approach to pitch and time articulation than conventional tape techniques. Computers particularly, offer the possibility of programming much of the compositional content of pieces such as I have just discussed as well as generating the actual sounds. Everything that applies to the generation of computer sounds in general applies equally to the generation of particular tunings and scales. In addition, however, several other points can be noted. For example, we have some programs now that link our compositional routines to our sound synthesis. Some of them are designed to generate pitches in the ordinary [illegible] scale with the pitches being assigned integer values from 1 upwards starting with C_1. A very simple little loop does the actual frequency computation for entry into the actual conversion routine. It is the obvious one of repeated multiplication by $\sqrt[12]{2}$ until a conditional transfer is activated (actually a TIX order in SCATRE language). This $\sqrt[12]{2}$ value is on one card which can simply be replaced by another card or alternately merely overwritten if a different equal-tempered scale is desired. For example, I propose to do this in the near future in order to generate some prototypes for rehearsals to be used in preparing a quarter-tone string quartet I wrote several years ago. For this I simply need to insert the value of the $\sqrt[24]{2}$. I need [illegible] point [illegible] the way, that frequency transposition becomes [illegible] task in the computer.

[illegible] hat different line, but also important, is the accurate tracking of frequency by computer analysis. We are currently [illegible] n that will, we hope, plot frequency versus time of [illegible] line of music. This in turn can be used to evaluate [illegible], tunings and scales actually used in performance. This problem is not quite so easy as it would seem, one complication being that the fundamental of a tone is often very weak compared to its upper partials. Accordingly, it may be obscured by inharmonicities of upper partials and other noise content. Nevertheless, we feel that the problem is amenable to computer processing and hope to have something to show on this subject within a few months.

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THE ISOLATION OF THE MICROTONAL COMPOSER

I.

THE INTEREST that the American Society of University Composers has shown in microtonal music today represents a welcome break in the clouds of isolation in which the majority of microtonal composers have operated since a brief and, I suspect, muted limelight was put on their work in the 1920's.

Conventional wisdom on the subject today seems to be that "microtonalism" was an experiment of the 20's that proved a useless mutation and has found its way to the "dustbin of history." To some extent this conclusion seems outwardly to be borne out by events. The aesthetic populism of the 1930's and early 1940's which partially eclipsed the Schoenberg school, all but totally eclipsed the quarter-tone composers such as [illegible] meyer, Jörg Mager, [illegible] Panach Ramos, Marion [illegible] Mildred Cooper as well. And when a new [illegible] techniques developed in the late 40's and [illegible] school came fully into its own, [illegible] the [illegible] no comeback whatsoever. Microtonal composition has continued (it never completely stopped, even in the 30's and 40's), and some of the composers have achieved a measure of renown: Hába in Czechoslovakia, Wyschnegradsky in France, Partch in America, and an international group of composers organized around Fokker in Holland. But contact between these composers and the "mainstream avant garde" has been minimal; often non-existent.

The isolation has been taken by many to indicate that the musical community at large no longer finds anything worthy of note in the microtonal composers; while this may indeed be largely true, the reason, I would suggest, comes from a wide divergence of viewpoint as yet unresolved, rather than a finished dialectic which has discarded the microtonalists permanently as a used-up "antithesis." What was not clear in the 20's, but seems clearer now, is that most microtonal composers and theorist-advocates, however much they may disagree with each other on details, share in common an analysis of the early 20th century crisis of musical materials which is fundamentally different from what has become the "mainstream" view.

A number of microtonalists, and Joseph Yasser in particular, have seized upon an article by Schoenberg in *Modern Music*[1] which asserts that the dissonances which he and other composers used are simply the more outlying consonances of the overtone series. Many a Schoenberg disciple has refuted this view and correctly pointed out that it had little or no application to Schoenberg's own music. The harmonic series is no longer widely regarded as valid absolute basis for establishing a musical system. The newer "mainstream" conventional wisdom on this subject, as expressed by Forte, is that ". . . the tonic-dominant relationship is far from axiomatic. On the contrary, the overtone series as a natural basis for this relationship is open to question. . . . The pure overtone series as it exists in nature is unknown to modern ears. Fine adjustments have been made to conform to equal temperament."[2] The majority of microtonalists, however, have continued right up to this day to accept the harmonic series as the generator of their musical systems. They have used microtones to capture the "fernerliegenden Konzonanten" of which Schoenberg wrote.

Taken in the broadest sense, the microtonalists see the early 20th century crisis of tonality as a conflict between music based on the

[1] "Problems of Harmony." *Modern Music* XI, Nov. 1934, p. 167.

