A brief history of the establishment of international standard pitch a=440 hertz

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In physics, the pitch of a musical tone is a function of the speed at which air has been set in motion. The speed is measured as the number of complete vibrations – backwards and forwards – made by a particle of air in one second. A speed of one complete vibration per second (or *cycle* per second) is one Hertz. The greater the number of cycles per second, the higher the pitch perceived. When pitch is produced by a vibrating column of air, the pitch of the same length of pipe varies with temperature: for one degree Fahrenheit difference, pitch will vary by 1/1000 of the Hz.

"International standard pitch," in which the A above "middle" C (a' in the British system of pitch designation, A4 in the American system) is tuned to 440 Hz, was adopted in the Western world for concert music only in the twentieth century, after a long history of unstandardized pitch.

EARLY HISTORY

In Europe prior to the twentieth century, pitch varied widely from place to place and from century to century. How widely, and how erratically, is evident from studies of organs (either historic instruments that had not been modified when tests were made, or replicas of historic instruments), early treatises that mention pitch, and historic tuning forks, To take Germany prior to 1600 as an example, organ pitch there is thought to have varied from a high of A=567 Hz for the first simple pipe organs of the Middle Ages to a low of A=377 Hz for the early modern German organ around 1511.[1] But not even at one particular time in one region of a country was standardization deemed necessary. It seems that composers and performers were accustomed to taking local variations in the tuning of organs and other keyboard instruments into account, either by writing a score in more than one key, or by transposing at sight – thereby accommodating the fixed pitch ranges of other instruments and the singers in the ensemble.[2]

Difficulties were naturally increased as scores and musicians traveled further. Two eighteenth-century international musicians, Handel and Mozart, are known to have favoured specific pitch levels — (again expressed in modern terms) A=423 Hz in the case of Handel and A=422 Hz in the case of Mozart, i.e. approximately one-half semitone lower than A=440 Hz.[3]

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[1]Alexander J. Ellis in *Studies in the History of Music Pitch: Monographs by Alexander J. Ellis and Arthur Mendel* (Amsterdam: Frits Knuf, 1968; New York: Da Capo Press), 23.

[2]Christopher Kent, "Temperament and Pitch," in *The Cambridge Companion to the Organ*, ed. Nicholas Thistlethwaite and Geoffrey Webber (Cambridge: Cambridge University Press, 1998), 53.

[3]Ellis, 23.

The nineteenth century saw a trend in Europe and North American toward the inexorable raising of the pitch level of instruments in performances. Alexander Ellis attributed this to two nineteenth-century developments: larger venues, and new developments in instrument making. As compared to Haydn or Mozart's day, public concerts in the nineteenth century were played before larger audiences, often in concert halls and opera houses larger than existed in previous times. These large rooms could accommodate – even required – high, brilliant pitches at climaxes, effects that could be achieved when playing eighteenth-century scores by employing instruments pitched higher than those that had performed the same scores in smaller rooms. For reasons such as this, nineteenth-century makers of wind instrument for band and orchestra sought to garner a niche in the market by developing and selling instruments pitched slightly higher so as to sound more brilliant than the competition's. Meanwhile, improvements to the strings of stringed instruments meant that these could be stretched tighter, i.e., tuned higher, to match the tuning of the newly acquired wind instruments of, say, an opera house.[4]

This gradual rise in pitch had a natural drawback, for human voices cannot be made to sing higher than they were "designed" for. Yet, in some European opera houses and concert halls singers were forced to risk their vocal health by singing operas and oratorios written with, say, A=423 Hz in the composer's mind, at pitch levels where A was reaching 450 Hz. That's over a semitone higher than Mozart's A=422 Hz.

RECENT HISTORY

The tide was turned when, in 1859, a French government commission made A=435 Hz law in that country. At the urging of singers in certain German and London opera houses, this standard was adopted for a time in opera houses and concert halls in other parts of Europe also. (Imagine all the new wind instruments that needed to be made and bought, also the tuning forks.) A=435 Hz was a compromise – between A=450 Hz, which was too high for singers, and A=422 Hz, which would not please audiences that had become accustomed to much more brilliance. Of course, other than in France, there was no reason that bands and orchestras should consider themselves forever constrained by A=435 Hz and the reduction in brilliance compared to the recent past.

In any case, Britain in the last decades of the nineteenth century went its own way. In 1896, London's Royal Philharmonic Society got around the practice of A=435 Hz in what appears to have been a contrived way. By the 1880s, scientists were able to calculate the amount by which the pitch of a wind instrument varies with room temperature. In Britain it was a common, but erroneous, belief that when the 1859 French commission decreed A=435 Hz, it had not specified an absolute frequency, but had specified 59° F as the room temperature under which the particular construction of the pitch-giving instrument (oboe) played A=435 Hz.[5] The Philharmonic Society, on the advice of their consultant, therefore reasoned that the same instrument, at normal room temperature, 68° F, would play the A above

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[4]Ellis, 27-28.

[5]A representative of the British Standards Institute hypothesizes how this belief began in Llewelyn S. Lloyd, "International Standard Musical Pitch," *Journal of the Royal Society of Arts* 98 (16 Dec., 1949), 80-81.

middle C as:

$$435 + [(68-59)\div 1000 \times 435] = 438.915 \text{ Hz}$$

which is A=439 Hz to the nearest integer. As a result, in 1896, A=439 Hz became a recognized pitch standard in Britain. In North America, meanwhile, the pitch of pianos and orchestras not only remained unstandardized in the first decades of the twentieth century but continued to creep upward.

