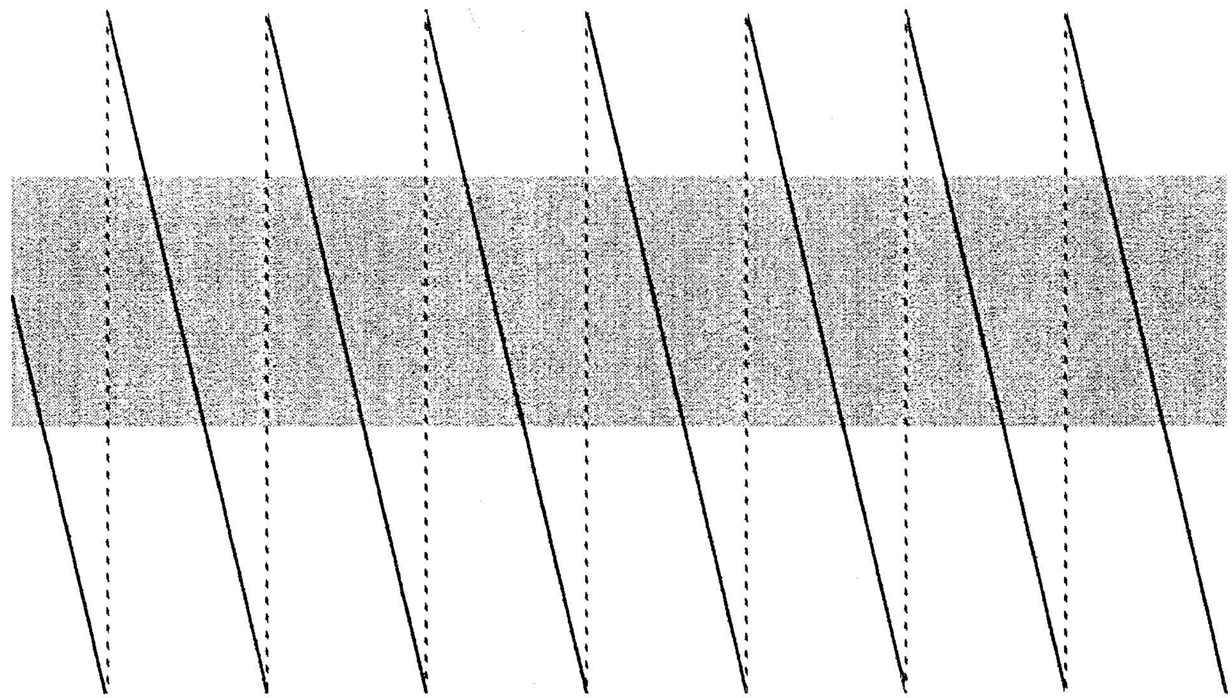
The Outer Edge of Consonance



Snapshots from the Evolution of La Monte Young's Tuning Installations

By Kyle Gann

Contrast is for people who can't write music.
La Monte Young

IF La Monte Young had not existed, it would be necessary to invent him, if only as a counterfoil to John Cage. In Cage's aesthetic, individual musical works are metaphorically excerpts from the cacophonous roar of all sounds heard or imagined. Young's archetype, equally fundamental, attempts to make audible the opposite pole: the basic tone from which all possible sounds emanate as overtones. If Cage stood for Zen, multiplicity, and becoming, Young stands for yoga, singularity, and being. Together they are the Heraclitus and Parmenides of twentieth-century music.

Since we're bringing up Greeks, let's begin with Young's inadvertent relation to a book that had a tremendous (if mostly vague) impact in the 1970s, *Formalized Music* by the Greek avant-gardist Iannis Xenakis. Many composers of my generation were inspired by the book's two philosophical chapters, those that didn't contain too much calculus for a nonmathematician. Reaching back into Byzantine chant, Xenakis drew distinctions between musical structures and categories that he called *outside-time, in-time,* and *temporal.*[1] He felt that by almost exclusively emphasizing music's forward direction in the temporal sphere European musicians had enervated music by too little attention to static, nontemporal aspects of musical architecture. "It is necessary to distinguish structures, architectures, and sound organisms from their temporal manifestations,"[2] Xenakis wrote, and later, "This degradation of the outside-time structures of music since late medieval times is perhaps the most characteristic fact about the evolution of Western European music."[3]

Formalized Music has never been on Young's reading list, but if there is a composer whose music addresses the phenomenon of outside-time structure (much more audibly, in fact, than Xenakis does), it is La Monte Young. Much of his music relinquishes forward motion altogether. His sound installations made up of sustained sine tones, tuned to perfect frequency ratios, shimmer in quasi-endless immobility. Even his most temporal works—those scored for human performers, such as *The Well-Tuned Piano* and *Chronos Kristalla*—stand ambiguously poised between forward movement and a potential auditory eternity. Just as Xenakis analyzed the structures of scales to isolate the outside-time aspects of chant, it is Young's tunings that, more than anything else, form the essences of his respective works. Morton Feldman once said, with some overstatement, that once he had chosen what instruments to use, his composing was basically finished; Young could more accurately say the same thing about his own tunings.

Young was virtually born with such concerns in his ears, for he cites as formative experiences the sound of the wind whistling through the chinks in the Idaho log cabin he was born in, and the endless electronic hum of the power plant transformers outside. As a conscious compositional program, however, the outside-time aspect of tunings appeared by stages in his music between 1958 and 1964, to be developed to unparalleled levels of complexity ever since. This article will trace Young's tuning conception from his 12-tone compositions of the fifties through his conceptualist, algorithmic, and improvisatory works to his recent sine-tone installations exploring the 1792nd through 2304th overtones. As Xenakis realized, that conception points in a direction diametrically opposite from the thrust of European music, back to a musical aesthetic ancient in its validity.

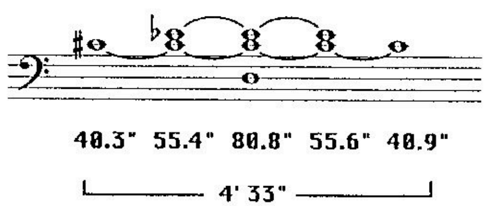
Sustained Tones in the Early Works

After periods of flirtation with the blues and Bartók in high school and college, Young began writing in the 12-tone idiom under the tutelage of Leonard Stein at U.C.L.A., who was Arnold Schoenberg's protegé. Young's first 12-tone work, *Five Small Pieces for String Quartet: On Remembering a Naiad* (1956) is classically Webernesque in the extreme brevity of its movements and its gestures seesawing between two notes a major seventh apart. (When I asked Young why the movements were all so similar, he replied, "Contrast is for people who can't write music.") *For Brass* of 1957 (a brass octet) goes even further in the direction of late Webern, consisting almost entirely of isolated notes, dyads, and chords, all based on intervals of the perfect fourth, major seventh, and their inversions. Rarely does an instrument have two notes not separated by silence, and, amid all the dotted half notes and staccato blips, there are a few notes to be held for 30 seconds—no easy feat on trumpets and trombones.

The following year, however, in his *Trio for Strings* (1958), Young pushed such tendencies to an unprecedented extreme, in a decisive step that forecast the direction of his future music. Here, the opening C♯ is to be held by the violist for approximately four minutes and 33 seconds (an homage, conscious or otherwise, to John Cage?) as other tones fade in and out. Lasting about 58 minutes, the *Trio* contains only 83 notes, few of them sustained for less than 15 seconds. In addition, the final interval (a perfect fifth in the cello) lasts for 112 seconds without change, and the piece's 29 gestures are separated by silences lasting from 8 seconds to nearly a minute. Silence takes up more than 13 minutes of the piece, a clear indication that Young was tuned into Cage's thinking.

These long, static notes, dyads, and chords mark the origin of Young's concern with sustained intervals, and their structure reveals his compositional archetypes. For example, the first gesture consists of a low D with a C♯ and E♭ a major seventh and minor ninth above it, respectively (example 1a; Young's notation is meticulously measured out in 8/8 meter, but for simplicity's sake I give only raw durations in seconds). This is a skeleton for the

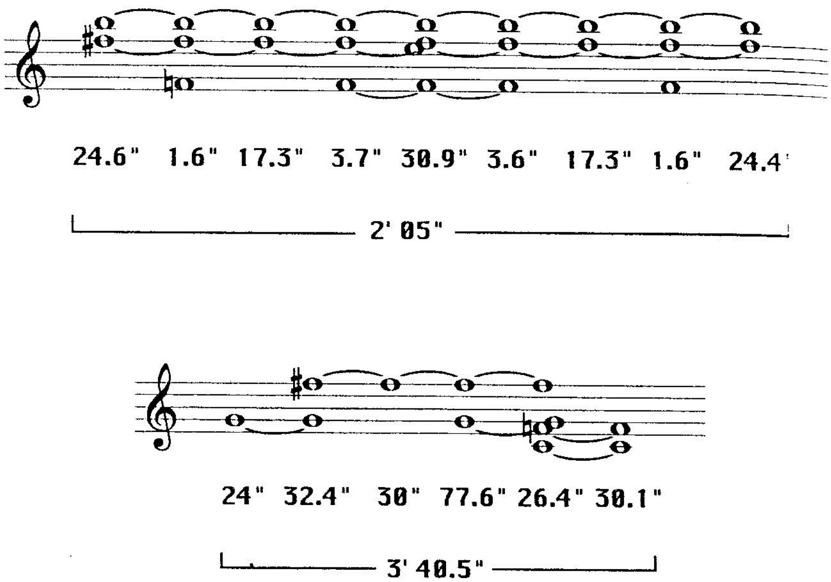
Example 1a: Trio for Strings, opening gesture



sine-tone installations of the late 1980s and 1990s, in which he experiments with overtones closely surrounding the octave over a low drone. The fact that the *Trio*'s intervals are all fourths, fifths, seconds, and sevenths, with thirds and sixths consistently excluded, will also gain relevance later. Notice the virtually symmetrical disposition of durations, entrances, and exits, found in 12 of the 29 gestures. Since our conscious experience of time moves unidirectionally forward, such symmetry is perceptually outside-time.

Equally significant, three of the gestures use a C F F♯ G pattern or its transposition, roughly corresponding to the 12th, 16th, 17th, and 18th harmonics over a fundamental F with octave displacements (examples 1b and 1c). This group of pitches, octave displacements included, will blossom into the more overtly static, less traditionally notated *Four Dreams of China*.

