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## On Reaming Flutes

It has been suggested that the conical bores of early wind instruments may have been produced by first boring the wood in steps with a series of cylindrical boring bits and then blending the steps with a long-handled tool directed by hand. We believe that this idea is mistaken. In fact there exists considerable documentary and artefactual evidence, from as early as the seventeenth century, to show that from this date, at the latest, conical bores were produced using tapered reamers. Our purpose here is to offer a brief summary in support of this argument, drawing on evidence for the use of reamers in flute-making.

There exists further compelling evidence from men known to us who learned their trade in long-established instrument-making businesses, all of whom used reamers, in many cases reamers of some antiquity. A centuries-old tradition of wind instrument making survives in London, and many elderly makers have been generous in passing on their knowledge. Men who worked for Rudall Carte & Co., a firm dating back to the 1820s, have described to us the tools and techniques used in their workshops; tools and techniques that might, in many manufacturing industries, have been considered old-fashioned a century ago. (For example, a pole lathe was still in use in the Rudall Carte workshops until the 1950s.) The surviving Rudall Carte workers remember Fred Handke, who was employed by that firm for over half a century from about 1905 and who would have learned his craft from older workers such as Edwin Ounsted, who had worked for Rudall Carte and their predecessors, Rudall & Rose, from about 1840. One of the former Rudall Carte workers, John Wicks, comes from a family of wind instrument makers that he has traced back to the eighteenth century. The late James Howarth, born in 1901, was taught by his instrument-maker

father George, who in turn learned his trade in the firm of Alexander Liddle, founded in the middle of the nineteenth century. Such a continuous tradition which, one may argue, probably extends back even more strongly to even earlier times, ensures that there is not, in fact, much mystery about early methods used in the making of wind instruments.

Conventionally, the conical bore of a woodwind instrument is made by first boring a cylindrical hole in a billet of wood, and then by enlarging the hole to the desired size and longitudinal profile using a shaped reamer which also imparts the final surface finish. The simplest modern form of reamer is of a form known to the mechanic as a 'D bit', and has a roughly semicircular cross-section. More sophisticated versions have one or more quadrant sections removed, or even have a number of reverse spiral flutes. The bore is completed first. A bored and reamed joint, with all sockets cut, is held by the bore on a mandrel in the lathe and its outside profile turned.

Older reamers seem usually to have been of a crescent section, with much more acute cutting edges. The earliest known illustration, by Christoph Weigel (1654-1725), merits particular attention (Figure 1).<sup>1</sup> This image, published in 1698, shows a maker of wind instruments surrounded by the tools of his trade, including, on the back wall to the right of the image, a somewhat idealised representation of tapered reamers similar to the surviving examples. A later illustration is found in Bergeron, who provides a (perhaps slightly confused) description of its use.<sup>2</sup>

The earliest known surviving reamers that can be associated with the making of woodwind instruments are those found amongst the contents of the private workshop of James Watt (1736-1819), who, as a young man, is known to have

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<sup>1</sup> Christoph Weigel: 'Der Pfeiffenmacher' from *Abbildung der Gemein-Nützlichen Haupt-Stände*, 1698 (Dayton C. Miller Collection, Library of Congress, Washington).

<sup>2</sup> Michael Wright: 'Bergeron on Flute-Making', *GSJ* XXIX (1976), pp. 26-34 and plate 1.

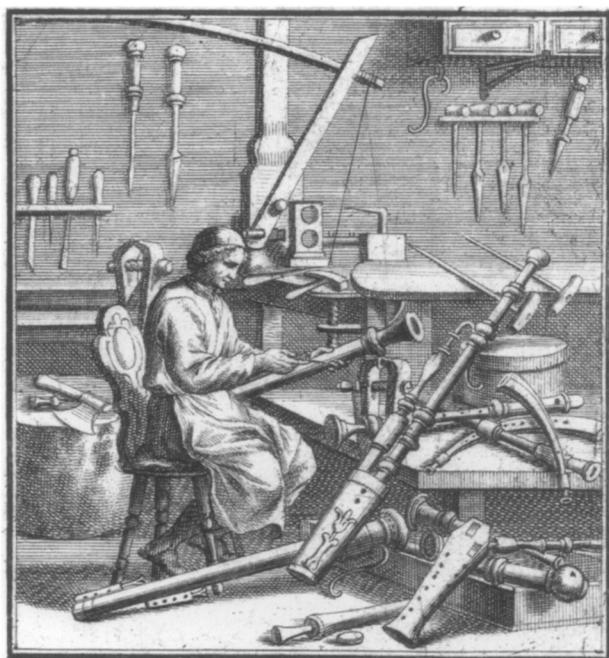


Figure 1. Christoph Weigel: 'Der Pfeiffenmacher' (1698) showing a wind instrument maker surrounded by the tools of his trade. Note the reamers hanging on the wall near the top right of the image (for detail see Figure 8).

