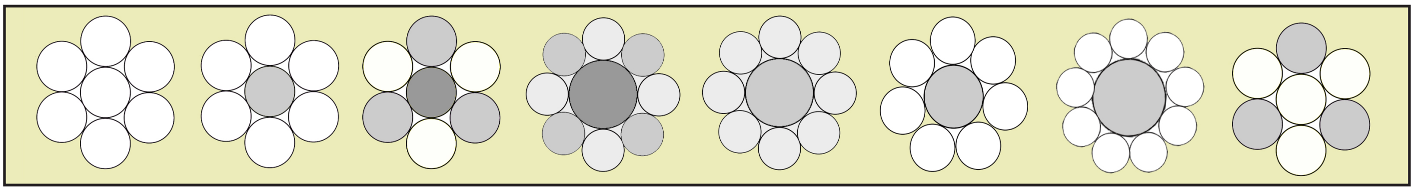
MILLEFIORI CANE DESIGN
by Alan Thornton



Millefiori canes: a building block for many of the paperweights that you see, and available in countless different designs. The image above may look like a random selection of just a few of the patterns that are possible for complex millefiori canes - however, 95% or more of the complex canes in paperweights are based on these few patterns, and the left hand four cover the majority. Why should that be, when there are so many to choose from?

I started to write this article a couple of years ago as a brief commentary upon some statements in earlier books and articles with which I disagreed. These concerned the origins of millefiori 'patterns', and suggestions that someone in Bohemia or Venice - perhaps Domenico Bussolin - had invented patterns which later makers reproduced. It would be absurd to credit anyone in the early 19th Century with the idea of creating millefiori canes *per se*, as canes have been around for thousands of years. But maybe the implication was that later makers lacked originality, and just copied the complex patterns into which individual canes were arranged.

Thinking about this, I felt that the role of the human designer (the 'art' element) was somewhat over-emphasised, and that the constraints of the laws of nature had been ignored. And as I thought more about what I wanted to say, I realised that this would need a more fundamental, more comprehensive - and longer article (or series of articles). I hope that does not mean it has turned out to be dull; and I hope that the comments which seem blindingly obvious to one person will be a fresh insight to another!

The canes in paperweights are usually described as 'millefiori' canes - regardless of whether that is strictly correct. And they are called things like simple, or compound, or complex, or detailed, or complicated, or rods, or cog canes, usually without any clear definition of what is meant. So I want to begin with a few definitions of what I (and I think many others) mean by certain words, particularly 'simple' and 'complex' when used to describe millefiori canes.

A <u>*simple*</u> millefiori cane is one that is made in a series of operations using hot glass that remains hot until the cane is drawn. It may be a complicated design, with various coloured and clear layers; it may have been pressed into a mould to give it a particular shape (perhaps more than once); but the glass will have been hot throughout, and the design will be concentric. Some typical examples of simple millefiori canes are shown in Figure 1.

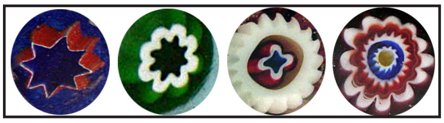


Figure 1. Some simple canes

A <u>*complex*</u> millefiori cane is made by taking a number of simple millefiori canes, bundling these together, re-heating them, and then using these as the basis for further moulding or addition of more layers of glass. It might be better to call these 'compound' canes, but 'complex' is the accepted term amongst collectors. The key difference from simple canes is that some elements of it will have been heated and cooled more than once. Some typical examples of complex millefiori canes are shown in Figure 2.

Figure 2. Some complex canes

Many complex canes comprise just one ring around a centre cane, but there are plenty of examples of canes with two or more surrounding rings like those in Figure 3.

Figure 3. Multi-ring complex canes

Why make the distinction between simple and complex? For a start, because significantly more time and effort is required to make a complex cane, and it will be more expensive. The bundled rods have to be worked carefully to make sure that all the air between the canes is expelled before further glass is added. Many manufacturers have therefore avoided complex canes, which means it is a useful distinction to be able to make when describing the typical features of a maker's canes.

Another point to clarify is what I mean by 'pattern' and by 'design'. The simplest explanation is that patterns can be shown in black and white, whereas designs need colour. There can be various designs using the same pattern. Figure 4 shows two different designs based on the same pattern.

