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~ Tuning The Bagpipe ~

~ Basic Principles & Random Advice ~

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Sounds rise like noxious fumes

Sounds rise like noxious fumes
from Goofy's out-of-tune pipes,
while Mickey protects his ears with muffs ...
Don't be this piper!

Few things are as obnoxious as an out-of-tune Great Highland Bagpipe (GHB), or for that matter any untuned bagpipe. Bagpipes heard out-of-tune are the major reason why many people dislike the instrument. Out-of-tune pipes may lead to social unrest, dog bites, high gasoline prices and shortages of Prozac. Divorce lawyers consider badly tuned pipes money in the bank. If politicians were not categorically deaf, they long ago would have made it a felony to inflate a bagpipe in public without at least intending to tune it.

An in-tune bagpipe, on the other hand, is a sweet-sounding thing indeed, and therein lies a secret: Even a fledgling piper, who perhaps hasn't yet developed the swiftest of fingers, can make nice music that will please not only himself but others as well, if the pipe is but played in tune.

In its most basic form, a bagpipe consists of a melody pipe, called the chanter, which produces a series of different notes depending on which of its fingerholes are open and closed, and at least one drone pipe, which produces a single constantly-sounding note. The notes of the melody pipe must be in tune with each other, just as the notes of a piano or any other instrument must be in tune with one another, and additionally the note produced by the drone must be in tune with the chanter's notes. If the bagpipe has more than one drone, then obviously the additional drones must likewise be in tune both with one another and with the chanter.

The interplay between the melody notes sounding against the steady tones of the drone(s) creates an effect that is the defining characteristic of a bagpipe. It's a case of the sum being greater than the parts - a drone heard alone is hardly impressive, and most chanters played alone don't sound like much either. But put them together and all sorts of fabulous fireworks ensue - if they are in tune. This is because the sounds of an in-tune chanter and the drones reinforce one another in complex and dramatic ways. If they're not in tune, not only is this effect lost but a discordant noise, rather than music, is generated. It's a huge, huge difference.

But what does "in tune" mean? That simple term is loaded with all sorts of different meanings. In a very basic sense, it means that when individual musical tones are played in a sequence, one at a time as in a melody, they are perceived by the ear as having a pleasing or at least a logical relationship to one another. Likewise, when two or more tones are played simultaneously, as when strumming a chord on a guitar or when playing a bagpipe with its drones and chanter sounding, "in tune" again means that the tones have a pleasing effect together. Here are some examples:

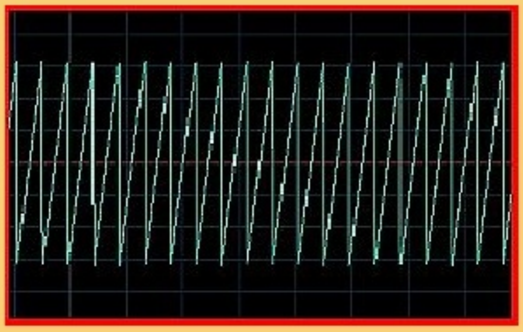
What Are Musical Sounds?

Sounds reach the ear as waves moving through the air, like ripples from a pebble tossed into a pond. Sound waves move at high speed, roughly 1200 feet per second. (Outrunning the sound of an out-of-tune bagpipe is sometimes attempted but always futile.) A simple non-musical sound - say the noise of a creaking floorboard - might have only few individual waves, of differing size and shape, and these might arrive at the ear at irregular intervals. Shown as a graph, such a noise looks like this:

Click on the graph to hear a simple non-musical sound

A musical sound is much more organized. For example, when a guitar string is plucked, the string vibrates rapidly and at a constant rate. This vibration is transmitted to the air and becomes a steady stream of waves, one for each complete back-and-forth swing of the string. The individual waves of a simple steady musical tone are evenly spaced and of uniform shape. As a

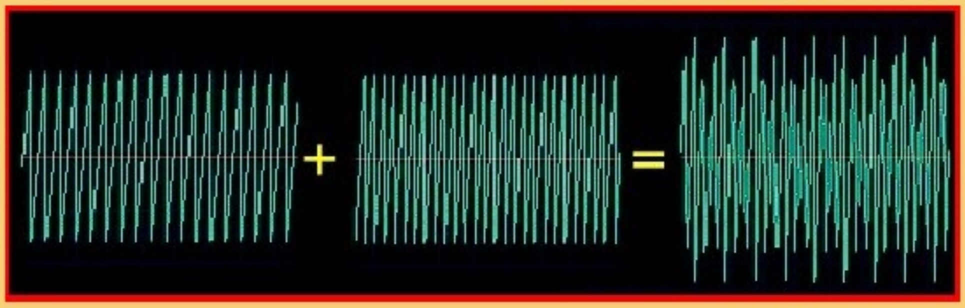
group they may be taller or shorter, which makes them sound louder or softer. A graphic representation of a musical tone looks like this:



Click on the graph to hear a simple musical sound

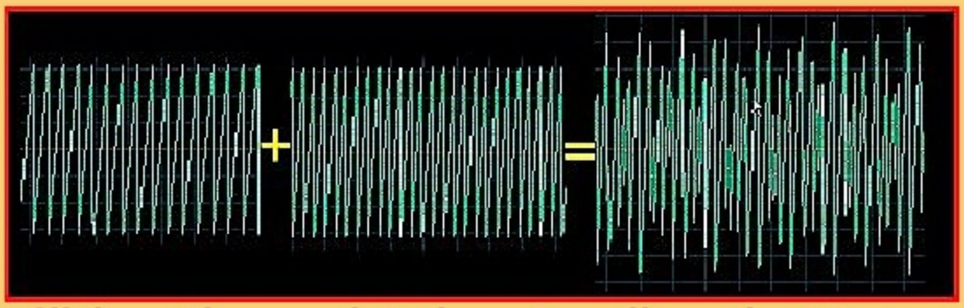
In-Tune and Out-Of-Tune Musical Sounds:

When different musical tones are played simultaneously, they will sound pleasing and musical, or grating and nasty, depending on the relationship they have with one another, as will be explained further along. Here is an example of two tones that sound good together. Each is first heard alone, then together.



Click on the graph to hear two tones that harmonize

Whereas here are two tones that don't fit together at all well:



Click on the graph to hear two discordant tones

Click on the graph to hear two discordant tones

The reasons why these combinations of tones are so very different from one another are discussed in the body of this essay. For now, looking at the two graphs, note that the first tone in each set, on the left, is the same; it is the second tones that differ from one another. Looking at the combined tones on the right end of the graphs, notice that the harmonious one looks much more regular and symmetrical than the discordant one.

