Ξεναρμονία Β΄

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Ivor Darreg, composer & electronic music consultant

UP-DATING

In the eight years since the first issue of *Xenharmonic Bulletin* appeared, Ivor Darreg has been active in exploring the possibilities of several non-twelve-tone tuning systems, rather than writing about them. There is an amazing amount of literature, pro and con, on the subject of tuning-systems and scales; but far too little in the way of instruments, recordings, or performances. Thus our order of priority was quite clear: To *do* something *in* non-12-tone scales rather than generate reams of silent printed words *about* them.

During this same period, the guitar has emerged as the principal instrument, challenging the place the piano had occupied since the French Revolution. One might as well coöperate with the inevitable, so the present writer has re-fretted several guitars and drawn charts for Hawaiian guitars and has made superposed tape recordings of combinations of these. In this way, the viability and practicality and feasibility of non-twelve-tone music have been demonstrated and many seemingly formidable obstacles have vanished as if by magic.

This writer has proposed the term *xenharmonic* for music, melodies, scales, harmonies, instruments, and tuning-systems which do not sound like the 12-tone equal temperament. In our own writings, we wish to stipulate that *microtones* shall refer to quartertones or still smaller intervals, i.e., to 1/25 octave or less. Of course, ambiguous borderline 'grey areas' will exist: that's to be expected.

It seems inappropriate to us to call such an interval as the 13th or 17th of an octave a microtone—and even those who wish to do so will have to go in for elaborate semantic gymnastics to call the 5-tone or 7-tone temperaments *microtonal*, but they certainly are very strange-sounding.

It should also be realized that the contracted semitones used by violinists et al. in playing their brilliant sharpened leading-tones may often be as small as the 18th or 19th of an octave. Xenharmonics may or may not include such interpreters' nuances, just as you like; but Xenharmonics is intended to include just intonation and such temperaments as the 5-, 7-, and 11-tone, along with the higher-numbered really-microtonal systems as far as one wishes to go.

The term 'xenharmonic' is derived from the Greek ξένος, *xenos*, meaning 'strange'. The other meanings of this Greek word, such as 'foreign' and 'hospitable', also seem appropriate enough. The models for this neologism are of course such terms as *enharmonic* and *philharmonic*.

The new resources of recent times, such as pocket-size electronic calculators, as well as big computers to relieve us of the drudgery of compiling theoretical tables by hand, and the fantastic precision now available with frequency standards, frequency counters, and automatic tuning devices, and the invention of stable circuits for holding such an instrument as an electronic organ permanently in tune, have profoundly altered the situation, so that it behooves us to re-examine and re-evaluate prior speculations. What was out of the question 15 years ago is now "off-the-shelf" reality.

The making of instruments thus becomes easier as their quality improves.

More important than these technological advances, however, is the fact which we have proved, viz. that xenharmonics gives the composer a wide range of new unexpected moods to share with the listeners. This is the *real* reason for going into xenharmonics. When you hear the results for yourself you will know!

(Addendum in 1977: Consult Xenharmonic Bulletin No. 5 of May, 1975 for additional information on these moods of the various tuning systems.)

INTRODUCTION TO TEMPERED TEMPERAMENTS

This article is the preliminary version of what will eventually be a lengthy monograph on the subject of Tempered Temperaments. Suggestions and additional pertinent references will therefore be welcomed.

While our label for such tuning-systems does not seem to have any precedent, the phenomenon itself has been around for quite some time. Thus our appellation for it represents a new *attitude* toward the situation more than anything else. We believe that this new attitude will have useful consequences.

The idea of re-tempering something which already has been tempered may seem strange. Why would anyone want to do something in two or more steps if it could be done as a single step? And indeed, many of the second-order or tempered temperaments are viewed as if they were only one-step procedures: their complexity is ignored.

The real importance of this new attitude arises because of what is actually heard from commonly-used instruments, and from the standard procedures by which these instruments are tuned.

The conventional twelve-tone equal temperament is almost always re-tempered or deviated from or warped or twisted in actual practice. It is more honored in the breach than in the observance.

Indeed, it is only comparatively recently that accurately-tuned and stable electronic frequency standards have been generally available. Ironically enough, this has somewhat increased the pressure to escape the 12-tone squirrelcage — the monotony of this finite-resource system.

Many of the arguments against non-12-tone systems have been based on the alleged difficulties of getting an accurate tuning of the system in question, and upon the unrealistic assumption that most people hear twelve-tone-tempered music from instruments which are accurately tuned and stay in tune to a precise and rigidly standardized 12-tone temperament.

After 38 years of tuning it is painfully obvious that this is not the case at all! The precision exists in laboratories to many decimal places, but not on real musical instruments of the conventional sort such as pianos or guitars. Electronic instruments that are accurately tuned sound 'dead' to most musicians, even if they don't know why.

