equivalents in the drawings of the younger American composers Tom Johnson and William Hellermann. Johnson often uses his deft renderings of anthropomorphic musical notes to illustrate points made in his columns of music criticism in the *Village Voice*. He has collected some of these drawings in an entertaining volume of *Imaginary Music*. Hellermann, for his part, has exhibited his "eye scores" — and had them performed — in a New York gallery. Painstakingly drawn, Hellermann's "eye scores" make the surreality of the art-music meld explicit in a humorous manner. Sometimes the "eye scores" are sculptural, as in a tray of ersatz ice cubes, pieces of what seem to be musical notes embedded in them, entitled *Music Isn't Melted Architecture*. Harley Gaber, another composer exploring graphic idioms, has exhibited freely-drawn, almost abstract expressionist scores, plus silkscreened images of Schoenberg, over which Gaber jotted numerical configurations relating to the 12-tone compositional system.

An artist who has brought visual art, music, and literature together into an almost seamless *Gesamtkunstwerk* is the English Tom Phillips. Phillips, best known for the impressive range and brilliant wit of his visual work, has also participated since the late 1960s in FLUXUS-oriented musical activity in his country. References to Brahms, Schumann, and other, often rather obscure composers abound in Phillips's paintings, drawings, collages, and prints — as they do in his partly notated, partly graphic, partly conceptual scores. Phillips's *magnum opus* is an ongoing manipulation of a rather banal late 19th century novel called *A Human Document*. After Phillips's myriad graphic treatments, which serve to obscure most of the words on each page amid pools of vivid color, the text is transformed into *A Humument*, another story told in a fragmented, but ultimately logical, sequential text. Parts of *A Humument* have been further transformed — or, rather, designated — by Phillips as an "opera," called *Irma*.

A musical score that looks like a Mondrian. One-word instructions for concert pieces. A room full of clicking. Rock and country bands in art-performances. Musicians playing sculpture. An artist playing a flute through a gas mask. A fragmentary opera gleaned from the words of a sodden Victorian novel. All these things and more comprise the breadth of contemporary research into the fusion of art and music — a fusion that is as old as the century, but is constantly being rediscovered as a potent alternative to the same old formats, the same old ways of thinking.

The tendency has lately even taken on the trappings of a trend. As with any intermedium, however, the fusion of art and music is not a mere fad; although some artists may move into it and out of it as if it were just another fashion, the implications and potential of this interface are far too great to fade with the waning of a few style-chasers' interest. On all levels of thinking, from the most mechanistically technical to the most abstrusely theoretical, an intermedium lying between visual art and music just keeps blossoming with promise.

Peter Frank

[1] *The Entire Musical Work of Marcel Duchamp*, ("The Bride Stripped Bare by Her Bachelors Even, Erratum Musical," "Erratum Musical 1913," and "Musical Sculpture") performed by the S.E.M. Ensemble, (Milan: Multhipla Records n.1., 1976). "The Bride Stripped Bare by Her Bachelors Even, Erratum Musical" (with "27'10.554" for a Percussionist" by John Cage) performed by percussionist Donald Knaack, (New York: Finnadar Records SR 9017, 1977). Side one.

[2] Earle Brown, "On Form in New Music," *Darmstädter Beitrage zur Neuen Musik X.* 1966. pp. 57-69.

[3] Al Hansen. *A Primer of Happenings & Time/Space Art*, (New York: Something Else Press, Inc. 1965), pp. 93-94.

[4] Ibid.

[5] La Monte Young, *An Anthology*, La Monte Young, ed., (New York: n.p., 1963).

[6] Max Neuhaus, In conversation with Hittner, (Amy. n. p., 1973).

XENHARMONICS: EXPLORING MICROTONAL RESOURCES

This story made the rounds of Hollywood a few years ago:

"Do you like modern music?"
"Well maybe — but it won't ever take the place of the old-fashioned earache!"

Sometimes the pop bands scare people by playing so loud, and a few of the more serious avant-gardists have used painfully loud sounds on occasion. That's one way of trying to extend the musical vocabulary — go the limit in both soft and loud — but that limit is soon reached. Nothing new about that, really: Liszt was famous for breaking piano strings and hammers in public. I got myself a pair of potent earmuffs disguised as headphones, for such emergencies.

