The Cutting of Cage Cups - David Hill

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Several different methods by which cage cups could have been made have been proposed in the past, but with close study of two particular sets of fragments of unfinished cups or bowls, we can easily determine not only the marking-out and preparatory cuts seen on these objects, but also propose a reconstruction of the entire sequence by which they were created.

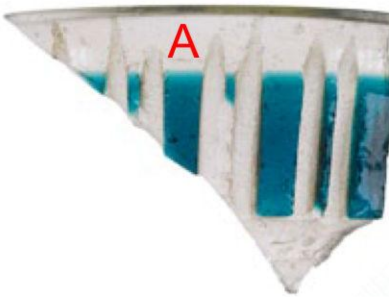
The large fragments of unfinished cage cup rim in the Benaki Museum (67, above) are of paramount importance to our understanding of how bell-shaped and other cage cups were created. Together with the equally significant Grenoble fragments from the cage of another unfinished vessel (68, left) they establish, beyond any argument whatsoever, that cage cups were carved from free-blown thick-walled glass blanks, (sometimes with coatings of different colored glass on their exteriors), using similar stone wheel cutting equipment as can be seen to have been used by Late Roman glassworkers in the decoration of many other cut glass vessels of their time (such as those illustrated in Fremersdorf 1967).

The abandoned Benaki vessel shards preserve and record at least three (possibly four or more) stages in the initial 'roughing-out' of the inscription frieze at the top of a vessel, and even suggest the point at which it was likely discarded. Josef Welzel (1927-2014) was the first to recognise the significance of these fragments (Welzel 1994, p. 36), and my own experiments following his example confirm that the cutting sequence, using a glass engraving machine fitted with interchangeable stone (possibly metal) wheels of different sizes, can be reconstructed as follows:

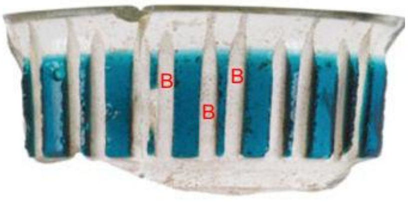
Stage 1: The Grenoble fragments (68), notably the important 'cross band' (right) show a grid plan of the cage mesh marked out as a squared pattern by parallel wheel-cut abrasions into the surface of the blue outer layer of the thick-walled blown glass blank, using a small, flat-faced or rounded stone wheel. For reasons affecting the order in which the sharper cutting stone wheels were used, I am confident that a complete outlining of the entire design of the cup, using similar lightly-abraded lines over the entire surface of the vessel blank was already in place before any deeper cutting took place. These guide lines enable the sequence of the different stone (and

possibly metal) wheels to be followed systematically. The glass blank (below) has been blown to be thick-walled (up to 2 cm), and it is usually necessary to grind both the base to create a flat foot for the lowest ring of the cup, and to ensure that the lip of the vessel is also level, which guarantees that the horizontal bands will be ground parallel to the lip when held against the 'stop'.

The cutting of any glass vessel using stone wheels demands that a supply of water is constantly dripped onto the surface of the object whilst it is brought into contact with a rotating wheel. The water both cools the glass to prevent cracking due to thermal shock, caused by the friction from the rotating stone wheel, and acts as a form of lubricant between stone and glass. If metal wheels are used, oil is used as lubricant, and to carry the abrasive in powdered form, but the evidence from the Benaki fragment strongly suggests the use of stone wheels, certainly at this stage. Modern glass-cutting makes use of waterproof marker pens to draw a carefully calculated grid upon the surface of the vessel blank, but the constant drip of water can easily wash these essential lines away, so lightly abrading the carefully marked-out plan onto the surface as an early step is both logical and necessary. (Photo, right, shows a blank for a reproduction of the Munich cage cup (24), marked out with a lightly stone wheel-abraded grid featuring both the correct number of letters and spaces for this particular inscription, and the location of the all-important 'cross bands' forming squares or rectangles, as seen on the Grenoble 'cross' fragment. These are the only reference points necessary when cutting the cage mesh).

