CHAPTER 5

The Irish Horns

During the Late Bronze Age in Ireland, a remarkable school of instrumental performance existed. It was supported by an equally remarkable school of manufacturer which produced instruments for the players and, over a period of time developed manufacturing techniques which enabled these instruments to be made to deliberate designs with considerable repeatability. A unique feature of these instruments is the presence of both side and end-blown instruments which, from their overall design and manufacture, are clearly from the same school of manufacture and made to be played together. (Plate. 5.29). From both organological and technological points of view this feature has important ramifications.

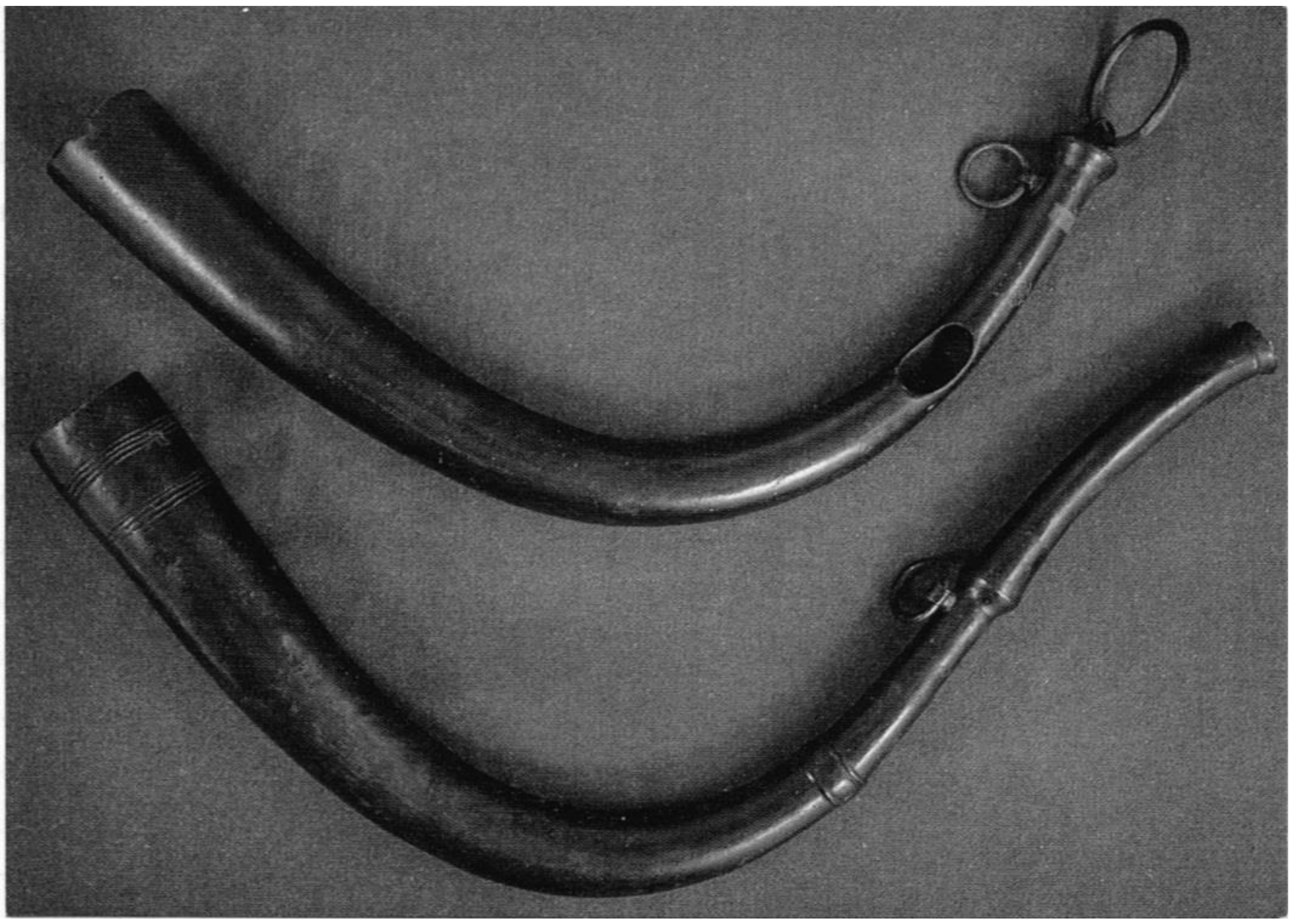

Plate 5.29: The Drumbest Pair of Horns

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The instruments have been studied for over 110 years, first being listed by Coffey in 1860, to be followed in 1881 by Evans and in 1945 by MacWhite. Most recently they have been studied by John Coles in 1963 who outlined the previous classifications and dating by these authors[188], and provided a comprehensive catalogue of all instruments known to that date[189] In addition, in his paper, Coles proposes a typology which is considerably simpler than those of Coffey and Macwhite and when related to the geographical spread of the instruments, shows a most convincing divergence between his type I and type II instruments.[190] This distribution map shows all the type I horns to have been found either in the northeast of the island or at Dowris, while all but one of the Type II instruments are found in the southwest or at Dowris.

Class I side-blown horns are generally of a smooth appearance and those with decoration have ribs or domes of low profile and incised or slightly raised ribs, grooves or zigzags. Their tip form runs smoothly into that of the horn body, sometimes having a somewhat spherical knob and sometimes a flared termination. Generally, two carrying features are present, frequently typical Late Bronze Age loops, one at the instrument tip and one between this and the blowing aperture. Some instruments, however, lack the tip loop and others have ring mounts added to the tube and tip, frequently with a ring still in the mount.

Class I end-blown instruments are generally similar in decoration to the side-blown ones and similarly have loops. Tubes of this type generally terminate in a female aperture and the bells in the corresponding male protrusion.

Class II side-blown horns are, as a group larger than their class I counterparts and terminate in a large conical feature at their tip. Their mounting features are generally added to tip and tube (as Class I), often still retaining the rings fed through these. At the bell end, conical spikes decorate the tube and holes, usually four, are spaced around their periphery.

MANUFACTURE OF THE HORNS

Practically all the Irish horns retain evidence of having been made in two part-moulds with a core to define the form of the instrument's bore. Thus, their manufacture would have involved the construction of two separate halves of a mould - the cope and the drag - and a centrally located core to form the bore. (See Figure. 5.1).

188 Coles, 1963, pp. 326 ff
189 Coles, 1963, pp. 349 ff
190 Coles, 1963, Fig. 3).

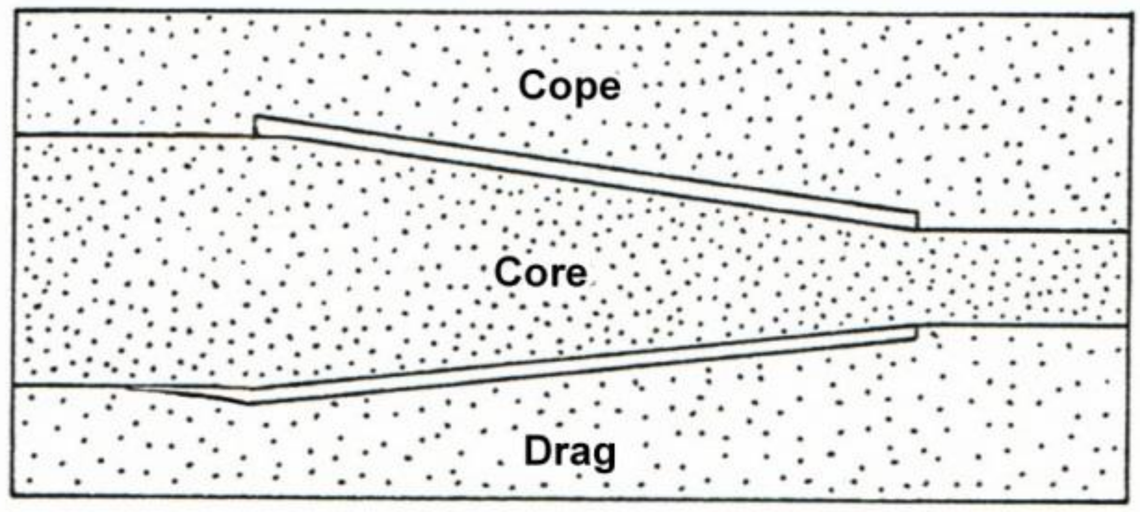


Figure 5.1: The General Layout of a Mould and Core

Most of the extant material has clear joint lines either as cleaned-up remnants of the flashlines or as featured decorative lines along the joint lines of the mould. Some instruments, presumably those which had developed faults in the casting operation, were not finished and still retain this extensive flash along the joint-line (See Plate 5.1(a) and 5.1(b) and Plate 5.2(b))

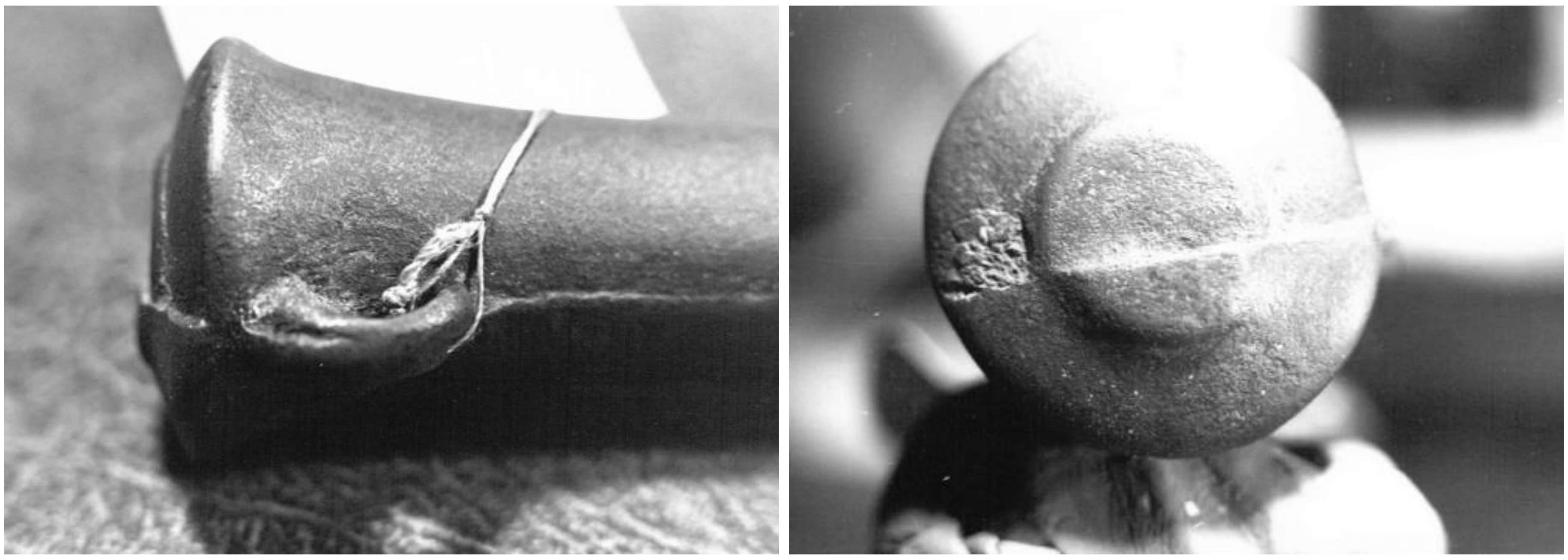


Plate 5.1 (a) & (b))

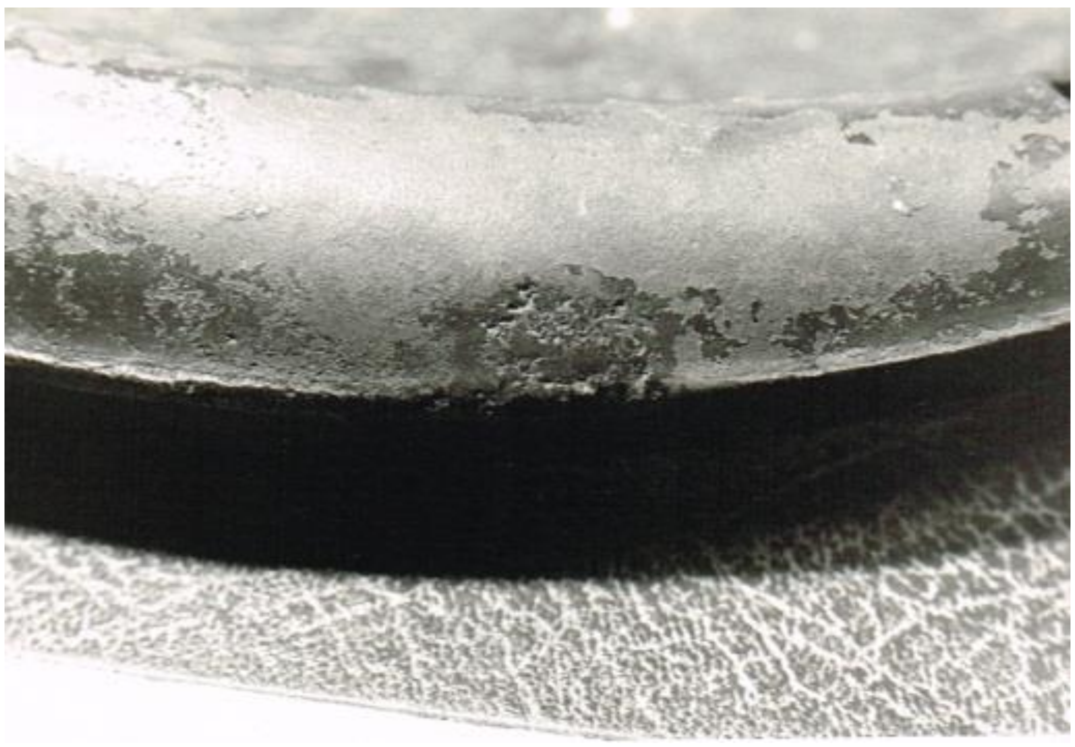


Plate 5.2(b)

Some instruments such as Dowris (14O) have flash remaining on the end face of the bell, where the metal has flowed between the male and female core prints during casting. This evidence suggests that, in this case, the core prints were the same diameter as the bell-mouth bore.[191]

When using two—part moulds accurate registration of the cope and drag is essential in both longitudinal and lateral directions. Many instruments display faults due to poor registration to some degree as illustrated below in Figure 5.2.

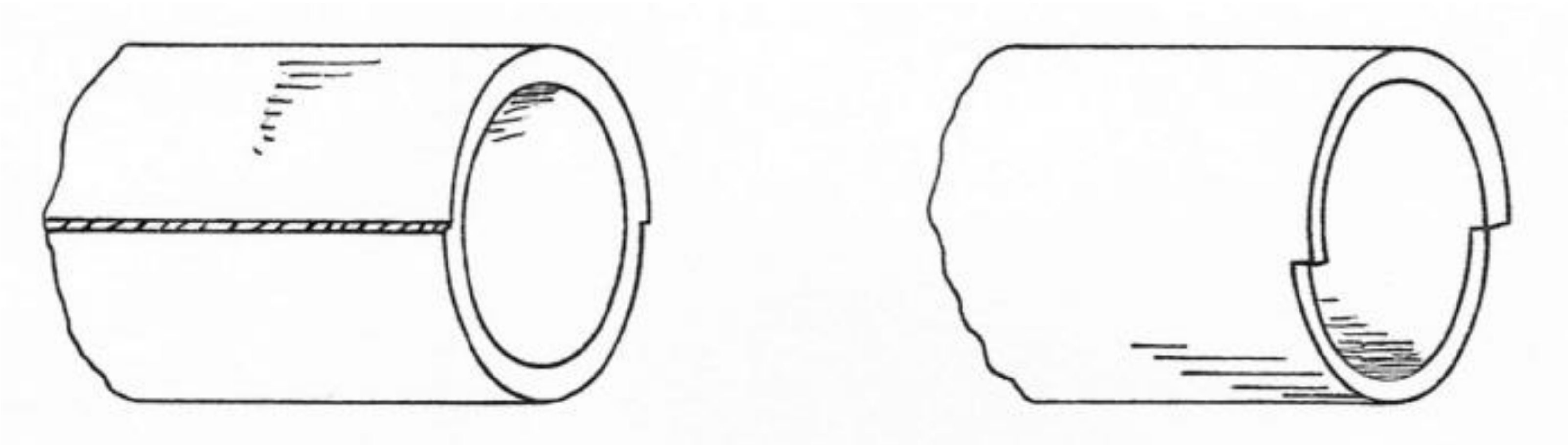


Figure 5.2a and 5.2b: Registration Errors in a Finished Casting

In (a) the fault due to poor lateral registration is shown while the fault due to poor longitudinal registration is illustrated in (b) that Such errors are seen on SD14E, 14G, 31), (See Plate. 5.1a and 5.1b (above); Plate 5.10 a, (below).

Even when accurate registration of the cope and drag has been achieved any radius or chamfer on the mould edges gives rise to a raised joint line. On some instruments this has been abraded away but on others the feature has been deliberately emphasised for its decorative effect. (See Plate. 5.2a.) It may also have been realised that this decorative feature down the length of the instrument also served to disguise poor lateral registration when it occurred.

Plate 5.2(a): Chaplets, Carrying Rings and Casting Seams

[191] Coles, 1963, pl. XXXI (upper).

A wide range of materials is used today to manufacture moulds and cores for casting but the evidence from Ireland in the Bronze Age seems to suggest that clay with or without admixture was the major constructional material. No moulds or fragments have been found which can be identified with the manufacture of horns but several are known that have been used to cast swords, axes and other such items. These mould fragments suggest that two-part mould casting was widespread in the highland parts of the U.K. and Ireland and contrasted with the extensive use of lost-wax casting in central, lowland, Britain and right throughout Europe.[192] The major application of the two part mould technique in this latter area was in the use of gravity die-casting with re-usable moulds of bronze which were built up with a core and header [193]

Evidence of the material used for the cores of instruments is obtainable from those horns that have blind ends, i.e., the side-blown types, where the casting core has been left in-situ following casting, and, to some extent, in the material adhering to the inner walls of the instrument, where the manufacturer was unable to remove this. (Plate. 5.3 (a))

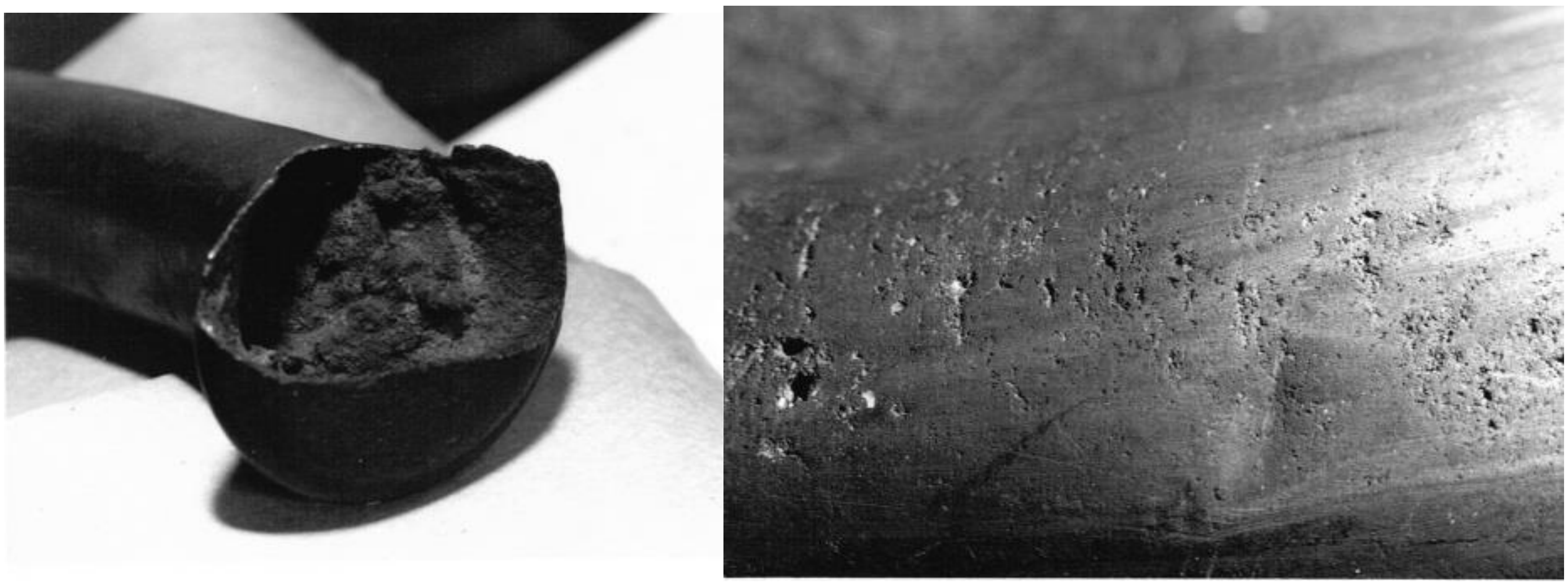


Plate 5.3(a) & (b)

In its simplest form, this type of casting requires three parts to produce an instrument: two mould halves; top = cope, bottom = drag, and core. (Figure 5.1) Once made, these would need to be spigotted together so that registration errors were avoided and the core was held in place by the fit between its prints and the cavity formed by the assembled cope and drag. This mould assembly would then need to be fixed rigidly and the cope weighted down while pouring so that the metal could be poured in and allowed to fill the mould cavity, Several instruments (e.g. SD29C) have inhomogeneities in casting quality which differ from one side of the joint-line to the other. On this instrument the obverse side (see appendix IV for definition of terms) has several areas where the casting has failed, with holes in the tube wall and areas of sluggish metal flow while its other side is relatively free from defect. (Plate. 5.3b)

[192] Hodges, 1954, 73.
[193] Hodges, 1954, 72, Table IV.

This evidence suggests that the mould was actually poured while horizontal and filled up progressively along a horizontal line, leaving defects aligned to this. Other evidence also strengthens this view such as the non-supported chaplets seen in instruments SD14M, 36B, and 40. These are simply irregular shaped pieces of metal, presumably broken off from earlier castings, which, when present as chaplets in tubes, lie flush with both outer and inner tube walls. Thus, during casting these were simply trapped between the core and mould and on those occasions when they were not held firmly by the mould/core surfaces were able to fall out of position. On 14M, one chaplet which was not adequately trapped slipped out of position to become trapped on the mould joint-line where it remained during casting. Another chaplet, which was considerably thinner than the mould/core gap remained in position as it had been placed on what was presumably the mould drag, being held there by gravity. On casting, this produced a thinner section at this point. See Figure 5.3. Had this mould assembly been stood vertically this chaplet would clearly have moved from this position.

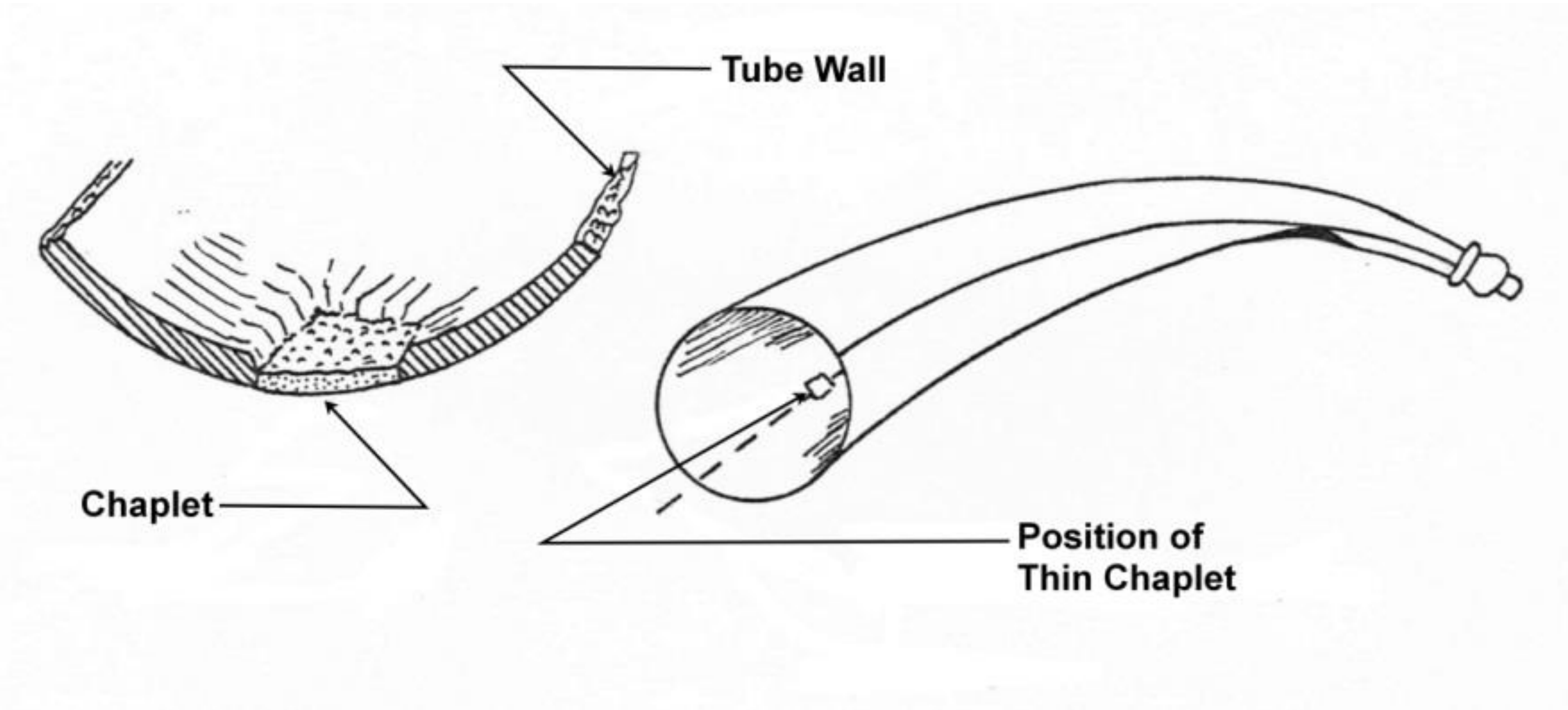


Figure 5.3 Surface Chaplets in a Tube Wall

The most common section failure on these instruments is along a line at right-angles to the joint-line and along the central part of the curved surface. See Figure 5.4. This is consistent with core rotation resulting from failure of the core prints to restrain this adequately. Again, such rotation would occur with gravity acting upon the mould when in a horizontal plane.

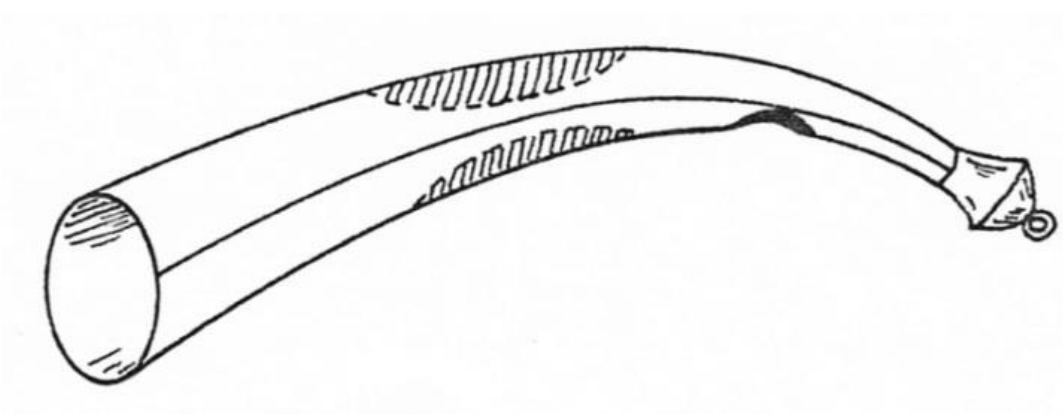


Figure 5.4: Areas where Castings Show Thin Sections

If instruments were cast in a vertical position then the core would have to be supported on the mould at some point, i.e. either at the tip or bell-ends. The evidence (discussed below) suggests pouring from the bell-end and, hence, this support would need to be from the tip. Thus, in the case of side-blown instruments a support of some form would need to be provided and should now be visible on the tips of these instruments. Only one specimen has such a possible feature (SD 36A) but this is problematic and is overwhelmed by the negative evidence of all the other instruments. In addition, those side-blown instruments which are fractured through their tips show no signs of sprues at this point and, in the case of those with tip loops would be difficult to sprue at this point. Hence, while many of the above factors are specific to side-blown instruments it also seems unlikely that the maker would develop two different casting procedures for side and end-blown instruments.

Runners would obviously be necessary to provide an entry for pouring the molten metal into the mould cavity and modern casting practice also utilises risers which act as vents, allowing the air and other gases inside the mould to be expelled as the metal enters. Lacking actual examples of moulds in a recognisably complete state, there is no evidence to suggest that runners and risers were used. Neither is it justifiable to assume their use as Coghlan did, when carrying out the experiment he reported [194].

Experiments carried out in the course of the present study suggest that the problem of gas entrapment may be less severe when using clay moulds than with modern moulding materials. Having formed a cavity in the two halves of the mould, these must be left for a week or so to dry and then may be subjected to further heating. During these processes water evaporates from the clay and then chemical recombination will occur if the material is heated strongly enough. Both these processes involve a decrease in volume of the clay which in a mass of material of complex form occurs in a complex way. The result is warpage partly caused by the complex shrinkage process and also possibly by inhomogeneity in the makeup of the clay mixture itself. Thus, the joint surfaces which previously mated accurately do not necessarily do so after drying and heating.

On the experimental castings produced in clay moulds for this study, a considerable flash-line was obtained which indicated that flow of metal and hence, of air had been possible between the two parts of the mould, allowing the air to escape from the mould and preventing miscasting.[195] A further possibility for the escape of casting gases would be presented by an air exit path between the core print and mould surfaces were the end-faces of the print to be open to atmosphere as suggested in Figure 5.1. On instrument 14O, for instance, the bell terminates in a clear rim of the same form as the featured joint-line. However, this bell rim is not straight or normal to the axis and is bounded at the down-stream end by a continuation of the tube diameter. See Figure 5.5. For the metal to flow into this zone the gas pressure must have been low, possibly atmospheric, suggesting that a, perhaps unintentional, gas vent existed at this point.

[194] Coghlan, 1951, 56.
[195] Curle, 1932, 120.

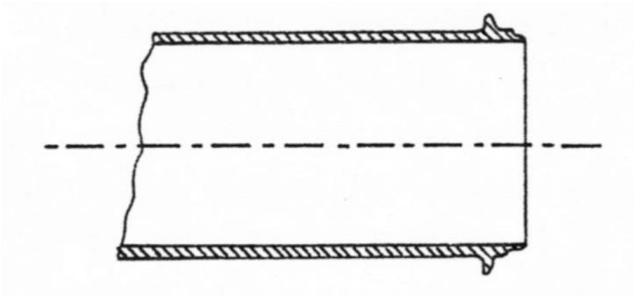


Figure: 5.5: A Bell-end Cross-Section

Shrinkage of the mould material can be reduced to some extent by mixing sand and/or grog (previously-fired clay) with the clay used to make the mould. However, as sand is added to the clay, it becomes less plastic, i.e. harder to mould and more coarse-grained, i.e. less able to reproduce detail from the pattern, or to be worked by hand to fine detail. The sand does increase the porosity of the clay mixture somewhat as the clay constituent shrinks away from the sand to leave voids. It does not, however, necessarily increase the permeability of the material which is the desired property if air entrapment is to be avoided.

Another admixture used in moulding materials is finely comminuted organic material. This has been obtained in the past from animal manure as this contains finely ground-up plant parts as well as longer strands of hay/straw etc. on drying, the smaller organic parts shrink leaving voids, thus increasing the porosity of the mixture. Longer organic strands similarly shrink, but, because of their length and larger cross-section tend to bind the clay matrix together while in the green state. However, if the mould is subsequently subjected to a degree of heat that will carbonise or even burn away this organic material, (c. 900°C) the porosity is increased by the removal of the fine material and the permeability by that of the coarse. In all cases of admixture, the passage for air to escape through the mould is likely to be far less than that provided by the poor fit of the mould halves.

On the clay moulds found both in Ireland and the U.K., the metal-contact surfaces are generally coated with a layer of fine clay. This enables a better surface finish to be obtained on the surface of the casting and finer detail to be reproduced. However, this layer is critical in terms of mould permeability as it effectively seals off the outer layers of the mould with a fine impervious clay. Thus, if such a layer is used, and remains intact during the casting process, it negates attempts to provide a path for air by use of a porous or permeable mould material.

A further treatment is visible on some of the mould fragments from Jarlshof in Shetland. These have had the casting surfaces painted over with a black coating, which according to Curle[196] was probably composed of "a fine clay slip mixed with soot." Such a coating would serve to produce a smooth surface on the mould as well as forming a release surface. Modern casting practice utilises similar release agents to ensure clean release of the casting from the mould.

[196] Curle, 1932, 119.

The two mould halves require a female impression of the horn outer surface to be produced on their mating face. This can be done by carving the form out from a block of clay or by using a pattern which is pressed into the two mating blocks. Several problems arise in the former case as with a large object which has a thin wall-section accurate registration of the two mould halves and the core is absolutely essential. If the wall thickness is 1 mm, for instance, an inaccuracy in registration in the two mould halves of the core of only 1 mm could result in the complete loss of wall section at some point. Added to this is the fact that it is more difficult to produce the required shape in mirror image, particularly as this is female in form. It is not possible to fully utilise parallax effects to judge roundness, depth etc. when the surfaces involved are sunk below the joint-line. In addition to this, each new mould comes out different from the last and, thus, precludes steady development towards a uniform product. It is, of course, not impossible to manufacture an instrument in this way but it seems likely that a maker would tend to follow the pattern method were he to make more than one instrument to one specific design.

The use of wooden patterns for the production of moulds is known from Ireland[197] both from the existence of patterns themselves and from surface texture on castings which reproduce the grain of the wooden patterns used to make the mould. It seems reasonable, therefore, to propose that patterns were used to produce the complex moulds needed for these horns. The only evidence which exists for their use is on some side-blown instruments which lack tip rings. (SD14 O, 17A, 36A). On these, the instrument tip is moderately round (Plate. 5.1b, above and Plate 5.4a, below) but the joint line cuts this circle into two very unequal parts.

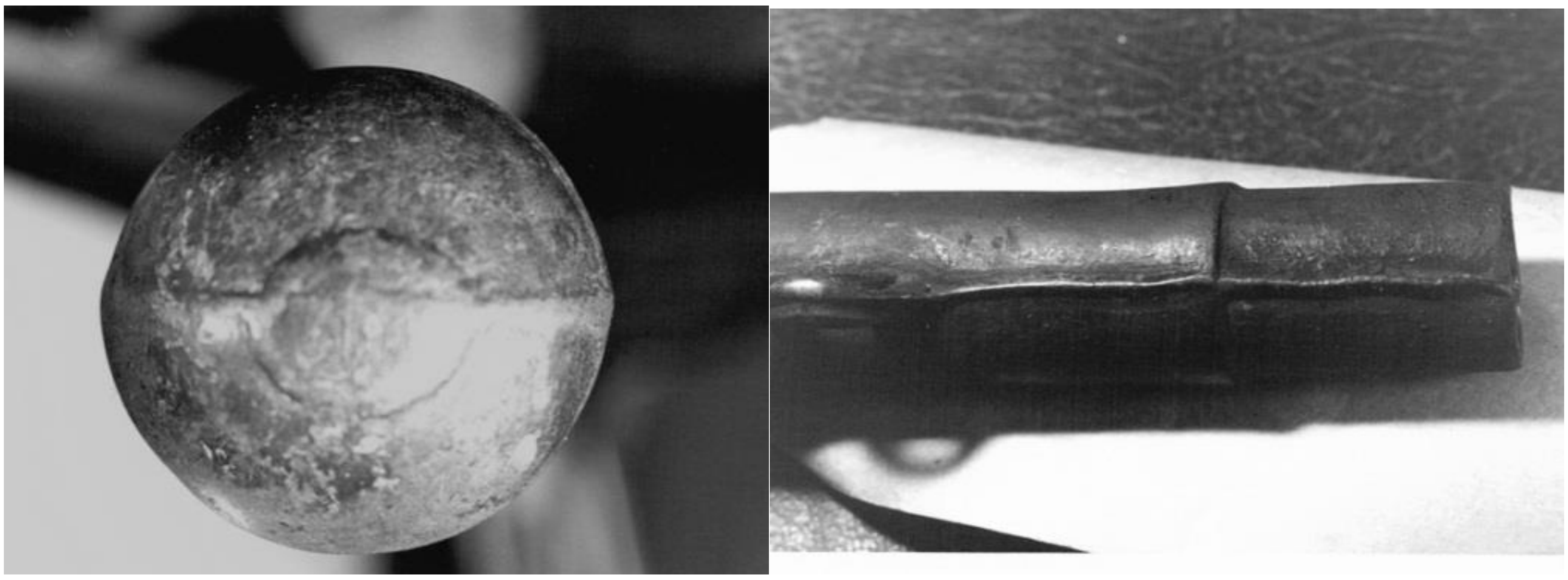


Plate 5.4 (a) & 5.4(b)

[197] Hodges, 1954, 64 ff.

