

ORIGINAL PAPERS AND DISCUSSIONS

ANCIENT AND MODERN METHODS OF GLASS MANUFACTURE*

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ABSTRACT

Progress in appliances and methods of glass manufacture since 1877.—The article contains a brief summary of the personal experiences and observations of one who for over forty years has actively participated in the development of appliances and methods used in various branches of the glass industry.

It must not be supposed, because of the subject of this paper, that it is necessary or that it is the intention of the writer to review the glass business and its methods of manufacture from the time of its discovery. That would indeed be tiresome and unprofitable, because there are many publications in which the discovery and ancient history of glass manufacture may be read. It is intended only to cover the personal experiences and observation of the writer for a period of a little over forty years of actual participation in the development and improvement of the appliances and methods used in the various branches of the glass industry. A careful comparison of the equipment and processes in vogue during that period will amply justify the use of the word ancient in the title.

In reviewing the progress made in the development of the various appliances and methods employed in the manufacture of glass, it is difficult to avoid indulging in personalities and the mention of many eminent men, leaders in the promotion of the industry, some of whom are still living, and, inasmuch as this is intended to be a review of the improvement in methods of manu-

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facture rather than a history of the business, it will be impossible to mention a great many of the prominent and capable men deserving of a permanent record in the history of the glass business. In the preparation of a full and complete record of development and improvement in the equipment and processes employed during this period, the difficulty encountered is not the discovery and recital of sufficient crucial and epoch making discoveries that are of interest today, but rather the impossibility of covering the subject completely in the brief manner necessary to avoid being too voluminous and tiresome.

Making Glasshouse Refractories in Early Times

The writer began his business career in 1877 with his father and uncle and one or two others composing the old firm of Thomas Coffin & Company, which had started in business in 1860 as manufacturers of glasshouse pots, furnace blocks and other refractory materials required by the glass trade of that time. This company was the only one engaged in that line of business, but it was the habit of many of the glass manufacturers of those days to make their own pots and refractory materials. Even then the elder members of this company were invariably consulted about the proper dimensions and construction of glasshouse furnaces, of which they had an expert knowledge acquired from a long experience. There was, however, at that time, no such business as furnace building. Thomas Coffin & Company manufactured all of the furnace blocks the trade required in a room 40 by 60 feet in size and had only one kiln, 16 by 18 feet, in which to burn them. It was the custom of glass manufacturers in those days either to manufacture their own furnace material or to purchase it from this company and then employ two or three of the expert furnace builders, bricklayers of exceptional ability, to do the construction work. Plans and specifications for such work were absolutely unknown, it being the habit to copy some other successful furnace and leave all of the details of construction to the brick mason, after obtaining some advice as to the proper diameter, spring of crown arch, size of the eye or fire box, etc. It was the custom in those days for the pot manufacturer, with a sufficient number of men, to deliver the pots to the glass factory,

place them in proper position in the furnace for preheating or in the pot arch as desired. Participation in this work brought the writer in contact with many of the older manufacturers of that day and gave excellent opportunity for observation. It is a delight and satisfaction now to recall how these real pioneers in the glass industry delighted to explain all of the intricacies of the glass business, including the operation of furnaces, and incidentally to recite how much better they were doing, how much more glass they were melting, than their competitors—a valuable school of instruction for a young man, scarcely appreciated at that time but which today is the source of many fond recollections of eminent and capable men of their time who have long since passed away, and which was the source of much profit in the development of after years.

Early Direct Fired Furnaces

The direct firing type of coal burning furnaces was universally used in those days and, because of the splendid fuel obtainable at a very low cost, there was very little inducement for the investment of capital in fuel saving furnaces. All flint or crystal, both lime glass and lead glass, was melted in covered pots in circular furnaces having a fire place or eye in the center. Many of these were teased, or stoked, through a tease hole in one of the pillars between the pots, from the glass factory floor. Afterwards an improvement was made by the design of a furnace in which the fuel could be pushed from the cave or basement into the eye of the furnace, and afterwards this was still further improved by the use of what was known as the bucket teaser. This was a mechanical device that was placed in the cave or basement immediately below the eye of the furnace. It was charged with coal and by means of gears and mechanical contrivances the coal was pushed up through the center of the fire bed, the grate in that case surrounding the bucket. This proved to be a very efficient, hot running furnace and came into use about 1878.

