The origin and development of early manufacturing art always provides some interesting speculation, and archaeologists, through excavations and studies of hieroglyphics and cuneiform texts, are adding facts to the speculations, so that slowly we are developing useful knowledge of the historical appearance of materials. Glass has always been accorded a prominent place in such studies, possibly because it represents the conversion of similar familiar materials into products with new and distinct physical characteristics. Metallurgy, which appears to have preceded glass, has its starting point in the working of native metals such as copper, gold, and meteoric iron; and, after the metal working technique had been developed, there followed the conversion of ore into metals. Until recently the discovery of glass was attributed to the Phoenicians; and the blue beads of Phoenician origin, found in Druidic mines in England, and the aggrí beads of the Ashantis, in West Africa, are very similar to beads discovered in Phoenician excavations, and not unlike Egyptian beads of the 18th dynasty. They may have been a medium of barter, like the red handkerchiefs and muskets of a later age. It is, of course, well known that in the third century A.D. Egyptian glass-makers resorted to the moulding of glass in the production of standard weight for gold coins—a practice which was later copied by the Arabs, and which led to a remarkable system of weights. In the eighth century there was a sudden outburst of accuracy in the production of weights, and three samples have been unearthed which agreed to within a two-hundredth part of a grain, and this notwithstanding the weights have been preserved for well over a thousand years. This emphasises the permanence of glass as a material for the production of weights, and the usefulness of the fact that nothing could be taken away without it being revealed. They bore the stamp of the Governor who ordered them, as well as the brand of the maker. From the maker's brand it was possible to trace a whole family of glass-makers for 150 or 200 years without a break. The nationality and location of the first glass-workers have not been definitely placed at the present time, for the reason that our views of Egypt as the birthplace not only of glass, but of pottery, copper, tools, bronze, etc., are subject to modification through explorations and discoveries of civilisations which seem to have existed in Asia Minor prior to
the first dynasty in Egypt. Ancient Sumeria, Babylonia, Assyria, Elam, and Mesopotamia now rival Egypt as happy hunting grounds for archaeologists; and, while many years of arduous labour in excavating and properly co-ordinating the discoveries will be required to fit these ancient peoples into their correct places in history, the evidence is already at hand to indicate the possible existence of a civilisation ante-dating the earliest Egyptian records. We do know that an early civilised race, the Sumerians, came out of Southern Central Asia and settled into what was later Babylonia and part of Assyria prior to the founding of the first Egyptian dynasty. These Sumerians, unlike the contemporaneous Egyptians, were familiar with and used the potter’s wheels. They produced pottery which ranks among the finest ever made, built canals, used pictographic writings, and even at that early date gave evidence of a still earlier history of art and manufactures. So far, Sumerian glass has not been discovered, but it is not an indication of its non-existence, for the total of the Sumerian excavation is small, and much remains to be uncovered. It is interesting to note that Sumerian influences can be traced in pre-dynastic Egypt. The motif of serpent-headed monsters with interlaced necks is Sumerian, and appears also in the earliest Egyptian art. Cylinder seals and linear pictographic writing, as found at Susa, the ancient capital of Sumeria, are also found in Egyptian tombs at a slightly later date. The Sumerians have a place in this paper because Sumeria once embraced Assyria in its empire; and the 650 B.C. glass factory of Nineveh, while it was operated by Assyrians, may have owed the wonderful state of development of its glass manufacturing art to this much earlier people. Glass beads are common objects in the tombs at Ur, which date back to about 2500 B.C., and some day the cycle of historical development may enable us to fill in the gap between 2500 B.C. and 650 B.C., and between the beads of 2500 B.C. and the first discovery of glass.

Explorations at Nineveh have yielded much useful information on the status of civilisation in Assyria, and there is a very complete picture of the glass factory of Nineveh as it existed in 668-626 B.C. But to the scientific worker nothing has an interest equal to the inscribed cuneiform tablets discovered there and recently translated by an Englishman, Mr. R. Campbell Thomson. The tablets are factory records, giving the complete details for preparing fritts and glasses, colouring agents, fuel for the furnaces, and the methods of starting up a furnace.