From this it would appear that the pattern was impressed into the second mould half while seated in the first presumably the deeper one. (The high degree of mould/core registration on instrument 14O is discussed below). What form the pattern took it is not possible to say. Indeed, at the time when these instruments were first made an existing instrument may well have been used to make the moulds for new instruments. Were this to be done too often, however, the maker would soon become aware of the decreasing size of his product and produce a standard from which to replicate.

The pattern used did clearly not contain all the features that were formed on the mould prior to firing. On instrument 14G, for instance, the smooth flow of the tube into the tip is broken by a step, in contrast to the design of all other such instruments. It appears in this case as if the major mould cavity was made with one pattern and the tip cavity formed by means of a second small pattern. Perhaps the tip end had been broken off the original pattern and a second pattern made to form the tip. Clearly had this piece of mould been hollowed out by hand, a smooth line into the tube form could readily have been generated.

On some instruments on which the joint-line is featured as a decorative element this is clearly not straight but undulates while maintaining a relatively constant thickness. (e.g. 14J, Plate 5.4 b, above and Plate 5.5a)

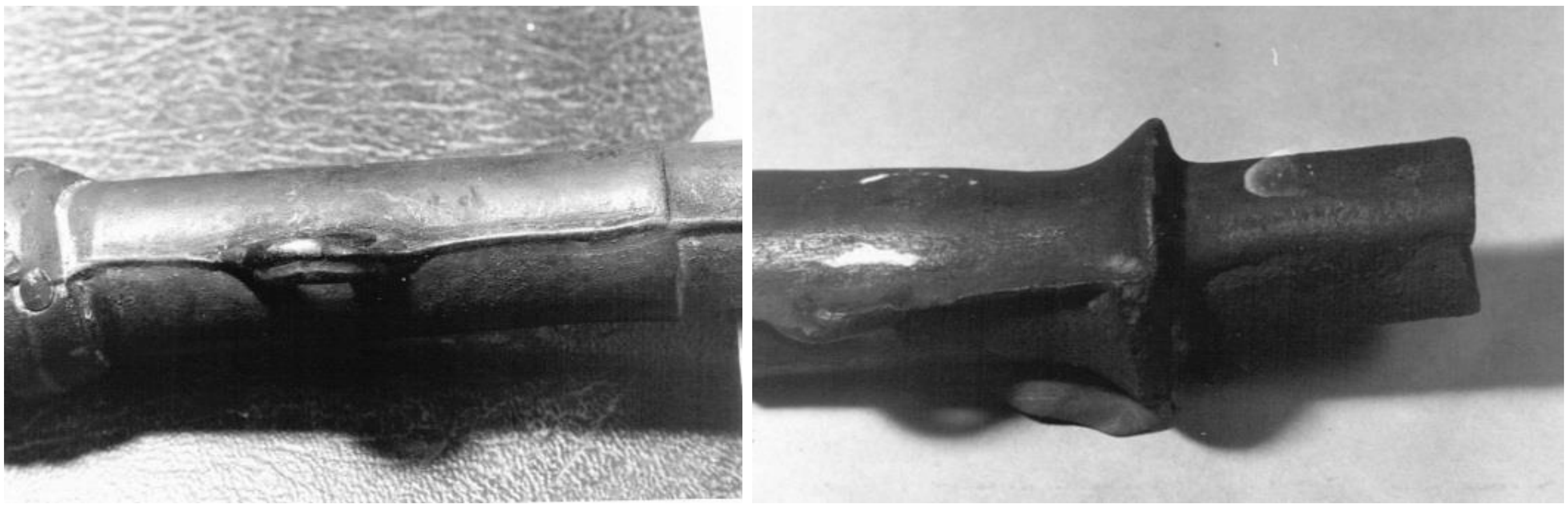


Plate 5.5(a) & 5.5(b)

This also points to the use of a pattern as, were such an undulating line to be produced independently on separate mould halves it would be highly likely that the joint-line would vary greatly in thickness. However, registration of the cope and drag would be considerably assisted by the interlocking of these two mould surfaces.

If as suggested below, a side-blow and end-blow instrument constitute a pair, the maker would be required to produce instruments in pairs. He could have done this by producing a pattern for one type of instrument and modifying this to form the mould for the other. This seems to have been done on SD4A, 37B, 39 and 14J, (Plate 5.5 b, above), the first three of these having cone-shaped features typical of the tip of a side-blown instrument but extended to form a parallel projection. In the case of SD39 this projection is quite clearly added oblique to the rest of the tube, its parallel portion having a distinctly-different surface-finish. Similarly, the surface-finish of the projection on 14J differs from the smooth surface of the remainder of the instrument, having a polygonal form made up from series of axial markings probably from tooling out the clay mould at this point. This part is integral with the remainder of the tube as the joint-line passes uninterrupted from one surface to the other.

Perhaps other end-blown instruments were produced by means of separate patterns for the instrument body and its tip end, as suggested above for 14G. If done skillfully, and the small pattern cavity blended in smoothly, no evidence need remain for this having been done. Having produced a suitable pattern for a particular instrument, a mould can be made from this. The process is not simply one of pressing the pattern into the mould material, however, as this does not flow readily to allow the incursion of the pattern. Rather, the mould material must be removed progressively while offering the pattern up to it, until the cavity is sufficient to allow the pattern to enter up to its centre-line. The pattern, thus serves only to shape the detail of the mould, the bulk of the cavity being excavated separately. The mould material can be made softer and, hence, more mobile by adding water but this is effective only to a limited degree as, when very wet, the clay becomes sticky and adheres to the pattern, preventing its removal. In fact between the dry powder form and that of suspension (clay slip) clay presents a whole series of faces. It is understanding of these that enables one to work it accurately, for instance, knowing when it is too dry to make additions that will integrate onto the surface and when it is too wet to have the necessary strength to prevent warping of the joint-line when the mould halves are handled independently.

It is quite clear that the use of two-piece moulds made of clay required a deep understanding of clays and clay mixtures quite as deep as but different in content from that required in lost-wax casting using clay. Indeed, Hodges[198] comments on the ability of the mould maker to refine his clay to a higher degree than the pottery maker of the time, but the potter created an object from a homogeneous mass whose shrinkage on drying would not impair its function. Furthermore, the actual degree to which it shrunk and, to some extent the distortion of the original form were both immaterial to the maker. In contrast, the moulder used clay as an engineering material. He made several parts which, when dry, had to fit together and required an awareness of shrinkage rates. From these parts, he expected a performance to suit their specific use in the mould. Thus, it is not surprising that the mould maker experienced a more intimate relationship with his working material and, most probably understood it better than his contemporary craftsman, the potter.

Having formed the basic shape of the horn in the mould, and repaired where necessary, many details were then added. These are principally features which could not readily be formed on the pattern or would prevent its removal from the mould.

The most obvious features added were the decorative spikes present on later instruments. If incorporated on the pattern these would prevent its removal from the mould by creating re-entrants. Figure 5.6).

[198] Hodges 1954, 63, footnote.

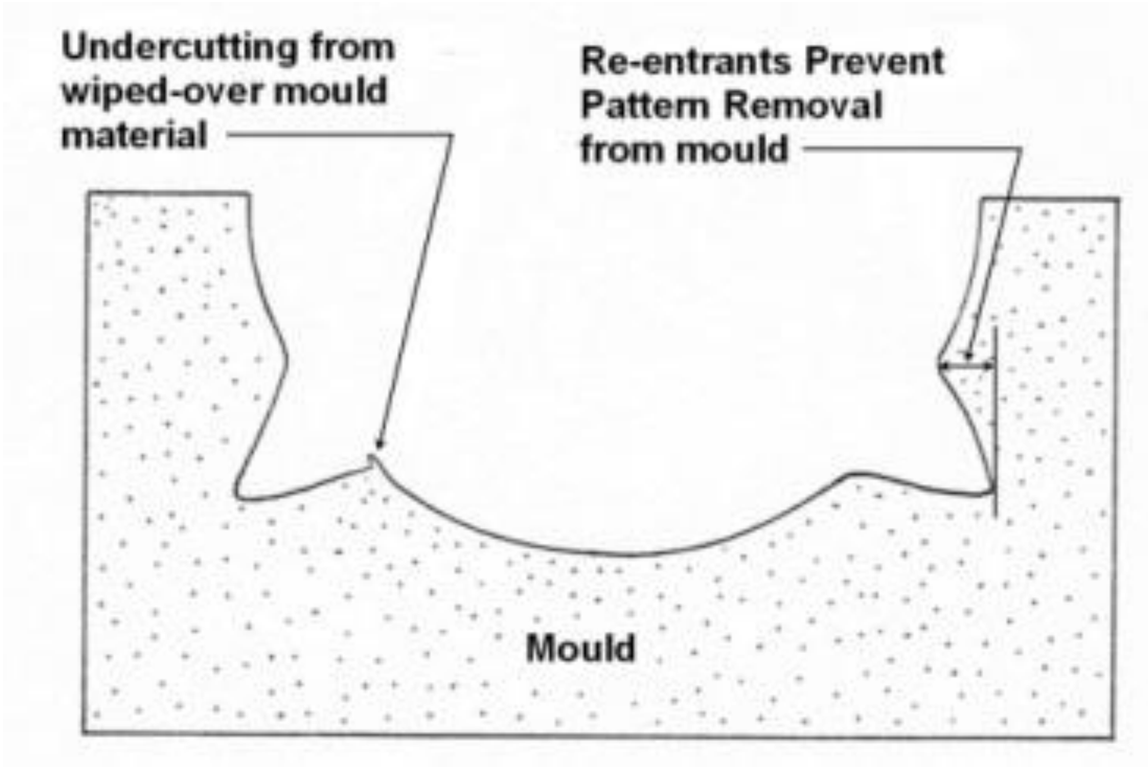


Figure 5.6: The Re-entrant Nature of Spikes

These spikes were probably produced by pressing a separate small pattern into the mould to form the required cavity. Undoubtedly the use of small formers would tend to distort the adjacent portion of mould and this would then be cleaned up or perhaps radiused in. In one case on SD7B the mould was wiped over for some reason, forming an overlap that subsequently left an undercut at the base of the spike. (Figure 5.6, above)

Three instruments (SD7F, 31 and 37B) have circumferential bands towards the bell end which were produced by removing rings of material from the mould surface. On SD31, the resultant cast raised bands are interrupted, on the inner and outer curves of the instrument, by a casting joint-line, indicating that they were developed on the mould prior to casting. On SD36A, three groups of bands were cut into the mould to form a bell decoration but between two of the groups a zigzag decoration was cut into the metal of the horn itself. It may have been that the maker saw the difference between an incised and a raised decoration as significant but it seems more likely that the difficulty of cutting this evenly on a female curve was too great.

Two instruments from Corracanvy (4B and 4C) have rope moulding cast integrally or cast-on around their bell. (Plate 5.6a)

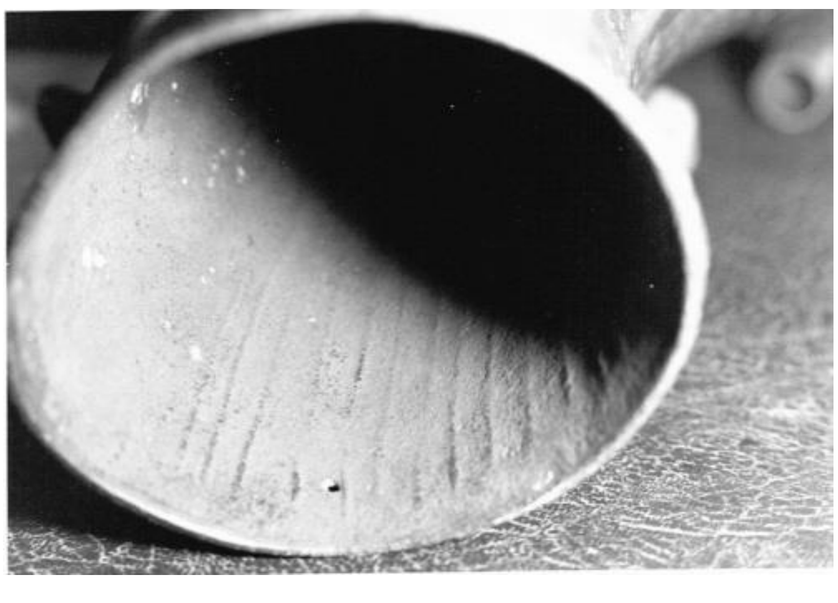



Plate 5.6(a) & (b)

The decoration is a true twisted decoration and was made by impressing a twisted string or wire into the wet clay mould. On 4B unwinding of the individual strands of the forming medium is visible while on 4C some 5*mm* of longitudinal mould offset shows the decoration to have been applied on the mould.

MANUFACTURE OF THE CORE

Following the manufacture of the mould, the core would need to be produced to suit this. Modern practice would utilise a core box which forms a core to the required dimension but no evidence exists for such a practice on these instruments. Cores can, of course, be hand formed and, subsequently worked to fit the mould, giving the required casting wall thickness. The limitation on this technique is imposed by requirement of wall thickness for, as the wall becomes thinner, it becomes increasingly difficult to manufacture a core which is both curved and round, to fit a mould to the required accuracy. Thus, as the trend towards thinner wall sections proceeded, i.e. towards lighter, more economical instruments, a technique was sought to produce accurate cores. This seems to have utilised the mould as a core-box to form the core, similar in some respects to the technique used to make cores for gravity die-casting of axes. However, if a core was pressed into a mould of dry-green clay this would rapidly absorb moisture from the mould and, hence, stick to it. This would suggest that the moulds themselves were actually fired so that at least their surface had been changed to ceramic and the danger of adhesion removed.

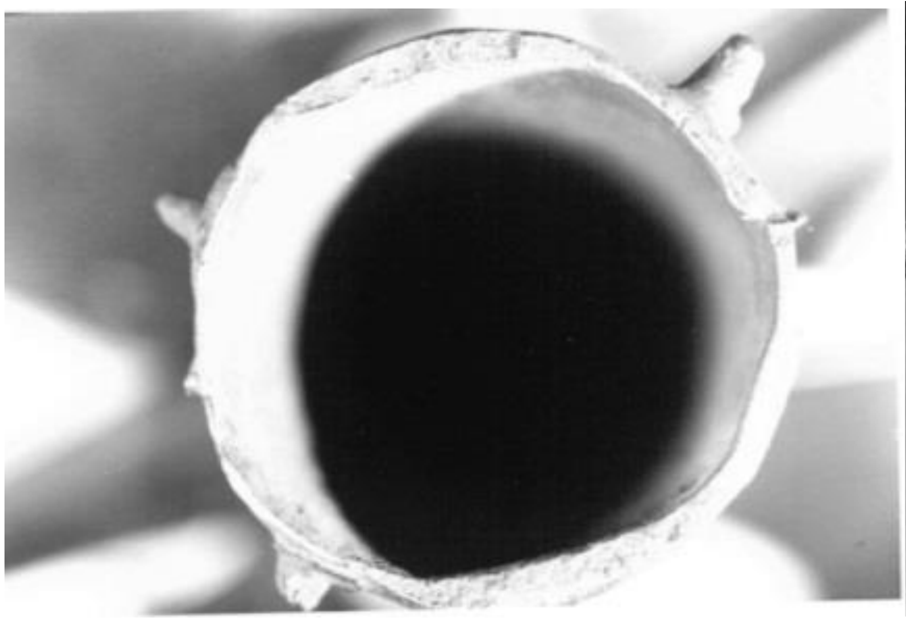
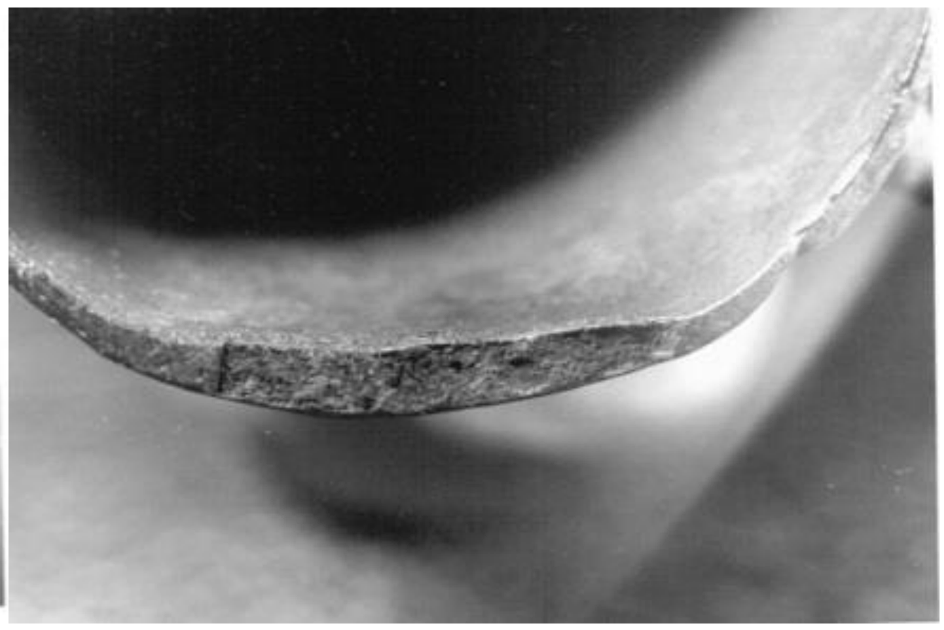



Plate 5.7a and Plate 5.7b

The evidence for use of the mould exists on tubes such as SD6C, 7D and 17B where features on the outer surface of the instrument are replicated in the bore i.e. tending towards the production of a constant wall thickness. On other instruments it is seen as hollowing underneath integrally cast spikes principally at the bell-mouth, these being more visible at this point. (Instruments SD13, 22B) (Plate. 5.8a).

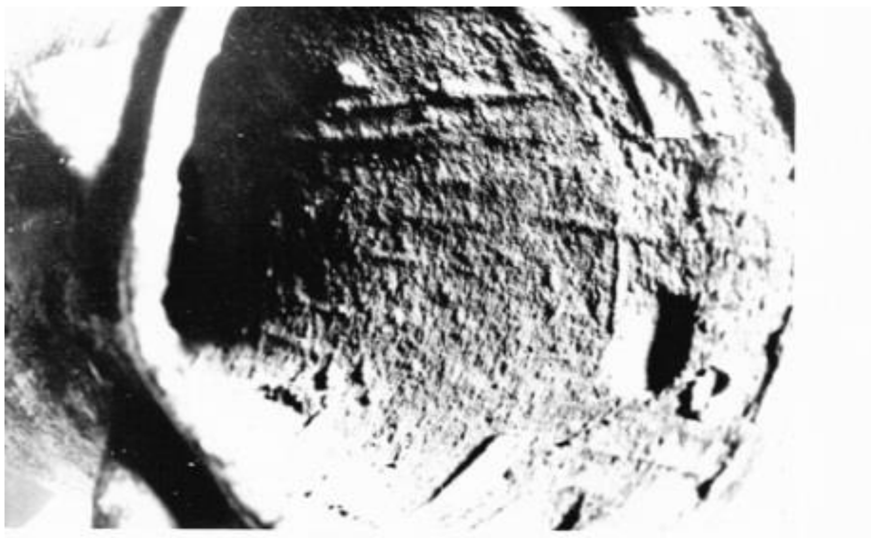
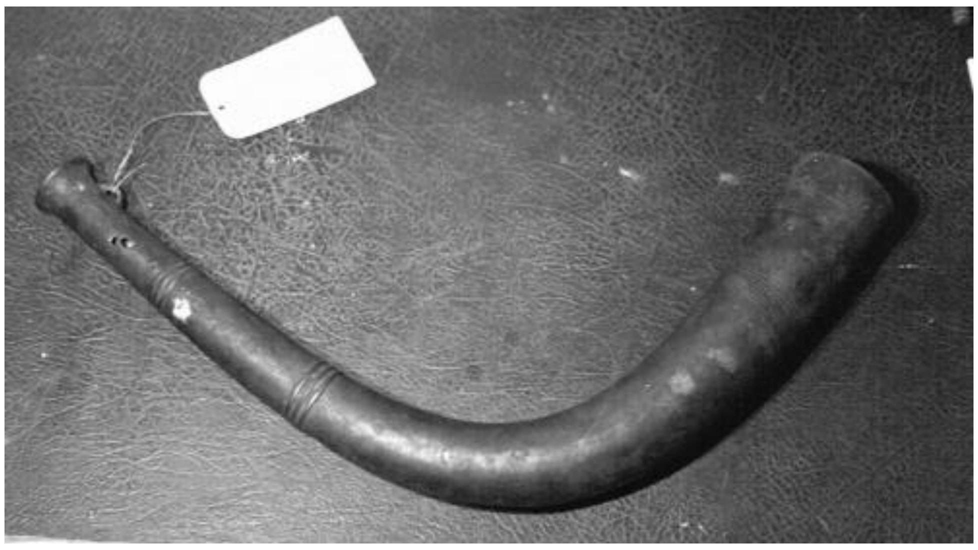
 

Plate 5.8(a) & (b)

Having produced a core to the same dimensions as the mould this, on -drying would shrink, becoming smaller in all three dimensions as well as changing its overall form. Thus, diameters produced from a mould would decrease to about 90% of their original size, so generating automatically, a gap between mould and core. In the case of a mould of 30*mm* diameter (approx. size of type II tubes) the core produced would shrink to about 27 mm, giving a core/mould gap of 1.5*mm*. In the case of the large diameters seen on bell ends e.g. SD41 its diameter of 93*mm* would shrink to about 84*mm* giving a core/mould gap of 4.5*mm*. However, on SD41, for instance, the tube wall-thickness averages 1.6*mm* indicating that the core, if made this way, would have required building up.

Other dimensions would, of course, also change as the clay shrunk and in the case of straight tubes would give rise to a clearly visible difference between the mould and core. 0n 6C for instance, the difference would be of the order of 70*mm* over its length and the maker would certainly have to accommodate such a change in length in his detailed manufacturing system. This can be fairly readily done with a straight parallel tube, where an additional section can be set into the core but this is not so for a curved conical tube. In this latter case the mean length of the tube decreases, reducing both the radius of curvature and the chord length. The resultant mismatch of shapes is such that after shrinking, the core no longer fits inside the mould. (Figure 5.7).

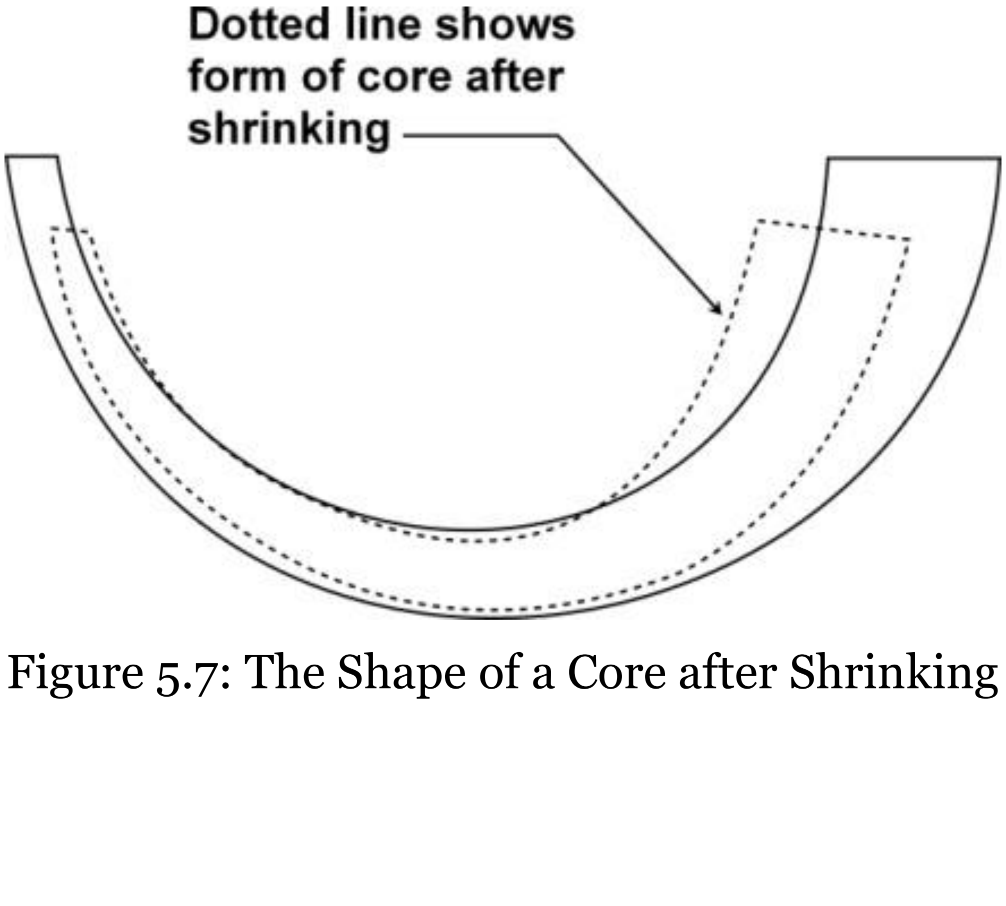


Figure 5.7: The Shape of a Core after Shrinking

Where such highly curved instruments were made, the cores were produced in parts, allowing the dried core to fit in the mould, albeit with an unequal mould/core gap. As individual matching of the core to the mould appeared to have been used, the mould/core gap had to be checked for each assembly. Apparently, to facilitate this, the core was further subdivided along a horizontal axis. This half-core could then be laid in the mould with chaplets or clay pieces to maintain the casting cavity and the flat "diameter" of the core trimmed to lie flush with the mould's joint-line. Bore evidence in the form of flash lines both along the axis of the instrument and normal to it are seen on instruments SD7E, 7G, 13, l6D, 27A, 27B, 29C, 36A, 40 and 41.

A further solution to the core-fitting problem was to design the instrument so that the dried core shrunk to a form that still fitted inside the mould. This was done by eliminating curvature at the tip and bell of the instrument and restricting this to its centre. Thus a curved "L" shaped instrument was evolved, on which the core shrunk towards the centre of the curve. (SD4A,4B, 14D, 14F, 14S, 16A, 16B, 31, 36A and 40) None of these instruments have a multi-part core. (Figure 5.8a, above and Plate 5.8b, above).

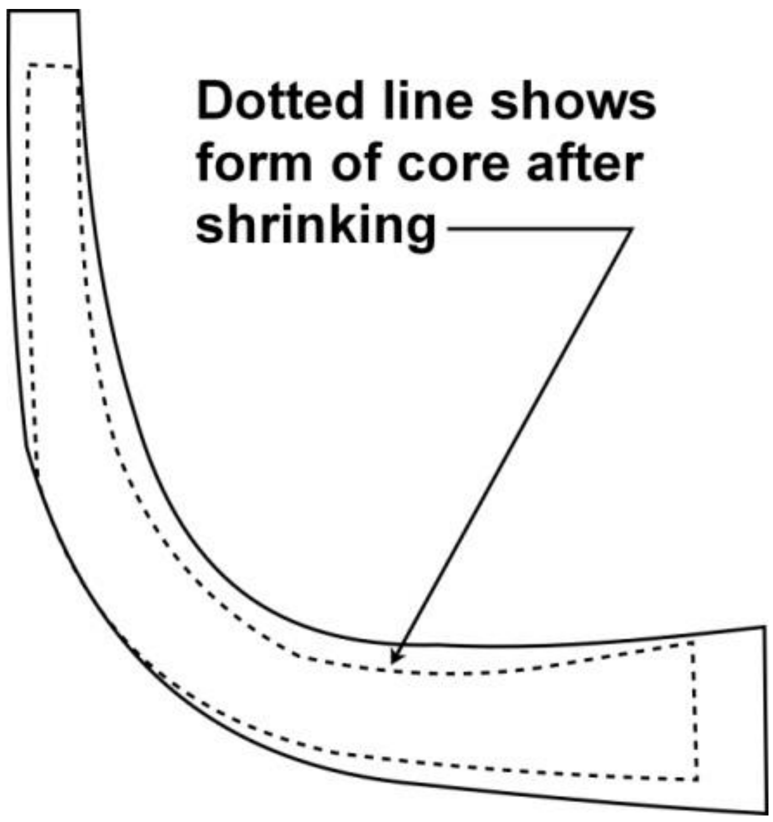


Figure 5.8(a): A Further Core Shrinkage Pattern

Several surface features are present on the bores of instruments and these are clearly attributable to the surface finish on the cores. On several of the Dowris instruments (14A, 14E, 14P, 14R and 14S) as well as 19A, the bores show features which are most likely produced from finger marks on the core. This suggests that these cores were not subjected to extensive working either while wet or dry and this seems to match the other primitive features of these instruments in terms of manufacturing technology. The thick walls of this instrument would accommodate considerable variation in form between the core and the mould without a hole in the wall being produced. Thus, it is possible that a core was produced from the finished mould in the case of these instruments, the shrinkage and consequent divergence in morphology of mould and core being accommodated in variation of wall thickness.

On other instruments e.g. SD37A and 41 the bores are very smooth, as if produced from a very fine clay which was subsequently worked to a very smooth finish, while others have a prickly appearance, dotted all over with fine incursions into the bore. (Plate 5.9a, below)

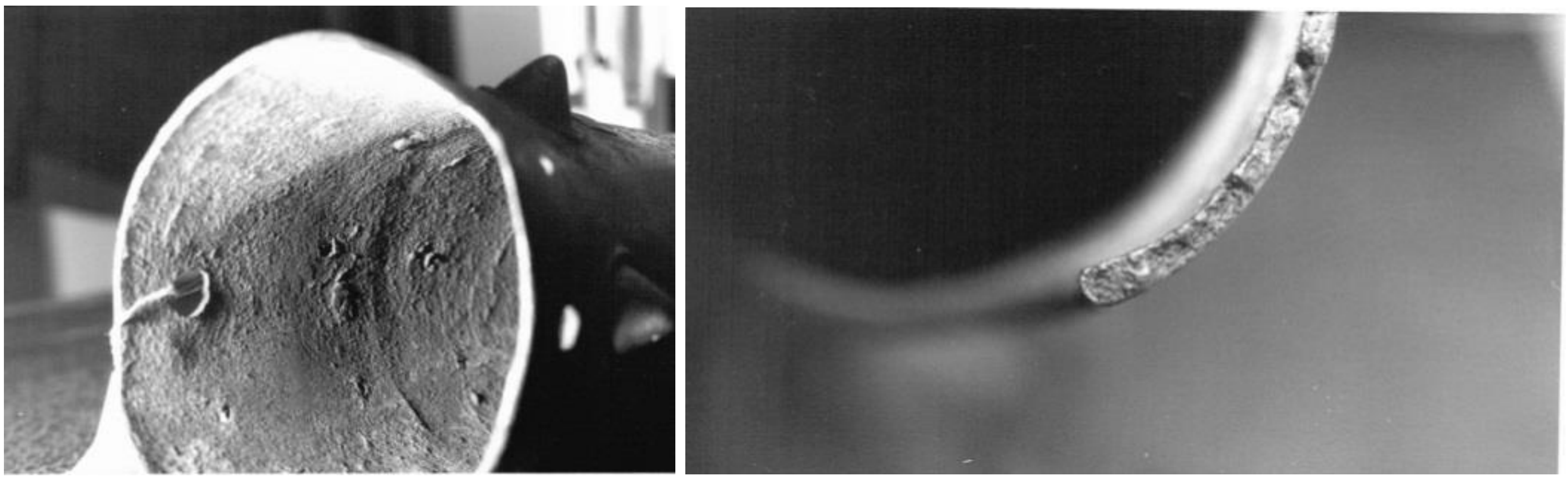


Plate 5.9 (a) & (b)

These instruments (e.g. SD29C, 14S) may have had a sandy core with this coarse material having pulled out on the surface leaving the voids or the sand could have been used as a parting material, hence leaving the hollows in the core. Two of these instruments, SD13 and 14S show signs of attempts to clean up this rough bore by use of a wet spatula wiped over the surface. Several instruments have axial striations in the bore, produced by scraping hollows in the core. On the finished instrument, these mimic growth lines seen on a natural horn as shown on Plate 5.29b. Two examples on the bronze instruments are seen in plates 5.6b and Plate 5.8 a, above.

Plate 5.8b: Growth Marks on a Natural Horn

FEEDING THE CASTING

If as suggested above, the moulds were poured while horizontal the metal could have been introduced from either tip or bell end of the instrument. However, in order to maintain constant practice when casting both side and end-blown instruments the most likely position for gating the mould would be at the instrument bell end. That this was the practice is borne out most clearly on instrument 14E which has two thickened sections of tube at its top and bottom surfaces. At these points the metal has clearly been fractured off and not subsequently cleaned up. (Figure 5.9 and Plate 5.7 a/b), above).

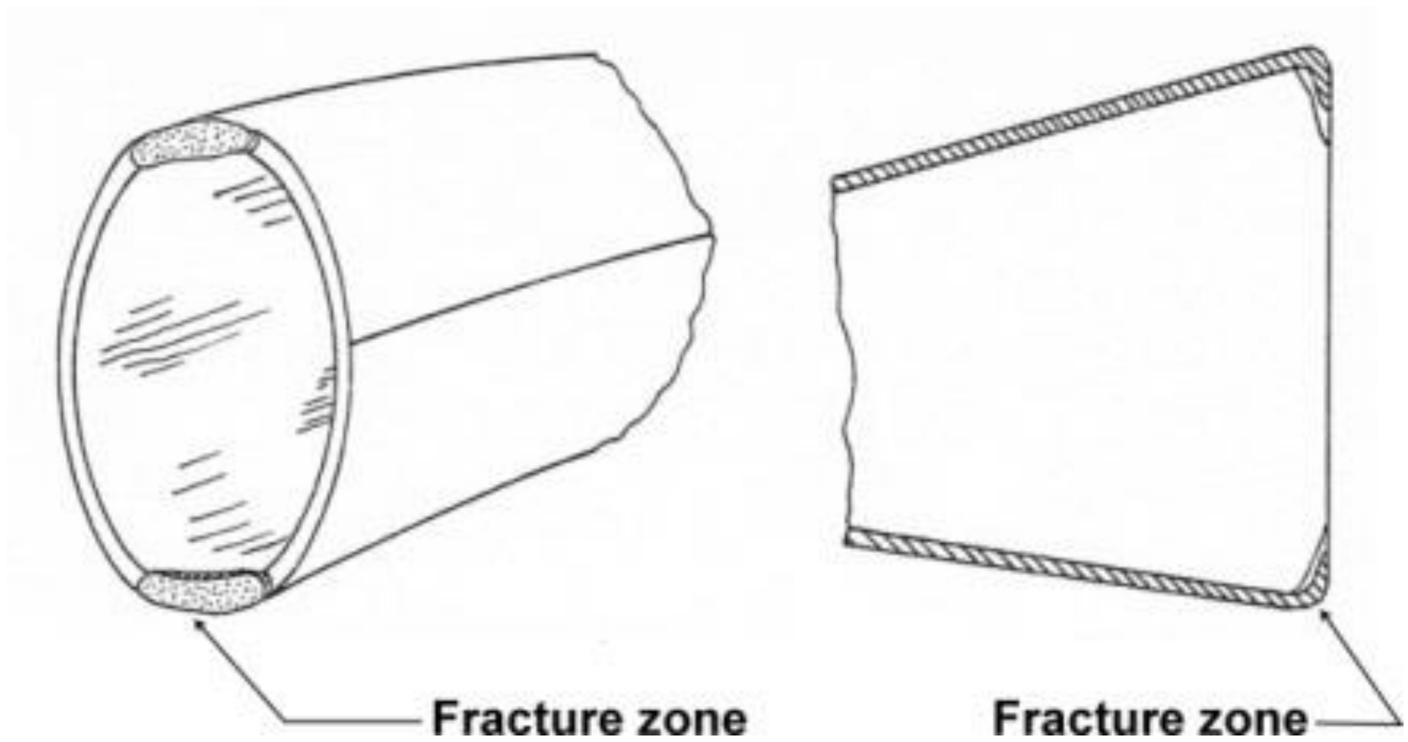


Figure 5.9: Evidence for the Sprue at a Bell End

No other instrument has such remnants showing the sprue fracture zone as, generally speaking the excess material has been abraded back. However, similar features, machined back, are present on SD14G, 27A, 29C, 32 and 40,and on SD27A and 40 the somewhat bulbous termination of the sprue remains at the bell end. Figure 5.10.