For each non-twelve system, it will be worthwhile to find out how much mistuning or intentional deviation will be tolerable. We do not find many references, even indirect, to this matter in the literature.

Accordingly, we have conducted and will conduct extensive experiments in this field, if the facilities are available.

What we have established is that the deviations from the twelve-tone-equal ideal are so gross and so widespread that the sting is completely removed from the arguments of the advocates of the 12-tone status quo: they simply don't have a leg to stand on!

That is to say, the usual keyboard or fretted instrument is in a tempered temperament, and some instruments are in a tempered tempered temperament.

On top of that, there may even be additional deviations. The situation in the orchestra or band is so irregular that it would be a ridiculous waste of time to try to evaluate it.

Let us instead go immediately to a practical situation—the piano and how it is tuned. Until quite recently, the majority of piano tuners have worked to a *routine*, which is practiced until it becomes an automatic subconscious habit. Details of the standard routines may be found in books on piano and organ tuning, such as the well-known texts by Howe and by White, and for an idea of the early stages of tuning-routines in England, Ellis's Appendix in his translation of the Helmholtz *Sensations of Tone* has some information, including a table of the deviations to be expected from a theoretically-equal temperament.

Here, then is a very important and much-used second-order or tempered temperament. The basis is this: Theoretically, each 12-tone-tempered fifth will beat at a different rate, such that the ratio between successive fifths' beating-rates, such as that between the beating-rates of the fifths a – e′ and b♭ – f′, will be as the twelfth root of two, to one, the same as the ratio between two successive degrees of the twelve-tone chromatic scale. Tables of such beat-rates have been published. *(Addendum in 1977: Consult Xenharmonic Bulletin No. 8 of July 1976.)*

Obviously, it is difficult to memorize all those beat-rates, and especially so when the tuner is not taught the physical and mathem-

atical basēs of the twelve-tone system in detail—hardly ever is he told *why*. Only the practical knowhow essential to acquiring a marketable tuning-skill is usually taught.

Furthermore, the piano is hardly a precision instrument; and as for the pianos and organs of more than a century ago, when the tuning-routines were being evolved, the less said about them, the better!

So the usual fourths-and-fifths routine aims for an equal beat-rate rather than a gradual increase in beat-rate as one goes up the scale—which explains the German term *gleichschwebende Temperatur* or equally-beating temperament. Because the fifths and fourths of twelve-tone are only 2 cents from perfect —a cent is a hundredth of a semitone, so this two cents we are talking about is only 1/600 of an octave, it is very easy to ignore this deviation from theory entailed by the one beat-rate instead of twelve to remember and learn.

Since most pianos have three strings to a note, the inevitable inaccuracies in the unisons further mask the deviation caused by such equal-beat-rate routines. So—that instrument which has kept the 12-tone equal temperament locked firmly in place for some 150 years has actually been giving us a tempered temperament, not the alleged ideal equality.

Alas!-the story does not end there: the piano goes out of tune; its bass strings are out of tune with themselves; and the octaves are stretched, and the stretch itself is stretched. We have therefore not only a tempered temperament but a stretched stretch.

As a result, the average person hearing a precise 12-tone temperament senses something 'wrong' even though this may be subconscious and never understood for what it is.

The organ, whether pipe, reed, or electronic, has its own foibles with respect to temperament. Tremolo and/or vibrato is used to help mask the harshness of the 12-tone system, and deliberately out-of-tune or "voix céleste" ranks are often incorporated into pipe and reed organs. A medium-sized instrument will have one or two sets of pipes tuned sharp of the main pitch; a large organ will have one or more "unda maris" ranks of pipes tuned flat of the main pitch. This does *not* mean a constant number of cents flat nor merely pitching the pipes to 443 or 438 instead of 440 for A; it means patiently setting a beat-rate which gradually increases up the scale, so that such flat or sharp ranks are rather 'sour' by themselves—distempered if you will! The result of this usual procedure is to produce *shrunk* rather than stretched octaves, making the organ still further from the piano's tuning-norm.

Sorry about that, but the effect is apt to become wearisome and enervating to all but confirmed pipe-organ addicts. For obvious technical (euphemism for financial) reasons, few electronic organs provide such extra tone-generator ranks; instead they try to imitate it with a smotheringly heavy vibrato and sometimes fancy speakers like the famous *Leslie* on top of said vibrato. But the noisome extreme is reached in the accordion, which in its more expensive forms has several extra sets of reeds carefully tuned 'off' in both directions. If you have wondered why the accordion is always played too fast, now you know: its timbre shows up the harsh thirds and sixth of 12--tone like the proverbial sore thumb, and desperate expedients must be resorted to in order to try to cover it up.

