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The Calmer Mood: 31 Tones/Octave

In our previous (July 1976) issue, XENHARMONIC BULLETIN #8, tables and tuning procedures for systems with unit-intervals larger than the quartertone were given—there just wasn't enough space to jam in the equally-important 31-tone system. In case any triakontamonophonists or tricesimoprimalists (that's Greek or Latin academic snobtalk for 31-ians) were wondering, they were not being ignored or neglected; it's just that one has only so much time and energy and also a single issue of this Bulletin should not get too bulky.

Instruments and compositions now exist in the 31-tone system; enough momentum has now been gained to ensure that it is here to stay. This is reinforced by the revival of Meantone Temperament. Both systems favor the major third, being willing to trade off a slight flattening of the fifths to smooth and calm down the major thirds.

This was well exemplified at the concert presented last April in Alhambra (a suburb east of Los Angeles) by the Netherlands organist Anton de Beer and the violinists Bouw Lemkes and Jeanne Vos, who were on tour in the U.S. A special electronic organ called the Archiphone, with timbres proper to the Swell manual of a regular organ, had the harmonic constitution necessary to define the intervals of the 31-tone equal temperament —and the continuity with the meantone era of keyboard instruments was demonstrated by using a harpsichord so tuned.

The overall effect was restful, calm, serene: it would not have done for an operatic storm-scene!

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Seventy Years Ago, Busoni Had A Dream

Ferruccio Busoni's name has come down in music history as a piano virtuoso, as a composer, and also because of editing and transcription. He lived from 1866 to 1924, but what we are concerned with here are some paragraphs in his New Esthetic of Music (German edition, 1907; English edition, 1911) and a brief epilog or commentary published in the German music journal Melos (August 1922), later appearing in a collection of Busoni's writings.

With some sadness, we have to tell you that Busoni had a very interesting and revolutionary concept, but did not carry it to fruition—indeed, the 1922 remarks reflect a timidity dangerously close to retraction on some points. It is almost as though someone had intimidated him, or the Musical Establishment of his time had brought subtle pressure to bear.

Perhaps in retrospect he was afraid of his earlier audacity; more likely, the pressures of routine business, concerts, and travel prevented him from any serious composition in his new system.

His main idea he called the "tripartite tone"; we would now say "third-tones" or the 18-tone system. Of course he was not the only one to investigate this system; Julián Carrillo had a third-tone piano and composed for it, while Alois Hába devoted some space to it in his books, and his 36-tone system contains it.

The point is that Busoni approached the third-tone as a traditional musician of both German and Italian background, steeped in the milieu of his time and enjoying some degree of recognition and respect by the conventional musical community; yet he dared to conceive of a system that went against the mainstream.

Even to imagine third-tones would have been quite an effort then; no wonder he

(Continued on following Page)

Busoni-et-al.'s Dreams

didn't gather a following on this point and didn't have enough encouragement from interested parties. The cost of building an 18- or 36-tone piano would have been formidable then; today it would simply be impossible.

Eventually, Busoni got far enough to conduct a very preliminary experiment: In New York City an aged piano-maker from Italy rebuilt an old harmonium with three manuals (such are very rare) and tuned it to 36 notes per octave, or sixth-tones, giving two rows of third-tones separated from one another by ordinary (12-tone) semitones. He tried the 18-tone scale out on an audience who had not seen the instrument, seated in the next room. Their impression was that they had heard an ordinary chromatic scale in semitones.

The 3-X-12 arrangement on the three keyboards was extremely awkward to manage, Busoni said; but these experiments proved that the third-tone interval was large enough to be appreciated as a legitimate melodic interval.

As Carrillo also said, the 18-tone scale has no fourths nor fifths. So Busoni felt obliged to go to 36 tones so that the conventional semitones could be kept. He was contemplating the use of third-tone melody accompanied by more or less conventional semitonal harmony—at least he says this in the 1922 article—this could be in the nature of a retreat from his younger dreams.

Carrillo had a third-tone piano made and presented in concert. I have a tape including a demonstration and actual composition on that piano. The effect is reminiscent of many efforts to carry on where Debussy left off. This is because the 6-, or whole-tone scale has no fourths or fifths either—that gives a vague mood overall.

George Whitman's Introduction To Microtonal Music, strictly based on Hába, but more narrowminded than he, gives actual exercises for violinists and cellists to practice third-tones.

There was no co-operation among those discovering and using third--tones—no "school" of such composers, no congenial instrument-makers, so it didn't come into general use. However, Busoni's sentences and paragraphs about the tripartite tone have been quoted and even more often cited in footnotes and references and articles on this or that aspect of music. Third-tones were never to be sounded, but it was O K to write about them, commend Busoni for his intelligence, his imaginative foresight, and willingness to indulge in wistful speculation about how nice it would be IF.

Even the occultist/composer Cyril Scott got in the act—the third-tone was supposed to help along the evolution of certain races —not us, of course! To which I must reply -Ug, and double-Ug.

Time here to break in and state that the SIZE of the tempered third-tone, 1/18 octave, is, I agree and many others agree, about right for an expressive melodic interval—cellists and violinists often sharpen leading-tones, so that the distance between F# and G, or B and C, in a melody, is about a third-tone rather than a semitone.

This admitted to be the case, there is a much better solution than 1/3 of 1/6 of an octave, of 1/18 of an octave: indeed, there are at least TWO solutions, the 17-tone and 19-tone systems, both of which are incompatible with 6 or 12 tones per octave, indeed 17 and 19 are both prime numbers—BUT they both have fourths and fifths, and therefore it is possible to play familiar tunes in these scales.

It is strange that none of these three composer-theorists happened on either of those two solutions, but then one must remember that conventional musical training tries to keep people from thinking for themselves, and above all forbids them to experiment.

18-tone compositions require some kind of new notation, whereas either 17-tone or 19-tone can be written WITHOUT NEW SIGNS, just the ordinary sharps and flats. So Busoni invented some suggested notations which he reproduced in A New Esthetic of Music, and these will be given in this issue.

Carrillo numbered the 18 tones, 0 through 17, assimilating this to his general system of numbering the tones of a system and not using note-heads, and a one-line instead of five-line staff. Hába used signs of his 36-tone notation, in effect agreeing with Busoni on the containment of 18 within 36. Whitman discards Hába's flats, retaining only the sharps, for either 18 or 36, or 24 for that matter. I think that goes against contemporary practice, which seems actually to prefer flats to sharps.

When we go to atonality, or to the use of special instruments which do not have certain partial tones in normal intensity, 18 becomes much more plausible.

Third-Tones &c.

For atonality, the absence of fourths and fifths would be an advantage—no longer necessary to avoid implying common chords, the very reason why much "12-tone school" composition sounds so strained and awkward and made up of traditional composers' rejected material! 18 may be regarded as 2 x 9, as well as the more obvious 3 x 6. Indeed some people have experimented with the 9-tone temperament.

Tuning 18-tone by ear has its difficulties, there being no fourths or fifths, so the ordinary tuner may not want to bother. That could well be why Busoni wanted a 36-tone instrument, and why both Carrillo and Hába went in for 36-tone also. Fretting a guitar to 18 is easy, because one can take a 12-tone guitar and yank out every other fret, making it 6-tone, then interpolate two frets in each gap where one fret had been. So you don't have to be a mathematician, although it helps.

Since 12-tone theory makes much use of the 2-x-6 relation, the "hexachord", extending this to 3-x-6 is hardly any problem. Main objection to 18 is the same as that to 12: it is too symmetrical, and of course 36 is still more symmetrical. Some composers may want such symmetry; I don't like it simply because it conduces to the exhausted trite 12-tone clichés I am so tired of, and which I escape by going in for systems incompatible with 12 or having prime numbers of tones such as 19 or 31. For atonality, primes such as 13 or 23 will break up the 12-tone cliché-patterns, and different amounts of symmetry are available in 14, 15, 16, 20, etc.—i.e. the composer may freely choose more or less symmetry of the scale, instead of being chained to twelve.

36-tone may be used as 3-x-12 or 2-x-18 or 4-x-9 or 6-x-6, and one may "modulate" (we propose the term "transfer") from one to the other.

Hába went so far as to set out a new notation (necessarily complicated) for the twelfth-tone or 72-tone scale. But he did not regard 72 as a means for getting excellent major and minor thirds, harmonic sevenths, and harmonic elevenths, alas and alack!—he merely set it out in skeleton outline as the synthesis of the third-, sixth-, and quartertone systems. I.e. the lowering of the 12-tone major third by 1/72 of an octave, which makes it restful and harmonious, he would have regarded as a departure or deviation from the sacred-cow 12-tone imitation major third.

In some later issue, we will take up the possibilities of the 72-tone system, but this is not the place for it—it belongs in the domain of computer music and automatically-played instruments where extreme precision can not only be attained, but maintained. Otherwise it would be useless fooling around. Why scare you off? Why leave all of us open to heckling by those who are only too anxious to use reductio ad absurdum and charges of 'quibbling over trifles' and 'impractical demands on listeners' ears' as they keep on doing?

72 tones per octave would surely be microtones, but 18 is not microtonal, if we accept the definition in certain establishment music dictionaries which now define microtones as anything smaller than quartertones. This is my motive for using the term xenharmonic: a term to cover certain systems such as 5 and 7 to the octave with larger intervals than 12 has, but not sounding like 12.

Busoni's harmonium experiment proved that 1/18 octave or a "third-tone" was not perceived as a tiny "bend" or "micro-inflection", so why call 18, or 17, or 19, microtonal? This interval-unit-size is just about right for recruiting neophytes, so third-tones will have their rôle in the scheme of things.

Names for the 18 pitch-classes? Well, the three exponents of this scale, and undoubtedly some other persons, have made up names: we will quote Busoni's. But I think in a case like this that Julián Carrillo's idea of numbering the tones is better: just call them 0 through 17. Otherwise we imply fifths and fourths that aren't there! The crucial difference between 18 on the one hand, and 17 or 19 on the other! The main reason for using 18 at all is its mood, its ambiguity, its impressionistic vagueness and character.

If 18 be set in a 36-tone framework, of course the tones can be called by their 36-tone names. If that is your pleasure, go ahead. The aspect of suspending some rules of harmony, or warping and twisting them, would be emphasized by assigning numbers, though.

Similar considerations attach to naming the intervals. I suppose 2/3 tone, 7-1/3 tones, etc. would do for some people, or 13°, 8°, etc. might not be a bad idea either.

Third- & Sixth-Tones, *continued*

George Secor recently suggested that this degree-sign° be used for the unit-interval of any equal temperament being discussed at the time. If necessary to indicate which temperament's degrees are meant, put that number after the degree-sign as: 10°31. Perhaps we should borrow the mathematicians' style and put the number of tones as a subscript: 7°_{22}.

Numbers of semitones in 12-tone are already in use by the atonal serialists in their theoretical articles, so it shouldn't be too hard to get this practice adopted.

With those temperaments that have representatives of the familiar intervals: thirds (both major and minor), fourths, fifths, and sixths, the usual names can be retained. Such is the case with the systems on either side of 18-tone or third-tone: 17 and 19. No name problem—indeed, no need for special accidental signs, although it is confusing that the 17-tone sharps are higher than their companion flats, while the 19-tone sharps are lower than their adjacent flats. It's an engineers' trade-off—Isn't the advantage of retaining familiar notation and being able to read familiar music without alteration while playing it in the new system, worth the confusion?

When we come to 18-tone, it's another matter entirely: we have to have some kind of new nomenclature. There are no fourths or fifths unless you want to call altered, dissonant intervals by familiar names and create an unnecessary confusion.

Sure, there is a brute-force method which will be used in some cases: "map" the 18 tones onto a conventional twelve-tone keyboard and write the name (more than one name is possible, as you know) for that key on the keyboard REGARDLESS of the actual sound you are going to get from that key when tuned to the 18-tone system. Synthesizer players will do this mapping-onto operation since it means no special, unfamiliar, expensive new keyboard is needed.

Very well; I have no objection to mapping-onto under such circumstances, but I do object to writing it on the staff, because it misleads others reading the examples or articles about 18-tone—even to the point of trying to play it in 12-tone, with dreadful consequences! The band and orchestra custom of "transposing instruments" written in one key and played in another has caused misery and distress for two centuries, and untold mistakes and recopying and rehearsing. This is extending that horrid idea to an even more exasperating extreme. It is asking for trouble and pleading for misunderstanding. The time to do something is NOW: nip this thing in the bud before it becomes a general disaster!

Not too long ago I ran across two new books on synthesizers in the library and here they are, telling you how to retune so that the keyboard of the synthesizer will be transposed up or down like a clarinet in B♭ or an alto sax in E♭. Shame on them! A golden opportunity to get rid of this absurd custom when and as new instruments are introduced, and they buck it and spurn it and want to condemn all future musicians to crazy confusion.

This in our progressive USA where we have been leading the world in many ways, and where the Europeans already have had some sense to start writing new scores strictly in C—i.e. parts in the new orchestra scores have no transposed notations. The 20th-century use of atonality has made the idea of a transposing instrument being in the KEY of A or B♭, or F or E♭, really ridiculous, so these Human-Roadblock people are hypocritical, as well as reactionary nuisances.

No, we do not mean that old music has to be rewritten nor that wind players throw out all their old sheet music. These new non-12 tuning systems have not been too practical until electronic and other new kinds of instruments appeared on the scene, so the romantic and classical setups for conventional compositions need not be disturbed. They should remain authentic. Then we would have a useful contrast between them and us. Why provoke the romantics and classicists? It's so much easier to leave them to their own devices and not interfere.

If we were going to have to redesign the symphony orchestra and the piano and pipe-organ and the band instruments and rewrite all the scores and parts and instruction-books, there wouldn't be enough money in the world to pay for it, and the results, even if achieved, would be disappointing; and this drastic, time-consuming re-design would have to be repeated for EACH TUNING-SYSTEM adopted.

No wonder Busoni's ideas didn't get off the ground! The electronic instru-

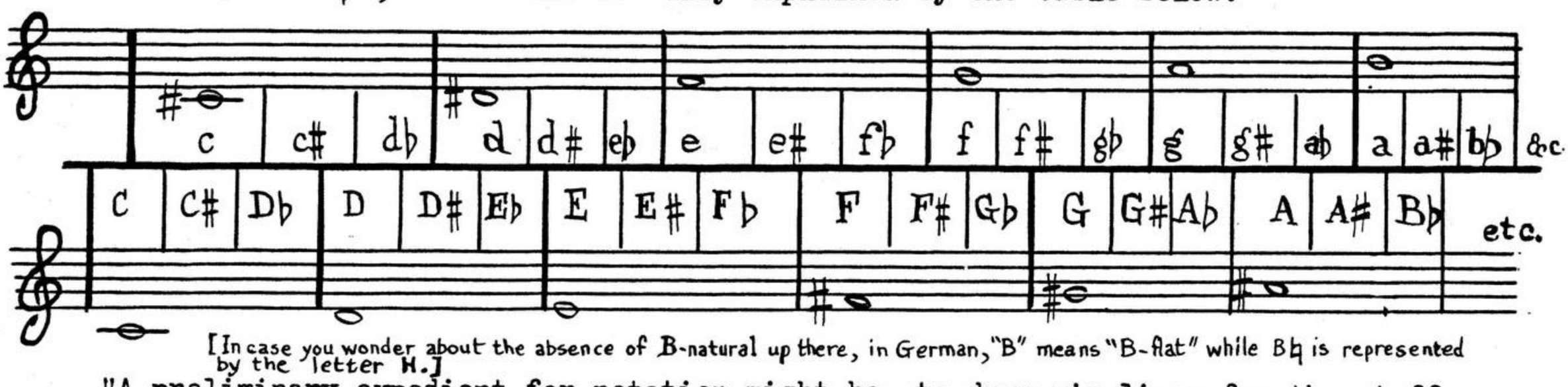
Third- and Sixth-Tones, continued

ments weren't available then. However, be it noted that Busoni was almost unique, in this 1907 publication of his, in recognizing the importance of one of the first electrical (not electronic then, of course) organs, Thaddaeus Cahill's Telharmonium, and calling attention to the fact that it was not tied down to the 12-tone equal temperament. He gave this reference: "New Music for an Old World" by Ray Stannard Baker, McClure's Magazine for July, 1906. Alas! it has taken all of 70 years for the electronic organ to mature and be accepted in its own right, rather than just a cheap shoddy substitute for a pipe-organ.

Just recently, we face another revolution: the electronic organ giving way to the integrated-circuit, microprocessor or computer-based instrument, in which the tuning and voicing and other particulars will be automatically programmed in. This is much more important to the progress of music than might seem to the layman.

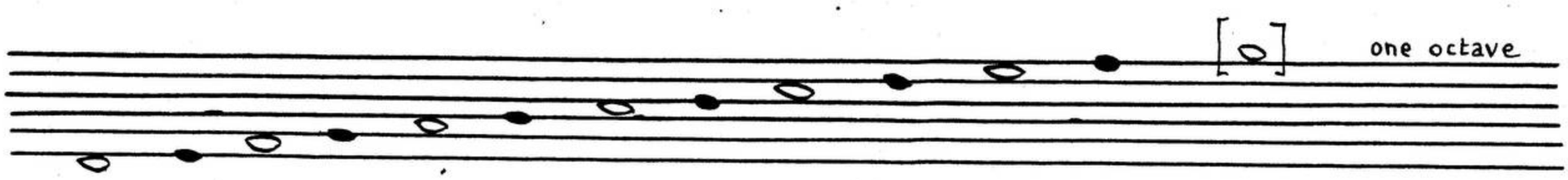
Now, for Busoni's notation ideas: Quoting from p.32, 1911 English edition of A New Esthetic of Music: "To summarize: We may set up either two series of third-tones, with an interval of a semitone between the series; or, the usual semitonic series thrice repeated at the interval of one-third of a tone.

"Merely for the sake of distinction, let us call the first tone C, and the next third-tones C♯ and D♭, and the first semitone (small letters) c, and its following third-tones c♯ and d♭; the result is fully explained by the table below:



[In case you wonder about the absence of B-natural up there, in German, "B" means "B-flat" while B♮ is represented by the letter H.]

"A preliminary expedient for notation might be, to draw six lines for the staff, using the spaces for the whole-tones and the lines for the semitones:



"then indicating the third-tones (and sixth-tones) by sharps and flats:



* * * "Only a long and careful series of experiments, and a continued training of the ear, can render this unfamiliar material approachable and plastic for the coming generation, and for Art."

(N.B.: There appear to have been several errors in the text of the book at this point: it would not be surprising if they had been errors in translating from German, or some kind of non-co-ordination between the type compositor and the music-printer. I have undertaken the risky task of emendation to what I think was meant.)

Before you criticize Busoni's ideas on notation too much, remember that that was all of 71 years ago that it appeared in print, and probably a while before that that he dreamt them up. At any rate, this and certain other passages by Busoni have been frequently cited or given as footnote references in many books and articles, but always in a spirit of "it would be nice if we could, but we must lay all such notions aside". The above was only a preliminary expedient after all.

Busoni et al., *continued* . . . .

The notation proposals just cited were of course based upon the whole-tone scale already contained in the 12-tone temperament by taking every other tone. Here is a passage from Busoni's 1922 feuilleton:

"The whole-tone scale with Debussy, and with Liszt before him, is like an anticipation of the whole-tone interval being filled in with the not-yet-existent tripartite-tone intervals. In this expectation, the semitone is passed over. But only in the melodic parts; the accompanying harmony remains the one that has long been established. Therefore one does not destroy, one builds up! Time automatically rubs off what is wrong and unnecessary and automatically takes up what is good and beautiful in order to keep it. And the great and beautiful thrive."

There have been a number of 12-tone notation-reform schemes based on the 6- or whole-tone scale—there is also a movement for a 12-tone keyboard on a 6-&-6 principle instead of the familiar 7-&-5. Once an electronic organ with such a keyboard was exhibited at a meeting. None of us could play a familiar melody or scale on it!

The third-tone system retains the whole--tone scale's mood. In that sense it is the extrapolation or filling-in of the whole--tone scale. But if it were to be used only with semitonal harmony, it would not be free to develop very far—it would remain something like today's "tone-bending" that keeps being pulled back to the 12.

Today we have many more resources, even if the ordinary musical world has kept on spurning them. In the case of a scale like 18-tone, with unfamiliar intervals, some of which lack the definition or clarity of our fourths and fifths, the answer may lie in "tailoring" special qualities of tone to fit. This requires a close cooperation between scientists, engineers, musical-instrument makers, musicians, and composers that so far has not been implemented. It involves the partial or complete removal of certain components of a musical tone that interfere with the free functioning of a system such as 18-tone, and the possible insertion of new components which may be inharmonic partials so far as ordinary practice is concerned. It is a much more difficult problem than the synthesis of musical tones for "normal" systems having familiar intervals or new intervals that happen to be members of the Harmonic Series.

Naturally, at the time Busoni dreamt of third-tones, the Piano was Emperor—its tones were Law. Atonality had not yet taken over the place in serious music that it occupies today, so the resistance to such an affair as a fifthless scale was very strong. Nothing like the 12-tone circle of keys for tonal music exists in 18. The 36 keys of the sixth-tone scale are in 3 circles of fifths which never intersect.

Not quite as severe a situation as the two non-intersecting circles of the quartone scale, however: the harmonic seventh of ratio 4:7 is closely approximated in the 36-tone equal temperament and conceivably it could be employed to bridge the chasms between the three non-meeting circles. It could today; but in Busoni's time that would have been unimaginable.

The haphazard motley assortment of instruments used in the traditional concert-hall were too strong a roadblock to the drastic revolution that the third-tone system would entail with most of them.

It had to wait for new instruments, and now we have some. Busoni called attention to the fact that violins could play third-tones—indeed they often do, by sharpening leading-tones in a melody. But you dare not ask a cellist or violinist to tune his instrument to the non-fifths of the 18-tone system! It's going to be hard enough to expect any 18-tone guitar players to tune their instruments to non-fourths.

Personally, I don't see as bright a future for the 18- and 36-tone systems as I see for 17, 19, 22, 31, 34, and 41, or for just intonation in various forms. It's not different enough from 12 and it still contains the now-pretty-much-exhausted 6- or whole-tone scale, with its mood, and it is just as symmetrical as 12, being 3x3x2 instead of 3x2x2—what such symmetry means, is that a series of major thirds does not pass through ALL the tones of the system, a series of whole-tones or ninths-of-an-octave does not either. But in 19-tone, any interval less than an octave MUST traverse all 19 tones before it returns to starting-point. This means more variety.

18 and 36 will have their place, now that automatically-tuned and rapidly--switching-from-one-system-to-another instruments exist, but it will be less important in the Scheme of Things.

