

THE ORIGIN OF GLASS BLOWING.

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A critical study of antique beads, begun some years ago, soon convinced me that the chronology and technique of glass beads were intimately connected with those of glass vessels. This led to a comparative study of these two groups of products of the glass-maker's art and a consideration of the various theories about the place, date, and manner of the origin of glass-blowing. Some of the results of these investigations will be set forth in this paper in a summary way, a more detailed discussion being in preparation.

The well known paintings found in Egyptian tombs of the VI and XII Dynasties, which have been interpreted as representing glass-blowing, led to the opinion, for a long time accepted as conclusive, that the art of blowing glass vessels from a glass bubble was known to the Egyptians in very remote times. Of late years, however, doubt has been thrown upon the correctness of this theory, principally by Flinders Petrie, for the following reasons:

(a) No glass of any kind has been found in Egyptian tombs of the VI or XII Dynasties. The very earliest dated specimen is a glass bead with the name of Queen Hatshepset, and this is properly assigned to her reign in the XVIII Dynasty. Glass beads are absent in the XII Dynasty, but exceedingly numerous in the XVIII Dynasty, the earliest types being imitations of similar types made of paste.

(b) No vessels of blown glass have been found in Egyptian tombs or excavations earlier than the Ptolemaic period, although innumerable specimens and fragments of glass vessels have been found which belong to the long period of over one thousand years between Thothmes III and the Ptolemies.

(c) All these glass flasks, bottles, and vases we now know to have been either moulded or formed by hand over a core of soft paste or clay, the core afterwards being scraped out. This discovery we owe to Flinders Petrie, and it can be confirmed by the

examination of the glass fragments excavated by the expedition of the Metropolitan Museum in the Palace of Amenhotep III at Thebes.

(d) The earliest vessels of blown glass date from the time of the Ptolemies. They consist of small flasks with short necks. The earliest I have seen was found with a Greek vase of the third century B.C.

These facts seem to me conclusive, and we are forced to doubt either the interpretation of the Egyptian wall paintings or their chronology, as it is absolutely inconceivable that no specimens of blown glass, or fragments of such vessels, should have come down to us had they actually been made. Nor is it likely that the Egyptians should have continued to make glass vessels in the old way after they had discovered the art of making them in a new, simpler and cheaper way. And this is proved, because after the appearance of the earliest flasks of blown glass, the old technique was abandoned, a technical revolution in fact being the result of the new discovery of blowing glass. So far as I know, no glass vessel made in the old way over a core has been found to be of a later date than the reign of Augustus.

An examination of the blown glass flasks of the Ptolemaic period revealed the interesting circumstance that they were nearly all made of two types of mosaic glass and not of monochrome glass ornamented afterwards. This fact seemed to me of great importance, because it is easily understood that mosaic glass cannot be blown from a fused glass bubble, as the melting of glass would have so diffused the pattern as to make it unrecognizable. The earliest blown flasks must have been produced in some other way. But before we enter upon that point it will be necessary to define the two kinds of mosaic glass used in the manufacture of the flasks.

*Dragged Mosaic Glass.*—This is one of the oldest types of mosaic glass, the type from which nearly all the flasks and vases of the XVIII Dynasty glass is made as well as most other ornamented glass vessels before the Ptolemaic time. Some of this glass possesses a fern and feather pattern and is almost too well known to need a lengthy description. I will state, however, that the technique used in producing the pattern was as follows:—The flask was made of monochrome glass, but before it had time to cool a spiral band of glass or glass thread was wound about the flask from neck to base. Before this band had time to solidify

99

it was combed or raked at intervals in one or two directions with a hook or point of metal. This raking carried the bands or threads in different directions, changing them into streamers or leaves, often carrying the topmost ones down to the bottom of the pattern in such a manner that one end of the streamer remained attached at the top while the loosened end diverged downwards, or vice versa. The pattern was finished by pressing it into the matrix of the bottle by rolling, and the finer specimens were afterwards, when cool, ground off and polished. The effect was a closed leaf and feather pattern similar in appearance to the finest mosaic glass made in any other way.

Of this kind of glass we can separate several varieties for which I propose distinct names.

1. *Arcades*.—The strokes separating or bending the bands are parallel to each other, beginning above and carried downwards. The result is a horizontal line of arches in upright position. If the strokes had been sufficiently heavy the arches are separated from each other, but if the strokes did not penetrate sufficiently deep, the arches connect horizontally.

2. *Festoons*, also called inverted arches.—The technique is the same as in the last variety, but the strokes pass from the lower part of the bottle towards the neck. The result is a number of more or less horizontally connected inverted arches or festoons, having the appearance of a row of hanging garlands, such as have been used since antiquity for the decoration of flat surfaces or in connection with cupids, the graces and dancers.

