really involves significant advantages … every guitarist needs to find that out for him/herself. Here are the Feiten-tuning-offsets proposed for electric guitars, to be adjusted after the nut- and bridge repositioning has been done:

E:	0 / 0	0 / 0
H:	+1 / 0	0 / –1
G:	–2 / 1	0 / +1
D:	–2 / 1	0 / +1
A:	–2 / 0	0 / +1
E:	–2 / 0	–1 / 0

Patent USA-6642442 (Feiten), uspto.gov:
Tuning-offset in cents relative the equal-temperament intonation. The first number holds for the open string, the second number is for the octave fretted at the 12th fret. Column on the left to be applied to electric guitars; the column on the right is for acoustic guitars.

In terms of the tuning offset, the Feiten-patent only distinguishes between electric guitar, steel string acoustic, and nylon string acoustic. It ignores the fact that, in wound stings, the ratio of core- to winding-diameter influences the inharmonicity of the partials. On the other hand, rather extreme precision is required, as the table for the acoustic guitar shows. The high E-string is to be tuned exactly to the (pure) octave for the 12th fret: for all other strings, the octave is detuned by **1 cent**. Just as a side-remark: if a string is heated up by a mere **1° C**, the string frequency diminishes (for unchanged mounting) by 9 cent. Therefore, the string may change its temperature by no more than 0.1 °C in order to maintain the Feiten-tuning! *That fearful sport, father attempt not too oft!* [Schiller]. And from the same author and the same poem ("The Diver"): *Let not man to tempt the immortals e'er try, Let him never desire the thing to see, That with terror and night they veil graciously*. And since there is still some room here: the unforgotten K.-H. Hansen tells us: *Easily does the lad talk big about the mil – he will be an old man by the time he achieves the hundredth part.*

In conclusion of this chapter a bit of an anecdote: a much-lauded Californian guitar god (we shall omit the name … for legal reasons) visits Germany to play a concert. Just before the gig, he takes his el-cheapo♥ six-string to the local shop for a quickie-bridge-adjustment. The latter, however, runs into a substantial snag because the bridge is attached so firmly with double-sided adhesive that to forcedly move the thing is deemed dangerous and inviting real damage. The guys in the shop don't dare to do anything, cause *let not man to tempt the immortals e'er try* (see above), especially with the gig looming that same night: with that god visiting Old Europe once every blue moon, you don't want to botch up his guitar – here in Germany, of all places. So: bring back the guitar unrepaired. That evening: the god plays god-like, in spite of the "displaced" bridge. Or was it because of the resulting special intonation? Who knows how exactly a god ticks?

♣ Larry C. is not really a spring chicken anymore; it's been a while since he passed the age of 6.
On impulse, also the thought pops up: what further heights might Jimi H. have climbed, had he in time ...
♥ The real (precious) stuff will probably and preferably stay safely at home in CA ...

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