Among the materials used at that time for colouring the various compound glasses were antimony sulphide, arsenic trisulphide, gold, oxide of copper, cinnabar, oxide of manganese, and ferric oxide.
The glasses produced, in addition to being crystal and opaque, seem to have been white, blue, lapis blue, pale blue, violet, black, brown, green, coral red, red purple, opaque red, yellow, and a magical glass which unfortunately is in incomplete form. The quantities specified are sometimes in parts and sometimes by weight; so from the weight formula we can deduce something of the size of the operation. The crystal glass formula calls for 20 mana of sand, one talent of alkali, 2 mana of saltpetre, 10 shekles of chalk, 6 shekles of oyster shell, and one mana of oxide of tin, which together amount to a little over 90 lbs. Another fritt is also melted in 90 lb. batches; so, considering the problem of attaining a sufficient temperature with a wood fire, the batch size can be said to at least equal the probable facilities. The various coloured glasses made by re-melting the fritts with additional colouring agents were worked in 1-4 lb. batches, possibly because the finished coloured glass articles were all small in size, a view borne out by the predominance of small glass articles discovered in the excavation, and the very rare occurrence of larger pieces such as the well-known Sargon Vase. The description of the furnace and the ceremonies connected with putting it into operation are sufficiently interesting to justify reading this part of the translation in full:—"When thou settest out the (ground) plan of a furnace for minerals, thou shalt seek out a favourable day in a fortunate month, and thou shalt set out the plan of the furnace. While they are making the furnace, thou shalt watch them, and shall work thyself (?) (in the house of the furnace); thou shalt bring in embryos; another (?) a stranger, shall not enter, nor shall one that is unclean tread before them; thou shalt offer the due libations before them; the day when thou puttest down the mineral into the furnace thou shalt make a sacrifice before the embryos; thou shalt set a censer of pine incense, thou shalt pour Kururna-beer before them. Thou shalt kindle a fire underneath the furnace and shalt put down the mineral into the furnace. The men whom thou shalt bring to be over the furnace shall cleanse themselves, and (then) thou shalt set them to be over the furnace. The wood which thou shalt burn underneath the furnace shall be styrax, thick decorticated billets which have not lain (exposed) in bundles, but have been kept in leather coverings cut in the month of Ab. This wood shall go underneath thy furnace." From the details of materials used and varieties of glass produced we have direct evidence of the excellent state of the glass manufacturing art in Nineveh two thousand five hundred years ago, and we can only speculate on the years which must have intervened between the first discovery of glass and its development to the stage represented in those tablets. We certainly cannot use the pro-
gress from Nineveh to our own time as a measure of probable time requirements, as we should then have to place the initial discovery far beyond the historical period of our world’s history.

Wandering a little more quickly from the discovery of glass, we find that, in the first century B.C., the Egyptians began with the ordinary blowpipes. It is known that the Egyptians were early in the field as glass-makers of skill, and that the Romans copied their product, quickly achieving a higher, distinctive phase of beauty. Romans used glass for more domestic purposes than we do to-day. Lacking fine porcelain, they fashioned glass objects to take its place for household use. The famous Portland Vase, which Wedgwood so faithfully copied, is of glass (cameo). It was found in a sarcophagus just near Rome in the 16th century, and is supposed to have been made in the time of Antonius, 138-161 A.D. This cameo glass is made by applying numerous layers of glass on top of the original foundation, then cutting away the outer coat to form the decorating pattern.