[2] Allen Forte, *Contemporary Tone Structures*. Bureau of Publications, Teachers College, Columbia University, New York, 1955, p. 11.

"natural" heirarchy of the small-number ratios and the 12-tone equal-tempered scale. Because the 12-tone scale admits within "tolerable" limits of error only the intervals of the first six numbers (the so-called "senario" of Renaissance theory), the saturation of harmonic possibilities within the senario — whose structural basis was limited to major and minor triads — produced a crisis. One of the two hypotheses had to be abandoned: either the hypothesis of a harmonic heirarchy based on the number series, or the 12-tone equal-tempered scale which unequivocally limited the applicability of this heirarchy to the first six numbers.

While "mainstream" theory and practice has opted to keep 12-tone temperament and drop the hypothesis of a harmonic heirarchy, microtonal usage makes it possible to expand organically the effective range of the numerical heirarchy and makes unnecessary, for those who accept these theoretical premises, its abandonment. The microtonalist can argue that the affective power of "tonality" is capable of infinite expansion and therefore need never be "exhausted." It is the 12-tone equal-tempered scale whose intersection with "tonality" is depressingly finite.

Because microtonality offers a "way out" for a composer with strong tonal predilections, it is quite natural that it has tended to attract tonally oriented composers whose characteristic sound-ideals seem startlingly "reactionary" and hence often "primitive" next to those of the "mainstream" composers. It is this "reactionary" outward appearance based on this fundamental theoretical divergence which has isolated most of the microtonal composers from the professional center of gravity far more than the complexity of his available tonal materials or their forbidding unfamiliarity.

In an age which respects many a composer who questions whether pitch specifications deserve a primary function among the properties of new music, the microtonalist's obsession with small pitch distinctions seems all the more irrelevant to many.

II.

If it is the ideological isolation from the musical "mainstream" which has kept the microtonal composer obscure, an even greater cause for his real difficulties is his general isolation from other microtonal composers. The field of microtonal music is factionally divided almost beyond recognition. Perhaps this is innate in its very nature. There is only one way to divide the octave into twelve equal parts; there are, however, an infinite number of ways not to do so.

First, there is the basic question of whether to subject the octave to an equal temperament. The majority of theorists and composers seem certainly to have favored equal temperaments, but the contrary opinion has been maintained at times most forcefully, especially by Partch. If, indeed, a theory of just ratios is called upon to support the abandonment of 12-tone equal temperament, Partch and others argue, why substitute one imperfect temperament for another?

However, it seems that no two advocates of "just intonation" can agree on which just intonation to use on fixed-pitch instruments. Partch's system, while demonstrably successful for himself, has yet to be taken up by other composers, perhaps because he has made the only instruments which can play music tuned his most specific way. Ben Johnston varies his own "just intonation" from work to work, which is fine as long as fixed-pitch instruments are not used. Seemingly unbridgeable are the gaps between composers whose just systems seek refinements of fifths and thirds by means of commatic alterations, such as Eivind Groven of Norway (and sometimes Johnston), and composers such as Partch, whose emphasis is on obtaining intervals of the higher partials (in Partch's case through 11).

With advocates of equal temperament, the problem is slightly [illegible]. Composers with interests as diverse as Carlton Gamer, [illegible], and myself, have found 31-tone equal temperament [illegible] for our work. However, there are many different views a[illegible] the [illegible]al number of equal tones per octave. Controversy exists between those favoring wide major thirds and those favoring small ones; between those willing to involve very small distinctions in order to gain greater accuracy with the natural consonances and those preferring simpler systems. Perhaps the greatest controversy of all is between those (so far the vast majority of microtonalists favoring temperament) who would favor temperaments closely duplicating the small-number ratios and those who favor temperaments which specifically avoid them, thereby offering a new language unfettered by involuntary allusions to the past. (Elliott Carter has verbally expressed himself as strongly in favor of the latter option.)

Perhaps most serious is the absence of a standard notational system whereby different microtonal composers could communicate in a manner easily interpreted by their peers. Despite their differences, microtonal composers usually seem to regard the works of their confreres with sympathy, but often they cannot decipher their scores.

The sympathy, despite doctrinal differences, is not surprising, for the very sensation of intervals outside of 12-tone equal temperament is a prominent fact of this music — more prominent now, perhaps, than it will seem later — and those who respond to it positively have a strong common bond. Perhaps the time has come to use this bond to break down the isolation each school of microtonal composers (including the "schools" consisting of one composer) now has from the others. An intonational lingua franca is needed with a common nomenclature and notation. To those composers who would rebel at abandoning their own personal systems, such a lingua franca could be a point of departure from which to measure their own intervals (as 12-tone temperament is today, except that a new lingua franca would be closer to most of their systems than is 12-tone temperament, and hence the departures would be smaller and the notation more precise).