Examples 1b, 1c: Trio for Strings, 2nd and 11th gestures



As Young became rooted in Manhattan's nascent Downtown scene from 1960 on, he was one of a small circle of composers writing music of extremely long durations and slow tempos. The others, notably Terry Jennings and Dennis Johnson, have fallen into obscurity, and their music would be worth resuscitating. Long durations, however, were not Young's only interest. Once in New York he temporarily found himself a pioneer in the conceptualist movement associated with what would come to be called the Fluxus group. In California he had already made pieces that consisted of simple actions, verbal instructions, or even just graphic enigmas, and by the early sixties he found himself associated with a group of similarly conceptualist Downtown Manhattan artists, including George Maciunas, Jackson Mac Low, Nam June Paik, George Brecht, Dick Higgins, and Yoko Ono.

One such composition, of many written in 1960, could be considered his first sound installation, the first work that contained no forward motion and was intentionally outside-time: *Composition 1960 #7,* which consists of a B and F♯ with the direction "to be held for a long time." This simple dyad sustains two pitches whose frequencies are related by a ratio of 3:2. Although many such conceptual pieces surrounding the Fluxus movement seem dashed off quickly and unintended to be taken seriously, they often reveal an unexpected power when performed in good faith. One recent performance of *Composition 1960 #7,* by students at the University of California at San Diego, involved a large ensemble and lasted six hours.

The Theatre of Eternal Music

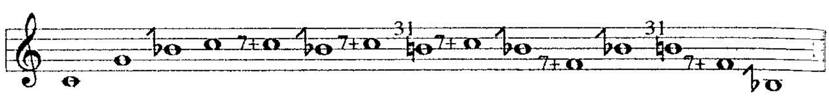
A phenomenally fluid blues saxophone player in his youth, Young developed a style of playing that flowed rapidly among a small number of pitches throughout the instrument's register: for example E♭, B♭ and D♭ in all octaves. The technique was a conscious attempt to create, with a melody instrument, the impression of a sustained chord, similar in intent if not in harmony to John Coltrane's "sheets of sound" from the same period. When Young did retain a blues idiom, as in his *Young's Dorian Blues* which he continues to play with his Forever Bad Blues Band, he would often spend as much as several minutes on one chord before proceeding to the next. Another early blues, *Early Tuesday Morning Blues,* stays on the IV7 chord for its entire duration. Even Young's blues improvisation style tends toward outside-timeness.

In 1962 he formed an ensemble that included poet and hand-drummer Angus MacLise, visual artist and singer Marian Zazeela, violinist Tony Conrad (also a filmmaker and mathematician, whom Young had earlier met in Berkeley), and later violist John Cale, Terry Jennings, and Terry Riley. By February of 1965 the group was calling itself The Theatre of Eternal Music. As they began exploring long sustained intervals, it was Conrad who pointed out to Young that the intervals of the harmonic series can be labeled and manipulated in terms of the positive integers; a purely in-tune perfect fifth, for example, is made by two tones whose frequencies have the ratio 3 to 2, and can therefore be notated as 3/2.[4] Although Young had been exposed to just intonation in an acoustics class by 1956, this revelation coming when it did opened him up to new possibilities. The Theatre of Eternal Music began exploring pure tunings.

Young's diaries for the period reveal that he notated his first work designated by frequency ratios (or harmonic numbers) on February 29, 1964. Later, after he had developed an ongoing series of pieces entitled *The Tortoise, His Dreams and Journeys,* he retroactively titled this earlier rule-based improvisation *Pre-Tortoise Dream Music,* and it was played by sopranino and soprano saxophones, vocal drone, violin, and viola. The piece is a melody with pitch ratio numbers as follows:

32 48 56 64 63 56 63 62 63 56 42 56 63 42 28[5]

Example 2: Pre-Tortoise Dream Music



Overtone number:	32	48	56	64	63	56	63	62	63	56	42	56	63	42	28
Ratio to fundamental:	1/1	3/2	7/4	2/1	63/32	7/4	63/32	31/16	63/32	7/4	21/16	7/4	63/32	21/16	7/8
Cents above fundamental:	0	702	969	1200	1173	969	1173	1145	1173	969	471	969	1173	471	-231

(Not at actual pitch)

Example 2 notates the melody in the unambiguously precise just intonation notation devised by Ben Johnston. For those unfamiliar with that notation, Johnston's system assumes that F A C, C E G, and G B D are all pure major triads, with frequency ratios of 4:5:6 in each case. A flat multiplies a frequency by 24/25, lowering it about 71.67 cents. (A cent is a measurement of perceived pitch distance, defined as 1/1200th of an octave or 1/100th of a half-step.) A sharp multiplies by 25/24, raising a pitch 71.67 cents. A 7 multiplies by 35/36, lowering a pitch 48.77 cents. A flat with a line descending from the stem is a 7 affixed to a flat, lowering by 14/15 or 119.44 cents. A plus (+) raises a pitch by the syntonic comma, 81/80, or 21.5 cents, and a minus (−) lowers by the same amount. A 31 raises by 31/30, or 56.77 cents. Johnston's notation is adequate for any just interval within 31-limit tuning and potentially higher; the symbols given here should suffice for the notation employed in this article. Note that in this article, all pitch-distance measurements in the examples will be rounded off to the nearest cent—1/1200th of an octave—for purposes of comparison. In practice, such rounding off wouldn't provide sufficient pitch resolution to obtain the ratios Young is working with.

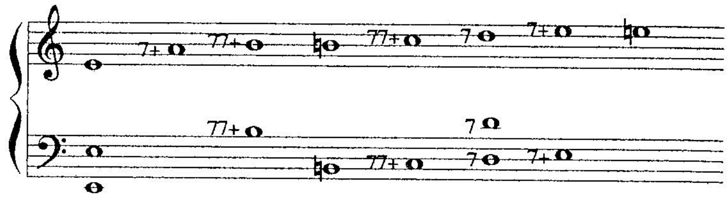
The melody of *Pre-Tortoise Dream Music* expresses a logic based in tuning, and the order of its pitches is conducive to feeling the tuning of each new note. It establishes first a tonic (32, or 2^5) and dominant (48, 3×2^4), and then the seventh harmonic (56, 7×2^3). It next establishes 63 as a 9/8 whole-step above the seventh harmonic (56:63 equals 8:9), and then the 31st harmonic (an octave higher as 62) as a lower neighbor note to the 63rd. Lastly, it introduces the 21st harmonic (42) as a perfect fourth below the seventh harmonic (56); otherwise, one would be tempted to sing the fourth as a 4/3 perfect fourth above the drone, which would be 27 cents too sharp. Young chooses 21/16 as a value for the fourth above the tonic rather than the simpler 4/3 because 21/16 is an overtone of the drone (and of the 7th harmonic), while 4/3 isn't.

On Young's recording of the piece, it is apparent that the 7th harmonic (56) is tonicized by drones through much of the middle of the performance, making the 7-based overtones (42, 56, and 63) easier to hear and perform. Over a 7 drone, 42 is a perfect fifth, 56 an octave, and 63 a 9:8 major second. Note that, except for 48 and 42, all the pitches fall in the range between 7/4 and 2/1 (969 and 1200 cents) in their respective octaves; this fact will take on significance in the late sine-tone installations. Curiously, the entire melody falls within seven-limit tuning (meaning that no primes larger than 7 are used as factors) except for the 62nd overtone, which is an octave of the prime number 31. The number 31 will also become more important in Young's later work.

Young's most important series of rule-based drone improvisations, *The Tortoise, His Dreams and Journeys,* began soon afterward. A sort of hypnotic musical analogue to the growing drug culture of the sixties, these works were whimsically titled with private references to members of the ensemble, and often accompanied by elaborate lighting designs made by Zazeela. A tuning chart exists for an improvisation recorded on August 15, 1965, entitled *The Obsidian Ocelot, The Sawmill, and The Blue Sawtooth High-Tension Line Stepdown Transformer Refracting the Legend of the Dream of The Tortoise Traversing The 189/98 Lost Ancestral Lake Region Illuminating Quotients from The Black Tiger Tapestries of The Drone of The Holy Numbers.* (The 189/98 Lost Ancestral Lake Region refers to an interval bearing those numbers, a large, 27:14 major seventh of 1137 cents which will recur prominently in *The Well-Tuned Piano.*) The group improvises on a raga-like scale made up of the harmonic numbers 21, 189, 3, 49, 7, and 63 over the fundamental, a scale elucidated in example 3.

On the recording, it is astonishing how clear these tuning relationships are, duplicating as they do the consonant septimal minor seventh (7th harmonic, 7/4) at several pitch levels. *The Obsidian*

Example 3: System of Frequencies for The Obsidian Ocelot, the Sawmill, and the Blue Sawtooth High-Tension Line Stepdown Transformer... from The Tortoise, His Dreams and Journeys (1964)



Overtone:	256 128 64	336	378 189	384 96	392 98	448 224 112	504 126	512
Ratio to fundamental:	1/1	21/16	189/128	3/2	49/32	7/4	63/32	1/1
Cents above fundamental:	0	471	675	702	738	969	1173	1200

1/1 = fundamental
21/16 = seventh harmonic above 3/2, or perfect fifth above seventh harmonic
189/128 = perfect fifth above 63/32
3/2 = perfect fifth above fundamental
49/32 = seventh harmonic of the seventh harmonic
7/4 = seventh harmonic
63/32 = 9:8 whole step above the seventh harmonic

B = 60 Hz; relative to A 440, then, actual pitch is a quarter-tone lower than notated.