It was not until the 15th century B.C. that Venice became the leader in the manufacture of glass, eventually monopolising the industry. A small group of men, pursued by religious fanatics, sought refuge on the cluster of Oozy Islands that were tabooed by all other human beings, and, by virtue of idealism and hard labour, made of them the glory and wonder of the world. The fragile quality of Venetian glass and its airy designs reminds one of bubbles and lakes, and its soft colours suggest the misty rainbow. Glass-making became an integral part of Venetian life, the artists working at first in a small way with little individual furnaces. They had extraordinary advantages of manufacture, abundance of fine sand, maritime plants yielding alkali, and isolation precluding competition. The existence of these natural advantages contributed to Venetian supremacy, but it is known that in the days of her triumph Venice was not content with home products, and sent boats to the classic river Belus to gather the sand celebrated by many pagan writers. Later on, becoming jealous of the prying world, Venice removed her glass workers to the easily guarded island of Murano, where the imprisoned artists brought their art to its supreme height. They could not escape, as the island, separated from Venice by an arm of the sea, made it almost impossible. In those remote days Venice was a proud republic, and its aristocracy built its villas on the island of Murano, making it a veritable Garden of Eden. Here the glass-workers, surrounded by the most highly evolved beauty of the world, honoured recipients of many privileges, found life worth while despite loss of liberty. The fact that intermarriage between
the nobles and the daughters of the glass-workers was tolerated at that time shows the concessions that were made to the workers in this important industry. However, these imprisoned geniuses once fled in a body and made a hurried trip over the Continent, even venturing into England, where they were cordially received by Henry VIII., who acquired from them a large collection of Venetian glass, which is now in the British Museum. They were allowed to set up a furnace in the hall of Crutched Friars. The king advanced them money. Wishing to preserve their secrets, the Venetians at home passed a law ordering all glass-blowers to return. Those in England replied that they were held prisoners until they repaid the advance money. They eventually returned, but, before doing so, the English learned much from these Muranians; but, probably, the latter could have taught the English much more.

Venetian glass-workers were constantly assisted by the master painters of the period, who gave designs and suggestions for the development of the industry. Their product was frequently reproduced in paintings of note. We find it worthy of the brush of Tintoretto and Titian, and it is from these paintings that modern Venetian glass-workers study the old designs. At the beginning of the 17th century Murano began to degenerate, and some of its master artists escaped to Northern Europe, establishing glass factories far from their native land. Shortly after, the fall of the Venetian Republic completely destroyed the glass industry in Venice. For 300 years it lay dormant. Then at the end of the 19th century the Renaissance of Murano glass began. But it was not until after the World War that, with the collaboration of foremost artists, there arose the nucleus of the excellent Murano glass of to-day. The modern Venetian glass-workers have recaptured the all but lost beauty of the early masters, and are reproducing blown glass that is in every way worthy of its prototype. The distribution of Venetian glass was more general, and its use was more varied than is generally supposed. Every Royal table of the middle ages was decorated with the Venetian. Every home of wealth had its treasured pieces. Perhaps that explains why the glass industry lagged behind in other countries, because for centuries Venetian models were copied everywhere. In the 14th and 15th century the Saracens made glass of great beauty, and it was about this time that the Germans began to manufacture glass; but, at first, it was coarse and heavy, and completely lacked the charm of the Venetian output. India, Persia, Spain, Assyria, and Greece all made glass of distinction at various periods; but in the long run France, England, Italy, Germany, and the Low Countries achieved leadership and still retain it, although America is not far behind and is gaining ground all
China has always excelled in every branch of ceramic art, but paid little or no attention to the making of glass until the 18th century. To-day they produce glass of the greatest beauty and most intricate workmanship. Often their objects of clear glass are painted on the inside with landscapes, birds, etc., and the biblots they cut from solid blocks of glass crystal or coloured quartz are not only delectable, but so costly as to be beyond the reach of most of us. In the 13th century the glass industry was introduced into Bohemia from Venice, and soon became of vast importance because of the clear crystal glass that was very similar to the Venetian models from which it was copied. Under the fostering care of Emperor Ferdinand III. it reached its heyday in the 17th century, and it was then that the elder and younger Schwanharts of Nuremburg turned out their masterpieces.

The cutting of glass was really derived from the art of rock crystal cutting, which was imported into Italy after the conquest of Constantinople in 1453; and then passed on to Nuremburg, and from there to Prague. Rudolph II. (1552-1612) was a chronic recluse; but he made it his business to invite to his castle at Prague all the celebrated lapidaries of his time, and chose a few whom he placed at the head of the glass-works that he himself founded. It was in the latter part of the 17th century that the renowned Ruby Glass made its appearance, brought to perfection by Johann Kunckel in his factory at Potsdam. Much Bohemian glass, both modern and ancient, is exceedingly heavy, because the style of decoration, deep cuttings, would be impossible otherwise.