For most of the 20th Century, *atonality* has been the accepted method for musical explorers. As all the chords and patterns within the classical harmony and key-system were used up, composers sought ever more pungent dissonances, finally reaching the tone-clusters — whole fistfuls of adjacent piano-keys — of Cowell and others. With myriads of composers exploring every nook and cranny of the conventional musical field for centuries, it became more and more difficult to find something that had not been done before while still obeying the classical rules of harmony and counterpoint.

Schoenberg and his successors, concerned lest total abandonment of those rules lead to chaos and anarchy, tried to invent Systems, which would impose new kinds of form and order upon the music. Unfortunately, the structure and order imposed by such systems as 12-tone Serialism is far more evident to the *reader* of the printed score than it is to listeners of the actual sounds of performing such a score. Each interval or combination of musical tones has a smooth or rough resultant wave-pattern in the air, which we hear as consonance or dissonance or something in between, and any system that ignores the physical facts is going to be less expressive and more limited in its vocabulary.

It is easy enough to write serial 12-tone music that *looks* novel, but very difficult indeed to write some which *sounds* different enough to be worth all the trouble. For one thing, it is necessary to avoid all the patterns of conventional "tonal" music, i.e. the harmonies of the usual key-system, as much as possible. This restricts the emotional range, making some critics refer to serialism and other premeditated atonality as "music in cold blood."

One way to escape this impasse would be to go in for unpitched and indefinitely-pitched sounds: the noise-music of the Futurists and the variegated effects in musique concrète, the old and new percussions of the present day, and new electronic resources of this genre. Some effective pieces of this kind have been done lately.

But I mentioned "microtones" at the beginning, and now I referred to *twelve*-tone atonality and serialism. What's 12 got to do with it? All down through the years, people have told me: "I thought there were 8 tones in an octave — doesn't 'octave' mean 'eight'?" Then someone else will say: "Aren't there *seven* notes in the scale: do re mi fa sol la ti?" So when I try to tell them about the 12 pitch-classes in ordinary music and the 12 as 7 white and 5 black keys on the keyboard and 12 frets per octave on guitars, they get confused and seldom wait to hear me out. Even professional musicians usually believe that the 12-tone equally-tempered scale is the ONLY equal temperament there is. So much serious misinformation is taught on that subject that I despair of ever setting it right.

Nevertheless, before I can tell you anything about non-twelve-tone music I have to explain: *Why* twelve? Bluntly, because it's cheaper. Twelve pitches per octave is the least expensive and least complicated tuning-system that can furnish tolerable music on certain conventional instruments. On the organ keyboard, every interval except the octave (yes, octave does mean 8 — 8 inclusively-counted degrees on the staff or 8 successive white keys on the keyboard; and this originated as an aid to singing) is out of tune. On the piano keyboard, even the octaves themselves are slightly stretched, because of the nature of piano strings. "Tempered" might almost be respelled as "tampered with" — to make-do with only 12 pitches per octave, one must distort the ratios of the musical intervals from their ideal theoretical values.

Inevitably, these distorted intervals (the major third such as C to E, and the major sixth such as C to A on the piano are too sharp) create an overall general effect of restlessness and harshness. This is to some extent subconscious, and the piano has evolved in such a way as to conceal it partially — the tones die away; and one instinctively plays fast to help conceal it. On the organ one pulls out the tremulant stop to cover it up. Why have we put up with the 12-tone system for over two centuries? (1) Back in the old days, composers had not mined it to exhaustion — there was room then for everybody to do his or her own thing. (2) For almost 200 years, the piano has been the principal instrument, and it is not practicable to make piano actions any narrower (to squeeze more notes into an octave) than they are already — the hammers etc. would be too flimsy. Furthermore, the design of the piano had to be frozen in order to affordably manufacture them in quantity. (3) Piano and organ tuners learn a stereotyped routine that is difficult to acquire, and they would almost all refuse to learn more routines to tune other systems. (4) Manufacturers and engineers and teachers and tuners are never told why the 12-tone system is standard, and they wouldn't care anyway! What a composer might want to try, cannot prevail against such a hidebound Establishment.

