A TRYAL OF GLASSE

The Story of Glassmaking at Jamestown

A Treatise on the Manner in which the *Virginia Colonists* built their Glass Furnaces and fashioned Objects of Glass; with a brief Description of the Ruins of the *Jamestown* Glass Factory, erected in the Year 1608 during the Presidency of Captain *John Smith*.

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A TRYAL OF GLASSE

The Story of Glassmaking at Jamestown

BY

J. C. HARRINGTON

THE DIETZ PRESS
RICHMOND, VIRGINIA

I followed the new begun workes of Pitch and Tarre, Glasse, Sope-ashes, and Clapboord; whereof some small quantities we have sent you.

Letter from Captain John Smith to "Treasurer and Councell of Virginia."

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River, possibly from very near the same source as those used in the original furnaces.*

Some compromises had to be made in building and operating the working model. For one thing, it was not practical — and certainly not safe—to use wood fuel in the furnaces. Superficially, however, each of these structures looks just as it must have looked in 1608. Possibly the most conspicuous departure from the 1608 picture is in the product being produced. In order to continue the operation after the 350th anniversary period, it was necessary to sell the product. Although every article sold at the glasshouse today is made there, it did not seem practical to make the kinds of objects probably turned out in 1608. And, of course, the sales counter is a necessary anachronism, as well as the temporary winter enclosure. But, on the whole, what one sees today is very much what a Jamestown settler would have seen had he gone over to Glass House Point from James Fort in 1608.

The glasshouse is now being operated by Eastern National in cooperation with Colonial National Historical Park, on a strictly nonprofit basis. This working exhibit, seen in conjunction with a visit to Jamestown Island and Jamestown Settlement, makes the early history of our country truly come to life.

* In the fall of 1974, the glass house burned. The reconstructed structure has fire proof square shingles instead of a thatched roof.

PREFACE

GLASSMAKING in America* began at Jamestown, Virginia, in 1608, where a glass factory was operating in the nearby forest just a little more than a year after the first colonists arrived from England. The "tryal of glasse" sent back to England that year was the first glass made by Englishmen in the New World, and the manufacture of glass, therefore, can justly lay claim to being the first factory industry in England's American colonies.

This booklet tells very briefly of that first glassmaking venture at Jamestown. It describes the evidence used—archeology, historical research, and laboratory analysis. But in a booklet of this size it is possible to present only a small part of the total evidence that contributed to the writing of the story of the Jamestown glasshouse. More detailed information can be found in the unpublished reports on file at Colonial National Historical Park, while the wealth of artifact material recovered from the excavations can be inspected and studied at the Jamestown Visitor Center.

Although that first glasshouse occupies an important and unique place in the history of glassmaking in America, it has an appeal beyond the strictly historical. Not only is glass collecting one of the most popular hobbies today, participated in by literally millions of people in this country alone, but most of us, whether or not we collect glass, are intrigued and amazed by the seemingly miraculous manipulations of the glass craftsman. If you have ever visited a glass factory where handmade glass is fabricated, and have watched the glassmakers at work, you very likely reacted much as did James Howell, who wrote in 1650 of just such an experience:

> But when I pry'd into the Materials and obſerved the Furnaces, the Tranſmutations, the Liquefactions, the Tranſubſtantiations that are incident to this Art, my Thoughts were raiſed to a higher Speculation.

*"America" is used here to refer to the area now included within the boundaries of the United States of America. Actually, glass was first made in the Western Hemisphere by Spanish craftsmen, probably at Puebla de los Angeles in Mexico, beginning about 1535.

Visitors to Jamestown can enjoy this very same experience at the reconstructed glasshouse, where the furnaces have been rebuilt exactly as the original ones are believed to have looked. Here one can see glass being made in the same manner as it was made only a short distance away more than three and a half centuries ago.

The documentary accounts of the beginnings of glassmaking in this country are scanty indeed, but a fuller and more accurate story of the Jamestown glassmaking ventures can now be written as a result of archeological explorations at the site, carried out by the National Park Service in cooperation with Glass Crafts of America, an organization of leading American manufacturers of handmade glass (see back cover). Interpretation of the results of the archeological findings were furthered by study of the excavations at English glass factories of the same general period, and of historical documents in British archives, made possible by a grant from Glass Crafts.

Construction of the full-scale working model of the Jamestown glasshouse, with its furnaces and equipment, was also a joint project of the National Park Service and the glass industry (see THE GLASSHOUSE TODAY). The glassmaking demonstration is being operated as a cooperative undertaking by Eastern National and Colonial National Historical Park.

In the last thirty years further research and archeology at Jamestown has increased our understanding of the artisans who plied their trades. Based on this research, it is evident early experiments with glassmaking occurred at the James Fort in 1608. Both the Poles and the Germans contributed to the establishment of glassmaking at the first permanent English settlement. The demonstration you see today is a living memorial to their collective enterprise.

The Glasshouse Today

THE foregoing account of the archeological investigations at the glasshouse site, and the description of the way glass was made at Jamestown in the early 1600's, interesting as it may be, lacks the excitement and educational value of watching glass actually being fashioned. Probably in no other of the early colonial crafts have the methods and traditions continued so consistently and widely as in the fabricating of handmade glass. Glassmaking, of course, has made tremendous technical advances since the Jamestown period, but many modern factories employ the very same tools and fashion glass objects just as in the Jamestown glasshouse in 1608.

In planning the interpretive development of the Jamestown area of Colonial National Historical Park in preparation for the 350th anniversary in 1957, it was decided to build a working glass factory at Glass House Point as a means of bringing to life one aspect of the original colony. Again, Glass Crafts of America, representing the handmade glass industry, offered to cooperate in building and operating a working model. A new non-profit corporation — The Jamestown Glasshouse Foundation — was formed and the present facility built in 1956.

The reconstructed glasshouse was placed near the original site so that visitors could inspect the excavated remains as part of their experience at Glass House Point, and a shelter was built over the ruins in order that they could be left exposed. The structure housing the working facilities was built in the "cruck" style of construction (see page 24), although there is less certainty as to the appearance of the original structure than of the furnaces. This type of construction was feasible, since suitable curved tree trunks were available from the right-of-way clearing along the new parkway between Jamestown and Williamsburg. Reeds for the thatched roof were obtained from nearby marshes, just as the colonists would have done in 1608, and boulders for the reconstructed furnaces were brought from upstream along the James

CONTENTS

soda glass to the age of lead glass, or crystal as we know it today.

It is hoped that this brief account of the first glassmaking ventures in America has not only added to the reader's knowledge of our country's history, but will add to his enjoyment and appreciation of modern handmade glass, as well as the works of earlier times.

panes. Only a few panes could be cut from the space around the "bull's eye," the thick, round swelling at the center where the ponte was attached.

Simple glass tumblers would have been made in much the same manner as bottles, the master workman shaping the glass at his chair. Decoration in the form of trailed threads or ribbons of glass would be applied as the master workman slowly turned the finished tumbler while it was still in the plastic state.

Very briefly we have followed the manufacture of simple utilitarian glass through every step from digging the sand along the James River beach to packing the finished product in wooden cases to be shipped back to England. That even a single case was ever filled and shipped, we can only surmise from the evidence of considerable activity shown by the furnace ruins, by the glassmaking refuse left around the place when the operation was abandoned, and by the broken pots. Since the excavations failed to provide the final answer, all we can do is keep on hoping that some day a shipping record or some document will show up telling what products were made at Jamestown and how many were sent back to England.

There has been space in this booklet to discuss only the main points of the project, and to describe very generally the evidence that came out in the course of the historical-archeological study of the glasshouse site at Jamestown. I hope I have dispelled any idea that the first glassmaking venture in America was completely barren. Even though the colony was not ready to support local industries of this type, we know now that glass was made in Virginia as early as 1608, and in greater quantity than we had assumed from the documentary evidence. From results of the archeological explorations, augmented by research along various other lines, we now have a relatively complete and presumably accurate picture of a typical small glasshouse of the early seventeenth century. It is, in fact, the most complete of any yet presented for that important period of glassmaking in England—the transition from a period of monopolies and foreign workmen to a mushrooming industry employing largely native craftsmen. It also was a transition from the long period of *Waldglas* and

Historical Introduction

BOOKS on glass, even the most abbreviated, usually begin with a review of the history of Egyptian and Roman glass, but I will depart from this customary treatment, even to the omission of a quotation from Pliny, who so nicely accounts for the discovery of glass by the accidental fusion of sand in a desert campfire. Our story can very well begin in London shortly before the *Second Supply* sailed for the Virginia colony in the summer of 1608, for it was in this Supply that the first glassmakers were carried to Jamestown.

Captain Christopher Newport had returned from Jamestown after replenishing the struggling colony with men and supplies, and officials of the London Company of Virginia were again recruiting settlers. The word that Newport brought back would have discouraged any but the most optimistic, for none of the objectives of the undertaking had been achieved, save the planting of the colony, and even that was in a precarious position. Most of the adventurers seemed carried away by the idea of finding gold and an easier route to the South Seas. But the business men in England who made up the London Company, though they too shared these visionary dreams, also had more practical goals in mind. With a virgin continent to draw upon, they hoped to find valuable raw materials needed back home, and the wherewithal for manufacturing goods that could be sold for a profit.

Prominent in the list of possible industries for which Virginia seemed suitable was glassmaking. In the past fifty years there had been a great increase in the demand for glass, but this demand could not be satisfied by the English factories. Few Englishmen were skilled in the craft, and though foreign glassmakers had come from the continent to practice their trade, and had presumably trained some Englishmen, a great deal of glass was still being imported. Expansion of the industry had been limited by the gradual depletion of the forests, for coal was just beginning to be used in glass furnaces.

Captain Newport had explored the vicinity of Jamestown and

would have known that the resources needed for glassmaking were readily available in the new land. Certainly the officials of the London Company had every reason to view a glassmaking venture in Virginia as entirely feasible and a likely source of profit. It seemed reasonable to assume that the cost of glass from a factory in Virginia would be much less than what was being paid in Italy and other continental glass centers. About the only things that would have to be sent to the new colony, in addition to the glassmakers themselves, would be a few tools and just enough equipment to get the factory started.