The story of glass in England began in 675 A.D., when the Abbot of Wearmouth sent to France for artisans to make glass, but it was not until 1350 that a glass-maker of Chiddingfold managed to supply enough flat, colourless glass to put in St. George’s Chapel, Windsor, and the chapel in St. Stevens, Westminster. By 1698 it is recorded that there were 88 glass factories in England, although the most important period in the industry did not come until the 18th century. At that time there was great development in all branches of glass-making; flint glass was perfected, and the art of cutting reached its height of beauty. After window glass ceased to be a novelty, there was a rage for mirrors and drinking glasses, only at first imported from Venice.

It is impossible to enumerate the different types of lovely English glass; but perhaps we are most familiar with that made in Bristol, with which we always associate the entrancing shade of sapphire blue glass, never equalled elsewhere. In Ireland the exceptional quality of the glass produced at Cork and Water-
Origin and History of Glass.

Ford fixed the attention of the world upon those places as the source of the best glass in that country. The production of both these factories belonged in the category of flint glass—that is, glass in which one of the alkaline bases is lead, as distinguished from the glass with an alkaline base of lime. Flint glass is softer and more lustrous than glass with a lime base, and lends itself more readily to the decorative process of cutting and engraving. True Waterford glass has a peculiar bluish green tinge, not noticeable unless placed where the light falls through it. This subtle trace of colour is one of its greatest claims to charm and distinction. It is usually heavy and thick, to make possible the profuse cuttings with which it is usually ornamented. The Waterford factory operated from 1729 to 1851, but it was not until 1740 that what we know as cut glass was made in Ireland. Much of the cutting was done away from the factory at home by men who had cutting sheds, which accounts for the variety and individuality of the work.

As early as the 6th century the French were notable workers in glass, and made many improvements in the process, importing Greek workmen for the purpose. Normandy was the first country to grant privileges to glass-workers, and Charles V. gave them exemption from taxes. In 1665 a mirror factory was opened in France, and men were brought from Venice to teach the French how to make mirrors. In his eagerness to render the home-made product fashionable Louis XIV. had mirrors set in his coach, and he lined one of the galleries of Versailles—the famous "Galleries des Glaces." Within their glittering walls many great moments of history have been enacted. Very little old French glass is to be found nowadays, and it is hard to understand why even collections of it are few and meagre. One of the modern Frenchmen, Rene Lalique, has done most to rejuvenate the art spirit of his country. Eminent as an architect, maker of jewellery and worker in iron, he at last shows glass as his medium of artistic interpretation, and has stamped it with his individual touch of genius. He uses but little colour, his designs are simple, he never duplicates them, and his whole purpose seems to bring out the pure crystalline qualities. He excels in the portrayal of nude figures, and each of his creations has the quality which can only be expressed by the French word, "raffine."

In Sweden the oldest factory of importance, founded in 1741, produced a long line of skilled workmen; but, until ten years ago, there were few artists with creative ideas, capable of "thinking in glass." The necessary combination of technique and talent was supplied when Eckman, of Gothenburg, bought the tiny glass work at Orrefors, which, lost to the world in the deep forests of Smaland, had for many years achieved
only a trifling production of ink bottles and window glass. But, here, two Swedish artists, taking the nude as the subject, produced works unexcelled in beauty, and reminiscent of the cut plaques of rock crystal of the Italian Renaissance and of the intaglios of the 16th century sculptors.

