Musical tuning

In music **tuning** an instrument means getting it ready so that when it is played it will sound at the correct pitch: not too high or too low.

When two or more instruments play together it is particularly important that they are in tune with one another. This means that when they play the same note it is indeed exactly the same note. If the two instruments are not in tune with one another it will sound unpleasant because two notes which are very slightly different in pitch will produce a “beat”.

Tuning instruments

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Instruments such as the piano or organ have to be tuned by people who are specialists in tuning. For most instruments, however, the players themselves need to tune their instruments before they play. Players of string instruments can turn the pegs at the top of their instruments to change the tension (tightness) of the string. Players of wind instruments can make their instruments very slightly longer or shorter by pushing out or pulling in one of the joints. Timpanists turn the taps which are around the top of their instruments to change the tension of the drum head.

When an orchestra gives a concert the instruments have to tune carefully so that they are in tune with one another. Usually it is the principal oboist’s job to stand up and play the note A so that everyone can tune to that note. In some countries such as the US it is tradition for the principal violinist (concertmaster) to give the A. If the orchestra are going to play with a piano soloist they will have to tune to the A of the piano because the piano has already been tuned by the piano tuner.

When a violinist tunes his instrument he is making sure that his four strings are tuned perfectly to G, D, A and E. Each string is wound around a peg near the top of the scroll, so that turning the peg changes the tuning. He may also have “adjusters” or “fine tuners” which are at the other end of the string where it is attached to the tailpiece. The adjusters make it easier to make small changes to the tuning. The violinist will make sure that the A is in tune, then the A and D can be played together so that they are exactly a fifth apart, then the D and G and finally the A and E are compared.

If they are not tuning to a piano, players of instruments sometimes use a tuning fork which gives an exact note (usually an A) so that they know they are in tune. There are also electronic tuning devices.

Tuning systems

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A tuning fork

When an instrument such as the piano is tuned, the piano tuner has to know how to make each note relate correctly to the others. During the course of music history there have been several systems of doing this. These different *tuning systems* are all about the exact scientific relationship between the notes of the scale. There has been an enormous amount of discussion among musicians about how best to tune instruments.

Comma of Pythagoras

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When two notes are an octave apart the higher note is vibrating at twice the speed of the lower note. For example: if a string is vibrating at 440 Hz (440 times a second) the note we hear is an A (the A above Middle C on the piano). If the string is stopped halfway up (e.g. because the player presses it down with a finger) it will vibrate at 880 Hz and we will hear the note one octave higher.

The note which vibrates at 1 ½ times the frequency of the basic note will be the note a perfect fifth higher (an E).

If a piano tuner starts by tuning a C, then tunes a G so that it is exactly 1 ½ times the frequency of the C, he can continue tuning in fifths (a D, then an A etc.) until he arrives back at C again. However, he will find that, for mathematical reasons, the last C is not in tune with the first C. This was discovered long ago by Pythagoras and is called “the comma of Pythagoras”.

Solutions to the comma of Pythagoras

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Musical tuning systems throughout the centuries have tried to find ways of dealing with this problem. From the 16th century onwards several music theorists wrote long books about the best way to tune keyboard instruments. They often started by tuning up a fifth and down a fifth so that these notes were perfectly in tune (e.g. C, G and F), then they would continue (tuning the D to the G and B flat to the F) until they met in the middle around F sharp. Sometimes old organs today are tuned by such a method. Playing in keys with very few sharps or flats (such as C, G or F) sounds very beautiful, but playing in keys with lots of sharps or flats sounds horribly out of tune.

In 1584, Zhu Zaiyu, a prince of Chinese Ming Dynasty, published the invention of equal temperament in his book *A New Account of the Science of the Pitch-Pipes.* In 1585 Simon Stevin invented a similar system. Some scholars think one of these really invented this system. Others think both did, or neither. Around 1700, based on this new system, Johann Sebastian Bach wrote two books of 24 preludes and fugues (called the *Well-Tempered Clavier)* to prove that it was now possible to play in any key.

Systems for the twelve-note chromatic scale

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Here are some of the main ways of tuning the twelve-note chromatic scale which have been developed in order to get round the problem that an instrument cannot be tuned so that all intervals are "perfect":

- **Just intonation**, in which the ratios of the frequencies between all notes are based on whole numbers with relatively low prime factors, such as 3:2, 5:4, 7:4, or 64:45; or in which all pitches are based on the harmonic series, which are all whole number multiples of a single tone. Such a system can be used on instruments such as lutes, but not on keyboard instruments.
- **Pythagorean tuning**, a type of just intonation in which the ratios of the frequencies between all notes are all based on powers of 2 and 3.
- **Meantone temperament**, a system of tuning which averages out pairs of ratios used for the same interval (such as 9:8 and 10:9), thus making it possible to tune keyboard instruments.
- Both just intonation and meantone temperament can be thought of as forms of **regular temperament**.
- **Well temperament**, any one of a number of systems where the ratios between intervals are not equal to, but approximate to, ratios used in just intonation.
- **Equal temperament** (a special case of well-temperament), in which notes of the scale which are next to one another are all separated by logarithmically equal distances, which are integer powers of $2^{1/12}$.

Related pages

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- Scordatura