A STUDY OF

MUSICAL INTONATION

by

Christopher Leuba

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To my parents who, without complaint, endured the strange and out of tune sounds which emanated from my French horn.

Christopher Leuba, horn

A native of Pittsburgh, Pennsylvania, Mr. Leuba is a noted music performer, pedagogue and author. Having started playing the horn during his senior year in high school, Mr. Leuba went on to study with noted hornists Aubrey Brain and Philip Farkas. Mr. Leuba served two terms in the United States Army and later performed with the Minneapolis Symphony, eventually rising to principal horn. He served as principal horn with the Chicago Symphony under Fritz Reiner during the 1960-1962 seasons. He has also appeared with the Philharmonica Hungarica under the direction of Antal Dorati.

During his extensive career, he has performed fourteen complete Wagner Ring cycles and appeared with Sarah Vaughn, Quincy Jones and the Bill Russo big band. Mr. Leuba taught at the University of Washington for eleven years, during which time he published several books on music performance. Mr. Leuba's *A Study of Musical Intonation* is highly regarded as a seminal work for teaching the principles of just intonation to musicians. His other publications include *Rules of the Game*, *Phrasing Concepts* and *Dexterity Drills* and are used by brass teachers around the country. He has been an invited clinician at the Annual Conference of The International Trombone Association at Belmont College.

Mr. Leuba is presently in his 20th season as Principal Hornist with the Portland Opera in Portland, Oregon.

PREFACE

"Good Intonation" is certainly one of the most discussed subjects among musicians, though, like the weather, much is said but little is done about it. Perhaps one of the most frustrating experiences in a young musician's life is to be told by the teacher, "You're out of tune . . . listen . . . play it in tune", or, by the more perceptive teacher, "You're playing that D too high: lower it". A little later, the student finds that, in another context, this lowered D is also just as badly out of tune. Why? No explanation is provided by the Teacher. Repeated often enough, this pattern leads to hopeless frustration for the conscientious player, and complete disregard for the subtleties of good intonation by the callous. The wind player has the stringed instruments as a scapegoat - the string player hides in the anonymity of the group.

Intonation as a "science" is often berated by the musician, who feels most often that it is against ones "artistic sensibilities" to bring any mechanistic approach to this, or any other aspect of the Art.

There seems to be insufficient progress towards the goal of teaching better concepts of tuning and intonation by the *intuitive* methods of most of our teachers. Yet, consider that the science and methodology of tuning (or rather, **un**-tuning) a piano is imparted with regularity to many persons lacking in musical gift. So, the following ideas are proposed to aid in the achievement of the goal of informed, controlled tuning.

This paper will first address the physical and acoustic phenomena relating to the problems of Intonation and Tuning.

Following, in the Second Part, will be some methods and suggestions concerning the use of *mechanical aids* in training the musician's perception, and some practical applications.

Christopher Leuba
Oregon City, OR 1995

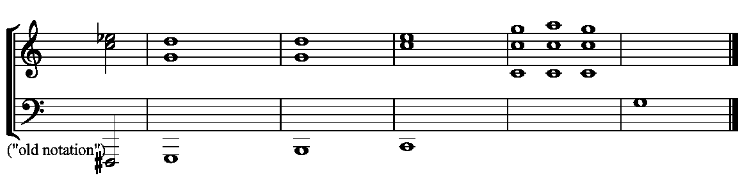
PART ONE

In order to arrive at a concept of "Good Intonation", let us examine several acoustic phenomena, well known to those who have studied the physics of sound, but, unfortunately ignored in our conservatories of music.

The most important of these phenomena will be referred to in this paper as the "resultant tone."

> ANY TWO NOTES, PLAYED SIMULTANEOUSLY BY TWO INSTRUMENTS, OR AS A DOUBLE-STOP ON A STRINGED INSTRUMENT, WILL PRODUCE A THIRD NOTE. THIS NOTE IS THE "RESULTANT TONE."

The frequency of the resultant tone is the difference of the frequencies of the two notes being played. Thus, a note of 1000 cycles per second (cps. or hz.), played with a note of 1100 cps. will produce a resultant of 100 cps. This note will not be of the same intensity as the generating tones, but it will often be audible. [1] Carl Maria von Weber utilised the resultant tone principle in the cadenza to the *Concertino for French Horn,* where the player plays one tone, hums another at the same time, and a third clearly audible tone is generated.