Hába wrote some sixth-tone compositions, so that is a good reason for discussing sixth-tones. One of Carrillo's pianos was in sixth-tones.

A guitar for the 36-tone system is difficult to negotiate. It should

Busoni, Hába, *et al.* *continued*....

have quite a long neck, i.e., long string-length (effective), in order to get the frets far enough apart. The practical obstacle to this, of course, is that the wound strings for guitars do not come in lengths much over one meter (39 3/8") so would have to be made to order at fantastic expense. As the length in use increases, the tuning must be lower in proportion. With special tunings and restricted bass compass, plain strings can be used, permitting unlimited length. Fret-tables for 18- and 36-tone will be given in this issue.

Three pianos tuned a sixth-tone apart have been tried. The only direct information I have was from Mildred Couper of Santa Barbara, California in 1942. She said that she tried this out, but it was very unsatisfactory in all the attempts, so she went back to two pianos tuned a quartertone apart and produced a number of compositions in the 24-tone system.

Modern computer and electronic-organ and synthesizer techniques make any talk of three pianos for 36-tone anticlimactic and completely obsolete. Three players would be required, and any third-tone themes such as Busoni was hoping for would be awkwardly divided up among the three players in almost ridiculous fashion. The presence of sympathetic resonance in each of the three pianos so far as its own 12-tone set is concerned, coupled with the lack of any sympathetic response from one piano to the other two, prevents integration of all 36 tones, defeating the purpose and destroying all those expectations.

The natural human desire to conserve is not always an unmixed virtue: in this case, composers have been hamstrung and hogtied by instrument-manufacturers, commercial interests, and performers' inertia, besides the very real technical problems any performer faces in reprogramming him- or herself. Insistence on keeping the 12-tone system on the new instruments blocks progress, because we have then 12 familiar sounds and X number of utter strangers, and the contrast between members and non-members obstinately remains. Since millions of 12-tone tempered instruments will continue to exist, there is no need of making the non-12 or xenharmonic instruments conform to them or conserve the 12-tone tradition; on the contrary, a contrast is desirable.

Many complaints have been uttered in the last 50 years or so about "quartertones tacked on", "super-twelve", "half-inches instead of whole inches", "non-structural deviations and/or mere embellishments", "florid microtonal inflections of the melodic line", and so on.

It boils down to xenophobia, or fear of the unknown. Performers and instrument-makers cannot understand why a composer might want out of the 12-tone squirrelcage. I say 'squirrelcage' because of certain 12-tone-scale patterns, such as the augmented-fifth chord, the diminished-seventh chord, the whole-tone scale which is also a chord-of-seconds, the ½-octave or augmented-fourth/diminished-fifth, which symmetrical series go round and round and round and have been just about exhausted by several generations of composers. They can't IMAGINE that which they never allow themselves to HEAR. So this produces the logical-enough desire to retain the original twelve tones as a security-blanket to hold onto while timidly poking an arm or leg into the unknown non-twelvular territory.

Having spent some years in non-twelve composition, instrument-building, design, and performance, I can assure you that you won't get sick or catch cold or get wet or suffer any damage to your 12-tone tuning or performing skills. On the contrary, they will improve. There is nothing to dread or be anxious about or be afraid of. Xenharmonics won't bite. It will expand and liberate your imagination and reduce boredom and monotony.

Time now to reproduce Alois Hába's microtonal signs. They are in use, either as shown or modified, by quite a number of composers.

TWELFTH-TONES OR SEVENTY-SECONDS OF AN OCTAVE:

Sharp: 1/12 1/6 1/4 1/3 5/12 1/2 7/12
2/3 3/4 5/6 11/12 1 tone

Flat: 1/12 1/6 1/4 1/3 5/12 1/2

QUARTERTONES BY THEMSELVES:

Sharp: 1/4 1/2 3/4 1

Flat: 1/4 1/2 3/4 1

If you want to invent your own brand of accidentals, you have lots of company. Far too many systems exist for all microtonal accidentals to be standardized, and besides, there are ideas such as Augusto Novaro's and Julián Carrillo's to eliminate accidentals altogether.

What I have quoted in this article must not be taken as condemnation or approval on my part; I merely report.

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31-Tone, the Calmer Mood...

continued from Page One

Those of you who still have my Xenharmonic Bulletin No. 5 for May, 1975 (it will be reprinted from time to time) may remember the lead article, NEW MOODS.

The 31-tone system commands a different spectrum of emotional expression and suggestive power than the 12-tone system does. The contrast is great, being mainly that of serenity vs. agitation, calm vs. restlessness.

How so? One reason has to do with 12's sharp major thirds and sixths, its flat minor thirds and sixths. In 31 the major third and minor sixth are almost perfect, being out 0.7 cent—i.e. these 31-tone-system intervals fail to be perfect by the 1714th part of an octave. This discrepancy is inaudible under all but special laboratory conditions. The corresponding discrepancy for the 12-tone intervals of the same names is 20 times as great, and manifests itself as a roughness or harshness—a "reedy growl" as one author called it.

In the $\frac{1}{4}$-comma meantone system, these intervals are perfect. The slight 31-tone discrepancy means that there is a circle of 31 major thirds and a circle of 31 fifths in the 31-tone system—it is cyclic or closed; whereas in the meantone temperament the cir-
doesn't quite close and theoretically meantone temperament has an infinite number of tones. In this practical world no-one has all eternity to test that and find out.

For purposes of building and playing guitars or organs or synthesizers or whatever instruments are practicable for meantone or 31-tone, the discrepancy does not matter, because the imperfections of instruments and performance upon them, and the quality of interpretation of compositions will not be different enough to get disturbed about.

A mathematician will care, of course. As mathematician. I doubt that he could tell the difference, listening to a record or a tape of an actual piece of music.

But the difference between 12-tone and 31-tone performances of the same piece: that is quite a different matter! Many of you have seldom heard a just, pure, beatless major third or even an approach to it. True, the 12-tone system has better fourths and fifths than 31-tone or meantone do; but the price is too high—those fourths and fifths being bought at the cost of degrading all thirds and all sixths, both major and minor.

With the ordinary style of harmony, the result is that 12-tone performances contain a continual unrelieved harshness or grating effect, whenever a major or minor chord is sounded. A single 12-tone major third may not be a crime in itself, but hundreds of them heard during the average concert add up to an overall mood of restlessness and failure to achieve true repose. Because this is subconscious, the average listener doesn't know why there is something wrong.

This wrongness or harshness or restlessness is not an Absolute. There are various ways of alleviating it, practiced by ordinary musicians in the course of performances, and by some instrument-makers also. So when the problem threatens to reach conscious awareness, one of these things is done as an artificial tranquilizer. Here are some:

1. Heavy vibrato.
2. Soft-pedaling—muting—composer or conductor calling for ppp and pp to subdue the harshness.
3. Auxiliary off-pitch melody-line reinforcements: in the pipe-organ, the voix céleste stop, tuned to beat slightly sharp of the main pitch, and the unda maris stop, tuned to beat slightly flat of the main pitch; in the orchestra, many first and second violinists, violists, and cellists playing the same part to "warm" it up; in rock groups, trick-boxes which add such pitches or add artificial reverberation.
4. A general dulling of timbres on 12-tone-tempered instruments: the piano became deficient in high harmonics as it became louder; many electronic organs have no "edge" or "bite", but instead a muffled blunted tone; although invented quite long ago, the keyboard bowed-string instrument never gained favor because it is intolerable in 12-tone temperament.
5. "Blue" notes and tone-bending.
6. Hurried harried hasty fast speeded-up velocity: if you can get the music up to vivace and presto, the short notes won't have time to beat with one another, and the animation, aided by the percussion or rhythm section, will distract from what harshness remains. This is why the accordion is always played too fast, and never is used for Bach fugues or lullabies; and why the tremolo of the mandolin and the rapid whizzing runs on the banjo are favored, and the circus orchestrion doesn't ordinarily play largo.
7. The piano has another gimmick: the stretched octave—the tuner does not leave perfect beatless octaves in either the low or high registers of the instrument. Piano bass strings are out of tune with themselves! Result: if ALL intervals INCLUDING THE OCTAVE, are tempered, there are NO just beatless intervals to compare the harsh thirds and sixths with on a proper basis, so this somewhat alleviates the effect. (Theoretically, temperaments should leave the octave strictly alone. However, stretched- and squeezed-octave tempera-

31-Tone is Calmer .....

ments have been proposed, and would indeed be useful for certain purposes. In later issues we can go into the matter more thoroughly. For the moment, referring specifically to 31-tone equal temperament, the late Prof. Adriaan Fokker had proposed a slightly-shrunken-octave version of 31, and some time ago I recommended that a somewhat stretched-octave version of 31-tone be calculated, viz. the 49th-root-of-3 equal temperament. This was done by Dr. John H. Chalmers, Jr., and recently I have made further calculations to produce tuning tables and comparison-tables for it.

My object in proposing the 49th root of 3--i.e. a tuning-system in which the twelfth or one-octave-plus-a-fifth interval was perfect, and then divided into 49 equal parts, which parts would then be used as if they were thirty-firsts of an octave (i.e. $\frac{1}{31}$ of a NORMAL unstretched octave), was that on certain kinds of organs and other possible instruments, a perfect third harmonic would sound clearer and more brilliant. On many organs there is a 2 2/3' stop which has three times the frequency of the nominal pitch. Often this stop is called the Twelfth; sometimes Nazard. The Quintadena stop on some organs sounds both fundamental and twelfth. The 49th root of 3 would result in a slightly-sharp major third and an improvement in the minor third and the fifth and ninth. All these effects would be subtle and perhaps subconscious.

There is a class of electronic organs, and a smaller class of synthesizers and electronic tuning-aids, on which this kind of temperament based on something else than the perfect octave, would be impossible or extremely difficult. But again, this 49th-root-of-3 scheme would not have very wide use anyway--valuable as a variant for special needs or alteration of the 31-ish mood. It could be approximated on the 31-tone guitar by a very slight moving of the bridge. Therefore we need not bother with a fretting-table for it. Fokker's contracted-octave system could also be so approximated. (Note to mathematicians: Yes, I am well aware than an error is involved. But in these cases the error would be inaudible to any Earthbound human being. So let's ignore it, OK?)

Back to the discussion of "artificial tranquilizers for twelve-tone harshness" on the preceding page: A prejudiced or narrow-minded twelvetonist will resort to anything he can dream up to bolster his side of the argument against xenharmonics or non-twelve. By insisting that the piano be the only instrument allowed to be touched during the argument, he can restrict the argument to duller qualities of tone and more importantly to tones which DIE AWAY so that most of their duration is relatively free from the harshness and roughness I have been squawking and grousing about here. The 40-year-long reign of the gear-wheel tone of the Hammond Organ (only recently have its makers abandoned the principle involved) which tries to alleviate the defects of 12-tone equal temperament by means of synthesizing timbres with imitation harmonics of which their gear-wheel mechanism provides only 1 2 3 4 5 6 and 8, without the 7th and with a sharp 5, has had a profound influence on the public ear. If you play only a nylon-string 12-tone guitar, and avoid anything like plectra or fingernails, you can de-fang twelve as much as the piano does, or more.

Ever since the highs-cutting tone-control was invented for radio sets, people have been using it, and even today's hi-fi fans will use this device to take all the sharp edges off whatever comes through their loudspeakers. As a reaction to this practice of several decades, rock people are using fuzzboxes, while classicists have revived the harpsichord with oooodles of high frequency components in its tones.

31-tone and meantone can stand far more penetrating, sharp-edged, strident, acute tones than 12-equal can. That's why I am spending so much space here on this subject, rather than merely doing a memorial to Christiaan Huygens and an appreciative gesture to Adriaan Fokker for re-discovering Huygens' important work and doing something about it.

Strident or penetrating tones have a greater precentage of higher harmonics which will define the intervals that do not exist in 12-tone music. Unless these "new" intervals are sounded with sufficient clarity, they will not make the proper impression on new listeners. Their raison d'être will not be clear. That is, the burden is on us: WHY go beyond 12 tones per octave? Justify the trouble and expense! 31 will cost more than 19 or 22. Is it worth it? Why is it worth it? You must be ready with adequate answers to such questions. Not tricks of the orator or flippant evasions--good reasons that make sense.

Best is a vivã-voce demonstration of the way 31-tone temperament SOUNDS. Of sustained chords in it--the new chords. Of the peculiar MOOD it has, the calm, the restfulness. No amount of verbal description is going to get that over. It must be heard to be believed. 12 notes out of meantone, tuned on a piano, are NOT nearly enough. That presentation can be downright deceitful and misleading. If that is all you have heard of either meantone or 31-tone, you simply don't have all the story yet. It has some value as history, no more.

31-Tone and Meantone . . . . .

Frankly, I'm tired of the endless monotonous stupid repetition in book after book of dreadful misinformation about meantone. Are all these people too lazy to look up the better sources? With the revival of the harpsichord and its resumption of full life and growth, and with the reprinting of Alexander J. Ellis's remarks on temperament in the appendix to his translation of Helmholtz' Sensations of Tone, and with the mention of meantone temperament in various scholarly articles, there is no excuse for the wrong rumors about it to be perpetuated.

The misinformation claims that meantone is unequal temperament and that it MUST have a wolf. (No, not Prokofiev's Peter and the Wolf, and not Disc Jockey Wolfman Jack either!) This wolf, so-called because of the howling discord it makes on organs, is a kind of compulsory mistake. If you have a harpsichord, clavichord, piano, or organ with only 12 keys per octave, and try to put it in meantone temperament, you end up with wolves. Let's say you go down to E-flat and up to G-sharp. I.e. the series (it is NOT a circle in meantone!) of Fifths reads E♭ B♭ F C G D A E B F# C# G#. Then the fifths G#E♭ and the fourths E♭G# will be woefully out of tune and distressingly dissonant. The major third B E♭ (really a diminished fourth) will be just as bad, if not worse. So unless you have provided yourself with a lot of sheet music that avoids distant keys, you will be more or less compelled to have that instrument put back in 12-tone equal.

That is not really a solution at all. It merely gets rid of the full-grown meantone wolves by giving you a big litter of 12-tone wolf-cubs in exchange. True, the fifths and fourths of 12-tone are nearly perfect, being out by only 1/600 of an octave, but the major thirds are out by 1/87 of an octave, while the minor thirds are out by 1/75 of an octave. Every interval except the octave is out of tune. And the octaves are also out of tune on pianos, except for the middle. This, if you want to know, is what killed off the reed-organ or harmonium. It shows up the defects of 12-tone only too well.

Innumerable compromises between 12-tone and meantone have been invented during the last two centuries or such a matter. This is another matter we must defer to a later issue, since too much digression here would derail your train of thought.

It is mentioned here because it forms an important part of the Opposition's ammunition and will come up whenever somebody advocates meantone temperament or 31-tone equal or certain other non-twelve systems.

Now: meantone temperament is not unequal. It does not favor one key over another key. What happens in the case usually discussed is that one decapitates and curtails it.

12 tones of meantone temperament on a conventional keyboard instrument is not full meantone; it is mutilated meantone, amputated meantone or crippled meantone! The endless infinite LINE, not circle, of meantone fifths does not stop at E♭ or A♭, nor at C# or G#.

No matter what the old textbooks on music say, no matter what your music teacher may have taught you, no matter what it says in certain music dictionaries, meantone temperament can be used in all keys. There is no wolf when you have enough of this system, and twelve is not enough.

I deplore the unfair, stacked-cards arguments of the opposition. They take only part of a system and claim it is complete, unequal, and inferior to 12-tone equal.

They go on to make even worse claims: that the case was settled in mid-19th century, that the case is closed forever, and some of them even go on to say that keys (in the sense of tonality vs. atonality, with triads and resolution of dissonances by consonances, and having a tonic or point of repose) are obsolete—that all contemporary composers MUST use twelve-tone serialism. Turn on your radio and listen! Are keys obsolete?

There is no reason why keys and atonality (free atonality and also serialism) can't coexist; indeed they do; and Debussy proved quite a while ago that you can go back and forth from tonality to atonality again and again.

Let us return to that infinite line of fifths, from uncountable numbers of flats to inconceivable numbers of sharps. Now obviously an infinite number of tones is not practical, if only because no ear could hear the differences between them.

Suppose we take this line beyond 12, starting from C. When we arrive at A𝄪, A-quadruple-sharp, the 31st fifth above C (of course deducting octaves as we go, or alternating fourths and fifths as a tuner does) we find ourselves only 1/200 of an octave short of C, i.e. flat. The 31st fifth downward, of course, would be the same distance above C or sharp.

So if we added a teeny-weeny interval, the 1714th of an octave mentioned a while ago, an inaudibly small amount, to each major third which is perfect in meantone temperament, 31 of the new major thirds would come out an even number of octaves and land us back where we started, and if we added the far tinier interval of 1/6154 of an octave to each meantone fifth, 31 of them would come out even, closing the circle and getting us back home safe. A-quadruple-sharp would then equal C. Nobody tuning by ear could ever get such accuracy. So let us assume for practical purposes that meantone and 31-tone are bosom twins.

31-Tone, the Calmer Mood ...

Then there is no reason why we can't consider the $\frac{1}{4}$-comma meantone temperament and the 31-tone equal temperament together. The difference is microscopic, and while it is of consequence to a theorist, the practical realization of either on a real musical instrument used for performing worthwhile musical compositions is indistinguishable from the other.

Even if an electronic tuning-device is used to tune the instrument, errors in transferring the tuning to the instrument will be greater than the difference between these two systems. To err is human, and all that.

At the time, 200 years ago or more, when meantone on keyboard instruments was common, there were no frequency-counters or precision tuning-devices, and no acoustical labs with international standards to check with, so what a given tuner did may have been almost anything under the sun. We don't know and we can't know, and after 39 years of tuning obstreporous instruments to the much cruder 12-tone system and checking the tuning of countless pianos and organs and other instruments, if it is that inaccurate today, what must it have been in small towns in the seventeenth or eighteenth centuries?

I realize that many meantone-fans are so purely for antiquarian reasons, but they should join forces with the forward-looking 31-ists, since composing in 31 has begun, and enough instruments now exist to show its value, and the majority of thirty-one-fans have no objection to playing meantone-period music--indeed many have done so on their own without contacting any meantonists.

The new factors entering the picture are mostly ignored or haven't even reached the antiquarian-meantonists. It's a terrible shame, since their co-operation would lend more clout to the xenharmonic movement.

One such factor is the re-fretting of guitars and other fretted instruments to 31. This brings 31 within the average person's pocketbook and opens up almost the entire guitar literature to 31-tone. Without even having to mark the sheet music up! Without having ever again to worry about tuning, since the frets, once calculated, set the temperament PERMANENTLY. And never a wolf! All the socalled "enharmonic pairs", such as C-sharp and D-flat, B-sharp and C, C-double-sharp and D and then E-double-flat, are available right under the hand.

To ask whether a guitar is 31 or meantone is annoying nitpicking. The difference is much smaller than the width of a fret and the unavoidable tolerance in fret-placing and string-tension and bridge-position. The only thing that matters is that 31-tone guitars work and work superbly. It takes a while to learn to play them fast, but this can be simplified by using a 19-tone guitar for the first few months. And you will want one anyhow, for its very different mood.

31-tone electronic organs exist. Several keyboard patterns have been invented. The Secor Generalized keyboard uses contrasting colors to identify the keys easily, and duplication of many keys so that no awkward changes of hand-position are required. It is not limited to 31, but capable of pushbutton change among several systems. Ervin Wilson has devised a number of keyboard-patterns that are suitable for the 31-tone system.

A number of 31-tone recordings are available. Last year Motorola Scalatron Inc. released a reel or cassette demonstration of the Generalized Keyboard applied to a special digitally-controlled electronic organ with some synthesizer-type effects, featuring 31, 19, 11, Pythagorean, and harmonic-series tunings, all on the same instrument.

Ervin Wilson has produced a number of 31-tone instruments, with metal bars, metal tubes, bamboo bars, as well as 31-tone guitars, and has compiled scales and harmonic data on the system for a number of years.

The Huygens-Fokker Foundation has a branch in Montebello, California, and concentrates on 31-tone music.

The word "meantone" has been used so many times in this article that you may have begun to wonder: Just what is a mean tone?

We have to get involved in theory here: you can skip this if it bores you, but a word used so much here has to be explained--the public has a right to know.

For melody without accompaniment, such as a violin alone, the question never arises--at least, it is of small importance. The Pythagorean system, in which all intervals other than the octave are arrived at by an infinite line of perfect fifths, is the usual intonation for melody on such instruments, because of its brilliance and sharp leading-tones.

The Harmonic Series--the partials or overtones, are integer multiples of a fundamental frequency. Taking the simplest integers, a scale was constructed for harmonic purposes, called the Just Scale. I have to omit all the ancient history here; we haven't time.

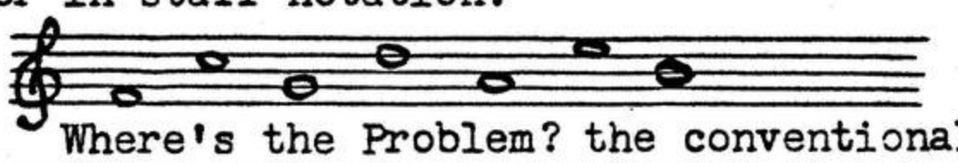
If the perfect major third be used in the diatonic scale to get the best and smoothest harmony, it will turn out to be a member of the Harmonic Series but not a member of the Pythagorean Line of Perfect Fifths, even though an excellent imitation can be found by going further in the "wrong" direction. Sorry, no time for that either just now!

Meantone & Thirty-One....

That is to say: working with staff-notation or using names or solfa syllables of the ordinary kind, it seems as if the C-major scale could be expressed as a line of fifths: F C G D A E B, or the French or Spanish or Italian would say:

fa dō sol ré la mi si

or in staff notation:



Where's the Problem? the conventional musician will ask—he will play it on the nearest piano. So what?

No problem, if all you play is unaccompanied melody. No problem, if you always play scales as fast as you can to get the technical practice on your instrument over with as soon as possible.

But suppose you want an organ to sound its best—no beats, smooth, calm, serene, unruffled. Or a chorus sings slowly and moderately loud, not straining their voices.

The notes of the Pythagorean Line of Perfect Fifths will not do for smooth harmonizing. They will be brilliant but so harsh. In mathematese, the ratios for a Pythagorean major triad made up of perfect fifths are: 64:81:96.

The smooth harmonious beatless calm just major triad has ratios: 4:5:6.

Obviously simpler. The difference is in the major thirds, the ratio between the two being 80 : 81, which is the syntonic or Ptolemy or Didymus comma. Not the same as the Pythagorean comma. The ratio 80:81 works out as about 1/55 of an octave.

