

THE FLUTE



by Albert Cooper

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To Willb
Best Wishes
Albert Cooper 1981



ACKNOWLEDGEMENTS

I would like to thank all the flute players who over the years have so willingly given their constructive opinions, but who unfortunately cannot be named individually as they are too numerous to list here.

I am grateful to Emmett Day for allowing me to include an extract from his book on flutemaking.

My special thanks to Martin Gordon for his photographs.

Cover photo by Martin Gordon.

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Working at my bench at Rudall Carte, in 1956.

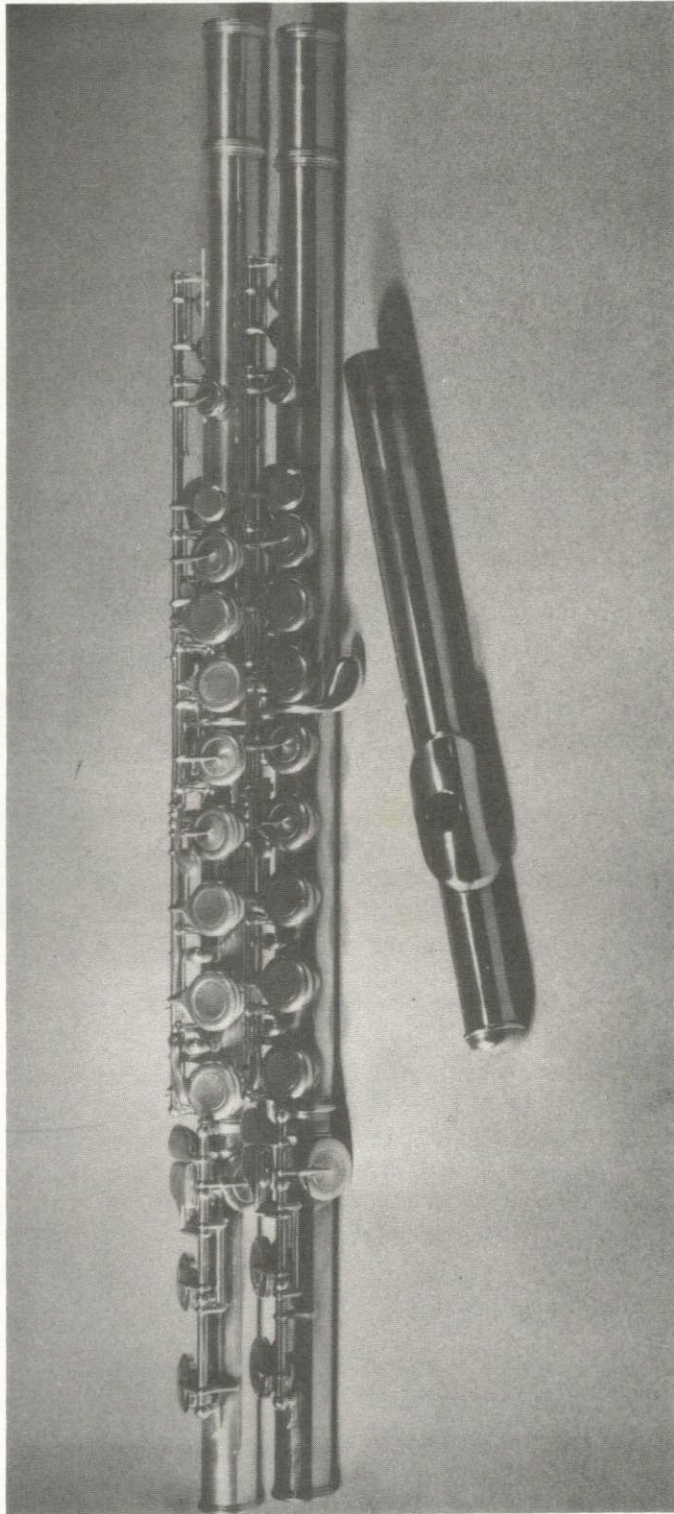
INTRODUCTION

When I first started work at Rudall Carte & Co. Ltd. in 1938 the fashion in flutes was very different than what we see today. Almost everyone preferred a wooden flute. Nobody ever thought about trying to improve the intonation, it was never questioned, the player was told he had a good instrument and it was up to him to play it. Nowadays the player tells the maker what he thinks is wrong with his instrument and demands that it be made to his requirements. Undoubtedly some players are better judges of intonation than some makers. Since 1945 the wooden flute has declined in popularity, they are still produced here in London but the majority of players prefer silver or gold flutes.