International conferences for the purpose of standardizing pitch had thus far been unsuccessful at drawing in every country having significant orchestras and opera houses. New to the twentieth century was music broadcasting, with its ability to juxtapose for listeners' ears the live or recorded performances of orchestras in concert halls from any part of the technologized world. In the 1930s, the broadcasting industry made a push towards total standardization of concert pitch in Europe and North American. Success was achieved at a 1939 international conference held in London. Presumably as a compromise between current tendencies and earlier pitch standards, it was agreed that the international standard for concert pitch would thenceforth be based upon A=440 Hz — very close to the Royal Philharmonic's A=439 Hz of dubious derivation. The B.B.C. began to broadcast the A=440 Hz tuning note, which, for the sake of accuracy was produced electronically:

> The B.B.C. tuning-note is derived from an oscillator controlled by a piezo-electric crystal that vibrates with a frequency of one million Hz. This is reduced to a frequency of 1,000 Hz by electronic dividers; it is then multiplied eleven times and divided by twenty-five, so producing the required frequency of 440 Hz. As 439 Hz is a prime number a frequency of 439 Hz could not be broadcast by such means as this.[6]

More recently, and according to the New Grove article, A=440 Hz was reaffirmed by the International Organization for Standardization in November 1955 and in January 1975.[7] That reaffirmation should be necessary suggests that (as Lloyd's 1949 lecture audience insinuated during their question-and-answer period) in practice after 1939, pitch continued to creep up, at least in some places.[8] Arthur Mendel sites the example of a New York orchestra:

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[6]Lloyd, 89. It is not clear from Lloyd's paper whether the B.B.C. method of generating the signal was a consideration in the choice 440 Hz rather than 439 Hz. Lloyd also mentions that, B.B.C. orchestras were then required to tune their instruments to the B.B.C. tone-generator (and other ensembles were urged to use a tuning fork rather than the unstable oboe).

It is worth mentioning that, whereas Lloyd says that the B.S.I. endorsed A=440 as a result of an international conference for which the B.S.I. made the "business arrangements" held in London in May *1939* ("some three months before the declaration of war on Germany"), an article in the 1981 *New Grove Dictionary of Music and Musicians* says that the British Standards Institute endorsed A=440 Hz at a *B.S.I. conference* held in May *1938*. [Mark Lindley et al.,"Pitch," in *The New Grove Dictionary of Music and Musicians*, Vol. 14 (London: Macmillan, 1980), 785]. It seems clear from Lloyd's paper that the B.S.I. adopted A=440 Hz *after* the May 1939 international conference, and that the authors of the *New Grove* article are referring to the same conference with the correct month, but incorrect year. Unfortunately, probably as a result of the *New Grove* article, 1938 is now given as the year in which the B.S.I. adopted the present pitch standard in other articles about the history of pitch, including Kent, op. cit., 54.

[7]Lindley, 785.

[8]Lloyd, 86.

> My own experience in tuning an electronic organ to be used as a continuo instrument with orchestra, in the late 1940s and early '50s, showed me that New York orchestra musicians could with difficulty be induced to tune their instruments to a'=440 Hz, but that if the organ were tuned to that pitch it would in the course of performance be flat as compared with the other instruments. If, on the other hand, I tuned the organ to a'=444 Hz, this difficulty disappeared, and I take it that this latter pitch is approximately that at which New York orchestra musicians habitually play, and to which they involuntarily tend to return even if they have started out by tuning their instruments to a'=440 Hz.[9]

As is well known, some musicians have absolute pitch recall, usually based upon the tuning of the instrument, often a home piano, with which they grew up. A musician having an innate sense of the frequency of each of the twelve divisions of the octave, when faced with a new pitch standard, could conceivably find it difficult to not return to the precise pitch level s/he learned in childhood.

To summarize, a "universal" standard of pitch was not necessary in Western music as long as (1) performance tended to be tied to the circumstances of a particular locale; (2) when the locale changed, instrumentalists were able to transpose at sight; and (3) scores conceived in relation to an older pitch level tended to fall out of use and then be lost. But, once musicians started to transfer scores to places and time-periods foreign to their original composition — scores that were so complex that accurate transposition by every player of a wind instrument or fixed-pitch instrument would have been risky — and because human voices have unchanging tessituras, the tuning of a fixed pitch instrument or the construction of any other instrument could thereafter vary only within practical limits, these limits being anything but arbitrary when it comes to voices singing existing scores. During the nineteenth century, also the first era in Western history that systematically began to dust off old scores for performance, the pitch of performances started to vary in only one general direction in Europe and North America, which was upwards. The twentieth-century choice of A=440 Hz was a compromise between two important traditions: the pitch level favoured by the composers of eighteenth-century music that remains important to the concert repertoire, and the more brilliant pitch levels introduced by the makers of nineteenth-century wind-instruments. Meanwhile, the revival in recent decades of period instruments tuned to one or the other historic pitch has prompted a new awareness of pitch as stylistically contingent rather than absolute.

[9]Arthur Mendel in *Studies in the History of Music Pitch*, 8, n. 3.