But enlisting English glassmakers to leave a flourishing industry at home and set up business anew in a strange land across the ocean was not easy. It is not surprising, therefore, to find the Company looking abroad, and among the seventy settlers who sailed for Virginia in the summer of 1608 were "eight Dutchmen and Poles," some of whom were glassmakers. The so-called Dutchmen undoubtedly came from Germany, for Captain John Smith in one of his letters mentions that the London Company had sent to Germany and Poland for "glasse-men and the rest," "the rest" referring to the makers of pitch, tar, soap ashes and clapboard. Moreover, it was customary in that day to refer to Germans as "Dutchmen."

Whatever the future might hold for glassmaking in Virginia, its introduction in the fall of 1608 certainly appeared at the time to greatly enhance the chances for the colony's success and supplied excellent propaganda for reassuring the uneasy investors in England. Things had been going from bad to worse before the arrival of the Second Supply. There had been quarreling among the settlers and they had been harrassed continuously by the Indians. It was evident that most of the leaders, as well as the rank and file of the colonists, were unfitted, both by temperament and training, to deal successfully with the problems of colonization. But in spite of this, they had maintained their beach head in the new land and had made a start toward achieving a permanent colony.

On the credit side they had explored the surrounding country; they had completed their fort and erected some livable, if poor, habitations; and they had cleared a few acres of land and planted crops. But the first real step toward permanency came with the Second Supply, which brought among its seventy new settlers a

When the glass article is finished by the master workman it is still very hot, and has to be cooled gradually to give it the necessary final strength. The workman removes it from the ponte by giving the ponte a sharp blow, and one of the helpers carries it to the annealing oven, or leer, using a forked stick or a two-pronged iron rod.

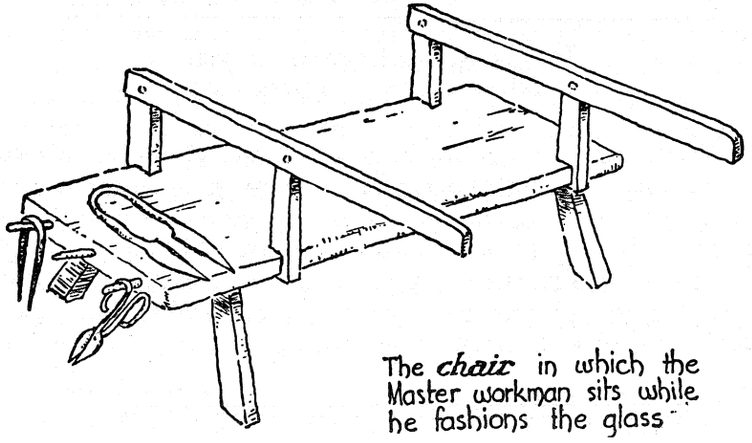
For carrying the finished glass to the leer

Probably as much progress has been made since the Jamestown period in annealing as any other process in glassmaking. The modern conveyor belt annealing furnace is a great advancement over the simple ovens at Jamestown, and is essential to the continuous operation of today's factory. At Jamestown the objects were stacked in a compartment at the back of the leer, and when the space was filled the opening was blocked up and the fire allowed to go out. The gradual cooling of the stone structure produced the desired annealing effect which is achieved in today's continuous "lehr" by moving the objects from the hot to the cool end on a slowly moving woven wire belt. By making alternate use of the paired annealing furnaces (Structures C and D), the glassmaking operation could continue more-or-less uninterrupted. While one of the leers was being filled with the day's product, the other would be gradually cooling.

The fashioning of window glass was not radically different from that described for the bottles. Both "crown" and "broad" glass were being made in England at that time. The crown method involved the blowing of a flat disk, while broad glass was made by blowing a cylinder, splitting it down the side and rolling it out flat. In view of the limitations of the facilities at Jamestown, it seems most likely that the crown method would have been used, provided window glass was made there.

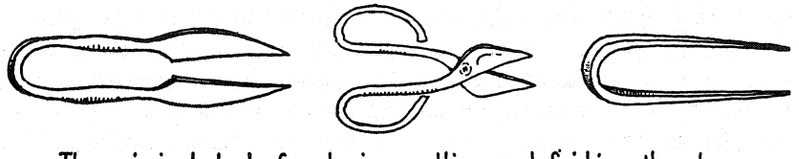
In making crown window glass, the paraison, after being attached to the ponte, would be spun rapidly at the working hole, the workman opening it out to form a flat disk, probably 12 to 18 inches in diameter. This round sheet of glass, after proper annealing, would later be cut into small diamond-shaped

used two or three simple tools, shown in the accompanying illustrations. Their counterparts are still found in modern glass factories where hand blown glass is made.



The *chair* in which the Master workman sits while he fashions the glass

Although we had no great hopes of finding remains of these tools, or of blowing irons, rakes, ladles, and shovels, we had thought it possible that one of the "marbles" might have been left for our special delight. This may have happened, although quite fortuitously, for the flat stone in the platform at the front of Structure B is very likely a marble left from the first factory, which the Italians used in repairing the brick platform. The chair and other wooden equipment, such as water buckets, tubs, tables, and bins, would have disappeared very soon after the site was abandoned. The iron tools, on the other hand, would have lasted until today, unless carried off by settlers or Indians, which they obviously were. Although none of the tools were found, something about them can be deciphered from impressions left on fragments of waste glass.



The principal tools for shaping, cutting and finishing the glass

number of artisans, including the eight Dutchmen and Poles, and possibly even more important, "Mistresse Forrest" and "Anne Buras, her maide," the first women to come to Jamestown. Captain John Smith, who had become President of the Council in September, dispatched some of the newcomers to making glass, tar, pitch, soap ashes and clapboard. Bad times still lay ahead, but for the moment things looked much brighter.

The glass factory, according to Smith, was located "in the woods neare a myle from James Towne," or, as William Strachey described it, "a little without the Island where Jamestown stands." There, as Strachey goes on to say, the glass workers and their helpers erected a glasshouse, which was "a goodly howse . . . with all offices and furnaces thereto belonging."

These newcomers must have set themselves to this task with greater diligence than most of the colonists had previously approached their work, for, when Captain Newport left for England late that year, he carried with him "tryals of Pitch, Tarre, Glasse, Frankincense, Sope Ashes; with that Clapboard and Waynscot that could be provided." Of what this first "tryal of glasse" consisted, the record gives no hint. It may have included only a few simple objects, but it must certainly have been sufficient to show the officials of the London Company that glassmaking was a reality in the new province.

The records tell us very little more about this first glassmaking venture at Jamestown. There are a few indirect references, such as when Smith tells of a fight he had with an Indian in the spring of 1609 when returning alone from the glasshouse. And then there is a reference to a second "tryal" being produced that spring. But these add little beyond the fact that there was some activity at the glass factory during the first six months or so following its establishment.

The "marble" used at Jamestown would have been simply a polished flat stone, whereas today's counterpart, usually called a "marver," is a steel plate.

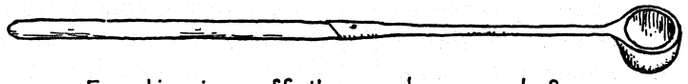
The blowing iron for giving the glass its hollowness and its general form

While the servitor has been giving the glass (at this stage called the "paraison") its general shape, the master workman has made a small gather on the end of another iron tool, called a "ponteglo" or "ponte." This implement, which in today's glass factory is usually called a "punty rod" or "pontil," was simply a solid iron rod, shorter than the blowing iron, and slightly enlarged at the end so that the glass will stick to it better. By means of

The *ponte* for holding the glass while it is being finished

this second gather of molten glass, the ponte is attached securely to the paraison by pressing the new gather against the end of the paraison exactly opposite the point where it is still attached to the blowing iron. The master workman then cracks or cuts the paraison from the blowing iron. By this time the glass has probably cooled too much to work, so he holds it at the working hole of the furnace and brings it back to a workable temperature. He then goes to his "chair," a simple contrivance, but one of the most ingenious pieces of equipment in the glasshouse. It is no more than a crude wooden bench with flat wooden arms extending out in front of the seat.

Seated in the chair, the master workman rolls, or trundles, the ponte back and forth over the arms of the chair, at the same time widening, constricting, or otherwise shaping the pliable glass until the final shape is achieved. During this process he may have to reheat the glass several times, depending upon how complicated an article is being fashioned. For a globular bottle, our Jamestown worker may only have to have "scalded," or re-heated, it once or twice. In this operation the workman has



For skimming off the sandever and for ladelling molten glass from one pot to another

Gradually the heat of the furnace is increased until finally, after another day, vitrification is complete and a true glass has been achieved. The fire is then slackened just enough so that the molten mass is at the right temperature for working when the crew comes on the next day. The glass has been tested from time to time by dipping out a small amount and letting it string out into a thread. Many fragments of such testing threads were found in the excavations. In addition to firing the working furnace, fires have also been started in the emptied annealing furnace so that it will be ready to receive the completed glass vessels.

The Jamestown crew, or "chair" as it is known today, would have had a boss who Merret calls the "master." A second specialist, known as the "servitor," started the show by collecting a blob of glass on the end of a hollow iron tube, called a "blowing iron." This blob of molten glass that the servitor collected on the iron was called the "gather." For a picturesque description of the first step in fashioning a glass object, such as a bottle, Merret's account serves quite admirably.

> The *Servitor* when the Metall [molten glass] is ſufficiently refined, puts his hollow Iron into the pot, and turning it about, takes out enough for the veſſel or work 'tis intended for, the Metall ſticks to the Iron like ſome glutinous, or clammy juice, much like but more firmly than *Turpentine* or *Treacle* taken by tradeſmen out of their pots. The figure it takes on the Iron, is roundiſh, and whil'st 'tis red hot the *Servitor* rouls it to and fro on a Marble that the parts thereof may be more firmly united; And then gently blowing into his hollow Iron raiſeth the Metall juſt as blowing doth a bladder or glove. As often as he blows into the Iron (and that muſt be very often) ſo often he removes ſuddenly the Iron from his mouth to his cheek, leſt he ſhould draw the flame into his mouth, when he reapplies it to the Iron. Then he takes his Iron and whirls it many times about his head, and ſo lengthens and cools the Glaſs.