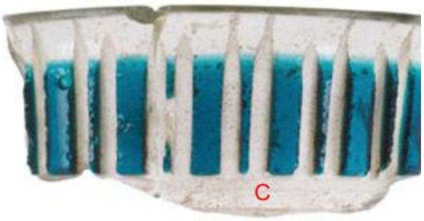


Stage 2: the area of the thick (c.1-1.5cm at this point) blank directly below the lip of the vessel (A) is cut horizontally with a relatively large size of hard stone wheel which has been given a gently curved profile. This wheel has a diameter of 10-12 cm, and a thickness of between 1.5 and 2cm. This cutting creates the downward sweep at the top of what will become the letters of the inscription frieze, and defines the outer surface of the flaring rim of the cup. It also enables the glasscutter to discover the exact depth of the colored outer layer of glass, and allows him to establish how much glass will be safe to excavate at a later stage. The whole flat rim of the beaker is held firmly against a wooden 'stop' plate, and the vessel is rotated away from the glassworker whilst bringing it into contact with the fast-rotating stone wheel, always cooled and lubricated with a supply of water. The use of the stop ensures a consistent smooth horizontal cut, with no wavering of direction in the passes of the larger stone wheel.



Stage 3: the frieze area of the vessel, previously marked out to the correct number of letters and appropriate spacing by abraded lines (see photo above), is cut into vertical stripes (B) using a much thinner stone wheel (c.2-3mm in thickness) which has a sharp 'rounded mitre' profile. This wheel needs to be much smaller in diameter than the first one (no wider than 2cm), allowing its curve to fit at least part of the way into the curving flare of the beaker at the lip. Two vertical cuts are made between

each letter - the wider stripes will be cut into letters, but the ‘unwanted’ thinner ones have an important role to play in the next stages, and are left in place at this stage, and only removed later, shortly before the inscription itself is carved, to allow the smallest wheels used to pass behind the letters.



Stage 4: a second larger sized stone wheel (diameter c.10-12cm), shaped to have a flat profile (c.10-12mm), is used to incise the horizontal band below the inscription (C), creating a flat edge to the letters and interstitial thinner stripes as it cuts deep into the cup, which is once more held and rotated against the stock plate. As can be seen, this removes all evidence of the lower, rounded mitre ends to the vertical cuts created by the thin wheel in stage 3. On the Köln-Braunsfeld cup (22), a straight horizontal line caused by (perhaps deliberate) overuse of the flat edge of this wheel can be seen as a band below to the inscription frieze, but which has the advantage of telling us the thickness of wheel used.

The thinner vertical stripes of glass, that were deliberately left in place in stage 3, prove particularly important - they stabilize the passes of the larger stone wheels as the vessel is turned against them, preventing the wider cutting wheel from wavering off course, both above and below the letters. My early experiments showed that if these thin stripes are removed *before* the wider bands above and below the letters are cut, the larger stone wheels invariably veer off-course where they encounter those areas where wide spaces have now been cleared. This creates both a wavering horizontal line, and cuts rounded edges to the tops and bottoms of the letters, which is both undesirable and, more importantly, never seen on the original vessels. When the thin stripes are left in place at this stage, however, they provide, along with their wider companions, a secure path for the wheel to travel along, guided by their edges, preventing any deviation.

It is very likely that at least some of the vertical piercing into the border at the top of the cage on the lower body of the vessel was also performed before the wide groove between frieze and cage was completed, so that any vertical cutting scars on the outside of the inner cup will be removed by passes of the wider stone wheel.

The next stages would likely have been to return to the first large stone wheel with the round profile (as used in stage 1) and carve away even more deeply below the lip of the vessel whilst rotating against the stock, to remove the upper rounded ends of the deep vertical mitre cuts (B) above the inscription letters. Use of two or more tracks of the round-profiled wheels against the stock at this stage will easily form the narrow horizontal raised rib below the lip seen on most cups,

The fact that this lip-tidying procedure, removing the upper edges of the vertical mitre cuts (B) below the lip and defining the tops of the letters, does not appear to have been attempted on the Benaki fragment, strongly suggests that the vessel broke, or was damaged beyond recovery at, or just before this stage in the process.

The three larger stone wheels that have been used so far are only employed in these early stages, defining the lip, frieze and the area above the cage, and a different selection of smaller diameter and different profile wheels, whether stone or metal, would have been required to execute the different style of fine cutting found on the cage itself. If an ovolo frieze was featured, this too may have been brought to near completion at this stage.

The initial stages of the cutting sequence as recorded on the Benaki fragments, therefore have implications that stretch far beyond the three or more steps after which it was abandoned. They offer important clues towards establishing the discipline which dictates the later sequence for the cutting of the main cage mesh. Informed by what he saw on the Benaki and Grenoble shards, Josef Welzel was able to reconstruct a completely logical sequence for cutting both the inscription frieze, and for the cage mesh in the lower parts of cups and bowls (Welzel 1994).