There is clearly considerable scope for design when making a paperweight from millefiori canes: even the basic form can be close concentric, spaced concentric, closepacked, garlands, rondellos, or many other shapes, before thinking about the different colours and shapes of canes to use. There is less choice about a simple millefiori cane, but the glass maker can use various colours and moulds to give variety. A glass maker can also work the glass into various shapes before drawing, to produce arrow canes, or even complicated designs like the '7/6' canes of some Old English paperweights. But although complicated in design, they are not 'complex' canes, as they are only heated once, and there is no re-bundling.

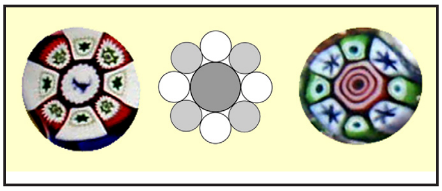


Figure 4. Two different designs based on the same pattern

Simple millefiori canes are cylinders - being circular (or nearly circular) in cross section when they are first drawn. To make a complex cane, the simple cane is usually drawn to a larger diameter than one intended for use straightaway. It might seem that there is a lot of scope for 'design' when a number of simple canes are bundled together - which there is, up to a point. But what cannot be avoided are fundamental laws of nature.

If you take a handful of the same sized cylindrical objects and press them together, there is no choice about the shape they make: you can try it yourself with some AA batteries, or pencils. Figure 5 shows a group of AA batteries: around the central one are neatly and exactly stacked 6 others - not 5, or 7, or some other number.

Figure 5. Tightly packed 1+6 arrangement

Moreover, this would be true if an alien on a distant planet tried to make a complex millefiori cane from the *same sized* circular elements: there would be one central element and 6 around it. This is not 'design' by the glass worker - it is destiny: it is fixed in the universal laws of mathematics. How to calculate the relative cane sizes for a perfect fit of any number is shown in a panel at the end of this article.

Another row of same sized canes outside the six will add another 6, making 12 canes, and another row a further 6 making 18. Figure 6 shows a Chinese bottle stopper with the 1-6-12-18

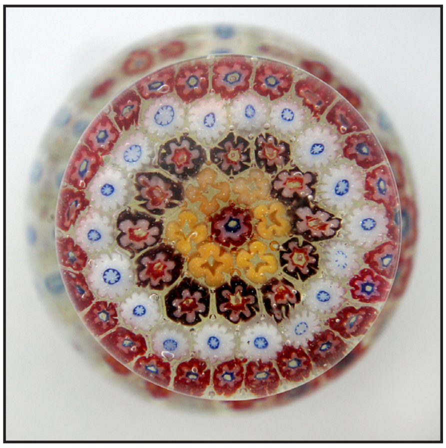


Figure 6. Canes packed into a 1+6+12+18 pattern

arrangement.
But what if the elements are not the same size? Suppose the central cane is bigger? The result is that more canes will be needed - but how many depends upon the difference in sizes, and is complicated because canes come in whole numbers. You cannot easily use 1/3 of a cane, for example, even if that may be what is needed to make a tight fit. Using our trusty batteries, but this time putting a larger AA size in the middle, one can fit seven of the smaller AAA batteries around it without any big gaps (Figure 7).

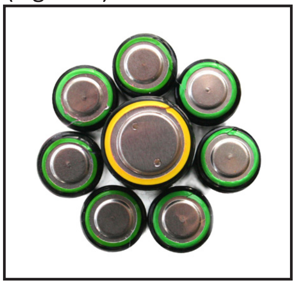


Figure 7. Larger central element with 7 smaller ones around it

Complex millefiori canes can be found with various numbers of outer elements around larger central canes. Figure 8 shows examples of 1+6 and 1+7 from antique Baccarat paperweights, alongside the 'battery' versions.

Figure 8. Theoretical patterns and real cane designs

There is, however, one significant difference in the way that batteries and glass canes behave: when the canes are heated the glass softens, and the shapes distort, allowing the canes to pack together a little more tightly. (There is more about cane distortion at the end of this article.)

