Experimental Musical Instrument
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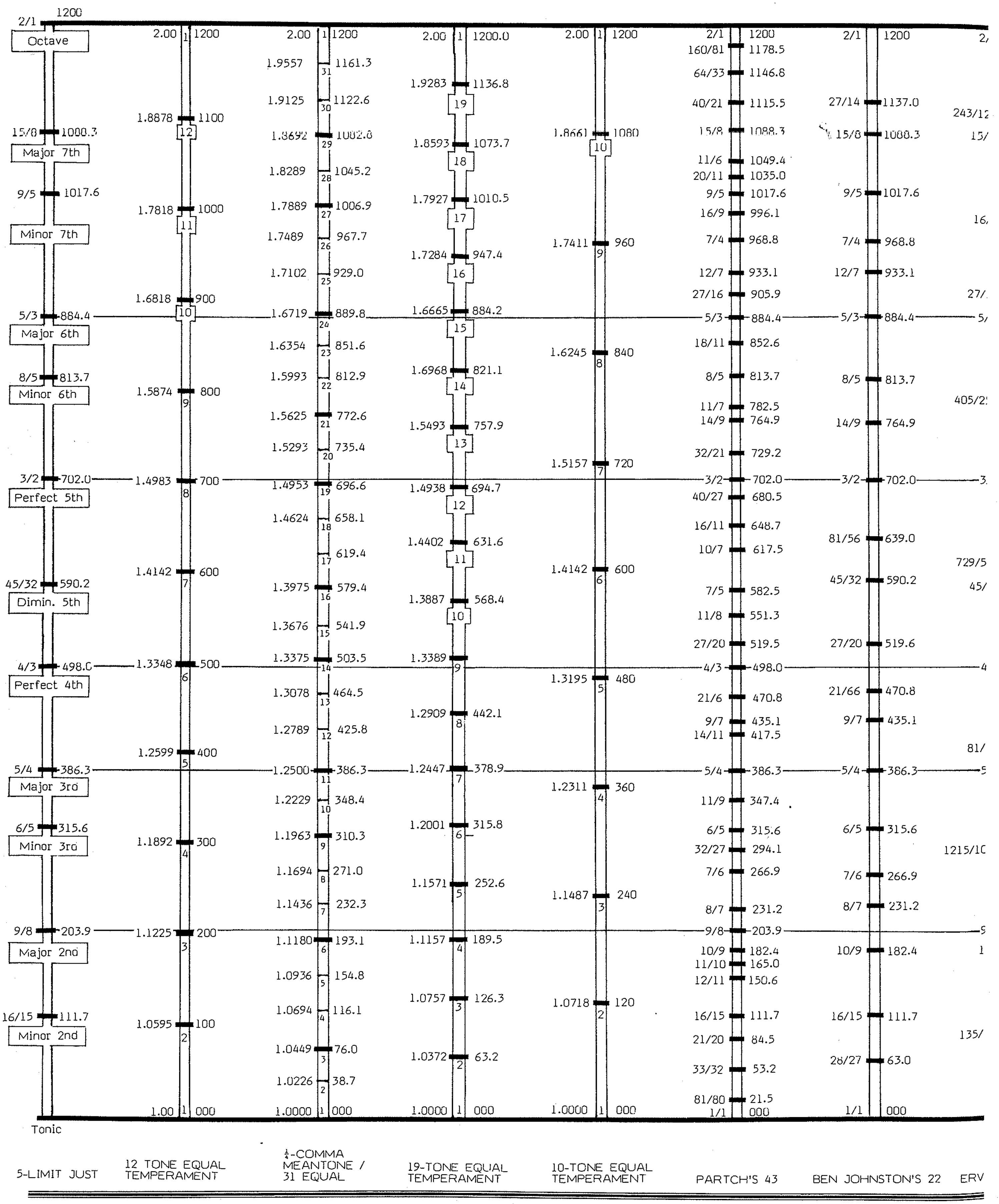
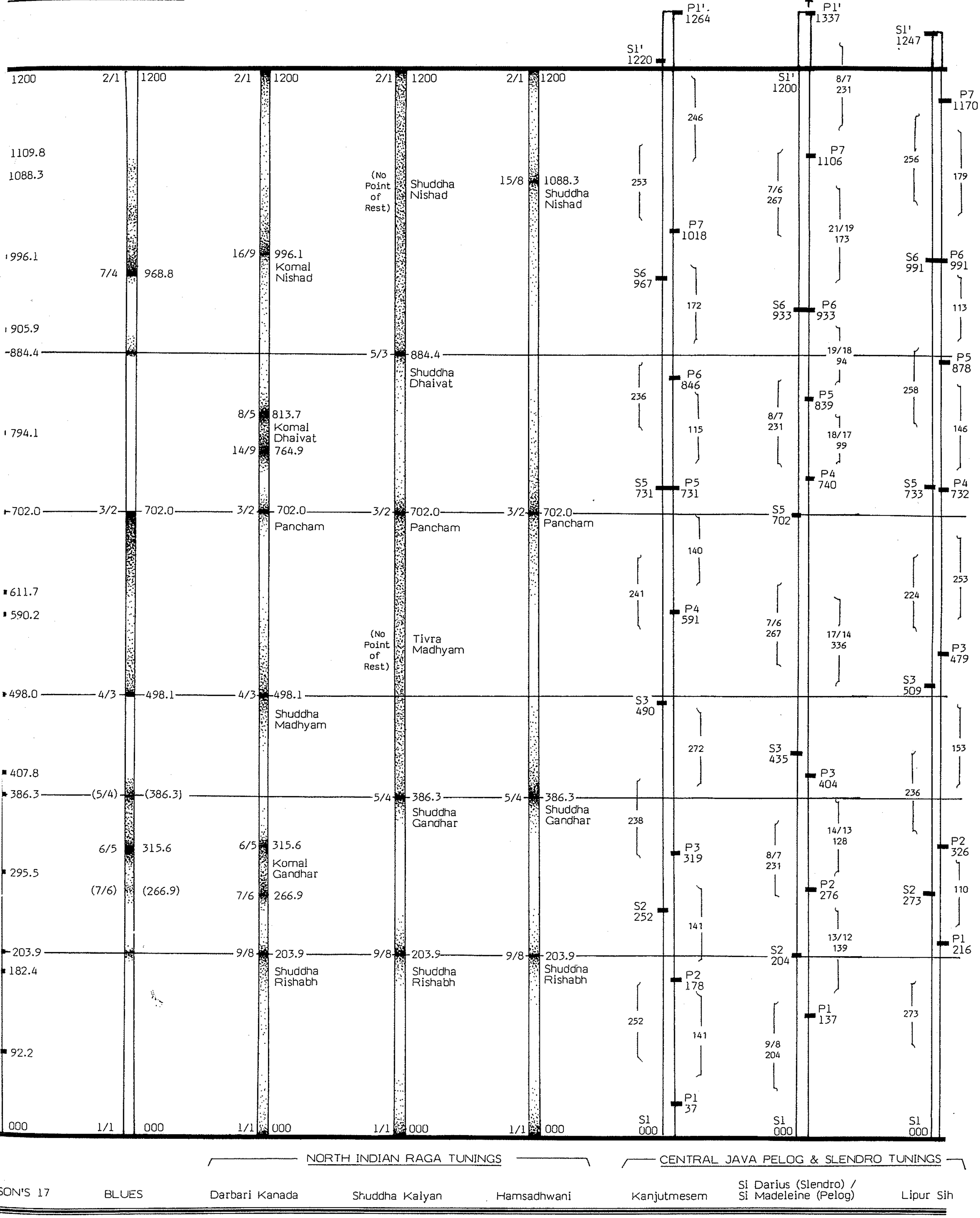