made and dealt in musical instruments.<sup>3</sup> This material comprises several small groups of tools, differing in their detailed design and in workmanship, as well as in the form of bore that they would have generated. While several of these reamers may have had no use in the making of woodwind instruments, some were undoubtedly intended for finishing the bores of flutes and were found in association with other flute tools and a few parts of flutes, and others were perhaps intended for bagpipe chanters. The biographical facts of Watt's life suggest that these tools were probably used between about 1757 and 1774.

All Watt's reamers are rather crudely made. They were forged by hand and dressed to shape by filing. The edges were sharpened, inside and out (producing an acute edge), with a rather coarse hone, and the backs (which would have rubbed in the bore) were not well finished. In a number of cases gauge-lines were scribed or filed across the back, to show the workman how far to let the reamer enter the workpiece.

The material is probably shear-steel or possibly a shear-steel blade welded to an iron shank. (One cannot be more certain without carrying out an unacceptable degree of cleaning.) The material yields to careful probing with the point of a scribe, indicating that it is not very hard.

Some of these reamers have tapered square shanks

to fit a pad chuck (of a lathe or, more probably, of a brace or other hand tool, or just possibly a socket in the bench) while others, including the largest, have a loop to accept a wooden cross-handle. (Such a handle survives, and it is the roughed-out head joint of a flute!) One reamer has a flattened tang, and was fitted with a fixed wooden cross-handle (still present, but now detached).

Several similar tools, of unknown date, survive amongst the relics of the flute-making firm Rudall Carte & Co., one example of which is shown in Figure 2. Typically, these crescent-section reamers are a little more substantial than Watt's, and they are better finished on the edges and backs. Their edges have been honed by laying the stone across both lips of the reamer so as to form a scraping edge more like that of the modern reamer, but this might not have been the original intention. These reamers have rather short, stout squared shanks (like those illustrated by Bergeron) and they too have gauge-marks filed on the backs.

For most, perhaps all, of these reamers, it appears to have been the maker's intention to make the edges and the backs straight, as though to cut a simple conical bore, but it is no easy matter to be sure by measurement quite what profile such a reamer will generate in practice. Some of Watt's reamers are curved along their length and some are twisted (apparently through being strained in use, a further indication that they are not very hard). Besides, it was thought interesting to find out how effective, and how difficult, the use of these crude tools might be. Three of the better-preserved Watt examples were accordingly selected, and one of the Rudall Carte examples. It was not considered desirable to sharpen the Watt specimens, but nicks in the edge were carefully stoned down. The reamers were lubricated with tallow and were used to open prepared holes in lengths of maple (which was chosen as being relatively easy to cut with unsharpened tools).

The results of the test bores produced with the reamers are shown in the chart, Figure 3, where the  $x$ -axis represents the diameter of the bore and the  $y$ -axis the length from the upper end of the tapered flute body, not including the cylindrical headjoint. It must be noted that the diameter is considerably exaggerated on this graph. Amongst the Watt reamers, the deviation from a simple cone is of the order of 0.1mm for example A; 0.2mm for example B; and 0.4mm for example C. The Rudall Carte reamer produces a simple cone over most of its length, but an area near the top of the tool has a deviation from the simple cone of some 0.4mm.

<sup>3</sup> Michael Wright, 'James Watt: Musical Instrument Maker', *GSJ* LV (2002), pp.104–129.