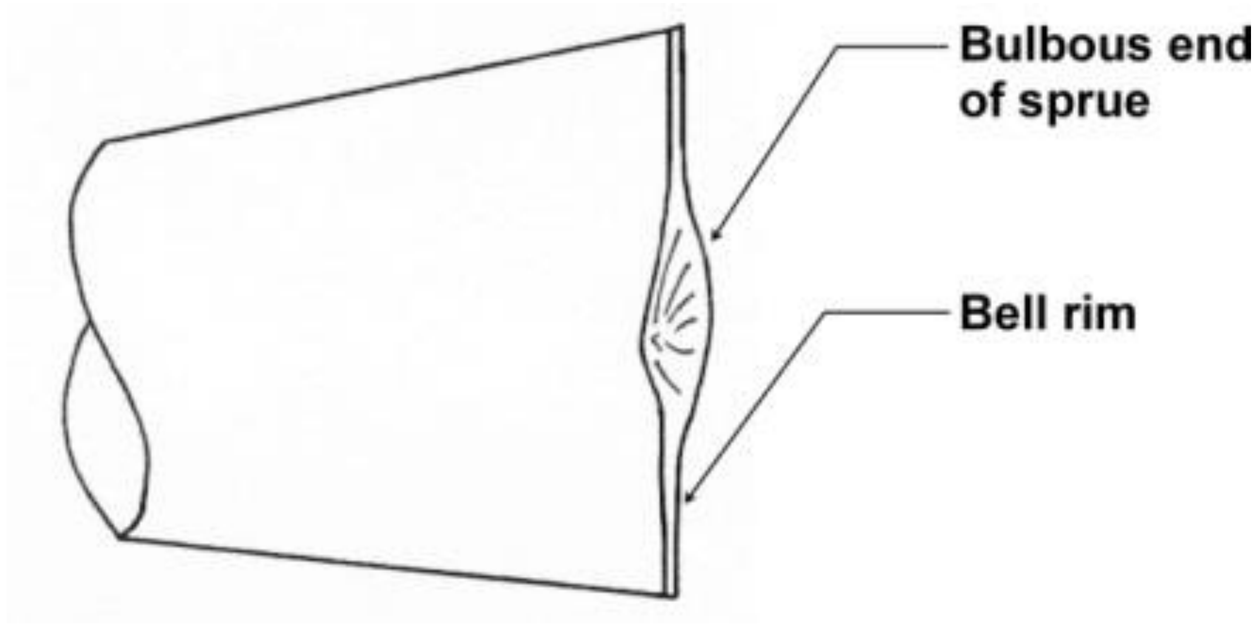


Figure 5.10: An Abraded-back Sprue Ending

The evidence on SD14E suggests that the sprues were simply fractured off from the tube to remove these and, in the case of SD40, while the one sprue was fractured satisfactorily, a section of tube was broken away when removing the other. This fracturing of the tube wall appears to have been a common occurrence and evidence of it having happened is also present on SD14L and to a lesser extent on several other instruments. (Plate. 5.10a)

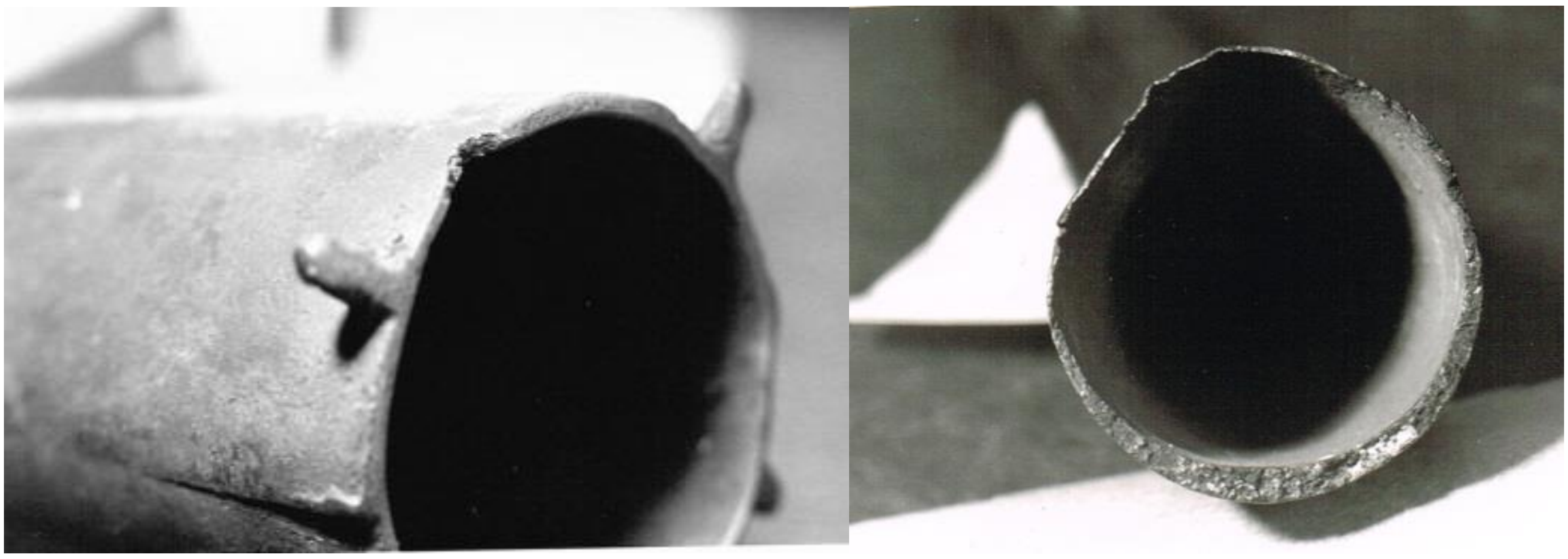
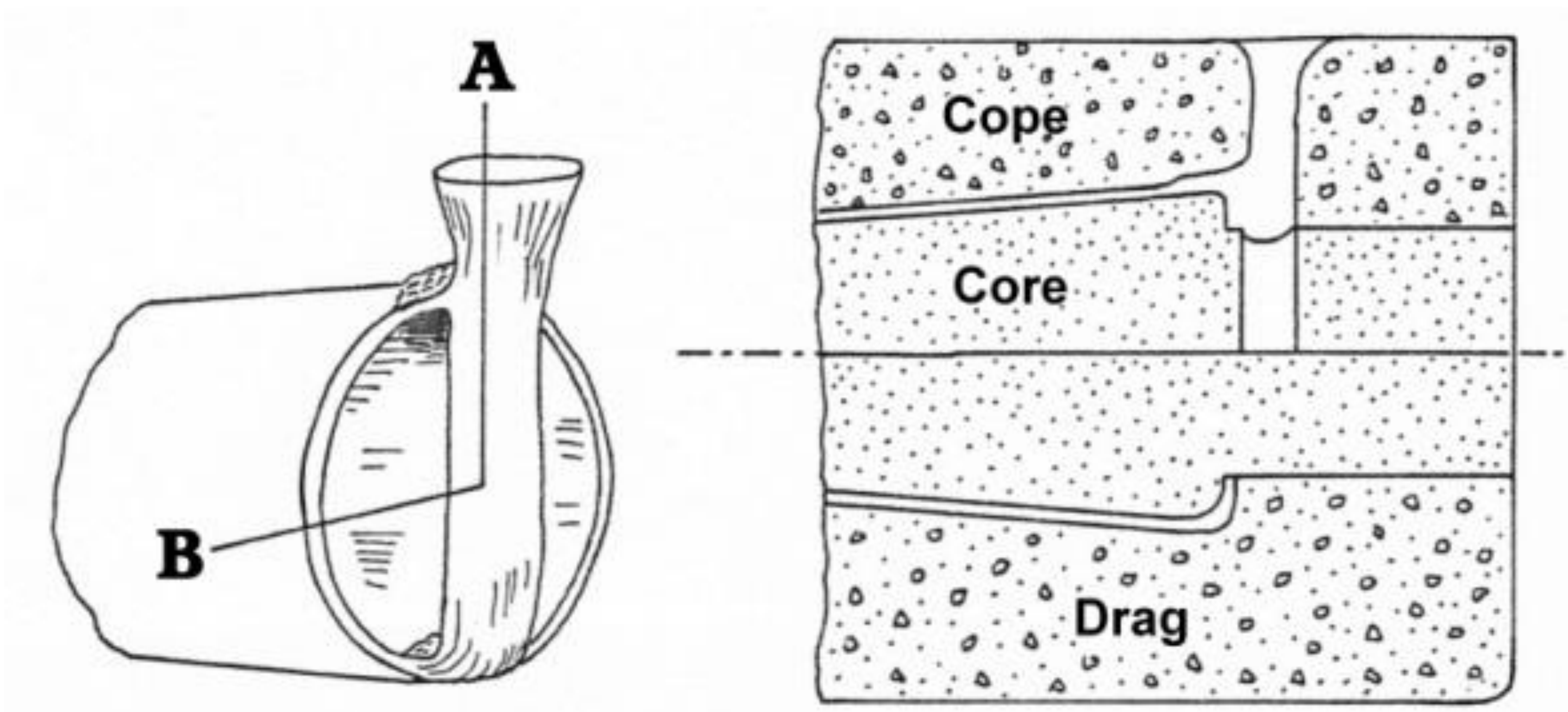


Plate 5.10: Registration Errors on Bell Ends
And Broken-off Sprue Endings

Only one instrument (SD14F) shows signs of possible gating from other positions although the evidence on this instrument is rather problematical.

Thus the mould cavity was probably fed from a sprue entering at the bell end. (Figure 5.11) This would have to feed through the core-print and may have been connected to the bell with a narrower feeder to facilitate its fracturing off later.



Finished Casting before Removal of the Sprue

Scrap Section Across A-B on Mould/Core Assembly

Figure 5.11: Feeding the Casting

Such an arrangement although probably arrived at empirically would prove reasonably effective, providing that the feeder was not fully blocked by metal during pouring. When partially open, this would allow entrapped gases, steam[199] etc. to escape and the mould would fill up from the drag expelling air into the cope and hence up the feeding channel.

On instrument SD27A, one sprue junction, probably that on the drag, is adjacent to the tube joint-line. Such a gating arrangement would remove the necessity of making a hole through the core thus weakening it. The probable gating arrangement is illustrated in Figure 5.12. This may well have been the technique adopted on instruments with split cores where this type of gating avoided having to align the two mould halves longitudinally to a high degree of accuracy.

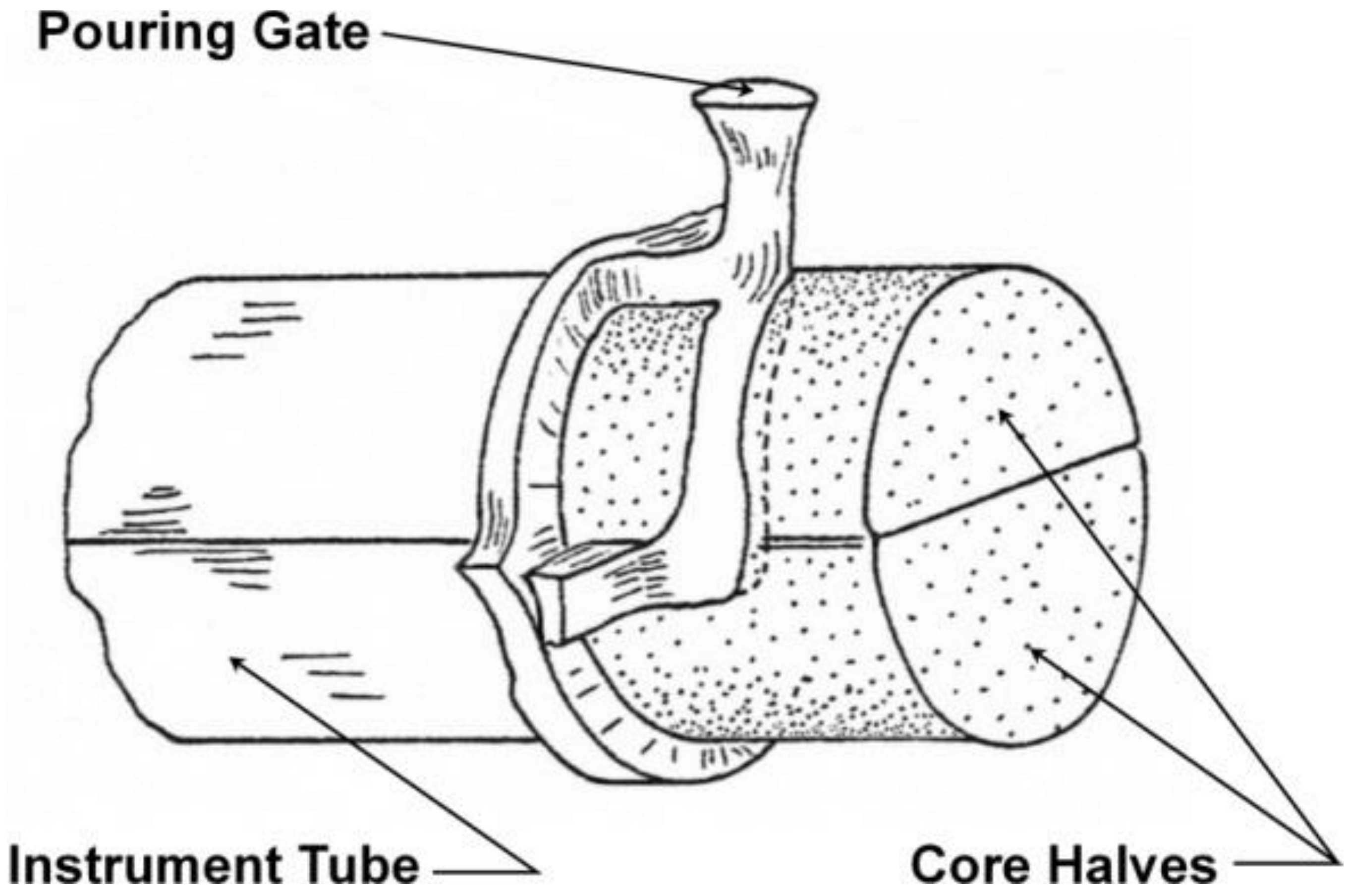


Figure 5.12:Gating Evidence on Bell Ends

No fragments of moulds remain to indicate whether or not these were fired prior to casting. Curle[200], describing moulds found at Jarlshof, Shetlands, suggested that the moulds for axes had been fired prior to manufacture of the core. Certainly, the core fragments remaining in the side-blown instruments are in the dry-green state with the ceramic change being visible only on that area in immediate contact with the bronze tube. It seems probable, therefore, that the mould/core assembly was not heated prior to casting, or at least to no high degree. This would account for areas of sluggish metal flow on instrument tubes, presumably where the metal was losing fluidity as the mould was being filled. (Particularly noticeable on SD29C, Plate 5.3b, above). It would also account for the feature on SD14M where a thin chaplet had acted as a chill and the casting charge

had failed to flow over this to fill up the space between this chaplet and the core - see Figure 5.5 (Left).

[199] My own subsequent casting experiments indicate that there would like be no steam present as the mould would need to have been preheated. Dampness in a casting environment can be disastrous!
[200] Curle, 1932, 122.

The simplest parts of instruments, in terms of manufacture are those which have apertures at both ends, allowing their cores to be supported adequately by core prints, such as instrument 14P and 14Q. (Figure 5.13).

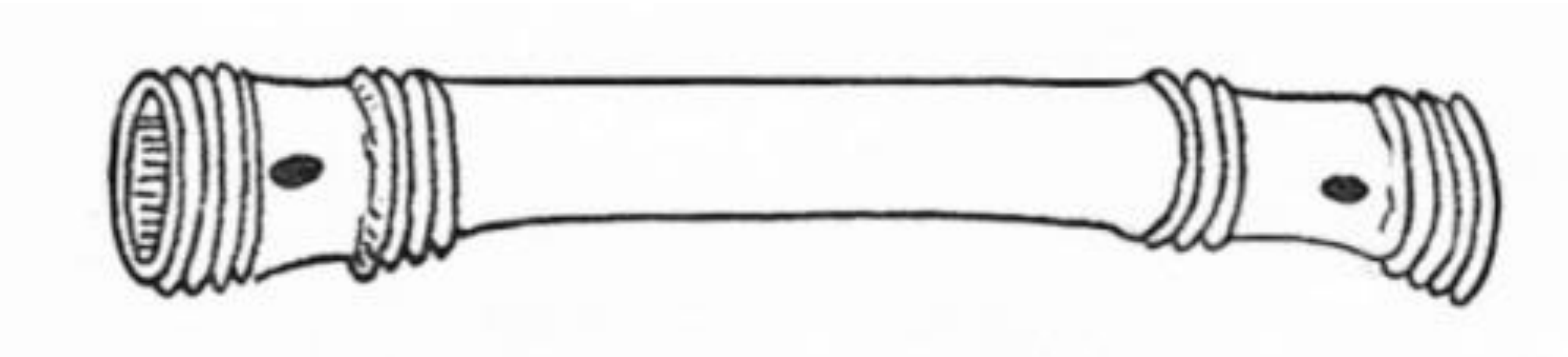


Figure 5.13

This could be cast quite simply as shown in Figure 5.1. However, as longer tubes are made, accurate positioning of the core becomes increasingly difficult even with straight tubes. Thus, any discrepancy in alignment of the core's prints or its axis will give rise to discrepancies in the thickness of the final tube wall. However, when tubes are made with curved axes the prints must not only restrain the core in a vertical plane but must also prevent it twisting inside the mould.

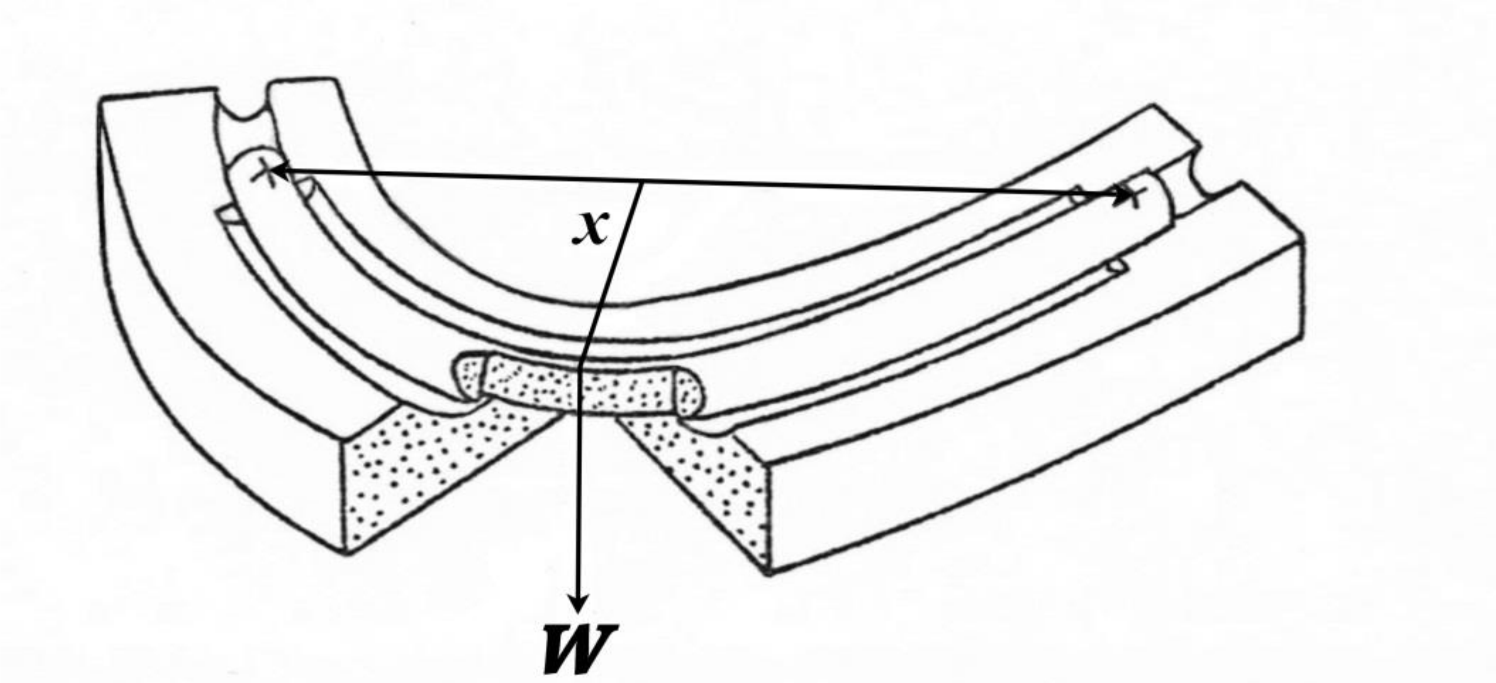


Figure 5.14: The Twisting Moment Acting on a Curved Core

Figure 5.14 illustrates the situation where a core weight of W acts at a distance of x from the pivotal axis of the core prints to give a turning moment of Wx. Accurately made core prints/print cavities would be sufficient to retain the core in position provided the cope were tightly held onto the drag. While the mould is assembled, the weight of the core tends to pull it downwards, thinning the section in the drag. However, when bronze is poured into the mould, the core is buoyant in the molten metal due to the difference in densities between these (approx. 8:2). Thus, if the core prints are a loose fit, it will tend to rise into the cope giving a thin section in this. A similar effect is also produced by the flow of metal

into the mould, this hydrodynamic lift also tending to lift the core in the mould. However, if the metal remains molten after the mould is filled the core has time to settle and regain an equilibrium position. Undoubtedly, misplaced cores have given rise to many thinly cast and missed sections on horns such as SD36A, 14I, 14R and 4A, the first three of these occurring at a point consistent with twisting of the core having been a cause. (Plate 5.10b, above).

Just whether the remedy of providing chaplets was worked out from observation of failed castings or from the desire to fix an insecure core is hard to say. The latter case would be an obvious one but to suggest that the makers were unable to understand the implications of thin sections produced from a seemingly adequate mould probably underestimates their understanding of the whole process.

The simplest complete instrument that utilised a mould made of the three basic parts would be a fairly simple analogue of an animal horn cast in bronze with the addition of a tube-mounted carrying loop. It would be made as a side-blown instrument with a cast-in blowing aperture. The apertures of instruments of this type are clearly cast-in and were probably made by protrusion of a suitably shaped portion of core through the core/mould gap. This piece of core would itself provide some positive location and is on these instruments, the only feature designed to maintain the core centrally. (Figure 5.15).

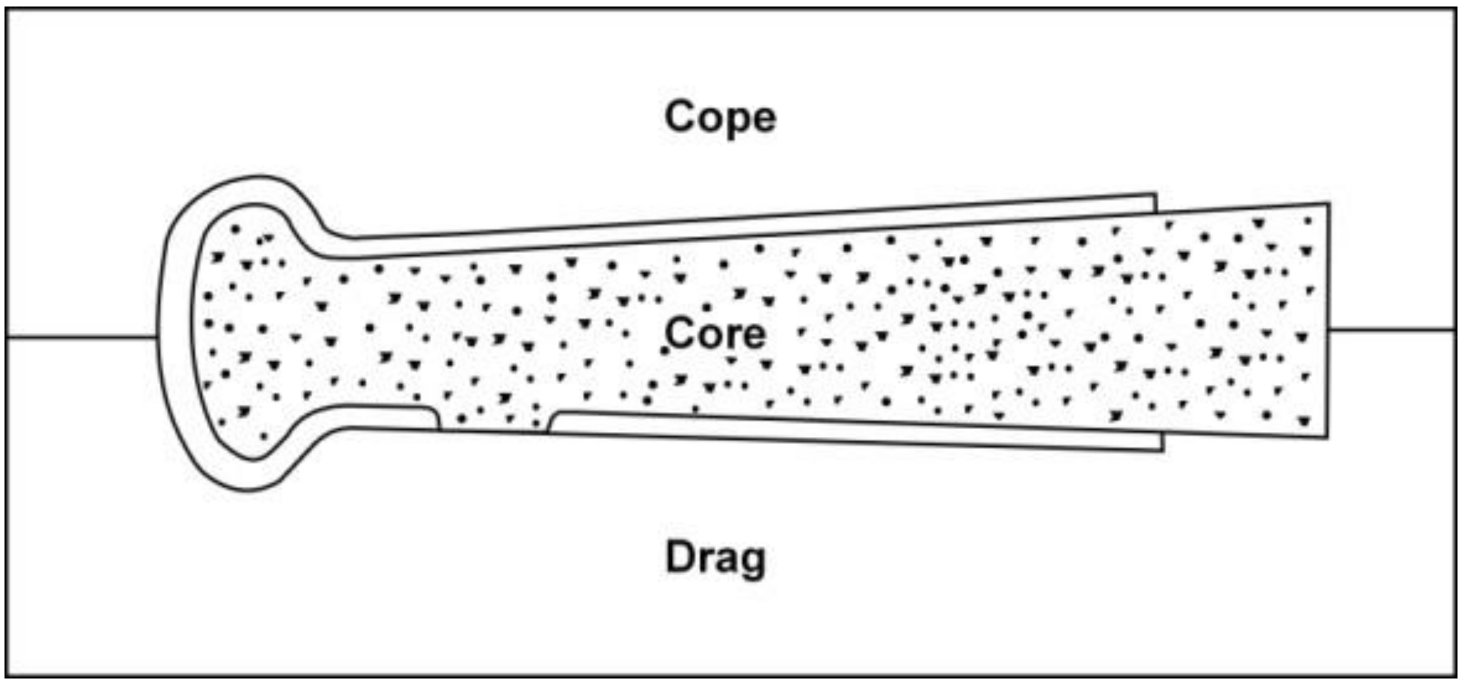


Fig 5.15: The Core-Support System for a Simple End-Blown Horn

Practically all the horns have smoothly-formed blowing apertures which show no signs of having been formed after casting. It seems reasonable to assume, therefore, that the core was used to form this aperture, it being easier to work accurately to achieve a desired shape.

As the blowing aperture is pressed to the lips when playing the instrument, it seems almost certain that the edges of this would be cleaned-up abrasively, before the instrument was used. This seems even more likely when considering the likelihood of a flash-line being formed over the aperture when the core is not pressed firmly onto the mould or does not

seat accurately all round the edge of the blowing aperture core. (Figure 5.16 (below) and Plate 5.11a, below).

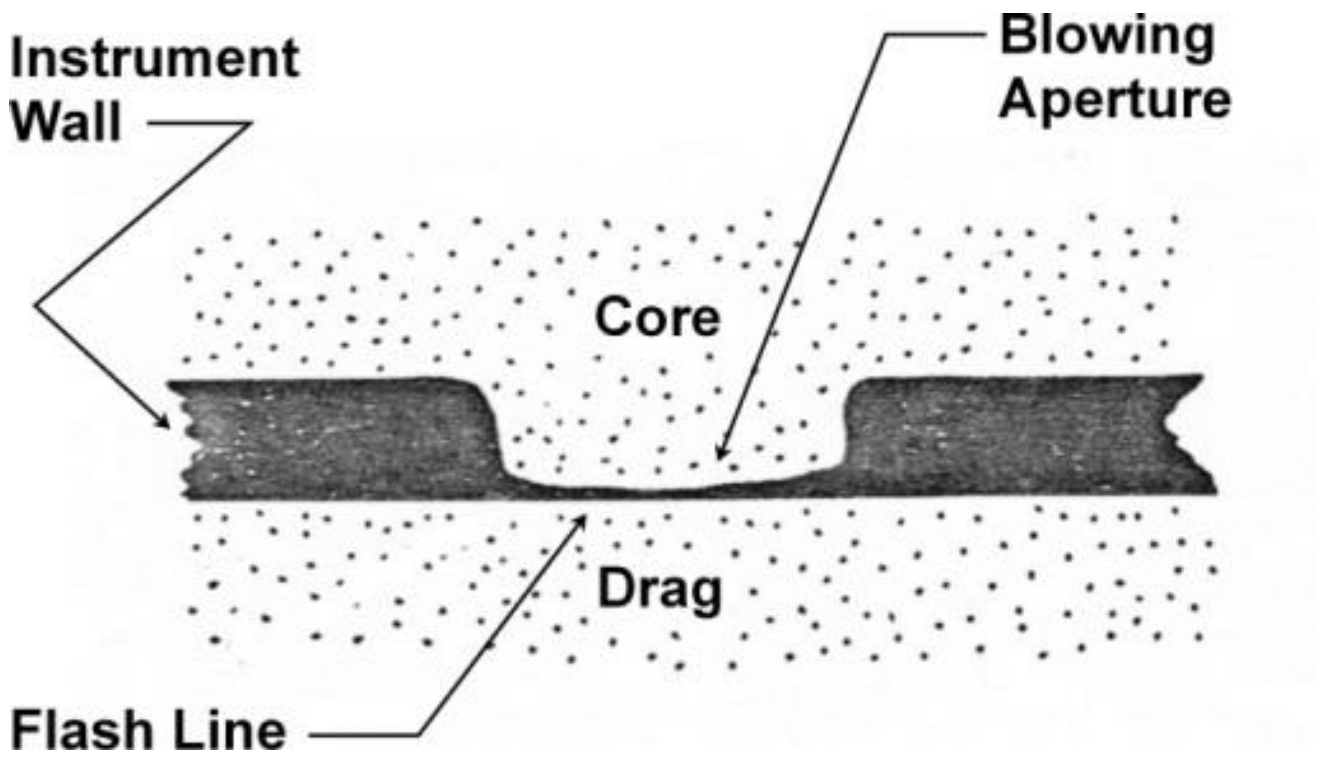


Figure 5.16: Possible Metal Flow Path over Blowing Aperture

The smoothly-radiused blowing apertures of the side-blown instruments could only have been formed by abrasive working (Plate 5.9 b, above) as to produce such a smooth flash-free aperture directly from a casting would require an extremely high degree of precision. Two instruments (SD4B and 36A) have a raised moulding around this aperture, the manufacture of which clearly required a very precise location of the core relative to the relevant mould-half. In order to form this, the core would have to protrude into a cavity formed in the mould itself. Whereas the location of a simple aperture would be determined by the core itself, however, both core and mould would be required to form a rimmed aperture. See Figure 5.17.

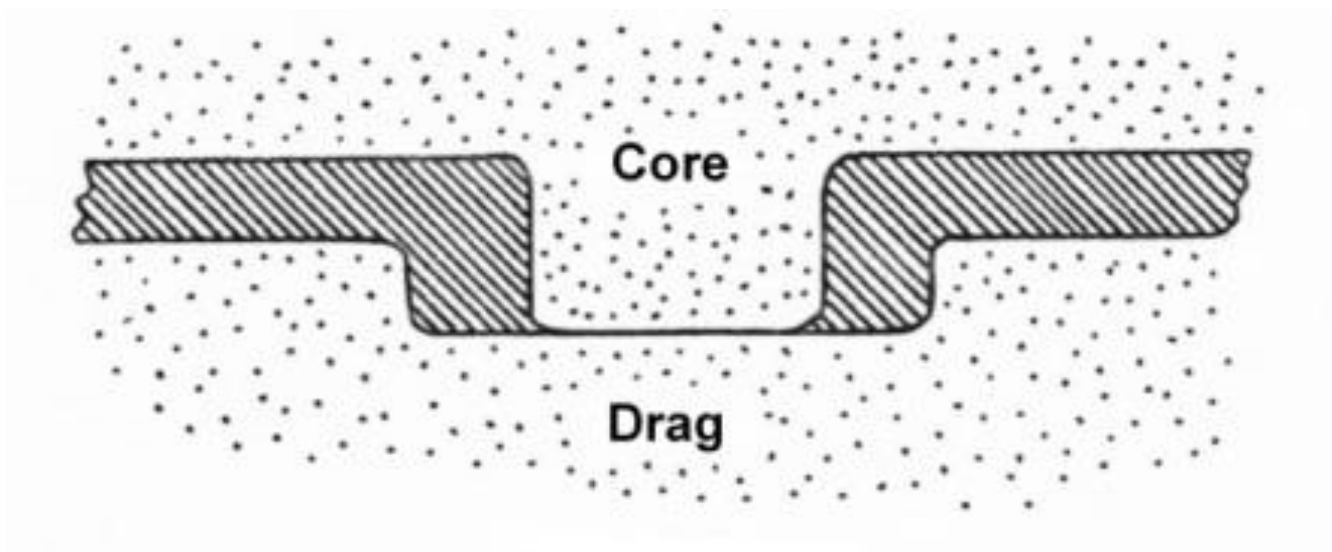


Figure 5.17

In view of the changes in both mould and core morphology which occur with the drying of the clay, such accuracy could only be achieved by producing the aperture cavity on the mould on final assembly. (Plate 5.11a)

Plate 5.11(a)

SUPPORTING THE CORE

Having made a mould and core, the maker would have to assemble these and would soon learn that accurate location of the core in its prints was essential if thin sections were to be avoided. He would thus, presumably, stand the core on either the cope or drag and check the casting cavity. The joint-line gap could be checked visually but not that beneath the core. Modern practice in checking this would be to put thickness gauges below the core to check if this rests on these. Somewhat less accurately, but more common in practice, plasticine or similar material could be placed under the core and this pressed down until it rests on its core-prints. The plasticine can then be removed and its thickness measured to give an indication of the core/mould gap. A similar exercise could have been carried out using wet clay and the support obtained from this might well have given rise to the idea of chaplets. Similarly, when assembling the two halves of a mould and the core, the casting cavity cannot be measured other than by use of spacers as described above. This problem was quite likely to be investigated as the core could well fit both mould halves, only to give mutual interference problems when the two mould halves were offered together, again giving rise to thin sections and totally missed sections of tube. It is not surprising that such failures are the most commonly found ones on these instruments.

Plate 5.12: Chaplet Evidence on Tube Walls

Side-blown instruments obviously differ from end-blown ones in that, lacking a straight-through core, additional core support problems are experienced at the instrument tip. Chaplets were obviously used here in the tip but their application was aided by the fact that the cores were left in the tip of practically all side-blown instruments and, hence, the intrusion of a large chaplet here was not considered to be detrimental to the performance or appearance of an instrument. On SD49, a fragment of the tip of a side blown instrument, its end is broken off and, between its mouthpiece and tip end a 7*mm* x 4*mm* tanged chaplet can be seen protruding into the core, obviously having provided considerable support during casting. (Plate 5.11b, above)

Plate 5.11(b)

The use of clay to measure the core/mould gap would demonstrate that the core could be supported at the critical points, i.e. around the tube curve, maintaining the gap. However, the use of clay as a support during casting would leave holes in the tube when the supports were removed subsequently. These would need to be cast-in as has been done on SD14F. On this, eight holes spaced four on the top tube surface around its curve and four similar ones on the bottom surface have been filled by cast-on material. (Plate 5.12a, above) One other instrument, SD14A has similar cast-on features but on this they appear to have a well-defined decorative function the group at the tip lying between two raised bands and those at the bell lying just upstream of the incised decoration. However, the clay that formed these holes could well have played an important role as a support during casting. As mentioned above, metal supports were used on quite early side-blown instruments to support their blind tips, these remaining in place after casting, and being concealed by the core left in this tip. On two instruments however, SD14J and 14S, two very large (in terms of chaplet size "enormous") pieces of metal were pushed into the core, to protrude just enough to support this in the mould. These were clearly put in place while the core was soft as no cracking or other distortion is visible adjacent to these chaplets. Spaced on the instrument curve, these were obviously placed there to prevent core rotation and were made from a piece of bronze c. 20*mm* by 2.5*mm* cross-section and protrude into the bore some 10-15 *mm* . Their innermost part has been formed into a crude point by breaking off the edges of the material. (Figure 5.18).

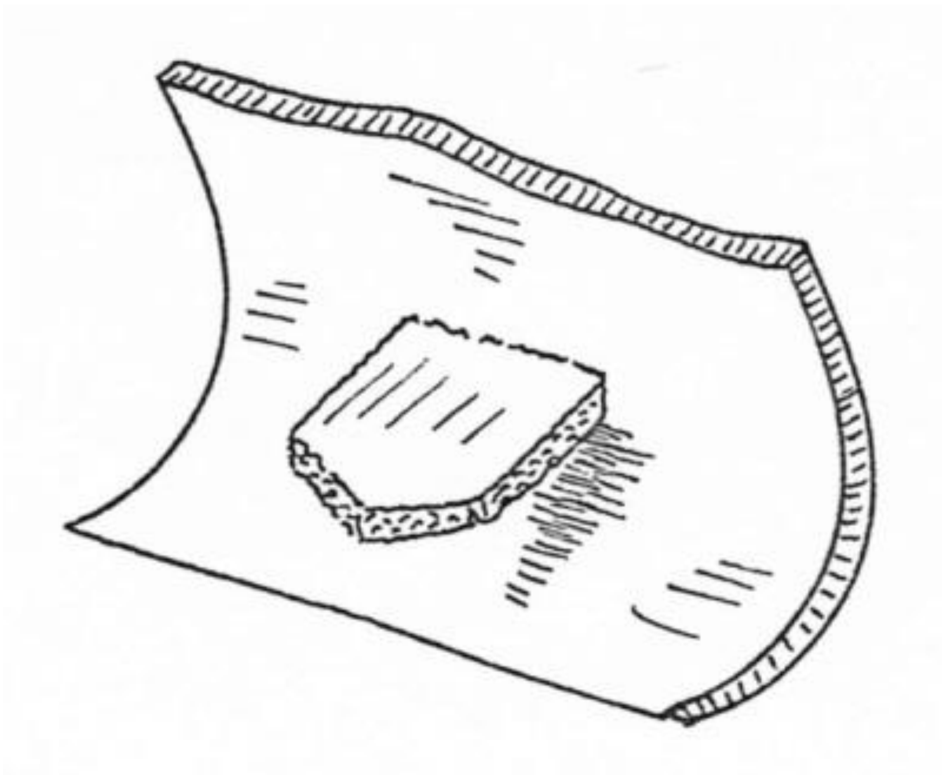


Figure 5.18: A Tanged Chaplet

The simplest (earliest?) developments in the application of chaplets, however, used irregularly-shaped pieces of bronze with edges up to 15*mm* long which were simply trapped between the core and mould (Figure 5.2 b, above and Plate 5.13a/b), below). Having been broken off from cast sheet, the chaplets are generally noticeably less round than the adjacent portion of tube and their surface extensively pitted. Also their junction with the cast tube material is almost always visible their perimeter being marked by a distinct hollow, probably as a result of chilling. One instrument, 14R, has one such chaplet placed in the centre of the tube's curve. In this particular case the arrangement proved inadequate as the core became displaced the thickness of the resulting tube varying from 0.46*mm* to 3.3*mm* as shown in Figure 5.19, below. More generally, a row or rows of such chaplets (here called "surface" chaplets) were used, the earliest positions of these appearing to be on the bottom centre-line of the mould as on instrument SD4D.