Ocelot combines these overtones with audible effectiveness, and once again the seventh harmonic is emphasized in the lowest octave, creating a kind of bitonality that paradoxically makes all the harmonies clearer, since 21, 189, 49, and 63 relate more simply to 7 (as 3, 27, 7 and 9) than they do to the tonic drone. It is actually possible to hear (though not necessarily to identify, naturally) the 189th harmonic as exactly in tune in relation to the 7th, 49th, and 63rd harmonics. *The Obsidian Ocelot* is one of Young's most remarkable tapes, a testimony to the power and performability of distant consonances.[6]

Young's Tuning Theory

Once aware of the theoretical implications of the harmonic series, Young was able to more specifically identify tendencies in his earlier works and build on them. For instance, the *Trio for Strings* and other 12-tone works had relied on intervals of the fourth, fifth, second, and seventh to the complete exclusion of thirds and sixths. Thirds and sixths, Young now realized, were historically derived in European music from the fifth harmonic: the major third is 5/4, the minor third 6/5, the minor sixth 8/5, the major sixth 5/3. Young has never cared for the sound of thirds, possibly, he theorizes, because they are among the most out-of-tune intervals in equal temperament. The major third on the modern piano is 14 cents sharp, and the minor third 16 cents flat, both quite sour for ears attuned to pure intervals. However, instead of seeking to achieve true 5-based thirds, Young has largely banished them from his musical universe.[7] One goal of his tunings for nonelectronic works became to create musical languages devoid of 5-based intervals, often substituting 7-based ones (such as 9/7 for a major third, 7/6 for a minor one, 12/7 for a major sixth, and 14/9 for a minor sixth).

Although Young's innovations are artistically fascinating enough to render scientific validation superfluous, he has expended considerable energy researching and theorizing about just intonation, compiling his conclusions in an as-yet-unpublished theoretical tome, *The Two Systems of Eleven Categories 1:07:40 AM 3 X 67–ca. 6:00 PM 7 VII 75* from *Vertical Hearing, or Hearing in The Present Tense.* While it will be impossible to do justice to his theories in a few paragraphs, a brief summary may clarify the intent behind his later works. For Young, the necessity of just intonation is physiologically based, for in order to access a music-induced psychological state, or "drone-state-of-mind" as he's called it, one must have the capacity for returning to the precisely same interval or harmony. "The place theory of pitch identification," he writes,

> postulates that each time the same frequency is repeated, it is received at the same fixed place on the basilar membrane and transmitted to the same fixed region in the cerebral cortex, presumably by the same fiber or neuron of the auditory nerve. The volley theory of pitch perception assumes that a sequence of electro-chemical impulses is sent travelling along specified neurons of the auditory nerve.[8]
>
> Current psychological research and the assumptions of place theory and volley theory suggest that when a specific set of harmonically related frequencies is continuous or repeated, as is often the case in my music, it could more definitively produce (or simulate) a psychological state since the set of harmonically related frequencies will continuously trigger a specific set of the auditory neurons which, in turn,

> will continuously perform the same operation of transmitting a periodic pattern of impulses to the corresponding set of fixed locations in the cerebral cortex.[9]

Continuing, he claims that "each harmonically related interval creates its own unique feeling."[10] "By feeling," he explains, "I do not mean states such as happy, sad, amorous, or angry, but rather the set of periodic patterns that is established in our nervous system and in our system for analysis, which is the representation of the air pressure patterns that couple with the ear."[11]

Because the usual tuning of equal temperament is based on a half-step with a ratio of the 12th root of 2 to 1 (1.059463. . .:1), its ratios (the octave excepted) are all represented by nonrepeating decimals. Therefore, the amount of time it takes for the periodicity of an equal tempered interval to return to its original phase is theoretically infinite. This means that the ear can never truly measure the exactness of an equal tempered interval. More pertinently, an equal tempered interval does not stimulate a perfectly periodic impulse in the auditory nerve, because the phase relationship of the tones is never the same twice. In just intonation, however, an interval such as 7:4 repeats its phase periodicity quickly, and the ear (with some familiarity or training, at least) can judge its exactness. Furthermore, because of the exact repetition of phase relationships, the continuous firing of identical neurons will create, according to Young's research, a more intense psychological state.

> Since intervals from the system of rational numbers are the only intervals that can be repeatedly tuned *exactly,* they are the only intervals that have the potential to sound *exactly* the same on repeated hearing. It is for this reason that the feelings produced by rational intervals within a gradually expanding threshold of complexity have the potential to be recognized and remembered and, consequently, develop strong emotional impact.[12]

Thus, for Young, tuning is a physiological exploration of feelings. This view of music is slightly reminiscent of the doctrine of affections first articulated in the Baroque era and revived in various forms during the nineteenth century, according to which each melodic interval possesses inherent expressive content: e.g., a minor sixth evokes sadness, a major seventh yearning or aspiration, a perfect fifth calm and stability. In Young's case, however, the intervals are harmonic and simultaneous instead of (or in addition to) melodic and successive, and the feelings are not affects, but psychological states as subtly distinguished by color as Zazeela's blue-and-magenta light environments.

Most composers attempt to elicit feelings via the progression of harmonies or rhythmic movement in their music. From Young's point of view, such progression is only necessary because the composer is not dealing with true intervals. Moreover, as he notes, European music history has passed down only a tiny repertoire of intervals, those drawn from the prime numbers 2, 3, and 5, with the result that the interval-poor Western composer is reduced to dependency on large formal or melodic contrast. In Young's theory, a pure interval by itself can induce feeling, and to elicit new feelings, one need only expand to new interval complexes never before heard. The essential feeling component of music is therefore outside-time, and movement within a piece is only, as it were, ornamental, provided to highlight various aspects of a complex harmony. From *Pre-Tortoise Dream Music* on, the temporal aspect of Young's music fades into the background as tuning becomes the dynamic element, and his subsequent music shows that static harmony, when complexly structured by someone who knows what he's doing, can be a very dynamic element indeed.

The Four Dreams of China

While many of Young's compositions during the sixties were rule-based improvisations, developed more in rehearsal than on paper, others were dependent on a more strictly notated system of rules, or as Young calls them, algorithms. Such is the case with the series of works in the *Dreams of China* series, including *The Four Dreams of China* (1962) and *The Subsequent Dreams of China* (1980). The composition and performance of the earliest of these works predate Young's interest in just intonation. When Young, Zazeela, Conrad, MacLise, and others first performed *The Second Dream of The High-Tension Line Stepdown Transformer* (alternate title for *The Fourth Dream of China*) at George Segal's farm in New Jersey in May of 1963, it was still notated in standard notation, with no relation to the overtone series.

All of Young's works in the *Dreams of China* series are drawn from a tetrachord first introduced in the *Trio for Strings:* C, F, F♯, G. Distinctions between the different pieces lie primarily in the octave displacement of the four pitches. The sonority sustained in the *Trio,* with the F♯ an octave higher than the F and G, became

Example 4: Pitch sets for <u>The Four Dreams of China</u>

	First Dream	Second Dream	Third Dream	Fourth* Dream
Pitch ratios:	48	17	24	18
	36	9	18	17
	32	8	17	16
	17	6	16	12

*also known as <u>The Second Dream of the High-Tension Line Stepdown Transformer</u>

the *Second Dream of China* (see example 4.) When Young first assigned just tunings to the four pitches, he used 35 as the median harmonic between 8 and 9, and arranged the entire complex as octave transpositions of the 24th, 32nd, 35th, and 36th harmonics. Later, in 1984 when he created the Melodic Version of these works, he revised the tuning to use 17 between 8 and 9, with the rationale that 17 is the sum tone of 8 and 9, and therefore reinforces their sum tone for a more harmonious blend. If 8 is an octave of the fundamental and 9 is 204 cents above it, 35 lies at 155 cents and 17 at 105 cents, so the retuning involved bringing F♯ down by an almost exact quarter tone.

The Second Dream of The High-Tension Line Stepdown Transformer (The Fourth Dream of China) has been recorded on Gramavision in its "melodic version" for eight trumpets led by Ben Neill. (In the Harmonic Versions of the *Dreams of China* series, each instrument is limited to one pitch; in the Melodic Versions, each instrument has all four pitches available, though they must be ordered according to certain rules analogous to those governing simultaneous pitches.) Young has called this work "the most completely finalized and notated score in the [*Dream*] series." The rules that govern which notes may be heard in combination are given in example 5. The performers may enter with any of the four pitches and sustain for any amount of time as long as the proscribed

Example 5: Rules for The Second Dream of the High-Tension Line Stepdown Transformer

acceptable combinations:

18	18	18	18	18	18	
17	17	17				
16		16	16	16		16
12				12	12	12

unacceptable combinations:

			18
17	17	17	17
16		16	
	12	12	12

combinations and sequences do not result, a limitation that requires sensitive listening. Note that the only harmonies forbidden are those in which the 17th harmonic is the highest pitch, or in which the 12:17 tritone is not "mediated" by the 16th harmonic. At least in part, these rules have to do with avoidance of the 5th harmonic, which results as a difference tone from the sounding of the 12th and 17th harmonics.

The Well-Tuned Piano

Simultaneously with his early *Tortoise* music, Young began developing his greatest masterpiece to date, a work now six hours long, performed around the world, and still unfinished: *The Well-Tuned Piano (WTP).* Part of the genius of the *WTP* is that it is so perfectly poised between outside-timeness and temporality. Its "clouds" of rapidly rearticulated notes hold pure, complex harmonies in place with the same insistence as the *Tortoise* music and the later sine-tone installations, yet embedded in and growing from these clouds are unidirectional themes that progress, modulate, and reappear at different pitch levels with the restless meandering of a European symphony. In the *WTP* Young managed to enfold a classical sense of large-scale form into his tuning conception in seamless fusion.

Young's earliest recording of the *WTP,* a version 45 minutes long and consisting of only a few clouds separated by silences, is dated June 4, 1964. The keyboard, with its 12 pitches per octave, strong push toward octave uniformity, and heavy limitations concerning pitch deviance, presented Young with a challenge he's faced at no other point in his career. He began with the six pitches of the *Pre-Tortoise Dream Music* and added six more to fill out the chromatic scale, using the same ratios in every octave. The *WTP*'s current tuning, a seven-limit scale with E♭ as the fundamental, is given in example 6, but the original tuning had three pitches

Example 6: Tuning of The Well-Tuned Piano, with historical derivations

Ratios relative to the tonic:	1/1	567/512	9/8	147/128	21/16	1323/1024	189/128	3/2	49/32	7/4	441/256	63/32
Cents above the tonic:	0	177	204	240	471	444	675	702	738	969	942	1173
Overtone:	1024	1134	1152	1176	1344	1323	1512	1536	1568	1792	1764	2016
Pitches different in the 1964 tuning:												
Ratios:		279/256				93/64					31/16	
Cents:		149				647					1145	
Pitches of The Pre-Tortoise Dream Music:												
Ratios:	1/2				21/16			3/2		7/4	31/16	63/32

different, all based on the 31st harmonic. Originally, C♯ was 31/16, G♯ a perfect fifth higher at 93/64, and E yet another fifth higher at 279/256. In 1973 he retuned E up 28 cents to 567/512, and in 1981 he lowered C♯ and G♯ to keep the entire tuning within seven-limit. Significantly, he lists the dates of the *WTP* as "1964–1973–1981–Present," indicating how much more he thinks of its composition in terms of its tuning than in terms of the themes and harmonic areas he's added over the years.