These furnaces were built of clay blocks for the pillars and crown, similar to those in use today; the eye was lined with burnt blocks of large dimensions, and the benches or sieges were made of bulk clay, similar to that in use at the present time. The

flues were distributed around the outside of the circle, passing through the breastwalls in front of the pots and up into the cone or chimney, over the furnace which supplied the draft necessary for the operation of the furnace.

Late in the seventies John Nicholson, Jr. introduced what was known as the Nicholson gas furnace, which was a modification of a French invention, by erecting one of this type at the works of the Rochester Tumbler Company, Rochester, Penna., and this proved to be a marked improvement over the ordinary type of furnace. It was particularly designed to use a cheap grade of fuel—fine slack coal—by converting it into gas and providing means for its complete combustion in the eye of the furnace. This furnace employed three of the old type Siemens natural draft producers located in the basement of the factory, in which the well known restricted grate area of the original Siemens producer was employed, and the fuel was fed through hoppers on the top of the producers. A continuous distillation of gas was obtained which passed through horizontal flues leading to the eye of the furnace, and the air utilized for its combustion was conducted around the walls of the producers and flues as well as the lining of the furnace eye, finally entering the eye near the bench level, where it met the gas from the producers and an approximately perfect combustion was obtained. The results were very economical, in that a saving in cost of coal was effected, and the temperature of the furnace was maintained more uniformly and at a higher degree, so that the production was materially increased. This furnace became very popular and a large number of them were constructed in the ten or twelve years following this first development.

About the same time, in the late seventies, Mr. J. J. Gill of Steubenville, Ohio, introduced what was afterwards known as the Gill furnace, which was an improvement and modification of the Boetius furnace used in Europe. This furnace was also designed particularly to use a cheap grade of coal—fine slack coal—and employed two producers of rather large dimensions, one on each side of the eye of the furnace in the basement or cave immediately under the bench, the coal being fired through tease hole doors in the front walls. The gas distilled from the coal in these produce:s

passed directly through apertures or ports in the back walls of the producers into the eye. The air for combustion was passed around the walls and crown arches of the producers, as well as around the walls of the eye, becoming heated by induction and absorption and finally being introduced into the eye just above the gas ports below the level of the siege or bench. This proved to be a great improvement over the old type of direct fired furnace and resulted in an increased production because of a higher and more uniform temperature, as well as a reduction in the melting cost because of cheaper fuel.

In the early eighties what is known as the deep eye furnace was developed in New Jersey and was particularly adaptable for the use of the semi-bituminous Georges Creek and Cumberland coals commonly used in that district. This consisted simply of an eye of greater depth than usual for use in flint glass furnaces in which the fuel bed was far enough below the level of the bench or siege to permit the introduction of a secondary supply of air above the fuel bed and in close proximity to the level of the bench, to accomplish the combustion of the volatile gases escaping from the fuel bed below. This was generally operated in a manner similar to the operation of a gas producer for the purpose of liberating the volatile matter and burning it above where it came in contact with the air entering a circular series of ports around the eye, after having been conducted around the walls of the fire bed absorbing such heat as it may by induction through the walls of the eye. This proved to be a very economical fuel burner and one that some manufacturers thought was as effective and economical as either a Gill or Nicholson furnace. This deep eye type of furnace was used extensively in the western bituminous coal district and is in use today in a number of factories where natural gas is not available, and where suitable coal is obtainable within a reasonable cost.

Expansion of the Glasshouse Refractories Business

Owing to the large number of deep eye, Gill and Nicholson furnaces erected within a comparatively few years, the demand for furnace blocks of good quality and special shapes was very much

increased, and necessitated a very large addition to the capacity of the block manufacturers.