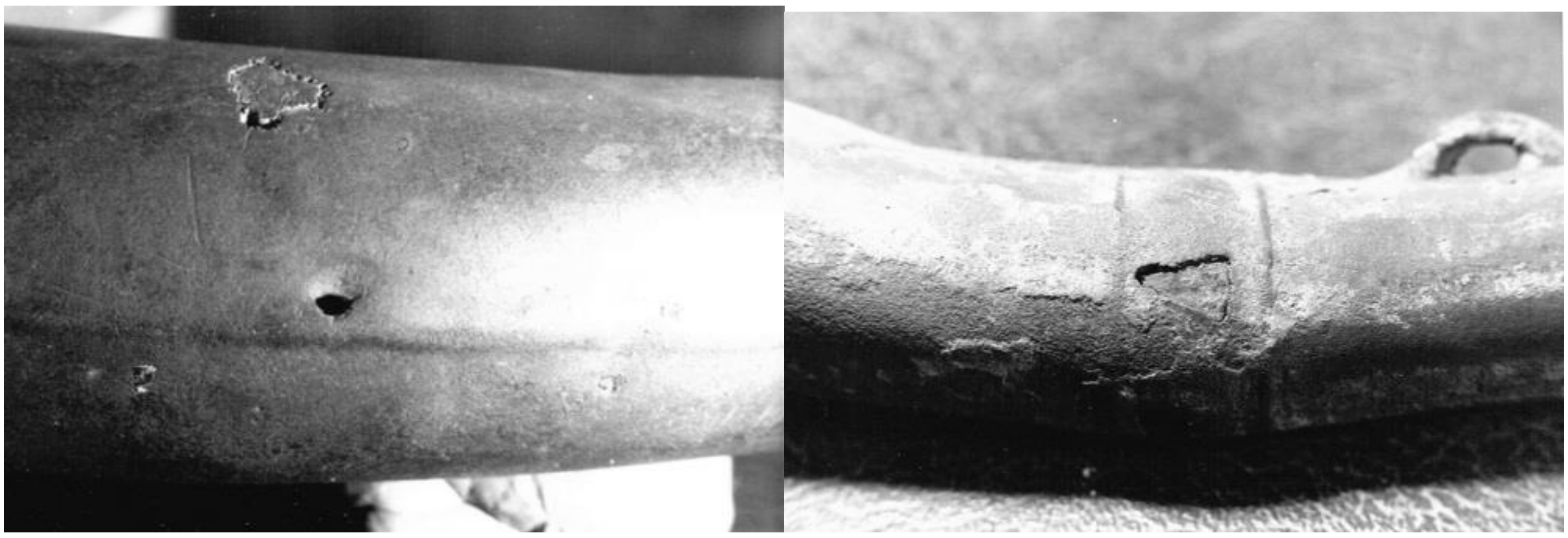


Plate 5.13

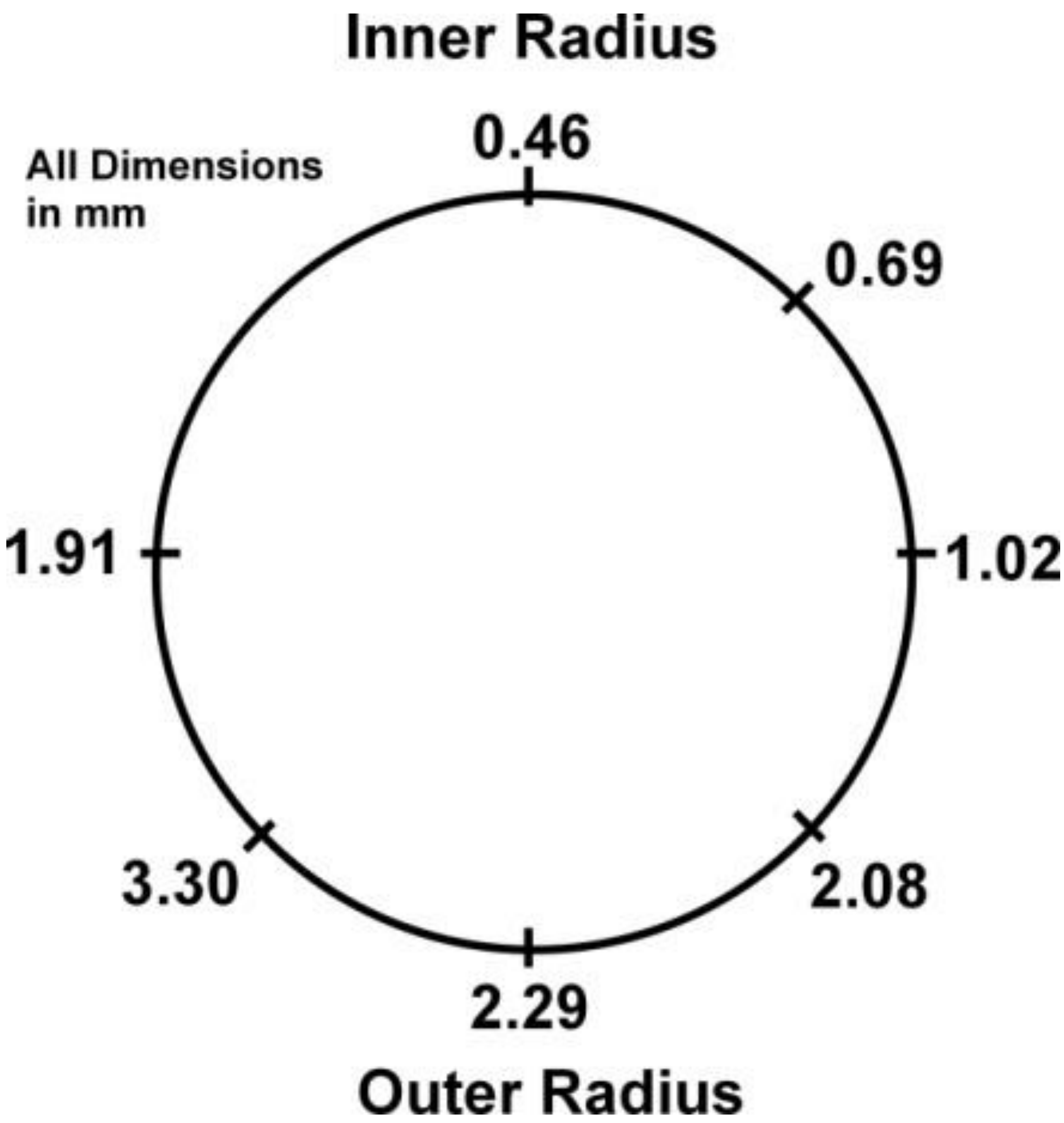


Figure 5.19: Tube Wall Thicknesses on SD14R

Two problems associated with the use of chaplets now presented themselves:

i) that the chaplet sitting on the core/mould surface, i.e. restrained by the nip between these surfaces, was liable to be displaced when this nip was insufficient

ii) either single or double rows of chaplets were insufficient to restrain the core adequately during pouring of the casting.

The evidence suggests that these two problems were worked on by more than one local industry, parallel development taking place, although there appears to have been some interchange of techniques between these. The single row of chaplets while providing static support for the core prior to casting did nothing to overcome its bouyancy during casting giving rise to thin sections on the instrument's top surface. Thus, moulds with two rows of chaplets were made, one row on the top of the mould and one on the bottom (SD1, 14D, 14E, 14J, 14K and 17A).

Although two rows of chaplets restrained the core more tightly, the loose chaplets were still able to slip out of position (Plate 5.14a, below), perhaps when the mould was being handled prior to casting or perhaps when the core moved as metal was being poured in.

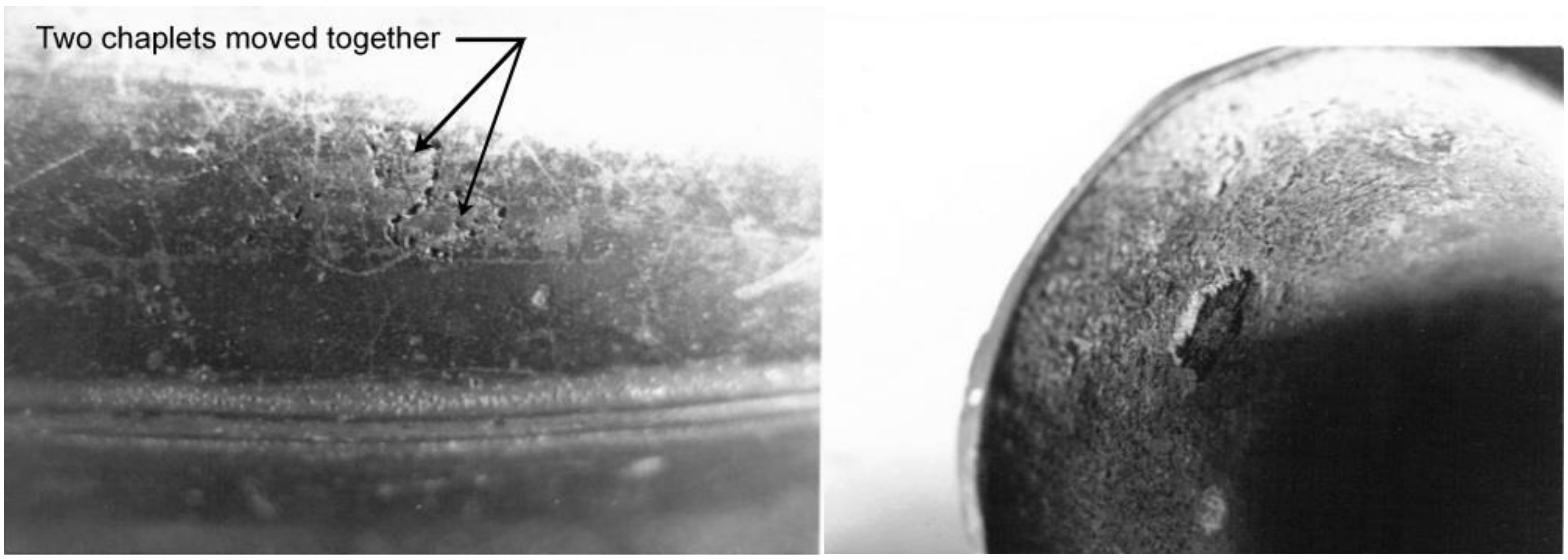


Plate 5.14: Chaplets in situ

Thus, a modified method of restraint was developed where the chaplet was thicker than the final desired instrument wall-thickness by 1 to 1.5*mm* and was pressed into the core by this amount (here called a keyed surface chaplet). This held in place satisfactorily and, when the core was removed subsequent to casting, left the chaplet to penetrate into the bore. (Plate 5.14b, above) Instruments SD1, 14K and 17A have the two row arrangement of chaplets with these pushed into the core. With the adoption of this technique, the chaplets used tended to be smaller than the earlier type, many being only half this earlier size and others being as small as 1.5 mm across. However, this pattern of development seems not to have occurred in all areas as instruments and SD14M and 36B have the simple surface chaplets but these are arranged in six separate rows. Thus, it seems that the industry that produced these chaplets concentrated on the development of a more satisfactory chaplet configuration while elsewhere workers were developing more sophisticated forms of chaplets themselves.

It is not possible to pick out a single stream of development beyond this stage, as both the chaplet form and configuration were undergoing developments in parallel, with constant cross-fertilisation between the two.

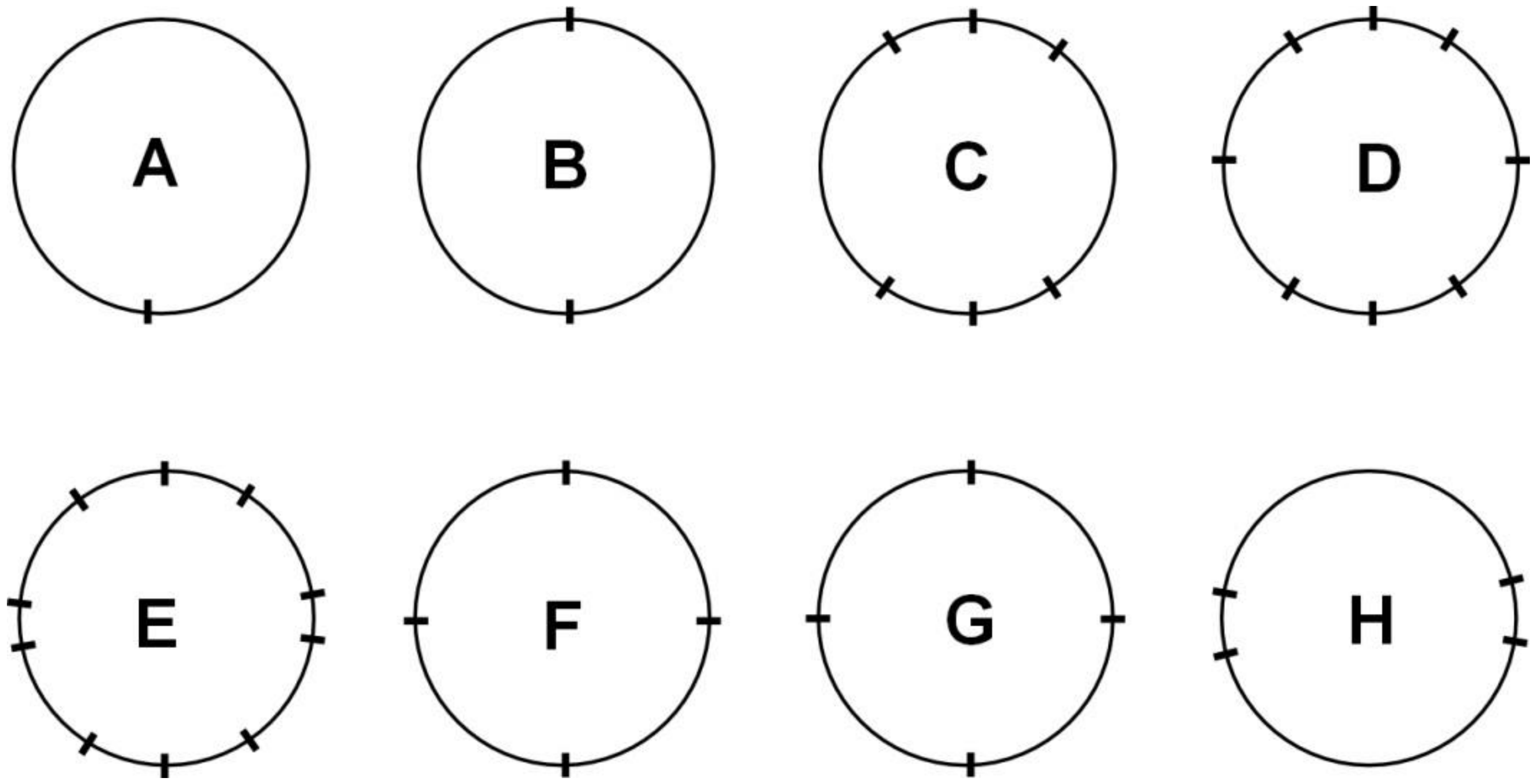


Figure 5.20: Different Chaplet Configurations

In terms of configuration, the six-row pattern 'C' on Figure 5.20, along with its variant D were the most common arrangements of chaplets seen. Pattern 'C' gives fairly uniform support all around the core although on most tubes none of the chaplets could be seen once the core was in place in the mould. With arrangement 'D', however, the two rows of chaplets on the joint-lines could be seen and their positions checked. It could also have been possible with these joint-line mounted chaplets that they protruded into the mould and rested in grooves cut in the joint-line surface. This protruding part could then be cut away following casting along with the flash on the joint-line itself.

Another arrangement where the chaplets could be seen on assembly but not allowed to protrude was configuration H. In this, the row of chaplets just below the joint-line (i.e. when core lies in the mould) serve to locate the core in its lateral position. In 'E' similar rows are used in conjunction with the six-row pattern (c). (Plate 5.12b, above and Plate 5.13a, above) Pattern 'G‘ is seen on SD14L, 4l and 43, where chaplets are placed top/bottom and left/right positions and one instrument (SD 7D) has pattern F.

Many of the instruments studied have chaplets which are still present. On these, it is often possible to locate chaplets by bore evidence using internal inspection equipment (Rank-Taylor Hobson Fibroscope) but extremely difficult to relate the observation to angular position (azimuth) on the instrument. However, with either improved fibre-optics devices or an attachment to give a measure of angular rotation of the viewing optics it would be possible to gain a much more complete picture of arrangements of chaplets on these instruments. As the chapletting of the core is such a fundamental feature of the casting

technology used, a correlation between chaplet configurations and the other products of local industries of the period might emerge.

Most of the larger chaplets are readily visible, except where a particularly heavy patina has covered them over. They would have certainly been visible on a newly made instrument and presumably this prompted the makers to attempt to reduce their visual impact by reducing their size. On 14D, some of the chaplets are in the form of largish irregular shapes while others are turned so that they protrude into the bore some 7*mm* or so. However, the two groups of three chaplets nearest the bell end are of the type which lie flush with the bore and are, thus, not too noticeable when looking down the bore. On this instrument, therefore, the maker appeared to wish to minimise the visual impact of those chaplets that could be seen, restricting the penetration into the core to those less visible ones.

Other instruments such as SD4A. 4C, 7B have yet narrower chaplets which were pressed into the core and protrude some 7*mm* or so into the bore. It appears that, whereas the piece of material used to form the earlier types of chaplet had been laid flat on the core, this type was now twisted so that the centre-line of the sheet lay along a radius of the core. (Figure 5.21) Thus, on these instruments the end face of the chaplet seen on the outer surface of the tube is much less noticeable.

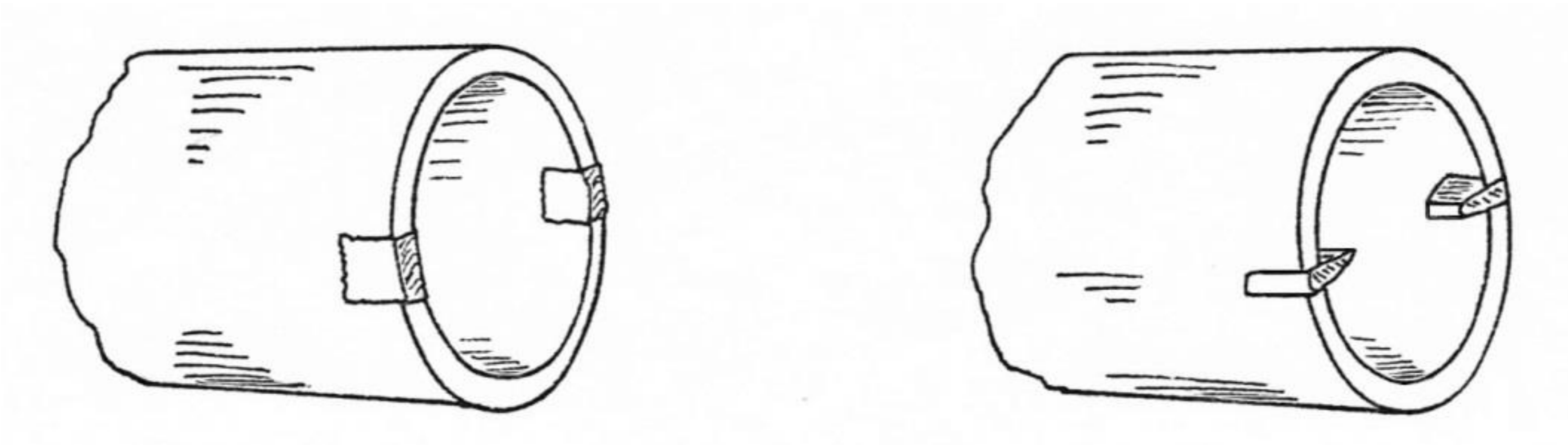


Figure 5.21: Bell-End Chaplets

The material for earlier chaplets had been fractured off from other cast material and had rough fractured edges. These later chaplets, however, were frequently hammered into a more lozenge or occasionally a triangular shape. (Plate 5.15a, below) The face presented to the molten metal by these chaplets, therefore, was smoother, gave poorer adhesion and more frequently leads to the total loss of the chaplet in use than width the earlier types. (Plate 5.13a, above ; and Plate 5.28b, below)

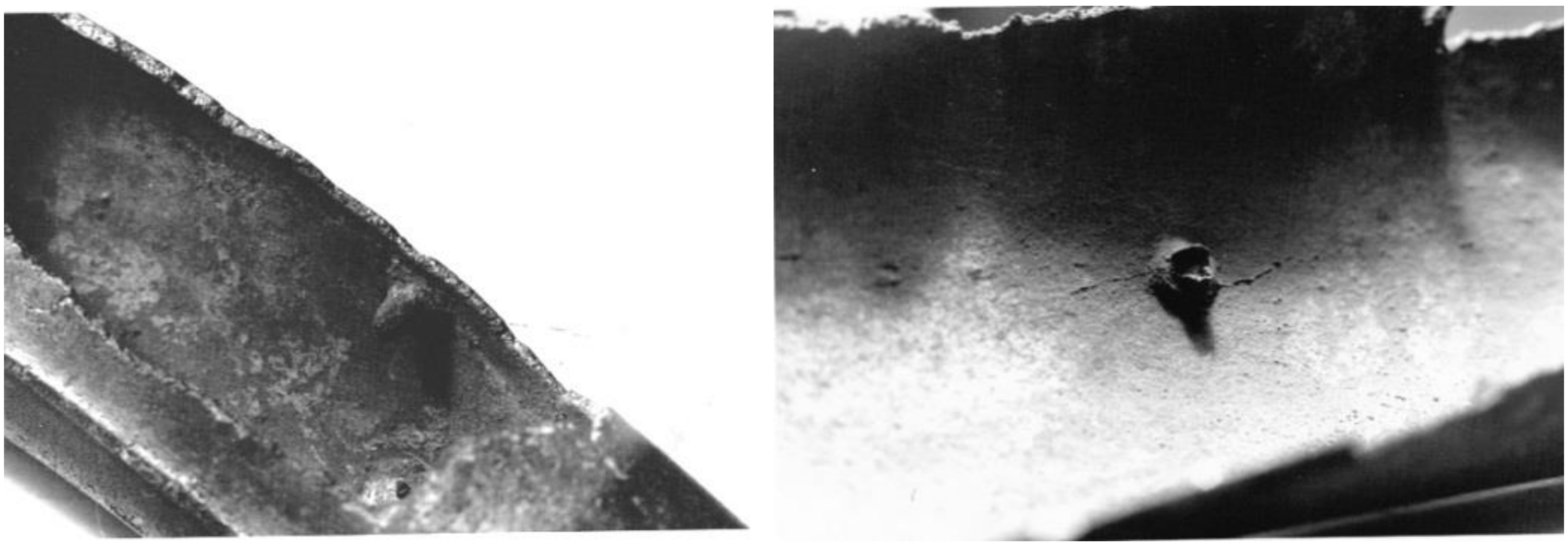


Plate 5.15: Chaplets in situ

Working the material in the way described, caused the metal of the chaplet to flow and, eventually led to the formation of a distinctly tanged type of chaplet. on this, the tang provides a feature which eases penetration into the core and serves to retain the chaplet during handling. (Figure 5.22, Plate 5.15b).

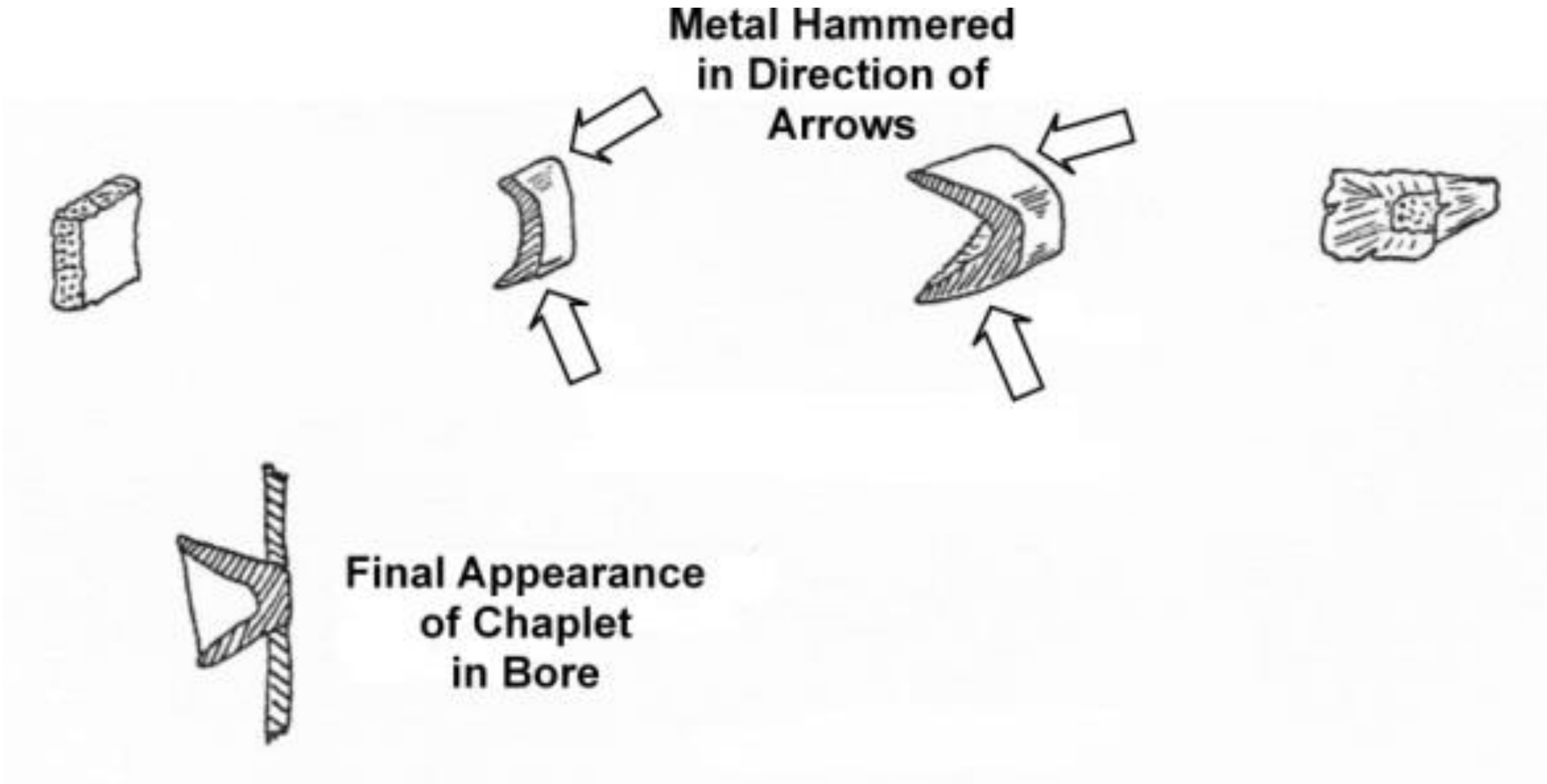


Figure 5.22: The Creation of a Tanged Chaplet

When the core is removed after casting the tang remains in the bore with the appearance of a tube projecting some 2-3*mm* into the bore. Where the chaplets have fallen out, their distinctive wedge shape can be seen in the hole remaining, along with a faceted outer form developed from the hammering of the metal. (Plate 5.28b, below) These chaplets are seen on five instruments (SD6C, 27A, 29C, 30 and 32) from both the north and south but all of a fairly advanced form. One of these (SD30) is fragmentary, allowing closer examination of the bore and, on this, the disturbance to the core caused by pushing in the chaplet can be seen as a raised annular feature around this. Also emanating from the chaplet site, is a crack which runs along the axis of the instrument to meet a crack developed at the neighbouring chaplet. (Figure 5.23,below, Plate 5.15b, above).

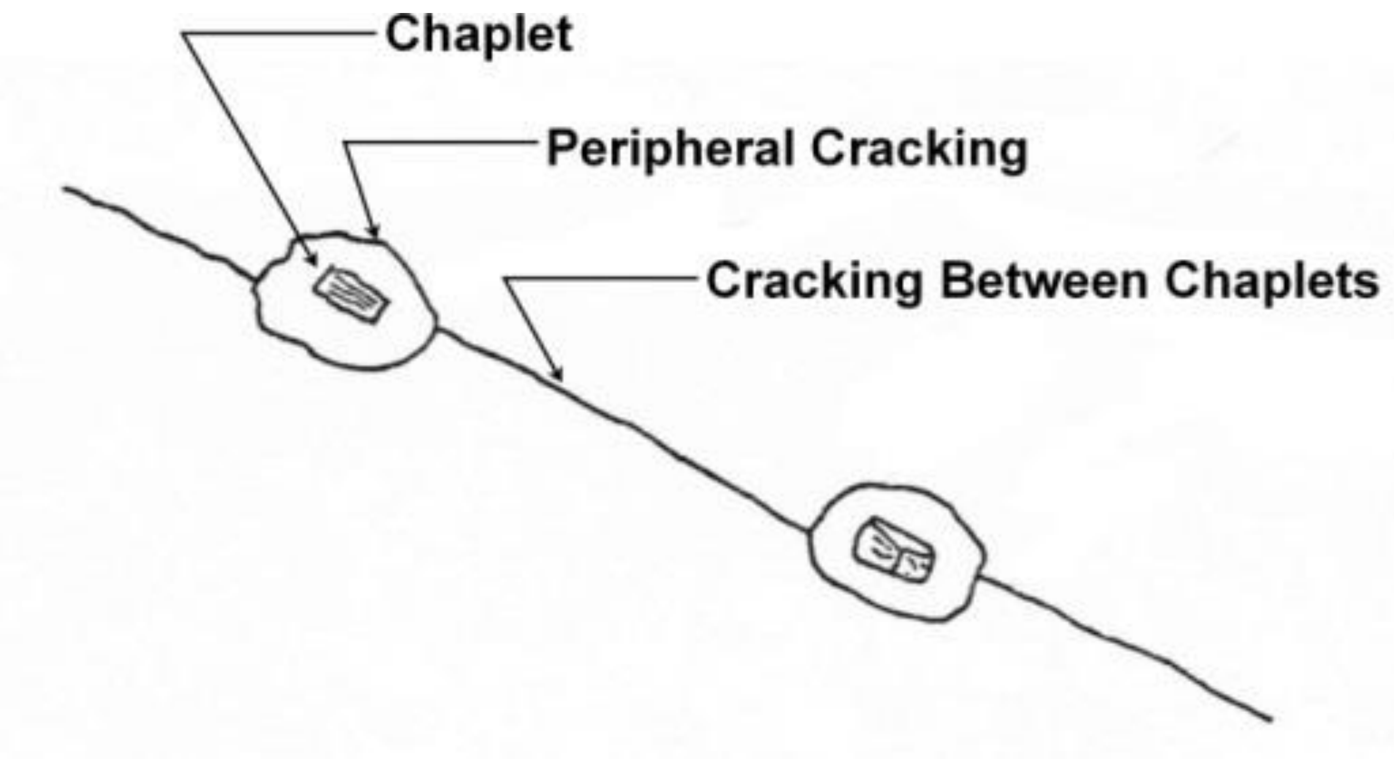


Figure 5.23: Cracking of the Core Around a Tanged Chaplet

This suggests that these chaplets were inserted while the core was in a fairly hard condition, perhaps "leathery" or even harder, a day or so after its basic manufacture. A few of the chaplets worked in the way shown in Figure 5.22 appear to have been folded over during working, again forming a type of hollow tube.

One other form of chaplet seen on instruments SD4A, 37A and 37B is a small, almost round (1-2*mm* diameter) rod which is either flush with the bore or penetrates into this a maximum of 2*mm*. On instrument SD37A these are spaced alternately down each side of the joint-line at about 25*mm* centres this characteristic position being seen all other instruments with this type of chaplet. (See Plate 5.12b, above and Plate 5.13 b, above) This instrument is peculiar in having these fine chaplets in conjunction with those of a "surface" type. As several stages of evolution separate the two types of chaplet it would appear that the fine joint-line type evolved separately and was then incorporated into a mould (SD37A) which had a "traditional" six-pattern of surface chaplets. No examples have been observed where these joint-line chaplets are used on their own. Many instruments now have holes left by chaplets which have fallen out and some of these have been filled sometimes with a soft grey metal like lead and at other times with bronze or brass. It is generally difficult to distinguish ancient repairs from modern but, whereas most of the lead infillings seem to be recent, i.e. they are superimposed on the instrument's patina, others are possibly ancient cast-in chaplet cavities infilled with a lighter-coloured metal, the repair having been done very neatly and now appearing quite unobtrusive.

INSTRUMENT TUBE WALL THICKNESS

The major parameter controlled by chapletting was the thickness of the instrument's tube-wall, as only with very firm control of the core could one ensure that it remained centrally located in the mould during pouring of the cast. A maker would become aware of the limitations on sectional thickness that arose from his chapletting arrangement and the fluidity of his melt by regard to his scrap-rate. This would clearly be a powerful indicator of what he could attempt in terms of wall thickness and, indeed a progression to thinner walls and, hence, lighter, more economical instruments can be seen in these instruments. Measurements were taken on these horns using conventional measuring equipment viz. micrometers, calipers etc. The ultrasonic thickness measuring equipment currently available can tolerate neither the poor surfaces found on these castings (giving rise to poor acoustic coupling) nor the large-grained and frequently porous metal (giving rise to high signal attenuation) that makes up their bulk. It is hoped by the manufacturers that the first of these problems will be overcome shortly and that use of a variable triggering threshold will enable the second problem to be met on an ad-hoc basis. Thus, the measurements available for analysis in this study are those near the edges of instruments i.e. at their bells, their mouthpieces and fractures. Three sources of variability in wall thickness exist with the casting technique employed here:

i) the difference in size and morphology (mainly roundness) between the core and mould
ii) the disposition of the core relative to the mould at the time when the metal solidifies
iii) the accuracy of registration between the cope and drag - mainly in the lateral mode - at the time when the metal solidifies.

Instrument SD32 shows errors in wall thickness resulting from the situation described in i) above. The instrument had a split core and was, thus, liable to variation due to the specific treatment applied to the joint faces of the core. In this particular case, the joint faces either needed to be rubbed down by a further 0,76*mm* or were being held apart by some material 1.52*mm* thick (This latter case is not too likely as a gap in the core of this magnitude would (a) be seen and (b) lead to a considerably more-prominent joint-line in the bore. Figure 5.24 shows the wall- thickness at the bell.

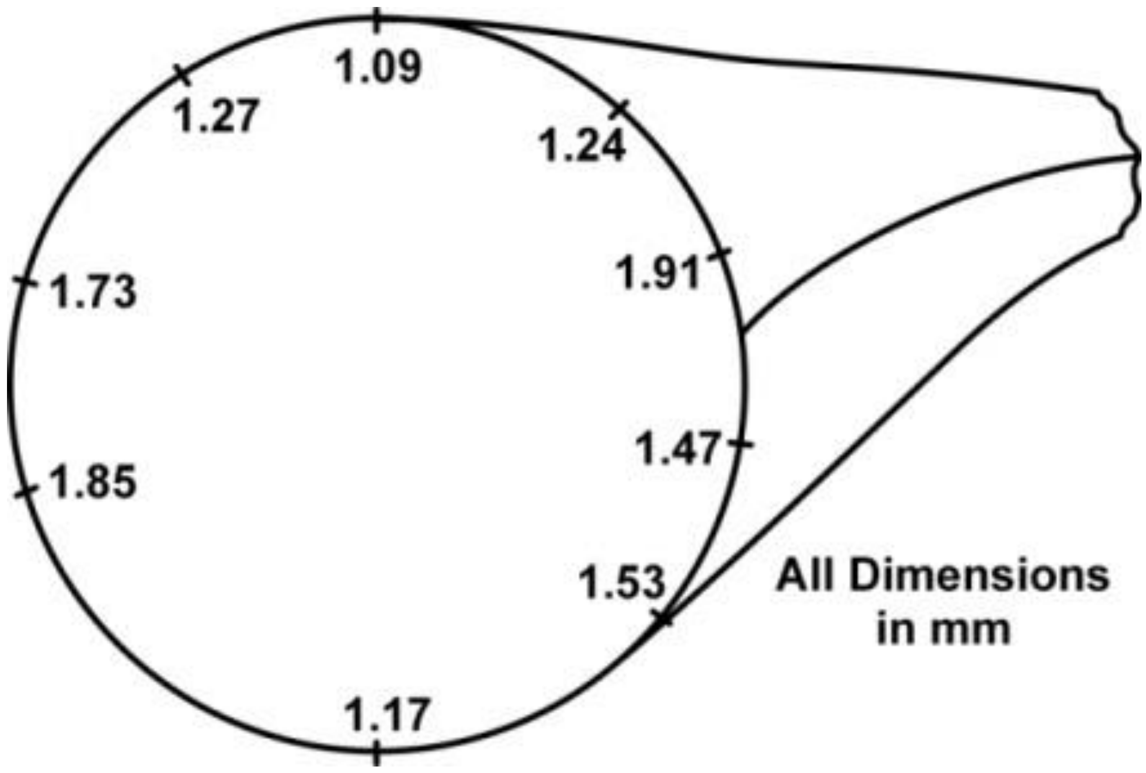


Figure 5.24: Measured Wall Thicknesses on Instrument SD32

Instruments SD16A and 40 both show errors that seem to arise from the dispositional relationship between the core and the mould, i.e. type (ii) errors above. In the case of 16A the core appears to be displaced towards the obverse side of the mould by about 1.0*mm*, while on SD40 the core seems to be displaced by about 0.37*mm* towards the reverse side of the mould.