The current tuning of the *WTP* may look forbidding, but it is as elegant in its simplicity and flexibility as the original just scale from which European music was born. Since Young has eliminated 5 as a factor in tuning, he has only 2, 3, and 7 to work with, and the 12-step scale can be simply refigured as a matrix with two axes (example 7). Read horizontally, the intervals ascend by

Example 7: Tuning grid for <u>The Well-Tuned Piano</u>

Perfect fifths (x 3/2) ⟶

↑	49/32	147/128	441/256	1323/1024	
	B	F#	C#	G#	
Minor Sevenths (x 7/4)	7/4	21/16	63/32	189/128	567/512
	C	G	D	A	E
	1/1	3/2	9/8		
	E♭	B♭	F		

3/2 perfect fifths; vertically, they ascend by 7/4 minor sevenths of 968.83 cents. (The more traditional just-intonation scale uses axes of 3/2 and 5/4.) As a result, the scale combines efficiency with variety. There are 19 possible intervals (or 38 if complements are counted separately, such as C-to-E and E-to-C), as opposed to only 6 (or 11 with complements) in an equal-tempered scale. The most consonant and widely used intervals are available at several pitch levels. The primary intervals of the *WTP* are as follows:

Ratio	Cents	Name	Number available in scale
3/2	702	Perfect fifth	9
4/3	498	Perfect fourth	9
7/4	968.8	Septimal minor seventh	7
7/6	266.9	Septimal minor third	6
9/7	435.1	Septimal major third	4
12/7	933.1	Septimal major sixth	6
14/9	764.9	Septimal minor sixth	4

The scale offers wonderful variety in the sizes of its half-steps, which range from only 27 cents (64/63) to 204 (9/8). Also, since there are three pitches closely grouped around F, two around G♯, three around B♭, two around C♯, and two around E♭, the scale has the feel of a pentatonic scale with alternate tunings available for each of the five pitches. This feature, resulting from giving harmonic criteria a higher priority than melodic ones, allows for remarkable flexibility in modulation, which just-intonation scales usually severely limit. Note that C♯ is pitched slightly *lower* than C and G♯ slightly lower than G; this is so all 3/2 perfect fifths in the tuning will appear as such on the keyboard.

One result of the *WTP*'s tuning was to interest Young in a particular segment of the overtone series. The opening notes of the *WTP* delineate an area between the 7th and 9th harmonics above the tonic. Within this 7-to-9 region the pitches D and E♭ further divide the interval into two 9/8 major seconds (C-to-D and E♭-to-F) with a diesis of 64/63 in the middle (D-to-E♭). The smallest numerical terms in which these four pitches can be expressed are 56:63:64:72. These four harmonics will recur over and over as structural boundaries in Young's late sine-tone installations, and his interest in them dates from the origins of the *WTP*.

There is no score to the *WTP* in the conventional sense, merely a large book of themes, scales, patterns, chords, and transcriptions of performed passages which Young uses as a memory aid. (Besides himself, only his protegé Michael Harrison has performed the *WTP*.) Yet the work is one of immense formal complexity, comprising in its latest versions more than 60 themes, improvisation patterns, chords, and cadences. Every entity is titled, often with Young's typically whimsical sense of classification: "The Interlude of The Wind and The Waves," "The Ancestral Böse Boogie," "The Goddess of the Caverns Under the Pool." In largest terms the music alternates between two mutually exclusive pitch areas, typified by the Opening Chord—E♭ B♭ C E♭ F B♭, with a ratio pattern of 4:6:7:8:9:12—and the Magic Chord, which will be discussed below. The Opening Chord is transposable at four pitch levels without alteration of harmonic content. Besides E♭, the notes B, F♯, G, and D appear commonly as drone pitches, emphasized as repeated bass notes, each drone providing a different series of intervals above it. Two of the themes, the Theme of the Dawn of Eternal Time and the Theme of the Lyre of Orpheus, are heard at more than one pitch level, and such transpositions partly determine the *WTP*'s modulating, forward-moving form. The *WTP* is the only work in Young's mature output to exhibit large-scale harmonic movement.

For a more detailed discussion of the *WTP*'s thematic and formal aspects, the reader is referred to my article "La Monte Young's *Well-Tuned Piano*" in the Winter 1993 issue of *Perspectives of New Music* (Volume 31, Number 1).

Chronos Kristalla

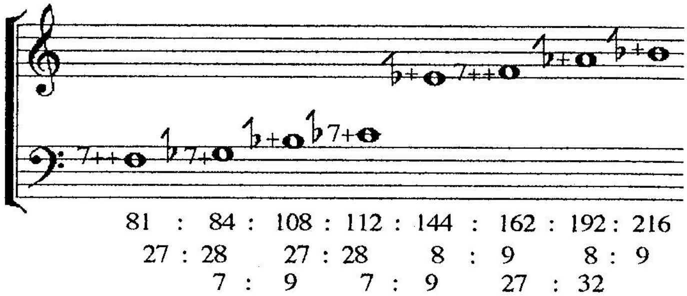
To discuss *Chronos Kristalla,* Young's 100-minute string quartet from 1990, at this point is to jump ahead chronologically, but is justified by the fact that the work is entirely drawn from the *WTP*'s Magic Chord. *Chronos Kristalla* marked Young's first return to conventional score notation since his *Death Chant* for voices and/or carillon of 1962. Though he had originally wanted to make the score algorithmically rule-based like the *Dreams of China,* Young acceded to the Kronos Quartet's request for a fixed score; an impression of rule-based improvisation, however, survives vividly in the finished piece. The eight pitches used in this quartet are transposed upward two octaves from the Magic Chord of the *WTP.*[13] The string players play entirely in harmonics, a limitation Young imposed partly because harmonics, based as they are on overtones, aid in achieving perfect just intonation intervals, but also because they approximate the purity of sine waves.

Example 8 shows the tuning of the Magic Chord in Johnston's notation both relative to E♭ as in the *WTP* and relative to C as in *Chronos Kristalla.* It also indicates which strings each harmonic is to be obtained from, and one can note that the strings are not all tuned to perfect 3:2 fifths. To obtain the low E and low F7 from the cello (an interval of 28/27), the G string must be tuned at 40/27 to the C string, notated as G− to C. In addition, the low C string of the viola must be tuned about 21 cents lower than the octave of the cello's low C for the E and B♭ to have a ratio of 81:112. (These distinctions are all theoretical; in reality the natural inharmonicity of strings enforces some eccentricity of tuning in any case.) For performance, Young has the string players tune each harmonic individually using a Rayna synthesizer as a frequency standard.

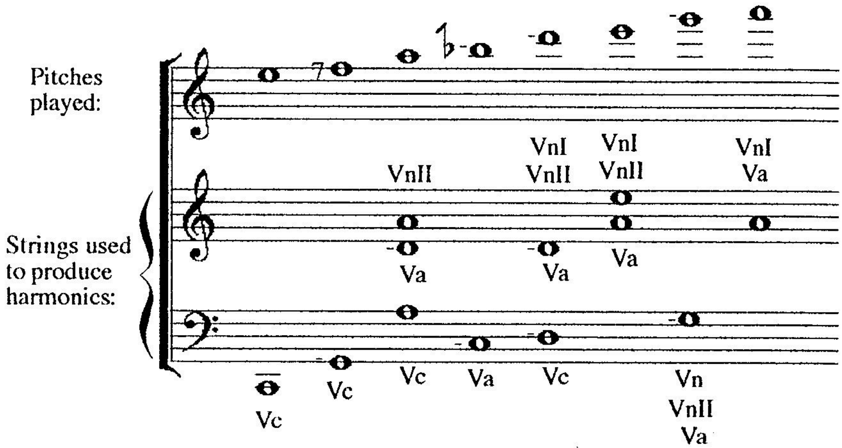
Since *Chronos Kristalla* consists of the same eight pitches throughout with no large-scale harmonic movement such as one finds in the *WTP,* it could be considered a sound installation articulated by rhythm. This is the work that reveals the essential

Example 8: The Magic Chord

As notated relative to E♭ in <u>The Well-Tuned Piano:</u>

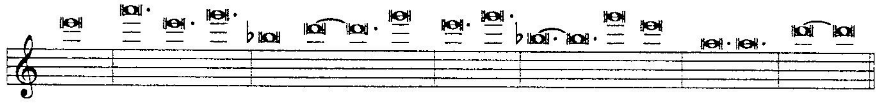


As notated relative to the cello's low C in <u>Chronos Kristalla:</u>



outside-time unity of Young's output, the point at which composition, rule-based improvisation, and sound installation merge. There is a subdued element of forward motion due to the influence of the theme (example 9). The implied resolution from B♭ in the theme's first and second phrases to A in its third runs throughout the work as a large-scale motif; for example, the only difference between two adjacent "clouds" (long sustained chords in this case) is sometimes B♭ in the first versus A in the second. There is a strong emphasis on sevenths, especially A-B♭ resolving downward to G-A. Many sections begin by moving from high E up to A or G, and end with low A and D.