But then what defines “pleasing”? Isn’t that merely subjective, perhaps just a reflection of what the ear is used to hearing in a particular culture? To a certain extent that might be true, but it happens that tone sequences and combinations that most people find pleasing have distinct and identifiable relationships to one another that can be expressed in simple mathematical terms, and that can be exploited when adjusting, or “tuning” an instrument. For example, in the above examples the nice-sounding combination consists of two tones with a mathematically expressed ratio of 3:2. That is, for every three sound waves of the higher tone that arrive at the ear, exactly two waves of the lower tone arrive. So the pattern created when the two are sounded together repeats itself often - about 100 times per second, in this instance. Thus the sound of the combination is smooth and regular, and that's why the graph also looks so regular. In the other, evil-sounding combination the two tones have a relationship of 77:56. That means that for every 77 arriving waves of the higher note, 56 waves of the lower note arrive. Now the pattern made when both of these tones are played repeats itself only about three times per second - the ear rebels at this, and labels the combination as noise, not music.

Before continuing, some definitions are in order. The attempt here is to explain the unique musical situation of the bagpipe to people who have little or no prior musical training or experience - we know from our mail that a great number of our visitors fall into that category. But we also know that many (probably most) professional musicians, conductors and composers don't understand the instrument either, and some of them also come here looking for information. We ask that the latter bear with us as we attend to the needs of the former, and point out that the following definitions may have a bit of usefulness even for the professional, as they are written from a piper's always somewhat unconventional perspective.

Some Definitions:

Perhaps the following terms are familiar to most who have found their way here, but around bagpipes things are not always the same as elsewhere. The ways some of these terms relate to bagpipes are quite important to what follows and it's about impossible to discuss the issues without using and understanding them. Our definitions may not be complete - here, attention is limited to the practical aspects of these terms in regard to bagpipes.

Pitch: The "pitch" of a musical sound refers to its perceived high-ness or low-ness. A particular pitch can be expressed as a frequency (see definition below) or it can be given a name, called a "note" (see definition below).

Frequency: The "frequency" of a sound refers to the rate at which the individual waves arrive at the ear. A guitar string vibrating at a rate of 440 swings per second generates sound waves at that same rate. So, this sound has a frequency of 440 cycles per second, sometimes abbreviated to 440 cps but more commonly expressed as 440 Hertz and abbreviated to 440 Hz (Hertz was a 19th century physicist who later founded a rent-a-horse empire). The higher the frequency, the closer together the waves and the higher the pitch waves and the higher the pitch.

Tone: A "tone" is a musical sound of a particular pitch. Tones are the steps of which a scale (see definition below) is comprised. The word "note" is often used interchangeably with "tone" though this is not always quite correct. Further confusion might arise from the use of the word tone as indicating a quality, as in "This chanter has a bright tone."

Semitone: The smallest interval (see definition below) used in ordinary Western music. Also called a "half-step." The common Western scale consists of an octave (see definition below) divided into twelve parts. Each of those parts is a semitone. Adjacent keys on a piano (regardless of color) are one semitone apart.

Cent: A "cent" is one-hundredth the distance between two semitones. Used primarily in tuning, not in written music. A note sounded on an instrument might be corrected or adjusted by a few cents, usually with the help of a tuning aid. Cents are also useful in discussing intervals between notes, as the numbers are not as unwieldy as frequencies.

Note: A musical "note" is a label or symbol assigned to a particular tone (and also its duration, but we won't worry about that here). Notes are commonly expressed (in ordinary speech and writing) as letters of the alphabet. The word is also used to mean the tones themselves. A series of notes makes up a "scale" (see definition below). The frequency (pitch) of a particular note is ultimately arbitrary and is usually a matter of mutual agreement. For example, in modern Western music the frequency, or pitch, of the note "*A*" is agreed upon by almost all musicians, composers and instrument makers to be 440 Hz (or a multiple thereof) - but not by makers and players of the GHB.

Scale: A musical scale is a division of a particular range of frequencies into a number of steps spaced apart by one or another scheme. There are a nearly infinite number of possible scales. For example we might take a starting frequency and double it, thus establishing a range of frequency, and then divide that range into, say, twelve parts and label each point of division a note. That happens to be the basis of the common Western scale. You can probably invent one that hasn't been heard before and name it after yourself - but it will likely not sound so hot. Most scales are based on the range just mentioned - a doubling of a given starting frequency. That distance is called an "octave" (see definition below). The actual usable scale of a given instrument, especially a simple one such as a bagpipe chanter, may be only one section of a full scale, or it may skip some of the steps. Thus for example the Highland Bagpipe has a range of two notes over an octave (its low G up to its high *A*), but can only produce nine notes within that range, rather than the full thirteen.

Octave: An "octave" is a range of frequency in which the top is double the frequency of the bottom. So if the bottom is 440 Hz, then the top would be 880 Hz. That low frequency, 440 Hz, as already explained, has been labeled as the note *A*. So the octave of *A*, double that frequency, is again named *A*. Half of the starting frequency, 220 Hz, is also an *A*. On a bagpipe chanter, with a limited range of notes, there are only two *A*'s and logically enough they are called the Low *A* and the High *A*.

Interval: An "interval" is the distance between any two notes or tones of a scale. This can be expressed as a proportion (ratio), or as "cents" (see definition, above) and it may also have a name. Thus if the interval between two notes is a doubling of frequency, it is 2:1 and is also called an octave. Intervals that can be expressed as ratios with small numbers, for example 3:2, have characteristics that are helpful in tuning, as discussed in the body of this essay.

Sharp: Another word with two meanings that can confuse. Most basically, "sharp" refers to a tone that is higher-pitched than another, or higher-pitched than its theoretical self. Usually, but not always, this refers to an undesirable situation. For example, if an instrument is producing an *A* that is supposed to have a frequency of 440 Hz but is sounding at 450 Hz, that tone is said to be sharp. If all of the other tones produced by this instrument are equally sharp it may not matter, so long as the instrument is being played solo. But if not all of its tones are equally sharp, or if it is played together with another instrument (or together with drones) not equally sharp, then it will sound nasty. The other use of "sharp" is as part of the labels for the notes of the common scale. For example, the next note above C is "C-Sharp" (written C#).