Now that the guitar, and some other of the fretted instruments: banjo, mandolin, &c., are becoming so popular, it is certainly àpropos to consider the peculiar tempered temperaments for the fretted fingerboard. The usual rule (before computers, anyhow) is to divide the effective vibrating length of the string, i.e., from nut to bridge, into 18 equal parts and to take 17 of there for the string-length to be produced by stopping the string at the first fret. Then *that* distance in turn is divided into 18 equal parts and 17 of *those* are taken, and so on. This amounts to pretending that the octave is equal to the twelfth power of 18/17 rather than to 2/1.

The ordinary semitone, 1/12 octave, is of course 100 cents in size; the interval of ratio 18:17 is 98.9546 cents wide. Twelve such intervals come to 1187.4552 cents, which is 12.5448 cents short of a full octave. Inaccuracies in cutting grooves for the frets in the fingerboard and setting the frets in them, coupled with irregularities in the strings themselves, help to mask some of this eighth--of-a-semitone discrepancy. The bridge can easily be adjusted to take care of some more of it, so this rule evolved long before computers, slide-rules, or adding machines is quite tolerable in actual practice with real guitars.

This use of 18/17, a rational number, as a substitute for the irrational twelfth root of 2, might almost be thought of as generating a distempered or justified temperament rather than a compound, re-tempered, or second-order temperament. However, it has to be regarded as *an approximation to another approximation*. You may be reminded of such affairs in other fields as chain discounts, multiple taxes and surtaxes, compound interest, rounding-off something already rounded, compound tolerances, etc., so this idea of a rational approximation to an irrational should be understandable.

This use of rational numbers has recently taken on additional relevance, since it is desirable in electronic organs to derive all the frequencies of the tones from a single master oscillator, which one can then afford to make of a high degree of precision. In the electromechanical (now happily being phased out at long last) Hammond organ and some other instruments, rational numbers *have to* be used in the gearing—as for instance 89 : 84 as a much better approximation to the 12th root of 2 than the above-mentioned 18 : 17.

Recent developments in digital circuitry and other concepts borrowed from computer technology are sure to make the use of rational numbers for temperament-simulation even more attractive. To xenharmonists it might be pointed out that the just minor third, ratio 6 : 5, when taken nineteen times in succession is only 3 cents away from the starting-tone—19 minor thirds come that close to closing a circle of 19 tones. Here, then, by applying this fact to electronic circuitry or to gearing, is an elegant way of simulating the 19-tone equal temperament.

The patent literature is full of approximations of this kind—it takes much thought to force a mechanical device or an electronic circuit that wants to be just, into an equal temperament, and oftener than not, the temperament is merely approximate!

Before we leave this use of rational numbers as proxies for the irrationals, we must mention the approximations to 12-tone given by Harry Partch in his book *Genesis of a Music*, and the numerous 'just constructions' diagrammed by Dr. M. Joel Mandelbaum in his Thesis on Multiple Division of the Octave: these are networks of just intervals which approximate a given temperament. This approach may be called 'turning temperament inside-out'.

The piano tuner's stretched octaves already alluded to, have brilliance of general effect as their primary motivation, with the inharmonicity of tight, thick steel strings as the other reason. Most theories of temperament assume the octave to be inviolate—the octave must not be tempered. Accordingly, recognition of the piano tuner's octave-stretching came slowly and with utmost reluctance. On harpsichords and clavichords there is little stretching; on organs almost none, but for 'chorus effect' there will be a slight departure from the perfect octave. And of course from perfect unison of the same notes on different ranks of pipes.

With many non-twelve-tone systems it may be desirable to stretch the octave; in some other cases, as in 22-tone, to *shrink* it instead. At a later date we may issue tables for some of these stretched and shrunken tunings. One way of doing this is to work with a root of 3 or even 5 instead of 2—to use some other overtone than the octave as the basic interval. On fretted instruments, a very easy way to temper a temperament is simply to move the bridge.

Other forms of tempered temperament arise from the need to save time and/or money. For instance, the author has used a scheme which will get 17-, 19-, 22-, and 31-tone guitars by refretting to 18, 18, 24, and 32 respectively, which permits leaving some of the original 12-tone frets in the fingerboard undisturbed, and then moving the bridge. The practical discrepancy in tuning simply does not matter in the performance of actual musical compositions, even though from a mathematical or theoretical point of view it irritates the theorist's or mathematician's sense of propriety: to him it *should* be horrible and obnoxious and that it is not, irritates him still more!

The errors just mentioned are much smaller than what piano and organ tuners get away with every day, even when tuning for academic or professional musicians.