In 1878 and 1879 there was an unusual boom in the glass manufacturing industry, especially in tableware and all lines of flint glassware. Idle furnaces were put into operation and new ones were constructed, with the result that the one pot manufacturing company existing at that time could not supply the pots and sufficient of the refractory materials demanded by the suddenly increased business. This led to the organization of the Pittsburgh Clay Pot Company by a number of the glass manufacturers who, for the first time, realized the risk, uncertainty if not danger, of depending upon the one company for their supply of these materials. Since that time the great increase in the business of manufacturing glasshouse pots, furnace blocks and other refractory materials is well known, and it has become one of the largest industries in the country. Glass manufacturers, as a rule, have entirely abandoned the manufacture of these supplies for themselves and depend upon the various institutions engaged in that business for their requirements.

Early Types of Pot Furnaces

In the seventies all window glass and green and amber bottle glass was made in open pot furnaces of the most primitive, direct firing type. They consisted of a square, or rectangular furnace chamber, erected over a cave or basement, the grate extending the full length of the furnace and discharging its ashes into this cave, which was also arranged to supply the air passing through the grate for combustion. The furnaces in the Pittsburgh district, which embraced quite a wide area, in those days were all built of sand stone obtained from quarries at Perryopolis, Pa. The benches or sieges were made of two layers of great slabs of sandstone, provided with wide open joints for expansion. The walls and crown arch were built entirely of the sandstone; the arch being so constructed that, while it was fully 12 inch in thickness, the stones only had a bearing of about 4 inch on the top and an open joint on the bottom of 3 to 3½ inches to provide for expansion, the arch having to rise to such an extent that the lower joints would come together and close after the furnace was heated.

It was the custom in those days for the Porter Brothers at Perryopolis to quarry and cut the stone for all of these furnaces during the period of furnace operation, and ship them so they would arrive in time for the construction of the furnaces during July and August of each year, when all glasshouse operations ceased for a period of at least two months. Porter Brothers, during that time, would erect the various furnaces and have them ready for operation in September, there being no clay material employed except the outside casing to back up the stone lining of the furnace walls. In other districts, such as New Jersey and New York, it was the custom to build the furnaces of unburned clay blocks of a mixture of Jersey sand and German pot clay, and frequently they were simply pounded over a wooden form while the clay was in a plastic state, being cut with a wire into sections to take care of the shrinkage and avoid cracking as much as possible. Many of these furnaces were not provided with any stacks but were constructed in the center of a building with a very high conical shaped roof with a cupola at the top. When the melt was being made all doors and windows were closed so that the draft would pull through the cave or tunnel beneath the furnace, through the grate, and out through the ringholes or flues of the furnace, up through the cavity formed by the high roof. Naturally, this method of firing resulted in an enormous loss of fuel and much smoke and soot. The firing of the coal was through the ends of the furnace and the very best grades of lump coal were used. In New Jersey and some other sections they used furnaces with a forced draft which enabled them to use the semi-bituminous coal of the Georges Creek and Cumberland districts, instead of the highly bituminous gas coal of western Pennsylvania.

Previous to 1880 very little had been accomplished in the introduction and application of fuel saving devices for the obvious reason that the best of fuel in most of the glass manufacturing localities was obtainable at a very low price. Of course, various attempts have been made to operate furnaces that would use the cheap grade of fuel, known as slack coal, which at that time was a drug on the market and was obtainable in abundance at the bare cost of mining and delivery. The Nicholson, Gill and deep eye

furnaces were particularly adaptable for the use of this cheap coal; but, while they reduced the cost by using cheaper fuel, they did not reduce the quantity required in a given time, nor did they in any way reduce the labor or skill required in the operation of direct fired coal furnaces.

Introduction of Regenerative Pot Furnaces

Although the well-known Siemens regenerative type of gas furnace had first been applied to the glass manufacturing business in England in 1861, it was not until many years after that it was made use of by the manufacturers of the United States. According to the United States Census Report of 1880 the Division of Glass Manufacture by Joseph D. Weeks, published in 1884, gives the number of Siemens regenerative pot furnaces in operation in 1879 as follows: Great Britain 12, France 22, Belgium 6, all other countries 31. The above covered plate glass, window glass, bottle glass and flint glass manufacturers. Siemens furnaces with daily melting tanks: Great Britain 6. Siemens furnaces with continuous melting tanks: Great Britain 4, France 10, Belgium 1, other countries 3.