Flat: The opposite of "sharp" in all regards, a tone that is "flat" has a lower pitch than expected or desirable. And again, the word is also used as part of a label in musical notation, for example "B-Flat" (written Bb) where there are no implications regarding the correctness of its pitch.

Drone: A continuous steady musical sound, usually produced with the intention of creating harmonies with the notes of a simultaneously played melody. Also the name of the pipe(s) of a bagpipe that produce(s) this sound. Depending on the exact natures of the sounds produced by the drones and the melody pipe (chanter) some very complex interactions take place that produce (or reinforce) yet more sounds, called overtones or harmonics (see definition).

Harmonics: (Also called "overtones" and "partials") Most musical instruments, when sounding a particular tone, are also simultaneously producing a number of other tones at the same time. These are mathematically related to the primary tone, and are usually weaker than that primary tone. They may not be individually obvious to the average ear, but they contribute greatly to the overall character of the sound. When a second instrument is played together with the first, and in tune with it, some of the harmonics of each may interact with one another, adding even with one another, adding even further sometimes surprising spice to the soup. In bagpipes, the sounds of the drones and the chanter are loaded with harmonics - four instruments' worth. It is the interplay of these harmonics, as much as anything else, that accounts for the differences in sound between pipes by different makers, and/or pipes fitted with different sorts of reeds. The mix and character of an instrument's harmonics are not generally under the control of the musician, but are established by the instrument's maker and in the case of bagpipes also by the reed maker. What is pertinent for the piper is to realize the importance of harmonic interplay - it's when the overtones are dancing together that the magic of bagpipes reveals itself. This only happens when the pipe is in tune, and spot-on in tune, not just close. A pipe can be just a bit off-tune and not sound bad - but those overtones won't be working together and the sound will be dulled.

Harmonious: Simultaneous sounds that are pleasing to the ear, and that therefore also happen to compliment one another mathematically, are called harmonious. The opposite is discord or dissonance. Sometimes the term "pure harmony" is heard - this may be used to differentiate a mathematically pure sound combination from one that is "tempered" and not quite perfect, as is commonly found in conventional western tuning. The very core of all bagpipe music is the harmony created by the melody playing against the drones.

Key: The "key" of an instrument refers to the particular parts of the scale that it produces comfortably. The "key" of a piece of music likewise refers to the part of the scale that dominates. Great Highland Bagpipe music is written in the key of *A*, and the instrument is in that key, even though it may not sound like *A* to a musician. As a practical matter, because the GHB is limited to nine notes, the piper need not concern himself much with this. Questions about what key a GHB is in usually arise only as that - questions, from people trying to understand the instrument.

To continue: The point here is to discuss the basic principles involved in tuning a bagpipe, and to provide some understanding and a bit of practical advice, not to provide either a comprehensive technical analysis or complete step-by-step instruction. Such specific instructions can be obtained in two ways: traditionally, face-to-face from a teacher or piper, or recently from high-quality tutorials such as Jim McGillivray's superb video productions or John Cairns' comprehensive series of books & CDs. The following is basic and simplified; the subject is deep, and there are nuances and deviations that are not mentioned here. The bagpipe is a very deceptive instrument in its superficial simplicity. Truly mastering even tuning it eventually involves some art, not just mechanical technique. However, understanding the fundamentals discussed below isn't difficult, and it might be enough to keep the beginning piper from being run out of town.

The Chanter Key Note: The Anchor

Almost all musical instruments are designed to be played together with other instruments. Thus it is necessary that they share a common tuning standard. Until the late 1800s this presented some major problems for musicians and makers of instruments. There was no universal standard or agreement defining the pitch of any particular note. So, an English oboe player, for example, might have his instrument in perfect tune with itself, only to find it clashing horribly with an equally well-tuned German's piano. Even though both instruments played the same scale, there was no common, absolute starting point. So an *A*, played on that oboe, might have had a frequency of 450 Hz, while that German piano's *A* might have been tuned to, say, 430 - together, these make noise, not music. As musicians began to travel more and more in the "modern" world, this difficulty became ever more common; finally, an agreement was reached to standardize the pitch of the note "*A*" at 440 Hz, and this is where it has remained ever since. The 440 Hz "*A*" and the subsequent frequencies of the rest of the scale are now referred to as "concert pitch" and are taken for granted by almost all western musicians ... except, you guessed it, pipers.

Makers of Great Highland Bagpipes generally accepted this standard at first, along with everyone else, but for a number of reasons that are beyond our scope here the pitch didn't remain there. Rather, it crept higher and higher during the next century, to the point today where the *A* of many pipes is up around 470Hz (and some pipes are being heard with the *A* as high as 485 Hz). All bagpipes being essentially solo instruments, the consequences of being out-of-tune with mainstream orchestral instruments were and remain minimal. Furthermore, even when the *A* of a GHB matches the *A* of an orchestral or band instrument, the pipe will not be in tune with that instrument elsewhere on the scale, as will be explained below.

A consequence of the GHB's *A* hovering around 470 Hz is the often heard but incorrect statement that the instrument is in the key of B-Flat. In modern concert pitch, B-Flat is 466 Hz, so quite close to the bagpipe's *A*, but the similarity stops there. The relationship is coincidental, nothing more. There is a slight practical value in that an orchestral B-flat can be used to get the *A* of the bagpipe in the ballpark.

The Rest of the Chanter Scale

Also affecting the piper is another more or less modern convention not employed in bagpipes - the "equally tempered" scale used in almost all modern Western music and instruments. (Don't go to sleep here - this is important.) By a quirk of fate and the laws of mathematics, the seemingly simple modern Western scale consisting of twelve divisions of an octave has a serious flaw. The ratios between some notes do not stay constant as music is shifted ("transposed") into other keys and octaves. So for example if a piano, which has a range of several octaves, were tuned so all the notes of the lowest octave were exactly doubled to create the next higher octave, and doubled again to make the third octave and so on, then certain combinations of notes would sound unexpectedly nasty. So the tuning of many notes is "tempered" - an interesting euphemism, because these notes are in fact intentionally tuned a bit off from true harmonic intervals, so they will not clash violently when played with certain other notes. It's a matter of spreading the problem around "equally," to accommodate the needs of modern musical gymnastics. A better name might be "equally compromised tuning." There exist many schemes for such "tempering" - there is a fascinating essay on the subject by Kyle Gann on his Web site at www.kylegann.com/tuning.html. The bagpipe, which can only sound one melody note at a time over a limited range, and with which shifting keys is not an issue, has no need to employ such compromises and retains true harmonic intervals. This again eliminates using ordinary instruments or ordinary electronic tuners as tuning aids. It also creates problems when Continental European bagpipes, which unlike the GHB are often tuned to 440 *A*, are played with "equally tempered" instruments - especially, as is most unfortunately fashionable in some circles, with accordions and such - the equally-tempered whining of these machines invariably destroys the inherent subtle harmonic sweetness of the pipes, no matter how skilled the driver is. But I digress.