The matter of needing whole numbers of canes to get a good 'fit' is a recurrent problem for makers. If you do not have a tight fit, then there is a significant risk of the set-up slipping during pick up and consolidation, so that one or more of the nice, neat concentric rings are distorted. The fewer canes in a ring, the more scope for problems, so designs using large canes are more vulnerable. This shows in some Bacchus paperweights with canes that have slipped inwards or outwards, distorting the pattern. I do not buy the 'they were trying to make a heart shape' argument!

One way to ensure a tight, stable set-up is to put in a cane that fits the final gap in a concentric ring - and that will often mean using a different design of cane. Some readers will have read about the 'rogue canes' in Bacchus (and other) paperweights. It has been claimed that these were put there as some form of hidden signature - but in my opinion that is nonsense: Bacchus were merely trying to stop the problem of slippage that plagued some of their designs.

So what scope does the maker have when designing the patterns of complex millefiori canes? First, there is the choice of the individual rods - which may be solid colour, millefiori, or even complex canes themselves. Then there is the question of how they are arranged in the pattern.

Perhaps the simplest pattern is made by using identical elements throughout - if these elements are six point cogs, we get the 'stardust' cane favoured by many makers. Next is a cane with a different centre element. Then come canes with two or more elements surrounding the centre, often arranged symmetrically: that though is not just human nature preferring symmetry - there is a good business reason.

When a section of cane is chopped off the end of a rod, the two ends are mirror images of each other, and so the cane needs to be put round the correct way in the set-up...unless the pattern has mirror symmetry, in which case both ends look the same. So a symmetrical cane pattern means that there is no need to spend time getting the correct end!

A common example of an asymetric cane is a 'whorl', where one end appears to spiral clockwise, the other end anticlockwise (it is this effect extended to 3 dimensions that allows us to distinguish torsades and filigree canes from Baccarat and Saint-Louis: whichever end or side you view them from, they twist in different directions.). It is uncommon to see a whorl cane included in a millefiori design, perhaps for this reason.

Another aspect of symmetry that comes into play is rotational symmetry: can you turn the cane part of the way round, and get the same pattern? If so, it has some degree of rotational symmetry. A 1+6 stardust cane rotated by one sixth of a turn looks the same - so it has 6-fold rotational symmetry. Why does rotational symmetry matter? Because a cane with no rotational symmetry may need to be pointed in the right direction, which takes time when making the setup.

The laws of nature constrain the maker if he wants to produce canes with mirror and / or rotational symmetry. With two different individual canes there are only 9 possible patterns for a 1+6 complex cane (Figure 9) - although the two colours can be switched round to get twice as many cane designs.

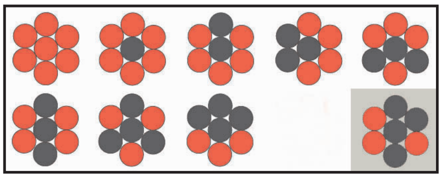


Figure 9. The possible patterns for a 1+6 cane using two colours

Only eight of these have mirror symmetry (the bottom right pattern does not), and of these eight only four have rotational symmetry (the left hand four). You probably do not need to guess which four patterns are used for nearly all 1+6 millefiori canes!

It is quite common to find a different centre cane for these patterns. This is not surprising, as the symmetry is not changed. This leads to the patterns on the bottom row of Figure 10. These are not the only ones used for 1+6 canes, but they probably account for 95% or more.

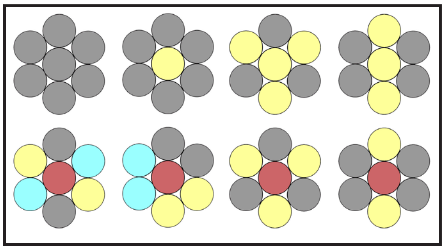


Figure 10. The most common 1+6 cane patterns

The 1+6 arrangement comes about naturally if one uses the same sized centre and outer canes, but there is no need to do this. A smaller centre cane might mean a 1+5 pattern, whereas a larger centre cane will mean more elements around the outside, giving 1+7, 1+8, 1+9 and so on. However, not all of these will offer the same scope for mirror and rotational symmetry. You cannot put two alternating colours around a 1+5 or 1+7 design (or any odd number, for that matter), so it is usual for all the outer canes to be the same in these. 1+8 offers scope for alternating colours, or for four groups of two around the edge. 1+9 can offer rotational symmetry if all the 9 canes are the same, but also if there are three sets of 3 different colours. If you search your millefiori paperweights for two row complex canes, you will find these patterns - and few others. The most common are the ones shown at the start of this article.