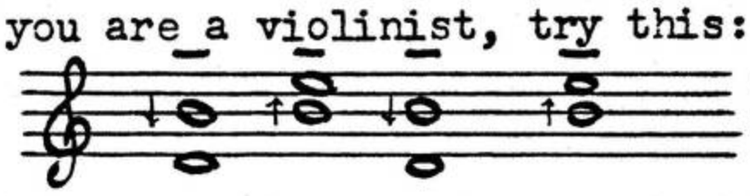
Now, with modern inventions like computer music and special electronic organs and other things coming up, it will be possible to use this small interval in justly-intoned (untempered) music in some cases. But for ordinary instruments like the violin and cello it is a dreadful nuisance even though they can do it.

For pianos and harpsichords it is out of the question entirely. For singers it is one cause of "flatting", since it misleads them. For pipe-organs it would be incredibly expensive. On guitars if the frets for notes a comma apart are provided, they are inconveniently close together. (Approximately one-fifth the distance between adjacent orthodox 12-tone frets.)

That C-major scale up there isn't so simple as you thought! If you want beatless harmony, you must provide TWO D's a comma apart. If you want to be able to modulate to G major, you must provide an extra A a comma higher than the first A. Otherwise you will get a horrible out-of-tune fifth between the correct D to be in tune with G, and the correct A to make a perfect major sixth to C. Modulation to G major will require raising the A a comma so that it is in tune with the first D you provided. And so on infinitely. I will spare you the bad news about minor keys and harmonic sevenths which are flatter than minor sevenths by a brand-new other kind of comma.

I must say this: From C you can go to two different D-minor's and at least three different keys of B-flat major.

If you are a violinist, try this: *tiny arrows show the direction to "bend" the B.*



The B which is right in one dyad is wrong in the other, if your violin is in tune.

Otherwise stated: the interval from C to D is wider than that from D to E or G to A, in an untempered scale. Or, dō to ré is not the same width as ré to mi.

These tones occur in the harmonic series as ## 8, 9, and 10. So they are as 9/8 and 10/9, which works out to 81/80 which we already met.

What can be done about it? For Pythagorean melodic playing, do nothing—use the wider 9/8 only. For the cheapest and most practical piano-building use twelfths of an octave, a good imitation-Pythagorean.

For those real smooth major thirds, use the Mean Tone—i.e. if the 8:9 and 9:10 intervals are both called whole-tones, take the geometric mean, which is:

$$1 : \frac{\sqrt{5}}{2}$$

Don't panic! It's simply half the width of a perfect major third. Very close to 5/31 of an octave, so we can use the 31-tone system.

Now, with that out of the way, we discover another feature of 31-tone: 25/31 of an octave make an interval very close to 4 : 7. This interval does not occur in the 12-tone scale, so those who grope for it, such as some blues singers, have to "bend" away from 12-tone to get it.

In 31-tone it is provided readymade in any of the 93 keys--31 major, 31 minor, and 31 neutral. 124 keys if you want to count the subminor keys with subminor thirds in them. It will take a long time to exhaust the 31-tone scale. If it took nearly three centuries to impoverish and ruin the twelve.

But 31 is not the only new scale. So we can explore other scales for their special moods and personalities to fit our own personalities at this or that time and appeal to this or that group of listeners. 31 is the choice when you want to undo the uptight and relax and need an antidote to the noise--and-bustle overexcitement.

31-Tone, the Calmer Mood..

It wouldn't be appropriate for Khachaturian's Sabre Dance or Musorgski's Night on Bald Mountain, or yet the Flight of the Bumblebee. But many of the classical sonatas might gain by being played in 31. The slow movements especially.

What we are driving at is, someone will say--indeed, five or six people have said--that there is no repertoire for the non-12 systems, or none for 31. What a shameful lack of imagination! Up to the strictest 12-tone tone-row serialism, almost everything written before that point was reached, can be played in 31-tone.

Much of it would be improved; some would lose its verve and punch--that which was meant to be restless and agitated would lose its bite.

No repertoire for 31-tone? Tens of thousands of pieces of existing music. that's all. And new music for it written in the last few years. Even some of the free-atonality pieces could be played in 31-tone to their advantage.

In a previous issue we showed what could be done about the problem of the Leading-Tone--either the seventh degree of the major scale, or the chromatic embellishments and ornamental tones which the violinist sharpens and closes up to their destination-tones, to increase the brilliance.

Some demonstrations of meantone were not readily appreciated because of the flatness of the leading-tone. That's easy--just play the tone 1/31 of an octave higher--never mind what it's called! Never mind either, if this melody-note you are sharpening will therefore clash with a note in the accompaniment which harmonic sense demands you NOT sharpen. It will work anyway! Have a little imagination. Try it; you'll like it.

What's the matter? Are you afraid of Bach's ghost? Or Ebenezer Prout's ghost?

Are you afraid to try something because it is impossible in twelve-tone? Or because it isn't in any book? If I write it out in notes again, as I did in the other issue, you might misunderstand me.

You'll just have to trust me that it is effective in the 31-tone system. To brighten up the "chromatics" and leading tones, you mark up your existing music to remind you to take the next higher thirty-first.

Similarly, most, but not all of the minor thirds in dominant-seventh chords on the top of the tetrad--i.e. B♭ in the C-7th chord, should be lowered by a 31st. This gives the 4:5:6:7 chord which is already implicit in the Harmonic Series.

Not blindly doing this to every such chord, but do it unless something in the passage contraindicates it.

Now that you have all those notes, and have escaped the limitations of 12, USE what you have! Otherwise why do it at all? Why tune only 12 notes of meantone and put up with wolves because that's all certain people could do 200 or 300 years ago? This is 1978. We can have ALL of 31, all of 22, all of 41, and freely go from one to another according to the mood. In the next few years, the added cost for non-12 will come down.

So far as guitars are concerned, the cost of non-twelve fretting is trivial. The only obstacle now is psychological. So far as the violin family is concerned, there is NO additional cost at all--it's purely psychological--getting the violinist to hear the non-twelve intervals and play them.

If you wonder how music written for only 12 pitches can be transferred to more and use more pitches effectively, I've already told you--alter the leading-tones, alter the ornamental or passing-tones, alter the 7th chords, and there are other possibilities, but those will use up a good many of the 31 pitch-classes you now have. Some modulations in ordinary music go further than they seem to. Sometimes an E𝄫 is written as D♮ and an F𝄪 is written as G♮, to make it easier to read.

This principle applies quite as well to 19-tone. So that, too, can draw on much of the existing repertoire. 22-tone, also. That is, don't throw away what you already have; don't break completely with your past; explore the kaleidoscopic iridescent variegated effects of taking the same piece through different systems.

I absolutely refuse to honor the argument that we can't move to new tuning-systems because there are no compositions in them, and we can't compose in non-twelve because there are no instruments, and so on around in a vicious circle. That's what they said about color television—they couldn't build broadcasting stations for color because there were no color sets, and they couldn't make programs because there were no color cameras, and they wouldn't build sets in color because there were no programs to watch and no TV stations to broadcast them. But it happened anyway.

I am not writing as an idle dreamer, but on the contrary as one who has composed in the 31-tone system for 15 years and who has instruments in that system and who furthermore exchanges tapes with other composers in that system. I am not writing about the distant future but about what I have already done and tested out and checked against others' opinions and reactions and proved practical.

The other extreme is possible, of course: some people who have taken up the 31-tone system refuse to have anything to do with 19 or 22 or 34. I hope I have shown impartiality in the pages of this Bulletin. We would not be any further ahead if we went to only ONE system other than 12-tone. I insist on

31-TONE AND MEANTONE .....

the importance of having a range of MOODS, as discussed in Xenharmonic Bulletin No. 5. People have different personalities and some like it quiet and some like it exciting, so will prefer this or that tuning-system.

There are certain combinations of instruments and tuning-systems that are congenial, while others are at cross-purposes. A 31-tone organ is ideal, but a 31-tone piano would be impossible to make, aside from the prohibitive cost. A 31-tone guitar does very well indeed, but a 31-tone banjo would not be worth making, and a 31-tone mandolin would be next-to-impossible to play with the frets so crowded together. The timbre also must be appropriate, as we already mentioned above.

Then there is the tempo of the music—31 suggesting if not demanding a slower range of speeds than 12 or 17 or 19. So all these factors have to be co-ordinated and considered in each instance. This could be one of the reasons that xenharmonics has been slow in getting off the ground—too much trouble making mechanical or acoustic instruments to designs without precedent; too expensive to go against commercial practice, and unreasonable to demand new techniques of instrument-makers and performers.

With electronics, much of this is alleviated, and now that we are beginning to have automatic tuning, and built-in tuning devices within the instrument, and better keyboard designs and computers to calculate parameters such as frets and string-lengths and design criteria which used to be matters of tedious trial-and-error, many of the formerly-impossible instruments become easy to make and more important, affordable.

With automatic tuning of organs built-in, it is but a step to changeable tuning from system to system, as with the Scalatron. So this is already a reality.

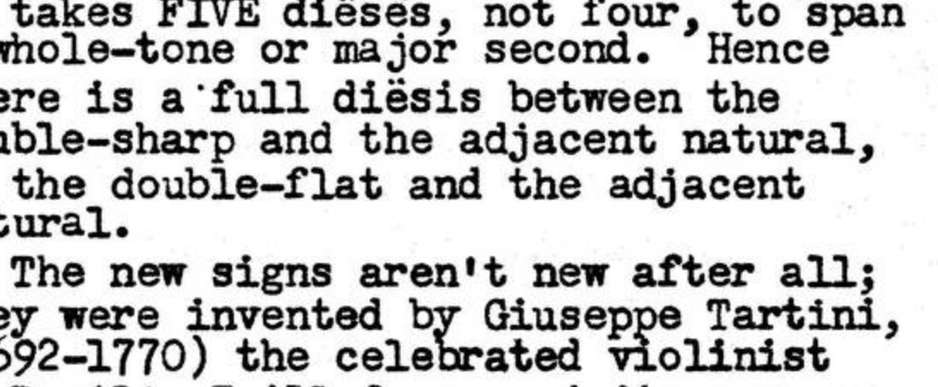
Visually-minded musicians are quick to ask: How do you write it down? There are notations for the thirty-one-tone system. We start with the important and fortunate observation that our ordinary staff-notation, with clefs and sharps and flats, was designed for meantone. It fits meantone temperament hand-in-glove. Just about perfectly. It follows that all the notes of the 31-tone scale can be represented by the conventional notation also. Let us set out the primary names of the 31 tones, as a series of fifths thus:

↷ G𝄫 D𝄫 A𝄫 E𝄫 B𝄫 F♭ C♭
G♭ D♭ A♭ E♭ B♭ F C G D A E B F♯
C♯ G♯ D♯ A♯ E♯ B♯ F𝄪 C𝄪 G𝄪 D𝄪 A𝄪 ↷

i.e. E𝄪 would be the same as G𝄫 in the 31-tone circle of fifths, and those tones would be 6 cents or 1/200 of an octave apart in the original meantone temperament.

Now it turns out that the serial order, i.e. going ultrachromatically upward degree-by-degree from C, is rather awkward to deal with if expressible only by the names of those notes above, --so for this and other reasons, special signs have been invented to offer alternative representations of the tones. I hesitate to call them "enharmonic equivalents", since "enharmonic" in most of these new tuning-systems has other meanings—as for instance, the various small intervals that can be used to render the Greek enharmonic tetrachords. Perhaps "synonym equivalents" or simply "synonyms" would do, when two or more names mean the same pitch.

Let us look at Adriaan Fokker's notation, since a number of composers have adopted it, and it has been reproduced in a few music-reference-books.



The double-sharp-sign 𝄪 which will look odd to you beside the usual ×, was an older variant; but just because Prof. Fokker preferred it, doesn't mean that we have to adopt it. It simply occurs in some music MSS. and a few fonts of music type, and only occasionally in engraved music.

Since 31sts of an octave, and the diësis shared with meantone, i.e. the interval between G♯ and A♭ in either system, is smaller than a quartertone, it takes FIVE diësēs, not four, to span a whole-tone or major second. Hence there is a full diësis between the double-sharp and the adjacent natural, or the double-flat and the adjacent natural.

The new signs aren't new after all; they were invented by Giuseppe Tartini, (1692-1770) the celebrated violinist of Devil's Trill fame, and discoverer of difference-tones (beat-tones) which he wrote about in a famous acoustical treatise.

The new signs may be called 𝄳 semiflat, 𝄲 semisharp, 𝄫 sesquiflat, ♯♯ sesquisharp, as with quartertone signs.

George Secor, who now has composed in the 31-tone system and played the Scalatron, had a discussion with M. Joel Mandelbaum, who also composes in the 31-tone system and performs in it; they have decided that the semiflat 𝄳 sign, on the staff in context, is not clear enough: it has been mistaken for a natural in some cases. So it has been suggested that the Couper Quartertone Notation, which is a modification of Ivan Vyshnegradski's, be used

The Calmer Mood: 31-Tone ....

also for the 31-tone system. Here are the signs proposed by Mildred Couper back in 1941 and which I have used for quartertones and sometimes for the 22-tone system:

Flats: 𝄳 𝄬 𝄭 𝄫 𝄪

Sharps: 𝄲 𝄰 𝄯 𝄱 𝄪

Ivan Vyshnegradski's system differs only in the flats: sesquiflat 𝄫 , semiflat 𝄭 . In both cases the semi- and sesquisharps are identical with those of the Fokker notation.

This kind of puts me on the spot: If I make the above change for 31, will I get in Dutch with the Netherlands composers who use the Fokker notation? Let's hope not—in any event, I now have pages and pages of Fokker notation that I have neither the energy nor the patience nor the time to re-write, so that much will have to stand as written.

In addition, some composers, such as Prof. Abram M. Plum in Illinois, are using arrows for the semiflats and semisharps, pointing up or down, thus: ↑ ↓ .

This is clear enough and why should this group of composers change? I have been using much smaller arrows for commas when giving examples in just intonation. ↓ ↑ ↓ ↑

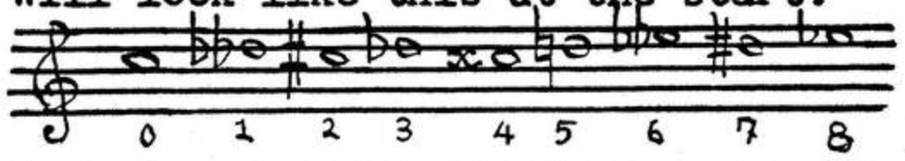
Premature attempts to standardize notation or keyboards or nomenclature for 31-tone can only cause more confusion than they would cure. If you want to call G-semiflat, G-minus instead, there is no law against it.

The whole purpose of this article is to promote the sounds of 31-tone, and any names or numbers or signs standing for said sounds are purely incidental and only a means to an end. It doesn't matter how they are written or what they are called! All that really matters is that more 31-tone instruments be built, that more computer-music-fans start programming in 31-tone, that the antiquarian meantonists join forces with the 31-tone contemporary composers and performers and instrument-makers, that owners of synthesizers or similar instruments capable of being put into 31-tone try it out, that bowed-instrument-players try it out also, that tapes and disks and cassettes in 31-tone be duplicated and circulated so that more people can hear the many new effects.

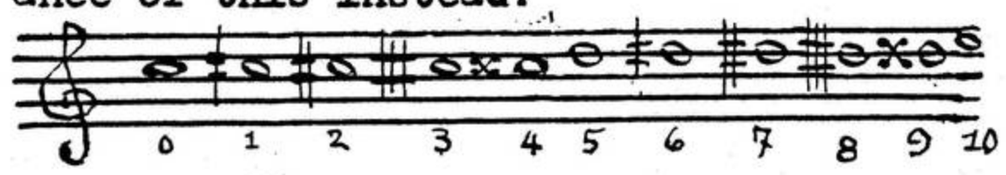
It is even more important that all the above be done without abandoning 12, 17, 19, 22, 24, 34, 36, 41, 53, just intonation, or inharmonic systems for atonality such as 11. 13, 14, etc. Diversity and contrast must be kept. Maybe this seems much too complicated for beginners; but it doesn't sound complicated when you listen to xenharmonic compositions or to familiar music played in new scales.

The EXPERIENCE of a new kind of harmony and a new dimension to existing compositions is worth any complication.

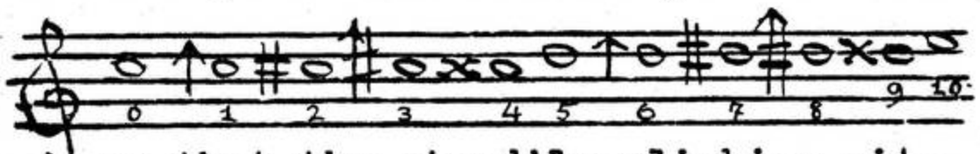
A little more about the writing of unit-interval series: If we use only conventional signs such as were shown above to be adequate for denoting the circle of 31 fifths in normal order, then the sequence of thirty-firsts of an octave, or the corresponding and nearly identical notes of meantone, will look like this at the start:



Now, the note-heads will bob up and down, won't they? C, D-double-flat, C-sharp, D-flat, C-double-sharp, D. Many people will prefer the appearance of this instead:



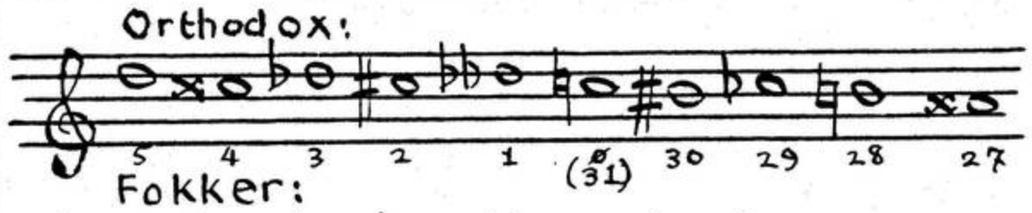
or in sagittarian notation, like this:



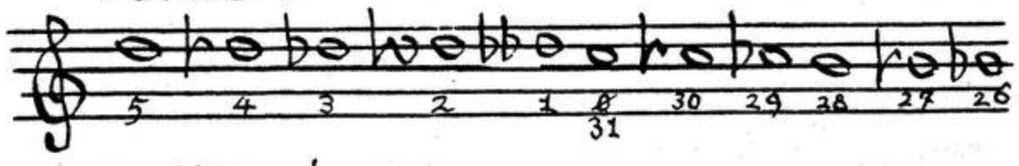
so that the steadily-climbing pitches don't appear to be coming back down when they are still going UP.

Likewise for a descending ultrachromatic sequence:
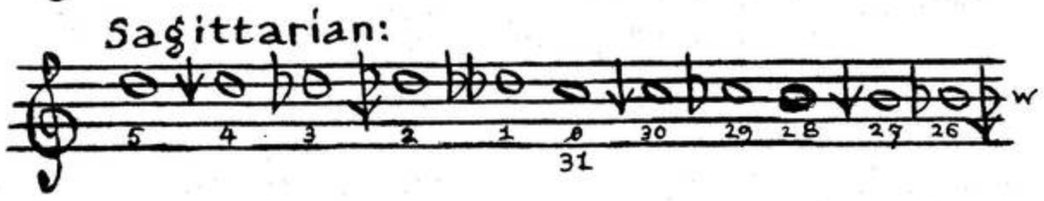
Orthodox:



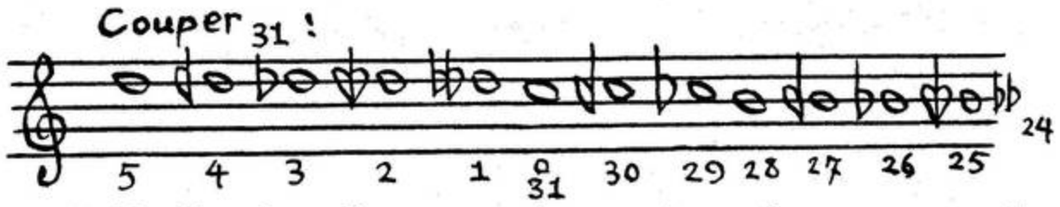
Fokker:



Sagittarian:



Couper 31 :



My lack of space here to give several other possible notations does not signify any disapproval of them; if enough readers show enough interest I will return to the subject some time later on. The importance and future of 31-tone are such that more new notations and nomenclatures are certain to be proposed and used.

Ervin Wilson has a special nomenclature and uses such names as "G-plus" on occasion; he also has a number of keyboards for 31, some of which are patented, and currently is developing instruments. His work on this and other systems is already influencing others in the field.

31-Tone and Meantone ....

Another reason for creating synonyms in notating 31-tone, is that the system gives excellent imitations of 7-based intervals, those whose ratios involve the number 7. For instance, the interval 4:7, which I call the subminor seventh after Alexander J.Ellis and some call the harmonic seventh, is only 1/1200 octave off. The corresponding error for strict meantone is three times as great, 1/400 of an octave—still a barely detectable amount. The errors for 5:7, 6:7, and 7:9 (these intervals occur in the harmonic forms of chords of the seventh and the ninth) ... are also very small.

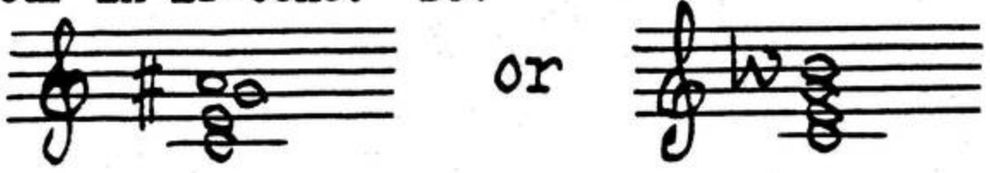
The errors for these intervals in the 12-tone system are so large it isn't even funny. In classical harmony one pretends that the seventh harmonic does not exist at all, carefully ignoring the greater dissonance of the interval substituted for it, and treating the dominant-seventh chord as a dissonance requiring resolution. I daresay that most professional musicians don't even know there are such things as subminor sevenths, subminor thirds, supermajor seconds, supermajor thirds, and septimal tritones flanking the augmented fourth and diminished fifth.

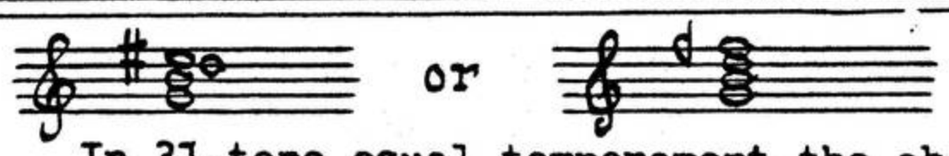
By a sort of gentlemen's agreement, the fact that a capella choruses often hit on the chord 4:5:6:7 and use it, is never discussed. Sometimes popular musicians will use these septimal intervals "instinctively", but still never writing them down, maybe calling them 'blue notes' or 'tone-bending'.