A final dollop of confusion is tossed in the stew by the way the notes of the Great Highland Bagpipe are labeled. The piper simply ticks off whole letters, in sequence, starting with the lowest note, G, then A, B, C, D, E, F, G and finally the highest note, again *A*. This is very convenient and makes the written music easy to read for the piper, but it again deviates widely from standard musical practice. When one plunks out this series of notes on a piano the sequence doesn't sound anything like the scale of the bagpipe, even when ignoring the already explained overall higher pitch and the lack of "equal tempering." It's a whole different set of intervals than the conventional musician would expect. This is because the wily piper, having only one C available, simply discards part of that note's conventional label, which is C-Sharp (written C#). The same applies to the F - it's "really" F#. Within the tight confines of the GHB and its music, it's just more convenient to call (in speech and written music) these tones by their first names only - but it can drive a non-piping musician nuts. So, in conventional musical language and notation (and again ignoring overall pitch and tempering) the scale of the GHB would read G, A, B, C#, D, E, F#, G, A. If the G were sharp, this would be an A-Major scale, but as it is, it's called a Mixolydian Mode. (Don't worry, I'm not going to attempt to explain "Mixolydian" except to mention that it's a neat word (pronounced mix-o-lid'-ian) that will impress your musical friends when you utter it.) What's important here is to understand that there is a gap between the GHB and the rest of the world in the way music is described in words and in notation. So, as a piper you cannot play even the most simple tunes as written in your kid's third-grade music book, and likewise you won't hear anything recognizable when you hand your pipe music to a guitarist.

The Highland Bagpipe Scale

Here is a chunk of the common Western scale, with the notes of the Great Highland Bagpipe chanter in red (ignoring the differences of overall pitch and tempering).

G Ab A Bb B C C# D D# E F F# G Ab A

The low *A* of the chanter is "A4" - that is, it corresponds to the fourth *A* on the piano keyboard - or it would, if the piano and the pipe were tuned to the same pitch.

Again, remember that the piper "loses" the sharp designators and thus writes the above as:

G A B C D E F G A

To review: The tuning of a GHB chanter differs in three ways from what one would expect by looking at the music, with the result that picking out a bagpipe tune on what would seem to be the correct nine keys of a piano results in something entirely different than what is heard on the pipe:

1. The keynote, *A*, and thus all the other notes, are higher-pitched than the piano notes;

2. The intervals between notes differ from those on the "equally tempered" piano;

3. Two notes, called C and F by pipers would be called C# and F# in a conventional scale (without considering the higher overall pitch and/or tempering).

So, the bad news is that ordinary tuning methods aren't very useful. The good news is that a bagpipe chanter normally needs to be tuned only to itself (or to other bagpipe chanters, as in a band), and that the bagpipe itself contains the necessary equipment to achieve this - its own drones. With practice, most people can eventually do a decent job of it.

The Drones

A bagpipe drone is a simple device that does nothing more than produce a single continuous tone of constant pitch. It consists of a hollow tube, open to the air at the top end and fitted with a reed at the bottom (bag) end. It is tuned by changing its length, by means of one or more sections that slide on tuning pins. The GHB has two different drones, a tenor and a bass. (There are two of the tenor drones, identical in all regards - early Highland pipes did not have a second tenor drone, which was added later to increase the volume of the pipe.)

The tenor and bass drones both sound an *A*, that is, an *A* as defined for the particular chanter being used. The tenor drone sounds the *A* one octave below the low *A* on the chanter, and the bass drone's *A* is another octave lower. (As already discussed, the chanter's low *A* might be anywhere from the concert pitch of 440 Hz up to somewhere chanter's low *A* might be anywhere from the concert pitch of 440 Hz up to somewhere around 485 Hz.) So the tenor drone will sound at exactly half of that frequency, and the bass drone will boom along at half of that again. For simplicity we'll use a 440 Hz *A* in the following discussion and examples.

The Beating Zone

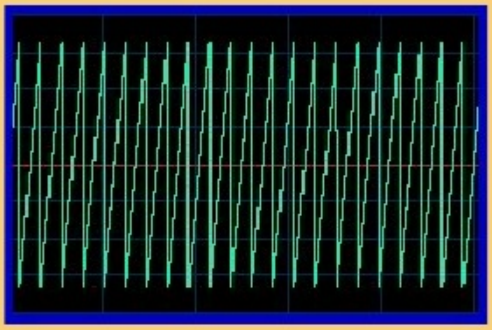
As already discussed, when two tones are out of tune their respective sounds interfere with one another, with nasty results that are heard as noise. However, if two tones are close, but not exactly, in tune with one another, the interference between them produces a recognizable effect that itself is the key to bringing the sounds into perfect tune. This effect is heard as a "beating" sound, ooooooooooowaaoooooooooowaaoooooooooowaaoooooooooowaaoooooooooo.

This rhythmic pulsing is the result of one set of sound waves meshing periodically and briefly with another slightly slower set, as both sets arrive at the ear. Imagine a string of race cars passing another slightly slower string of cars as you sit by the side of the track. Most of the time a car from either one or the other of the groups will go by you alone, and you might not hear much if any difference between them. But now and then (regularly, if the speeds of the two groups are constant), two cars - one from each group - will go by you together, and that will of course produce a recognizably different sound.

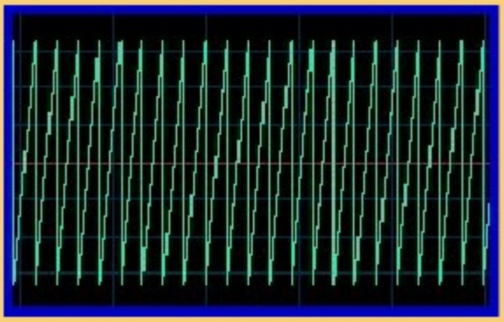
Learning to hear this beating sound when two tones are close to being in tune is not difficult, and has nothing to do with any ability, or lack thereof, to distinguish the pitch of a tone, or whether one tone is higher or lower than another, or even if there is a difference at all.