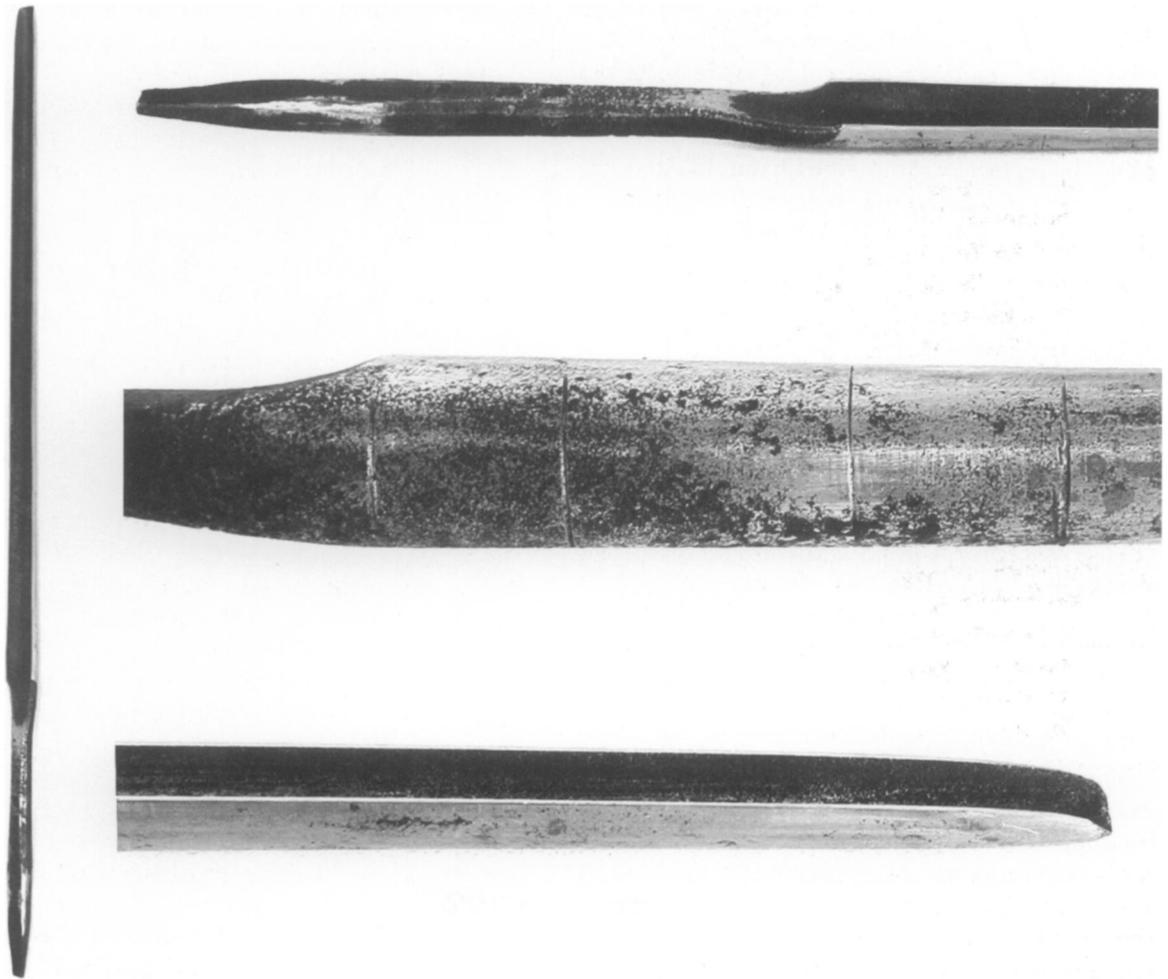


Figure 2. *Four views of the reamer formerly belonging to Rudall Carte & Co. Note the gauge marks on the back of the reamer, used to show how far to insert the tool.*

Possibly we have here a truly conical reamer that has been damaged; the effect could have been produced by bending the reamer, perhaps by being trodden on, followed by an imperfect attempt to straighten it. Measurement suggests it was originally a simple cone, but that the cutting edge has been deformed.

The head of a so-called conical flute is always cylindrical, and many instruments have a further cylindrical section at the top of the bore of the left-hand joint. A cylindrical bore can be produced by letting the 'shoulder' of the reamer (the widest part of the blade, next to the tang) enter the work. The bores of head joints often show a helical trace that must have been generated by the use of a tool of which only rather a narrow part of the edge was cutting at the finished diameter. In other words, the finish in these cylindrical bores is consistent with the use of a conical reamer in this way. The graph of the Rudall Carte reamer in Figure 3 shows the

effect of such an action.