We cannot avoid hearing these intervals, because they are present in normal qualities of tone. In clarinets and other reed and brass instruments, they may be quite prominent. Occasionally a train-whistle or an auto-horn or some gearing or other sound-producer in a machine will emit these intervals. Some piano-makers put the hammer's striking-point at about 1/7 the length to kill the seventh harmonic, but ordinarily there is a trace of it in piano tone, and certain strings in the bass register may have it stronger. Some organ-stops have it.

Because it is about 1/6 tone flat of the member of the 12-tone scale nearest it, the fiction has been allowed to grow, that it is out-of-tune, too flat, useless, etc. In the meantone system it is approximated by the augmented sixth, e.g. C to A#, very closely, so on a meantone instrument it will be heard once in a while, willy-nilly.

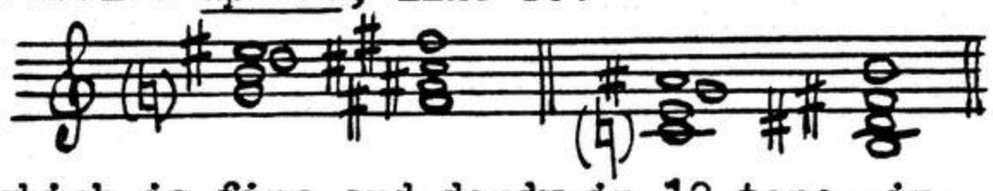
By using the alternative notations given above, we can call the 4:7 interval a seventh instead of an augmented sixth, which seems to make some people more comfortable. Such is the psychology of prejudice! Non-composers denying composers a useful and fairly consonant interval because it doesn't occur in 12-tone. So:





In 31-tone equal temperament the above pairs mean the same thing—this is also true of meantone temperament if you have carried it out far enough—you don't have to take it to 31 notes, but if you will take it as far as 16 or 19 notes, this approximation to the harmonic or subminor seventh and its kindred intervals will appear and be usable.

Now we run into more "sacred-cow" tradition and prejudice, alas! The tradition is that the augmented sixth must resolve upward, like so:

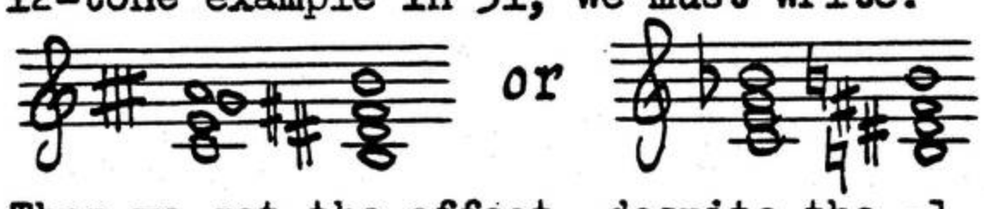


which is fine and dandy in 12-tone—indeed, it is part of the 12-tonish bag of tricks and stunts to modulate unexpectedly to a distant key: you thought you were going to have a dominant seventh to a C-major (or C-minor) chord, but instead you land in F# major, just like that! and what are you going to do about it?—fooled you that time, eh?

Hence the term "deceptive cadence". If violins or certain other instruments are involved here, they will go Pythagorean—i.e. the augmented sixth will be taken even sharper—in the violin scheme of things, A# is sharper than B♭, and in a case of this kind where dissonance and brilliance are wanted, the difference is often exaggerated. Because it works, that's why.

Now, in 31-tone, as in meantone, the situation is quite the other way around. The above progression, if slavishly read as written, will result in a wishy-washy, tame, much too demure and softened effect, totally lacking in zonk or clout. In these systems, A# is flatter than B♭, and the wide diatonic semitone just is not a leading-tone or scintillating zingy sharp effect. The same would be true in just intonation and in some other temperaments besides 31, notably 19.

The so-called augmented-sixth chord shown above, comes out in 31-tone or meantone as a consonance that does not demand resolution the way the 12-tone or violinists' exaggerated Pythagorean affair does, and it wants to be resolved INTO, not OUT OF. Indeed, with some of the "blues" singing without accompaniment, that really happens. So, if we want the effect of the above 12-tone example in 31, we must write:



Then we get the effect, despite the allegedly "wrong" notation; and if an old fogy harmony-teacher or conservatory official objects, tell them to go and [expletives deleted].
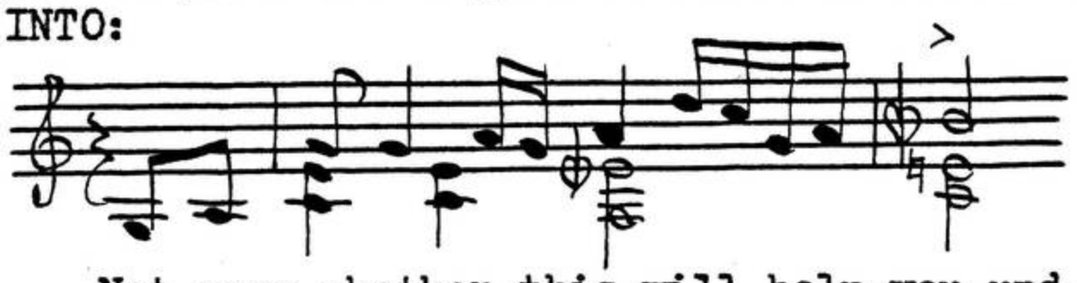
31-Tone and Meantone

If we wish to play existing music in 31, we will have to do some marking-up of music, but it will be confined to special cases like the chords illustrated.

A certain amount of ingenuity will be required to carry out some things which cannot be done in 12-tone and therefore are not even suggested in the original score. Ornaments, such as trills, turns, mordents, etc. may sound better by microtonal alterations. In the earlier music, much favored by meantone enthusiasts, performers were expected to do their thing—to insert extra ornaments or to vary from the printed score, or to make some modifications. Only in the middle of the 19th century was this creative urge thwarted and the textbooks and music teachers often became nasty martinets, looking for more things to forbid.

Of these fanatical rule-makers, how many became more famous and remembered than the other composers?

Might as well write out a "blues"-like progression, where the subminor seventh or 31-tone/meantone augmented sixth is resolved INTO:



Not sure whether this will help you understand, mislead you, or make you mad at me, —but might as well be hanged for a sheep as a lamb.

The systems have tolerable representatives of the eleventh, thirteenth, and some of the higher-up harmonics, as well as the 7th with which we have been dealing. Prof. Fokker went into this matter and produced some observations on the subject.

It would seem logical to take one step at a time—to treat first of the addition of the seventh harmonic and its consequences to the musical palette, then to go on to the next prime number, which is 11, then 13, and so on. We have devoted so much space to the seventh harmonic because it is the principal element of progress in this direction which has been held up by the extensive use of 12-tone temperament for two centuries.

Now let's backtrack. My explanation of why a certain system is called meantone had to be interrupted for the practical reason that we can't explain four or five things at once, and there are so many loose ends to tie up, and so many misunderstandings to clear up, and so much misinformation to counter, that this article must necessarily be just as ragged as the confused situation surrounding meantone and its twin, 31-tone equal temperament.

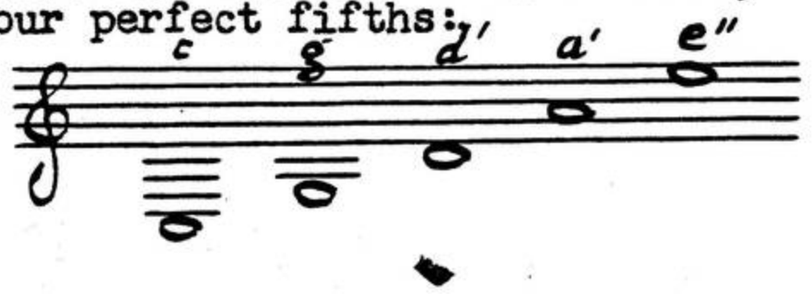
What has taken several hundred years to get into a mess cannot be resolved overnight. What has been ignored for over a century cannot be clarified in one issue of a journal like ours. All I can do is try to help.

Meantone has been advocated by historians and antiquarians and those whose interests are back in the past, as a revival in the interests of justice to the composers of the time when it was the principal system for keyboard instruments. So the whole truth about meantone, and Christiaan Huygens' admirable discovery of the 31-tone system which makes the meantone idea more useful, and moreover makes it something for the future, and for non-keyboard instruments also, and not just a curiosity for the dead past, has not been coming out.

Not only has the 12-tone gap been so long-lasting, thus putting a wedge between the past of meantone and the future of meantone/31, but the atonalists have tried to make out that any search for more consonant harmony was unnecessary—their method was the ONLY way to progress. Maybe it was the only way to progress beyond the 12-tone tonal key-system dead end; but there are dozens of escapes from that, some of which are tonal and some of which are atonal.

Back on pages 11 and 12, I explained about the minute discrepancy between $\frac{1}{4}$-comma meantone and 31-tone equal, so that the two systems sound alike, and can be considered together. Then I showed some of the facts about an interval called the comma, and what a mean tone was—the geometric mean of the two whole-tones of just intonation, or, one-half the width of a perfect, smooth, beatless major third. I explained that the scale based on perfect fifths alone, i.e. the usual explanation of the C major scale being made up of the series of fifths F C G D A E B, was not good for harmony, even though it works for unharmonized melody.

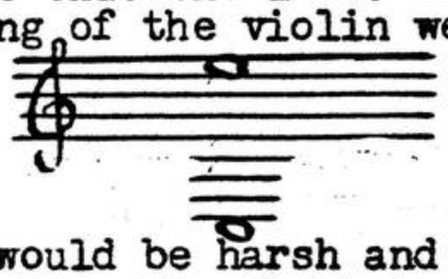
But I had to press on to other matters, so now it's time to tie up a few more loose ends. Why one--FOURTH-comma meantone? Are there other meantone systems? Yes, there are, a whole family of them, but no space in this issue to finish up that. Suppose we had a violin and a viola, so that between the two there was a chain of five notes, four perfect fifths:



31-Tone and Meantone ....

This is not such a hypothetical situation at that: a string quartet tuning up, or in an orchestra you will hear the effect of all those fifths, as they get ready to play.

Now, suppose that the low C of the viola and the E-string of the violin were sounded together:



The effect would be harsh and "edgy", not harmonious at all. The fifth harmonic of the low C is a true two octaves and a major third above it, and it is present in viola tone. The E-string of the violin, correctly tuned by the chain of four fifths, would be a comma sharper, and the two tones would beat at a rate of 8.15 beats per second.

Now, both these E's—the 5th harmonic of tenor C (which can be elicited by itself on a viola by touching that string lightly at ANY fifth of its length—1/5,2/5,3/5,4/5) and the E of the open violin string, obtained by tuning four perfect beatless fifths from that same tenor C, have equal right to be called E. Which one is the REAL E?

Both are! It depends on what context either note is to be played in. The process could be repeated, getting an infinite number of notes a comma (about 1/55 octave) apart, up and down from this pair of E's, and all of them would have the right to the name! This is the basic dilemma of the un-tempered (natural, pure, just) scale. It has inspired/compelled countless attempts at solution.

People have gone bonkers, bananas, blotto, berserk, and galley-west over this problem. It is further complicated by the existence of other kinds of commas, but I will spare you that for the present.

Now that guitars are becoming so very important, if you had a fretless electric guitar and tuned the six strings to perfect beatless fourths and that one perfect beatless pure untempered just major third between the G and B strings, the two E strings would not be exactly two octaves apart. The first string would be a comma flat with respect to the sixth string! If you didn't know that, you might spend days trying to iron out the discrepancy. On an electric guitar, that false octave would be pretty hairy. You don't need a fretless guitar to experiment: just use the open strings without using the frets at all.

This forces us to conclude that the guitar, lute, and viol frettings were not designed for a just untempered scale. The attempts to get a 12-tone temperament on fretted instruments thus antedate the present custom of tuning all keyboard instruments to 12-tone equal temperament.

On guitars, lutes, etc. the 12-tone system was not so harsh as it was on pipe organs, because the fretted instruments had gut strings mostly, these were not uniform, the tone died away quickly, the frets were not accurately set because they didn't have computers and frequency standards and accurate measuring devices to deal with thousandths of an inch or tenths of a millimeter.

So please don't extrapolate our Age of Ultra-Precision back to the 16th or 17th century; as so many writers of scholarly articles on music theory are wont to do!

The intellectuals of the time might have been able to make calculations, just as they were doing for astronomy, but that does not mean that the average musician could realize precisely all the results of such calculations on the instruments of the time.

I'm repeating myself, but strictly accurate 12-tone equal temperament on organs or other instruments capable of sustained tones in qualities of tone where the beats and harshness of thirds and sixths were clearly audible, had to wait for mid-19th-century before being really achieved in laboratories or by experts, and then well into the 20th century before the average listener to music could hear enough of such accurate 12--tone tuning (in proportion to the huge amount of inaccurate 12-tone and haphazard practical tunings) to affect him or her emotionally or psychologically.

That is to say, that is why we have endured it so long. We had a considerable variety of accidental deviations from the 12-tone ideal up until the ultraprecision of the present day became mass-producible and built into some of the instruments listeners are exposed to, directly and on records.

So the scholarly debates over Bach and his contemporaries and their instruments are not relevant to 1978 composers trying to break through to restart the musical progress which has been stymied and arrested and thwarted for such an unconscionably long time!

Your problem and mine are not those of Huygens when he discovered 31-tone. Nor those of Bach writing two books of preludes and fugues. Nor is our problem that of the composers seated at their pianos in Europe in 1900. Today we are drowned in an overproduction of mediocre trivial music and innumerable repetitions of the greatness of the past, so can hardly see our way clear.

I am trying to show you how to escape this frustration. Now, that comma over there set thinkers to calculating and figuring and estimating and trying to get rid of it.

Tune the fifths right on a keyboard

31-tone, Meantone, and All That ····

and the thirds and sixths will be sour so far as harmony is concerned. That's what a comma means in terms of practical consequences.

The statement is made that a string quartet plays in just intonation. That isn't quite so. In the first place, they were taught 12-tone by their teachers and the books, and were taught to tune in perfect fifths, sometimes called Pythagorean intonation by theorists, but not by any cello or violin teachers I ever met or took lessons from!

They play Mozart or Beethoven or whomever, and occasionally run into a comma discrepancy. Without consciously analyzing it, and certainly without stopping their rehearsal to look up books on acoustics or tables of logarithms, they "intuitively" play around the comma, tempering on the run, so to speak. Do they play in 12-tone equal, then? Nope. It's practical and moreover it's ELASTIC TUNING. So it isn't fair to use string quartets either as propaganda for 12-tone equal or for just intonation.

In this era when we are going to compose on typewriter keyboards for computers to play it, and are going to have all manner of brand--new electronic instruments in our homes and studios to play manually, what string quartets do and what orchestras did, and what piano--tuners do is no longer relevant. So the 17th and 18th and 19th centuries' solutions for the comma problem may be necessary historical background, but must not determine the 1978 and 1985 and 2003 solutions to that problem. If you want to escape to the past, you are free to do so, but that just isn't my bag. I don't even enjoy going back to my childhood in 1925, since I feel much better in the good new days.

If I had been born in 1826, I could have gotten along with plenty of room to compose something different, because there still was unexplored territory on conventional means. Now it all has been conquered and we have to open up virgin fields.

Back to those two E's: Alexander J. Ellis in his translation of Helmholtz's work and in his appendix to it, distinguished the two E's by using plain E for the one tuned by fifths and E_1 with subscript numeral for the other one a comma lower which is the fifth harmonic of plain C or a harmonious serene major third to it. Then the C-major scale looks like this:

C D E_1 F G A_1 B_1 C

Before him, other devices such as lines above and below the letters like $\underline{E}$, or capital and small letters, were used; or today we might use asterisks or similar marks as E_* .

On the staff, if I have to indicate a comma, which is very rarely, I use tiny arrows. ♭↓↑

I prefer to record the just-intonation music on tape and evade writing it at all!

I can't afford to hire an orchestra of specially-trained experts to play it and so far, I couldn't afford computer time either. So why write it out?

Just that I have to tell you here how it CAN be written, if necessary.

Commas matter in adagio and largo with brilliant tone-quality and steadily-sustained tones and when you want subtlety. It wouldn't make any difference in a presto agitato or allegro furioso con fuoco.

So in the majority of cases, we want to eliminate the comma somehow. This means sacrificing the thirds for the sake of the fifths, or vice versa.

The atonalist and most serialists say, Scrap the whole affair, and forget classical harmony, and then commas are meaningless. Once in a while, this is the way to go, but not limited to 12-tone--hundreds of possible atonal systems are usable. Let it be understood that I am not against this.

Back to meantone. Sacrifice the perfect fifths for the sake of the thirds and sixths. Take that 1/55 of an octave discrepancy and cut it into four equal pieces. Echh will be about 1/220 of an octave, then. Now, since four perfect fifths upward from C (tenor) gave us an E which was about 8.15 hertz sharper than the harmonious E_1 vibrating exactly 5 times as fast as the Tenor C, let's cut a tiny piece off each fifth so that four of the new fifths give us the smooth harmonious E_1 instead of the icky edgy needly-sharp Pythagorean E. We find that although the error of these meantone fifths is about $2\frac{1}{2}$ times as great as that of the 12-tone fifths, it still doesn't matter in the vast majority of performances of real music. Only when we need brilliance and hard edges and steely glint and bright sparkle, some system with perfect or sharp fifths will be better.

In the new electronic age, we can afford many systems, and do not need to restrict ourselves to just one.

We can even have more than one system in the same piece.

Now: we shrunk all the fifths to get perfect major thirds. No more commas to worry about. Each fifth is $\frac{1}{4}$ comma flat, hence this affair is called $\frac{1}{4}$-comma meantone. And it so happens that when it is carried out to 31 pitch-classes, the circle almost closes; so 31-tone equal is the same thing for all practical music. We already tempered; why not retemper a teensy-weensy bit? No one will EVER know.

For those of you who love math, you

31-Tone and Meantone ····

can use your calculators and computers and tables to figure out the other possible meantone temperaments, and compare each with the others. The actually-usable meantone family runs all the way from 1/3-comma (perfect minor thirds and perfect major sixths; major thirds are about as flat as fifths are flat, thus cancelling out the error of the minor third) to 1/6-comma with noticeably-sharp major thirds, and theoretically continues as far as you wish to go, like 1/10-comma with no audible difference from 12--tone-equal and beyond that up to Pythagorean, i.e. 0-comma, and I suppose negative fractions of a comma with sharp fifths to provide a wacky theoretical basis for the 22-tone equal temperament, if your imagination runs that way.

If you like tricky semantics, call 12-tone equal temperament a variety of meantone, since the whole-step is half of a 12-tone imitation major third. Some people would rather play around with weasel-words like that, than listen to music anyway.

As the 1/4-comma meantone approximates 31--tone equal, 1/3-comma meantone approximates 19-tone equal, and 1/5-comma meantone approximates 43-tone equal, for those interested in such things. So it's not necessary to calculate everything when those equal systems are so close as to suffice for any actual trials.

I wouldn't have had to say much about meantone at all, were it not for the woeful misinformation about it in so many books, written by people who usually never heard it, and very rarely if ever have heard an instrument on which meantone was carried out more than 12 notes per octave so as to allow it full function and expressive power with its real, live, useful distinction between D-sharp and E-flat, B-sharp and C, C-double-sharp, D, and E-double-flat, etc. Non-musicians, non-composers, performers who never play anything other than the 12 ordinary pitch-classes, simply cannot understand why a composer needs non-12 TODAY, regardless of whether anyone needed it 50 or 100 or 150 or 200 years ago—those situations simply are not relevant any more.

Remember: the "wolf" is a compulsory mistake resulting from tuning meantone on an instrument it shouldn't have been tuned on in the first place. If you have a size 10 foot and insist on wearing size 8½ shoes, you are going to get corns and it's going to hurt. Don't blame the shoe factory. Unlike the piano-factories, they don't insist that you buy something too small.

The real issue here is hardly ever discussed --it involves fitting the ability of the human ear to distinguish differences in pitch to the instruments not capable of fine tuning, instead of the other way around—designing instruments and tunings for them which make EFFICIENT AND FULL USE of the human being's abilities. Why cripple your inborn powers to please manufacturers and non-musician engineers?
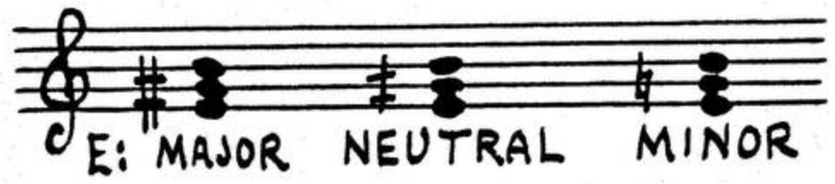
A final word about additional resources of the 31-tone system: Besides the major and minor triads, 31 has a neutral triad, neither major nor minor, but halfway between, dividing the Fifth into equal halves. This means neutral scales and neutral keys, 31 of each!

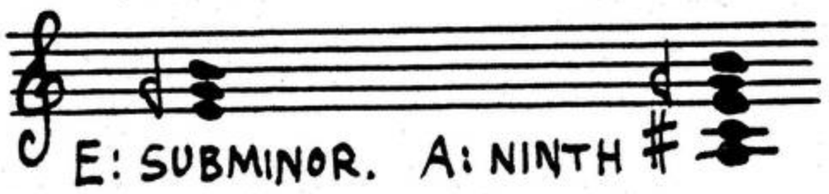
There are also subminor triads, with subminor and supermajor thirds, based on the just ratio 6:7:9. And 31 subminor keys and scales.
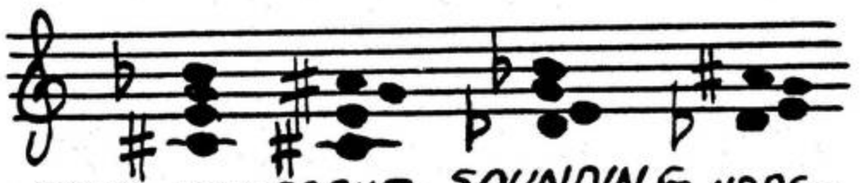
The supermajor triad is dissonant, so it won't be that important, but if I don't mention it, somebody will squawk.