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[1] Paul Hindemith, *Craft of Musical Composition* (Associated Music Publishers, New York 1945) Volume 1, p. 57 ff.

This resultant tone itself reacts with its generators to produce further, but weaker , resultants of the second order. [2]

The resultant tone principle is also used by organ builders. In order to produce certain qualities of sound, or perhaps as a spacesaving device, organ builders have utilised two very small pipes producing frequencies above the range of human hearing, tuned in such a manner that when played together, they produce one very deep, and audible tone. [3] This effect can also be discovered by blowing together two high pitched whistles which, if tuned closely together but not at an exact unison, will produce a clearly heard resultant. [4]

When three notes are played together, *three* resultants are produced. For example, in the triad G-B-D, the resultant tones would be produced by each of the pairs: G-B, B-D and G-D. It follows that in large ensembles the number of resultant tones at any gfiven moment is quite large, since every single note played interacts with every other one, and with the resultants as well.

Now, let us examine the *Harmonic Series* which is the sequence of notes which can be produced by a string under tension or a column of air, as it vibrates in progressively smaller segments. The ratio of frequencies of tones in this sequence of tones always remains the same: each step, or "mode" of the series is separated from its adjacent mode by the frequency of the fundamental tone of the series (produced when the column of ar, or the string, vibrates as a whole), and each octave in a given series has a frequency double that of the octave below it.

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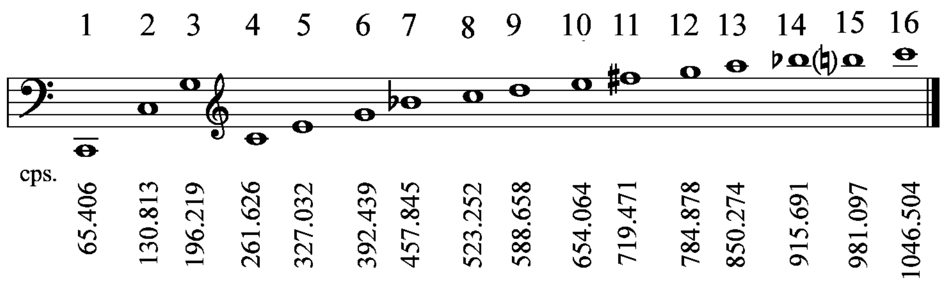
2 See R. Morley-Pegge, *The French Horn* (Ernest Benn, Ltd., London 1960) p. 147 ff; also, Birchard Coar, *The French Horn* (privately printed, DeKalb IL 1947) p.91 ff.

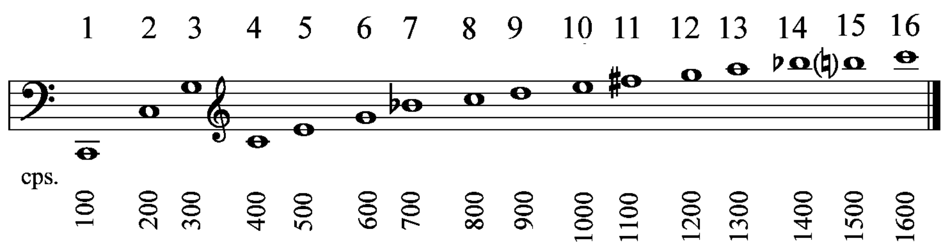
3 Paul Hindemith, Op. Cit., p. 59

4 Arthur H. Benade, *Horns, Strings and Harmony* (Anchor Books, Doubleday & Company, Inc. Garden City NY 1960) p. 80 ff.



Harmonic Series based on C 65.406 cps.

In the following discussion and examples, an arbitrarily selected fundamental tone of 100 cps, called "C" will be used for convenience in calculation, viz,



Harmonic Series based on "C" 100.00 cps.

Observe that when any two adjacent tones of an harmonic series are played simultaneously, the resultant tone (the difference of the two frequencies) will always be of the same frequency as the fundamental tone of the series. Thus , for example . . .