Very likely the first glassmaking venture came to a close about the time that John Smith returned to England in the fall of 1609. He had been the guiding force in the various enterprises initiated the previous year, and there seemed to be no one else capable, or willing, to push these new undertakings. In any event, glassmaking most certainly would not have continued during the terrible period of starvation and sickness which followed Smith's departure—a period realistically labelled "The Starving Time," during which all but 60 of the 500 inhabitants at Jamestown died. Relief came to the colony in the spring of 1610, but there is no evidence that the glass factory was revived at the time.

Twelve years later, and less than a year after the Pilgrims landed at Plymouth, a second glassmaking venture got under way at Jamestown. It was a well organized, businesslike undertaking, quite unlike the earlier pioneering effort of 1608. Well planned, reasonably well financed, and staffed with experienced Italian glass workers, it appeared to have a much better chance of success than the earlier venture. The records concerning this second undertaking are much more complete than those for the first, although they reveal nothing as to the location of the glasshouse or what products were made there.

This second venture was organized largely through the initiative of Captain William Norton, not a glassmaker himself, but an adventurous soul with some money to invest. In June, 1621, he petitioned the London Company for a patent to "sett upp a Glasse ffurance [in Virginia] and make all manner of Beads & Glasse." He proposed to take four "Itallyans" and two servants to Virginia, who were to have the glasshouse operating within three months after their arrival.

After considerable haggling over terms, arrangements were finally made and funds to assist Captain Norton in the venture were raised by the sale of joint stock. The assemblage, including Norton, his family and personal servants, and six Italians with their families, sailed for Jamestown in August, 1621. With them the Company dispatched a letter to the colonial authorities stating:

> We comend unto you Capt. *Wm. Norton* who is now sett out by the general Company and many private Adventurers for the erectinge of a Glaſs Worke; . . . and eſpecially have a Care to ſeat him neare ſome well inhabited Place, that neither

his Gange be ſubject to Surprise, nor the Commodities of Glaſſe and Beads be vilified by too common a Sale to the *Indians*.

The Italians proved a difficult crew to deal with, and offered one excuse after another for failing to make glass. They did have some hard luck, however. First their glasshouse blew down; then the Indian massacre of 1622 put a stop to everything for the time being. Finally Captain Norton died, and even the Italians "fell extremely sick." George Sandys, resident treasurer for the Company, took over the project upon Norton's death, but fared little better in getting results. He repaired the furnace and the crew set to work in earnest in the spring of 1623, but without success.

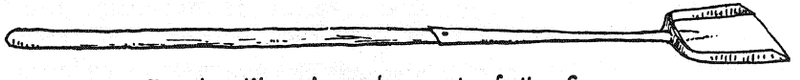
> The Fier hath now beene ſix Weekes in ye Furnace, and yett nothing effected. They complaine that ye Sand will not run. . . but I conceave that they would gladly make the Worke appeare unfeaſable, that they might by that Meanes be diſmiſſed for *England*. Much hath beene my Truble herein, and not a little my Patience.

In a desperate effort to make something of the enterprise, Sandys even sent to England for sand that might better suit the glass workers, but he finally was forced to give up completely in the spring of 1624. The records are not conclusive, but they would certainly suggest that little, if any glass was made during this second glassmaking venture at Jamestown.

In both of these attempts to get the glass industry started in America, individuals in England had invested rather heavily. By 1624, when the London Company lost its charter and Virginia became a crown colony, they must have been fairly discouraged. It certainly was obvious, even before 1624, that financial profits in the colony would come easier and faster from tilling the soil than from uncertain manufacturing ventures. The growing of tobacco was already the principal attraction of Virginia, both to new settlers and investors. The introduction of slaves and other factors contributed to the attractiveness of tobacco raising, and it continued to gain in importance all through the colonial period at the expense of industrial enterprises, such as glassmaking.

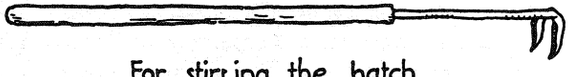
of a glass object. There are several excellent accounts describing just how a piece of glass is fashioned, and told in more detail than is possible in this booklet. Mostly, however, these accounts tell how a piece of fancy tableware is made, and since I am dealing specifically with glassmaking at Jamestown, I will describe very briefly the fashioning of the simple objects which might have been made there in 1608.

A logical starting point in the glassmaking cycle is the day after the glass had been worked out of the pots and the furnace had been allowed to cool down slightly, preparatory to recharging the pots and getting ready for the next run. We can assume that this interruption has not been long enough for the heavy stonework to have cooled off materially, but it has provided a chance to rake out the ashes, to make any necessary minor repairs to the furnace, and to replace damaged pots.



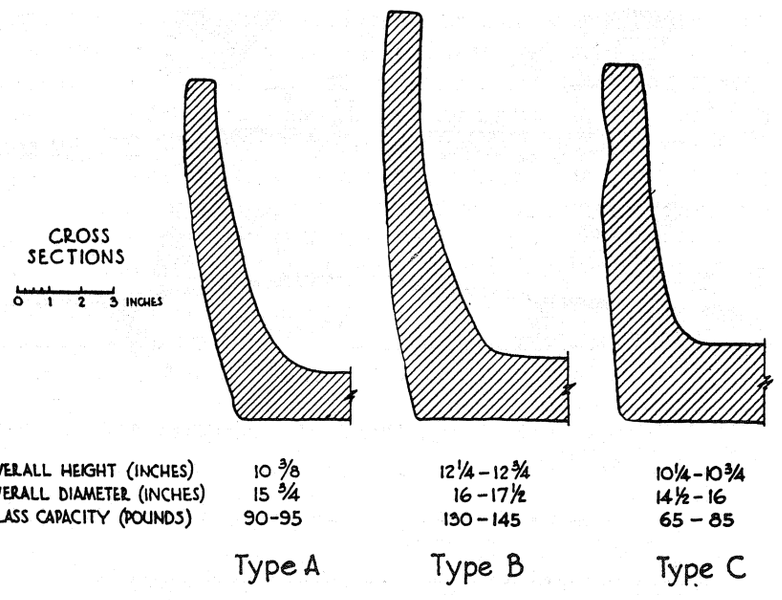
For shovelling the ashes out of the furnace

Now the fire is started up again and the desired combination of the raw materials placed in the pots. As the batch begins to melt, more ingredients are added, until finally, after about a full working day, the pots are fully charged. During this early stage of melting, the material is stirred with a special iron rake.



For stirring the batch as it melts in the pot

At first there is only a sticky mass in the pots, but gradually the material liquifies and takes on the appearance of molten glass. Impurities rise to the surface causing a white spongy scum to accumulate. This "sand gall," or "sandever," is removed immediately with an iron ladle. As Merret says, the master workman has "to scum the Sandever, and dross, from the pot wherein he worketh."



CROSS SECTIONS OF THREE TYPES OF MELTING POTS USED AT THE JAMESTOWN GLASS FACTORY. TYPES A AND B WERE IMPORTED; TYPE C WAS MADE LOCALLY.

One very small pot, previously mentioned, showed evidence of having been used to melt blue glass. Another slightly larger pot—one of the homemade variety—was likely used by the Italians for experimental purposes, but shows little evidence of use. In fact, none of the locally made pots seem to have been used to any extent.

These broken pots add considerable to our knowledge of what went on at the Jamestown glass factories. Above all, they show that a serious attempt was made to turn out glass products, and that the first glassmaking effort was much more than just a public relations stunt designed to promote the financing of the Company's colonizing venture.

The Glass Blower at Work

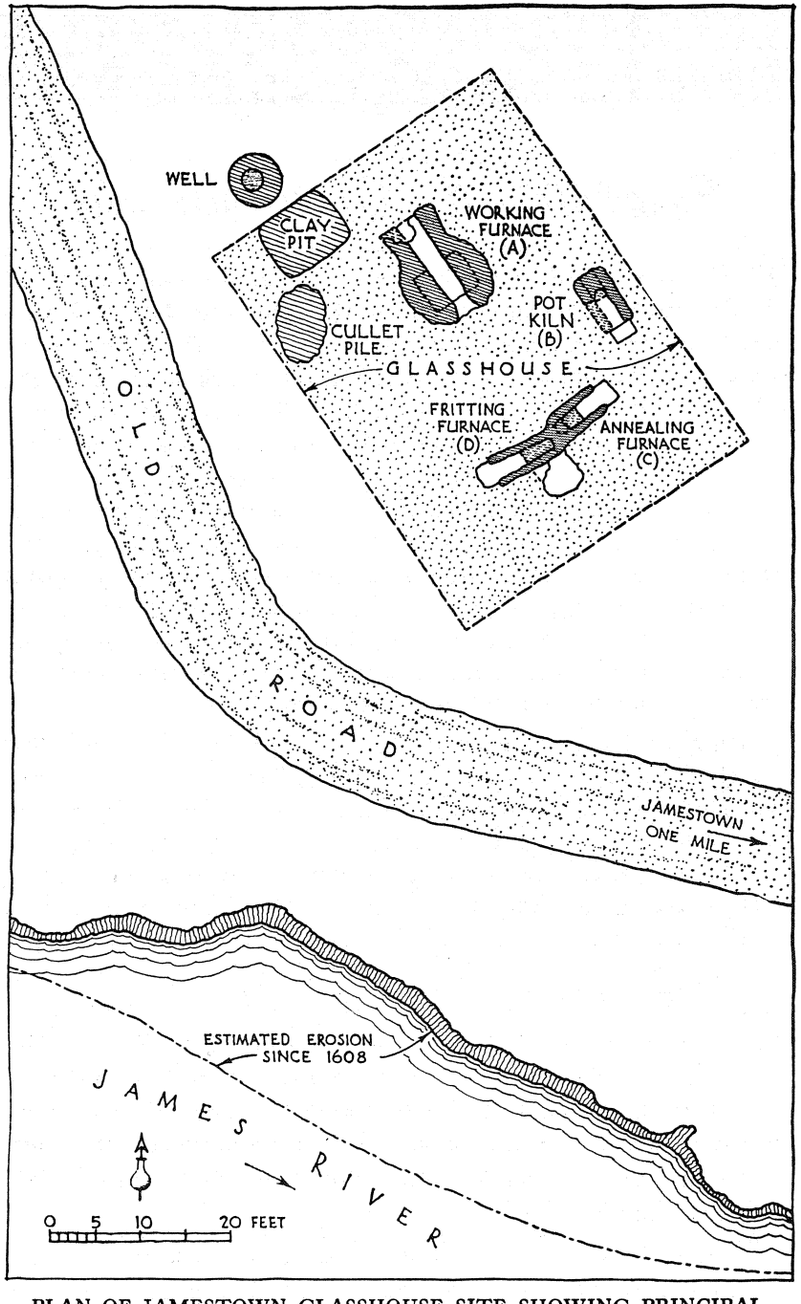
These various preparations and behind-the-scenes activities, as important as they may be, are not particularly glamorous. The really fascinating part of glassmaking is the actual fabrication