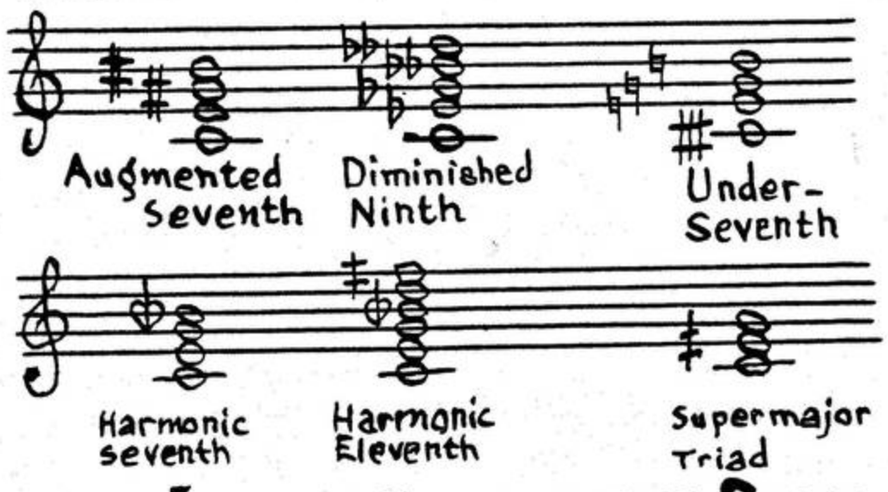
Since 31 is nearly 30, it has approximately-equal 6- and 5-tone scales, which can be used to simulate exotic faraway ethnic music. Since 31 is nearly 32, there is a nearly-equal 8-tone scale. The nearness to 30, 5×6, means you can call the unit-intervals "fifth-tones" if you don't want to call them diesēs or degrees.

There is no mathematical theory of moods. There is no visual way of showing you the unique flavor of 31-tone harmony. Don't knock it if you haven't heard it. Enough people have heard it to ensure its survival.









*** JUST A FEW OF THE POSSIBILITIES AVAILABLE IN 31-TONE #.

Sneak-Thieves' Ripoff!

The majority of moves are disasters, but this last one, July 1976, just after completing XENHARMONIC BULLETIN NO.8, was particularly so.

It was a forced move with insufficient notice, because the owners broke their promise to let the editor keep on renting from the new owners. Not certain whether the old address or the present address was burglarized, as it was during the lengthy moving process that two guitars were stolen. Both were electric guitars—one converted to the 19-tone system and the other refretted to the 31-tone system. It would, we hope, be very difficult for the thieves to pawn or sell them, and conversion back to 12-tone would also be an onerous process. Photos of both instruments exist.

Phone calls were not referred very long, and the telephone company pursued its relentless policy of reassigning old numbers all too soon --and with the recent deterioration of the postal service, the forwarding of mail ceased after about ten months. This has been a severe loss. Nobody seems to know where Glendale is. For your information: Glendale is a separate city of about 140 000 population, just north of Los Angeles a little over 7 miles (12 km) from Los Angeles' business district. It is thus closer than such famous parts of Los Angeles as Hollywood or the western part of the Wilshire District.

Unfortunately again, many copies of XENHARMONIC BULLETIN #8 for July 1976 were circulated with the old address and phone number which are absolutely useless for locating us.

NEW INSTRUMENT NEWS

Ventures beyond the confines of the twelve--tone scale necessarily involve new instruments, as well as the modification and redesign of certain existing instruments. Unless more people become involved in this endeavor, there will not be enough progress in the field. It is not sufficient to write and talk ABOUT non--twelve—the world has had far too much of that, to the point of boredom and retrogression. There would be no point whatsoever in starting and continuing the XENHARMONIC BULLETIN, if no sounds of the new systems were ever heard.

In case the Bulletin's policy is not clear to you, the emphasis is on those tunings which do not SOUND like 12-tone equal temperament, rather than on slight variants or subtle differences which require CONCENTRATED ATTENTION to notice at all.

Within this bulletin and certain other publications previous and forthcoming, there is a STIPULATION: the term microtones means, the intervals less than quartertones—less than 50 cents or 1/24 octave. From 1/22 octave through 1/24—from 55 cents or hundredths of a twelve-tone semitone to 50 cents, will be considered a "Grey Area" to which the term "microtones" applies in an attenuated sort of way.

Some people insist that microtones are any interval less than a twelfth of an octave, 100 cents, the usual semitone. Let them do so for their own writings. But let them so stipulate! And preferably say WHY they mean it that way.

The other day I had to consult the standard standby Grove's Dictionary of Music & Musicians. (5th edition in this case.) The brief article on MICROTONES clearly and unambiguously says "smaller than quartertones"; so does a similar article in a recent music dictionary. Scholes' Oxford Companion to Music says the contrary, "smaller than the semitone".

The point here is that XENHARMONICS is not a mere synonym for MICROTONES. If that were so, it would be another irritating superfluous word. The equal temperaments with larger intervals than the semitone—5, 7, 8, 9, 10, and 11 to the octave—are xenharmonic because they do not sound like 12-tone and have new intervals in them; likewise the Pelog and Slendro, which have large intervals as units.

The scale of the Highland Bagpipe is xenharmonic because of the unusual intervals some of its 9 notes make with the drones.

On the other hand it is possible to have microtones WITHOUT xenharmonics—certain expressive deviations by violinists, vocalists, etc. from a 12-tone accompaniment which are too small to disrupt the 12-tone patterns, and certain instruments out-of-tune noticeably or even deliberately by small intervals--the voix céleste, vox angelica, unda maris, etc. of the organ are tuned a tiny bit sharp or flat, but used only for 12-tone melody and harmony.

The deviations are REALLY micro-. 1/200 octave and like that! Vibrato will not be treated here because it needs a very extensive analysis.

We suggest "minitones" for the less-than-semitone and down to quartertone. Current computerese jargon and even general slang have made the maxi-, mini-, macro-, micro- notions fairly popular and understood.

So much for that. Now to instruments: Graham Johnson of Hollywood finding out about the stolen guitars, provided a bright-red electric

NEW INSTRUMENT NEWS, continued

guitar, which has been converted to 31-tone.

A suitable replacement for the 19-tone stolen guitar has not been found, at the time of writing this.

In May 1977, Susan Rawcliffe, who has been designing and making wind instruments, brought an ocarina which can, among other things, play the Japanese scale with the characteristic minor second.

In November 1977, John Reuschel, builder of harpsichords, brought a 5-stringed instrument of the monochord/sonometer order, which he calls the Tune-A-Fish, since it is in the shape of a stylized fish such as used for planking or as wall-decoration. Monochords have long been used for transferring tuning from one instrument to another, as well as teaching frequency-ratios and string-lengths.

In December 1977, Ervin Wilson and Glen Prior brought a two-octave set of metal tubes in the 17-tone system. They had been building such instruments in the 31-tone system for some time, and the successful results with this latest effort have inspired them to make another 17-tone instrument for themselves.

In October 1977, Glen Prior presented the largest Megalyra in the course of a recital at Los Angeles City College on the border of Hollywood. The audience received it with great enthusiasm.

Updating on the Megalyra: there now are 5 of these instruments, and more will undoubtedly be built before long. Some description of the idea has been given before: basically, it is an extrapolation of the steel-guitar principle--a board with steel strings and magnetic pickup (and/or contact microphone), the usual guitar frets being replaced by painted, inlaid, or stencilled lines, and the various pitches obtained by using a "steel" which is a metal bar or tube serving as slidable movable bridge cutting off this or that vibrating length.

Now: the traditional (if I may use that word for something about 50 years old) Hawaiian or steel guitar has been restricted to such tawdry trite boring trivial music most of the time that serious musicians and composers became justifiably disgusted. Indeed, during the 1940's or such a matter and the early 50's it suffered eclipse and was almost a dead duck to most people. What could one expect from an affair with six strings tuned to an A-major chord and often played by incompetents who slid around aimlessly? This misuse gave the instrument a very bad name, and hardly anyone analyzed the situation or had any imagination.

Above all, no one seemed to recognize its close similarity with that highly respectable early keyboard instrument, the CLAVICHORD.

Both instruments have vibrato as an essential power of expression, and both depend on the intimate contact of a movable piece of metal with metal strings.

In 1940, I built an amplifying clavichord 8'4" long (2,54 m) and still have tape-recordings of it, and the resemblance to the steel guitar is indisputable. Unfortunately and alas! the clavichord is now rusting away in storage because there is no place to keep it here or elsewhere, and furthermore it was severely damaged by numerous moves and unavoidable weathering and deterioration.

So now is about the right time and place to suggest that someone or a group sponsor the making of amplifying clavichords, and of large psalteries on its pattern, with xenharmonic tunings such as 19- or 22-tone, for which its timbre is excellent.

I am not keen on 12-tone clavichords because after 39 years of tuning 12--tone I am thoroughly tired of it, but those who insist on twelve can engage me as consultant and supervisor of the construction. The traditional clavichord is so extremely soft-toned that its gentle voice is lost in this noisy environment, whereas amplifying clavichords have not only plenty of volume, but extensive variety of timbre.

With many new keyboard designs, there is no excuse at all for anyone wasting any more time on 12-tones of meantone or any of the numerous compromises between meantone and 12-tone equal temperament, nor any of the desperate so-called "well-tempered" or unequal and incomplete schemes, as already stated in the article on 31-tone.

Such tunings and the pseudoproblem involving them, and that dreary tiresome question of what did Bach really use? are NOT the concern of xenharmonics. In xenharmonics we are concerned with what composers can do TODAY, right NOW, to sound different from what has gone before—to use a new musical vocabulary.

The first steel guitars were in the familiar hourglass silhouette of the classical guitar—it took some time, even after solid-body instruments solely for amplification were built, to get away from this now useless design, and to start increasing the number of strings.

One bypath already taken by now is the socalled "pedal steel", with from 10 to 20 strings or more, and built as a less-portable instrument on a stand, with pedals and knee-levers to alter the tension of four or more of the strings to change the available chords. We have to mention this (mainly "country & Western") instrument to show two features about it that differ from our design principles: the alterations in tuning are by 12-tone semitones; the 12-

NEW INSTRUMENT NEWS, continued ...

-tone fret-line pattern not only is stencilled or silk-screened onto the non-fingerboard underneath the strings; it is used as essential component of the special tablature for pedal-steels—the number of the fret-line — so many semitones above the note to which the open string in question happens to be tuned at the moment—takes the place of lines and spaces—degrees—on our conventional five-line staff. That is to say: They pretend that those lines are real frets like a Spanish guitar preventing the instrument from sounding non-12-tone pitches! This is a subconscious psychological roadblock, but very real nevertheless.

So I built my first Megalyra without any fret-lines, but people soon demanded them. I was counting on my own cello experience, rightly or wrongly. Likewise with the two Kosmolyra instruments, which have a variety of chords on their four sides, all of which are strung, and the Hobnailed Newel Post, likewise a 4-sided chordal instrument.

What was the best course for the Megalyra and to retrofit onto the other instruments? Seeing as how I was involved in non-12. And already having designed the Megalyra for certain purposes: 1) to be capable of playing existing music both solos and the bass part in orchestras; 2) to fill a gap in the scheme of things--the "electric bass" does not go down to Contra C, 33 Hz, but only to E near 41 Hz; 3) to play unisons and octaves as the pedals of an organ do, even twelfths & double octaves; 4) to have chorus-effect; --i.e. by playing in unisons and octaves to simulate the whole group of cellos and contrabasses in orchestras, or the corresponding wind instruments in a band; 5) to make certain features of the organ, guitar, clavichord, piano, and harpsichord available in flexible, non-keyboard form.

This is the age of COLOR. Drab black and gray and dark browns are somewhat passé, unless accented with bits of color. So, put color to work as the painting consultants do in our now environment. Not mere decoration but functional.

Red sharps and blue flats. Black or white naturals, depending on the ground-color of that particular instrument. (There are yellow, blue, and green Megalyrai so far —maybe red, orange, black, or purple before we get through.) Yellow harmonic nodal points—where to elicit the harmonics 5th to 16th. Orange on the yellow instrument. Green 12-tone short fret-lines, unless the instrument is green, in which case, black. The main fret-lines extending most of the way across the board, are a selection of 19 to 25 notes of just intonation per octave. Any more would defeat their own purpose.

The 12-tone lines are there for two purposes: so the conventionally-trained musician can continue playing with 12-tone instruments and won't get lost; and as a very inexpensive means of converting the instrument into an educational comparison-chart showing clearly how much each just interval differs from 12-tone. The 12-tone lines are like dashes or hyphens on the near-the-player side of the board.

Both sides of the Megalyra are strung, so the basic design is repeated on both sides, but farther apart on the side having longer strings, of course.

Non-12 temperaments can be estimated fairly well from the two sets of lines; if not, removable plastic charts can be attached for those who need them.

UNEXPECTED BONUS: These instruments were equipped with square endpieces to permit their being laid down in any of 4 positions, so that the strings will always be clear of the table, floor, or rug. Immediately it was found they would stand erect, saving storage space —and then, lo and behold, they looked like Mondrian Totem-Poles in cages. With overtones of Kandinsky and Miró. I had unique abstract sculptures on my hands, whether the instruments worked or not.

Amplification is via magnetic pick-ups—each set of strings has pickups in different positions for bright and subdued timbre. Contact microphones can also be used.

Since these instruments descend to the lowest C on the piano keyboard and could be taken an octave still lower—they range in length from 2 m (6ft. 7in.) to 2,49 m (8 ft. 2 in.) and longer ones are possible, the steel-guitar principle at last has dignity, solidity, and depth at full volume or down to a whisper.

Also, going beyond original dreams expectations, or plans, the strings may be plucked, struck with padded or hard mallets, or struck with the steel itself, duplicating the clavichord principle exactly, and a more piano-like tone is obtained with a "wooden steel" i.e., striking the strings with wooden bars and holding them down firmly.

Further elaborations of the idea will come by actual use of these instruments by real people in various situations. It's too early to freeze the design, although an optimum median size and basic tunings now exist as guidelines.

Those who want to learn the Megalyra will start with existing cello, double-bass, tuba, trombone instruc-

NEW INSTRUMENT NEWS, continued

tion-books, according to the teacher's judgment, and probably supplemented with the special pedalboard study books for organ students. So at the beginning it won't be necessary to prepare special method-books until it is time for going into xenharmonics. That is, in the case of the Megalyra, the problem of repertoire is already solved. Both conservative and popular orchestrations already have suitable parts, and besides that there are solo works quite suitable for the instrument—it wasn't designed in an ivory tower for Utopians, but with full awareness of the current situation from which it has to start.

Not only that, but it had to be practical to make these instruments without elaborate and expensive special equipment.

In later issues the chordal instruments will be discussed—at present we are conducting a sort of survey to find out what designs are best. Experiments so far prove that the steel-guitar idea can be taken very far indeed from the primitive stage it had remained in for so long, and also: it intersects with some other instrument-ideas such as psaltery, dulcimer, clavichord, etc. so there will be enough work to keep many inventors busy for a long time to come.

The important point now is that these instruments are here right now and they work; they are not vague future plans but solid hardware reality, so one of the obstacles to just intonation has disappeared without making it necessary to have them incompatible with existing music or not playable with other ordinary instruments.

So the time has come to make deals and form business associations of whatever kind on however small a scale at first, and to farm out whatever ideas I have no time or energy to complete. As a composer primarily, I have to put the taping and copying recordings of compositions first, so other things have to be delegated in whatever way proves practicable.

Some other kinds of instruments have to be "dedicated"—e.g. a Spanish guitar is fretted in one system, usually an equal temperament, so cannot be used in another. Even there, it is possible to make-do: a 24-tone (quartertone) guitar can be used as 22-tone by moving the bridge, creating a theoretical error, which only bothers in the higher register. An 18-tone guitar (refer back to the Busoni article) can be used as 17 or 19 by moving the bridge, again with theoretical errors which only become serious beyond the octave from the open string. I have such instruments and use them.

Jonathan Glasier of San Diego (southwest corner of California) came up to this area and demonstrated a special psaltery capable of just and other tunings. He plans more instruments soon, and has had a cassette copied.

As a result of a letter published in the July-August issue of Synapse, a magazine dealing with electronic music and synthesizers, I have gained a number of correspondents and one visitor so far, Jasun Martz of Tujunga.

The letter dealt with applying new tuning-systems to synthesizers. Everett Hafner of EMSA in Northampton, Massachusetts, said he had been modifying synthesizers for just that purpose. In this case, UNdoing a built-in restriction to 12-tone in that kind of synthesizer.

I call that "Exorcising the Piano's Ghost".

I heard from David Vosh, now of 2340 Vermont Ave.,Apt.2,,Landover MD 20785, who has a group and has a synthesizer capable of non-12, but who didn't know anyone else was actually working with non-12 seriously until he saw my letter. He and his group thus felt extremely isolated.

His friend, Prentice Whiddon of 17720 Towne Crest Drive,#102, Gaithersburg MD 20760, wrote me about his experiences: he heard notes in his mind which were not on the piano or 12-tone instruments, and the music teachers etc. denied there were such, so he had to go in for musique concrète; and says he didn't really hear those odd notes that ran through his head until he listened to the tape that I sent to David Vosh. Prentice Whiddon is a laboratory glassblower and so is exploring the possibilities of making all manner of new instruments out of glass in one form or another. Both these people wondered how many nontwelvists there were: so here is your chance to tell them.

These people have moved; check addresses at libraries.

GUITAR INNOVATION SHOWN

In November 1977, I was taken to hear Tom Stone's demonstration of a special guitar modification--the instrument he used was a nylon-string "classical" equipped with an aluminum slide-channel of his design. Special interchangeable fingerboards which mate with this device by sliding over it and locking-in, permit the one guitar to be used for a variety of tunings. Those demonstrated included an Arabic scale, a just scale for one key and its nearest relations, 12 tones of meantone, 12-tone equal, and fretless. Others will

INTERCHANGEABLE FINGERBOARDS, contd.

be available later on. The Sharmachord was also demonstrated—this name is derived from a Sanskrit word—using a segment of the Harmonic Series (16 to 32) and having a special tuning starting from contra A. The effect is very subdued and tranquil. A variant of the 12-tone, using ratios based on 2:3 and 16:19, was also demonstrated.

Information can be obtained by writing Intonation Systems, P.O. Box 932, Fair-Field Iowa 52556.

FORTY-FIVE-YEAR DELAY IS OVER!

In 1941, Ivor Darreg, residing at the time in Santa Monica, was referred by the composer John Cage to Mrs. Mildred Couper then of Santa Barbara CA, as being involved with the quartertone system. Two of her pieces for 2 pianos tuned $\frac{1}{4}$ tone apart were published by the then firm of New Music Editions—I have not seen them for about 30 years, but presume they are on a good many library shelves about the country still. Quartertonists should try to hunt out and revive these pioneering compositions.

Mildred Couper loaned me the booklet in French by Ivan Vyshnegradsky (this name has many transliterated spellings, some of which begin with W or Wi-; and the original Russian spelling is as follows: Вышнеградский) for some six months, during which time I translated it into English for my own reference and as propaganda for musical progress. During the war and having to move several times, it was of course impossible to get it published, and for some years it was lost (the English translation, I mean) and it was found and lost again several times between 1944 and 1974. When I did have it on hand, nasty critics scolded me for "being ahead of my time"; what they said about Vyshnegradsky, Carrillo, Hába, and other quartertonists is not printable.

Manuel d'Harmonie à quarts de ton, or Quartertone Harmony Manual as we might call it in English, was published in Paris in 1933, and actually is rather conservative in tone. But we have to start SOMEwhere, and for certain types of people this is the best way. In 1974 I resolved to publish my translation after revision and writing brief preface and commentary.

After getting a few Xerox copies of it off to my friends, Motorola Scalatron Inc. in Illinois offered to print up some copies, which they did; and sent me a few. (See next item) In 1978, it is now 45 long agonizing tedious years since Vyshnegradsky wrote the booklet,—only just that he get some posthumous recognition.

This XENHARMONIC BULLETIN has contained articles on the quartertone system in a number of previous issues, and will continue to do so in future numbers. Surely after all these years have passed, it should now be safe to promote quartertones. One favorable factor has been the revival of Ives' quartertone pieces, long neglected.

The greatest stumbling-block has been the unavailability of suitable instruments at affordable prices and with the proper tone qualities to define the new intervals. As I have told you hundreds of times already, piano-tone-quality is not suitable because it doesn't contain enough 7th and 11th harmonics. Harpsichord tone does. The tones of some electronic organs do. Guitars with steel strings do. Electric guitars do, IF and ONLY if they have pick-ups located about 1/10 to 1/15 the active string-length. That is seldom the case. The violin family does. On synthesizers, one has to adjust for high higher-harmonic content.

If sufficient interest develops, plans are to produce articles continuing from the point where Vyshnegradski left off, and stating the quartertone possibilities in the contemporary environment with all the facilities now available. Meanwhile, a suite, FIVE SUBMINOR SKETCHES by Ivor Darreg is available as scored for violin and using Couper notation—address on page One of this Bulletin.

Melody is more important than harmony in the 24-tone system, for reasons given in other issues of this Bulletin. Those seriously interested in harmonic progress should at least consider the 22-tone temperament. Back in 1941 when I was translating, and also composing in quartertones, and planning that my amplifying clavichord would be equipped with 6 octaves of quartertones, I didn't even know there WAS a twenty-two-tone system. Few people do now!

THE SOUNDS OF NON-TWELVE

No longer available

At last report, a demonstration tape or cassette (as you prefer) from Motorola Scalatron Inc.

Played by George Secor of Chicago on the generalized-keyboard Scalatron, this tape contains examples of pythagorean, 19, 31, just intonation with harmonic series, and atonal 11. They also had informative literature.

JUST INTONATION AT RANDOM

Shortly before moving to Glendale, I was asked to wire up some attachments to an electronic device called a Lim Tuner. It contained a binary switch-controlled countdown. While I had it a couple of days, I discovered I could play its non-keyboard!

RANDOMLY JUST. *continued ...*

The slide-switches were never designed for any such thing; the idea was to set up, in binary one's and zero's, the divisor of a large number (or radio-frequency, if you wish to call it so), then the device would output an audio-frequency square wave (clarinet-like tone with rough edges) a definite submultiple of the original, and thus these settings would have definite ratios among themselves.

See what I mean by imagination and attitude? Often the inventor and the builders of a device never think of many things their device can do well, because of their mental blocks or narrow-rut habit-patterns, not the physical properties of the materials in the machine. Sometimes, invention consists in seeing an already-existing thing from a different viewpoint!

I bring this up because the teaching of music has fossilized and gotten rigid over a long period of time, such that creativity is presented as obsolete and the masterworks of the past are considered not only final, but complete—a revealed dogmatic "religion", rather than a living, growing field in which the present and future generations continue to work and produce new items and attitudes and modes of action.

* * * So I got out the tape-recorders and took down the sounds produced, and then superposed them in two parts, once some acceptable themes had been played.