Just recently, all that has changed. Electronic organs and synthesizers do not have the piano's mechanical limitations. Guitars can be fretted to other scales at nominal cost. All kinds of electronic

precision tuning devices are on the market, and better still, there are instruments with their own automatic tuning built right in, or it can be programmed in, computer-style.

You can't make your own piano at home — it was designed for mass production in factories. But you can make your own electronic organ or harpsichord or clavichord or guitar; and with the growth of the do-it-yourself and handicraft movements the BUILDING of musical instruments as well as the playing of them is returning to the individual at home, where it belongs.

Near the top of the list of innovators in recent memory stands the late Harry Partch, who against fierce and fanatical opposition persisted for years and years, developing a new musical system and building the instruments to make it possible, then painstakingly training the performers to put on theatrical spectacles. Truly, he did it the hard way; but this has made things much easier for us who come after him. He rejected all temperaments for a just or untempered tuning, and for his particular scheme of composing, chose a set of 43 unequally-spaced tones. (This has been misunderstood so often that I have to emphasize: these pitches are *un*equally spaced through each octave; they are justly-intoned, which means all their intervals have exact integer ratios. His 43-tone scale does not sound like 43-tone equal temperament; indeed it sounds more like 41-tone equal temperament, or some other equal system with a larger number of tones.)

Just intonation, or the pure or untempered scale, does not have to be laid out in Partch's individual way. There are dozens of possibly just systems. Its value is that exact-ratio intervals have a restful, calm, unruffled smoothness, creating a mood impossible in the 12-tone system. With new electronic equipment and calculations, great precision of tuning is now available to the average experimenter. I don't have to overplead the case for serene harmonies to soothe people in these agitated troubled times. To *hear* just tuning is persuasion enough.

But we human beings have a wide range of emotions to express. There are storms and yearnings and passions and searchings; there are nameless feelings hard to put in words, and there are peculiarly musical emotions also. The unruffled calm of the just scale cannot take care of everything. That is why the crusaders for untempered tuning in the last century — notably Hermann L.F. Helmholtz in his *Sensations of Tone* 101 years ago, and his English translator, Alexander John Ellis, who wrote his own book on the subject, but modestly called it an *Appendix* to Helmholtz's, didn't get very far. The Romantic Period in music was then at its height; the divorce between art and science was virtually complete, so the crusade for just intonation was cruelly misunderstood by writers on music ever since, who even to this day pour out polemics and ridicule every time the subject is brought up. I hope we can be wiser and more reasonable now.

It's also time to correct the nonsense copied slavishly from one book to another, about Bach having invented equal temperament (it was on fretted instruments long before him) and about the meantone temperament for keyboard instruments being incapable of functioning in distant keys like B major or G-flat major. Meantone temperament requires more than 12 tones per octave to play in a wide range of keys' and if for mechanical and financial reasons the additional keys were not provided, discords were heard when G-sharp was used in place of A-flat, for example. This is no longer necessary today, since we have better instruments and many new possibilities at reasonable cost.

Nor is it necessary to abolish the 12-tone system, since it has moods of its own, which are still suitable for certain kinds of music: the restlessness of 12-tone temperament is appropriate for the storm-scene in an Italian opera or for a military band marching the soldiers from point A to point B. Certain atonal compositions are properly harsh and restless. But the 12-tone mood cannot be appraised unless one has SOMETHING ELSE TO CONTRAST IT WITH! The fish is not aware of the water unless and until he gets caught.

It was my good fortune a while ago to discover that certain of the non-12-tone tuning-systems had new moods of their own. This has been hinted at in the literature, but never stated openly, because experimenting with a variety of different tunings has been impossibly expensive until just lately. So if you are wondering, Why bother with microtones and xenharmonics (strange harmony), this is the good and sufficient reason: new ways of tuning instruments add greatly to the composer's vocabulary. Also, a great deal of existing music can be played in other systems, often enhancing its value.