The torque required to make these reamers cut is quite considerable, enough to show that their use, held in the hand and presented to a workpiece rotating in the lathe, would be distinctly hazardous and ill-controlled. It is hard to imagine that the hazard, which is associated with the tendency of the tool to 'grab' and to become set fast in the wood, would be very much reduced even by careful sharpening. Besides, in the simple wood turner's lathe which, even to the end of the nineteenth century, was commonly driven by the workman himself using a foot-treadle, it is simply not possible to apply that much torque. There seems no doubt that, whether or not the initial boring of the joint were performed in the lathe, the reamer, with its long cutting edge, must have been used by hand. Bergeron suggested that the reamer should be held in the vice, and the joint, fitted with a wrench if need be, was rotated over it.<sup>4</sup> The

<sup>4</sup> See note 2. Bergeron describes and illustrates a wrench made for the purpose, but he is surely misguided in suggesting that the whole flute was turned on the reamer, using a wrench fitted to just one joint. It seems more likely that the joints were reamed separately. See also note 5.

short, stout tangs of the Rudall Carte reamers suggest that they may have been used in this way. On the other hand, the tangs of Watt's reamers, designed for the fitting of handles, suggest that in his workshop the workpiece was held stationary while the reamer was turned by hand. In either case, we would expect the bore to be completed before chucking the joint on a mandrel in order to finish-turn the outside in the lathe.<sup>5</sup>

It does not follow that because such reamers existed they were always used. To the suggestion that the bores of instruments could have been finished using boring tools held freehand while the work rotated in the lathe, we object that it matters to the seller of instruments that the product should be consistent, and consistency simply could not have been secured without the use of a reamer. Besides, there is no reason to suppose that the making of flutes was very different from any other artisans' activity, and the tendency is always to adopt either the quickest or the surest way of turning out the work. The use of a reamer to open the conical bore is the obvious choice.

The question as to how the bores of instruments were actually finished may be approached from the other end, by the examination of surviving specimens, and we show here that evidence for the use of reamers can indeed be seen in surviving instruments. For the purposes of this study three flutes by Thomas Stanesby Junior in the Horniman Museum, London, were measured and examined with an endoscope (Figure 4).<sup>6</sup> These three flutes were chosen for a number of reasons: they were made by a maker known

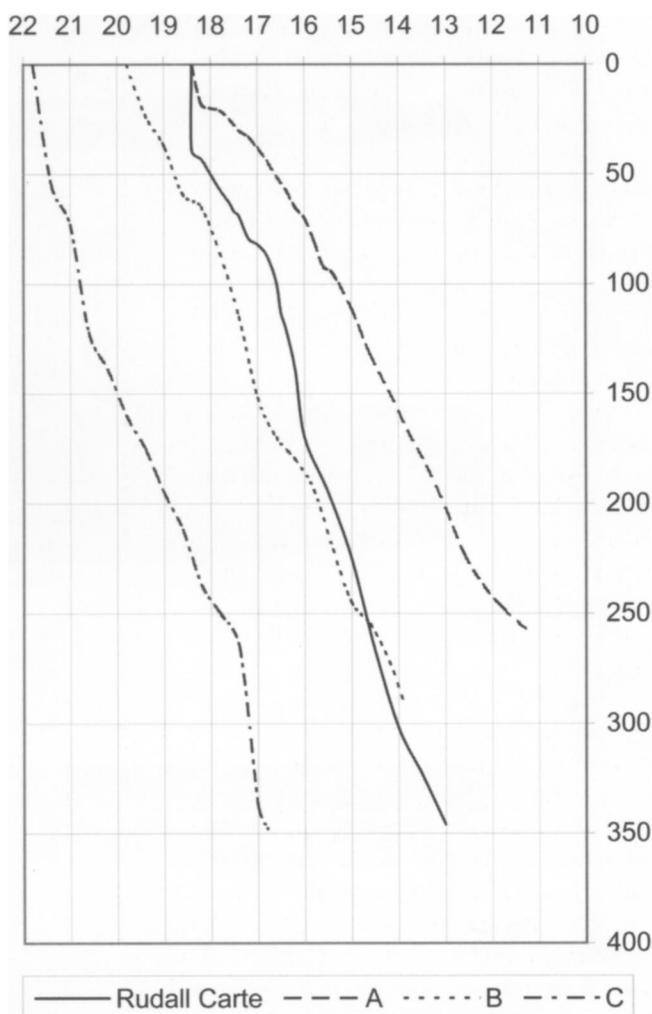


Figure 3. Graph of test bores produced by the Rudall Carte reamer and the three reamers from the Watt workshop (A, B and C). Measurements in millimetres; x-axis represents diameter, y-axis represents length.