The basic ordering of the pitches is in a subharmonic series:
$\frac{1}{1}\ \frac{1}{2}\ \frac{1}{3}\ \frac{1}{4}\ \frac{1}{5}\ \frac{1}{6}\ \frac{1}{7}\ \frac{1}{8}\ \frac{1}{9}\ \frac{1}{10}\ \frac{1}{11}\ \frac{1}{11}\ \frac{1}{13}\ \cdots$,
and the result was suspiciously like the key of F minor in ordinary music. The arpeggio or harmonic implied framework is what some people now call the sub-seventh, D♯ F A♭ C or a minor chord with a subminor third added below it. The sub-eleventh, or F#, puts in an occasional appearance. This kind of thing works passably well in the 31-tone scale, which is one reason for including it in this issue.

This composition is in just intonation, because ratios among most of the tones are exact by countdown.

Unlike the violinist or singer, the performer on an instrument of this sort is never anxious about being on pitch. So an entirely different attitude toward the just scale can be taken; therein lies the novelty of this piece. Neither the seeking of the right pitch, nor the constraints operating when a keyboard is used in a just tuning.

Title? WELCOMING DANCE FOR THE ASTRONAUTS, AS PERFORMED BY THE GIANT COCKROACHES OF MARS. Available on order as tape or cassette copies.

UNEXPLORED TERRITORY: THE 34-TONE EQUAL TEMPERAMENT

Since this issue has discussed the 31-tone system so extensively, and the 36-tone system to some extent, it would look like neglect or prejudice if some space were not devoted to another usable system which lies between them.

Sort of a stepchild or more accurately, a poor little orphan! Indeed, I know of no compositions in 34-tone except a couple of preliminary attempts of my own. I know of no fair treatment of the system except the passing mention by M. Joel Mandelbaum in his Doctorate Thesis on Multiple Division of the Octave and the Nineteen-Tone Temperament (Indiana University 1961) still not yet published in book form.

I might not even have learned about 34-tone, but for that Thesis. The reasons for this neglect are several: 31-tone has such great capabilities and potentialities that it overshadows any other system near it. Once instruments have been dedicated to 31-tone, the economic facts of life deter dedicating another expensive instrument to something "nearby" which from mathematical theory doesn't seem worth added expenditure.

Now that we have computers, tables, midget calculators in every home, and the necessary data to re-fret guitars ——and synthesizers and the exciting future of computer music—and built-in automatic retuning of electronic organs—the financial restraints no longer kill off our dreams.

From mathematical calculations, the fact that 31- and 34-tone have different MOODS in actual music composed or played in them, cannot be predicted. Calculations show that 34-tone does not have the excellent approximation to the 7th harmonic that 31 has, so again certain people dismiss it unheard. Fair enough, if you were still forced to have just one sole non-twelve system; but that is no longer the case. Sometimes you need subminor sevenths and subminor thirds; sometimes you don't, or a less-accurate imitation will work.

$34 = 2 \times 17$.

This arithmetical fact has much bearing, in both ways, on the 34-tone tuning. 34 is to 17 as 24 is to 12. Otherwise stated, 34-tone is a Second-Order System. Two circles of 17 Fifths each, which have no tone in common. That's like 24.

LONG-NEGLECTED 34-TONE, cont'd.

The major thirds of 34 are excellent, while the major thirds of 17 are inharmonious even though melodically brilliant. Since both the major thirds and the fifths of 34 are slightly sharp, the error of the minor third partially cancels out—with the result that the errors of major and minor thirds and sixths are practically the same.
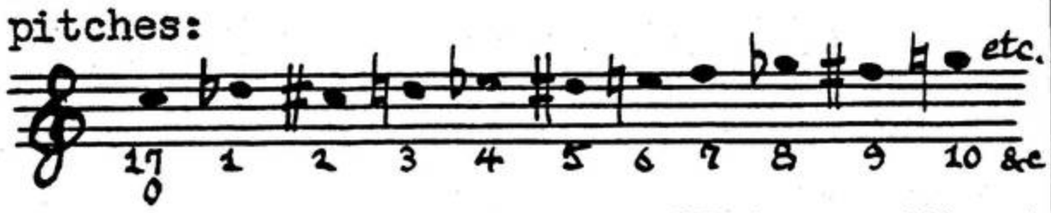
In one respect, the two non-intersecting circles of fifths in 34 do not matter as much as those of 24 (quartertones) because while there is no circle of major thirds going through all 12 tones of 12 nor all 24 tones of 24, there is such a circle of major thirds in 34 which MUST go through all 34 tones before returning to the starting-point, which means that many of the conventional means of modulation will reach all 34 keys, both major and minor. To some extent this mitigates the theoretical disadvantages of having two, rather than one, circle of fifths.

34 also has the neutral thirds and other intervals and chords enjoyed by 24 and 31. Probably the brilliant mood of 17 will show through in most 34-tone music, and a compromise affair in which 17-tone melodies are accompanied with 34-tone harmonies will get considerable use. Cf. the Busoni notion about 18-tone being accompanied by the 12-tone harmony inherent in 36-tone.

Since any compositions previously done in 34-tone apparently never were published or even written about, I felt free to invent a special notation for extending the obvious notation for 17 to include 34.

Unless someone can come up with something provably superior, and worthwhile 34-tone compositions in it, I think the following will stand:

17-tone is notated with no extra signs, but the circle of 17 fifths, since they are 4 cents sharp, results in strange equivalences: E#=Gb, and in the sharps being sharper than their adjacent flats, in contradiction to 19 and 31. A few pitches:

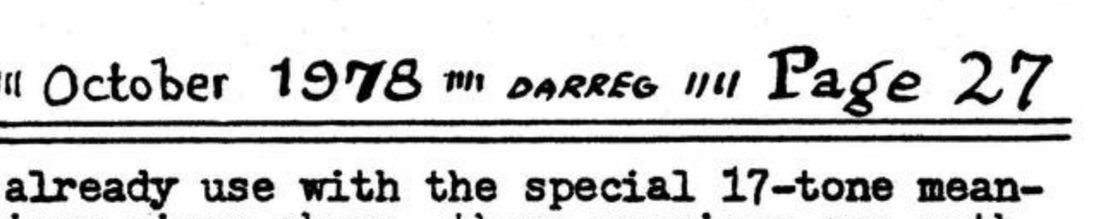


Other aspects of using 17-tone without going into 34 at all will be discussed in future issues of this Bulletin.

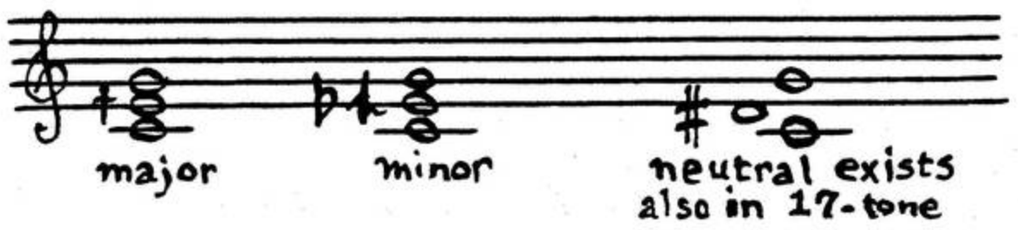
Since 17 is contained in 34, it would be irritating and disruptive to upset the above scheme when using 34. So: two new signs, 𝄲 and 𝄳, simply the familiar printer's obelisk or dagger, erect and inverted, pointing up and pointing down, are used with or without the ♯ and ♭ we already use with the special 17-tone meanings given above—these meanings are nothing more than slight exaggerations of the Pythagorean meanings of sharp and flat signs already familiar and even preferred by violinists.

Just like the arrows already used by many composers for pitch-bending, if the point of the dagger points down, the pitch is to be lowered 1/34 octave, and if the point of the (inverted) dagger points up, the pitch of the tone is to be raised 1/34 octave. This will create equivalents or synonyms, but the relation of the good major thirds of 34 to the fifths will result in the lowering of sharps and raising of flats, much more than the other way around. Very much like the comma in just intonation, or the single degree in systems like 41 or 53.

Hence, a few pitches:



Sample chords:



If nobody but me ever uses this scheme, I won't cry; I won't even mope or sulk. You can always just number the tones 0 through 33 as Carrillo does for 30 and 36 and thus evade the confusion among systems in respect to the meanings of "sharp and flat". Or you can resort to graph-paper. Or forget about writing down and use a tape-recorder. All I care about is that some composers try 34-tone. It deserves a better fate than it has received all these centuries.

34 lies on the upper limit of guitar-playing difficulty, of course. Therefore a longer neck and active string-length than standard is recommended. In most cases people would want to approach 34 by way of 17. Players of bowed instruments should be able to follow along in 34 without too much trouble.

I don't want to repeat the sad mistake which has retarded the development of 19, 24, 31, and some other systems by setting up rules of harmony and melody-writing in 17 or 34, so won't make rules to cramp your style. I hope nobody else writes regulations in advance either. Principles of composition and adaptation into 17 and 34 must be arrived at through actual experiment on real instruments with people listening and feeding back their reactions. ~

INTERVAL

The second issue of a new magazine called INTERVAL has just appeared. Edited by Jonathan Glasier, it bears the subtitle "A Microtonal Newsletter" and features letters, articles, illustrations, and reviews of concerts and books.

Subscription price has been set at $12 per year, and communications may be addressed to INTERVAL, Postoffice Box 8027, San Diego CA 92102.

The stress is on practice rather than theory, and there will be How-To articles as well as illustrated descriptions of new instruments and techniques of performance.

The terms "interval" and "microtonal" are meant to imply, much as this Bulletin has been saying for some time, that the moment in history has finally arrived to escape the wornout 12-tone equal temperament--and this means new intervals, and many such intervals happen to be micro.

The 8 preceding issues of the Xenharmonic Bulletin have been working off a backlog of accumulated information which necessarily has involved getting technical at times, and very often necessitated going into careful details. INTERVAL, on the other hand, is a brand-new magazine focussing on current un-twelvular happenings and the people who have now begun to interact with one another to extend the general tonal vocabulary.

Thus the term "newsletter" has some relevance, although this is a professionally printed magazine, not a fly-by-night mimeo sheet or hastily-thrown-together 'flyer'.

Because the San Diego area where this new publication started was the abode of the late composer Harry Partch, and the Foundation in his memory and some instruments and memorabilia are there, the first issues of INTERVAL necessarily have a Partchian aspect. Partch's system represented such a departure from "tradition" and the stuffy conventions of concert-halls, that his followers have had to exert extra effort to ensure the survival of his work and they have developed considerable ingenuity in building new instruments to carry on his ideas from where he left off.

Two new instruments by Cris Forster of San Francisco are typical of this action, and are described in the two issues. Ample constructional and tuning details are given in the respective issues.

Jonathan Glasier is active in improvisational and performance groups and is producing copy-cassettes of some of these.

He observes that, without actual performance and sufficient HEARING of the new scales, chords, and intervals involved in the non-twelve systems, xenharmonics would never get off the ground. One way to get something started without further delay is to improvise. Far from a mere ego-trip, this includes group improvisation where people prevent each other from stagnating at awkward dead spots. When improvisation is conducted in new tuning-systems, many of the stock clichés become impossible.

I have pointed out frequently in this Bulletin and elsewhere that music is sounds, rather than silent ink-mark notation. It is dangerous to write too much at first in non-12 tuning systems, without hearing all the new interrelations between the tones. The twelve-tone rules and frozen practices must not be allowed to kill spontaneity.

A new set of auditory memory-images and attitudes must be installed in listeners as well as performers. The quickest way to do this is to improvise in non-twelve. Since the new instruments are being developed along with new scales for them, group improvisation becomes a means of discovering how to fit new and old instruments together, and what techniques on the new instruments are going to work.

Interval will also carry announcements of new activities, a small amount of advertising, and an extremely important feature called the Tape Exchange—until now, contemporary composers have been virtually unable to hear one another's works! Without the sounds of the new intervals, all writing and printing would be worthless.

* * *

NEW GUITAR PROGRESS

The February, 1978 issue of GUITAR PLAYER magazine, on pp. 24 sqq., contained an article by Ivor Darreg on Non-Twelve-Tone Guitars, which unleashed a flood of correspondence from distant places--and is still doing so, the latest missive being from Australia.

This correspondence has resulted in playing this typewriter far more than any of my instruments the last several months. Definitely it can now be said that enough persons want untwelvic tunings that we really have a movement going.

The guitar is suited to systems of moderate numbers of tones, and re-fretting is much less expensive than building special keyboard instruments, so the average guitarist can realize the new sounds before curiosity and interest have any chance to fade.

NEW GUITAR PROGRESS, *cont'd.*

Fretting tables for 19-,22-, and 31-tone guitars of standard size with 650mm active string-length ("scale length" as it is called in the trade) are included in the article. The Editors of Guitar Player added considerable introductory material and included the Bibliography.

A surprising number of readers save back numbers, and evidently get around to answering, even 7 months later! So we are publishing a few names and addresses in this Xenharmonic Bulletin 9 so that you can help establish a Xenharmonic Guitar Network. The ease of refretting, the portability of guitars, and the happy fact that 95% of standard guitar literature is performable in the 19-tone and 31-tone systems without any marking-up of the sheet-music, make the guitar an ideal entry into non-twelve. There must be about 45-50% of the existing literature playable in the 22-tone system—as the only obstacle is the visual notation problem. A different fretting is nowhere near the obstacle that a new keyboard, or the mapping of a xenharmonic system onto a 12-tone standard keyboard, presents to the newcomer.

The 24-tone or quartertone guitar is also easy to acquire, since all the 12-tone frets remain in place; but it requires composing and improvising new music for it. The 17-tone guitar is probably the easiest refretting to get accustomed to, but 17 favors melody so much over harmony that again, new compositions and adaptations from one--note-at-a-time instruments such as violin solos will be required. A considerable amount of existing music could be played on a 34-tone guitar, but would need some arranging.

Choice of systems depends mostly on the mood of the music to be played, and on one's own personality—some people prefer 22 and some people prefer 19;and no doubt psychologists will put this in their Personality Tests someday. However, a decade of interviewing and opinion-gathering has shown that one can recommend a definite order of proceeding through the systems practical on the guitar: first 19, then 22, then 31, then 17, then 24, then any others whether harmonic or inharmonic, up to the practical technical limit of close-togetherness of frets.

Note carefully: If you are not into guitars, but want to start with keyboard instruments, it is practical to start right in with the 31-tone system, if that is your cup of tea. It's just that on the guitar, 31 is definitely far more difficult than 19, and you will be held back by purely technical problems unless you practice in 19-tone first. I found this out the HARD way. This is not propaganda against 31 or 41 or 53. In later issues of this Bulletin, the many-toned systems will get their due. There are promising futures for 41, 43, 46, 50, 53, 65, 72, 77,87, and some other systems of many tones per octave—mostly by way of computers, automatic players, special electronic organs, and the like.

While it is possible to fret guitars to unequal temperaments and to the just-intonation system carried out to say 20 or 30 tones, the standard tuning entails splitting frets and this increases the expense and difficulty. So that phase of non-12 was not stressed in the article. Instead, a 19-tone Prelude was published in toto, and some examples of harmony and notation for 19, 22, 24, and 31 were included.

Also, while there are some fretLESS guitars and basses, this was necessarily passed over quickly, as for the average student and newcomer to xenharmonics, just tunings are more advanced technically and require greater care on the part of the performer.

So far as I am concerned personally, I am using the Hawaiian or Steel guitar principle of a sliding bar which is a moveable bridge and can be also a hammer on the clavichord principle, to make just intonation practical and inexpensive and accessible to the average interested person. This is being done via the Megalyra, Kosmolyra, Hobnailed Newel Post, and some new Drone Instruments. You will be kept up-to-date in future Xenharmonic Bulletins. [Refer back to pages 22 & 23.]

Guitars would be suitable for Busoni's and Carrillo's 18-tone or third-tone system, but more difficult for the 36-tone or sixth-tone system—this latter would require extra-long strings.

But the most important thing about the February 1978 GUITAR PLAYER article is that it CAUSED quite a number of people to re-fret their guitars and start composing and performing in non-twelve. The lid is off Pandora's Box and the 12-tone Squirrelcage lies in ruins and it is much too late for anyone to stop us.

Because of the guitar vogue, non-twelve is open to everyone, not just esoteric specialists or persevering scholars.

The new frets SYSTEMATIZE and legitimize the socalled "bent" tones, which now can be logically integrated into coherent melodic and harmonic schemes.

JUST-INTONATION RECITAL, contd.

in Los Angeles, Cris Forster presented a recital including readings from Walt Whitman, accompanying himself on instruments that he had built.

Most unusual of these is the Chrysalis, which has two disk-soundingboards, built as a wheel, and this wheel can be revolved on its axle to where the desired notes are, and it will stay in any position, as it is carefully balanced. On each wooden disk are stretched 82 strings, tuned by guitar-type tuning-gears to just ratios in an extended version of Partch's system, going to ratios involving the number 13.

The wheel is mounted by its axle on a special stand, so that the strings are at a proper height for performance.

Forster's version of the Harmonic Canon is much sturdier and heavier than Partch's various forms of this instrument—this invention of Partch's has 48 strings and movable bridges for accurate measuring-off of fractional string-lengths. Thus if the strings are tuned to unison for their full lengths, the movable bridges can be set at a measured fraction of that length to get other pitches bearing a definite ratio to the full length. Partch's Harmonic Canons and similar instruments used thin strings, such as guitar B-strings; Forster's uses heavier strings looking more like those on the piano. The frame is necessarily heavier accordingly. The effect of this new Harmonic Canon was at times like the una corda pedal on a grand piano—but in this case no longer subject to 12-tone temperament.

The Forster version of the Diamond Marimba used ratios involving 13, again going beyond Partch's 11 limit. This is a peculiar arrangement of tones, making easy certain patterns impossible on ordinary instruments, while some familiar patterns become difficult or impossible on this.

Cris Forster presented a special composition, ASCENT OF THE PHŒNIX, taking advantage of the potentialities of this tone-arrangement.

The large living-room was exactly the right size for the volume of these acoustic instruments and for the audience.

53 System Lives Again

Those of you who have, or who at least have read, the English translation of Helmholtz's SENSATIONS OF TONE will have run across both the comments of Helmholtz himself and of the translator, Alexander J. Ellis, on the 53-tone equal temperament and its extreme closeness to just intonation. The fifths are out by a fifteenth of a cent, which is such a tiny deviation that one could not count the beats by ear. The major thirds are out by only a small amount. 1.4 cents or 1/852 of an octave, far too small to bother about in musical performances. Intervals determined by higher harmonics do have greater errors.

The Appendix on theory of tuning which Ellis added to the Helmholtz work, contains impassioned pleas for adopting the 53 system, but this came at a point in history coinciding with the zenith of the piano's development and the fuzzy mushy lush style of the Romantic period, and worse yet, the most agonizing point of the Divorce between Art and Science.

So, quite literally, no-one was listening. In the century since, unconscionable slanderous invective has been poured out on Ellis. As atonality and serialism were born and flourished, the disdain of 53 and just intonation grew. Thus nothing was ever done about trying out 53-tone for any worthwhile musical purposes. It stayed silent on library shelves.

Until just lately! Larry Hanson.

became interested in this system, unearthed some forgotten information about it, and had Ervin Wilson and Glen Prior build three sets of aluminum-tubing instruments, each with two octaves of the 53-tone system.

It now is possible to experiment. Other instruments will follow later on. When they do, of course this will be discussed in future Bulletins.

Instead of getting rid of the comma as many other temperaments do (refer back to pages 12 & 18, this issue, where the comma is explained), the 53 system flaunts it. Subtle effects in melodies are possible, and certain familiar intervals come in different varieties, a comma apart. The 53-tone comma is a compromise between the Didymus and Pythagorean commas.

The XENHARMONIC BULLETIN has not yet dealt with many-toned temperaments, and it will take one or two more issues before the proper time to discuss 53-tone in depth is reached. But there has been no practical playable realization of the 53-tone system for a century, and no-one has revived the experimental instruments of that time, so this story can't wait.

When we get to the territory beyond 31, automatic performance and the computer become increasingly important, and will ensure the future of such systems.

Revival of 53-tone System — continued

As detailed in Xenharmonic Bulletin No. 8 when certain routines for tuning by ear were set out, it becomes impractical to push one's accuracy beyond a certain point. Novice piano-tuners are discouraged and often give up entirely, when they fail to close the circle of 12 fifths. The usual 12-tone piano-tuning routines do not in fact produce an equal temperament, but a tempered temperament i.e. a second-order compromise.

This will be true for other than 12-tone temperaments, and by the time we reach the 53-tone system, the frequency stability of musical instruments available at the time Ellis and Helmholtz wrote their arguments in behalf of 53-tone was too poor to hold a fine tuning, however well the job might have been done.

Today, those obstacles no longer exist: we have crystal control and other frequency-maintaining means which can serve as clocks, so great is their accuracy. Electronic tuning devices abound and their price is coming down. Sustained tones, such as those of organs and synthesizers, can further be checked with frequency-counters having direct digital readout. Thus the stability of an electronic tuning device AND of the instruments it tunes can be frequently monitored by an independent standard.

Counting circuits developed for computers have been adapted to providing a set of stable tempered pitches for electronic organs and the new digital synthesizers.

Further developments are on the drawing-boards and in the laboratories. 53-tone thus becomes as easy as any other usable tuning-system. The problems which remain pertain to musical notation, performance techniques customary today, and adaptation of existing printed music to 53-tone.

It is too early for me to make any statement on the mood of this system, as I have had only limited experience hearing and performing in it. Since the small intervals are extremely subtle, it is safe to assert that compositions specifically for 53 will feature slow tempi and sustained tones.

Conventional 12-tone-system harmony is inadequate to deal with commas, so a great amount of experimentation will be necessary. This, of course, is understandable to theorists and acousticians, but very difficult to bring home to musicians and composers, who have so long been told not to think of experimenting.

The Pythagorean tuning, which uses exact perfect fifths in an infinite chain in both directions, is extremely close to the 53-tone equal temperament. Thus violinists and other string players would not be estranged by the excellent imitation of Pythagorean intonation which the 53 system provides.

In 1876, R.H.M. Bosanquet published a treatise on musical intervals and temperament in which his keyboard layout for 53 was depicted. This design has been the basis for a number of special keyboards in recent years, some of which are generalized: they can be used for many tuning-systems merely by reassigning the digitals. So there is no need to worry about keyboard problems.

With modern technology and the availability of great precision, it is no longer necessary to concentrate on just one system for music--we can have all the systems we can use. Now that instruments exist, the road is clear.