There was no mathematical or theoretical way to predict these moods, much less to predict that any of them would have new values. Until now, all the arguments about scales and tunings and harmony have been purely on paper, and highly prejudiced. So long as the Piano was the Only Game in Town, and all composers were commanded to be pianists, and even the violins and trombones had to pretend they had 12-tone keyboards, and voice-teachers used a piano in the vain attempt to install 12-tone frets on our vocal cords, experiment was suppressed and laughed out of court. Now we have guitars and synthesizers and electronic organs, and electronic devices to replace the trained tuner, so the only obstacle facing us is the Piano's Ghost.

In fashionable computerese jargon, hardware is not subject to software. We can program instruments and people to any tuning we like. Design is unfrozen and free once more. Moreover we can now afford it.

Getting down to cases: Ervin Wilson has built many new instruments in a variety of scales. He encouraged me and a number of other people to refrett guitars. He has developed tubular metallophones in a variety of tunings, both just and tempered, particularly for the 31-tone equal temperament. Glen Prior has even presented his 31-tone compositions in public, and they collaborated to provide me with a 17-tone metallophone of this kind which is impressing visitors. I refretted a number of guitars to such systems as 17, 19, 22, 24, and 31 tones per octave, and have composed for them, and published an article which in turn is inducing others to refret and compose on their own.

Just intonation, as stated above, is calm and smooth and soothing. 17-tone equal temperament is brilliant to the point of harshness, with considerable clout. 19-tone temperament is aggressive and carries a great deal of zonk — it can jar people out of their 12-tone ruts almost instantly. Dr. M. Joel Mandelbaum wrote a thesis on Multiple Division of the Octave and happily produced a set of 9 Preludes for two pianos so tuned between them, which turned me on, back in the '60s. He is now composing in 31. The 22-tone system has an entirely different, somewhat more restful, mood than the 19 has. I have conducted several years of comparisons and interviews involving over 200 persons, with the result that there seem to be 'Nineteen' and 'Twenty-Two' types of personality: usually people are for one *or* the other and find it difficult to be impartial in this matter. 31 is very calm; it is also so close to the old meantone system that only under laboratory conditions is there any measurable difference. Thus 31-tone provides a needed bridge between Renaissance and Baroque keyboard music before Bach, and the present day, neatly getting around the immense amount of musical literature produced during the 19th century and then in the atonal/serial period. George Secor, with a special generalized keyboard for the Scalatron (a new kind of electronic organ that is also a polyphonic synthesizer) has composed in 31-tone as well as other systems; he has also evolved new temperaments, some of which are unequal. His keyboard is easy to learn and use despite its initial impression of complexity. Ervin Wilson has invented many keyboard designs. The Huygens-Fokker Foundation, based in the Netherlands, promotes 31-tone music and a special 31-tone organ called the Archiphone, with a different keyboard and layout. They have succeeded in having a number of contemporary composers embrace the 31 system.

Beyond the 31-tone system there are such temperaments as 34, 36, 41, 43, 50, 53, 65, 72 . . . as far as the imagination will stretch. L. E. Hanson has had a 53-tone metallophone built; the effect is very intriguing. Since keyboards may get unmanagable beyond 53, we may have to go to computers and automatic playing to explore the higher systems thoroughly.

Time for a little history. Music uses a surprising number of Ancient Greek words: tone, harmony, rhythm, melody, theme, chord, diapason, lyric, polyphony, tetrachord . . . and this is no accident.

Unfortunately some of these terms are not used with the ancient meanings, so there has been confusion. Relevant here: ENHARMONIC, which originally meant "suitable" or "fitting," i.e., "in harmony with." Then it came to mean a special configuration of the tetrachord (four strings, hence four notes in a scale) containing small intervals, approximately what is now called a quartertone. During the 19th century, an entirely different meaning was invented, "synonyms — two or more names for what is only one and the same pitch on 12-tone keyboard instruments, such as G-sharp and A-flat."

So, much as I would like to call much of the new music and instruments and tunings enharmonic, I can't; so I devised the term "xenharmonic" to refer to everything that does not sound like 12-tone equal temperament. This includes systems like 5, 7, 10, and 11 tone with larger intervals than our standard semitone — now you can't call them "microtones!" *Xenos* means "strange" in Greek; it also means "hospitable" — I hope we will become hospitable to new strange harmonies.