The Grenoble fragments, marked out into squares with fine surface abrasions, and showing clear evidence for the use of mitred wheels in the areas adjacent to the corners of the squares marked on the fragments (right), provide the final clues to enable us to piece together the sequence for the cage mesh cutting, and forever dismiss any notion of these vessels being created by some hypothetical form of 'moulding' or 'casting'. The illustration below is based upon Welzel's cutting sequence, using four different cutting wheels, enabling the ring meshes seen on most cups and bowls to be defined first, then further excavated to the final depth of the inner cup, before finally joining up the cuts beneath the meshes. A simple wooden calliper device, enabling one to continually check the thickness of the inner cup is all that is necessary to ensure that the correct amount of glass is removed over the entire body, creating a consistent thickness of 1-2 mm.

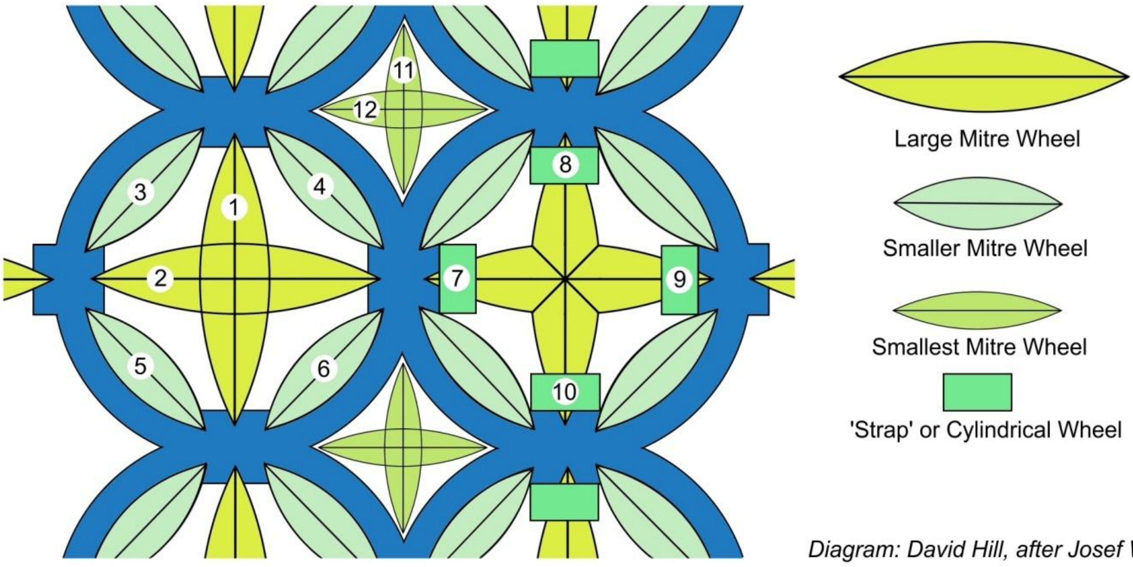


Diagram: David Hill, after Josef Welzel

Later work employing the smallest (and even smaller) mitre wheels to tidy the debris between cage and cup, as well as defining the thickness of the inner cup, also carefully sculpts the narrow posts that support the cage, which are usually carved to a square section, reflecting the four angles that they are approached from by the wheels.

This reconstructed method, and our modern experiments, lead one to conclude that Late Roman glass-cutters must have had at their disposal, a sophisticated machine that featured something like:

- a circular motion driven shaft (as opposed to a reciprocating shaft, as found on crude bow-drills), powered by pedal, 'great wheel' or some other power source. It is possible that several types of machine were employed in the same workshop – one holding larger stone wheels, and others for the finer wheels for the more delicate work.
- shafts holding the wheels that were engineered to be remarkably 'true', i.e. displaying no lateral movement or vibration whatsoever.
- a location system whereby many different interchangeable wheels (or wheels secured to interchangeable shafts), large and small, whether metal or stone, could be fitted easily and reliably, and could be trimmed to be both true and perfectly circular.

That such a machine was the equal of our modern equivalent, the glass cutting lathe, is remarkable. The single most important factor of those outlined above is the 'trueness' of the rotating drive shaft. No lateral movement can be tolerated when cutting beneath the often perilously fine and fragile cages, particularly in the 'excavation' behind and between posts and inscription letters. Any deviation from perfect rotation as a result of their not being trued to absolute symmetry is guaranteed to spell disaster when used.

It is unlikely that the number of glasscutters capable of this advanced form of diatretus work on glass was large. Close similarities of design and style between the different groups of cage cups suggest that there may have been only a handful of such skilled specialist workers together with their machines at most. Their products would therefore have been all the more exclusive and appropriately expensive, and therefore desirable to the wealthiest of Roman society.