Excavating the Glasshouse Site

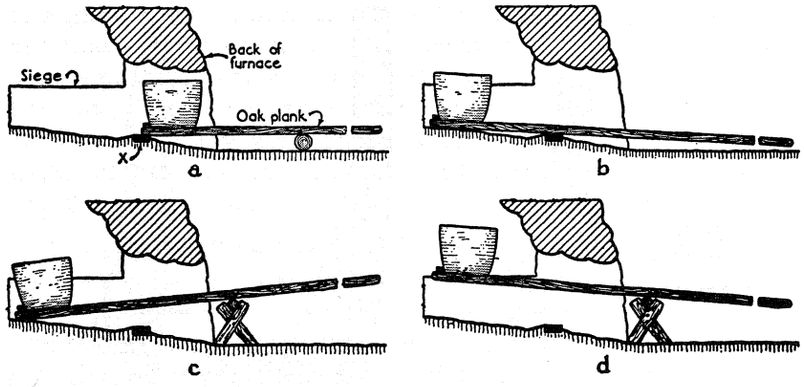
THE location of the Jamestown glasshouse was discovered almost through pure chance by the late Jesse Dimmick who owned the property before it was acquired by the Government as part of the Jamestown area. Mr. Dimmick knew that the glasshouse site might be on his land, for he was well acquainted with the old records. These records were too vague to tie down the exact location of the glass factory, but they did offer some clues. Land records furnished the best evidence. Francis Moryson acquired a tract of land in 1654, described in the property transfer as the "Twenty four Acres of Land commonly known by the name of the Glass house." From that date on, a continuous chain of title can be found for this tract, thus providing a location within reasonable limits. In more recent years the area has been known as Glass House Point.

Much of the land, even today, is heavily wooded, with low underbrush and leaf mold covering the ground. This would have concealed the slight surface indications of buried remains that might otherwise have been apparent. One version of the story is that Mr. Dimmick was walking through the woods one evening in 1931 and accidentally kicked up a piece of slag. Whether he found other evidence just then, I am not sure, but he recognized the significance of the find, and shortly began some test excavations. He uncovered what appeared to be three stone structures, and in the earth removed from these ruins, found fragments of glass and portions of old crucibles, or melting pots. He did a little more digging the following year and then covered over the ruins and fenced in the site. Rapid growth of underbrush and vines probably furnished better protection from vandalism than the fence.

Thus the site stood until excavations were started by the National Park Service in the fall of 1948, exactly 340 years after Captain John Smith put men to work building a glasshouse



PLAN OF JAMESTOWN GLASSHOUSE SITE SHOWING PRINCIPAL REMAINS UNCOVERED DURING ARCHEOLOGICAL EXCAVATING.



PROBABLE METHOD OF PLACING A NEW MELTING POT IN THE WORKING FURNACE.

a. Pot set on end of plank; rolled into opening at back of furnace until plank rests on stone slab X.

b. Roller removed and plank slid forward on smooth stone slab.

c. Plank lifted up and horse slid under.

d. Pot end of plank teetered up to level of furnace siege, and then pot pushed off plank by means of rake operated through one of the working holes.

Among this assortment of pots are four which were made locally (Type C). This was clearly shown by laboratory tests of pot fragments and local clays. Spectographic analyses showed that Type C had the identical chemical constiuents as the local clay, while Types A and B were radically different. Except for being more roughly formed, and with somewhat thicker bodies, these locally made pots were similar to those brought from England. All are the same shape and size as pots recovered from archeological excavation of contemporary English glasshouses. We cannot be sure which of the pots were used by the Poles in 1608 and which by the Italians, nor can we be certain who were responsible for the ones made locally. Of the imported varieties, there appear to be two main types (A and B in drawing), and the archeological evidence, although not conclusive, suggests that Type A was used in the first glasshouse and Types B and C in the second.

ready for molding. After digging, it was worked over very thoroughly with a spade, then mixed with just the right amount of water and stored in a pit to cure, preferably for several months. (Possibly the square pit at the corner of the glasshouse was used for this purpose by the first group.) For use in tempering the clay, glassmakers ground up old broken pots and added a given quantity of this "grog." The clay was then kneaded long and patiently by a barefooted workman, who could tell by feel just when the clay had reached the desired uniformity and consistency.

When the clay had been worked to the satisfaction of the pot maker, he began forming the pot, molding it by hand from coils of clay, and without the aid of a potter's wheel. While being formed, it was pounded with a wooden mallet to drive out air and to fuse the coils together. Careful as the workers were, pots often broke along these coil lines, as evidenced from the fragments found at the Jamestown site. The finished pot was allowed to dry out slowly, or cure, for several months before being put in the kiln, or pot furnace, to bake. No step in the life of a pot, from digging the clay to placing the pot in the working furnace, was hurried.

In replacing a pot on the furnace siege, the temporary plug at the rear would be removed, the broken pot raked out, and the new, preheated pot eased into place. This could have been done by sliding it in on the end of a green oak plank and teetering the pot end up level with the siege, swinging it over and then pushing the pot off the plank onto the siege with an iron rake. With a Jamestown pot, weighing only about 75 pounds, this would have been a fairly easy and rapid operation compared to the task of replacing a large pot in a modern furnace.

Literally hundreds of pot fragments were recovered in excavating the Jamestown site. The pieces were all small, but it has been possible to restore some of the pots which were not too badly warped, and to determine the shape and size of ten of the approximately fourteen pots represented. Except for two small ones, the pots were all approximately the same general size and shape. The bottoms were flat, about 2 inches thick, with vertical or slightly outflaring sides, varying from 1 to 1½ inches thick. Their overall diameter ran from 14 to 17 inches, and their height from 10 to 16½ inches. They would have held from 65 to 145 pounds of molten glass, quite different from the pots of today, some of which hold as much as a ton of glass.

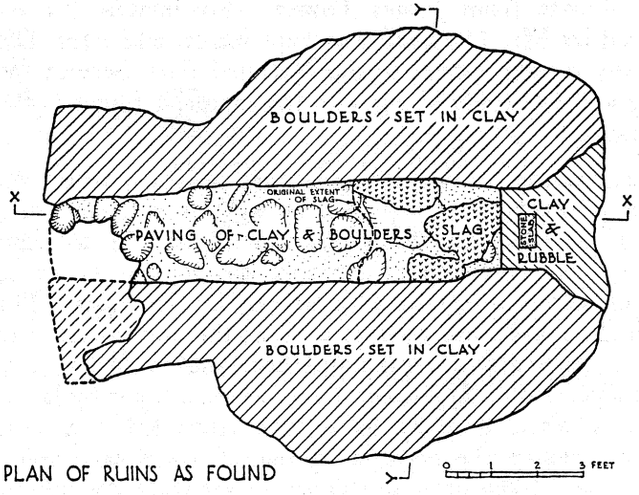
"neare a myle from James Towne." Fortunately the material recovered by Mr. Dimmick was kept intact, and Mrs. Dimmick generously turned it over to the National Park Service for safekeeping and for study along with the material found in the later excavations.

In excavating an archeological site it is important that the location of every object found, as well as masonry ruins and other evidence of former occupation or use, be accurately recorded. The most convenient way to do this is to set out reference stakes over the area at regular intervals. This was done at the glasshouse area as soon as the underbrush had been removed, along with several copperhead snakes. An area roughly 50 feet square was then carefully excavated, layer by layer. The earth was wheeled away as it was trowelled out, and then screened, keeping the material recovered from each unit within the area, and from each soil layer, in separate containers. The digging was done very carefully and slowly, for we were quite confident of finding glass beads. Although not a single bead was found, fragments even smaller were recovered, as well as thin threads of glass, often as fine as a small needle.

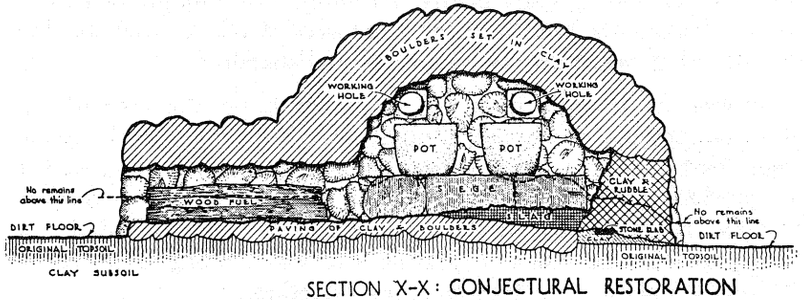
It was not enough, however, to excavate just the area of the glass factory itself, for there might have been other buildings in connection with the glassmaking operations, such as houses for the workmen. There might also have been refuse dumps outside the glasshouse. Consequently, test trenches were extended out from the furnace ruins, exploring the surrounding area for a distance of about 100 feet in every direction.

The first test trench revealed that nearly a foot of earth had accumulated over the original surface of the ground. This was most fortunate, for it had provided protection to the furnace ruins and had sealed over the floor of the factory. We were especially anxious to examine the original floor for what it might reveal as to the surmounting structure. Because of the very nature of glassmaking, in which salvaged glass is a valuable and necessary ingredient in every new batch, we could not hope to find much old glass, but we were confident that occasional pieces would have been tramped into the dirt floor, and there was the remote possibility that a supply of broken glass had been left behind when the factory was abandoned.