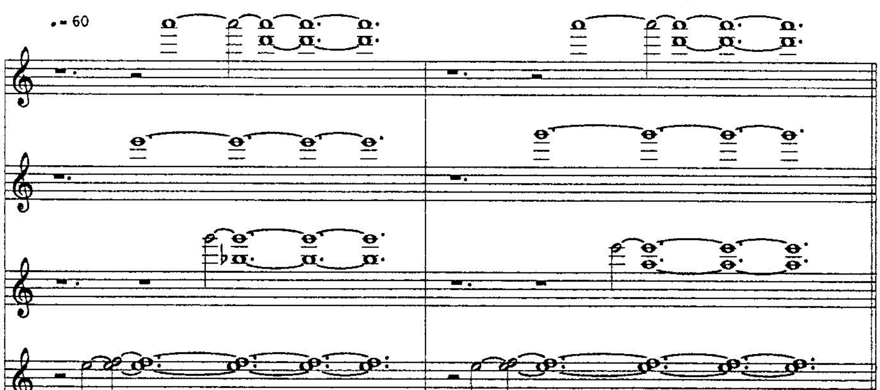
Example 9: The Theme of the Magic Chord from Chronos Kristalla



Comparison of example 9 with example 10, from the opening of the "15/2 Variation," shows how the theme influences the formation and content of clouds. The entire work, in fact, is conceived somewhat as a theme and variations, and sections are labeled with clinical reference to the theme: "The Antecedent of the Theme in its Own Two-Part Harmony with the First Half of the Consequent Unaccompanied and the Second Half of the Consequent in its Own Two-Part Harmony," or "The Subtractive Variations of the Theme Leading to the Introduction of Big Clouds," or "The Antecedent of the Theme over an F Drone Ending in Two-Part Harmony with the First Half of the Consequent in Three-Part Harmony followed by the Penultimate Note to the Cadence of Paradise in Four-Part Harmony."

While it is certainly easy to analyze *Chronos Kristalla* conventionally as variations on a theme, the harmonic movement and resolution of pitches are so consistent throughout that one could also analyze it in terms of rules governing which pitches can be heard when, very much like such unscored algorithmic works as *The Four Dreams of China*. For instance, the perfect fifth D-A is never heard in isolation, though the perfect fourth A-D is common at

Example 10: Opening of the 15/2 Variations from Chronos Kristalla



cadences. No form of a D minor triad is heard without E present. Sustained clouds never consist of only middle notes; they always contain either the high A or G or the low E or F. Low E is present throughout the "Introduction to the Pitches," then disappears for two-thirds of the work until "The Cadence of Paradise." A and B♭ are never melodically conjunct in either order, nor are they ever sounded together harmonically except in the case of the full chord. (This last rule applies only to the half-step, not the A and B♭ a major seventh apart.)

The intuitive basis of such rules is quite obvious. In this static context, Young would naturally want to avoid the tonal stability, the closure, that a sustained, undissonated D minor triad would suggest. And because it is impossible to say whether Young imposed rules on himself in composing, or whether intuition simply resulted in the appearance of having followed rules, any distinction between intuition and rule-based composition disappears (as indeed it does in so many disciplined musical contexts). It would be conceivable (and Young has considered it) to create a version of *Chronos Kristalla* that consisted of only the eight pitches and a list of rules for their combination. It would also be possible to turn the work into an unchanging sine-tone installation; in fact, Young had essentially already done so in his installation *The Magic Chord from the Well-Tuned Piano,* discussed below.

Drift Studies and Sine-Tone Installations

By 1962 Young had conceived of a Dream House in which musicians and electronic sound installations would play around the clock so that he could study the effect (if any) of long-term exposure to pure intervals on the human psyche and nervous system. In September of 1966 he and Zazeela became able to realize that dream in their Church Street loft, and began continuously playing electronic sine tones tuned to ratios from *The Tortoise, His Dreams and Journeys.* No aspect of Young's output has been more radical or more suggestive of fertile musical worlds yet to be explored than his sine-tone installations. From 1967 through the mid-seventies most of his works are assemblages of sine tones tuned to specific frequency ratios, several of them diagrammed in example 11. Just as Conlon Nancarrow's career can be summed up to an extent by the way the tempo ratios of his *Player Piano Studies* ascend through the number series (from 3:4:5 to 17:18:19:20 to the square root of 2, e, π, and 60:61), Young's resume is a series of number columns beginning with 3:2 and increasing in general complexity to matrices bristling with high primes.

Many of the first installations were called *Drift Studies* from the tendency of early oscillators to fluctuate slightly, causing the periodicities to go in and out of phase. When the phase angle of the upper sine tone was slower than that of the lower drone, Young writes, the psychological effect was that of a "relaxed, lazy summer afternoon"; when faster, the resulting feeling was one of "progress, industry, and achieving."[14] One of the simplest *Drift Studies,* dated 31 I 69 12:17:33–12:49:58 (Young's typical format for indicating the length and date of a work, with the month as a Roman numeral), appeared on a flexible plastic disc in *Aspen* magazine; it contained only two sine tones, tuned at a ratio of 31:32. A *Music and Light Box* commissioned by Betty Freeman, designed jointly by Young and Zazeela with plexiglass, ultraviolet light, and small speakers, emitted an even closer interval (27.26 cents) an octave higher in the harmonic series, 63:64.

Tuning of such installations was still motivated by theoretical attempts to avoid the number 5 and all its derivatives. The Robert C. Scull Commission of 1967, for example, contains all harmonics from 56 to 72 except for those divisible by 5 (see example 11). Young thinks of the work as containing two "small octaves" of seven notes each, one from 56 to 63, the other from 64 to 72; in filling in the structural tetrad 56:63:64:72, drawn from the *WTP,* the Scull Commission could be considered the generating work of the recent installations of 22 tones and more. Naturally, given such long exposure, Young began to take into account all kinds of secondary acoustical phenomena in structuring his installations, including sum and difference tones, the perceived tones whose frequencies equal the sums and differences of each pair of frequencies actually present. He increasingly decided to filter out 5 not only as a component of the harmonics actually used, but as a first-order difference tone, detailing at length the arithmetical conditions for acceptable sets in his theoretical work, *The Two Systems of Eleven Categories 1:07:40 AM 3 X 67–ca. 6:00 PM 7 VII 75* from *Vertical Hearing, or Hearing in The Present Tense. Drift Study 14 VII 73* (with ratios 7:16:18, recorded on a Shandar vinyl disc) is an example of an installation containing no difference tones of 5: 16 minus 7 is 9, 18 minus 7 is 11, and 18 minus 16 is 2.

Due to oscillator instability and imprecision, Young was limited during the sixties and seventies to relatively simple ratios between frequencies. But with the acquisition in 1984 of a custom-

Example 11: Tuning Ratios of Selected Sine-Tone Installations and Rule-Based Improvisation Works, 1960 - 1984

Composition 1960 #7	3 2
The Four Dreams of China (1962; as tuned before 1980) — First Dream	96 72 64 35
Second Dream	35 18 16 12
Third Dream	48 36 35 32
Fourth Dream	36 35 32 24
Pre-Tortoise Dream Music (1964)	63 62 56 48 42 32
The Obsidian Ocelot, the Sawmill,.... (1965) from The Tortoise, His Dreams and Journeys	512 504 448 392 384 378 336 256 224 189 128 126 112 98 96 64
Betty Freeman Commission (1967) (Music and Light Box)	64 63
Claes and Patty Oldenburg Commission (1967)	18 14 13 12
Robert C. Scull Commission (1967)	72 71 69 68 67 66 64 63 62 61 59 58 57 56
Drift Study 5 VIII 68 4:37:40 - 5:09:50 NYC	28 27 24 21 18
Drift Study 31 I 69 12:17:33 - 12:49:58 PM NYC (in Aspen magazine)	32 31
Drift Study 14 VII 73 9:27:27 - 10:15:33 PM NYC (Shandar recording)	18 16 7
The Four Dreams of China (as tuned after 1980) — First Dream	48 36 32 17
Second Dream	17 9 8 6
Third Dream	24 18 17 16
Fourth Dream	18 17 16 12
Opening Chord from the W.T.P. (1981)	12 9 8 7 6 4
The Magic Chord from the W.T.P. (1984) (Chronos Kristalla, 1990)	216 192 162 114 112 108 84 81
The Magic Opening Chord from the W.T.P. (1984)	1536 1512 1344 1152 1134 1024 1008 896 784 768 756 588 567 512

designed Rayna interval synthesizer, made by David Rayna and accurate to within one beat a year, Young suddenly found harmonics from the 72nd to the 2304th and higher at his disposal. Among the first installations to use the instrument were several taken from the *WTP*, including the Opening Chord, the Magic Chord, and the Magic Opening Chord; the ratios are given in example 11. Since 1986 Young has composed and implemented several sound installations consisting of upwards of 20 sine tones pitched at whole-number ratios playing continuously, optimally for months at a time (though more often switched off at night or during the week). The purity of sine tones is necessary for the kind of exact pitch relationships Young wants, since any other tones would emit secondary harmonics whose complexity would interfere with the specificity of the results. As he puts it with what might be considered dry understatement, "not only is it unlikely that anyone has ever worked with these intervals before, it is also highly unlikely that anyone has ever heard them or perhaps even imagined the feelings they create."[15]

Throughout his creative life, Young has been fascinated by prime-numbered intervals just larger or smaller than an octave, as already evidenced in the *Trio for Strings.* Christer Hennix, the mathematician who has long advised Young on mathematical aspects of his work, pointed out that intervals just smaller than an octave include Mersenne Primes, defined by Marin Mersenne as fitting the formula 2^p-1. The prime 31, prominent in the earliest version of the *WTP,* is a Mersenne prime (2^5-1), as are 7 and 3; *Composition 1960 #7* was Young's first work to express a Mersenne Prime relationship. Young realized, however, that his interests included not only Mersenne Primes, but a larger set of intervals formed by harmonics adjacent to higher octaves of prime harmonics. Hennix called harmonics of this set Young Primes, defined by the formula $p \times 2^n-1$, where p is any prime and n is any positive integer. For example:

$3 \times 2^2 - 1 = 11$ (one less than an octave of 3)
$7 \times 2^1 - 1 = 13$ (one less than an octave of 7)
$17 \times 2^2 - 1 = 67$ (one less than an octave of 17)

In addition, Young also became interested in a still more inclusive set of primes, not only adjacent to octaves of primes, but adjacent to octaves of nonprimes. These were expressed by the formula $p \times m^n - 1$, where p is any prime, m is any positive integer not a power of 2, and n is an integer greater than 1. Hennix denotes the former class of primes as P_{yI}, and this new class as P_{yII}. Examples of P_{yII} include:

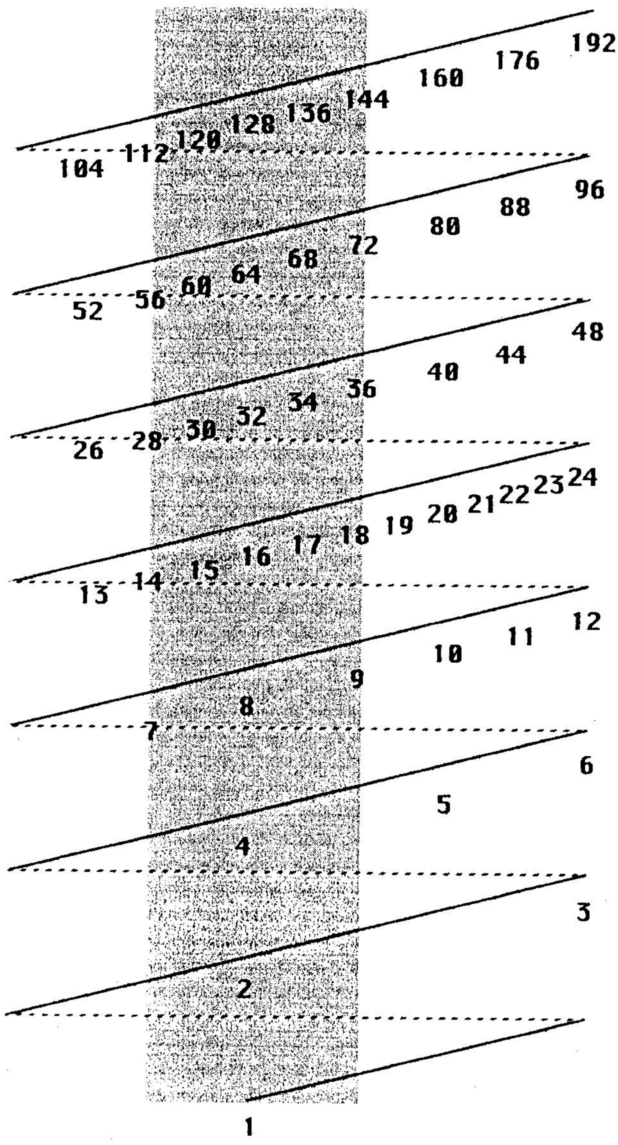
$2 \times 3^2 - 1 = 17$ (just below an octave of the 9th harmonic)
$2 \times 6^2 - 1 = 71$ (" " " " " " " ")
$3 \times 6^3 - 1 = 647$ (just below an octave of the 81st harmonic)

(Note that, like the formula for Mersenne Primes, these formulas do not *generate* prime numbers, for many numbers that fit the definitions are not prime. Rather, the primes that *can* be expressed by the formulas constitute a class Young is interested in. One might note that Young also evinces a strong interest in *non-prime* harmonics expressible by these formulas, which he calls Young Integers, such as 9 and 63.) As esoteric as these definitions may look, their intent is rather simple: they describe harmonics that adjacently *approximate* prominent harmonics (that is, harmonics heavily reinforced by consonance with other harmonics in the harmonic series). The thrust of Young's theory is a large-scale conceptual extension of the Webernesque major sevenths and minor ninths he used in his early 12-tone music.

One further type of prime that has come to interest Young he calls Twin Primes: pairs of primes separated by two, such as 29 and 31, 59 and 61, 137 and 139. For one thing, groups of these primes all have in common a difference tone of 2, thus reinforcing the octave of the fundamental. Note that while Young has expressed particular interest in Young and twin primes, and uses them as guides for his conceptualization, he does not limit himself to these primes. In the analyses below we will find him using all primes that fit whatever self-imposed definitions he's using at the moment.

Young's sound installations since 1989 are characterized by the confluence of two passions, that for Young Primes and twin primes, and that for the region between the 7th and 9th harmonics in the harmonic series. To grasp the artistic intent of these recent works, one should imagine the harmonic series as a spiral traversing the same continuum of pitches (or, technically, pitch-classes) over and over again but rising an octave with each cycle (see example 12). Circling the fourth octave, one finds harmonics 7 and 9; 7 is approximately 231 cents below the octave, 9 is 204 cents above it. In the next octave, this same pitch area is bounded by harmonics 14 and 18, and contains the 15th, 16th, and 17th harmonics. In the next octave it is defined by harmonics 28 through 36, and so on. This is the same region prominent in the

Example 12: 7-to-9 Region in the harmonic spiral (shaded)



WTP, expressed by harmonics 56 and 72 and divided by two 9:8 major seconds—56:63 and 64:72—separated by a tiny 63:64 interval of only 27 cents. Young has exhaustively developed this area of the harmonic series in his recent sine-tone installations.

Before proceeding with analysis of these installations, let's look at what prime-numbered harmonics exist in each octave of the 7-to-9 region:

7:9 region:	7									
14:18 region:	17									
28:36 region:	29	31								
56:72 region:	59	61	67	71						
112:144 region:	113	127	131	137	139					
224:288 region:	227	229	233	239	241	251	257	263	269	271
	277	281	283							
448:576 region:	449	457	461	463	467	479	487	491	499	503
	509	521	523	541	547	557	563	569	571	

These numbers are the basic materials of the recent sine-tone installations. Primes between 448 and 576 will be adequate for the analyses below, but Young has already begun working with primes two octaves higher, between 1792 and 2304.

A clear example of Young's overtone-combining procedures is *The Romantic Symmetry (over a 60 cycle base) in Prime Time from 144 to 112 with 119* (1989). It consists of 22 sine tones, whose frequencies are related by the ratios shown in example 13. The 60-cycle base referred to in the title indicates that the lowest pitch, the 8th harmonic, is 60 cycles per second, a quarter-tone-flat B. The installation's fundamental frequency, then, is 60 divided by 8, or 7.5, the number that can be multiplied by all of the frequency ratios to obtain the work's exact frequencies. Notice that every pitch is either between 969 and 1200 cents above the fundamental (above the 7th harmonic), or between 0 and 204 cents (below the 9th harmonic; in other words, there are no pitches between 205 and 968 cents). The disposition of pitches according to octave and distance above the fundamental is diagrammed in example 14. Young rather jokingly calls this piece "Romantic" because, like so much Romantic orchestration, it contains octave doublings: the

Example 13: The Romantic Symmetry (over a 60 cycle base) in Prime Time from 144 to 112 with 119

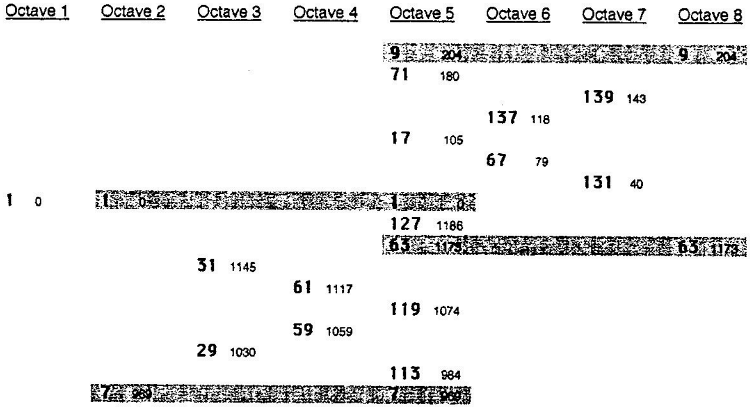
Frequency Ratio	Cents above fundamental	Description
1152	204	(9×2^7) octave of 9
1008	1173	($9 \times 7 \times 2^4$) octave of 63
556	143	(139×2^2) octave of twin prime
524	40	(131×2^4) octave of prime
274	118	(137×2) octave of twin prime
268	79	(67×2^2) octave of prime
144	204	(9×2^4) octave of 9
142	180	(71×2) octave of Young prime (P_{yII})
136	105	(17×2^3) octave of Young prime (P_{yII})
128	0	(2^8) octave of fundamental
127	1186	Young prime (P_{yI})
126	1173	($9 \times 7 \times 2$) octave of 63
119	1074	(17×7)
113	984	prime
112	969	(7×2^4) octave of Young prime (P_{yI})
61	1117	twin and Young prime (P_{yI})
59	1059	twin prime
31	1145	twin and Young prime (P_{yI})
29	1030	twin prime
16	0	(2^5) octave of fundamental
14	969	(7×2) octave of Young prime (P_{yI})
8	0	(2^3) octave of fundamental

56th, 63rd, 64th, and 72nd harmonics (outlining the division of the 7:9 region in the *WTP*, and shaded in the diagram) are all octave-doubled.

Despite the apparent complexity of the arithmetic, the strategy for creating this work was rather simple (though arrived at, like most simple art, via a tremendous amount of sketching and theoretical thought). First, take all the prime harmonics, and octaves of lower prime harmonics, in the region 112 to 144. There are 12 of these: 113, 116 (29×2^2), 118 (59×2), 122 (61×2), 124 (31×2^2), 127, 131, 134 (67×2), 136 (17×2^3), 137, 139 and 142 (71×2). Embed these harmonics within an octave of the nexus 56:63:64:72. As shown in example 14, Young reinforces these four harmonics by octave doubling, thus suggesting the term "Romantic." Harmonic 127 then becomes the central axis of symme-

Example 14: <u>**The Romantic Symmetry (over a 60 cycle base) in Prime Time from 112 to 144 with 119**</u>

Large numbers denote harmonics in lowest-octave form; small numbers indicate cents above fundamental.
Shadings show the octave-doubled 56:63:64:72 grid that forms the basic structure.



try, because it neatly divides the region between the 63rd and 64th (126th and 128th) harmonics. In order to give as many harmonics below 127 as above, Young adds 119 (17×7) to balance 17, even though it is neither a prime nor the octave of one. (Also, as the product of two primes already within the system, its inclusion has predecessors in traditional tuning. Most importantly, perhaps, Young relates that he "liked the way it sounded.") Next, *below* 127, move all the harmonics you can (116, 118, 122, and 124) down into their lowest octaves. *Above* that harmonic, transpose the corresponding harmonics (139, 137, 134, and 131) up an octave or two to make a pattern symmetrical to the harmonics below 127, and the piece is finished.