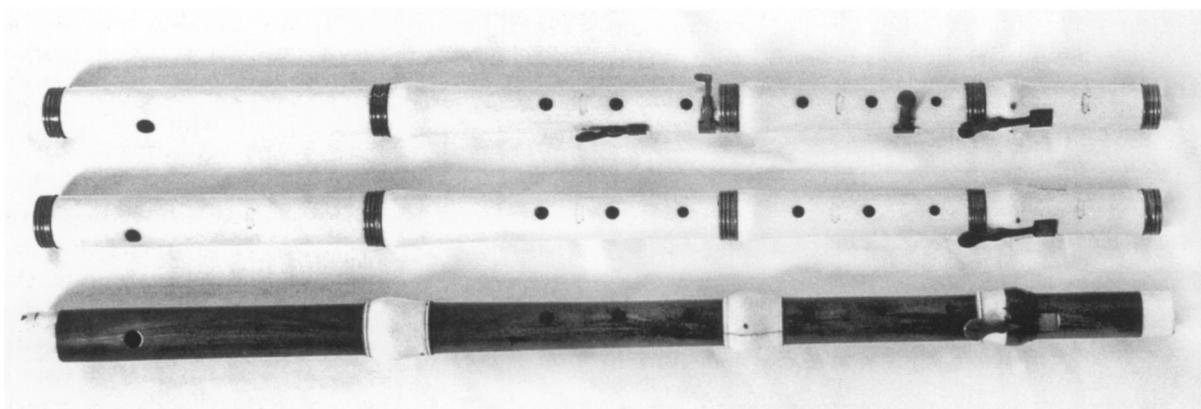


Figure 4. Three flutes by Thomas Stanesby Junior from the Horniman Museum, London (top to bottom: museum numbers 14.5.47/264, 14.5.7/281 and 14.5.7/241).

<sup>5</sup> It is hard to know what to make of Bergeron's suggestion that the whole flute was assembled and finished on a long reamer at once, after the external turning was done. Such a finishing process could not have included the head, which always has a *cylindrical* bore, and it could only have been limited to a very light cut.

<sup>6</sup> Horniman Museum numbers 14.5.47/241, 14.5.47/264 and 14.5.47/281.

to have been successful and prolific; they are made of different materials; and they have been stored in identical conditions for over half a century. Stanesby must have made flutes in some quantity, and his clientele must have been wealthy as most of his surviving instruments are made of expensive materials. Of the flutes discussed here, one is made of lignum vitae with large ivory ferrules, and the other two are made of ivory with silver ferrules. The two ivory flutes have coats of arms, presumably of their first owners, engraved on their crowns. Maurice Byrne has shown that Stanesby did well from his endeavours and died a wealthy man.<sup>7</sup> Stanesby's flutes exhibit exceptional craftsmanship. There can be little doubt that these instruments represent the best practice in wind instrument making in eighteenth-century London.

It was thought that the conical bores of these three Stanesby flutes might afford a useful test. If they could be shown to be closely similar then it would be difficult to believe that they were produced essentially freehand while the work rotated in a lathe, but must have been finished using reamers. Measurement reveals that the bores are in fact very nearly identical. This should be no surprise; simple commercial considerations would lead a maker to develop a consistent product, and simple manufacturing considerations would lead him to standardise his design. It is now, and it must have been in the eighteenth century, easier to make the various parts of flutes in batches rather than produce complete instruments one at a time, and for a maker employing others it would have been to his advantage to reduce the specific knowledge required in the completion of as many operations as possible.