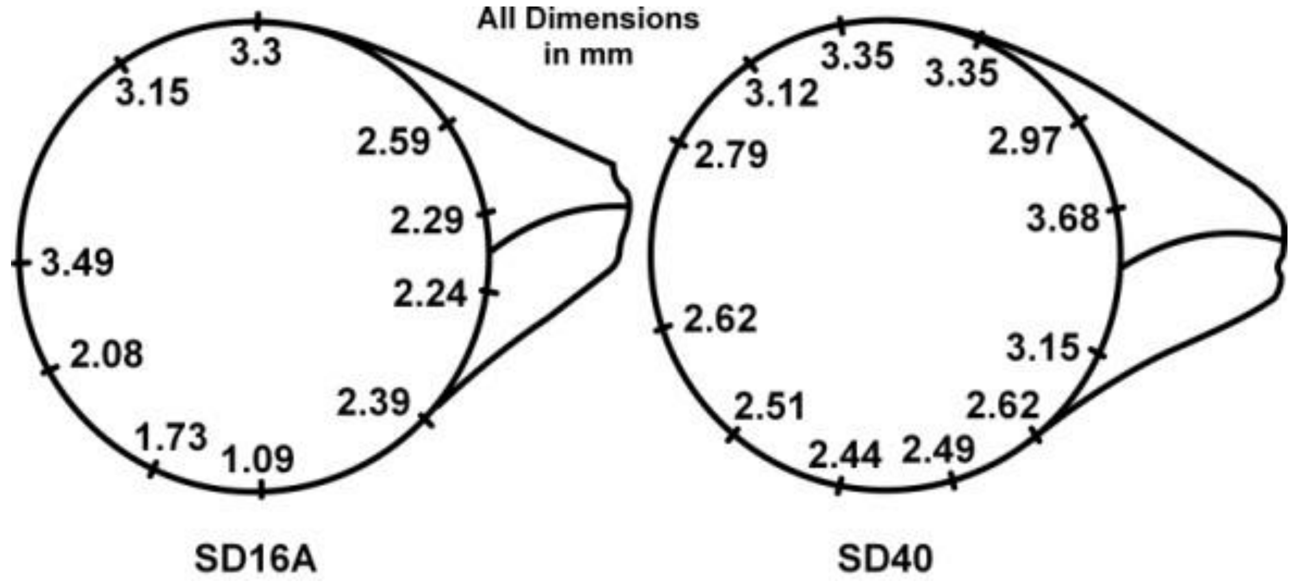


Figure 5.25: Measured Wall Thicknesses on SD16A and SD40

Error resulting from poor lateral registration is present on SD19A; where one half of the mould is displaced by about 1.0*mm* laterally relative to the other half. This is shown in Figure 5.26(a- left) along with the resulting thicknesses when a lateral shift of 1.0*mm* is applied to "correct" this error. (Figure 5.26b - right) These latter figures show also that the cavity in the obverse mould half was actually 0.50*mm* wider than the reverse, giving a section generally thicker by half this amount on the obverse side of the instrument.

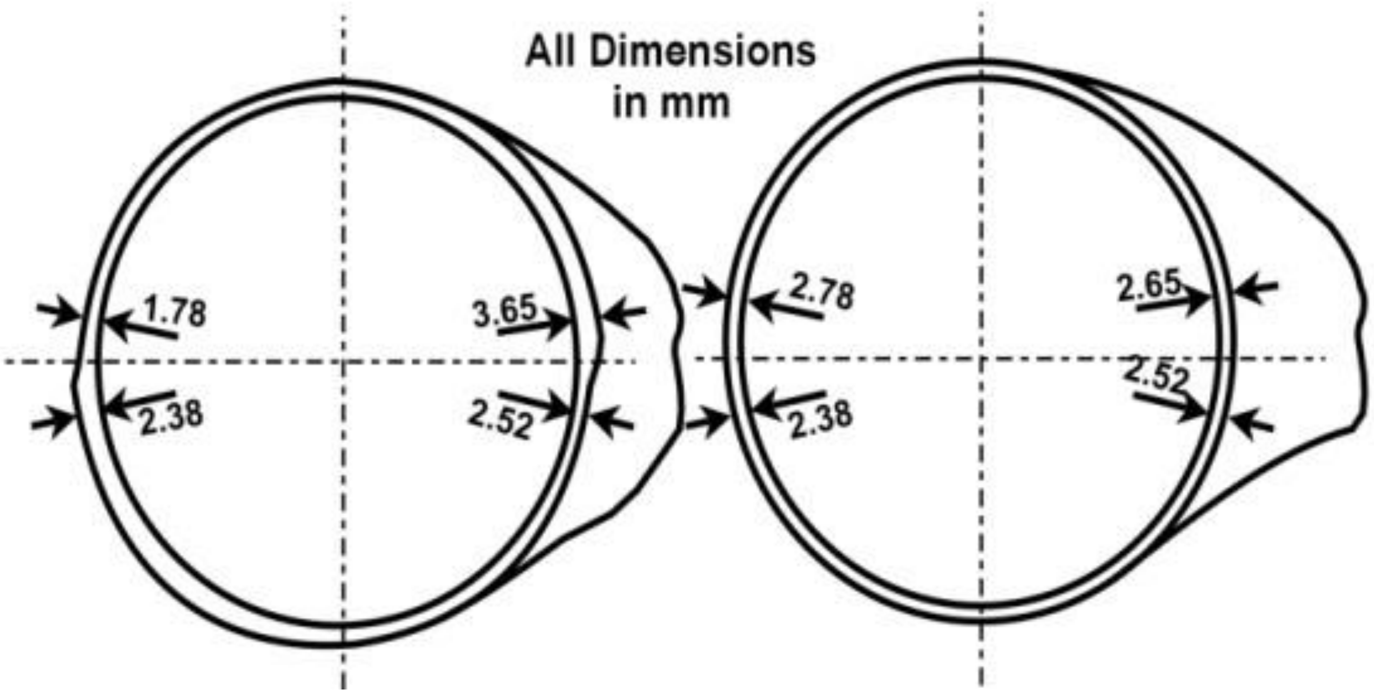


Figure 5.26: Measured Wall Thicknesses on SD19A

No instruments measured showed large random errors resulting from poor match of core and mould. Thus, these must have been made to the same standard of form, i.e. roundness or one generated from the other, presumably the core from the mould. In fact, more noticeable than error is the generalised high degree of accuracy. On SD14E for instance, six wall thickness measurements at the bell gave values of (in *mm*) 2.39, 2.36, 2.49, 2.49, 2.44 and 2.39, i.e. a measured value of 2.43 ±0.065 mm or a maximum variation in bell

wall thickness of 0.13 mm. Similarly on instrument SD14O, eight measurements around the blowing aperture give a wall thickness value of 1.08 ±0.075*mm* i.e. a maximum variation of 0.15*mm*. Measurements at the bell of this instrument gave a mean of six value of 1.36 ±0.23*mm* i.e. a maximum variation of 0.46*mm*. In addition, the measured diameters at the bell of this instrument were (4 stations in *mm*) 25.79, 25.53, 25.75 and 56.19, a diametral variation of 0.66 mm.

These figures cannot claim to be truly representative of the instruments as a whole nor of the generalised value of wall thickness over their whole surface. However, they do indicate that, in the limited stations measured, the makers were able to form both core and mould to match accurately and, in the case of 14O, round to within 0.66*mm*. In the case of SD16B, the instrument showing the roundest element, one carrying ring measured 29·21 ±0.03*mm*, i.e. it was round to within 0.06 mm. (4 Stations) (Figure 5·6, below).

Thus the cores were obviously made to suit the mould and very carefully and firmly assembled prior to casting. There seems to be no clear relationship between the actual thicknesses of these castings and the variation on the instruments measured. However, the sample measured was very small and, in any case, one is only looking at the successful castings, the others, presumably, having been re-melted as scrap. Were the mould halves to be used as core boxes, they would need to have been fired first and these, complete or fragmentary, would then have been quite durable. It seems strange, therefore, that none of these have been reported in Bronze-Age finds.

POST-CASTING TREATMENT

Following removal of the casting from the mould, several operations would be required prior to its use. Firstly the sprues would need to be removed and these seem to have been broken off with the result that a portion of the instrument bell often broke off with the sprue. (SeePlate. 5.10a, above) On some instruments, this coarsely-fractured surface was cleaned up abrasively (SD14G, 27A and 32) while on SD14E it was left in its fractured state.

The casting core would then need to be removed; however, it appears that, on several instruments where failures in wall section had occurred, this core was utilised in the casting-on process. This could be done either by pouring metal directly onto the failed tube or, more elaborately, by removing the core beneath the edges of the tube to give a key to the cast-on metal.

Following any casting-on that may have been required, the core could then be removed. This seems to have been done by poking it as out dry and not by soaking it out as could have been done with an unbaked core. The use of water in this way would have softened the clay at the instrument tip equally and removed this too, whereas most side-blown instruments have the core remaining in the tip. Other instruments also have clay adhering to the more inaccessible parts of the bore; this also would have been removed by soaking out.

Excess flash could then be removed first by chipping off and then by abrasive working. Some instruments feature the joint-line and, on these, the flash would be cleaned up carefully to radius off its upper surface neatly as on SD36B (Plate 5.2a), above). On this instrument, the top and end surface of the joint-line have clearly been worked but the radius between the joint-line and the tube surface is in an as-cast condition. This indicates that this radius was very carefully formed on the edge of the mould prior to casting. The flash in the carrying loops would then be removed by means which are discussed below.

Several instruments (SD4A, 4B, 14P, 14Q, 16A, 16B and 37A) have incised decorations on the bell that was clearly cut in after casting. On five of the instruments this decoration consists of groups of circumferential lines cut into the tube. In the case of the two Dowris tubes (SD14P and 14Q) the lines are very heavily incised into a thick wall while instruments SD37A, 16A and 16B are more lightly done. On 37A, however, the form of the groove cut externally on the bell can be seen on the bore, where the maker came very close to abrading right through the tube. Instrument SD4A has an incised decoration at the bell end consisting of two circumferential cuts downstream of a series of vee-shaped cuts at the bell end. A more elaborate decoration of the same general style is seen on SD8 and consists of three groups of four circumferential cuts with two rows of v-shaped cuts between these. (Figure 5.27) On SD57A a decoration using the same basic elements is used but has an incised v decoration between three groups of raised line.

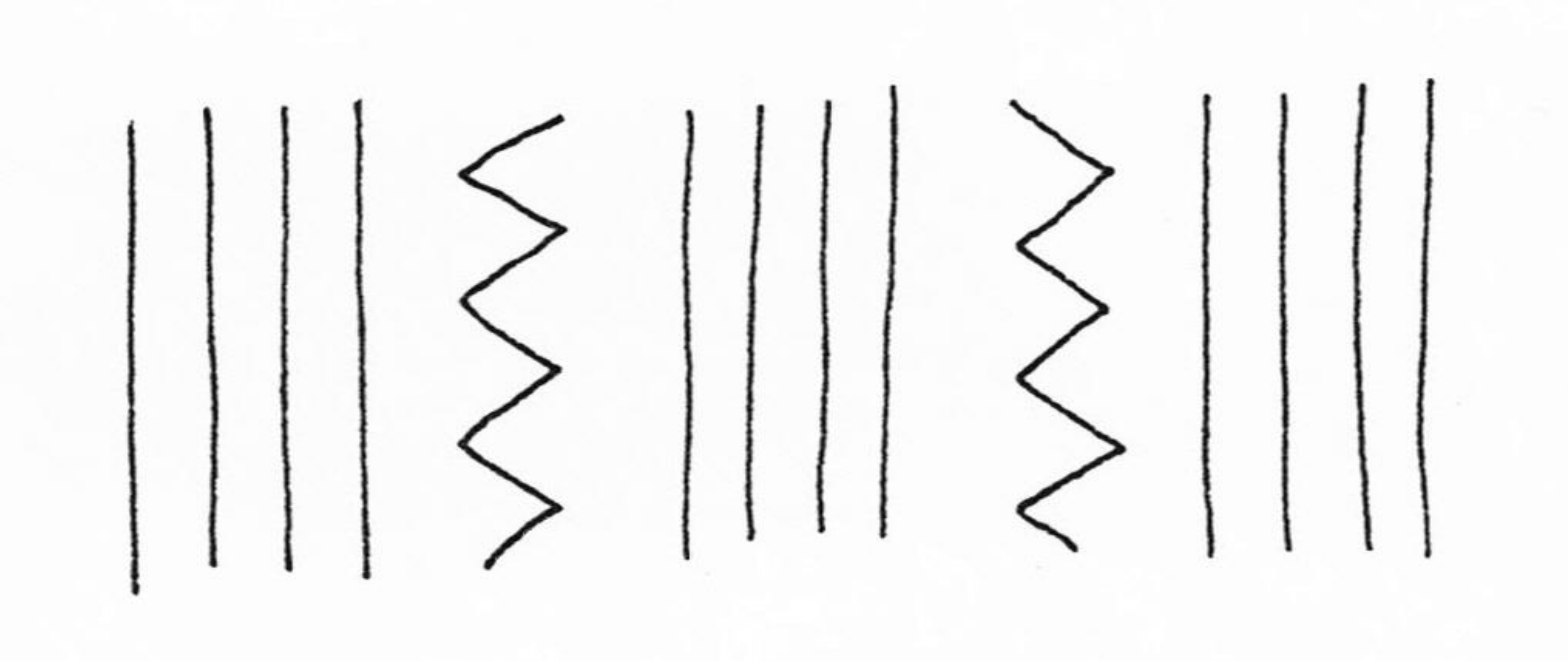


Figure 5.27: A Typical Incised Bell Decoration

THE DEVELOPMENT OF CARRYING FEATURES

The earliest instruments have an integrally cast loop whose position varies widely on the end blown instruments but is generally immediately adjacent to the tip bulb on the end-blows. Loops of this type are common on artefacts such as axes from the bronze-age and their manufacture presented a common problem in the formation of a suitable mould form. In order to form the cavity of the loop the mould halves would need to protrude adequately to core this out. See Figure 5.28

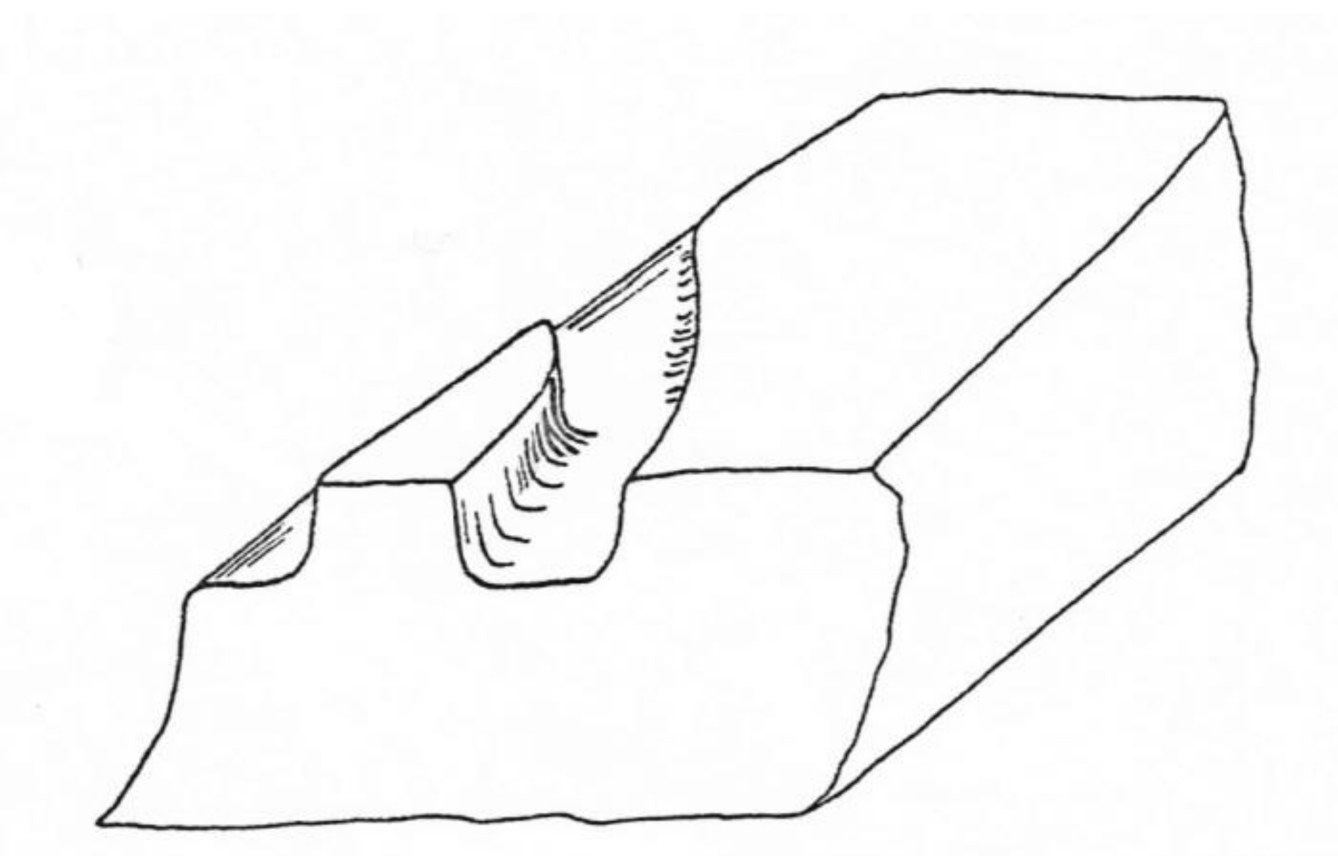


Figure 5.28: Creating an Integral Carrying Loop

Many instruments have examples of excessive flash in the loop cavity which subsequently had to be removed and on one instrument, SD35, this flash remains in position. (Plate 5.16a) Thus, this flash would have to have been removed before the loop could be used.

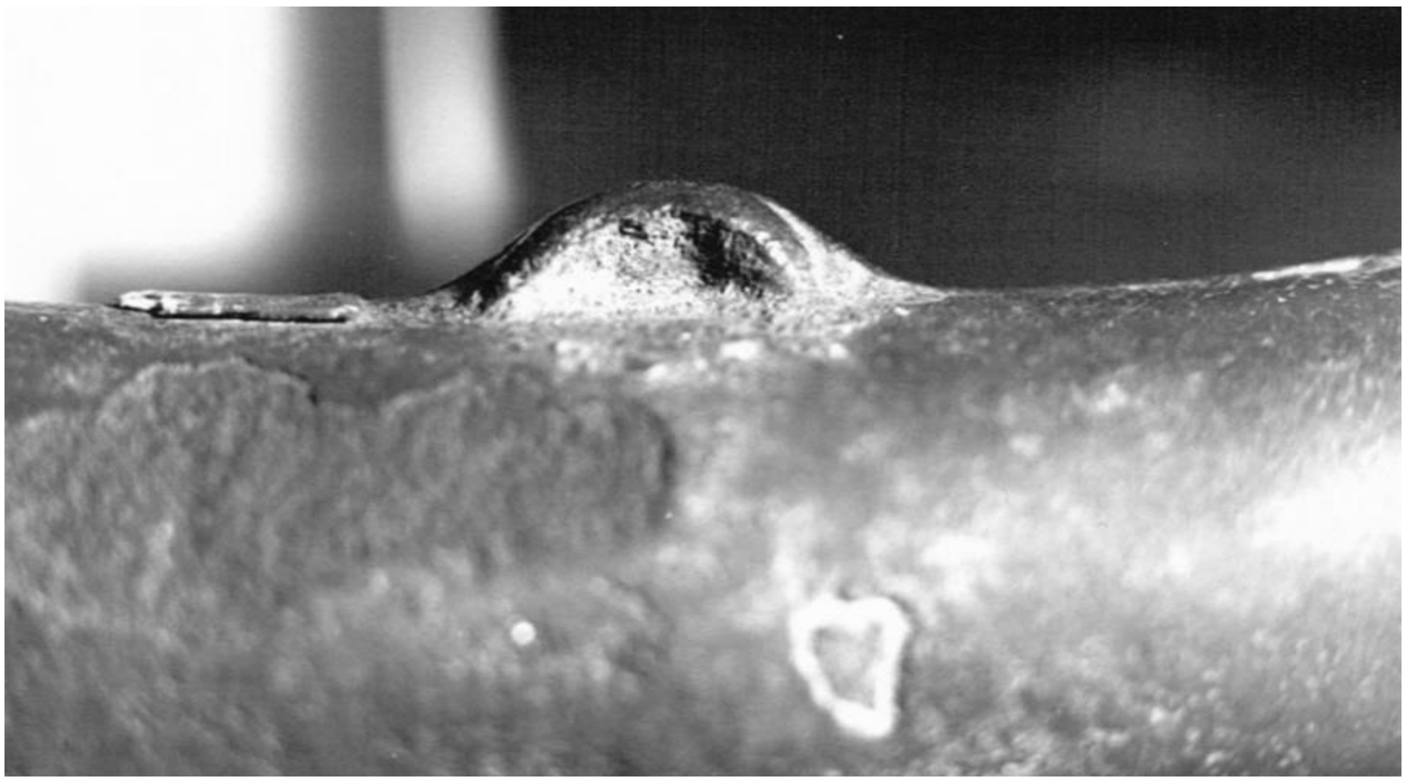


Plate 5.16a: An Uncleared Carrying Loop

On instrument SD36 this flash has been chipped away to clear the loop (Plate 5.16b), producing a relatively small hole with a jagged edge.

Plate 5.16b: A Cleared-out Carrying Loop

However, most other instruments have had the loop cleaned out much more effectively by either abrading out the flash or drilling it out. Evidence for abrasive cleaning is seen on instruments SD48, 14D and 14J, where the loop's aperture follows the form of the loop itself. Other instruments such as SD4A, 14F, 14G, 14L and 37A, have holes whose shape and bore form indicate that they are drilled out. (Plate 5.17a), below).

While the original cross-section of the loops was parallel-sided a development towards a more elegant waisted form is seen on SD14K and 30. On the latter the thickness of the loop is fairly consistent with other instruments but SD14K has a loop that is narrow at its centre (approx. 2*mm* wide) and splays out very elegantly where it meets the instrument tube (Plate 5.17a and 5.17b, below)

Plate 5.17: Carrying Loop Features

A further variety introduced at the tip of side-blown instruments was a larger loop of wider pitch and hence with a larger aperture, for example on SD4A. However, several side-blown instruments (e.g. SD14K and 49) have a tip that is fractured, probably as a result of an excessive load being put onto the loop. On two other instruments (14L and 37A) such a load has caused failure of the loop by pulling it out at the root, leaving behind two torn-out holes in the tip. (Plate 5.18a, below and Plate 5.19a, below)

Plate 5.18: Carrying Loop Features

This design of tip-loop was very susceptible to weakening due to a misplaced core during casting. Thus, were the core to be displaced longitudinally by the thickness of the tip end face, giving rise to a thin section at this tip, then the loop would be very inadequately fixed to the main body of the instrument. In addition to the problems experienced when a successful casting is made, the provision of a suitable pattern featuring an integral loop also presents problems.

When providing a ring mount of adequate size on a wooden pattern a weak section exists at the joint of the mount and the tube, where the woodsgrain flows across the thin section of this mount. (Figure 5.29, below) This weakness would most likely lead to the protruding part breaking off if pressed into the clay. The larger the loop, the more likely it is to break off and, hence the more attempts are made to provide a mount in other ways.

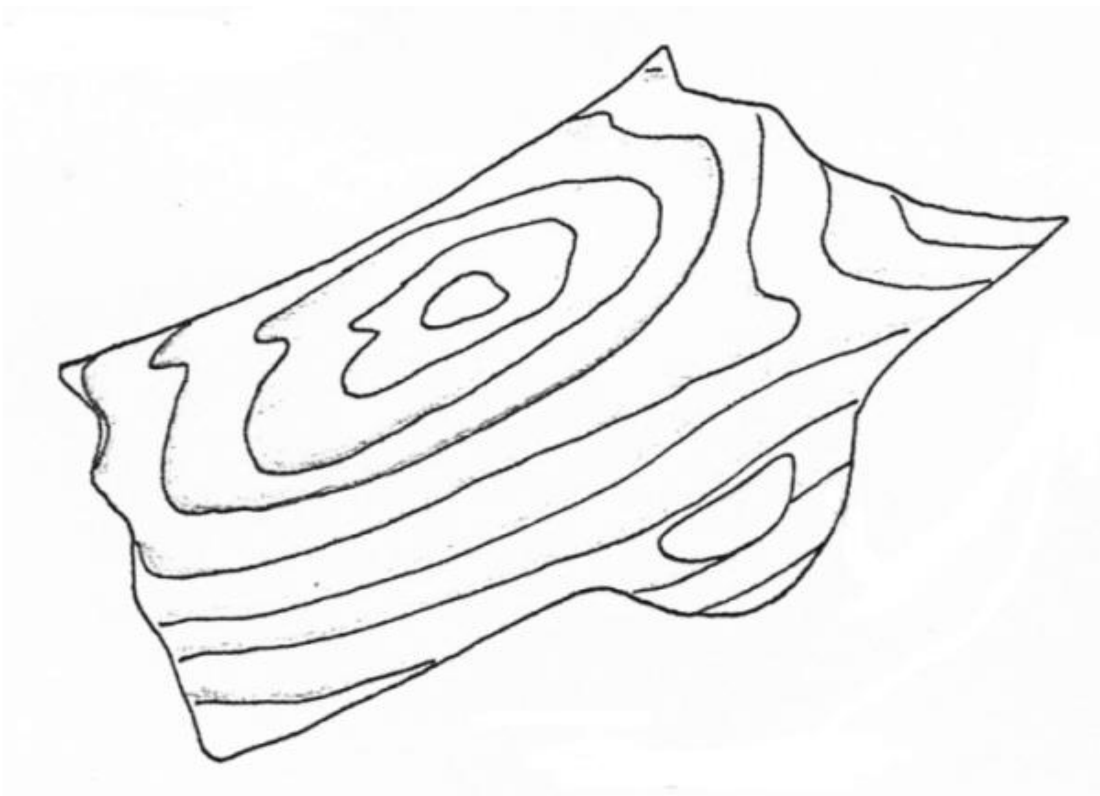


Figure 5.29: The Provision of a Loop on a Wooden Pattern

It is not possible to say in what order the attempts to provide better mounts were made, but one novel design broke away entirely from the established ways of making loops. On this the maker probably saw the loop-cavity infill as a type of core but one that was difficult to make and to maintain during casting. He thus conceived the idea of twisting the core through 90° so that its axis was parallel to that of the instrument. This produced a mount with a hole running along this axis. (Figure 5.30, below) It does not seem possible to explain this in any other way than by saying that it was a deliberately thought out and executed solution.

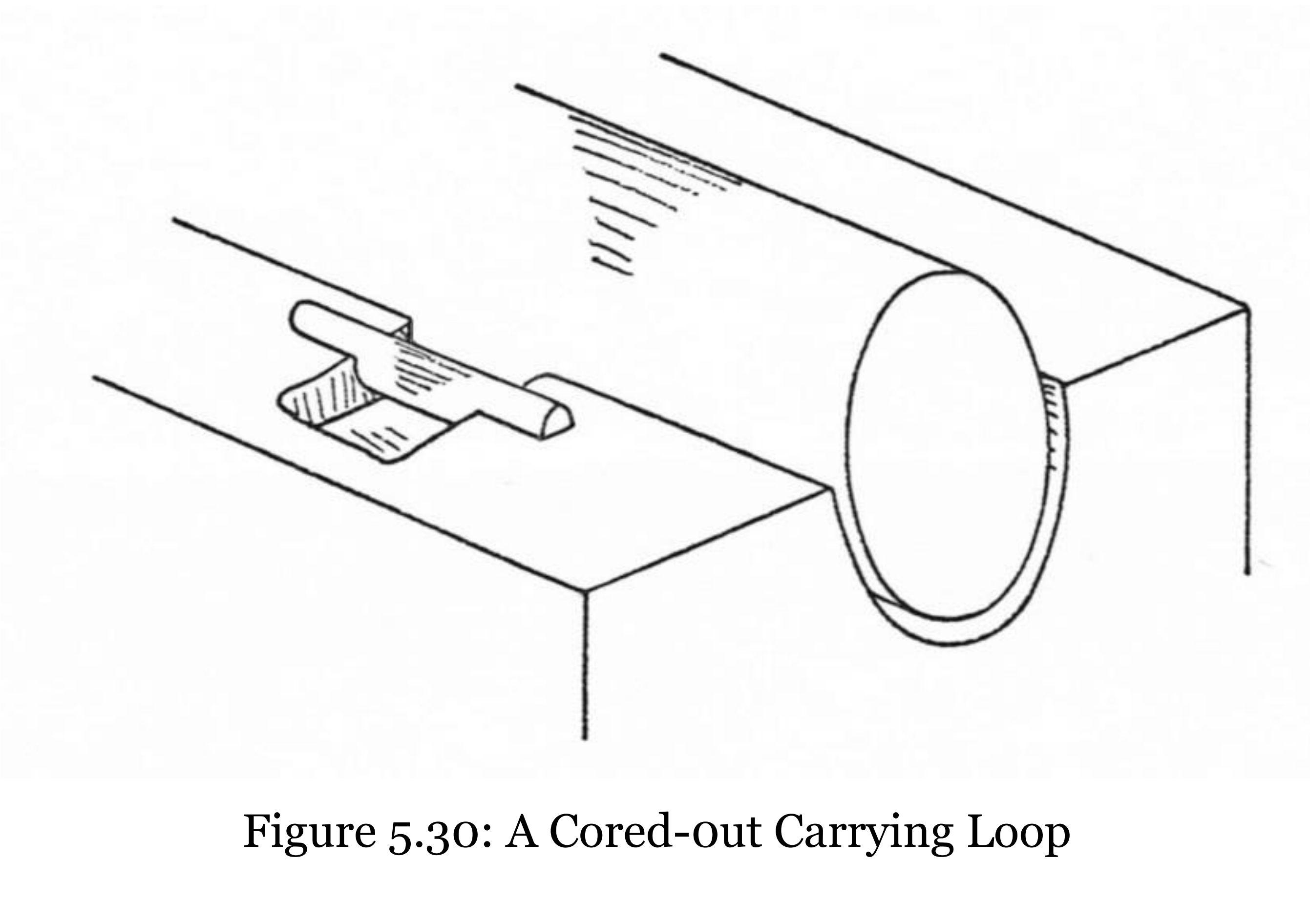


Figure 5.30: A Cored-out Carrying Loop

Only one example of this solution exists, however, on instrument SD14I on which the hole is clearly cored. It is too close to the tube surface to have been drilled and is much deeper, more parallel and rounder than other holes of this period. In addition, the majority of the bore has a clearly cast surface finish with only its two ends having been abraded back to radius it into the tube yard proper. (Plate 5.19b, below, Plate 5.20a, below)

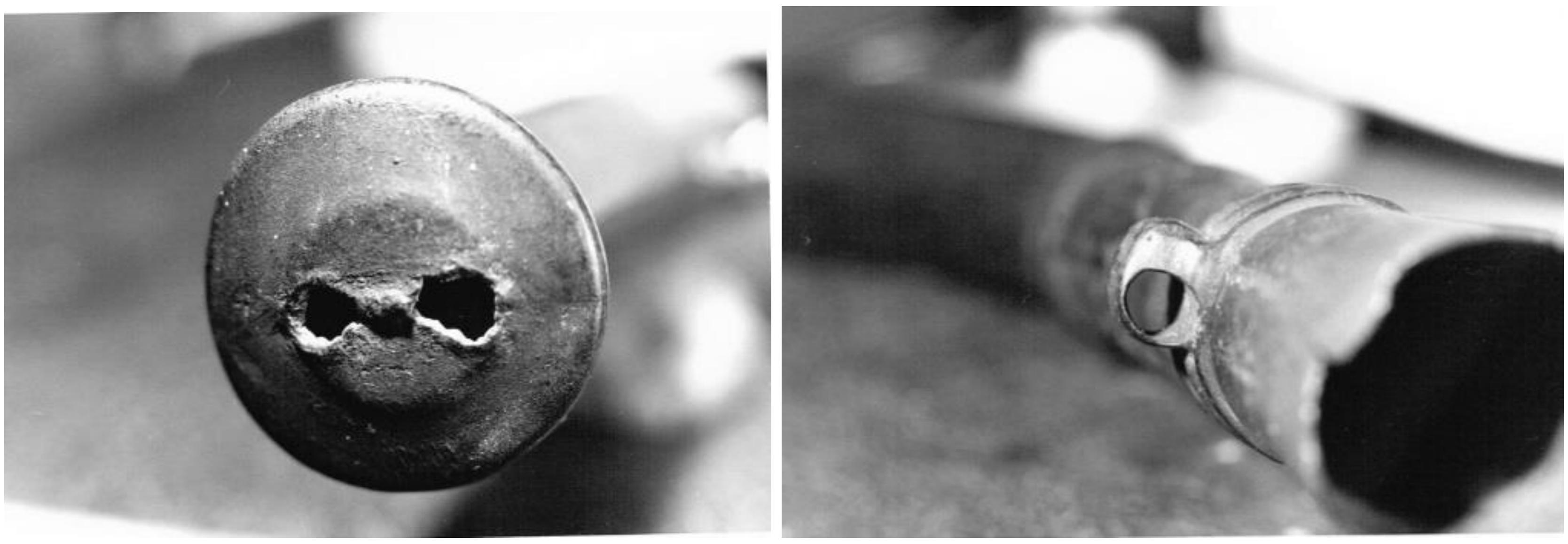


Plate 5.19: Carrying Loop Features

In spite of the adequacy of this design in providing a solution to the problem, it was not adopted as a general solution. Perhaps it was too complex a coring job or perhaps the twisting of the aperture was not acceptable at the time. Nevertheless, the mount aperture parallel to the tube axis became a standard feature on later added mounts.