It can be seen from this report that, while the Siemens regenerative principle had been extensively applied to the iron and steel business, it had not been adopted by many of the glass manufacturers. In 1866 or 1867 the first Siemens regenerative furnace was applied to the glass business in the United States. This was erected by the engineers of Sir William Siemens, the inventor of this type of furnace, at the O'Hara Glass Works of James B. Lyons & Company on 30th Street in Pittsburgh. It proved to be a failure because of the wrong application of the producer gas to the furnace chamber. At that time the old type of natural draft producer was used in connection with the long cooling tube supposed by the Siemens engineers to be necessary, and the air and gas ports were so constructed that the flame was introduced into the furnace chamber in a horizontal direction above the level of the pots. Great difficulty was experienced in keeping the furnace supplied with gas from the producer because of the accumulation of soot in the cooling tube and flues leading to the furnace. In the application of this principle to the iron and steel

furnaces, this trouble was not considered serious, because they could stop at any time between melts or between heats and remove the soot from the cooling tube and other flues, but in a glass melting furnace where pots were employed this would result in damage to the pots and it was necessary to maintain a continuous supply of gas to preserve a uniform temperature in the furnace that would safeguard the pots. The other difficulty, and the one that was most fatal to the successful operation of this furnace, was the fact that the intense heat of the flame above the pots destroyed them by melting in the crowns, so that it was impossible to maintain a melting temperature and at the same time preserve the pots. While it was not realized at that time, it subsequently became apparent that to operate with such a furnace it was necessary to employ the well known reverberatory principle where the fuel was introduced vertically through the bench or siege in the middle of the furnace within the circle of pots, so that the force of the flame and intense heat would be spent against the crown arch of the furnace and rebound in such a way as to surround the pots and heat them without injury. Inasmuch as this was not understood at that time, this furnace, after a little over one year of operation, was abandoned and the entire equipment torn out for the purpose of restoring the old type of direct fired furnace.

Regenerative pot furnaces are now extensively used with raw producer gas, clean producer gas and natural gas, and have been so improved that greater economy of fuel is obtained as well as largely increased production. These furnaces are built for 14, 16, 18 and 20 pot capacity, the pots being of such dimensions as to contain from 3000 to 4000 pounds of glass; and, where working conditions will permit, the melts are made in about 24 hours after filling.

Early Tank Furnaces

While the continuous melting regenerative gas fired tank furnace was first introduced in England early in the sixties, it was not until 1880 that the first furnace of this type was built in the United States. This was built by the engineers of Sir William Siemens at Poughkeepsie, N. Y., and in 1882 the second furnace

of this kind was erected at La Salle, Ill. While much trouble was experienced in the operation of these furnaces, principally because of lack of skill and training, they were really the pioneers and, while only common green and amber bottle glass was made in them, they demonstrated the adaptability of this type of furnace for various lines of glass manufacture. Information gained from the operation of these tank furnaces enabled William F. Modes and others to design a modified form of Siemens regenerative tank furnace which they afterwards installed at the works of the Streator Bottle & Glass Co., Streator, Ill. and subsequently in a number of other factories for the manufacture of bottles. It was in 1884 and 1885 that the first successful continuous melting tank furnace for the manufacture of window glass was introduced at Streator, Ill. by the Streator Window Glass Company.