A glance at the chart makes the symmetry apparent. Nine of the 22 pitches are clustered together in the fifth octave, within a septimal major third (7:9, 435 cents). The others are transposed into upper and lower octaves symmetrically around the fifth-octave axis. The two harmonics adjacent (in terms of cents within a single octave) to the 17th harmonic, 67 and 137, are transposed an octave higher. Those adjacent to the 119th harmonic, 59 and 61, are transposed an octave lower, and so on. The only disturbance in the arithmetical symmetry is the reinforcement of the fundamental. Note that the harmonics above the central cluster are all slightly *higher* than the octaves of the fundamental, while those below the cluster are all slightly *lower* than octaves of the fundamental. If one could visualize this configuration of overtones, it would resemble a ladder whose upper rungs are bowed slightly upward, and whose lower rungs are bowed slightly downward, with an extra thick fifth rung in the middle. The opening notes of Young's *Trio for Strings*—a D with a C♯ and E♭ sustained a major seventh and minor ninth above it—could be considered a distant prototype for this work.

Young has also, with considerable success, "arranged" the *Romantic Symmetry* for a 23-piece ensemble, the *Dream House* Theatre of Eternal Music Big Band, playing the frequencies in the lower half up to 112. As in *The Four Dreams of China,* the performers follow a set of algorithmic rules determining what combinations can sound together, with primacy given to the Young primes. The players play along with the installation. Within each timbre represented, the 14th and 31st harmonics can enter only if 16 is already present, 29 can enter only if 31 is present, 61 can enter only if 31 is sounding, and 59 can enter only if 61 is present. In addition, 14 is intended to behave as a lower neighbor note to 16, and similarly 29 to 31 and 59 to 61, a melodic logic highly reminiscent of *Pre-Tortoise Dream Music.* This version of *The Romantic Symmetry* is distinguished by the title *The Lower Map of The Eleven's Division in The Romantic Symmetry (over a 60 cycle base).*

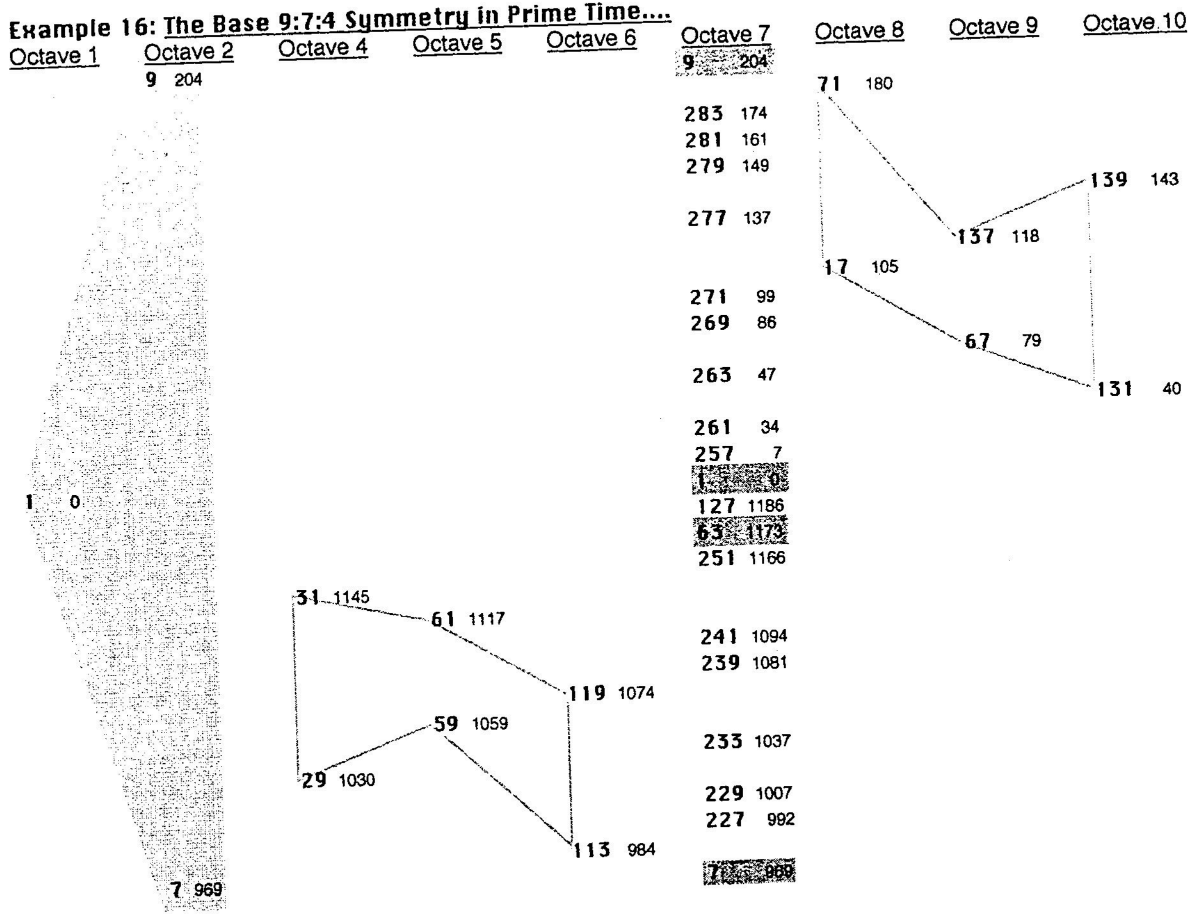
For the insightful and extremely patient, Young's latest installation to date (1991) is almost entirely explained by its catchy 107-word title, *The Base 9:7:4 Symmetry in Prime Time When Centered Above and Below The Lowest Term Primes in The Range 288 to 224 with The Addition of 279 and 261 in Which the Half of The Symmetric Division Mapped Above and Including 288 Consists of The Powers of 2 Multiplied by The Primes within The Ranges of 144 to 128, 72 to 64, and 36 to 32 Which Are Symmetrical to Those Primes in Lowest Terms in The Half of The Symmetric Division Mapped Below and Including 224 within The Ranges 126 to 112, 63 to 56, and 31.5 to 28 with The Addition of 119.* The frequency ratios that comprise the work are given in example 15.

Looking at the diagram of the installation in example 16, one can see that the layout of *The Base 9:7:4 Symmetry in Prime Time* is a development and expansion of *The Romantic Symmetry,* derived through analogous means taken an octave higher. Once again, the upper rungs of the ladder are bowed slightly upward from the fundamental, those below slightly downward. Here the central cluster is in the seventh octave above the lowest tone, and contains 20 of the 35 tones within a 9:7 septimal major third. This cluster contains all the 13 prime-numbered harmonics in the region from 224 to 288. It includes octaves of the 56:63:64:72 division. It includes an octave of the 127th harmonic, subdividing the 63:64

Example 15: The Base 9:7:4 Symmetry in Prime Time When Centered Above and Below the Lowest Term Primes in the Range 288 to 224 with the Addition of 279 and 261...

Frequency Ratio	Cents above fundamental	Description
2224	143	(139 x 2^4) octave of twin prime
2096	40	(131 x 2^4) octave of prime
1096	118	(137 x 2^3) octave of twin prime
1072	79	(67 x 2^4) octave of prime
568	180	(71 x 2^3) octave of Young prime (P_{yII})
544	105	(17 x 2^5) octave of Young Prime (P_{yII})
288	204	(9 x 2^5) octave of 9
283	174	twin and Young prime (P_{yI})
281	161	twin prime
279	149	(9 x 31)
277	136	prime
271	99	twin and Young prime (P_{yI})
269	86	twin prime
263	47	prime
261	33	(9 x 29)
257	7	prime
256	0	(2^8) octave of fundamental
254	1186	(127 x 2) octave of prime
252	1173	(9 x 7 x 2^2) octave of 63
251	1166	Young prime (P_{yII})
241	1095	Young prime (P_{yII})
239	1081	prime
233	1037	prime
229	1007	twin prime
227	992	twin prime
224	969	(7 x 2^5) octave of 7
119	1074	(17 x 7)
113	984	prime
61	1117	twin and Young prime (P_{yI})
59	1059	twin prime
31	1145	twin and Young prime (P_{yI})
29	1030	twin prime
9	204	region boundary
7	969	region boundary
4	0	(2^2) octave of fundamental

Example 16: The Base 9:7:4 Symmetry in Prime Time....



with geometric evenness (126:127:128). In addition, Young once again adds 119, and also 261 and 279, the 9th harmonics of a pair of twin primes, 29 and 31. Both are above the fundamental, so while the pitches in upper and lower octaves exhibit symmetry, the pitches within the cluster aren't as literally symmetrical as they are in *The Romantic Symmetry.*

To obtain the pitches in the remaining octaves, we look at the primes in the six regions Young mentions in his title:

above		below	
32 to 36:	no primes	28 to 31.5:	29, 31
64 to 72:	67, 71	56 to 63:	59, 61
128 to 144:	131, 137, 139	112 to 126:	113

Pitches above the cluster, then, are those within the 9:8 region over the fundamental; those below fall within the 56:63 region, which is the 9:8 interval above the 7th harmonic. Below the cluster, the five prime harmonics within these definitions are given in lowest terms (not as higher octaves). Above the cluster, the remaining harmonics are transposed upward by the number of octaves needed to create symmetry with the lower harmonics. Young has now used all the primes which fit his basic definitions. He then adds harmonic 119 (17×7), the one he had added to *The Romantic Symmetry* on an intuitive basis. To preserve his symmetry, he then has to also add an octave of the 17th harmonic (544), which has a triple advantage: it forms an 8:7 interval with 119, it geometrically subdivides the upper 9:8 (18:16) interval of the cluster, and it is the only prime harmonic within the 7-to-9 region in the lower octaves. It has every right to join the party.

Finally, Young adds a base of 9:7:4 at the bottom to reinforce the boundaries and fundamental of his harmonic regions. This is an optional move, for *The Base 9:7:4 Symmetry in Prime Time* is one of a family of sound installations called *The Symmetries in Prime Time,* differentiated from each other according to which pitches are present below 29; in one version none are included, in another only 7, in another only 8, in another 8 and 14, and so on.