3. *Foliate*.—Fern and leaf pattern, plumate glass. The technique differs only in the direction of the strokes, which alternate from top to bottom and from bottom to top. The resulting ornamentation is a series of horizontally corresponding leaves which sometimes connect in a horizontal line, but sometimes stand diagonally in such a manner that one end of an individual leaf ends near the top of the glass vessel while the other end is near its base.

4. *Semifoliate*.—The band spiral was first divided by downward strokes from top to bottom. Afterwards intermediate strokes were made from bottom upwards, one in each arcade. But instead of cutting through all the arcades the stroke was halted halfway up, leaving the upper arcades intact, the lower ones having been broken up into leaves.

5. *Waves*.—The band spiral was first rolled into the matrix

and then made wavy by light up and down strokes. The crests and valleys remain rounded and the wave bands are more or less separated.

6. *Zigzags.* The band spiral was wound close, so that the tiers touch, and then rolled into the matrix. It was afterwards zig-zagged by strong and deep strokes which caused both crests and valleys to be angular as in ordinary zig-zag patterns. The close winding of the band and the previous rolling in prevented irregularity in the design, and the impossibility of the formation of leaves with long, tapering points.

*Beads Made of Dragged Mosaic Glass.*—Beads made of this kind of glass are common in the XIX-XX Dynasties, and some were found in the Palace of Amenhotep III of the XVIII Dynasty. The variety continued to be made, the shape of the beads varying in different periods like the details of the technique and the colors of the glass. In the eighth and seventh centuries B.C. the favorite form is a cylinder. In the fourth and third centuries B.C. the spherical form is predominant. In the sixth century A.D. the cylinders come once more into fashion, but spherical beads are found in about the same quantity.

*Earliest Blown Flasks of Dragged Mosaic Glass.*—As has already been stated, all the old Egyptian flasks with dragged ornamentations were moulded or core-dipped, and this practice continued in use until the Ptolemaic period. About the third or second century B.C. we begin to find blown flasks with this ornamentation. All these earliest flasks are small, three or four inches high, and with a more or less globular or egg-shaped body. They possess the characteristic that the festoons are indistinct, irregular, and more or less confluent on the body, while they are better defined as we approach the neck. It seems thus evident that these vessels were not given their pattern after they had been shaped, but before the body had been blown. If these flasks had been ornamented in the same manner as the old Egyptian flasks or as all dragged flasks down to that date, it would be difficult to explain the sudden degeneration of the pattern at a time when the glass technique had suddenly emerged from a degenerate period into a perfect one, remarkable for the invention of columnar mosaic glass and for the perfection of several other types. But before we discuss this subject we will consider another type of mosaic glass.

*Stratified Mosaic Glass.*—This glass appears after the fifth

century B.C., the earliest specimen having been found with a Greek vase of the third century B.C. After that time the specimens made of this glass multiply rapidly and characterize the second half of the Ptolemaic period, continuing to be made several centuries afterwards.

This glass is made up of numerous parallel layers of glass of different colors which penetrate from surface to surface, like the units in a pack of playing cards. The layers vary in thickness, the opaque white being used to separate other colors from each other, the white sheets being generally much narrower than the colored ones, sometimes looking like hair lines, while the others are often a centimetre thick. The object of the white sheets was to reflect the colors of the other sheets from the depth of the glass matrix.

The technique consisted in annealing strips of different colored glass by fusion, a technique that could not have offered any great difficulties, and the type seems to have been quickly perfected. In the bottle found with the Greek vase, we find the strips to be violet, white, gold glass, cobalt blue, and emerald green. The gold glass was made by enclosing thin sheets of gold leaf between two sheets of transparent glass and then fusing and rolling them flat.

*Beads Made of Stratified Mosaic Glass.*—These do not appear until after the fifth century B.C. and, so far as I know, the same chronology applies to the beads as to the crude glass and to the flasks. We can distinguish three distinct types of these beads, which it is of importance to define.

1. The bead is made of a sheet of stratified mosaic glass which has been rolled up on itself, in such a manner that the strips and stripes have remained more or less parallel. A seam can often be seen where the margins of the sheet meet. In this variety the junction layers do not form any figures or fields, but if the end stripe is of the same color at each end, the meeting of the two will of course form a thicker stripe.