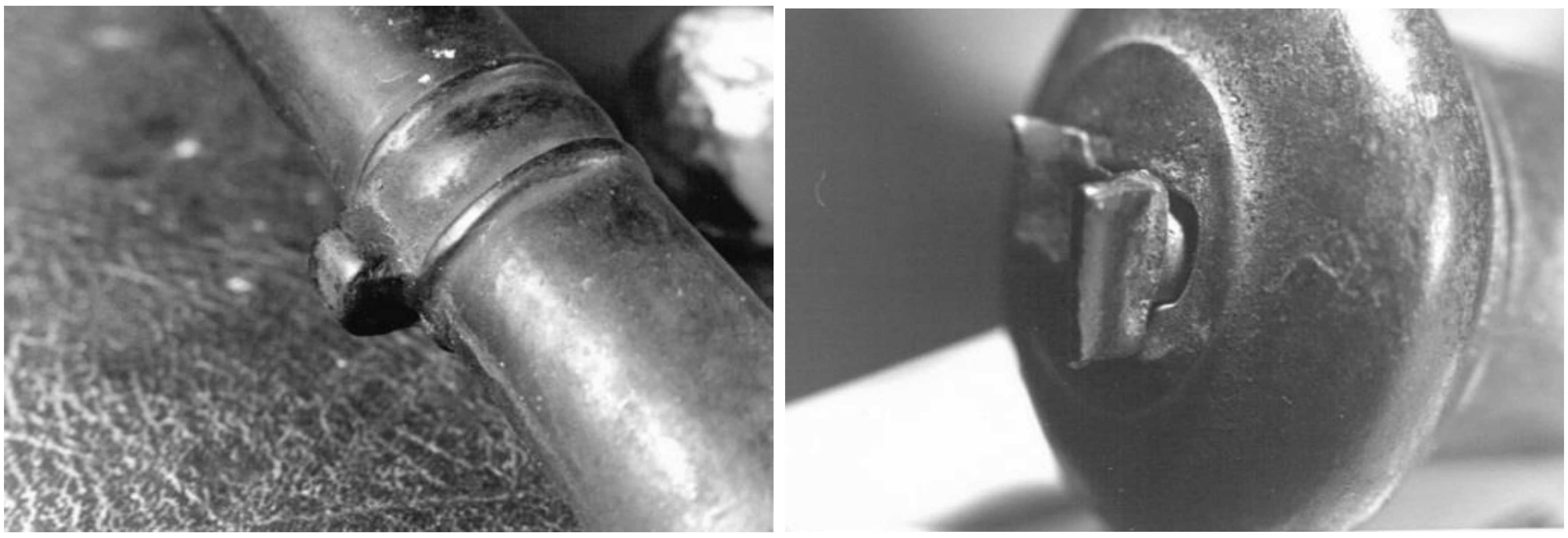


Plate 5.20: Carrying Loop Features

Future solutions seemed to concentrate on fabrication by the addition of preformed mounts. This can be seen in one form on instruments SD6C and 8 and 36B where a pre-cast ring-mount with an integrally cast root was cast into the tube or the spherical tip bulb. (Figure 5.31)

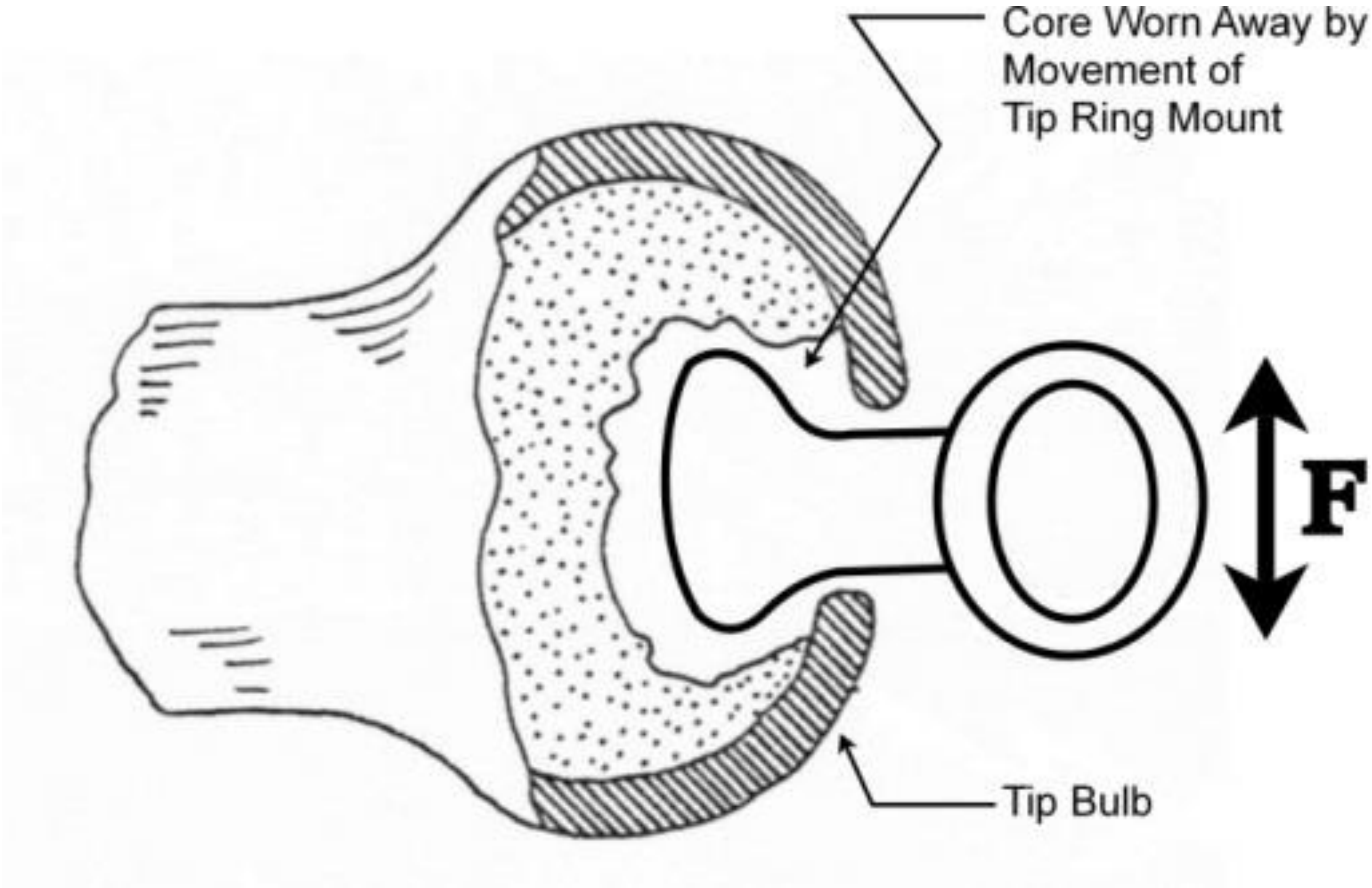


Figure 5.31: A Cast in Tip Ring Mount

As the mould/core assembly appears not to have been heated prior to assembly, the molten metal, on contacting the cold mount probably chilled and, failing to melt its surface layer did not produce a "welded" joint. Hence, when the mount is subjected to a force in direction "F" on Figure 5.31, this pivots on the thin wall section, the core offering little resistance to the movement. Eventually the movement wears away both the wall section and the core, leaving an enlarged hole. This situation, as illustrated on Figure 5.31, is seen on several instruments (e.g. SD6C) where the hole is still small enough to retain the mount. (Plate. 5.20b, above)

On instruments 14M and 7G the cast-in mount seems to have worked loose following considerable use which has worn through its base. This movement has worn away a hole in the tip which is still visible. However, the loose tip has been pushed down into the core and metal poured around this to re-fix it in the tip. (Plate 5.21a and Plate 5.21b, below)

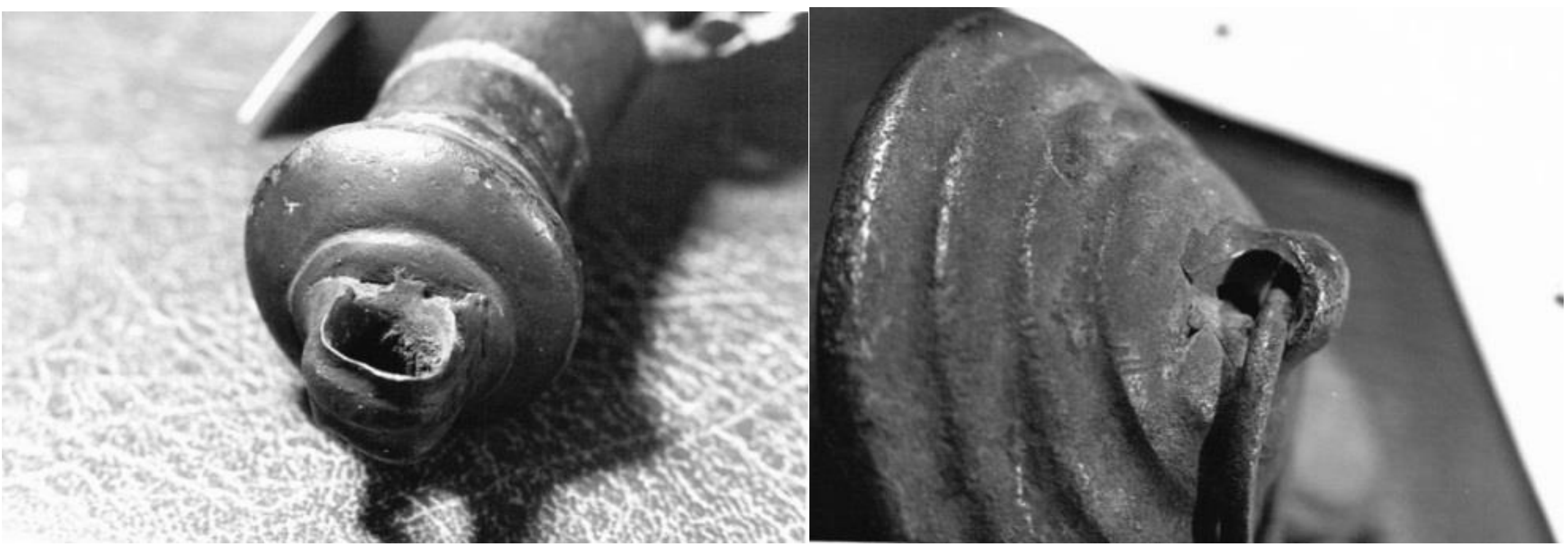


Plate 5.21: Tip End Carrying Loop Features

One important side-effect of the cast-in ring mount is that it provides a further means of supporting the core during the casting operation. Thus, the pre-cast ring would be set into the tip of the core during its manufacture, being adjusted to an appropriate depth i.e. allowing for the thickness of the metal tip. (Figure 5.32) A suitable depression is then made in the cope and drag to take the protruding ring-mount. The whole mould can then be assembled with the two mould halves supporting the tip mount/core assembly.

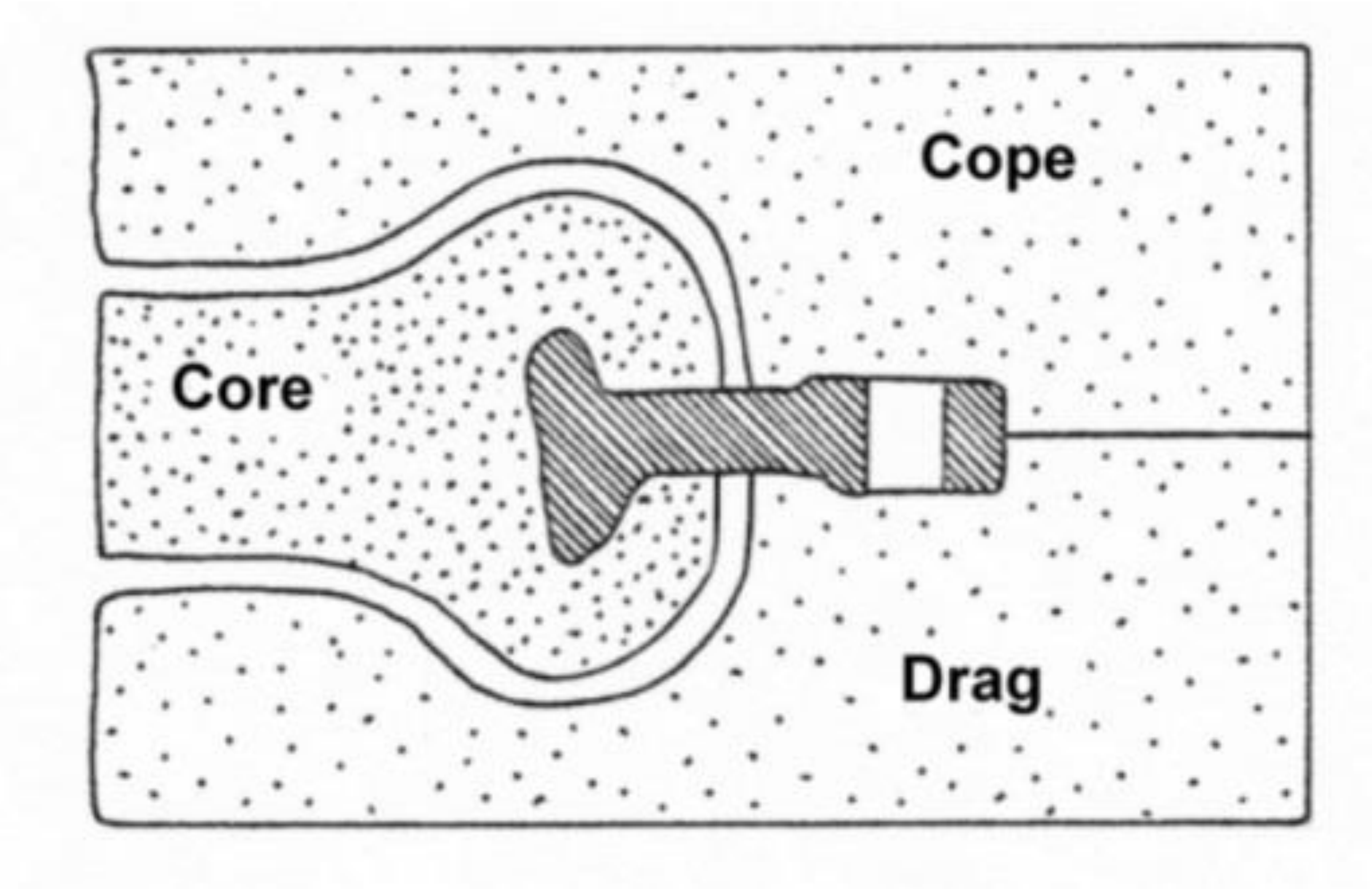


Figure 5.32: Casting in a Tip Ring Mount

A similar technique was utilised to fix the ring mount to the tube yard, this necessitating its fixture near to the tip of the horn where either a suitable wall thickness could be left or the root of the mount could be left in situ without blocking the tube. It may also be that the presence of the core in this zone was seen as further supporting the tip mount root, giving a positive reason for not removing it.

The breaking open of a mould is always an exciting affair being made so by the uncertainty of success. For this reason constant attempts were made to lessen the investment in each casting operation and to break down manufacture into prime-manufacture and assembly. Hence, the latest of the Irish horns were cast without ring mounts, such features being separately cast or wrought and then attached to the tube or tip.

One of the earliest attempts to affix a separately cast ring appears to be on SD36B on the tube, possibly as a repair. On this instrument a hole was made or possibly cast into the tube and a depression in the core excavated. Into this was poured molten metal, to form a blob on the tube wall and the pre-cast mount pressed into this. (Figure 5.33 and Plate 5.2a, above)

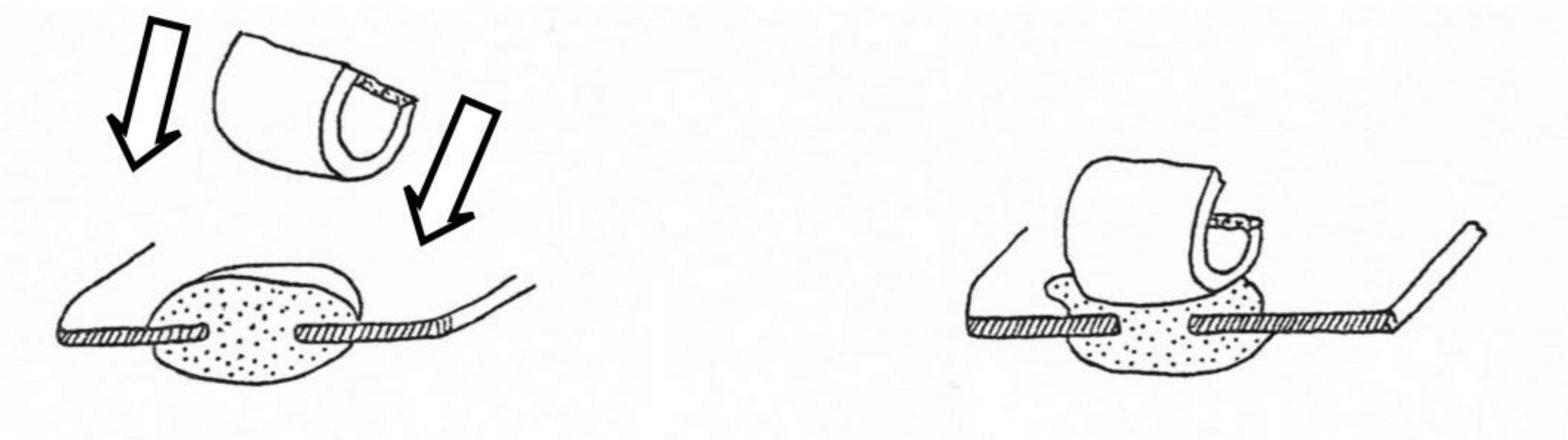


Figure 5.33: Attaching Tube Ring Mounts

Although the mount itself is now broken the area of previously-molten metal around it can be seen as well as metal that has been squashed out on pressing in the mount.

Around the mount itself (on 36B) there is no room for metal to have been poured in and this is in contrast with instruments such as SD7D and 29C where a pre-cast mount is clearly set in a pool of molten metal. (Plate 5.23(a), p. 272) This is most clearly seen on SD29C where a hole has been drilled in the tube wall and subsequently filled with molten metal. The edges of the drilled hole can still be seen as can several blow holes on the infilling material. Whether these came from gas escaping from the core or from burning away of tin is difficult to say. At some stage the mount was set into this material and remains in position although being set at an angle. Two other instruments, SD7B and 19B may have been joined in a similar way, but on these the metal has overflowed the hole and run onto the tube surface obscuring evidence that may have existed. (Plate 5.22(a), p.268._)

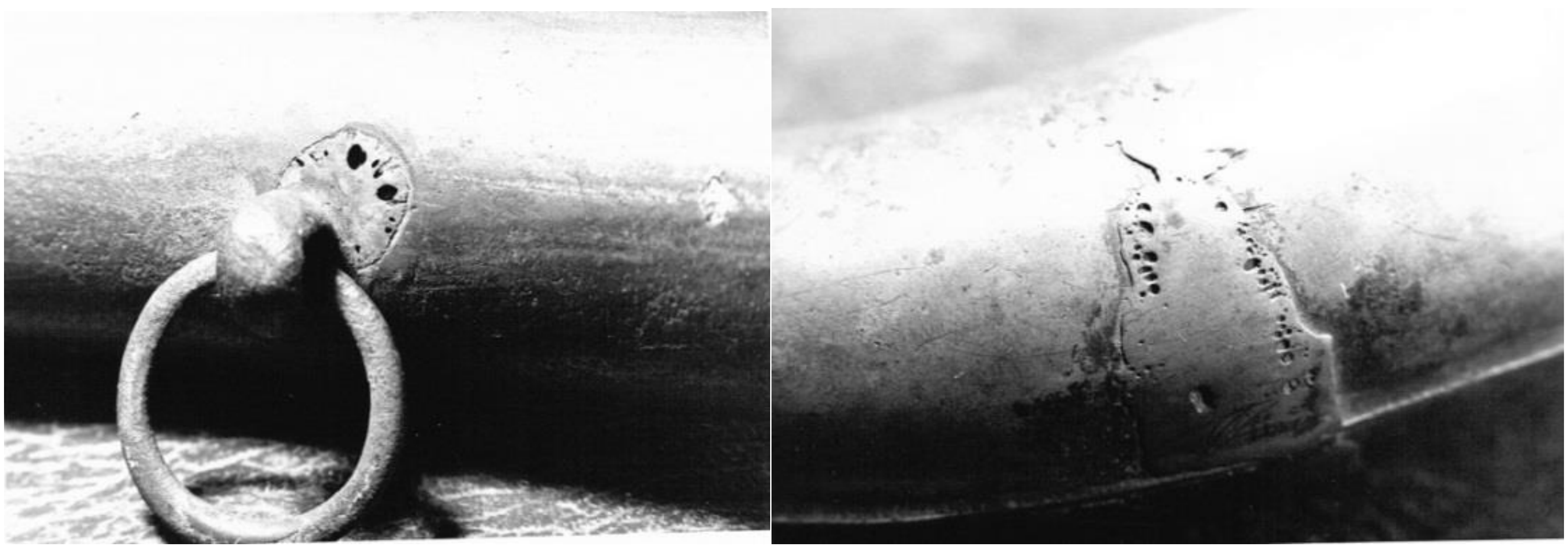


Plate 5.23: Attaching a Ring Mount and a Repair

Where they can be seen internally, the cast-on portions which serve to retain mounts are generally of fairly uniform form and have clearly been cut carefully into a core. On some instruments these are in the form of a blob of material somewhat oval in form approximately 10 *x* 15*mm*, on others they are kidney-shaped and on SD19B this consists of a uniform, neatly cast ring over approx. 270° of the bore.

Eight instruments (SD6C, 7G, 13, 16A-D and 19A) have mounts which are made from sheet and fixed to the tube by the use of added metal. The use of sheet in this way possibly represents a later development than the cast mounts, being used, presumably, when sheet became more readily available and, hence, providing an easier way of producing a mount than casting. That the mount itself is of sheet, is generally confirmed by its uniform section, signs of wrought work and in some cases, as for example SD19A and 16D the presence of the seam where the two edges of the sheet meet (Figure. 5.34). In addition on several mounts e.g. SD13 and 19A, the sheet has formed to a concave cross-section on folding over to form the mount. (See Figure 5.34 and Plate 5.22 a, above)

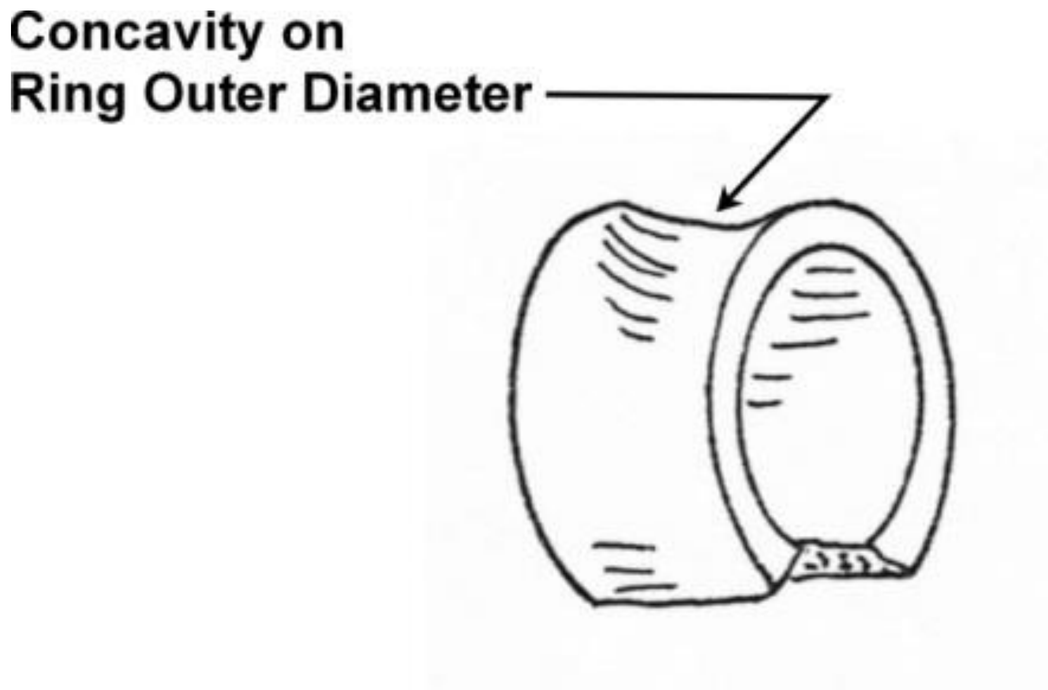


Figure 5.34: Sheet Metal Ring Mount Form

This cross-section is a typical deformation form for thick rectangular section material and is unsuitable for casting in a two piece mould. On instrument 19A, the added metal seems to have been poured through a hole in the centre of the mount probably into a cavity formed in the core. (Plate 5.22a, above) Where the metal was poured in a concave oval of lighter coloured material can be seen with clear sinking towards its centre. On this instrument the mount appears to be very loose and, hence was examined by the British Museum Research Department (Report in Appendix V). They considered that it had not been added but was cast in situ. However, around the mount are fillers of lighter-coloured material which has patinated in a different way from the tube itself and in the case of the tip mount, this adheres to the mount but has broken away from the tube surface. This interpretation does not conform to the opinion expressed in the British Museum report (Appendix V) but their comment on the interpretation of the X-ray photograph seems significant. The "lump of metal" that they identify is probably the rest of the poured-in material used to fix the ring mount to the tube. If this is the case, then the sequence of manufacture could have involved: manufacture tube yard; drill hole in tube where mount to be fixed; remove core to allow metal to flow in to produce a root for the mount; fix ring mount with pre-drilled hole in tube; pour in molten metal through hole in ring mount; (Plate 5.22a, above)

This could produce a root for the mount with a key similar to that used on the cast-in ring mounts (Figures 5.31/32) and the possibility of attaining a braze-type joint between the metal in this key, the tube yard and the ring mount.

One instrument, SD13, has a wrought tip-mount but its ends meet the tip at a steep angle, unlike SD19A where they meet tangentially. On SD13, the mount appears to disappear into the tip itself. It may be on this instrument, that keying-in of the mount, as well as stability during manufacture was attained by use of a bifurcated root attached to the mount itself. (Figure 5.35).

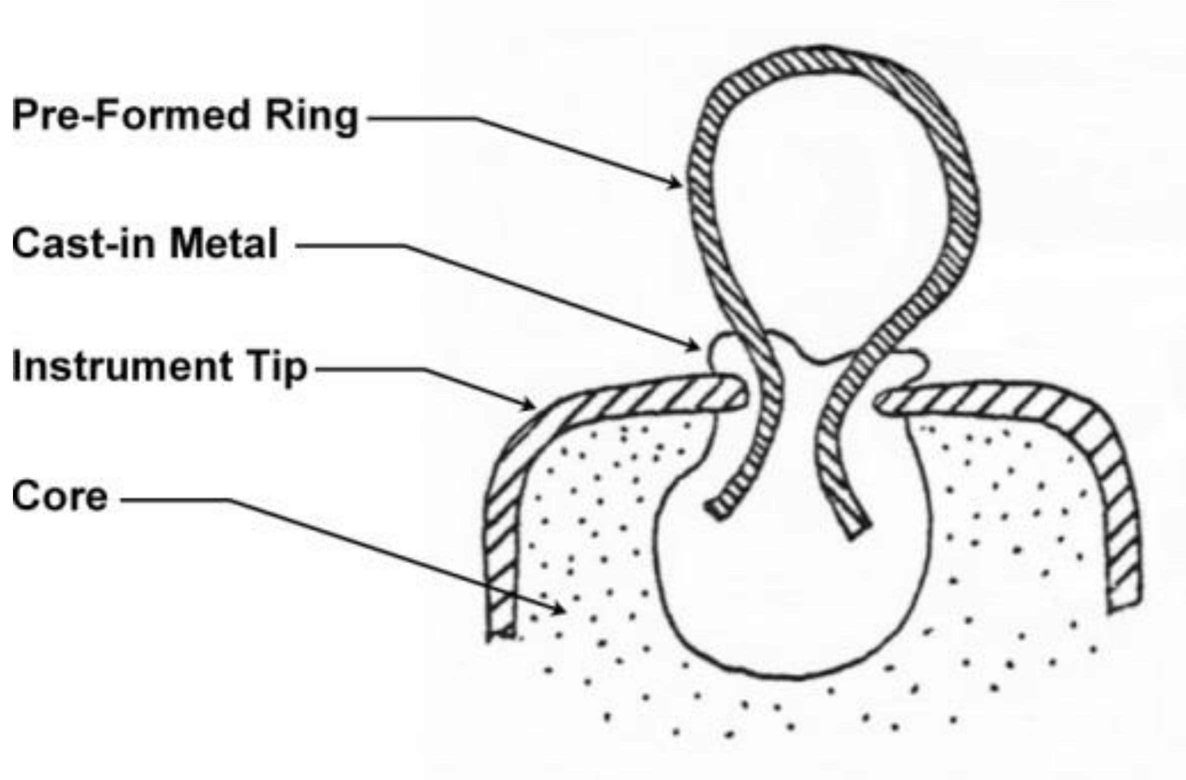


Figure 5.35: A Wrought Cast-in Ring Mount

Molten metal could then be poured around this to attach it firmly to the tip. Pouring in of metal around the mount would have been quite difficult to do neatly and it is possible that a pouring gate was provided to assist in this. Three other instruments also had holes drilled through the top of the mount probably to enable the metal to be poured through this and onto the joint area. On SD7G a blob of metal has run down the mount, presumably having been spilled during the casting-in process and, on instrument SD16D, this hole has been filled in with cast-on material. The provision of larger wrought mounts enabled bronze rings to be attached through these to the instrument. With these mounts the pre-formed ring could be fed through the mount prior to fixing it to the instrument itself. The earliest way of making such a ring would appear to have been to cast this in a two piece mould. However, only one instrument, SD7G, has a ring that still has evidence of a joint line internally, the others apparently having been fabricated and then joined together.

Evidence for this mode of manufacture is most clear on SD19A. Overall, the form of the ring is not round but becomes markedly straighter towards the join where a lighter coloured material is visible. Such a form is commonly obtained when folding metal around a mandrel, as the first formed part can be easily bent and follows the mandrel smoothly. Towards the joint, however, insufficient metal is available to lever the metal around and the ends of the rod then meet at an angle. Also in this case, the inner part of the rod tends

not to meet and leaves witness of the join. Such a gap is clearly visible on the inside curve of the ring on SD19A.

On three of the Drumbest instruments, SD16A, B and D, evidence of a join in the rings can be seen. Here, however, this is in the form of a swelling in the tube diameter where material has been cast-on over the join. (Similar to that seen on Plate 5.23a, above) With these instruments the rings attained their largest size, clearly performing an aesthetic function as well as a functional one. Figure 5.36 gives the dimensions of these rings from 16B and 16D. These figures suggest that both rings were formed on a mandrel of approximately. 29.1*mm* bore from rod of approx. 5.5*mm* diameter. In the case of the SDl6B, the ring is round to within 0.27*mm* (4 stations) and on SDl6D to within ±0.05 mm (only two stations). In the former case this degree of roundness (±0.27 mm) would only be attainable by forming around a mandrel and this, in turn, could probably only be made by a generation process. The rod diameter used to make the ring on SD16B varies by 0.5 mm (4 stations) and that on SD16D by 0.81 mm (5 stations). This is of an order that could probably be judged by eye if done carefully but is probably towards the limit of visual perception. On instrument SD16D the tip ring is considerably larger than the tube ring (59*mm*(approx.) bore of 7*mm* diameter rod) and quite recognisably less round than the tube ring.

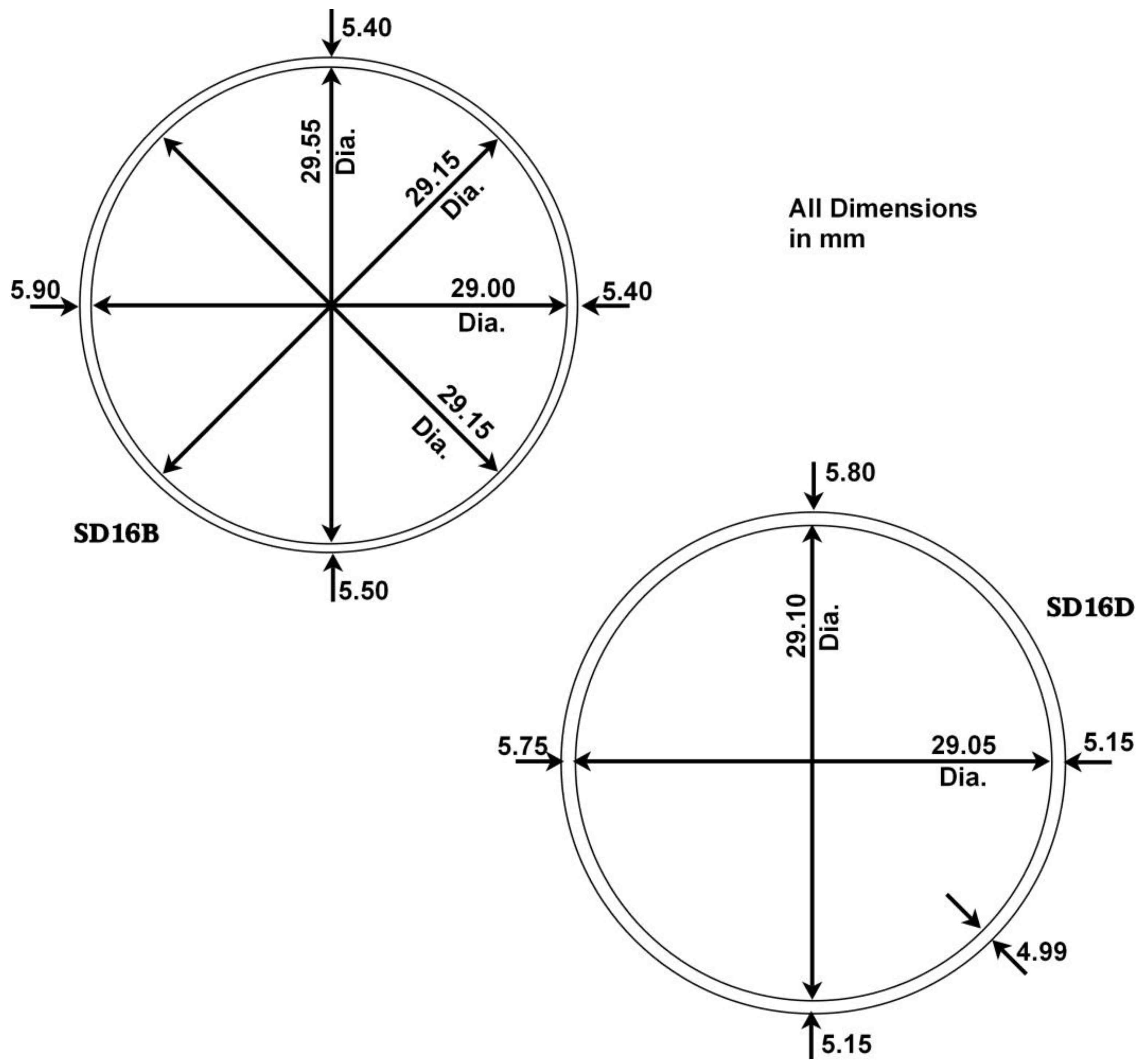


Figure 5.36: Dimensions of the Drumbest Carrying Rings

CASTING-ON PROCESSES

As instruments grew larger, the problems of casting larger sections naturally increased. To some extent, this was solved by improved manufacturing technology as witnessed by the large sections on side-blown instruments such as SD7B, 13 and 19A, but techniques were also developed for casting-on sections and joining by casting-on. In both these cases, a mould had to be made which incorporated the parts to be added to or joined together, as well as providing the cavity for casting into. This involves a deeper conceptual grasp of mould design than in lost wax casting where the material to be added is modelled onto the previous casting in wax, thus producing an analogue of what is finally required. When using a split-mould technique the cavity has to be carved out to the desired form in mirror image.