I left Rudall Carte at the end of 1958 to set myself up as a flute repairer but soon changed course and decided to become a flutemaker. The difficulties of producing flutes single-handed soon became apparent, especially when one makes all ones own components. The question of what sort of flute to make soon arose. Should I copy an existing make as some others had done, or should I work out an original pattern? As I am not a flute player and advice from players seemed to conflict, I decided to measure up as many flutes of different makes as I could lay my hands on. During my time at Rudall Carte I had been engaged on repairs at various times and had had many different makes of flutes through my hands. I had not failed to notice that a variety of different size tone holes were in use and also the positioning of the holes along the tube did vary considerably. In due course I made a collection of flute measurements. With all this data and comment I was able to arrive at some definite conclusions not hitherto realised. My early flutes were made to a pattern which I abandoned after having used it for about ten instruments.

It was based on the logical reasoning from faults and virtues found on other flutes. I then changed to a mathematically calculated scale which was slightly different and I was soon convinced that it was even better. After using this new scale for several years certain criticisms were levelled at it and I again made certain slight alterations. I now feel that I have more or less reached the end of the road scale-wise.

I like to think that I am a good listener; by that I do not mean I have a good ear for pitch, but that I like to hear constructive comments from players. The London players to me have become the most critical in the world and I believe that I have helped to make them so. We may not always be in full agreement but I hope the majority are on my side. One sometimes hears an interesting opinion from the amateur player; they are by no means to be ignored – this also applies to the student. I feel it would be wrong if I were to learn the art of flute playing and inflict my ideas on my would-be customers. I can always get a good cross-section of opinion just for the asking – which is more valuable to me than the opinion of one man whoever he is. To satisfy the majority is the best aim because no-one can satisfy all.



2 flutes I have made, a gold one in C and a silver one in B.

THE EQUAL SIZE HOLE FLUTE

Should there be any doubt let us confirm the basic principles of tuning. If a hole is made larger it sharpens — and if it is made smaller it flattens. If it is moved towards the embouchure it sharpens and towards the foot-joint it flattens.