Caution: I mentioned the 22-tone equal temperament. This is not the same as the 22 śrutis of the Hindu scale, which are quite unequal, and based on just tuning. There is only a slight cousinly resemblance between the equal and unequal 22-tone systems.

Quartertones or 24-tone equal temperament continues a notion that goes back to the ancients, and indeed many people think that this is all that lies beyond the ordinary twelve semitones. Earlier in this century and on into the '20s, a number of composers went to the trouble and expense of acquiring quartertone pianos, or using two pianos tuned a quartertone apart: Alois Hába, Ivan Vyshnegradski, Julián Carrillo, Hans Barth, Charles Ives, and Mildred Couper. Why hasn't this set the world on fire?

The explanation lies in the tone-quality and physical constraints of the standard piano. Had the quartertone system been advocated in the clavichord and harpsichord era, the story might have come out very differently — but the piano evolved during the 19th century in just such a way as to make quartertone intervals and chords sound *worse*. The 7th and 11th harmonics upon which the brilliance and definition of the new quartertone intervals depends, were suppressed and almost eliminated from most piano tones. You can't jam twice as many keys and hammers and tones and strings into a piano's interior space. Doubling the tension on the frame would collapse it!

So what do you do? Either you pile two grand pianos one on top of the other, creating a nightmare monster (how dare you be so cruel to piano movers?), or you tune two pianos a quartertone apart and hire two pianists. In this second case you destroy the very soul of the piano, its crowning glory, which is the sympathetic resonance and reaction of all the strings through the soundingboard upon each

other. You convert a cooperative association of all those strings into two armed camps battling it out across the stage. The quartertones will sound even more like unwelcome intruders than they should. The fact that the two sets of 12 tones each are not related by any familiar intervals such as fifths or thirds is exaggerated to an intolerable extent.

So, if you would like to try quartertones, and they do have great melodic possibilities and can render the Greek enharmonic genus passably well, then do it on a harpsichord, a clavichord, violins, or a special organ or synthesizer. Forty years ago I composed in quartertones for the cello. Fretting guitars to quartertones is easy.

Since quartertones still contain the ordinary semitones, the restless mood of 12-tone remains and even increases; 24 is a divisible number like 12, which means that the patterns are too symmetrical, and cannot avoid certain clichés we already are tired of in 12-tone.

Third- and sixth-tones, as proposed by Busoni, Hába, and Carillo, share this fault. Some 18- and 36-tone compositions sound like warmed-over Debussy. (Debussy exploited the 6-tone or whole-tone system to the limit — everything in it since then is anticlimax.)The 8-tone scale within quartertones sounds much like the whole-tone scale, sharing that mood of vague dreaminess.

When systems such as 17 19 22 31 are adopted, there are new melodies, new chords, and new rules of harmony, different for each system. This automatically avoids clichés and affords variety. More and more information on non-twelve systems is being published.

Many people have tried non-12 and it works. I don't want my negative remarks about the limitations of 12-tone atonality and serialism to be taken as a blanket condemnation — this is a phase through which music necessarily *had* to go; and now great possibilities are open. Atonal music will be far more effective and worthwhile in inharmonic scales such as 13-tone or 11-tone or 23-tone temperament. Serialism can be applied to any tuning-system whatever — it is not restricted to the 12-tone keyboard.

Most music theorists have ignored the profound influence of timbre — tone-quality and overtone-proportions — upon the "rules" of harmony. Accordingly this is seldom taught composers and arrangers, even in books on orchestration! By choosing certain tone-qualities, it is possible to make any tuning-system sound excellent or horrible, at will. There has been too little control over tone-quality on conventional instruments, but this is changing. Those opposed to non-12 music can "doctor" the results by choosing this or that instrument with its timbre — so the musical world has too long been denied its rightful resources.

Musical notation and abstract purely-visual drawing have merged. There has been too much concentration on writing down all compositions, as if we could do just as well if totally deaf. Recently, counter-movement featuring improvisation and spontaneity has surfaced. The tape-recorder is another aid which can preserve the music as spontaneously performed, and then the "clinkers" can be edited, without destroying any spontaneity. If I wish to express myself visually, I am fully capable of doing so — why should I disguise it or smuggle it in as "musical notation?"

