

## THE GRAPH AND THE COVERED HOLE FLUTE

The principles I have talked about so far concern a covered hole flute with the same large size holes throughout the octave length; however nobody wants a flute like this: – it may give a powerful, strong low and middle octave but I fear one would run into difficulties with the top octave – extra stubborn top E3, F#3, G#3, A3 being the worst notes. We must therefore reduce the hole diameters to give the flute a better balance between all three octaves; most flutemakers use three or four diameters within the octave length.

The object of the graph is to give the distance that a hole must be moved when reducing the diameter yet keeping the pitch of the note the same. I have used my graph for years and have found it accurate – it was arrived at by logical reasoning taking measurements from existing flutes at the point where diameters change. I am not suggesting that this is the ultimate way to do this, but at this point in time I have not found anything better.

For calculating any scale I think it is always best to use a C1 to C2 hole octave length as a basis whether it is a piccolo alto or bass flute. The obvious way to check an octave length when playing a flute is to firstly adjust the head-joint to give a correct A; then play a low C1, it does not matter if you have a C or B foot-joint, then having got the pitch firmly in your mind over-blow and play the octave C2 from the low C1 fingering, having satisfied yourself that you are blowing a perfect octave, then compare the over-blown C2 with the normal fingering of C2. They ought to be the same pitch. If the normal C2 is sharp then your octave length is too long and vice-versa; by adjusting the head-joint to get both fingerings of C2 the same pitch, the flute should be best in tune with itself but you may well find that you have strayed from your original A. It must also be remembered that some flutes may have an extra sharp C2, or an extra flat low C1 which would make the octave length too long only on one side of the A1 hole, or put another way the A1 hole is in the wrong position within the octave length for whatever pitch was intended.



*With Lewis Deveau at the Boston Flute Convention in 1980.*

## THE HOLE DIAMETERS

The next thing to decide is what size holes make the best flutes. This is difficult to answer and opinions between players may well differ. I can only suggest limits to keep within although I do have certain definite ideas about the closed G# and C2 thumb holes. Some hole diameters within the octave length are more important than others. Foot-joint holes are acceptable to me any size between .600 and .617 inches. I have it in mind on some future occasion to make an experimental foot-joint with a larger diameter D# hole than the D1; the object being to widen the D#1 to D#2 octave; or a smaller D1 hole may help narrow the D1 to D2 octave. It is difficult to measure the sharpening and flattening effect of the opening of the small C# hole on these octaves in relation to the foot-joint hole diameters – the small C# hole could be the governing factor irrespective of the foot-joint diameters.

As previously stated the larger the hole the wider the octave, but any difference within the sizes I am suggesting will be so very little it can almost be ignored. As for the four right hand holes of the middle joint any size between .547 and .562 inches is acceptable and is usually found on most modern flutes.

The left hand holes I think should be given the most thought. On many flutes the C2 thumb and closed G# are a smaller size than the B, A# and A – this idea I assume comes from the Louis Lot flute. Exactly why Louis Lot chose to do this I can only guess; probably to keep these holes as far as possible from the water line – the closed G# is even oval shaped to help this further. I do not like this idea at all. These holes usually average about .496 to .500 inches and a smaller cup is used than that found on the main line. I much prefer to see larger hole diameters even if it means a larger cup as is used in the line. The smaller size C2 thumb hole is a good idea for top G#3 – it undoubtedly makes it a better note to tongue pianissimo using the normal fingering. The main disadvantage of these two smaller holes is that it makes top C4 sharp, and if the G# hole is oval it will tend to make it more difficult to produce. I much prefer the same diameter as the left hand holes in the line (but not larger than .522 inches) for both these holes, the octaves are wider and better in tune, the quality of sound is better because of the extra venting, top C4 is a shade flatter because both holes are further from the embouchure and the C2 hole gives a much needed venting support to C#2 and C#3. I do not regard the G# hole as nearer the water line than a Louis Lot oval hole; on the flutes I have made this hole is placed further back towards the rib and the back is angled well down to give maximum clearance under the trill keys; to avoid any weakness in the cup arm and to help get enough key rise without touching the trill keys I have often made a bent arm to give the key strength. This size of .522 inches maximum for the G# hole is important because if it is larger, when slurring from G#2 to D#3 it could become difficult – there is a tendency to get some higher harmonic in this particular interval. The B, A#, and A holes usually average between .511 and .535 inches. I prefer on a standard covered hole flute to keep all left hand holes the same size; I would think it gives the best chance to keep the low to middle octave even. Taking all makes of flutes into consideration I hear more criticism about the left hand octaves than the right hand octaves. The larger the B and especially the A# hole the more stubborn top F#3 will become and also top B3 suffers. While it may be true to say large holes produce the best sounding middle octave (and most playing is done in the middle)

to have the best balance throughout it is best to compromise, and that for me means .522 inch hole diameters on the left hand. Having damned any smaller diameter there is one exception – that is the duplicate G# hole in the line. Here it is probably best to use a .496 or .500 inch hole to give top E3 and A3 slight assistance; this need not apply to flutes with a split E but I would use it as well, to assist top A3. The only possible disadvantage that I can see is that it may make certain fingerings of top G3 and A3 trill very slightly more difficult where the A and duplicate G# holes actually do the trilling.