Another installation from 1990, *The Prime Time Twins in The Ranges 576 to 448; 288 to 224; 144 to 112; 72 to 56; 36 to 28; with The Range Limits 576, 448, 288, 224, 144, 56, and 28,* is structured somewhat differently, and more simply derived. Within the 7-to-9 region, Young used all of the twin primes up through 576. The resulting frequency ratios are as in example 17, appearing in the harmonic spiral as in example 18. The primes here have been

Example 17: The Prime Time Twins in the Ranges 576 to 448; 288 to 224; 144 to 112; 72 to 56; 36 to 28; with the Range Limits 576, 448, 288, 224, 144, 56, and 28

Frequency Ratio	Cents above fundamental	Description
576	204	(9×2^6) octave of 9
571	189	twin prime
569	183	twin prime
523	37	twin and Young prime (P_{yI})
521	30	twin prime
463	1026	twin and Young prime (P_{yI})
461	1018	twin prime
448	969	(7×2^6) octave of 7
288	204	(9×2^5) octave of 9
283	174	twin and Young prime (P_{yI})
281	161	twin prime
271	99	twin and Young prime (P_{yI})
269	86	twin prime
241	1095	twin and Young prime (P_{yII})
239	1081	twin prime
229	1007	twin prime
227	992	twin prime
224	969	(7×2^5) octave of 7
144	204	(9×2^4) octave of 9
139	143	twin prime
137	118	twin prime
61	1117	twin and Young prime (P_{yI})
59	1059	twin prime
56	969	(7×2^3) octave of 7
31	1145	twin and Young prime (P_{yI})
29	1030	twin prime
28	969	(7×2^2) octave of 7

Example 18: The Prime Time Twins in the Ranges 576 to 448...

Octave 1		Octave 2		Octave 3		Octave 4		Octave 5	
				9	204	**9**	204	**9**	204
								571	189
								569	183
						283	174		
						281	161		
				139	143				
				137	118				
						271	99		
						269	86		
								523	37
								521	30
31	1145								
		61	1117						
						241	1095		
						239	1081		
		59	1059						
29	1030								
								463	1026
								461	1018
						229	1007		
						227	992		
7	969	**7**	969			**7**	969	**7**	969

kept in their lowest octave. Notice that only in certain octaves are the "range limits"—octaves of 7 and 9—included. Young found that a range limit improved the overall harmony only if it were sufficiently close to a pair of twin primes; he therefore decided upon a criterion to include only those octaves of 7 which had a pair of twin primes within the 9:8 above them, and only those octaves of 9 which had a pair of twin primes in the 9:8 below them. Even though, as he points out, this installation is atypical in that it doesn't articulate a 9:8 interval (nor the fundamental, although all those pairs of primes separated by 2 reinforce the second harmonic as a difference tone), 9:8 still plays a part in its structuring. Yet another installation, *The Young Prime Time Twins,* includes only those pairs of twin prime harmonics in which one is a Young Prime.

Rarely have musical works been so susceptible to complete description in physical terms. And yet, our aural vocabulary quickly shows its poverty when it comes to describing the perceptual effect of these numbers, and without perceptual distinctions, all the foregoing arithmetic has at best merely anecdotal interest, as a bizarre attempt to musically analyze columns of numbers. The only two large installations that I've had prolonged experience with under optimal conditions, *The Romantic Symmetry* and *The Base 9:7:4 Symmetry,* were quite different in their feelings and behaviors. Any reasoned analysis of the aura of these installations I could produce long after the fact would pale next to the enthusiastic description I sketched while listening to *The Base 9:7:4 Symmetry in Prime Time* and published in the *Village Voice:*

> Walk into *The Base 9:7:4 Symmetry* and you'll hear a whirlwind of pitches swirl around you. Stand still, and the tones suddenly freeze in place. Within the room, every pitch finds its own little niche where it resonates, and with all those close-but-no-cigar intervals competing in one space (not to mention their elegantly calculated sum- and difference-tones), you can alter the harmony you perceive simply by pulling on your earlobe. . . . [W]hile *Romantic Symmetry* was more "melodic" in a sense, since its overtones were more evenly spread throughout the range, *The Base 9:7:4 Symmetry* is more textural. Moving your head makes those tones leap from high to low and back, while that cluster in the seventh octave, with its wild prime ratios like 269:271, fizzes in and out. . . .
>
> Both the sound and [Marian Zazeela's] light sculptures are static entities that move wildly within your eyes and ears, proving with pure wave forms how subjective perception is.[16]

The simpler installations can also be dramatic in their effects and variations. The *Opening Chord* installation from the *WTP* is a warm and calming chord whose tones change slowly as you move; for me, the fifth harmonic was quite audible, reinforced as a difference tone of 9 minus 4 and 12 minus 7, and also in higher octaves as a sum tone of 6 and 4, 12 and 8. The *Magic Chord,* however, is far more complex and throbbing. The *Magic Opening Chord,* more complex still, is smoother because it contains its fundamental (as the *Magic Chord* doesn't). As you move it plays diatonic melodies in your head reminiscent of Terry Riley. And when the *Magic Opening Chord* is obtained by playing the *Opening Chord* at one end of a room while the *Magic Chord* is played at the other (as Young set it up for me), the feeling-changes of the stereo effect as you move back and forth are dazzling.

The shimmering, melodious effect that characterizes not only the sound installations but also the *WTP* (especially during clouds), *The Four Dreams of China,* and any other pieces in which pure tunings are allowed to accumulate at high volume is due to facts of acoustics that no earlier music (and perhaps no other composer except Alvin Lucier) has ever capitalized on. Because each pitch has a different wavelength, each is reinforced at some points in a room by bouncing back on itself in phase, and canceled out at other points in the same room where the bounce-back is 180 degrees out of phase. The pitch A at 440 cycles per second, for example, has a wavelength of 2.75 feet, and the highest C on the piano is about 2.5 inches long.[17] Thus, every point in the space has its own pattern of reinforced and canceled frequencies. The more complex the pitch structure is, and the smaller the spaces between the pitches, the less the ear has to move to find itself confronted with a very different harmony.

And yet, because all those tones are harmonics of a single fundamental, and because their sum and difference tones all support each other and create psychoacoustic effects of pitches not actually present but harmonious, the evanescent harmonies that appear and disappear so ephemerally are only diverse aspects of one harmony, illusory multiplicity within the seamless unity of the natural number series. Theoretically less dissonant than the irrational tuning of the modern piano, such chords represent the outer edge of consonance. The work of art in its physicality is outside-time, because those perfectly tuned periodicities are programmed to repeat endlessly without change. But one's experience of the piece is entirely temporal and subjective, for each listener takes a different route, has a different earlobe-shape, and thus encounters a different progression of harmonies. To return to Xenakis's metaphor of Byzantine scales and chants, it is as though Young has composed the eternal harmonious scale and each listener composes his or her own private chant simply by moving around.

It is not, however, that Young has brought to culmination or ultimate fruition any tendency in the history of music. Rather, what is so striking is what a vast tract of hitherto unexplored territory he has made the first tentative charts of. Even if the next generation develops the expressive potential of intervals like 63:64 and 71:72, Young's frontier is still five octaves further. Seen not as a counterpart to Cage but as himself the beginning of a new, open-ended tradition, Young may be not the Parmenides of new music but a modern Pythagoras, for it was Pythagoras who propounded the doctrine that the cosmos is music, and that music is number made audible. What could be more Pythagorean, more suggestive of the music of the spheres, than a La Monte Young sound installation?

Notes

1. Iannis Xenakis, *Formalized Music* (Bloomington: Indiana University Press, 1971), 183.

2. Ibid., 192.

3. Ibid., 193.

4. This article will notate just intervals within an octave scale as fractions between 1 and 2: e.g., 3/2, 63/32, 189/128. Harmonics above a fundamental will be indicated simply by whole numbers: 3, 63, 189. Ratios between frequencies will be notated with colons: 32:42:63. Those unfamiliar with tuning theory should keep in mind that any pitch (frequency) multiplied or divided by 2 remains the same pitch, only in a different octave. For example, in any given scale or overtone series 7/4, 7, 14, 28, and 56 all denote the same pitch (or, more technically, pitch-class). Moreover, any power of 2 (1, 4, 16, 128 and so on) represents the fundamental.

5. Actually, following the first statement, another 64 is to be inserted between the opening 48 and 56 for subsequent repetitions.

6. Young has never been able to make this tape, nor many others, public due to an ongoing dispute with Tony Conrad and John Cale, who claim equal status with Young as co-composers of many of the rule-based improvisations in *The Tortoise, His Dreams and Journeys*, and have threatened to sue for rights and royalties. While I have no wish to take an official position regarding legal distinctions about events that happened in a distant city when I was a boy, for the purposes of this article I treat the *Tortoise* works in accordance with Young's claim that he should be considered sole composer.

7. An exception is the 5/3 interval present in the subdominant chord of his *Young's Dorian Blues*, the music for his Forever Bad Blues Band.

8. La Monte Young, "Notes on the Continuous Periodic Composite Sound Wave Form Environment Realizations of *Map of 49's Dream The Two Systems of Eleven Sets of Galactic Intervals Ornamental Lightyears Tracery*," in La Monte Young and Marian Zazeela, *Selected Writings* (Munich: Friedrich, 1969).

9. La Monte Young, program essay, "*The Well-Tuned Piano*," 6.

10. Ibid.

11. Ibid., 5.

12. Ibid., 6.

13. Or rather, approximately two octaves. In just-intonation notation, the pitches are spelled differently when based on the low C of the cello and viola strings than when based on the E♭ of the *WTP*. The A on Young's keyboard is a 189/128 interval to 1/1 E♭, and therefore spelled B♭7+ in Johnston's notation; but it is 27/16 relative to the cello's C string, and therefore spelled A+. Since the E♭ of the *WTP* is 75 cents flat anyway, the pitch difference implied by these variances of spelling is illusory.

14. La Monte Young, program notes for 30-Year Retrospective.

15. La Monte Young, program notes to *The Prime Time Twins in The Ranges 576 to 448; 288 to 224; 144 to 112; 72 to 56; 36 to 28; with The Range Limits 576, 448, 288, 224, 144, 56, and 28*, 1.

16. Kyle Gann, "The Tingle of p × m^n-1," *Village Voice,* October 4, 1994, 84.
17. Alvin Lucier, "Seesaw: a sound installation," in *Words and Spaces,* ed. Stuart Sanders Smith and Thomas De Lio (Lanham, N.Y.: University Press of America, 1989), 221.