2. The stripes run in various directions so that the place of junction of the two margins of the glass, the sheet having been rolled up on itself, form a pattern. The simplest pattern consists of a large, egg-shaped, central field around which the other stripes follow concentrically. The technique in its simplest form consisted in bending a stratified and striped bar of such mosaic glass from the centre of its long axis, just as we fold up a necktie, the

centre forming an end-loop, and the two ends, now joined, forming the other extremity. Or if two bars are had with the same succession of colors, but with the stripes running diagonally, in one from left to right and in the other from right to left, the junction might be made to present a central diamond-shaped field, around which the other stripes are arranged in succession. The same effect could also be produced if the original glass was made up of sheets of glass meeting to form a zig-zag or field-and-band pattern.

3. The third type does not show any junction of two margins of a sheet and was made by simply perforating a bar of stratified glass with longitudinal or zig-zag stripes, or by packing zig-zag layered glass around a longitudinal axis.

*Earliest Blown Flasks of Stratified Mosaic Glass.*—The earliest blown flasks occur in the Ptolemaic period about the same time as the earliest blown flasks of the plumate glass. They show the peculiarity that the strips of the matrix are much thinner in the neck, running parallel from the bottom to the top of the neck, and sometimes continuously from the top of the neck to the bottom of the flask. In other flasks we see the stripes meet on the body of the flask, then turn in a loop and pass upwards through the whole length of the neck. In some flasks we have the stripes parallel in the neck, but at the junction of the neck and the body they abruptly spread out and grow in depth while widening laterally. Using these characteristics we can distinguish three types which it is of importance to define.

(a) The stripes are more or less parallel from neck to base, and the bowl or body of the flask is without field, loops and curves. Junction lines are present.

(b) The stripes are parallel in the neck and spread abruptly over the body, forming either a loop or arch on the body or continuing to the bottom of the flask. Junction lines are visible between the patterns.

(c) The body shows no junction lines between the parts of the pattern, which is more or less unsymmetrical.

*Earliest Technique of Glass Blowing.*—It is of course apparent to any one that mosaic glass does not lend itself readily to be blown from a bubble, as this would so distort the ornamentation as to make the pattern useless and perhaps even disagreeable to the eye. In most instances we should find that the original pattern of the mosaic glass had been completely lost, and in the

most favorable cases it would have been much disturbed. How then were these flasks produced? In my opinion by blowing out a bead or a tube intended for a bead, after the farther end of the tube had been closed. The technique differed in some types and shapes, but the principle was the same. First a tube of mosaic glass was made, either by piercing a hole through a solid bar of mosaic glass, or by folding a sheet of mosaic glass so as to form a tube, or by fusing several strips of mosaic glass longitudinally after first having doubled each unit on itself. The following are the principal technical types:

*Dragged Glass.*—A tube was made of a plain glass matrix and ornamented with a succession of rows or rather spirals of arches, festoons, or foliations, from one end of the tube to the other, according to the taste of the artisan. Next the distant end of the tube was closed, then the tube was heated to the point of proper liquefaction. The next step was to blow in the distant cool end of the tube with or without a mouth piece. The result would be that the pattern would remain more perfect and regular on the neck of the flask, but would spread out, and the individual stripes would widen out and become more irregular as the bowl or body widened. Where the tube had been closed a thick lump would probably remain, at least in a primitive attempt. Such is actually the case, for a small flask in the possession of Kouchakji Frères shows an exceptionally thick square lump at the bottom of the flask, while the bowl of the flask is exceptionally thin.

*Stratified Mosaic Glass.*—The flasks have a striking similarity to beads made of the same type of glass, and it seems probable that the flasks resulted from the effort of the artisan to produce flasks from the same material from which his beads were made, because I think the beads came first, the flasks later.

*Simplest Form, Longitudinally Striped.*—The artisan made a tube of striped mosaic glass by rolling up a sheet so that the stripes would all remain longitudinally parallel. The tube was closed and the blower blew into the distant end. The result would be a flask with longitudinal, more or less parallel stripes, wider on the bowl, narrower on the neck. In closing the distant end of the tube the stripes or strata were often twisted spirally, thus adding beauty to the pattern.

Such flasks are in many collections, the finest example being figured in colors by Anton Kisa in his work on glass (*Das Glas im Altertume*, pl. II, fig. 3), well known as the principal work on

antique glass. In this beautiful flask we see the colored bands proceed from top to bottom in a slight spiral, but in a general way perpendicular to the base. It has a remarkable similarity to many beads of that period which seems to have extended into the first century A.D.