Beating Drones

Here are graphics and sounds illustrating what we're talking about.
The below two waves are 220Hz and 218 Hz.
Listening to them individually, they sound very much alike:

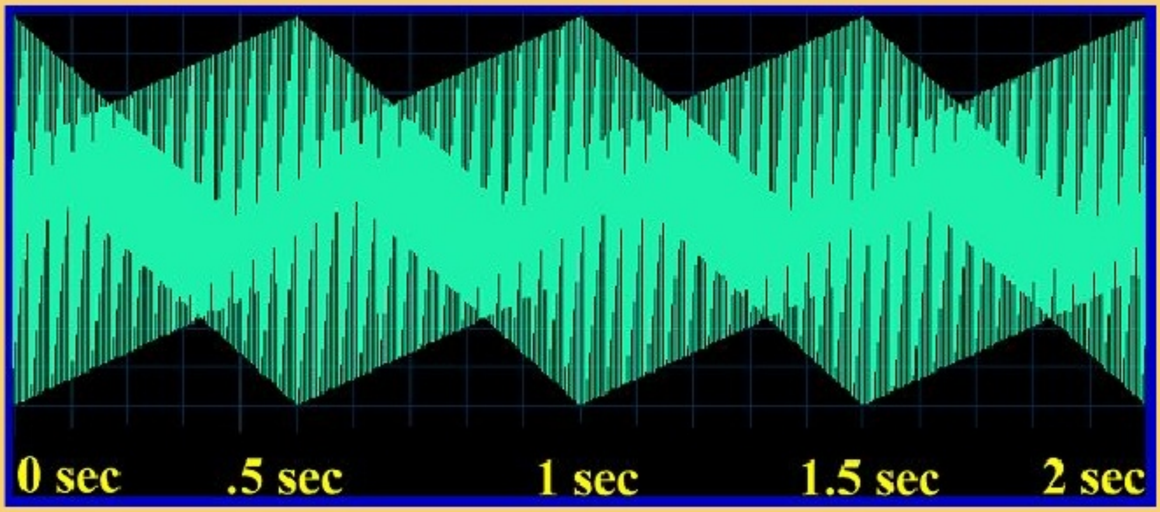


220 Hz
click on the graph to hear the tone



218 Hz
click on the graph to hear the tone

But when these two are played together,
a strong beating effect takes place:



220 Hz plus 218Hz
click on the graph to hear the beating tones

If we now gradually change the frequency of either of our tones, the beating will become faster or slower. For example, if instead of sounding 220Hz and 218Hz, we sound 220Hz and 216Hz, the beating will occur four times per second. The two tones are further from being in tune than before. Continuing in that direction, as our second tone is moved further and further away from the first the beating becomes faster and faster, until the ear can no longer distinguish the individual beats, at which point we're back to making nothing but useless noise.

But if we move the other way, bring the tones closer together, the beating becomes slower. At 220Hz and 219Hz there is only one beat per second. At 220Hz and 219.5 Hz there will be one beat every two seconds. As we get very close to perfection, the beating becomes ever slower and again it will be difficult or impossible to hear, even though it is still present (we'll deal with the problem this creates later). And of course at 220 and 220, there is perfect harmony, with no beats at all.

A drone sliding section seen high on its tuning pin (left) and low (right);
The longer configuration results in lower pitch.

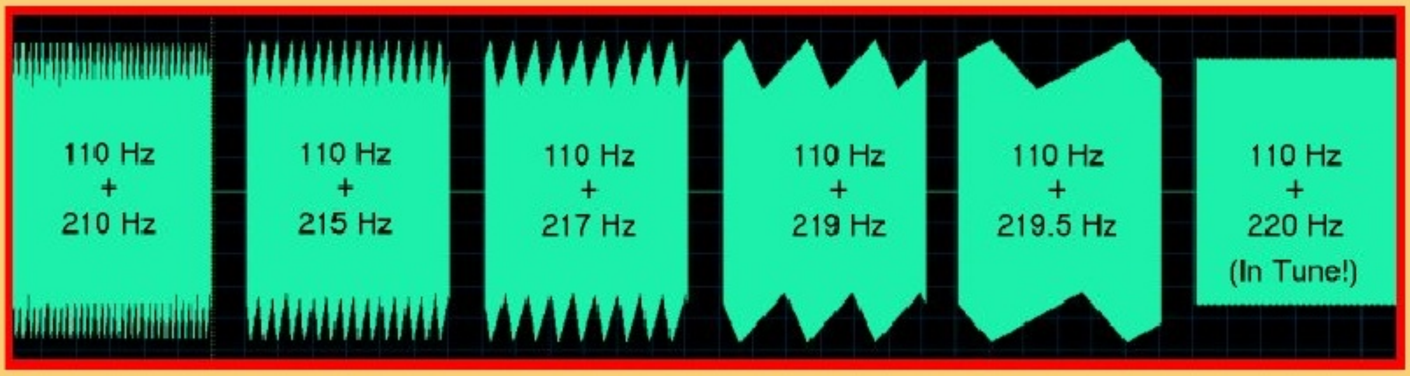
Importantly, this effect is not limited to two tones that are close to identical in frequency, as in the above example. The beating will occur in the same fashion between a number of different combinations of tones that have simple mathematical relationships - that is, tones that when in tune with one another produce harmony will produce beating when they're a bit off. For example, if one tone is 220 Hz and another is almost but not quite double that, or half of it, beating will take place. This allows the beating effect to be used to tune the bass drone, tenor drone(s) and chanter to one another.

Below is another sound sample, in which the slowing of the rate of beating can be heard as a (simulated) tenor drone is brought into tune with a bass drone:

Drones Moving Into Tune

Here is a graph and a corresponding sound file simulating a bass and tenor drone being brought into tune. The bass drone stays at 110 Hz, while the tenor, starting at 215 Hz, is brought up to the correct pitch, 220 Hz. For demonstration purposes the sequence, which runs from left to right, is divided into six steps, each of which is constant. In actuality the movement, both graphically and in pitch, would of course be

continuous rather than in steps. The tenor drone is being raised in pitch, therefore it is being shortened. Note that the last step before the two tones are in tune is only 1/2 Hz (which produces one beat every two seconds).



click on the graph to hear the steps

Nuts and Bolts:

So, that's pretty much the background. This essay will conclude with some practical suggestions but, again, this material is not intended as a tutorial. There are a number of relevant matters that are not touched on at all here, or that are simplified.