The three Stanesby flutes studied are remarkably consistent even though they are made of different materials. Any shrinkage or distortion after reaming was either identical in the different materials, which it must be said is improbable, or else any shrinkage or distortion was corrected before the instruments finally left Stanesby's workshop. Figure 5, a graph of the bores of the three Stanesby flutes (not including the headjoints), shows the similarity in their bores. On the graph the *x*-axis represents the diameter and the *y*-axis

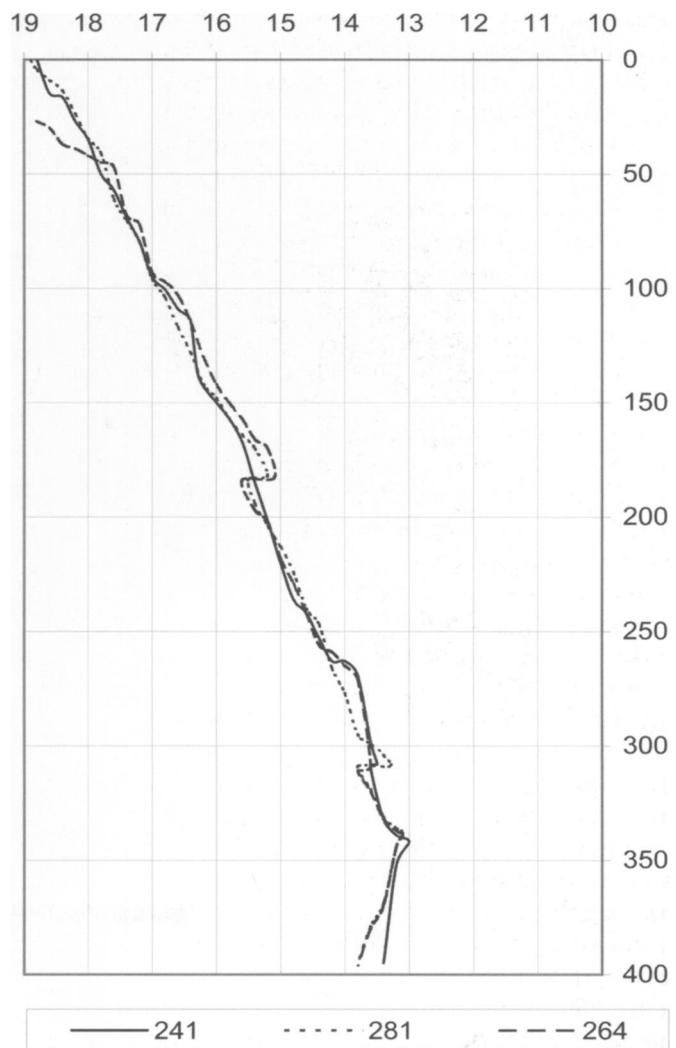


Figure 5. Graph of the bores of the three Stanesby flutes, not including the headjoints. The steps between the sections on flutes 264 and 281 were caused by the maker inserting the reamer further into the wood. Measurements in millimetres; *x*-axis represents diameter, *y*-axis represents length. The graph of flute 264 does not begin at zero as the internal damage at the top of the tapered section of the flute prevented accurate measurement of the diameter.

represents the length. (As with the graph of the test bores it must be noted that the *x*-axis is greatly exaggerated.) The similarities between the bores are striking, apart from some variation in the footjoints. It is impossible to believe bores as similar as these could have been produced other than with reamers. The alternative suggestion that they were turned freehand cannot be supported; such a task would have required the maker to manipulate a slender tool with great accuracy at a distance up to some 200mm away from the end of the flute, working blind, and to do so in precisely the same way on one instrument after another. Even the

<sup>7</sup> Maurice Byrne: 'Some More on Stanesby Junior' *GSJ XLV* (1992) pp. 115-122.