Glass-making was America’s first industry. In 1607 enterprising colonists of Virginia started a small bottle factory about a mile from Jamestown, and two years later a shipment of glass bottles was the first export therefrom. After this success glass-blowers were brought from Italy, and another factory was established for the purpose of making beads to trade with the Indians for furs. During the century other attempts were made to produce glass, amongst those successful being those of Baron William Henry Steigel, who brought skilled workmen from Europe to Mannheim, in Pennsylvania, and there made richly coloured glass that lost nothing in comparison with the finest wares of Bohemia. The fires were lighted under the pots in his first glass house in 1765, and the output was chiefly bottles ranging in size from gallon jugs to small perfume bottles. These blue and amethyst toilet bottles are exquisite in colour, and show some of his best designs, notably the diamond pattern, and the four diamonds within a diamond.

Glass-making, as a whole, covers a very, very wide range, each section of which is more or less a separate industry. Such are the making of bottles or containers (this includes containers of all kinds), window glass, plate glass, pressed glass, cut glass, and optical glass. It is impossible to embody them all in one paper; so this paper will be confined to giving an outline of one of our local industries—that is, the making of bottles and containers. In the making of containers glass is playing a most important part. It is becoming more important that the excess food production of one period be preserved for the use of another period, and that the great production in one area be preserved for transportation to another area, where there is no such production, or less than that which is required. Glass makes this type of container supreme. It gives nothing—it takes nothing. That which is consigned to its care is delivered back uncontaminated, and not robbed of any of its qualities. A glass container conceals nothing, requiring only the best to be packed in glass. Australia is rapidly making use of glass to preserve her almost inexhaustible food supply, and is venturing into foreign markets with splendid results and reports. This phase of the glass industry, i.e., the making of bottles and containers, has been carried on since the time of the Egyptians until the latter part of the last century with very little alteration. The whole of the work was done by
hand labour, and it was not until the year 1888 that, after sundry attempts, a machine was devised in England for the production of containers. Since then, of course, the improvement in machinery for the actual bottle-making has made rapid strides, until to-day we can say that this industry embraces some of the most complicated and cleverly designed machines in the world. At the same time, all the methods of handling and melting the raw material have likewise become mechanical. When we consider that the generation in which we live has, in the space of a few short years, accomplished such mechanical improvements, it brings to our mind forcibly the high standard of the era in which we live, and this branch of the glass industry brings it to our mind, possibly more forcibly, than any other industry which had such an early origin. In the modern glass factory, all the products which go to make glass are melted in a huge tank which, in this instance, is fired with gas. These tanks can also be fired with oil fuel or electricity. The coal is packed from bunkers into an overhead hopper by means of an ordinary steam crane and grab bucket, and from this hopper the coal passes through a crusher, and is elevated into the gas producer bunkers, and from there it is fed down chutes over a feeding mechanism, from which it falls into the gas producer itself, which will gasify from 2500 lb. to 4000 lbs. of coal per hour. The gas passes from the producer into a dust collector, and from there along a steel flue lined with insulating bricks and firebricks to the down cast of the flue. From there it passes through a reversing drum, and from then on to the furnace. The furnace is of the regenerative type, and is "reversed" once every hour. These glass furnaces are made from refractory material, and are usually about 40 ft. long x 20 ft. wide in the melting end, and about 20 ft. wide and 15 ft. long in the refining end, the depth of the glass being about 3 ft. 10 in. deep. The gas is fed through side ports, each side alternately being used either as an inlet for gas and air or as an exist for the products of combustion. The products for the making of glass are stored in overhead silos, each containing roughly about 200 tons of material. Underneath, running on rails, is a combined travelling mixing machine and weighing machine. This weighs and measures each ingredient which it takes from the hoppers; and, by means of its rotating drum, mixes the material thoroughly, and shoots it into an elevator, from which it is conveyed into hoppers situated at the feeding end of the tank proper. The material is fed into the tank by means of a spiral screw, which is regulated to suit the amount of glass which is being drawn out at the other end. As the raw material floats forward into the flame, it is gradually melted until the whole becomes a viscous mass. The melting
end of the tank is divided by a partly submerged bridge, at the bottom of which is a small hole, about 10 in. x 12 in., through which the melted glass flows into the refining chamber. From there the glass flows through holes in the front wall into specially designed feeders, which control the flow of the glass, and the temperature is controlled so as to feed uniform charges of plastic semi-molten glass into the bottle-machines situated directly underneath them. The glass is melted at a temperature of about 2500 deg. F.