The First Step: Steady As She Goes

Tuning a bagpipe is different than tuning any other instrument because bagpipes differ from other instruments both mechanically and musically. Mechanically, the (Highland) bagpipe is really four instruments - the melody pipe (chanter) and the three drones. All four pipes are driven by the same air supply, and thus the reed of each must produce a desired pitch at the same air pressure as each of the others. If pressure fluctuates (intentionally or otherwise), the effect on one reed may not be the same as on another, and the bagpipe falls out of tune with itself - that is, one or more of its individual pipes may no longer be in tune with one or more of the rest. Furthermore, the reeds are tucked away out of reach of the piper, who thus cannot make reed adjustments affecting pitch with his lips, as does a clarinet, oboe or other reed-instrument player. So, to

successfully tune a bagpipe, it must first of all be operated at a constant, steady pressure. This is a mechanical, rather than a musical, requirement. It is fulfilled through practice. The objective is to make the back-and-forth supplying of air, by alternately squeezing and blowing and squeezing and blowing, seamless and (importantly) automatic.

This process is fundamental and critical. It is not really part of tuning a bagpipe as such, but without having mastered it, the rest is impossible!

The easiest way to train the ear to hear and use the beating sounds is to experiment with the two tenor drones, or one tenor drone and the bass drone, of the Highland pipe, with the chanter stock corked off and the likewise the third drone either removed or corked at its business end. Fire up the two drones and slowly shorten and lengthen one of them until you detect the beating. Once you hear the beating, move the sliding section in the direction that causes the beating to become slower. Keep going until you can't distinguish the beating any longer - the drone you've been adjusting is now very close to being in tune with the other one. Now go even further in the same direction, and soon you'll start hearing the beating again as you go past the point of perfect unison. Go even further - the beating will become faster and faster until you can't distinguish it (watch for the cat, the dog, and neighbors carrying club-like objects at this point). Now go back the other way, towards being in tune, with the beating again slowing. Again pass the point of unison as the beating disappears, and note how far you're moving the drone section before you can again pick up the beating. What you want to do is develop a feel for the area in which you lose the beating when it becomes too slow to hear - the center of that area is the point of perfection. To land exactly on that sweet spot using only the beating as a guide, you'll need to split the distance between losing and regaining the beating sound. It's like dialing in a station on an old-fashioned radio or adjusting a TV antenna on the roof (for those of you who remember those days...): Find the sweet spot by going back and forth past it, and then zero in on it.

Roughly how far must a drone sliding section be moved to get from the point at which beating is heard to the point where the pipe is in tune? Well, a GHB bass drone is about 32 inches long when playing (depending on a number of things, that measurement may vary by a few inches) and a tenor drone is about 16 inches long (this because half the length produces a sound one octave higher). If the target frequency for the bass drone is 110 Hz (a concert-pitch *A*), and the drone is currently sounding, say, 105 Hz, simple math reveals that it will need to be shortened about 1/20th of its length to bring the pitch up to the desired point. This would be about an

1/20th of its length to bring the pitch up to the desired point. This would be about an inch and a half. If the drone is closer to the desired pitch, say within 1 Hz, the movement would be much less, about a quarter inch. We have seen that half a Hz is easily heard, and an eighth of an inch will change the pitch by that much. A tenor drone is twice as sensitive, so the corresponding adjustments are half the distance - 1/16th of an inch will be significant.

What may not be obvious but must be remembered is that the beating will be the same whether the drone you're tuning is too high-pitched or too low-pitched. The math is the same in both directions - 220Hz on one drone and 218Hz on the other drone will produce two beats per second, but so will 220Hz and 222Hz. Now, a well-practiced (or naturally blessed) ear will detect the 222Hz as sharp in relation to the 220Hz and the 218Hz as flat, and so its owner will know right off in which direction to move the drone to approach harmony. Everyone else, however - and that's most of us - will often simply resort to sliding the drone top in a random direction to start, and if beats don't develop then reversing and looking in the other direction. The object is to get into the beating zone, and it doesn't really matter if you land above or below the other drone's pitch as a starting point.

Remember that with all else being equal, a shorter pipe will produce a higher pitch than a longer one. Many pipers substantially lengthen a drone that is to be tuned, flattening the pitch well below the target, and then bring the sliding part downward, shortening the overall length and thus raising the pitch gradually into the beating zone. By throwing the drone to be tuned well off to begin with, the question of what direction to move to begin with is answered, and many people find that moving a drone section inward can be done with more physical control than moving it outward. (This also eliminates the embarrassing possibility of moving a drone section right off its pin while tuning.) But it's a matter of taste (and your instructor's wishes) and there isn't any fundamental difference between entering the beating zone from above or below.

Rotating the movable drone section while moving it can be helpful in making fine adjustments smoothly, as the hemp wrapping on the tuning pin acts a bit like fine screw threads, and having the sliding section in rotary motion when lengthening or shortening it will help prevent any jerkiness.

With an understanding of the above and some practice, it is possible to quickly and accurately bring any number of drones into tune with one another. But tuning drones to one another at some random basic pitch doesn't ultimately do a thing for having an in-tune pipe overall. It will do no good to have the drones in harmony with each other if the chanter notes don't also harmonize with them.

Tuning the Chanter

As already discussed, the GHB chanter is nominally in the key of *A*, and the drones sound *A* also, one and two octaves (tenor and bass drones, respectively) below the chanter's low *A*. So it would seem that all that needs to be done to tune the drones to the chanter is to sound the chanter's *A* and, using the technique outlined above, tune one drone to it. Once one drone is in tune with the chanter, the other drones are started and brought into tune, one at a time, until the chanter and all three drones are humming along sweetly. Ah, if only it were that simple! Before tuning the drones to the chanter, the chanter itself must be in tune, or in "balance" with itself. In other words, the chanter must play a correct, true scale. It will do no good to have wonderful harmony between one, or a few, of the chanter's notes and the drones if other notes played on the chanter combine with the drones to sound like a panicked cat.

But tuning a drone to the chanter's low *A* is indeed the place to start. The process is exactly the same as already explained - hunt for the beating zone with a drone while playing the chanter's low *A* (which is played by covering all but the lowest fingerhole on the chanter). But right off there's a mechanical problem. It takes both hands to sound the chanter's low *A*, and most people can't reach a drone with their teeth to tune it.

There are two solutions. One, which requires some experience, is to simply let go of the chanter with the bottom hand, move the drone a bit, replace the hand on the chanter and play the *A*, listen for beats, let go again & move the drone again, resume playing the *A* and again listen for beats, and keep doing this. When beats are heard the process is continued, listening for a slowing of the beating on each adjustment, and eventually zeroing in on the "sweet spot." This sounds awkward and it is, but an experienced piper who has developed both an ear for the pitch and a sense of how far a drone must be moved can do this quite quickly.