* * * *

New Drone Instruments

After building several of the Kosmolyra and Megalyra instruments, a new possibility appeared out of the blue. Glen Prior plays the Highland Bagpipe, which has a 9-tone scale on its melody-reed or chanter, and three drones tuned to B-flat second line bass staff and the second and third drones to B-flat top space bass staff. This instrument has stubbornly resisted conforming to the 12-tone temperament--it has mainly just intervals and some slight variants all its own.

Music for the bagpipe is written all in naturals, and the pitch which seems to be B-flat based on A=435 is called "A".

What if a steel-guitar-type instrument were made, which was about the same length as the Megalyrai, and it had unison and octave strings on one side of the board with fret-lines for the bagpipe scale, and a set of drone strings on the other side? It could be amplified with a big amplifier, and could play all the regular bagpipe tunes. So I made such an instrument. It is called Drone I for the time being. Played softly, it sounds with a sitar-buzz just like something fresh off the boat from India, not Scotland. So an extra set of drone strings tuned to E-flat was installed. It can play Indian tunes which often are used with a soft drone.

The drone principle is helpful when someone wishes to learn new intervals--if one component of the interval is held constant, it serves as a point of reference—it usually is the tonic, but may be some other scale-degree.

DRONE INSTRUMENTS, CONTINUED —

The vielle or hurdy-gurdy, and some country dulcimores and bowed instruments, have drone strings, so the principle is shared by many continents and cultures.

A second drone instrument was then built, called simply Drone II for the time being. This has long, very thin strings on the front side, 8 tuned in unison to Tenor C, and 4 somewhat thicker strings tuned an octave lower. A long steel can span all 12 strings, or a smaller number of them if so desired. This gives a very rich chorus effect. The magnetic pickups are located so as to accentuate the high harmonics, for a "thin" reedy tone which helps define xenharmonic intervals.

The fret-line-pattern is the same as that on the Megalyra, two octaves each of 12-tone and just intonation carried out to at least 19 pitches, and harmonic nodes up to the 16th.

On the reverse side are 10 strings, in 5 pairs, tuned in octaves, C D F G A (or this could be altered to several other pentatonic patterns) and these five drones will take care of a very wide range of folk and exotic tunes. It is not necessary to use these drones at all--they are optional --but having them available can be very helpful on many occasions.

Just recently a duplicate of the above, Drone III, was completed.

These instruments will be available for use by interested parties from time to time and as many variations on this idea are possible, considerable room for experimentations exists. Using the drone is like picking up your magnifying glass--the differences between close-together pitches are "magnified" and show up clearer.

* * * *

COMPOSITIONS AND INSTRUMENTS !

Brian Hartzler, 823 South Gilbert Street, Anaheim CA 92804, composed a 19--tone guitar piece after refretting a guitar to that system. Soon he will be going on to further systems.

Martin Sweidel. Cincinnati Ohio composed a 19--tone guitar piece some time ago and authorized me to make a few copies of it. He has also worked in the 31-tone system.

Lists of Ivor Darreg's compositions will be updated and kept available. They include a number of systems.

Someone should gather up the forgotten non-12-tone compositions and make a bibliography. Few were published in any quantity.

For information on 31-tone compositions and the progress of the 31-tone movement in the Netherlands, the U.S. address is:

C. Albanese, Representative, Huygens--Fokker Foundation, 816 Carmelita Avenue, Montebello CA 90640.

Or you may write directly abroad:

Huygens-Fokker Foundation, Anton de Beer, Kleine Houtstraat 116, Haarlem, The Netherlands.

For information on his several instruments built in the 31-tone system,

Ervin M. Wilson, 844 North Avenue 65, Los Angeles CA 90042.

Glen Prior is composing for 31-tone instruments--one piece is based on Wilson's "hexany" arrangement of the 31 tones, which creates an unusual melodic and harmonic patterning. That is, while, as stated in the 31-tone article in this issue, 31-tone embraces the regular key-system and indeed expands it, it also permits new orderings of tone-patterns inconceivable in the 12 system.

Dr. Abram M. Plum, School of Music, Illinois Wesleyan University, Bloomington IL 61701, has composed in the 31-tone system and recently produced a new score.

Webster College, 470 East Lockwood, St. Louis MO 63119, under the direction of its President, Leigh Gerdine, has been promoting the 31-tone system for some time.

***We can't cram everybody in xenharmonics into this issue, but we tried. Next Bulletin out soon enough, and more there.

San Diego Lecture/Recital

In April of this year, Ivor Darreg was taken down to San Diego with 11 of his instruments and introduced around by Jonathan Glasier, who arranged a lecture/recital at Calliope's Coffeehouse before a capacity audience. This was also a reunion, in that Mr. and Mrs. John Metzger attended the concert—Ivor Darreg lived in San Diego in 1937-38, 40 years ago, and played cello and electronic keyboard oboe in John Metzger's orchestra.

The recital began with Darreg's earlier piano compositions, some of which were composed back then, and proceeded to the Megalyra and Kosmolyra in just intonation, and guitars in 19, 22, and 31. A 5-string amplifying cello was demonstrated, and the "zero" system, Futurist intoned noise, was taken care of by the electric keyboard drum (capable of polyrhythms).

John Glasier Sr. joined Jonathan Glasier in 17-tone and pythagorean improvisations to exemplify that aspect of xenharmonics.

The lecture portions were interspersed, and featured live comparisons. * * * * *

FRETTING-TABLES FOR THE 31-, 34-, & 36-TONE SCALES FOR ACTIVE STRING-LENGTHS 720, 810, & 1000 mm

In XENHARMONIC BULLETIN № 7, six fretting tables were given, for the 17-, 19-, 22-, 24-, 31-, and 34-tone systems, all for the standard 650 mm (25 5/8 ") active string length (scale-length is a common alternative term) which appears to have been decided on by some guitar-makers in Spain in the last century, and has been approximated in other countries to a considerable extent. These tables continue to be available.

It should be obvious enough that, the more frets per octave, the closer together they have to be placed. This means that the frets cannot be carried up as high as they should be, if the number of tones per octave is increased beyond a certain point and one still insists on ordinary scale-lengths. It also means that some other fretted instruments, such as the mandolin, will not be able to have frets beyond 19 or 22 tones per octave, unless one is willing to leave much of the fingerboard unfretted. (This was in fact the case with many of the old viol family, which did not carry frets as far as one octave, so it remains a realistic possibility.)

Electric basses, the rare mando-cello, and some other fretted instruments have longer strings than guitars; also, most readers of this Xenharmonic Bulletin will have, or plan on having, a monochord or other experimental string instrument with measuring--rulers or -scales on it; also, these fretting-tables can be used for fret-lines or -charts of the steel-guitar type. Furthermore, in planning string-length layouts for psalteries, harpsichords, harps, hammer-dulcimers, etc., these tables give proper lengths for a considerable portion of the compass, and can easily be extrapolated.

Tables for constructing charts or laying out fret-lines for instruments of the Kosmolyra and Megalyra types, as long as 2 meters or more, are available on special order.

There are so many active string-lengths in use that it is impractical to publish all tables for all lengths. With an electronic calculator it is easy enough to take the table for 1 meter and multiply it by the actual wanted scale-length. To get the distance from the nut instead of that from the bridge, each entry must be subtracted from the total length. On many instruments, it is not practicable to assume a fixed bridge-position, or it is not practicable to insert frets or lay them out while the bridge is in its final position on the instrument.

⟶IMPORTANT: On many guitars, it is necessary to correct the nut-position by moving it toward the bridge 1 or 1.5 mm. This depends on the individual instrument, and ordinarily is not necessary if the guitar has a special zeroth fret. It is more important on a 31-tone guitar than on a 17, for instance. These tables DO NOT include any such correction, since there are a number of fretted instruments not requiring a correction. Whether to deduct the distance when laying-out frets, or actually to move the nut by taking that much off the top end of the fingerboard, is up to the craftsman. Mainly: don't write angry letters about the tables being wrong!

The 34-tone table can also be used for 17-tone by taking only alternate frets. Likewise the 36-tone table can also be used for 18-tone or (ugh!) 12. A 36-tone guitar could be used as 34 by moving the bridge, or vice-versa—the error is small in actual performance, since other errors are also involved, of similar magnitude.

After consulting with interested parties, we propose a scheme of scale-lengths as follows: 650 mm, 720, 810, 915, and 1000. This gives approximately 9:8 or whole-tone steps per increment, and can be extended downward as well as upward, to reduce the too great number of fretted-instrument active string-lengths now in use. Reasons for those numbers: 650 mm is already fairly standard internationally as one of the lengths. 720 and 810 stand in 9:8 ratio. 915 is very close to the yard (exactly 914.4) so there may be existing instruments with that length, and there may be monochords etc. which were designed to be used with a 36" yardstick. 1 meter is a standard for monochords, sonometers, etc., and was the basis for John H. Chalmers, Jr.'s computer printouts, from which these tables are derived.

There is no longer any point giving tables in inches, since the metric conversion will slowly but inevitably take over, and millimeter rulers and tapes are now easily obtainable. These tables are for 1980 and 1990 people rather than 1900 or 1920.

FRETTING TABLES FOR 31-TONE TEMPERAMENT
STRING-LENGTHS OF 650, 720, 810 & 1000 mm

Fret Number	Distance From Bridge	Distance From Nut	Distance From Bridge	Distance From Nut	Distance From Bridge	Distance From Nut	Distance From Bridge	Distance From Nut
0	650.0	0.0	720.0	0.0	810.0	0.0	1000.0	0.0
1	635.6	14.4	704.1	15.9	792.1	17.9	977.9	22.1
2	621.6	28.4	688.5	31.5	774.6	35.4	956.2	43.8
3	607.8	42.2	673.3	46.7	757.4	52.6	935.1	64.9
4	594.4	55.6	658.4	61.6	740.7	69.3	914.4	85.6
5	581.2	68.8	643.8	76.2	724.3	85.7	894.2	105.8
6	568.4	81.6	629.6	90.4	708.3	101.7	874.5	125.5
7	555.8	94.2	615.7	104.3	692.6	117.4	855.1	144.9
8	543.5	106.5	602.1	117.9	677.3	132.7	836.2	163.8
9	531.5	118.5	588.8	131.2	662.4	147.6	817.7	182.3
10	519.8	130.2	575.7	144.3	647.7	162.3	799.6	200.4
11	508.3	141.7	563.0	157.0	633.4	176.6	782.0	218.0
12	497.0	153.0	550.6	169.4	619.4	190.6	764.7	235.3
13	486.0	164.0	538.4	181.6	605.7	204.3	747.8	252.2
14	475.3	174.7	526.4	193.6	592.3	217.7	731.2	268.8
15	464.8	185.2	514.8	205.2	579.2	230.8	715.1	284.9
16	454.5	195.5	503.5	216.5	566.4	243.6	699.2	300.8
17	444.5	205.5	492.3	227.7	553.9	256.1	683.8	316.2
18	434.6	215.4	481.4	238.6	541.6	268.4	668.7	331.3
19	425.0	225.0	470.8	249.2	529.6	280.4	653.9	346.1
20	415.6	234.4	460.4	259.6	517.9	292.1	639.4	360.6
21	406.4	243.6	457.4	262.6	506.5	303.5	625.3	374.7
22	397.4	252.6	440.2	279.8	495.3	314.7	611.5	388.5
23	388.7	261.3	430.5	239.5	484.3	325.7	597.9	402.1
24	380.1	269.9	421.0	299.0	473.6	336.4	584.7	415.3
25	371.7	278.3	411.7	308.3	463.1	346.9	571.8	428.2
26	363.4	286.6	402.6	317.4	452.9	357.1	559.1	440.9
27	355.4	294.6	393.7	326.3	442.9	367.1	546.8	453.2
28	347.5	302.5	385.0	335.0	433.1	376.9	534.7	465.3
29	339.9	310.1	•376.5	343.5	423.5	386.5	522.9	477.1
30	332.3	317.7	368.1	351.9	414.2	395.8	511.3	488.7
31	325.0	325.0	360.0	360.0	405.0	405.0	500.0	500.0
32	317.8	332.2	352.1	367.9	396.1	413.9	489.0	511.0
33	310.8	339.2	344.3	375.7	387.3	422.7	478.1	521.9
34	303.9	346.1	336.7	383.3	378.7	431.3	467.6	532.7
35	297.2	352.8	329.2	390.8	370.4	439.6	457.2	542.8
36	290.6	359.4	321.9	398.1	362.2	447.8	447.1	552.9
37	284.2	365.8	314.8	405.2	354.2	455.8	437.2	562.8
38	277.9	372.1	307.9	412.1	346.3	463.7	427.6	572.4
39	271.8	378.2	301.1	418.9	338.7	471.3	418.1	581.9
40	265.8	384.2	294.4	425.6	331.2	478.8	408.9	591.1
41	259.9	390.1	287.9	432.1	323.9	486.1	399.8	600.2

Note Nº

Values for the 31st root of 2 and its powers and reciprocals derived from tables computed by Dr. John H. Chalmers, Jr. and Ervin M. Wilson.

The difference between a 31-tone equal temperament fretting and a $\frac{1}{4}$-comma meantone fretting is extremely small and so there is no point compiling fretting tables for meantone. This will be discussed in future Xenharmonic Bulletins. Unavoidable errors in instruments would exceed the differences.

FRETTING TABLES FOR 17- AND 34-TONE EQUAL TEMPERAMENTS

FOR ACTIVE STRING-LENGTHS OF 650, 720, 810, AND 1000 mm

FRET №(17)	FRET №(34)	DISTANCE FROM BRIDGE	DISTANCE FROM NUT	DISTANCE FROM BRIDGE	DISTANCE FROM NUT	DISTANCE FROM BRIDGE	DISTANCE FROM NUT	DISTANCE FROM BRIDGE	DISTANCE FROM NUT
0	0	650.0	0.0	720.0	0.0	810.0	0.0	1000.0	0.0
	1	636.9	13.1	705.5	14.5	793.7	16.3	979.8	20.2
1	2	624.0	26.0	691.2	28.8	777.6	32.4	960.0	40.0
	3	611.4	38.6	677.3	42.7	761.9	48.1	940.6	59.4
2	4	599.1	50.9	663.0	56.4	746.6	63.4	921.7	78.3
	5	587.0	63.0	650.2	69.8	731.5	78.5	903.1	96.9
3	6	575.2	74.8	637.1	82.9	716.7	93.3	884.9	115.1
	7	563.6	86.4	624.2	95.8	702.3	107.7	867.0	133.0
4	8	552.2	97.8	611.6	108.4	688.1	121.9	849.5	150.5
	9	541.0	109.0	599.3	120.7	674.2	135.8	892.4	167.6
5	10	530.1	119.9	589.2	132.8	660.6	149.4	815.6	184.4
	11	519.4	130.6	575.4	144.6	647.3	162.7	799.1	200.9
6	12	508.9	141.1	563.7	156.3	634.2	175.8	783.0	217.0
	13	498.7	151.3	552.4	167.6	621.4	188.6	767.2	232.8
7	14	488.6	161.4	541.2	178.8	608.9	201.1	751.7	248.3
	15	478.7	171.3	530.3	189.7	596.6	213.4	736.5	263.5
8	16	469.1	180.9	519.7	200.3	584.6	225.4	721.7	278.3
	17	459.6	190.4	509.1	210.9	572.8	237.2	707.1	292.9
9	18	450.3	199.7	498.8	221.2	561.2	248.8	692.8	307.1
	19	441.3	208.7	488.8	231.2	549.9	260.1	678.9	321.1
10	20	432.4	217.6	478.9	241.1	538.8	271.2	665.2	334.8
	21	423.6	226.4	469.2	250.8	527.8	282.1	651.7	348.3
11	22	415.1	234.9	459.8	260.2	517.3	292.7	638.6	361.4
	23	406.7	243.3	450.5	269.5	506.8	303.2	625.7	374.3
12	24	398.9	251.5	441.4	278.6	496.6	313.4	613.1	686.9
	25	390.5	259.5	432.5	287.5	486.6	323.4	600.7	399.3
13	26	382.6	267.4	423.8	296.2	476.7	333.3	588.6	411.4
	27	374.9	275.1	415.2	304.8	467.1	342.9	576.7	423.3
14	28	367.3	282.7	415.2	304.8	467.1	342.9	576.7	423.3
	29	359.9	290.1	398.6	321.7	448.5	361.5	553.7	446.3
15	30	352.6	297.4	390.6	329.4	439.4	370.6	542.5	457.5
	31	345.5	304.5	382.7	337.3	430.5	373.5	531.5	468.5
16	32	338.5	311.5	375.0	345.0	421.9	388.1	520.8	479.2
	33	331.7	318.3	367.4	352.6	413.9	396.1	510.3	489.7
17	34	325.0	325.0	360.0	360.0	405.0	405.0	500.0	500.0
	35	318.5	331.5	352.7	367.3	396.8	413.2	489.9	510.1
18	36	312.0	338.0	345.6	374.4	388.8	421.2	480.0	520.0
	37	305.7	344.3	338.6	381.4	380.9	429.1	470.3	529.7
19	38	299.6	350.4	331.8	388.2	373.2	436.8	460.8	539.2
	39	293.5	356.5	325.1	394.9	365.7	444.3	451.5	548.5
20	40	287.6	362.4	318.5	401.5	358.3	451.7	442.4	557.6
	41	281.8	368.2	312.1	407.9	351.1	458.9	433.5	566.5
21	42	276.1	373.9	305.9	414.1	344.1	465.9	424.8	575.2
	43	270.5	379.5	299.7	420.3	337.1	472.9	416.2	583.8
22	44	265.1	384.9	293.6	426.4	330.3	479.7	207.8	592.2

Values of the 17th and 34th roots of 2 and their powers and reciprocals derived from computer printout by Dr. John H. Chalmers, Jr. and checked against 17-tone tables compiled by Ervin M. Wilson.

When frets get too close together, as in the 34-tone table used for 650 mm, the last few frets can be mere painted lines, protected by a sheet of transparent plastic cemented over them.

FRETTING TABLES FOR THE 12-, 18-, & 36-TONE TEMPERAMENTS FOR ACTIVE STRING-LENGTHS OF 720, 810, & 1000 mm

FRET NUMBERS			Distance		Distance		Distance	
12	18	36	from Bridge	from Nut	from Bridge	from Nut	from Bridge	from Nut
0	0	0	720.0	0.0	810.0	0.0	1000.0	0.0
		1	706.2	13.8	794.5	15.5	980.9	19.1
	1	2	692.8	27.2	779.4	30.6	962.2	37.8
1		3	679.5	40.5	764.5	45.5	943.8	56.2
	2	4	666.6	53.4	750.0	60.0	925.9	74.1
		5	653.9	66.1	735.6	74.4	908.2	91.8
2	3	6	641.4	78.6	721.6	88.4	890.9	109.1
		7	629.2	90.8	707.9	102.1	873.9	126.1
	4	8	617.2	102.8	634.3	115.7	857.2	142.8
3		9	605.4	114.6	681.1	128.9	840.9	159.1
	5	10	593.9	126.1	668.2	141.8	824.9	175.1
		11	582.6	137.4	655.4	154.6	809.1	190.9
4	6	12	571.5	148.5	642.9	167.1	793.7	206.3
		13	560.6	159.4	630.7	179.3	778.6	221.4
	7	14	549.9	170.1	618.6	191.4	763.7	236.3
5		15	539.4	180.6	606.9	203.1	749.2	250.8
	8	16	530.6	189.4	596.9	213.1	736.9	263.1
		17	519.0	201.0	583.9	226.1	720.9	279.1
6	9	18	509.1	210.9	572.8	237.2	707.1	292.9
		19	499.4	220.6	561.8	248.2	693.6	306.4
	10	20	489.9	230.1	551.1	258.9	680.4	319.6
7		21	480.5	239.5	540.6	269.4	667.4	332.6
	11	22	471.4	248.6	530.3	279.7	654.7	345.3
		23	462.4	257.6	520.2	289.8	642.2	357.8
8	12	24	453.6	266.4	510.3	299.7	630.0	370.0
		25	444.9	275.1	500.5	309.5	617.9	382.1
	13	26	436.5	283.5	491.0	313.0	606.2	393.8
9		27	428.1	291.9	481.6	328.4	594.6	405.4
	14	28	420.0	300.0	472.5	337.5	583.3	416.7
		29	411.9	308.1	463.4	346.6	572.1	427.9
10	15	30	404.1	315.9	454.6	355.4	561.2	438.8
		31	396.4	323.6	445.9	364.1	550.5	449.5
	16	32	388.8	331.2	437.4	372.6	540.0	460.0
11		33	381.4	338.6	429.1	380.9	529.7	470.3
	17	34	374.1	345.9	420.9	389.1	519.6	480.4
		35	367.0	353.0	412.9	397.1	509.7	490.3
12	18	36	360.0	360.0	405.0	405.0	500.0	500.0
		37	353.2	366.8	397.3	412.7	490.5	509.5
	19	38	346.4	373.6	389.7	420.3	481.1	518.9
13		39	339.8	380.4	382.2	427.8	471.9	528.1
	20	40	333.4	386.6	375.0	435.0	463.0	537.0
		41	327.0	393.0	367.8	442.5	454.1	545.9
14	21	42	320.8	399.2	360.9	443.1	445.5	554.5
		43	314.6	405.4	354.0	456.0	437.0	563.0
	22	44	308.6	411.4	347.2	462.8	428.6	571.4
15		45	302.8	417.2	340.6	469.4	420.5	579.5
	23	46	297.0	423.0	334.1	475.9	412.5	587.5
		47	291.2	428.8	327.6	482.4	404.5	595.5
16	24	48	285.8	434.2	321.5	488.5	396.9	603.1

Values for the 36th root of 2 and its powers and reciprocals from computer printout by Dr. John H. Chalmers, Jr.