Casting-on was also used generally, to repair defective castings and those broken in use, to add on additional parts to instruments and apparently to modify instruments to suit changing needs in decoration etc. Repairs effected by casting-on vary greatly in their quality and effectiveness. On instruments SD29C and 43, for instance, the general quality of casting-on is poor with the added metal being poorly formed and, in particular causing considerable blockage of the bore. On two other instruments (SD14O and 13), broken tubes were repaired very effectively by casting-on. In the case of SD14O, at least two phases of casting-on can be recognised from the difference in colour of the two alloys used. (Plate 5.23b, above) The added metal here, however, is only 1-2*mm* at its thickest point and it seems probable here that the molten metal was simply poured over the tube. With the other instrument, a side-blown type, the tube failure occurred across the mouthpiece and a more elaborate joint was made. To do this, four holes were abraded through tube adjacent to the fracture and several other notches were made which did not break through. A core was then built up inside the tube and holes made in this to correspond with the holes in the tube. It is probable that a two-piece mould was then built up around the area to be cast, no evidence remaining to verify this although the cast-on material appears to be homogeneous. On pouring, a band around the tube was formed and metal flowed through the holes in the tube and over the rim of the mouthpiece aperture forming a lip. (Figure 5.37)

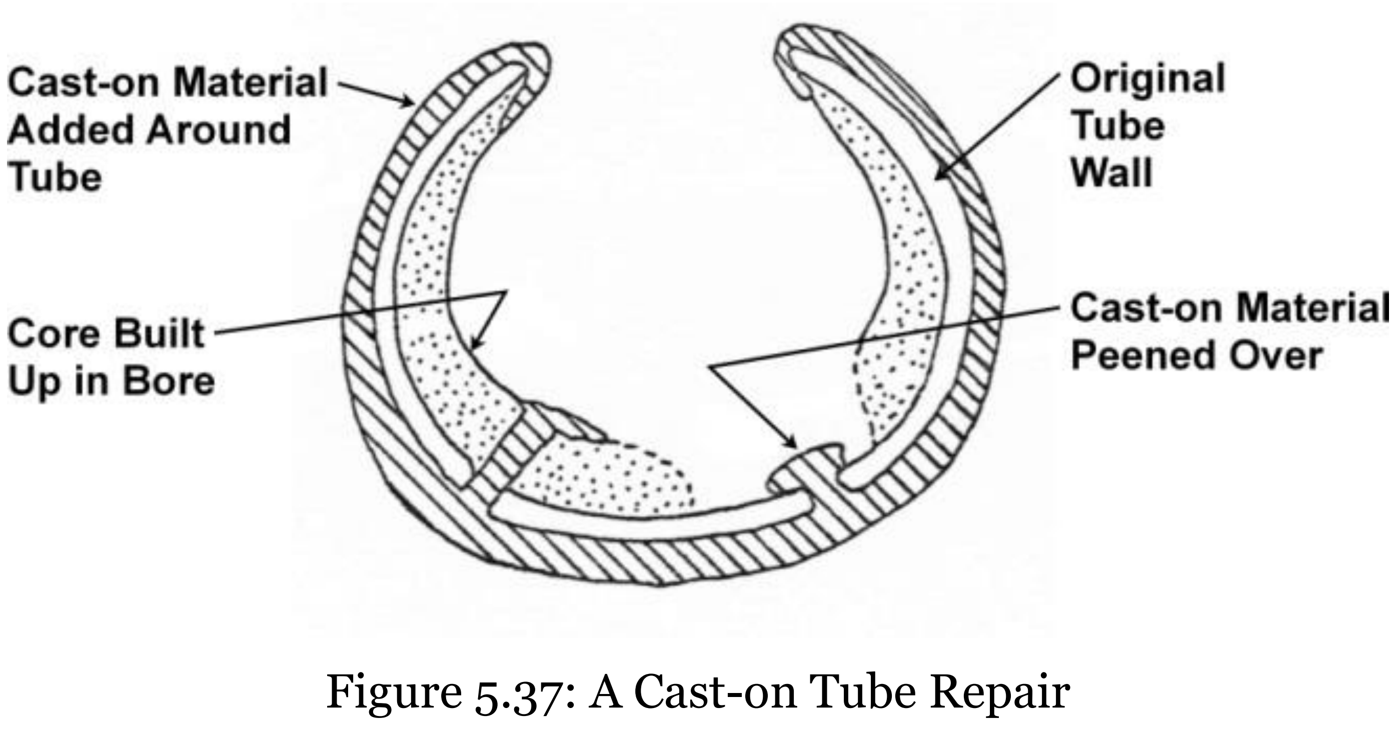


Figure 5.37: A Cast-on Tube Repair

The core was then removed and the metal that had flowed through the holes peened over to effect a tighter grip on the tube. (Plate 5.22b, above)

Evidence of the use of two piece moulds when casting-on is seen on SD14I, where a section of tube is cast-on over the original tube. The joint-line on this cast-on portion is clearly visible and is not coincident with the original joint-line. Over the top of this repair, was then cast-on a band which also has a clearly visible - an individual joint-line. (Plate 5.24a)

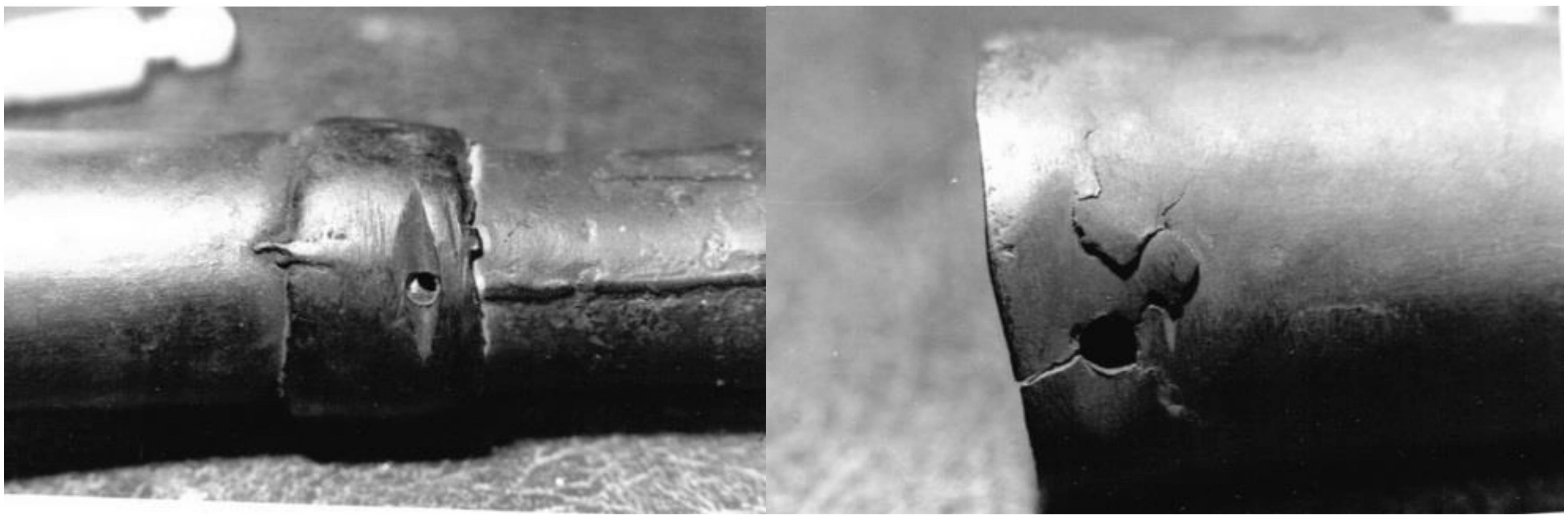


Plate 5.24: Post-Casting Work on Tubes

As a process in its own right, casting-on was developed to a high degree, as witnessed by the repair carried out to the mouthpiece of 16B. This was broken by fracturing off a segment around the rim - l6A is still in this condition - and a piece of bronze, clearly not the original piece, was set in by casting-in with molten bronze.

Many instruments have cast-on repairs at their bell end, presumably many of these restore the parts of tube broken off when removing the casting sprues. However, decorative features such as spikes and mouldings were also added by casting on, the former of these being discussed below. Rope moulding was cast-on onto the bell of SD4B along with 12 small decorative spikes. Instrument 14I was similarly added to at the bell but, in this case, the added material served to fill in four holes that were formerly present there. Subsequently two new holes were drilled through this cast-on material. (Plate 5.24b, above).

When casting-on, one of the major problems is the formation of a reasonable bore, i.e. the provision of a suitable core. This could be less of a problem when repair to a defective casting was being carried out as the core remains in situ. However, under other conditions, a core would have to be constructed specially to suit the area being repaired. Such a core seems to have been made in instruments SD22A and 43, where the bore is only roughly formed and metal has flowed over the end of the core to constrict the bore. On the latter of these instruments five pieces of tube had been bent over into the bore probably to hold the core in place during the casting-on operation.

Several instruments have had slots abraded on the surface to key in cast-on metal and SD13 had holes drilled to provide a key. It is not possible to say, however, whether or not particular attempts were made to clean surfaces or to apply fluxes to these prior to attempting to join metal to metal. The earliest reference to the use of fluxes is in Pliny[201] and the recipe given is long and involved. However, he is writing from a society which has a tradition of metal working passed on over 4000 years from the Middle East.[202] Unfortunately, we can claim no such continuity of technical development for Ireland and hence cannot assume that the knowledge from the Middle East was available to the Late Bronze-Age Irish craftsman. Indeed, as far as the joining of metal to metal goes, many cast-on features have a film of fine clay between the two metal surfaces (SD7B, 24D and 4L). The latter two of these instruments have only a fine film that can be seen but on SD7B two layers of clay, some 1-2*mm* thick are present. These lie between the instrument tube and two separately cast rings at the tip of this instrument and adjacent to the fracture which currently terminates it.

Casting-on was utilised on SD19A, a large type II side-blown horn to add on the tip cone. Its use on this instrument was very effective in that it is still intact and only reveals the joint between the tube and tip following close inspection. It is clear, therefore, that a technique of flow-welding had been developed which allowed the metal adjacent to the joint to be heated up to its melting point in order to achieve fusion of the metal. In the case of this joint, construction of the mould was probably facilitated by leaving in the core-print which was then carved to the desired shape and served as part of the core for the addition.

End-blown instruments, being longer than side-blown were more generally assembled by casting-on sections or joining sections by this process. Instrument SD14I, for instance, was made up from a tube and a bell joined by a cast-on boss to form what appears to be an integral instrument. Two other longer instruments, SD16A and 16B were made up from tube and bell parts cast together, but the level of craftsmanship on these is very high, of a different order from most of the simpler casting on.

The cast-on joints on these instruments are virtually identical and were clearly made by the same craftsman. They seem to have had four stages in manufacture as outlined on Figure 5.38, these stages being:

- (i) casting of the tubes
- (ii) casting—on of the raised mouldings around their tube end
- (iii) assembly of the two tubes
- (iv) casting-on of the thin wedge of material between the two tubes.

It is hard to explain why stages (i) and (ii) were done separately as it would seem that these could have been done in one casting operation to fuse together the two tubes.

[201] Pliny Liber XXXIII Chap. V, Sections 26, 28 and 29.
[202] (Maryon, 1938, 190)

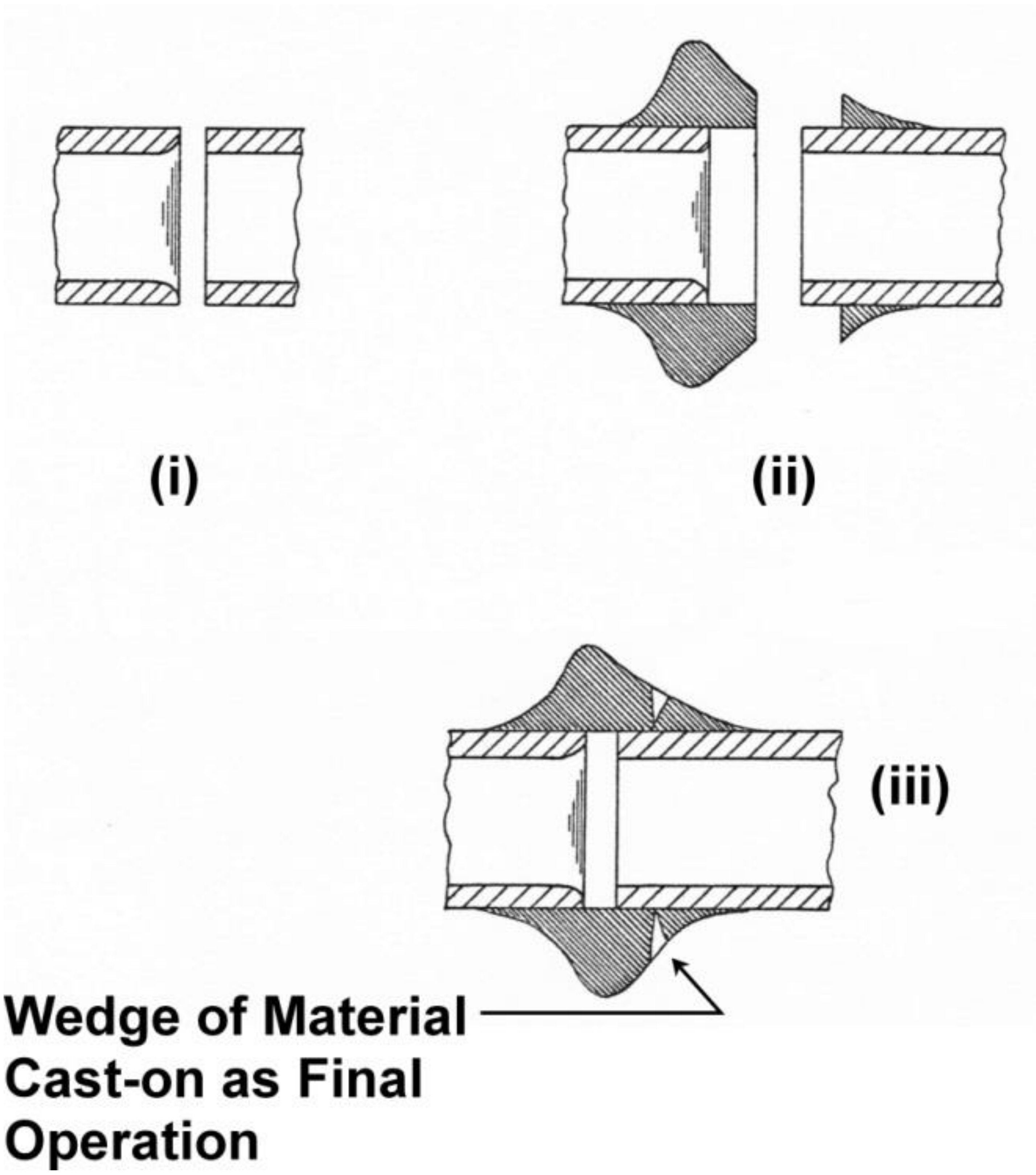


Figure 5.38: Joining together of the Drumbest End-Blow Instruments

THE PROVISION OF "SPIKES"

Most of the horns identified as type II instruments by Coles[203] (1963, 326 ff.) are decorated with prominent conical spikes. These are well developed on the later instruments and of a fairly regular form.

However, considerable variation in both form and method of manufacture exists throughout the instruments as a whole and several stages of development can be identified. Many instruments with spikes at their bell end also have holes drilled here, frequently downstream of the spikes and, in the case of SD7C, 26 and 27A the number of spikes and holes are the same and on the latter two instruments match up in position. There is, thus, a clear design relationship between holes and spikes on these. This relationship can be seen on instrument SD14A to be one of identity. On SD14A three holes were drilled at the bell end of the instrument spaced as for four. One of these remains in its drilled condition, a second has been infilled with bronze which bears signs of both hammering and abrasive working while the third still contains a bronze rod of

[203] Coles, 1963, 326 ff.

approximately 4.5*mm* diameter. This was set in by pouring molten metal around the rod while placed in the drilled hole. The rod and the viscous-looking cast-on material meet each other over most of their length at about 90°, i.e., the liquid metal did not wet the surface of the added rod and was cast too cool. Protruding from the tube surface by about 10*mm*, the outer end of the rod is peened-over somewhat.

Plate 5.25a: A Cast-on Spike

It appears, therefore, on this instrument, that the holes were provided as sockets to hold these rods while casting them in. A further possibility exists, of course, that a change of use of the holes occasioned their filling-in in this manner, A similar type of construction, i.e. casting-on, was utilised on instruments SD14F, 14K and 17A although, on these, the spikes are conical in form. On 14K, these are fairly sharp cones and their junction with the tube is obscured by a build-up of cast-on material. (Figure 5.39; Plate 5.25a, above) Similar features are seen on the large cauldrons such as those in both Dublin and Belfast museums. On these the spikes have generally been identified as rivets and this may, indeed, be part of the story. However, some casting-on has taken place around these features as witnessed by the deposits of cast material around the spikes themselves -as shown on Figure 5.39.

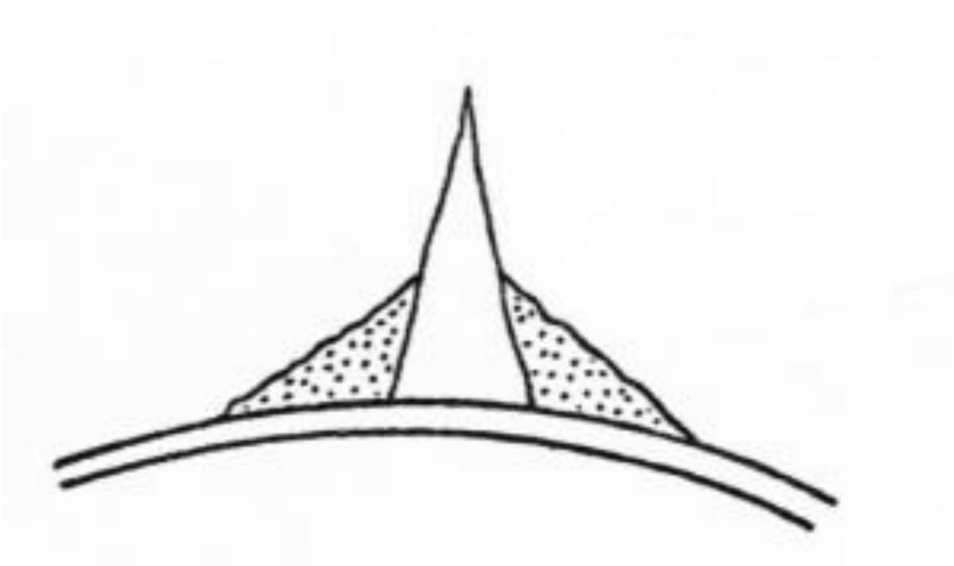


Figure 5.39: A Cast-On Spike on SD14K

The casting-on of small features such as spikes is technically quite difficult for, not only must the cast-on material be restrained to give the right form but it also contains little heat and is, therefore, very readily chilled by the metal with which it comes into contact. Such problems are eliminated when the spikes are cast integrally as was done on most of the later instruments. However, the earliest attempt to provide integral spikes seems to have formed these directly on the end face of the bell itself. These are seen on only one instrument where four rectangular "spikes" are spaced with each between the sprue junction and the joint-line and their end face is common with the instrument bell end. (Plate 5.10a, above) To form the mould cavity for these, material had been removed from the end face of the mould halves and the containing wall re-formed by the core butting up against the mould end face. See Figure 5.40

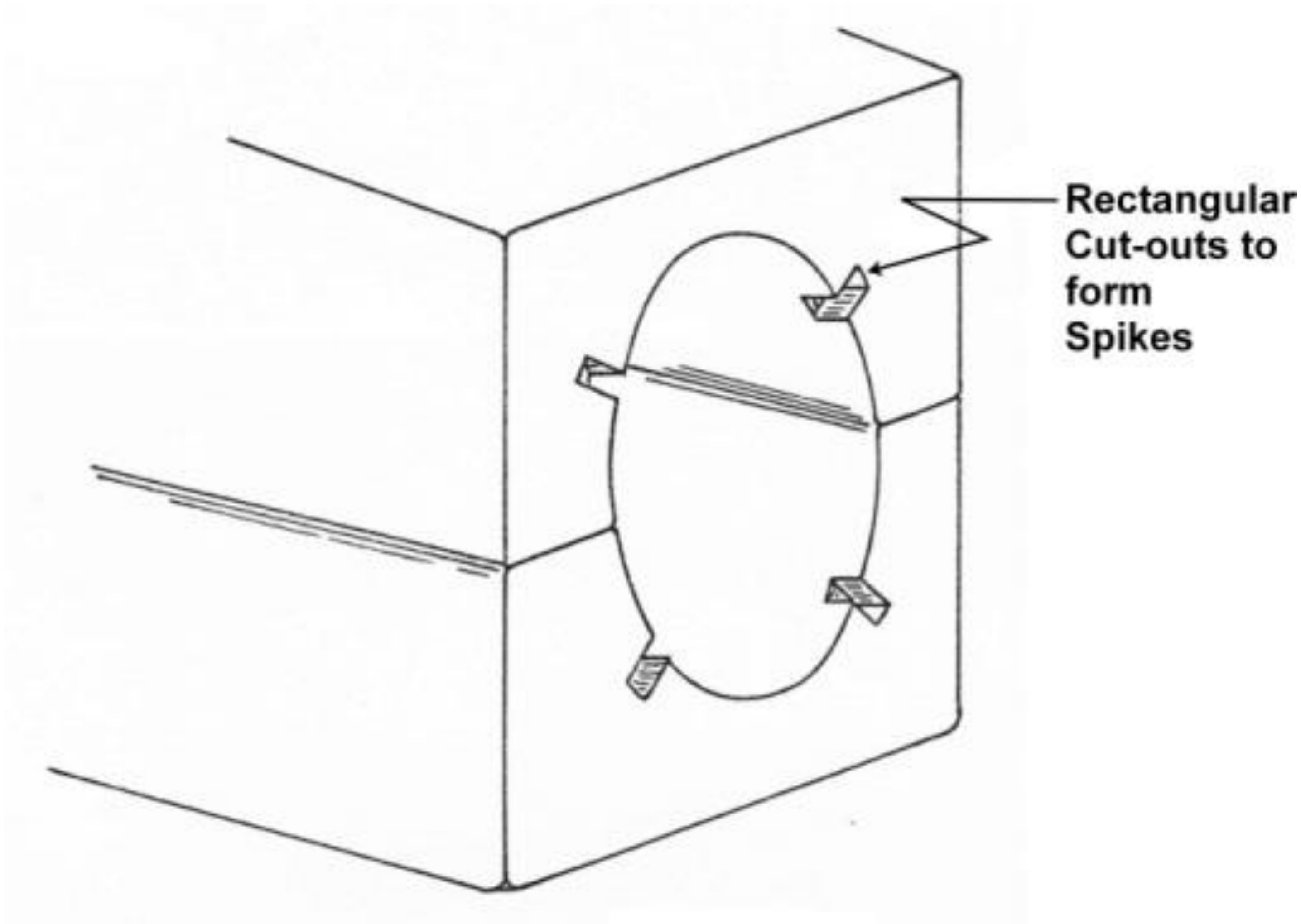


Figure 5.40: Forming the Spikes on a Bell End

Instrument SD14L has "spikes" spaced around the periphery of the bell in a similar way but these are generally set in by a millimetre or so from the instrument end face. Hence on this instrument, the "spikes" had been formed by pressing a cylindrical former into the mould to form these cylindrical features. It appears that a similar technique to that on SD14 had been employed in the construction of the mould and that the core print diameter was greater than that of the bore ·itself. This left a thin wall at the mould edge which in the case of one "spike" broke away, giving rise to one irregularly shaped feature. (Plate 5.26(a))

Plate 5.26: Tube 'Spikes'

Having formed the spikes in the mould in this manner, the way was clear for their "migration" upstream to the commonly found location a few centimetres from the instrument's bell edge. The restriction on the form of these "spikes" was also removed in that, whatever form could be pressed into the mould and then satisfactorily retracted could be used - and a conical form was ideal for this. Thus, many later instruments have conical, integrally cast, spikes spaced around their circumference, some of these having hollowing underneath them.

Once the technique for forming the spikes had been developed, the way lay open for the evolution of different forms of these. Many forms did develop from eye-shaped cross-sections on cones, through slightly spherical cones through to small domed or hemispherical shapes. Their most developed form seems to be that seen on instruments SD27A and 27B where a slightly spherical cone is surrounded by a raised concentric circle. (Plate 5.26b, above.)

On SD27A these spikes are present both at the bell end and the tip, this being the only instrument so decorated. This spike form is similar in some respects to decoration seen on bell discs of lurs from the Zeeland group (See Chapter 4, above). Viewed on its own, this form of spike appears to be the latest of the series and, the other advanced features on this instrument tend to re-enforce the view that this instrument is one of the latest made.

Many instruments contain holes which were provided for several purposes and in several ways, the commonest location for holes being at the bell-mouth where there are almost always four holes. Probably the earliest such apertures are on SD14F, where they appear to originate from clay plugs used to support the core during casting. (Plate 5.12 (a), above) Among the crudest holes is that seen on Plate 5.27a which was produced entirely by abrading through the tube, obtaining an ill-formed hole.

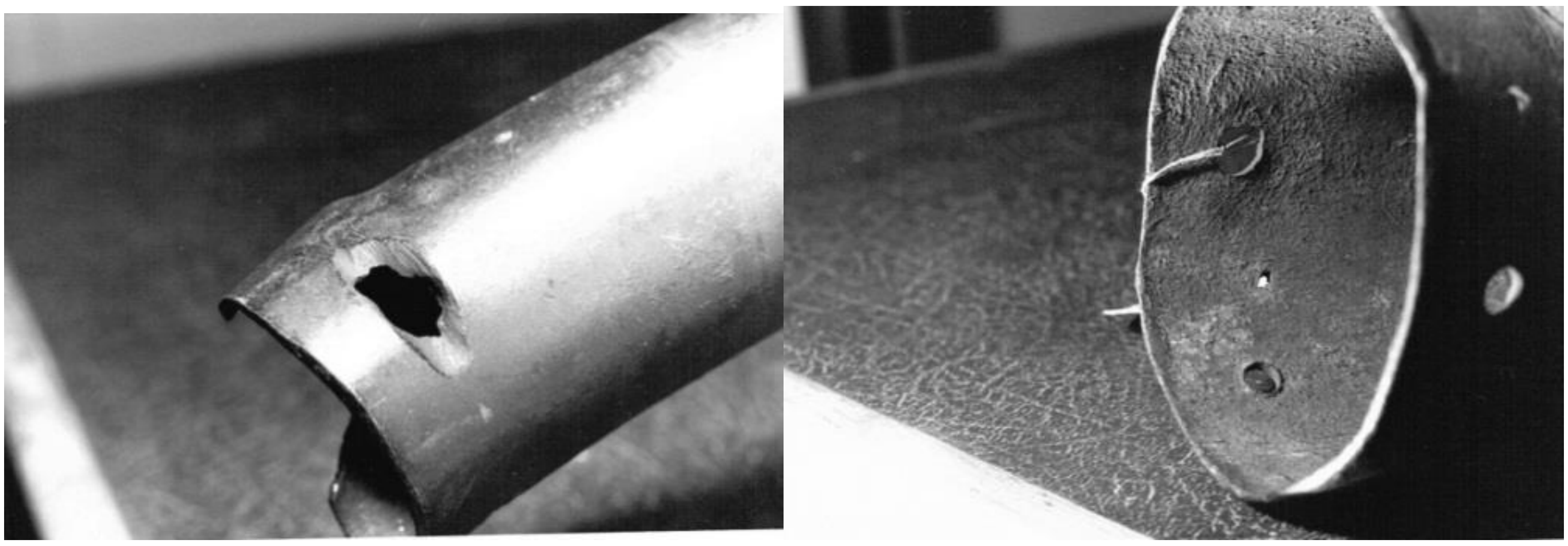


Plate 5.27: Post-Casting Work on Tubes

Many other instruments, however, (e.g. SD7D, 14A, 14I, 19B, 29D and 41) bear signs of having been notched prior to drilling. (Plate 5.24a and 5.24b, above) In the absence of a centre-punch and, particularly when faced with a brittle cast tube, abrading an initial breach in the tube wall would give a good lead-in for drilling.

There are many instruments which have holes of both slotted and unslotted types and the presence of the former may well tell something of the technology available for drilling holes, in particular the form of the drill bit itself as well as, in some instances something about the abilities of the actual craftsman working on that particular instrument. Many much earlier examples of holes made abrasively in this way exist, the earliest reference found in this study being of a hole in a shell of Turritella found in a Palaeolithic site at Sagvarjite in Georgia.[204]

Considerable pressure seems to have been applied when drilling holes in this material as many holes (in particular on SD7D and 1B) show very heavy burring-over on the bore. Only few show evidence of deliberate removal of these burrs SD7A having been abraded in the bore adjacent to the holes and those in SD17B having been roughly countersunk. Also on instrument SD29C, the hole made in the tube, to allow the tube-mount to be cast in, was fairly heavily countersunk, (Plate 5.23a, above) Holes were also used for keying cast- on material (e.g. SD13) and SD49 seems to have been prepared for a casting-on operation by drilling a series of holes around the edge of the broken tip but nothing further was then done on these. (Plate 5.28a, below.)

[204] Semenov, 1964, fig. 22.

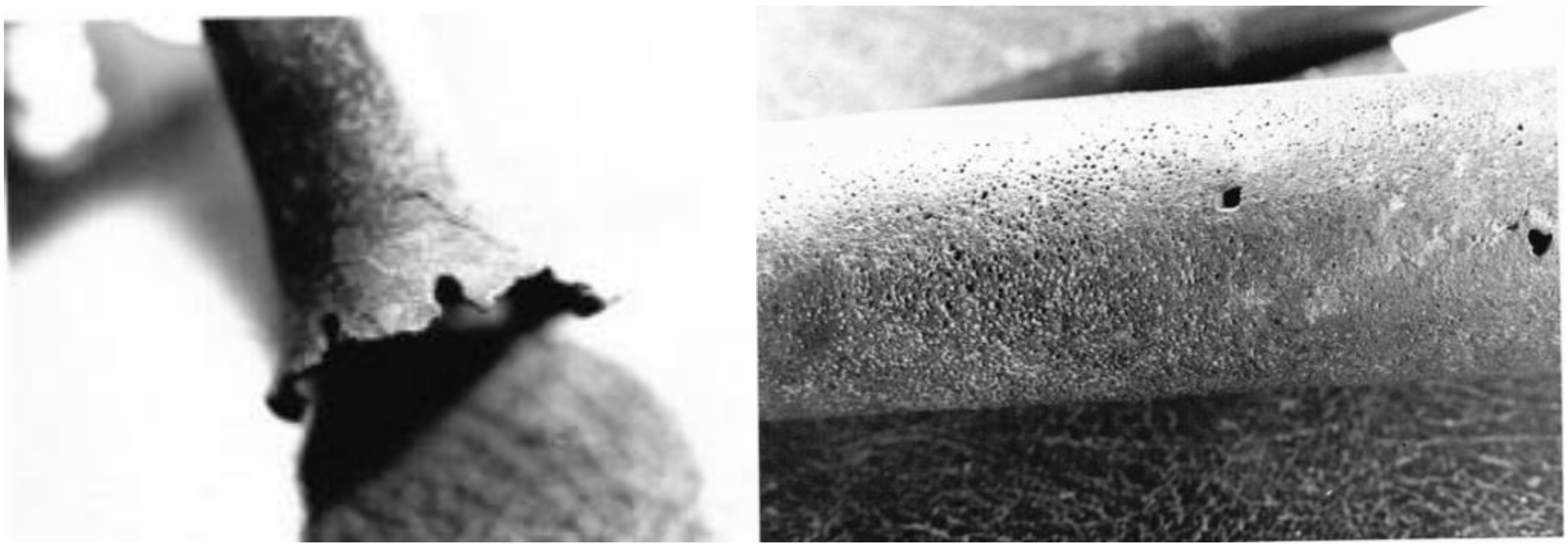


Plate 5.28: Post-Casting Work on a Tube and Tube Surface Finish

Many holes on these instruments are clearly very tri-lobed, the common morphological error to this day whereas others are clearly very round, one of the best examples being the hole drilled through a tube loop on SD14K. (Plate 5.17a, above) .

The diameters of holes on these instruments range from about 2*mm* to 7.5*mm* and are generally fairly consistent on an individual instrument, one glaring exception from this being SD43 where they vary from 5.8*mm* to 7.1*mm*. However, the diameters of holes measured on other instruments are (in mm):-

SSD7E	7.4	6.8	7.4	7.4
SD7G	5.3	5.4	5.3	5.4
SD7G	5.3	5.4	5.3	5.4
SD13	6.6	7.5	6.7	7.3
SD22B	5.2	5.7	5.2	4.4
SD41	5.0	5.2	5.0	obscured by casting on

These figures show a general repeatability to within about 0.7*mm* suggesting that, in each case, the holes were cut by the same tool, it was a fairly sophisticated cutting device and the maker was both able to and intent on cutting the holes to the same diameter. One of the key features of such a device would be the primary cutting faces of the drill-bit end. These would need to be sharp, formed at the same angle and in such a way that the point of the drill lay on the centre-line of its axis. Where this point lies off-centre, the outer cutting edge cannot follow the path defined by the drill centre and will extend a horizontal force on this, causing chattering and lobing of the hole. Thus on instrument 7G (dimensions above), the geometrical form of the drill tip must have been very carefully defined and produced, resulting in the production of eight holes all within ± 0.05*mm* of 5.35*mm* diameter. A strikingly well-drilled hole - drilled in a difficult position - is seen on SD14K where the tube-mounted loop has been drilled out to clear the flash (Plate 5.17, above).

Figure 5.41, below shows the hypothetical form of a drill tip, which could be made in a hard fine-grained material such as flint or quartzite and would derive sufficient central control from the tip form to allow a round and parallel hole to be drilled. The alternative process of abrading out a hole using a flat-ended drill and an abrasive would not produce holes round to the degree seen here, nor would it produce burrs of the size seen on many instruments.

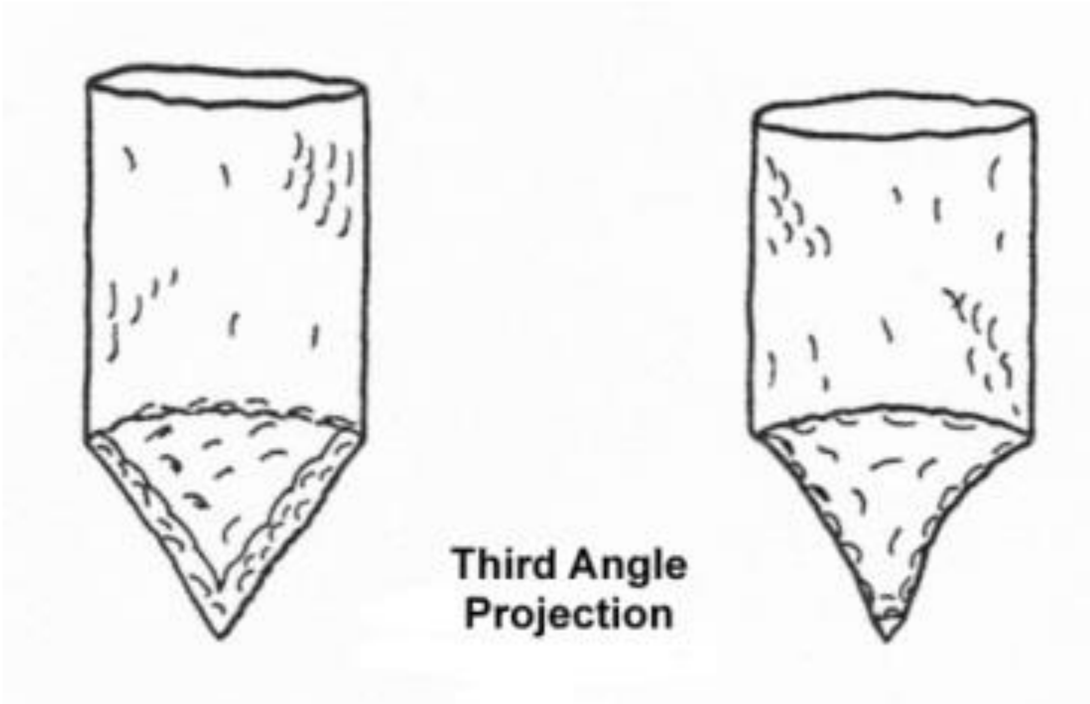


Figure 5.41: Possible Designs of the Drill Bit
Used to Drill Tube Walls

Several horns have portions of defective casting and in particular, miscasting occurs at the centre of the instrument curve. (Figure 5.4) Other typical casting failures are seen on SD1, where the whole tube is generally very porous. On SD29C, the areas of porosity are graded circumferentially with the obverse portion of the tube being more porous (Plate 5,3b, above). Several other instruments have blow holes over their surface, having been subjected to overheating since being cast (Plate 5.28b, above) and several show local pitting where overheated while fixing mounts. Generally, however, the casting quality is very good indicating that the maker had a fair knowledge of casting temperature requirements in order to cast the thin sections present on these instruments.

THE ORIGIN OF THE IRISH HORNS

Both the end-blown and side-blown instruments appear to have an origin in an animal horn, the side-blown having retained the animal-horn form with a short parallel addition at its tip while the end-blown was modified by addition of a more substantial tube yard. A horn from an animal of the bos genus has a hollow form when removed from the core that remains on the skull of the animal. At the tip, however, is a solid portion which extends some way down the horn and has a considerable effect on the use that can be made of the horn as a musical instrument. Use can be made of this tip of solid horn to fashion a mouthpiece as is seen on the shofar, the Iron-Age Scandinavian and many other instruments, it can be removed to present a clear bore but one which opens with a considerable diameter, much larger than the throat of a well-developed mouthpiece or it can be used to provide the end for a side-blown instrument with an aperture cut into the horn wall. The second route seems to be the one from which the Irish instruments evolved as none of the extant specimens has more than what could be described as a mouthsupport and all totally lack any developed throat. Starting from such a truncated horn, therefore, the end-blown instruments would evolve by the addition of a tube and the side-blown paradoxically by re-blocking the tube end and cutting an aperture downstream of this. It is the fact that the location of the blowing aperture is generally well downstream of the tip and the ubiquitous presence of a tip cone/bulb that would lead one to propose this sequence of development. No instruments have a tapered tip as a relic of pre-metal1ic forms as on virtually all other side- blown instruments reported in recent times. The early, pre-metal form of these end-blown instruments, therefore, would have been of a horn with the tip removed and a tube inserted into this. Then, in the case of the side-blown instruments, a blowing aperture was cut into this, while in the end-blown instruments the tube end could be utilised.

Very close ethnographic parallels are seen in the case of the side-blown instruments, in the Matto Grosso in Brazil. There a cow's horn has its tip removed and a bamboo cane inserted into the hole. It is then fastened with cord and sealed with wax. (Plate 5.30a, below, from Collaer[205].) Collaer describes several other uses of side-blown instruments many of which utilise bamboo as the blowing tube and comments (op. cit.) "It is a very remarkable fact that the actual tube of the trumpet is closed at the top end by the septum formed by the natural knot, although we would expect to find the mouthpiece there. The blow-hole is cut into the side-wall of the tube. The area of distribution of trumpets that are side-blown and held cross-wise extends basically across the Amazon and the country to the south of it.

Plate 5.30: Ethnographic Parallels to the Irish Horns

This seems to provide a very close parallel, furnishing a basic structural arrangement for both the side and end-blown instruments. It is probable, then, that the earliest instruments were of an end-blown type but whether these evolved in Ireland or elsewhere can only be guessed. The idea of an animal horn as musical instrument may have been

[205] Collaer, 1973, 166, fig. 93.

brought into Ireland i.e. a low level of design diffusion or indeed have originated there. It does seem clear, however, that the side-blown design evolved while the instrument was still being made in the original horn as the tip cone/bulb form would quite likely have developed differently had the point of divergence been from a bronze ancestor. A peculiar development then seems to have been strongly affected by the form of the tip-cone/bulb, as discussed below.