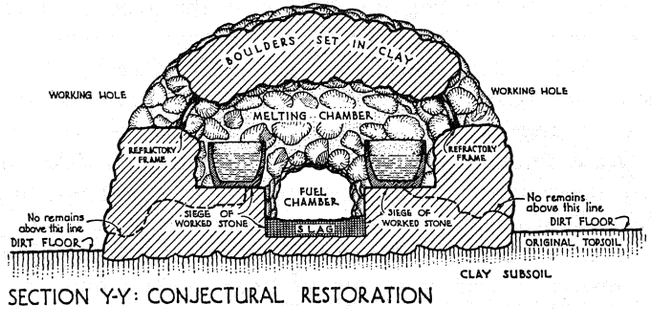
These hopes were realized to a degree. After removing the



PLAN OF RUINS AS FOUND



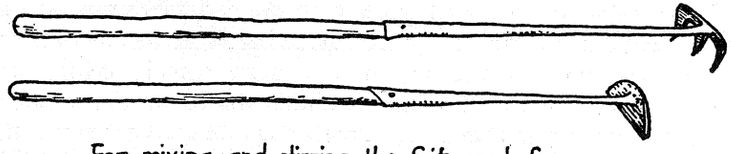
SECTION X-X: CONJECTURAL RESTORATION



SECTION Y-Y: CONJECTURAL RESTORATION

STRUCTURE A, THE MAIN WORKING FURNACE IN WHICH THE GLASS WAS MELTED.

as fritting, and the resulting product was called "frit." It was carried out in a furnace known as a "calcar," and the man who looked after this operation was the "founder." At Jamestown, of course, the founder may well have been one of the glass blowers. To make frit, the sand, lime, potash, and soda were thoroughly mixed and shovelled onto the ledge at the back of the calcar. As the heat of the furnace rose, the founder stirred the mixture and worked it over with a long-handled rake or hoe. As soon as this semi-fused mixture reached the proper stage, it



For mixing and stirring the frit, and for all sorts of uses around the glasshouse

was quickly pulled out of the furnace onto the stone platform, and, after cooling, was broken up and stored for future use. As mentioned elsewhere, however, it is possible that the process of making frit was never employed at the Jamestown factory.

Melting Pots

There was no more important operation around the glasshouse than the making of melting pots. A few would have been brought from England to use until replacements could be made, but the turnover was high, and steps would have been taken at once to provide for future needs. Even under the best conditions pots go to pieces very quickly when in use, and no glasshouse can afford the expense of too frequent shutdowns, all aside from the glass lost when a pot breaks in the furnace. Not only does the heat cause the pot to start to soften, but the corrosive action of the glass eats into the pot and eventually destroys it. Many of the pot fragments found at Jamestown show a great deal of deterioration from this corrosive action, and almost all of them are warped out of their original circular shape.

Making a glass pot was an exacting job, and one that was not turned over to just anyone who happened to be idle for the moment. Suitable clay was the first consideration, and this apparently was available right at the site. As in making bricks or pottery, the clay underwent a lengthy treatment before it was

ents. But in a less sophisticated operation, especially when making common green glass, it is altogether possible that wood ashes, shovelled directly into the melting pot, furnished the necessary lime, potash, and soda. Wood ashes contain these ingredients, and in quantities that would account for the percentages found in the Jamestown samples. The other chemicals would have been introduced quite unintentionally in the sand and ashes. They would have affected the color and quality of the glass, but not its workability.

The final ingredient was old glass, or "cullet." After the operation was well underway, enough waste glass would accumulate around the glasshouse for this purpose. But some "cullet" would have been needed at the outset, so a barrel or so of it would likely have been brought along from England. Any broken glass discarded at the settlement would have been gathered up, but glass was rare in the colonists' homes at that early date.

This accounts for the materials that went into the glass: sand from the nearby beach; lime, probably from England in the form of ground up limestone; crude potash prepared from ashes raked from the furnaces, or simply the ashes themselves; a little soda, sparingly parcelled out from the supply brought from England; and finally the cullet.

What sort of a crew would there have been around the first glass factory to fashion the glass as well as dig and wash sand, cut wood, mix ingredients, tend fires, and do all the other odd jobs? The crew that actually made the glass articles would probably have consisted of two or, at the most, three experienced glass workers with one or two helpers. In addition, there would have been a number of other helpers, or "boys," who did the unskilled work or performed more particular jobs under the supervision of the glass workers. There may have been as many as five of these helpers but the Jamestown plant could not have been staffed as fully, or as efficiently, as a going concern in England, and even the glassmakers themselves probably participated in tasks that normally would have been assigned to unskilled workmen.

In addition to the actual fashioning of the glass objects, there were two operations that required special skill and experience. One was the fritting and the other the making of melting pots. The preliminary partial fusion of the raw ingredients was known

three-century earth accumulation, careful excavation of the original earth floor of the glasshouse produced a fair amount of broken glass, all very small. But by far the most material of this sort came from a small deposit at one corner of the glasshouse. It quite obviously had once been a small pile of waste glass lying on the floor, ready for use in new batches. The material in this pile consisted of every type of glass that one might find around a glass factory—broken glass objects, as well as drippings and other refuse from glassmaking.

Our biggest surprise was in not finding any glass beads or other evidence of bead-making, but the keenest disappointment was that none of the glass fragments were large enough to show what the original objects had been.

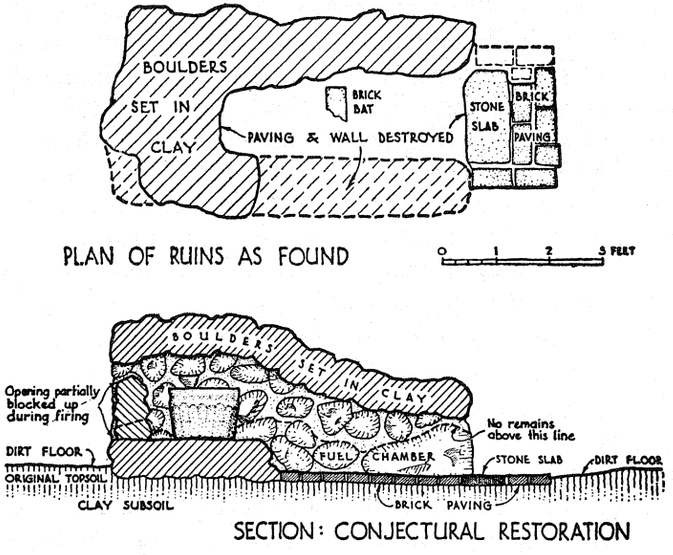
Of greatest interest, of course, were the remains of four stone furnaces, or ovens, all built of rounded river bolders imbedded in clay. The largest of these, here referred to as "Structure A," was clearly the remains of the main working furnace in which the glass was melted in clay pots. It is surprising how much can be learned from the very fragmentary remains of this structure. The main body of the furnace was circular, roughly 9 feet in diameter, through the center of which ran a stone-floored chamber about 2 feet wide and 2 to 6 inches above the glasshouse floor around the furnace. Lying on this stone paving were thick deposits of slag, indicating rather extensive use. Although Mr. Dimmick had removed everything found within this furnace, except part of the slag, it appears that he found a considerable accumulation of furnace refuse, such as ashes, broken crucibles, stone spalls, and glass drippings. At either side, and 1 foot above the stone paving, were remnants of the platforms, or "sieges," on which the crucibles set when the furnace was operating.

A three-foot extension at the front of the furnace, with a stone floor at the same level as the floor of the melting chamber, provided the fire box. In a semi-circle around the front of the furnace was found a thick deposit of ashes and fine charcoal. Through the rear wall of the furnace, beyond the melting chamber, was an irregular, unfloored, flared opening. As found, it was filled with clay, stone spalls, and fragments of broken crucibles. Obviously the furnace had been fired after this opening was last blocked up, for the clay was burned hard from the heat

and some of the slag on the floor of the melting chamber had piled up against this clay and rubble filler.

No bricks or other materials were found that would give any suggestion as to the original construction of the upper portion of the furnace, other than fragments of collars, or frames, which had sat in the working holes just above the tops of the melting pots. These frames were made of clay, similar in composition to the melting pots, and some had stone spalls fused to them, showing that they had been set in a stone wall. Available evidence, therefore, indicates that the entire structure was built of boulders, imbedded in clay.

The boulders varied considerably in size from small, rounded ones only 5 or 6 inches across to large, irregular ones as much as 2 feet in length. All are a common sandstone which appears in outcroppings at the Fall Line some 75 miles up the river from Jamestown. Identical boulders, however, are found on bars and beaches along the James River where they have been deposited by flood waters. The colonists knew of these deposits of



STRUCTURE B, A SPECIAL FURNACE, POSSIBLY USED AS A KILN FOR FIRING NEW POTS AND FOR PREHEATING POTS BEFORE THEY WERE PLACED IN THE WORKING FURNACE.

All of this glass is essentially the same, characterized by its low silica and high lime content. It probably all represents the same basic recipe, for the variations are no greater than one would expect from factory to factory and the use of impure ingredients. The one conspicuous, and possibly significant, difference is the higher proportion of lime and magnesia in the samples known to have been made at Jamestown, roughly 30 percent, as against 25 percent for the English product.

This is a glass that would not be used today, even for pop bottles. Its greatest drawback is its relatively high melting point, and the small span of temperatures over which it can be manipulated by the glass worker. It would have had to have been reheated constantly while being worked, but this would not have been too great a disadvantage, since it was seldom used for fancier articles, such as stemmed goblets, which require a longer time to fashion than window glass, bottles, and tumblers.

Laboratory analysis of glass can reveal its chemical content, but does not tell us what raw ingredients were brought to the glass factory. Silica, for instance, can be obtained from various rocks, as well as from sand. Lime is found in relatively pure form in sea shells and in various deposits, such as limestone, chalk, and marl. Samples of Jamestown glass were analyzed for two reasons. First of all we wanted some clue as to the materials that went into the glass. We also had hopes that there might have been significant differences in the recipes used by the Jamestown workers and their fellow craftsmen in England to permit us to detect any Jamestown product. We thought, too, that there might have been unique impurities in the Jamestown glass, coming from the local sand, which would earmark the glass made there.

Sand for the Jamestown glass almost certainly came from the nearby beach. Analysis shows this sand to be high in metallic oxides, but perfectly suitable for the type of glass turned out at the first glass factory. The Italians, who would have tried to produce a clear glass, could never have succeeded with this local sand. Their contention that it would not "run" was probably true, although it may have been just another indication of their perversity.

On first thought, the source of the lime, potash, and soda was a problem. At many glasshouses in England, these chemicals were provided in controlled quantities by adding the requisite ingredi-

ably more durable than the soft soda glass of the period. The Germans called this ordinary green glass *Waldglas* (forest glass), and in France it was known as *verre de fougère* (fern glass). This common green stuff was the principal product of most of the English glasshouses at that time, particularly those operated by the Huguenot workers.