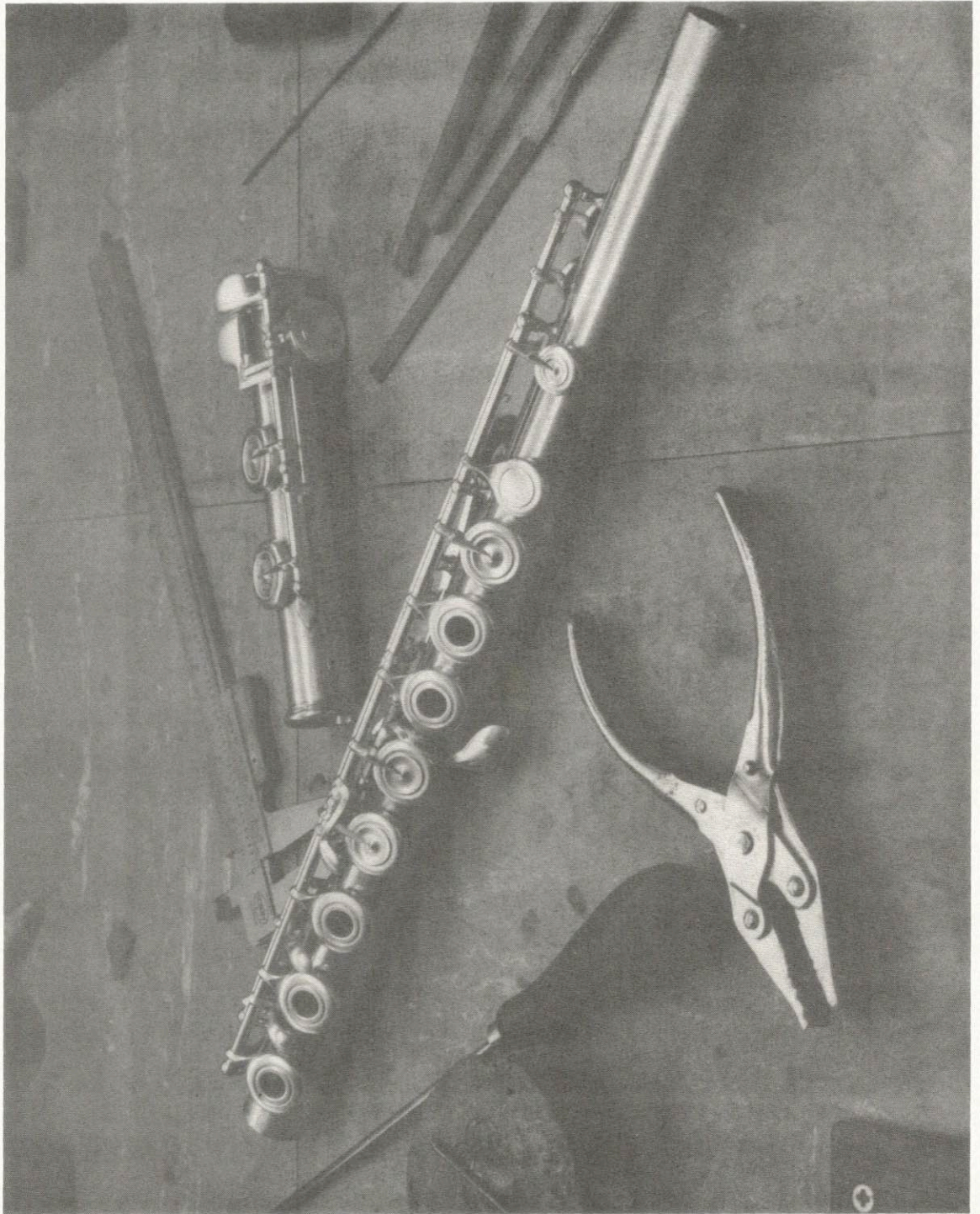
The first thing to establish for any flute is the octave length; by this I mean the actual distance between the C2 thumb hole and the low C1 hole on a B foot-joint measured from the hole centres. All scales begin for a flute with equal size holes — I find it best that the scale is based on the largest size hole desired on the instrument.

In any case to arrive at a measurement for the octave length one must have two C holes of equal diameter whatever size is used. One cannot measure an octave length between different size C holes.

The position of the A hole within the octave length is most important; obviously the interval between C2 and A1, also A1 and C1 must be perfect. These intervals were arrived at by trial and error over a period of years. It must be remembered that the A hole is never in the wrong position, if the A is out of tune it must be corrected by adjusting the head-joint. To arrive at the positions for the rest of the scale a mathematical calculation is used. We now have to divide the interval C2 to A1 into three parts to give us the position for the B and A # holes and the A1 to C1 interval into nine parts for the G # to C # holes. To do this each semi-tone from A1 up to C2 must decrease by 17.835 and from A1 down to C1 must increase by 17.835. Note that I work from the A hole in each direction.

This figure of 17.835 I read in a book on guitar making; it was given for working out the position of the frets on the neck. Boehm's schema was also based on string lengths; however, I do not know if his string lengths are the same as mine. If Boehm's schema is applied to my octave length the A hole appears in a sharper position within the octave length. I suppose you could say it is a sort of two unequal halves of two different Boehm scales joined at the A hole, or is it? The 17.835 method may be different. (?)

I did make an equal size hole flute based on Boehm's schema but it was rejected. However, there is no doubt that Boehm's work is the greatest advance ever made for the flute — this should never be forgotten.



*Martin Gordon's work-bench showing a new Brannen-Cooper flute which he has nearly finished making.
Photo: Martin Gordon*

BOEHM SCALE – BOEHM KEY SYSTEM

Before going any further let us try and clarify some points which seem to cause confusion. All the flutes I have seen which were made by Theobald Boehm have had an equal size hole from the C thumb hole down to the lowest hole on the foot-joint; the sizes may have varied between different instruments, but a constant size was applied to each flute. I have heard that Boehm did make some flutes with a larger hole on the foot-joint only – but I have never seen one. How Boehm made the calculation as to how far these larger foot-joint holes must be moved to keep the pitch the same has never been made known.