A slight variation on this process of making a cane would be to lay the outer ring of canes not around a central cylinder, but around a star shape, so that they fit in between the points of the star. This is shown in Figure 11 as a pattern with small cog canes around an 8 pointed star, and in an antique Baccarat cane where the process has been repeated twice in making the cane - first with blue/white canes, then with white/red trefoils.

So to what extent does a maker 'design' a complex millefiori cane? In the choice of individual elements, and the choice of the few basic patterns, certainly.

Let us pretend that we are a glassmaker in the first part of the

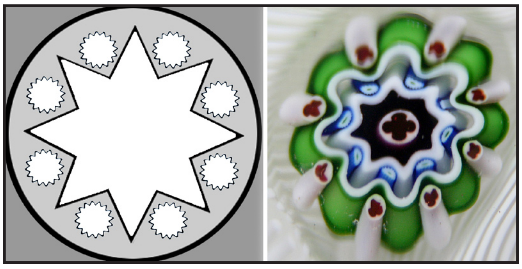


Figure 11. Star and small rods cane pattern, and a real Baccarat cane

19th Century, and that we want to make millefiori canes for the first time. We would have available various coloured rods and frits, and maybe molten glass of various colours as well as clear, but maybe no more than a couple of moulds to make shapes because these cost money. So we might have a six or eight pointed star mould, and a cog mould with 12 or 16 points. We would probably have worked out how to make 'petal' canes (arrow canes) in order to produce simple flower canes. Starting from these few items, what sort of simple canes could we make? The answer is a huge number, but the pressures of time would keep us focussed on the less complicated designs.

Next, if we are going to make complex canes from these simple canes, what patterns and designs might we have produced? Once we recognised the benefits of mirror and rotational symmetry (perhaps not in such an explicit manner!), then we would have found that there were only few patterns available to us, though our range of simple canes would permit many designs.

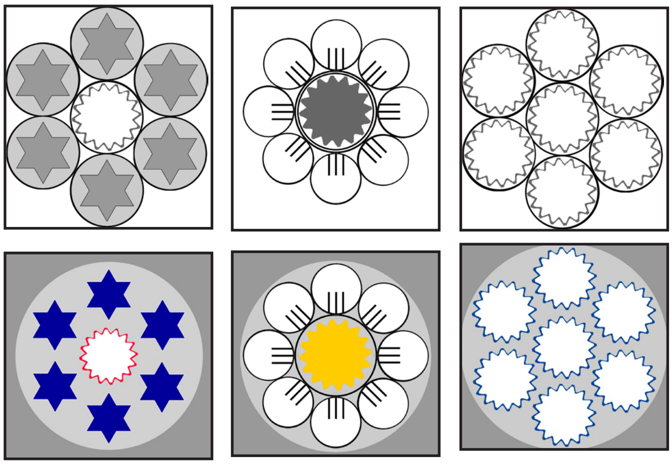


Figure 12. Cane patterns made using a few simple elements: a cog cane, a star cane, a petal cane and a rod

If we make some slightly more complicated (but still simple) canes, with several layers of different colours pressed into different moulds, then we can make complex canes that look quite detailed, such as the ones in Figure 13.

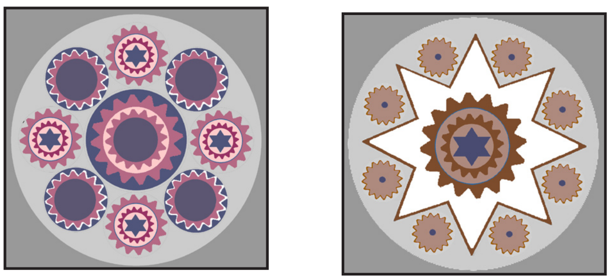


Figure 13. Two possible canes designs based on simple patterns from Figures 11 and 12

What we have 'designed' in Figure 13 turn out to be very similar to some of those patterns used by Bussolin - not by copying him, but as a result of having similar constraints. That is not to take anything away from the work that he put in to reviving the art of making millefiori canes, but it does emphasise that he had relatively limited choice when it came to making practical patterns for complex canes - and that would apply to any other glass maker, whether in Roman times, in the 19th century, or the present day. Consequently, finding 'Bussolin' style canes in early Bohemian paperweights in not surprising, and does not necessarily mean that they are Bussolin canes: to be confident you need to be able to match them more closely than in pattern alone.