FREQUENCIES IN HERTZ FOR 31-TONE EQUAL TEMPERAMENT

A=440 Hz

0 & 31	1	2	3	4
C	C♯ D♭♭	C♯ D♮	C♯♯ D♭	Cx D♮
16.4433	16.8150	17.1953	17.5841	17.9817
32.8865	33.6301	34.3906	35.1682	35.9638
65.7730	67.2603	68.7811	70.3363	71.9261
131.5461	134.5205	137.5622	140.6727	143.8535
263.0291	269.0410	275.1244	281.3454	287.7070
526.1842	538.0820	550.2488	562.6907	575.4140
1052.3682	1076.1643	1100.4980	1125.3818	1150.8279
2104.7364	2152.3286	2200.9961	2250.7636	2301.6558
4209.4729	4304.6572	4401.9923	4501.5273	4603.3116
8418.9458	8609.3144	8803.9846	9003.0546	9206.6232

5	6	7	8	9
D	D♯ E♭♭	D♯ E♮	D♯♯ E♭	Dx E♮
18.3882	18.8041	19.2293	19.6641	20.1087
36.7764	37.6081	38.4585	39.3281	40.2174
73.5529	75.2163	76.9170	78.6562	80.4347
147.1062	150.4325	153.8340	157.3124	160.8695
294.2125	300.8651	307.6680	314.6249	321.7390
588.4249	601.7301	615.3360	629.2497	643.4779
1176.8495	1203.4598	1230.6720	1258.4994	1286.9560
2353.6990	2406.9196	2461.3441	2516.9988	2573.9120
4707.3980	4813.8393	4922.6883	5033.9977	5147.8240
9414.7960	9627.6786	9845.3766	10067.995	10295.648

10	11	12	13	14
E	E♯ F♭	E♯ F♮	F	F♯ G♭♭
20.5634	21.0283	21.5038	21.9901	22.4873
41.1267	42.0567	43.0076	43.9801	44.9746
82.2535	84.1134	86.0153	87.9602	89.9491
164.5070	168.2267	172.0306	175.9204	179.8982
329.0140	336.4534	344.0611	351.8408	359.7965
658.0279	672.9068	688.1222	703.6816	719.5929
1316.0558	1345.8139	1376.2443	1407.3628	1439.1854
2632.1116	2691.6278	2752.4886	2814.7257	2878.3708
5264.2233	5383.2556	5504.9772	5629.4515	5756.7417
10528.446				

15	16	17	18	19
F♯ G♭	F♯ G♭	Fx G♮	G	G♯ A♭♭
22.9957	23.5157	24.0474	24.5912	25.1472
45.9915	47.0314	48.0949	49.1824	50.2945
91.9830	94.0629	96.1898	98.3647	100.5889
183.9660	188.1257	192.3795	196.7295	201.1778
367.9320	376.2515	384.7590	393.4590	402.3557
735.8639	752.5029	769.5180	786.9179	804.7113
1471.7278	1505.0059	1539.0364	1573.8360	1609.4223
2943.4556	3010.0118	3078.0728	3147.6720	3218.8446
5886.9113	6020.0236	6156.1456	6295.3440	6437.6892

A=440 Hz

FREQUENCIES IN HERTZ FOR 31-TONE EQUAL TEMPERAMENT, CONTINUED

20 G# Ah	21 G#Ab	22 Gx Ar	23 A	24 A♯ B♭♭
25.7158	26.2973	26.8919	27.5000	28.1218
51.4317	52.5946	53.7839	55.0000	56.2436
102.8634	105.1893	107.5677	110.0000	112.4873
205.7268	210.3785	215.1355	220.0000	224.9745
411.4535	420.7571	430.2710	440.0000	449.9490
822.9070	841.5141	860.5419	880.0000	899.8977
1645.8138	1683.0281	1721.0837	1760.0000	1799.7953
3291.6276	3366.0563	3442.1675	3520.0000	3599.5907
6583.2553	6732.1126	6884.3350	7040.0000	7199.1814

25 A# Bh	26 A#Bb	27 Ax Br	28 B	29 B♯ Cb
28.7577	29.4079	30.0729	30.7529	31.4483
57.5154	58.8159	60.1458	61.5058	62.8965
115.0308	117.6318	120.2916	123.0116	125.7930
230.0615	235.2636	240.5832	246.0231	251.5861
460.1230	470.5271	481.1664	492.0462	503.1721
920.2459	941.0544	962.3328	984.0926	1006.3442
1840.4918	1882.1088	1924.6656	1968.1851	2012.6884
3680.9836	3764.2176	3849.3312	3936.3702	4025.3769
7361.9672	7528.4352	7698.6624	7872.7404	8050.7538

30 B# Cr
32.1593
64.3187
128.6374
257.2748
514.5495
1029.0992
2058.1985
4116.3971
8232.7942

NOTES:

Values for the 31st root of 2, and its powers from table calculated by Ervin M. Wilson. Frequencies derived from this, checked against computer printout by John H. Chalmers, Jr.

Names of the 31 tones are those recommended by Adriaan Fokker, ultimately according to Huygens and Tartini. Other nomenclatures and staff-notations are in use, and no discrimination against them is intended or implied. It is too early to standardize such affairs.

EXAMPLES OF ALTERNATIVES: G♯ = G+ = G† = G↑

B𝄲 = B− = B𝄳 = B𝄴 = B↓ C♯♯ = C♯+ = C♯↑ E♭♭ = E𝄫 = E2♭

D𝄪 = D𝄫 = D♭↓ F𝄪 = F𝄪 = F♯♯ = F2♯ (= A𝄫 = A3♭)

Nine octaves and a major third, the compass shown in this table, is the range of the largest organs. While the highest notes are hardly ever sounded by themselves, on "mutation" stops they represent harmonics of lower pitches. Likewise, fundamentals of the lowest octave may be below the threshold of audibility, but they can still be tuned by means of their harmonic series.

A = 440 Hz

FREQUENCY TABLE, 34-&17-TONE EQUAL TEMPERAMENTS

0 & 34 C	1 C↓	2 D♭	3 C#↑	4 C#
16.186	16.519	16.859	17.207	17.561
32.372	33.038	33.719	34.413	35.122
64.743	66.077	67.437	68.826	70.244
129.486	132.153	134.875	137.653	140.488
258.972	264.306	269.750	275.305	280.976
517.945	528.612	539.499	550.611	561.951
1035.889	1057.224	1078.999	1101.222	1123.902
2071.779	2114.448	2157.997	2202.443	2247.805
4143.557	4228.897	4315.995	4404.886	4495.609
8287.115				

5 D↑	6 D	7 D↓	8 E♭	9 E♭↓
17.923	18.292	18.669	19.053	19.445
35.845	36.584	37.337	38.106	38.891
71.691	73.167	74.674	76.212	77.782
143.381	146.334	149.348	152.424	155.564
286.763	292.669	298.696	304.848	311.127
573.525	585.337	597.393	609.697	622.254
1147.050	1170.675	1194.786	1219.393	1244.508
2294.100	2341.349	2389.572	2438.787	2489.016
4588.200	4682.698	4779.143	4877.574	4978.032

10 D#	11 E↑	12 E	13 F↑	14 F
19.846	20.255	20.672	21.098	21.532
39.692	40.509	41.344	42.195	43.064
79.384	81.019	86.128	84.390	86.128
158.767	162.037	165.375	168.781	172.257
317.535	324.075	330.749	337.562	344.514
635.070	648.150	661.499	675.123	689.028
1270.140	1296.299	1322.998	1350.246	1378.056
2540.279	2592.599	2645.996	2700.492	2756.111
5080.559	5185.198	5291.991	5400.985	5512.223

15 F↓	16 G♭	17 G♭↓ F#↑	18 F#	19 G↑
21.976	22.428	22.890	23.362	23.843
43.951	44.856	45.780	46.723	47.685
87.902	89.713	91.561	93.446	95.371
175.805	179.426	183.121	186.893	190.742
351.610	358.851	366.242	373.785	381.484
703.219	717.702	732.484	747.570	762.967
1406.438	1435.405	1464.968	1495.141	1525.935
2812.876	2870.810	2929.937	2990.282	3051.870
5625.752	5741.620	5859.864	5980.563	6103.740

FREQUENCY TABLE FOR 34- & 17-TONE, continued:

20	21	22	23	24
G	G↓	A♭	A♭↓ G#↑	G#
24.334	24.835	25.346	25.869	26.401
48.668	49.670	50.693	51.737	52.803
97.335	99.340	101.386	103.474	105.605
194.670	198.679	202.772	206.948	211.210
389.341	397.359	405.543	413.896	422.421
778.681	794.719	811.087	827.792	844.841
1557.363	1589.438	1622.174	1655.584	1689.682
3114.725	3178.875	3244.348	3311.167	3379.364
6229.450	6357.750	6488.695	6622.334	6758.729

25	26	27	28	29
A↑	A	B♭↑	B♭	A#↑ B♭↓
26.945	27.500	28.066	28.644	29.234
53.890	55.000	56.133	57.289	58.469
107.780	110.000	112.266	114.578	116.938
215.560	220.000	224.531	229.156	233.875
431.121	440.000	449.062	458.311	467.750
862.241	880.000	898.124	916.622	935.501
1724.482	1760.000	1796.249	1833.244	1871.001
3448.965	3520.000	3592.498	3666.488	3742.003
6897.929	7040.000	7184.996	7332.977	7484.006

30	31	32	33
A#	B↑	B	C↑
29.837	30.451	31.078	31.718
59.673	60.902	62.156	63.437
119.346	121.804	124.313	126.873
238.692	243.608	248.625	253.746
477.384	487.216	497.251	507.492
954.768	974.433	994.502	1014.985
1909.536	1948.866	1989.004	2029.970
3819.073	3897.731	3978.008	4059.940
7638.146	7795.462	7956.005	8119.880

Based upon 17-tone equal temperament table compiled by Ervin M. Wilson. 34-tone values interpolated and compared with computer printout by John H. Chalmers, Jr.

Nomenclature for the 34-tone system has not been discussed in the accessible literature. The note-names in the 17-tone system are those resulting from the series of fifths, and because the fifths are sharp, this places C# higher than D♭. Ivor Darreg's recommendation is that the printer's obelisk or dagger ↑ be used, erect and inverted, to alter by 1/34 of an octave, up or down as the point indicates. This will alert readers and performers at once that the system in use is 34, not 31 or 36 or something else. Note-names will then be as shown in this table. ↓ might be read as "up" and ↑ as "down".

FREQUENCY TABLE FOR 18- & 36-TONE TEMPERAMENTS

Italic Numerals: 18-Tone or Third-Tone System

C	C+	C++,Db-	C#,Db	C#+
0 0	1	*1* 2	3	*2* 4
16.352	16.669	16.994	17.324	17.661
32.703	33.334	33.987	34.648	35.321
65.406	66.678	67.974	69.296	70.643
130.813	133.356	135.948	138.591	141.286
261.626	266.712	271.897	277.183	282.571
523.251	533.424	543.794	554.365	565.143
1046.502	1066.847	1807.587	1108.731	1130.286
2093.005	2133.694	2175.173	2217.461	2260.570
4186.009	4267.388	4350.347	4454.924	4521.141
8372.018	8534.776	8700.694	8869.848	9042.282

C#++,D-	D	D+	D++,Eb-	D#,Eb
5	*3* 6	7	*4* 8	9
18.004	18.354	18.711	19.075	19.445
36.008	36.708	37.422	38.149	38.891
72.016	73.416	74.843	76.298	77.782
144.032	146.832	149.687	152.597	155.563
288.065	293.665	299.374	305.194	311.127
576.129	587.330	598.748	610.388	622.254
1152.259	1174.659	1197.495	1220.776	1244.508
2304.518	2349.318	2394.990	2441.551	2489.016
4609.345	4698.636	4789.981	4883.102	4978.032
9218.070	9397.272	9579.962	9766.205	9956.063

Eb+,D#+	D#++,E-	E	E+	E++,F-
5 10	11	*6* 12	13	*7* 14
19.823	20.209	20.601	21.002	21.411
39.647	40.418	41.203	42.004	42.821
79.294	80.835	82.407	84.009	85.642
158.588	161.671	164.814	168.018	171.284
317.176	323.341	329.628	336.036	342.568
634.351	646,683	659.255	672.072	685.137
1268.702	1293.366	1318.510	1344.143	1370.274
2537.404	2586.732	2637.021	2688.286	2740.547
5074.809	5173.465	5274.040	5375.494	5481.094
10149.617	10346.927	10548.080		

F	F+	F++,F#-	F#,Gb	F#+,Gb+
15	*8* 16	17	*9* 18	19
21.827	22.251	22.684	23.124	23.574
43.654	44.502	45.367	46.249	47.148
87.307	89.004	90.735	92.499	94.297
174.614	178.009	181.469	184.997	188.594
349.228	356.017	362.939	369.994	377.187
698.456	712.035	725.877	739.989	754.375
1396.913	1424.070	1451.754	1479.978	1508.749
2793.826	2848.139	2903.509	2959.955	3017.499
5587.652	5696.279	5807.018	5919.910	6034.998

FREQUENCY-TABLE FOR 18- & 36-TONE TEMPERAMENTS, continued

C- F#++	G	G+	Ab- G++	G#, Ab
10 20	21	*11* 22	23	*12* 24
24.033	24.499	24.976	25.462	25.956
48.065	48.999	49.952	50.923	51.913
96.130	97.999	99.904	101.846	103.826
192.260	195.998	199.808	203.692	207.652
384.520	391.995	399.616	407.385	415.305
765.040	783.991	799.232	814.780	830.609
1538.081	1567.982	1598.465	1629.539	1661.219
3076.161	3135.964	3196.929	3259.078	3322.438
6152.323	6271.928	6393.857	6518.156	6644.876

Ab+ G#+	A- G#++	A	A+	Bb- A++
25	*13* 26	27	*14* 28	29
26.461	26.976	27.500	28.035	28.580
52.922	53.951	55.000	56.069	57.159
105.845	107.902	110.000	112.139	114.318
211.689	215.805	220.000	224.277	228.637
423.378	431.609	440.000	448.554	457.274
846.757	863.219	880.000	897.108	914.548
1693.514	1726.437	1760.000	1794.216	1829.096
3387.028	3452.874	3520.000	3588.432	3658.192

A#, Bb	A#+	B- A#++	B	B+
15 30	31	*16* 32	33	*17* 34
29.135	29.702	30.279	30.868	31.468
58.270	59.403	60.558	61.735	62.936
116.541	118.807	121.116	123.471	125.871
233.082	237.613	242.233	246.942	251.742
466.164	475.226	484.465	493.883	503.485
932.327	950.453	968.930	987.767	1006.969
1864.655	1900.906	1937.860	1975.533	2013.938
3729.310	3801.812	3877.526	3951.066	4027.876
7458.619	7603.622	7751.441	7902.132	8055.752

B++ C-
35
32.080
64.159
128.318
256.636
513.273
1026.546
2053.091
4106.182
8212.364

Busoni's notation ideas for these systems are given on Page 5 of this issue, while those of Hába are referred to on Page 7. Other notations have been suggested elsewhere. Names used in this table are suggested as easy to print. Julián Carrillo simply numbered the tones as done above.

Frequencies in hertz derived from computer printout by John H. Chalmers, Jr. and compared with standard 12-tone frequency-tables. Italic numerals designate degrees of the 18- or third-tone system, while erect numerals designate those of the 36- or sixth-tone system. 12-tone bears the ordinary names.

While not very much exploited by microtonalists, the 36-tone system has a usable approximation to the subminor seventh and other septimal intervals. Error for the subminor seventh is 2.16 cents or 1/556 octave.

A=440 Hz IVOR DARREG Carried to 40 Notes

FREQUENCY TABLE FOR ¼-COMMA MEANTONE TEMPERAMENT

C	Bx	C♯	B♯♯♯	D♭
32.898	33.789	34.375	35.076	35.200
65.797	67.139	68.750	70.153	70.400
131.593	134.277	137.500	140.307	140.800
263.181	268.555	275.000	280.615	281.600
526.363	537.109	550.000	561.229	563.200
1052.726	1074.219	1100.000	1122.458	1126.400
2105.451	2148.438	2200.000	2244.917	2252.800
4210.902	4296.875	4400.000	4489.834	4505.600
8421.804				

Cx	D	C♯♯	D♯	Cxx
35.918	36.781	37.532	38.431	39.218
71.836	73.563	75.064	76.863	78.436
143.675	147.123	150.127	153.730	156.868
287.349	294.246	300.254	307.459	313.737
574.699	588.492	600.507	614.919	627.473
1149.397	1176.983	1201.013	1229.837	1254.947
2298.795	2353.966	2402.026	2459.675	2509.893
4597.590	4707.932	4804.052	4919.350	5019.786

E♭	Dx	E	D♯♯	F♭
39.354	40.158	41.122	41.962	42.109
78.710	80.317	82.244	83.923	84.218
157.419	160.633	164.488	167.847	168.436
314.838	321.266	328.977	335.693	336.872
629.677	642.533	657.954	671.387	673.744
1259.353	1285.065	1315.907	1342.773	1347.489
2518.707	2570.131	2631.814	2685.547	2694.977
5037.414	5140.262	5263.628	5371.094	5389.954

E♯	Dxx	F	E x	F♯
42.969	43.846	44.000	44.898	45.976
85.938	87.692	88.000	89.797	91.952
171.875	175.384	176.000	179.593	183.904
343.750	350.768	352.000	359.187	367.807
687.500	701.537	704.000	718.373	735.614
1375.000	1403.073	1408.000	1436.747	1471.229
2750.000	2806.146	2816.000	2873.494	2942.457
5500.000	5612.292	5632.000	5746.987	5884.914

Quarter-comma meantone is the principal member of a family of temperaments which A.J. Ellis and some others call "linear"--they have an infinite series of pitches in both the sharpward and flatward directions, so this table has to stop somewhere short of infinity. By carrying it to 40 notes, the existence of close-together pairs of pitches, almost but not quite closing a circle at the thirty-first fifth of ¼-comma meantone, is revealed.

FREQUENCY TABLE FOR 1/4-COMMA MEANTONE TEMPERAMENT, *continued*

E###	Gb	Fx	G	F###
46.915	47.079	48.041	49.193	50.198
93.829	94.159	96.081	98.387	100.396
187.658	188.317	192.162	196.774	200.791
375.317	376.635	384.324	393.548	401.583
750.633	753.269	768.648	787.096	803.166
1501.266	1506.538	1537.297	1574.192	1606.332
3002.533	3013.076	3074.594	3148.384	3212.663
6005.066	6026.153	6149.187	6296.767	6425.326

G#	Fxx	Ab	Gx	A
51.403	52.452	52.636	53.711	55.000
102.805	104.904	105.273	107.422	110.000
205.610	209.808	210.545	214.844	220.000
411.221	419.617	421.090	429.688	440.000
822.442	839.233	842.180	859.375	880.000
1644.884	1678.467	1684.361	1718.750	1760.000
3289.767	3356.934	3368.722	3437.500	3520.000
6579.534	6713.867	6737.443	6875.000	7040.000

G###	A#	Gxx	Bb	Ax
56.123	57.470	58.643	58.849	60.051
112.246	114.940	117.286	117.698	120.101
224.492	229.880	234.573	235.397	240.203
448.983	459.759	469.146	470.793	480.405
897.967	919.518	938.291	941.586	960.810
1795.934	1839.036	1876.583	1883.173	1921.621
3591.867	3678.072	3753.166	3766.346	3843.242
7183.734	7356.144	7506.331	7532.691	7686.483

B	A###	Cb	B#	Axx
61.492	62.747	62.968	64.253	65.565
122.984	125.495	125.935	128.507	131.130
245.968	250.989	251.871	257.013	262.260
491.935	501.979	503.741	514.026	524.521
983.870	1003.957	1007.483	1028.052	1049.042
1967.740	2007.915	2014.966	2056.104	2098.084
3935.480	4015.830	4029.931	4112.209	4196.167
7870.960	8031.659	8059.862	8224.418	8392.334

Frequencies in hertz derived from John H. Chalmers, Jr.'s table of the meantone-to-pythagorean family of linear temperaments, and carried to 8 octaves. Note that A-quadruple-sharp, the last entry, differs from C, the 31st fifth below it, by 6.0687 cents, or 1/198 of an octave. Further information on the following page.

31-TONE EQUAL TEMPERAMENT AND ¼-COMMA MEANTONE TEMPERAMENT COMPARED.

For the past century and more, an amazing amount of misinformation and incomplete information usually misleadingly presented, has circulated in music textbooks and articles, on the subject of meantone temperament. It just has to be one of the greatest scandals in music history. Meantone temperament, in a very incomplete form, only 12 notes of it to fit the standard keyboard layout, was used on keyboard instruments for a considerable period of time before the 19th century. With the recent revival of the harpsichord and the "Baroque" design of pipe organs, and the pre-Bach keyboard literature to go with them, there also has been a revival of meantone temperament.

Unfortunately, the antiquarians and traditionalists have carefully ignored Christiaan Huygens' writings on the 31-tone equal temperament, which for all practical purposes of musical performance, is not audibly different from the ¼-comma meantone temperament. Therefore it becomes necessary to show the difference between the two systems, and how very small it is. Hence the frequency-tables for both systems in this issue, and the fretting-tables for 31-tone, so that guitars, monochords, viols, and other fretted instruments may be put in 31-tone to perform the earlier music as well as contemporary compositions, and to make demonstrations, comparisons, and calculations possible.

31-tone-equal is cyclic—there is a circle of 31 fifths, 31 major thirds, and 31 subminor sevenths. ¼-comma meantone is linear—an infinite series of fifths extends forever in both directions from the starting-note, ordinarily considered as C. On a comparison chart such as Ivor Darreg's wall-chart No. 3, certain pitches of 31 equal are represented by close-together (about 1/200 octave apart) pairs of meantone pitches. This 6-cent failure of the meantone to close a circle of fifths, happens to be similar to the 5.4-cent flatness of the fifths in meantone, so that by carrying ¼-comma meantone far enough, nearly perfect fifths could be obtained; but of course this is out of the question on practical musical instruments, although it might be an interesting computer-music stunt.

Major thirds are perfect, beatless, exact 4:5 ratio in meantone, while the major third in 31-tone is 0.7 cent sharp, causing slow beats. For example, the major third on Middle C would beat 0.91 of a time per second—say 10 times in 11 seconds. Since very few chords are sustained as long as a second in ordinary musical performances, this discrepancy is negligible in actual practice. Two musicians trying to play the same pitch, or a just major third, on anything short of a computer, are hardly ever going to hit it off that well!

The flatness of the 31-tone fifth is 0.1958 of a cent (a 6129th of an octave) less than that of the ¼-comma-meantone fifth. As if anyone cares. The meantone fifth on Middle C would beat 2.447 times a second, while the corresponding 31-tone fifth would beat "only" 2.1654 times a second, giving a difference of 0.2816. As a tuner of some 39 years' experience I can assure you that such minutiae have no practical importance.

Admittedly, a greater difference exists between the meantone and 31-tone versions of the subminor or harmonic seventh (just ratio, 4:7), which often is notated as an augmented sixth. Basing this interval on C, beats for meantone, 3.231 per second; for 31-tone, 0.7119 per second; difference, ≈2.519. Even so, this is a tempest in a teapot. However, if I didn't reveal it, hecklers might make a big fuss about the matter.

Let's look at it this way: We now live in an electronic and computer age of fantastic precision. Just intonation is now practical and attainable as never before. This means that hairsplitting quibbling over a tiny difference between two temperaments is now pointless. That is to say, objecting to the simulation of ¼-comma meantone by 31-tone equal is tantamount to demanding an accurate amount of error. What an absurdity! If, for any reason, such errors are not tolerable, why, you can have just intervals at no extra cost.