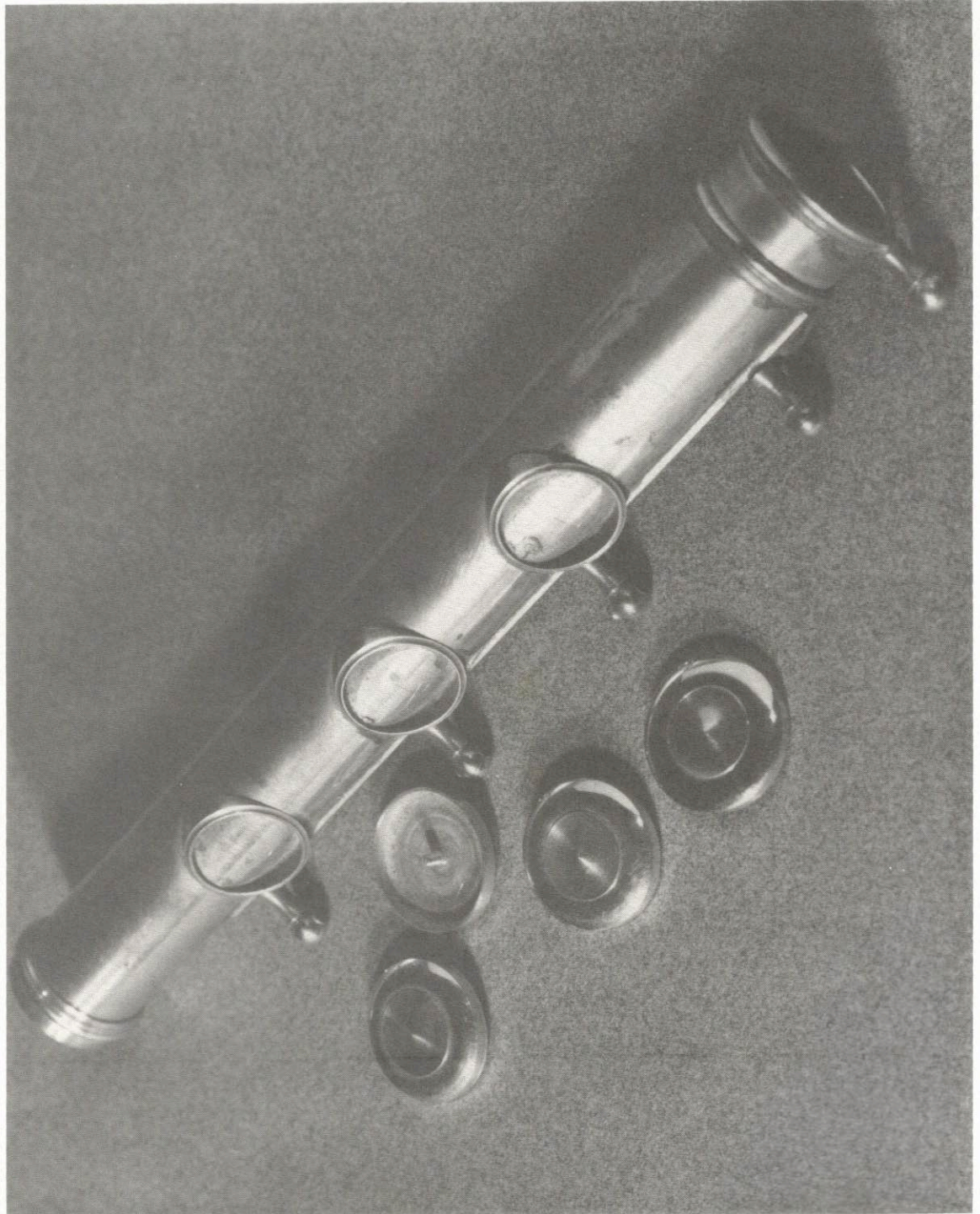
As flutemakers today use at least 3 or 4 different hole diameters it is difficult to compare their scales with Boehm's schema. I did devise a graph with which one could easily convert a modern flute to a Boehm equal size hole schema scale on a drawing board for comparison; the conclusion arrived at was that no flutemaker today based their scales on Boehm's schema, but of course the fingering system remains. Boehm never gave any data on open-hole key-work scales nor to my knowledge did he ever make an open-hole key-work flute.