Natural Gas and the Glass House Migration

While the furnaces above mentioned were operated with raw producer gas made in the old type of Siemens natural draft producers, it was at this propitious time—1883 to 1885—that natural gas was first utilized as fuel for the manufacture of glass. The first use of natural gas in a glass furnace was in 1883 at the works of the Bradford Window Glass Co. at Bradford, Pa. Its first application was not successful and it was not until 1885 that the furnace was properly arranged to utilize this fuel effectively. The first introduction of this fuel to a flint glass melting furnace was made at the Riverside Glass Works, Wellsburg, W. Va.; and it operated successfully and economically from the beginning. The discovery of this valuable fuel in such abundance, its cheapness and ease of application without serious alterations to the furnaces in use at that time, caused a complete revolution in the glass manufacturing industry; evolution might be a better term to use but those who can remember the rapid changes and enormous increase in the number of factories, their migration from place to place, will agree that it is difficult to find a term that properly expresses the rapid development of this industry, due solely to the abundance and cheapness of natural gas. Its adoption and use by the manufacturers of the Pittsburgh district was attended by what is now understood to have been criminal

carelessness and waste; the pipe lines were carelessly laid in the haste of rival gas companies to be first in the market, and ridiculous inducements were offered manufacturers to use it on a contract basis that was an incentive to waste it, and it was not until some years afterward, when it was sold by meter measurement, that, even with the low price prevailing at the time, was there any encouragement or inducement to economize in its use. After comparatively few years of revelry in the super-abundance of this most ideal natural fuel, the fields in close proximity to the Pittsburgh district began to be exhausted, and then commenced the great migration to other fields. In 1885 the great Karg well was struck in Findlay, Ohio, and the boomers of that town immediately began to offer inducements to glass manufacturers to move their plants, or build new ones in that vicinity. They offered free land for a factory site, natural gas for fuel absolutely free and, in many cases, as a further inducement, a cash bonus to assist in building the factories. Gas in the meantime had been discovered in other localities contiguous to the Findlay district and in comparatively few years a very large glass industry had been built up in that section. The same waste and disregard of economy prevailed here that was practiced in the Pittsburgh district, with the result that the supply was rapidly exhausted, and the manufacturers began to look for other locations.

In the meantime, natural gas had been discovered in Indiana in the neighborhood of Marion, which was afterward developed into a very wide, extensive and prolific field, and the booming of numerous towns was here repeated—free land, free gas and cash bonuses induced the establishment of a large number of factories in districts where hitherto the glass business had been unknown. The experience in this district was similar to that of Findlay, Ohio, and Pittsburgh and resulted in a number of the factories moving to the gas fields of Kansas. Upon the exhaustion of the gas in Kansas district, the industries moved to the gas fields of Oklahoma and Texas, where they are still holding on and operating with the hope that they have at last found an inexhaustible fuel supply. There are factories in this district which were built by parties who originally left the Pittsburgh district and have moved to each succeeding gas field. There are few who realize the extent of this migration or evolution in the glass business.

In the Pittsburgh and Ohio River districts a great many of the old established glass manufacturing companies have actually gone out of business, largely due to the unusual competition of cheap natural gas and methods employed by newly created manufacturing institutions unfamiliar with the glass trade. There are many conservative business men who are of the opinion that the use of natural gas in this industry has not been of permanent benefit to those engaged in the business, although great benefit has resulted in the improvement of the quality of the glass produced as the result of the use of this fuel.

The state of West Virginia appears to be the most prolific field and source of supply at the present time and is serving a very wide district outside of the locality where the wells are located. Pittsburgh today depends very largely upon this district for its fuel. A very large glass industry has been established in this state and the manufacturers have the advantage of being located where there is an abundant supply of bituminous coal, so that the substitution of coal gas producers in this district will obviate the necessity of moving to other localities when the natural gas is exhausted.

From the city of Pittsburgh alone thirty-three glass manufacturing establishments have either moved to other localities or have gone out of business entirely; thirty of these were from the "South Side" alone. In the Findlay, Ohio, district there were at one time over thirty glass factories in operation; today there are none; all having been abandoned or moved to other localities. In the Indiana district, while many of the factories have moved elsewhere, a number of them have adopted the use of gas producers and still maintain their business on a permanent fuel basis by using coal.

Naturally, this great movement of glass factories and the establishment of new ones, together with the improvements in furnaces, the adoption of the continuous melting tank and other innovations furnished the opportunity for the establishment of the business of building glasshouse furnaces and appliances, and it was in 1884 that the writer first engaged in that business.

(To be continued)