A fairly large number of samples of glass from Jamestown were analyzed, all conforming roughly to samples 1 and 2 in the following table.

Material		Sample and Origin			
		1 (Jamestown 1608)	2 (Jamestown 1608 or 1621)	3 (Jamestown or England)	4 (England)
Silica	SiO_2	57.0%	57.0%	59.9%	60.7%
Alumina	Al_2O_3	4.6	4.7	4.8	5.1
Iron oxide	Fe_2O_3	1.0	1.1	1.1	1.7
Titanium oxide	TiO_2	0.5	0.6	0.8	0.2
Lime	CaO	25.8	25.5	22.7	22.4
Magnesia	MgO	4.2	4.5	2.4	2.5
Soda	Na_2O	1.3	1.3	1.8	1.1
Potash	K_2O	4.5	3.8	4.3	5.4
Sulphur	SO_3	0.7	0.6	0.2	0.5
Chlorine	Cl_2	0.4		0.4	0.2

In each sample, the remainder making up the 100% was mostly material lost on ignition. In the few samples in which manganese oxide occurred (sometimes used to offset green color), the amount was 0.2 to 0.3%.

Col. 1—Sample from refuse pit, almost certainly from the 1608 venture.

Col. 2—Sample from floor of glasshouse; could be from either period.

Col. 3—Sample from cullet pile, which could be refuse from the Jamestown operation, or imported as a "starter" from England.

Col. 4—Sample from an English glasshouse of comparable period.

river boulders, for the record of Captain Newport's first exploration up the James in 1607 relates that about 30 miles above Jamestown "the shoare began to be full of greate Cobble stones." Interestingly enough, stone of this type is not found in England, further evidence that the building material was secured locally.

This is about all that the excavations tell us of the main working furnace. The three other smaller structures were also built of river boulders, similarly imbedded in clay. Archeological evidence provides few hints as to the purpose of these smaller furnaces, or ovens. Each shows clear evidence of having been fired, for the clay between the stones is burned from heat, and charcoal and ashes were found inside them and on the glasshouse floor around them.

The smallest of these auxiliary units, "Structure B," was built with exceptionally large boulders, suggesting that it might have been taller than the other two, although it had the smallest fire chamber, only 1½ feet wide and 4½ feet long. At the front was a small platform consisting of a flat stone and several soft, red bricks.

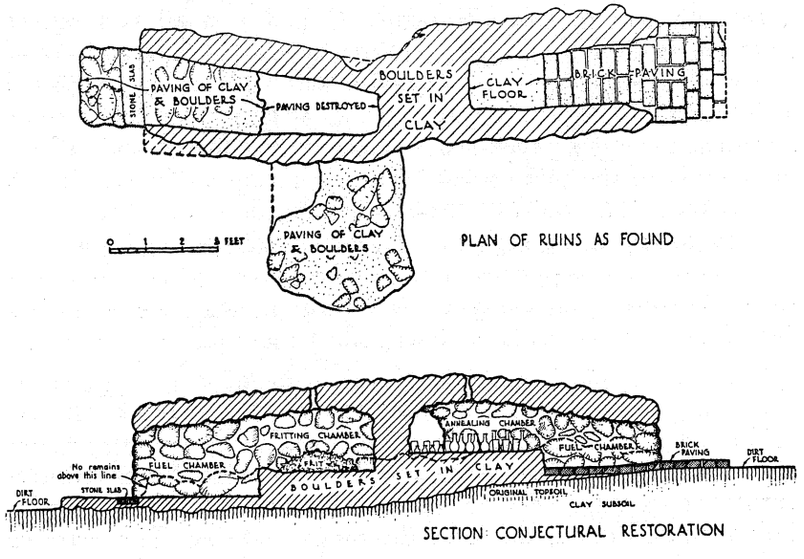
The other two units, labelled Structure "C" and Structure "D," were built end to end. Structure C had a small rectangular platform at the front, similar to Structure B, but built entirely of bricks. The fire chamber, 2 feet wide and 5 feet long, was paved with bricks. Structure D resembled its neighbor, but had a stone platform and stone paved fire chamber, rather than brick. It was the longest of the three small furnaces, having an interior length of 6½ feet. The walls of these twin structures were less than a foot thick, and being built of relatively small, rounded boulders, could only have supported low, semi-circular arches. A square stone platform lying alongside Structure D suggests a secondary use of this furnace, as later described.

One of the most important features found in the excavation was a pit, located near the front of the main furnace. It was roughly 8 feet square and extended down about 1½ feet below the original ground level. The bottom was filled with furnace refuse, containing ashes, fragments of old melting pots, working hole frames, stone spalls, glass drippings, and slag. This material quite obviously came from a furnace, and the only logical conclusion is that the pit dates from the second glassmaking venture of 1621. In rebuilding the old furnaces, these later workmen

would have secured their clay as close to the scene of operations as possible, but the resulting hole at the corner of the glasshouse would have been in the way and would have been filled up with whatever material was at hand. Here was just the place to dispose of the refuse found in the abandoned furnaces.

Further evidence that the material in this pit came from a furnace is the absence of any fragments of fabricated glass, such as found in the pile of salvaged glass described above. Also of interest is that the only pottery vessels found at the site, other than the crucibles, came from this pit. Fragments of two articles were recovered, one a leadglazed, red earthenware cooking vessel; the other a small Indian pot. Obviously the first glassmakers at Jamestown had used one of the furnaces for cooking their food, and here may have been prepared America's first "genuine Boston baked beans."

Although the river was close at hand and would have furnished water for general use, clean, fresh water would have been required for drinking and for the final washing of some of the ingredients that went into the glass. It was not surprising, there-



STRUCTURES C AND D, SPECIAL FURNACES, OR OVENS, USED FOR ANNEALING THE FINISHED GLASS. STRUCTURE D MAY ALSO HAVE BEEN USED FOR "FRITTING" (PRELIMINARY FUSION OF INGREDIENTS).

Glassmakers at Work

THE stage is now set for the craftsmen and their helpers to start making glass. The furnaces have been built and a serviceable shelter has been constructed. The next thing the workers had to do was to assemble the raw ingredients that were to go into the glass, and to have a good supply of dry wood on hand for fuel. In describing the various processes a few technical terms cannot be avoided, for they are not only part of the picture, but usually there is no satisfactory synonym. Where the seventeenth century spelling is known, it will be used in preference to present day usage, as "leer" in place of "lehr" and "ponte" in place of "punty rod."

Glass is composed largely of silica, which occurs most commonly in nature as sand. Although the sand available to glassmakers usually contained appreciable quantities of impurities, it has probably always been the most popular source of silica for glassmaking. But glass cannot be made with silica alone. Other ingredients must be added to facilitate melting, to make the molten glass workable, and to produce a stable product.

From the earliest times, these added ingredients were mainly soda and lime, with potash sometimes being substituted for soda, or used along with it. These materials are known today as the "flux," but at the time of the Jamestown factories they were called "salts." Through the years, and with few exceptions up until lead glass was developed in England during the last half of the seventeenth century, glass was formed primarily from some combination of these basic ingredients. At any given time, and in almost every glasshouse, there were innumerable variations in the recipes. The wide variation in chemical content, as revealed by laboratory analyses of old glass, is accounted for both by intentional diversity in recipes and from uncontrollable impurities in the raw ingredients.

The glass made at Jamestown was referred to by writers of that period as "common green." "Common" meant that it was just ordinary, run-of-the-mill stuff, although actually it was prob-

to have an abundance of native resources. We must admit, then, that there is no evidence whatever to support the theory that beads were made at Jamestown in 1608-1609. Those who want badly to believe the Jamestown bead legend can only take refuge in the contention that we have found only the first glasshouse, and that the Italians had their bead factory elsewhere, admittedly a possibility, but one that the present evidence does not support.

fore, to come upon a well, located near the glasshouse. Whereas the square pit probably furnished clay for the later furnace repairs, the original structures were very likely built with clay recovered when digging the well.

The well, like so many found in the excavations at Jamestown, was simply a 4-foot circular hole, dug about 2 feet below the normal ground water level, with a large wooden barrel set in the bottom of the hole. This particular well was about 8 feet deep. The barrel, much of which was still in a good state of preservation, was nearly 4 feet tall, and was made with oak staves held together with four iron hoops. But unlike many of the wells on the Island, it was unlined, and the earth fill contained no artifacts of interest or significance.

Every glass factory must have some sort of a cover over the furnaces and a protected working space for the glass workers and their materials. Such a building at Jamestown would undoubtedly have been very crudely constructed, but even so, we had hoped to find some trace of it. No actual remains of such a structure were discovered, but sufficient indirect evidence was found to arrive at the original size and location of the glasshouse. This was possible through determining the extent of the original working floor. The hard-packed dirt floor, into which had been tramped small bits of charcoal, glass, and other debris, stopped abruptly on each side, forming a rectangle 37 by 50 feet. The original building, represented by this indirect evidence, was just large enough to cover the four furnaces and provide working and storage space around them.

In the exploratory trenches radiating out from the main excavations, no remains of other buildings were found, but a really important discovery was an old road with ditches along each side. By digging test trenches at intervals and following surface traces, this road was followed for a considerable distance. It is clearly the remains of the old road that ran along the shore from Jamestown to the glasshouse, then straight into the mainland. In later years it was the main road to Greenspring, Governor Berkeley's plantation, and to other plantations and towns that could not be reached by water.

The archeological explorations, described very briefly here, actually revealed a great deal about the physical facilities used by the glassmakers and something about the way glass was made

at the Jamestown factory. Above all, they show that the colonists made a sincere attempt to start a manufacturing enterprise, and that even though the time was not ripe for success in their glass ventures, they were able to, and did, produce a workable glass comparable to that made in English glasshouses.

But even after the digging was completed, there were other lines of research to pursue. First of all there were numerous laboratory analyses to be made to see if we could determine which glass was made at Jamestown, and whether there were noticeable and consistent differences in the composition of glass made at Jamestown and in England. We also hoped to determine the origin of the melting pots from laboratory tests of the clay used in making them.