Old Rudall Carte and French flutes had scales which were used for both open and covered key work which in my view, was a mistake. The old French flutes seem to have been the first to have 3 or 4 different hole sizes on the centre joint (excluding the trills and small C#), the old Rudall Carte flutes having an equal size hole on the centre joint. Where Louis Lot and other old French makers got their scale measurements from is unknown to me – my guess is that they were tuned by ear. However, the old Rudall Carte flutes do seem to have been based on Boehm's schema.

Boehm's actual key-work mechanism remains virtually unchanged to this day and for this we owe him a great debt.



*Eating "Chinese" with James Galway and Alex Weeks.
Photo Michael Emmerson*



*A new B foot-joint which I have not yet finished.
Photo: Martin Gordon*

TUNING THE SCALE

To get the best overall tuning compromise certain holes for various reasons have to be moved from their mathematical positions. The obvious one to start with is the F# hole; Boehm sharpened it quite a lot, allowing for the flattening effect of the E and F hole. I have experimented by not sharpening it at all on flutes that have a Brossa F# key or any other special independent F# key – to moving it nearly as much as Boehm did on standard flutes. As a result I decided on a measurement in between – Boehm's correction was all right for those old flutes made to A435, also Boehm used a smaller hole diameter which would give less venting from the F# and F holes adding slightly to flatness.

The low D1 hole on the foot-joint I flatten slightly to lower middle D2 which I think is very slightly sharpened by the need of having to open the small C#2 hole. In other words the octave D1 to D2 is always very slightly wide; if I am right about this the choice is – a very slightly flat low D1 and a perfect D2 or a perfect low D1 and a slightly sharp D2. As middle D2 is on the break of the scale and C#2 immediately below it is a note which is also a little sharp – you do not want two notes together that seem to belong to another pitch. Most players either adjust the C# with their lip or if time permits close the four right hand holes to flatten it and boost the quality. When playing around the break the less lipping around you have to do the better your performance. There is not much complaint about D1 being flat, it is so slight; in an odd sort of way it seems to add a brightness to D# and E when ascending from low D1; and to low C1 when descending.