As the tuning system making possible the union of the greatest number of diverse approaches, I would suggest 31-tone equal temperament. (It was not the first microtonal tuning which attracted me, and a prominent reason I have come to prefer it for some of my own work is that others were already using it.) 31-tone equal temperament provides excellent intonations for just major thirds (5:4) and for natural sevenths (7:4), thereby expanding the repertory of pure consonances beyond the traditional senario, and its one flaw, a slightly out-of-tune perfect fifth, can easily be adjusted whenever voices or instruments without fixed pitches are used.

The smallest unit in 31-tone equal temperament closely approximates the diesis (128:125) which is the difference between three just major thirds and an octave. It is therefore admirably suited to mark the difference between "G#", derived upwards from C by two major thirds (C-E-G#), and A*b*, derived downward from C by a major third.[3] It is useful to have these traditional names of tones, and even diatonic staff notation during any transitional period; the practice is no more outmoded for 31-tone music than for most recent 12-tone music — in fact, it is probably less so. Eventually, however, should 31-tone temperament or any other new temperament become widely used, a new staff system with an irregular pattern of horizontal lines unequal distances apart which repeats every octave might prove

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[3]A conventional, diatonic nomenclature follows from this relationship, with G# and Ab not an identity, but rather consecutive tones in the system. Not so conventional is the alignment that the practice of just major thirds provides — A*b* is *higher* than G#. For the remaining tones, semi-sharps (‡), sesqui-sharps (‡#), and double sharps (✕) suffice, with their enharmonic equivalents in flats. The 5 steps from C to D are:

C * C‡ = D*bb* * C[illegible] = D[illegible] C[illegible] = D*b* * C✕ = D[illegible] D more efficient. Rather similar models of such a notation were independently drawn up by A. D. Fokker in Holland and Erwin Wilson in Los Angeles.

Composers not wishing to play with the just intervals in 31-tone temperament might enjoy ways of using the primeness of the number 31. No matter what interval one cares to use, a complete cycle of 31 of them is required to return to the original tone. In 12-tone temperament the octave can be bisected or trisected. On the other hand the perfect fifth, which cannot be divided into equal parts in 12-tone temperament, can be bisected or trisected in 31-tone temperament.

Rather interesting possibilities for serial techniques in 31-tone temperament are suggested by Carlton Gamer in this same issue.

In recommending a lingua franca such as 31-tone temperament, I am aware of the objections of such composers as Partch, to whom just intonation is just intonation and 31-tone temperament has essentially the same limitations as any other equal temperament, including 12-tone. Nevertheless, in spite of the richness of Partch's own music, and the magnificent consort of instruments he has built, I know of no other composers working in his tuning system and with his instruments. On the other hand, the two instances I know of where relatively crude 31-tone tempered organs were built (one designed by Fokker in Haarlem, and the other by David Rothenberg in New York, and built by Pels and Moog respectively), a cluster of composers has quickly formed around the instruments. Needless to say, a proliferation of 31-tone instruments, especially around our universities, would be desirable.

III.

Perhaps, in their quest for unity, it would not be unwise for microtonal composers to resort to the favorite device of our profession: a publication. Ivor Darreg, an indefatigable explorer of microtonal systems, has made such a suggestion, complete with the name such a publication might bear. He proposes that the generic name for all non-12-tone tunings be "Xenharmonic" ("xen" meaning "strange"). A publication would appear four times a year and would be called *Xenharmonic Quarterly*, the initials of which would be a fine addition to the librarians' catalogues and bibliographic footnotes.

"Xenharmonic"

DEEP SCALES AND DIFFERENCE SETS IN EQUAL-TEMPERED SYSTEMS

THE 15TH CENTURY theorist and composer Ugolino of Orvieto, in his *Declaratio musicae disciplinae*, maintains that speculative music, or the study of the mathematical foundations of music, is as essential a discipline for the true musician as is composition or performance. Quoting from Aristotle's *Physics*, he describes the speculative method as follows:

> "There is an inborn path in us from those things which are more known and more certain. . . into the specifics. We are taught that in acquiring knowledge and in learning we ought to proceed from those things which are more known [to] us to those things which are less known to us, for this is the natural order of learning, so that through the cognition of the known we may come into the conception of the unknown, and thus from the facts known [to] us we may arrive at the facts of nature."[1]

[1] Seay, Albert: "Ugolino of Orvieto, Theorist and Composer," *Musica Disciplina*, Vol. IX (1955), p. 148.