An important phase of the post-excavating studies involved research in England, made possible by a grant from Glass Crafts of America, which enabled the writer to spend three months there in the spring of 1950. No new documents bearing directly on Jamestown came to light, but a great deal of information was found concerning glassmaking at the time the Jamestown glass factories were operating. Particularly valuable were the results of archeological excavations at old glasshouses. Although worthwhile material was found in unpublished manuscripts and obscure reports, the most valuable sources of information were from discussions with students of glass and glassmaking. The list of these scholars, who gave so wholeheartedly of their knowledge and enthusiasm, includes professors, business men, collectors, manufacturers, and museum "keepers." Each of them made contributions to the Jamestown study that could never have been secured from museum and library resources alone. There is no doubt that the story of the Jamestown glasshouses would be far less complete, or, at least less accurate, had it not been for the research I was able to carry on in England.*

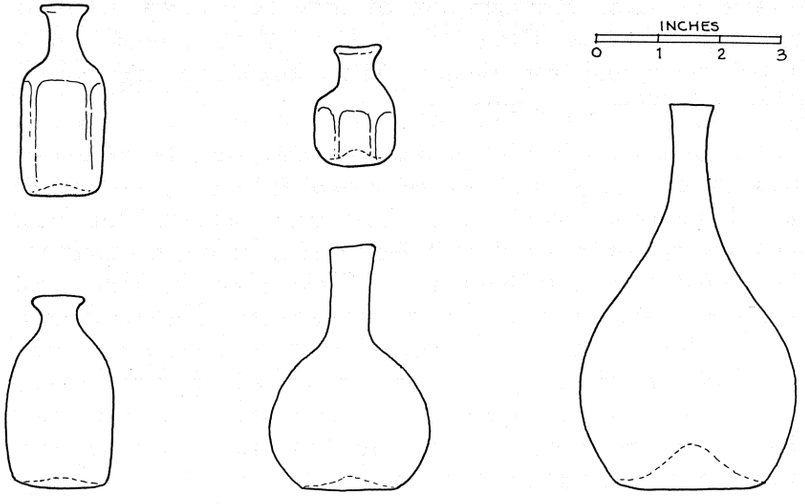
*Most of this material, and considerably more, has since been assembled by Mr. G. H. Kenyon of Kirdford, Sussex, England, and published in 1967 in his book titled THE GLASS INDUSTRY OF THE WEALD (see Selected References, page 55).

Various types of surface decoration were common at the time, and would probably have been used if the enterprise had been more successful. They include trailing and other types of applied ornament, such as "prunts," various combinations of which are suggested in the illustration. Another very common decorative technique of the period was the forming of ribs and flutings by means of a dip mold. This involved blowing the glass in an open-top mold, on the inner surface of which a pattern had been cut. This type of decoration usually took the form of vertical ribs, and very often a more attractive appearance was achieved by twisting or swirling the glass after it was removed from the mold, producing the so-called "wrythen" effect. Applied decoration was sometimes used in conjunction with molded ribbing.

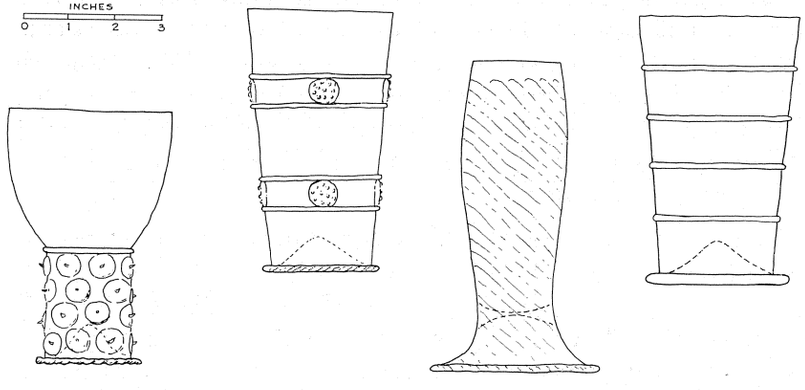
Painting, enamelling, engraving, and other decorating techniques would probably not have been attempted, although the small pot with remains of blue glass suggests the possibility of painting or enamelling.

The general range of shapes and sizes of the drinking glasses that the first Jamestown glassmakers might have made, or planned to make, are shown in the accompanying drawing. It is hard to believe that they would have attempted any but the most simple, everyday products. On the other hand, if the Italians had been successful in assembling satisfactory materials and had really got down to making glass, a much more elaborate and fancier array of glasses could be looked for.

Although the second factory was established primarily for the purpose of making beads, there is nothing to support the legend that beads were made at the first glasshouse. It is true that England was importing glass beads from Venice in 1608, but the production of goods suitable for trade with the Indians apparently played no part in the plans for the first venture. Resources were available which would permit a product to be manufactured that was in great demand in England. The men who were sent over to start this industry would probably not even have known how to make beads, and certainly could not have produced them in competition with the highly specialized bead industry of Venice. Furthermore, native ingredients, as the Italians learned, were not suitable for making beads, and it was not part of the scheme of things in 1608 to bring raw materials from England to be fabricated in the new land that was supposed



ANY BOTTLES MADE AT THE JAMESTOWN GLASS FACTORY WOULD PROBABLY HAVE BEEN LIKE SOME OF THE TYPES SHOWN HERE.



IF DRINKING GLASSES WERE MADE AT JAMESTOWN, THEY WOULD PROBABLY HAVE BEEN SIMILAR TO SOME OF THESE.

Several types of drinking glasses fit into the picture. Although not necessarily so, they would probably all have been a one-piece proposition, that is, without separate stems and feet being added while the glass was being fashioned. Some might have had solid, flat bases, while others could have been made with raised, hollow bases.

Building the Glasshouse

AN archeologist does not dig just for the fun of it, nor is he simply a relic hunter. After the excavating is finished and all the related studies completed, he must interpret his findings. The things that interest and concern us most in connection with glassmaking at Jamestown are what the glasshouses looked like, how they operated, and what was made in them.

Archeological evidence points to the conclusion that the Italians repaired the earlier furnaces without material alteration, and operated with about the same facilities as those used by the first glass workers. Evidently a new shelter was built over the furnaces, but it was probably not much different from the earlier one. Certainly it was crudely built, for the records tell of its being blown down by a windstorm. Actually there is no absolute proof that Captain Norton located his glasshouse on the site of the first one, but, in view of the highly suggestive archeological evidence, it seems to be a sound assumption. At least we have no reasonable alternative until, or unless, further historical or archeological evidence is discovered.

Although there are no descriptions or pictures of the Jamestown glasshouse, we are aided in our conjectural reconstruction in knowing something about the facilities used in glassmaking in Europe at that time, what was made, and how it was made. We benefit, too, from the conservatism of glassmaking. Even the furnace described by Theophilus about 1000 A. D. was similar, for the most part, to one of the two types in use in England six centuries later. In fact, many of the steps in producing handmade glass have not changed even to this day. Our final picture, therefore, of what the glasshouse looked like, how the furnaces were built, the tools and articles used in the factory, and how the glass was melted and fashioned is probably correct in the main, even though the archeological and documentary evidence seems meager.

The most important consideration in starting a glass factory was the availability of an adequate supply of fuel. There was plenty of fuel in Virginia in 1608. Accounts tell of the great

forests of oak, pine, black walnut, ash, elm, cypress, white poplar, cedar, and other trees. Of the wood near Jamestown suitable for glassmaking, oak was by far the most prevalent, and the supply must have appeared unlimited to the colonists.

An adequate fuel supply was not the only consideration in picking a location for the glasshouse. Important, too, was a site close to the shore of the river, for the colonists had to rely almost entirely upon water transportation. A factory site on Jamestown Island, as desirable as it might have been from the standpoint of transportation and safety from Indians, was not feasible, for the available high ground was being cleared and planted, and it would not have been long before the securing of fuel would have been a problem. The location chosen was about as safe and convenient as any spot that could be found on the mainland, and was on high enough ground to be above normal high tides.

Having selected a site, the first task was to build the "howse with all offices and furnaces thereto belonging." We can visualize a scene, then, in late October with workmen digging a well, others unloading boulders from a barge, possibly one of those referred to by John Smith as an open barge "of two tunnes burden," while others, including the "Dutchmen," were working on the shelter over the area marked out for the glasshouse. Possibly one or two crude huts were being built nearby for the glass-workers to live in.

Just what the factory building looked like we can only guess, for no archeological information concerning it was discovered, other than its overall size, approximately 37 by 50 feet. Nor do we have any good information as to what such buildings looked like in England in that day. Engravings picturing the interior of glasshouses of a century later show simple, wood-framed, factory-like structures. An old print, probably dating from about 1500 A. D., shows a plain shingled roof supported on corner posts, with no covering on the sides. The Jamestown structure could have been of framed timber design, with simple truss roof, as commonly built in England at this time for barns and other large wooden buildings. On the other hand, with an abundance of large trees at hand, the unique method known as "cruck" construction, might well have been used.* In this type of construc-

*This method was used in the reconstructed working model (see THE GLASS-HOUSE TODAY, pages 53-54).

nizable as such. Paintings are of little help except to show goblets and bottles. Drawings for illustrations in books are a better source, and from them we find bottle shapes and various pieces of laboratory equipment.

Probably most helpful in this connection are the results of excavations at English glasshouse sites of the same period as the first Jamestown venture. They were producing, for the most part, a range of goods comparable to what we might expect the Jamestown factory to have made. What effect the Jamestown workers having come from northern or central Europe is hard to say. We can assume that they followed the general European *Waldglas* (green glass) tradition, but, regardless of their background, the products they made at Jamestown would have been dictated by the customers' demands, and the customers were certainly to be Englishmen.

All factors considered, it would seem most probable that the articles the first group set out to make would have included nothing more complicated than window glass, bottles and vials, and simple one-piece drinking glasses. Window glass would appear at first glance to be one of the most likely products. When cut and packed, or even packed in its original blown sheets, it occupied relatively little space and could be shipped with much less danger of breakage than bottles or drinking glasses. They might also have considered the possibility of disposing of some of it right in the colony.