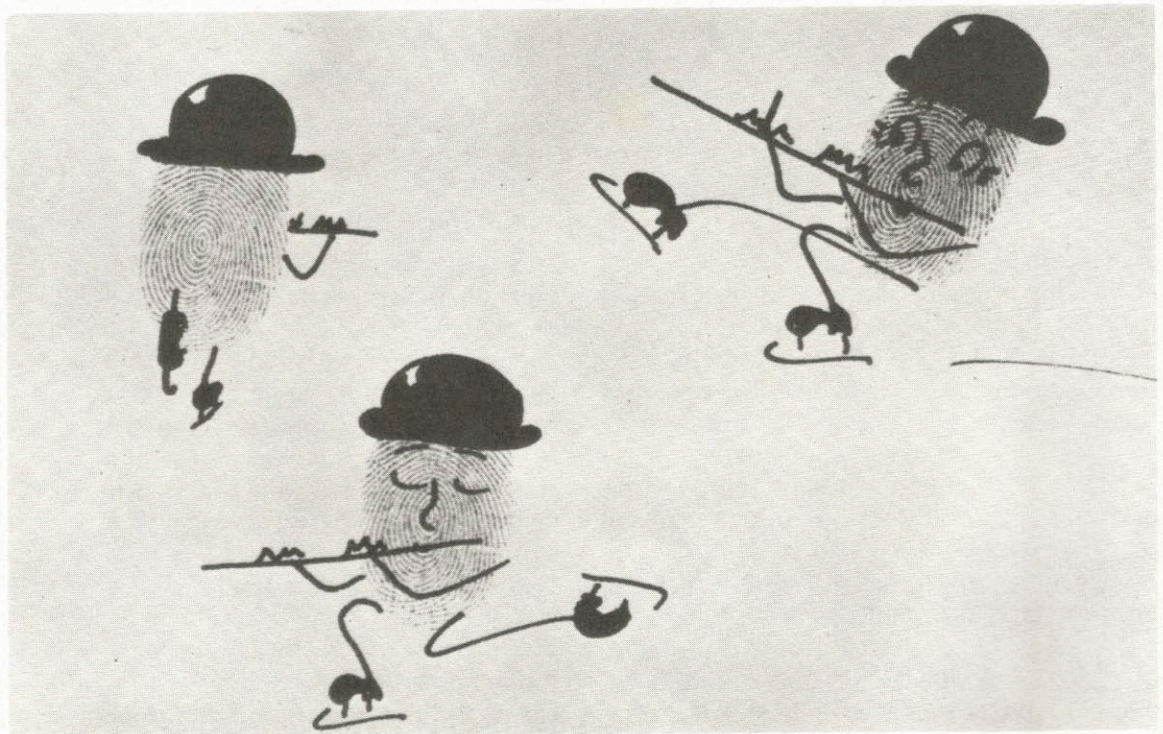
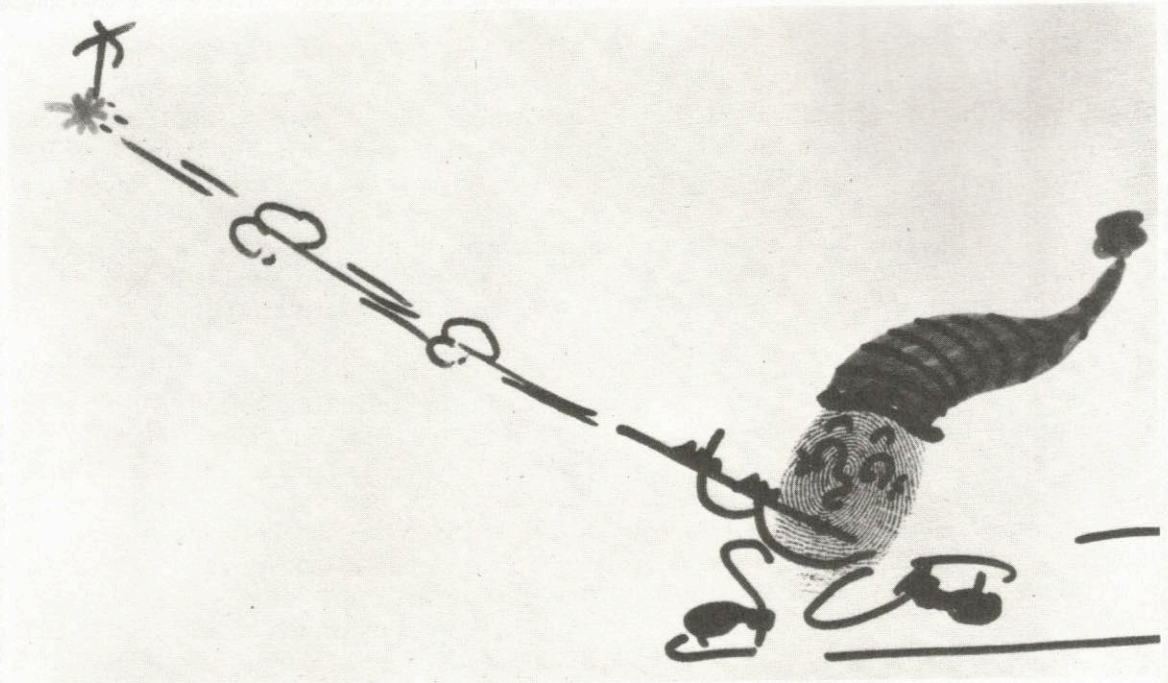
The wide octave between D1 and D2 is much more of a problem on piccolos and extends to top D3 which is prone to flatness. On flutes which to me have been tuned entirely by ear, low D1 always comes out even flatter.

The C# hole on the foot-joint I also flatten slightly to help blend in the evenness of the chromatic scale and deceive the ear.