Regarding the top octave, and here I refer mainly to all notes from D#3 to G#3, most players seem to think the smaller holes, not less than .511 inches, give the best results. This may well be so; I am just guided by majority opinion. As stated previously top G# is usually very slightly sharp and can be flattened and the attack improved by closing the E and F holes on the right hand. The half closing of the C2 thumb key from the closed G# key has a similar effect and is automatic. This idea has a great appeal to me – it rectifies the disadvantages to top G#3 suffered when its diameter was increased to .522 inches with the added bonus that it flattens further top C4 and to my mind, makes it perfectly in tune; however, it is not worth applying the half closing idea to C2 thumb holes with diameters less than .522 inches. Also it works best on C foot-joint flutes. Some players find it sufficient if it only closes by a third. It is an optional extra, not an essential.

If one prefers to measure a scale from the head-joint end of the middle joint, or even from the embouchure, this can be done. I always prefer to work from the foot-joint tube end when producing one-off flutes because I find it is more accurate to mark off the centre joint having already applied the foot-joint tone holes and box; working the other way round it does not seem right to fix the D# tone hole after the box has been applied because usually they touch. Drawn boxes are good but I prefer the applied ones.

Accepting that the A hole is never wrongly positioned, A being the tuning note one always adjusts the head-joint for the correct pitch required, I am often asked about the distance from the embouchure to the A hole. No definite measurement can be given for various reasons which will be mentioned later.

I feel it is best that head-joint length should be the same for all pitches; the total length of the combined centre and foot-joints should get shorter as this is better for the interchange of head-joints.

I also feel flutes should be marked for the pitch they are intended A440, A442 etc., as a guide for the flutist, something I regret not doing in the past.

## THE OPEN HOLE FLUTE

Open hole flute measurements are not the same as covered hole measurements — at least I do not think they should be. On my flutes I have made adjustments to allow for the extra venting from the open hole cups. I know some manufacturers have used their same patterns for each model in the past; this practice in my opinion, would be acceptable only if the key rise were taken to an excess. By excess I mean that any flattening effect which the keywork undoubtedly has is removed. However, a flute with such a high key rise would be too uncomfortable to play. As one who remembers handling old Louis Lot flutes which were padded in France, they had a lower key rise than that which is average today. I remember being asked to open up the key rise on these flutes and in so doing all the cork was removed from the tails; obviously the instrument was never intended for this.

