

# INSTRUMENTS

## A SET OF ALUMINUM JUST-INTONATION TUNING FORKS by Warren Burt

Warren Burt is an American composer living in Australia. In this article he describes a set of hand-held tuning forks he has created. What is especially interesting about these instruments is not so much their design, or how they sound individually (though the tone is wonderfully clear, pure and long-sustaining), but rather how the players handle them in performance. On a physical level, the individually-held forks can be manipulated freely to modify their sound. On a social level, some very appealing possibilities appear in the musical interaction of a group of people, with or without musical training, holding such simple yet fully musical sound sources. In the article below, Warren describes the design and construction of the forks, and then goes on to describe some of the ways he has brought out their musical and social potential.

About 1970, Edward Keyes, a friend who dabbled in acoustics, showed me a set of eight aluminum tuning forks he had made and tuned to the C major scale. These were band-sawed out of 20 x 40 mm aluminum. They filled the octave ending on the C above the treble staff, and had a lovely pure tone that rang on for about thirty seconds. At that time, he gave me a reject fork from his project, one tuned to approximately the D above his highest C, suggesting that I might find a use for it.

Over the years, that fork was used in a variety of contexts. It was especially useful between 1976 and 1979, when I was a member of the live electronic performance group Plastic Platyplus, which specialized in performances with cassette recorders, home-built electronics and percussive trinkets of all kinds. The high ringing D of Ed's fork can be clearly heard in the recording of Ron Nagorcka's "Atom Bomb" (available on the cassette NMAAPE2, from NMA publications, PO Box 185, Brunswick, Vic. 3056 Australia, for \$6.50 Australian plus postage), and forms the central structural element in my 1977 piece "Tasmanian 'D'" for seven cassette recorders, hand-held percussion and hand-operated 7 channel sound switching system. More recently, the fork was used as a solo sound source in my 1985 accompaniment for choreographer Jane Refshauge's realization of Deborah Hay's "Leaving the House," where its single sustained highly directional sine-wave provided an ideal counterpoint for Jane's slow, elegant, and suspended movements.

These experiences convinced me of the desirability of having a set of these forks, and my interest in exploring various tuning systems provided further impetus in this direction. I did not have the opportunity to realize the project, however, until September, 1985, when I was selected to be one of the Australian Commonwealth Scientific Industrial Research Organization's (CSIRO)

artists-in-residence, as part of the Australia Council's "Artists and New Technology" scheme. I chose to work at the CSIRO's National Measurement Laboratory (NML) at Monash University in Melbourne, where precise frequency measuring equipment and a small machine shop were available. The forks were made here between September and December 1985.

A just intonation scale of 19 tones/octave was eventually settled on after a number of preliminary experiments. During these experiments, Schlesinger's ancient Greek modes (cf. The Greek Aulos, by Kathleen Schlesinger) and Yasser's 19 tone equal tempered scale (cf. A Theory of Evolving Tonality by Joseph Yasser) were considered. They were eventually passed over in favor of the much simpler just scale used here, based on the theories of Ptolemy and Partch (cf. Harmonics, Book II, by Claudius Ptolemaeus, and Genesis of a Music, by Harry Partch). The scale that evolved is symmetrical, based on G=392 hz, and has as subsets a number of the ancient Greek genera. Of particular acoustic interest are the beating pairs of tones 10/9 & 9/8, 7/5 & 10/7, and 16/9 & 9/5, which produce quite lovely beats when played together.\* For those interested in just tuning, here is the scale the forks are tuned to:

RATIOS:>	1/1	28/27	16/15	10/9	9/8	6/5	5/4	9/7	4/3	7/5
CLOSEST PITCH IN E.T.}	"G"	"G#"	"A"	"A#"	"B"	"C"	"C#"			
RATIOS:>	10/7	3/2	14/9	8/5	5/4	16/9	9/5	15/8	27/14	2/1
CLOSEST PITCH IN E.T.}	"C#"	"D"	"D#"	"E"	"F"	"F#"	"G"			

The forks themselves are made of standard aluminum bar, 25 x 40 mm for the top two octaves and 40 x 40 mm for the bottom two octaves. A number of experiments were carried out to determine the optimum design for them, and to see how the sound they made could be controlled. The end design had two tines ten mm wide of equal length on top of a fifty mm base. The length of tines varied as pitch varied. A computer program written by Robert Rigby of the NML calculated the lengths of bar necessary for each fork, and the amount of aluminum necessary to be milled off to fine-tune each fork. The metal work on the forks was carried out by myself, with very helpful and necessary assistance from NML's Stan Boothey, Ken Peel, and Ron Cook.

There are a total of 89 forks. Four octaves

\*These ratios and those given below, in keeping with nomenclature encouraged by Harry Partch and now gaining wide currency, are a means of precisely indicating relative pitch relationships. The numerator and denominator correspond to the frequencies of two pitches, in this case, the frequency of a higher scale degree over that of the basic pitch on which the scale is built.

The word "beating" here refers to the tremolo-like rise and fall in volume that results as two simultaneous vibrations of close but not identical frequencies move in and out of phase, alternately reinforcing and cancelling one another.

"E.T." on the chart below refers to 12-tone equal temperament, the standard tuning system in most current Western music.