The small C#2 hole which affects so many notes never seems ideally positioned for any of its functions. Assuming it is in too sharp a position for the perfect D1 to D2 octave it is in too flat a position for the perfect D#1 to D#2 octave. It has been suggested to me that a larger diameter D# hole would help widen this octave. This may be so, but would mean a larger cup and would add to the cost of a flute. Undoubtedly the larger any hole the wider the octave from low to middle, but so very few flutists have complained about it that for years I accepted the situation that perhaps the D#1 to D#2 octave was narrow if anything – and was not worth worrying about. Although I am not easily persuaded to alter tone hole positions, I did decide to sharpen the D# hole slightly, mainly for D#2.

As a general rule it would appear that a note is more acceptable a fraction sharp than a fraction flat if it cannot be perfect.

The next problem hole is the closed G# hole, and this applies to the majority of flutes; open G# flutes seem to be getting scarcer. On closed G# flutes we have two G# holes, one in the main line that does not tune anything directly and the one at the back which obviously affects the G#s. This duplication makes G#1 and G#2 too sharp because the bore



Canadian flute players, by Ellen Cash.
Photos: Martin Gordon

is larger at this point, therefore it is necessary to flatten the G# slightly to allow for this. The G# hole in the line is best positioned half-way between the A and G holes, although this is not best should the flute have to be altered to open G#, but it does allow maximum space for the closed G# key touch-piece and a split E lever to move between the cups.

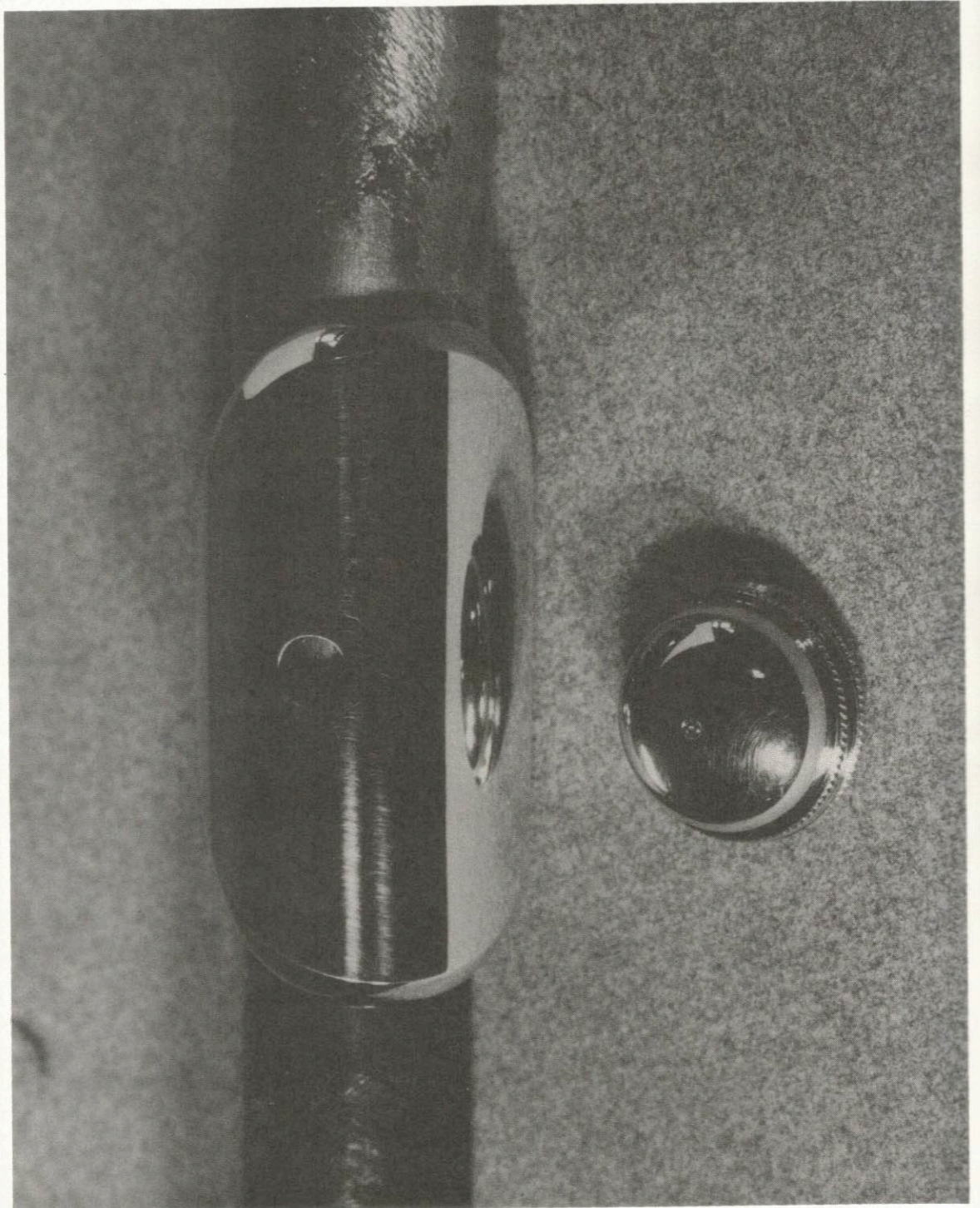
The duplication of the G# holes also affects to a lesser degree the pitch of the A#, A and G, or so it seems to me; these notes need to be flattened slightly by varying amounts. This may be due to other reasons such as inaccuracies in my whole method of approach or the tone hole graph which will be dealt with later.