The other method, perhaps more suitable for the beginner, for experimenting, or for when other complications (such as work on the reed) are involved, is to temporarily cover the three fingerholes that the index, middle and ring fingers of the lower hand would normally cover, thus freeing that hand to reach the drone. The covering can be tape (plastic electrical tape is best) or it can be a simple device made for the purpose, called a "third hand" (available through us).

Once the drone is in tune with the chanter's low *A*, the high *A* is played, with the drone still sounding. Since the high *A* is played with the three just-discussed lower-hand fingerholes closed, the tape or third hand is left in place. With a whole lot of luck the high *A* will be in tune - but probably not. It will be either sharp or flat. It may be so far off that no beating can be heard. What needs to be determined is in which direction it's off - sharp (too high-pitched) or flat (too low-pitched). Move the drone one way and then the other until beating is heard, and then zero in as before. If the drone was shortened - raising the pitch - to get it in tune with the high *A*, then the chanter's high *A* is sharp relative to its low *A*; conversely, if the drone was lengthened, then the high *A* is flat. If you've lost track of whether the drone ended up longer or shorter, re-tune to the low *A* and repeat the process, paying special attention to the drone position. By starting over several times and moving the drone only one or the other way each time it will become clear whether the high *A* is sharp or flat.

Let's assume that the high *A* is found to be flat relative to the low *A*. Obviously it will do no good to just tune the drone to this flat high *A*, because then the low *A* will be out of tune with the drone. So, the high *A* needs to be sharpened - raised in pitch -

out of tune with the drone. So, the high *A* needs to be sharpened - raised in pitch - relative to the low *A*. There are several methods by which the pitch can be raised, including adjusting the position of the chanter reed in the chanter, working on the reed itself, and operating the pipe at a different air pressure (see box above regarding air pressure).

A basic and very important principle is that adjustments of any kind will have a greater effect on the higher notes of the chanter than on the lower ones. This has to do with the way chanters are designed, and with the nature of the musical scale. So if we do something that raises the pitch of the higher chanter notes, it will also raise the pitch of the lower notes but not by as much. This allows us to make relative adjustments between notes - otherwise, if adjustments affected the entire chanter equally, a change would merely change the overall pitch of the entire chanter, without changing the balance of one end to the other.

Working on the reed itself is beyond the scope of this essay, and operating pressure is yet another subject, so for now we'll only discuss making an adjustment by changing the position of the reed in the chanter. Our high *A* is flat, which means we want to raise its pitch. A shorter pipe, as already described, produces a higher pitch. The length of the chanter includes the length of the reed, so the chanter length can be shortened by seating the reed deeper into its seat. It may be necessary to remove some of the wrapping at the bottom of the reed to accomplish this. Once the reed is seated more deeply, repeat the entire tuning process beginning with the low *A*.

If the high *A* was sharp to start with rather than flat, we would seat the reed less deeply, thus lengthening the system. Again, these adjustments will affect the high notes more than the low ones.

Eventually (and hopefully, if something else isn't drastically out of whack) a position will be found at which the low and high *A* are both in harmony with the drone, and thus of course in harmony with one another.

Chanter Construction

The length and shape of the chanter's bore, the size, shape and position of the chanter's fingerholes, the internal finish level, the thickness of the bore walls, and not least the design of the reed all determine what notes a chanter produces at a particular operating pressure. The pipe maker has, we hope, constructed his chanter so that all of these factors work together properly, with the result that it is possible to tune the chanter correctly. Bagpipe chanters in general and the GHB chanter in particular are extremely high-

performance, ultra-sensitive devices. Tiny variations in any of the parameters mentioned can have very large effects. Even natural expansion and contraction of the wood can cause significant changes.

Inconsistently-made chanters (along with bagpipes and practice chanters) constructed of random wood (often called "rosewood" or "cocus" or such, which are meaningless terms unless accompanied by the Latin name), such as those made in Pakistan and hawked on eBay and by darling little high-brow "Celtic" music shops festooned with harps and dragons, are rarely tunable without major hassles and are most often simply hopeless. When you see Pakistani bagpipes for sale in a shop or on the Web, clamp both hands on your wallet and head for the door. The predators behind the counter know perfectly well what sort of rubbish they're peddling, and their hope (and experience) is that you will blame yourself, or bagpipes in general, for the pathetic squawkings of these miserable bundles of kindling.

So now we have a chanter that sounds good together with the drone(s) at the top and bottom of its scale. But what about the middle notes? Because of all the variables, it is as likely as not that one or more of the middle notes will be off - either sharp or flat. If a middle note sounds "off," check it with the drone-tuning technique and determine if it is sharp or flat. This will not be easy or even possible in all cases - the beating technique has its limitations, especially when trying to tune the notes that do not have simple and direct mathematical relationships with one another. Beating is easily heard when approaching some target intervals but not others. If we are tuning to an octave, beating when we're close will be strong. Beating when approaching other intervals may be less obvious or absent. But at least some of the middle notes can be set in this way, by beating them against a drone's *A*. For example an *A* and a D or an *A* and an E both are powerful harmonic combinations that produce strong beating when they're out of kilter. (Again, it is beyond the scope of this article to detail the reasons for these differences.)

Traditionally, pipers used beeswax applied in small amounts inside the top edges of individual fingerholes to change the relative pitch between notes. By filling in part of the upper edge of a fingerhole, the hole is effectively moved downward on the chanter, thus lengthening the bore above it and flattening the tone. So a note that is sharp can be adjusted this way. Today, most Highland pipers accomplish the same thing by covering the upper edge of a fingerhole with a wrap of thin black plastic tape rather than using wax (which requires more fussing around).

Tape applied across the upper edge of a fingerhole to flatten pitch (left hole); beeswax performing the same job (right hole).

However, the pitch of a note cannot be raised using tape - blocking off the lower edge of a hole won't do that. The only way to raise the pitch of the note produced by a single fingerhole without affecting the pitch of any other note is to physically remove material from the top edge of the hole, thus moving it upward on the chanter. This is essentially an irreversible adjustment and should only be undertaken by someone who has the knowledge and experience to, first of all, be certain that it is really necessary and/or desirable and, secondly, who has the skill to carry it out properly. Such changes can affect the tone quality of a chanter as well as the pitch, or have other subtle effects that may not be desirable. The subject is beyond the scope of this article, but here is a very interesting overview of the practice, especially as it relates to pipe bands, kindly provided in a letter by a visitor from Australia.