TUNINGS CHART



for the table came from two sources: Standard ratios derived from Helmholtz, and some very fine theoretical work by Dr. Jayant Kirtani. The conclusions of both Helmholtz and Kirtani were basically in agreement and validated by the computer experiment. However, a few minor points relevant to the raga required modification.

Raga (or Rag) is an aesthetic concept embodying both musical and non-musical components. For the present purposes, however, I will confine my discussion to modality, because this is the area where intonation has the greatest significance.

A raga may be composed of 5, 6 or 7 notes. These notes are derived from a 12 note scale much as western scales are derived from the 12 note chromatic scale. The augmented fourth (tiura madhyam) has been subject to considerable variation. The value of 53/37 was derived entirely theoretically by Dr. Kirtani. I have placed this value in my computer and have found it to be most acceptable.

It must be pointed out that these values do not have the same significance as they would in a western system. The reason is that these "notes" are not considered discrete building blocks for the music. In practice, the entire tonal continuum is used, and the specific pitches indicated here are simply considered convenient resting places. This totally microtonal approach to the music produces some very interesting variations in the utilization of the pitches. The concept of "notes" being mere resting points has some interesting twists to it. There appear to be three possible ways of regarding a given "note." In the simplest approach, a single pitch serves as the resting point. This approach is illustrated in the chart under Rag **Hamsadhwani.** It is also possible to have notes in the rag which do not have any resting point at all. This is demonstrated by the Shuddha Nishad (major 7th) and the Tivra Madhyam (augmented 4th) of Rag **Shuddha Kalyan.** These notes exist only in the form of an elongated slide from Sa (octave) down to the Dhavat (major 6th) and another slide from Pancham (5th) down to the Gandhar (major 3rd). Another concept is to have oscillating resting points. This is illustrated by the two values for Komal Dhaivat (minor 6th) in **Darbari Kanada.** This approach is characterized by alternating between the two values in a slow shake or vibrato.

Even the supposedly "simple" resting point turns out to be not quite so simple. As described earlier, the "resting point" concept presupposes that the pitch can "wander" around. If such a process were random we could expect to see what is referred to as a normal distribution. In reality, however, it is common to see a skew in the distribution around the stated values. The most common examples are the use of Shuddha Nishad (major 7th) and the Komal Rishabh (minor 2nd). It is a very common practice to raise the Shuddha Nishad in ascending passages and to flatten the Komal Rishabh in descending passages. Other notes may also show a skew, but these these tend to display themselves only in particular ragas.

Data for three Indian scales appear on the chart: Darbari Kanada, Shuddha Kalyan, and Hamsadhwani. Many many more ragas exist. Remember that what is presented here is only pitch information, which is only a skeleton; each raga has many other associated musical and extra-musical qualities.

Pelog & Slendro

The gamelan ensemble of Central Java often takes the form of twin instrument sets tuned to two different sets of pitches. The two tunings, called slendro and pelog, are not universally fixed, but vary, within limits, from gamelan to gamelan. Tunings from three different gamelan appear on the chart. The data was gathered by Larry Polansky, who has provided the following comments.

NOTES ON THE TUNINGS OF THREE
CENTRAL JAVANESE SLENDRO/PELOG PAIRS

by Larry Polansky

In the accompanying chart, three slendro/pelog pairs are given. The first is the measurement of the famous slendro/pelog gamelan at the Mangkunegaran Palace in Solo, Central Java, called Kanjutmesem. The second is the tuning for Lou Harrison and Bill Colvig's gamelan Si Darius/Si Madeleine, an aluminum gamelan built at Mills College. The third is my own measurement of the pelog/slendro pair of the two slenthem (a large, resonated bronze mallet instrument) in gamelan Lipur Sih, built and tuned by Tentrem Sarwanto of Semanggi, Solo, Central Java, and owned by myself and Jody Diamond.