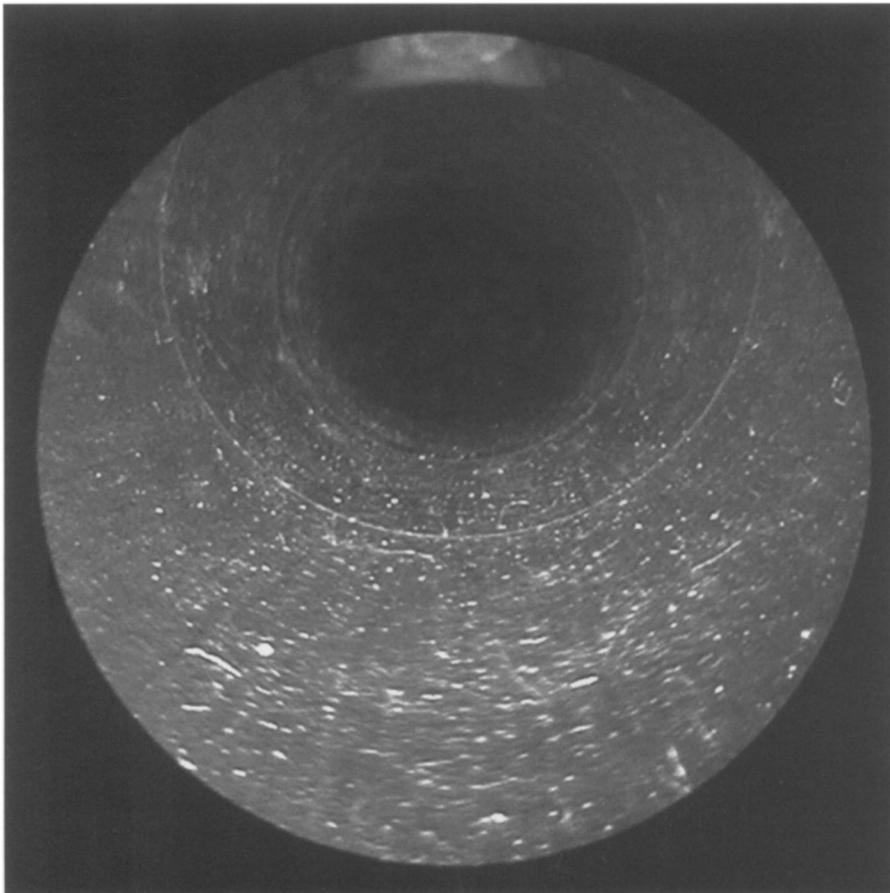


Figure 6.  
*Endoscope photograph of the bore of the left-hand section of the wooden Stanesby flute (14.5.47/241). Note the marks in the bore left by nicks on the cutting edge of the reamer.*

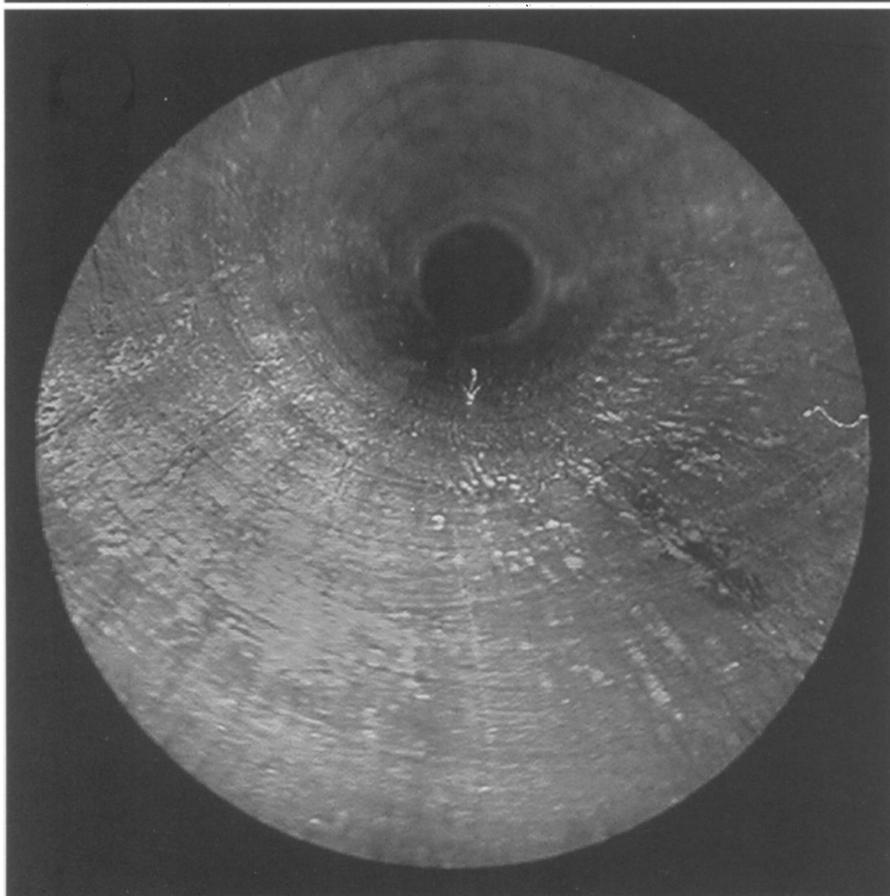


Figure 7.  
*Endoscope photograph of the bore of the headjoint of the wooden Stanesby flute. Note the helical mark probably produced by the shoulder of a conical reamer run right through the billet of wood to produce a cylindrical bore.*

outsides of the two ivory flutes by Stanesby studied here, while similar, exhibit greater variation than do their bores.