THE EVOLUTION OF SIDE-BLOWN INSTRUMENTS

The evolution of the side-blown instruments is discussed first as greater continuity of development can be seen on these. One of the earliest developments that took place had to be the plugging of the hole left by removal of the tip. This was probably done by the use of a bronze bung with a carrying loop identical to those on axes of the time. These loops are placed very close to the end of the bung which opens out in a wedge shape for convenience in wedging into the tube. Translated into bronze this type of instrument is seen in SD14O, 17A and 30. (Plate 5.1a, above, Plate 5.8b, above and Plate 5.25b, above) Adding a further loop on the tip cone (SD35) obviously gave a more-easily carried instrument, and the enlarging of this loop as on SD4B improved matters further. However, once the instrument had been established in bronze, the wedge form of the tip could be modified at will and forms such as SD17A, 30 and 36A emerged with a more rounded or bulbous tip along with SD14G, 14K and 14L i.e. with a similar smoother profile but having tip loops. Eventually, bulbous tips such as SD8 emerged. Parallel to these bulk changes in morphology the developments in chapletting took place although no obvious single train of events can be outlined. Some instruments, SDl6A, 16B and 16D, for instance, have what appear to be an early form of chaplets combined with a ring/ring mount combination supposed to be late in form. It is obvious from these and similar instruments that workshops were working quasi-independently·with only limited or occasional access to the developments which were taking place elsewhere.

The final developments which took place were connected with the large Type II side-blown instruments featuring holes and conical spikes. Being much longer than the northern instruments and having a much larger diameter, the manufacture of these instruments called for the largest castings of all to be produced. Their cores were made in several parts and several post-casting operations carried out to add rings and mounts to their tubes.

THE ORIGINAL FORM OF THE END- BLOWN INSTRUMENTS

Most end-blown instruments are found incomplete, unlike the side-blown and their original form is, therefore, more difficult to reconstruct. However, some early instruments such as SD14I appear to be complete suggesting a form for the early end-blown types. It lacks a clearly formed mouth-support but the end-face of the tip is, in parts, finished off normal to the tube's axis. (Figure 5.42).

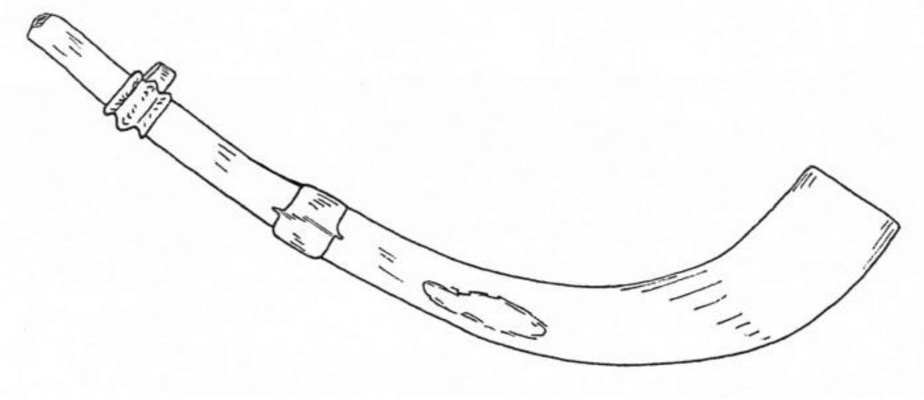


Figure 5.42: The Form of Instrument SD14L

Although only 0.54 metres long, it is made up of three parts joined by means of two cast-on bands. Like all the other instruments from this province, it lacks any evidence of ever having had a developed mouthpiece and would, therefore, only ever have produced three tones - its first, second and third formants. The latter of these it would doubtless only do with difficulty.

As the ability to cast longer sections was developed, no doubt the tube yard section of the instruments themselves were made longer. Aesthetic considerations may have been principally responsible for such increases, although where an upper formant was only marginally obtainable on an instrument, a few centimeters on its length could make a noticeable difference.

TYPE II END-BLOWN INSTRUMENTS

One other instrument similar to SD14I is known and is made up from SD9D and 9E. This however, is clearly of a type II form and is made up of bell and tube yards. No information is available about the archaic mode of joining of the two yards as these are now soldered together. Its overall length is approximately 0.66*m* long[206] and is, thus, some 120*mm* longer than SD14I. As on 14I, its end-face appears to terminate as a straight tube with no provision for a mouthpipe or tube yard extension piece. Further increases in length of the tube yard seem to have been accommodated by the manufacture of a separate tube yard which was presumably fixed to the mouthsupport and bell portion on final assembly. These tubes have four holes at both ends where these fit into both mouthpipe and bell yard sockets and were probably pegged into position using wooden pegs. One pair of tube and bell yards SD7E/7D have four holes drilled in their mating portion, which were produced selectively on assembly to take the pegs which would locate and retain them. None of the sockets or bell ends are round or smooth enough for their mating fit to be airtight and it would, thus, be necessary to seal this joint by means of some suitable material. For this a wax or resin impregnated piece of cloth could be used to wrap around the joint to make it air-tight. The presence of such wrapping material was reported on several finds, although, on none of these, were instruments in an assembled condition, and no such material has survived to the present day.

One instrument, SD14B has three holes - drilled as for four - at its tip apparently for fixing as described above. However, these holes are drilled through thicker sections of tube, where the wall has been locally thickened by making indentations on the core. (Figure

[206] Coles, 1967, 115.

5.43) These features seem designed to locate the tube and the wear on their internal diameter suggests that they have, indeed been in contact with this. While so assembled, the two tubes would be held fairly rigidly by the point-contact of the small bore protrusions and at the same time have an annular space between these that could be filled with resin or wax to seal the two parts together.

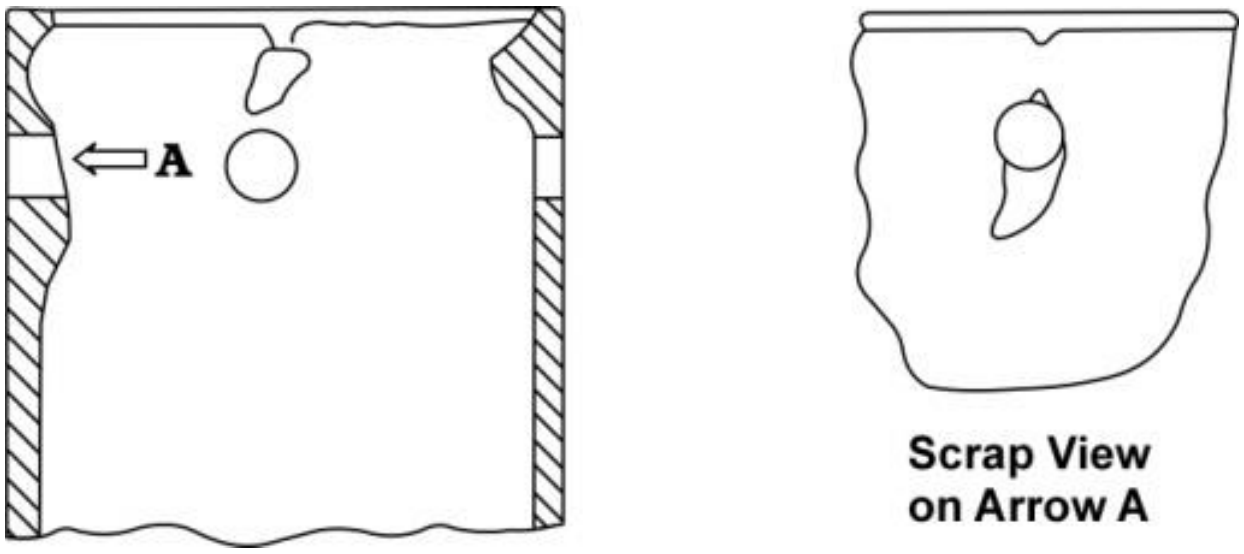


Figure 5.43: Local Wall Thickening

Type II tubes that have been found, have reduced diameters at both ends and one would expect these to have been fixed to other features at both ends. However, no separate blowing features have been found and it is only possible to guess that they were originally similar in form to that seen on instruments SD16C and 16D.

However, as the length and, therefore, the weight of the instrument increased, the attitude in which it was played probably changed too. While SD14I could well have been held out horizontally, this would not be so for some of the longer instruments. At least, they could not have been held in such a way for long periods. Thus the longer of these instruments have tube yards with ends that turn through a small angle, allowing the instrument to curve downwards thus making it easier to support.

Such a change may have been introduced while the straight tube yards, such as SD19B were in use. In this case, the changed form could have been accommodated in a crooked mouthpipe. However, it seems to have been built into later tube yards as these have both ends turned through an angle. (Figure 5.44)

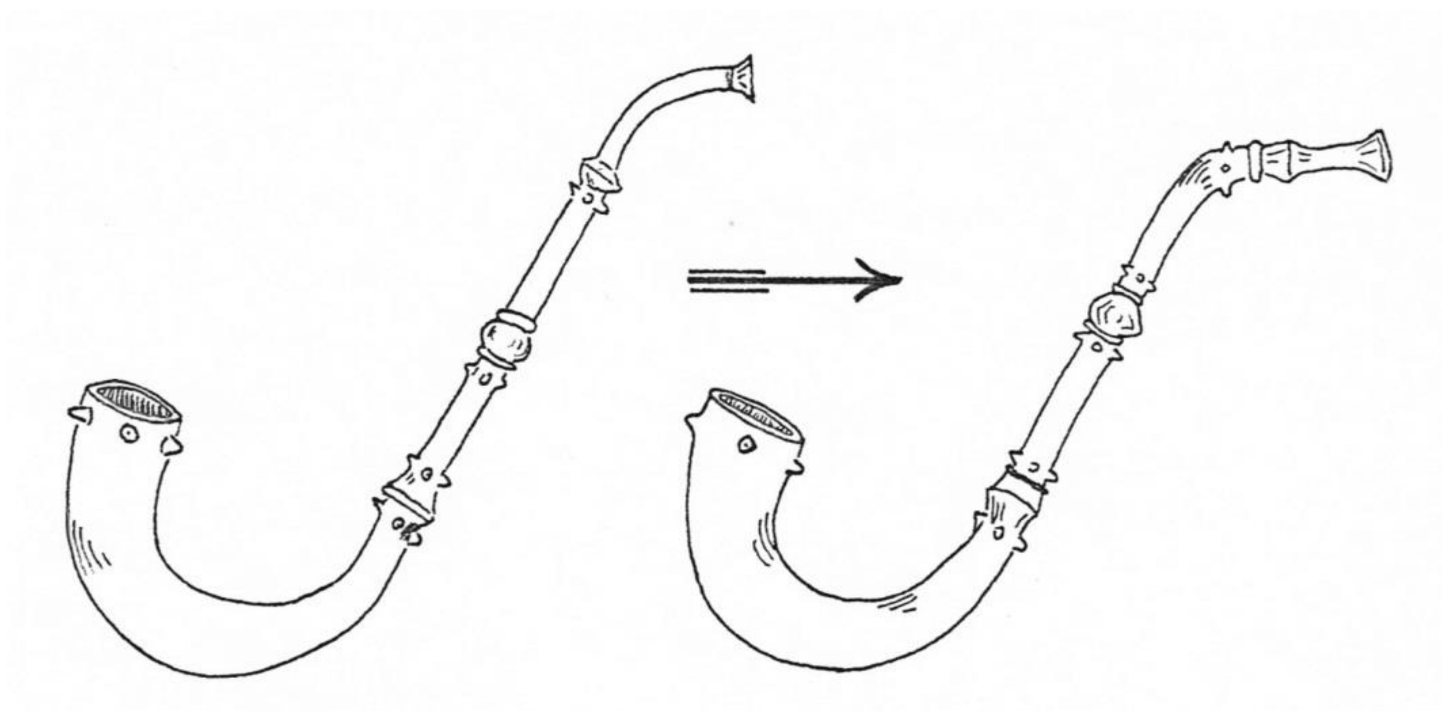


Figure 5.44: Development of End-Blow Instrument Morphology

Type II bell yards were universally joined to the tube yard by inserting the small diameter end of the tube into the tip of the bell yard. Sometimes these tips are plain with a bore running smoothly into that of the bell while on other occasions the bells are provided with sockets at their tip, into which their respective tubes fit. Later varieties were also decorated with conical spikes here, and, on the instruments from Macroom, by a re-enforced band. (Plate 5,26b, above) Their overall form is always very curved, their bell-yard centreline describing a semicircle, and in their assembled form they would appear as in Figure 5.44, above.

TYPE I END-BLOWN INSTRUMENTS

Like the type II instruments, the tube yards of the Type I instruments became progressively longer but differed in detail of construction. On these instruments, the bell-yards had at their tip a small diameter portion that was, presumably, designed to fit in a corresponding socket on the mating part. Several double-socketed junction pieces have been found that mate with these bells and, presumably with tube yard or mouthpipe. However, no parts that mate with these junction pieces have been found, and the presumed original form of such parts can only be conjectured. The most advanced form of Type I instruments was attained in instruments SD16A and 16B. (Plate 5.29, at the beginning of this chapter). Bell and tube yard were cast-on together on this instrument to produce an instrument with an overall length of about 0.72*m*. A slight curvature was added to the tube yard, giving a very faint 'S' shape to the instrument overall. At the end of this tube a mouth support was cast integrally and provided a rim of about 31*mm* diameter. On 16B the four notes listed in Coles[207] F3, D#4, C5 and F5 can be sounded, but the instrument also sounds a very resonant F2, when played with a very relaxed embouchure such as would be used on a variable tone-colour instrument. What is more surprising however, is that the blowing aperture seems well suited to blowing in this mode and during tests on this instrument one member of the museum staff came into the room to see who was playing "a didjeridu."

One other complete type I end-blown instrument is illustrated in MacWhite[208], although the whereabouts of this latter instrument is no longer known. The instruments are slightly 'S'-shaped somewhat after the shape of a modern alto saxophone and would, most probably, be played in the same attitude, i.e. in front of the player. From the form of these complete instruments, it would seem that mouthpipes and mouthsupports would have been provided for the other Irish horns although no such parts remain today.

THE MUSIC OF THE HORNS

The end-blown instruments are, as discussed above, metal analogues of an animal horn and a tube. As such they have a common heritage - with the vast number of other PVAs and one view of their use tends to be conditioned by the usage patterns of these other instruments. The side-blown instruments, however, have resemblances to some contemporary and recent side-blown instruments but none with archaeological material.

[207] Coles, 1963, 339, fig. 6.
[208] MacWhite, 1944, Fig. 4b.

Even when compared with the recent material, fundamental differences can be found which could lead to a conclusion that their usage differed from that of this material. However, both the side-blown and end-blown instruments were clearly used together, a common find association being one of each and the use proposed for one instrument should, therefore, reflect the use of the other. For this reason the side-blown instruments, being harder to interpret are considered first in an attempt to avoid the danger of drawing simplistic parallels.

As on the present-day and recent side-blown horns, the Irish Bronze- Age instruments have their blowing aperture some way from the instrument tip. This enables one hand to grasp this portion of the tube and to pull the instrument towards the player's face in order to maintain a seal around the lips. In this way the ancient instruments are similar to many modern ones. However, the morphology of the blowing apertures of the Irish instruments is simple being a large oval hole formed in the tube wall. This contrasts with those of other side-blown instruments which are generally much smaller and are built out from the bore with a considerable radius leading into the aperture. Figure 5.45 shows the mouth aperture of a small (approx. 260*mm* long) side-blown ivory horn from East Africa (Author's collection).

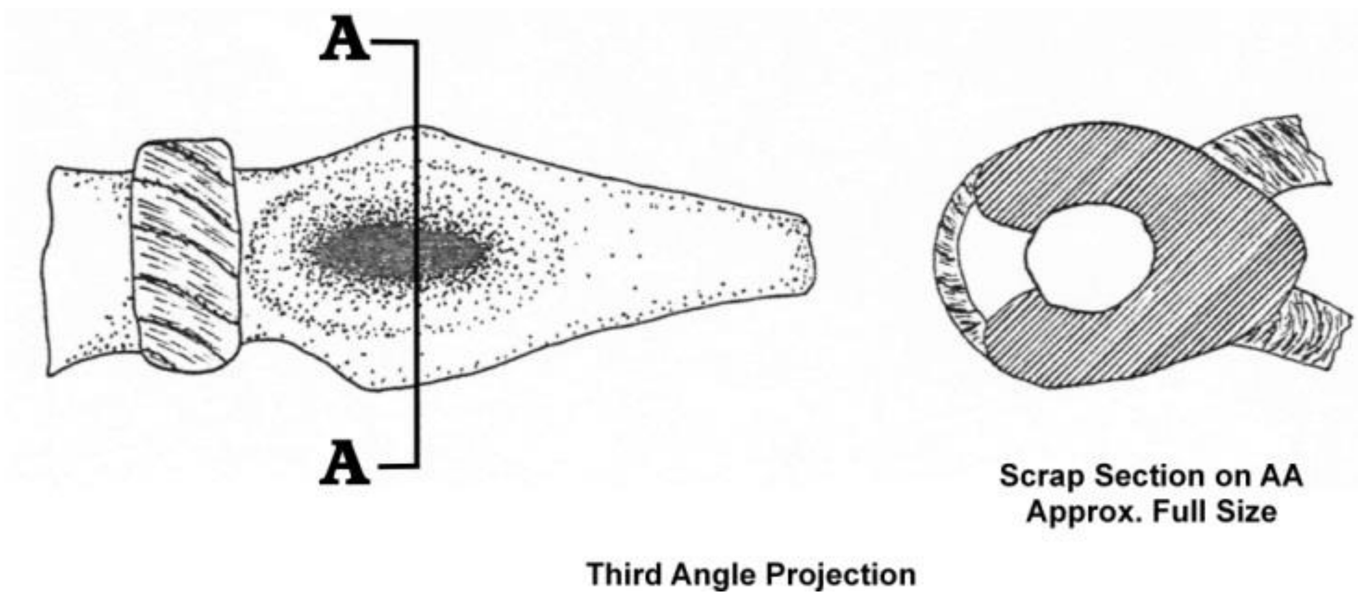


Figure 5.45: Side-Blown Instrument Blowing Apertures

Obviously, this general form can be accommodated in the thick ivory wall of the horn, but, nevertheless, the actual blowing apertures of ivory instruments are always smaller than those seen on the Irish horns. Similar mouthpieces are seen on analogues made of wood both in Africa and Asia. One is clearly visible on p. 20 no. 72 of Collaer, 1968, although it is not clear what material this is made from.

Also widespread in its use, both in time and geographical extent is the shell trumpet. Known from prehistoric times to the present, it exists in both end-blown and side-blown varieties. On this latter, however, the aperture provided is generally round, and small enough to give considerable support to the lips. (Figure 5.46) Similar to this, is the aperture of a composite end-blown trumpet again with a circular blowing aperture. (Figure 5.46b)

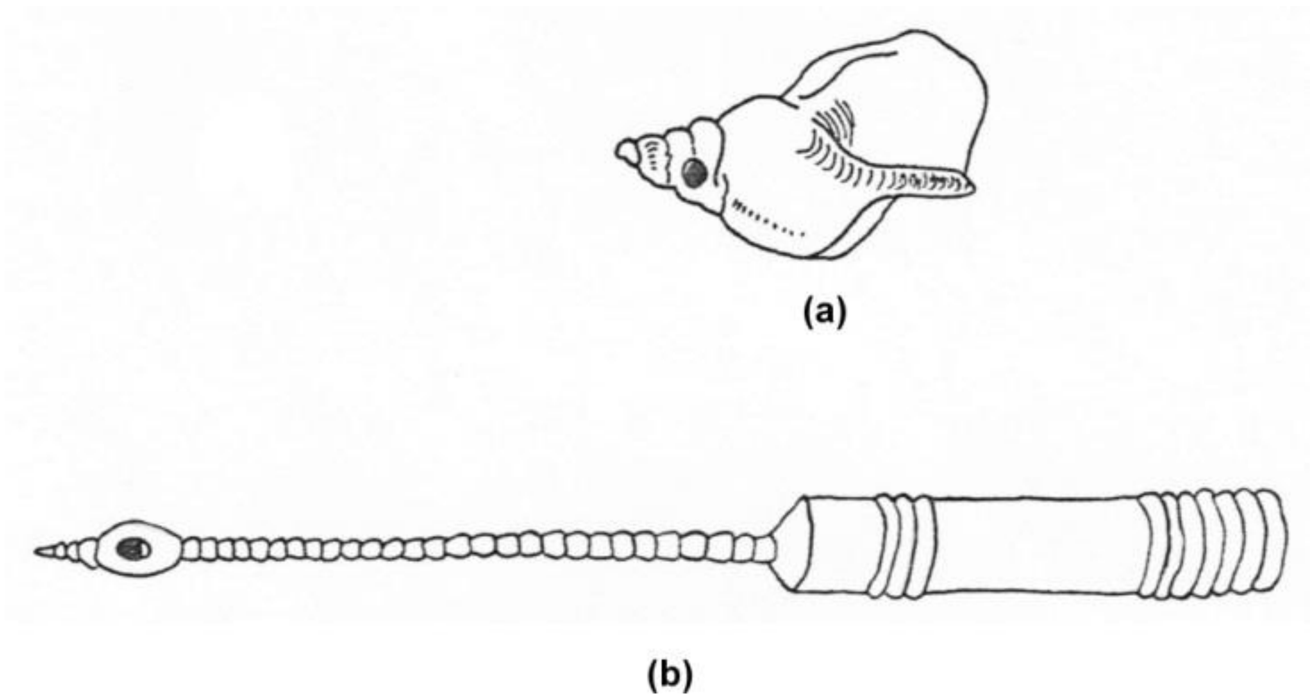


Figure 5.46: Side-Blown Instrument Blowing Apertures

With the use of metal to manufacture horns, the design restrictions placed on the mouth aperture arose principally from the technology employed. Hence, the aperture can be tailored largely to suit the organological requirements of the instrument. Such "metal instruments" commonly found represented on bronzes from Benin are representations of ivory horns and, on none of those found can the form of the mouth aperture be seen. The only metal side-blown horn found for this study is a specimen which was bought from an

Asian crafts shop in Dublin by the author. This was lost-wax cast in brass, is highly ornamented with integrally-cast decoration and has small jingles attached to the outer radius. It is illustrated on plate 5.31, below). On this, the mouth aperture is parallel-sided with semi-circular ends. It measures 50*mm* by 15*mm* and because of the small diameter of the tube at this point - c. 15 mm - occupies the whole of the circumference of the instrument inner-radius at that point. This mouth-aperture is, therefore, of a form very similar to those on the Irish horns although it is only about half their linear size (or one quarter of their area.) (Plate 5.11a, above, 5.22b, above and Plate 5.29a, above.)

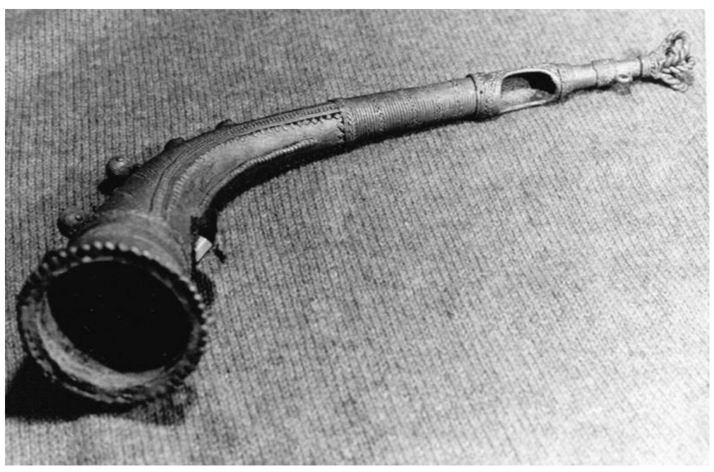


Plate 5.31

There are no references, iconographic or literary to the use of the Irish Bronze-Age instruments and one must, therefore, rely on the evidence of the extant material itself to recreate their original form. The possibilities are, that the instruments were used as they are now seen or that some device was fixed to the mouthpiece to reduce the aperture size, producing an instrument more like the side-blowns seen today. However, should the maker of the time have wished to produce an instrument with a smaller aperture, he could readily have done so by reducing the size of the core portion that formed this. This would have required very little modification to his detailed manufacturing procedure and not entail operations that were outside his abilities.

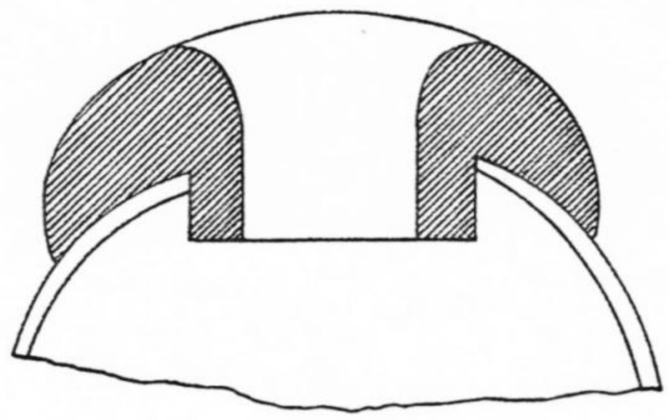
Two instruments, SD4B and 36A, have mouth apertures that are more elaborate than the simple holes on the rest of the instruments. (Plate 5.11a, above) The significance of this feature is discussed later.

On the other hand, a thicker mouthsupport may have been required and again this could have been cast integrally. In this case, though, a rather heavy instrument would have been produced and such a mouth aperture form would more likely have been provided by use of an added part, probably in wood. No such parts have been found, and it would be most unlikely that, had they been used, all of them would have perished. This is particularly so under the conditions of many finds in Ireland where acidic peat conditions have preserved wooden artefacts well. A further possibility that exists, of course, is that the mouth aperture fittings were removed while the instrument was not in use. In several parts of the world taboos exist on the touching or, in some cases, even the seeing of trumpet/horn mouthpieces by other than the priest or shaman and, in many cases particularly not by women. Such a ritual could have been observed in Ireland in the late Bronze Age and could account for the lack of mouth aperture parts. This taboo was clearly not practiced when the Drumbest end-blown instruments, SD16A and 16B, were made as these have integral mouthpieces not separable from the instrument. Even were it to be so that the parts were hidden on other instruments, however, it would seem likely that some evidence of such parts would have been found somewhere in Ireland, indeed the act of hiding could have accomplished the first necessary stage of survival.

Undoubtedly, on the ivory and wooden instruments, the thickened section around the mouthpiece (Figure 5.45) does provide considerable lip support. However, its major function may well be more in strengthening the tube section at the point where the mouth aperture is cut out. Clearly, on an instrument such as the small brass end-blown horn described above, 50% of the sectional strength is lost where the mouth aperture is cut out. This is equally true with the Irish Bronze-Age horns although, generally speaking, the mouth apertures occupy a smaller part of the instrument circumference. Nevertheless this section is the weakest on the tube yard and is the point where most tube yard failures have occurred. In fact, two instruments, SD13 and SD14O have been repaired at this point by casting-on thus thickening up the section here. From this evidence, therefore, it would appear likely, that, had a thicker section been required in the area of the mouth support it would have been produced by casting integral with the remainder of the tube.

What is more critical to the performer than the thickness of section at this point or, indeed, the size of the radius around its edges, is the size of the mouth aperture throat. As both side-blown and end-blown instruments appear to have been used together, the player called upon to blow a side-blown would almost certainly have tried blowing an end-blown. Thus, in the case of the Drumbest instrument, a player using an oval side-blown mouth support of 47*mm* by 25*mm* (SD16D) would have blown the round end-blown mouthpiece of 50*mm* diameter of the two end blown instruments (SD16A and 16B). He would, therefore, have been aware of the greater support given by the smaller mouthpiece and, presumably, wished to affect the design of future instruments to facilitate blowing. A further function of the mouthpieces examined on side-blown instruments of recent origin, is to provide an aperture that is more readily sealed by the lips. Thus, where the instrument tubes are essentially curved, the built-up mouthpiece presents a flat face to the lips upon which the lips can seal. This could have been readily accommodated by a change of tube form to flatten the area of the mouth aperture. Even if extra parts were to be added to this, a flat tube surface at this point would have made it easier to effect a seal here. The feature present on the mouth aperture of SD4B does nothing to ease this problem of sealing but appears to be designed to produce a form to which the lips can seal. This suggests that, in this case, at least, no other parts would be added to this instrument to facilitate its use.

However, assuming that the use of ethnographic parallels is a valid procedure in attempting to reconstruct a mouth aperture assembly, it should be possible to make some assessment of what could have been used. Figure 5.47 shows a possible assembly in which a wooden (or other material) part builds up over the mouth aperture, restricting its size and providing some measure of support for the lips. Clearly, such a part would give support to the lips in a similar way to the blowing apertures of recent side-blown instruments. However, it would be difficult to make, and require fastening very rigidly to the tube. In addition the metal aperture would not need to be of the same form as that in the added part, a square shape being easier to match up to. Nor would the blowing apertures on the horns themselves need to be so carefully radiused as they are on all the instruments examined. (Plate 5.9b, above)



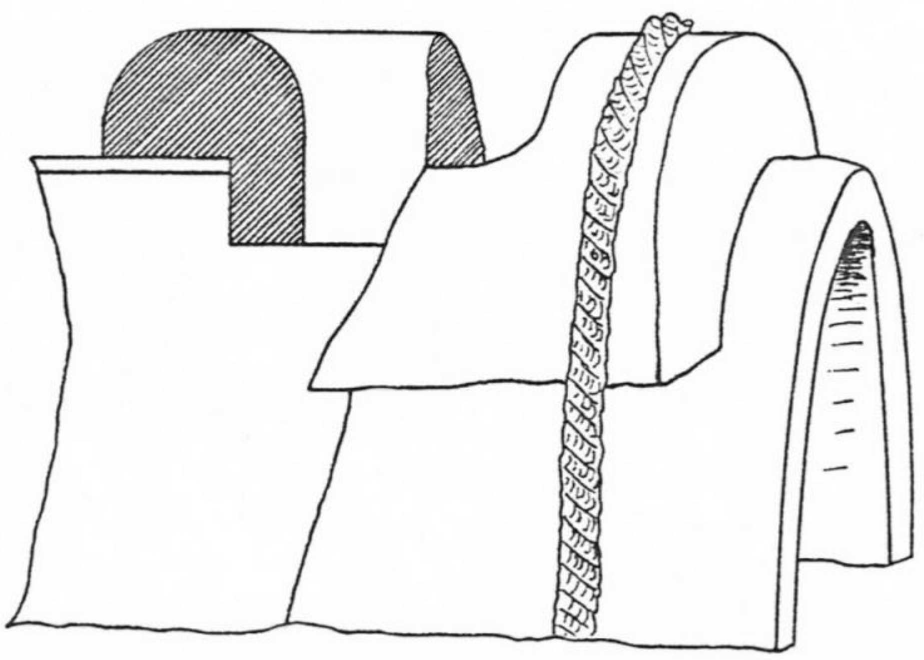


Figure 5.47: A Possible Design of an Additional Mouthpiece
For a Side-Blown Horn

If separable mouth support parts were to be provided on these instruments, then their sound output would be comparable with that from other recent end-blown instruments. However, if these instruments are to be considered as complete with the mouth apertures that they now have, then comparisons with ethnographically reported side-blown instruments are not possible. Only were one able to find organologically similar material would a direct comparison be possible, and no such material has been found in this study. A different approach to the problem could be taken by considering the basic attributes of a side-blown horn and freeing these from the morphological constrains imposed by specific designs seen in the Bronze-age material. Thus, these horns could be described as having a large, generally oval, mouth aperture with no throat leading to a tube that has an unusually large diameter compared with its length when considering PVAs in general. Having thus re-defined the instrument form, it can be seen to be similar to a member of the variable tone-colour sub-group of PVAs. (See Chapter 1)

Thus, the end-blown instruments as they stand now are capable of producing two notes with a moderately experienced player, i.e. their first and second formants, approximately one octave apart. With the addition of extra parts to the blowing aperture, which restrict lip vibration, they become capable of producing the second formant only. It can be said with certainty, therefore, that, with these instruments, the bronze age player had available the means of performing after the manner of variable tone-colour instruments as they are now played.

The possibility remains strong, therefore that both the end and the side-blown instruments were used as variable tone-colour instruments to provide a basis for ritual singing or chanting with possible simple idiophone accompaniment. Of the present day use of instruments such as these - the didjeridus·-Jones[209] says that it is, (as these horns from Ireland) a simple sound producing device:

> *"Yet in the hands of accomplished players the result is amazing in its subtlety and complexity. .... The function of the didgeridoo is to provide a constant drone on a deep note, somewhere between D flat and G below the bass clef. This drone is not a simple held note, but is broken up into a great variety of rhythmic patterns and accents by the skilful use of the tongue and cheeks. Nor is it constant in timbre, for many different tone-colours are achieved by altering the shape of the mouth cavity and the position of the tongue and by shutting off various parts of the anatomy which act as resonating chambers for the human voice. The variety of sounds thus produced is impossible to describe in words, and must be heard to be believed.*
>
> *It is not, however, in the manipulation of this droned fundamental, nor in the slight rise and fall of pitch used to accent a rhythm, that the greatest skill of the didjeridoo player lies, but in his use of two entirely different notes, which are alternated in rapid succession to form complex and fascinating cross-rhythms. These two notes are not haphazardly chosen, but invariably are pitched a major tenth apart, the upper note being the first overtone ....*
>
> *......Instead of snatching quick breaths at irregular intervals as do these players of the Bunggal songs, the didjeridoo-men of the western or "Lira" style favour a method of drawing in air through the nose while blowing from the cheeks, like a glass-blower. An endless fundamental tone can be produced in this way for any length of time, without undue fatigue. But these players have discovered an ingenious means of varying the timbre of this note by singing the overtone (i.e., the tenth) instead of blowing it. The two sound waves of the blown fundamental and the vocalised overtone combine in the tube to form beats, and a reedy, vibrant chord results,*
>
> *forming a rhythmic pulsation with the pure fundamental. One cannot detect the sound of the voice itself even when one is very close to the player."*

From this picture of instrumental usage today, it is possible to gain some insight into the potential musical life of bronze-age Ireland. These horns are neither simple to make nor simple to play and both these activities must have resulted from several generations of artisans, technical or musical, and have been deeply rooted in society. As the author has discovered in two years of learning to play the didjeridu it is not an art to be easily

[209] Jones, 1957, 8.

mastered. Jones[210] tells that "Like the songmen, didgeridoo-players are trained from an early age and devote their life to their profession." Good players often become celebrities and go on *Grand tours* around the district". Unfortunately, due cognizance is not taken of this fact when instruments such as these Bronze-Age horns are blown at gatherings of men of letters. The instrument is but one part of a whole and, devoid of accompanying song or chant, the appropriate ritual to surround its use and, above all, the atmosphere, a performance on a single horn becomes clinical and inappropriate.

Thus, bronze-age society in Ireland may well have utilised song and chant, as do the present-day aboriginals of Australia, and accompanied this on pairs of horns, possibly one end and one side-blown, along with simple idiophones. The blowers of these instruments may have been ritually-pure individuals or simply experts in performance. Whatever, their religious status, however, they would most likely be experts. Each horn represented an enormous investment in time - and bronze - and such an investment would be unlikely to have been spent unwisely. From the occurrence of both side and end-blown instruments, it would seem that the smallest group of players to perform together would be two and the differing tonal characteristics of these two types would clearly enhance their performance. Whether the Drumbest find of four instruments signifies a larger group of performers is hard to say but while the doubling of the instruments in this way could lead to the development of complex rhythmic and harmonic patterns all one can be sure of is that it would increase the volume.

In Australia many styles of didjeridu playing exist in different areas while the basic technique for sounding the instrument is common throughout the country[211]. This results from the fact that the didjeridu is essentially very simple from a technical point of view and the variety in performance comes from variations in blowing technique. This is not so with the Irish horns, however, as the instruments themselves are technically quite complex and show variation, from north-east to south-west, both in design and manufacture. Nevertheless, these instruments are unique to Ireland and, thus, have a fundamental commonality throughout the island with the organological variety being relatively superficial This was probably also the pattern in the musical performance with the fundamental basis of the music being determined by the side-blown/end-blown combinations of horns and the variety arising from the differences north-east to south-west in size of the horns, size and shape of the blowing apertures and the technique utilised in sounding them.

Undoubtedly, interchange of ideas did take place between the two cultural areas as witnessed by several similarities in developmental trends such as the morphology of instruments and the methods of attaching mounts to tubes. In the same way musical elements of performance must have migrated between one culture and another to produce a pattern very similar to that seen in Australia, of varied local schools of performance. The Irish bronze-age horns are indigenously developed and unique in the archaeological record, as would have been the schools of performance that grew up to use them. No trace remained of their use in the iron age although the large Celtic riveted horns seem to have continued the tradition of using large-bored PVAs without constricted bore mouthpieces.

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[210] Jones, 1957 p. 8.
[211] Jones, 1967.