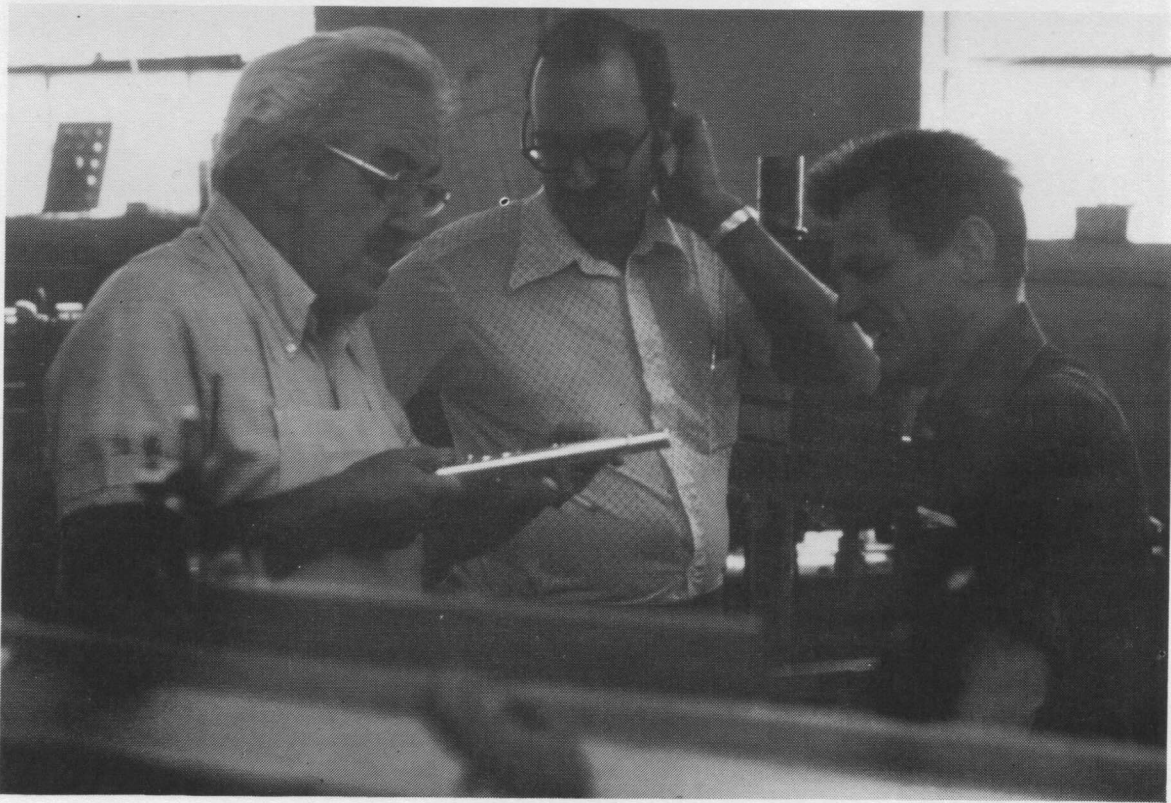


*In my sitting room with Jadzia Michalska*

## KEY RISE

If you open up the key rise on an open hole flute what happens? So far as the low and middle octaves are concerned everything except the lowest note on the instrument will sharpen slightly according to the extent of the operation and depending on what the key rise was in the first place. The notes that have a covered hole key that immediately affects the pitch are more prone to pitch change than the notes that have an open hole key; the extra venting in the first place of an open hole key makes it less prone to pitch change. If I am right about this the key rise of an open hole flute should be established before the instrument is designed, and once decided on it should not be altered by any appreciable amount.

The question is often asked what is the average key rise? For me I always measure it at the F# hole, and for an open hole flute 2.9mm to 3.00mm is average. For the foot-joint however, I prefer to give it a bit more – 4.1mm to 4.2mm. On the middle joint of a covered hole flute one can increase it above 3.00mm if so desired because any sharpening effect would be equal throughout. Although a high key rise in the main may seem beneficial to the sound in general, the bad notes – top E3, F#3 and G#3 tend to become worse. This applies particularly to top F#3 on the open hole flute. If I played an open hole flute and experienced sharpness on C2/C3, B1/B2, G#1/G#2 and G1/G2 I would be tempted to lower the key rise.



*Discussing flute-making with Ed Machon and Bick Brannen.*

## PAD WASHERS AND SCREWS

The pad washer screw on the covered hole keys can also affect the pitch relationship with the open hole keys; if the screw head is too thick it can have a flattening influence in which case the key rise must be opened or the screw head reduced. Actually the type of pad washer used by Louis Lot I think is best — I know that these old screw-on washers are not popular with today's flutemakers and repairers — I am probably the only one still using them. Apart from the very slight venting advantage they offer, I like to be able to adjust the height of a washer in relation to the pad level. With the others once the screw is tightened the washer height cannot be altered. I would have thought that the washer height could affect the pitch of a note, this being so the correct relationship between open and covered keys cannot be over stressed.

I remember a flutist saying to me once "Why make open hole flutes different measurements than covered ones?" He demonstrated on an open hole flute by playing a few low notes and then compared the pitch of these notes by sealing off the open hole key concerned with his finger without closing it. With him playing neither he nor I could hear any difference in pitch change; however this is no test. You must put corks or plugs in the open hole keys exactly down to pad level to make a fair comparison. What the experiment does reveal is how very little air, if any at all, does pass through the open hole key. It seems to me that the area of the hole is just a space for air to circulate more than escape; this hole area in the centre of the pad undoubtedly has a sharpening effect and a correction in hole position to compensate is essential.