For the three Stanesby flutes it is possible to detect the use of four reamers to produce the bore up to the point where the taper reverses in the footjoint. All four reamers can be seen to have produced simple cones: one reamer produced the bore from the top end to about 185mm, a second produced the bore from there to about 270mm, a third produced the bore from that point to about 300mm, and the final one to about 350mm. In all cases the deviation from a simple cone is within the margin of error of the tools used to measure the bores, and it is possible to surmise that the blacksmith who made the reamers intended them to produce simple cones. Indeed, it is difficult to imagine how the blacksmith could have deliberately (and accurately) produced a reamer that produced different tapers along its length.<sup>8</sup>

Further evidence of the use of reamers is provided by examination of the bores with an endoscope. Figure 6 is a photograph taken through an endoscope of the bore of the left-hand joint of the wooden Stanesby flute (14.5.47/241) showing marks left by nicks on the cutting edge of the reamer. Figure 7 is a photograph of the bore of the cylindrical headjoint of the same flute, showing a helical mark probably produced by the shoulder of a conical reamer run right through the billet of wood to produce a cylindrical bore. The survival of these marks suggests that the use of the reamer was not followed by the use of any sort of abrasive.

In this note we have summarised readily-accessible evidence in favour of the use of reamers since the late seventeenth century, and have indicated possible further lines of enquiry. It is our firm belief that further light can be shed on such questions of manufacture by careful observation of the surviving evidence taken together with

awareness both of the circumstances in which the instruments were made and the limitations of contemporary tools and workshop practice.

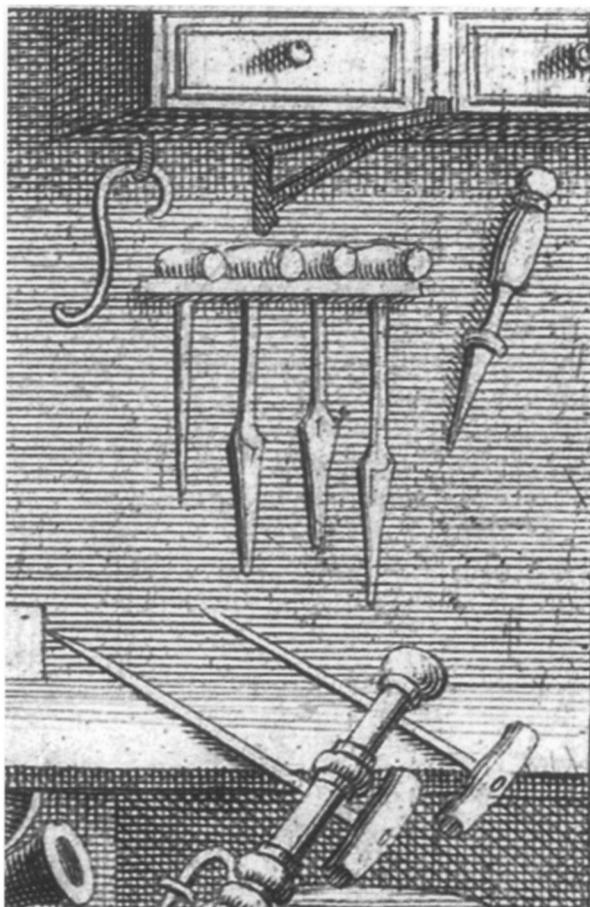


Figure 8. *Christoph Weigel: 'Der Pfeiffenmacher' (1698). Detail of reamers.*

#### ACKNOWLEDGEMENTS

We are grateful to Miss Margaret Birley, Dr Bradley Strauchen and Dr Louise Bacon of the Horniman Museum for their time and cooperation in giving us access to the instruments in their care.

<sup>8</sup> Modern reamers, by contrast, are made by machining, and can be made with any number of different tapers along their length.