In my notation for these tunings, I have started each pair on slendro 1 (S1), but not because this is an any way a "root," tonic, or fundamental. There is nothing to suggest that S1 is any more primary than other notes in slendro. Pitches are labelled simply as S1-S6, P1-P7, with S1' and P1' denoting a higher octave of that degree. The absolute cents intervals from S1 are written next to the pitch name, and the cents interval to adjacent pitches is written between the pitches.

I have included these three pairs of slendro/pelog because I am interested in the ways that the two gamut relate, a subject which has not received as much attention as the absolute interval widths of each individual gamut. I hope that these simple graphs will give the reader some idea of the complex system of tuning in Central Javanese "double" gamelan.

Some notes on the slendro/pelog pairs described here:

1) These tunings, including the Harrison/Colvig gamelan, represent intonational ideas from Central Javanese pelog and slendro in the court gamelan tradition. Quite different tunings will be found in villages, other ensembles (like street Siteran and so on), and other parts of Indonesia (Bali, Sunda, East Java, Cirebon, etc.).

2) Certain important aspects of Central Javanese tuning practice are not fully represented in these charts, notably: stretched octaves (generally 10-20 cents), the wide variation in interval size in different gamelan, the relationships of tuning to pathet (mode), and the variation in tuning when different tumbuk (a note that is the same in slendro and pelog) are used. Note that two out of the three gamelan described here are tumbuk 6 (meaning that slendro 6 is equal to pelog 6). Tumbuk 6, 5, and to a lesser extent, tumbuk 2, are the most common tumbuk. These ideas, and others,

deserve discussion at length, but are beyond the scope of these brief notes.

3) A common theoretical model for gamelan tunings is the Idealized ET Tuning, which presents slendro as 5-tone equal, and pelog as a subset of 9-tone equal. For tumbuk 6, the pitches in ascending sequence would be:

S1 (nominally at 0 cents), P1 (160¢),
S2 (240¢), P2 (293.3¢), S3 (480¢),
P3 (560¢), P4 (693.3¢), S5 (720¢),
P5 (826.6¢), S6/P6 (960¢), P7 (1093.3¢),
S1' (1200¢), P1' (1360¢).

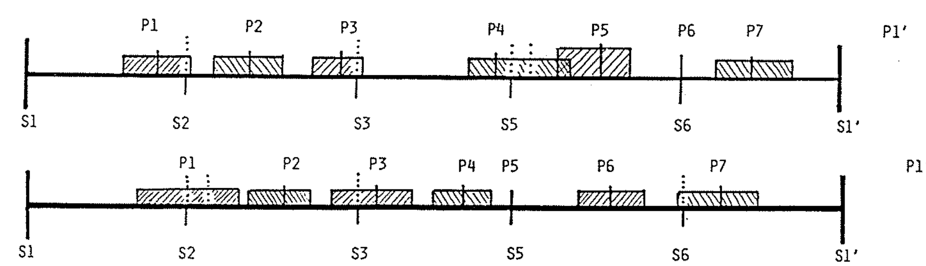
This model is useful and appears frequently in the writings of both western and Javanese theorists. In James Tenney's recent work, The Road to Ubud, for prepared piano and gamelan, the piano is tuned to a pelog based on 9-tone equal. As far as I know no gamelan has ever been tuned exactly this way.