There is no law against decorating and ornamenting one's instruments, or lighting up the stage, or using visual art on album covers or having it around while the music is going on. Just that they shouldn't be yoked tightly together like a team of cat-and-zebra.

While we are about it, the restriction to 12 tones per octave, and those 12 equally-spaced, is something like Paint-By-Number. All right for beginners, perhaps, but crippling to explorers and innovators. Just as the limited palette does not exercise our vision fully, the 12-tone scale does not use our hearing efficiently. It wears ruts and grooves overly deep while ignoring wonderful resources we aren't supposed even to desire. Unaware of what they are doing, jazz and rock musicians "bend" tones or play "blue" notes to use their hearing in a better way.

In examining some of the physical-mathematical-acoustical underpinning for just intonation, we must consider the Harmonic Series — the overtones or partials (although overtones and partials can also be inharmonic, or subharmonic in rare instances). Every normal musical tone is accompanied by subsidiary vibrations of twice, thrice, four times, etc. the frequency of the first harmonic or fundamental. There may also be noise and inharmonic partials. Some tones do not have harmonics, or their components are not harmonically related: clock-chimes, bells, certain drums and plucked reeds, xylophones, gongs, etc. Some tones do not have all the harmonics: clarinets, square-wave on synthesizers, stopped flutes on pipe-organs, etc. But it is possible for recording machines, amplifiers, fuzzboxes, and other apparatus to insert normal harmonics into tones lacking them.

Thus a normal musical tone from, for example, a cello or violin, trombone or trumpet contains a set of simple tones (a dull hum — like a tuning-fork or softly-played ocarina) which are harmonically-related and ordinarily fuse mentally into a compound tone possessing a characteristic "coloring" (hence the French word *timbre*). By training the attention, one can analyze a compound tone and actually hear the individual components, or at least one or two of them. that is, according to the listener's attitude and training, the same sound can be heard as one or several entities. A sung vowel can also be heard these two ways, and in a third way as a speech-sound such as OH or AW or EE. Our hearing has developed to meet the needs of speech-recognition. Incidentally, it is also suitable for music. The combination of harmonics forms a chord, and these chords suggest harmony and scales, indirectly.

Jonathan Glasier and his collaborators in San Diego are becoming known as a new microtonal center; they build instruments, compose and improvise and teach. Recently they have been developing the concept of singing inharmonics — in such a way that the fundamental constitutes the bass to some tune, while the particular harmonic of the vocal tone that is accentuated at the moment is the melody. This is a novel approach to just intonation, using the instrument humans are "factory-equipped" with. The listeners must cooperate by training their attention in the right direction.

Normal musical tones must contain exact harmonies, but when these tones are tuned to a tempered scale, their harmonics interfere with those of other tones sounded with them, causing "beats" or "waves." Some tempered scales have good approximations to the Harmonic Series; others do not. We can change the effect of the music by choosing this or that tempered system, or not using temperament at all. In particular, the 12-tone equal temperament represents Harmonics 1 2 3 4 6 8 9 well, 5 and 10 poorly, and 7 and 11 not at all. If we want new harmonies and new chords, we are going to have to adopt systems that either are untempered or have good approximations to Harmonics 7 and 11, and possibly 13. Sometimes melody is more important than harmony, or we really need atonality — no chords, no keys, just dissonant counterpoint all prickly and porcupinish — and in that case, will deliberately pick an inharmonic scale and/or abnormal tone-qualities with inharmonic partials. The whole continuum between pure tones and random noises is available to us. Why should noncomposers be allowed to tell us what not to compose? It's not a question of revolution — abolishing anything we already have, but of adding to it. It is not a question of evolution, gradual change, because normal changes have been stymied for two centuries. Rather it's a question of making up for that much lost time. The symphony orchestra is no longer a viable outlet for today's composers. The piano belongs to the 19th century. That doesn't mean, throw them out. It means, respect them for what they are, preservers of the dead past. And go on to new instruments and new ways of using existing ones.

Ivor Darreg