*The Stripes Form Loops on the Bowl.*—The technique in this pattern is more complicated and it is necessary to give a detailed description of a typical example of such a flask. The finest specimen I have seen is in the private collection of Kouchakji Frères, who have permitted me to study it at my leisure. The flask is  $4\frac{1}{2}$  inches high and 11 inches in circumference, the bowl being more or less turbinate on account of the projecting girdle region. The neck is short and narrow. The matrix is deep blue with fine stripes of white which form a horizontal set of six wide loops in the girdle region, the ends of the stripes that run upwards being parallel in the neck. Below the girdle region we see a festoon pattern of five or more vertical rows of white festoons, which also correspond to the five loops above, the upper ends of the festoons penetrating into the angles formed by the loops, and between the five upper loops. An examination with a magnifier shows that the matrix is made up of a series of alternating strata, perpendicular to the surface of the bowl. The white strata are like hair lines, the blue much wider. There are five white and five blue strata in each loop, all standing on end and appearing to vanish down in the matrix of the glass in the manner seen in many types of stratified and columnar mosaic glass in which the minor units are opaque and the matrix, or grosser units, translucent. The festoons show the same characteristic, and when we observe the base or bottom we see that there is a twist of four such strata in the navel. The technique is absolutely faultless, and was as follows:—

Five long strips of stratified glass were made, each strip being twice as long as the loops, each consisting of five layers of thin, white, opaque glass and five layers of thicker, blue glass. These strips were doubled lengthwise, forming five separate loops, like pears with long slender necks. These loops were placed in a horizontal row, fused side to side and then rolled into a tube, which naturally was wider in the loop end than in the end of the parallel stripes. In order to cause the loops to appear on the bowl above the girdle region, the tube had to be lengthened towards the base. And this was done by first making a long



strip of stratified glass of two white and two blue layers, retaining the same proportions of thickness as in the loops. This strip was twisted spirally into a tube of the same thickness as the loop tube and the two tubes were fused together so as to form a longer tube. The lower twisted end was closed in twisting, as the pattern shows distinctly. We had now a single long tube in which the future pattern was in a compressed state and all that was needed to bring it out as we see it on the bowl was to blow in the open free end of the tube while the rest of the tube was brought to fusion. Finally the lower part was surface dragged.

Another yet more complicated pattern is seen in the Evan Gorga collection in Rome. This bowl-flask is of stratified glass in white and violet layers. It has four loops on the girdle, but possesses the characteristic that the central field in each loop consists of *plumate mosaic glass* of alternating leaves of white and yellow, they being so arranged that they could not possibly have been produced on the bowl *after this had been blown out*. In fact the plumate mosaic fields consist of fragments of *already made* plumate glass evidently taken from another broken bowl and fitted in when the four loops were rolled into a tube, the white leaves ending sharply and abruptly against the innermost band in the loop.

These two types being the most complicated and thus most difficult to explain satisfactorily, all others may now, in order not to lengthen this article too much, be deferred to a future time, and it remains only to summarize the conclusions based upon the arguments set forth above.

In regard to the actual blowing of these earliest blown flasks, we can assume three different methods.

The cylinder of glass was blown into directly without a mouth piece, or a metal tube was used. If this metal tube was inserted deeply in the cylinder, the neck of the bowl would correspond to the length of the tube and the bowl would spread out abruptly, as, for instance, in the Perugia flask or in that of the Metropolitan Museum. Both are rarer than the next form. If no metal pipe was used, or if it was not deeply set in the glass tube, the glass bowl would widen out gradually and carry the pattern along. Such flasks are very common in collections.

In regard to flasks which show no meeting seams between the loops and which were made from a solid bar of mosaic glass, the technique was more or less the same. These flasks are generally

much thicker than the others, but their capacity is small. Some seem to have been bored out while fusing and only slightly enlarged by blowing.

If the correctness of my investigations set forth in a superficial manner in this paper is sustained, we may conclude that:

1. There are two distinct types of glass-blowing, one from a tube of glass; one from a bubble of melted glass. The tube-blowing is the earliest, invented in the Ptolemaic period.

2. The earliest blown vessels are made of mosaic glass which could not be blown from a bubble, and the only way to explain their nature is to assume that they have been blown from tubes.

3. The discovery of glass-blowing was the result of the effort of the artisan to make flasks out of the same kinds of mosaic glass from which he made his beads. The various steps leading to glass-blowing from a bubble would be about as follows:—Mosaic glass; mosaic glass beads; cylinder made of mosaic glass; closing the cylinder at one end and blowing in the other; using a metal tube as mouth piece; taking a film of fused glass on the end of the pipe and producing a bubble.

4. No blown glass vessels existed before the Ptolemies. During this period the four great events in the glass industry were the discovery of columnar mosaic glass; the dipped and cut-off rod; the blowing of glass first from a cylinder and later from a bubble by means of a metal tube or pipe.

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