So far as G1 and G2 are concerned these notes on no account want to be flat, it is better they are slightly sharp as this helps to keep top D3 up to pitch. On open G# flutes I have kept to the mathematical scale from A# down to G, but now I have decided that the corrected positions for A#, A and G are more acceptable, which again points to the fact that my whole approach may be wrong or it is just impossible to arrive at a scale mathematically which is acceptable to the ear of the majority.

Before adding the small C# hole and trill holes to the scale the question of tone hole height must be established. It seems that the old Louis Lot flutes have had a great influence on modern flutes. Of the ones I have examined the tone hole height has varied from .5mm to .85mm. Either of these two heights I regard as suitable, or any one in between; all scales I use are for tone hole heights within these limits. I have always measured tone hole heights (perhaps incorrectly) not taking into account tube thickness – as it varies so little it is not worth worrying about. However, the height must be the same throughout the flute except for the small C#2 hole which should be slightly higher than the others – on the Louis Lot flutes this hole is the same height. The advantages of making it higher are that one can position it nearer the embouchure which helps to keep top D3 and top A3 up to pitch, it also helps widen the D#1 to D#2 octave and also it improves the quality of D#2.

The disadvantages are that it widens the D1 to D2 octave, and sharpens top G#, which however can be flattened by other means which will be explained later; the diameter in my opinion should never be larger than .270 inches, it can be enlarged from .265 (the size I use) to .270 inches should the player feel his C# is flat. I would readily agree that the C#2 is a little sharp; inevitably with such a small hole the octave is narrow. While also agreeing the diameter should be as large as possible to improve the quality of sound, if it exceeds .270 inches a deterioration of sound quality begins to creep in on middle D#. The Louis Lot flute, in my view has this fault – their C# holes are .275 inches. There is nothing new about making the small C# hole higher; I have seen it higher than I am suggesting – but for me it is not the best compromise; the disadvantages previously mentioned are worse. Its best position on the flute was arrived at by trial and error. The best octave C#2 to C#3 is obtained by having the extra trill key for this purpose which we will call the large C# hole, and is usually placed between the C2 thumb key hole and the trill keys and has a diameter equal in size to the C2 hole.

The trill holes again are positioned by trial and error; the D# hole never seems to get criticised, but the D hole is often said to be positioned too flat making top A#3 flat. I have been moving this hole around for years – I have positioned it so close to the D# that the



Lip-plate and crown ready to be engraved
Photo: Martin Gordon

cups have almost touched and even in this position the top A#3 was flat and it also made some of the trills sharp. Some players have said they do not mind the trills being sharp – who can tell the pitch of a note when trilling – most trills are out of tune anyway; position the hole to give most sharpening advantage to top A#3.

The other point of view is the position the D trill hole to give most tuning advantage to the trills, and use some of the alternate fingerings for top A#3 which are better in tune. It is a case of individual preference.



With David Sanders at the Head-joint Convention he sponsored in Rotterdam