Of the "hollow ware," bottles and vials would have been the most likely product. They were in great demand at that time for almost every conceivable use, especially in pharmaceutical and medical fields. Bottles, too, were beginning to supplant earthenware and metal containers for the storage of all sorts of liquids in homes and shops. Many contemporary illustrations show globular, long-necked bottles, presumably used for spirituous drinks, oils, and other household liquids. Small bottles, or vials, were used for perfumes and for numerous pharmaceutical purposes. Some of the types of bottles and vials of the early Jamestown period are shown in the accompanying drawing. Possibly no bottles were ever made at Jamestown, but if they were, they would have looked like some of these.

ground. Even if the beads had been cut and finished elsewhere, fragments of the glass tubing would be found. More convincing, however, is the fact that there is no evidence of the melting of colored glass, with one exception. A very small pot, no larger than a chemist's crucible, was found in the main furnace ruins, and on its inside surface is a thin coating of blue glass. This may have been a small-scale experiment by the Italians to work out a suitable bead glass formula. It would have been too small a quantity to have been used in drawing out a bead tube, and seems much more likely to have been for special colored glass to be used in some sort of applied decoration. This was a technique with which the Polish glassmakers would almost certainly have been familiar, so we must consider the possibility of its dating from the first factory.

If the Italians only puttered around trying to produce a glass suitable for clear drinking glasses and colored glass for beads, which the evidence now suggests was the case, what was made by the first workers with their "common green" glass? One clue is consideration of what sort of objects were being made with this material at that time. Merret, the first Englishman to write at length on glassmaking, lists many uses to which glass was put, among which the following might have been made from "common green" glass:

> In domestick Affairs it makes drinking Veſſels, infinite in Faſion, Colour, Largneſs
> Bottles and Veſſels to keep Wine, Beer, Spirits, Oyls, Powders
> Diſhes to keep and to ſerve Sweetmeats
> Glaſſes to meaſure Time [hour glasses]
> Sleek-ſtones for Linnen [linen smoothers]
> Windows to keep us warm and dry, and to admit Light into our Dwellings
> Tubes and Syphons and other experimental Equipment

Such lists furnish a clue as to the things glass was used for, but they do not tell us what these articles looked like. One could reasonably assume that this information could be found in museum collections and from contemporary paintings and drawings. These sources, however, are not as fruitful as we might expect. Practically no specimens of the plain, utilitarian wares from that period are to be found today, or, at least, none that are recog-

tion, the basic framework is composed of curved or bent tree trunks, joined at the top and supporting a heavy ridge pole. This framing, which resembled a Gothic arch, carried the rafters and bracing, to which was attached the thatched roof. Any solid walls below the low eaves would have been wattle-and-daub construction. Although the use of this method had largely died out in England by 1608, due to scarcity of suitable timber, it is known to have been employed in constructing the chapel in the first fort. In any event, the roof would have been thatched, probably using reeds from the nearby swamps. Although it was not imperative that the building be enclosed, the two sides facing the river would likely have been covered to provide protection from the cold winds and rains that sweep down the broad James at this exposed point. This windbreak may have been no more than a covering of bark, fastened to poles attached to the main framework. There would have been no need for windows or doors, but even air-conditioned as the building was, openings would have been left in the roof to let the smoke and heat escape.

With the large shed completed, the well dug, and a good supply of boulders delivered, the workmen then set about to build the furnaces. The walls of the main working furnace had to be thick to conserve heat, and the vaulted dome over the melting chamber would be built as low as possible to deflect the flames down close to the tops of the melting pots. The sieges on which the melting pots sat were exactly one foot above the floor of the fire chamber, but their length and breadth could not be determined from archeological remains. The furnace ruins excavated at Bishop's Wood in England had sieges the same height, and approximately 3 feet long by 16 inches wide. This provided room for two regular sized pots on each siege. From the overall size and shape of the Jamestown ruins, we can assume that the interior construction was similar to the Bishop's Wood furnace. Externally, the furnace would have had the general appearance of an Eskimo igloo.

Openings were left in the walls of the furnace at the proper height for the glass workers to have access to the pots. At Jamestown, these working holes were made by setting prefabricated pottery frames into the wall as it was built. There is no way of telling how many of these working holes there were, but available evidence suggests four; that is, one for each pot. For one thing, with the very thick walls required by the available

CONJECTURAL RESTORATION OF INTERIOR OF THE JAMESTOWN GLASSHOUSE.

Bottles and Bull's Eyes

WHAT was made at the Jamestown glasshouses? The answer, if one believes what he reads, ranges from "nothing to speak of" to "thousands of beads." The correct answer, which we will never know, must lie between these two extremes, and probably closer to the "nothing to speak of" estimate.

Documentary evidence reveals almost nothing. It would suggest that the first group made a few "tryals" to convince the homefolks that the enterprise was functioning. If one were inclined to pay attention to promotional literature, great quantities of beads and other glasses are indicated from the second venture. But the later accounts quite definitely suggest that the Italians may well have produced nothing whatever.

Archeological evidence contributes little more. It does show, however, that considerable glass was melted and fabricated. It shows also that all of it was "common green" glass. The Italians would almost certainly have tried to make clear glass (*cristallo*), and that fact may well explain the reason for the failure of the second venture. Captain Norton and his Italian "gange" came over with the intention of making "glasses" and beads. "Glasses" would probably have meant drinking glasses, presumably of the fancier variety. For beads, they would have needed colored glass.

We must choose, therefore, from the following alternatives: (1) The Italians were unsuccessful in producing any glass whatsoever, except some experimental batches; (2) Any objects they made were also of the "common green" glass; (3) The site of their factory was elsewhere and the remains we have excavated represent only the first venture. There is not space here to present all of the arguments, *pro* and *con,* although some of them have been indicated briefly. I believe the evidence to date, however, favors the first of these three possibilities.

Certainly if beads had been made at this site some evidence would have been left. At least one or two beads, out of the thousands allegedly made, would have been dropped on the

building materials, it would have been awkward, if not impossible, for two pots to have been reached through a single hole. The best evidence, however, lies in the frames themselves. The fragments recovered represent six frames, four of which are different from the other two. Parts of two specimens of the first type were found in the refuse pit where rubbish from a furnace had been dumped, and we can assume, therefore, that the four similar frames were used in the first furnace. Presumably when it was rebuilt by the Italians, new frames were made to replace those that could not be reused.

These frames were made of similar materials to the melting pots, and tests show that the four, which probably belong with the first furnace, were not made of local clay. They were undoubtedly brought from England, along with a supply of pots and the glassmaking tools. These frames, formed in a single piece, were about 1 ½ inches thick and made to fit an opening in the furnace wall about 9 inches square. The circular opening in the center of the frame was about 7 inches in diameter. The position of these working holes in the furnace wall can be estimated closely from the level of the glasshouse floor, the height of the sieges, and the height of the melting pots.

There was no chimney in the furnace, for it was important that the flames and combustion gases be drawn around and over the melting pots. The working holes would have served as the principal draft flues, although it is possible that additional flues in the form of small, irregular ports, may have been provided in the crown of the furnace. Such ports, as well as one or more of the working holes, could be blocked off as required to properly control the draft. In addition to serving as the access to the molten glass, the working holes were also used by the glass workers to reheat their glass as it was being formed.

In most furnaces of that day, the working holes were made large enough to provide a means of replacing broken pots. Such openings were normally closed down to a small size by a temporary filling. The construction limitations at Jamestown, however, where rounded boulders, rather than cut stone, were used, made such a scheme difficult. Moreover, the stone spalls fused to many of the working hole frames show that they were set in solid stone openings. Also, their fragile nature would not have permitted recurrent removal. The problem of replacing broken pots was solved, as it was in the Bishop's Wood furnace, by

providing a large opening at the back of the furnace. Normally this opening was kept blocked up with clay and rubble, just as found when excavated. When a pot went to pieces in the furnace, this temporary filling could be dug out and the pot replaced without having to cut down the heat of the furnace materially. Then, as today, replacing broken pots was one of the most troublesome problems of glassmaking.

The matter of determining what the three small furnaces were used for and how they were constructed is more difficult. Neither old records nor excavated remains in England help us much. Descriptions of glasshouses of that period refer to the various operations requiring separate furnaces or ovens, but the descriptions are usually too general to be of any help in reconstructing the Jamestown ruins.

First of all, a small furnace, or kiln, was needed for firing the new melting pots. We must assume, of course, that a supply of pots was brought over when the glass workers first came, for the factory was operating within a month or two after they arrived, far too brief a period for making even a single pot. But glass pots had a relatively short life and the workers would have taken steps at the very outset to provide for future needs. Structure B seems a likely candidate for the pot kiln, for it was smaller than the other two auxiliary furnaces, although its walls were heavier, suggesting a taller structure. There was just enough room at the back to have provided a platform on which a single pot could have sat. The pot furnace was also used to preheat pots before putting them in the working furnace, and the location of Structure B was particularly convenient for this operation.

An important operation in old glasshouses, later discontinued, was the process known as "fritting," involving a preliminary fusion of the raw ingredients before they were placed in the melting pots. The mixed materials were placed on the floor of a small furnace and subjected to just enough heat to produce a partial fusion without actually melting the glass. It is suggested that Structure D served as the fritting furnace, for the following reason. The square stone platform outside and at the back of this furnace shows evidence of having been subjected to heat after being laid in place. The only reasonable conclusion is that the hot frit was shovelled or raked out of an opening near the back of the furnace onto this platform. If this interpretation is correct, then Structure D would have been a low, arched, tunnel-like

structure, probably having a raised stone floor at the rear and an opening between this ledge and the square platform outside. There may have been one or more draft holes in the top of the arch. It is by no means certain that this preliminary fusion of materials was employed at Jamestown, although the platform at the side of Structure D is difficult to explain otherwise. It is more likely that the raw ingredients were placed directly into the melting pots, as will be described later.

Another requirement in all glasshouses is a means of tempering or annealing the glass articles after they are fashioned. This was usually done in a separate furnace called a "lehr" or "leer." Structure C was probably used for this purpose, as was also Structure D when it was not being used for "fritting." There would have been a low platform, or ledge, at the back of the fire chamber, with an access opening on the side. Like Structure D, it would probably have been a low, tunnel-like affair, possibly with draft openings in the crown of the arch.

The suggested reconstruction of the furnaces, as described here very briefly and portrayed in the accompanying drawings, does involve some guesswork, but it is probably very close to the original. As fragmentary as the archeological ruins are, we appear to have at Jamestown the most complete picture available today of a seventeenth century glass factory.