4) The measurements for Kanjutmesem are taken from an important article by Surjodiningrat, Sudarjana and Susanto, of Gadjah Mada University, in Jogjakarta (1972) entitled "Tone Measurements of Outstanding Javanese Gamelans in Jogjakarta and Surakarta." I have used their spelling for the name of the gamelan (rather than the more modern Kanyutmesem). Their measurements, which correct some important flaws in Kunst's earlier measurements (Music in Java, Volume II, edited by E.L. Heins, The Hague, Martinus Nijhoff, 1973, 3rd edition) are in hertz. There is a 1 hz. difference between S5 and P5 here that I have "rounded off" for simplicity and my interest in showing a tumbuk, but the reader is advised that whether a "real" tumbuk is perceived in this tuning is open to question. In the computations of cents values from the actual frequencies measured, I have rounded off to the nearest cent. This gamelan tuning is included because it is one of the most recorded gamelan in the world, and has been influential in the study of classical Central Javanese gamelan in the west. Its current tuning is significantly different than the one measured by these authors in 1972, since it has been "renumbered." Kanjutmesem, like Lipur Sih, has significantly stretched octaves, so that, for example, P1 is not a 2/1 to P1'. Note also the unusually wide (for measured Central Javanese tunings) P3-P4 interval -- likely the result of a renumbering in the past, meaning that this interval appeared between two different pelog tones at an earlier time. But, as Carter Scholz has pointed out, this interval (P3-P4) is smaller than two steps of 9-tone equal, and considerably smaller than Si Madeleine's 336¢. The slendro is remarkably close to the much maligned 5-tone equal model of slendro.

5) Lou Harrison and William Colvig have built several gamelan, each with a different tuning. The Si Darius/Si Madeleine tuning, I believe, represents a fairly early model of Harrison's just intonation interpretation of slendro and pelog, and is influenced by, but not a copy of, the tuning of gamelan Kyai Udan Mas (a tumbuk 6 gamelan which has been in residence and the University of California at Berkeley since 1976). Harrison's more recent tunings have avoided the perfect 3/2 fifth of these earlier tunings, and he is now working with stretched octaves as well. However, this pair is an important model for the study of American tuning systems in gamelan, and it is interesting to compare it to some actual Javanese tunings. Joan Bell Cowan's M.A. thesis from Mills College, "Gamelan Range of Light: The Influence of Instrument Building in Composition" (1985), presents Harrison's tuning in comparison with two other American tunings for aluminum gamelan, her own Range of Light and Daniel Schmidt's Berkeley Gamelan.

6) The tuning for the slendro/pelog pair of gamelan Lipur Sih was measured within a few days of its construction and first tuning (in December, 1988), using some tuning measurement and analysis software I wrote for the Amiga computer using the computer music language HMSL. For these measurements, the steady-state (middle) section of the tone was used. There is usually no low 6 or high 1 (P1') on a pelog slenthem, and the low 6 of the slendro slenthem, not given in the table, is 234 cents below the low S1.

7) It is interesting to compare this data with two "charts." These are constructed from descriptions and drawings made by Tentrem Sarwanto as an explanation of the possible archetypes of relationships between pelog and slendro. The first chart is the possible and common relationships between slendro/pelog pairs with tumbuk 6, and the second of those with tumbuk 5. These two charts are quite general as intervals may vary significantly, and pelog/slendro relationships are not consistent from gamelan to gamelan, even with the same tumbuk. In this chart I have tried to show: the range that each pelog interval may assume in relation to a given slendro interval; the "most likely" value that each pelog interval might assume in general proximity to its slendro neighbor (indicated by a heavy vertical line); and possible equivalences between slendro and pelog, besides the tumbuk itself (indicated by a dotted line). For example, with a tumbuk 6, slendro 5 can usually replace pelog 4 "in a pinch" (which is economically more feasible in the case of the larger bronze instruments: it means that only ten pitches are needed instead of eleven!). Other equivalences are possible and common, such as the near equality of slendro and pelog three in Lipur Sih. I have described these pairs in terms of the relationship of pelog to slendro because I believe that slendro is most often tuned first, and pelog is "fitted" to the slendro. While this is not always the case, there is theoretical and empirical evidence that this is a common occurrence.



ABOVE: Tentrem Sarwanto's generalized chart showing possible relationships between pelog and slendro, with tumbuk 6 (top) and tumbuk 5 (bottom).