The author exhibited numerous slides of the works of art in glass mentioned in the text, and also of street lampshades made in Australia, and slides demonstrating the architectural use of glass both for external and internal walls and decorations, including glass bricks and glass tiles.
DISCUSSION

The President said he had noticed that much of the work was in very deep relief. Was that cut away, or partly moulded in the initial stage?

Mr. Simcock said the cameo work was glass laid on and then cut away. The rest of the work was cut entirely from the solid, leaving the figures in relief. If a shape were outlined first in glass the slightest slip would cause the whole thing to be wrong, but all the artists employed the same method, and just expressed their artistic temperament.

Mr. J. T. Noble Anderson said he wished to express his appreciation of the immense amount of trouble the lecturer had taken to convey to members the extreme interest of such work. Every imaginable phase of the subject had been touched upon. It was remarkable that in the short period since 1888 the antiquated methods of glass moulding and working had been replaced by such machinery as Mr. Simcock had shown on the screen. And what would the next 2000 years show?

Mr. J. H. Harvey, A.R.V.I.A., said he had been fascinated by what he had heard; he wished to express his thanks to the lecturer and also to the Institute for having afforded him the opportunity of attending.

Mr. A. E. Hughes, expressing his appreciation, said that the lecturer's survey of the history of the Australian Glass Industry showed that 20 years ago the industry had practically no machinery; but the machinery depicted on the screen was evidence of the wonderful strides the industry was making. It could be seen that articles such as jars, cordial bottles, and ale bottles would recoup the design and manufacture of elaborate machinery.

Mr. WM. Chas. Rowe said he would like to add his thanks to Mr. Simcock for his lecture. It had been deeply interesting, and it seemed almost impossible that the works of art that had been shown on the screen could have been made in glass. It had been said that art was largely a matter of personal opinion, but he could not help comparing the beauty of the decoration of the first vase with those of later make. He remembered, as a lad in his home town in England, a large building where the windows on one side were composed of glass painted black because of the tax on window glass. He was associated with the commencement of the works with which Mr. Simcock was now connected, when they were very small indeed. Therefore he could appreciate the enormous strides that had been made. The bottle-making machine was one of the mechanical wonders of
the world. That portion of the mechanism that transferred the glass to the annealing machine was a beautiful piece of work.

Mr. GEO. LOUDON said he was very greatly interested in the paper. He had not previously realised how much civilisation depended upon glass. To anyone interested in glass-making machinery the Patents Office, where all such records were stored, was a mine of information. From the point of view of complications and beauty of mechanism glass-making machinery stood alone. The specifications revealed the development of the art very clearly indeed.

The PRESIDENT said Mr. Rowe had referred to the beautiful examples of glassware shown on the screen. Those wonderful mechanisms, that had been invented for the mechanical manipulation of such a difficult material as glass, were, to the engineer, also things of beauty, appealing rather to intellectual emotions. Mr. Simcock had outlined many of the uses of glass, and had forecasted that there would still be many further uses for that material. With that he entirely agreed. The use of alloys, having the same co-efficient of expansion as glass, had led to the manufacture of reinforced glass for windows for fire protection and other purposes. Glass, chemically, was a very permanent material, and the cost of its manufacture was becoming less and less, and would be still further reduced if there were more collaboration in the industries in the direction of the conservation of waste heat, etc. In the future glass would have further uses on account of its greater cheapness and increased strength, and he anticipated the application of glass in the direction of pipes for sewerage, gas, and even for conveying water.

Mr. G. O. SIMCOCK, in reply, said that quite a lot of glassware was made entirely by hand. A large number of lamp shades, and also small lines, even to the common container, were hand made. But in the course of time everything would be made by machinery. As to the use of glass for pipes, for 12 months they had had a machine for that purpose. The matter was still in its experimental stage, but they hoped shortly to place on the market glass drain pipes, etc., at a price that would compare with the earthenware article, and that would give more effective service.
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