So, are we stuck if a flat middle note needs to be raised to be in harmony? No, but here's where it gets tricky. A possible solution is to re-set the reed further into the chanter, sharpening the offending note enough to get it into tune. But that's going to make other notes sharp. Those notes can then be brought back down to pitch with tape. It's not unusual to see Highland chanters with tape on numerous holes. Eventually this can become quite a juggling act. There are also other problems that can arise - occluding more than a little bit of a hole can affect tone and volume. Ideally, it shouldn't be necessary to tape more than a couple of holes, if any at all, especially if the pipe is being played solo. If a chanter can only be brought into tune by massive taping, it may be time to look for other solutions, such as working on the reed itself - which again is not something that's up for discussion here.

Bagpipes by their nature are affected by a large number of variables, many of them out of the control of the piper while the pipe is being played. Getting and keeping a bagpipe in tune is a challenge under the best of circumstances, and without an bagpipe in tune is a challenge under the best of circumstances, and without an understanding of the fundamentals involved it's just about hopeless. I hope that this essay has provided an understanding of at least some of the basics, both for the beginning piper and for others who are curious about this unique and wonderful instrument.

~ Oliver Seeler, Albion, California, May 2004

Your Comments, Please...

This has been a much more difficult (and time-consuming) essay to write than I thought it would be, because I wanted it to be useful for both the novice with little or no musical background and the professional who knows a lot about music but nothing about bagpipes. I am very much interested in hearing suggestions, criticisms and comments of all kinds on the above - please let me hear from you! (Email link below.)

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A Letter On Carving Chanter Fingerholes

On December 21, 2004 we received the following interesting letter from piper Andrew Fuller of Adelaide, Australia regarding our now-modified blanket recommendation in this essay to not carve chanter holes in order to achieve desired tuning:

Dear Sirs,

I read Mr Seeler's article "Tuning the Bagpipe" with great interest. It is indeed a well researched article and is also very entertaining and witty. Thank you.

I'd like to make one comment, however, regarding your statement that "many chanters" have been ruined by carving/removing material from the holes and that carving should be avoided. No doubt many chanters have been ruined by excessive practices, however from a band perspective my experience with carving holes has been a very rewarding one and I'd encourage you to research this more as you will discover it is 'the norm' in this day and age.

I've played with several grade one pipe bands, most notably Victoria Police Pipe Band (1998 World Pipe Band Champions), and the tune-up regime has, with a few subtle differences, been the same in every band. Victoria Police (Vic Pol) was regarded as having a very "broad", "accurate" and "powerful" sound and yet we didn't play 'big' gut-buster reeds. The power of the sound came from the accuracy of tuning and the harmonics we achieved.

It has been my experience that every top grade band, for as long as I can remember, has carved holes (mostly undercut) to achieve the desired tuning. This practice, in the hands of the right person, is very effective and quite safe. When Strathclyde Police were dominating the pipe band scene their Sinclair chanters had holes that were so big one could barely cover them and yet the sound was sweet and deadly accurate.

The Sinclair chanters (at Vic Pol), after individual testing, were carved typically on B, C, D, a bit on E, F and a bit on High A. The other notes were typically needing to be flattened once the 'balance' of each chanter had been identified. The carving was overdone to allow for some scope to further sharpen the note by lifting the tape. Tape was then used to control the size of every hole and we would then seat the reed in its optimal position to ensure that

holes were not over-taped
tape coverage was relatively equal on each hole
the chanter felt and sounded 'free' and vibrant
the scale was harmonically accurate against the drones
desired pitch was achieved

Those responsible for tuning the Vic Pol pipe corps would always tune their chanters against their drones to get the intervals correct and a harmonic effect on every note. Electronic tuners were never used to set notes on the scale, it was always done by ear. Tuners were only used for setting the drones of the whole pipe corps en masse.

Carving holes also enabled the band to work around variable playing conditions (ie wet, cold, hot, dry etc.) but note due to the design and physics of the chanter (thicker walls at the top and thinner walls at the bottom), temperature is conducted at differing rates eg the bottom hand will usually change quicker than the top hand due to there being less material therefore faster conductivity of temperature. In fact, all notes move at differing rates due to the taper of the internal bore of the chanter which gradually thins the walls towards the bottom. This is why tuning to Low A, when the pipes have come straight out of the box, can be risky (especially in cold conditions). Low A (bottom hand in general) climbs in pitch quite quickly during the initial warm-up period and this can result in 'tail-chasing' if the piper is inexperienced and has put all his or her eggs in the Low A basket - ie they tune to Low A but the top hand sounds sharp against the drones so they tape-down the top hand notes without realising the bottom hand is actually flat (but won't be for long!) which eventually results in a bottom hand that then gets up to running temperature (and would have balanced-up with the top hand had it been left to settle) and a top hand that is now flat (because it was flattened when it was actually more accurate than the bottom hand in the beginning). Sometimes E is a better reference point when first starting up as it rarely changes at the rate of Low A due to there being more timber/material at that point of the chanter. It also allows the piper to gain a better appreciation as he or she can hear the bottom hand coming up to meet the drones that are tuned to E as they warm-up their pipes.

There are no two reeds alike but generally speaking there is a certain position in the reed seat that will best suit a particular reed/chanter marriage. The opposing view (of driving a reed into the seat to lift certain notes and to avoid carving) can have a dampening effect on the overall tone of the chanter. This is because the reed can sometimes be 'strangled' and cannot vibrate as freely if it is seated well into the throat of the chanter. It can also lead to that dreaded double tone on F that pipers fear.

Carving holes allows each individual note to be isolated from the others and enables accurate and fast tuning with more options available at the time as opposed to uncarved holes that still ultimately rely on reed manipulation. In Vic Pol we almost forgot what our chanter reeds looked like because it was virtually all done with tape, 'cold steel' and a reed of good tonal quality. Furthermore, the less tampering with a reed the more likely it is to last longer than a reed that is constantly handled, plus it is more likely to remain stable and reliable and in the end that's what this caper is all about.

I've done my best to make sense but it's a topic that always promotes healthy debate. This subject can also indicate the 'vintage' of each of the protagonists. I've always subscribed to the 'horses for courses' debate when it comes to solos but for bands I have experienced the pinnacle and would not sway my views.

I hope this has provided another point of view.

Cheers and good piping!

Regards

Andrew Fuller
Adelaide, Australia

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