I have said previously that I prefer the screw-on type of pad washer; there are also the American plastic ones which simply press on. These have several advantages as unlike many of the others, they have no hole through the centre which from the sealing point of view gives them a positive advantage, and also the domed smooth shape is more desirable for air to glance off than a screw head extended by a paper washer. Obviously the lower the key rise the more the screw head will be in the way; if a large screw head does affect pitch it must also affect venting. Some flutes do have a very good thin screw head down to pad level and I am sure that venting and pitch are virtually not affected. However, the best screw heads I have seen are ones where the washers are actually countersunk to take the screw heads down to washer level. One disadvantage with all types of washers, except the screw-on type, is that a larger hole needs to be punched in the pad to take the nut; whereas the pad that takes a screw-on washer need only have a hole small enough for the pin. Surely the smaller the hole the better the seal. I accept the argument that screw-on washers tend to twist or crease the skin more, but I have never had any trouble ironing out creases. Pad washers seem to be getting larger and no doubt this is a good thing as it spreads and makes a tighter cushion when the pad impression is close to the edge. These larger washers would certainly twist the skin much more if they were screwed on.

I do not hold the view that large washers improve the sound. I do not know who invented the plastic washer but he certainly deserves some credit. The ideal pad washer I think should be flat or slightly concave, with no hole and should press on easily with some means of height adjustment and the pad only requiring a small hole; no doubt someone will get an idea for an improved design.

Much that has been said about the covered hole flute applies to the open hole flute also. It appears to me that the main unavoidable differences in tuning between the two models is in the left-hand octaves. The G1 to G2 octave is usually acceptable within the hole diameters stated, the G#1 to G#2 is bound to be narrower if the hole diameter is .500 inches or less, the A1 to A2 octave with an open hole key is bound to be very slightly wider; this also applies to the A#1 to A#2 octave. The B1 to B2 octave with a covered hole key is usually regarded as about right, and the C2 to C3 octave I think will be narrow if the C2 thumb hole is .500 inches or less. Of course I am being very critical — most open hole players adjust these very slight differences automatically with their lip and it does not worry them. On the average open hole flute the left hand holes give an odd assortment of venting and wide variations of sound qualities and ease of attack between E3 and A3.

All the hole diameters quoted for the covered hole flute are suitable for open hole flutes, with one exception. The .522 inch hole that has a great appeal to me for all the left hand holes is not suitable for the A hole; for some reason I cannot explain, an open hole flute with or without a split E and a .522 inch A hole makes slurring difficult from A2 to E3; there is a tendency to get some higher harmonic between this particular interval. The .531 inch A hole eliminates this. For the A# and B holes I prefer the .522 inch size; but if all equal sizes are preferred in the line the .531 inch size is probably best. The closed G# and C thumb holes, I think, are best with a .522 inch diameter maximum; smaller sizes are not good for the tuning of top C4 on either C or B foot-joints nor for ease of playing on B foot-joints.



*Three flute-makers: Dick Jerome, John Lehner and Ed Machon*

## TONE HOLE HEIGHT

The question has often been asked what effect does taller than average tone holes have? My guess would be this:— If you have a flute with tone holes .8mm high and it has satisfactory intonation played at A440 and it were possible then to increase the height to 2.8mm what effect would this have? Firstly when you played your A it would be flatter than A440 owing to the extra 2.0mm height at the A hole, so you would push in the head-joint approx 2.0mm to correct this, but what of the other holes? As you went down the scale from the A, I think it would tend to get progressively sharper because the extra 2.0mm added on each tone hole would not flatten each semitone equally, and as you went up the scale from the A it would get progressively flatter. To get the best intonation the flute would have to be played at some pitch higher than A440. Raising the tone hole height I would think shortens the octave length; C2 would be flattened twice as much as C1. Also the increased bore area may have a flattening effect which partially corrects the octave length. Food for thought. What different sound characteristics the flute might have I do not know.

I once played a low C1 on a flute with a B foot-joint and adjusted the head-joint so that it was perfectly in tune with a piano. I then removed the low B key and removed the C1 tone hole and played the low C1 again minus key and tone hole; it was considerably sharper in pitch and a much better quality sound. I then pulled the head-joint out to re-tune low C1 and found that it needed to be pulled out 5.2mm to get low C1 again in tune with the piano. I then repeated the same experiment on the C2 thumb key hole, again removing key and tone hole and found that the head-joint had to be pulled out 2.6mm to re-tune C2 with the piano. This experiment enabled me to measure the flattening effect of the tone hole and key; note that the 2.6mm required for correcting C2 is exactly half of the 5.2mm required for the C1. My efforts at trying to play the flute are poor; I cannot seem to play a note twice the same pitch so these measurements may not be accurate. Assuming for the moment they are, and one wanted to increase tone hole height keeping the positions the same; I suspect it would have to be done starting at the C2 hole on an increasing basis so that the C1 hole has about twice the increase of the C2(?) I have often thought that the flattening effect of tone hole and key should be taken into account for any method of calculating a mathematical scale; no doubt someone will find a formula — I have tried without success.



*With Jane Henkel at the Boston Convention in 1980.*