Another viewpoint from which to examine tempered temperaments is that of the numerous approximations to the meantone temperament and variants of ¼-comma meantone. The 31-tone equal temperament, for example, is so close to ¼-comma meantone that the 31st meantone fifth up, or A-quadruple-sharp, is only 6 cents flatter than the starting-note C. Any other note closer in, such as D-flat or G-sharp, is going to differ from 'real' meantone by only a tiny fraction of this amount, so the difference will not be heard. One might as well pretend that the 31-tone equal and the ¼-comma maantone systems are temperaments *of each other*. It would be futile hairsplitting to insist that one of them is primary and the other is secondary. Similar reasoning applies to the extremely close relationship between the 19-tone temperament and Salinas' 1/3-comma temperament.

Again, the similarity between 1/5-comma meantone variant and the 43-tone equal temperament has been noted in the literature, so we don't have to flog that horse here.

Another variety of tempered temperaments that has been much written about, and actually tried out as well, consists of the so-called *unequal temperaments* using only twelve tones per octave. These range all the way from trivial—even inaudible or inconsequential—deviations from 12-tone equal, to noticeably-different systems where some keys sound exceptionally smooth and other keys are harsh: the ability to have different characters of

keys is highly prized by some people, and much sentimental gushing nonsense about this was promoted during the Romantic Period.

At the twelve-pitches-extracted-from-mean-tone end of the spectrum are innumerable attempts to close the Wolf-Gap—the difference between G-sharp and A-flat in most cases. With weary reluctance we will have to admit such systems to the class of tempered temperaments.

Under the head of saving time above might be cited the 'Marpurg' versions of 12-tone where some fifths are tuned perfect so that others can be detuned to beat faster and so the beginner can learn and use them sooner.

Still another class of tempered temperaments of practical importance, although it is not really systematic or mathematically specifiable, would be the various forms of 'expressive intonation' as practiced by violinists and other concert soloists. The sharpening of leading-tones going upward and the less frequent flattening of leading-tones resolving downwards are the salient feature of these tempered temperaments—one can call them such because they are usually superposed on a basic technical training to use the 12-tone equal temperament as one's standard, and they are considered as deviations from these twelve 'ideal' points. The amount of such deviations, and when and where to use them, are supposed to be passed on from teacher to pupil and 'pupil' here means *interpreter*—the poor composer is forbidden to write such nuances down in the score and is scornfully told to keep his hands off!

In the popular music world, the practice of 'tone-bending' and/or using 'blue notes' occupies a similar place, and might be considered a tempering of temperament.

In either case above, one cannot set up rigid standards nor systematize the practice too much.

It is possible to have *automatically tempered temperaments*. The author's specially-constructed electronic organ could retune itself while chords were sounding, thus improving—justifying—whatever temperament it might be tuned to. This effect is specially noticeable in the fifths. They often refuse to beat at all! A given note sounded by itself will have a different pitch than when sounded with others. This pitch-adjustment is mutual, and takes noticeable time to complete. It thus resembles the mutual pitch-adjustments made by members of a live ensemble. In the design of a new instrument, the amount of such adjustment could be controlled and even made variable at will.

Obviously enough a computer could be programmed to do this also.

Further, it is conceivable that one could have automatic arrangements for warping a temperament differently as the music being played modulated to new keys or changed its character. It would be possible to play everything in just intonation, or to compromise and go partway toward it, or to transfer from one temperament to another by a specially-modified intermediate system.

Allied to the subject of tempered temperaments is another phenomenon which occurs in practice, that we might as well call *just constructions erected on tempered degrees*. The classical example of this, of course, is the mixture stops on pipe organs, which are supposed to be tuned to just chords based on the twelve tempered pitches of the fundamentals of said chords. A far more important case at the present time, since most electronic organs do not have mixture stops for crass financial reasons, is the steel guitar, which is tuned usually to a just chord but is normally stopped with the steel over one of the twelve-tone-system fret-lines painted on its non-fingerboard.

When such a Hawaiian guitar is played with other instruments, just chords will clash with tempered chords played by such instruments, unless, and this is but seldom, the steel guitar is deliberately tuned to a 12-tone-tempered chord in the first place, and if it is so tuned, it is going to sound harsh and grating by itself, because most amplifiers have enough intermodulation distortion to generate loud combinational tones, which will be terribly out-of-tune when the chord is tempered, providing a false bass and often false middle voices. With just chords, these combinational tones will be in tune.

At the loud volume levels of contemporary groups, this is inevitable. Contemporary counterpart of what Helmholtz said a century ago: the clashing of just and tempered chords in the mixture stops of pipe-organs produced a hellish screaming. After attending some 'traditional' organ recitals, we have to agree—Helmholtz was correct.

Non-twelve-tone tunings may alleviate this problem; elastic tuning, however achieved, will also alleviate it.

In conclusion, it should now be evident that the average musical performance is far more likely to be in tempered temperament than in precise simple temperament. Often this is an actual advantage.

The complications introduced by compound, elastic, and varying tempering make it very difficult to predict practical results from the standard theories, but that does not give anyone an excuse to ignore the phenomenon.

* * THE END * *