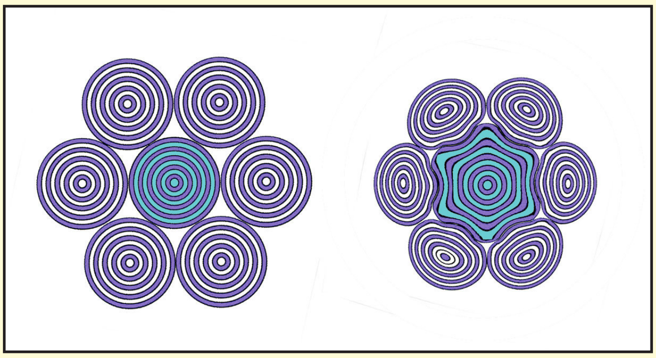
In the next issue I will be looking at what we can deduce about attributions from the precise shapes of the individual elements such as star and cog canes, and discussing how the quality of the millefiori canes gives an insight into the early stages of paperweight production at Baccarat.

Alan Thornton

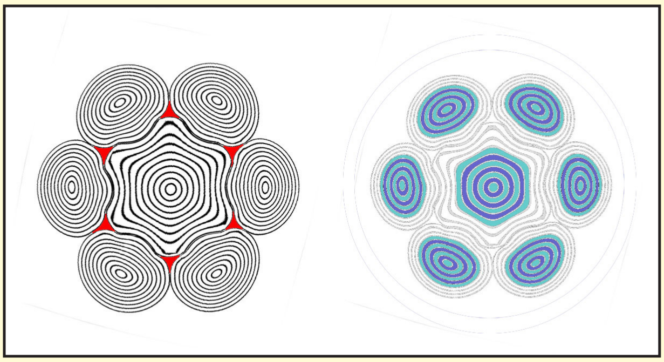
Cane distortion

When a group of circular canes are packed together - either to make a complex cane, or to make the set-up of a paperweight - there will be gaps between them. It is important to close these gaps during the manufacturing process, otherwise they will trap air, which will result in bubbles on top of the canes after encapsulation. The gaps are closed by heating the canes to get them soft, and then compressing them by rolling on a marver or by a flat tool.

The process of squashing the canes together distorts them, with the outside undergoing greater change. There is therefore a great advantage when making complex canes in covering them with a layer of clear glass, because the distortion in this is not visible. The two images below show what happens in theory with a 1+6 arrangement. When the canes shown on the left are squashed together, the central cane becomes a more hexagonal shape, whereas the outer canes become more oval.



The next two images show the remaining channels that can trap air (on the left, in red), and the way that visible distortion is reduced by adding a layer of clear glass around the coloured elements. What this suggests is that a complex cane will show less distortion in the finished paperweight if it has a good layer of clear glass around the elements of the cane and the finished cane itself.



Furthermore, the distortion will be less obvious if the outer canes have an irregular edge (such as is found in a cog or star cane). These are common features of many millefiori canes, particularly in older paperweights. If a large number of similar sized circular canes are packed together in the set-up of a paperweight, then they will form a hexagonal array when they are squeezed together during manufacture. The image below is a close-up of a Murano paperweight, showing how the canes have formed a hexagonal array, and that the clear glass around each cane forms a just visible hexagon. It also appears that the air channels were not completely closed, as there is a tiny bubble at each of the points where three canes meet, as predicted.

If a complex cane has eight elements set around the centre, then the outside of that middle element will be distorted into an octagonal shape, and the outer elements into a shape rather similar to the keystone of an arch. The Baccarat cane shown below demonstrates this quite clearly: although it has a six pointed star at the centre, the white matrix of that cane now has an octagonal shape.

Cane packing The size and number of small canes that fit perfectly around a larger central one can be calculated using mathematics that was taught at age 16 when I was at school - so it is no doubt first year university level now. The ratio (R) of the diameter of the smaller outer canes to the diameter of the larger inner cane, when 'n' small canes pack perfectly around the centre one, is given by R=sin(Pi/n)/(1-sin(Pi/n)).